SJ001A WaveJudge 5000 Wireless Analyzer Toolset

Describes the SJ001A WaveJudge 5000 Wireless Analyzer Toolset, the first over-the-air monitor solution with real-time visibility into the interaction between protocol and physical layers in wireless transmissions: modular, scalable, customizable, and cost effective.

KEYSIGHT

USER'S GUIDE

Notices

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Contents

Preface

Purpose of this Documentation

Thank you for purchasing a WaveJudge wireless network test system. We hope you will find the WaveJudge an indispensable tool that fulfills all of your wireless network analysis, characterization, and problem solving needs.

The purpose of this WaveJudge documentation is to provide the proper tools and information necessary to maximize your WaveJudge hardware and software in an enterprise environment. This documentation provides instructions on how to use the WaveJudge to capture and analyze wireless network traffic. It includes explanations of all WaveJudge menus and toolbars, examples of typical setup, usage and troubleshooting scenarios.

Intended Audience

This documentation is written with the intention that the typical user of a WaveJudge system is an engineer with experience in wireless network testing and vector signal analyzers. It assumes the user has knowledge of wireless network test concepts and experience configuring, testing, and analyzing wireless equipment and data.

Documentation Outline

This SJ001A WaveJudge 5000 Toolset, User's Guide consists of:

– WaveJudge 5000 Introduction on page 23
  An introduction to the WaveJudge 5000 wireless network test system and its capabilities.

– Chapter 2. Getting Started with WaveJudge Software
  A step-by-step guide to download, install, and authorize WaveJudge software. It also provides quick guides to common set-up tasks.

  The last section Getting Started with Data has a linked outline of steps to quickly get started using WaveJudge to take a capture.

– Install Hardware on page 29
  A step-by-step guide to set up and configure WaveJudge hardware. It provides a description of WaveJudge hardware components and details how to set up sample signal configurations to execute different test scenarios.

– Configure and Capture 5G NR on page 67
  Introduces the 5G NR protocol, WaveJudge 5000 RXJudge 5G cards, and describes how to use WaveJudge for 5G analysis. This chapter also helps new users quickly set up a 5G test environment.

What's in the WaveJudge 5000 Box

The WaveJudge 5000 unit was carefully packed for safe travel. The contents of the shipment include the following items:

- WaveJudge 5000 unit
- Power Adaptor and Cord
- USB Dongle and Dongle Key Certificate[1]
- Attenuator 3 dB (one per 5G module)
- MCX Terminator[2], quantity 7
- MCX to MCX Cable[2], quantity 3
- MCX to SMA Cable[2], quantity 2
- Twinax Differential Cable[3]
- SRIO Cable[3]
- Trigger Cable Set; one per system
- 1000 Base-T Ethernet SFP plug [4]
- NetGear Gig Switch (U.S. Only)

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[1] If purchase included a software license.

[2] Only included in 4G LTE orders (RXJudge and SynthJudge modules)

[3] Quantity may vary based on system configuration.

[4] One per *Follower* chassis; *Follower* chassis are connected to and controlled through a *Leader* chassis.

Technical Specifications for WaveJudge 5000

Technical specifications include system requirements for Windows, as well as the physical hardware, power, torque, and environmental details for WaveJudge 5000.

PC System Requirements

The table below indicates the minimum requirements that your PC or laptop must meet in order to sucessfully install the WaveJudge 5000 software.

Table 1. PC Configuration for WaveJudge 5000

	WaveJudge (Minimum)	**IntelliJudge (Minimum)**	**Recommended**
Operating system	*Windows 7, 8, 8.1, or 10 (64 bit)*	*Windows 7, 8, 8.1, or 10 (64 bit)*	*Windows 7, 8, 8.1, or 10 (64 bit)*
CPU	*Intel Core 2 Duo 2 GHz - e.g., Intel Core 2 Duo E6400*	*Intel Core 2 Duo 2 GHz - e.g., Intel Core 2 Duo E6400*	*Intel Core i5 or i7 at 3.0 GHz or higher - e.g., Intel Core i7-880*
RAM	*4 GB, for Windows 7 or 8*	*8 GB, for Windows 7 or 8*	*16 GB or more*
Hard Drive	*SATA at 7200 RPM*	*SATA at 7200 RPM*	*SSD, m.2 or SATA 6 Gb/s*
Free Disk Space	*Disk Space* [1]	*100 GB* [2]	*S250 GB* [2]
High Speed Interface [3]	*GigaBit Ethernet NIC*	*GigaBit Ethernet NIC*	*GigaBit Ethernet NIC*
Ethernet Cable	*CAT 6 Ethernet Cable*	*CAT 6 Ethernet Cable*	*CAT 6 Ethernet Cable*

[1] WaveJudge Standalone requires disk space to save captured data and temporary space while processing the file. The largest capture files may be 4 GB or more if there are many ports.
[2] The maximum capture size may be limited to 40-50% of free space. Disk space is required to stream data from the IntelliJudge to the PC.
[3] DHCP software required for directly connected systems.

Physical Dimensions

WaveJudge Chassis

- Dimensions (HxWxL):
  (H) 1.75 in x (W) 16.73 in x (L) 13 in; (H) 44 mm x (W) 425 mm x (L) 330 mm
- Weight (approx.):
  8-12 lbs. (3.7 - 5.4 kg.) depending on configuration; weight of the chassis depends on the number of cards included.

mmWaveJudge Converter

- Dimensions (HxWxL):
  (H) 0.9 in x (W) 3.54 in x (L) 2.16 in; (H) 23 mm x (W) 90 mm x (L) 55 mm

Power Specifications

- Voltage Range (V):
  Input voltage: 100-240 VAC; Output voltage: 12 VDC
- Frequency Range (Hz): 50/60 Hz
- Power in Watts and Current (A):
  Input current: 3.0 A; Output current: 18.3 A 220 W

NOTE The instrument can operate with main supply voltage fluctuations up to ± 10% of the nominal voltage.

Torque Specifications

- Maximum torque to apply to the front panel signal connectors:
  7 to 10 in-lb or 79 to 112 N-cm

NOTE The input terminals for this product are classified as Measurement Category: None.

Environmental Specifications

- Humidity: 0% to 80% (Relative, Non-Condensing)
- Operating Temperature Range: 0 °C to +35 °C (33.8 °F to 95 °F)
- Storage Temperature Range: -40 °C to +80 °C (-40 °F to 176 °F)
- Indoor Use Statement: For indoor use only
- Altitude Spec (m): 2000 m

CAUTION This product is designed for use in INSTALLATION CATEGORY II and POLLUTION DEGREE 2.

Supported WaveJudge Hardware

This release of the manual contains:

- The WaveJudge 5000 modular system and its component modules.
- The newer high-bandwidth and mmWave capture components of the WaveJudge 5000 modular system, supporting 5G NR capture.

Customer Support

Contact Keysight Technologies Customer Support via the following website links:

- Sanjole Wireless Analyzers: https://www.keysight.com/find/sanjole
- General Support: https://www.keysight.com/find/support
- Service/Repair: https://www.keysight.com/find/assist
- Using 'find' in the URL query results in the correct local version of that page; 'find' will not appear in the resulting URL.

Email:
Send technical support questions to:
SJ-support@keysight.com

Telephone:
+1 808-457-1452

Mail:
Keysight Technologies
Pacific Park Plaza
711 Kapiolani Blvd., Suite 1050
Honolulu, HI 96813 USA

Online Help

The vast majority of this documentation is available as Online Help within the WaveJudge user interface. To access the Online Help system, use the menu selection Help | Help (F1). For example, if you have the WaveJudge Message List open with your cursor on it and select F1, the Help menu will open to the explanation of the WaveJudge Message List.

1 WaveJudge 5000 Introduction

When developing, certifying, or implementing 4G LTE or 5G NR wireless technology, troubleshooting functional and interoperability issues can be a challenge. It can be difficult to determine what messages were sent, what events occurred, and the timing of those messages and events. Diagnosing the root causes of problems between layers often takes hours, days, or even weeks resulting in delays in certification, late deployment, reduced credibility, added costs, and lost revenue. Additionally, one of the problems of over-the-air (OTA) testing is that conditions cannot be tightly controlled and reproduced. When you encounter an error, running the test again may not create the same wireless environment.

With WaveJudge 5000, protocol messages, remote frequency (RF) signal characteristics, and errors are captured over the air. This true air capture promotes testing integrity that results in accurate identification of the error source. The ability to characterize the channel conditions when analyzing application behavior and protocol exchange provides distinct advantages over base station (BS) logging capabilities. WaveJudge provides data about all aspects of wireless communications, particularly the upper layers through activity in the physical (PHY) layer.

Using WaveJudge 5000, you'll be able to:

- Understand the interactions between the mobile station or user equipment and the base station at all layers.
- Identify complex issues that cause interoperability problems.
- Improve the performance of the overall wireless connection.
- Verify base station behavior from an over-the-air interface, including complex antennae and modulation schemes.
- Evaluate the impact on performance of multiple input multiple output (MIMO), beamforming, and scheduling.
- Capture wireless conditions in the field for replay in the lab.
- Accurately identify anomalies that effect throughput and delay.

1.1 WaveJudge 5000 Features and Capabilities

The WaveJudge 5000 wireless network testing system supports the following features:

- Numerous options to capture wireless traffic
- Multiple hardware and software standards
- MIMO configurations
- Cross-probing interface integrates analysis between PHY and medium access control (MAC)
- Multiple view options to display, save, and interpret data
- Efficient capability to identify anomalies
- Faster product development by reducing troubleshooting cycles

The benefits of using a WaveJudge 5000 are they help you identify and analyze:

- Download (DL) assignment and Upload (UL) grants
- Scheduling errors
- DL/UL timing offsets
- Resource block assignments
- Subcarrier energy usage
- Layer 1 to Layer 3 usage
- MIMO type and rank comparison
- MIMO decodes
- Handover issues
- Synchronization and reference signal errors
- Network entry failures

WaveJudge 5000 capabilities include:

- 6 Modulation Formats:
    - Orthogonal Frequency Division Multiple Access/Single Carrier FDMA (OFDMA/SC-FDMA)
    - Binary Phase Shift Keying (BPSK)
    - Quadrature Phase-Shift Keying (QPSK)
    - 16QAM (Quadrature Amplitude Modulation)
    - 64QAM
    - Zadoff-Chu sequence

- 2 Port Triggers:
    - Manual Trigger In
    - Trigger on Boolean Phrase (e.g., Power > -20 dBm)

- 12 Traces:
  - Constellation
  - Time Domain Power
  - Error Vector Magnitude (EVM) vs. Subcarrier
  - EVM vs. Symbol Time
  - MIMO rank per subcarrier
  - MIMO rank per symbol
  - Spectral flatness (Frequency Domain)
  - Amplitude flatness (Time Domain)
  - Complementary Cumulative Distribution Function (CCDF)
  - Peak to Average Power Ratio (PAPR)
  - Spectral Power
  - Amplitude, Phase, Frequency during synchronization signal
  - Impulse Response

- 10 Formats for Statistics Output:
  - Relative Constellation Error (RCE)
  - RCE Peak
  - Reference signal RCE
  - Carrier and sampling clock frequency error
  - IQ offset
  - Control Format Indicator (CFI) error rate
  - Payload bits
  - Received Signal Strength Indicator (RSSI)
  - Reference Signal Received Power (RSRP)
  - Reference Signal Received Quality (RSRQ)

- 6 Protocol Analyzer Decodes:
  - MAC
  - Radio Link Control (RLC)
  - Packet Data Convergence Protocol (PDCP) level messages
  - Radio Resource Control (RRC)
  - Non-Access-Stratum (NAS)
  - TCP/IP (WireShark supported decodes available)

1. 2 WaveJudge 5000 Architecture

WaveJudge uses a proprietary modular architecture that lets you install or remove modules (SSD cards) as needed. This modularity allows the flexibility to customize a test solution to your specific situation and provides scalability to expand a solution in terms of ports, or memory, as your needs change.

The WaveJudge 5000 system consists of a chassis and multiple plug-in modules and depending on the intended use, it includes various combinations of the following components:

①WaveJudge 5000 Chassis
②RXJudge 40 MHz 4-port RF Receive Module
③SynthJudge 2-OCXO Clock Module
④IntelliJudge2 Analysis Dual DSP Module

WaveJudge 5000 Components

1. 2. 1 RXJudge 40 MHz 4-port RF Receive Module

RXJudge 40 MHz Module modules feature superior sensitivity and dynamic range enabling you to test in the lab and in the field. Each module features four independent, configurable 40 MHz receivers. It provides an RF connection to the monitored devices connected to RX channels one through four over SMA connectors. The center frequency for each pair of RX channels is provided by the SynthJudge.

1. 2. 2 SynthJudge 2-OCXO Clock Module

SynthJudge modules are capable of providing two center frequencies to the RXJudge 40 MHz Module Each frequency is associated with one of two groups of four frequency outputs. Alternately, the SynthJudge may be configured to provide the same center frequency to all eight frequency outputs.

1. 2. 3 IntelliJudge2 Analysis Dual DSP Module

The latest in DSP cores, field programmable gate array (FPGA) density, dynamic RAM and technology specific accelerators power the IntelliJudge2 modules and provide real-time testing. You can analyze, trigger, filter, log, and chart everything in the wireless channel for any amount of time. By default, the frequency is synthesized based on a software-selectable 100 MHz internal oscillator. Alternately, one of three other sources may be selected to provide the clock: an external 10 MHz oscillator, GPR, or PPS. The external oscillator is connected over the REF IN port on the front of the SynthJudge module. The PPS In and GPS connections are lcoated on the front of the chassis.

The DSP module houses the GBIC SFP connector, multiple DSP chips, and an SRIO connector. These components provide communication to the PC, real-time decode, temporary storage for IQ samples, and forward the decoded IQ data between two or more chassis. The system may contain multiple DSP modules. A single GBIC SFP module is required to provide Gigabit Ethernet connectivity to your PC and must be plugged into the far right DSP module of chassis 1, the master chassis in the configuration.

A system that contains a single DSP module is capable of only non-real-time capture. Real-time captures and decodes require two or more additional DSP modules. The SRIO connector on the front of the DSP module allows the user to serially interconnect multiple chassis.

Four Ports Per Module Each WaveJudge module supports four independent ports. Each port has its own radio, includes internal resources, and can be configured as either a receive (RX) or transmit (TX) port to allow accurate reception of DL/UL signals from a wide range of power levels. The ports can be driven either from the same or from separate low-noise highly accurate OCXO (oven-controlled crystal oscillator). Ports also provide maximum flexibility in test configurations requiring multiple ports, such as:

- Tower handover
- MIMO solutions including transmit diversity, spatial multiplexing, and UL collaborative with rank measurements
- Co-channel interference across multiple sectors

WaveJudge can support:

- Up to 32 truly synchronized ports in each coherent set. Test 8x4, 8x2, or 4x4 MIMO configurations and incorporate multiple layers beyond the current two-layer scheme. Large-scale testing of up to 64 chassis (up to 256 modules) can be daisy-chained per system.
- Up to five instances of carrier aggregation (CA) with 40 MHz channels.
- Enough RAM and SSD memory to store hours of I/Q data, with flexible configuration options to track long-term trends or isolate intermittent anomalies.

In addition to the base WaveJudge 5000 system, the following tools are available.

1. 2. 4 StoraJudge IQ SSD Storage Module

Keysight WJ5000A-MA1 StoraJudge IQ SSD Storage Module, 1 TB Memory, can customize the system to analyze short captures, track long-term trends, or isolate intermittent anomalies. Down-converted analog I/Q signals are stored on the memory modules instead of a fixed 4 GB cache.

1. 2. 5 CipherJudge Key Intercept Hardware Kit

Keysight WJ1100A CipherJudge Key Intercept Hardware Kit provides real-time SIM key retrieval and parsing of ciphered traffic and enables User Equipment (UE) signal identification during over the air analysis of LTE mobile devices in encrypted high-traffic wireless networks.

1. 2. 6 AutoJudge Command Line Interface (CLI)

Keysight AutoJudge Command Line Interface (CLI) automates wireless testing via the command line interface (CLI).

2 Install Hardware

This section describes how to configure the WaveJudge 5000 physical equipment. For a list of parts included in the WaveJudge 5000 system, refer to What's in the WaveJudge 5000 Box on page xix.

2. 1 WaveJudge 5000 and 5G NR

Keysight WaveJudge 5000 includes a seamless integration with the proprietary RXJudge 800 MHz module (RXJudge 5G). This combination produces a WaveJudge 5000 capture as a non real-time, post-processed capture file.

The WaveJudge 5000 system supports everything up to 3GPP Release 16 (Rel 16) including:

- Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD)
- All LTE/5G channel bandwidths (up to 800 MHz/1400 MHz)
- All LTE/5G frequency bands
- Higher-order MIMO (2x2, 4x4, 8x8)
- Up to eight carriers
- 5G SA and NSA access
- All 5G numerologies

WaveJudge 5000 Chassis - Front

In a common configuration for 5G NR capture, as shown here, the front side of the WaveJudge 5000 5G chassis contains two 5G RXJudge modules (left side) and a SynthJudge (right side).

WaveJudge 5000 Chassis - Back

2. 1. 1 Setting Up WaveJudge 5000 Hardware

Most WaveJudge 5000 modules must be in a specific chassis slot. They are shipped from the factory in the following configuration.

1. RXJudge – Slot 1 or 3 when available
2. SynthJudge – Slot 2
3. IntelliJudge2 with chassis SRIO interconnect
   – Alternates between slots 4 and 3
4. IntelliJudge2 with Gigabit Interface Converter Small Form-factor Pluggables (GBIC SFP) – Slot 4

In a multi-chassis system, the main chassis (or chassis 1) is identified with the label **M**. **The 1000 Base T SFP must be plugged into the main chassis**. Do not move the SFP to another chassis, unless recommended by Keysight.

1. If you have several WaveJudge 5000 chassis, interconnect them by using the included serial rapid IO (SRIO) and twin-axial interconnection cables; see Connect Multiple WaveJudge 5000 Chassis on page 53.
2. If you are using a pulse per second (PPS) or global positioning system (GPS) clock source, connect your clock source to the PPS or GPS connector; see External Precision Clocks on page 32.
3. Connect the primary (main) WaveJudge 5000 chassis to your PC over Ethernet using one of the following four methods; see WaveJudge 5000 PC Connections on page 35.
   - A. Over a Gigabit Switch on page 35
   - The PC and the WaveJudge 5000 will transmit DHCP requests; the corporate LAN will supply the IP addresses.The data traffic passing between the the PC and the WaveJudge 5000 will isolate from the LAN by the switch through MAC learning. Connect to a PC Over a Gigabit Switch B. Over a Gigabit Router on page 35
   - The PC and WaveJudge 5000 will transmit DHCP requests; the router will provide an IP address. Connect to a PC Over a Gigabit Router C. To a PC Over a Network on page 36
   - D. Directly Connect via DHCP on page 37 (requires DHCP software installation)

2. 1. 1. 1 WaveJudge 5000 Front Panel

Minimally, the WaveJudge 5000 front panel has at least one RXJudge 800 MHz module on the left and a SynthJudge module on the right. An RXJudge 800 MHz card (or the original RxJudge 40 MHz card) can be added; the difference is the maximum obtainable frequency range achieved by each card.

Front Panel of WaveJudge 5000

The hardware dictates the constraints for a valid capture configuration. For example, the maximum bandwidth/sampling rate on the original RXJudge card is limited to 40 MHz without real-time processing, and 20 MHz with real-time. A combined RXJudge 40 MHz/RXJudge 5G (800 MHz) capture must use real-time processing on original RXJudge ports for LTE and non-real-time capture on RXJudge 5G (800 MHz), etc.

The list of standard modules/cards available and their specifications are described in the section WaveJudge 5000 Modules on page 40.

External Precision Clocks

The external clock signal connectors on the left are for GPS antenna signal or PPS.

IMPORTANT **Only use these connectors if the chassis is identified as the primary (main) chassis.**

Some older WaveJudge 5000 chassis may contain an Ethernet port, which should not be used.

Back of WaveJudge 5000 - Left Side Clock Connections

GPS ANT: Connects to a GPS antenna utilizing an LNA (low noise amplifier).

CAUTION **To avoid damage, refer to GPS on page 322 section prior to connecting a GPS antenna.**

GPS PPS: Accepts a one Pulse Per Second (PPS) TTL signal.

Chassis Clock Interconnects

The chassis clock connection transmits the PPS to an alternate device and references the sample clock to cascade from the primary (main) chassis to each additional chassis in a single system. The cascaded signal allows all chassis and all SynthJudge modules to synchronize to a single clock source and function as a single unit.

Back of WaveJudge 5000 - Right Side Clock Connections

Clock connections are described below.

PPS OUT:

Outputs a one pulse per second (PPS) transistor-transistor logic (TTL) signal based on the selected precision clock source.

- When the precision clock is GPS, the output is enabled once the clock is locked.
- When the precision clock is PPS, the PPS signal goes forward over the PPS Out connector.

SYNC OUT:

Primary twinax differential output clock from the SynthJudge module that synchronizes the clocks for another WaveJudge 5000 chassis.

SYNC/AUX OUT:

Secondary twinax differential output clock from the SynthJudge module may synchronize the clock for a third WaveJudge 5000 chassis.

SYNC IN:

Twinax differential input clock to the SynthJudge module of a secondary chassis.

TRIGGER/AUX IN:

Twinax differential input signal (for future expansion).

DC IN:

12V⎓, 15 AMP power connector.

2. 1. 1. 2 WaveJudge 5000 Back Panel

The back panel has the WaveJudge 5000 label and two sets of connections. The left side connections accept external precision clock sources; the right side connections allow clocks to cascade between multiple chassis to maintain a single clock source.

Back Panel of WaveJudge 5000

2. 1. 2 Connecting WaveJudge 5000 Software to the WaveJudge 5000 Chassis

1. Start the WaveJudge 5000 software (for example, click the WaveJudge shortcut icon on your desktop to launch the application).
2. Click the vertical button **Connect Type** to set the Choose Connection Type Window on page 232.
3. Click the vertical button **Configure Chassis**.
4. If required, check the box to enable the optional IntelliJudge Real-Time Capture mode. Then, select one of the Precision Time Sources: None, GPS, PPS In from the drop-down menu.
5. If you are using an external time source, select one of the Frequency Reference Sources:Calibration, External 10 MHz, GPS, PPS In.
6. Configure a Test Scenario on page 72, or load a previously saved test configuration.
7. Configure the Configure Cells on page 77, Configure Downlink/Uplink Port Groups on page 148, and Configure Rx Port Settings on page 151.

IMPORTANT On each RXJudge module of the WaveJudge 5000, ports Rx 1 and Rx 2 of the card always have the same center frequency; likewise, ports Rx3 and Rx 4 of the card always have the same center frequency.

8. Check the physical configurations for each port in the Configure Rx Ports on page 86.
9. Connect the cables or antennae to the receivers on the chassis; see WaveJudge 5000 Modules on page 40.

10. Click the Connect button in the toolbar .
11. Select your chassis from the list.
12. Set the gain settings for each Rx port.

NOTE Setting the Rx port gain correctly is an important step to assure proper operation, optimum results, and successful decoding.

To set gains correctly, refer to Configure and Capture 5G NR on page 67 and Configure Rx Ports on page 86.

13. Set Up Capture Window on page 162

2.1.3 WaveJudge 5000 PC Connections

The WaveJudge 5000 chassis connects to your PC over a Gigabit Ethernet connection based on an IP address. The connection may be made either directly, through a router, or a switch. The IP address is obtained from a Dynamic Host Configuration Protocol (DHCP) server. A DHCP server must be available through either the PC, LAN or, router that connects to the WaveJudge 5000.

1. In most connections, the DHCP configurations should be available. Verify DHCP is up and running prior to starting WaveJudge 5000.
2. Connect a Cat 6 Ethernet cable from the WaveJudge1000 Base-T SFP connector on the front panel to the PC.
3. Plug in the 1000 Base-T SFP connector into the Digital Signal Processor (DSP) module in Slot 4 of the **primary (main)** WaveJudge chassis.
4. Connect to the PC in any one of the following four ways.

A. Over a Gigabit Switch

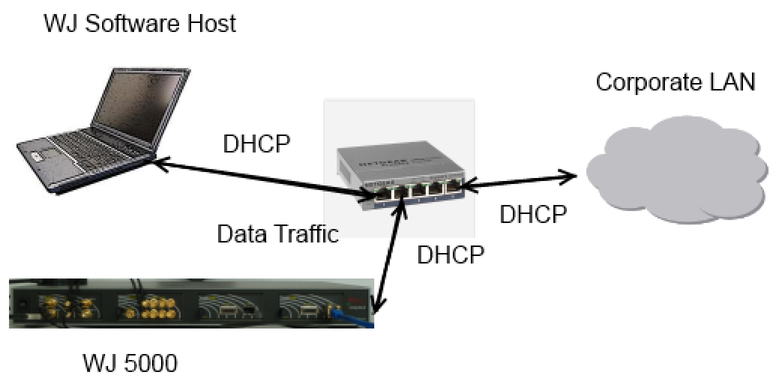
The gigabit solution is the easiest solution that will not impact the corporate LAN.

a) Connect a gigabit Ethernet switch to the corporate LAN.

b) Connect the host PC and the WaveJudge 5000 to the switch

c) Turn the devices on.

- The PC and the WaveJudge 5000 will transmit DHCP requests; the corporate LAN will supply the IP addresses.
- The data traffic passing between the the PC and the WaveJudge 5000 will isolate from the LAN by the switch through MAC learning.



Connect to a PC Over a Gigabit Switch

B. Over a Gigabit Router

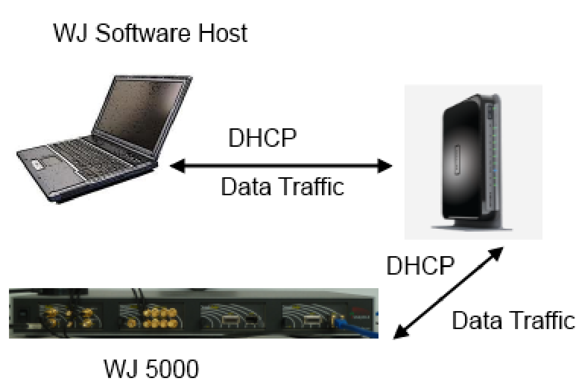
The gigabit router solution assumes the router includes DHCP; it is useful during remote testing when a LAN is not available to provide DHCP.

a) Enable router with DHCP.

b) Connect the PC and the WaveJudge 5000 to the router.

c) Turn on the devices.

- The PC and WaveJudge 5000 will transmit DHCP requests; the router will provide an IP address.



Connect to a PC Over a Gigabit Router

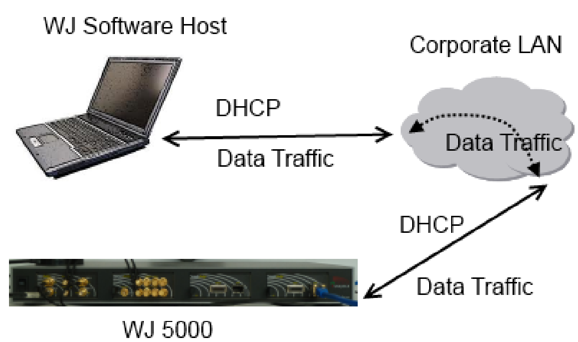
C. To a PC Over a Network

Connecting directly over a network that supports DHCP is the easiest solution. However, it has the potential to saturate the network if real time captures are performed.

a) Turn on the devices to obtain IP addresses from the network.

b) Monitor network performance.

c) If there are drops in performance then use an alternative solution.



Connect PC Over a Network

D. Directly Connect via DHCP

In the direct connect solution you will need to install and run a DHCP server. In some corporate environments, an IT manager may not allow you to disable the firewalls, as required for DHCP.

a) Configure the PC NIC based on the DHCP server configuration.

b) Start the DHCP server.

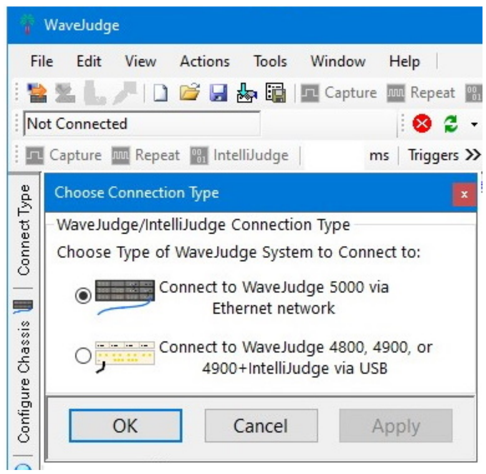
c) Connect the WaveJudge 5000 to the PC and turn it on.

d) The DHCP server will allocate an address to the WaveJudge 5000.

Connect PC via DHCP

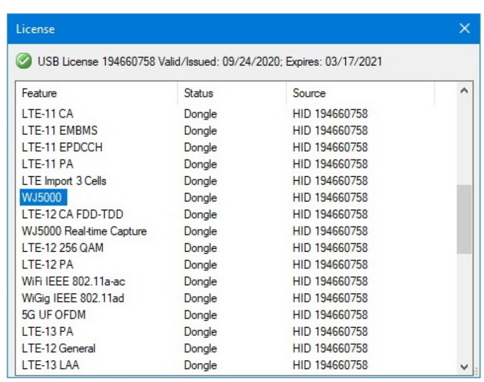
5. After each power cycle the LEDs on the WaveJudge 5000 front panel modules will flash; they will stop after they boot up. You'll then hear a faint beep to indicate they have an IP address and are ready to connect.

6. Start the WaveJudge 5000 software. Prior to connecting to the WaveJudge 5000, you must initially set the Connection Type to the WaveJudge 5000 via Ethernet which it will maintain, until you change it.



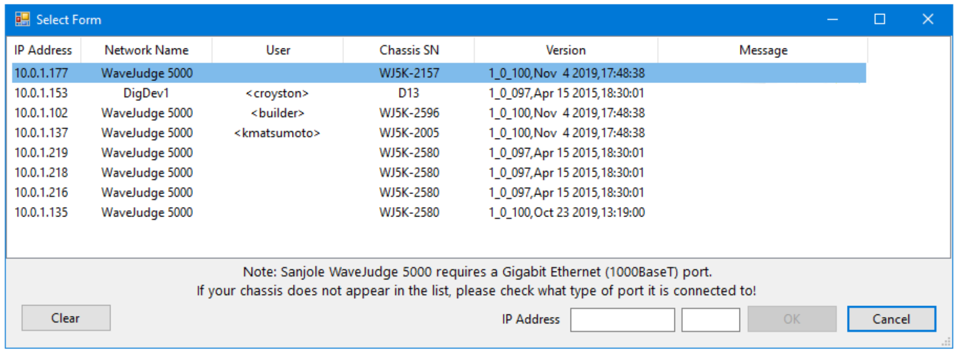
WaveJudge 5000 License Enabled

7. The Connect Type tab will be present only if the WaveJudge 5000 license is enabled. You can confirm if it is enabled by clicking the Help menu and then select License; scroll down the list until you see WJ5000.



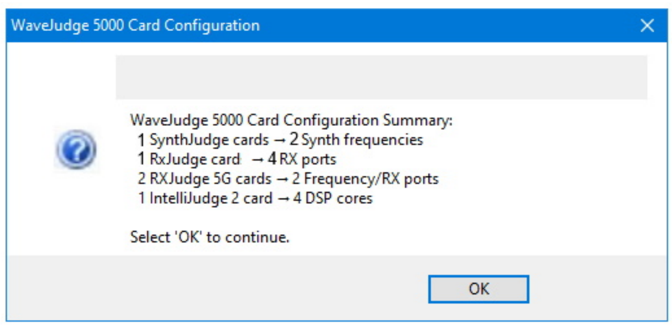
WaveJudge 5000 License Enabled

8. After the WaveJudge 5000 is selected as the connection type, click the Connect button  on the toolbar. WaveJudge will automatically populate and display a connection list. If you receive a “no USB present” message verify the “WJ5000” is identified as the connection type.



Select Form Lists all WaveJudge 5000 Licenses

9. Double-click the WaveJudge 5000 line item. After successful completion of the discovery process the following window will display.



WaveJudge 5000 Card Configuration Window

WaveJudge 5000 is now ready to use.

2. 2 WaveJudge 5000 Modules

The WaveJudge 5000’s ability to process and decode an RF signal and accept an external trigger or clock is based on three pluggable modules: the RXJudge, SynthJudge, and IntelliJudge2. Addtionally, the back panel of the chassis provides inputs for a GPS, PPS signals, and the capability to interconnect multiple chassis.

The following sections provide an overview of different WaveJudge 5000 chassis and modules, their ports and connnectors, and instructions to physically connect them with WaveJudge 5000 software.

2. 2. 1 RXJudge Modules

Depending on the band frequency range and the bandwidth to capture, several different types of WaveJudge 5000 modules may be used to capture 5G NR. For some bands, the RXJudge 40 MHz module (for example, the original RxJudge) in combination with SynthJudge will be the best capture option, as it typically is for LTE. For other bands, the RXJudge 800 MHz module (RXJudge 5G) will be the only capture option - or the best option. The combination of the mmWaveJudge Converter/Receiver on page 49 and the RXJudge 800 MHz is the only way to capture bands in FR2.

It is also possible to configure a system with a combination of RXJudge 40 MHz modules and RXJudge 800 MHz modules. This typically would be used to capture an NSA configuration with LTE being captured in real-time on the RXJudge 40 MHz modules as an "IntelliJudge" capture, and 5G NR in FR1 or FR2 being captured on the RXJudge 800 MHz modules as a non-real-time capture.

NOTE **Currently, IntelliJudge cannot capture 5G NR in real-time, you can only use it on 4G LTE.**

When capturing (non-real time) 5G NR with the RXJudge 800 MHz module, with or without the mmWaveJudge, the WaveJudge 5000 software has some additional features that allow you to configure it to split the 800 MHz band it into anywhere from two to eight component carriers. Configure this setting in the Configure Test form via the Configure 5G Port/Carrier panel, which may optionally be used as a "wizard" to help create the portion of your 5G test configuration working with high bandwidth modules.

When you connect to a system with RXJudge 800 MHz modules, with or without mmWaveJudge, the list of 5G module types in the WaveJudge 5000 GUI is immediately updated to match the type of modules physically present. The list of modules cannot be changed at that point. If you edit the configuration, you are restricted to only configuring settings that will work for the type of modules in the system you are connected to; however, it is usually possible to change the carrier definitions, frequencies, or cell assignments while connected.

Upon disconnection, the WaveJudge 5000 will automatically retain the 5G module settings. At this time, the module type settings can again be changed via the drop-down menus in the Configure 5G Port/Carrier configuration panel. A different set of 5G module type settings can also be restored by loading a capture or configuration file.

Each RXJudge module has four RF ports and two frequency inputs. Each port has an associated Error and OK LED.

IMPORTANT **For the WaveJudge 5000 RXJudge Module, Rx 1 and Rx 2 must be set to the same center frequency; ports Rx 3 and Rx 4 must be set to the same center frequency.**

---

2. 2. 1. 1 RXJudge 800 MHz 5G Module

The WaveJudge 5000 system RXJudge 800 MHz Baseband/IF module connectors are SMA for IF input (2.375GHz to 11.625GHz) and SMA for LO output (to mmWave Converter RF). There is one input port on the RXJudge 800 MHz module. The DRAM capture size is 4GB, with a capture time up to 3.56 seconds (start capture on Trigger: Port 1 only). The bandwidth is 5 MHz to 800 MHz with 1-8 channels and can be contiguous or non-contiguous in a 1400 MHz channel.

RxJudge 800 MHz 5G Module

The module's base capture rate is 2400 M samples/second. This includes downsampling up to a factor of eight if the channel bandwidth allows:

- 5G captures at 200 MHz bandwidth or less (300 MHz sampling rate or less): capture up to 3.56 seconds (3560 ms);
- 5G captures at up to 400 MHz bandwidth (600 MHz sampling rate): capture up to 1.78 seconds (1780 ms);
- 5G captures at up to 800 MHz bandwidth (1200 MHz sampling rate): capture up to 0.89 seconds (890 ms).

The exception are frequencies from 2.8 GHz down to 2.3 GHz, where the capture duration is 890 ms.

At channel bandwidth of 100 MHz (sample rate of 150 MHz), the module minimum center frequency is 2.375 GHz (band from 2.325 GHz - 2.425 GHz). At channel bandwidth of 200 MHz (sample rate of 300 MHz), the minimum center frequency is 2.450 GHz (band from 2.350 GHz - 2.550 GHz).

When it comes to TDD, 1 BB module dedicated to the UL may be needed if input levels of DL/UL are not similar. This means that SISO requires one BB module, but possibly two; MIMO 2x2 requires two BB modules, but possibly three.

RxJudge 800 MHz 5G Module Specifications

RxJudge 800 MHz module 1x1400 frequency, bandwidth, and amplitude specifications are as follows.

Frequency:

- Channel coverage extent including instantaneous bandwidth : Range -700 to +700
- Full Range: 2.3 to 11.7 GHz

Bandwidth:

- Instantaneous bandwidth: 1.4 GHz

Amplitude:

- Optimal Input Power Range: -32 to -2 dBm
- Absolute Maximum Input Power Range: 15 dBm

The image below shows the RXJudge 800 MHz module connections.

RxJudge 800 MHz 5G Module Connections and LEDs

Functional descriptions for the RXJudge 800 MHz module connectors are described below.

RF IN

RF IN is the primary connector for input signals in the 2.3 GHz - 11.7 GHz. The RF IN connector is used for the following tasks:

- For high-bandwidth 5G signals in the Sub-6 GHz bands, it is the direct RF input.
- When the RXJudge 800 MHz module is used with the Keysight mmWaveJudge converter, the RXJudge 800 MHz module (RXJudge 5G) RF IN connector will be

used to connect the RF Out output of the mmWaveJudge.

- When RXJudge 800 MHz module is used with an Intermediate Frequency (IF) signal before upconversion to millimeter wave frequencies, or with a third party millimeter wave downconverter, it is the IF input.

mmWAVE

This port must only be used with the mmWaveJudge converter for the special cable supplying its power. (It may be labeled RF Power on some older modules; these modules may not be used with mmWaveJudge until they have been upgraded at Keysight.)

CAUTION **mmWave must only be connected or disconnected when the WaveJudge 5000 is completely powered off. Connecting the cable while powered on may damage the RXJudge 800 MHz module, mmWaveJudge, or both.**

LO OUT

Future mmWave expansion module signal.

LO OUT provides an output signal at the RXJudge 800 MHz module's true RF/IF center frequency. With the mmWaveJudge, it is used to provide a reference RF signal, but it may be used for other purposes.

NOTE **This frequency does not necessarily match the center frequency for any of the bands being captured unless it is manually configured. WaveJudge 5000 software automatically adjusts the module frequency to optimize signal quality for the 5G bands.**

REFCLK

REFCLK supports the input of a high-precision reference clock signal, to further improve the precision of the frequency oscillator and 5G sampling rate clock. RXJudge 5G supports a standard 10 MHz reference clock signal. Once connected, in order to use the reference clock input, you must enable it in the appropriate control of the **Configure WaveJudge 5000 Chassis** window.

NOTE **The clock signal should be connected only to REFCLK on the primary RXJudge 800 MHz module (RXJudge 5G), which is the first module on the left in the first WaveJudge 5000 5G chassis. The primary RXJudge 800 MHz module will synchronize its clock to this signal and distribute the high-precision signal to all secondary modules in all of the connected 5G chassis.**

TRIG IN

TRIG IN may be used to connect an external capture trigger source to the RXJudge 800 MHz primary module. In that scenario, the WaveJudge 5000 can be configured to trigger a capture on a signal from the external source. This should be a standard TTL level signal, triggering on rising edge. For more information, see the Keysight WJ5000A WaveJudge 5000, Data Sheet.

To use the external trigger, it must be enabled in the **Set up Capture** window.

NOTE The trigger source should be connected **only** to TRIG IN on the RXJudge 800 MHz primary module, which is the first module on the left in the first WaveJudge 5000 5G chassis. It will synchronize the start of capture on all RXJudge 800 MHz modules in all of the connected chassis.

AUX OUT

Not currently in use. The AUX OUT connector is only used for development and production purposes and cannot be enabled in the WaveJudge 5000 software.

LEDs

- **LOCK (top):** LED indicates the module has locked to the configured clock source of Internal, GPS, PPS, or REF IN.
- **LOCK (bottom):** BLINK LED indicates waiting for sample clock; LIT indicates locked to sample clock.
- **RF (top):** LED indicates external mmWave module is detected.
- **ERR:** LED indicates a board failure is detected.
- **EXT REF:** LED indicates the external reference clock is locked (first RXJudge 5G module only).
- **PROG MEZZ:** LED indicates mezzanine is detected and running.

2. 2. 1. 2 RxJudge2 800 MHz 5G Module

The RXJudge2 800 MHz 5G modules are exactly the same as the previous 5G modules; however, they have slightly different specifications and higher signal quality, especially at high bandwidth.

RxJudge2 800 MHz 5G Module

The RxJudge2 800 MHz specifications for frequency, bandwidth, and amplitude are as follows.

Frequency:

- Channel coverage extent including instantaneous bandwidth: Range -400 to +400 MHz
- Card Center Frequency Range: 2.4 to 11.0 GHz
- Full Range: 2.0 to 11.4 GHz

Bandwidth:

- Instantaneous Bandwidth: 800 MHz

Amplitude:

- Optimal Input Power Range: -32 to -2 dBm
- Absolute Maximum Input Power Range: 15 dBm

The connectors, summarized below, are exactly the same as the RxJudge 800 MHz module.

REFCLK

- Connector: SMA
- Impedance: 300 Ohm
- Coupling: AC
- Maximum P-P Voltage: 1.8 V p-p
- Minimum P-P Voltage: 0.8 V p-p

TRIG IN

- Connector: SMA
- Impedance: 100K Ohm
- Coupling: DC

- Maximum Voltage In: 3.3 V
- Minimum Voltage In: 0 V
- Trigger Level: 1.2 V

AUX OUT

- Connector: SMA
- Hi Level Out: 3.3 V
- Low Level Out: 0 V
- Drive Strength: 50 mA

LEDs

- LOCK (Bottom): LIT indicates baseband sampling clock is working correctly.
- ERROR: Board failure detected.
- EXT REF: Blink indicates secondary module failed locking to primary module. LIT indicates secondary module locked to primary module.
- PROG-MEZZ: Mezz detected and running.
- LOCK (Top): Unused

2. 2. 1. 3 RxJudge 40 MHz Module

The RxJudge 40 MHz module (for example, the original "RxJudge") may be used for capturing any protocol, including all releases of LTE and all 5G NR bands up to 40 MHz bandwidth within FR1. The module has four ports and supports frequencies between 380 MHz to 6 GHz.

RxJudge 40 MHz 5G Module

Each RXJudge 40MHz module has four RF ports and two frequency inputs. Each port has an associated Error LED and OK LED.

IMPORTANT **For the WaveJudge 5000 RXJudge Module, Rx1 and Rx 2 must be set to the same center frequency; ports Rx 3 and Rx 4 must be set to the same center frequency.**

Functional descriptions for the RXJudge 40 MHz connectors and LEDs are listed below.

SYNTH 1 IN: Synthesizer frequency input for Rx ports 0 and 1.

CH 0: Rx port 1 RF connector

CH 0 ERR LED:

1. Flashes at power 'on' prior to initialization; turns off after initialization.
2. On a primary (main) chassis, the LED will flash after a sudden loss of the reference clock after the software connects to the chassis. Based on the configuration the clock may be the internal clock or an external 10 MHz clock.
3. On a secondary chassis, the LED begins to flash after connecting to the chassis to indicate a loss of the Back Panel SYNC Connections on page 54.

CH 0 OK LED:

1. Flashes at power up until startup code is read from flash.
2. Once powered up, it remains on to indicate SRIO communications to the module is functioning across the backplane.

CH 1: Rx2 RF port connector

CH 1 ERR LED: Rx2 ERR LED functionality

CH 1 OK LED: Rx2 OK LED functionality

SYNTH 2 IN: Synthesizer frequency input for Rx ports 2 and 3.

CH 2: Rx2 RF port connector

CH 2 ERR LED: Rx2 ERR LED functionality

CH 2OK LED: Rx2 OK LED functionality

CH 3: Rx3 RF port connector

CH 3 ERR LED: Rx3 ERR LED functionality

CH 3 OK LED: Rx3 OK LED functionality

2. 2. 2 mmWaveJudge Converter/Receiver

The mmWaveJudge converter is designed for use with the WaveJudge 5000. It supports basic 2x2 MIMO or massive MIMO applications at mmW bands, an RF output range of 2.5 to 11.5 GHz, a mmW input range of 24-30 GHz band, a 37-42.5 GHz band, and a mmW bandwidth of 1.4 GHz.

mmWaveJudge Converter/Receiver

The mmWaveJudge Converter has four connections:

mm: mmWave input port; received from the device under test.

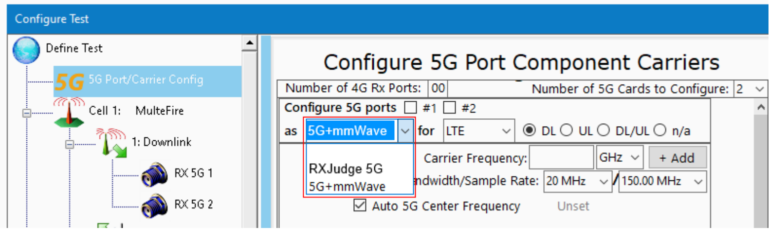
LO OUT: LO input port; receieved from 5G card's LO output port.

USB: USB connector; connects to the 5G card's USB connector.

IF: Intermediate Frequency. Frequency down converted IF signal from mmwave band; output port feeds into 5G card's RF input port.

The mmWaveJudge converter can be used with the latest model of RxJudge 5G to capture 5G signals in the millimeter wave ranges, making it possible to capture 5G component carriers in the ranges 23.7-30.3 GHz and 36.7-42.3 GHz. WaveJudge 5000 will automatically detect 5G cards with an attached mmWave receiver module on connecting to the WaveJudge 5000 and set up the valid 5G frequency range for those cards accordingly.

To set up a configuration using mmWaveJudge while offline, open the **Configure Test** window. In the **5G Port/Carrier Configuration** panel where you configure **Component Carriers for a 5G port**, click the drop-down menu to set the 5G port type to **5G+mmWave**. This will allow you to enter mmWave carrier frequencies in the extended range and create and save a configuration for mmWave ranges.



Configure Ports as"5G+mmWave"

2. 2. 3 SynthJudge Module

Each SynthJudge module can provide two frequency clock sources - one per bank of four MCX connectors. Depending on the software mode selected, SynthJudge will also accept a 10 MHz reference clock or an external trigger in/out over the AUX MCX connector.

SynthJudge Module

NOTE As shown in the figure above, older SynthJudge chassis are labeled **REF IN** on their front panel; this connector is currently labeled **AUX IN/OUT** to reflect the multi-functional behavior of the connector.

The SynthJudge's ports and indicators are:

1x8 LED: Status to indicate FREQ 1 OUT and FREQ 2 OUT are providing the same frequency clock.

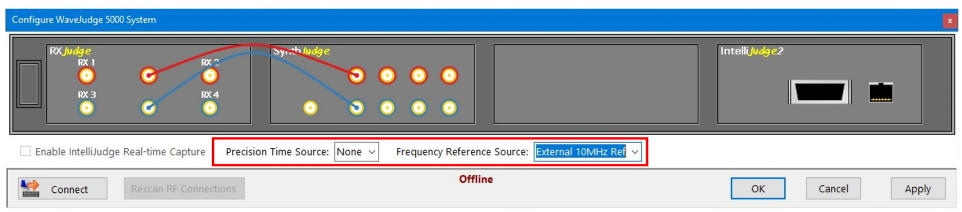
2x4 LED: Status to indicate FREQ 1 OUT and FREQ 2 OUT are providing different frequency clocks.

FREQ 1 OUT: First block of four MCX connectors to simultaneously output the same frequency clock.

FREQ 2 OUT: Second block of four MCX connectors to simultaneously output the same frequency clock.

AUX IN/OUT: Multi-function MCX connector, can provide either of the following functions:

- **10 MHz Input Reference Clock:** Locks the SynthJudge's OCXO to an externally sourced reference. The clock can receive a frequency of 10 MHz. It drives the WaveJudge's sample clock and carrier clock on all RF ports.
  - Termination: 50 ohm
  - Level: .8 V - 3.3 V pk maximum
- **External Trigger In:** To use the AUX IN/OUT connector for external 10 MHz clock input enable it by setting the Precision Time Source to None and the Frequency Reference Source to External 10 MHz Ref.



For SynthJudge, Set the Precision Time Source and Frequency Reference Source

ERR LED: Secondary chassis is not receiving a signal from the SYNC IN.

LOCK LED: The module has locked to the configured clock source of Internal, GPS, PPS, or REF IN.

2. 2. 4 IntelliJudge2

The IntelliJudge2 module stores and processes I/Q data using internal DSPs (Digital Signal Processors). It also includes an SRIO connector, an SFP connector cage that accepts a 1000 Base-T SFP, and status LEDs.

IntelliJudge2

The IntelliJudge2 module's ports and indicators are:

SRIO: SRIO connector for inter-chassis communication path; required to connect multiple chassis.

SFP Connector Cage: Accepts a 1000 Base-T SFP usable for Ethernet connection in slot 4 of primary (main) chassis.

OS Status LED: Operating Service Status LED blinks to indicate a hardware fault has occurred.

B Status LED:

- During power-up, it may flash to indicate this IntelliJudge2 module is starting normally.
- After connection from the PC, this LED normally turns off.

A Status LED:

- During power-up, it flashes to indicate this IntelliJudge2 module is starting normally.
- At the end of power-up it is normally ON while awaiting connection from the PC.
- After connection from the PC, this LED normally turns off.

IS Status LED: In-Service Status LED; ON indicates the device is functioning with no faults.

2. 2. 5 StoraJudge Module

The StoraJudge consists of a 1 TB SSD module and two SRIO connectors. When paired with the RXJudge 40 MHz module, the SSD may extend capture durations by up to 30 minutes. SRIO connectors function as interconnects between chassis. When paired with the RXJudge 800 MHz module, they function as interconnects only. For more information, see StoraJudge Module on page 505.

StoraJudge Module

2. 2. 6 CipherJudge

CipherJudge is a combined software/hardware system that lets you decode ciphered traffic captured by IntelliJudge specific to your device. CipherJudge software automatically installs when you install the WaveJudge 5000 software. It monitors events between your device and the SIM card that generates the keys required to cipher and decipher traffic. It then forwards the keys to the WaveJudge 5000 software and hardware to permit them to decode the traffic. For more information, see CipherJudge Hardware Kit on page 515.

2. 3 Connect Multiple WaveJudge 5000 Chassis

You can interconnect multiple WaveJudge 5000 chassis to operate as a single system. Currently, you can connect a maximum of 16 chassis. The chassis must be interconnected both through the SRIO connectors on the front of the IntelliJudge2 modules and the SYNC connectors on the back of the waveJudge 5000 chassis. The signals cascade from the primary chassis to the next chassis, and then from each chassis to its next chassis. If other types of connections (such as a 10 MHz reference clock) or an external trigger are provided, they must connect to the primary chassis.

2. 3. 1 IntelliJudge2 Module SRIO Connections

In the four chassis configuration below, **the primary (main) chassis is identified by the 1000 Base-T SFP module plugged into the IntelliJudge2 module in slot four of the top chassis**. The first SRIO cable must always be plugged into the IntelliJudge2 module on the fourth slot of the primary chassis. That cable then connects to the

IntelliJudge2 module on the fourth slot of the second chassis. The SRIO cable plugs into the IntelliJudge2 module on the third slot of the second chassis, which then connects to the IntelliJudge2 module on the third slot of the third chassis. To add additional chassis, it is recommended to always continue the SRIO cabling alternating in this fashion.

Four WaveJudge 5000 Chassis Interconnected via SRIO

2. 3. 2 Back Panel SYNC Connections

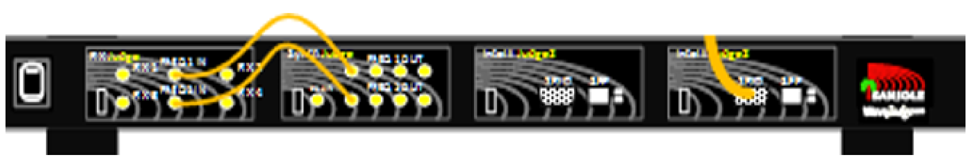
The image below illustrates three WaveJudge 5000s, where the top chassis is the primary. Just as with the SRIO connections, the SYNC OUT signal originates from the primary chassis and is connected to the SYNC IN of the second chassis. Next, the SYNC OUT of the second chassis is connected to the SYNC IN of the third chassis. If you add more chassis, repeat the continuous feed of SYNC OUT to SYNC IN.

Three WaveJudge 5000 Chassis Connected via Sync In and Sync Out

2. 3. 3 NSA Chassis Configurations

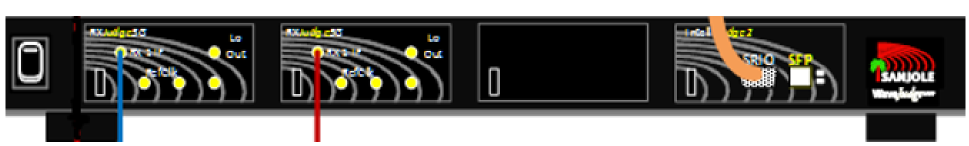
Customers can purchase one or two chassis at time, or a combination of both 4G/LTE and 5G, depending on your needs. Shown below are examples of several system configurations.

Example 1 shows a basic 4G/LTE system consisting of one chassis using four 40 Mhz ports. Two 40 Mhz ports connect RXJudge to two 40 Mhz ports on SynthJudge.



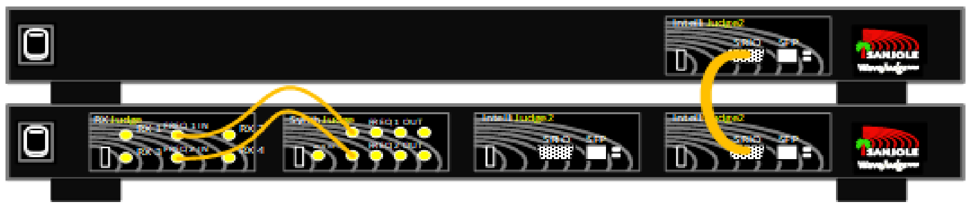
Example 1: 4G LTE Chassis with Four 40Mhz Ports Connect to RxJudge 5G

Example 2 shows a simple 5G system of one chassis. One RXJudge 800 Mhz port is set up for UL and the other RXJudge port is for DL.



Example 2: 5G System - One Chassis with Two 800 MHz Ports

Example 3 shows a 4G/LTE system with two chassis capable of capturing real-time traffic. As shown in Example 1, two 40 Mhz ports connect RXJudge to two 40 Mhz ports on SynthJudge chassis; however, one IntelliJudge chassis connects to a second IntelliJudge chassis that provide the real-time support.



Example 3: Real-Time 4G/LTE System - Two Chassis with Real-Time Support and Four 40Mhz Ports

Example 4 shows a combined LTE and 5G system using three chassis.

Example 4: Combined LTE and 5G System Using Three Chassis, Four 40 MHz Ports, and Four 800 MHz Ports

Example 5 shows a system with three WaveJudge 5000 chassis configured for 4G LTE real-time capture with the original RXJudge, plus two WaveJudge 5000 5G chassis hosting three RXJudge 800 MHz modules which can be configured for high-bandwidth 5G NR capture. The top two cahssis support the RXJudge 800 MHz module for 5G NR captures. The bottom three chassis support the RXJudge 40 MHz for LTE captures.

Example 5: NSA (4G LTE and 5G) Front Panel Configuration

The LTE system must be the primary controller for the system, so the Ethernet connection is connected to the first of the three LTE chassis at the lower right. The red line indicates the connection of the trigger cable between the SynthJudge in the LTE primary controller and the primary RXJudge 5G module.

NSA Chassis Back Panel Cabling

When a set of one or more WaveJudge 5000 chassis with SynthJudge and RXJudge (for example, a 4G chassis) are connected to a set of one or more WaveJudge 5000 5G chassis, the back panel connections should resemble the image below.

NSA WaveJudge 5000 Chassis Back Panel Connections

Follow these steps to configure the chassis connections.

1. Connect the first WaveJudge 5000 4G chassis SYNC OUT to SYNC IN of the next WaveJudge 5000 4G chassis.
2. Repeat connecting WaveJudge 5000 4G chassis SYNC OUT to SYNC IN of the next WaveJudge 5000 4G chassis until all chassis up to the WaveJudge 5000 5G chassis have been connected.

3. Connect the last WaveJudge 5000 4G chassis SYNC OUT to TRIGGER AUX IN on the first WaveJudge 5000 5G chassis.

WaveJudge Back Panel: Trigger - AUX IN Connection

NSA Chassis Front Panel Cabling

When a set of one or more WaveJudge 5000 chassis with SynthJudge and RXJudge (4G chassis) are connected to a set of one or more WaveJudge 5000 5G chassis, the front panel SRIO connections should be made just as if all the chassis were the same type. See the example below.

1. Connect the SRIO cable from the IntelliJudge 2 module in slot 4 of the first WaveJudge 5000 chassis, where the Ethernet is connected, to an SRIO connector on the IntelliJudge 2 or StoraJudge module in slot 4 of the next WaveJudge 5000 chassis.
2. If the module you have just connected to is a StoraJudge, which has a second SRIO connector, connect an SRIO cable from its unused SRIO connector to the module in slot 4 of the next WaveJudge 5000 chassis, which will be an IntelliJudge2 or StoraJudge module.
3. If the module you are connected to is an IntelliJudge 2 which has only one SRIO connector, connect an SRIO cable to the SRIO connector on the first free StoraJudge or IntelliJudge 2 module counting from the right of the chassis - this will be slot 3 or 4 - and connect the other end to the module in slot 4 of the next WaveJudge 5000 chassis, which will be an IntelliJudge 2 or StoraJudge module.
4. Continue connecting each chassis to the next via an SRIO cables until all chassis have been connected via SRIO.
5. Finally, make a connection between the AUX IN/OUT on the SynthJudge module of the first WaveJudge 5000 chassis, and the TRIG IN of the first 5G RF module. The interconnect between the two modules is an MCX Male to Female SMA cable. This will pass the trigger signal between the 4G and 5G subsystems.

NSA WaveJudge 5000 Chassis Front Panel Connections

2. 3. 4 Other WaveJudge 5000 Connections

If an external trigger or 10 MHz reference clock is required, the signal must connect to the AUX IN found on the SynthJudge module in the first chassis. The SRIO cable will distribute the trigger to the other chassis. The 10 MHz clock provides a reference source for the internal clock signal, which is distributed via the backplane and by the SYNC Out port located on the back of the WaveJudge 5000 chassis.

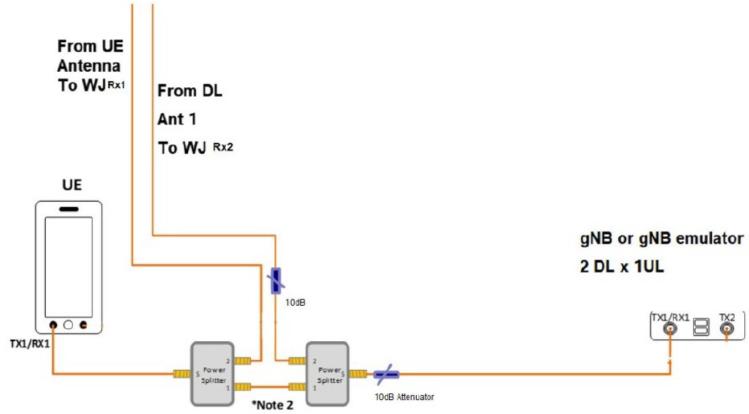
If you choose to use a GPS or PPS source for a precision time source, connect it to the GPS or PPS connector only on the primary chassis. The following connections must always be made on the primary WaveJudge 5000 chassis:

- Initial SRIO OUT
- Trigger IN
- Reference 10 MHz IN
- GPS IN
- PPS IN
- Initial SYNC OUT

2. 3. 5 Lab Test Configuration Drawings

The following subsections provide an overview of possible test configurations and scenarios and how to connect WaveJudge 5000 for them.

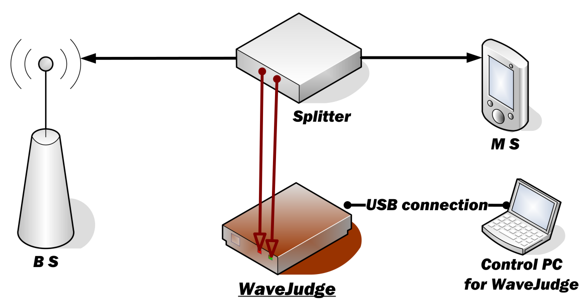
In the figure below, the transmitter and UE are directly cabled together and not going over the air at all. This image illustrates how to wire this up in the laboratory.



Lab Test Concept of a Transmitter and UE Cabled Together for Three Port Phone System

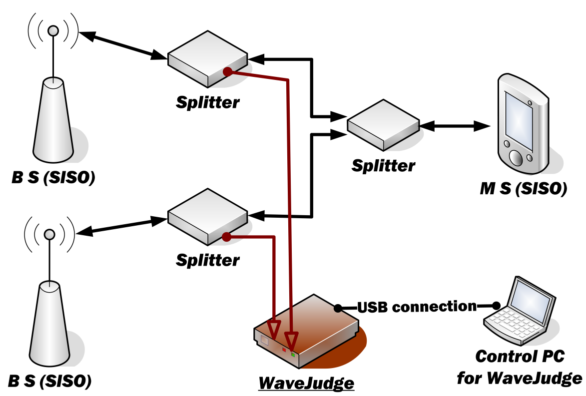
Lab Test for a SISO Configuration

A Single Input Single Output (SISO) configuration typically resembles the illustrated concept below. A control PC with WaveJudge 5000 installed on it connects to the WaveJudge 5000 chassis via a USB connection. The WaveJudge 5000 chassis connects to a splitter that sends a signal to a base station (BS) and a mobile station (MS).



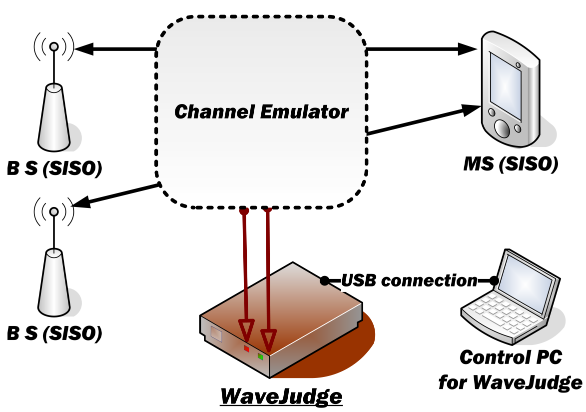
Lab Test Conceot for a SISO Configuration

In some occasions it is necessary to use more than one base station. In this case, set the configuration as indicated in the figure below. A control PC with WaveJudge 5000 installed on it connects to the WaveJudge 5000 chassis via a USB connection. The WaveJudge 5000 chassis connects to two splitters that send and receive signals to two base stations (BS), it also connects to a third splitter to send and receive messages to a mobile station (MS). Notice the two BS splitters are directly connected to the WaveJudge 5000 chassis (not connected to each other) so they send signals to the MS splitter.



Lab Test Concept for a SISO Configuration Using Two BS and Three Splitters

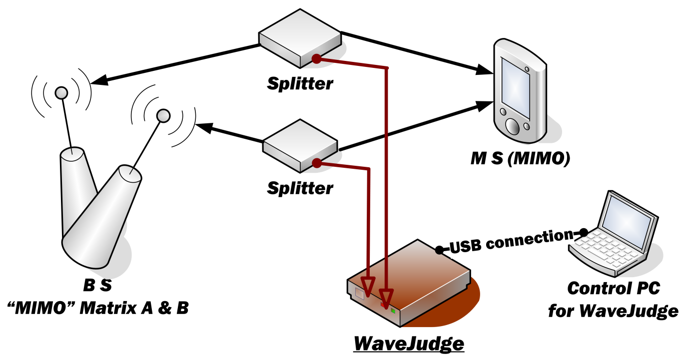
On the occasion where your system requires cross communication among multiple base stations and a mobile station, use a channel emulator. Set up the configuration as indicated in the figure below. A control PC with WaveJudge 5000 installed connects to the WaveJudge 5000 chassis via a USB connection. The WaveJudge 5000 chassis connects to the channel emulator, which sends signals to the base stations and mobile stations. Notice the channel emulator has one connection to transmit signals and another one to receive.



Lab Test Concept for a SISO Configuration Using a Channel Emulator

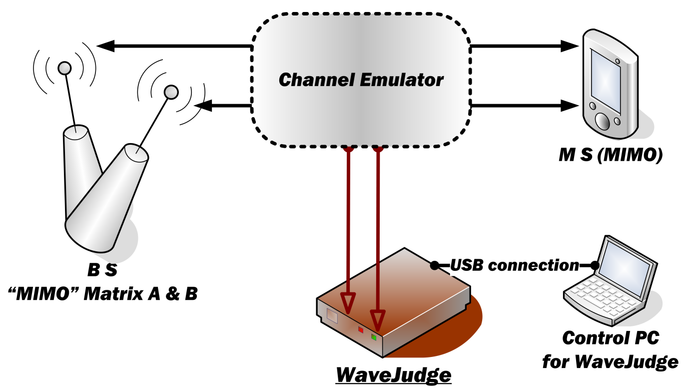
Lab Test for a MIMO Configuration

A Multiple Input Multiple Output (MIMO) configuration typically resembles the illustrated concept below. A control PC with WaveJudge 5000 installed connects to the WaveJudge 5000 chassis via a USB connection. The WaveJudge 5000 chassis connects to two splitters; notice the splitters are not connected to each other. Splitters send messages to the bases stations (labeled A and B) and a mobile station.



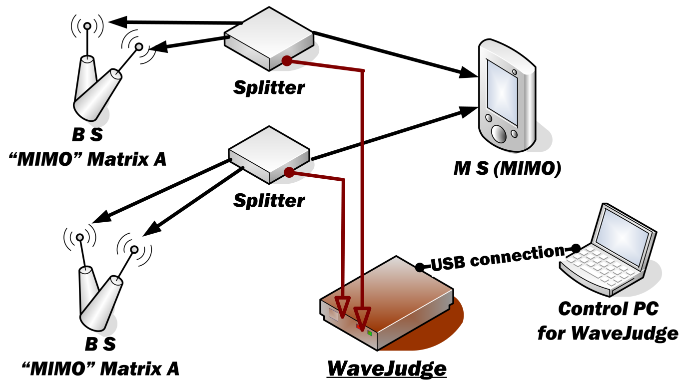
Lab Test Concept for a MIMO Configuration

In some cases a MIMO configuration may require a channel emulator; set up the configuration as indicated in the figure below. A control PC with WaveJudge 5000 installed connects to the WaveJudge 5000 chassis via a USB connection. The WaveJudge 5000 chassis connects to the channel emulator; notice the chassis has two connections to receive signals. The channel emulator sends signals to the bases stations (labelled A and B) and a mobile station.



Lab Test Concept of a MIMO Configuration Using a Channel Emulator

A MIMO configuration using two splitters is shown in the figure below. A control PC with WaveJudge 5000 installed connects to the WaveJudge 5000 chassis via a USB connection. The WaveJudge 5000 chassis connects to two splitters; notice each splitter sends signals to the chassis. Each splitter sends signals to the bases stations and the mobile station.



Lab Test Concept of a MIMO Configuratio Using Two Splitters

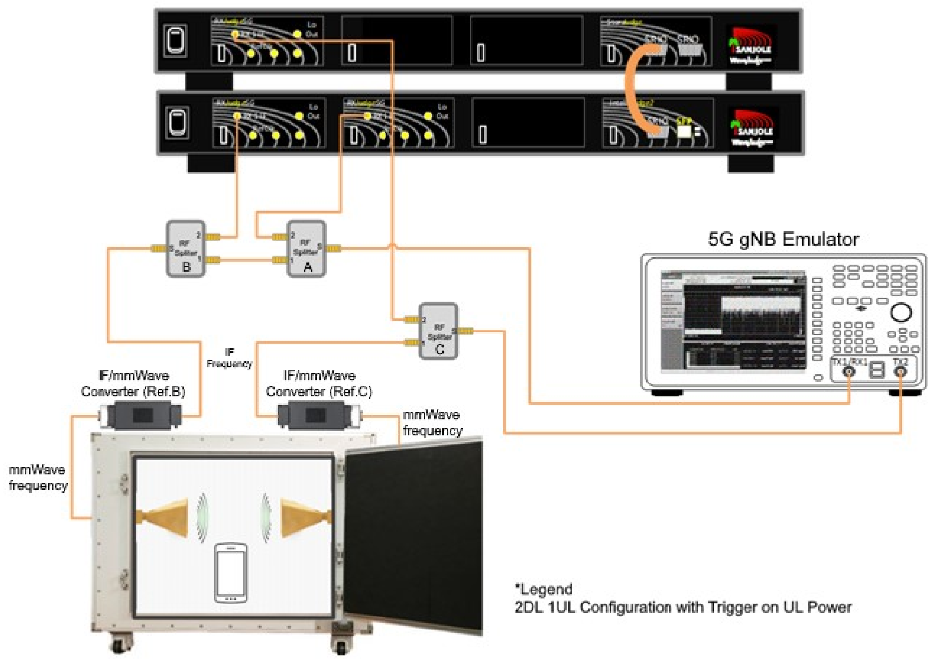
2. 4 Testing FR2 and mmWave Bands

As shown in the figures below, there are several ways to connect the WaveJudge 5000 with test equipment to test 5G UE. To simulate Test Scenario 1, follow these steps.

NOTE The letters A,B,C (e.g., Splitter A) indicate references shown in the figure, for clarity.

1. Connect the gNB emulator (for example, simulator) port TX1/RX1 to RF Splitter A.
   - Connect RF Splitter A port 1 to RF Splitter B port 1.
   - Connect RF Splitter A port 2 to RXJudge 5G panel DL port RX1 (refer to image of lower chassis).
   - Connect RF Splitter B port 2 to a second RXJudge 5G panel (UL) (refer to image of lower chassis).
   - Connect RF Splitter B serial port (S) to an Intermediate Frequency (IF)/mmWave converter (converter reference B).
   - Connect IF/mmWave converter B to the radio frequency isolation chamber (e.g,, a Faraday cage) where the test UE is located. The signal from the UE is converted to IF. WaveJudge 5000 monitors the IF signal directly from the mmWave signal.
2. Connect the gNB emulator port TX2 to an RF Splitter C.
   - Connect RF Splitter C port 2 to a third WaveJudge 5000 RXJudge 5G panel (top)
   - Connect RF Splitter C port 1 to the IF/mmWave converter (reference C)
   - Connect IF/mmWave converter C to the Faraday cage where the UE is

3. Connect the WaveJudge 5000 StoraJudge (top) SRIO port to an IntelliJudge (bottom) SRIO port (refer to the thick orange lines).

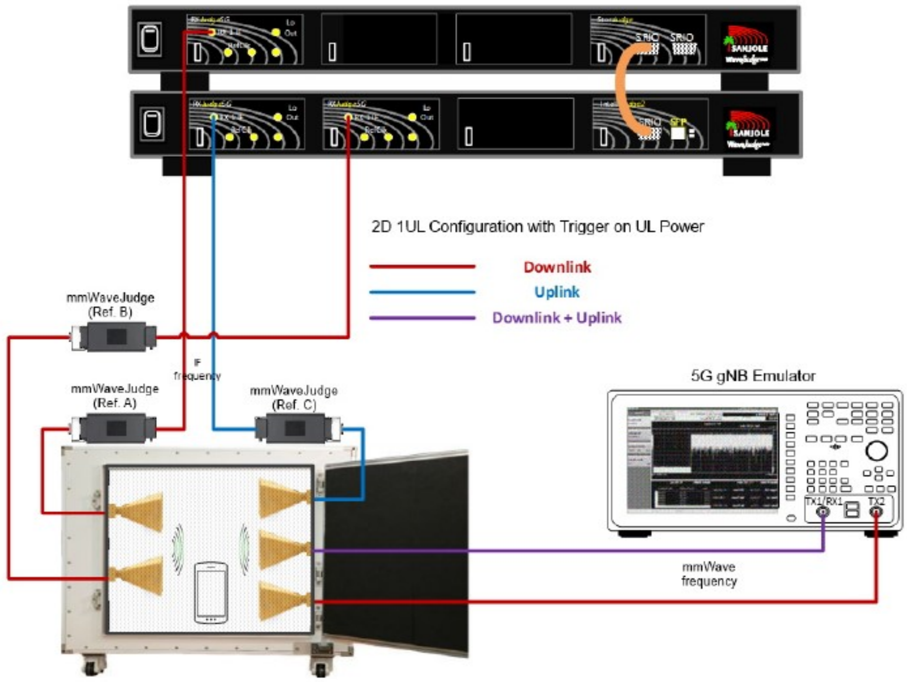


Lab Test Concept for FR2 and mmWave Bands - Scenario 1

In Test Scenario 2 (illustrated below) each RXJudge 5G panel connects directly to an mmWaveJudge via a DL port (red line) and a UL port (blue line). RXJudge receives mmWave signals from both the 5G UE and the 5G gNB, or simulator. To simulate this test scenario follow these steps. Note: The letters A,B,C (e.g., mmWaveJudge A) indicate references shown in the figure, for clarity.

1. Connect the 5G gNB emulator TX1/RX1 port directly to the Faraday cage with the UE inside (refer to the purple DL and UL line).
2. Connect the 5G gNB emulator TX2 port directly to the Faraday cage (refer to the red DL line).
3. Connect one WaveJudge 5000 RXJudge 5G panel (DL port) to an mmWaveJudge 5000 converter; connect the converter to the Faraday cage (refer to top WaveJudge 5000 chassis image with red line).
4. Connect a second WaveJudge 5000 RXJudge 5G panel (DL port) to an mmWaveJudge 5000 converter; connect the converter to the Faraday cage (refer to bottom WaveJudge 5000 chassis image with red line).
5. Connect a third WaveJudge 5000 RXJudge 5G panel (UL port) to an mmWaveJudge 5000 converter; connect the converter to the Faraday cage (refer to bottom WaveJudge 5000 chassis image with blue line).

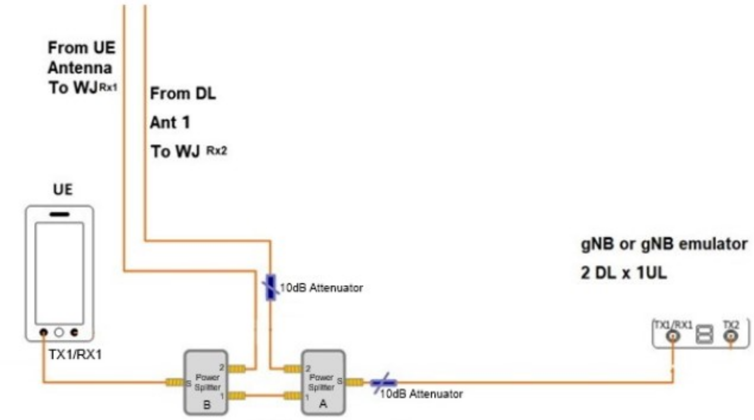
6. Connect the WaveJudge 5000 StoraJudge (top) SRIO port to an IntelliJudge (bottom) SRIO port (refer to orange lines).



Lab Test Concept for FR2 and mmWave Bands - Scenario 2

In Test Scenario 3, the transmitter and UE are directly cabled together; signals are not transmitted over the air. To simulate Test Scenario 3 follow these steps. Note: The letters A and B (e.g., Power Splitter A) only refer to the figure.

1. Connect the gNB (or gNB emulator) TX1/RX1 port to a 10db attenuator, then connect the attenuator to Power Splitter A.
2. Connect Power Splitter A port 1 to Power Splitter B port 1.
3. Connect Power Splitter A port 2 to a 10 db attenuator that connects to WaveJudge 5000 port RX2.
4. Connect Power Splitter B port 2 to WaveJudge 5000 port RX1.
5. Connect Power Splitter B serial port (S) to the UE port TX1/RX1.



Lab Test Concept for FR2 and mmWave Bands - Scenario 3

3 Configure and Capture 5G NR

This section describes how to use WaveJudge 5000 for 5G New Radio (5G NR). 5G NR was developed by the European Telecommunications Standards Institute (ETSI) Third Generation Partnership Project (3GPP). Following 4G LTE, 5G NR is the fifth generation technology standard for cellular networks.

The first 5G specification (Release 15) was released in 2017, with 5G testing and deployment commencing in 2018. In 2019, deployments expanded into additional regions and increased the number of frequency ranges. It is anticipated that 5G will continue to grow exponentially as consumer needs expand.

Key points to note about 5G NR:

- 5G NR is intended to go beyond the capabilities of LTE. It uses independent technologies and protocols, although certain concepts and portions of higher protocol layers are still shared with LTE.
- 5G NR is designed to work within the context of an existing 4G LTE network:
  - for a mixed 4G/5G mobile network
    - where 5G is interoperating with 4G LTE
    - this is called "5G Non-Standalone" (5G NSA)
  - or, as a completely independent 5G-only deployment
    - where there are 5G independent operations
    - this is called "5G Standalone" (5G SA)
  - In the LTE protocol, the network uses specific LTE Radio Resource Control (RRC) and higher layer messages to configure and control mobile devices as they join a network or after joining a network. For instance, RRC is used to command a phone to connect at a preferred carrier's frequency or connect to a secondary cell for more bandwidth.
  - In a 5G NSA deployment, with integrated LTE and 5G, new versions of higher-layer messages are used on the 4G network to command an LTE mobile device with 5G capability to connect to the 5G network. These messages are also used to fully configure devices for 5G network entry.
  - In a 5G SA deployment, 5G mobile devices are configured entirely via the 5G network by broadcast messages and 5G messages that are transmitted when a device joins the network.
- A significant difference between LTE and 5G, is that 5G is intended for use in

two entirely separate frequency ranges, "FR1" and "FR2".

- FR1 is in the range of bands commonly used for cell phone service, LTE, WiFi, and other wireless services. The range is as low as 600 MHz to 7.125 GHz. FR1 is sometimes also referred to as "sub-6 GHz" 5G because all currently defined bands are below 6.0 GHz.
- FR2 includes a pair of ranges with much higher frequency and millimeter wavelengths, also referred to as "mmWave." The currently defined FR2 includes frequencies between 24 GHz and 30 GHz, and between 37 GHz and 40 GHz.

3. 1 WaveJudge 5G Frequency Ranges

WaveJudge 5G NR supported frequency ranges and bands are shown in the following tables. The first table shows the WaveJudge 5G NR FR1 band support, which has a range of n1 to n95. The second table shows the WaveJudge 5G NR FR2 band support, which has a range of n257 to n261.

5G NR bands are defined with a prefix of "n". When a 5G NR band overlaps with a 4G LTE band, they share the same band number. The **RXJ** column indicates bands that use the RXJudge 40 MHz Receive Module; similarly, the **RXJ5G** column indicates bands, for 5G NR, that use the RXJudge2 5G Receive Module.

Channel Bandwidths, shown as **bold**, require the RXJudge2 5G Receive Module (BB-1x1400). Note that certain n50 channel bandwidths (for example, 50, 60, and 80) are not covered by either module type.

WaveJudge 5G NR FR1 Band Support

Band	Duplex Mode	f (MHz)	Common Name	Subset of Band	Uplink (MHz)	Downlink (MHz)	Duplex Spacing	Channel Bandwidths (MHz)[1,2]	RXJ	RXJ 5G
n1	*FDD*	*2100*	*IMT*	*n65*	*1920-1980*	*2110-2170*	*190*	*5, 10, 15, 20*	*X*	
n2	*FDD*	*1900*	*PCS*	*n25*	*1850-1910*	*1930-1990*	*80*	*5, 10, 15, 20*	*X*	
n3	*FDD*	*1800*	*DCS*		*1710-1785*	*1805-1880*	*95*	*5, 10, 15, 20, 25, 30*	*X*	
n5	*FDD*	*850*	*CLR*		*824-849*	*869-894*	*45*	*5, 10, 15, 20*	*X*	
n7	*FDD*	*2600*	*IMT-E*		*2500-2570*	*2620-2690*	*120*	*5, 10, 15, 20, 25, 30,*	*X*	*X*

[1]Channel Bandwidths, shown as **bold**, require the RXJudge2 5G Module (BB-1x1400).

[2]Channel Bandwidths, shown as <u>underlined</u>, are not covered by either module type.

Band	Duplex Mode	f (MHz)	Common Name	Subset of Band	Uplink (MHz)	Downlink (MHz)	Duplex Spacing	Channel Bandwidths (MHz)[1, 2]	RXJ	RXJ 5G
								40, **50**		
n8	FDD	900	Extended GSM		880-915	925-960	45	5, 10, 15, 20	X	
n12	FDD	700	Lower SMH		699-716	729-746	30	5, 10, 15	X	
n14	FDD	700	Upper SMH		788-798	758-768	-30	5, 10	X	
n18	FDD	850	Lower 800 (Japan)		815-830	860-875	45	5, 10, 15	X	
n20	FDD	800	Digital Dividend (EU)		832-862	791-821	-41	5, 10, 15, 20	X	
n25	FDD	1900	Extended PCS		1850-1915	1930-1995	80	5, 10, 15, 20	X	
n28	FDD	700	APT		703-748	758-803	55	5, 10, 15, 20	X	
n29	SDL	700	Lower SMH		N/A	717-728	N/A	5, 10	X	
n30	FDD	2300	WCS		2305-2315	2350-2360	45	5, 10	X	X
n34	TDD	2100	IMT		2010-2025	2010-2025	N/A	5, 10, 15	X	
n38	TDD	2600	IMT-E		2570-2620	2570-2620	N/A	5, 10, 15, 20	X	X
n39	TDD	1900	DCS-IMT Gap		1880-1920	1880-1920	N/A	5, 10, 15, 20,25, 30, 40	X	
n40	TDD	2300	S-Band		2300-2400	2300-2400	N/A	5, 10, 15, 20,25, 30, 40, **50, 60, 80**	X	X
n41	TDD	2500	BRS	n90	2496-2690	2496-2690	N/A	10, 15, 20, 30, 40, **50, 60, 70, 80, 90**	X	X
n48	TDD	3500	CBRS (US)		3550-3700	3550-3700	N/A	5, 10, 15, 20,40, **50, 60,80, 90, 100**	X	X

[1] Channel Bandwidths, shown as **bold**, require the RXJudge2 5G Module (BB–1x1400).

[2] Channel Bandwidths, shown as underlined, are not covered by either module type.

Band	Duplex Mode	f (MHz)	Common Name	Subset of Band	Uplink (MHz)	Downlink (MHz)	Duplex Spacing	Channel Bandwidths (MHz)[1, 2]	RXJ	RXJ 5G
n50	TDD	1500	L-Band (EU)		1432-1517	1432-1517	N/A	5, 10, 15, 20,30, 40, 50, 60, 80	X	
n51	TDD	1500	L-Band Extension (EU)		1427-1432	1427-1432	N/A	5	X	
n65	FDD	2100	Extended IMT		1920-2010	2110-2200	190	5, 10, 15, 20	X	
n66	FDD	1700	Extended AWS		1710-1780	2110-2200	400	5, 10, 15, 20,40	X	
n70	FDD	2000	AWS-4		1695-1710	1995-2020	300	5, 10, 15, 20,25	X	
n71	FDD	600	Digital Dividend (US)		663-698	617-652	-46	5, 10, 15, 20	X	
n74	FDD	1500	Lower L-Band (US)		1427-1470	1475-1518	48	5, 10, 15, 20	X	
n75	SDL	1500	L-Band (EU)		N/A	1432-1517	N/A	5, 10, 15, 20	X	
n76	SDL	1500	Extended L-Band (EU)		N/A	1427-1432	N/A	5	X	
n77	TDD	3700	C-Band		3300-4200	3300-4200	N/A	10, 15, 20, 40, **50, 60, 80, 90, 100**	X	X
n78	TDD	3500	C-Band	n77	3300-3800	3300-3800	N/A	10, 15, 20, 40, **50, 60, 80, 90, 100**	X	X
n79	TDD	4700	C-Band		4400-5000	4400-5000	N/A	40, **50, 60, 80, 100**	X	X
n80	SUL	1800	DCS		1710-1785	N/A	N/A	5, 10, 15, 20, 25, 30	X	
n81	SUL	900	Extended GSM		880-915	N/A	N/A	5, 10, 15, 20	X	
n82	SUL	800	Digital Dividend (EU)		832-862	N/A	N/A	5, 10, 15, 20	X	
n83	SUL	700	APT		703-748	N/A	N/A	5, 10, 15, 20	X	

[1]Channel Bandwidths, shown as **bold**, require the RXJudge2 5G Module (BB-1x1400).
[2]Channel Bandwidths, shown as underlined, are not covered by either module type.

Band	Duplex Mode	f (MHz)	Common Name	Subset of Band	Uplink (MHz)	Downlink (MHz)	Duplex Spacing	Channel Bandwidths (MHz)[1,2]	RXJ	RXJ 5G
n84	*SUL*	*2100*	*IMT*		*1920-1980*	*N/A*	*N/A*	*5, 10, 15, 20*	*X*	
n86	*SUL*	*1700*	*Extended AWS*		*1710-1780*	*N/A*	*N/A*	*5, 10, 15, 20, 40*	*X*	
n89	*SUL*	*850*	*CLR*		*824-849*	*N/A*	*N/A*	*5, 10, 15, 20*	*X*	
n90	*TDD*	*2500*	*BRS*		*2496-2690*	*2496-2690*	*N/A*	*10, 15, 20, 30,40,* ***50, 60, 80, 90, 100***	*X*	*X*

The following table shows the WaveJudge 5G NR FR2 band support, which has a range of n257 to n261 (24.25 GHz to 52.6 GHz). Bands in this millimeter wave range have shorter range, but higher available bandwidth than bands in FR1.

WaveJudge 5G NR support for FR2 bands requires both the RXJudge2 5G Receive Module (BB-1x1400) and the mmWaveJudge Remote Receiver (RX-mm2839).

WaveJudge 5000 5G NR FR2 Band Support[3]

Band	f (GHz)	Common Name	Subset of Band	Uplink/Downlink (GHz)	Channel Bandwidths (MHz)	RXJudge 5G (BB-1x1400)	mmWaveJudge (RX-mm2839)
n257	*28*	*LMDS*		*26.50-29.50*	*50, 100, 200, 400*	*X*	*X*
n258	*26*	*K-band*		*24.25-27.50*	*50, 100, 200, 400*	*X*	*X*
n260	*39*	*Ka-band*		*37.00-40.00*	*50, 100, 200, 400*	*X*	*X*
n261	*28*	*Ka-band*	*n257*	*27.50-28.35*	*50, 100, 200, 400*	*X*	*X*

[1] Channel Bandwidths, shown as **bold**, require the RXJudge2 5G Module (BB-1x1400).

[2] Channel Bandwidths, shown as **underlined**, are not covered by either module type.

[3] WaveJudge 5000 5G NR support for FR2 bands requires both the RXJudge2 5G Receive Module (BB-1x1400) and the mmWaveJudge Remote Receiver (RX-mm2839).

3. 2 5G NR Standalone (SA) Settings

This section describes how to configure the chassis, setup the software parameters, import a file (for example, same as taking a hardware capture), and execute the capture process for a 5G NR SA system.

3. 2. 1 Configure a Test Scenario

To start, it is recommended that you first enable the context sensitive Help option, via the blue question mark icon. With this enabled, as you click on each field, you will see explanations of each setting at the bottom of the window.

Configuring a 5G test can be described in the following five steps.

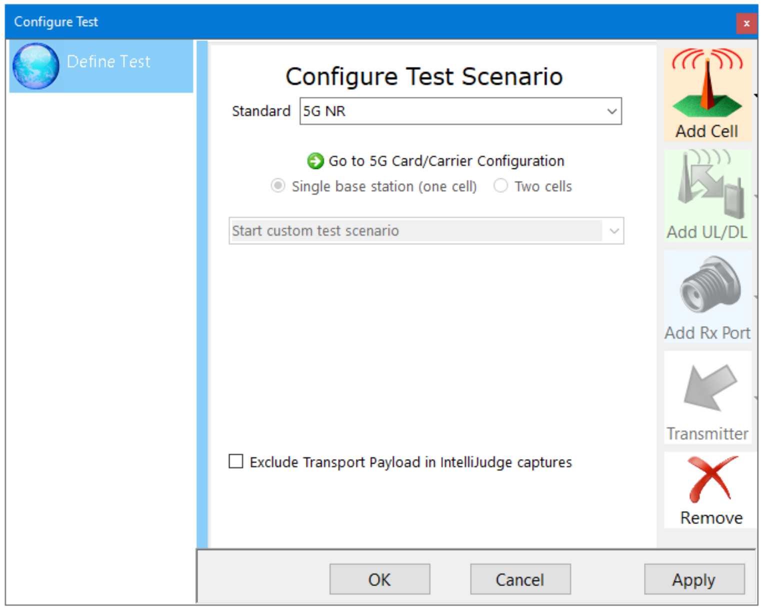
1. Define a Test Scenario on page 72
2. 5G Card/Carrier Configuration Wizard on page 73
3. Configure Cells on page 77
4. Configure Port Groups/Downlinks on page 85
5. Configure Rx Ports on page 86

To start, open the **Configure Test Window** click the Configure Test icon in the vertical button strip on the left.

3. 2. 1. 1 Define a Test Scenario

The first step to create a test scenario for a wireless network is to set the standard whether it's 5G NR, 3GPP 4G LTE, WiFi, WiMAX, or anything else.

1. From the File menu, click the first option New Test Configuration.
2. In Configure Test Scenario pane, select 5G NR as the standard.
3. Click the green arrow message Go to 5G Card/Carrier Configuration.



Configure Test Scenario for 5G

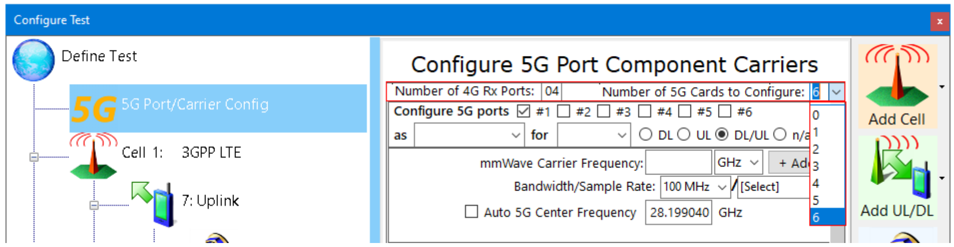
NOTE At the bottom of the window, leave the checkbox Exclude Transport Payload in IntelliJudge Captures empty; it applies only to IntelliJudge real-time captures and is only useful in certain scenarios.

3. 2. 1. 2 5G Card/Carrier Configuration Wizard

Next, set up the carrier ports. Functions such as bandwidth, sampling rates, and SSBs must be set. Similar to LTE, the fields are standards-based. Thus, any field that refers to a standard should always be configured to the latest standard, unless you know it is referencing an older one.

Each segment of this window is described below.

1. Number of 4G Ports: Enter a two-digit value for the number of 4G ports needed, if necessary.
2. Number of 5G Cards to Configure: Select the number of 5G cards to configure. The maximum number of carriers is eight, however it must include the uplink carriers.



Configure 5G Port Component Carriers - Set Number of Ports and Cards

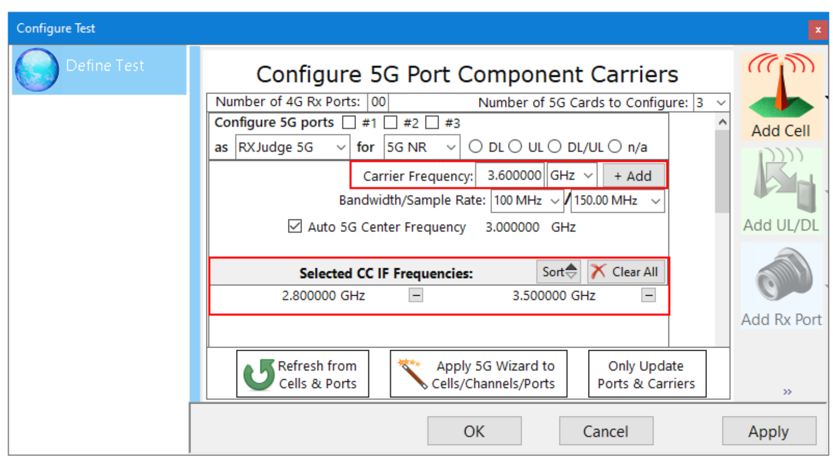
NOTE The downlink should have more ports than the uplink. The number of downlinks and uplinks are dependant on the MIMO mode, the number of antenna layers available. If there are four layers there will be four ports. You could have more ports than you have layers. However, you don't want to have fewer ports than layers because it will cause decoding errors and miss part of the signal.

3. Configure 5G Ports: Depending on the number of carriers you selected in Step 2, the same number of checkboxes will populate with corresponding port numbers. Check the boxes for the ports to configure (example: #1, #2, #3, #4, #5, #6 as shown in the graphic above).
   - Configure 5G Ports - as: Options are limited to either RxJudge 5G or 5G millimeter wave, depending on the frequencies.
     - RXJudge 1400 is from 2.3 GHz to 11.7 GHz.
     - mmWave is 24 GHz to 30GHz, and 37 GHz to 42.5 GHz.
   - Configure 5G Ports - for: Select from the drop-down menu, options are **5G NR**, **5GTF**, and **LTE**.

4. Configure 5G Ports (link): Select one radio button; options are **DL**, **UL**, **DL/UL**, and **n/a**. You can set your downlinks first, your uplinks first, or set the same for both. Typically, users set the DL first because they have more ports and will populate in the left pane in the order they are set here.
   - Select the DL button. This example is for a 4x4 MIMO downlink.
     - Carrier Frequency:
       - Set the Carrier Frequency, e.g., 3.5 GHz.
       - If the first field is not auto-populated, type a number in the text field. From the drop-down menu next to it, select **GHz** or **MHz**.

- If you have added a new frequency to the list click the Add button.
- Each time you click the Add button the next frequency auto-populates in the Selected CC IF Frequencies section.
- In a **contiguous carrier**, there is no break between frequency bands. Just keep clicking the Add button.
- To create a **noncontiguous carrier,** for example, one that has a break between frequencies, enter the first carrier frequency and click the Add button. Then enter the second carrier frequency and click the Add button. Both of the frequencies will populate in the Selected CC IF Frequencies section.
  - If the break is too large, one would go to another port card and it would have to be one of the preceding frequencies.
  - The **Instantaneous Bandwidth** is 1.4 GHz. However, the real available bandwidth for analysis is 800 GHz.

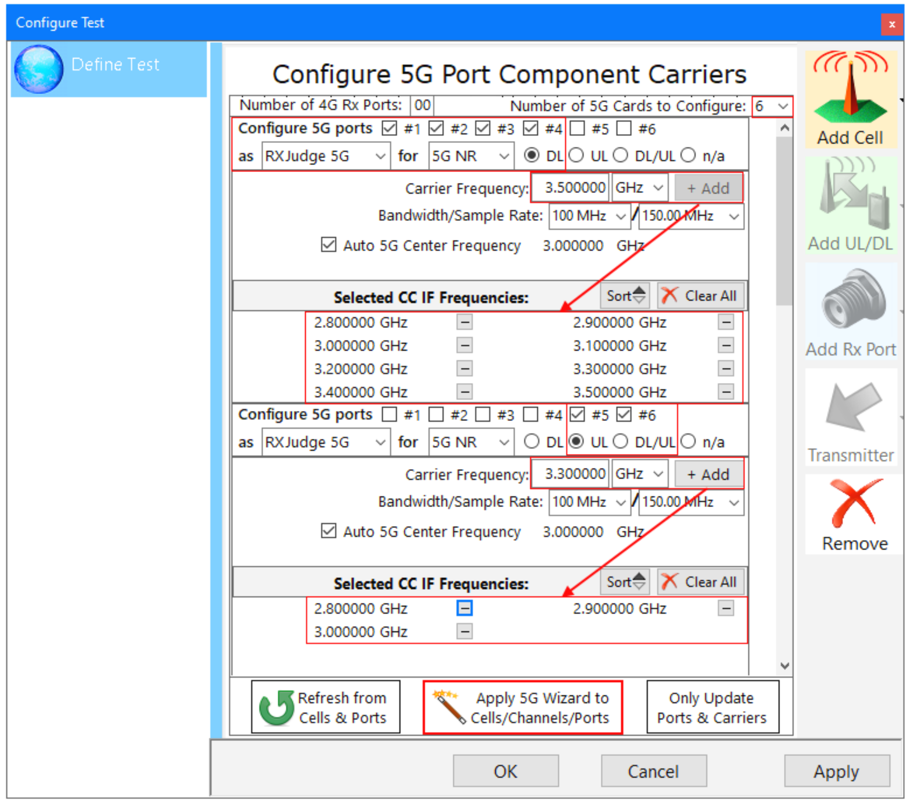
- Bandwidth / Sample Rate: Select a bandwidth from the first drop-down menu, options range from 4 MHz to 400 MHz. Select the sample rate from the second drop-down menu, options are **150.00 MHz**, **300.00 MHz**, and **600.00 MHz**. Each additional frequency is auto-incremented by this number.



Adding Noncontiguous 5G Carriers

5. Set the Configure 5G Port settings for the uplink channel (assuming you set the top channel for downlink as in the example above).
   - Check the boxes for the ports to configure (example: 5, 6).
   - Select the UL button.
   - Set the Carrier Frequency. Add more if needed.

– Set the Bandwidth/Sample Rate.



Contiguous Carrier Configuration

– Auto 5G Center Frequency: Select the checkbox to use an auto-populated GHz frequency; uncheck the box to enter a different frequency in GHz.

– Selected CC IF Frequencies: Offset frequencies will show in the box below, such as 3.530080 GHz. Click a button Sort Clear All to **Sort** or **Clear All** frequencies. To select a single item in the list, click the minus button to the right of the line item.

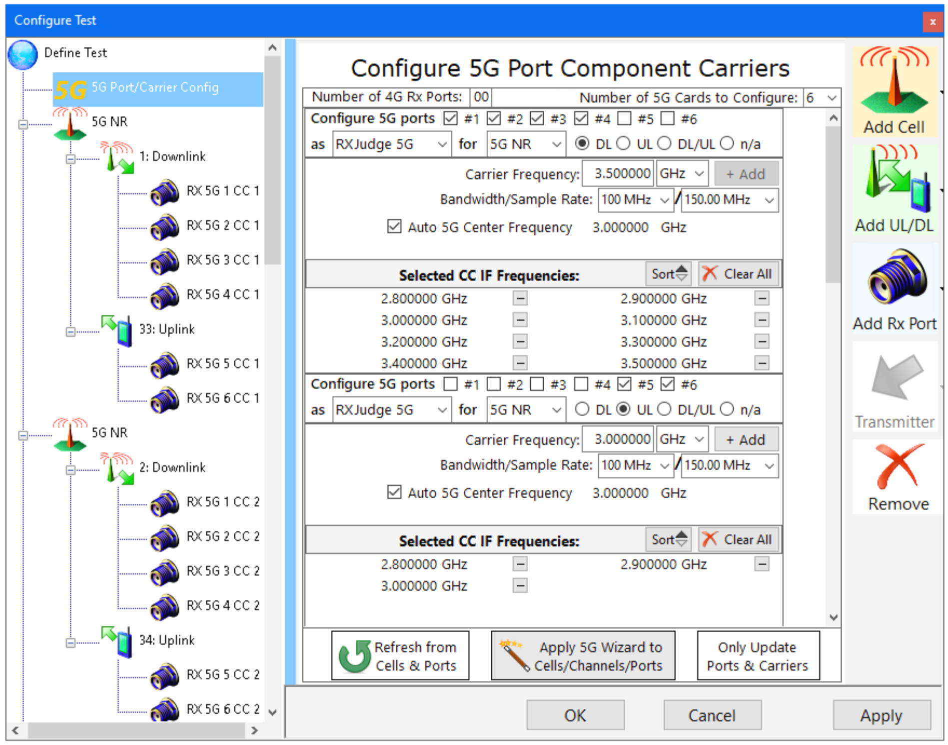
6. The three buttons at the bottom of the window are:

   – Refresh from Cells and Ports: Refresh from Cells & Ports After a change is made to settings, click this button to refresh and update all data based on the new input.

   – Apply 5G Wizard: Apply 5G Wizard to Cells/Channels/Ports WaveJudge creates the channels and ports according to configurations set on this page. After you click this button, the channels will be visible in the left panel.

   – Only Update Ports and Carriers: Only Update Ports & Carriers Only updates ports and carriers, does not update frequency settings.

7. Click the button at the bottom Apply 5G Wizard to Cells/Channels/Ports. As shown in the figure below, WaveJudge creates all corresponding cells, channels, and ports according to the settings on this window.

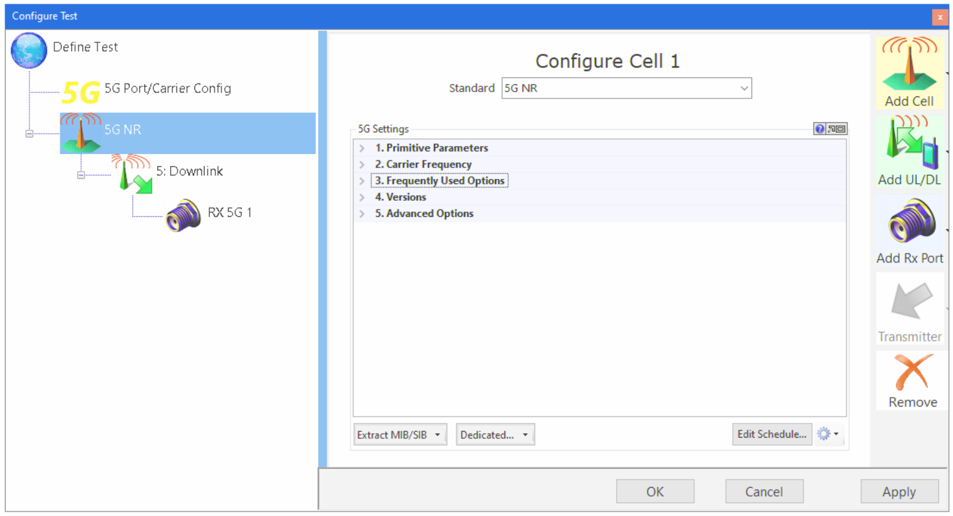


5G Wizard Creates Ports and Channels in Left Pane

3. 2. 1. 3 Configure Cells

Next, click the third button in the left pane of the Configure Test window, in this example it is the 5G NR 

.



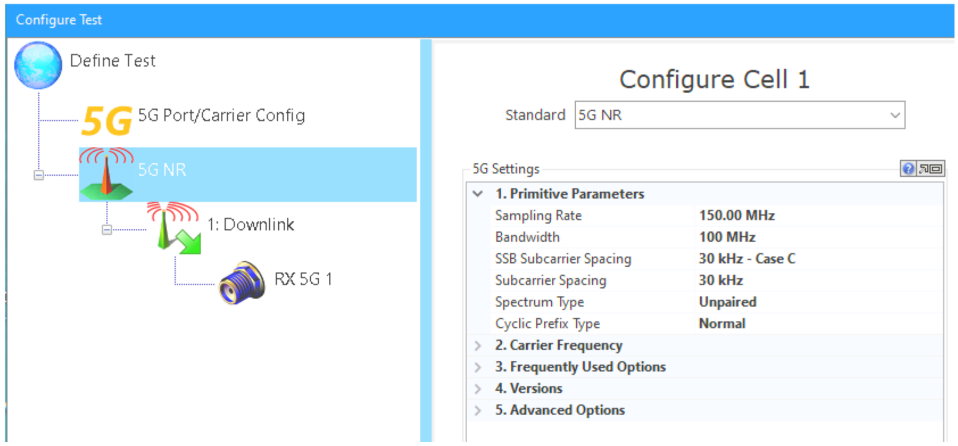
Configure Test: 5G NR - Configure Cell 1

As with all wireless configurations, this window has many options specific to the standard you have selected. The 5G Settings pane is organized into five drop-down menus and a set of buttons at the bottom.

- 5G Settings: 1. Primitive Parameters on page 78
- 5G Settings: 2. Carrier Frequency on page 79
- 5G Settings: 3. Frequently Used Options on page 80
- 5G Settings: 4. Versions on page 81
- 5G Settings: 5. Advanced Settings on page 82
- Other 5G Cell Settings on page 84

5G Settings: 1. Primitive Parameters

On the right side pane under 5G Settings, click on an item in a list to view and set individual properties.



5G Settings: Section 1. Primitive Parameters

Section 1. Primitive Parameters are described below.

Sampling Rate: Select a rate from the drop-down menu, options range from 1.92 MHz to 1966.08 MHz.

Bandwidth: Select from the drop-down menu, options range from 5 MHz to 400 MHz.

SSB Subcarrier Spacing: Select from the drop-down menu, options are: 15 kHz, 30 kHz - Case B, 30 kHz - Case C, 120 kHz, 240 kHz, and 480 kHz.

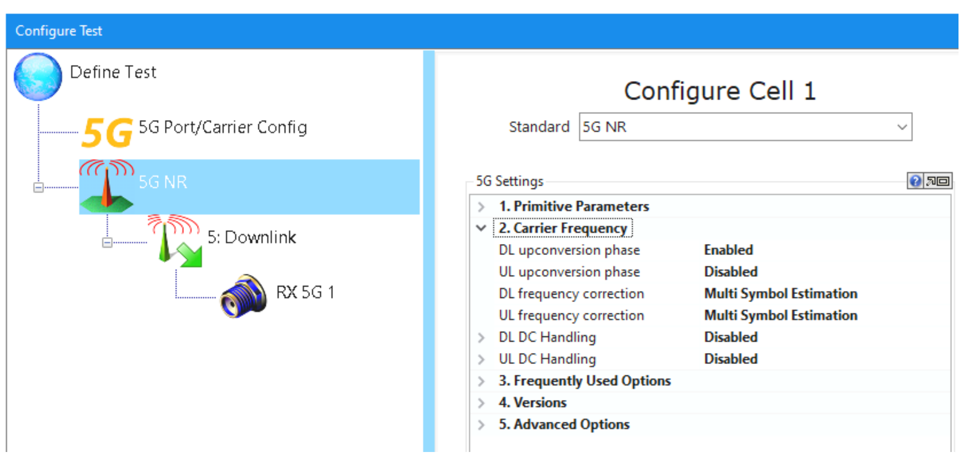
Subcarrier Spacing: Select from the drop-down menu, options are: 15 kHz, 30 kHz, 60 kHz, 120 kHz, 240 kHz, and 480 kHz.

Spectrum Type: Select Paired or Unpaired from the drop-down menu.

Cyclic Prefix Type: Select Normal or Extended from the drop-down menu.

5G Settings: 2. Carrier Frequency

On the right side pane under 5G Settings click section 2. Carrier Frequency to show UL and DL carrier options.



5G Settings: Section 2. Carrier Frequencies

Section 2. Carrier Frequencies in this section are as follows.

DL upconversion phase: Select Enabled or Disabled from the drop-down menu.

UL upconversion phase: Select Enabled or Disabled from the drop-down menu.

DL frequency correction: Select Disabled, Single Symbol Estimation or Multi Symbol Estimation from the drop-down menu.

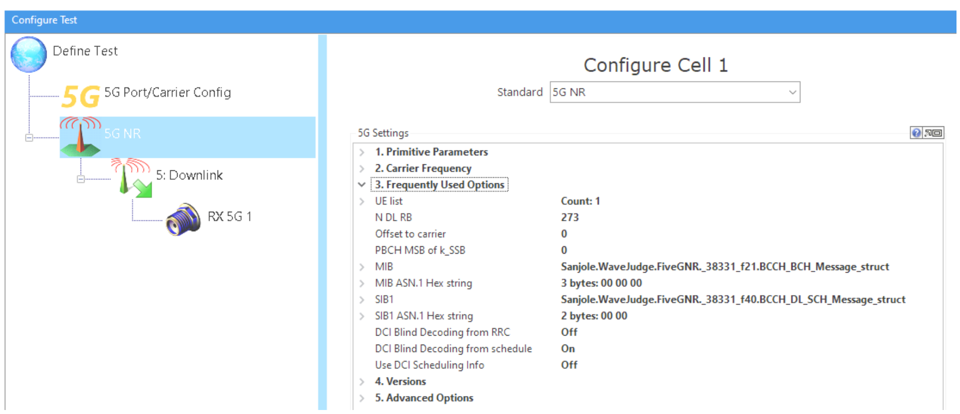
UL frequency correction: Select Disabled, Single Symbol Estimation or Multi Symbol Estimation from the drop-down menu.

DL DC Handling: Will show if it is Enabled or Disabled; the number of N Subcarriers, and the Subcarrier Offset.

UL DC Handling: Will show if it is Enabled or Disabled; the number of N Subcarriers, and the Subcarrier Offset.

5G Settings: 3. Frequently Used Options

In the **5G Settings** window, click the section **3. Frequently Used Options** to display a drop-down menu of the most popularly used parameters.



5G Settings: Section 3. Frequently Used Options

There are numerous submenus for these parameters; the top-level and most important parameters are described below.

UE List: List of UE specific parameters. Click on the ellipse button ... to the right of UE List. Click on an item in the window to view and set individual properties.

- [0]: Cell 0
  - **ConfigDedicated:** Collection of UE specific configuration parameters.
  - **ASN.1 Hex String:** Represents the CellGroupConfig RRC message.
  - **DCI Size Override:** Fields that (when non-zero) override the DCI size

calculation.
- DCI Size Calculation per BWP: Steps 0 to 4 of DCI size alignment.
- Cell Info: Cell information extracted from RRC IEs.
- Active DL BWP: Active downlink bandwidth part index.
- Active UL BWP: Active uplink bandwidth part index.
- RNTI: Radio network temporary identifier the parameters will be applied to. To configure the parameters used by default, delete the RNTI value and press Enter, or type "Default".
- N DL RB: Number of physical download (DL) resource blocks (RB).
- Offset to Carrier: Offset in frequency domain between Point A (lowest subcarrier of common RB 0) and the lowest useable subcarrier on this carrier in number of PRBs (using the 'subcarrierSpacing' defined for this carrier). The maximum value corresponds to 275*8-1.
- PBCH MSB of K_SSB: If Lmax < 64, designates the additional most significant bit contained in PBCH to the MIB field "ssb_SubcarrierOffset" also called k_SSB.

N DL RB: Number of Physical Resource Blocks (PRB).

Offset to Carrier: Offset in frequency domain between Point A (lowest subcarrier of common RB0) and the lowest useable subcarrier on this carrier in number of PRBs (using the 'subcarrierSpacing' defined for this carrier). The maximum value corresponds to 275*8-1.

PBCH MSB: If Lmax < 64, designates the additional most significant bit contained in PBCH to the MIB field. "ssb_SubcarrierOffset" also called k_SSB.

MIB: Master Information Block.

MIB ASN.1 Hex String: ASN.1 Hex string representing the MIB RRC message.

SIB1: System information block 1 RRC message (systemInformationBlockType1).

SIB1 ASN.1 Hex String: ASN.1 Hex string representing the SIB1 RRC message.

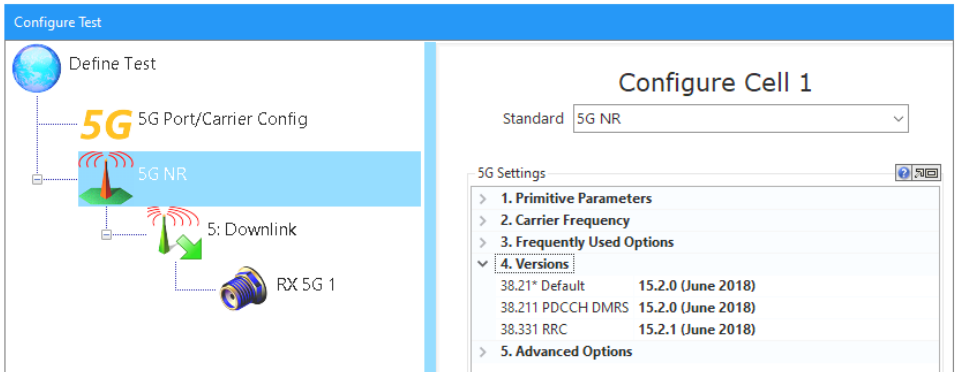
DCI Blind Decoding from RRC: DCI Blind Decoding from RRC configuration in the UE list.

DCI Blind Decoding from Schedule: DCI BLind Decoding from PDCCH assignments entered in the "Edit Schedule" panel.

Use DCI Scheduling Info: Use DCI info to schedule PDSCH and PUSCH automatically.

5G Settings: 4. Versions

In the right side pane under 5G Settings click the section 4. Versions to view and set version specifications.



5G Settings: Section 4. Versions

Options for Section 4. Versions are as follows.

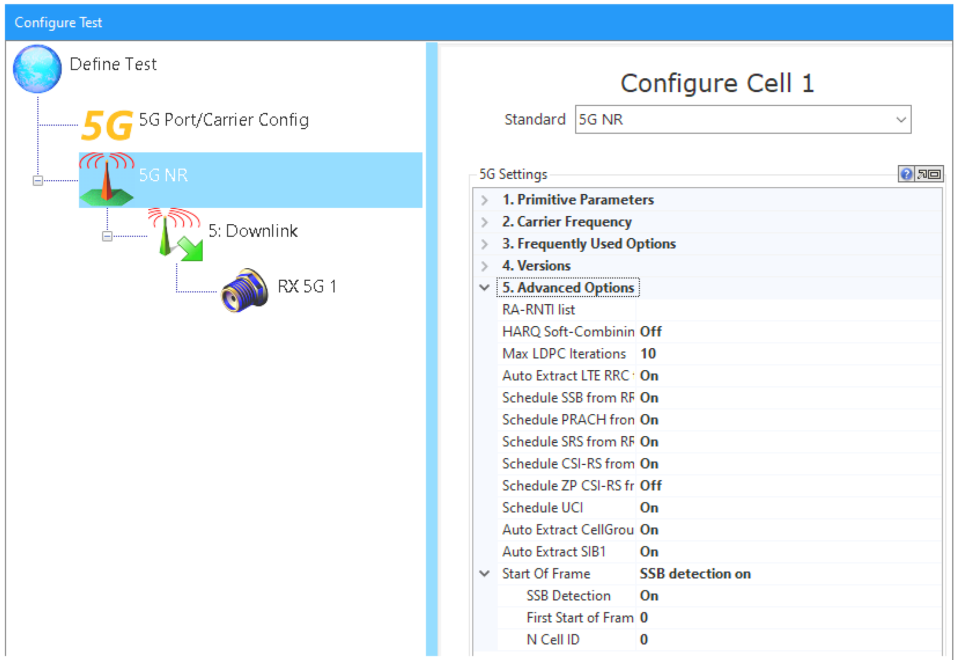
38.21* Default: Version of the 38.21x specifications. Select the line and click the activated arrow on the far right side to select an alternate version from the drop-down menu.

38.211 PDCCH DMRS: Version of the 38.211 specifications used for PDCCH DMRS. Select the line and click the activated arrow on the far right side to select an alternate version from the drop-down menu.

38.331 RRC: Version of the 38.331 specification used for RRC parameters. Select the line and click the activated arrow on the far right side to select an alternate version from the drop-down menu.

5G Settings: 5. Advanced Settings

In the right side pane under 5G Settings click the section 5. Advanced Settings to view, select and set additional advanced parameters.



5G Settings: Section 5. Advanced Options

Section 5. Advanced Options are described below.

RA-RNTI List: List of values reserved for RA-RNTI. For example: 1-14, 16, 20-34, designates the values that are either between 1 and 14, or equal to 16, or between 20 and 34.

HARQ Soft-Combining: This parameter control the use of soft-combining on HARQ retransmissions.

Max LPDC Iterations: Maximum number of LDPC decoding iterations, from 2 to 100. Larger numbers provide more decoding gain for PDSCH and PUSCH, which is required in a noisy environment, but it also slows down processing. The error correcting code for PDSCH and PUSCH is a Low-Density Parity-Check (LPDC) code. Its decoding algorithm is iterative, and each iteration attempts to correct more errors.

Auto Extract LTE RRC to 5G UE Config: If On, when a real-time LTE capture is present for a 5G NR NSA scenario, WaveJudge automatically extracts its RRC messages for 5G UE configuration and applies them before 5G processing.

Schedule SSB from RRC: Use RRC parameters ssb-PositionsInBurst and ssb-periodicityServingCell to schedule SSB; for example, PSS, SSS, and PBCH.

Schedule PRACH from RRC: Use RRC parameters to schedule PRACH occasions.

Schedule SRS from RRC: Use RRC parameters to schedule Sounding Reference Signals (SRS).

Schedule CSI-RS from RRC: Use RRC parameters to schedule CSI-RS.

Schedule ZP CSI-RS from RRC: Use RRC parameters to schedule ZP (zero-power) CSI-RS.

Schedule UCI: Use DCI messages and RRC parameters to schedule UCI.

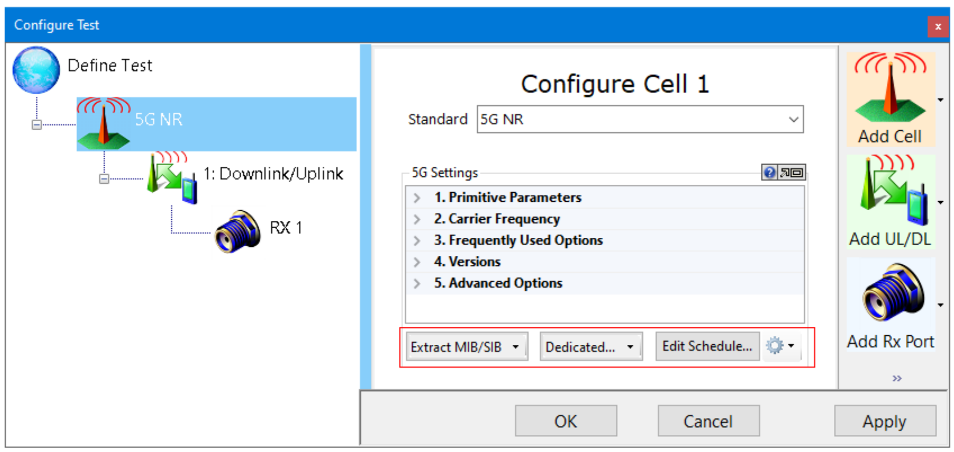
Auto Extract CellGroupConfig: If On, WaveJudge extracts the Config Dedicated parameters from RRC Setup/Reconfiguration messages and applies them on the fly while processing.

Auto Extract SIB1: If On, WaveJudge extracts the configuration parameters from SIB1 messages and applies them on the fly while processing.

Start of Frame: Configures how the start of frames is determined.

Other 5G Cell Settings

There are also four options at the bottom of the Configure Cell 1 window.



5G Settings: Four Options at Bottom of Window

Each one is described below.

Extract MIB/SIB: Select WaveJudge from the drop-down menu to extract and apply MIB and SIB from WaveJudge.

Dedicated...: Select WaveJudge from the drop-down menu to extract dedicated RRC from WaveJudge.

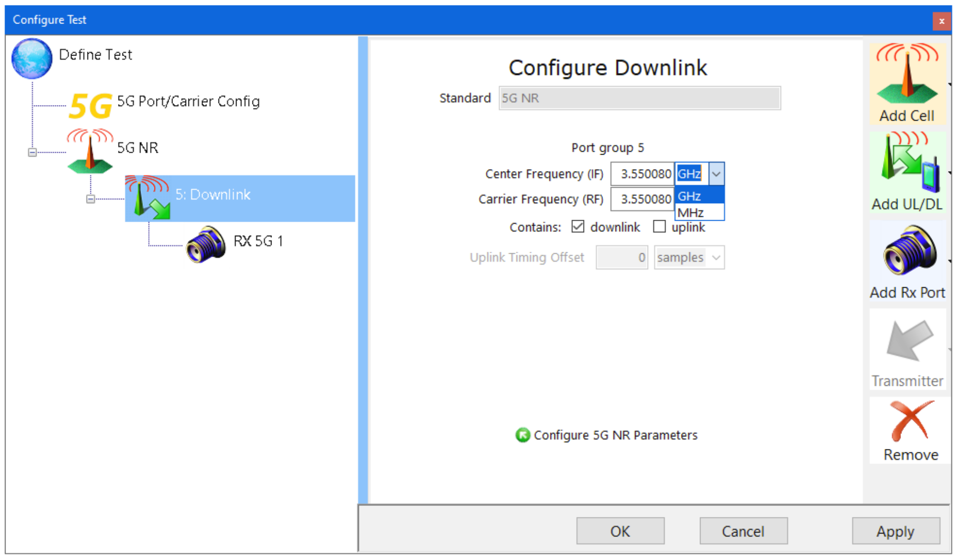
Gear Icon  : Opens a drop-down list with four options:

- Import Config... Opens a window to browse and select a file.
- Export Config... Opens a window to browse and save a file.
- Import Schedule... Opens a window to browse and select a file.
- Export Schedule... Opens a window to browse and save a file.

Edit Schedule: Opens the Edit Schedule window and lists all system frame numbers and slots. For more information, refer to 5G Edit Schedule on page 330.

3. 2. 1. 4 Configure Port Groups/Downlinks

Next, click the fourth button in the left side pane of the Configure Test window, in this example it is the 5: Downlink 5: Downlink .



Configure Test: 5G NR - Configure Downlink Settings

The Configure Downlink settings are as follows:

Standard: This field is consistent with the settings indicated in previous steps, it is greyed out. If you wish to change the setting return to Step 1 (above) and select a new option.

Center Frequency (IF): An auto-populated intermediate frequency (IF) will appear in the text field, although you can click in the field and enter a new number. In the drop-down menu next to the field, select either GHz or MHz.

Center Frequency (RF): An auto-populated radio frequency (RF) will appear in the text field, although you can click in the field and enter a new number. The default frequency is GHz.

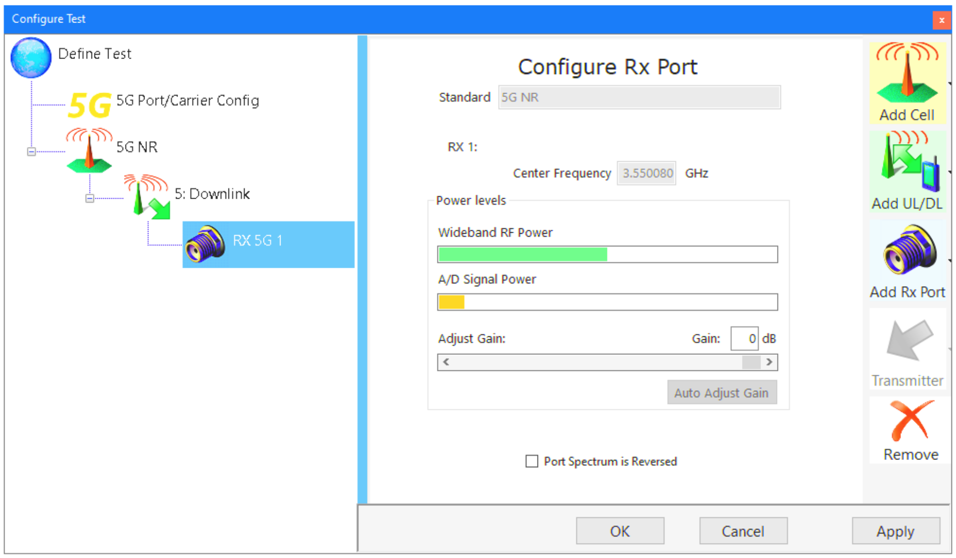
Contains: Select a checkbox for either downlink or uplink.

Uplink Timing Offset: For uplink transport blocks only, indicates uplink timing offset for this transport block or the physical transport block associated with this message. This section may be greyed out.

Configure 5G NR Parameters: Configure 5G NR Parameters This is a reminder to return to Step 3 (above) and complete the parameters. You will only see this message if you skipped ahead in the step-by-step process.

3. 2. 1. 5 Configure Rx Ports

Next, click the fifth button in the left side pane of the Configure Test window, in this example it is the RX 5G 1 RX 5G 1 .



Configure Test: 5G NR - Configure Rx Port

The Configure Rx Port settings are described below.

RX 1: Indicates the cell you are creating the settings for.

Center Frequency: An auto-populated field that calculates the center frequency in GHz.

Power Levels:

- Wideband RF Power: This graphic visually displays the relative wideband RF power level at the mixer, after attenuation. The bar should always be green; a red bar indicates probable saturation, an orange bar indicates the signal is too weak.
- A/D Signal Power: This graphic visually displays the relative power level of the signal at the Analog/Digital converter after attenuation. The bar should always be green; a red bar indicates the signal is saturated, an orange bar indicates the signal is too weak.
- Adjust Gain: Adust this control to change the gain either using the slider or by directly entering a gain level until both of the above displays are green and the A/D Signal Power bar is as far to the right as possible without ever changing to red. Gain adjustments made here enable the internal attenuators in the RF card; it is still critical to keep the external power level from going too high or the card may be damaged. Enter a value in the text field on the right, or move the slider bar anwhere in the range **Rx Gain -60 dB** to **Rx Gain 0 dB**.

Port Spectrum is Reversed. Select this checkbox only if the Rx port has an inverted spectrum, which means that each subcarrier is mapped to its symmetrical subcarrier with respect to the center frequency. In a Time Domain chart this inversion translates into swapping the real and imaginary parts of the signal, typically called I and Q.

3. 2. 2 Settings for 5G SA Mode

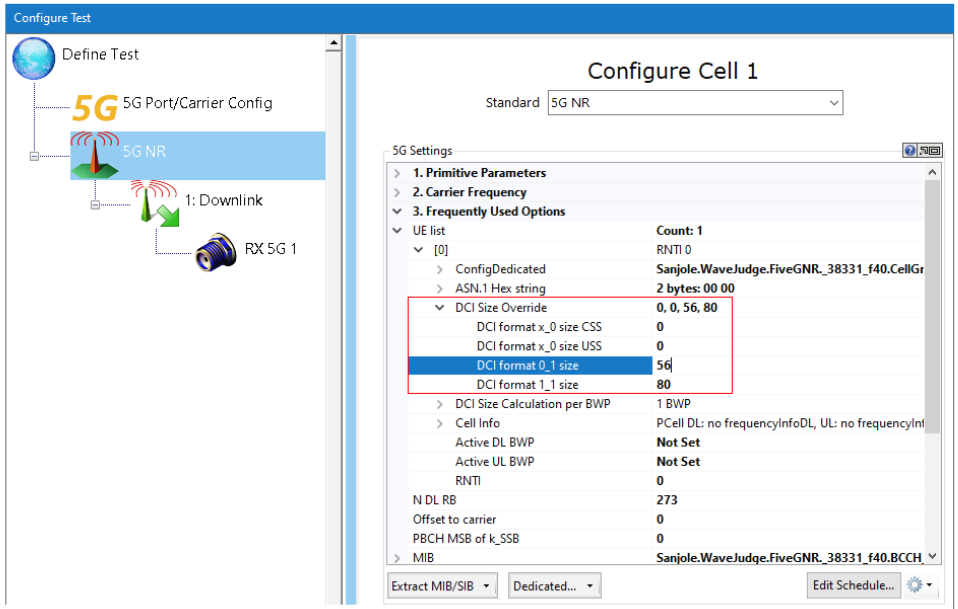
In SA mode, you must first extract MIB/SIBs before any blind Downlink Control Indicator (DCI) scheduling. Then you can begin decoding. Like LTE, the decodes will be for the config common parameters; they apply to broadcast messages PRACH and MAC-RAR, among others.

To decode UE traffic, the **Connection Setup** message must be decoded. Similar to LTE, that information is configured in the UE list made up of config dedicated entries for each UE. If a decode of the setup message occurs, add a UE entry to the UE list. Then click the ASN.1 control to paste the log information into the control and extract the information.

3. 2. 2. 1 Setting Automatic DCI Detection and Scheduling

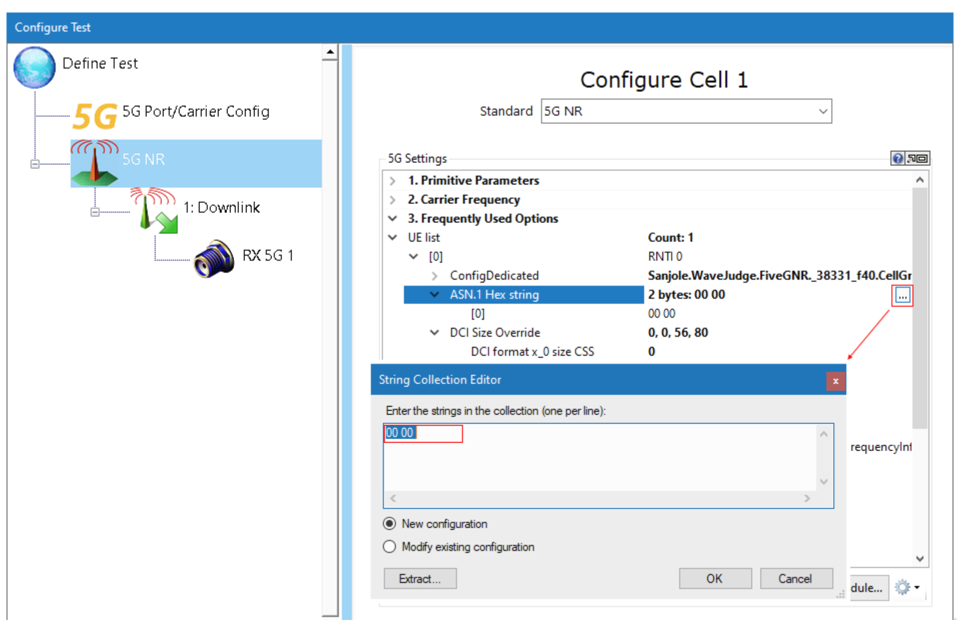
To set automated DCI detection you need to configure the ASN.1 Hex string and PDCCH for blind decoding. The left aligned bit sequence representing the **CellGroupConfig IE** is the required ASN.1 Hex string.

1. Open the **Configure Test** window by clicking the vertical Configure Test button on the left side of the GUI.
2. Select the second cell on the left **5G NR** to open the **Configure Cell 1** pane on the right.
3. Scroll down to section **3.Frequently Used Options** and click **UE List**, then enter the **DCI format x_0** and **DCI format x_1** sizes.



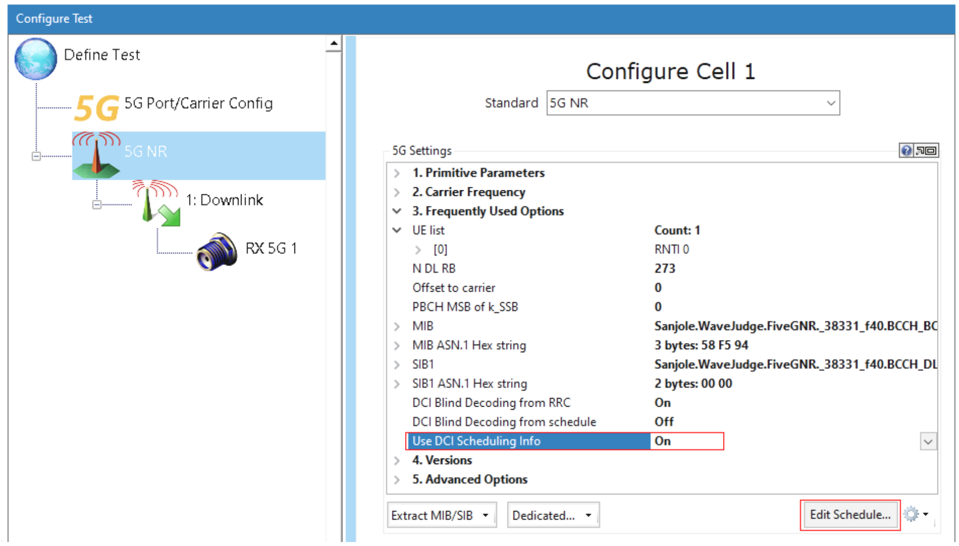
Change the DCI Format Sizes

4. Click the ASN.1 Hex string entry and on the far right click the ellipse button ... .
5. The String Collection Editor will open, paste a CellGroupConfig ASN.1 Hex string in the highlighted field.



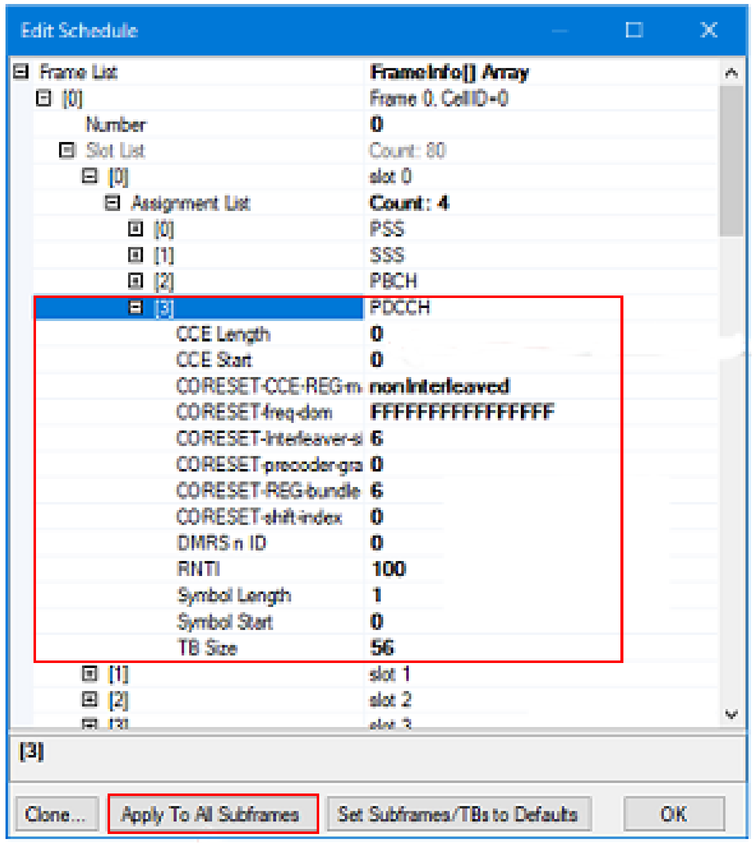
Paste "CellGroupConfig ASN.1 Hex" in the String Collection Editor

6. Set **Use DCI Scheduling** to **On**.
7. Click the **Edit Schedule** button.



Set "Use DCI Scheduling Info" to On and Click the "Edit Schedule" Button

8. Set **CCE Start** to **0**.
9. Set **CCE Length** to **0**.



Set the "CCE Length", "CCE Start" and Other Parameters

10. Fill out all other parameters.
11. Select the PDCCH and click the **Apply To All Subframes** button.

3. 2. 3 Import a File

Importing a file is considered the same type of event as taking a hardware capture, so the value entered for IF is recorded with the file. If you modify the value after importing the file it will apply a frequency shift. If you do not edit IF after importing a file the parameter is left unused. The only parameter used is RF, and it is mostly used for phase compensation.

WaveJudge lets you import or export I/Q samples in ASCII format via two columns: one for I and one for Q. It can analyze I/Q data captured by other devices and you may use I/Q data captured by WaveJudge with other analysis tools.

For more information on the WaveJudge importing and exporting RF data process, see Importing and Exporting RF Data :Export RF" /> on page 173.

3.2.4 Capture Process

Center Frequency (IF) is the hardware frequency. The Carrier Frequency (RF) is the frequency of the signal before downconverting to IF. If there was downconversion, the RF frequency is the same as the IF. After a capture, if you modify the IF, it will apply a frequency shift on the data.

To capture and process data

1. Set Up Capture Window on page 162 with the Capture button.

   Once a **capture** is triggered, the progress bar on the toolbar reflects the progress of the capture then the time left to upload the I/Q samples to the client PC via the USB or Ethernet connection. Upload time is proportional to the size of the sample.
2. Next, the uploaded I/Q samples are automatically processed. Processing time is a function of traffic captured as well as the processing power of your PC. The processing progress bar (on the toolbar) shows the amount of data processed out of the total captured data.
3. To update the charts and WaveJudge Message List with the data processed so far, click the ReProcess button. This feature lets you analyze the currently processed traffic while the remaining portion of the captured data continues processing in the background.

When processing is complete, all of the active charts and lists will update with the results of the processing and analysis.

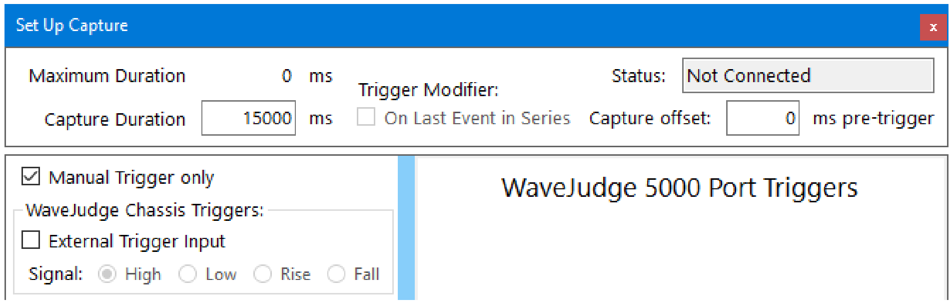
3.2.5 5G Triggers

There are four types of 5G triggers: 5G Manual Triggers on page 91, 5G External Triggers on page 92, 5G Power Triggers on page 93, and 5G Protocol Triggers on page 94; each one is described below.

3.2.5.1 5G Manual Triggers

A manual trigger is the simplest type of trigger. This occurs when the operator starts a capture by clicking the **Capture** button or selecting **Capture** from a menu, and the WaveJudge 5000 captures the signal and triggers the capture. It will immediately begin filling the data capture region and stop capturing once it is full.

Alternatively, you can click the Setup Capture button Set up Capture to open the window and select the checkbox for Manual Trigger Only.

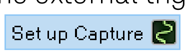


Setup Capture Window - Select Manual Triggers

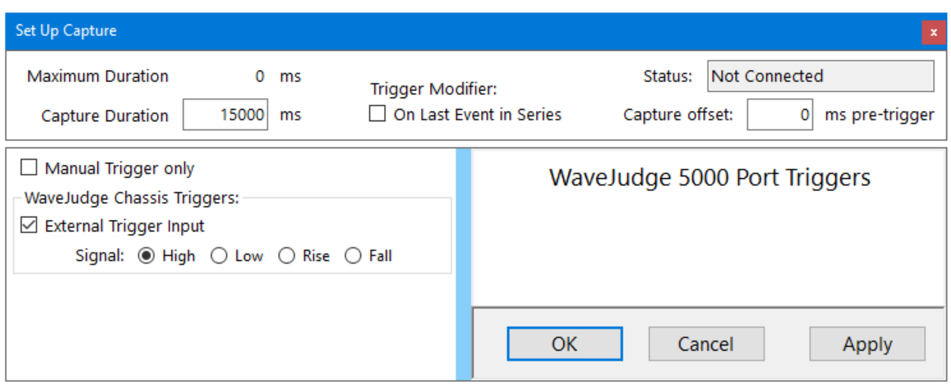
Manual triggers are typically used in the folllowing scenarios:

- When the operator of the WaveJudge 5000 wants to sample and decode an arbitrary section of an ongoing signal, such as Over the Air (OTA) traffic on a live network.
- When there is a repetitive signal to capture and analyze.
- When the operator also controls what will be transmitted and can start it as the same time they start the capture. One example is turning on a UE (mobile device) so it will connect to a network immediately on clicking **Capture**.

3. 2. 5. 2 5G External Triggers

When the external trigger is configured via the **Setup Capture** window (click the vertical 

button on left side), the WaveJudge 5000 will start capturing the signal until it is triggered by an external signal into the WaveJudge system. Under WaveJudge Chassis Triggers, select the checkbox for External Trigger Input, and click a button for High, Low, Rise, or Fall.



Setup Capture Window - Select Manual Triggers

External trigger options are as follows.

High: Trigger value for a high pulse width-triggered signal.

Low: Trigger value for a low pulse width-triggered signal.

Rise: Trigger when the signal value is increasing.

Fall: Trigger when the signal value is decreasing.

On that signal, it will fill its data capture region and then stop capturing once the capture area is full. The input should be a rising edge TTL level signal, similar to that used with many kinds of test equipment.

For the RXJudge 800 MHz 5G Receive Module, the trigger signal should be connected to the connector labeled **TRIG IN** on the first RXJudge 800 MHz 5G Receive Module in the WaveJudge 5000 system. This is the primary module and will automatically trigger all the secondary RXJudge 800 MHz 5G Receive Modules to capture at the same time.

An external trigger is typically used in the following scenarios:

- When the WaveJudge 5000 is used with other test equipment capturing other sorts of information and the same signal will be used to trigger all of them.
- When the WaveJudge 5000 is triggered by a component of the system being tested, immediately before data of interest will be transmitted. For example, control output from an eNB or gNB might be converted by intermediate equipment into a TTL level signal to trigger the WaveJudge.
- When the WaveJudge 5000 is triggered by a high-precision clock signal (such as a 1PPS) to measure synchronization of the devices being tested or synchronization of the WaveJudge with the devices.

In a standalone 5G configuration, the **TRIG IN** port of the 5G module may be used for external trigger input. The signal voltage specifications are in line with inputs for the WaveJudge 5000, but only the Rising Edge of Signal (RISE) trigger mode is supported.

For more information on RXJudge 800 MHz 5G Receive Module types, refer to RxJudge 800 MHz 5G Module Specifications on page 42.

3. 2. 5. 3 5G Power Triggers

A power trigger is primarily used in scenarios where the operator wants to capture an initial network entry by a UE and does not have easy access to higher level signaling. When the power trigger is configured via the **Setup Capture** window, a given power threshold in dBm will be set on a specific WaveJudge port. The threshold is usually approximate to within a few dBm.

The WaveJudge 5000 will start capturing the signal when the user starts a capture and will continue capturing until it is triggered by a given power level. The first time a power level higher than that is detected on the given port it will fill its data capture region and then stop capturing once the capture area is full.

For 5G captures, the power threshold must always be configured on the first RXJudge 800 MHz 5G Receive Module port in the system, as that is the primary module. The primary module will trigger all secondary modules to capture at the same time.

By configuring a pre-trigger offset for the capture, the operator can capture the initial signal triggering the capture as well as what follows it. For 5G, the WaveJudge software configuration and physical cabling configuration for the signals must be configured so that the uplink signal from the Device Under Test (DUT) is on the first RXJudge 800 MHz 5G Receive Module port. The power threshold should be set slightly below the initial transmit power for the UE and the capture is started before the UE is enabled. When the UE first transmits its signal asking to join the network, WaveJudge will begin capturing.

If a sufficient pre-trigger offset was configured (e.g., 100 ms pre-trigger), then the WaveJudge 5000 will capture and decode traffic before the UE sends its first signal, the signal itself, and then whatever follows that.

3. 2. 5. 4 5G Protocol Triggers

In connection with a system supporting IntelliJudge real-time decoding of LTE, a particular LTE message can be configured to trigger the WaveJudge 5000 capture. This is called a protocol trigger. In this case, you **do not** need to use the **Capture** button or menu to start the capture. Once the IntelliJudge capture is started and when the WaveJudge software decodes the correct message, it will trigger the WaveJudge to begin the radio signal capture.

3. 3 WaveJudge 5000 5G Expansion Modules

The following sections describe modules that are compatible with WaveJudge 5000 in a 5G capacity.

NOTE There are constraints dictated by the capture hardware for a valid capture configuration. For example, the maximum bandwidth/sampling rate on the original RXJudge 40 MHz 4-port RF Receive Module is limited to 40 MHz without real-time processing, and 20 MHz with real-time capture. Using a combined RXJudge 40 MHz Receive Module/RXJudge 5G Receive Module capture must use real-time processing on original RXJudge 40 MHz Receive Module ports for LTE and non-real-time capture on RXJudge2 5G Receive Module, etc.

3. 3. 1 RXJudge 40 MHz 4-port RF Receive Module

The RXJudge 40 MHz Receive Module (original RXJudge) may be used for all 5G NR bands up to 40 MHz bandwidth within FR1. The module has four ports and supports frequencies between 380 MHz to 6 GHz. For more information on the module, refer to RXJudge 40 MHz 4-port RF Receive Module on page 95.

RXJudge 40 MHz Module

3. 3. 2 RXJudge 800 MHz 5G Receive Module

The RXJudge 800 MHz 5G Receive Module connectors are SMA for IF input (2.375 GHz to 11.625 GHz) and SMA for LO output (to mmWave Converter RF). There is one input port on the RXJudge 800 MHz 5G Receive Module. The DRAM capture size is 4 GB, with a capture time up to 3.56 seconds (start capture on Trigger: Port 1 only). The bandwidth is 5 MHz to 800 MHz with 1-8 channels and can be contiguous or non-contiguous in a 1400 MHz channel.

RXJudge 800 MHz 5G Receive Module

The module's base capture rate is 2400M samples/second. This includes downsampling up to a factor of eight if the channel bandwidth allows:

- 5G captures at 200 MHz bandwidth or less (300 MHz sampling rate or less): capture up to 3.56 seconds (3560 ms);
- 5G captures at up to 400 MHz bandwidth (600 MHz sampling rate): capture up to 1.78 seconds (1780 ms);
- 5G captures at up to 800 MHz bandwidth (1200 MHz sampling rate): capture up to 0.89 seconds (890 ms).

The exception are frequencies from 2.8 GHz down to 2.3 GHz, where the capture duration is 890 ms.

- At channel bandwidth of 100 MHz (sample rate of 150 MHz), the module minimum center frequency is 2.375 GHz (band from 2.325 GHz - 2.425 GHz).
- At channel bandwidth of 200 MHz (sample rate of 300 MHz), the minimum center frequency is 2.450 GHz (band from 2.35 GHz - 2.550 GHz).

When it comes to TDD, 1 BB module dedicated to the UL may be needed if input levels of DL/UL are not similar. This means that SISO requires one BB module, but possibly two; MIMO 2x2 requires two BB modules, but possibly three.

For more information on the RXJudge 800 MHz 5G Receive Module, see the Keysight WJ5000A WaveJudge 5000, Data Sheet.

3. 3. 3 RXJudge2 Digital IF (800 MHz) 5G Receive Module

The RXJudge2 5G Receive Module functions almost exactly the same as the previous RXJudge 5G Receive Module; however, they have slightly different specifications and higher signal quality, especially at high bandwidth. For more information, refer to RxJudge2 800 MHz 5G Module on page 45.

The RXJudge2 5G Receive Module and the RXJudge2 Digital IF (800 MHz) 5G Receive Module may be freely intermixed in a WaveJudge 5000 system or within the same WaveJudge 5000 5G chassis, either with or without the mmWaveJudge Remote Receiver.

RXJudge2 5G Module and RXJudge 5G Module in a Two Chassis System

3. 3. 4 mmWaveJudge Remote Receiver

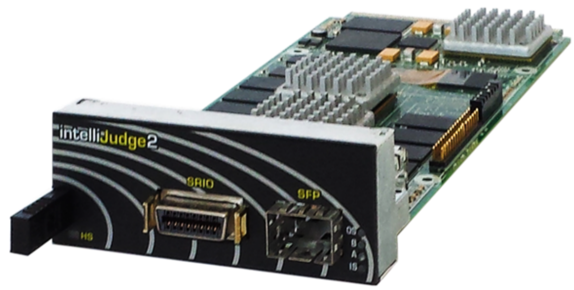
The mmWaveJudge Remote Receiver is designed for use with the WaveJudge 5000. The mmWaveJudge module supports basic 2x2 MIMO or massive MIMO applications at mmWave bands, an RF output range of 2.5 to 11.5 GHz, a mmWave input range of 24-30 GHz band and 37-42.5 GHz band, and a mmWave bandwidth of 1.4 GHz.

mmWaveJudge Converter

3. 3. 5 IntelliJudge2 Analysis Dual DSP Module

The IntelliJudge2 DSP Module is used for control, routing, and connectivity. This means that IntelliJudge2 DSP Module controls all of the modules and routes all I/Q, protocol, controls, and user plane data. You can use the IntelliJudge2 for your Ethernet connection to your PC and for the SRIO connection to other chassis. See IntelliJudge2 on page 51 for more information.

NOTE IntelliJudge does not capture 5G in real time; you cannot use IntelliJudge for real-time captures on 5G.



IntelliJudge2 Analysis Dual DSP Module

3. 3. 6 SynthJudge Module

The SynthJudge module is used together with the RXJudge 40 MHz module; it is not needed when using the RXJudge 800 MHz 5G Receive Module. The SynthJudge covers all LTE bands (380 MHz to 6 GHz) and may be used for all 5G NR bands within FR1 (663 MHz to 5.0 GHz). The SynthJudge has central clocking from one primary SynthJudge module in the first chassis of the system. The systemwide reference is derived from an internal 100 MHz OCXO, which may be referenced to an external 10 MHz reference or a GPS 1pps from the backplane. In addition, the SynthJudge has trigger input and output. See SynthJudge Module on page 50 for more information.

SynthJudge Module

3. 3. 7 StoraJudge Module

The StoraJudge consists of a 1 TB SSD module and two SRIO connectors. When paired with the RXJudge 40 MHz module, the SSD may extend capture durations by up to 30 minutes. SRIO connectors function as interconnects between chassis. When paired with the RXJudge 800 MHz 5G Receive Module, they function as interconnects only. See Install Hardware on page 29 for more information.

StoraJudge Module

3. 4 NSA (Combined 4G/5G System) Settings

The WaveJudge 5000 supports captures of 4G protocols (such as LTE) concurrently with capturing 5G NR. Your WaveJudge system may include both types of components and chassis to capture low-bandwidth signals (using the original RXJudge 40 MHz module with SynthJudge), higher-bandwidth 5G NR signals (using the newer RXJudge2 Digital IF (800 MHz) 5G Receive Module), or both.

A combined configuration (for example, an LTE cell and a 5G cell) will transmit the LTE configuration message carrying the 5G Serving Cell Config IE first and then assist with decoding 5G NR NSA mode traffic. With this configuration, WaveJudge will monitor traffic on the LTE cell in real-time as the UE attaches to the 4G network or performs handover to the 5G network. It may be programmed to automatically trigger the capture of 5G signals when it detects the reconfiguration message. This requires having both an LTE 15 and a 5G NR license as well as the physical requirements detailed below.

IMPORTANT **Currently, in a combined capture configuration using the RXJudge 800 MHz for 5G NR captures above 40 MHz bandwidth, the 4G LTE traffic can only be captured and saved as a real-time capture and can not be processed or saved as a non-real-time capture.**

For customers who have a combined 4G and 5G system, it is important to connect the chassis properly with the correct cable configurations. The next section explains configurations in detail.

With this latest release, WaveJudge supports operation of a single combined 4G/5G system for IntelliJudge real-time LTE captures and decoding, combined with 5G NR WaveJudge non-real-time capture and decoding of 5G signals at up to 400 MHz bandwidth on Keysight's RxJudge 5G cards. In this configuration, a 5G capture may be triggered either automatically from an IntelliJudge trigger on the correct handover message, or by manually clicking the WaveJudge Capture
Capture: Single Repeat button on the GUI. Timing of the WaveJudge capture should normally be synchronized with the IntelliJudge capture to within a few microseconds.

> **NOTE**
>
> In this mixed 4G/5G hardware configuration for combined triggered 5G non-real-time captures, a trigger signal cable must be connected from the **Aux/In Out** on the front panel of the SynthJudge in the 4G primary chassis, the first chassis of the system, to the **Trigger In** on the front panel of the left-most 5G card in the first 5G chassis.
>
> In addition to the trigger signal, the SYNCH signal must be passed from the last 4G chassis in the chassis chain to the first 5G chassis. To do so, connect the SYNCH OUT connector found on the back panel of the 4G chassis to the AUX Trigger IN connector on the back panel of the 5G chassis.

For 5G NR configurations using up to 20 MHz bandwidth in the sub-6 GHz range, WaveJudge allows combined real-time LTE and non-real-time LTE + 5G NR captures using only the original RxJudge (4G) and SynthJudge cards. Configure it in the normal way, with one LTE cell and one 5G NR cell, and it should be possible to capture the LTE cell in real-time and both cells in non-real-time, and optionally use the real-time capture to trigger a combined LTE/5G NR capture on a RRCConnectionReconfigurationComplete message containing the scg-ConfigResponseNR-r15 response IE.

A WaveJudge 5000 system containing some WaveJudge 5000 chassis with a RXJudge 40 MHz ("4G chassis") and some WaveJudge 5000 5G chassis with RXJudge 800 MHz may be used to capture either LTE signals, 5G NR signals, or a combined test configuration such as 5G NR NSA with both LTE and 5G NR. This system configuration has very specific chassis order requirements and cabling requirements.

For chassis configurations, refer to Install Hardware on page 29 under the sections NSA Chassis Front Panel Cabling on page 58 and NSA Chassis Back Panel Cabling on page 57.

3. 4. 1 Step 1. Set Decoding Parameters for 5G NSA

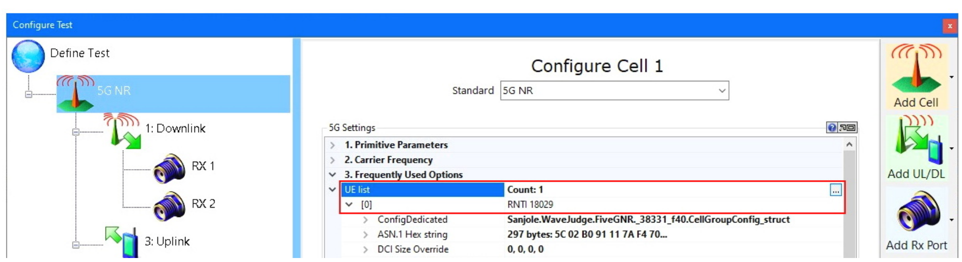
After you create a 5G NR test scenario, you need to configure and set the decoding parameters. This allows you to capture or import data and set up processing options, such as automatic DCI detection and scheduling.

NSA mode includes both 4G and 5G networks. Typically in NSA mode, the UE first attaches to the 4G LTE network. Then, based on the parameters passed in the reconfiguration message, it will attach to the 5G network.

Hex strings are required to decode 5G signals as well as PSS/SSS, PBCH, and MIB. The ASN.1 hex string contained in the reconfiguration message includes both the Config Common parameters in the LTE/SA mode SIB messages and UE-specific parameters normally carried in LTE setup and reconfiguration messages.

To set automated decoding and populate the UE list:

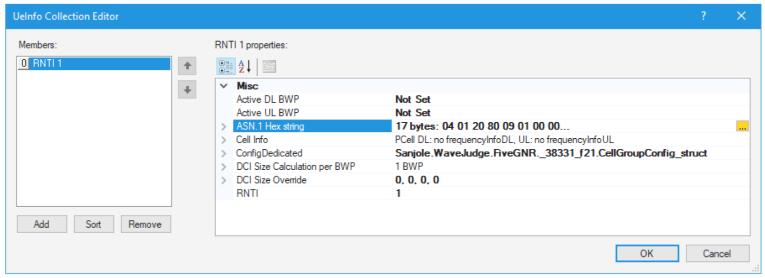
1. Click the vertical Configure Test button Configure Test on the left side of the window.
2. In the Define Test / Configure Test Scenario pane, in the Standard drop-down menu, select 5G NR.
3. On the left side pane, click the third button 5G NR 5G NR
4. In the 5G Settings window (right side pane), click on **3. Frequently Used Options** to open the drop-down list.
5. Click **UE list**.
6. Click in the small box with the elipse ... . This will open the UEInfo Collection Editor window.



5G Settings Window - Populating the UE List for Automated Decoding

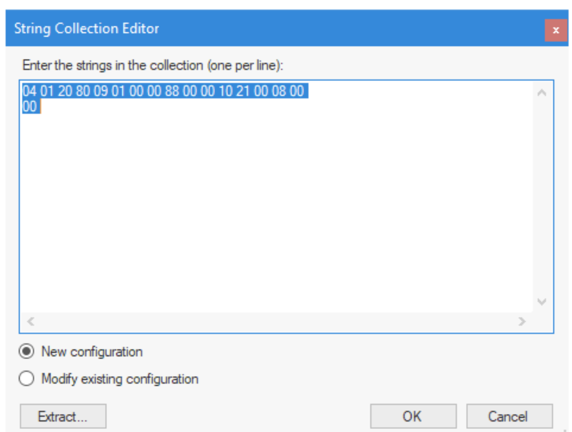
7. Next, encode all higher level parameters. From the **UEInfo Collection Editor** window under the **Misc** drop-down menu, select **ASN.1 Hex string** and click the small box with the elipse ... .

NOTE If you do not see the ellipse, expand the window to the right so you can see the text.



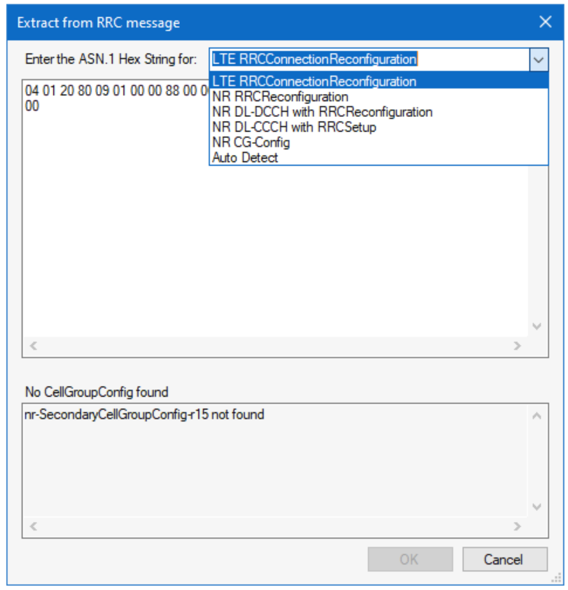
UEInfo Collection Editor Window - Select ASN1 Hex String and Click the Ellipse Box

8. The ellipse button  in the UEInfo Collection Editor will open the String Collection Editor window, shown here.
   - Copy (Ctrl+C) the set of numbers highlighted.
   - Click the Extract button.



String Collection Editor Window

9. The Extract button will open the window Extract From RRC Message.
   - Paste (Ctrl+V) the numbers into the top portion of the window
   - From the drop-down menu at the top right, select LTE RRCConnectionReconfiguration.



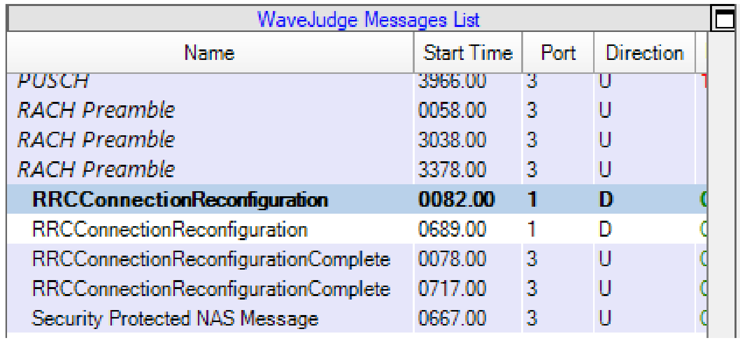
Extract from RRC Message Window

The ASN.1 parameter required in the UE list does not come from SIB1, but from the CellGroupConfig IE, which is contained in the **LTE RRCConnectionReconfiguration** message.

3. 4. 2 Step 2. Adding 4G LTE Settings to 5G UE List

This section explains how to correlate captured LTE signals by adding them to the 5G cell's UE List. Essentially, this task requires you to extract the **RRCConnectionReconfiguration** message, enter the ASN.1 Hex string to the 5G UE List, turn on DCI Blind Decoding from the RRC, and set the DCI schedule.

1. Identify the **RRCConnectionReconfiguration** message with the **nr-Config-r15 IE** (you may set a filter for IE).

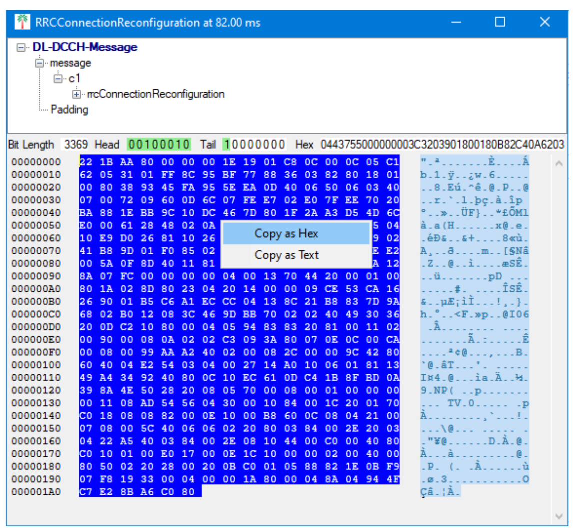


Double-click on RRCConnectionReconfiguration in WaveJudge Message List

2. Double-click the message. The entire hex panel will be highlighted.

   NOTE If the panel does not highlight, navigate to the hex pane and highlight the entire hex field.

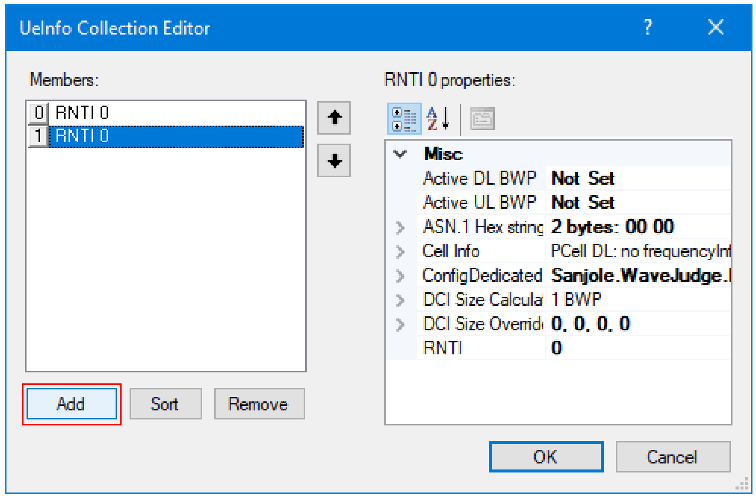
3. With your cursor in the hex pane, right-click and select **copy as Hex**.



Right-Click in Highlighted Hex Code, Select "Copy as Hex"

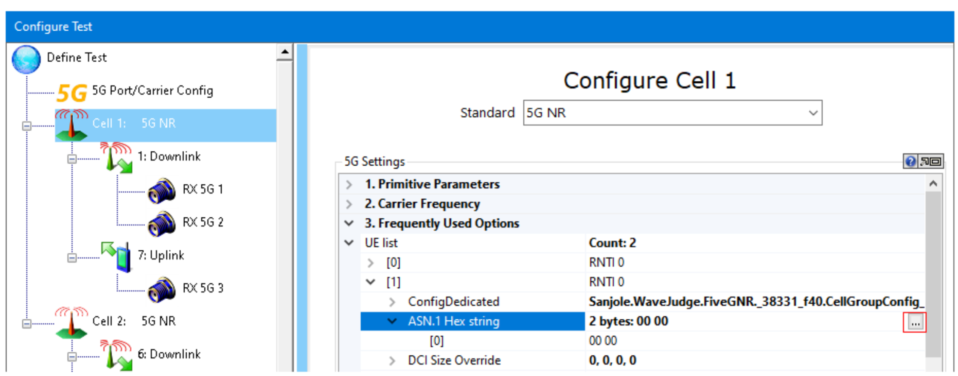
4. Click the vertical button **Configure Test** Configure Test.
5. Select the second cell in the left pane **Cell 1: 5G NR**.
6. In the right side pane under 5G Settings panel, click **3. Frequently Used Options** and double-click on UE List.
7. This opens the **UEInfo Collection Editor**. Click the Add button to add a UE to the

list.



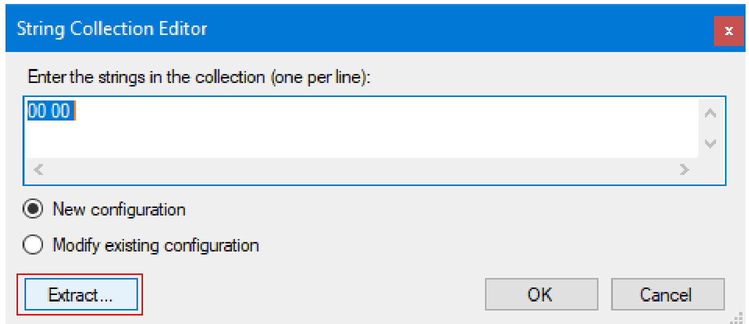
Add a UE to the UEInfo Collection Editor Window

8. Click the OK button to close the window.
9. Under the UE List submenu, click the **ASN.1 Hex String** entry. Then click the ellipse button ... on the right side.



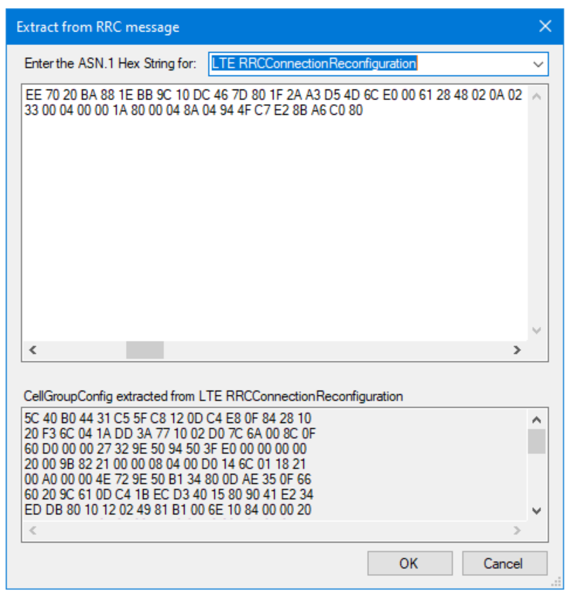
Select ASN.1 Hex String and Click the Ellipse Box

10. This opens the String Collection Editor window. Click the Extract button at the bottom.



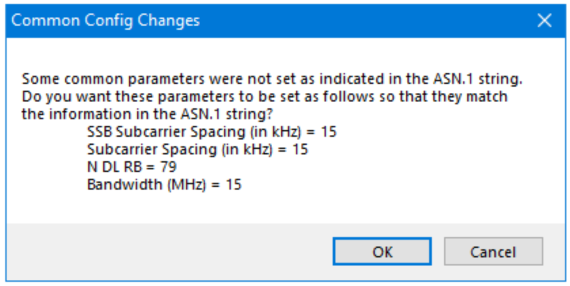
Click the "Extract" Button in the String Collection Editor

11. This opens the Extract from RRC message window. Place your cursor in the upper pane and paste the copied hex data into the top pane. Select **RRCConnectionReconfiguration** from the drop-down menu at the top.



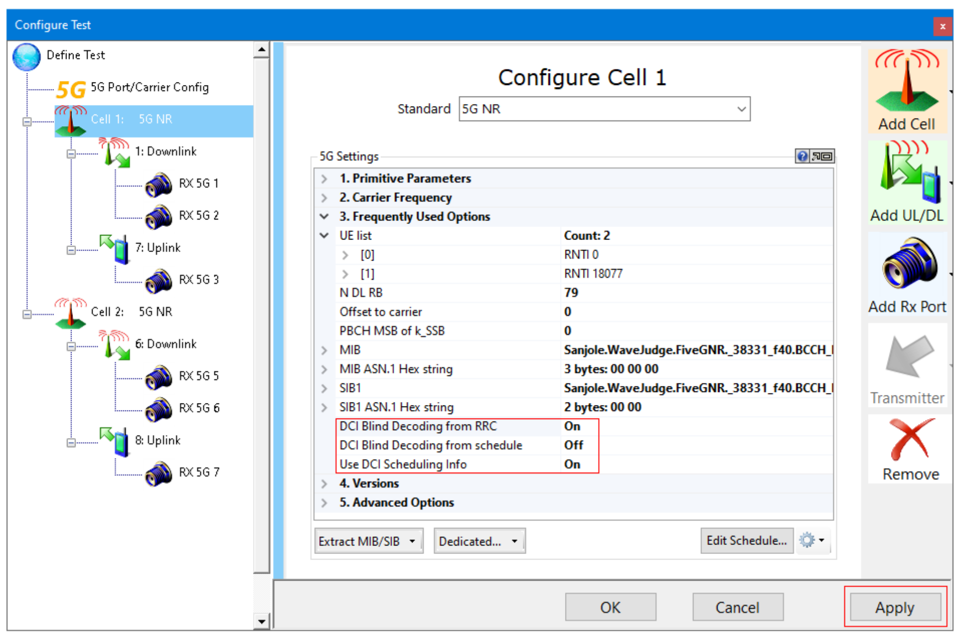
Click the "Extract" Button in the String Collection Editor

12. Click **OK** button to close the Extract from RRC message window.
13. Click **OK** to exit the String Collection Editor window.
14. Click **OK** to confirm the Common Config Changes window.



Click the "OK" Button to Confrm Common Config Changes

15. Set **DCI Blind Decoding from RRC** to **On**.
16. Set **DCI Blind Decoding from schedule** to **Off**.
17. Set **Use DCI Scheduling Info** to **On**.
18. Click the **Apply** button.



Change DCI Blind Decoding Settings to "On"

19. Click **OK** button to close the Define Test window.
20. Save and reprocess the 5G capture.

NOTE

In the case where the LTE capture **is not** available, the user must obtain the hex data by some other means. Often it will be a copy and paste from the UE or the eNodeB's log to the ASN1 extract

NOTE

control.

Exactly how you obtain the hex data does not matter. However, you must still use the above referenced procedure to create a UE entry and populate it with the ASN1 hex data. If you **do not** have the hex data, then you will need to manually configure the appropriate cell config common and specific fields in the UE entry.

NOTE

Some third party decoders and logs may encapsulate the reconfiguration message in unexpected ways that cannot be predicted by the WaveJudge software. In this case, the software may be unable to properly extract the message content. So your only choice at this point is to email **Keysight Technical Support** the ASN1 hex data for analysis, along with the capture. It cannot be addressed in real-time.

3. 4. 3 Step 3. Setting Up a NSA 4G LTE-Triggered Capture

In combined configurations where LTE is being captured in real-time, it is possible to configure a software trigger for an LTE message which will trigger the 5G NR capture to begin on the high-bandwidth RXJudge modules. Detailed instructions for trigger configuration are given below.

After the 5G NR data is captured, you can open the Configure Test window and extract the 5G Config Dedicated information and apply it to the capture. The capture can then be reprocessed or saved for further reprocessing of the 5G traffic with the appropriate parameters to allow DCI blind decoding and PHY channel scheduling. There are requirements for successfully extracting the 5G config information and applying it to the capture such as having both an LTE 15 and a 5G NR license, as well as the physical requirements explained above.

NOTE

In the latest versions of WaveJudge, for a 5G NR NSA test with standard signaling you can enable automatic extraction and processing of 5G UE "dedicated" information from the real-time LTE capture to the matching non-real-time 5G NR capture. To do this, in the Configure Test control's 5G cell settings set Auto Extract LTE RRC to 5G UE Config to 'On'.

This takes the place of extracting the 5G configuration via the Configure Test control in the steps below, or of manually pasting it from messages.

Briefly summarized, these are the steps to set up a 5G and 4G-LTE triggered capture. The first three items were previously desribed elsewhere in this manual, click a link if you need to review the procedures.

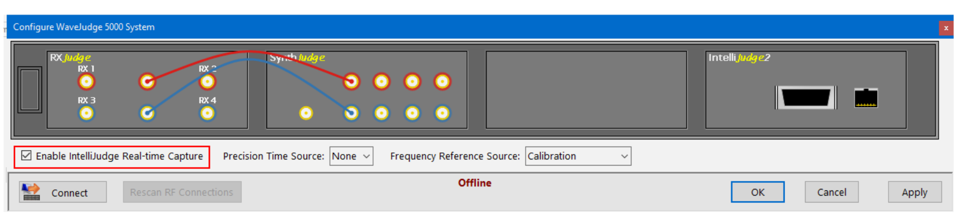
1. NSA Chassis Front Panel Cabling on page 58.
2. NSA Chassis Back Panel Cabling on page 57.
3. Configure a Test Scenario on page 72.

   The following steps are described in the sections below.

4. Step 4. Enable IntelliJudge Captures on page 109
5. Step 5. Configure IntelliJudge 5G NR Trigger on page 109
6. Step 6. Set Up Capture Duration on page 110
7. Step 7. Connect to the Chassis on page 111
8. Step 8. Verify Power Levels in the Rx Port on page 113
9. Step 9. Start IntelliJudge Capture on page 114
10. Step 10. Start the UE and Capture Traffic on page 115
11. Step 11. IntelliJudge Capture with the RRC Connection Messages on page 116
12. Step 12. Access the ASN Hex String on page 117
13. Step 13. Acknowledge a Trigger from the UE on page 118
14. Step 14. Verify a UE Entry Will Populate in a Cell on page 119

3. 4. 4 Step 4. Enable IntelliJudge Captures

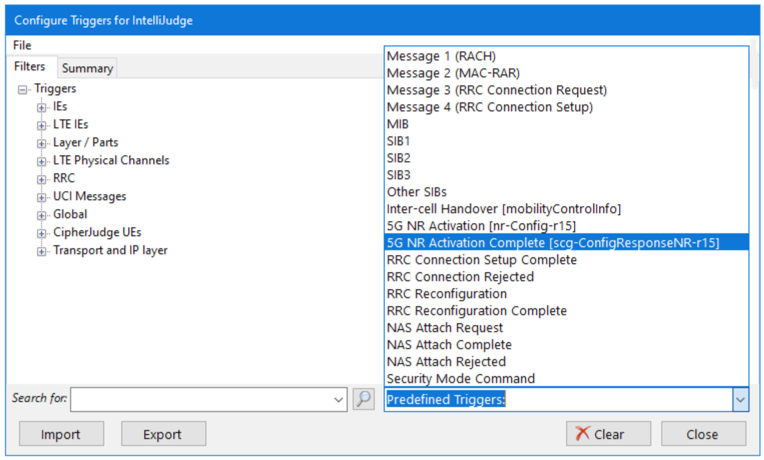
Click the vertical Configure Chassis button on th left side Configure Chassis to open the Configure WaveJudge 5000 System window. Select the checkbox Enable IntelliJudge Real-Time Capture.



Enabling IntelliJudge Real-Time Capture

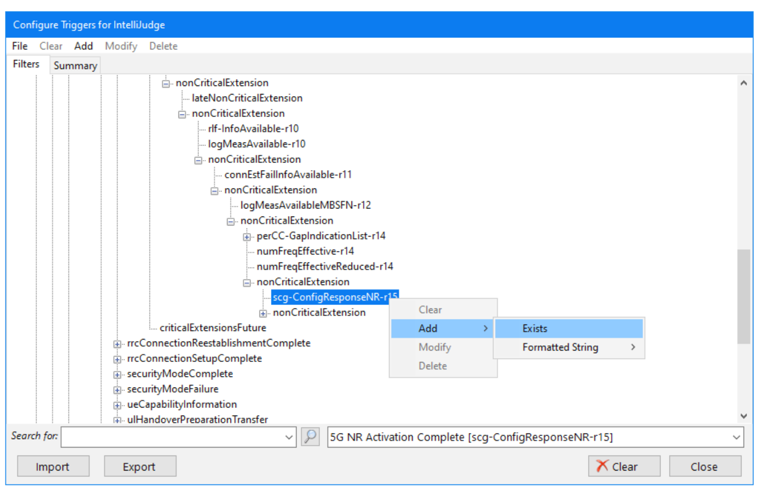
3. 4. 5 Step 5. Configure IntelliJudge 5G NR Trigger

On the Tools menu, select IntelliJudge Triggers. Click the Predefined Triggers menu in the lower right corner and select 5GNR Activation Complete (scg-ConfigResponseNRr15). An alternate trigger that makes the 5G capture start earlier is 5GNR Activation (nr_Config-r15).



Select "5G NR Activation Complete" in IntelliJudge Predefined Triggers List

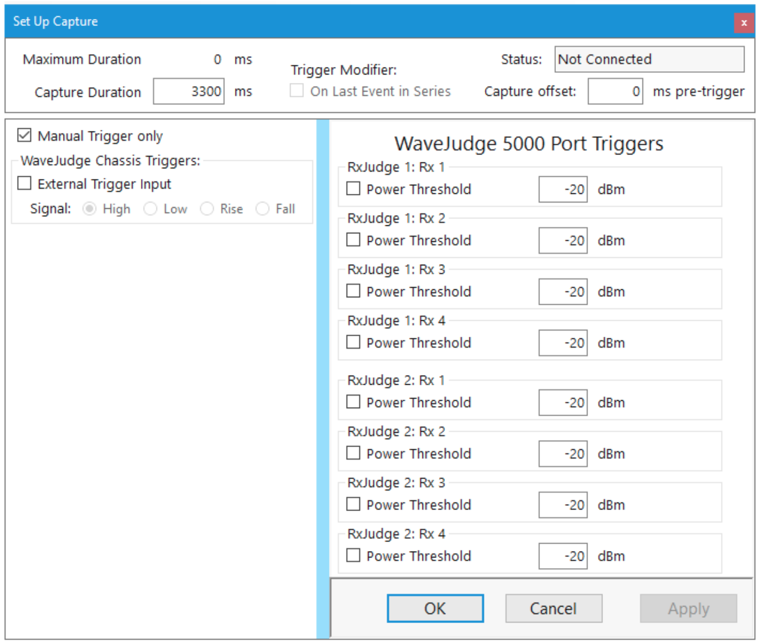
Next, right-click **scg-ConfigResponseNR-r15** and select **Add**. Then select **Exists**.



Add IntelliJudge Trigger "scg-ConfigResponseNR-r15"

3. 4. 6 Step 6. Set Up Capture Duration

Click the left side vertical button Set up Capture to open the SetUp Capture window.



Set Up Capture Duration Window

Duration times are briefly summarized here; for complete information on capture settings, refer to Set Up Capture Window on page 162.

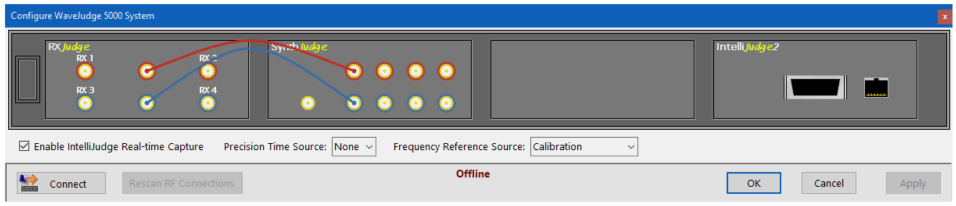
Maximum Duration: The maximum duration of a capture varies according to the type of WaveJudge chassis which is connected, and according to the Cell Bandwidth, as configured on the Configure Cell Pane. If hardware is not then connected a value of 0 is displayed.

Capture Duration: Defines the length of the capture once a trigger condition exists. Enter a value from 1 ms to the Maximum Duration. The maximum duration will reset if input exceeds the maximum.

When in **Repeat Capture** mode (e.g., setting up gain parameters) it is useful to set the duration to short lengths to minimize the processing time between iterations.

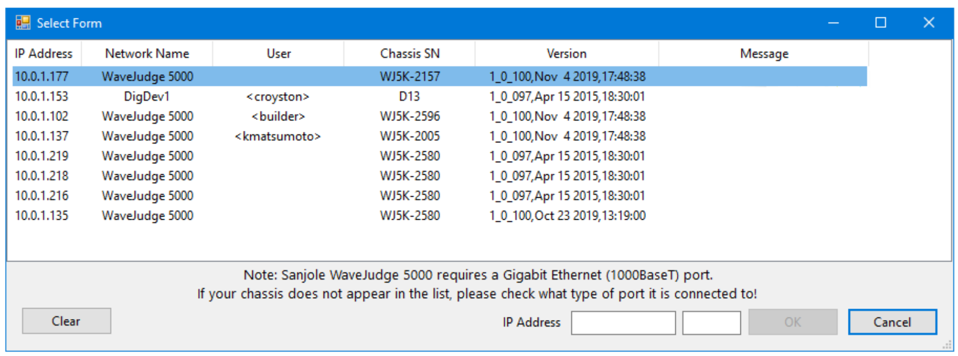
3. 4. 7 Step 7. Connect to the Chassis

Click the left side vertical button Configure Chassis to open the Configure WaveJudge 5000 System window. Click the Connect button.



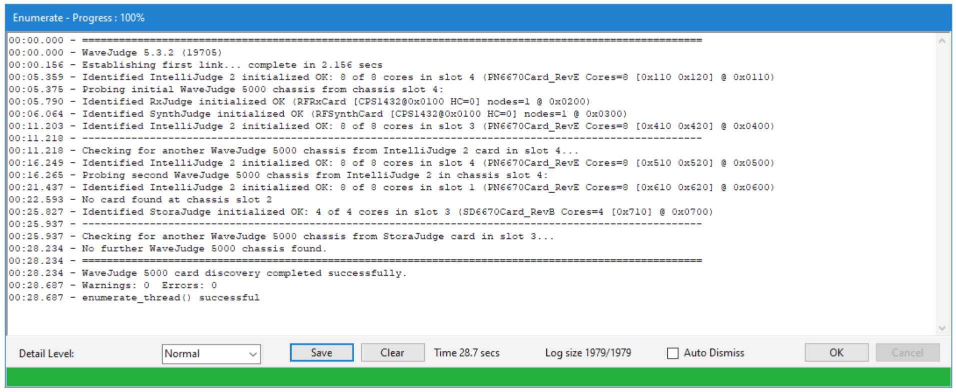
In the "Configure WaveJudge 5000 System" Window Click the "Connect" Button

The Select Form window will open, click on a line to select a chassis from the auto-discovered list. The OK button will activate, click the OK button to connect.



In the "Select Form" Select a Chassis to Connect To

Next, the Enumerate - Progress window will open and establish the connection then check for errors, etc. Click the OK button. Your WaveJudge software and chassis are working and in sync.



The "Enumerate Progress" Window Establishes Connectoin and Confirms Synchronization

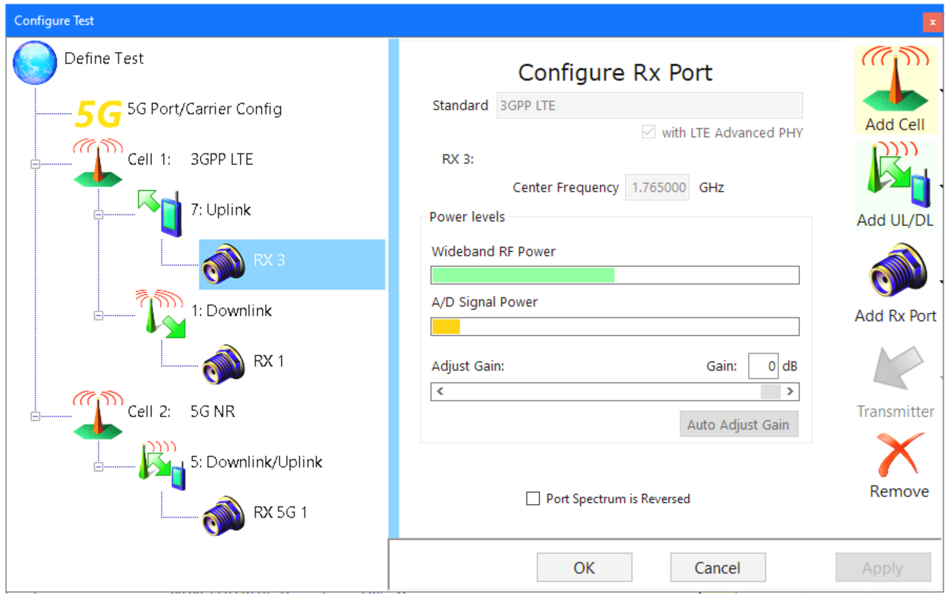
3. 4. 8 Step 8. Verify Power Levels in the Rx Port

Next, you want to verify the gains in your Rx port. All graphics should be green, if they are not adjust the Auto Gain slide bar until all three are green.

To get to this window, click the vertical Configure Test button 

. In the top left pane, click Define Test and from the Standard menu select 5G NR.

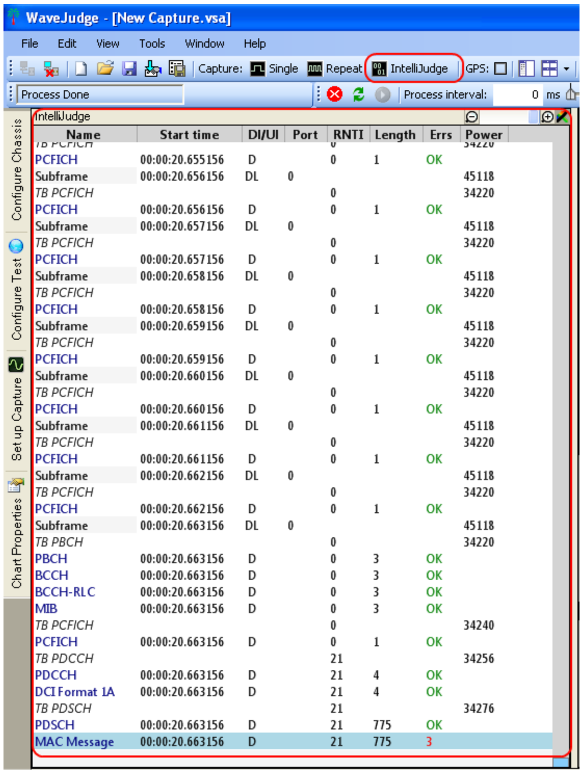
In the left pane, select the RX port; in the scenario below it is RX3. For more information about power levels, refer to Configure Rx Ports on page 86. Monitor the RF while turning on the UE to verify it doesn't turn red and generate a saturated signal. You may need to power cycle the UE more than once.



Verify Rx Port Power Levels

3. 4. 9 Step 9. Start IntelliJudge Capture

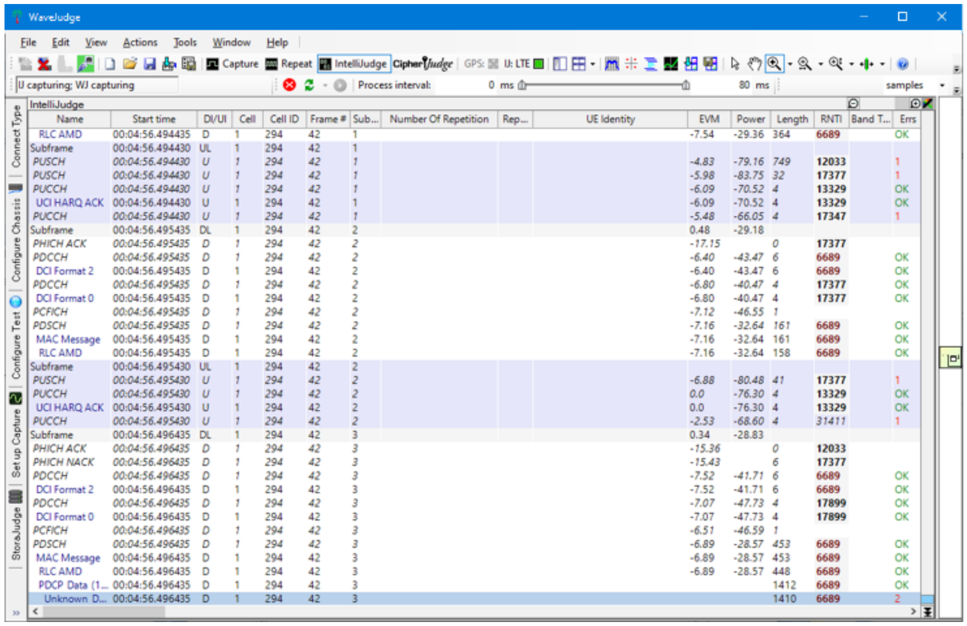
The main tool bar will show the capture buttons are active (for example, not greyed out). Click the **IntelliJudge** button to start a capture. Results will appear in the IntelliJudge Message List.



Start IntelliJudge Capture

3. 4. 10 Step 10. Start the UE and Capture Traffic

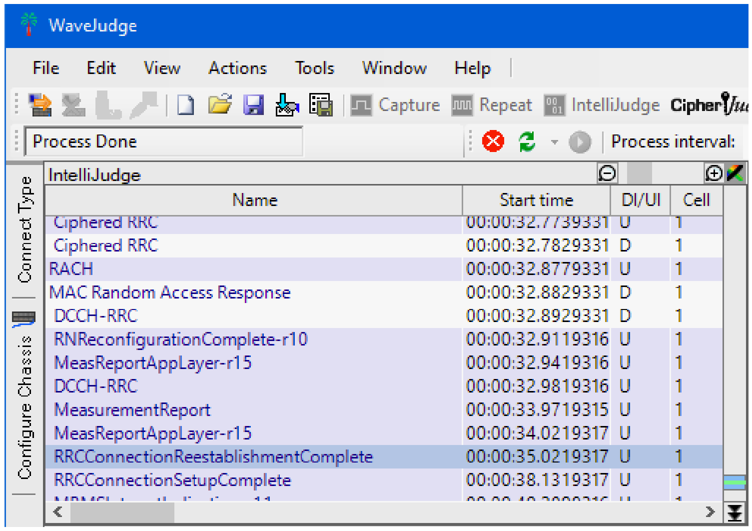
Power on the user equipment (UE). WaveJudge will immediately start capturing signals. When WaveJudge has finished capturing (as indicated by the status message and the green capture progress bar) click the Stop button to end the IntelliJudge capture.



IntelliJudge Capturing Real-Time LTE Signals

3. 4. 11 Step 11. IntelliJudge Capture with the RRC Connection Messages

In the IntelliJudge Message List, scroll down and locate the RRC Connection messages. This shows the state of the software after the capture on the 5G module is complete.



IntelliJudge Message List Shows RRC Connection Reestablishment Complete

IMPORTANT

If the 5G NR cell's 5G Settings option Auto Extract LTE RRC to 5G UE Config is enabled, and if standard signalling is being used, you should not need to perform the steps 12 - 14 below.

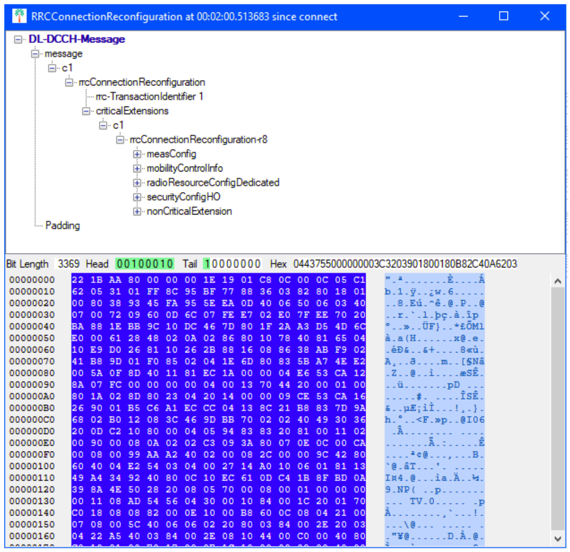
Before the non-real-time processing begins, WaveJudge will search IntelliJudge for relevant LTE RRC messages. The 5G NR decoding should be configured to automatically decode the 5G NR UE or UEs.

3. 4. 12 Step 12. Access the ASN Hex String

NOTE

IntelliJudge captures everything necessary, therefore the 5G configuration data should be automatically extracted and applied. Most of the time, users do not need to cut and paste hex data.

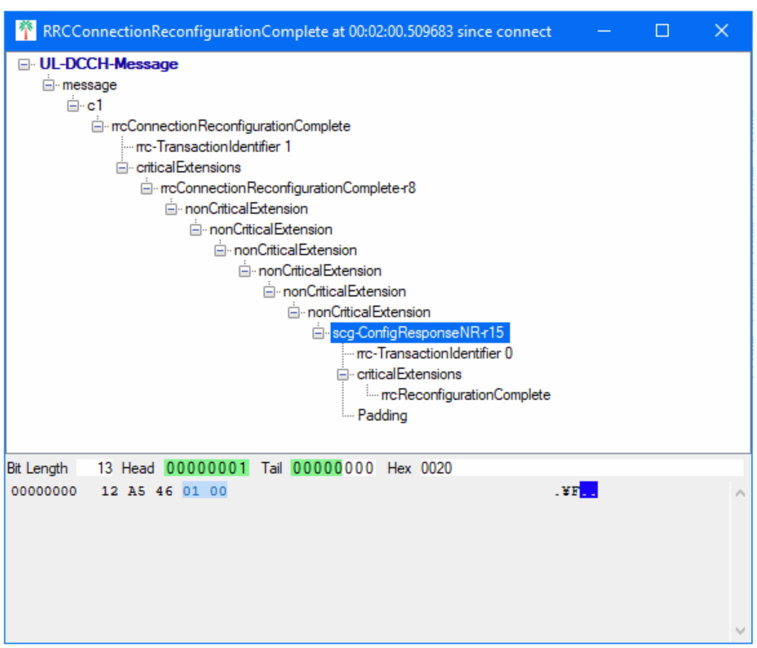
Find the RRC Connection Reconfiguration message and double-click it to pop up and view in the decoder window.



RRC Connection Reconfiguration Shows ASN Hex String

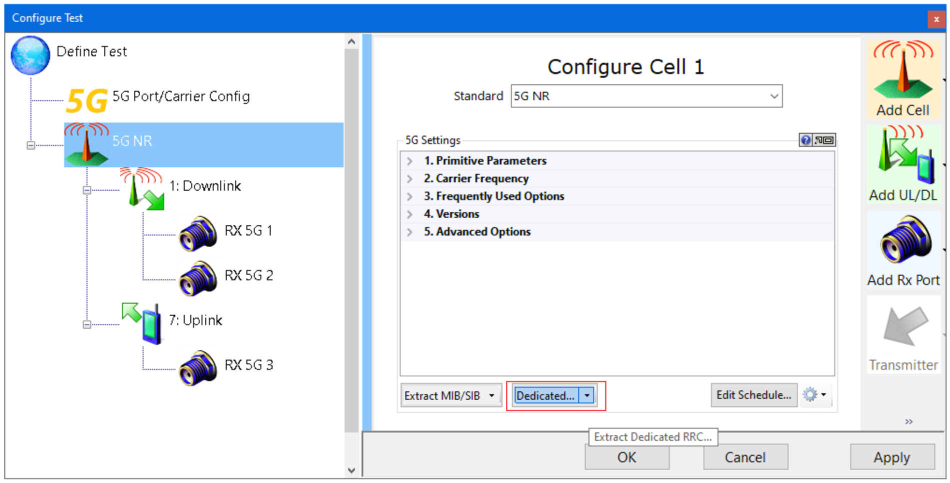
3. 4. 13 Step 13. Acknowledge a Trigger from the UE

To confirm and acknowledge the trigger from the UE: in the IntelliJudge Message List find the message **RRCConnectionReconfigurationComplete** and double-click on it. Open all the sublists until you reach the **scg-ConfigResponseNRr-15** entry.



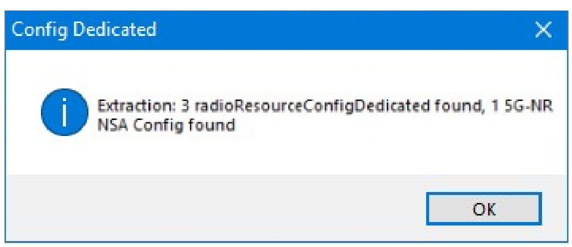
Acknowledge UE Message for the Trigger

In the Configure Test window, on the left pane, click the third item down (5GNR) to open the Configure Cell 1 pane on the right. At the bottom of the window, click the button Extract Dedicated RRC.



Select "Dedicated From WaveJudge" from the Drop-down Menu

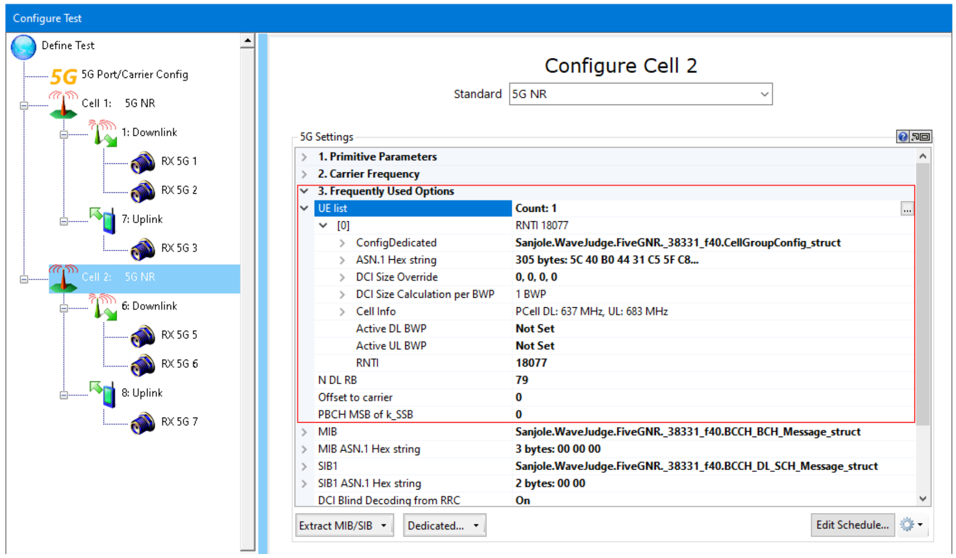
The Config Dedicated confirmation window will open.



Config Dedicated Extraction Message

3. 4. 14 Step 14. Verify a UE Entry Will Populate in a Cell

To verify the UE will populate data, click the second icon 5G NR to Configure Cell 2. In the right side pane, scroll down to the level **3. Frequently Used Options** and click open the **UE List**. This is where you can confirm all UE properties.

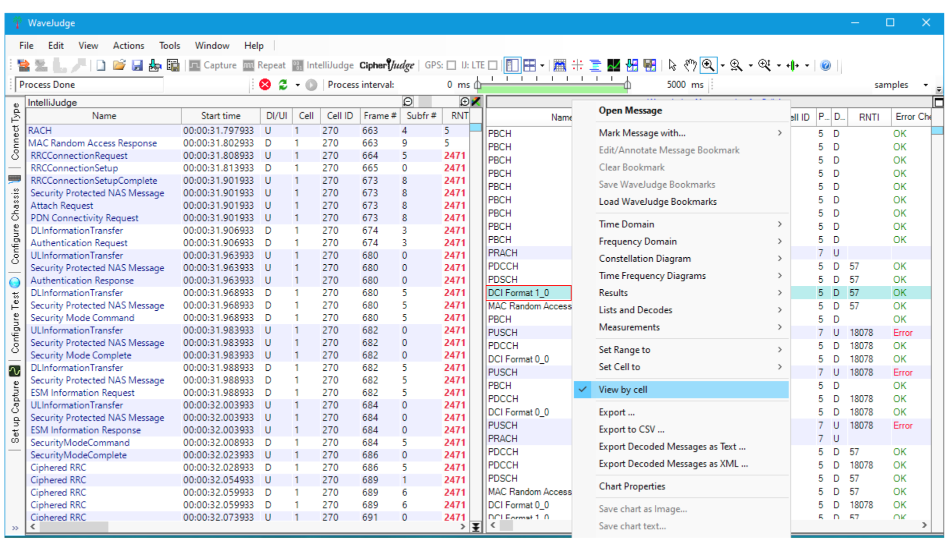


Verifiy UE Properties in the "Configure Cell 2" Pane

Click **OK** button and then process the WaveJudge capture. 5G NR processing is now configured to automatically decode the 5G NR UEs.

3. 4. 15 Step 15. Setting IntelliJudge Triggers for NSA 5G Real-Time Captures

IntelliJudge can only be used for real-time capture of LTE, therefore, it can only run in a NSA 5G configuration. As shown in the image below, the real-time 4G LTE data will be appear in the IntelliJudge Message List on the left. 5G data will appear in the WaveJudge Message List on the right.



NSA Showing IntelliJudge LTE on Left and WaveJudge 5G on the Right

You can tell a 5G capture from LTE because the WaveJudge Message List includes the filter DC Format 1_0. With two or three cell lists open, it's best to set the WaveJudge Message List property to View by Cell, rather than Set Charts by Protocol. To do this, right-click anywhere in the WaveJudge Message List and select View by Cell.

There are different uses for 5G, in some cases it can be used to augment the uplink; not necessarily the downlink. That's because the uplink bandwidth may be constrained on the LTE leg, so you can allocate the 5G leg to allow for additional traffic on the uplink.

TIP If WaveJudge is taking a long time to process, go back into the Configure Test / Config Cell Pane and remove or delete other cells (ie., right click on a cell and select Remove; or click on a cell and select the remove). This will speed up the processing. Afterward, click the Reprocess icon on the menu.

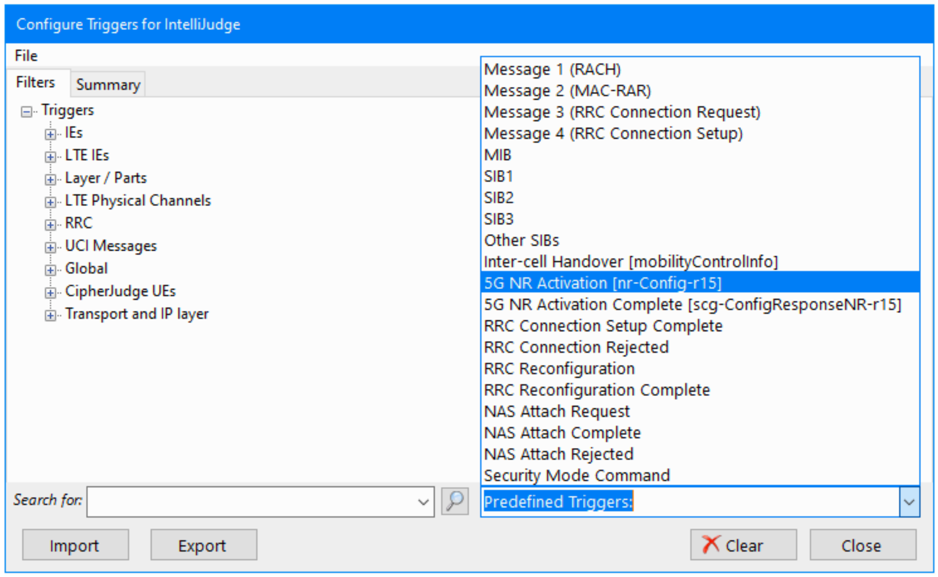
3. 5 Take IntelliJudge Real-Time NSA 5G Capture Using CipherJudge

The steps to take an IntelliJudge real-time capture using CipherJudge are:

1. Step 1. Set Up CipherJudge on page 122 (see steps below).
2. Set up the IntelliJudge test configuration (refer to for LTE - Create an IntelliJudge Triggered Capture on page 170).
3. Step 2. Set IntelliJudge Triggers for CipherJudge and 5G on page 123 (see steps below).
4. Step 3. Connect to WaveJudge and Capture Traffic on page 127 (see steps below).
5. Show IntelliJudge and WaveJudge Message Lists in GUI'; for example, click to the Window menu and select Both Message Lists Only.
6. See that CipherJudge is open on your desktop; for example, the CipherJudge window is visible on your desktop.
7. Turn on the UE.

If you don't have a license for CipherJudge, the 5G Activation [Nr-Config-r15] or [NR-SecondaryCellGroupConfigr15] would not be available. This trigger is also shown in the

Predefined Triggers list in the lower right corner of the Configure Triggers for IntelliJudge window.



5G NR Activation Messages in IntelliJudge Predefined Triggers List

3.5.1 Step 1. Set Up CipherJudge

To take a triggered capture (over the air, on a public network) in addition to WaveJudge and IntelliJudge, you need to use Keysight's CipherJudge. CipherJudge is designed to monitor commands issued by a mobile phone and read data from the SIM card. Basically, it is a piece of hardware that fits between the phone and the SIM card. It is very easy to use because it only has two connectors: one to the phone and the other to the SIM card. Data read from the card is stored away.

To set up CipherJudge:

1. Remove the SIM card out of a test equipment (for example, the phone).
2. Plug the removed SIM card into a CipherJudge slot.
3. Plug one CipherJudge connector into the phone.
4. Plug another connector into to the CipherJudge hardware.
5. Open CipherJudge. (Go to the Start menu, open the Keysight folder, select CipherJudge from the list).
6. Turn on the phone.
   - The phone will read the SIM card through the CipherJudge. It acts as a bridge, or "man in the middle". The traffic goes from the card to the phone.

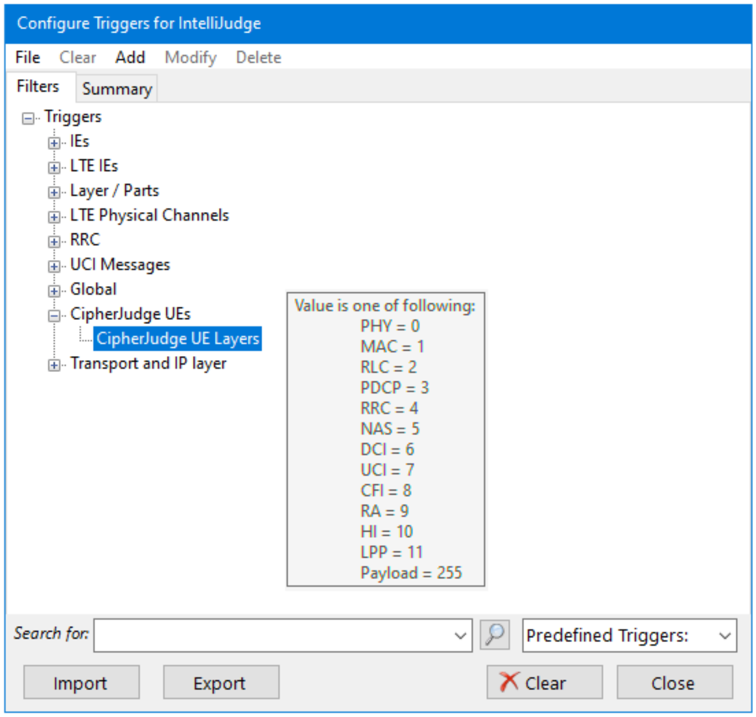
7. You’ll see the lower section of the CipherJudge screen go blank and then reset; it’s trying to load the cipher keys and send the keys to the network.
   - 3G AUTH REQ and 3G AUTH RESP are the authentication messages.
   - IMS AUTH REQ and IMS AUTH RSP show it’s on the network.
8. The phone saves the cipher keys to the SIM card as well, refer to the “Key Event” column in CJ shows SAVE KEY.

CipherJudge Shows IMS AUTH and SAVE KEY Messages

3. 5. 2 Step 2. Set IntelliJudge Triggers for CipherJudge and 5G

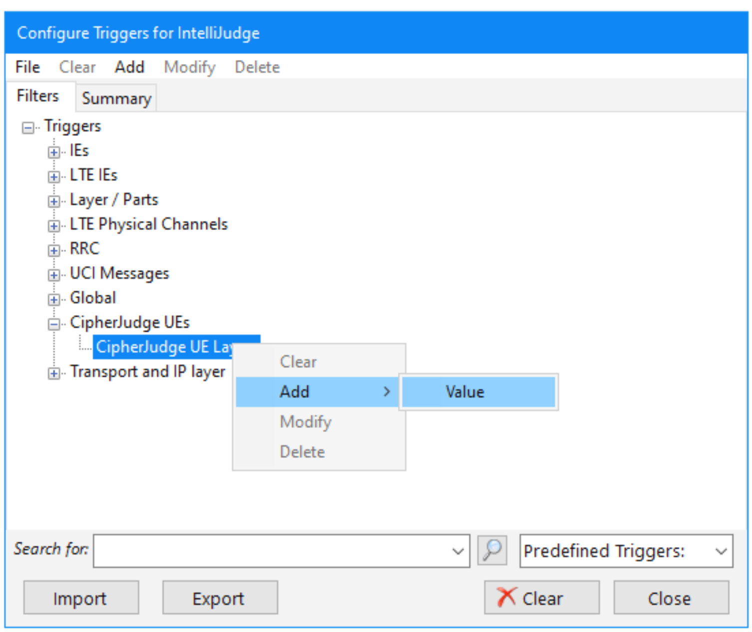
Click on the **Tools** menu and select **IntelliJudge Triggers**. Scroll down and click on **CipherJudge UE Layers**, this will display a popup window with the values for filters. This data tree appears whether you have CipherJudge turned on or not.

- PHY = 0
- MAC = 1
- RLC = 2
- PDCP = 3
- RRC = 4
- NAS = 5
- DCI = 6
- UCI = 7
- CFI = 8
- RA = 9
- HI = 10
- LPP = 11
- Payload = 255



Set IntelliJudge Triggers for CipherJudge

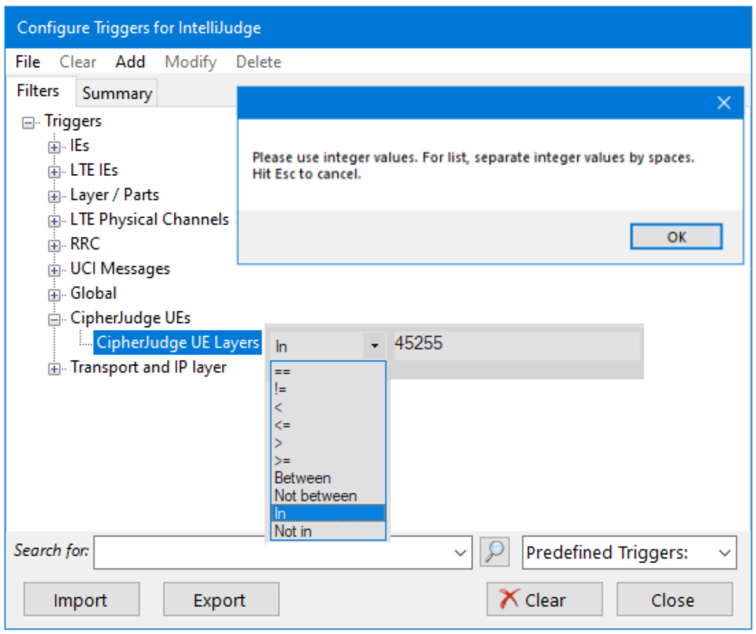
Right click and select Add then Value. If there is already a value set that you want to change then right click, and select Modify.



Set IntelliJudge Triggers for CipherJudge - Right Click to Add Values

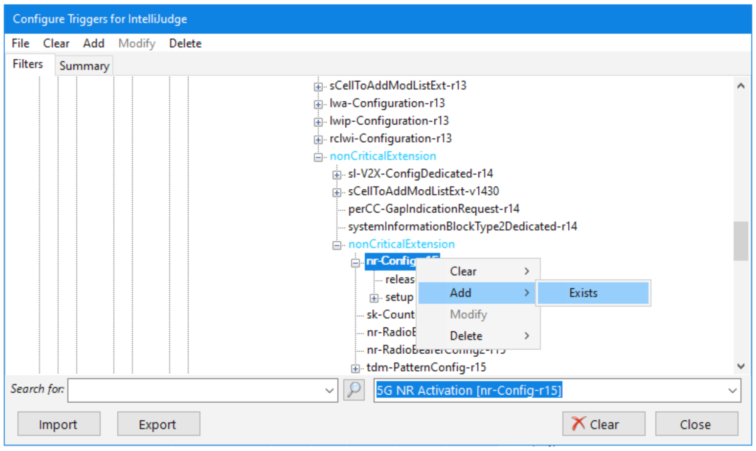
Set whatever messages you are interested in. In the figure below, the user wanted RRC (value of 4 from the list), NAS (value of 5 frrom the list), and Payload (value of 255 frrom the list).

- Use only integer values, do not use commas to separate numerals.
- From the list of options in the drop-down menu, select In.



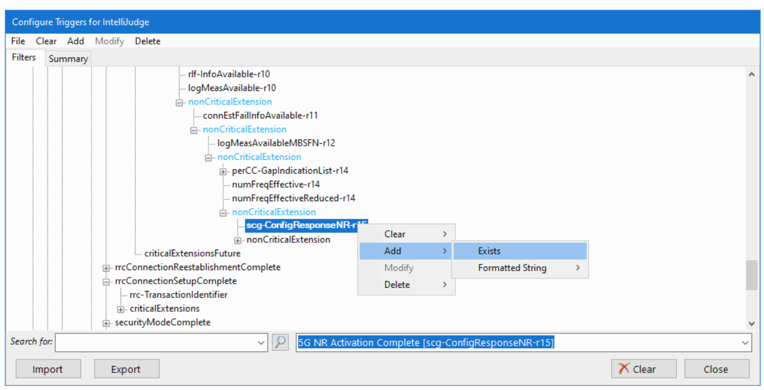
Set IntelliJudge Triggers for CipherJudge - Add Integer Values Based on Menu

To set the trigger 5G NR Activation [nr-Config-r15], open the Configure Triggers for IntelliJudge window and select it from the Predefined Triggers list. Right-click and select Add then select Exists.



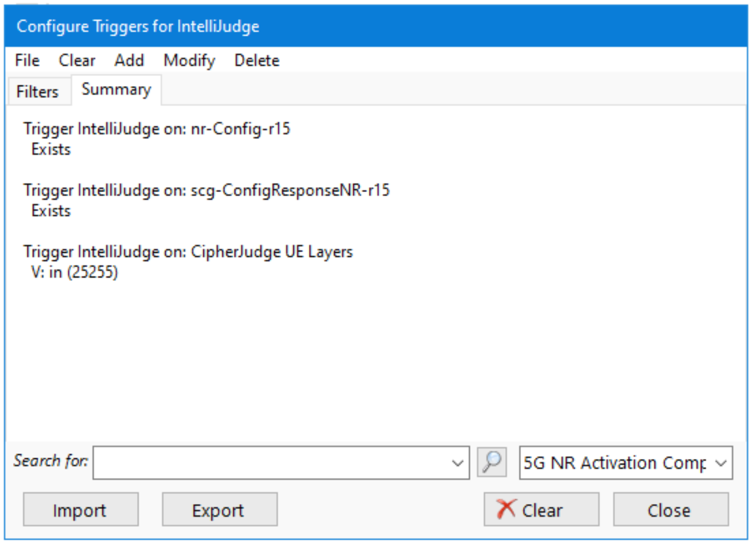
Set IntelliJudge Triggers for 5G NR Activation

To set the trigger **5G NR Activation Complete [scg-ConfigResponseNR-r15**, open the Configure Triggers for IntelliJudge window and select it from the Predefined Triggers list. Right-click and select Add then select Exists



Set IntelliJudge Triggers for 5G NR Activation Complete

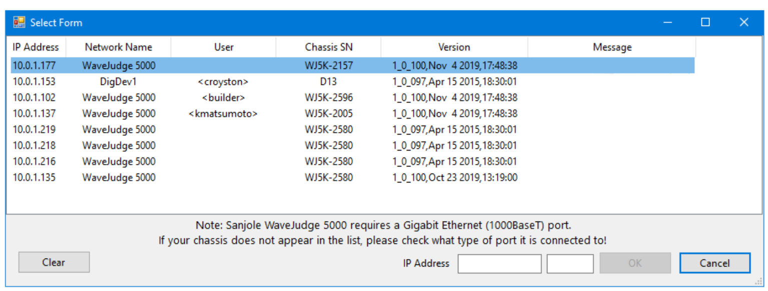
When you're done setting triggers, click the Summary tab to confirm all set triggers.



Review IntelliJudge Triggers Summary Tab

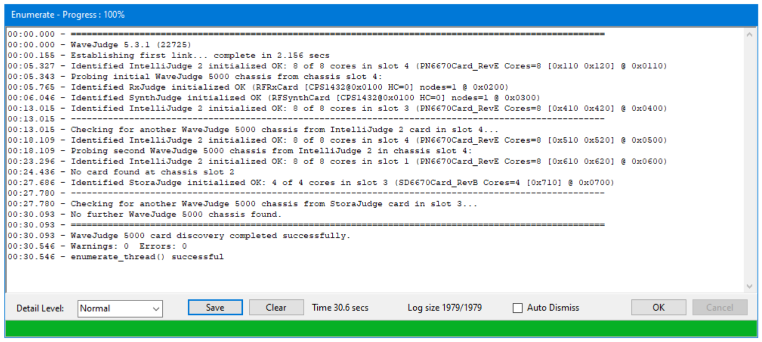
3. 5. 3 Step 3. Connect to WaveJudge and Capture Traffic

Now that everything is configured, click the **Connect** icon  on the top menu. The Select Form opens, select a chassis from the list.



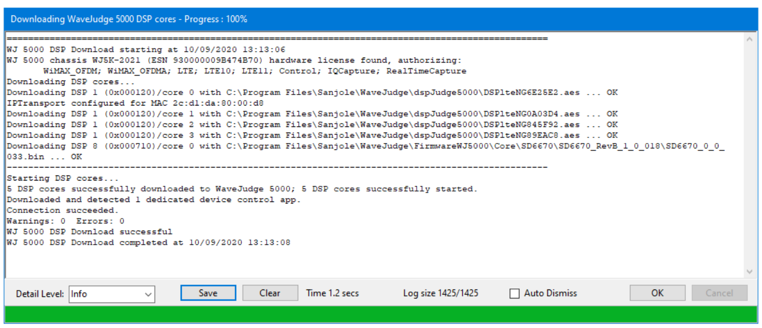
Connecting to WaveJudge - Select a Chassis from the Select Form

The Enumerate - Progress window opens and checks the status of all cards, clocks, etc., in the selected chassis.



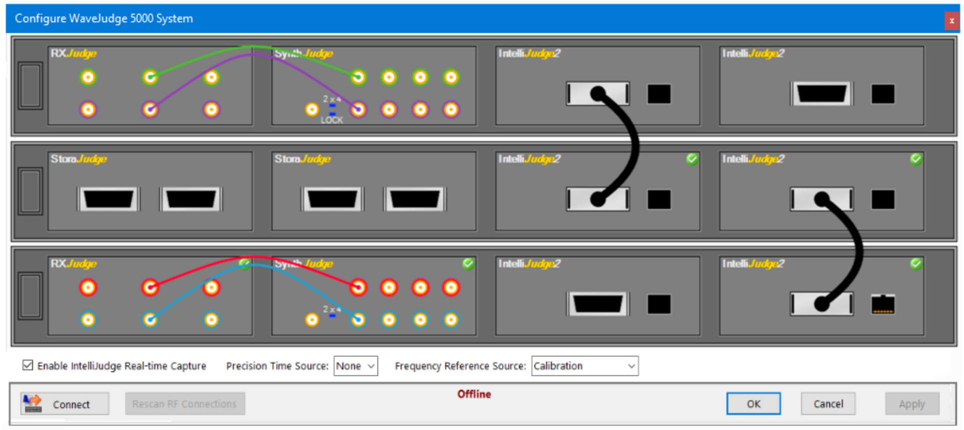
Connecting to WaveJudge - Enumerate Progress Window Checks Status of all Cards

When that completes, the Downloading WaveJudge 5000 DSP Cores window opens.



Connecting to WaveJudge - Downloading WaveJudge 5000 DSP Cores

When that completes WaveJudge shows an image of your chassis setup – all the chassis that are present and the cards within them.



Connecting to WaveJudge - Example of Chassis Setup with Cards

Go to the Window menu and select IntelliJudge Messages Only.

Now that your system is connected, start an IntelliJudge capture (for example,click the IntelliJudge icon IntelliJudge in the menu).

- If you notice there are error messages (e.g., Stopped at 0 ms / 50000 ms) in the top left status window, or filters are missing from the IntelliJudge Message List, try again.
- If you see "IntelliJudge Capturing. WJ Data captured" in the top left status window, it is working.

If you are using CipherJudge, make sure the CipherJudge window is open on your desktop before you turn on the UE; you'll see the CipherJudge reset and the traffic begin to flow.

4 Configure and Capture 4G LTE or WiFi

This section describes the settings and procedures to capture and process wireless network data.

- The first three sections introduce WaveJudge's primary configuration windows:
  - Configure Chassis
  - Configure Test
  - Set Up Capture

  These windows help connect WaveJudge hardware and software to set up and capture data correctly.
- After you're familiar with the basics, you're ready for the next section Configure a Test Scenario; this is where you open the Configure Test window and capture your first data set.
- The next two sections provide directions to set up other parameters: GPS describes how to set up your GPS input, and the Options window describes various options to display your data.
- Finally, the section Process Data describes how to save and load previously captured data files.

Several ports are required to test multiple input/multiple output (MIMO) schemes, handover operations, and frequency division duplex (FDD) systems. WaveJudge lets you configure, capture, and process complex test scenarios, such as working with a multi-chassis WaveJudge 5000 system to capture 24 ports or more of data, or two WaveJudge 4900s for up to eight ports of capture data. The WaveJudge 4900 is the only chassis that features the ability to use transmitters.

To quickly understand WaveJudge's user interface terminology we present the concepts of cells, ports, and port groups.

- A **cell** represents one sector of a base-station, i.e., the air interface downlink and uplink communications related to one downlink PHY. The ability to define multiple cells is designed specifically to allow handover or carrier aggregation testing.
- A **port** belongs to a port group and represents one physical radio frequency (RF) connector on the WaveJudge chassis, or one pair of baseband I/Q sample columns in an imported text file.
- A **port group** is a set of ports combined for MIMO processing; it is contained within a cell. You can set each port group as a downlink, an uplink, or both. The ability to separate downlink and uplink into two different port groups is primarily to support FDD.

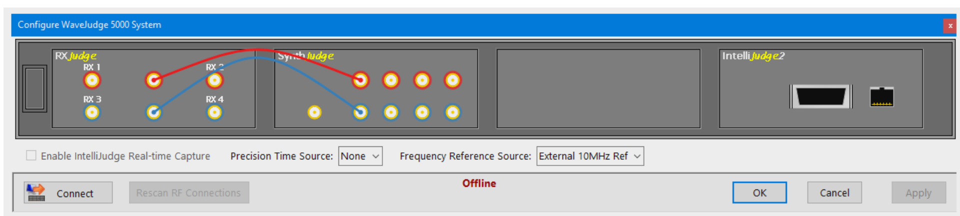
4.1 Configuring the Chassis

The Configure Chassis window is where you set up and view the configuration of the WaveJudge capture hardware. To access the Configure Chassis window, click the Configure Chassis button 

located on the vertical button strip to the left. This window may take one of two formats depending on whether you are working with a WaveJudge 5000 or a WaveJudge 4900.

4.1.1 Configuring the WaveJudge 5000 System

If you are using WaveJudge 5000 when you select the Configure Chassis button, a window will open that resembles the figure below. WaveJudge will adjust the connections you see in the window to match the configurations of your chassis.



Configure WaveJudge 5000 System Chassis

Each segment of this window is described below.

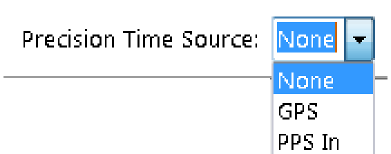
Enable IntelliJudge Real-time Capture:

Select this checkbox to enable a search for IntelliJudge real-time capture.

NOTE IntelliJudge only works with LTE and WiFi; IntelliJudge is not able to capture real-time data for 5G NR.

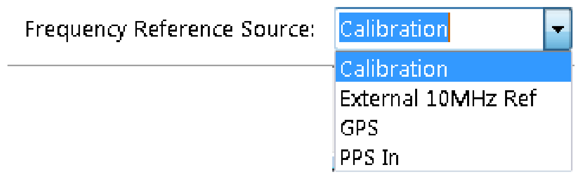
Precision Time Source:

Select a time source method from the dropdown list, options are:
None, GPS, and **PPS In**.



Frequency Reference Source:

Select a frequency reference from the dropdown list, options are: **Calibration, External 10 MHz reference, GPS,** and **PPS In.**



Rescan RF Connections:

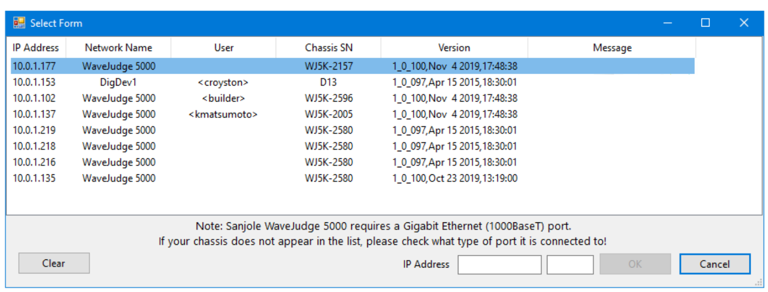
Click the **Rescan RF Connections** button 

at the lower left corner of the window to rescan radio frequency connections.

Connect:

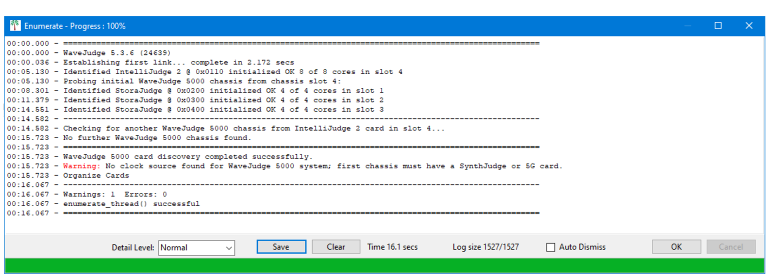
To connect the software to the hardware click the **Connect** button 

at the lower left corner of the window. The Connect button prompts the Select Form to open. Select a chassis or nework by clicking a line item, which will highlight in blue.



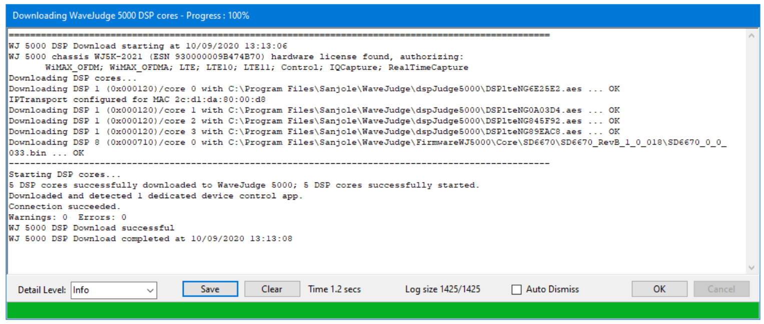
Connect Chassis Window - Select Form

The Enumerate - Progress window opens and the progress bar shows the level of data completion.



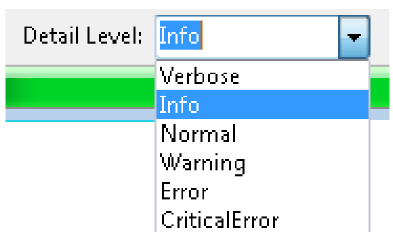
Connect Chassis Window - Enumerate Progress Window

Click the OK button on the right side of the window. A new window will open and show data downloading.



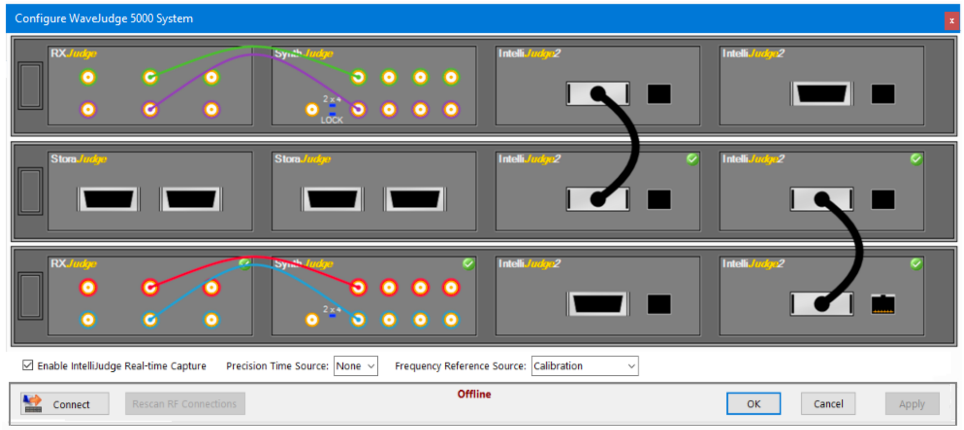
Connect Chassis Window - Downloading DSP Cores

At the bottom left of the Downloading WaveJudge 50000 DSP Cores window there is an option to change the detail level. Click the menu to view the detail level options **Verbose, Info, Normal,Warning, Error,** and **Critical Error**.



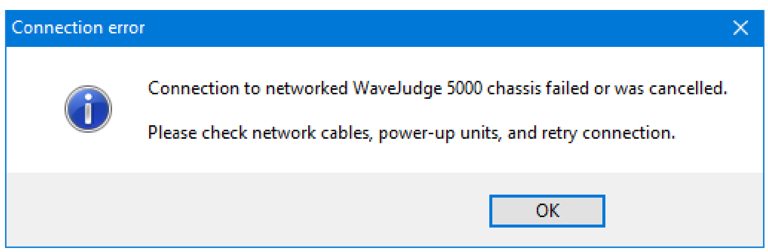
Connect Chassis Window - Detail Level Dropdown Menu

Finally, the Configure Chassis window opens and displays the WaveJudge configuration according to the data in the file. In the example below, the selected file rendered three WaveJudge chassis.



Connect Chassis Window Showing Three WaveJudge Units and Configurations

However, if you click the **Connect** button before your hardware is set up, or if there is any other error in configuration, you may receive an error message. For explanations and actions to fix problems, refer to Error Messages on page 583.



Connect Chassis Window - Connection Error

4. 2 Configure Test Window or Define a New Test

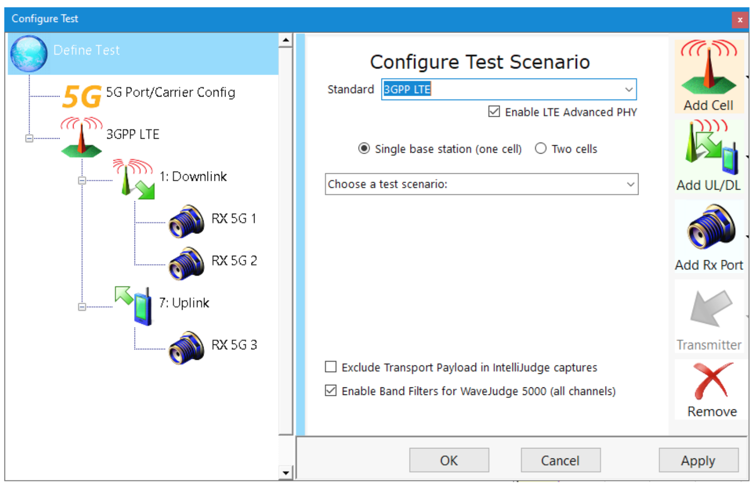
This section describes settings and options in the Configure Test window; this is where you set the parameters to create and test a new scenario. There are two ways to get to the Configure Test window.

1. Click the vertical **Configure Test** button on the left side of WaveJudge interface.
2. From the File menu, select New Test Configuration.

The Configure Test window has two sections: the left side panel which consists of Cells, Port Groups, and Rx ports; and the corresponding right side panels where you configure the specific settings.

Start at the top left Define Test pane and corresponding Configure Test Scenario pane on the right. The data for each panel change according to the type of equipment you use. The figure below shows examples in the Configure Test Scenario Standard menu with 3GPP LTE selected.

IMPORTANT For proper data capture you must set the parameters for all Cells, Downlink/Uplink Port Groups, and Rx Ports.



Define Test: Configure Test Scenario Pane

Standard:

WaveJudge supports 5G NR, 5GTF, LTE standards including MultiFire and WiMAX.

- For WiMAX, you can choose either fixed or mobile standards.
- For mobile WiMAX, several revisions are listed in the combination box. The supported LTE standards are compliant with various versions of TS.36, starting at 8.1.0.
- To select an LTE version, go to the **LTE Settings** in the Configure Cells for LTE on page 139.

Single Base Station or Two Cells:

Choose one base station or two base stations.

- Two-Port Group applications:
  - Separate the uplink and downlink Port Groups to test an uplink signal with different frequency and gain from the downlink signal (e.g., FDD testing in OFDM).
  - To receive MIMO signals create two Rx ports in a Downlink/Uplink Port

Group.

- For HO testing: two base stations with one Port Group per cell: create a Downlink/Uplink Port Group with a Rx port, and another Downlink/Uplink Port Group with a Rx port on a different cell.

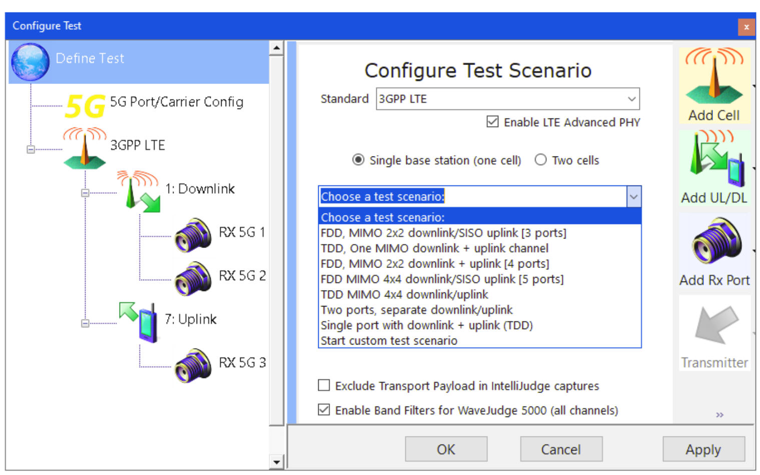
Enable LTE Advanced PHY

PHY settings configure the capture and process parameters of the signal. Settings are applied when the buffer is processing. If the settings are incorrect, or if any of the parameters must change, the buffer must reprocess before the change will take effect.

- Changes to the following parameters require a new capture: Center Freq, Gain Settings, and Bandwidth.

WARNING Make sure the power level of the signal connected to the WaveJudge is under 10 dBm to ensure proper analysis of the signal. Any signal above 17 dBm will severely damage the unit. See also WaveJudge 5000 Modules on page 40.

The Configure Test Scenario pane, located on the right side of the Configure Test window, is where you set the parameters to create and test a scenario. After selecting the Standard and number of base stations you plan to use, the Choose a Test Scenario dropdown box will populate commonly used scenarios accordingly. To create a unique test scenario, click the last option Start a Custom Test Scenario.



Define Test: Configure Test Scenario Pane - Choose a Test Scenario

Predefined Test Scenarios: This dropdown menu populates common scenarios based on the **Standard** and number of base stations you choose. When you select a predefined test scenario, the tree view on the left updates to match your selection.

For directions to configure the uplink and downlink ports see the section Configure Port Groups/Downlinks on page 85.

For directions to configure the Rx ports, see the section Configure Rx Ports on page 86.

Exclude Transport Payload in IntelliJudge Captures:

Normally, this should be left unchecked; it applies only for real-time (IntelliJudge) captures and is only useful in certain scenarios. When capturing signals with very data-intensive traffic, such as live traffic with many UEs, this instructs the WaveJudge to skip sending the contents of the PUSCH and PDSCH messages which contain only end-user data, so that the data link between the PC and the WaveJudge 5000 can keep up more easily and the GUI can keep up with decoding the incoming data as it arrives.

Enable Band Filters for WaveJudge 5000 (all channels):

Has the same effect as checking or unchecking **Enable Band Filter (WaveJudge 5000)** for every downlink and uplink on its **Configure Downlink/Uplink**. On the WaveJudge 5000 RXJudge 40 MHz only, enabling this option will apply a digital filter to the incoming signal during capture, based on the selected protocol and bandwidth. This may improve signal quality when there is an intefering signal on a nearby frequency.

4. 2. 1 Configure Cells for LTE

The Configure Cell pane has parameters related to the type of **Standard** you use. After choosing the **Standard** the cell pane updates and displays parameters for the **Standard** selected.

On the left side select **3GPP LTE** to open the **Configure Cell 1** pane on the right. At the top of this pane notice the **Standard** menu indicates a greyed-out **3GPP LTE**, whateever standard was selected in the previous step remains consistent across all **Configure Test** windows.

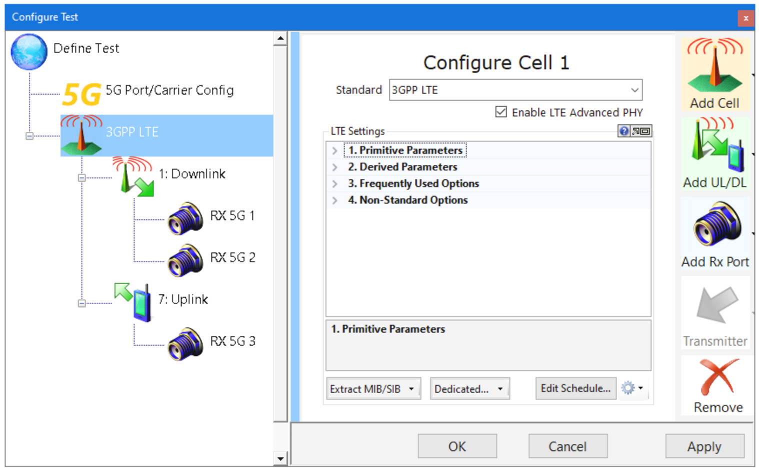
Enable LTE Carrier Aggregation:

Carrier Aggregation configurations require the advanced LTE PHY enabled; check the **Enable LTE Carrier Aggregation** checkbox to enable it.

LTE Settings menu has the following submenus that are explained in the LTE Test Settings appendix.

1. Primitive Parameters on page 707
2. Derived Parameters on page 708

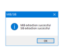
3. Frequently Used Options on page 709
4. Non-Standard Options on page 735



Define Test: Configure Cell 1

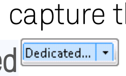
The three buttons and gear icon at the bottom of the window are described below.

Extract MIB/SIB... Click this button to extract MIB/SIB messages, a popup window will confirm which messages are successfully extracted.



Extract Dedicated RRC: Opens a dropdown menu to select the RRC messages from WaveJudge or IntelliJudge.

Select one or the other and a confirmation widnow will appear with the results.

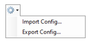
If you have a WaveJudge capture that contains the RRC messages then there’s no need to click the Dedicated  dropdown menu.

However, if you want to take another capture and the UE configurations have not changed, you should select WaveJudge from the Dedicated dropdown menu so the information will be part of the configuration and applied to the new capture.

A second case is when an IntelliJudge capture has the RRC messages but the WaveJudge capture only has data taken after the RRC messages. In this case, click the Dedicated dropdown menu and select from IntelliJudge. Then reprocess the WaveJudge data.

Edit Schedule: Opens the Edit Schedule window; this window is described in the section Edit Schedule Window on page 141 below.

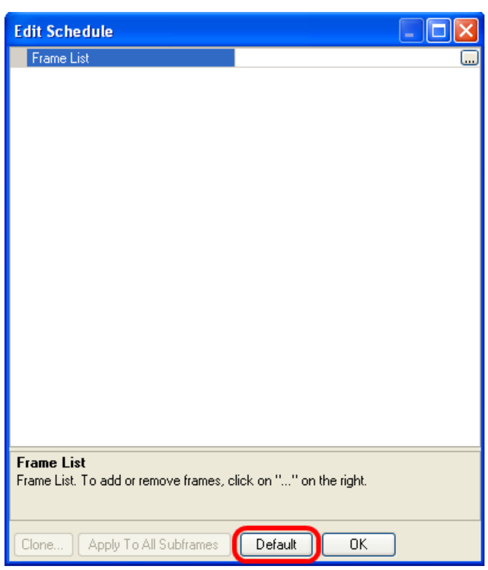
Gear Icon Opens a dropdown menu with an option to import or export cell configuration as text. This function saves fields in the configuration to a text file and lets you load them into another configuration. This is convenient for saving and retrieving UE configured dedicated parameters for use in a new test configuration.



If you select the Extract MIB/SIB... button and the Extract Dedicated RRC button, and the SIB and RRC messages are present in the capture, then it's not necessary to configure these parameters. However, SIB is periodic and it may not start at the beginning of the capture. This will prevent some messages from decoding, like the RACH. It may also prevent the proper uplink, downlink, and special subframe configuration in TDD mode from starting at the beginning of the capture. To avoid this situation click the Extract MIB/SIB... button. If the values are not present at all then the default SIB values are used. In this case, you may need to configure these parameters.

Edit Schedule Window

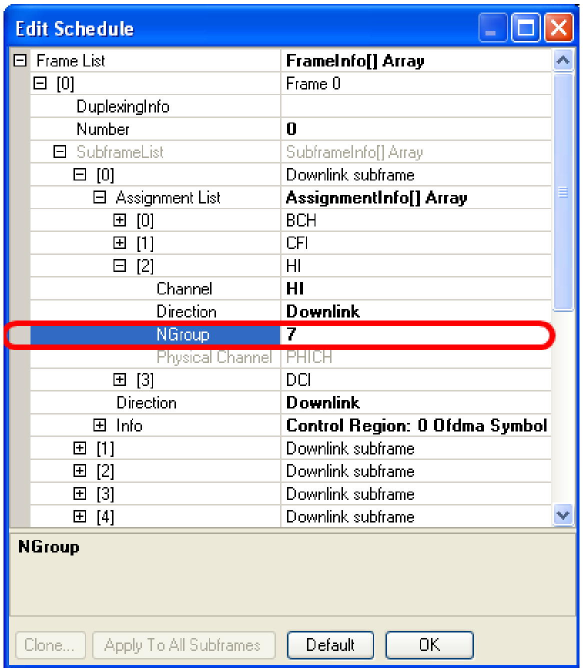
This section explains how to set the schedule for an LTE frame. Click the Edit Schedule... button to open the Edit Schedule window. An empty Edit Schedule window will open. You can manually create your own schedule, or click the edit **Default** button to populate a predefined schedule.



LTE Cell Edit Schedule Window "Default" Button

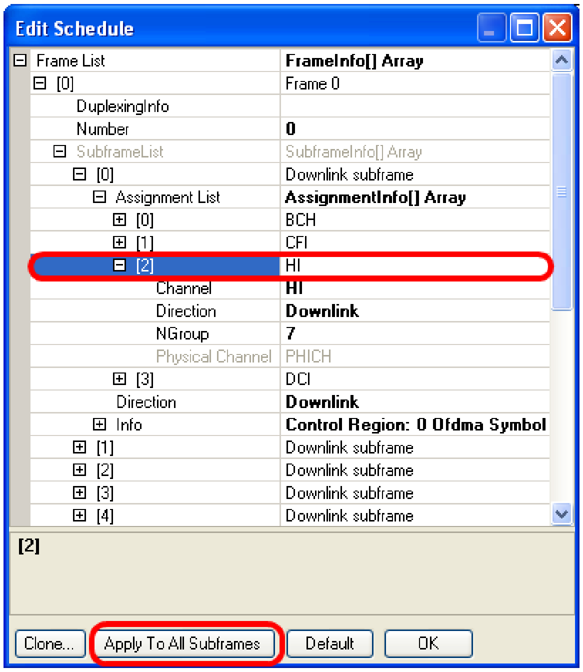
N GroupAssignment

If you select the Default button then you must modify several parameters. The first parameter is the **Assignment HI's NGroup**. Scroll down the list until you get to the HI's NGroup parameter. Set the parameter to your test settings.



LTE Cell Edit Schedule Window - N Group

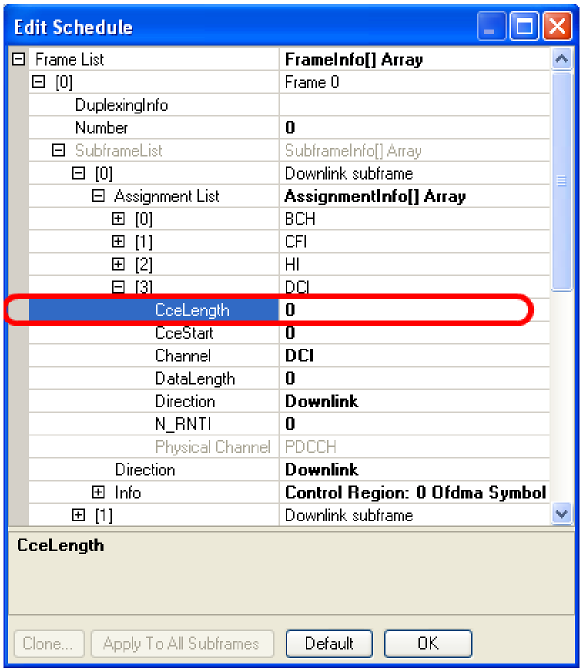
Once you have input the NGroup value, enter the same value for all other subframes in the schedule. To do this automatically click the HI assignment and then click the Apply To All Subframes button. This function assigns the values in the HI assignment to all other HI Assignments in the schedule. You may use the Apply To All Subframes button with any assignment.



LTE Cell Edit Schedule Window "Apply to All Subframes" Button

DCI Assignment/Blind Decoding

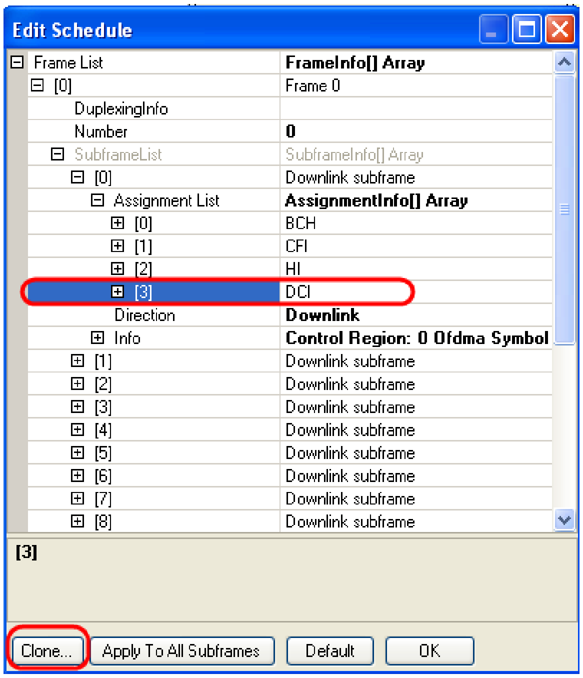
The second parameter to set is the downlink control information's (DCI) Assignment. **The default for the DCI CCE length is 0.** When the DCI CCE length is 0, WaveJudge automatically tries to decode the DCI using blind decoding. If blind decoding is not working well for you, you may manually enter the DCI parameters. Remember to use the Apply To All Subframes button after entering the DCI parameters.



LTE Cell Edit Schedule Window - Blind Coding

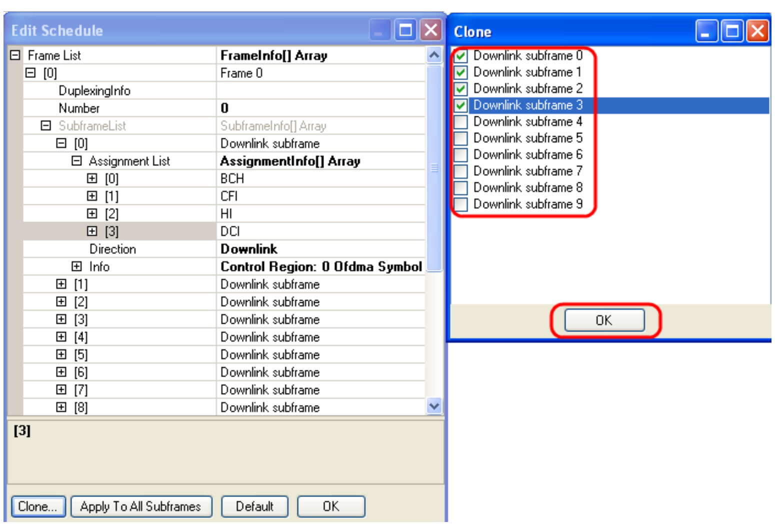
Add or Remove Assignments

The default assignments may not be the configuration you wish to test so you may edit the number and type of assignments for each subframe. There are two ways to add assignments to a subframe. The first way is to clone an assignment. To clone an assignment, click on any assignment in a subframe's assignment list. The Clone... button will enable. Click the Clone... button to open the **Cloning** window.



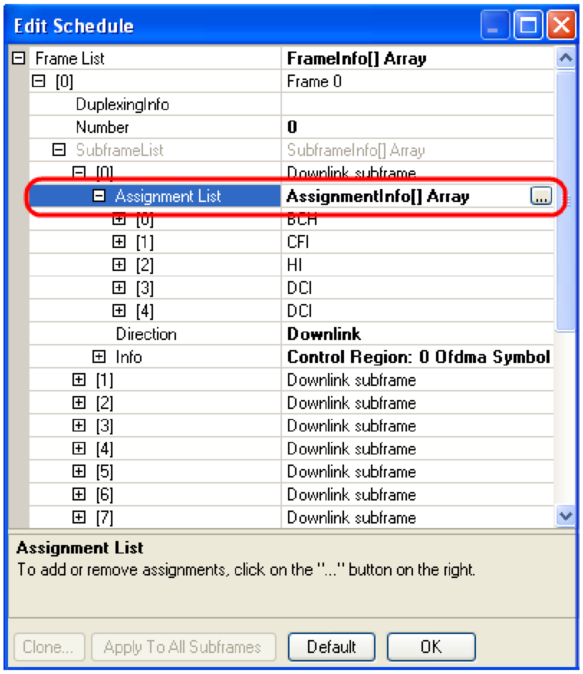
LTE Cell Edit Schedule - Cloning Assignments

The Cloning window has a list of downlink or uplink subframes depending on the assignment you choose to clone. Select the subframes you wish to clone this assignment to and press the **OK** button to clone.



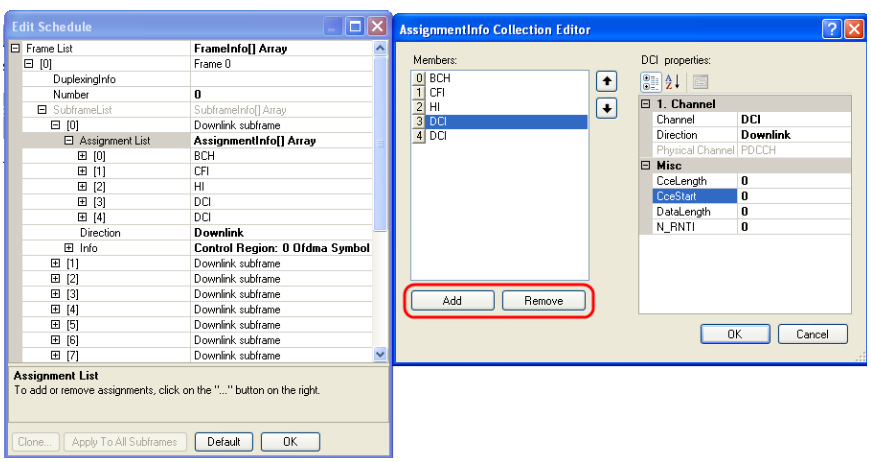
LTE Cell Edit Schedule - Cloning Popup Window

The second way to edit the assignments in a subframe is to select the **Assignment List**. An ellipse icon on the right will appear. Click the icon to open the Assignment Collection window.



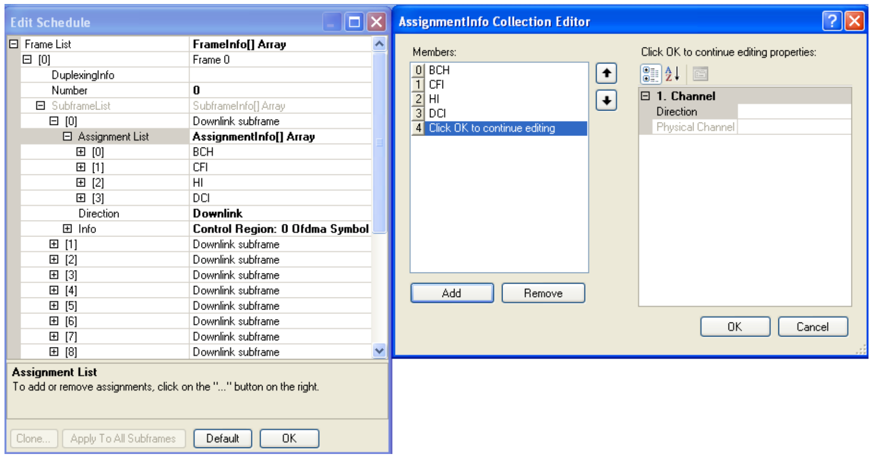
LTE Cell Edit Schedule Window - Edit Assignments

In the **Assignment Collection Editor** window, you may add, remove, or edit any assignment in this subframe. To add an assignment, click the **Add** button.



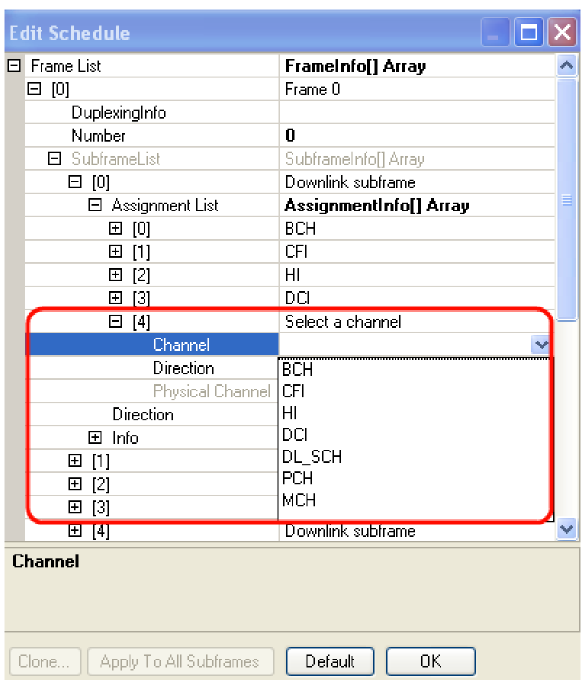
LTE Cell Edit Schedule Window - Edit Assignments Popup Window

After clicking the Add button, a new empty assignment is added to the list of assignments. Click the **OK** button to continue editing the new assignment.



LTE Cell Edit Schedule Window - Edit Assignments: Add Assignment

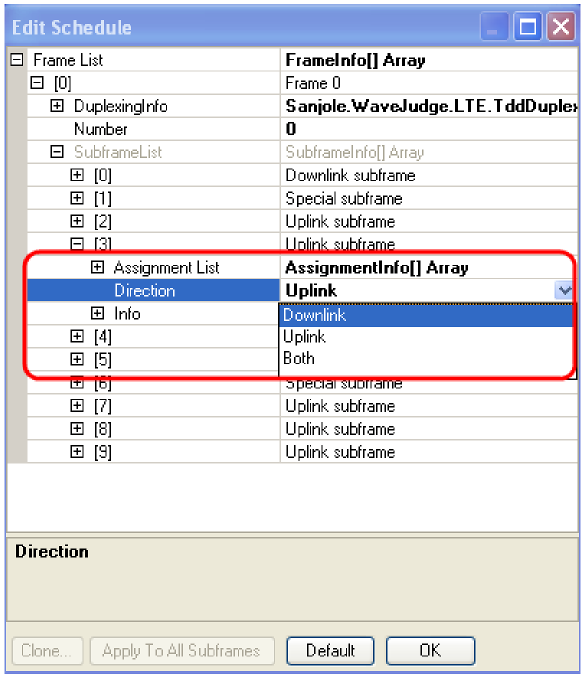
Select the newly created assignment and go to the **Channel** field. Select the type of assignment you wish to add and edit it's parameters.



LTE Cell Edit Schedule Window - Edit Assignments: Add Assignment > Select Channel

Edit Subframe Uplink/Downlink Configuration (for TDD)

For TDD, clicking the **Default** button creates a valid subframe list. Although it is valid, there are many different downlink/uplink subframe configurations. To change the downlink/uplink for a single subframe select a subframe from the subframe list. In the Direction field, you can change the downlink/uplink subframe configuration.

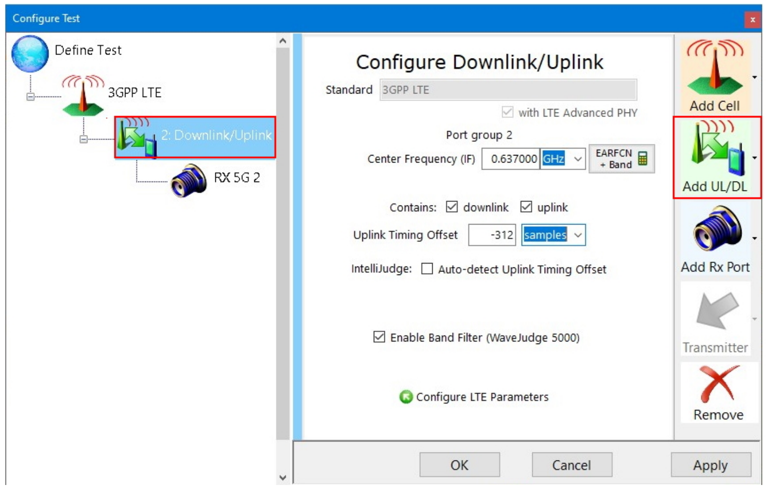


LTE Cell Edit Schedule Window - Subframe Direction

4. 2. 2 Configure Downlink/Uplink Port Groups

The Configure Downlink/Uplink pane contains parameters you can change related to a Port Group. Click on any available Downlink/Uplink Port Group icon in the tree view to select that port group's parameters. You can also choose to add a new downlink/uplink port group on the right side using the Add UL/DL button.

You can use up to four port groups. Port groups allow multiple configurations: Downlink and Uplink, Downlink Only, Uplink Only. You can receive DL and UL on the same port group provided the signal levels of each Rx port associated with the port group are relatively close (20-30 dB); or, the test configuration can separate DL and UL into two independent port groups.

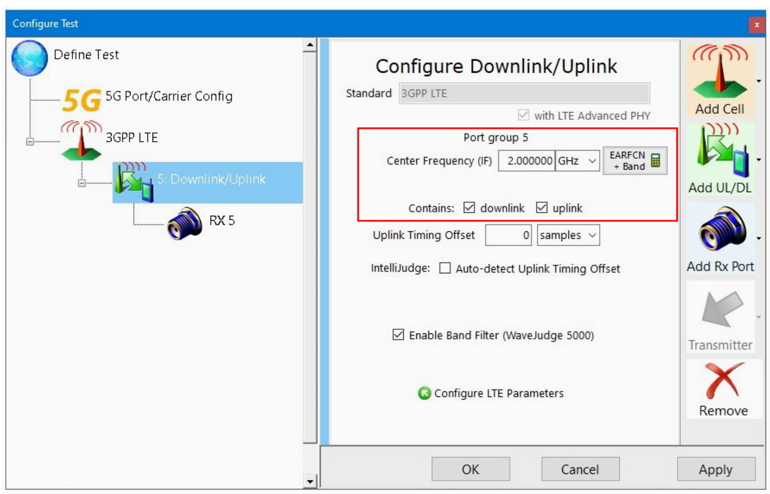


Configure Test Window - Configure Downlink/Uplink

To receive uplink data, set one port group to `Downlink`.

Center Frequency:

For FDD or inter-frequency HO set all Rx ports to different center frequencies.



Configure Downlink/Uplink - Center Frequencies

Contains:

Check a box to set the Port Group to `Downlink` and/or `Uplink`.

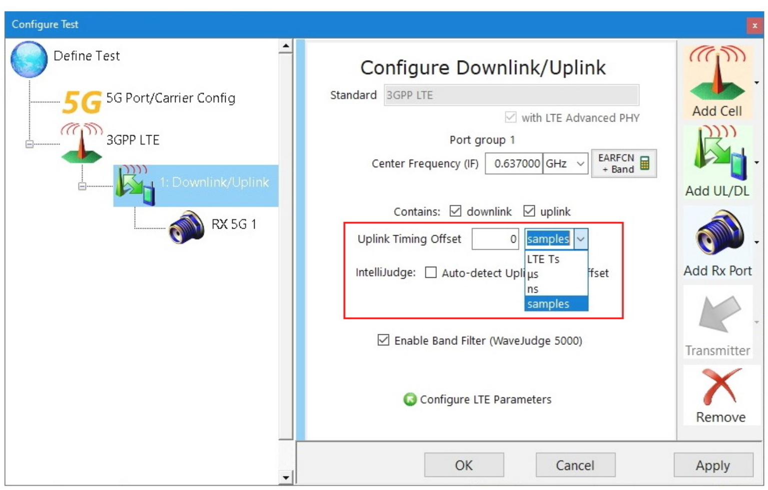
Uplink Timing Offset:

Allows modifications to adjust to a timing offset that is measured from the device under test (DUT). The subscriber station (SS) DUT might have a UL burst that is early or late compared with the base station UL-MAP information. WaveJudge looks at the map information and handles the offset without using this feature providing the offset is within the cyclic prefix length. If the offset is greater than the cyclic prefix length you can use this feature to indicate the severity of the offset.

- If the timing offset is too early, enter a negative number to subtract the amount of time required to match the expected arrival time as dictated by the base station.
- If the timing offset is later than the expected arrival, enter a positive amount to add to the late arrival.

The value is based on the timing delay based on the delay in the UL responses to DL transmissions like the RACH and MAC-RAR. Part of the delay is introduced by the TA value that is transmitted in the MAC-RAR. IntelliJudge uses this understanding to automatically configure the uplink timing offset, but it can only do this if the RACH/MAC-RAR pair is present.

The Uplink Timing Offset indicates the number of samples at baseband rate. For example, if the timing offset in the map chart is 500 samples later than the expected arrival according to the UL-MAP information, enter 500 in the Uplink Timing Offset field to add the required time to the late arrival. Once you enter the timing offset, save the file and click the Reprocess button to reload or reprocess the I/Q samples.



Configure Downlink/Uplink - Uplink Timing Offset

Enable Band Filter (WaveJudge 5000):

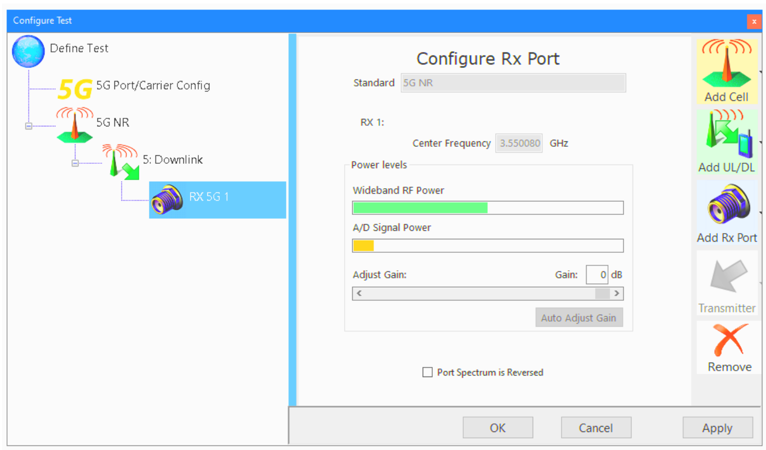
Has the same effect as checking or unchecking "Enable Band Filter (WaveJudge 5000)" for every downlink and uplink on its "Configure Downlink/Uplink". On the WaveJudge 5000 RXJudge 40 MHz only, enabling this option will apply a digital filter to the incoming signal during capture, based on the selected protocol and bandwidth. This may improve signal quality when there is an intefering signal on a nearby frequency.

Configure LTE Parameters:

The Configure Cell Parameters button Configure WiMAX Parameters shown as **Configure LTE Parameters** Configure LTE Parameters , directs you to the cell that contains the selected Port Group. This button quickly accesses the parameters of the cell.

4. 2. 3 Configure Rx Port Settings

The **Configure Rx Port** pane contains parameters related to receive ports. The instructions here are for the Rx Port pane displayed for the WaveJudge 5000.



Configure Test Window - Configure Rx Port

The displays and controls in this pane are described below.

Wideband RF Power:

This graphic visually displays the relative wideband RF power level at the mixer, after attenuation. The bar should always be green; a red bar indicates probable saturation and an orange bar indicates the signal is too weak.

A/D Signal Power:

This graphic visually displays the relative power level of the signal at the Analog/Digital Converte after attenuation. The bar should always be green; a red bar indicates the signal is saturated and an orange bar indicates the signal is too weak.

Adjust Gain:

Adust this control to adjust the gain either using the slider or by directly entering a gain level until both of the above displays are green and the **A/D Signal Power** bar is as far to the right as possible without ever changing to red. Gain adjustments made here enable the internal attenuators in the RF card; it is still critical to keep the external power level from going too high or the card may be damaged.

Port Spectrum is Reversed:

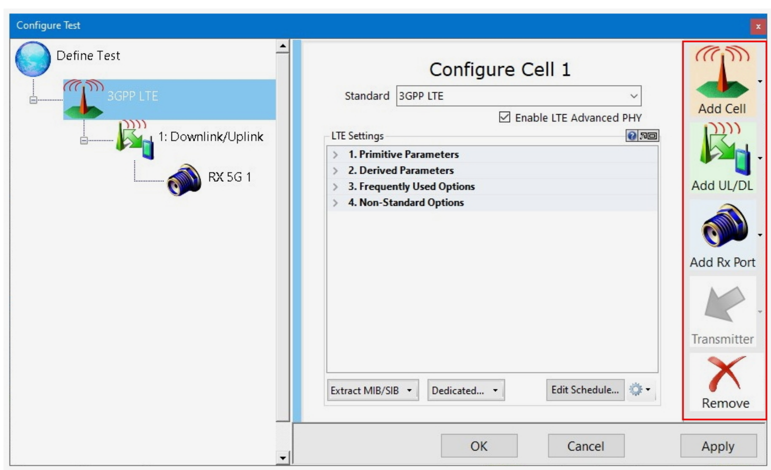
Select this checkbox ☑ Port Spectrum is Reversed only if the Rx port has an inverted spectrum, which means that each subcarrier is mapped to its symmetrical subcarrier with respect to the center frequency. In a Time Domain chart this inversion translates into swapping the real and imaginary parts of the signal, typically called I and Q.

IMPORTANT

Normally it is never necessary to use the Port Spectrum is Reversed feature and it should not be checked. In rare cases, it may be useful for RF developers performing cabled tests on hardware in early prototype stages, where it is possible for the I and Q signals to be unintentionally swapped.

Add/Remove Cells, Downlink/Uplink Port Groups, Rx Ports, and Transmitters

This section provides instructions to add or remove Cells, Downlink/Uplink Port Groups, Rx Ports, and Transmitters. You can perform each of the actions by pressing a button in the Configure Test Window or Define a New Test on page 136 as indicated in the figure below.



Configure Test Window - Configure Test Buttons

TIP

You can drag and drop existing Downlink/Uplink Port Groups into other cells. All associated Rx ports will move as well.

TIP

You can also drag and drop existing Rx ports into other Downlink/Uplink Port Groups.

You can drag and drop existing transmitters into other cells; all parameters of the Downlink/Uplink Port Group, Rx Port, and transmitters remain unchanged.

If you drag a Downlink or Downlink/Uplink Port Group to a different cell, the Downlink or Downlink/Uplink Port Group will become the new cell's Downlink Port Group. Also, the first Port Group, if any, from the old cell will become the new Downlink Port Group for that cell.

Add a Cell:

1. Click the Add Cell button on the right side of the **Configure Test** window.
2. A window will open, select a type of cell to add.
3. A Downlink Port Group and a Rx Port (if available) are associated with the newly created cell.
4. You may add up to two cells into your configuration.

Remove a Cell:

1. Select the cell you wish to remove.
2. Click the Remove button.
3. The **Remove** button removes all associated Downlink/Uplink Port Groups and Rx ports.

Add a Downlink/Uplink Port Group:

1. Select the cell you wish to associate the Downlink/Uplink Port Group with.
2. Click the Add UL/DL button on the right side of the **Configure Test** window.
3. A window will open allowing you to select a Downlink, Uplink, or Downlink/Uplink Port Group. Select the type of Port Group you wish to add.
4. A Rx port (if available) will accompany the newly created Port Group.
5. You may add up to four Downlink/Uplink Port Groups into your configuration.

Remove a Downlink/Uplink Port Group:

1. Select the Downlink/Uplink Port Group you wish to remove.
2. Click on the Remove button. button.
3. All associated Rx ports will also be removed.

Add a Rx Port:

1. Select the Downlink/Uplink Port Group you wish to associate the Rx Port with.
2. Click the Add Rx Port button  on the right side of the **Configure Test** window.
3. A window will pop up allowing you to select an available Rx Port. Select any available Rx Port.
4. You may add up to four Rx Ports in your configuration.

Remove a Rx Port:

1. Select the Rx Port you wish to remove.
2. Click the Remove  button.

4. 3 WiFi - Manually Configure Test Settings

WaveJudge also features the ability to create configurations for WiFi capture and analysis, either with WiFi alone or together with LTE capture data. Many of the WiFi charts are similar to WaveJudge's LTE charts, and many are the same as LTE or WiMAX charts.

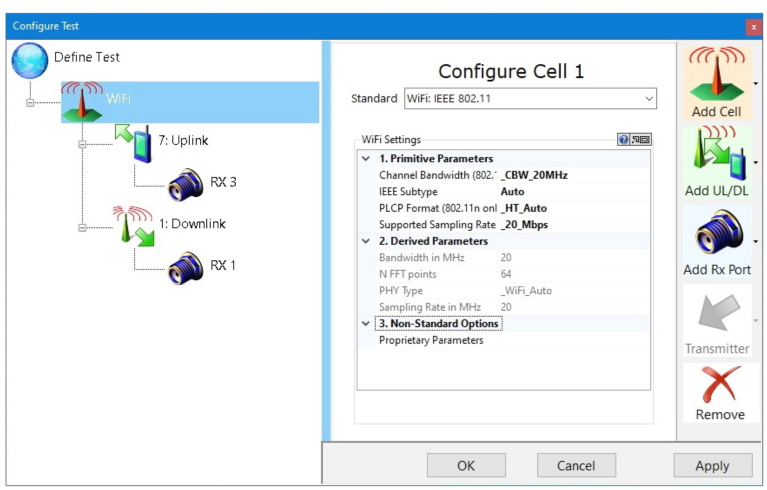
There are two ways to select and configure WiFi settings: open an existing WiFi capture file or set them manually. The easier way is to open an existing WiFi capture file; this automatically sets the Configure Test window parameters to the previously used WiFi settings.

Perform the following steps to manually configure the WiFi test settings.

1. Open the Configure Test window (click the Configure Test button located on the left side vertical button strip). On the Configure Test Scenario pane (right side) set the Standard to **WiFi**.
2. In the Define Test pane (left side) click on WiFi to open the Configure Cell pane (right side).

TIP

Notice the two icons at the top right corner of the WiFi Settings panel. The blue circle with the question mark opens the inline Help Menu that provides information about the parameter in the section near the bottom of the window. The arrow wth the rectangle opens the WiFi Settings panel in a floating popup window.

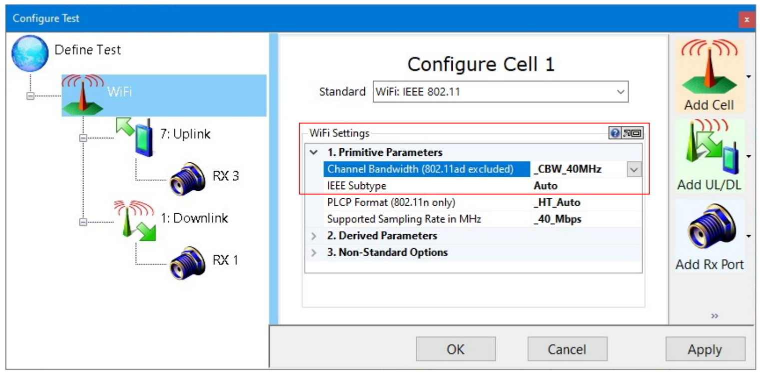


Select WiFi from the Standard Menu

3. In the WiFi Settings panel , under 1. Primitive Parameters, change the Channel

Bandwidth to CPW-40MHz.

4. In the WiFi Settings panel , under 1. Primitive Parameters, change the IEEE Subtype to Auto.



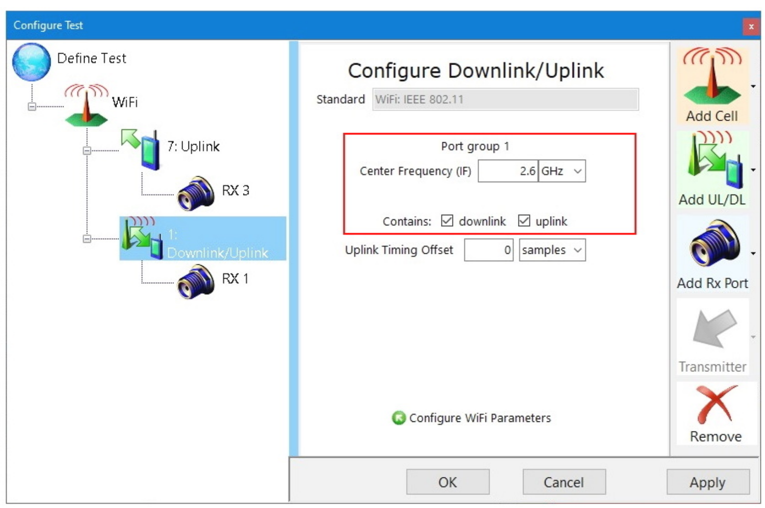
WiFi - Change the Primitive Parameters

5. In the Define Test pane, click on Downlink/Uplink to open the Configure Downlink/Uplink pane (right side).

   A. Change the Center Frequency to 2.6 GHz.

   B. Check both boxes for downlink and uplink.

   C. Click the Apply button to accept changes. That's it, you are ready to capture WiFi.



WiFi - Change the Center Ferquency to 2.6 Ghz, Select Uplink and Downlink Boxes

Although it is not necessary to change any other settings in Configure Cell pane to start obtaining a WiFi capture there are in addition to the few briefly indicated above, other options are available that are described below.

WiFi Settings: 1. Primitive Parameters

Channel Bandwidth (802.11 ad excluded): Options are 20 MHz, 40 MHz, 80 MHz, or 160 MHz.

IEEE Subtype: Standards are Invalid, Auto (a/n/ac), IEEE 802.11a, 802.11n, 802.22ac, or 802.11ad.

PLCP Format: Physical Layer Convergence Procedure; options are HT Auto, NA, HT Mixed, HT Greenfield, and HT Auto.

Supported Sampling Rate: Options are 20 Mbps, 22.5 Mbps, 40 Mbps, 45 Mbps, 80 Mbps, 160 Mbps, 11 Mbps, 1760 Mbps DMG SC Chip Rate, and 2640 Mbps DMG OFDM Rate.

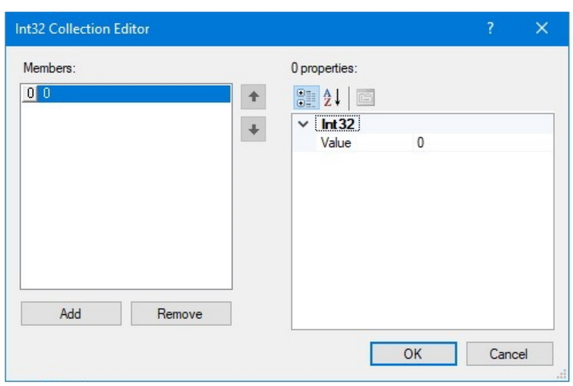
WiFi Settings: 2. Derived Parameters

This section does not have any dropdown menus; simply type in the value for each parameter; i.e., Bandwidth in MHz, N FFT points, PHY Type, and Sampling Rate in MHz.

WiFi Settings: 3. Non-Standard Options

Proprietary Parameters:

Select this item and click the ellipse button to the right, this opens the Int32 Collection Editor window.

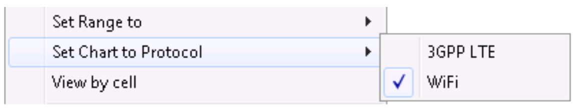


WiFi - Int32 Collection Editor Window

4. 4 Combined LTE and WiFi

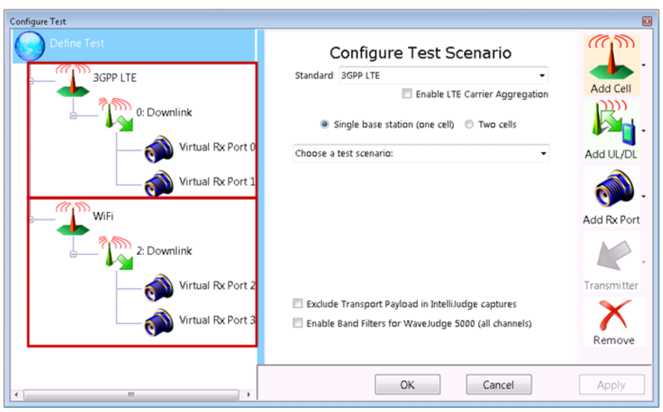
The Chart Context Menu for WiFi is the same as the LTE Chart Context Menu except the option Set Chart to Protocol shows WiFi rather than 3GPP-LTE.

- When you have a combined LTE and WiFi file open the Set Chart to Protocol menu item will show LTE and WiFi options
- If you have only an LTE file open, then it will only show LTE. By selecting one option you can easily set all charts to LTE or set all charts to WiFi.



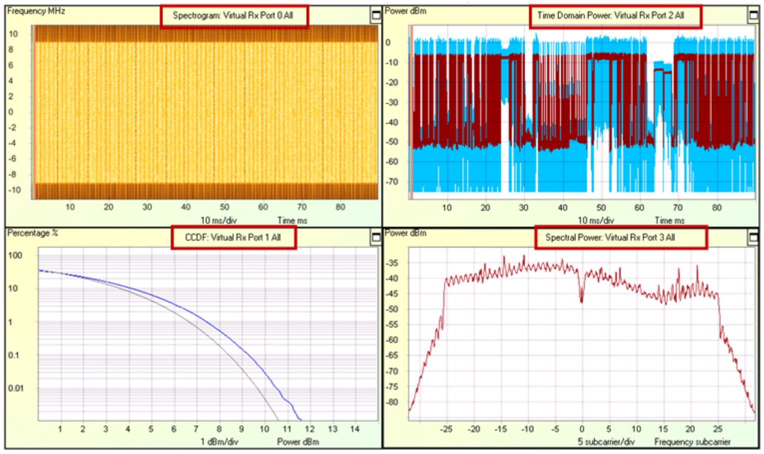
WiFi - Chart Context Menu: Set Chart to Protocol

When you are using a combined LTE and WiFi capture file it's easy to confuse which chart is which. To confirm which cell is LTE and which one is WiFi, open the Configure Test window. In the example below, Cell 0 is LTE and Cell 2 is WiFi.



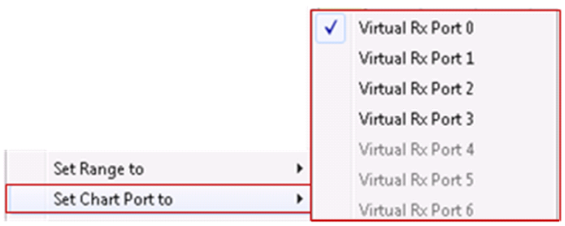
WiFi - Configure Test Window Shows Which Cells are WiFi vs LTE

When you are reviewing charts and analyzing capture data in WaveJudge, keep in mind that you may be looking at data for the WiFi port rather than the LTE one, or vice-versa. As an example the Time-Frequency View (below) shows fours charts that are assigned to different ports: the Spectogram shows data for Port 0, the CCDF chart shows data for Port 1, the Time Domain Power chart shows data for Port 2, and the Spectral Power chart shows data for Port 3.



WiFi - Time Frequency View with Four Port Views

If you select a View (for more information, refer to Result Views on page 435). The chart sets will automatically set to the same port; for example, they will all set to Port 0. To set an individual chart to a different port, right-click the chart to access the Chart Context Menu, scroll down to the option Set Chart Port To and select an active port from the submenu.



WiFi - Set Chart Port Submenu

NOTE	If you are working offline with a saved capture file, the ports are labeled “Virtual Rx Port”, beginning with Port 0, to match the way the ports are labeled in the Configure Test window. When connected to a WaveJudge chassis and working with a live capture, the ports are labeled to match the physical input they represent on the type of WaveJudge chassis in use.

4.5 WiFi Charts

This section introduces the charts available for WiFi. WiFi charts are subsets of LTE charts, therefore they function and look exactly the same as LTE charts. Each WiFi chart listed below is linked to the LTE chart for a description of it and it's Chart Properties Window.

NOTE If you are working with a combined LTE and WiFi file then the LTE charts are the default and you will see the longer LTE list of available charts.

WiFi Time Domain Charts

- Time Domain Power on page 365
- EVM Per Symbol on page 366
- Baseband IQ Input on page 366
- Impulse Response on page 367

WiFi Frequency Domain Charts

- EVM Per Subcarrier on page 374
- Spectral Power on page 375
- MIMO Channel Per Subcarrier on page 376

WiFi Constellation Chart

- Constellation Diagram on page 380

WiFi Time Frequency Charts

- 2D Power Chart for 5G on page 381
- Spectrogram on page 387

WiFi Lists and Decodes

- WaveJudge Messages List on page 240
- Channel Decoding Chart on page 393

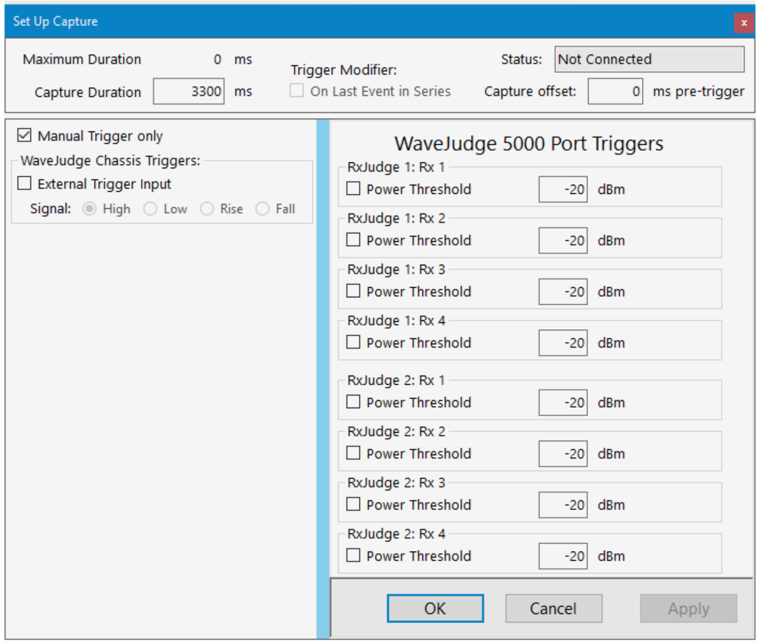
WiFi Measurements

- CCDF on page 394

4.6 Set Up Capture Window

The Set Up Capture window is where you define the triggers to initiate a capture as well as the length or duration of the capture. To access this window click the Set Up Capture 

button located on the vertical button strip to the left.



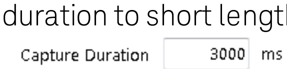
Configure Test Window - Set Up Capture Pane

The maximum duration of a capture is dependent on the bandwidth, sampling rate settings, and WaveJudge model. The range may be anywhere from 3 to 190 seconds on all Rx ports. Detailed tables list the mapping between protocol, bandwidth, and maximum capture durations identified in Configure Downlink/Uplink Port Groups on page 148. The upper limit of eNodeBs, gNodeBs, or Base Stations to capture is one per cell; for MSs, it is unlimited.

Maximum Duration:

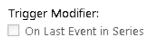
The maximum duration of a capture varies according to the type of WaveJudge chassis which is connected, and according to the cell Configure Cells on page 77, as configured on the Configure Cells on page 77. If hardware is not then connected, a value of 0 is displayed. 

Capture Duration:

Defines the length of the capture once a trigger condition exists. Enter a value from 1 ms to the **Maximum Duration**. The maximum duration will reset if input exceeds the maximum. When in **Repeat Capture** mode (e.g., setting up gain parameters) it is useful to set the duration to short lengths to minimize the processing time between iterations. 

Pre-Trigger Position:

Defines how data is captured immediately in front of and in back of a trigger event. This entry positions the trigger with respect to the captured data and is related to the duration set for the capture. Typical settings allow the trigger to occur at the beginning, middle, or end of the data capture. For example, if the duration of the capture is set to 20 ms, a trigger position of 0 ms would capture traffic for 20 ms after the trigger (beginning). A trigger position of 10 ms would cause a capture of data 10 ms prior to the trigger, and 10 ms after the trigger occurred (middle). A trigger position of 20 ms would cause a capture of data 20 ms prior to the trigger occurring (end). You can also set the trigger to a negative number to delay the start of the capture. If the trigger position is set to -10 ms, the capture will occur 10 ms after the trigger.

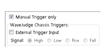


Trigger Status:

Indicates if the trigger is armed or has occurred. Trigger states are: Waiting for Trigger, Capturing, and Capture Done.

Trigger Condition:

Defines the methods available to trigger a capture; provides information relative to the incoming signal levels: manual and external.



- Manual:

  Trigger occurs as soon as capture is armed: capture begins as soon as you press the **Single Capture** button. For **Repeat Capture**, after the previous capture ends, a new capture begins without any other event occurring.

- External:

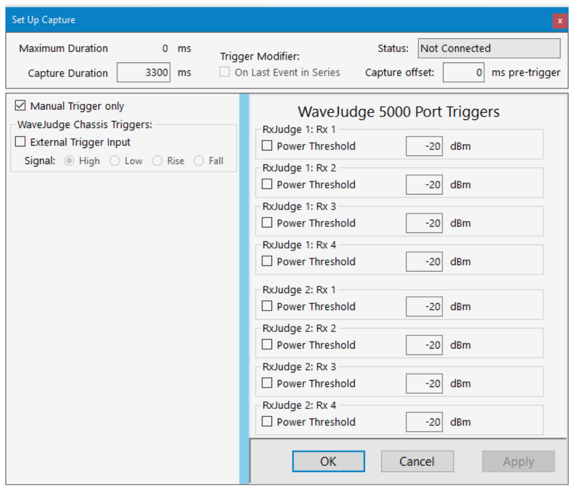
  Different chassis and modules differ in the way the external trigger connectors are labeled.

  a. Enable the trigger input by selecting the External Trigger Input checkbox on the Capture Setup window.
  b. Select the radio button for the state of the external signal on which to trigger. The options are: High (signal between 1.7V and 3.3V), Low (signal between 0V and 0.7V), Rise (rising edge of signal), and Fall (falling edge of signal).
  c. To arm the external trigger for capture, press the **Capture** button on the toolbar. While armed WaveJudge will force a capture any time a signal with the state specified by the radio button is present on the trigger input. See WaveJudge 5000 Modules on page 40 for the external signal level expected in the trigger input jack.

NOTE WaveJudge hardware must be connected for the software to enable the Capture buttons on the toolbar.

Rx Port 0 - 3 Power Threshold:

Allows WaveJudge to trigger a capture based on the detected power level or amplitude of the signal. If the signal is equal to or greater than the entered threshold it will trigger a capture. If more than one Rx port is enabled for a power-level detection trigger the Rx port will trigger a capture if the port meets or exceeds any thresholds.



Set Up Capture Window - Port Triggers Panel

- Threshold:

  Enter the power level the signal must reach to trigger a capture. If a power threshold is enabled for any Rx Port and the signal meets or exceeds this value, a capture will occur.

- Current:

  The instantaneous power level of the signal for each Rx Port.

- Maximum:

  Maximum power level measured since the last time the Reset Maximum button was pressed. This value aids in setting the power threshold. For example, to trigger a capture on a UL message (such as RNG-REQ) first reset the maximum value and then observe the maximum value measured. Once the maximum value is observed set the threshold above this value to ensure that the UL message triggers a capture.

- Reset Maximum:

  Clears the Maximum field and resets the power level to the current signal power on the Rx port. Use this function to set the Maximum value if capture must be triggered on a higher power threshold.

4.7 LTE - Configure a Test Scenario

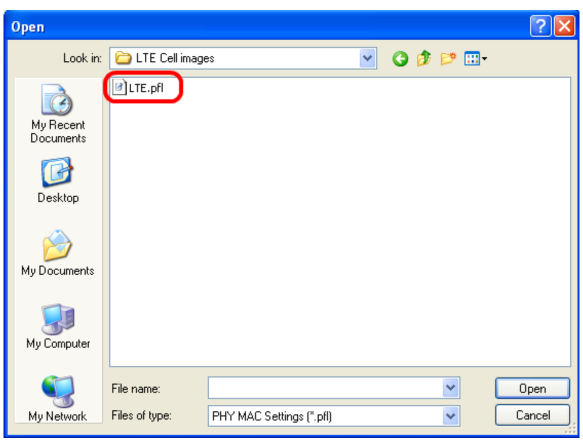
The approach to configure WaveJudge is based on test scenarios that appear on the configuration screens. This interface is intended to be easy for novice and experienced users. It allows you to readily configure test setups for up to 24 ports using a WaveJudge 5000 system or eight ports using two WaveJudge 4900s, and create test setups using more than one cell (multiple base stations).

4.7.1 Load from a Capture File

If you have already run tests with WaveJudge with the configuration you want to use you can simply load the configuration from one of your saved capture files. Configuration files from previous versions are backwards compatible.

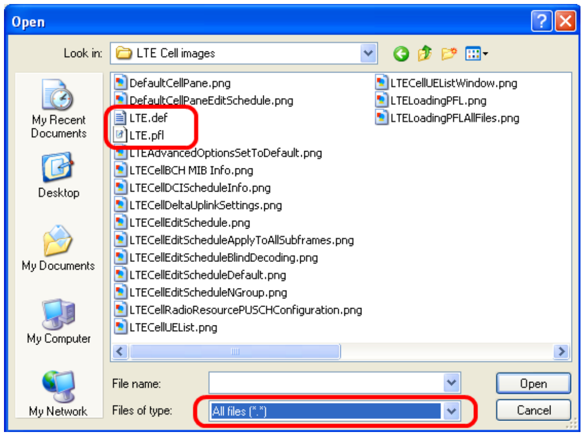
1. Load the capture file previously taken using the desired configuration.
2. Click the **Configure Test** button to open the Configure Test Window or Define a New Test on page 136. The configuration window will open and allow you to view and edit the configuration.
3. Click OK or Apply in the Configure Test Window or Define a New Test on page 136 to accept the configuration.

When loading a LTE configuration file, a .def file is also loaded. The .def file contains the frame schedule configuration, without it you will not be able to properly decode a capture. When you save a configuration you essentuailly create a .pfl and a .def file.



*LTE Load a *.PFL Capture File*

When you load a configuration file WaveJudge automatically loads the .def file corresponding to the .pfl file. This is important because if you move the .pfl file to another location you must also move the .def file.

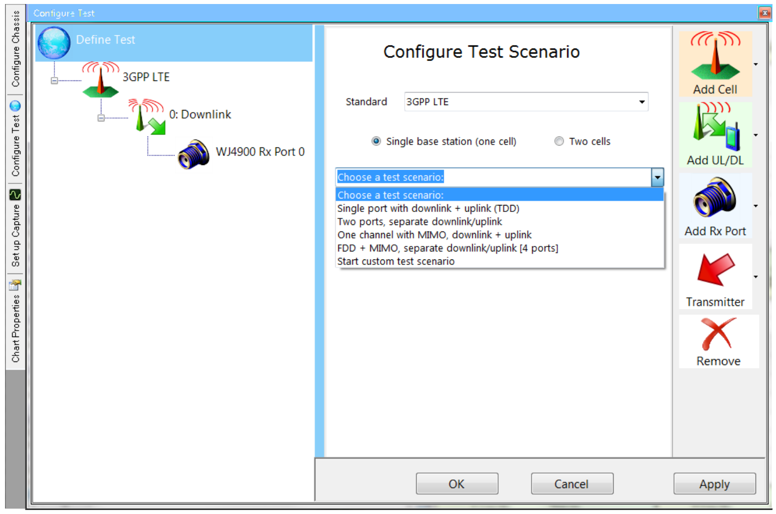


*LTE - Load All *.DEF and *.PFL Files*

4. 7. 2 Create a New LTE Test Configuration from a Predefined Scenario

WaveJudge includes a number of predefined scenarios for the most likely configurations. You can configure test scenarios involving TDD, FDD, MIMO, and more than one cell by choosing it from the Define Test pane in the Configure Test Window or Define a New Test on page 136, shown below.

1. Click the New icon on the toolbar, or select FileNew Test Configuration from the File menu. The configuration window will open showing an empty configuration with the Define a Test Scenario on page 72 pane visible.
2. On the Configure Test Window or Define a New Test on page 136 pane, select the Standard you want to test and then choose whether you want to analyze data from a single cell (one base station) or two cells (two base stations).
3. The list of scenarios automatically adjusts to the combination of Standard and the number of cells you chose. Select a test scenario from the dropdown list.



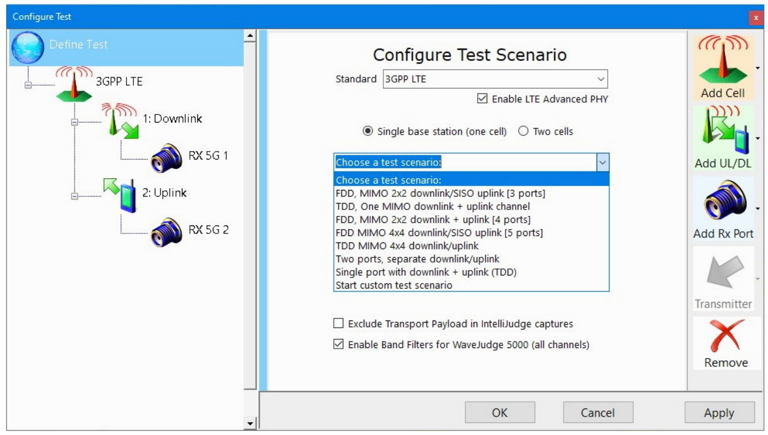
LTE - Configure Test Scenario Window

4. The selected scenario will appear in the tree view, and the Configure Cell page for the first cell is highlighted. Adjust the cell parameters to match your test configuration.
5. When you are done, click OK or Apply in the Configure Test Window or Define a New Test on page 136 to accept the configuration.

4. 7. 3 Create a New Custom Test Configuration

You are not limited to the predefined test scenarios; if you prefer you can create an entirely new test configuration.

1. Click the New icon on the toolbar, or select New Test from the File menu. The configuration window will open showing an empty configuration with the LTE - Configure a Test Scenario on page 167 window.



LTE - Configure Test Scenario Window

2. Click the icon Add Cell to the right of the window, add a cell with the Standard you want to test. When the Configure Cell pane for that cell is selected you may begin adjusting the cell parameters to match your test configuration.
3. WaveJudge will automatically add a Downlink Port Group under the cell, and a Rx port under the Downlink Port Group.
4. Use the buttons on the right to add more Cells, Port Groups, Rx Ports, or Transmitters as needed. You can drag Port Groups, Rx Ports, and Transmitters within the tree while editing.
5. Adjust the parameters for the Configure Cells on page 77, Configure Port Groups/Downlinks on page 85, and Configure Rx Ports on page 86 to match your test configuration.

NOTE For more information on adding or removing Cells, Port Groups, Rx Ports, or Transmitters; refer to the Add/Remove Cells, Downlink/Uplink Port Groups, Rx Ports, and Transmitters on page 152 section.

6. When you are done, click OK or Apply in the Configure Test Window or Define a New Test on page 136 to accept the configuration.

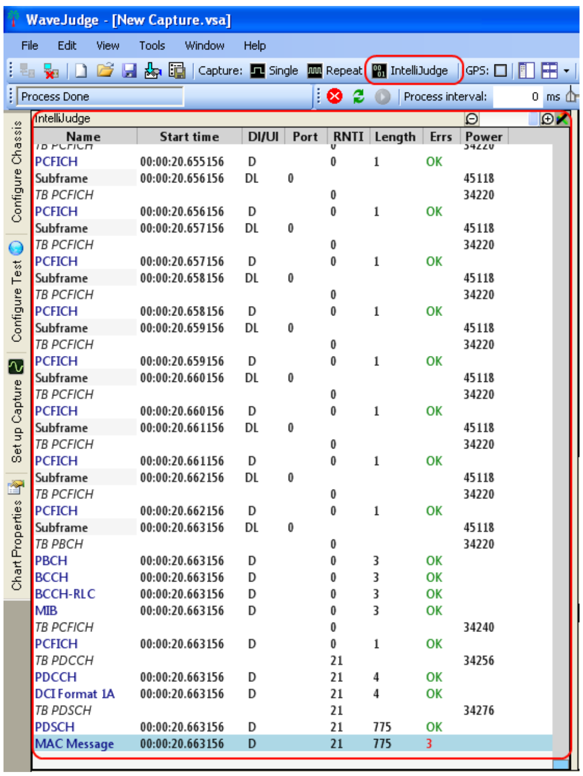
4.8 LTE - Create an IntelliJudge Triggered Capture

After connecting to the WaveJudge chassis to the IntelliJudge hardware, taking an IntelliJudge Triggered Capture requires the following three steps.

1. Set up the configurations for your capture. You can either Configure a Test Scenario on page 72 or use the Configure Test Window or Define a New Test on page 136 window to set up a configuration.

2. Set up the Capture Duration and Capture Offset of the triggered capture. You can set this in the Set Up Capture Window on page 162 window.
3. Set up the IntelliJudge Triggers. Click the Tools menu and then select the IntelliJudge Triggers menu item. Set the triggers the same way you set filters. (Go to Filtered Messages on page 495.)

For more information on the results of an IntelliJudge Triggered Capture, refer to the LTE - Create an IntelliJudge Triggered Capture on page 170 section.



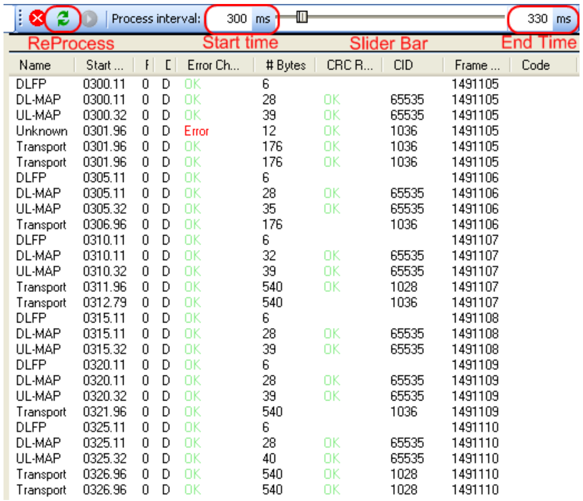
IntelliJudge Capture

4.9 Process Data

This section descibes how to process specific time intervals from data within a capture.

4.9.1 Interval Analysis

WaveJudge lets you select an interval to process data, this feature lets you choose the time interval of the capture to process. In long captures (such as a 24 second capture), this is very useful and convenient. To use this feature enter the start time and end time in the process interval toobar. The start time must be greater than 0 and less than the end time. The end time must be less than or equal to the number of microseconds (ms) of captured data. Alternatively, you can move the slider bar to the appropriate time interval. After selecting the interval, click the **ReProcess** button > .



Name	Start ...	F	D	Error Ch...	# Bytes	CRC R...	CID	Frame ...	Code
DLFP	0300.11	0	D	OK	6			1491105	
DL-MAP	0300.11	0	D	OK	28	OK	65535	1491105	
UL-MAP	0300.32	0	D	OK	39	OK	65535	1491105	
Unknown	0301.96	0	D	Error	12	OK	1036	1491105	
Transport	0301.96	0	D	OK	176	OK	1036	1491105	
Transport	0301.96	0	D	OK	176	OK	1036	1491105	
DLFP	0305.11	0	D	OK	6			1491106	
DL-MAP	0305.11	0	D	OK	28	OK	65535	1491106	
UL-MAP	0305.32	0	D	OK	35	OK	65535	1491106	
Transport	0306.96	0	D	OK	176		1036	1491106	
DLFP	0310.11	0	D	OK	6			1491107	
DL-MAP	0310.11	0	D	OK	32	OK	65535	1491107	
UL-MAP	0310.32	0	D	OK	39	OK	65535	1491107	
Transport	0311.96	0	D	OK	540	OK	1028	1491107	
Transport	0312.79	0	D	OK	540		1036	1491107	
DLFP	0315.11	0	D	OK	6			1491108	
DL-MAP	0315.11	0	D	OK	28	OK	65535	1491108	
UL-MAP	0315.32	0	D	OK	39	OK	65535	1491108	
DLFP	0320.11	0	D	OK	6			1491109	
DL-MAP	0320.11	0	D	OK	28	OK	65535	1491109	
UL-MAP	0320.32	0	D	OK	39	OK	65535	1491109	
Transport	0321.96	0	D	OK	540		1036	1491109	
DLFP	0325.11	0	D	OK	6			1491110	
DL-MAP	0325.11	0	D	OK	28	OK	65535	1491110	
UL-MAP	0325.32	0	D	OK	40	OK	65535	1491110	
Transport	0326.96	0	D	OK	540	OK	1028	1491110	
Transport	0326.96	0	D	OK	540	OK	1028	1491110	

Process Interval - Long Capture

4. 9. 2 Save and Load Capture Files :Load Capture File" />

Once a capture is complete you may save it for future reference using the Save option on the File menu (CtrlS) or by pressing the Save icon on the toolbar .

To save this file under a different filename, select FileSave Capture As.

If you do not wish to save the entire capture you can save the currently selected portion of the capture to a file using the Save Selection As item from the File menu. WaveJudge capture files have the extension .vsa and are associated with the WaveJudge software.

In addition to saving the capture data, the current configuration settings (e.g., Configure Test Window or Define a New Test on page 136, Set Up Capture Window on page 162) also save to the .vsa file.

IMPORTANT When saving capture data the **current** configuration settings are saved to the file, which may differ from the settings in effect when the data were captured. Save your capture data before altering configuration settings to avoid later confusion.

To examine a previously saved capture, load the .vsa file using the FileOpen... item on the File menu (CtrlO) or click the Open icon on the toolbar. This action loads the previously saved capture data with the configuration settings that were in effect when the file was saved.

4.9.3 Save and Load Test Configurations :Save and Load" />

The following sections desribe how to save and load test configurations.

Save a Test Configuration

Once you have created a test configuration with any of the above methods, you can save the WaveJudge test configuration settings, such as those set by Configure Test Window or Define a New Test on page 136 settings or the Set Up Capture Window on page 162 window, as an independent settings file. Perform the steps below to save the settings.

1. Click the Save Settings icon in the tool bar, or select FileSave Test Configuration ... from the main menu.
2. You will always receive a prompt to create a file name. Name the configuration file.
3. Click Save to save it.

WaveJudge settings files have the extension .pfl. If there is a protocol definition that must be saved with the file, such as the LTE settings, then WaveJudge will automatically create and save it in a matching file with the extension .def.

Load a Test Configuration

To use a .pfl file containing previously saved settings, load the file using the FileOpen... item from the File menu and look for the file with that format, or press the Open Test Configuration button on the toolbar. If there is a another file with the same prefix and the extension .def in the same directory it will automatically open with it and load any protocol-specific definitions.

NOTE **Loading a .vsa file after loading a configuration settings file will override the settings specified by the .pfl file.**

4.10 Importing and Exporting RF Data :Export RF" />

WaveJudge lets you import or export I/Q samples in ASCII format via two columns: one for I and one for Q. WaveJudge can also analyze I/Q data captured by other devices. You may also use I/Q data captured by WaveJudge with other analysis tools.

4. 10. 1 Import RF Signals as I/Q Data Values

To access and read text files, import I/Q data by selecting FileImportI/Q Samples from text file.... Format the text file in two columns of integer numbers representing I and Q samples at baseband and base sampling rates. You can separate the columns by tabs or spaces; the integer numbers are 16-bit signed integers between -32768 and +32767. Alternatively, the two columns can represent double precision floating point numbers without any range restriction.

There are three rules to import I/Q data.

1. **There is one I/Q pair for each port.** If there are four ports then you will have eight columns of I/Q data; if there are eight ports then you will have 16 columns of I/Q data, and so on. If you use multiple ports, format the text file using four columns for two ports, six columns for three ports, and eight columns for four ports. The first two columns represent I and Q for port 0, the next two columns represent I and Q for port 1, etc. Ensure that all port and UL/DL configuration settings are correct before you import a file.

   NOTE

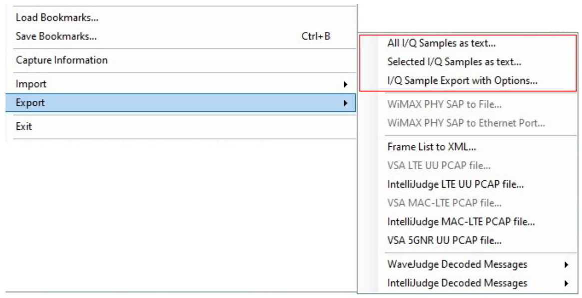
   - You may have to pad the beginning of the file with a certain number of lines of zero samples before the first start-of-frame, and the file should extend with a certain number of lines past the end of the last frame, to ensure WaveJudge can fully process all frames of actual data.
   - With I and Q baseband inputs, WaveJudge uses Rx Port 0 as the default Rx Port for analysis.

2. **The sampling rate must be the same.** Whether you have two 5G NR files, or a 5G and an LTE, both files must have the same sampling rate. The bandwidths, however, may be different.
3. **Ports must be sequentially numbered.** There can be no breaks in the port labels. For example, if you have eight ports, they must be numbered 1, 2, 3, 4, 5, 6, 7, 8. You cannot skip over a number.

4. 10. 2 Export RF Signals as I/Q Data Values

There are a group of related functions to export RF data in an I/Q data format. All functions are compatible with the import format - any file that is exported can also be re-imported. The columns are delimited by a tab character, and the I and Q values are by default exported as 16-bit signed integers between -32768 and +32767.

The menu selection FileExportAll I/Q Samples as text... provides the most basic I/Q export method. This selection exports the entire contents of the current WaveJudge capture (all RF signal data for the entire capture) to the selected file name.



File Menu - Export Options for I/Q Samples

The menu selection FileExportSelected I/Q Samples as text... exports only the contents of the selected time range within the current WaveJudge capture (RF signal data from the currently selected time range) to the selected file name.

The menu selection FileExportI/Q Sample Export with Options... provides additional options to export I/Q data by opening an Export Options window where you can choose the options to export the RF signal data.

4.11 LTE Enhanced PHY Types

This section intoduces the latest LTE protocols now included in the WaveJudge 5000 system:

- LAA/eLAA on page 175,
- eMTC on page 177,
- NB-IoT on page 179, and
- V2X on page 183).

NOTE **For LAA, eMTC, NB-IoT and V2X, the cell is essentially an LTE cell with special configurations, described in the sections below.**

4.11.1 LAA/eLAA

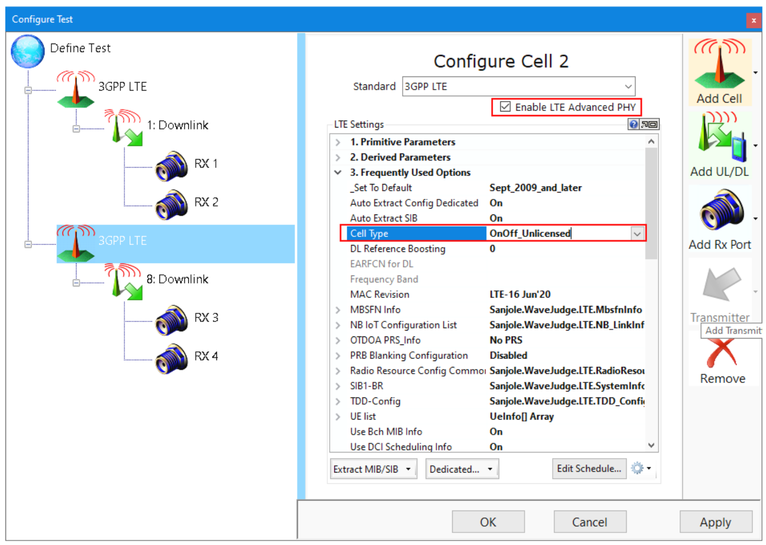
Licensed Assisted Access (LAA) is a new feature of LTE that uses the unlicensed spectrum in the 5 GHz range (LTE-U). To comply with global WiFi coexistence standards, LAA requires Listen-Before Talk (LBT). It also uses carrier aggregation to combine licensed and unlicensed carriers, resulting in better user throughput, seamless mobility, and quality of service.

3GPP Rel-13 defined LAA only for the DL. However, 3GPP Rel-14 defined enhanced-Licensed Assisted Access (eLAA), which includes UL operation in the unlicensed channel. Thus, LAA supports both UL and DL.

Create a Test Scenario for LAA/eLAA

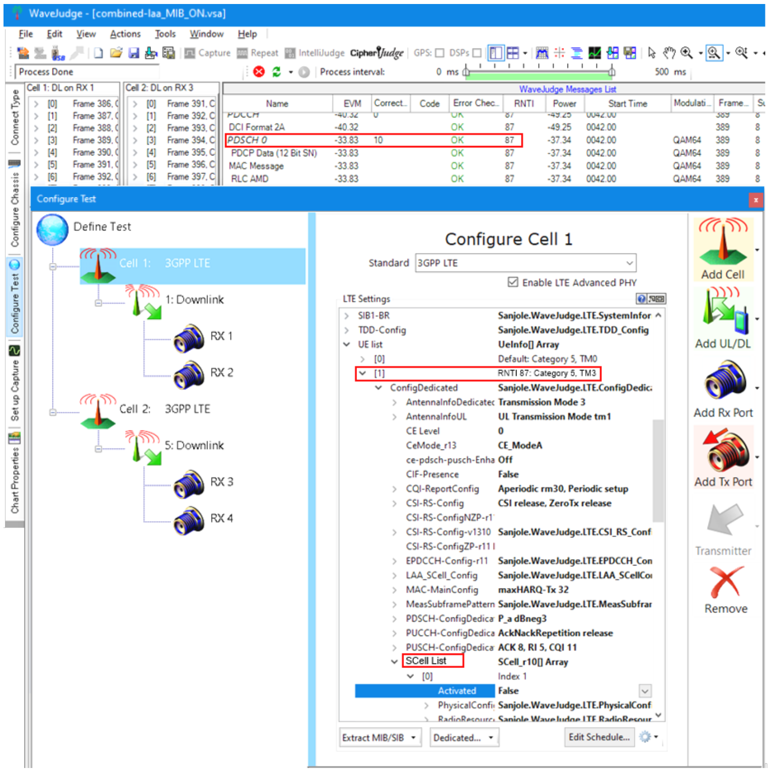
With the introduction of LAA/eLAA, LTE may support carrier aggregation over unlicensed spectrum. In order to set up a successful LAA test with WaveJudge, it's important to follow the notes detailed below.

1. Check the box to Enable LTE Advanced PHY.
2. Always configure the primary cell (PCell) as the first LTE cell on the WaveJudge GUI.
3. Configure the Cell Type of each LAA secondary cell (SCell) on the WaveJudge GUI as "OnOff_Unlicensed".



LAA/eLAA - Set Secondary Cells to Cell Type to "On/Off Unlicensed"

4. If the RRC message that sets up the LAA CA for the target UE under test is not included in the capture itself, it is critical to set up this message for the UE under the PCell. UE List is located under LTE Settings 3. Frequently Used Options.



LAA/eLAA - Set Secondary Cells to Cell Type to "On/Off Unlicensed"

4.11.2 eMTC

eMTC is a type of LTE-M network published by 3GPP in the Release 13 specification. eMTC is a low power wide area technology which supports IoT through lower device complexity and provides extended coverage, leveraging a mobile carriers existing LTE base stations.

eMTC is a sub-type of LTE-M network, although the two terms are often used interchangeably. However, GSMA has determined "LTE-M" is the preferred term to refer to Cat-M1 networks. An eMTC Cat-M1 network is limited to 1.08 MHz channel width and has a maximum data rate of 1 Mbps, whereas an LTE-M device may have a data rate up to 10 Mbps by using any existing LTE channel width.

LTE Cat-M1 configurations are:

- **Deployment/Frequency Band(s):** In-Band LTE, Standalone
- **Channel Bandwidth(s):** 1.08 MHz
- **DL Multiplexing:** OFDMA
- **UL Multiplexing:** SC-FDMA
- **DL Rate (Peak):** 1 Mbps
- **UL Rate (Peak):** 1 Mbps

- **Duplex Mode:** FDD, TDD, HD-FDD
- **Modulation:** QPSK, 16QAM

Create a Test Scenario for eMTC

Because eMTC is essentially designed as a part of an LTE network, by default, WaveJudge supports eMTC decoding automatically. That is, there is no special setting on the WaveJudge GUI that would trigger WaveJudge to support eMTC decoding. Nonetheless, in terms of system usability, a user may find the following tips helpful for a test.

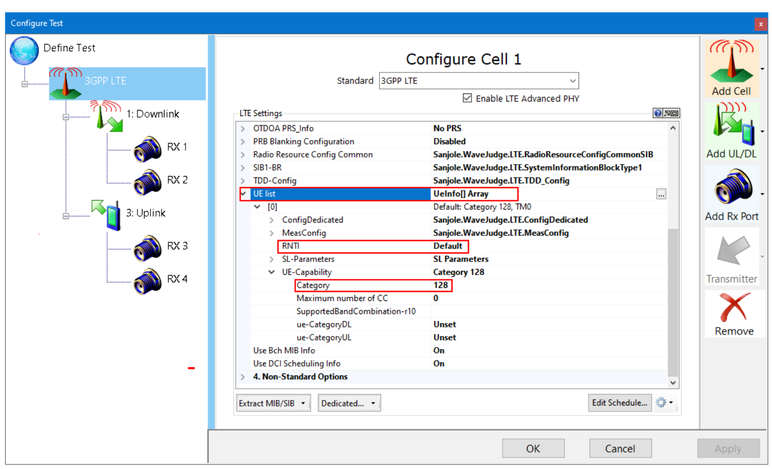
TIP

Set up a default BLCE UE on the WaveJudge GUI.

The main benefit to set up a default UE for the WaveJudge eMTC support is that it can help to speed up the WaveJudge non-real-time decoding processing speed, if most BLCE UEs are configured with the same UE-specific search space. Setting up a default BLCE UE would also trigger the WaveJudge non-real-time decoding support for the PBCH repetition, if applicable.

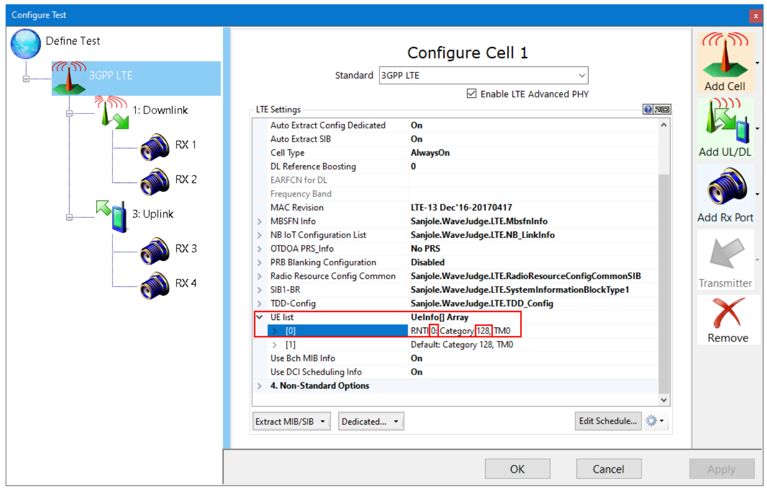
There are two ways to set up a default Bandwidth reduced Low complexity Coverage Enhancement (BL/CE) UE for a WaveJudge system.

1. If the main focus of the test is eMTC, configure the default UE in the UE List with UE Category M (i.e.,128). UE List is is located in the LTE Settings panel under Section 3. Frequently Used Options.



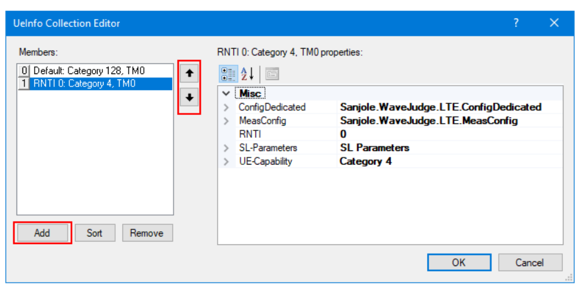
eMTC - Under UE List, Set RNTI to Default and Category to 128

2. If both legacy LTE UEs and BLCE UEs are needed in a test, leave the default UE as a legacy LTE UE and add a BLCE UE with RNTI "0" under the WaveJudge UE List.



eMTC - Under UE List, Set RNTI to 0 and Category to 128

To add RNTI, click the line item UE List and select the ellipse button on the far right side, this opens the UE Info Collection Editor. Click the Add button. To make RNTI the default in Cell 0, use the arrow button to move RNTI up to Cell 0.



eMTC - Use the UEInfo Collection Editor to Add or Move RNTI

To change the UE category to 128 (or other number) under the UE List expand UE Capability to show the submenu, select Category and manually type the value on the space to the right.

4.11.3 NB-IoT

NB-IoT is a feature from 3GPP Release 13 that reuses principles of the LTE physical layer and higher protocol layers, and defines a new LTE Cat-NB1 UE protocol. Compared to traditional networks, it provides extended coverage through an ultra-narrow bandwidth of only 180 kHz. In comparison to a conventional LTE deployment, NB-IoT supplies an additional 20 dB of link budget, equating to roughly ten times the coverage of a normal base station.

Designed for intermittent communication with lightweight, low data usage devices that may only transmit once an hour NB-IoT has fewer requirements for data rates, fewer demands for low latency, and as a result, frequency bandwidths can be narrower. NB-IoT can be deployed in three modes:

1. Within an existing LTE channel;
2. Using the unused resource blocks within a LTE carrier's guard-band; or
3. As a standalone service, via an entirely separate carrier.

NB-IoT LTE Cat NB1 protocol configurations are:

- **Deployment/Frequency Band(s):** In-Band LTE, Guard-Band LTE, Standalone
- **Channel Bandwidth(s):** 180 kHz
- **DL Multiplexing:** OFDMA
- **UL Multiplexing:** SC-FDMA
- **DL Rate (Peak):** 50 kbps
- **UL Rate (Peak):** 50 kbps
- **Duplex Mode:** HD-FDD
- **Modulation:** QPSK

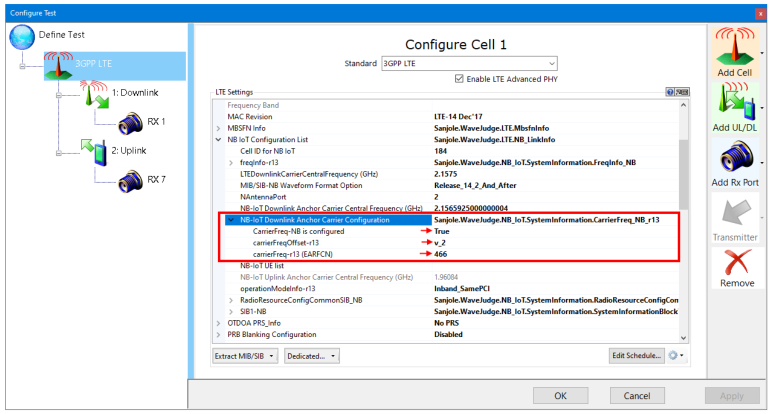
Create a Test Scenario for NB-IoT

When using a WaveJudge system for NB-IoT decoding support there are two test scenarios: 1) the NB-IoT cell is deployed with an LTE cell; and 2) the NB-IoT cell is deployed by itself.

Test Scenario 1: The NB-IoT DL anchor carrier is deployed over inband or over guard band of an LTE cell.

Unlik eMTC, an NB-IoT cell has its own synchronization signals. Therefore, when an NB-IoT cell is deployed with an LTE cell, either with the "inband" or the "guardband" operation mode, a WaveJudge user has the option on the WaveJudge GUI to turn on or turn off the NB-IoT support.

For test scenario 1, the user must first set up a legacy LTE test properly. To turn on the NB-IoT support, if the user knows the EARFCN value of the NB-IoT cell's DL anchor carrier, simply set this field under the NB IoT Configuration Listwith the correct value and flag this field as **"Configured"**, the WaveJudge NB-IoT support, both real-time decoding and non-real-time decoding, will turn on automatically. This setting is located under LTE Settings, Section 3. Frequently Used Parameters.



NB-IoT - Downlink Anchor Carrier Configuration Settings

In some test cases under this test scenario, the user may not know the EARFCN value of the NB-IoT DL anchor carrier, hence the user needs to accurately configure the GUI field "NB-IoT Downlink Anchor Carrier Central Frequency (GHz)" in order to set up the NB-IoT support.

Set the following NB-IoT Downlink Anchor Carrier Configuration paramters, as shown in the figure above.

NB-IoT Downlink Anchor Carrier Configuration:

WaveJudge.NB_IoT.SystemInformation.CarrierFreq_NB_r13

- CarrierFreq-NB is configured: TRUE
- CarrierFreqOffset-r13: v_2
- carrierFreq-r13 (EARFCN): 466

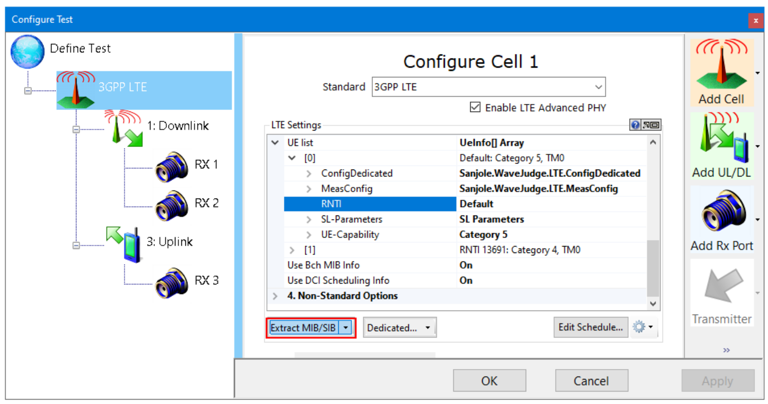
In case that the precise value of the NB-IoT DL carrier's center frequency is not available to the user, and instead, the user only knows the PRB allocation index of the NB-IoT DL anchor carrier within the LTE cell, the user can use the following formula to get the value for the field "NB-IoT Downlink Anchor Carrier Central Frequency (GHz)". which is given as follows. Note the formula applies to the guard band operation mode as well.

Assuming "n_PRB" is the PRB index of the NB-IoT DL anchor carrier relative to the PRB 0 of the underlying LTE cell,

- if n_PRB >= N_DL_RB / 2 (the PRB is above the LTE DC) NB_IoT_ AnchorCarrierCentralFrequency (GHz)' = f_0 + ((12 * n_PRB - (N_DL_RB * 6) + 6.5) * 15 / 1000000)
- if n_PRB < N_DL_RB / 2 (the PRB is below the LTE DC) NB_IoT_ AnchorCarrierCentralFrequency (GHz)' = f_0 + ((12 * n_PRB - (N_DL_RB * 6) + 5.5) * 15 / 1000000)
- where, 'N_DL_RB' and 'f_0' respectively denote the number of PRB and the

central carrier frequency of the underlying LTE cell.

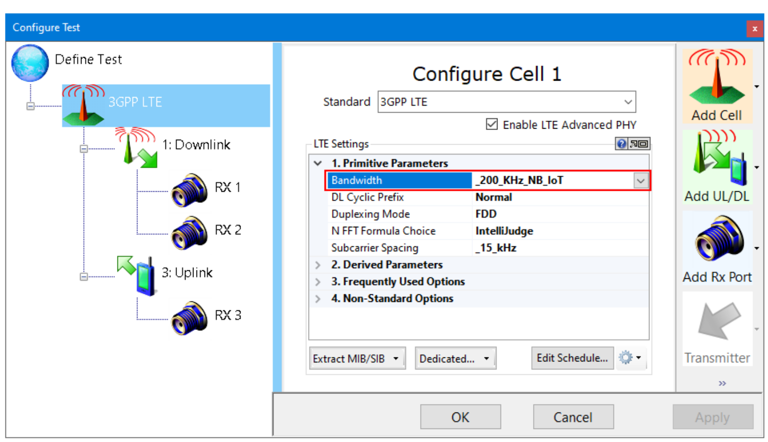
NOTE When testing under the Test Scenario 1, and your WaveJudge system has enough DSP cards to support both LTE and NB-IoT real-time decoding, it is always desirable to click the button Extract MIB/SIB from IntelliJudge before you start processing the VSA capture.



NB-IoT - Click "Extract MIB/SIB from IntelliJudge" Before Processing the Capture

Test Scenario 2: The user is only interested in the decoding of the NB-IoT cell.

Under Test Scenario 2, the user only needs to properly set the WaveJudge DL/UL center frequency as the NB-IoT cell's DL anchor carrier and UL common carrier's center frequency, respectively, and set the Bandwidth field on the WaveJudge GUI as "_200_KHz_NB_IoT".



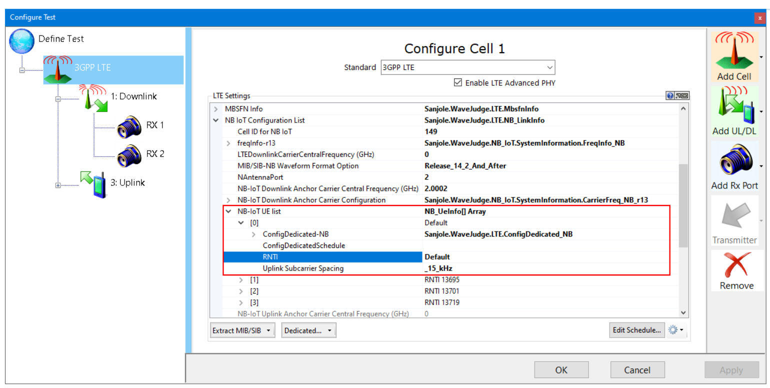
NB-IoT - Set Bandwidth to 200 KHz

You find the following notes helpful to set up a NB-IoT test.

NOTE It is desirable to set up a default NB-IoT UE on the WaveJudge GUI.

The main benefit of setting up a default NB-IoT UE for the WaveJudge NB-IoT support is that it can help to speed up the WaveJudge non-real-time decoding processing speed, if most NB-IoT UEs are configured with the same UE-specific search space.

To set up a default NB-IoT UE, in LTE Settings, Section 3. Frequently Used Options, under the NB-IoT UE List add a UE with RNTI set to "Default", as illustrated below.

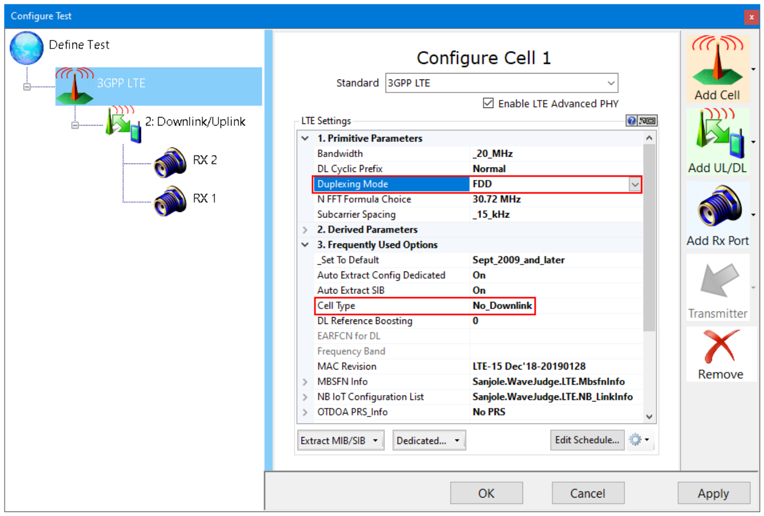


NB-IoT - Under NB-IoT UE List, Set RNTI to "Default"

NOTE WaveJudge currently does not support real-time decoding for an NB-IoT cell under Test Scenario 2.

4.11.4 V2X

WaveJudge now provides non-real-time decoding support for communications among V2X UEs though the side link. In order to set up a V2X test with WaveJudge, you must first configure an LTE cell with the Cell Type set to No_Downlink and the Duplexing Mode as FDD, otherwise WaveJudge will report a configuration error. You must also set the "DL/UL" channel for each WaveJudge port.



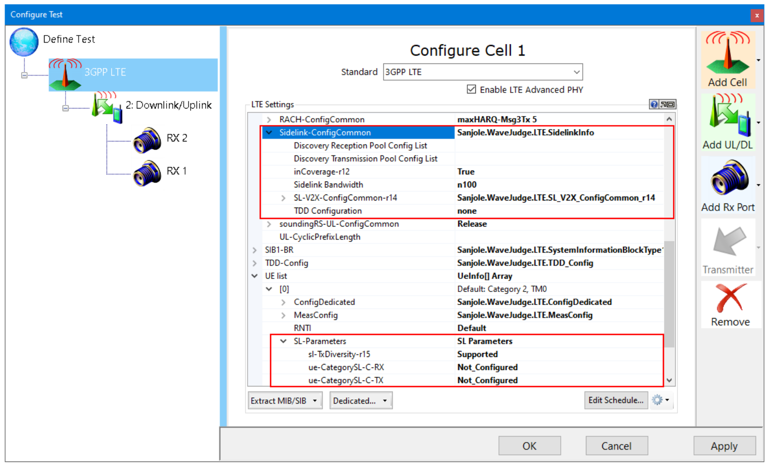
V2X - Set the Duplexing Mode and Cell Type

Besides the cell configuration, it's also important to understand the following notes for a UE under a V2X test using WaveJudge.

NOTE Since a UE communicating over sidelink derives the frame index and boundary from the UTC, in order to support OTA V2X decoding, the WaveJudge system must contain a GPS/PPS module. Otherwise, by default, WaveJudge software assumes the start of the capture is the starting boundary of a frame.

NOTE The static pre-configured time/frequency resource pools available to the UEs under a V2X test should be configured in the Sidelink-ConfigCommon field (under LTE Settings, Section 3. Frequently Used Options).

Configure the Sidelink Parameters under the Default UE in the WaveJudge UE List, as illustrated below.



V2X - Set the Sidelink Config Common and Sidelink Parameters

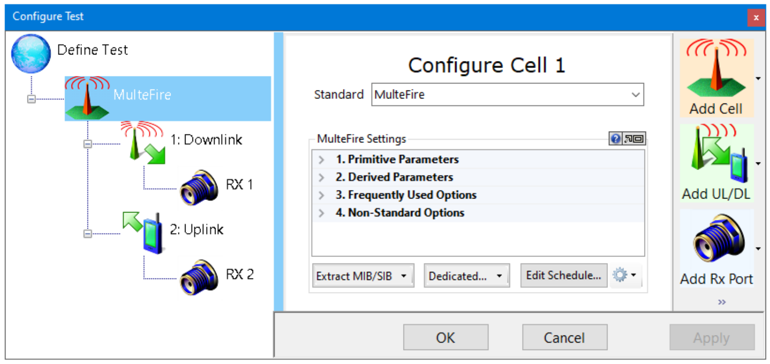
4.12 MulteFire

MulteFire is an LTE-based technology that operates standalone in unlicensed and shared spectrum, including the global 5 GHz band. A key principle in the design of MulteFire is fair coexistence with WiFi. It is based on Licensed Assisted Access (LAA) and uses similar coexistence technologies such as “Listen Before Talk,” which is required for global deployments. It was developed by the MulteFire Alliance (MFA) and released in 2017. MulteFire technology supports:

- Listen-Before-Talk
- Private LTE
- Neutral host deployment models
- Industrial IoT, enterprise, cable market segments

4.12.1 Create a Test Scenario - MulteFire

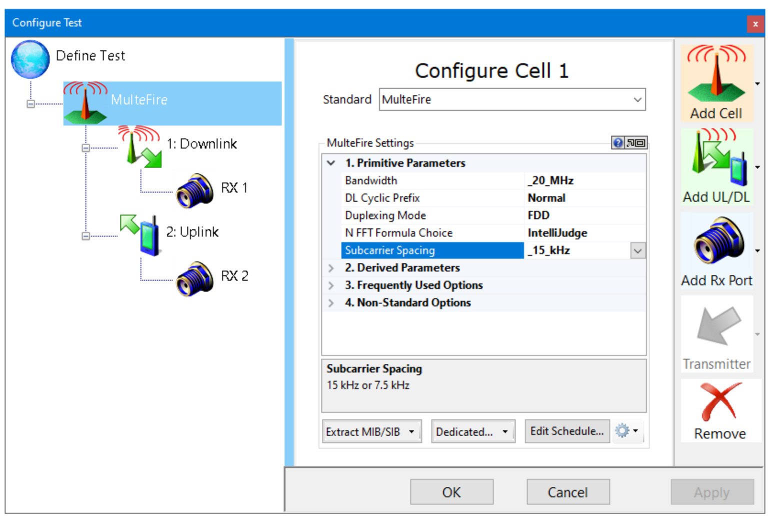
To configure a MulteFire test, click the vertical Configure Test botton on the left side of the screen. This opens the Configure Test window. Click the first item Define Test on the left side pane, it opens the corresponding pane Configure Test Scenario on the right; on the Standard dropdown menu, select MulteFire. Select a test scenario from the dropdown menu.



Define Test - Select "MulteFire"' from the Standard Menu

Next, click the second line item on the left side Multefire which opens the Configure Cell 1 pane on the right side.

Click the inline Help button across from the MulteFire Settings panel title, this will show brief descriptions and options for any selected item in this window. For example, in the figure below **Subcarrier Spacing** is selected, therefore a brief description appear in the text field at the bottom of the window.



Multefire - Configure Settings for Cell 1

Unlike the regular Configure Cells on page 77 described above, MulteFire has four settings: Primitive Parameters, Derived Parameters, Frequently Used Options, and Non-Standard Options.

Configure MulteFire Settings: 1. Primitive Parameters

DL Cyclic Prefix: Choose Normal or Extended

Duplexing Mode: Choose Frequency Division Duplexing (FDD) or Time Division Duplexing (TDD)

Subcarrier Spacing: Choose 15 kHz or 7.5 kHz

Bandwidth: Choose 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz, or 200 MHz for NB-IoT

N FFT Formula Choice: Formula used to derive the number of FFT points from bandwidth or Sampling Rate.

- When set to 'Original', N FFT is the smallest power of 2 larger than 12 *N_DL_RB, except for 15 MHz bandwidth, where N FFT = 2048.
- When set to 'IntelliJudge' N FFT is the same as 'Original' except for 20 MHz and 15 MHz bandwidths where N FFT is 1536, instead of 2048.
- When set to 'Static_512', 'Static_1024', 'Static_1536', or 'Static_2048', N FFT is equal to 512, 1024, 1536, or 2048 respectively, for all bandwidths. They are useful for automatic bandwidth detection.
- Please note that the largest value of N FFT which may be used with IntelliJudge or the WJ 4900 phase-aligned synthesizer is 1536.

Configure MulteFire Settings: 2. Derived Parameters

The input fields are autocompleted by WaveJudge and will appear greyed out.

Frame Structure: Type 1 for FDD, Type 2 for TDD, Type 3 for LAA (Type 3). MFA can only be configured as Type 3.

N DL sc: Total number of subcarriers (600)

N RB sc: Number of subcarriers per physical resource block (12)

N DL RB: Number of physical resource blocks (50)

NFFT: Derived number of FFT points (1024)

Sampling Rate (MHz): (15.36)

Configure MulteFire Settings: 3. Frequently Used Options

RadioResourceConfigCommon-MF: Specifiy MF-specific common radio resource configurations in the system information (WaveJudge.LTE.RadioResourceConfigCommon_MF)

MF UE List: List of UE-specific parameters: N-RNTI, UE category, ConfigDedicated from RRC messages (RRCConnectionSetup, RRCConnectionReconfiguration, and RRCConnectionReestablishment). Click the [0] to set each parameter.

_Set To Default: Set All Advanced Options to the default value for a standard version.

DL Reference Boosting: Assumes that all downlink reference signals are boosted by a static number in dB. Its effect is to scale the constellation by the specified number in decibels. A positive number expands the constellation, while a negative number contracts it. It acts globally as the opposite of the UE-specific parameter p-a, defined in TS 36.213. If the UE-specific parameter p-a is provided by RRC messages, or set manually in the "ConfigDedicated" section, the "DL Reference Boosting" should remain 0.

Use DCI Scheduling Info: Use DCI information to schedule the PDSCH and PUSCH automatically. Options are "On" and "Off".

Use Bch MID Info: When set to "On", automatically reads the number of PHICH groups and applies it to the right subframes. Options are "On" and "Off".

MAC Revision: Version of TS 36.331 used to decode MAC messages. Select this option from the dropdown menu on the right.

SIB1-BR: Collection of parameters set in SIB1-BR messages. Click BandwidthReducedAccessRelatedInfo to access the following options.

- **si-WindowLength-BR-r13**: Common SI scheduling window for all SIs
- **si-RepetitionPattern-r13:** Indicates the radio frames within the SI window used for SI message transmission.
- **fdd-DownlinkOrTddSubframeBitmapLC-r13:** The set of valid subframes for FDD downlink or TDD transmissions.
- **fdd-DownlinkOrTddSubframeBitmapLC Length:** The bitmap length can be 10 or 40 bits. Value 0 indicates the downlink bitmap is not present.
- **fdd-UplinkSubframeBitmapLC-r13:** The set of valid subframes for FDD uplink transmissions for BL UEs.
- **startSymbolLC-r13:** For BL and UEs in CE, indicates the OFDM starting symbol for any MPDCCH, PDSCH scheduled on the same cell except the PDSCH carrying SystemInformationBlockType1-BR.
- **schedulingInfo:** Indicates scheduling information of SI messages.

TDD-Config: Collection of parameters used to specify the TDD specific physical channel configuration.

- **specialSubframePatterns-v1450:** Indicate if ssp10-CRS-LessDwPTS is configured for specialSubframePatterns 10. Options in dropdown menu are "Release" or "sp10-CRS-LessDwPTS".
- **specialSubframePatterns for SRS with ssp10:** Indicate specialSubframePatterns for SRS when specialSubframePatterns is ssp10. Options in dropdown menu range from ssp0 to ssp9.

Radio Resource Config Common: Collection of parameters set in SIB12 messages.

- **PUSCH-ConfigCommon:** Common configuration for PUSCH, from SIB2 messages
- **PDSCH-ConfigCommon:** Common configuration for PDSCH, from SIB2 messages
- **PRACH-Config:** Configuration for PRACH, from SIB2 messages
- **soundingRS-UL-ConfigCommon:** Common configuration for uplink sounding reference signals, from SIB2 messages
- **PUCCH-ConfigCommon:** Common configuration for PUCCH, from SIB2

messages

- **RACH-ConfigCommon:** Common configuration for RACH, from SIB2 messages
- **PCCH-Config:** Common configuration for paging.
- **Sidelink-ConfigCommon:** Common configuration for Sidelink Channels, from SIB18/SIB19/SIB21/ MIB_SL messages.
- **UL-CyclicPefixLength:** Uplink cyclic prefix length can be normal or extended.
- **FreqHoppingParameters:** Frequency hopping parameters. Click an option below to set parameters.
  - **mpdcch-pdsch-HoppingNB-r13:** The number of narrowbands for MPDCCH/PDSCH frequency hopping. Takes the values of {nb2, nb4}.
  - **interval-DLHoppingConfigCommonModeA-r13:** FDD: Takes the values of {int1, int2, int4, int8}. TDD: Takes the values of {int1, int5, int10, int20}.
  - **interval-DLHoppingConfigCommonModeB-r13:** FDD: Takes the values of {int2, int4, int8, int16}. TDD: Takes the values of {int5, int10, int20, int40}.
  - **interval-ULHoppingConfigCommonModeA-r13:** FDD: Takes the values of {int1, int2, int4, int8}. TDD: Takes the values of {int1, int5, int10, int20}.
  - **interval-ULHoppingConfigCommonModeB-r13:** FDD: Takes the values of {int2, int4, int8, int16}. TDD: Takes the values of {int5, int10, int20, int40}.
  - **mpdcch-pdsch-HoppingOffset-r13:** Frequency hopping offset for MPDCCH/PDSCH. Takes the values of {1 to maxAvailNarrowBands-r13 (16)}.

OTDOA PRS_Info: Positioning Reference Signals parameter

- **prs-Bandwidth:** This field specifies the bandwidth that is used to configure the positioning reference signals on. Enumerated values are specified in number of resource blocks (n6 corresponds to 6 resource blocks, n15 to 15 resource blocks, etc.) and define 1.4, 3, 5, 10, 15, and 20 Mhz bandwidth.
- **prs-ConfigurationIndex:** This field specifies the positioning reference signals configuration index I-PRS as defined in TS36.211.
- **numDL-Frames:** This field specifies the number of consecutive downlink subframes N_PRS with positioning reference signals, as defined in TS36.211. Enumerated values define 1, 2, 4, or 6 consecutive subframes.
- **prs-MutingInfo periodicity:** This field specifies the periodicity T_REP of the muting sequence and can be 2, 4, 8, or 16.
- **prs-MutingInfo:** This field specifies the PRS muting configuration of the cell.

NB IoT Configuration List: Configuration parameters related to NB IoT.

- **operationModeInfo-r13:** NB IoT Cell Operation Mode: Inband-SamePCI, Inband-DifferentPCI, Guardband, and Standalone
- **NAntennaPort:** Number of antenna ports: 1 or 2
- **MIB/SIB-NB Waveform Format Option:** Waveform option for physical channels carrying MIB/SIB-NB messages (old format until Release 14.10 or new format since Release 14.2.0).

- **NB-IoT Uplink Anchor Carrier Central Frequency (GHz)**: Central frequency (GHz) of NB-IoT uplink anchor carrier. If the EARFCN for this carrier is not configured, it displays as 0.
- **NB-IoT Downlink Anchor Carrier Central Frequency (GHz):** Central frequency (GHz) of NB-IoT downlink anchor carrier. If the EARFCN configuration for the anchor carrier is not configured, the formula to derive this field from the n_PRB index of the Inband support is shown here.
- **NB-IoT Downlink Anchor Carrier Configuration:** EARFCN configuration for NB-IoT downlink anchor for Carrier defined in TS 36.101 5.7.3F.
  - **CarrierFreq-NB is configured:** Indicates this IE is configured by a higher layer. Otherwise, shall use the anchor carrier.
  - **carrierFreq-r13 (EARFCN):** The EARFCN applicable for the NB-IoT carrier frequency as defined in TS 36.101 5.7.3F. Taking value from 0 to 262143.
  - **carrierFreqOffset-r13:** Offset of the NB-IoT channel number to EARFCN as defined in TS 36.101 5.7.3F.
- **LTEDownlinkCarrierCentralFrequency (GHz):** Central frequency (GHz) of the underlying LTE cell's downlink carrier if running under the "Inband_SamePCI" operation mode.
- **SIB1-NB:** Collection of parameters set in SIB1-NB messages.
  - **eutraControlRegionSize-r13:** For NB IoT under inband operation mode, indicates the OFDM starting symbol for NPDCCH and NPDSCH. Takes vales 1, 2, or 3.
  - **downlinkBitmap-r13:** NB-IoT downlink subframe configuration for downlink transmission. If the bitmap is present, the UE shall assume that all subframes are valid.
  - **downlinkBitmap-r13 Length:** The bitmap length can be 10 or 40 bits. Value 0 indicates the downlink bitmap is not present and all DL subframes are valid.
  - **Nrs-CRS-PowerOffset-r13:** NRS power offset between NRS and E-UGTRA CRS, see TS 36.213 [23, 16.2.2]. Units in dB. Default value of 0.
  - **si-WindowLength-r13:** Common SI scheduling window for all SIs.
  - **si-RadioFrameOffset-r13:** Offset in number of radio frames to calculate the start of the SI window. Can take values from 0 to 15.
  - **schedulingInfoList-r13:** The SchedulingInfoList-NB-r13 for the SIB messages
- **RadioResourceConfigCommonSIB_NB:** Collection of parameters set in RadioResourceConfigCommonSIB_NB.
  - **rach-ConfigCommon-r13:** Used to specify generic random access parameters for NB-IoT UE.
  - **PCCH-Config-NB-r13:** Used to specify common parameters needed for the transmission of paging.

    - **NPUSCH-ConfigCommon-NB-r13:** Used to specify common parameters needed for the transmission of NPUSCH.
    - **NPRACH-ConfigSIB-NB-r13:** Used to specify common parameters needed for the transmission of NPRACH.
    - **DL-GapConfig-NB-r13:** Used to specify the downlink gap configuration for NPDCCH and NPDSCH (except BCCH).
- **freqInfo-r13:** freqInfo-r13 configured by SIB2-NB.
    - **UL-CarrierConfigDedicated-NB-r13:** Carrier frequency related configuration.
    - **CarrierFreq-NB is configured:** Indicates this IE is configured by a higher layer. Otherwise, shall use the anchor carrier.
    - **carrierFreq-r13 (EARFCN):** The EARFCN applicable for the NB-IoT carrier frequency as defined in TS 36.101 5.7.3F. Taking value from 0 to 262143.
    - **carrierFreqOffset-r13:** Offset of the NB-IoT channel to EARFCN as defined in TS 36.101 5.7.3F.
- **NB-IoT UE List:** List of NB-IoT UE specific parameters: N_RNTI, ConfigDedicated from RRC messages (RRCConnectionSetup, RRCConnectionReconfiguration, and RRCConnectionReestablishment).
- **Cell ID for NB IoT:** Cell ID for NB IoT before NSSS is decoded. Taking values from 0 to 503.

MBSFN Info: Multicase Broadcast Single Frequency Network.

- **MBSFN Subframe Config List:** The IE MBSFN-SubframeConfig (from SIB2) defines subframes that are reserved for MBSFN in downlink.
- **MBSFN Area Info List:** The IE MBSFN-AreaInfoList (from SIB13) contains the information required to acquire the MBMS control information associated with one or more MBSFN areas.
- **MBSFN-AreaInfoList-r16:** The IE MBSFN-AreaInfo-r16 List (from SIB13) contains the information required to acquire the MBMS control information associated with one or more MBSFN areas.
- **MBSFN Area Configuration List:** Opens the MBSFN Area Configuration Collection Editor window. Click the ADD button to get started.

Auto Extract Config Dedicated: WaveJudge extracts the Config Dedicated parameters from RRC Connection Setup / Reconfiguration / Re-establishment messages and applies them on the fly while processing.

Auto Extract SIB: If 'On', WaveJudge extracts the configuration parameters from SIB messages and applies them on the fly while processing.

Cell Type:

- "Always On" is used for an LTE PCell and most SCells; other values are used for MulteFire or an SCell which may turn on and off (small cell, LTE-U, LAA). If enabled for IntelliJudge real-time operation, Cell ID Mode must be set to "Equal" and the CellID must also be correctly set in the Cell ID List. When set to

"Always On", the cell is always on and an UE may expect the eNB will always transmit core signals (including PSS/SSS and CRS).

- When set to "OnOff_Licensed" the cell can be turned off and a UE may not expect the eNB will always transmit.
- When set to "OnOff_Unlicensed" a UE shall assume the cell is LAA SCell (Frame Type 3) - also applied to MulteFire.
- When set to "No_Downlink" a UE may expect no eNB DL is present, and the only synchronization reference a UE may use is a time-base, such as SLSS or GNSS.
- When set to "MBMS Dedicated" a UE shall assume the cell is an MBMS-dedicated cell.

EARFCN for DL: EARFCN derived from Frequency Band and DL Center Frequency

Frequency Band: Frequency Band Indicator extracted from SIB

Configure MulteFire Settings: 4. Non-Standard Options

5G UF OFDM: Enables 5G UFMC extensions to LTE; requires corresponding license. Choose Enabled or Disabled.

5G UF OFDM Parameters: 5G UFMC extension parameters. Opens the **Int64 Collection Editor** window; click the Add button to start.

NAntennaPort: Number of antenna ports: 1, 2, or 4; not needed if N Antenna is set to BCH.

UL Reference Modulation: Mode for modulating uplink reference signals. It should be set to "Standard" to conform to TS 36.211. When set to "Static" it uses the "UL Reference Static u" option.

UL Reference Static u: Parameter used for modulating uplink reference signals, only when "UL Reference Modulation" is set to "Static".

DL Reference Modulation: Mode of modulating downlink reference signals. It should be set to "Standard" to conform to TS 36.211. When set to "Static" it uses the "DL Reference Static x1" and "DL Reference Static x2" options.

DL Precoding Version: Version of TS 36.11 used for precoding downlink transport blocks.

DL Bit collection NL: NL stands for Number of Layers, it is a parameter defined in TS 36.212, section "Bit collection, selection and transmission." The options "Standard" and "NLayerPerBlock" are equivalent and conforms to TS 36.212. The options "_1" and "_2" can force NL to be statically set to 1 and 2 respectively.

DL Reference Shift: Frequency shift applied for mapping downlink reference signals to resource elements.

UL Reference Boosting: Assumes that all uplink reference signals are boosted by a static number in dBs. Its effect is to scale the constellation by the specified number in decibels. A positive number expands the constellation while a negative number contracts it.

BW / Bandwidth: Can be used to define non-standard bandwidths. It is recommended to leave it equal to 0.

BW / NRB: Can be used to define non-standard number of RBs. It is recommended to leave it equal to 0.

BCH Reference N Ant: Number of antenna ports assumed when sending BCH.

BCH Over N Frames: Number of frames over which BCH is sent.

BCH Mapping to RE: Version of TS 36.211 used for mapping BCH to Resource Elements.

PHICH: Version of TS 36.211 used for PHICH.

PDCCH Mapping to RE: Version of TS 36.211 used for mapping PDCCH to Resource Elements.

DL Channel Coding: Version of TS 36.212 used for downlink channel coding.

UL Channel Coding: Version of TS 36.212 used for uplink channel coding.

Proprietary Parameters: Parameters used to configure non-standard, proprietary variants of LTE.

UE-Specific PDSCH RE Mapping Option:

Version of TS 36.211 used for UE-specific PDSCH RE mapping.

DCI Version: Version of TS 36.211 used for DCI detection.

RNTI Version: Version of TS 36.211 used for RNTI determination.

N Antenna: "BCH" is extracted from Broadcast Channel CRC. Alternate option is "User Defined".

N Control Region OFDMA Symbol: "CFI" is extracted from Control Format Indicator. Alternate option is "User Defined".

DCI Blind Decoding Message Sizes: "Valid" is the default setting instructing WaveJudge to detect only DCI messages with valid lengths. When set to "All" WaveJudge looks for DCI of any size, including invalid sizes. This was a useful feature when the LTE specs were changing and not everyone agreed on how to interpret the DCI sizes. If WaveJudge detects an invalid size, it reports it as "Unknown DCI format".

HARQ Soft-Combining: This parameter controls the use of soft-combining on HARQ retransmissions.

Cell ID Mode: The default for this parameter is "Auto". When set to "Equal", only cells matching the specified "Cell ID List" are analyzed. When set to "Different", only cells not matching the specified "Cell ID List" are analyzed.

Cell ID List: This list specifies the Cell IDs of cell to be analyzed or skipped if "Cell ID Mode" is to "Equal" or "Different" respectively. It is ignored when "Cell ID Mode" is set to "Auto".

SchedulingInfoSIB1-BR: This field contains an index to a table that defines SystemInformation BlockType1-BR scheduling information, which takes Value 0 to 18. Value 0 means that SystemInformation BlockType1-BR is not scheduled.

NOTE WaveJudge treats an MFA cell as an independent PHY type (from LTE). After setting the cell configuration step, everything is automatic; continue setting the Rx port, downlink, and uplink, as described elsewhere in this manual.

4.13 5GTF

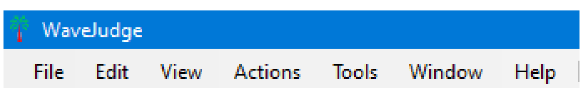
The 5G Technical Forum (5GTF) is a group of leading manufacturers in the wireless industry (i.e., Verizon, Cisco, Ericsson, Intel, LG, Nokia, Qualcomm, and Samsung). The 5GTF protocol was an early proposal for a 5G protocol using the mmWave spectrum.

5 Use the Graphical User Interface (GUI)

This section describes all of the WaveJudge 5000/5900 Graphical User Interface (GUI) elements such as menus, submenus, toolbars, chart panes, buttons, lists, windows, and forms, including elements of the IntelliJudge user interface.

5.1 Main Menu

This section describes the main menu and the options available under each menu category.



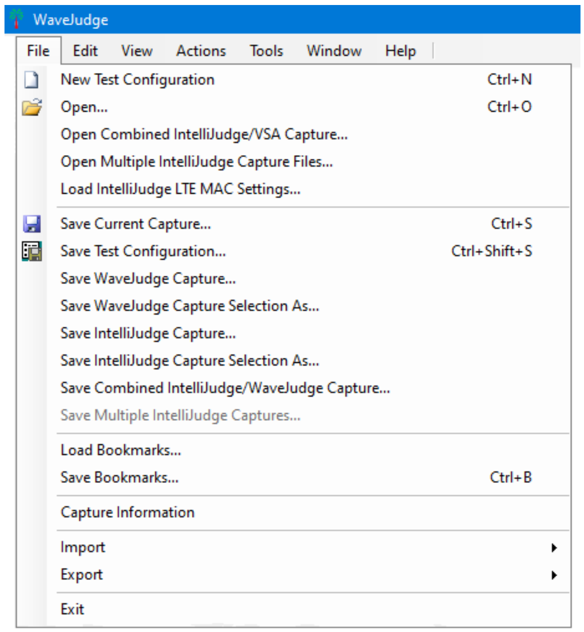
Main Menu

The seven main menu categories are:

1. File Menu on page 196
2. Edit Menu on page 201
3. View Menu on page 203
4. Actions Menu on page 208
5. Tools Menu on page 210
6. Window Menu on page 215
7. Help Menu on page 217

5.1.1 File Menu

Similar to MS Windows, the WaveJudge 5000 File menu is where you open, save, import and export files, as well as create and load bookmarks.



File Menu

The File menu options are described below.

Ctrl+N New Test Configuration

Opens the Configure Test window with a blank configuration so you can create a custom scenario.

Ctrl+O Open...

Opens a capture/configuration file from the PC for WaveJudge analysis. You can load either WaveJudge RF signal capture files or IntelliJudge real-time capture files. You can load a file from any PC that has a WaveJudge user license (allowing offline data analysis). A saved WaveJudge or IntelliJudge file contains the captured data and configuration settings.

Open Combined IntelliJudge/VSA Capture...

Simultaneously loads an IntelliJudge capture file (or files) and a WaveJudge capture file created by an IntelliJudge triggered capture, then begins decoding and processing them beginning with the IntelliJudge capture. When selecting the files, if you select only one format WaveJudge will locate a file with the same name and the other extension. For example, if you select a WaveJudge capture file with a `.vsa` extension, the software will automatically try to find a matching file with the same path and name but with the IntelliJudge `.rtphysap` extension.

Open Multiple IntelliJudge Capture Files...

Opens a group of IntelliJudge capture files from the PC as part of a single configuration, and automatically begins decoding and processing them. The files must have been saved as part of a single real-time capture involving multiple IntelliJudges, or a multiple cell configuration on the WaveJudge 5000, and will typically end with a series of numbers before the `.rtphysap` extension. For example, a file set might be named `NewCapture_00.rtphysap` and `NewCapture_01.rtphysap`.

Load IntelliJudge LTE MAC Settings

Loads a previously exported file containing LTE and medium access control (MAC) layer settings and applies it to the currently loaded IntelliJudge capture. Some of the information contained in the LTE MAC settings include the MAC version, C-RNTI values, encryption keys, and RLC setting.

Ctrl+S Save Current Capture...

Saves the currently active capture file or set of capture files; determined by the most recently captured or most recently loaded type of capture.

Ctrl+ShiftS Save Test Configuration...

Saves test configuration settings used during capture and analysis of a file. To reload data into the WaveJudge later, use the Save Test Configuration Settings command to save the current configuration.

Save WaveJudge Capture...

Specifically saves a WaveJudge capture file (RF signal capture) to the PC under a different file name, with the `.vsa` extension. A saved WaveJudge capture file contains both captured RF signal data and configuration settings.

Save WaveJudge Capture Selection As...

Saves only the data from the currently selected time range of the WaveJudge capture, visible as the charts' selected time range, into a WaveJudge capture file (RF signal capture).

Save IntelliJudge Capture...

Specifically saves the current IntelliJudge capture to the PC, as an IntelliJudge capture file under a new file name, with the `.rtphysap` extension. A saved IntelliJudge capture file contains both IntelliJudge real-time decoded physical layer message and configuration setting; which allows you to process and analyze the data at a later time.

Save IntelliJudge Selction Capture As...

Saves the selected range of IntelliJudge messages as a new file with the `.rtphysap` extension.

Save Combined IntelliJudge/WaveJudge Capture...

Specifically saves both the IntelliJudge real-time capture and WaveJudge RF signal capture file created by an IntelliJudge triggered capture. The IntelliJudge capture will save either as a single file, or if necessary as a set of multiple IntelliJudge capture files ending with a series of numbers before the IntelliJudge `.rtphysap` extension; the WaveJudge capture is saved with the `.vsa` extension. This allows the group of files to reload later with the Open Combined IntelliJudge/VSA Capture... command without losing the relationships between them.

Save Multiple IntelliJudge Captures...

Saves an IntelliJudge real-time capture involving multiple IntelliJudge 4900 RTs, or a real-time multiple cell configuration on the WaveJudge 5000, which must save as a set of multiple IntelliJudge capture files. The files save as a group with the same base portion of the name and typically end with a series of numbers before the `.rtphysap` extension. For example, a set of two capture files might save as `NewCapture_00.rtphysap` and `NewCapture_01.rtphysap`.

Load Bookmarks

Opens a window to load a bookmark file. The file extension is *.bookmark and is identified as a Bookmark file.

Save Bookmarks

Saves an active IntelliJudge and/or WaveJudge message list bookmark.

When you highlight a selected range of message list lines by using Shift with a mouse click, either for the IntelliJudge Message List or the WaveJudge Message List, WaveJudge puts a pair of colored markers into the scroll bar, for the range's beginning (green) and end (red.)

By clicking the green line in the scroll bar for the beginning, or the red line for the end, you can jump immediately to the beginning or end of the selected range, without changing the selection. Hovering over either the line in the scrollbar will show a description of what it means, 'Selection Start' or 'Selection End'.

WaveJudge also supports two Temporary Markers for convenience, which work in a similar way. Holding Control while clicking a line will put 'Temporary Marker 1' there, highlighting the line in orange with a corresponding orange line in the scrollbar. Holding Alt while clicking a line will put 'Temporary Marker 2' there, highlighting the line in violet with a corresponding violet line in the scrollbar. (You may also set them by selecting a line, right-clicking, clicking 'Mark Message with...' on the second line of the popup context menu, and then choosing 'Temporary Marker 1 or 'Temporary Marker 2'.) You can likewise see their label by hovering over its line, or jump immediately to either of marker by clicking its line in the scroll bar without affecting the selection.

When this is not enough, or if you want to make a more permanent note or annotation on something of importance, the Bookmarks feature allows users to annotate a capture’s message lists with "bookmarks" containing a description, color code, and optional notes.

To add a bookmark on a message, select the message, right-click, choose Mark Message with... on the second line of the popup context menu, then choose New Bookmark. A popup edit box will appear allowing you to create it and set its name, color, and notes.

Like the selection range or Temporary Markers, Bookmarks will highlight a line in the chosen color, appear in the scrollbar as the highlighted color lines indicating their relative position in the list. Clicking the line will jump directly to that position within the list. Unlike the Temporary Markers, you may give your bookmark a name and add notes to it - when you point to the line in the message list or the scroll bar, a floating bubble will appear with the bookmark name and any notes you added on it.

You can save these annotations as a .bookmarks file which you can then load at a later time to find the messages you were interested in, or send the file to another user looking at the same capture for them to load the bookmarks file, to guide them to points of interest.

Capture Information

Opens a small window that provides data about for the current capture; for a full description refer to section Capture File Information on page 277.

Import

Opens a submenu that may contain different data import options. Normally, only one option is available.

- Import I/Q Samples from Text File...

  Imports a set of I/Q data values as numeric values from the specified ASCII text file. Each line of the file represents a single data sample for Rx Ports 0 - 3. Create the I/Q data file with one of the Export menu commands or use an external software package. Once the data loads it will process automatically. The input file may contain either two numbers per line, which are interpreted as I and Q values for a single port, mapped to Rx Port 0; or four numbers per line, which are interpreted as I and Q values for Rx Port 0, followed by I and Q values for Rx Port 1. Each line may contain up to eight numbers which correspond to Rx Ports 0 - 3. If the file contains a single channel of data it will always load into Rx Port 0.

- Import I/Q Sample Import with Options...

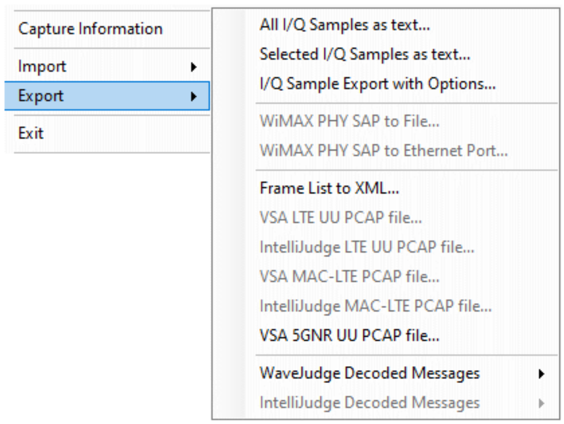
  I/Q import is based on the number of ports configured where there is a 1:1 mapping between I/Q column pairs and ports. In addition to the ports, the bandwidth and sampling rates must match.

  If using CA bandwidth then the I/Q samples must equal the aggregated bandwidth across multiple carriers.

After loading a configuration that matches the I/Q samples, click an I/Q sample file to process. Additional configuration information is required such as Edit Schedule, UE Configuring Dedicated Parameters, etc., to process and schedule the data.

Export

Opens a submenu containing many different data export options. For full descriptions of all submenu options, refer to Export Options on page 315.

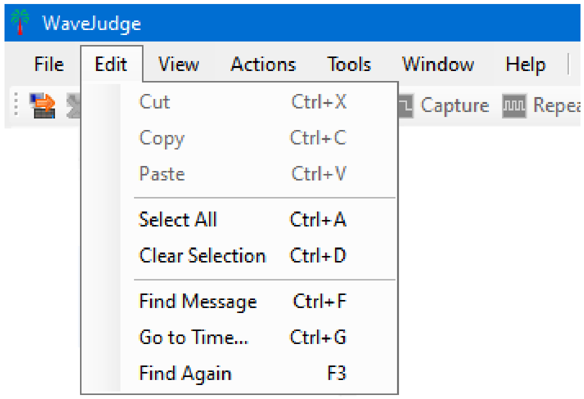


Exit

Exits WaveJudge software.

5. 1. 2 Edit Menu

The Edit menu provides options to cut, copy, paste, and select file options.



Edit Menu

The Edit menu options are described below.

Ctrl+X Cut

Currently disabled; “cuts” selected data and saves it to the clipboard.

Ctrl+C Copy

Currently disabled; copies selected data and saves it to the clipboard.

Ctrl+V Paste

Currently disabled; pastes data that was copied or cut and saved to the clipboard.

Ctrl+A Select All

Selects the entire time range of the current WaveJudge capture then applies it to all active charts set to **Selection** and to the PHY frame lists.

Ctrl+D Clear Selection

Clears the selection so that no time range is selected for all active charts.

Ctrl+F Find Message

Opens a Find Message window where you can search the WaveJudge or IntelliJudge Message List for a message matching a specific name or value. For details, refer to Find Message Window on page 320.

Ctrl+G Go To Time...

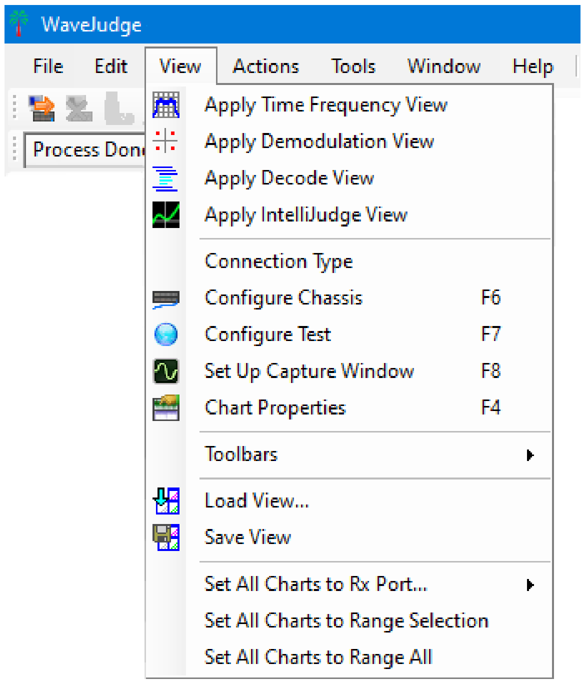
Opens a Go To Selected Time window allowing you to move the selection and display to an exact time in the IntelliJudge Message List. Specify the relative time in hours, minutes, seconds, and milliseconds as HH:MM:SS.MS. For details, refer to Go to Time on page 321.

F3 Find Again

Automatically repeats the last search made via the Find Message window beginning from the current line in the message list. If no previous search was made it will open the Find Message window as the Find Message menu selection does. For details, refer to Find Message Window on page 320.

5. 1. 3 View Menu

The View menu is where you set the display attributes.



View Menu

The View menu options are described below.

Apply Time Frequency View

Changes all chart displays to a preset Time Frequency view for radio frequency (RF) analysis and verification of overall RF characteristics including the Spectrogram, CCDF, Time Domain Power, and Spectral Power charts. This has the same effect as the Apply Time Frequency View button on the standard toolbar.

Apply Demodulation View

Changes all chart displays to a preset demodulation view suitable for modulation quality analysis including the Constellation, Time Domain Power, RCE Per Symbol, RCE Per Subcarrier, and Estimated Frequency charts, as well as the Summary statistics. This has the same effect as the Apply Demodulation View button on the standard toolbar.

Apply Decode View

Changes all chart displays to a preset decode view suitable for PHY/MAC correlation including the WaveJudge Messages List, 2D Logical charts, and enabling selection mode for the Constellation, Time Domain Power, 2D Logical, RCE Per Subcarrier, Channel Decoding charts, as well as the Summary statistics. Use the Selection mode on charts to allow timestamp and physical transmission correlation between messages, frames, and charts. See Correlation LTE on page 479. This has the same effect as the Apply Decode View button on the standard toolbar.

Apply IntelliJudge View

Changes all chart displays to a preset IntelliJudge view, suitable for real-time capture analysis while taking and processing an IntelliJudge capture, including the IntelliJudge Subframe RSRQ, IntelliJudge Subframe RSRP, IntelliJudge CRS SINR, and IntelliJudge Throughput PDSCH charts. These charts display an overview of some critical signal quality and signal strength measurements while capturing in real-time. This has the same effect as the Apply IntelliJudge Chart View button on the standard toolbar.

Connection Type

Select this option to open the Choose Connection Type window. This has the same effect as the Connect Type button on the Configure Buttons toolbar on the left edge of the main window; for more information see Connect Type Button on page 232.

F6 Configure Chassis

Select this option to open the Configure Chassis or Configure WaveJudge 5000 System window. This has the same effect as the Configure Chassis button on the Configure Buttons toolbar on the left edge of the main window; for more information see Configure Chassis Button on page 233.

F7 Configure Test

Select this option to open the Configure Test window. This has the same effect as the Configure Test button on the Configure Buttons toolbar on the left edge of the main window; for more information see Configure Test Button on page 234.

F8 Set Up Capture

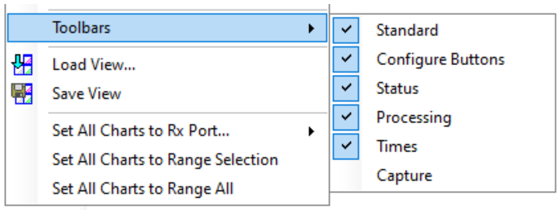
Select this option to open the Set Up Capture window. This has the same effect as the Set Up Capture button on the Configure Buttons toolbar on the left edge of the main window; for more information see Set Up Capture Button on page 235.

F4 Chart Properties

Select this option to open the Chart Properties window. This has the same effect as the Chart Properties button on the Configure Buttons toolbar on the left edge of the main window; for more information see Chart Properties Button on page 236.

Toolbars

Opens the Toolbars submenu and provides controls regarding which toolbars (groups of graphic buttons and displays) to display in the user interface. Within the Toolbars submenu, you can enable or disable the following tool groups.

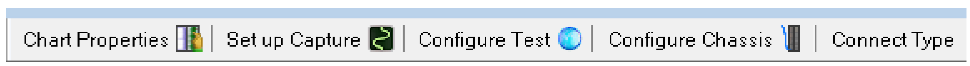


- ToolbarsStandard

  Enables or disables the Standard toolbar, normally shown just under the main menu.

- ToolbarsConfigure Buttons

  Enables or disables the Configure Buttons toolbar at the left edge of the window.

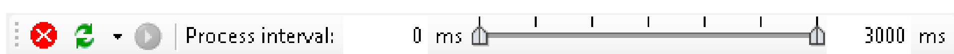


- ToolbarsStatus

  Enables or disables the small Status toolbar.

- Toolbars Processing

  Enables or disables the optional Processing toolbar.



- ToolbarsTimes

  Enables or disables the small Times toolbar.

- ToolbarsCapture

  Enables or disables the optional Capture toolbar.

Load View...

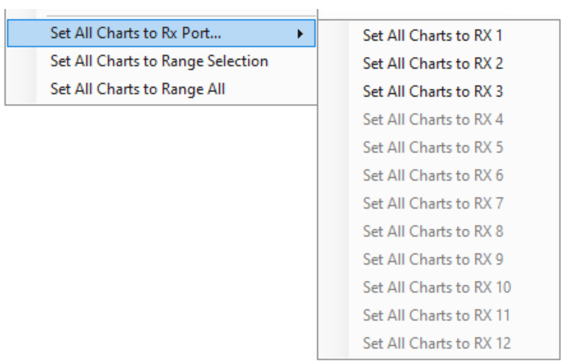
Opens a file window to load a previously saved WaveJudge “view” which is an arrangement of panels, charts, and chart options from a `.vw` file. This has the same effect as the Load View button on the standard toolbar.

Save View

Saves the current arrangement of panels, charts, and chart options as a WaveJudge “view” to a user-specified `.vw` file. This has the same effect as the Save View button on the standard toolbar.

Set All Charts To Rx Port ...

Opens the Set All Charts To Rx Port... submenu where you can set all charts to a particular source of data. The menu items for the ports are updated and labeled dynamically according to the current state of the software. If offline and working with a saved capture file, the ports are labeled “Virtual Rx Port” and begin with Port 0 to match the way the ports are labeled in the Configure Test window. When connected to a WaveJudge chassis and working with a live capture the ports are labeled to match the physical input they represent on the type of WaveJudge chassis in use.



- ViewSet All To Charts To Rx Port 1

  Sets all charts to display data relating to virtual Rx Port 1 in the configuration. Charts (such as the Constellation chart) that relate to a group of ports (a downlink or uplink channel) are set to the group this port belongs to; charts that relate to a specific cell are set to the cell this port belongs to.

- ViewSet All To Charts To Rx Port 2

  Sets all charts to display data relating to virtual Rx Port 2 in the configuration. Charts (such as the Constellation chart) that relate to a group of ports (a downlink or uplink channel) are set to the group this port belongs to; charts that relate to a specific cell are set to the cell this port belongs to.

  ViewSet All To Charts To Rx Port 3

  Sets all charts to display data relating to virtual Rx Port 3 in the configuration. Charts (such as the Constellation chart) that relate to a group of ports (a downlink or uplink channel) are set to the group this port belongs to; charts that relate to a specific cell are set to the cell this port belongs to.

Similar entries appear for every valid port in the current configuration. This submenu shows any port that you can define, however only the menu entries for ports that are actually in use are enabled.

Set All Charts To Range Selection

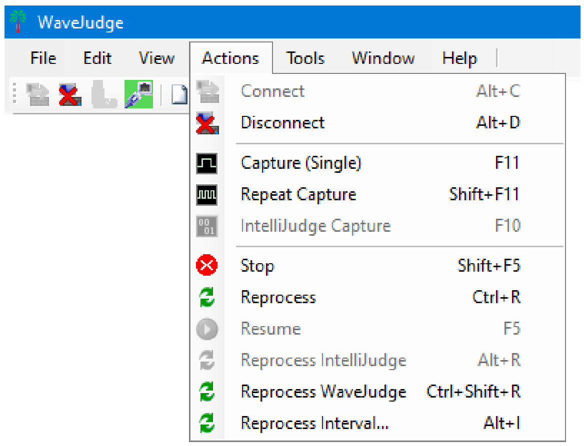
Sets all charts that support a “Selection” range to display only the selected time range or message from the current WaveJudge capture.

Set All Charts To Range All

Sets all charts that support a range of “All” to display all data from the current WaveJudge capture.

5. 1. 4 Actions Menu

The Actions Menu lists actions associated with connecting to or disconnecting from a WaveJudge capture system, capturing, and processing data. All of the actions on this menu also appear on one or more toolbars and can be performed through the keyboard shortcuts listed in this section.



Actions Menu

AltC Connect

Connect begins the sequence to connect a WaveJudge chassis for data capture; this may be a multi-step process. This has the same effect as the Connect button on the standard toolbar. Connecting to a WaveJudge system is discussed in detail in WaveJudge 5000 Modules on page 40.

AltD Disconnect

Disconnect disconnects from a WaveJudge system which had been previously connected to for data capture. This has the same effect as the Disconnect button on the standard toolbar. Disconnecting from a WaveJudge system is discussed in detail in WaveJudge 5000 Modules on page 40.

F11 Single Capture (Single)

Capture starts taking a WaveJudge capture of RF signal data. This has the same effect as the Capture button on the standard or Capture toolbar. Capturing RF signals with a WaveJudge system is discussed in detail in the Capture Toolbar on page 229.

ShiftF11 Repeat Repeat Capture

Repeat Capture starts taking a series of WaveJudge captures of RF signal data. This has the same effect as the Repeat button on the Standard or Capture toolbar. When taking a repeat capture, usually of very short time intervals, WaveJudge begins capturing the data. Once triggered it will download, process, and display the data. After a short delay it will begin capturing again, thus the charts and message lists are all periodically updated. Capturing RF signals with a WaveJudge system is discussed in detail in Capture Toolbar on page 229.

F10 IntelliJudge IntelliJudge Capture

IntelliJudge Capture starts taking an IntelliJudge real-time capture of already-decoded data, decoded in real-time by a WaveJudge 5000 real-time system or an IntelliJudge 4900 RT. This has the same effect as the IntelliJudge button on the Standard or Capture toolbar. Capturing IntelliJudge data with a WaveJudge 5000 system is discussed in detail in Capture Toolbar on page 229.

ShiftF5 Stop

Stops any capture in progress and stops all processing of a WaveJudge or IntelliJudge capture. This has the same effect as the Stop button on the Standard or Processing toolbar.

CtlR Reprocess

Reprocess stops any processing of a WaveJudge or IntelliJudge capture in progress. If there is a single unambiguous capture type to process, it begins processing the current WaveJudge or IntelliJudge capture from the beginning. This has a similar effect to the Reprocess button on the Standard or Processing toolbar except that it does not drop-down a menu if it is not clear what it should process.

F5 Resume

Resume begins processing the current WaveJudge capture if it had been stopped, continuing from the point where it ended. This has the same effect as the Resume button on the Standard or Processing toolbar.

AltR Reprocess IntelliJudge

Reprocess IntelliJudge stops any processing of a WaveJudge or IntelliJudge capture in progress. If there is an IntelliJudge capture present then it begins processing the current IntelliJudge capture from the beginning. This has the same effect as the Reprocess IntelliJudge drop-down menu selection on the Processing toolbar.

Ctrl+ShiftR Reprocess WaveJudge

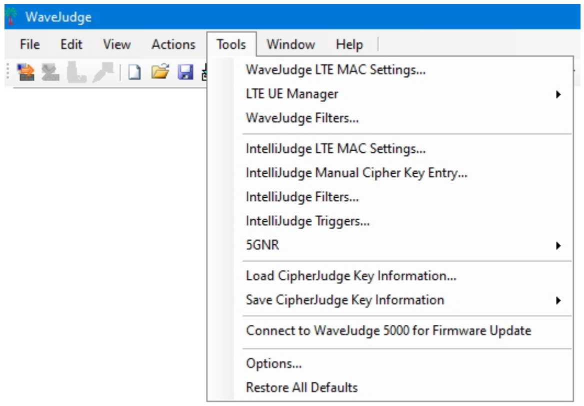
Reprocess WaveJudge stops any processing of a WaveJudge or IntelliJudge capture in progress. It then begins processing the current WaveJudge capture from the beginning. This has the same effect as the Reprocess IntelliJudge drop-down menu selection on the Processing toolbar.

AltI Reprocess Interval

Reprocess Interval stops any processing of a WaveJudge or IntelliJudge capture in progress. It then begins processing a specific time interval within the current WaveJudge capture beginning at the start time shown in the Process Interval. This has the same effect as the Reprocess IntelliJudge drop-down menu selection on the Processing toolbar.

5.1.5 Tools Menu

The Tools Menu provides a list of windows to access different capture tool settings.



Tools Menu

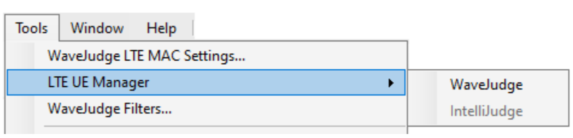
The Tools Menu options are described below.

WaveJudge LTE MAC Settings...

Opens an LTE MAC Settings window to configure LTE MAC Settings (higher layer decoding options) for the WaveJudge capture. Using the LTE MAC Settings window to decipher is discussed in IntelliJudge LTE MAC Settings for CipherJudge on page 530.

LTE UE Manager

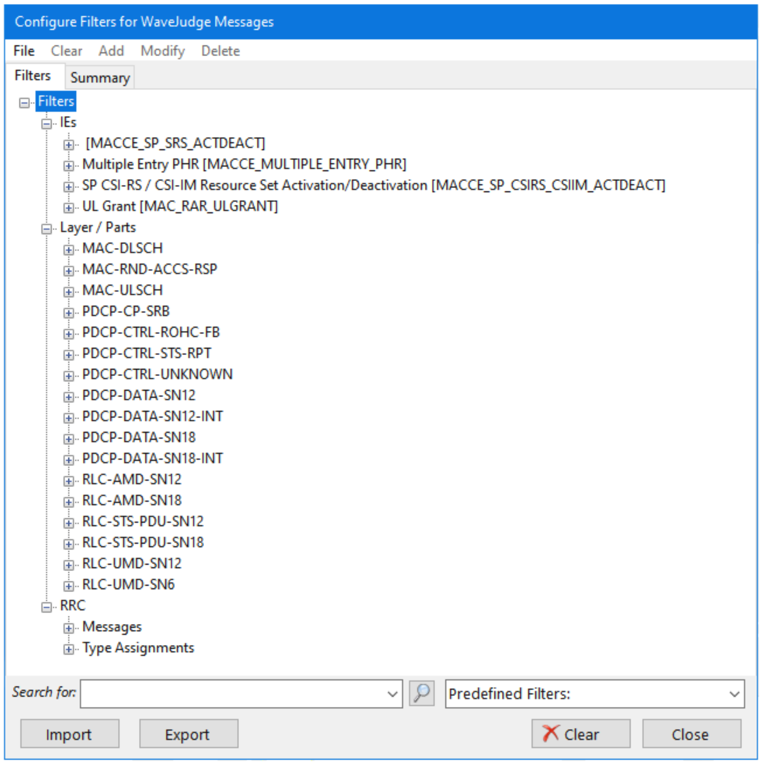
Opens a submenu to select which UE Manager window to display. The LTE UE Manager window is simply a scrollable display listing the RNTIs identifiable for all UEs on one of the captures in process. Where the higher-layer processing code can identify that a succession of RNTIs are associated with or belong to the same actual UE, they are grouped together into a single entry.



- LTE UE ManagerWaveJudge opens the LTE UE Manager on page 309 display for the current WaveJudge capture.
- LTE UE ManagerIntelliJudge opens the LTE UE Manager on page 309 window display for the current IntelliJudge capture.

WaveJudge Filters

Opens a Configure Filters for WaveJudge Messages window to configure the WaveJudge message list filters; use this option to automatically highlight and screen higher layer messages in the WaveJudge Message List based on a number of criteria.



Configure Filters for WaveJudge Messages Window

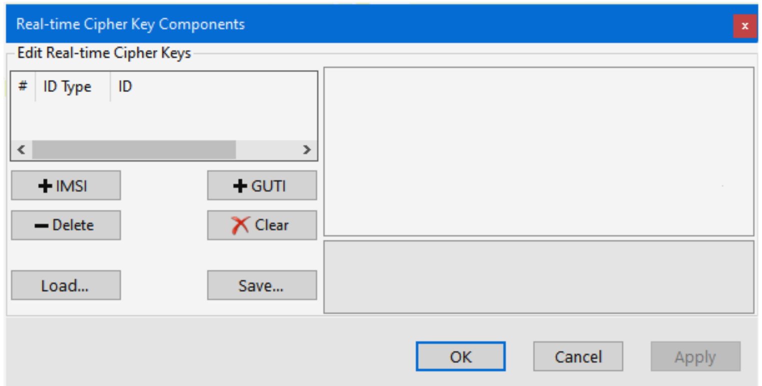
Using the **Configure Filters** window is discussed in detail in Configure Filters on page 287. Configuration and use of the message list filters are discussed in detail in Filtered Messages on page 495.

IntelliJudge LTE MAC Settings...

Opens an **LTE MAC Settings** window for IntelliJudge to configure the LTE MAC Settings (the higher layer decoding options) for the IntelliJudge capture. Using the LTE MAC Settings window is discussed in Radio Link Control (RLC) on page 474.

IntelliJudge Manual Cipher Key Entry...

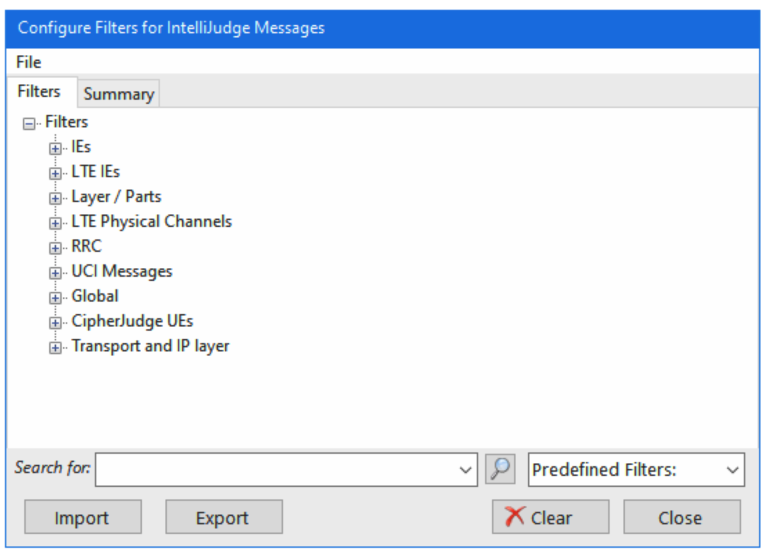
Opens the **Real-time Cipher Key Components** form. Use this form to manually configure LTE cipher keys and associate them with specific UEs via either a GUTI or IMSI entry. This is useful to decipher IntelliJudge captures specifically when using the Test USIM replacement for a normal UE SIM card. For more information, see the general discussion about deciphering in CipherJudge Hardware Kit on page 515.



Real-Time Cipher Key Components Window

IntelliJudge Filters...

Opens a **Configure Filters for IntelliJudge Messages** window to configure the IntelliJudge Message List filters. Use this form to automatically highlight and screen higher layer messages in the IntelliJudge message list based on a number of criteria you select.

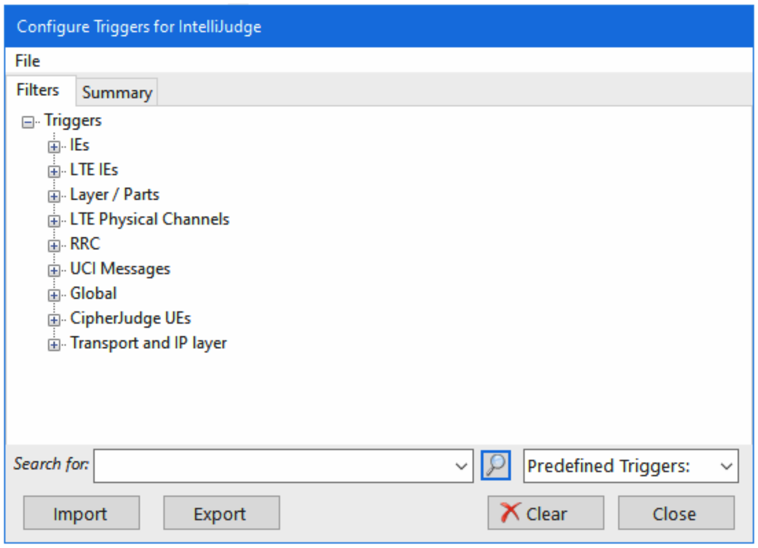


Configure Filters for IntelliJudge Messages Window

Using the **Configure Filters** window is discussed in more detail in the Configure Filters on page 287 section and configuration of the message list filters is discussed in detail in Filtered Messages on page 495.

IntelliJudge Triggers...

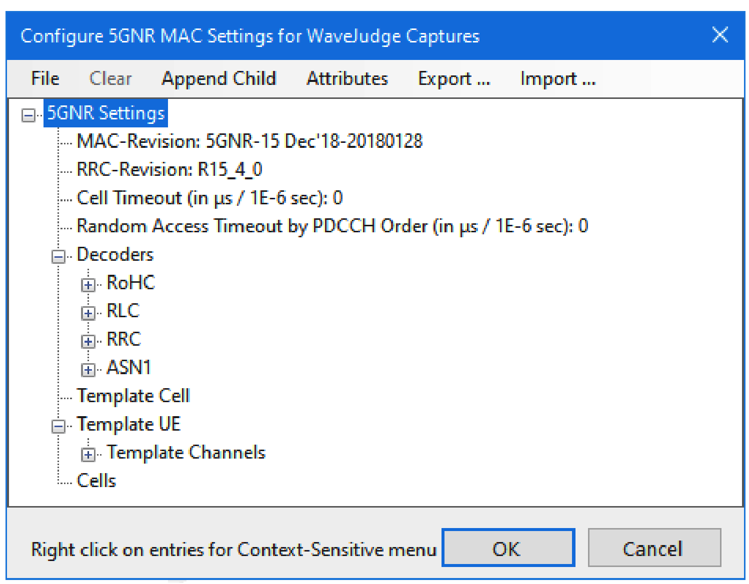
Opens the **Configure Triggers for IntelliJudge** window, for example, a special version of the **Configure Filters** window, to configure IntelliJudge triggers. When taking and processing an IntelliJudge capture, and when a message is processed that matches an IntelliJudge trigger, the software will automatically trigger a WaveJudge capture synchronized to the time for that message on the IntelliJudge. This provides a very powerful technique for in-depth troubleshooting. For more discussion of this topic, see the Configure Triggers Window on page 328.



Configure Triggers for IntelliJudge Window

5G NR

Opens the submenu Configure the MAC Settings for WaveJudge Captures.



5G MAC Settings Window

Load CipherJudge Key Information...

Opens a file window to load a previously saved CipherJudge key file with a `.cjkeys` extension into the software. This is generally required to allow decryption of a previously captured IntelliJudge or WaveJudge capture file that was captured together with a set of keys from CipherJudge (or in some cases with keys manually entered via the IntelliJudge Manual Cipher Key Entry... form.) For more information, see the discussion of deciphering in CipherJudge Hardware Kit on page 515.

Save CipherJudge Key Information

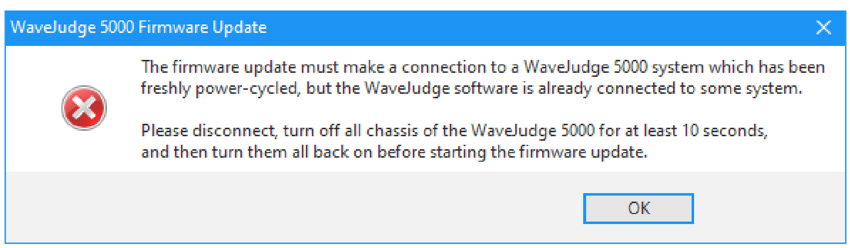
Opens a submenu to select which keys to save for the associated capture:

- Save CipherJudge Key Information From WaveJudge Capture... saves the CipherJudge key set associated with the current WaveJudge capture.
- Save CipherJudge Key InformationFrom IntelliJudge Capture... saves the CipherJudge key set associated with the current IntelliJudge capture.

Either choice opens a file window to save that capture's decryption key information as a CipherJudge key file with a `.cjkeys` extension. Always save this file because it is required to allow decryption of an IntelliJudge or WaveJudge capture file that was decrypted using cipher keys (retrieved via CipherJudge or manually entered cipher keys). For more information, see the discussion of deciphering in CipherJudge Hardware Kit on page 515.

Connect to WaveJudge 5000 for Firmware Update

Click this option to check for firmware updates. The following warning window will appear, confirm all WaveJudge chassis are turned off for at least 10 seconds. Click OK to continue.



The Select Form will open and show a list of chassis on your network; details for each chassis include the IP address, network name, user, serial number, and version.

Options

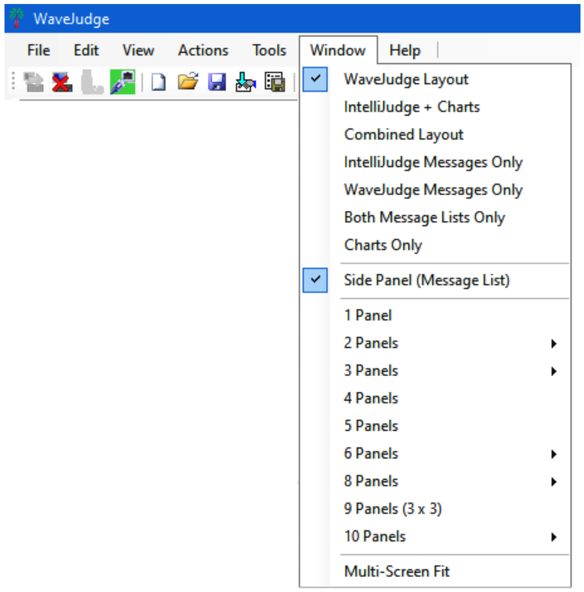
Opens the Options window, which controls various options for the WaveJudge software to update data that are usually not updated in the course of capturing or analyzing. The Options window is discussed in detail in Options Window on page 311.

Restore All Defaults

This selection is rarely needed, use it only if there is some persistent problem with a saved configuration file setting. This command erases the current default setting files and restores the software to a default state, recopying the chart settings, configuration, and LTE settings from the original files which came with the software installer.

5.1.6 Window Menu

The Window Menu determines the layouts, charts, and panel displays for your data.



Window Menu

The Window Menu options are described below.

WaveJudge Layout

Selects the normal overall layout to view WaveJudge captures. This is the original layout for the WaveJudge software that shows the PHY Frames List, the Side Panel (normally the WaveJudge Messages List) and the main Charts Panel area with any charts that are selected. The IntelliJudge Messages List is hidden.

IntelliJudge + Charts

Selects the normal overall layout to view IntelliJudge captures. It shows the IntelliJudge Messages List and the main Charts Panel area with whatever charts are selected. The PHY Frames List and the WaveJudge Messages List are hidden.

Combined Layout

Selects all display panels including the IntelliJudge Messages List, the PHY Frames List, the Side Panel (normally the WaveJudge Messages List) and the main Charts Panel area with whatever charts are selected. Use this view to analyze a combined IntelliJudge and WaveJudge capture.

IntelliJudge Messages Only

Shows only the IntelliJudge Messages List in the main window area. The PHY Frames List, the WaveJudge Messages List and the Charts Panel are hidden.

WaveJudge Messages Only

Shows only the Side Panel with the WaveJudge Messages List in the main window area. The IntelliJudge Messages List, the PHY Frames List, and the Charts Panel are hidden.

Both Message Lists Only

Selects an overall layout showing only the IntelliJudge Messages list and the Side Panel (normally the WaveJudge Messages list.) The PHY Frames List and the Charts Panel are hidden.

Charts Only

Shows only the Charts panel in the main window area, with the open charts selected. The IntelliJudge Messages List, the PHY Frames List, and the the Side Panel with the WaveJudge Messages List are hidden.

Side Panel (Message List)

Toggles to either hide or show the Side Panel chart, which normally contains the WaveJudge Messages List.

1 Panel

Sets the Chart Panel area to display only one chart panel.

2 Panels

Displays a submenu to select a layout of the chart panel using only two panels; the submenu selects a vertical or horizontal layout:

- 2 Panels2 panels (Vertical)
- 2 Panels2 panels (Horizontal)

3 Panels

Displays a submenu to select a layout of the chart panel using three panels; select a vertical or horizontal layout:

- 3 Panel3 panels (Vertical)
- 3 Panel3 panels (Horizontal)

4 Panels

Sets the Chart Panel area to display four panels in a rectangular two by two layout, as used for the preset Time Frequency view.

5 Panels

Sets the Chart Panel area to display five panels in a two column format as used for the preset.

6 Panels

Displays a submenu to select a layout of the chart panel using six panels; select one of three layout options:

- 6 Panels...with Constellation
- 6 Panels6 panels (Horizontal / 3 x 2)
- 6 Panels6 panels (Vertical / 2 x 3)

8 Panels

Displays a submenu to select a layout of the chart panel using eight panels; select a vertical or horizontal layout:

- 8 Panels8 panels (Horizontal / 4x 2)
- 8 Panels8 panels (Vertical / 2 x 4)

9 Panels (3 x 3)

Displays nine panels; three columns with three columns.

10 Panels

Displays a submenu to select a layout of the chart panel using ten panels; select a vertical or horizontal layout:

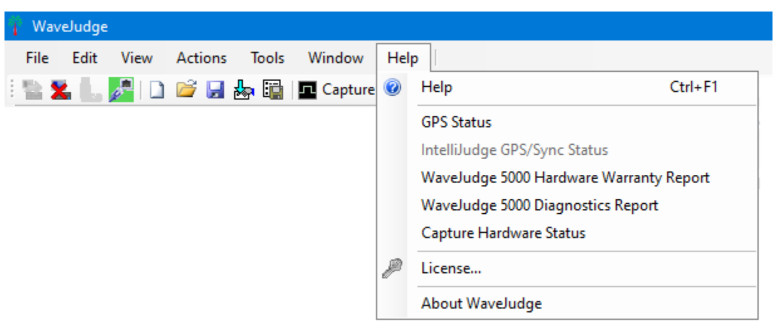
- 10 Panels10 panels (Horizontal / 5 x 2)
- 10 Panels10 panels (Vertical / 2 x 5)

Multi-Screen Fit

Resizes the main WaveJudge window to fit across all screens of a multiple-monitor system.

5. 1. 7 Help Menu

The Help Menu provides quick access to common tasks so you don't have to look them up. To open Help, select the Help icon.



Help Menu

TIP F1 opens the Help system.

The Help Menu options are described below.

Ctrl+F1 Help

Opens the Online Help system, starting with the table of contents.

GPS Status

Opens the GPS Status window; this is only active when connected to a WaveJudge system. The GPS Status window displays information on the GPS module (which is used as an optional precision time source in the WaveJudge chassis) including its current status, the GPS input signal status, and the precision of its time signal. The contents of the GPS Status window are discussed further in GPS Status Window on page 325.

IntelliJudge GPS/Sync Status

Opens the IntelliJudge GPS/Sync Status window, it is normally used only with the IntelliJudge 4900 real-time (RT) system. It is only active when connected to a WaveJudge/IntelliJudge system. The IntelliJudge GPS/Sync Status window displays combined information on the status of the IntelliJudge and the GPS module including its current status, the GPS input signal status, and the precision of its time signal. They are displayed together in this form because IntelliJudge uses the GPS signal for precise synchronization of dual IntelliJudge 4900 RT systems as well as for the time information in the message data it reports during a capture. The contents of the IntelliJudge GPS/Sync Status window are discussed further in GPS Status Indicator on page 325.

WaveJudge 5000 Diagnostics Report

This begins a series of windows and prompts to walk you through selecting a filename to save a diagnostic report, followed by connecting to a WaveJudge 5000 on the network, then retrieving and saving a diagnostic report from it.

NOTE **This selection is normally used only when the Keysight support group asks you to provide a diagnostic report for a WaveJudge 5000 that is experiencing problems.**

Capture Hardware Status

Opens a special diagnostic window for the WaveJudge 4900; this is only active when connected to a WaveJudge 4900 or a WaveJudge 4900/IntelliJudge 4900 RT system. This provides limited diagnostic information for the WaveJudge 4900's hardware status.

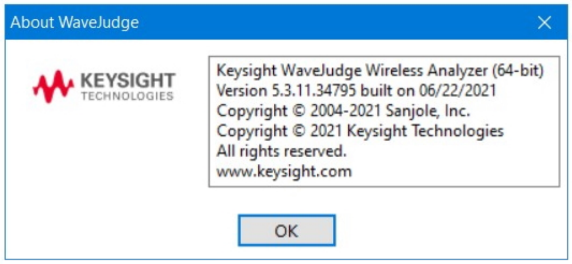
NOTE **This selection is normally used only when the Keysight support group asks you to provide diagnostic information for a WaveJudge 4900 or IntelliJudge 4900 RT which is experiencing problems capturing data.**

License...

Opens the Using the WaveJudge License Window on page 603. Use this option to view the list of currently licensed and enabled features in WaveJudge and to locate information about the license source providing those features.

About WaveJudge

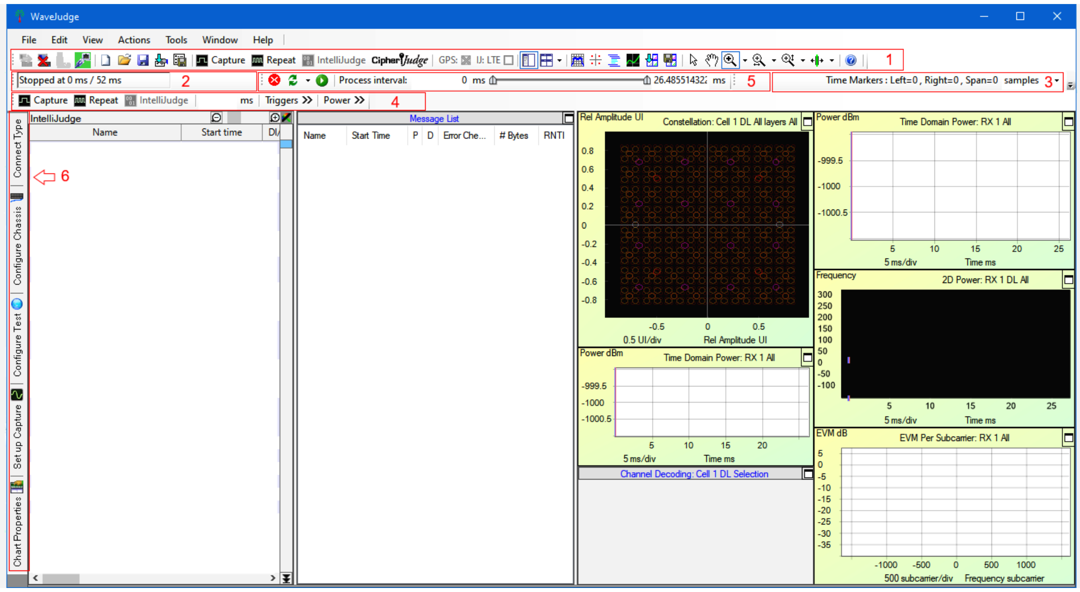
Opens the **About WaveJudge** window to display the WaveJudge version, memory model, release date, and copyright information.



About WaveJudge Window

5. 2 Toolbars

The WaveJudge user interface has six toolbars, as indicated in the figure below.

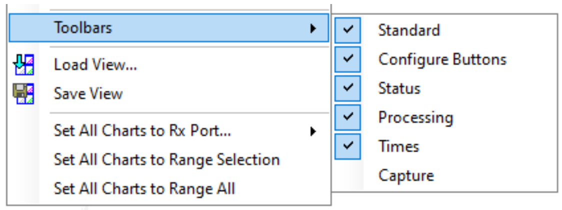


Six Toolbars on the User Interface

Each toolbar is described in the following subsections.

1. Standard Toolbar on page 221
2. Status Toolbar on page 228
3. Times Toolbar on page 229
4. Capture Toolbar on page 229
5. Processing Toolbar on page 230
6. Configure Buttons Toolbar on page 231

If your screen does not show any or all of these tool bars click the View Menu, scroll down to Toolbars, and select each tool bar as needed.

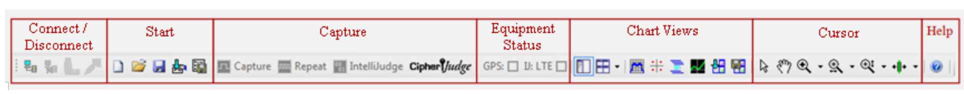


Scroll Down the View Menu to Select Toolbars Options

5. 2. 1 Standard Toolbar

The Standard Toolbar has seven groups of tools; each group is described in detail below.

1. Connect/Disconnect Tool Group on page 221
2. Start Tool Group on page 222
3. Capture Tool Group on page 223
4. Equipment Status Tool Group on page 224
5. Chart Views Tool Group on page 225
6. Cursor Tool Group on page 226
7. Help on page 228



Standard Toolbar

5. 2. 1. 1 Connect/Disconnect Tool Group

The **Connect/Disconnect Tool Group** buttons provide visual confirmation for each component that is plugged in and properly configured. An icon that is greyed-out indicates the item is either not in use or is not properly configured.

Standard Toolbar - Connect/Disconnect Tool Group

The connect/disconnect buttons are described below.

 **Connect / Disconnect**

Connects/disconnects your PC to/from the WaveJudge unit through the USB port. Once cabled, click the Connect button to load FPGA files to the hardware to operate the WaveJudge wireless network analyzer.

USB Status / Gb Ethernet Status

Displays the USB status, if connected. If USB is not connected then the icon is greyed-out. Displays the Gb Ethernet status, if connected. If an Ethernet cord is not connected then the icon is greyed-out.

5. 2. 1. 2 Start Tool Group

The Start Tool Group consists of five icons that prompt common actions such as start or open a new test, save to your computer, download test configuration settings, and save test confirmation settings.

Standard Toolbar - Start Tool Group

The Start Tool Group buttons are described below.

New/Open/Save

Press the New button to clear the charts.

The Open and Save buttons open/save files from/to your PC for WaveJudge software analysis. You can load files from any PC with a WaveJudge user license that allows offline analysis. A saved file contains both captured data and configuration settings.

Open Test Configuration

Loads test configuration settings to use for data capture and analysis. You can use this tool to change configuration settings on any loaded file.

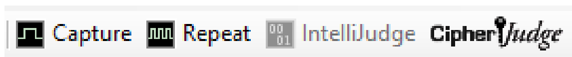
NOTE Configuration settings are applied to a buffer as it is captured from the WaveJudge hardware or imported into the software; therefore, load the preconfigured Test Configuration settings prior to capturing or importing a signal. Test Configuration settings were previously known as PHY/MAC settings.

Save Test Configuration

Saves Test Configuration settings used during capture and analysis of a file. To reload data into the WaveJudge later, use the Save Test Configuration button to save the current configuration.

5. 2. 1. 3 Capture Tool Group

The **Capture Tool Group** has four tools to capture and analyze mobile communications including buttons to trigger IntelliJudge or CipherJudge captures.



Standard Toolbar - Capture Tool Group

The Capture Tool Group buttons are described below.

Single Capture (Single)

Capture starts taking a WaveJudge capture of RF signal data. This has the same effect as the Capture button on the Capture toolbar.

Repeat Repeat Capture

Repeat Capture starts taking a series of WaveJudge captures of RF signal data. This has the same effect as the Repeat button on the Capture toolbar. When taking a repeat capture, usually of very short time intervals, WaveJudge begins to capture the data. Once triggered, it downloads, processes and displays the data, and then after a short delay it begins to capture again; thus the charts and message lists are all periodically updated.

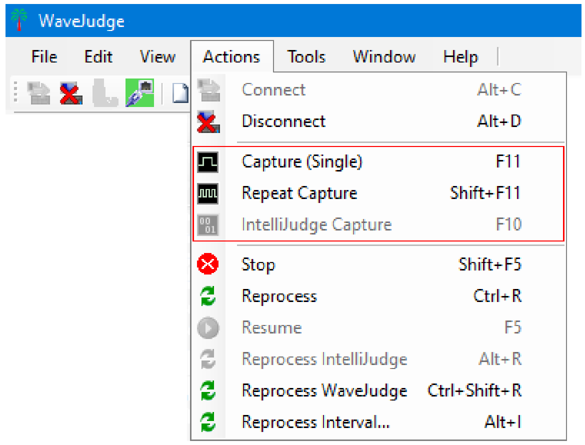
IntelliJudge IntelliJudgeCapture

IntelliJudge Capture starts taking an IntelliJudge real-time capture of already-decoded data, decoded in real-time by a WaveJudge 5000 real-time system or an IntelliJudge 4900 RT. This has the same effect as the IntelliJudge button on the Capture toolbar.

CipherJudge CipherJudge

Launches the separate CipherJudge application, which is usually required when using a live network with encryption enabled to access the keys from a UE (mobile device) SIM card.

Most of the Capture Tool Group commands are also available on the **Actions** menu. For additional information, refer to the Capture Toolbar on page 229 section.



Actions Menu - Capture Tool Group

5. 2. 1. 4 Equipment Status Tool Group

The Equipment Status tool group has two buttons with status icons: GPS and IntelliJudge: LTE.

Standard Toolbar - Equipment Status Tool Group

The two Equipment Status buttons are described below.

GPS

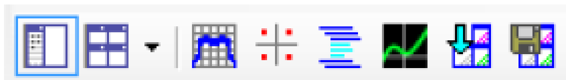
- Provides GPS status and control
- Gray: Disabled
- Red-Orange: Lock Lost
- Green: Locked
- Clicking the button will reset the GPS unit.

IntelliJudge (IJ) LTE

- Provides status and control
- Gray: Disabled

5. 2. 1. 5 Chart Views Tool Group

The Chart Views Tool Group has three sections: panel layout, preconfigured analysis views, and a load/save view section. To see the name of an icon simply hover your cursor over it.



Standard Toolbar - Chart Views Tool Group

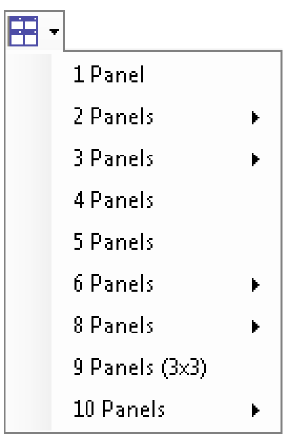
These buttons let you configure the charts in a variety of viewing modes and layouts and control how they present data. You can resize all of the panes and view any chart in any pane.

Side Panel

Adds/removes the Side Panel next to the main charts panel; normally displays the WaveJudge Messages list.

Panel Layout

Click the arrow on the right to access the drop-down menu and select one of the many panel layout options.



Apply Time Frequency View

Changes all chart displays to a preset Time Frequency view suitable for RF analysis and verification of overall RF characteristics including the Spectrogram, CCDF, Time Domain Power, and Spectral Power charts. This has the same effect as the Apply Time Frequency View selection on the View menu.

Apply Demodulation View

Changes all chart displays to a preset Demodulation view suitable for modulation quality analysis, including the Constellation, Time Domain Power, RCE Per Symbol, RCE Per Subcarrier, and Estimated Frequency charts, as well as the Summary statistics. This has the same effect as the Apply Demodulation View selection on the View menu.

Apply Decode View

Changes all chart displays to a preset Decode view, suitable for PHY/MAC Correlation, including the WaveJudge Messages List and 2D Logical charts and enabling Selection mode for the Constellation, Time Domain Power, 2D Logical, RCE Per Subcarrier and Channel Decoding charts, as well as the Summary statistics. Using the Selection mode on charts allows timestamp and physical transmission correlation between messages, frames, and charts. See Correlation LTE on page 479. This has the same effect as the Apply Decode View selection on the View menu.

Apply IntelliJudge Chart View

Changes all chart displays to a preset IntelliJudge view, suitable for real-time capture analysis while taking and processing an IntelliJudge capture, including the IntelliJudge Subframe RSRQ, IntelliJudge Subframe RSRP, IntelliJudge CRS SINR, and IntelliJudge Throughput PDSCH charts. These charts display an overview of some critical signal quality and signal strength measurements while capturing in real-time. This has the same effect as the Apply IntelliJudge View > selection on the View menu.

Load View

Opens a file window to load and apply a previously saved WaveJudge “view”, an arrangement of panels, charts, and chart options from a `.vw` file. This has the same effect as the Load View selection on the View menu.

Save View

Saves the current arrangement of panels, charts, and chart options as a WaveJudge “view” to a user-specified `.vw` file. This has the same effect as the Save View selection on the View menu.

5. 2. 1. 6 Cursor Tool Group

The Cursor Tool Group has four components: measure, drag, zoom, and set markers. Select a cursor button to change the behavior relating to the charts.

Standard Toolbar - Cursor Tool Group

The cursor operations buttons are described below.

Measure

Provides the exact measurement WaveJudge has for any point on a chart. Typically provided in X,Y coordinate values. Position the arrow over any point on a chart for measurement values.

Drag

Lets you drag or reposition a chart. This tool is also available by clicking the Shift key and operating the mouse in any other cursor mode.

Zoom

Point, click, and drag the cursor from the upper left to lower right of a chart to zoom in. The size of the square shows the area of interest for zoom-in. Iterative operations provide additional zoom-in capability.

To zoom out one level, press and hold the Ctrl key and click on a chart. To zoom out all the way, point, click, and drag the cursor in the lower right to upper left direction over the chart.

Horizontal Zoom

Allows zoom-in on the X-axis while maintaining Y-axis values. Left to right movement over a chart provides horizontal zoom-in capability. Right to left movement resets the chart to the original view. To zoom out one level, press and hold the Ctrl key and click on a chart.

Vertical Zoom

Allows zoom-in on the Y-axis while maintaining X-axis values. Upper to lower movement provides vertical zoom-in capability. Right to left movement resets the chart to the original view. To zoom out one level, press and hold the Ctrl key and click on a chart.

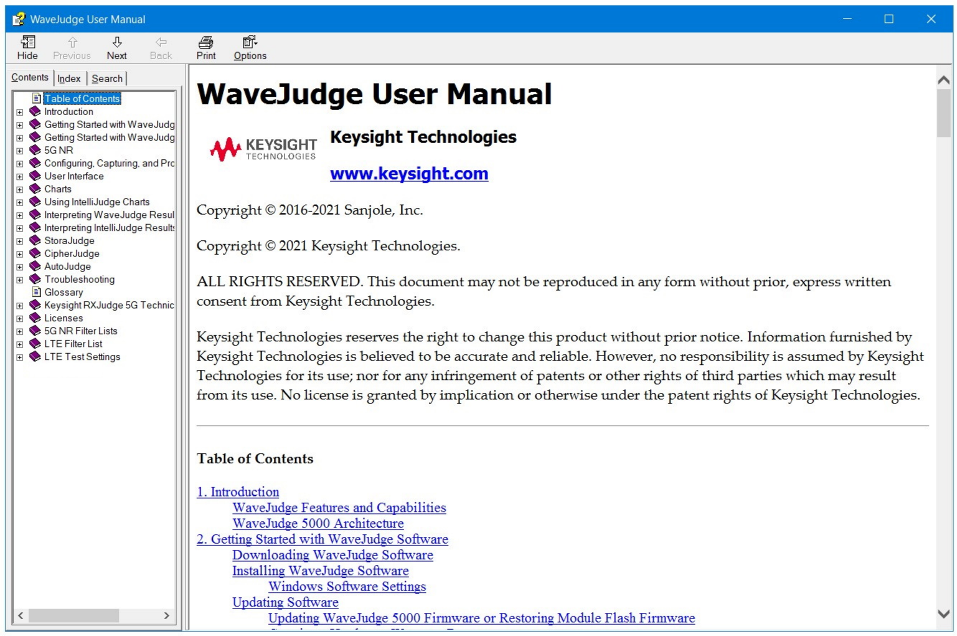
Set Markers

Time range markers let you place markers on a time-domain chart to create a time range interval for measurement, which will be automatically tracked on any chart that has Set Range toSelection enabled (see Set Range to on page 356). To set the markers, click the Set Markers button, click on a chart, and drag over the desired area for the time interval starting from the left-most position and proceeding to the right. This action sets both the left and right markers.

To set the markers separately, activate the drop-down menu next to the Set Markers button and select Left Marker or Right Marker. Click on a chart to apply each marker. The left marker is green and the right marker is red. You must set the left and right markers to determine the time interval selected for analysis. This interval is displayed on the right side of the status bar with units you can select from the Time Markers drop-down menu. The interval also displays on the PHY Frames and the Message List.

5. 2. 1. 7 Help

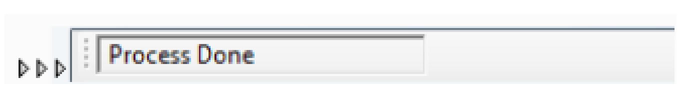
On the Main Menu bar to the far right, click the Help Menu icon Help to access the HTML help file / user manual, as shown below. Or, click the Help Menu icon in the Help Menu.



Help Menu Button Opens the WaveJudge User Manual

5. 2. 2 Status Toolbar

The small Status Toolbar is movable, but most often appears directly under the Standard toolbar; it shows the software's current status to capture or process a capture or file.



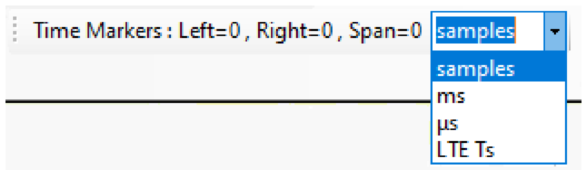
Status Toolbar

The status message box identifies the current capture process status.

- **Process Done:** Capture is idle.
- **Processing + Green Bar:** WaveJudge capture data is processing.
- **Triggered:** Trigger received, capture is initiated.
- **Capturing:** Data is storing in the capture buffer.

5. 2. 3 Times Toolbar

The small Times Toolbar is movable, but most often appears to the right of the window under the standard toolbar; it displays the times associated with the WaveJudge capture's time range selection markers.



Times Toolbar

The Time Markers display specific times associated with the left and right time selection made by the Set Markers tool and the total time span for the selection. This is useful to measure the time period associated with a selection.

Use the drop-down menu to set the time values in one of these units:

- **samples:** actual sample count at the current sampling rate
- **ms:** milliseconds
- µ: microseconds
- **LTE Ts:** LTE sample time unit, of 1 sample at 30.72 MHz (1/30.72 microsecond)

5. 2. 4 Capture Toolbar

The movable Capture Toolbar is optional; if used, it provides a shortcut to some of the controls of the Set Up Capture window, allowing you to quickly change the capture duration or set options relating to the triggers.

Capture Toolbar

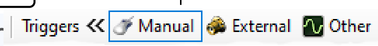
If you enable the Capture Toolbar the three capture buttons, **Capture**, **Repeat**, and **IntelliJudge**, will move from the Standard Toolbar to this one and will continue to function just as they did on the Standard Toolbar. The capture buttons are only enabled when the software is connected to the WaveJudge hardware.

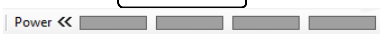
To configure the capture duration (for example, the amount of data stored) enter the time in milliseconds in the Set Up Capture Button on page 235 window.

- Click the Capture button to start a single WaveJudge RF data capture operation.

- Click the Repeat capture button to start a continuous series of WaveJudge RF data capture operations. When you select a Repeat Capture, when the specified trigger occurs, data will automatically download from the hardware into the WaveJudge software and begin processing.

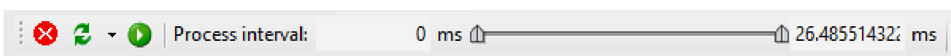
Upon completing the processing cycle and after a brief delay the trigger will automatically rearm and the software will resume waiting for a trigger, download the data, and process it. This cycle continues until you end it by clicking the Stop Processing button.

- Click the IntelliJudge button to start an IntelliJudge capture.
- Click the Triggers >> button to open the icon menu with three options: Manual, External, and Other 

- Click the Power >> button to view the power level.


5. 2. 5 Processing Toolbar

The movable Processing Toolbar is optional; if used, it will most often appear to the right of the Status Toolbar below the Standard Toolbar. If the Processing Toolbar is enabled, the three capture buttons, **Stop**, **Reprocess**, and **Resume**, will move from the Standard Toolbar to this toolbar.



Processing Toolbar

The Processing Toolbar buttons are described below.

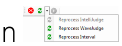
Stop

Stop suspends processing of the WaveJudge or IntelliJudge capture; it will also stop any capture in process and update the display. The message in the Status Toolbar indicates where in the buffer processing stopped. Once processing has stopped the Reprocess or Resume Process buttons are enabled so you can press either one to resume.

Reprocess

Reprocess restarts processing the collected data.

Use this button after you complete a capture/process cycle and change parameters that affect decoding. Or, use it after loading a saved capture file and altering some parameters. If you alter a parameter that affects how data is captured (e.g., bandwidth) and attempt to reprocess already captured or saved data, results will be invalid. In this case, use the Single Capture button to capture a fresh set of data and process it. The Reprocess button is only useful when adjusting parameters that do not affect the capture process itself.

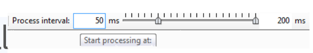
The down arrow next to the **Reprocess** button  indicates it has a drop-down menu. The menu options let you specify exactly what you want to reprocess, if there are possible choices. The drop-down menu options are: Reprocess IntelliJudge, Reprocess WaveJudge, and Reprocess Interval.

Resume Process

Press the **Reprocess Process** button during processing to receive a snapshot of received data. You can continue processing WaveJudge capture data if it was paused using the Stop button. The Resume Process button is only effective if there is unprocessed capture data.

You cannot resume IntelliJudge capture or processing with the Resume button. If you stop processing an IntelliJudge capture before it is complete you must reprocess it from the beginning to continue.

If the Resume Process button is pressed during capture then processing will complete and the data will display, but the software will not return to capture mode.

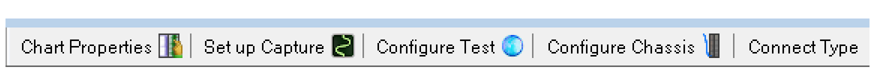
Process Interval 

The Process Interval control lets you select a region of a WaveJudge capture to process by the starting and ending time. Hover the cursor over the left text box to reveal the tool tip “Start processing at:” or over the right text box to reveal the tool tip “End processing at”.

To indicate the time to start processing within a WaveJudge capture, place your cursor in the left text box and type or edit the number for the start time, in milliseconds (ms). To change the time to stop processing place your cursor in the right text box type or edit the number for the ending time, in ms.

5. 2. 6 Configure Buttons Toolbar

The Configure Buttons toolbar is located vertically on the left side of the main WaveJudge window. The figure below shows the buttons from the tool strip rotated horizontally.



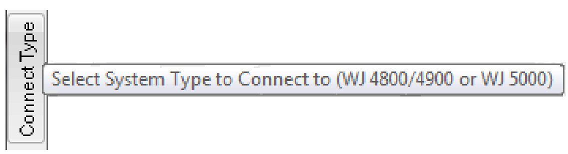
Configure Buttons Toolbar (rotated from vertical position)

There are five Configure Buttons. Each button is descibed in sections below; the sections are in the order you see them on the user interface from the top down. It's also the same order you use to set up the hardware and software, start capturing data, and then analyze the test results.

1. Connect Type Button on page 232
2. Configure Chassis Button on page 233
3. Configure Test Button on page 234
4. Set Up Capture Button on page 235
5. Chart Properties Button on page 236

5. 2. 6. 1 Connect Type Button

The Connect Type button is one of the five vertical buttons located on the left side of the user interface and is also shown as Connection Type in the View Menu. Hover the cursor over the Connect Type button to preview the tool tip text "Select System Type to Connect to (WJ 4800/4900 or WJ 5000)".

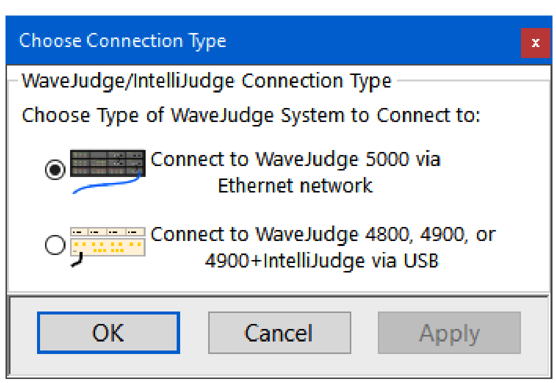


Hover Your Cursor Over the Connect Type Button to Preview the Tool Tip

Click this button to open the Choose Connection Type window.

Choose Connection Type Window

The Choose Connection Type window is where you select the type of WaveJudge System to connect to. If the WaveJudge software detects a WaveJudge chassis attached via USB, both radio button seletions will be enabled. If it does not, only the radio button for Connect to WaveJudge 5000 via Ethernet Network will be enabled.

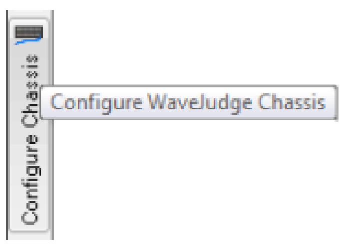


Choose Connection Type Window

If you work with more than one type of WaveJudge hardware system, then before connecting, use this window to select which type of WaveJudge system and the type of connection it uses. It is not normally necessary to use this window if working exclusively with WaveJudge 5000 equipment or if working entirely offline or with imported data.

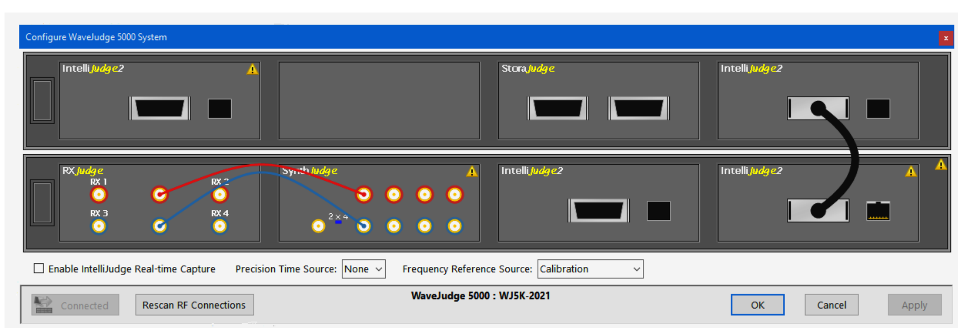
5. 2. 6. 2 Configure Chassis Button

The Configure Chassis button is one of the five vertical buttons located on the left side of the user interface Configure Chassis, and is also shown as Configure Chassis in the View Menu. Hover the cursor over the Configure Chassis button to preview the tool tip text "Configure WaveJudge Chassis".



Hover Your Cursor Over the Configure Chassis Button to Preview the Tool Tip

Click this button to open the correct chassis configuration window for the type of system you are working with. It will automatically open the Configure WaveJudge 5000 System window when working with a WaveJudge 5000.

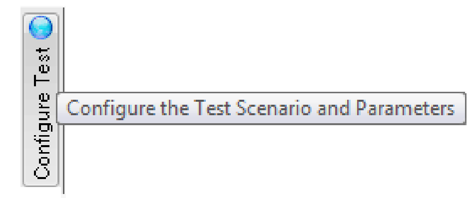


Configure Chassis Button Opens Configure WaveJudge 5000 System Window

For more information, see Configuring the Chassis on page 133 and Configuring the WaveJudge 5000 System on page 133.

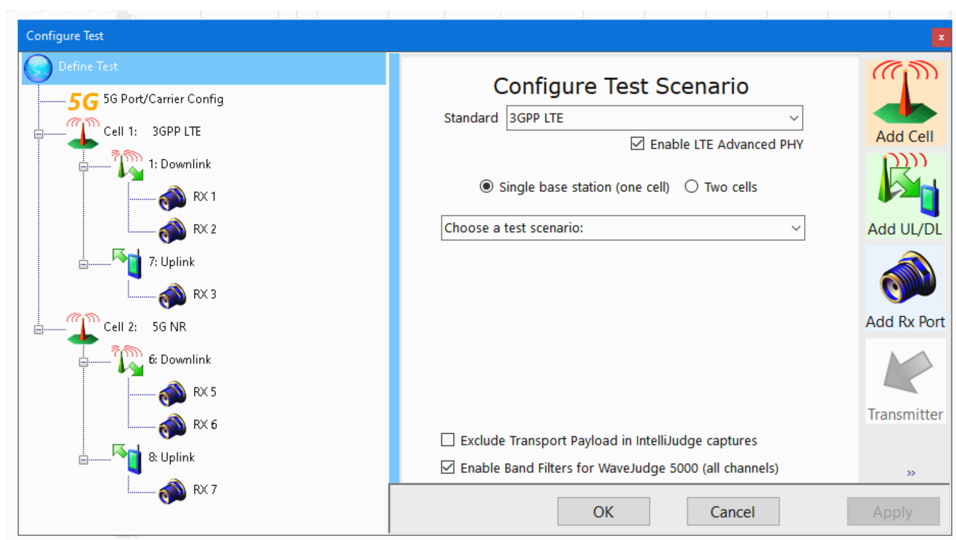
5. 2. 6. 3 Configure Test Button

The Configure Test button is one of the five vertical buttons located on the left side of the user interface Configure Test, and is also listed as Configure Test in the View Menu. Hover the cursor over the Configure Test button to preview the tool tip text “Configure the Test Scenario and Parameters”.



Hover Your Cursor Over the Configure Test Button to Preview the Tool Tip

This button opens the Configure Test window.

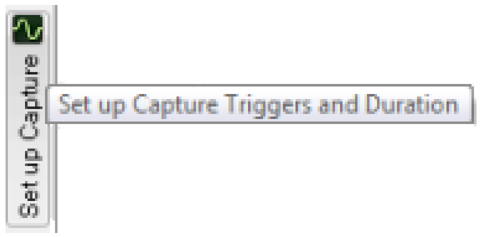


Configure Buttons Toolbar - Configure Test Window

Using the Configure Test window to examine or create a test configuration is explained in Configure Test Window or Define a New Test on page 136.

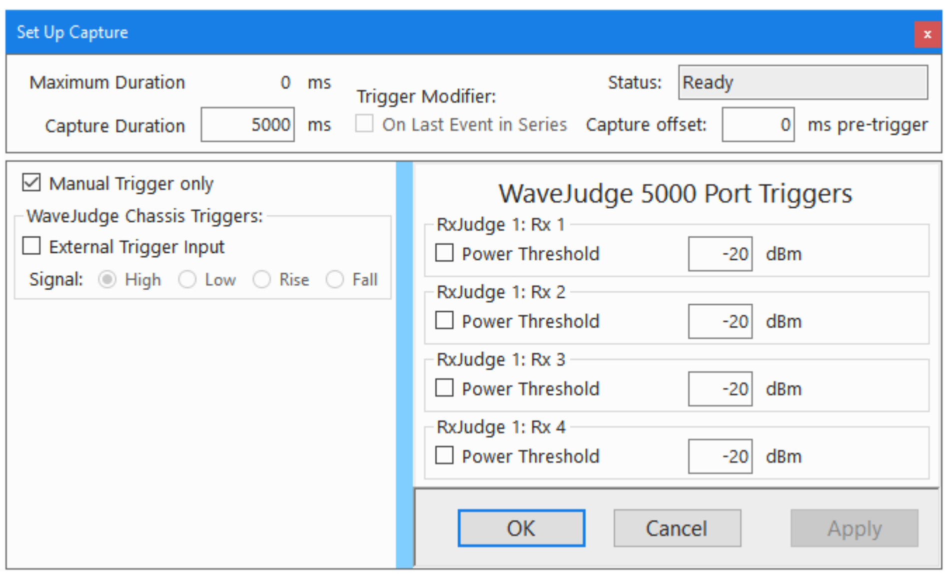
5. 2. 6. 4 Set Up Capture Button

The Set Up Capture button is one of the five vertical buttons located on the left side of the user interface Set up Capture, and is also shown as Connect Type in the View Menu. Hover the cursor over the Set Up Capture button to preview the tool tip text "Set up Capture Triggers and Duration".



Hover Your Cursor Over the Set Up Capture Button to Preview the Tool Tip

Click the Set Up Capture button to open the Set Up Capture window.



Configure Buttons Toolbar - Set Up Capture Window

The Set Up Capture window is where you define the triggers to initiate a capture, as well as the length or duration of the capture. The maximum duration of a capture is dependent on the bandwidth, sampling rate settings, and WaveJudge model and components. The range may be anywhere from three seconds on all Rx ports up to hours, if using a system with StoraJudge capture modules.

Trigger Status:

Indicates if the trigger is armed or has occurred. Trigger states are: **Waiting for Trigger, Capturing,** and **Capture Done**.

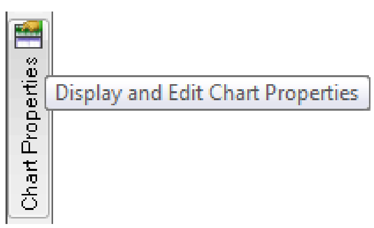
Trigger Condition:

Defines the methods available to trigger a capture; provides information relative to the incoming signal levels: manual and external. A Manual Trigger occurs as soon as capture is armed; capture begins as soon as the user presses the Single Capture button. For Repeat Capture, after the previous capture ends, a new capture begins without any other event occurring.

The Set Up Capture window is discussed in greater detail in Set Up Capture Window on page 162.

5. 2. 6. 5 Chart Properties Button

The Chart Properties button is one of the five vertical buttons located on the left side of the user interface Chart Properties, and is also shown as Chart Properties in the View Menu, and as Properties in the Chart Context Menu. Hover the cursor over the Chart Properties button to preview the tool tip text “Display and Edit Chart Properties”.



Hover Your Cursor Over the Chart Properties Button to Preview the Tool Tip

Click the Chart Properties button to open the Chart Properties window and set the display options for an individual chart. To view the properties for a particular chart, you can either open the Chart Properties window first and then click on the chart you want to configure, or right-click on a chart to open the Chart Context Menu and select Properties from that menu to open the window.

Chart Properties Window

The settings in the Chart Properties window control the properties and options available on individual charts and lists. Each type of chart (or list) has its own set of properties to view results in different ways. While the Chart Properties window is open, if you click on or select different charts, the properties and options available will always change to follow the specific chart you select and will reflect its properties.

For example, clicking the vertical Chart Properties button on the left side will open the Chart Properties Window - WaveJudge Messages for the first six Window main menu selections (for example, WaveJudge Layout, IntelliJudge + Charts, Combined Layout, IntelliJudge Messages Only, WaveJudge Messages Only, Both Message Charts Lists). This chart has two tabs: Basic Detail Levels and Advanced Element Choices. This chart is discussed further in the section below WaveJudge Messages List on page 240.

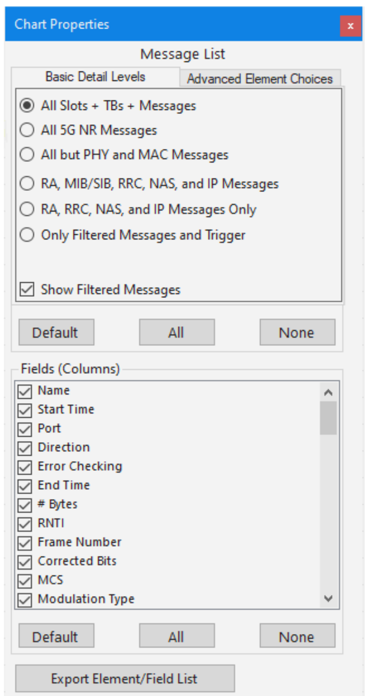


Chart Properties Window - WaveJudge Messages

Chart Properties Window – Right Click from a Chart

However, if you right-click from a chart and select the option Chart Properties from the drop-down menu then a different Chart Context window will appear that is specific to the chart.

The figure below shows the Chart Properties window when the Constellation chart is selected. The six options next to the color lines are called "traces" or "series" ; the color of the line indicates how that content will appear in the chart. Individual charts are discussed in the Chart Panes on page 265 section below.

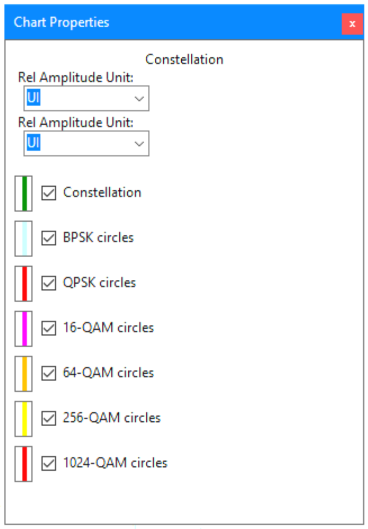


Chart Properties Window - Constellation

- Use the Chart Properties window to change the units of measure for a chart and to select which data to graph or display.
- To update any Chart Properties settings, click the appropriate checkboxes or use the pull-down menu to select from the multiple-choice options, such as the Unit selectors.

Examples of the Chart Properties window traces for the Spectral Power and Time Domain Power charts are shown below. In some cases, it is better to select a single trace, as in Spectral Flatness Adjacent Ratio for Spectral Power; for other charts, it may be useful to select multiple traces for additional analysis of the signal, as shown in the Time Domain Power example.

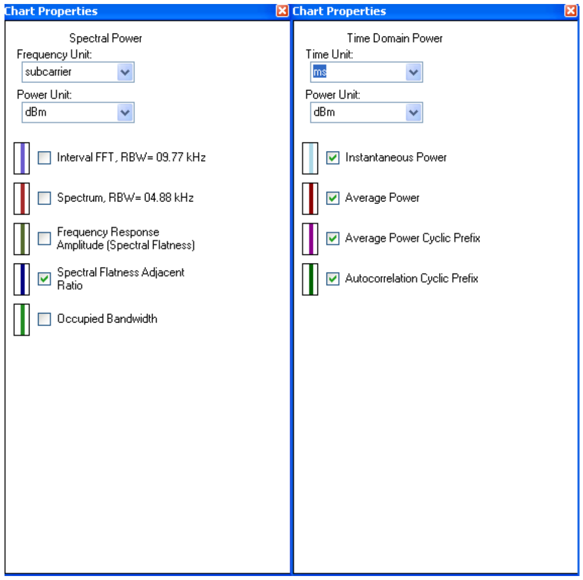
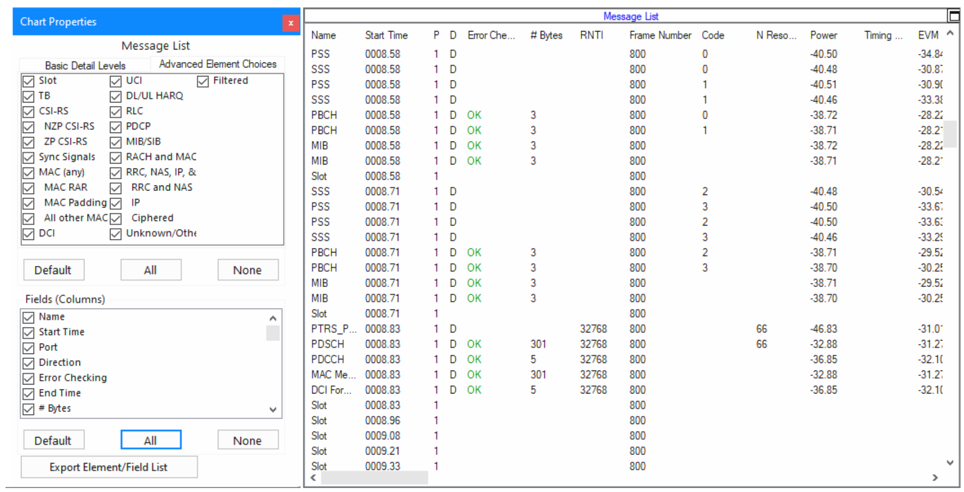


Chart Properties Windows - Spectral Power and Time Domain

5. 3 WaveJudge Messages List

The WaveJudge Messages List is a table that displays all messages decoded from the current WaveJudge capture data (for example, a non real-time, post-processed data), it is one of the most useful and heavily used charts in WaveJudge. Normally it is preassigned to one of the major panels but you can also add one to a different chart pane by right-clicking in a chart pane and selecting Lists and DecodesWaveJudge Messages.



5G WaveJudge Message List and Chart Properties Window

Each successive capture resets the data with the latest data uploaded from the WaveJudge hardware, each reprocess of the data redecodes the data for the Message List.

- To **customize** the elements and fields displayed in the WaveJudge Messages list, right-click in WaveJudge Messages to bring up the Chart Context Menu and select Properties, or click the Chart Properties Button on page 236 button. For more information on which elements and fields you can select, see the 5G WaveJudge Messages - Chart Properties Window on page 241 section below for descriptions of the WaveJudge Messages elements (rows) and fields (columns).
- To **rearrange**WaveJudge Messages List columns, click on a column header and drag it to the desired location.
- To **change the units** for a given column, where applicable, click on a column header to activate the column drop-down menu and select one of the units shown in the drop-down menu.
- The **sort** feature lets you sort list items in a column in ascending (Sort Up) or

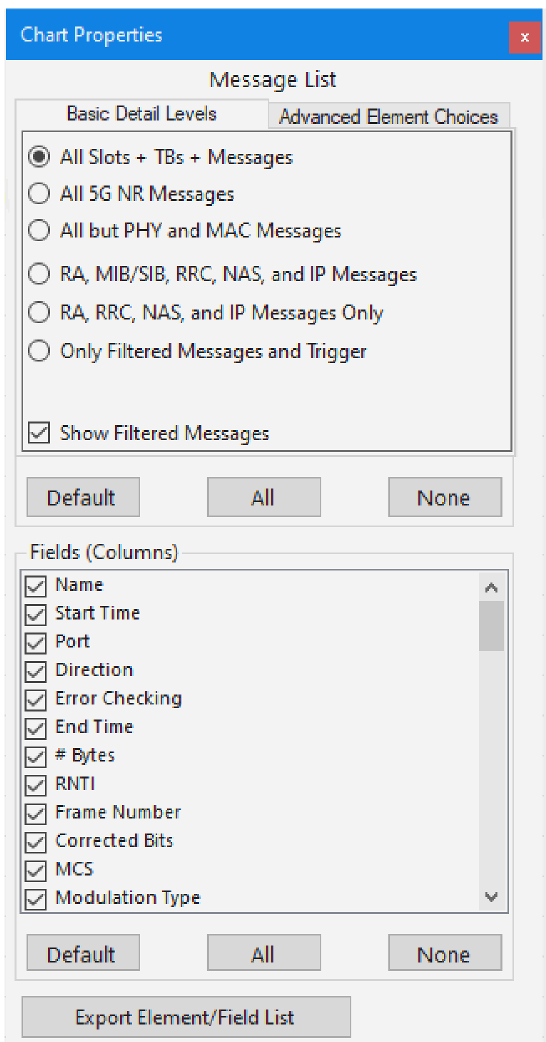
descending (Sort Down) order. Click on a column header to activate the column drop-down menu and select Up or Down.

- To **save** message information to a text file, right-click on a message to bring up the Chart Context Menu and select Export.

To learn how to interpret and use WaveJudge Message results, see WaveJudge Messages List on page 240.

5.3.1 5G WaveJudge Messages - Chart Properties Window

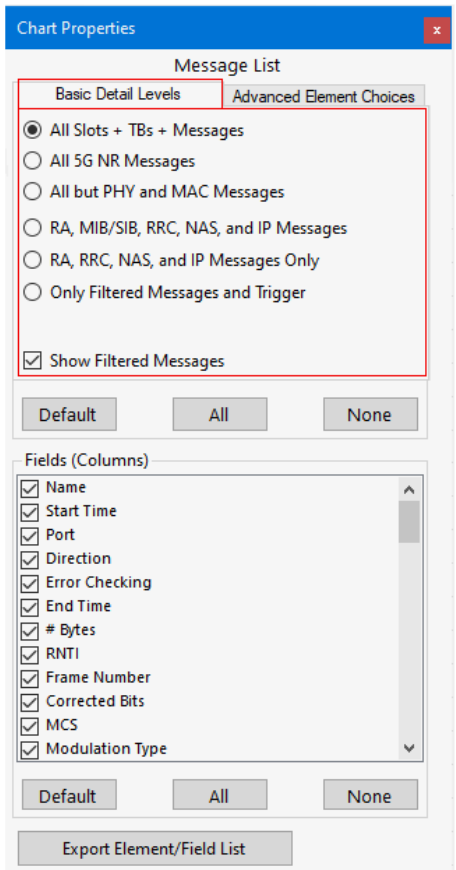
The figure below shows the Chart Properties window when the WaveJudge Messages List is selected when using a 5G capture file. It is structured quite differently from the properties for the graphic charts.



5G WaveJudge Messages - Chart Properties Window

5. 3. 1. 1 5G Chart Properties Window - Basic Detail Levels Tab

The WaveJudge Messages Basic Detail Levels tab has six radio buttons, however you can only select one.



5G WaveJudge Chart Properties Window - Basic Detail Level Tab

The radio buttons on the WaveJudge Messages Basic Detail Levels tab are as follows:

All Slots + TBs +Messages: Displays all slots, transport blocks (TB), and messages

All 5G NR Message Types: Displays all 5G NR messages.

All But PHY and MAC Messages: Displays everything except physical layer (PHY) and medium access control layer (MAC) messages.

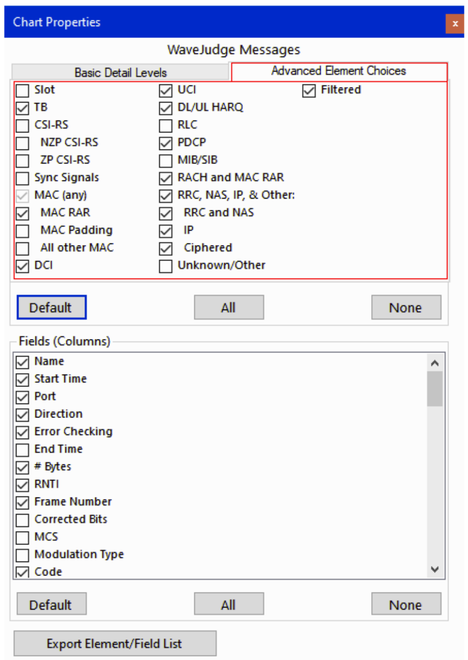
RA, MIB/SIB, RRC, NAS, and IP Messages: Displays all random access (RA), Master Information Block (MIB)/ System Information Block (SIB), radio resource control (RRC), non-access stratum (NAS), and internet protocol (IP) messages.

RA, RRC, NAS, and IP Messages Only: Displays all random access (RA), radio resource control (RRC), non-access stratum (NAS), and internet protocol (IP) messages.

Only Filtered Messages and Trigger: Displays only messages configured via the message list filters window and the trigger message.

5. 3. 1. 2 5G Chart Properties Window - Advanced Element Choices Tab

The WaveJudge Messages Advanced Element Choices tab has two columns of options to choose from; you can choose one, select them all, or select any custom combination.



5G WaveJudge Chart Properties Window - Advancec Element Choices Tab

5G Chart Properties Window - Advanced Element Choices: Default

Click the Default button to clear all settings and show only the following default settings.

Tb: Transport blocks

MAC RAR: Medium access control (MAC) random access response (RAR)

DCI: Downlink control messages

UCI: Unified configuration interface

DL/UL HARQ: Downlink/uplink hybrid automatic repeat request

PDCP: Packet data convergence protocol level messages

RACH and MAC RAR:

Random access channel (RACH) and medium access control (MAC) random access response (RAR)

RRC, NAS, IP, and Other: Ratio resource control (RRC), non-access-stratum (NAS), internet protocol (IP) and other messages

RRC and NAS: Ratio resource control (RRC), non-access-stratum (NAS) messages only

IP: Internet protocol messages

Ciphered: Ciphered messages

Filtered: Filtered messages

5G Chart Properties Window - Advanced Element Choices: Optional

The following settings are optional, select as few or as many as needed.

Slot: Port

CSI-RS: Channel State Information - Reference Signal

NZP CSI-RS: Non-Zero Power Channel State Information - Reference Signal

ZP CSI-RS: Zero Power Channel State Information - Reference Signal

Sync Signals: Synchronizes signal

MAC: Medium access control layer messages

MAC Padding: Padding Protocol Data Unit (PDU) or padding bytes; FF

All Other MAC: All other MAC messages not classsified as MAC-RAR or MAC with a padding field

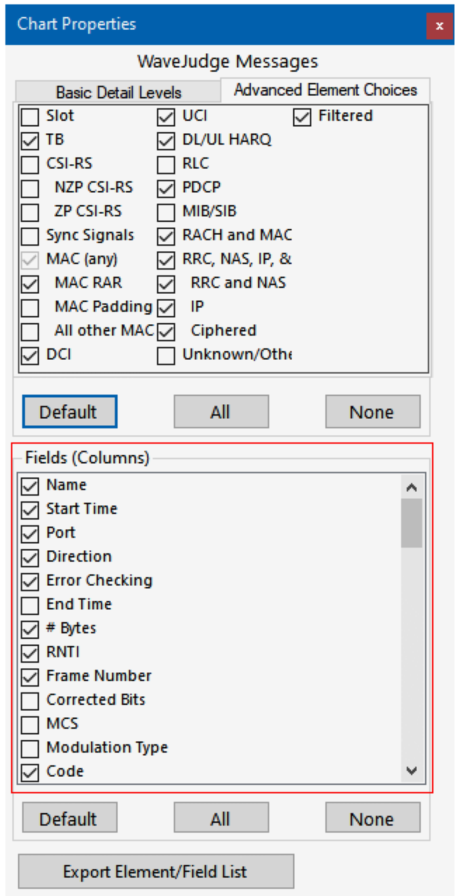
RLC: Radio link control

MIB/SIB: Master Information Block / System Information Block uplink or downlink transmission. Paging (address 65534) is a wake-up message that a sleeping UE monitors.

Unknown/Other: Other messages

5. 3. 1. 3 5G Chart Properties Window - Fields (Columns)

The bottom half of the **Chart Properties** window for the **WaveJudge Messages List** is called **Fields (Columns)** and it has many options to determine which columns of data to show in your configuration.



5G WaveJudge Chart Properties Window - Fields (Columns)

- The Default button erases all selections and replaces the options with only the default settings
- The All button selects all checkboxes.
- The None button deselects all buttons, no options are checked.

Each checkbox on the Chart Properties Window - WaveJudge Messages Fields (Columns) portion of the control is described here; each selects a particular column of field values to display. They may be selected in any combination.

5G Chart Properties Window - Fields: Default

Selecting the Default button erases all selections and replaces the options with the following fields.

Name: Name of message, transport block, burst, or other element (e.g., frame or subframe).

Start Time: Start time of the transmission for this message or element, in the selected units; by default, relative to the start of capture.

Port: Receive (Rx) Port number (0 - n) which the message or element was received on; for a multi-port MIMO configuration, this will show the first port associated with the downlink or uplink.

Direction: Direction of captured traffic: U = Uplink (mobile station transmission, color coded in light purple for quick identification) or D = Downlink (base station transmission).

Error Checking: Any error flag.

Bytes: Length of a particular item's message content in bytes, if applicable.

RNTI: The Radio Network Temporary Identifier (RNTI) that currently identifies transmissions to or from a given user equipment (UE).

Frame Number: Frame number for this message or element; for LTE, the LTE frame number, in range 0 to 1023.

Code: A miscellaneous field to indicate the generic resource index of a given PHY entity. For PRACH/RACH and MAC RAR, indicates the RAPID (Random Access Process ID) for this PRACH transport block or associated with it in the MAC RAR reply; for UCI CQI, contains the Channel Quality Indicator (CQI) code.

N Resources: The number of Resource Blocks (RBs) allocated for this transport block or the physical transport block associated with this message.

N Resources:PDSCH: The number of RBs allocated for this entity or the entity associated with this message.

N Resources:PDCCH/MPDCCH/EPDCCH/NPDCCH: The number of CCE/ECCE/NCCE allocated to this entity.

Power: Power measured for the given entity - for example, frame, subframe, zone, burst, sub-burst, or TB. The default unit is in dBm. For higher-level messages this is taken from the unique physical message that it is derived from.

Timing Offset: For LTE, the timing offset of the uplink (UL) compared to downlink (DL), based on the Random Access preamble. This value indicates the offset between DL and UL in samples; e.g., 10 means that the UL was received with a delay of 10 samples, -20 means that the UL was received 20 samples earlier than expected.

EVM: Error vector magnitude for the given entity - for example, frame, subframe, zone, burst, sub-burst, or TB. For higher-level messages, this is taken from the unique physical message that it is derived from.

UE Identity: Identifies the user equipment (UE) for this message via the best available information about the identity of the UE from the network attach process. If SIM information is available (e.g., via CipherJudge), this may display a phone number; otherwise, it will display IMSI if available, or GUTI if that is available, or an earlier RNTI if it is possible to reference this message's session to a session on a previous RNTI.

Cell ID: LTE Physical Cell ID for this message or element; the unique number that identifies each base transceiver station (BTS) or sector of a BTS on a given frequency within a physical range.

Slot Index: Denotes the slot index of the allocation of a PHY entity in a frame (10ms duration).

5G Chart Properties Window – Fields: Optional

The following settings are optional, you can select one or as many as needed.

EndTime: End of transmission time of this message or element. For LTE, in most cases it is considered the end of the message's subframe, 1ms after its Start Time.

CorrectedBits: The number of bits corrected by the error correcting algorithms for this transport block or the physical transport block associated with this message.

MCS: Modulation and coding scheme code number used for this transport block or the physical transport block associated with this message.

ModulationType: Displays the modulation type (in readable form) used for this transport block or the physical transport block associated with this message.

Frequency Offset: Reports the difference of the measured frequency from the expected (or configured) frequency for the given entity.

RV: Redundancy Value used in transmitting this transport block or the physical transport block associated with this message; this value can also be found in the PHY frames list for LTE.

N Code Words: Number of codewords used for a MIMO type transmission; this value can also be found in the PHY frames list for LTE.

HARQ Process Number: HARQ Process ID value used in transmitting this transport block or the physical transport block associated with this message. Note: HARQ Process ID is part of the HARQ processing procedure for LTE.

NDI: HARQ New Data Indicator; this value can also be found in the PHY frames list for LTE. Note: HARQ NDI is part of the HARQ processing procedure for LTE.

N Layers: Number of layers per codeword used for a MIMO type transmission; this value can also be found in the PHY frames list for LTE.

Mimo Type: MIMO type identified in the Transport Block, for example Spatial Multiplexing or Transmit Diversity.

Decrypted: The decryption status for encrypted messages, if applicable, based on the key information provided during the network attach process.

Validated: The cryptographic validation status for authenticated messages, if applicable, based on the key information provided during the network attach process.

NBundled: Displays Bundle number for a block of 4 TTIs in bundled transmission.

NreTx: Retransmission number for the given transport block or entity.

RSSI: Received Signal Strength Indicator for the given transport block or entity.

RSRP: Reference Signal Received Power value for the subframe.

RSRQ: Reference Signal Received Quality value for the subframe.

SINR: Signal to interference plus noise ratio for this entity, calculated from its EVM.

IMSI: International mobile subscriber identity.

GUTI: Globally unique temporary identity.

LCID: Logical channel identity.

TMSI: Temporary mobile subscriber identity.

PHY RNTI: Physical layer Radio Network Temporary Identifier (RNTI), where this may differ from the logical RNTI. This may allow the user to associate the SPS/TPC RNTI with the logical C-RNTI associated with a UE.

TtiBundlingIndex: TTI Bundling Index 1-4 for the transmission for the given transport block or entity.

IP Source Addr: For decoded messages at IP transport layer only, the IPv4 or IPv6 source address of the message. Note: Will only be observed if traffic decryption is successful or the network traffic is unencrypted.

IP Dest Addr: For decoded messages at IP transport layer only, the IPv4 or IPv6 destination address of the message. Note: Will only be observed if traffic decryption is successful or the network traffic is unencrypted.

IP Version: For decoded messages at IP transport layer only, the IP version (4 or 6). Will only be observed if traffic decryption is successful or the network traffic is unencrypted.

IP Protocol: For decoded messages at IP transport layer only, the IP layer protocol such as TCP, UDP, ICMP, or DHCP. Will only be observed if traffic decryption is successful or the network traffic is unencrypted.

Appln Port: For decoded messages at IP transport layer only, shows the more meaningful of the IP Source Port or IP Destination Port, if possible translated to a named application protocol such as "HTTP query", "DNS reply", or "FTP". Will only be observed if traffic decryption is successful or the network traffic is unencrypted.

Source Port: For decoded messages at IP transport layer only, shows the IP Source Port (sending port number) as a numeric value. Will only be observed if traffic decryption is successful or the network traffic is unencrypted.

Dest Port: For decoded messages at IP transport layer only, shows the IP Destination Port (receiving port number) as a numeric value. Will only be observed if traffic decryption is successful or the network traffic is unencrypted.

ECID: Enhanced Cell Identity (ECID) of cell for this message or entity.

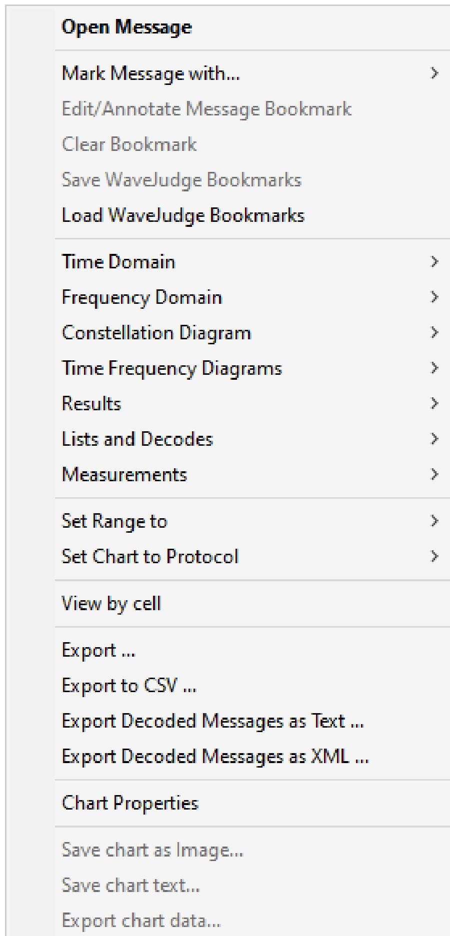
EARFCN (DL): Evolved Absolute Radio Frequency Channel Number for downlink (LTE carrier channel numbers).

Time Alignment Error: Reports the difference of the measured time alignment from the expected (or configured) time alignment for the given entity.

Cell #: Physical cell number identified on configuration control vs Cell ID advertised in cell synch signal.

5. 3. 2 5G WaveJudge Message List Context Menu (Right-Click)

Right-click inside the WaveJudge Messages List and a new **WaveJudge Message List Context Menu** will appear.



5G WaveJudge Message List Context Menu

Many of the options are the same as the WaveJudge Chart Context (right-click) menu, such as **Time-Domain**, **Frequency Domain**, **Constellation Diagram**, etc. However, this menu includes many more options, described below.

Open Message

Opens the message your cursor is on.

Mark Message with...

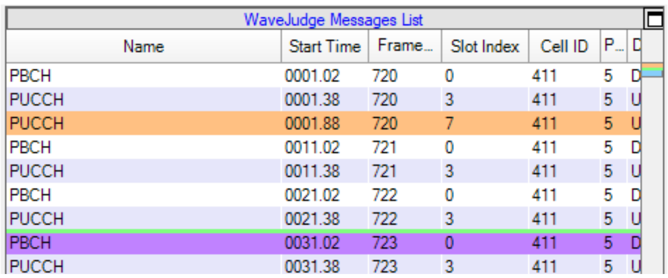
Opens a submenu with options to create temporary or a new permanent bookmark. There are two pre-defined temporary markers, orange and purple. These let you mark a message in the IntelliJudge or WaveJudge message list; it will then be highlighted with a matching color line in the scroll bar, allowing you to instantly jump back to that message from elsewhere in the list by clicking the line. Temporary markers are not saved as bookmarks but can be set on any message and moved any time.

- Mark Message with...Temporary Marker 1

  Creates the starting position for a temporary bookmark on a selected message; shades the selected message line orange.

  Mark Message with...Temporary Marker 2

  Creates the end position for the same temporary bookmark on a selected message; shades the selected message line purple.

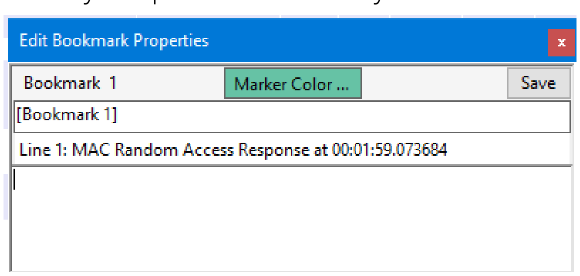
  WaveJudge Messages List

Name	Start Time	Frame...	Slot Index	Cell ID	P...	D
PBCH	0001.02	720	0	411	5	D
PUCCH	0001.38	720	3	411	5	U
PUCCH	0001.88	720	7	411	5	U
PBCH	0011.02	721	0	411	5	D
PUCCH	0011.38	721	3	411	5	U
PBCH	0021.02	722	0	411	5	D
PUCCH	0021.38	722	3	411	5	U
PBCH	0031.02	723	0	411	5	D
PUCCH	0031.38	723	3	411	5	U

- Mark Message with...New Bookmark

  Creates a permanent bookmark on the selected message. Right-click on a message, in the popup context menu select Mark Message With... then select New Bookmark 1 from the submenu. The Edit Bookmark Properties window will appear.

  - In the second line, rename [Bookmark 1] to something appropriate (for example, why you bookmarked it).
  - Click the Marker Color button to open a color picker window and select any color.
  - The bookmarked message line will change accordingly. The next time you open the same file you will be able to quickly find the message.

Edit/Annotate Message Bookmark

Opens the selected bookmark to allow editing.

Clear Bookmark

Deletes the bookmark.

Save WaveJudge Bookmark

Saves the bookmark as a WaveJudge bookmark.

Load WaveJudge Bookmarks

Restores all previously saved WaveJudge bookmarks to a message.

Time Domain

The Time Domain Power chart shows the power level (energy) of the signal over time. See Time Domain Power Chart on page 268 below.

Frequency Domain

Frequency domain chart shows how much of a signal lies within each given frequency band over a range of frequencies. See Frequency Domain Charts on page 373 below.

Constellation Diagram

The Constellation chart visually displays the modulation quality of the signal. See Constellation Diagram on page 380 below.

Time Frequency Diagrams

The Time Frequency charts show the power level and frequency of a signal over time. See Time Frequency Diagrams on page 381 below.

Results

- ResultsSummary The Summary Chart shows text results and a summary of measurements for the entire capture or time interval. See Summary Chart on page 389 below.
- ResultsPer User Statistics Each user has its own channel quality and communication throughput. This option can show useful statistics for users through LTE signaling. See Per User Statistics (LTE Only) on page 390 below.

Lists and Decodes

The Lists and Decodes submenu allows you to select the WaveJudge Messages List, a Legacy Message List, or the Channel Decoding chart. See Lists and Decodes on page 392.

Measurements

- Measurements CCDF Complementary Cumulative Distribution Function is the only measurement currently available. See section CCDF on page 394 below.

Set Range to

This submenu in the Chart Context Menu is where you may set a chart's range to either All or Selection. See section Set Range to on page 356 below.

Set Chart to Protocol

Sets your charts to LTE, WiFi, or both. See section Combined LTE and WiFi on page 159.

View by Cell

View WaveJudge messages by cell.

Export

Opens a submenu containing many different data export options.

ExportExport to CSV...

- Export data to an Excel compatible worksheet.

ExportExport Decoded Messages as Text...

- Opens a Save As window to save the file as text file (*.TXT).

ExportExport Decoded Messages as XML...

Opens a Save As window to save the file as text file (*.XML).

Chart Properties

Opens the WaveJudge Chart Properties window. See previous section Chart Properties Window on page 236.

Save Chart as Image

Opens a window to name and save chart as an image (.GIF, .JPG, .BMP, .TIF, or .PNG) on your computer. See section below Save Chart as Image on page 360.

Save Chart Text

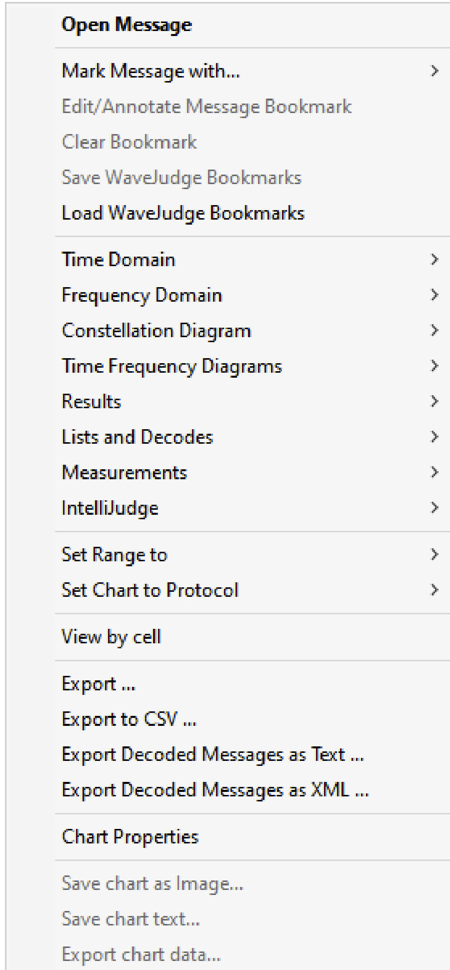
Opens a window to save the chart as .TXT or .CSV format. See Save Chart Text on page 360.

Export Chart Data...

Opens a window to save the chart as text as .TXT or .CSV format. See Export Chart Data on page 361.

5. 3. 3 4G LTE WaveJudge Message List Context Menu (Right-Click)

Right-click inside the WaveJudge Messages List and a new **WaveJudge Message List Context Menu** will appear. At first glance, the only noticeable difference appears to be the addition of IntelliJudge to the list.



4G LTE WaveJudge Message List Context Menu

Unlike 5G, only the 4G LTE Context Menu contains the IntelliJudge charts. Also, the 4G LTE WaveJudge Message List Context Menu has five more charts than the 5G Context Chart does. The additional 4G LTE charts are listed below.

1. 4G LTE **Time Domain** charts include:

   CRS SINR Per Subframe (LTE Only) on page 370

   Port Phase Differences Per Subframe (LTE Only) on page 371

   Time Domain Phase Noise (LTE Only) on page 372
2. 4G LTE **Frequency Domain** charts have one new option: Phase Noise Relative Power Spectral Density (LTE Only) on page 379.
3. The **Results** charts include Per User Statistics (LTE Only) on page 390.
4. Only 4G LTE has access to **IntelliJudge** charts:

   IntelliJudge TB EVM Chart on page 404

   IntelliJudge TB Power Chart on page 404

IntelliJudge TB CRC Error Chart on page 405
IntelliJudge Throughput Chart on page 406
IntelliJudge TB Count Chart on page 407
IntelliJudge TB SINR Chart on page 408
IntelliJudge CRS EVM Chart on page 408
IntelliJudge CRS SINR Chart on page 409
IntelliJudge Subframe Power Chart on page 410
IntelliJudge Subframe RSSI Chart on page 410
IntelliJudge Subframe RSRP Chart on page 411
IntelliJudge Subframe RSRQ Chart on page 412
IntelliJudge 2D Physical Chart on page 412

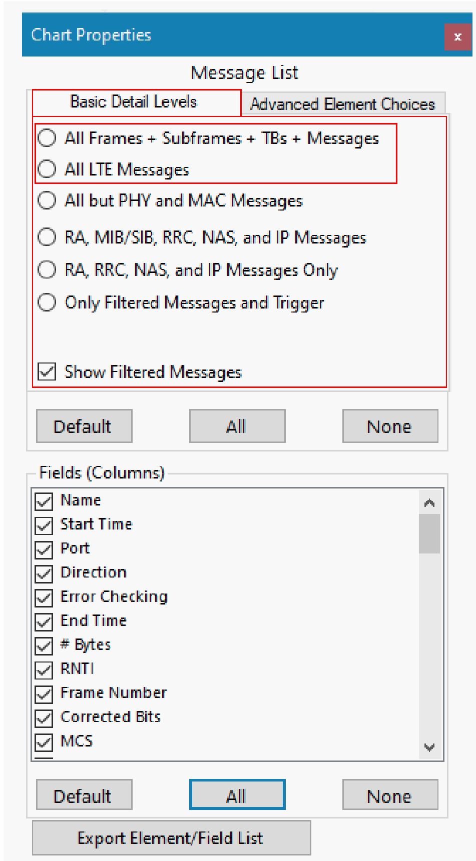
5. Chart Properties: Opens the 4G LTE WaveJudge Chart Properties window. See 4G LTE WaveJudge Chart Properties on page 254.

5. 3. 4 4G LTE WaveJudge Chart Properties

The **4G LTE WaveJudge Messages Chart Properties** window is very similar to the 5G Chart Properties described in the previous section. This section describes the LTE chart properties and differences.

5. 3. 4. 1 4G LTE Chart Properties - Basic Detail Levels Tab

The figure below shows the **Chart Properties** window when the **WaveJudge Messages List** is selected when using an LTE capture file. The first two items are specific to LTE: **All Frames + Subframes + TBs + Messages**, and **All LTE Messages**.



LTE WaveJudge Chart Properties Window - Advanced Element Choices Tab

You can only select one of the following options.

All Frames + Subframes + TBs + Messages: Displays all frames, subframes, transport blocks (TB), and messages.

All LTE Messages: Displays all LTE messages.

All But PHY and MAC Messages: Displays everything except physical layer (PHY) and medium access control layer (MAC) messages.

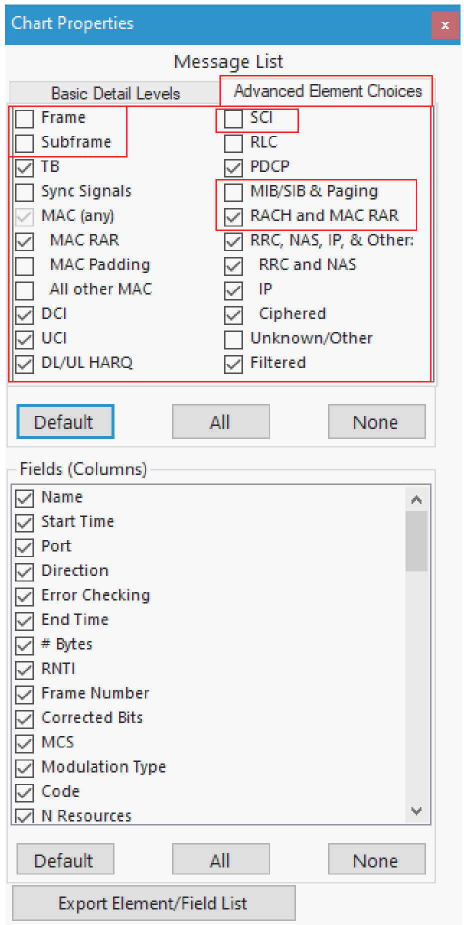
RA, MIB/SIB, RRC, NAS, and IP Messages: Displays all random access (RA), Master Information Block (MIB)/ System Information Block (SIB), radio resource control (RRC), non-access stratum (NAS), and internet protocol (IP) messages.

RA, RRC, NAS, and IP Messages Only: Displays all random access (RA), radio resource control (RRC), non-access stratum (NAS), and internet protocol (IP) messages.

Only Filtered Messages and Trigger: Displays only messages configured via the message list filters window and the trigger message.

5. 3. 4. 2 4G LTE Chart Properties - Advanced Element Choices Tab

The WaveJudge Messages Advanced Element Choices tab for LTE is also very similar to 5G. The only differences are the additional options to select **Frame**, **Subframe**, **SCI**, **MIB/SIB and Paging**, and **RACH and MAC RAR** as highlighted in the figure.



LTE WaveJudge Chart Properties Window - Advanced Element Choices Tab

4G LTE Chart Properties Advanced Element Choices - Default Settings

Each of the default settings in the LTE WaveJudge Messages Advanced Element Choices tab is described here.

Tb: Transport blocks

MAC RAR: Medium access control (MAC) random access response (RAR)

DCI: Downlink control messages

UCI: Unified configuration interface

DL/UL HARQ: Downlink / uplink hybrid automatic repeat request

PDCP: Packet data convergence protocol level messages

RACH and MAC RAR: Random access channel (RACH) and medium access control (MAC) random access response (RAR)

RRC, NAS, IP, and Other: Ratio resource control (RRC), non-access-stratum (NAS), internet protocol (IP) and other messages

RRC and NAS: Ratio resource control (RRC), non-access-stratum (NAS) messages only

IP: Internet protocol messages

Ciphered: Ciphered messages

Filtered: Filtered messages

4G LTE Chart Properties Advanced Element Choices - Optional Settings

The following settings are optional, select as many as you like.

Frame: Wireless standard-defined frame; may contain uplink and/or downlink subframes.

Subframe: Uplink or downlink subframe

Sync Signals: Synchronizes signal

MAC Padding: Padding PDUs or padding bytes; FF

All Other MAC: All other MAC messages not classsified as MAC RAR or MAC with a padding field.

SCI: Sidelink control information

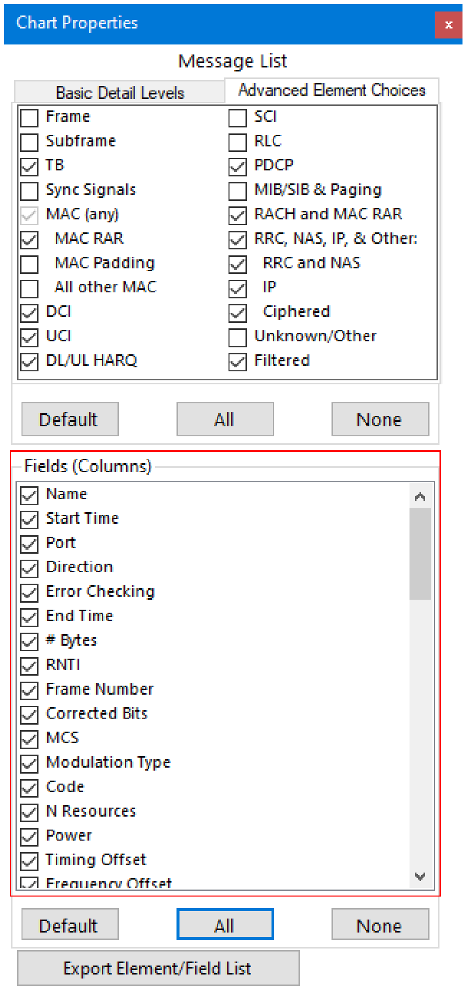
RLC: Radio link control

MIB/SIB and Paging: Master Information Block (MIB) / System Information Block (SIB) uplink or downlink transmission. Paging (address 65534) is a wake-up message that a sleeping UE monitors.

Unknown/Other: All others that are not classificed as listed above.

5. 3. 4. 3 4G LTE Chart Properties Fields (Columns)

The bottom half of the **Chart Properties** window for the **LTE WaveJudge Messages List** is called **Fields (Columns)** and it has many options to determine which columns of data to show in your configuration.



LTE WaveJudge Chart Properties Window - Fields (Columns)

4G LTE Chart Properties Columns - Default

The default headers, also known as column titles or field titles, are described below.

Name: Name of message, transport block, or element (e.g., subframe).

Start Time: Start time of the transmission for this message or element, in the selected units.

Port: Receive (Rx) Port number (0 - n) which the message or element was received on; for a multi-port MIMO configuration, this will show the first port associated with the downlink or uplink.

Direction: Direction of this message or element (downlink or uplink).

Error Checking: Any error flag.

#Bytes: Length of a particular item’s message content in bytes, if applicable.

RNTI: Radio Network Temporary Identifier for this message or element.

FrameNumber: LTE frame number for this message or element, in range 0 to 1023.

Code: For PRACH/RACH and MAC RAR (Random Access Response), indicates the RAPID (Random Access Process ID) for this PRACH transport block or associated with it in the MAC RAR reply; for UCI CQI, contains the Channel Quality Indicator (CQI) code.

N Resources: The number of Resource Blocks (RBs) allocated for this transport block or the physical transport block associated with this message.

Power: Power level for this message or element, from the physical transmission.

Timing Offset: For LTE, the timing offset of the uplink (UL) compared to downlink (DL), based on the Random Access preamble. This value indicates the offset between DL and UL in samples; e.g., 10 means that the UL was received with a delay of 10 samples, -20 means that the UL was received 20 samples earlier than expected.

EVM: Error vector magnitude for this message or element, from the physical transmission.

UE Identity: Identifies the user equipment (UE) for this message via the best available information about the identity of the UE from the networkattach process. If SIM information is available (e.g., via CipherJudge), this may display a phone number; otherwise, it will display IMSI if available, or GUTI if that is available, or an earlier RNTI if it is possible to reference this message’s session to a session on a previous RNTI.

Cell ID: LTE Physical Cell ID of cell for this message or element.

Subrame Index: LTE subframe index for this message or element, in range 0 to 9.

4G LTE Chart Properties Columns - Optional

The following options are only available in LTE, they are not in 5G charts. The first entry in each section is how the column headers appear in the message list; the names in parentheses indicate the column names as they appear in the Chart Properties window, if they are different.

EARFCN (DL): Evolved Absolute Radio Frequency Channel Number for downlink (LTE carrier channel numbers).

The following four fields are related to ICIC-ABS and the pattern of "Almost Blank Subframes" utilized for interference avoidance between Macro and Small Cell. The configuration of patterns found in the RRC messages are sent to ABS capable UEs; they form part of the Physical Dedicated parameters found in the **LTE Settings** UE list:

- **CsiMeasSubframeS1:** If subframe patterns for CSI (CQI/PMI/PTI/RI) reporting are configured via the RRC csi-SubframePatternConfig parameter, this field displays the parameter for the subframe pattern corresponding to csi-MeasSubframeSet1.
- **CsiMeasSubframeS2:** If subframe patterns for CSI (CQI/PMI/PTI/RI) reporting are configured via the RRC csi-SubframePatternConfig parameter, this field displays the parameter for the subframe pattern corresponding to csi-MeasSubframeSet2.

- **MeasSubframePatternPCell:** Time domain measurement resource restriction pattern used for the PCell measurements (RSRP, RSRQ and the radio link monitoring).
- **MeasSubframePatternNeigh:** Time domain measurement resource restriction pattern applicable to neighbor cell RSRP and RSRQ measurements.

The items below are optional LTE fields (that are the same as 5G charts), select as few or as many as needed.

EndTime: End of transmission time of this message or element. For LTE, in most cases it is considered the end of the message’s subframe, 1ms after its Start Time.

Corrected Bits: FEC errors received on a per-burst basis; applicable to frame, subframe, and TB elements.

MCS: Modulation and coding scheme code number used for this transport block or the physical transport block associated with this message.

ModulationType: Displays the modulation type (in readable form) used for this transport block or the physical transport block associated with this message.

Frequency Offset: Reports the difference of the measured frequency from the expected (or configured) frequency for the given entity.

RV: Redundancy Value used in transmitting this transport block or the physical transport block associated with this message; this value can also be found in the PHY frames list for LTE.

N Codewords: Number of codewords used for a MIMO type transmission; this value can also be found in the PHY frames list for LTE.

HARQ Process Number: HARQ Process ID value used in transmitting this transport block or the physical transport block associated with this message. Note: HARQ Process ID is part of the HARQ processing procedure for LTE.

NDI: HARQ New Data Indicator; this value can also be found in the PHY frames list for LTE. Note: HARQ NDI is part of the HARQ processing procedure for LTE.

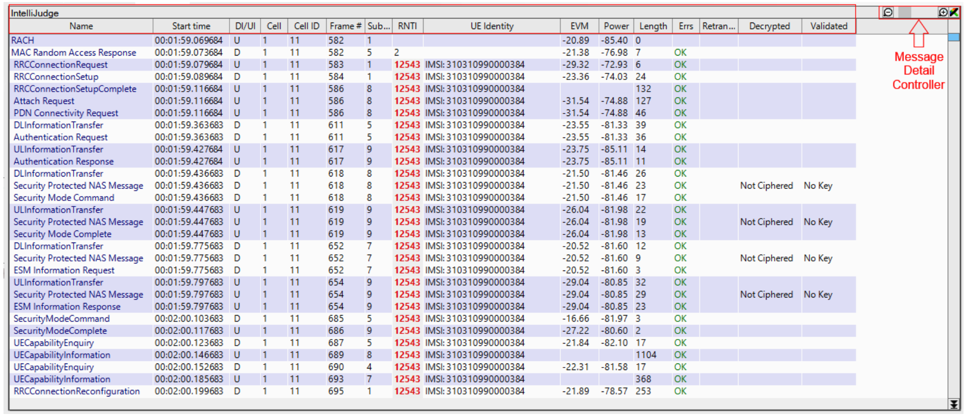
Mimo Type: MIMO type identified in the Transport Block, for example Spatial Multiplexing or Transmit Diversity.

Decrypted: The decryption status for encrypted messages, if applicable.

Validated: The cryptographic validation status for authenticated messages, if applicable.

5. 4 IntelliJudge2 Message List

The **IntelliJudge Message List** contains the data captured from IntelliJudge (for example, 4G LTE, real time data) and processed; you can configure the list in many different ways to filter data. This window automatically opens and loads data from any saved IntelliJudge file.



IntelliJudge

Name	Start time	DI/UI	Cell	Cell ID	Frame #	Sub...	RNTI	UE Identity	EVM	Power	Length	Errs	Retran...	Decrypted	Validated
RACH	00:01:59.069684	U	1	11	582	1			-20.89	-85.40	0				
MAC Random Access Response	00:01:59.073684	D	1	11	582	5	2		-21.38	-76.98	7	OK			
RRCConnectionRequest	00:01:59.079684	U	1	11	583	1	12543	IMSI: 310310990000384	-29.32	-72.93	6	OK			
RRCConnectionSetup	00:01:59.089684	D	1	11	584	1	12543	IMSI: 310310990000384	-23.36	-74.03	24	OK			
RRCConnectionSetupComplete	00:01:59.116684	U	1	11	586	8	12543	IMSI: 310310990000384			132	OK			
Attach Request	00:01:59.116684	U	1	11	586	8	12543	IMSI: 310310990000384	-31.54	-74.88	127	OK			
PDN Connectivity Request	00:01:59.116684	U	1	11	586	8	12543	IMSI: 310310990000384	-31.54	-74.88	46	OK			
DLInformationTransfer	00:01:59.363683	D	1	11	611	5	12543	IMSI: 310310990000384	-23.55	-81.33	39	OK			
Authentication Request	00:01:59.363683	D	1	11	611	5	12543	IMSI: 310310990000384	-23.55	-81.33	36	OK			
ULInformationTransfer	00:01:59.427684	U	1	11	617	9	12543	IMSI: 310310990000384	-23.75	-85.11	14	OK			
Authentication Response	00:01:59.427684	U	1	11	617	9	12543	IMSI: 310310990000384	-23.75	-85.11	11	OK			
DLInformationTransfer	00:01:59.436683	D	1	11	618	8	12543	IMSI: 310310990000384	-21.50	-81.46	26	OK			
Security Protected NAS Message	00:01:59.436683	D	1	11	618	8	12543	IMSI: 310310990000384	-21.50	-81.46	23	OK		Not Ciphered	No Key
Security Mode Command	00:01:59.436683	D	1	11	618	8	12543	IMSI: 310310990000384	-21.50	-81.46	17	OK			
ULInformationTransfer	00:01:59.447683	U	1	11	619	9	12543	IMSI: 310310990000384	-26.04	-81.98	22	OK			
Security Protected NAS Message	00:01:59.447683	U	1	11	619	9	12543	IMSI: 310310990000384	-26.04	-81.98	19	OK		Not Ciphered	No Key
Security Mode Complete	00:01:59.447683	U	1	11	619	9	12543	IMSI: 310310990000384	-26.04	-81.98	13	OK			
DLInformationTransfer	00:01:59.775683	D	1	11	652	7	12543	IMSI: 310310990000384	-20.52	-81.60	12	OK			
Security Protected NAS Message	00:01:59.775683	D	1	11	652	7	12543	IMSI: 310310990000384	-20.52	-81.60	9	OK		Not Ciphered	No Key
ESM Information Request	00:01:59.775683	D	1	11	652	7	12543	IMSI: 310310990000384	-20.52	-81.60	3	OK			
ULInformationTransfer	00:01:59.797683	U	1	11	654	9	12543	IMSI: 310310990000384	-29.04	-80.85	32	OK			
Security Protected NAS Message	00:01:59.797683	U	1	11	654	9	12543	IMSI: 310310990000384	-29.04	-80.85	29	OK		Not Ciphered	No Key
ESM Information Response	00:01:59.797683	U	1	11	654	9	12543	IMSI: 310310990000384	-29.04	-80.85	23	OK			
SecurityModeCommand	00:02:00.103683	D	1	11	685	5	12543	IMSI: 310310990000384	-16.66	-81.97	3	OK			
SecurityModeComplete	00:02:00.117683	U	1	11	686	9	12543	IMSI: 310310990000384	-27.22	-80.60	2	OK			
UECapabilityEnquiry	00:02:00.123683	D	1	11	687	5	12543	IMSI: 310310990000384	-21.84	-82.10	17	OK			
UECapabilityInformation	00:02:00.146683	U	1	11	689	8	12543	IMSI: 310310990000384			1104	OK			
UECapabilityEnquiry	00:02:00.152683	D	1	11	690	4	12543	IMSI: 310310990000384	-22.31	-81.58	17	OK			
UECapabilityInformation	00:02:00.185683	U	1	11	693	7	12543	IMSI: 310310990000384			368	OK			
RRCConnectionReconfiguration	00:02:00.199683	D	1	11	695	1	12543	IMSI: 310310990000384	-21.89	-78.57	253	OK			

IntelliJudge Message List

IMPORTANT IntelliJudge and WaveJudge Message Lists are enhanced to be more helpful when you add new columns, or fields, to either one. When you add a new column to a message list display (in the standard layout) the first column you add will be positioned in the third column just to the right of the **Start Time** column, rather than at the right end of the columns. Each new column after that will be added to the right of the last column added; if you move the column you just added to a different position in the list, it will continue adding columns from there.

The **IntelliJudge Message List** top frame contains two parts: the **Message Detail Controller** sidebar and buttons, and the headers. To learn how to interpret IntelliJudge messages and results, see Interpret IntelliJudge2 4G LTE Results on page 441.

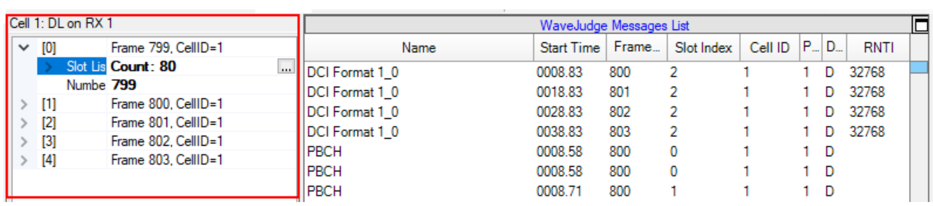
5. 5 PHY Frames

5G protocols consist of a user plane (UP) located between the IP layer and the PHY layer, and a control plane (CP), which is the Radio Resource Control (RRC) protocol.

The PHY layer (Layer 1) Downlink Channel is made up of three physical channels:

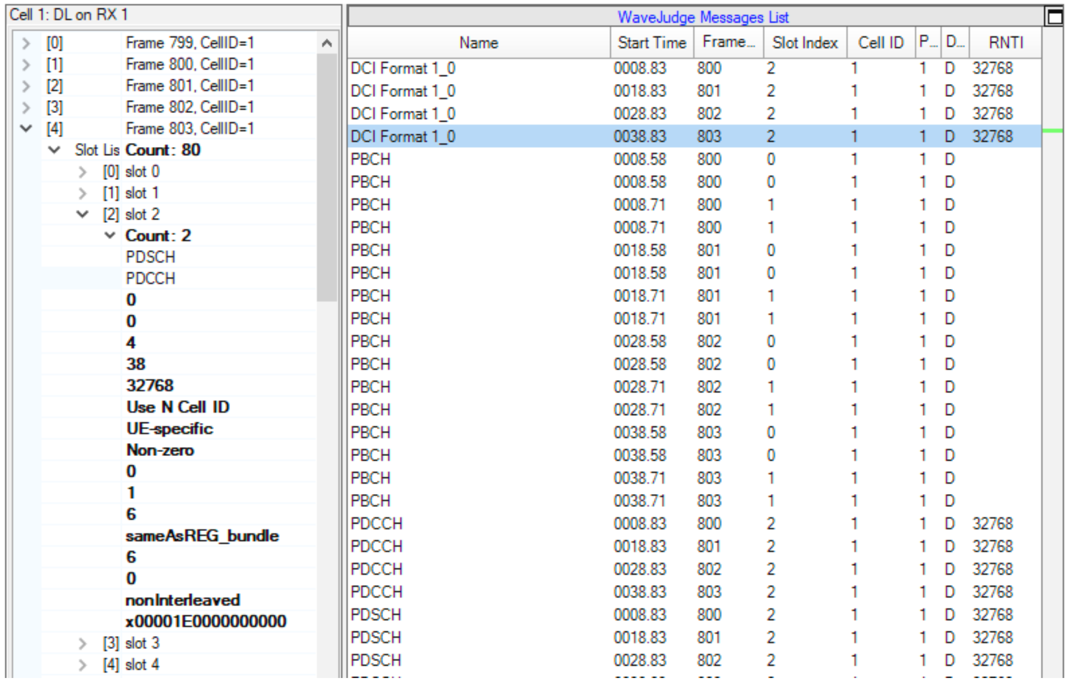
- **Physical Broadcast Channel (PBCH):** Carries encoded system information required by the UE to access the network.
- **Physical Downlink Shared Channel (PDSCH):** Carries encoded user data and paging information to the UE.
- **Physical Downlink Control Channel (PDCCH):** Conveys encoded control information and scheduling decisions for PDSCH reception.

The PHY Frame contains decoded data of the frames, subframes, assignments, and codewords from the processed data. It contains a large amount of data - within each frame there are lists of subframes and each subframe contains a list of assignments. Each assignment contains the decoded data for that assignment. You can view all of the decoded data by reviewing each assignment.



5G PHY Frame

To view the data for a particular assignment select a message in the WaveJudge Message List. The corresponding PHY frame will expand and select the corresponding assignment. You can further expand the assignment to view all of it's decoded data.



5G PHY Frame Assignment Details

The Data Link layer (Layer 2) in 5G NR has four sublayers:

- Medium access control (MAC)
- Radio link control (RLC)
- Packet data convergence protocol (PDCP)
- Service data adaptation protocol (SDAP)

The SDAP protocol is new in 5G NR compared to the LTE protocol stack. SDAP handles the new Quality of Service (QoS) framework of the 5G System in the 5G Core. SDAP also applies to LTE when connected to the 5G Core. The introduction of SDAP enables end-to-end QoS framework that works in both directions.

5G NR stack layers provide key enhancements over their LTE counterparts. The PDCP, RLC, and MAC protocols handle tasks such as header compression, ciphering, segmentation and concatenation, and multiplexing and de-multiplexing. PHY handles coding and decoding, modulation and demodulation, and antenna mapping.

The QoS flows between the UP protocol stack UE and the NR network node (gNB) are the same.

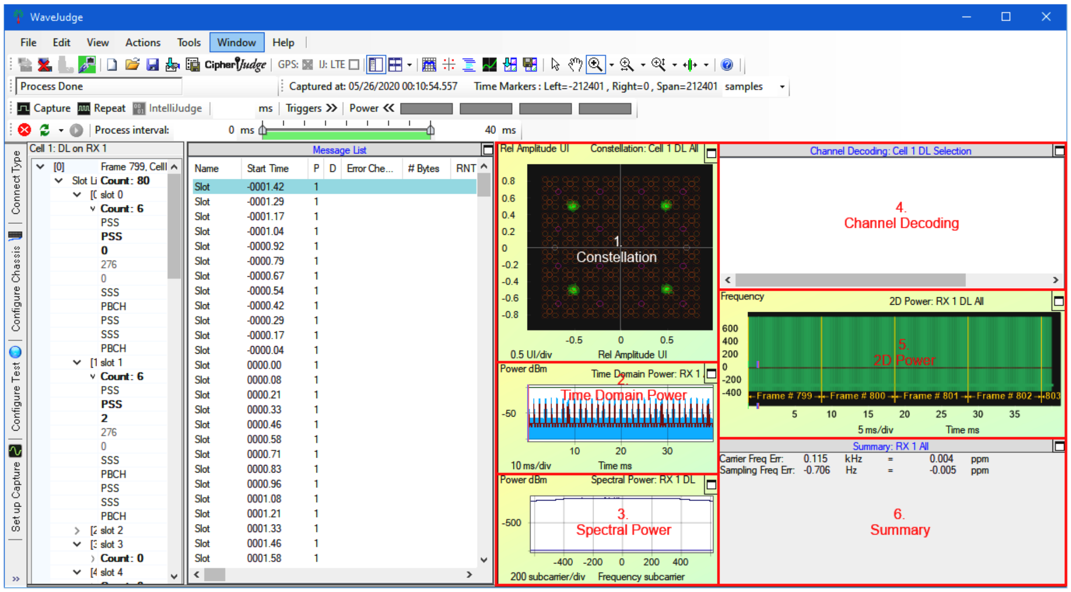
- **SDAP Channels:** SDAP layer in UE stack communicates in both directions with the SDAP layer in gNB.
- **PDPC Channels:** PDPC layer in UE stack communicates in both directions with the PDPC layer in gNB.
- **RLC Channels:** RLC layer in UE stack communicates in both directions with the

RLC layer in gNB.

- **Logical Channels:** MAC layer in UE stack communicates in both directions with the MAC layer in gNB.
- **Transport Channels:** PHY layer in UE stack communicates in both directions with the PHY layer in gNB.

5. 6 Chart Panes

Charts are one of the primary methods to view and work with data results in WaveJudge. A chart represents the analysis of all data collected during the last capture or from a loaded file. This is why the user interface features upto ten chart panes on the right side; although only six charts are commonly used.



Six Most Commonly Used Charts

To select a chart type, right-click in a pane to access the Chart Context Menu and select a chart from the categories in this menu; for more information refer to Chart Context Menu (5G) on page 355.

To select the number of charts visible on your screen go to the Window menu and select the number of panels from the drop-down menu.

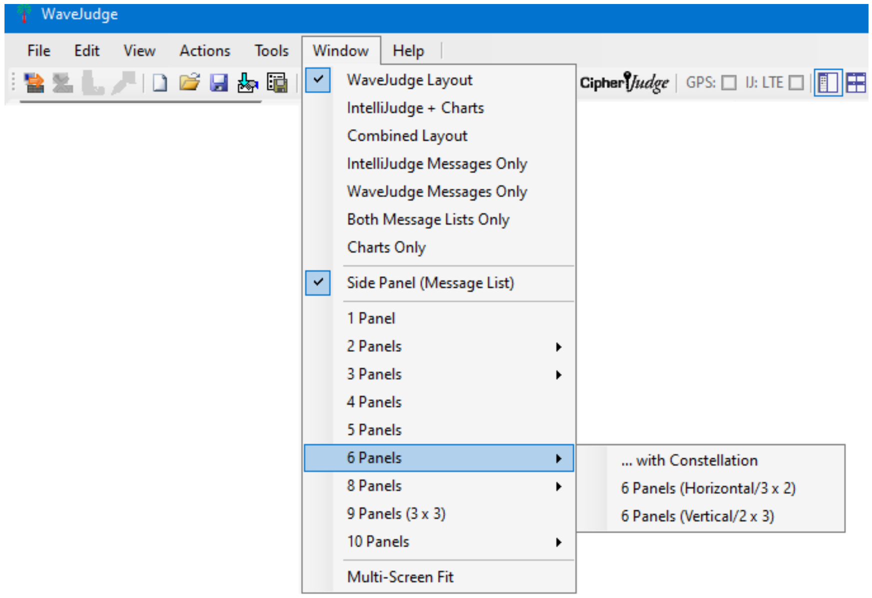


Chart Panel Layout Options

This section describes the six most commonly used charts:

1. Constellation Chart on page 267
2. Time Domain Power Chart on page 268
3. Spectral Power Chart on page 269
4. Channel Decoding Chart on page 272
5. 2D Power Chart on page 274
6. Summary Chart on page 389

You can use a chart with the Set Range to Selection option (accessed from the Chart Context Menu) to associate it with WaveJudge's cross-probing. The All and Selection options for charts are described in Set Range to on page 356. Cross-probing uses global input from several places; see the Correlation section for Analysis of 4G LTE on page 479 .

You can choose from a variety of views to arrange several selected charts in a particular way, as explained in Result Views on page 435.

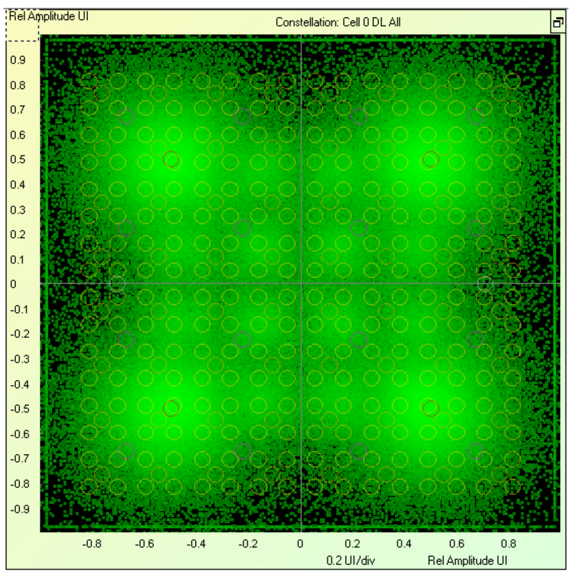
- Load any predefined view, which gives you a set of useful charts as explained under Preconfigured Views on page 435.
- Where these view options do not suit your needs you can define your own view, as explained in Create a Custom View on page 438. Custom views let you select the overall layout of the WaveJudge window into panels, lay out the arrangement of charts within the chart panel, assign specific charts to particular panels and select their settings.
- You can then save this as a custom view that you can load later as explained under Save/Load a Custom View on page 439.

- If WaveJudge software is running on a computer with multiple displays you can click the Multi-screen Fit from the Window menu to extend the main window to fill the area across all displays.

For more information and a comprensive list of charts, see Chart Context Menu (5G) on page 355.

5. 6. 1 Constellation Chart

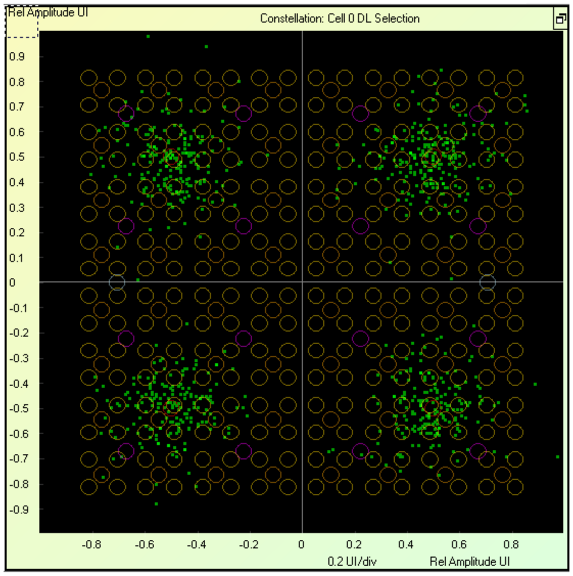
When the Constellation diagram is set to the range All, it provides a view of signal quality for all of the symbols captured and processed thus far in the WaveJudge capture.



Constellation Chart - Range Set to “All”

Each new capture or processing cycle refreshes the Constellation with a new set of points, and the EVM (RCE) calculation in the Summary Chart on page 389 table is performed over the new data.

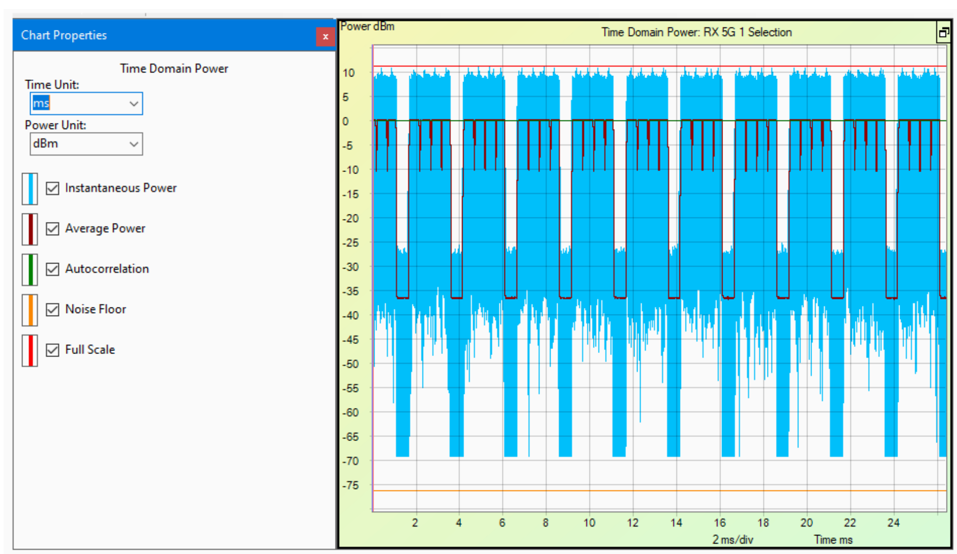
To view the Constellation per burst (message) or per time span (e.g., symbol or subframe), right-click on the chart and select Set Range toSelection. This option causes the Constellation chart to plot only the values for specific selections made from a message list, frame list, or a time domain chart. To display the timestamp, subcarrier, and EVM value for any point select the Measure tool on the toolbar and place it over a constellation point.



Constellation Chart - Range Set to “Selection”

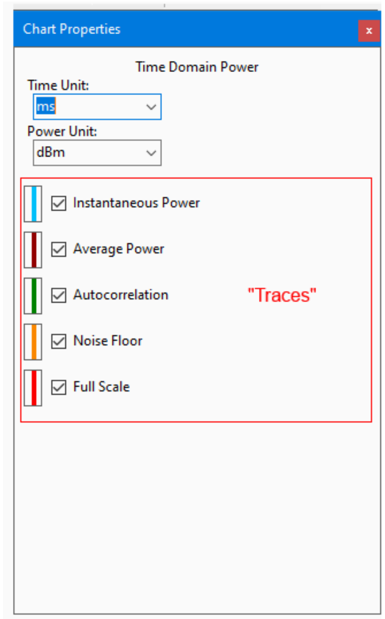
5. 6. 2 Time Domain Power Chart

The Time Domain Power chart shows the power level (energy) of the signal over time.



Time Domain Power Chart and Chart Properties

The five checkboxes on the Chart Properties window are called "traces".



Time Domain Power Chart Properties - Traces

Traces for this chart are:

Instantaneous Power: Power measured per sample.

Average Power: Computed per sample averaged over number of FFT points over a sliding window.

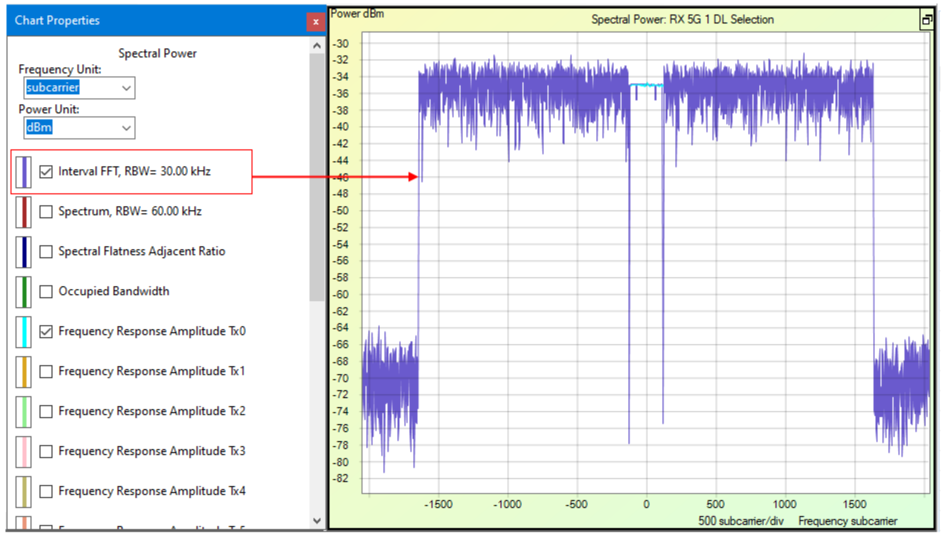
Autocorrelation: Detects the beginning of a burst sync signal for a frame (LTE); autocorrelation does not apply to 5G.

Noise Floor: Indicates where the baseline is.

Full Scale: Adds a bar at the top of the diagram to put the scale into perspective.

5. 6. 3 Spectral Power Chart

The Spectral Power chart shows the power level (energy) of the signal in the frequency domain, over a range of frequencies, either for a specific selection or for the entire WaveJudge capture.



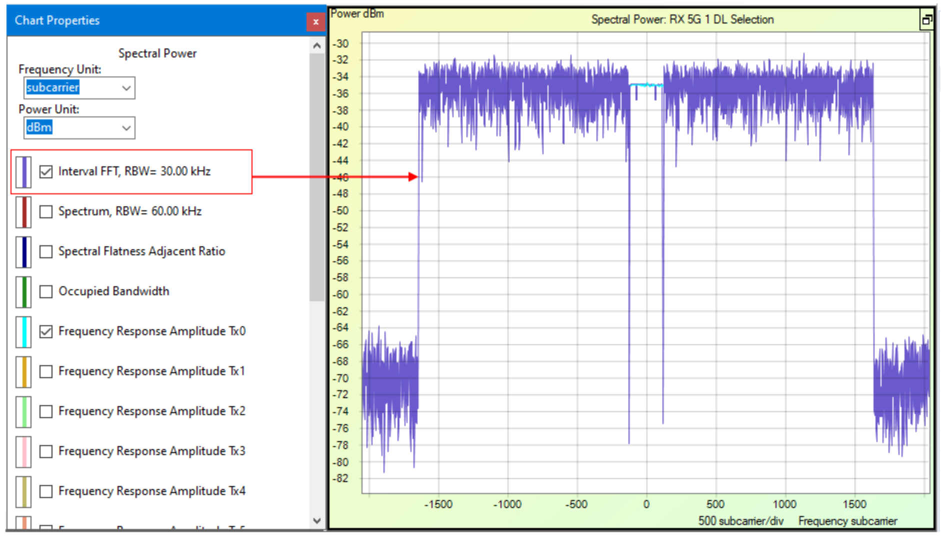
Spectral Power Chart - Interval FFT

The Spectral Power Chart Properties Window has many traces (indicated by the checkboxes with color lines), the Frequency Response Amplitude ranges from Tx0 to Tx15.

1. Interval FFT, RBW = 15.00 kHz
2. Spectrum, RBW = 07.50 kHz
3. Occupied Bandwidth
4. Frequency Response Amplitude Tx0
5. Frequency Response Amplitude Tx1
6. Frequency Response Amplitude Tx2
7. Frequency Response Amplitude Tx3

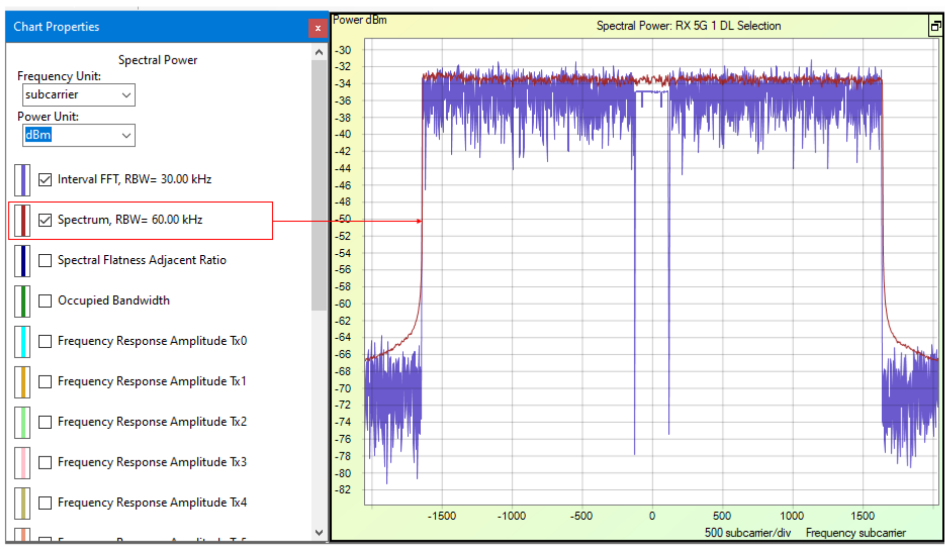
Different types of traces are described below. To illustrate the results when a specific trace is selected, all of the examples below are based on the same data capture.

Interval FFT, RBW = 30.00 kHz: In the figure below, the purple lines indicate the fast Fourier transform when the resolution bandwidth (RBW) hits 30.00 kHz.



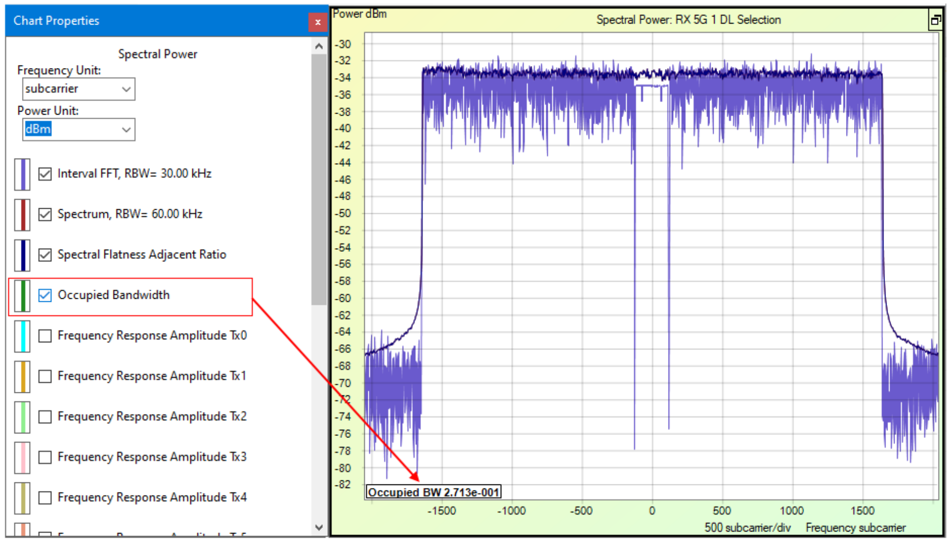
Spectral Power Chart - Interval FFT, RBW = 30.00 kHz

Spectrum, RBW = 60.00 kHz: In the figure below, the maroon lines indicate the spectrum begins when the resolution bandwidth (RBW) hits 60.00 kHz.



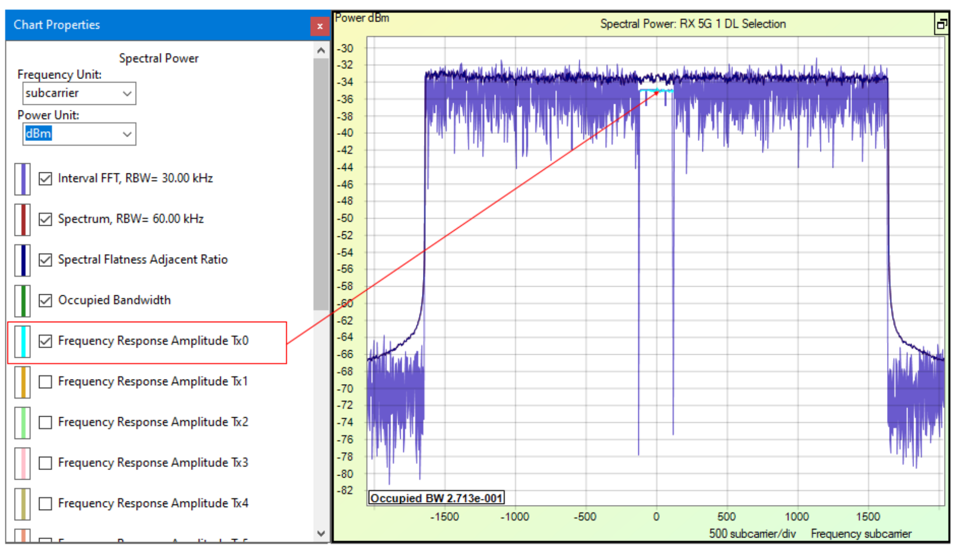
Spectral Power Chart - Spectrum, RBW = 60.00 kHz

Occupied Bandwidth: Selecting the occupied bandwidth trace displays a text box at the lower left corner that indicated the occupied bandwidth.



Spectral Power Chart - Occupied Bandwidth

Frequency Response Amplitude Tx0: In the figure below, the Frequency Response Amplitude for Tx0 is shown in light blue.

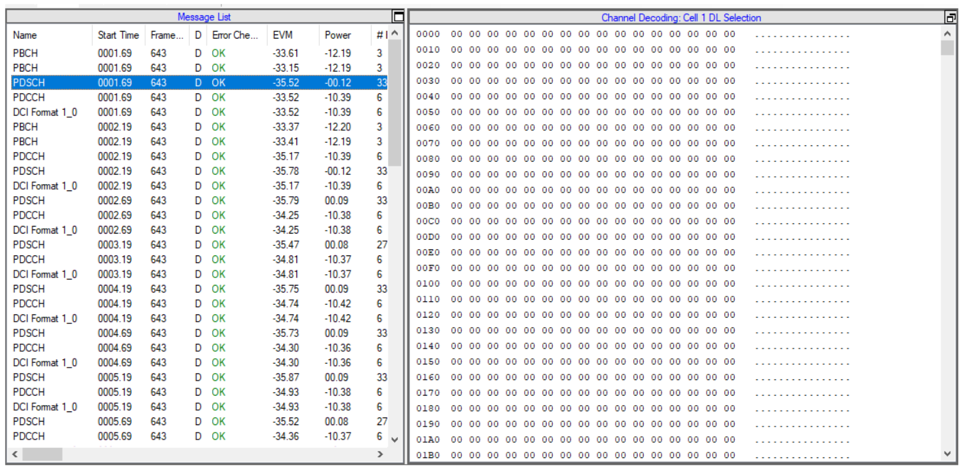


Spectral Power Chart - Frequency Response Amplitude Tx0

5. 6. 4 Channel Decoding Chart

The Channel Decoding chart displays a hexadecimal data dump for any selected burst or message. This hex dump is the output of the PHY after all coding, randomization, and interleaving have been removed and includes any padding contained in the burst.

Click on an individual message to display it's corresponding decoded chart. In the figure below, the selected message is PDSCH.

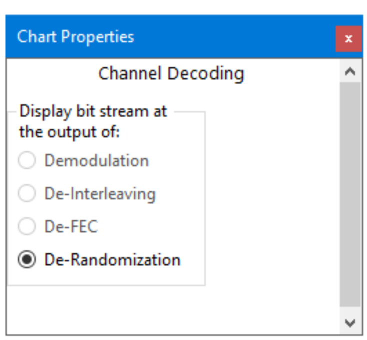


Channel Decoding Chart

To view the Channel Decoding output, right-click in a chart area and select Set Range toSelection to set the chart range to Selection. Then whatever message, burst, or other transmission is selected on the PHY Frame Lists on page 432 or WaveJudge Messages List on page 240 is shown in the Channel Decoding pane. The Hex information shown pertains to the entire burst selected in the PHY Frames list. (See Correlation/Message List Analysis of 4G LTE on page 479.)

To save a burst Hex dump from the Channel Decoding screen to a file, select the entire Hex dump in the Channel Decoding screen (click in the screen and press CtrlA to select all items), and then press CtrlC to copy the data. The raw data is now in the clipboard and can be pasted into any text editor.

To change parameters, open the Channel Decoding Pane's Chart Property Window.

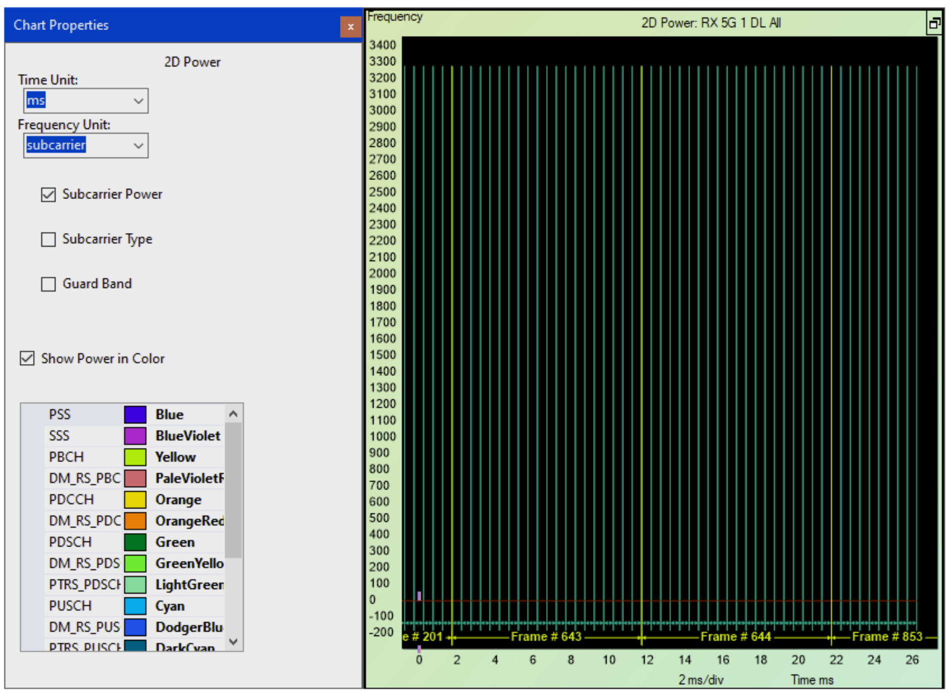


Channel Decoding Pane - Chart Properties Window

In the Chart Properties Window you can change the display bit stream at the output of demodulation, de-interleaving, de-FEC, and de-randomization.

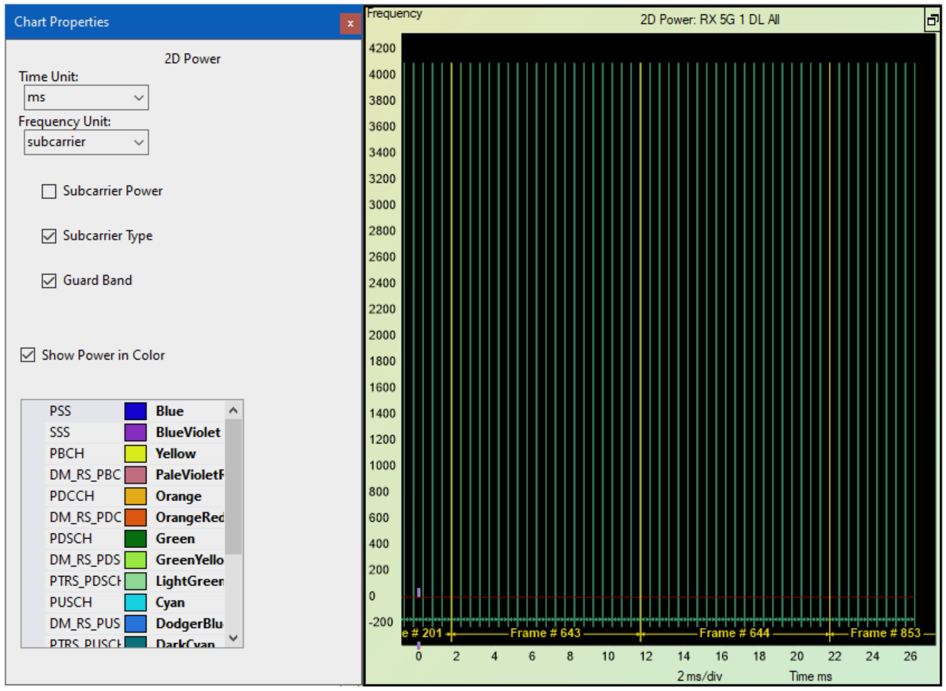
5. 6. 5 2D Power Chart

The 2D Power diagram displays all subcarriers in the time-frequency plane. In this chart, the subcarriers are shown in the physical frequency space (as ordered after performing the IFFT of the incoming data) as opposed to the logical frequency space in which bursts are contiguously allocated. There are two sets of data you can overlay on the chart, Subcarrier Power and Subcarrier Type.



2D Power Chart - Subcarrier Power

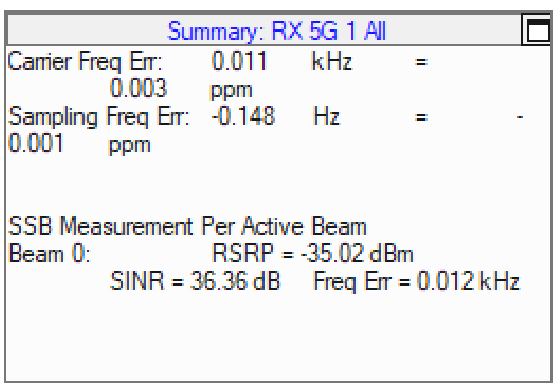
The figure below shows the same 2D Power chart showing the **Subcarrier Type** and the **Guard Band** down the left side.



2D Power Chart - Subcarrier Type

5. 6. 6 Summary Chart

The Summary chart presents text results and provides a summary of measurements of the entire capture or time interval. The figure below shows an example of a **Summary** for a 5G file.



5G Summary Chart

The properties in this chart as as follows.

Carrier Frequency Error: Offset relative to center frequency.

Sampling Frequency Error: Offset relative to the sampling frequency, where sampling frequency is defined as the bandwidth x Sampling Factor.

- If the Carrier Frequency Error and the Sampling Frequency Error ppm numbers are significantly different, it indicates that the Carrier clock and the Symbol clock are not tied to the same source, per wireless standards.

SSB Measurement Per Active Beam: Provides the RSRP, SINR, and the relative frequency offset measured from each active SSB beam of the cell.

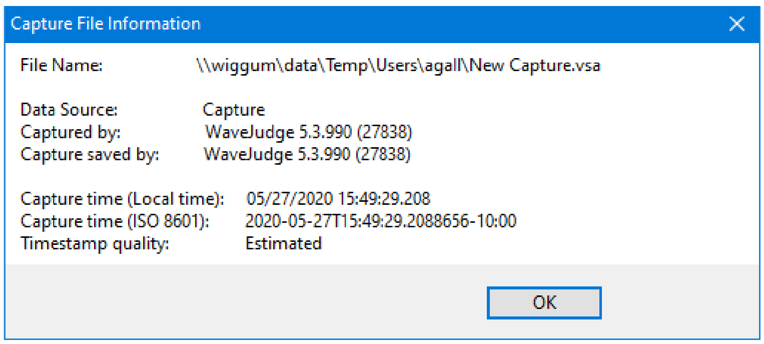
For additional Summary Charts, refer to Use 5G NR Charts on page 355, and Summary Chart - LTE on page 389 .

5. 7 Other Forms and Windows

This section provides information on other WaveJudge forms and windows that are useful, but not used very often.

5. 7. 1 Capture File Information

The WaveJudge main **File** menu contains a **Capture Information** menu item. This displays a **Capture File Information** window that shows essential information about the current WaveJudge capture whether it is taken in the current session or loaded from a saved capture file.



Capture File Information Window

Capture File Information fields are as follows:

- **File name:** File location and name
- **Data source:** Capture
- **Captured by:** Version of WaveJudge software.
- **Capture saved by:** Version of WaveJudge software.
- **Capture time (Local time):** Displays seven digits after the seconds (to within 0.1 microseconds).
- **Capture time (ISO 8601):** Capture time defined by the 24-hour clock format: date (YYYY-MM-DD) and time (hh-mm-ss).
- **Timestamp quality:** Precision or estimated.

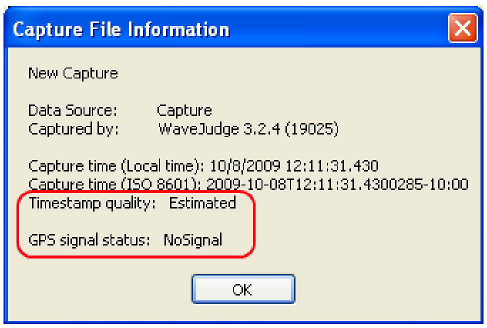
The Capture File Information window includes the precision of its timestamps (for example, whether it was taken with a GPS signal available and locked) and the status of the GPS at that time. If the capture was taken with a GPS signal locked, the window parameters include:

- **Timestamp quality:** Precision
- **GPS signal status:** GoodLock or Lock Unstable

- **Capture time (Local time):** Displays seven digits after the seconds (to within 0.1 microseconds).

If the capture was taken without the GPS signal locked, the window parameters include:

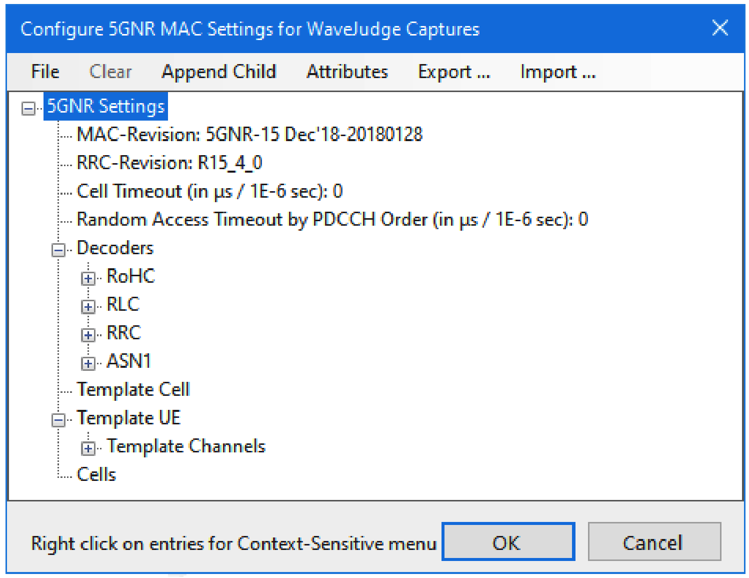
- **Capture time (Local time):** Displays only three digits after the seconds (to the nearest millisecond).
- **Timestamp quality:** Estimated
- **GPS signal status:** NoSignal



Capture File Information Window - Without GPS

5. 7. 2 Configure 5G NR MAC Settings

In the main menu Tools dropdown menu, select 5Gand the submenu MAC Settings. The figure below shows the window to configure 5GNR MAC settings.



Configure 5GNR MAC Settings for WaveJudge Captures Window

The window has six menu options that show only when your cursor is placed on the top level 5GNR Settings inside the chart. Otherwise, the menu options change according to the element. Optionally, you can select a menu item and right-click anywhere in the window to reveal a popup menu with specific options for that element.

Each menu is described below.

File

Opens a file to load or save.

- FileLoad

  Loads a file to create settings for.

- FileSave

  Saves a file to a specific location.

Clear

Erases any unsaved settings specific to a menu item

Append Child

Identifies all branches that have additional branches or attributes associated with its parents.

- Append ChildUEs

  Identifies all child UEs

Attributes

- AttributesAdd

    - All
    - Database Logging
    - Match STMSI in GUTI keys
  - AttributesClear
    - MAC-Revision
    - RRC-Revision
    - Cell Timeout (in µs / 1E-6 s)
    - Random Access Timeout by PDCCH Order (in µs / 1E-6 s)
  - AttributesDelete
    - MAC-Revision
    - RRC-Revision
    - Cell Timeout (in µs / 1E-6 s)
    - Random Access Timeout by PDCCH Order (in µs / 1E-6 s)
  - AttributesSet
    - MAC-Revision
    - RRC-Revision
    - Cell Timeout (in µs / 1E-6 sec)
    - Random Access Timeout by PDCCH Order (in µs / 1E-6 s)

Export...

Opens a window to save the file as a Settings file (*.sxl)

Import...

Opens a window to find a Settings file (*.sxl)

The following parameters are typical of the 5G NR MAC Settings window.

- MAC-Revision: Populates data from the latest 3GPP release; 5GNR-15 indicates Release 15, date June 2018.
- RRC-Revision: Populates data from the latest 3GPP release; R15 indicates Release 15.
- Cell Timeout (in µs / 1E-6 sec): Sets the default cell timeout in microseconds; 1E-6 indicates 1 with six zeros per second; for example, 1,000,000 seconds.
- Random Access Timeout by PDCCH Order (in µs / 1E-6 sec): If PDCCH Order to RA is seen, MAC-RAR within this period does NOT clear UE. Outside of this time range, a new UE is assumed.
- Decoders
  - RoHC: Robust header compression decoder
  - RLC: Radio link control decoder
  - RRC: Radio resource control decoder
  - ASN1: Abstract syntax notation 1 decoder

- Template Cell: Allows the user to define the maximum RA-RNTIs supports if the parameters are not present.
- Template UE: Defines template channels to handle RLC decodes based on the configuration of the channel identified by the LCID. It is used when the RLC configuration for the particular LCID user by the UE has not be decoded by the WaveJudge in a capture.
  - Template Channels: Allows the user to define and configure the channel identified by the LCID.
    - Channel {0}: The first channel available in a series.
- Cells: The service areas of a cellular network.

5G NR MAC Settings for Cipher Keysets

Additionally, under the Template UE, there is also the Template Keysets, configure these parameters to decode ciphered traffic when the keys are not in the current capture.

NOTE Currently, there is no automatic extraction of radio bearer configurations in 5G because there are no separate UEs.

Configure 5GNR MAC Settings for WaveJudge Captures - Template Keysets

Set the following parameters under Template Keysets, as needed.

Current KSI: Current Key Set Identifier

Next KSI: Next Key Set Identifier

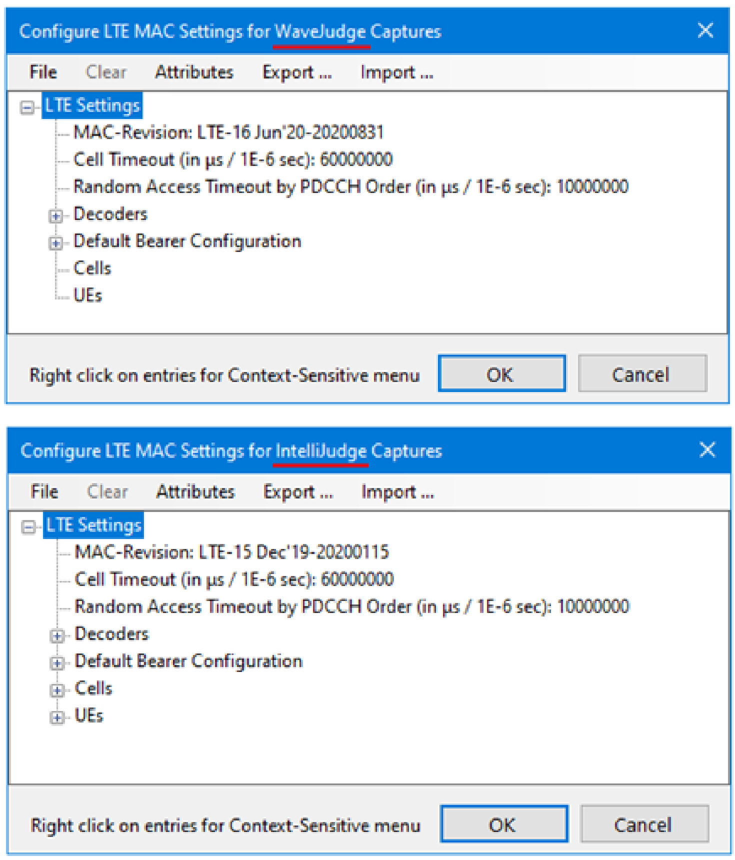
KeySet {0}: Key Set 0 is the first key set in a series

- KSI: Key Set Identifier
- NASContext: Non-Access Stratum (NAS)
  - Cipher Algorithm Override
  - Integrity Algorithm Override
  - Cipher Key Override
  - Integrity Key Override
- gNB Context: The logical 5G radio node.
- NCC Ovderride: Next Hop (NH) Chaining Counter (NCC)
- SRB Context: For RRC signalling (Signaling Radio Bearers), ciphering provides signalling data confidentiality and integrity protection signalling data integrity.
- DRB Context: For user data (Dedicated Radio Bearer), ciphering provides user data confidentiality and integrity protection provides user data integrity.

5. 7. 3 Configure LTE MAC Settings

There are individual LTE MAC Settings Windows for WaveJudge and IntelliJudge, however their menus are almost identical. This section describes the menus they have in common and then describes the different LTE Setting trees that are specific to WaveJudge and IntelliJudge.

- To access the WaveJudge LTE MAC Settings window, open the Tools menu and select WaveJudge LTE MAC Settings from the drop-down list.
- To access the IntelliJudge LTE MAC Settings window, open the Tools menu and select IntelliJudge LTE MAC Settings..



WaveJudge and IntelliJudge LTE MAC Settings Windows

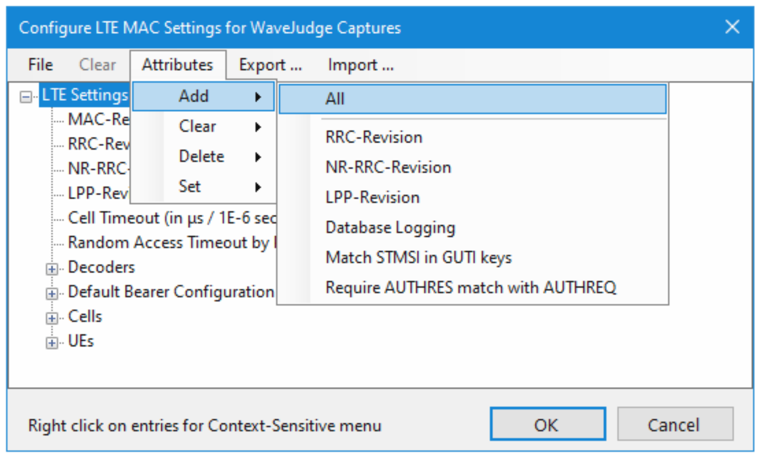
The LTE MAC Settings Window has five main menus: File,Clear, Attributes, Export..., and Import.... If these menus do not appear in a window, click on the top line item to activate the menu options. Click on a lower line item and one of two alternate menus appear with one or two different options added.

File: Provides an option to Load or Save a file.

Clear: Deletes a setting.

Attributes: Provides options to Add, Clear, Delete, or Set attributes to different settings.

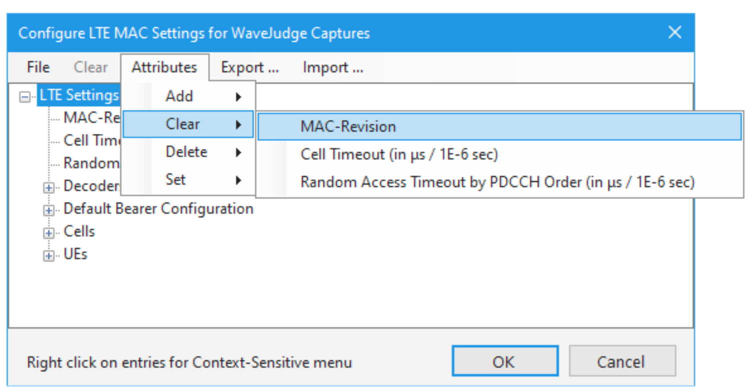
- The Add submenu is where you can add all attributes listed in the submenu beneath it, or select one of the options: RRC-Revision, NR-RRC Revision, LPP-Revision, Database Logging, Match STMSI in GUTI Keys, or Require AUTHRES match with AUTHREQ.



LTE MAC Settings Window - Attributes - Add Submenu Options

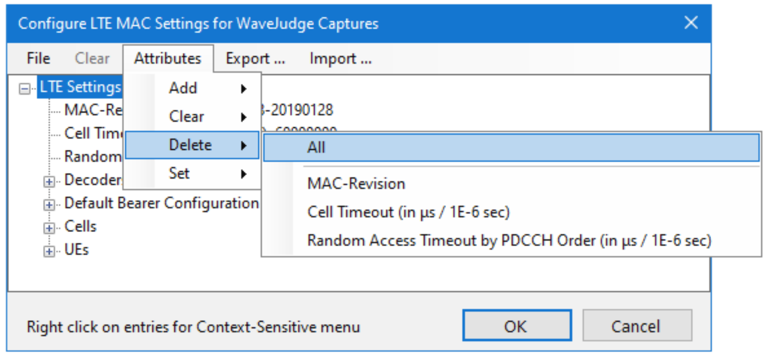
For information on RRC-Revision, see Radio Resource Control (RRC) on page 493.

- The Clear submenu is where you can select which specific groups of attributes to reset to default properties; options are MAC-Revision; Cell Timeout (in µs / IE-6 s); and Random Access Timeout by PDCCH Order (in µs / IE-6 sec).



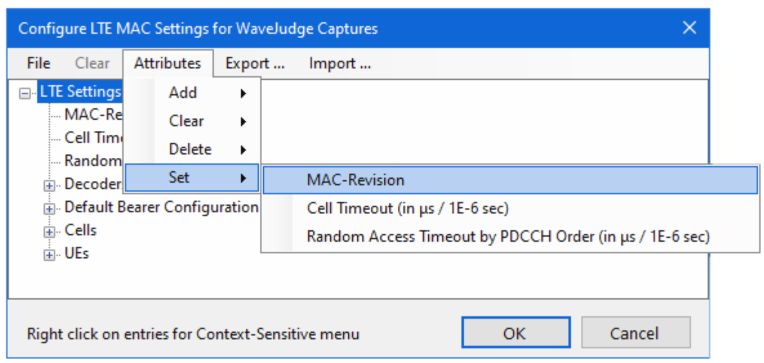
LTE MAC Settings Window Attributes - Clear Submenu Options

- The Delete submenu is where you select which specific groups of attributes to delete; options are All, MAC-Revision; Cell Timeout (in µs / IE-6 sec); and Random Access Timeout by PDCCH Order (in µs / IE-6 sec).



LTE MAC Settings Window - Attributes - Delete Submenu Options

– The Set submenu is where you can select a specific group of attributes to set to default; options are MAC-Revision; Cell Timeout (in µs / IE-6 sec); and Random Access Timeout by PDCCH Order (in µs / IE-6 sec).



LTE MAC Settings Window - Set Submenu Options

Export...: Opens a Save As window where you can save the settings to your PC in .SXL format.

Import...: Opens an Open window where you can locate and open settings (.SXL) file

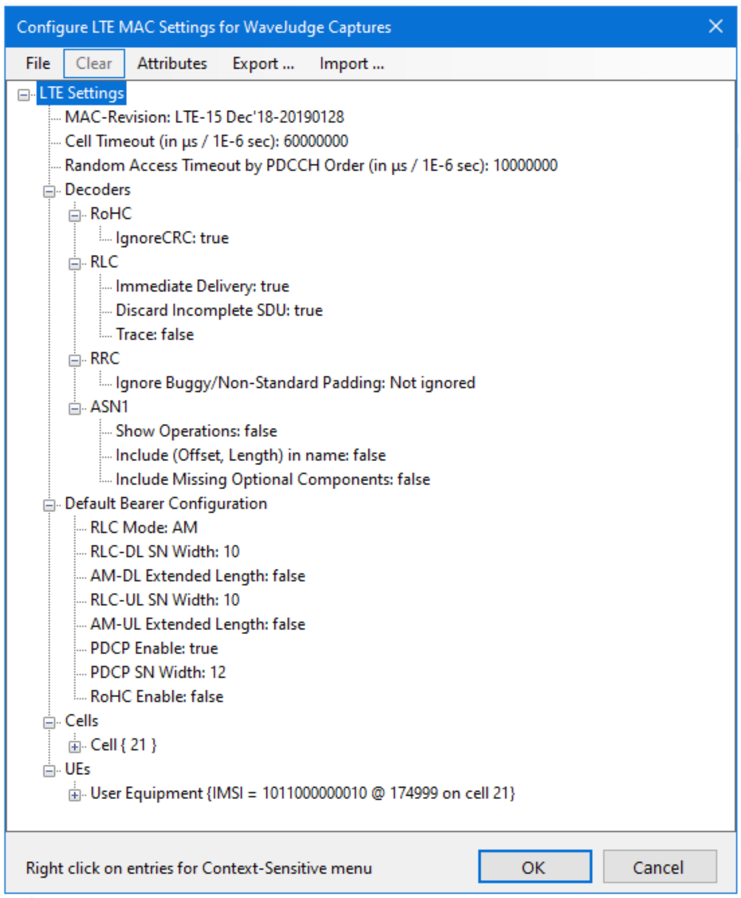
You can access an alternate LTE MAC Settings Window by right-clicking on a setting; the same window menu options appear in a popup box that are listed in the alternate menu window. The most common options are previously described above, however the following new options also appear in both menus.

Add: Attributes or branches of a child that are mandatory are automatically created; however, you may add optional or other mandatory attributes.

Append Child: Identifies all branches that have additional branches or attributes associated with its parents. Options may include kASME Algorithm, User Equipment, or Cell.

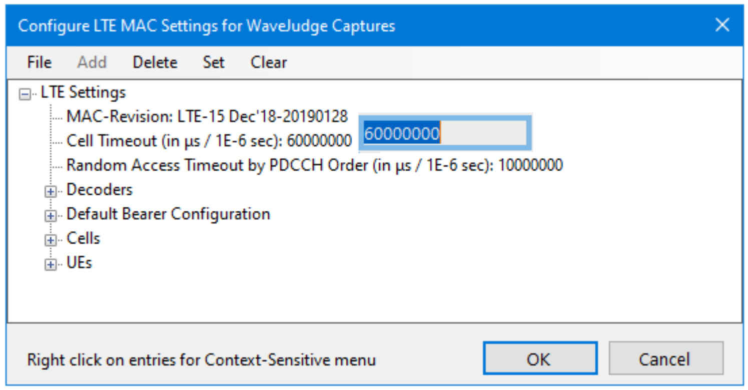
5. 7. 3. 1 WaveJudge LTE MAC Settings Window

To access the WaveJudge LTE MAC Settings window open the Tools menu and select WaveJudge LTE MAC Settings.. from the drop-down list. A window similar to the one below will open; however the figure below shows the tree setting menus (for example, LTE Settings, Decoders, Default Bearer Configuration, Cells, and UEs) expanded. This information is built from the information in the capture. Generally, you do not have to configure these fields, they simply allow you the option to add information not in the capture if necessary.



LTE MAC Settings Window - Expanded

To access and change any line item properties click on it (it will highlight in a blue background) and then right-click to access options, such as **Set** and make your edit in the blue text field that appears.

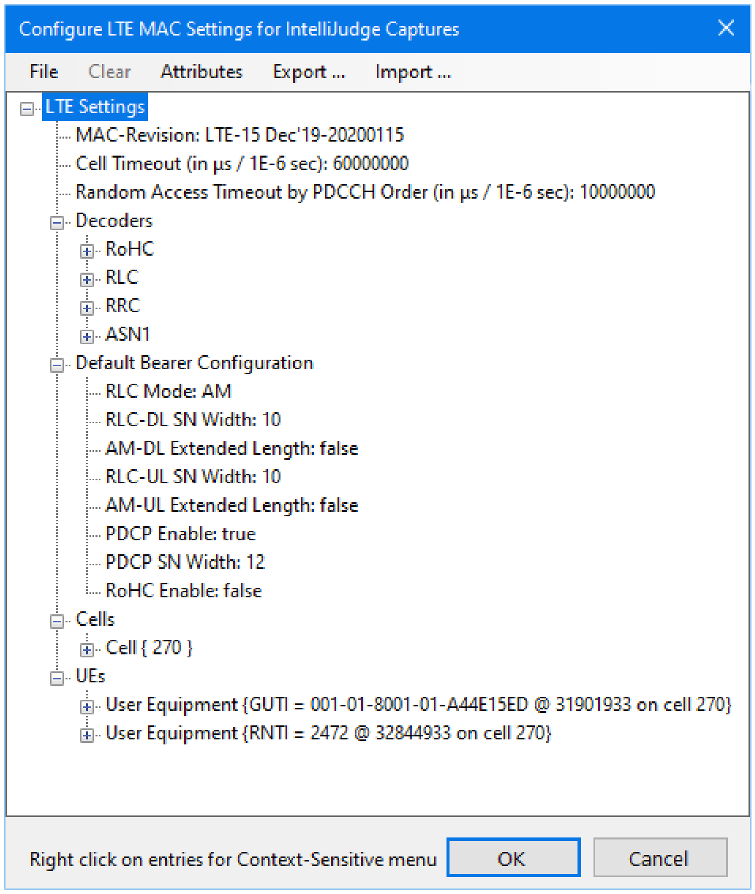


WaveJudge LTE MAC Settings Window - Right Click to Edit

Regarding MAC, RRC, and LLP revisions, if you use the " Set the default" option you do not need to change the settings. However, if you want to use a different MAC or RRC revision than what is shown under LTE Settings on the Configure LTE Cell Pane then you should change the settings. As an example, if you upgrade your license from LTE 9 to 10, 11, or 12, and you use an old configuration then you would need to manually configure these fields if the capture includes data specific to the new standards.

5. 7. 3. 2 IntelliJudge LTE MAC Settings Window

To access the IntelliJudge LTE MAC Settings window open the Tools menu and select IntelliJudge LTE MAC Settings... A window similar to the one below will open; however the figure below shows the tree setting menus (for example, LTE Settings, Decoders, Default Bearer Configuration, Cells, and UEs) expanded.



IntelliJudge LTE MAC Settings Window - Expanded

To access and change any line item properties click on it (it will highlight in a blue box or blue background cell) and then right-click to access options.

IntelliJudge LTE MAC Settings Window - Right Click to Edit

5. 7. 4 Configure Filters

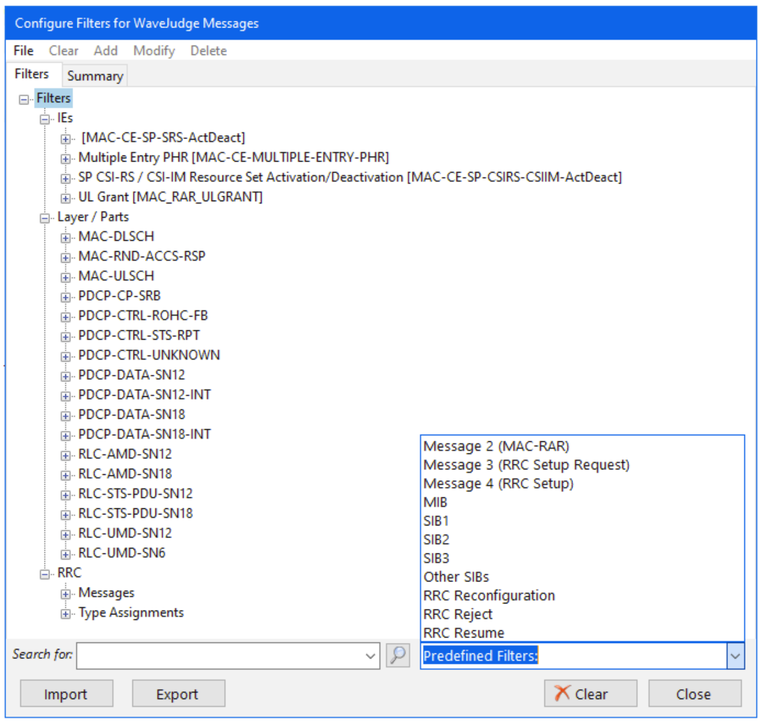
WaveJudge lets you configure complex filters to identify specific high-level messages of interest. You can configure filters:

- to emphasize and select specific messages in the WaveJudge Messages List;
- to emphasize and select specific messages in the IntelliJudge Message List;
- to set up IntelliJudge Triggers which will be used to trigger a WaveJudge capture when an event of particular interest is detected during an IntelliJudge capture.

The same basic user interface and form type is used for all of these purposes. In the example illustrations below, the IntelliJudge Filters are shown but the operation of the Configure Filters Window is the same in all cases.

5. 7. 4. 1 Configure Filters for 5G WaveJudge Messages

To access the list of filters for WaveJudge processing and the WaveJudge Messages List, go to the main menu and pick ToolsWaveJudge Filters. The Configure Filters for WaveJudge Messages window will open.



Configure Filters for 5G WaveJudge Messages

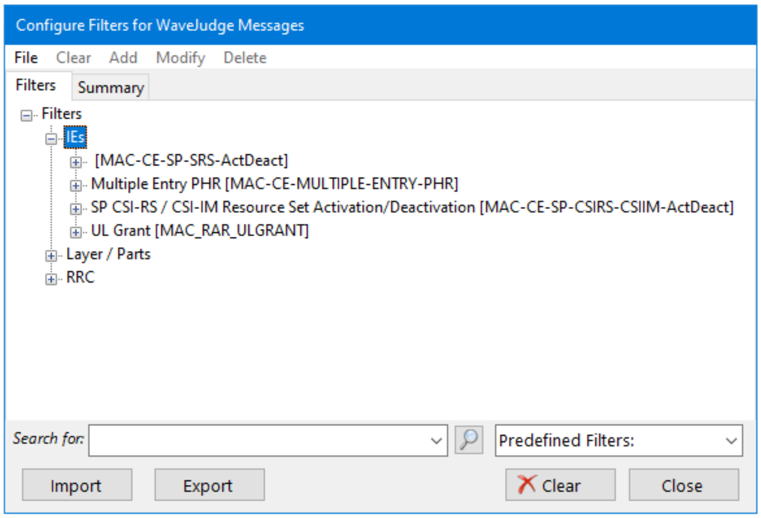
The bottom right corner of this window shows the **Predefined Filters**. Click on a filter to open it in the data tree and set your preferences.

- Message 2 (MAC-RAR)
- Message 3 (RRC Setup Request)
- Message 4 (RRC Setup)
- MIB
- SIB1
- SIB2
- SIB3
- Other SIBs
- RRC Reconfiguration
- RRC Reject
- RRC Resume

The three default 5G NR filter categories, IEs, Layer/Parts, and RRC are briefly described below.

5G WaveJudge Filters - IEs

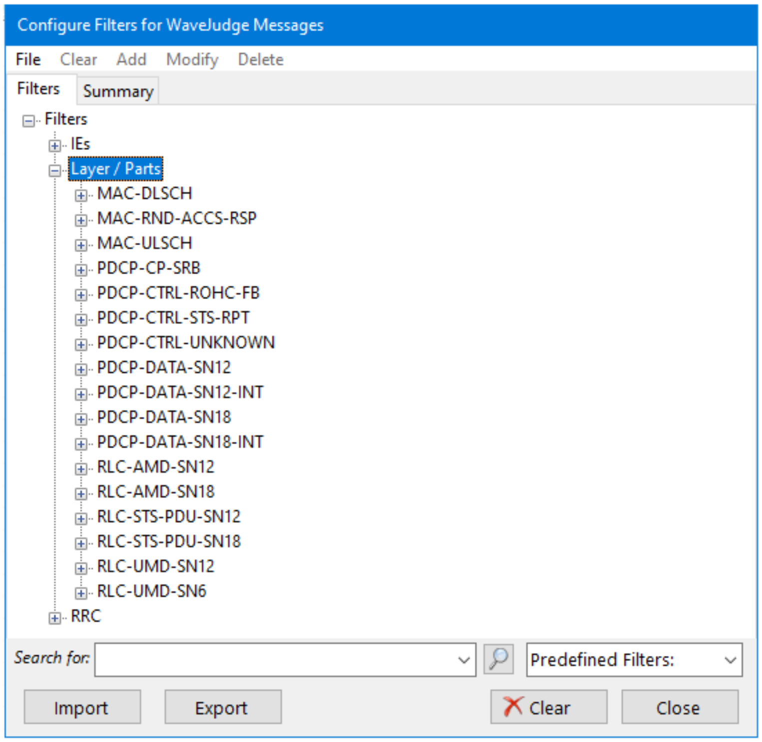
For a list of the default 5G IE filters, refer to 5G Default Filters - IEs. For additional protocol-specific 5G IE filters, refer to 5G Other Filters - IEs.



Configure 5G Filters for WaveJudge Messages - IEs

5G WaveJudge Filters - Layers/Parts

For a list of the default 5G Layer/Parts filters, refer to 5G Default Filters - Layer/Parts. For additional protocol-specific 5G filters, refer to 5G Other Filters - Layer/Parts.

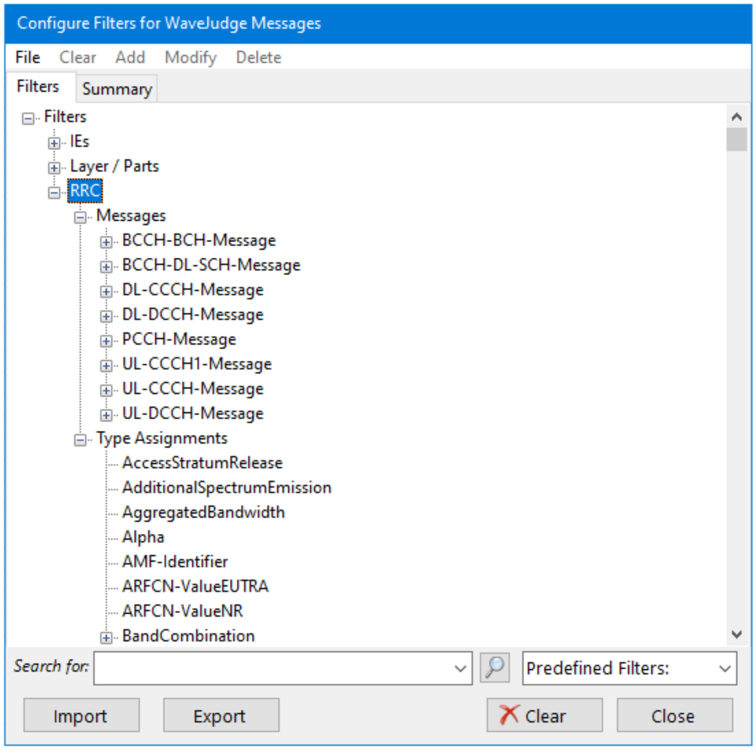


Configure 5G Filters for WaveJudge Messages - Layer / Parts

5G WaveJudge Filters - RRC

For a list of the default 5G RRC filters, refer to 5G Default Filters - RRC. For additional protocol-specific 5G filters, refer to 5G Other Filters - RRC.

Note the list of Type Assignments is too extensive to document, refer to an actual open Configure Filters for WaveJudge Messages window to locate the filter you are looking for.



Configure 5G Filters for WaveJudge Messages - IEs

5. 7. 4. 2 LTE Filters

Since filter categories are determined by the decoding process, they depend on the current active protocol. For example, WiMAX and LTE have different filters.

In some cases, the details of the filters available depend on the exact protocol revision currently selected. For example, LTE 12 will have additional filters for fields and elements not defined in LTE 9 or 10.

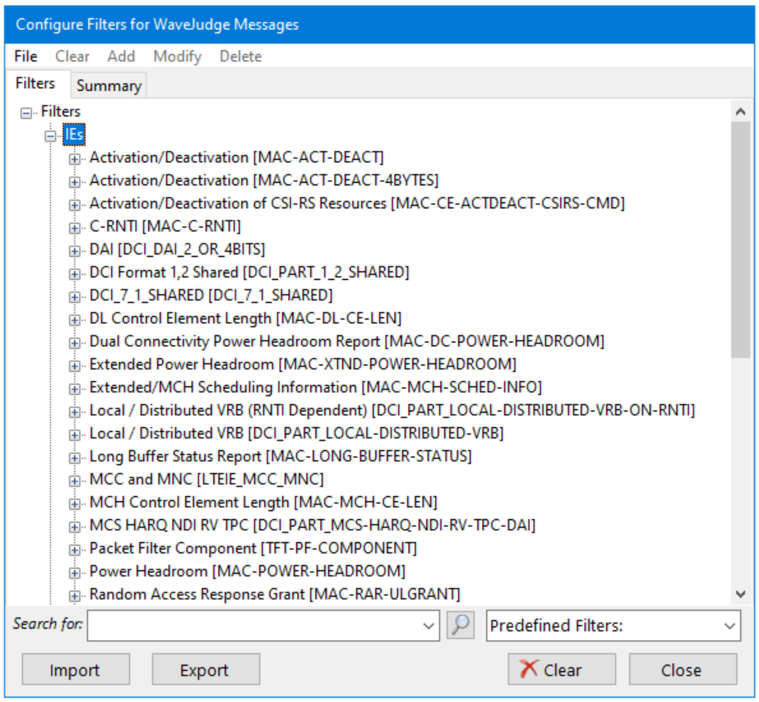
LTE filters are divided into the following categories.

1. LTE Filters - IEs on page 292
2. LTE Filters - LTE IEs on page 293
3. LTE Filters - Layer/Parts on page 293
4. LTE Filters - Physical Channels on page 294
5. LTE Filters - RRC on page 295
6. LTE Filters - UCI Messages on page 296
7. LTE Filters - Global on page 297
8. LTE Filters - CipherJudge UEs on page 297
9. LTE Filters - Transport and IP Layer on page 298

NOTE The lists of WaveJudge LTE filters are the same as IntelliJudge LTE Filters. The only difference is whether you select WaveJudge Filters or IntelliJudge Filters from the Tools menu, the resulting window will reflect the option.

LTE Filters - IEs

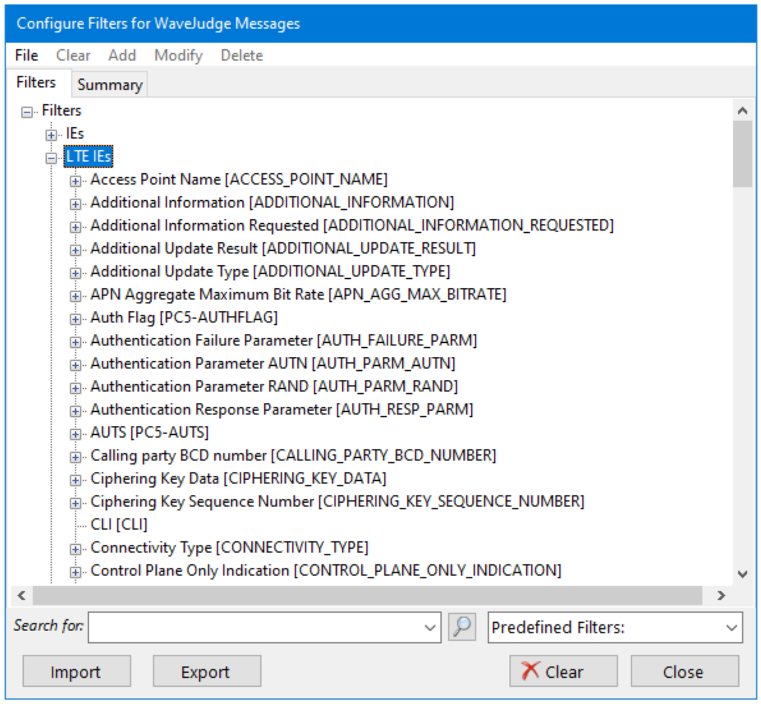
LTE IE filters are shown below and listed in LTE Filters - IEs on page 685.



Configuring WaveJudge LTE Filters - IEs

LTE Filters - LTE IEs

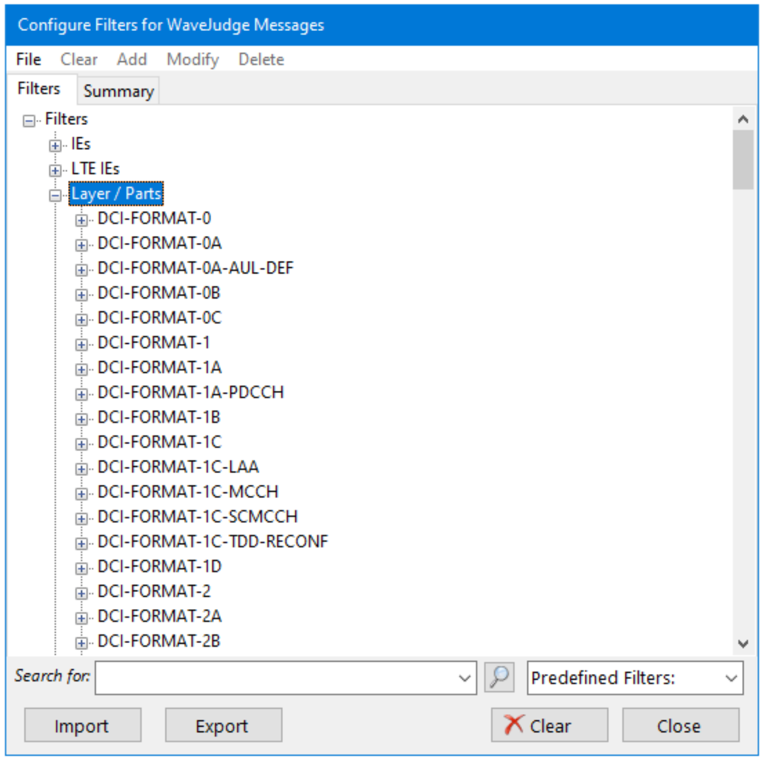
LTE IE list of filters is extensive, refer to LTE Filters - LTE IEs on page 689.



Configuring WaveJudge LTE Filters - LTE IEs

LTE Filters - Layer/Parts

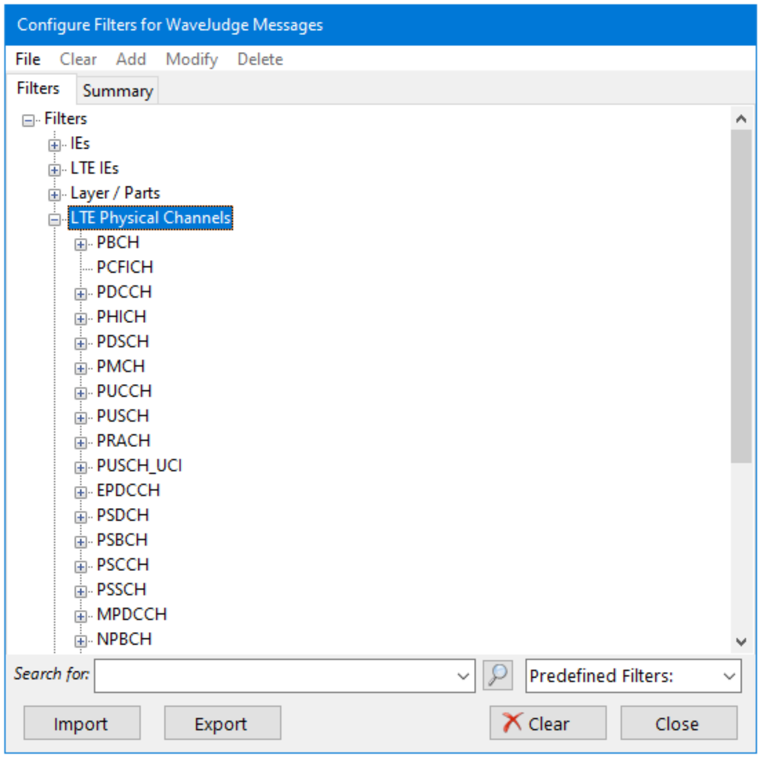
LTE Layers/Parts filters are shown below and listed in LTE Filters - Layer/Parts on page 696.



Configuring WaveJudge LTE Filters - Layer/Parts

LTE Filters - Physical Channels

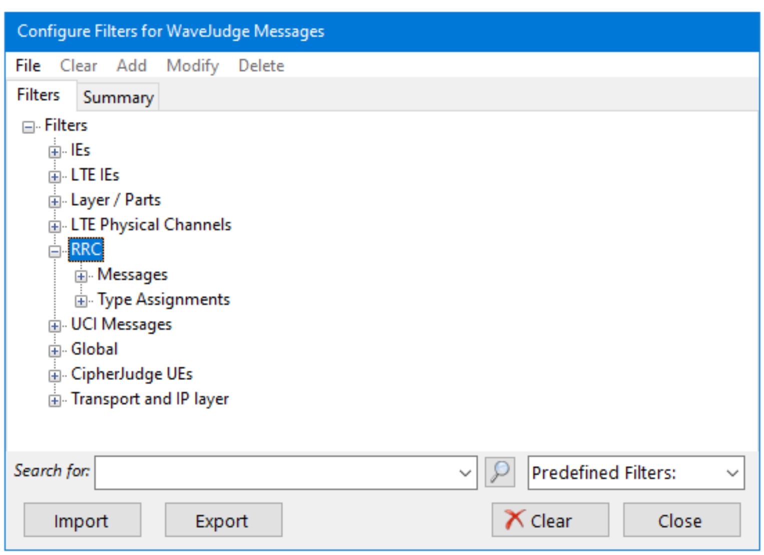
LTE Physical Channel filters are shown below and listed in LTE Physical Channels on page 702.



Configuring WaveJudge LTE Filters - Physical Channels

LTE Filters - RRC

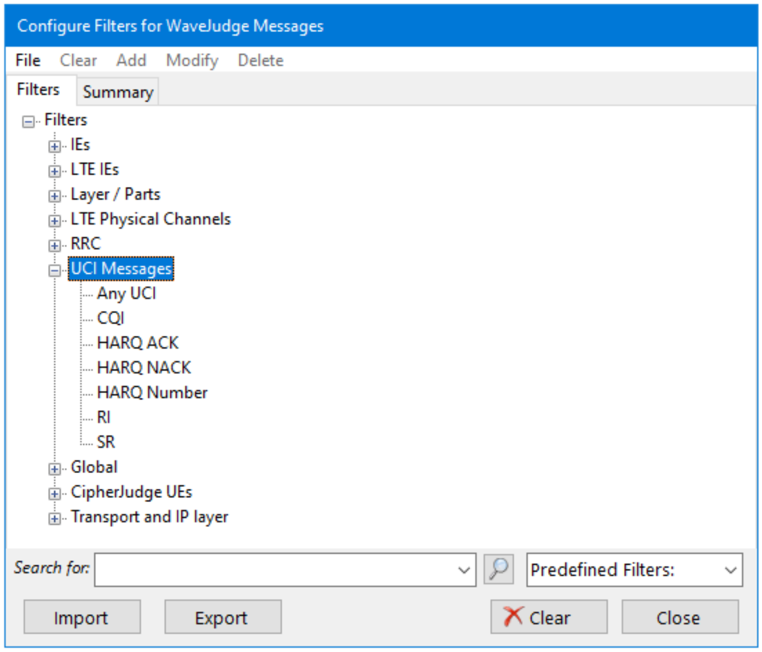
A brief list of LTE RRC filters is in LTE Filters - RRC on page 703. The Type Assignments subsection has hundreds of filters; refer to the actual filters window - whether for IntelliJudge or WaveJudge - to locate the filter you are looking for.



Configuring WaveJudge LTE Filters - RRC

LTE Filters - UCI Messages

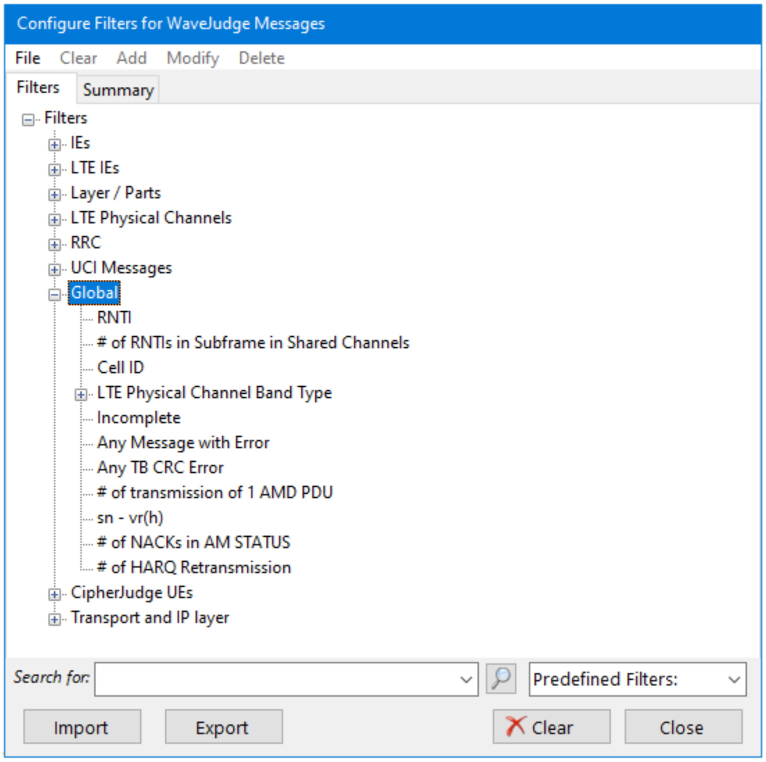
LTE UCI Message filters are shown below and listed in LTE Filters - UCI Messages on page 704.



Configuring WaveJudge LTE Filters - UCI Messages

LTE Filters - Global

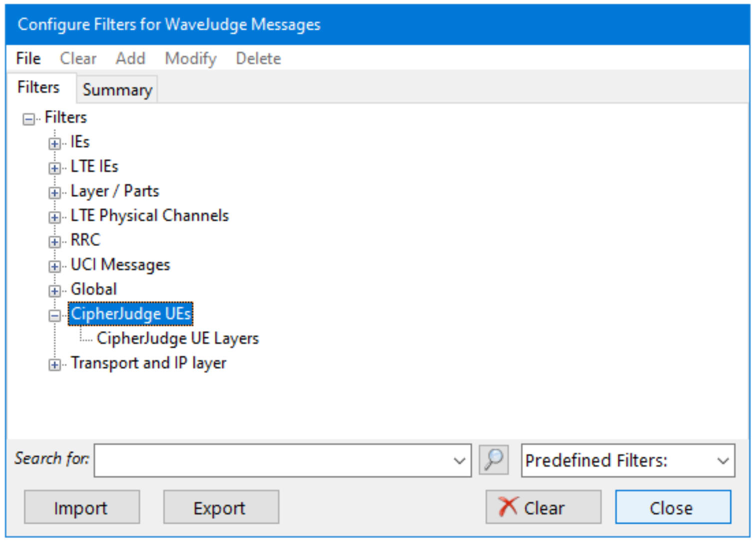
LTE Global filters are shown below and listed in LTE Filters - Global on page 704.



Configuring WaveJudge LTE Filters - Global Filters

LTE Filters - CipherJudge UEs

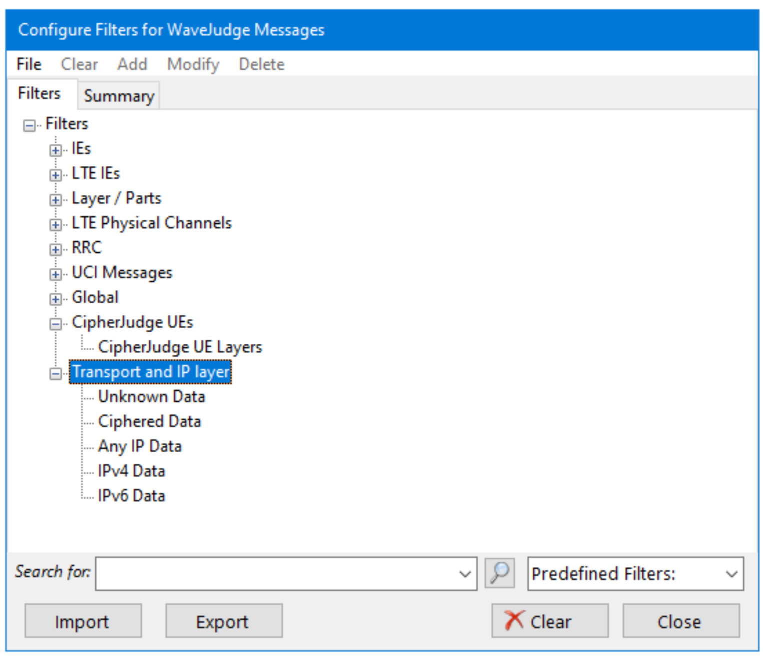
There is only one CipherJudge protocol filter - CipherJudge UE Layers. For more information, refer to LTE Filters - CipherJudge UEs on page 704.



Configuring WaveJudge LTE Filters - CipherJudge UEs

LTE Filters - Transport and IP Layer

LTE Transport and IP Layer filters are shown below and listed in LTE Filters - Transport and IP Layer on page 705.



Configuring WaveJudge LTE Filters - Transport and IP Layer

5. 7. 5 5G NR Reference Signal Windows

To increase protocol efficiency and keep transmissions contained within a slot or beam without having to depend on other slots and beams, NR has following four main reference signals.

- Demodulation Reference Signal (DMRS)
- Phase Tracking Reference Signal (PTRS)
- Sounding Reference Signal (SRS)
- Channel State Information Reference Signal (CSI-RS)

5G NR is different from LTE in several ways.

- In NR, there is no Cell-specific Reference Signal (C-RS).
- The new Time/Frequencyreference tracking is called Phase Tracking Reference Signal (PTRS).
- DMRS is for both downlink and uplink channels.
- In NR, reference signals are transmitted only when it is necessary; whereas LTE reference signals are constantly exchanged to manage the link.

5. 7. 5. 1 5G DMRS Message Window

The Demodulation Reference Signal (DMRS) is specific to a UE, it is used to estimate the radio channel and is transmitted on demand. A system can beamform the DMRS, keep it within a scheduled resource, and transmit it only when necessary in either DL or UL.

DMRS design and mapping is specific to each downlink and uplink NR channel through NR-PBCH, NR-PDCCH, NR-PDSCH, NR-PUSCH, NR- PUSC. Multiple orthogonal DMRSs can be allocated to support MIMO transmission.

To view the **DMRS Message Window** double-click a DMRS message.

Channel Matrix options are as follows.

Power in dBm: The aggregated power in the unit of dBm over all the DMRS tones associated to this channel path.

EVM in dB: The ratio in the unit of “dB” of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

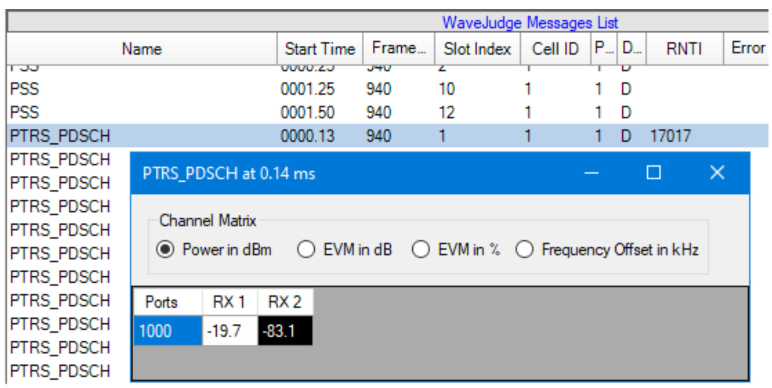
EVM in %: The ratio in the unit of a percentage (%) of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

Frequency Offset in kHz: The relative frequency offset estimated from this channel path in the unit of “Kilohertz”. In both PDSCH and PUSCH, WaveJudge uses the previous valid SSB as the reference for this measurement.

5. 7. 5. 2 5G PTRS_PDSCH Message Window

Phase noise of a transmitter increases as the frequency of operation increases. Phase Tracking Reference Signal (PTRS) plays a crucial role (especially at mmWave frequencies) to minimize the effect of the oscillator phase noise on system performance. Due to phase noise properties, PTRS has low density in frequency domain and high density in time domain. One of the main problems that phase noise introduces into an OFDM signal appears as a common phase rotation of all the subcarriers, known as common phase error (CPE). PTRS is present both in uplink (NR-PUSCH) and downlink (NR-PDSCH) channels.

To view the PTRS-PDSCH Message Window double-click a PTRS_PDSCH message.



PTRS_PDSCH Message Window

Channel Matrix options are as follows.

Power in dBm: The aggregated power in the unit of dBm over all the DMRS tones associated to this channel path.

EVM in dB: The ratio in the unit of “dB” of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

EVM in %: The ratio in the unit of a percentage (%) of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

Frequency Offset in kHz: The relative frequency offset estimated from this channel path in the unit of “Kilohertz”. In both PDSCH and PUSCH, WaveJudge uses the previous valid SSB as the reference for this measurement.

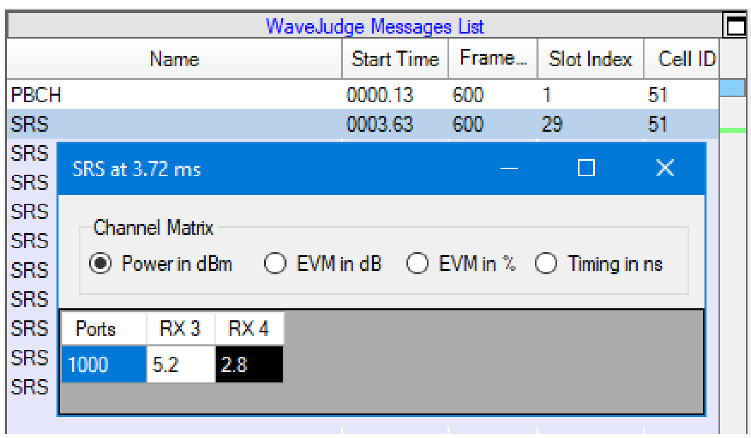
The brightness of a box indicates the relative heuristic confidence level for the value in the box (the brighter, the more trustworthy).

5. 7. 5. 3 5G SRS (Uplink) Message Window

Sounding Reference Signal (SRS) is a UL-only signal transmitted by the UE to help the gNB obtain the channel state information (CSI) for each user. CSI describes how the NR signal propagates from the UE to the gNB and represents the combined effect of scattering, fading, and power decay with distance. The system uses the SRS for resource scheduling, link adaptation, Massive MIMO, and beam management.

In a Time Domain chart, SRS spans 1/2/4 consecutive symbols which are mapped within last six symbols of the slot. Multiple SRS symbols allow coverage extension and increased sounding capacity. The design of SRS and its frequency hopping mechanism are the same as those used in LTE.

To view the SRS Message Window double-click an SRS message.



SRS Message Window

Channel Matrix options are as follows.

Power in dBm: The aggregated power in the unit of dBm over all the DMRS tones associated to this channel path.

EVM in dB: The ratio in the unit of “dB” of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

EVM in %: The ratio in the unit of a percentage (%) of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

Timing in ns: The relative timing offset estimated from this channel path in the unit of “Nanosecond”. For a PDSCH, its reference is the signal timing transmitted on the previous SSB. For a PUSCH, its reference is the signal timing transmitted on the previous SSB with adding the adjusted UL timing offset configured on the WaveJudge GUI for this channel.

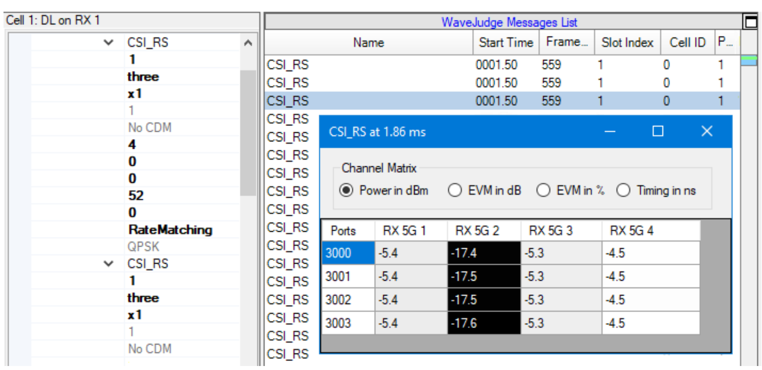
The brightness of a box indicates the relative heuristic confidence level for the value in the box (the brighter, the more trustworthy).

5. 7. 5. 4 5G CSI-RS (Downlink) Message Window

Channel State Information Reference Signal (CSI-RS) is a DL-only signal used for DL CSI acquisition. The CSI-RS that the UE receives estimates and reports the channel quality information back to the gNB.

During MIMO operations, 5G NR uses different antenna approaches based on the carrier frequency. At lower frequencies, the system uses few active antennas for MU-MIMO and adds FDD operations. In this case, the UE needs the CSI-RS to calculate the CSI and report it back in the UL direction.

To view the CSI-RS Message Window double-click a CSI-RS message in the WaveJudge Message List.



5G NR CSI-RS Message Window

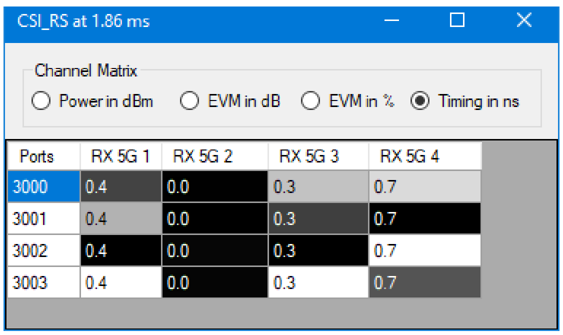
Channel Matrix options are as follows.

Power in dBm: The aggregated power in the unit of dBm over all the DMRS tones associated to this channel path.

EVM in dB: The ratio in the unit of “dB” of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

EVM in %: The ratio in the unit of a percentage (%) of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

Timing in ns: The relative timing offset estimated from this channel path in the unit of "Nanosecond". For a PDSCH, its reference is the signal timing transmitted on the previous SSB. For a PUSCH, its reference is the signal timing transmitted on the previous SSB with adding the adjusted UL timing offset configured on the WaveJudge GUI for this channel.



5G NR CSI-RS - Timing in Nanoseconds Shows Shaded Cells

If you do not see any CSI-RS messages, right-click in the WaveJudge Message List and select Properties from the Context Menu. In the Chart Properties window on the Advanced Element Choices tab, check the box for CSI-RS; the sub category boxes for NZP CSI-RS and ZP CSI-RS will automatically be selected with it. Click the Reprocess button ; you should see the messages. To sort the list, click the Name column and select either Sort Up or Sort Down from the options.

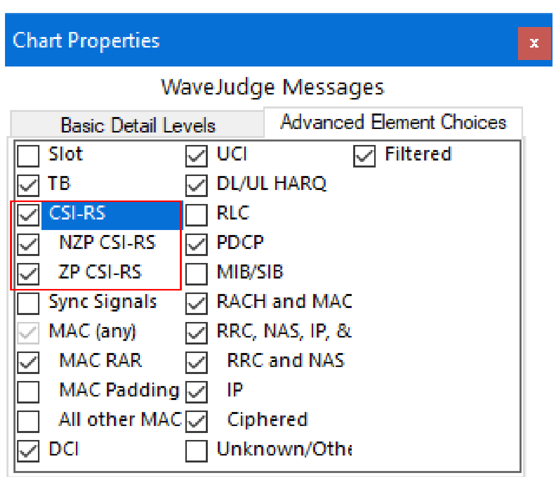
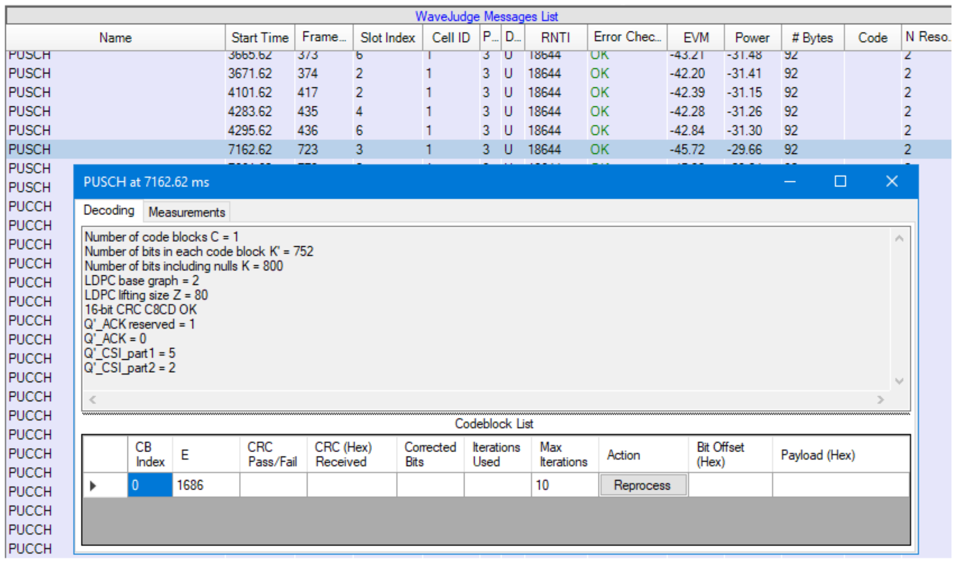


Chart Properties Window - Select CSI-RS

5. 7. 5. 5 5G PDSCH and PUSCH Message Windows

Click on a PDSCH or PUSCH message in the WaveJudge Message List to open a message window that allows you to decode or reprocess a code block. There are two tabs at the top of the window: Decoding and Measurements. The PUSCH decoding tab is identical to PDSCH.



PDSCH/PUSCH Message Window - Decoding Tab

Sort any column by clicking on the column title which activates a small arrow icon to sort with. Data fields in the Decoding tab are as follows.

Number of code blocks C: The total number of code blocks for this transport block as defined in TS 38.212 Clause 5.2.2.

Number of bits in each code block K': The number of bits in each code block of this transport block, which is the interim parameter K' defined in TS 38.212 Clause 5.2.2.

Number of bits including nulls K: The number of bits, including nulls, in each code block of this transport block, which is the parameter K defined in TS 38.212 Clause 5.2.2.

LDPC base graph: The Low Density Parity Check base graph selection for this transport block as defined in TS 38.212 Clause 5.2.2 and 5.3.2.

LDPC lifting size: The LDPC lifting size Z as defined in TS 38.212 Clause 5.2.2 and 5.3.2.

24-bit CRC 000000: The CRC attachment for this transport block as specified in TS 38.212 Clause 7.2.1.

PDSCH message window columns are as follows.

CB Selection: When clicking this "Code Block Selection" arrow, the corresponding data for the code block displays on such as the Constellation panel, the 2D-Power panel, and the EVM Per Subcarrier panel.

CB Index: Code block number as defined in TS 38.212 Clause 5.2.2.

E: The rate matching output sequence length for this code block as defined in TS 38.212 Clause 5.4.2.

CRC Pass/Fail: Indicates the payload of the code block is properly decoded or not based on the code block CRC attachment check as specified in TS 38.212 Clause 5.2.2. Shows either **OK** (green cell) or **Error** (red cell).

CRC (Hex) Received: The CRC attachment displayed as HEX for this code block, as specified in TS 38.212 Clause 5.2.2.

Corrected Bits: The total number of corrected bits for the decoded output sequence of this code block.

Iterations Used: The number of iterations used to decode this code block.

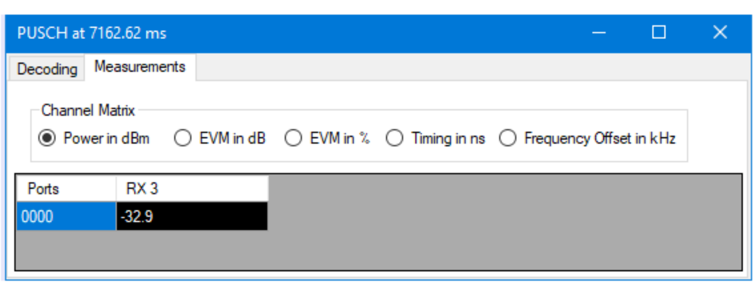
Max Iterations: The maximum number of iterations applied to the LDPC decoder for this code block.

Action: Click this button to reprocess the channel decoding for the code block.

Bit Offset (Hex): The total bit length displayed as HEX of all code blocks before this code block in this transport block, excluding CRC attachments.

Payload (Hex): The decoded payload for this code block.

Click the PDSCH MessageWindow Measurements tab to show your preferred timing measurement. On the channel matrix table, each row represents a distinct transmitter antenna and each column represents a distinct WaveJudge receiving port. All the channel measurements are derived from the configured DMRS tones associated to the PDSCH/PUSCH under the query. The brightness of each entry of the table is relative to the estimated Signal to Interference and Noise Ratio (SINR) of this channel path.



PDSCH Message Window - Measurements Tab

The description of each field under this measurement tab is provided as follows.

Power in dBm: The aggregated power in the unit of dBm over all the DMRS tones associated to this channel path.

EVM in dB: The ratio in the unit of “dB” of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

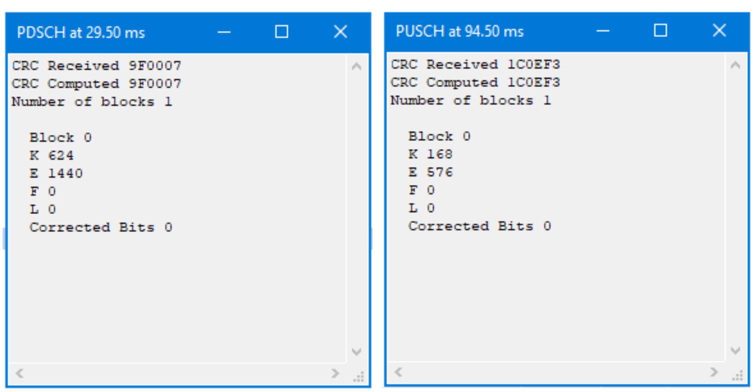
EVM in %: The ratio is in the unit of percentage (%) of the overall DMRS constellation error to the overall DMRS constellation power (for example, Error Vector Magnitude), which is an essential unbiased estimator of the ratio of channel noise to channel power of this channel path over the full channel bandwidth.

Timing in ns: The relative timing offset estimated from this channel path in the unit of “nanosecond”. For a PDSCH, its reference is the signal timing transmitted on the previous SSB. For a PUSCH, its reference is the signal timing transmitted on the previous SSB with adding the adjusted UL timing offset configured on the WaveJudge GUI for this channel.

Frequency Offset in kHz: The relative frequency offset estimated from this channel path in the unit of “Kilohertz”. In both PDSCH and PUSCH, WaveJudge uses the previous valid SSB as the reference for this measurement.

LTE PDSCH and PUSCH Message Windows

Double-click on a PDSCH or PUSCH message in the WaveJudge Message List to open a message window and view data for the code block. Unlike their respective 5G windows, the LTE PDSCH and PUSCH Message Windows are not interactive.



LTE PDSCH/PUSCH Message Windows

Data presented in the LTE version of the PDSCH and PUSCH message windows are as follows.

CRC Received: The 24-bit CRC attachment is received for the whole transport block and for each code block, respectively, as specified in TS 36.212 Clause 5.1.2. Result is displayed as a six-digit hex code.

CRC Computed: The 24-bit CRC attachment is calculated based on the decoded output payload for the whole transport block and for each code block, respectively, as specified in TS 36.212 Clause 5.1.2. Result is displayed as the same six-digit hex code as CRC Received

Number of blocks: The total number of code blocks for the transport block, as defined in TS 36.212 Clause 5.1.2.

Block: Index of the code block within the transport block.

K: The encoded bit length of the code block, as specified in TS 36.212 Clause 5.1.3.

E: The output bit length of the code block after rate matching, as specified in TS 36.212 Clause 5.1.4.

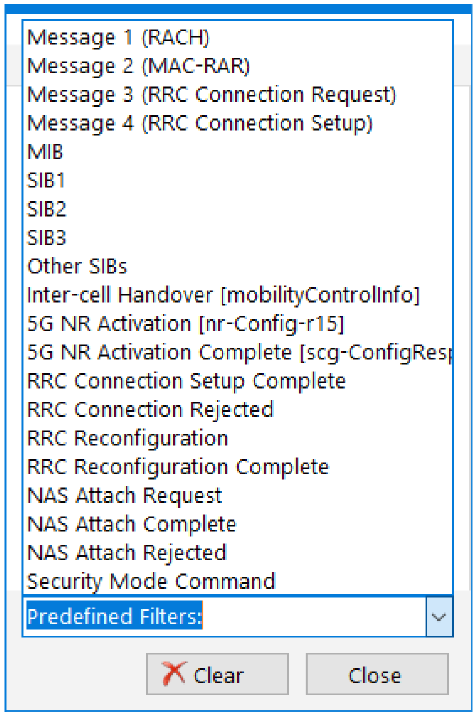
F: The number of filler bits as defined in TS 36.212 Clause 5.1.2, which should always be 0.

L: The additional number of bits for CRC attachment for each code block, as defined in TS 36.212 Clause 5.1.2, which should be 0 when there is only one code block in the transport block and 24 otherwise.

Corrected Bits: The total number of corrected bits for the decoded output sequence of this code block.

5. 7. 6 Predefined Filters for LTE

Notice the **Predefined Filters** drop-down menu box near the bottom of the **Configure Filters Window**; click the arrow to see the list of predefined filters you can select. These provide a shorthand method to rapidly configure some of the most commonly used filter types. Selecting a message type from this menu expands the Filters tree structure in the body of the window to the corresponding message, jump to it, and open the menu to add a filter, ready for you to select any additional options you want on the filter.



Configure Filters Window - Predefined Filters For LTE

Each predefined filter is described below:

Message 1 (RACH): Physical channel filter on PRACH

Message 2 (MAC -RAR): MAC-RND-ACCS-RSP DL layer part (MAC Random Access Request)

Message 3 (RRC Connection Request): rrcConnectionRequest UL RRC message (RRC Connection Request)

Message 4 (RRC Connection Setup): rrcConnectionSetup DL RRC message (RRC Connection Setup)

MIB: Master Information Block RRC message (BCCH-BCH-Message)

SIB1: System Information Block 1 RRC message (systemInformationBlockType1)

SIB2: System Information Block 2 RRC message

SIB3: System Information Block 3 RRC message

Other SIBs: Other RRC System Information Block types

Handover: mobilityFromEUTRACommand DL RRC message (inter-cell handover)

RRC Connection Setup Complete: rrcConnectionSetupComplete UL RRC message (RRC Connection Setup Complete)

RRC Connection Rejected: rrcConnectionReject DL RRC message (RRC Connection Rejected)

NAS Attach Request: NAS-ATTACH-REQ layer part (NAS Attach Request)

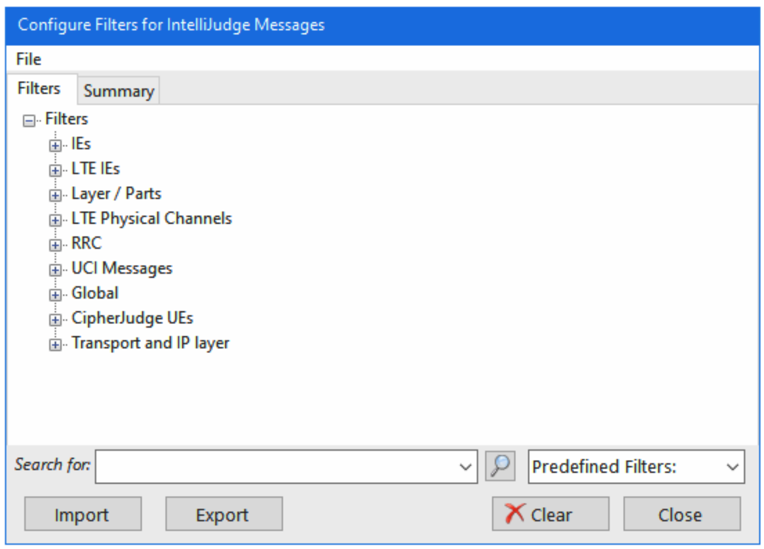
NAS Attach Complete: NAS-ATTACH-CPLT layer part (NAS Attach Complete)

NAS Attach Rejected: NAS-ATTACH-REJ layer part (NAS Attach Rejected)

Security Mode Command: NAS-SEC-MODE-CMD layer part (Security Mode Command)

5. 7. 7 Configure Filters for LTE / IntelliJudge Messages

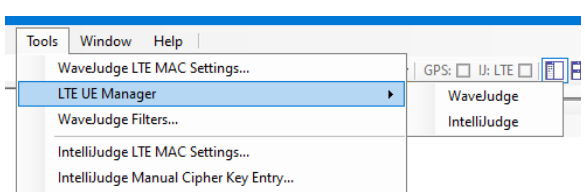
To access the list of filters for IntelliJudge, either go to the main menu and pick ToolsIntelliJudge Filters or select the button Open IntelliJudge Filters ... on the IntelliJudge Message List Chart Properties Window. In either case, the Configure Filters for IntelliJudge Messages window will open.



Configure Filters for IntelliJudge Messages Window

5. 7. 8 LTE UE Manager

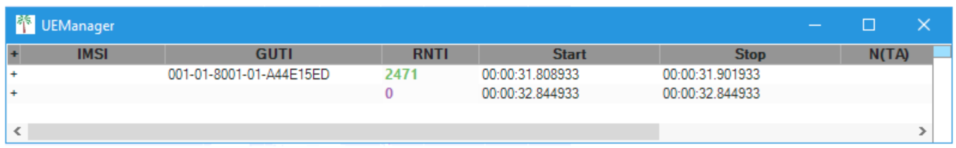
To access either the WaveJudge or IntelliJudge UE Manager, click the Tools menu, select LTE UE Manager and the select either WaveJudge or IntelliJudge from the submenu.



LTE UE Manager Window - Select WaveJudge or IntelliJudge

The UE Manager Window lists each UE it discovers during the capture. RNTI, IMSI, and GUTI are possible identifications available and are based on the messages in the capture. The IMSI and GUTI are only available if the messages in the attach process are decoded. It identifies when it first detects the UE as well as the time of the last message it decode for the UE. N(TA) represents the Timing Advance found in the MAC-RAR message.

NOTE WaveJudge and IntelliJudge LTE UE Manager windows are exactly the same.



LTE UE Manager Window

The UEManager fields are described below.

IMSI: International Mobile Subscriber Identity, detects the UE associated with the connection

GUTI: Globally Unique Temporary ID, identifies the UE and the MME involved in the connection

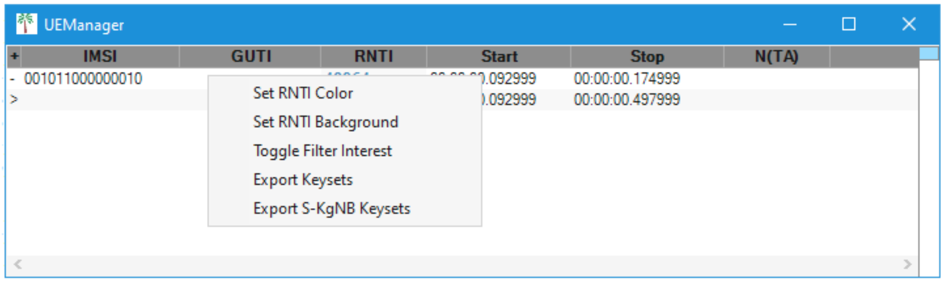
RNTI: Radio Network Temporary Identifier; identifies a connected UE in the cell, a specific radio channel, a group of UEs (for paging), a group of UEs for which power control is issued by the eNB, or system information transmitted for all UEs by 5G gNB.

Start: Starting time of the capture.

Stop: Time the capture ended.

N(TA): Represents the N(Timing Advance) found in the MAC-RAR message.

Right-click on a line item in the UE Manager to open the UEManager context menu; select one of the five options to edit: Set RNTI Color, Set RNTI Background, Toggle Filter Interest, Export Keysets, or Export S-KgNB Keysets.



LTE UE Manager Window - Right Click Options

If you select Set RNTI Color or Set RNTI Background the color-picker box will appear. Select your color and then press the OK button. Alternatively, you can select a custom color by clicking the Define Custom Colors>> button.

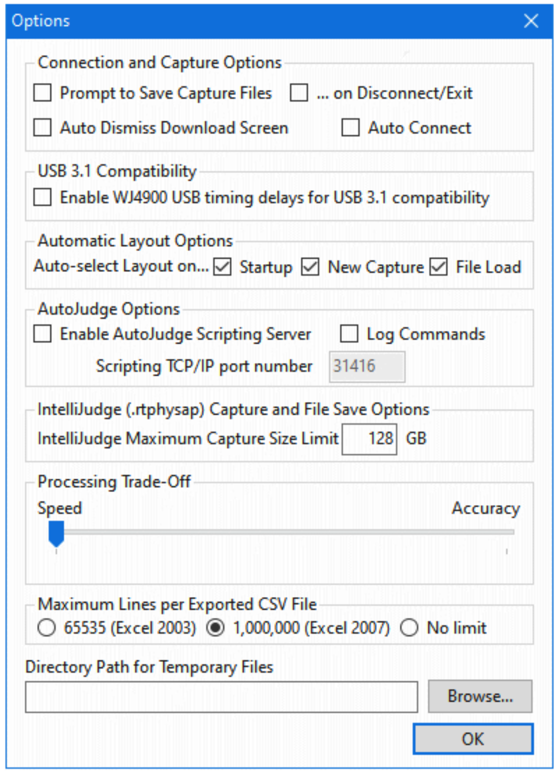
LTE UE Manager - Color Picker

Toggle Filter Interest: Toggles the "UE of Interest" user-level flag. For example, if you toggled it on a user, and your CipherJudge (IntelliJudge or WaveJudge) filter is set on certain Layers (e.g., RRC NAS, IP = "4 5 255"), then, when you do a PA level reprocess (open LTE MAC Settings for IntelliJudge/WaveJudge) and click OK (it wont trigger a VSAServer reprocessing), then the message layers you marked to filter should be highlighted.

The options Export Keysets and Export S-KgNB Keysets each open a window to export and save the data as file type KeySets (*.keysets.sxl).

5. 7. 9 Options Window

The Options window contains miscellaneous settings for the WaveJudge software and user interface. To open the Options window select ToolsOptions.

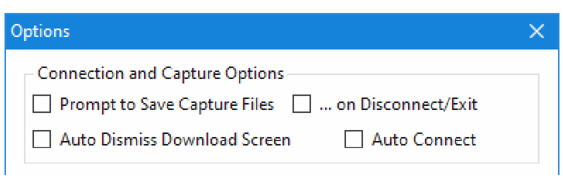


Tools Menu - Options Window

Most options in this window take effect immediately. However, the **Enable the AutoJudge Scripting Server** option takes effect only after you click the OK button. Changes to the Processing Trade-Off option (for example, speed versus accuracy) takes effect on next processing or reprocessing a WaveJudge I/Q capture.

The Options window has the following configurable parameters.

Connection and Capture Options:



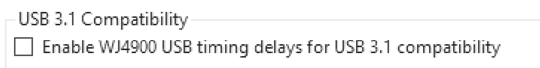
Prompt to Save Capture Files: Check this checkbox if you want the software to always prompt you to save any unsaved capture files before taking another capture.

...On Disconnect/Exit: Check this checkbox if you want the software to always prompt you to save any unsaved capture files before exiting the software or disconnecting from the WaveJudge hardware. (Recommended.)

Auto Dismiss Download Screen: Check this checkbox if you want the Connection window (which automatically opens up while connecting to the WaveJudge hardware) to automatically close upon completion of the hardware discovery and/or firmware download.

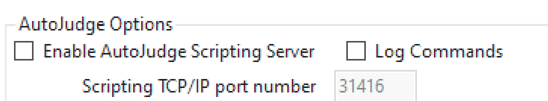
Auto Connect: Check this checkbox to automatically attempt to connect to the WaveJudge hardware on startup.

USB 3.1 Compatibility: Check this checkbox to enable timing delays for USB 3.1 compatibility.



Automatic Layout Options: Select any or all of the checkboxes for **Startup**, **New Capture**, or **File Load**.

AutoJudge Options:



Enable AutoJudge Scripting Server: Check this checkbox to have WaveJudge listen for automation scripting requests on its scripting TCP/IP port. To enable the scripting server you must have a WaveJudge license installed for the AutoJudge scripting feature. When enabling scripting the default Scripting TCP/IP Port Number is set to 31416; however, you may change it if necessary.

After scripting is enabled, click OK to close the Options window and start the scripting server. Subsequently, scripting is automatically enabled and the scripting server listens on the selected port each time you run WaveJudge.

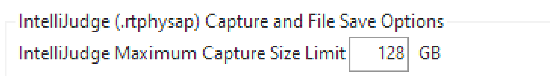
NOTE	To configure the scripting port, first you must have a valid WaveJudge license for scripting to enable the scripting server. Then you can configure the scripting port.

Log Commands: The Log Commands checkbox is for AutoJudge developers to use for debugging. Check this checkbox to have WaveJudge automatically record a log of all AutoJudge commands it receives during a session and save them as text in a log file.

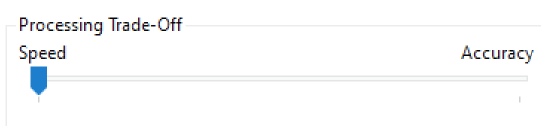
Save PHY Definition Files In: Select one of three radio buttons to determine the internal format used for saving PHY definition files (`.def`)

Options are 1) Newest Format Always (required for handover support); 2) New Format Whenever Needed (two of more cells in use); and 3) Pre-4.2 Format Always (WaveJudge 4.1 or earlier compatible). The default, Newest Format Always, is strongly recommended.

IntelliJudge (.rtphysap) Capture and File Save Options: Enter the maximum capture size limit in GB; 128 GB is the default. If you want each file size compressed, check the box to **Compress LTE MAC Settings in Capture**.

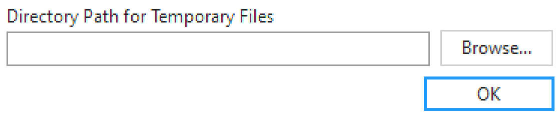


Processing Trade-Off: The Processing Trade-Off slider adjusts the internal WaveJudge processing algorithms to optimize either speed or accuracy. When Speed is selected (the default setting), processing is faster but it may have difficulty decoding marginal signals. When Accuracy is selected, the WaveJudge software uses slower algorithms that may enhance the ability to decode signals of marginal quality.



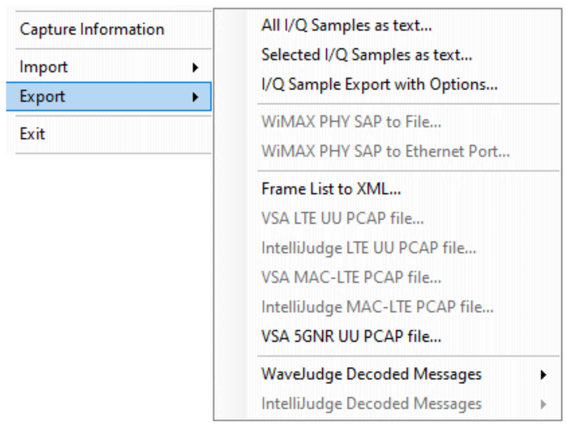
Maximum Lines Per Exported CSV File: This option lets you determine the length of a comma separated values (CSV) file, which automatically formats to a Microsoft Excel file. Select one of three radio button options: 65,535 (Excel 2003), 1,000,000 (Excel 2007), or No Limit.

Directory Path for Temporary Files: Click the Browse... button to open a Browse for Folder window, find and select a file from your computer.



5. 7. 10 Export Options

WaveJudge lets you export data in many different ways. To select an export option, click the File menu and scroll down to Export. Hover your cursor over Export and a list of options will appear in a submenu.



Tools Menu - Export Submenu Options

The various Export commands do not save the current configuration into the exported file; thus, if the data is to reloaded into WaveJudge later, save the configuration using the Save Test Configuration command so you can reload it later with the data. Each export option is described below.

ExportAll I/Q Samples as Text...

Exports the entire contents of the current WaveJudge capture (all RF signal data for the entire capture) to the selected file name as I/Q sample data. This is the most basic I/Q export method. Clicking this option opens a window to name and save the file with a *.txt estension to a folder.

ExportSelected I/Q Samples as Text...

Exports only the contents of the selected time range within the current WaveJudge capture (RF signal data from the currently selected time range) as I/Q sample data to the selected file name. Clicking this option opens a window to name and save the file with a *.txt estension to a folder.

ExportI/Q Sample Export with Options...

Exports the current WaveJudge capture as I/Q sample data; provides options to export I/Q data by opening an **Export Options** window where you can choose the options to export the RF signal data; this window is described in the I/Q Sample Export with Options on page 319 section below.

ExportWiMAX PHY SAP to File...

Exports the PHY SAP decoded binary data for the current WaveJudge WiMAX capture (all decoded MAC input data for the entire capture) to the selected file name and saves the file in .PCAP format. This menu item is only valid and enabled when a WiMAX capture file is currently loaded.

ExportWiMAX PHY SAP to Ethernet Port...

Exports the PHY SAP decoded binary data for the current WaveJudge WiMAX capture (all decoded MAC input data for the entire capture) by retransmitting it onto an Ethernet interface, for input into other packet capture software. This menu item is only valid and enabled when a WiMAX capture file is currently loaded. After selcting this option from the File menu a window resemling the figure below will open, select the network card to retransmit data to.

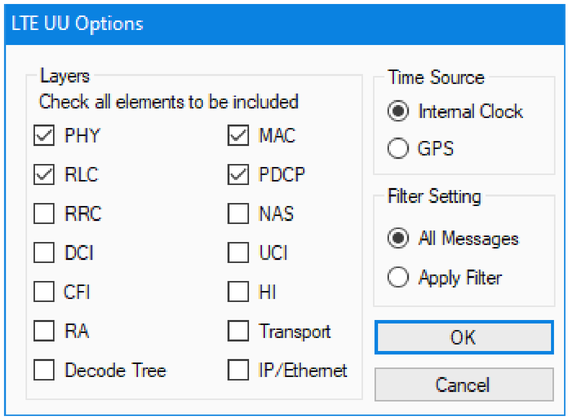
Export WiMAX PHY SAP to Ethernet Port

ExportFrame List to XML...

Exports the PHY Frames List for the current WaveJudge capture. Clicking this option opens a window to save to the selected file name in XML format.

ExportVSA LTE UU PCAP File...

Opens the **LTE UU Options** window to export WaveJudge capture LTE message contents into a .PCAP file, using a Keysight proprietary PCAP file format extension. This menu item is only valid and enabled when an LTE WaveJudge capture file is loaded.



LTE UU Options Window

The LTE UU Window options are described below.

Layers:

- PHY: Physical layer messages
- RLC: Radio link control messages
- RRC: Radio resource control (communication layer)
- DCI: Downlink control information
- CFI: Control Format Indicator; corresponds to PCFICH
- RA: Random Access messages; corresponds to RACH/PRACH
- Decode tree: Shows the expanded tree settings
- MAC: Medium access control layer
- PDCP: Packet data convergence protocol (communication layer)
- NAS: Non-access stratum (communication layer)
- UCI: Uplink control information
- HI: Hybrid ARQ indicator; corresponds to PHICH
- Transport: Transport layer messages
- IP/Ethernet: IP/Ethernet layer messages

Time Source:

- Internal Clock: Use the interal clock as the time source
- GPS: Use GPS as the time source

Filter Setting:

- All Messages: Saves a file with filter settings for all messages
- Apply Filter: Saves a file with onlu the selected filters

Select your options and press the OK button; this opens the next window to save as UU .pcap format.

ExportIntelliJudge LTE UU PCAP File...

Opens the LTE UU Options Window (descrobed above) to exports WaveJudge capture LTE message contents into a .PCAP file (using a Keysight proprietary PCAP file format extension). This menu item is only valid and enabled when an LTE IntelliJudge capture file is loaded.

ExportVSA MAC-LTE PCAP File...

Exports the VSA MAC LTE messages in the WaveJudge capture contents into a .PCAP file, using a Keysight proprietary PCAP file format extension. This menu item is only valid and enabled when an LTE WaveJudge capture file is loaded.

ExportIntelliJudge MAC-LTE File...

Exports MAC LTE messages from an IntelliJudge capture into a .PCAP file using a Keysight proprietary PCAP file format extension. This menu item is only valid and enabled when an LTE IntelliJudge capture file is loaded.

ExportWaveJudge Decoded Messages

Opens an export submenu for higher-layer messages in the WaveJudge Messages List.

- ExportWaveJudge Decoded MessagesAs Text...

  Exports higher-layer messages in the WaveJudge Messages list, as decoded by the WaveJudge protocol analyzer, into a text formatted file where the hierarchical structure of the decoded messages is represented via indentation. Opens a Save As window to save the file in .TXT format.

- ExportWaveJudge Decoded MessagesAs XML...

  Exports higher-layer messages in the WaveJudge Messages list, as decoded by the WaveJudge protocol analyzer, into an XML file, where the hierarchical structure of the decoded messages is directly represented via the XML structure. Opens a Save As window to save the file in .XML format.

ExportIntelliJudge Decoded Messages

Opens an export submenu for higher-layer messages in the IntelliJudge Messages List.

- ExportIntelliJudge Decoded MessagesAs Text...

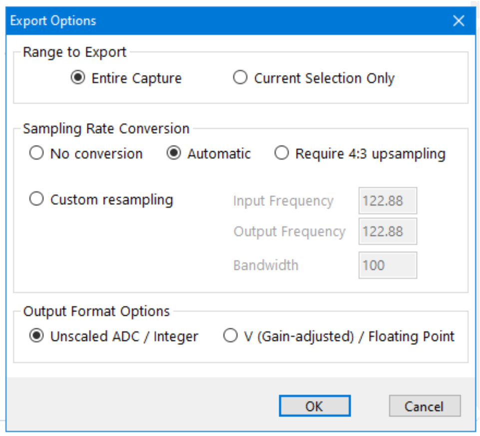
  Exports higher-layer messages in the IntelliJudge Messages list, as decoded by the IntelliJudge protocol analyzer, into a text formatted file, where the hierarchical structure of the decoded messages is represented via indentation. Opens a Save As window to save the file in .TXT format.

- ExportIntelliJudge Decoded MessagesAs XML...

  Exports higher-layer messages in the IntelliJudge Messages list, as decoded by the IntelliJudge protocol analyzer, into an XML file, where the hierarchical structure of the decoded messages is directly represented via the XML structure. Opens a Save As window to save the file in .XML format.

5. 7. 10. 1 I/Q Sample Export with Options

The Export Options window provides options to export data in different ranges, sampling rate conversions, and format options.



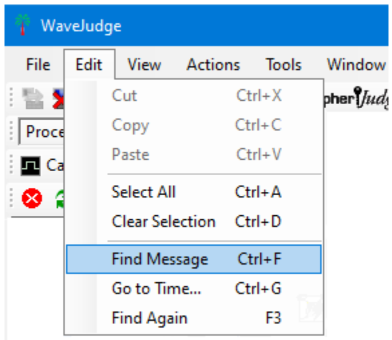
I/Q Sample Export Options Window

Export Options are described below.

- Range to Export:
  - Entire Capture: Exports the entire capture
  - Current Selection Only: Exports only the selected time interval
- Sampling Rate Conversion:
  - No Conversion: Exports data as-is
  - Automatic: Only applies to sampling rate 23.04 MHz which gets automatically converted to 30.72 MHz
  - Require 4:3 Upsampling:Converts to sampling rate 4/3 of current sampling rate, so 23.04 MHz gets converted to 30.72 MHz.
  - Custom Resampling:
    - Input Frequency: Current sampling rate
    - Output Frequency: Sampling rate of the exported data
    - Bandwidth: Bandwidth preserved during resampling
- Output Format Options:
  - Unscaled ADC / Integer: The normal output format, integers range from -32767 to 32767.
  - V (Gain Adjusted) / Floating Point: The option 'V (Gain Adjusted)/Floating Point' indicates that the I/Q data export will convert each port's I/Q data to Volts, using the gain the capture recorded for that port to scale it. All exported values will be floating point numbers representing absolute signal level in units of Volts.

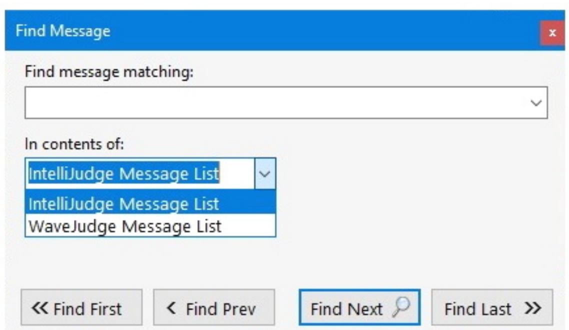
5.7.11 Find Message Window

To find messages in either the IntelliJudge or WaveJudge Message List, you can use the Find Message window. To open the form, select Ctrl+F or select EditFind Message from the main menu.



Select '"Find Message" from the Edit Menu

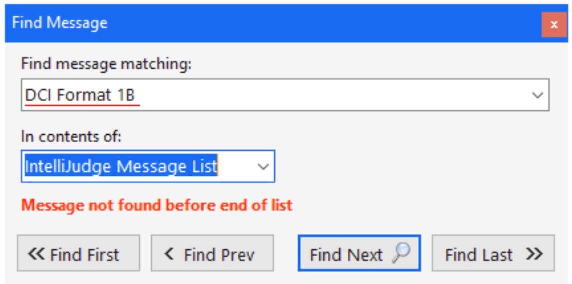
The Find Message window lets you choose whether to search for the message in the WaveJudge Messages List or the IntelliJudge Message List.



Find Message Window

Type in the name of the desired message and click on the Find Next button. This will find and highlight the next matching message starting from the currently highlighted row; clicking it repeatedly will step through each occurrence in the message list. If you wish to start searching from the start of the specified message list click on the Find First button; you may also use Find Last and Find Prev to search backwards through the list.

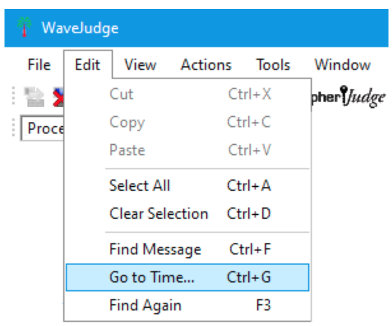
If you are unable to find a message with the specified name, a red text warning will display Message not found before end of list.



Find Message Window - Message Not Found

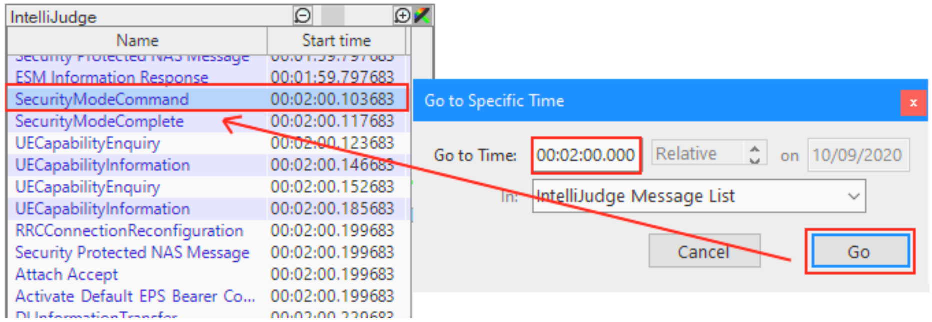
5. 7. 12 Go to Time

To go to a specific time in the IntelliJudge or WaveJudge Message List use the Go to Specific Time window. To open the form, either press Ctrl+G or select EditGo to Time... from the main menu.



Select "Go To Time" from the Edit Menu

In the Go to Specific Time form, enter the time you wish to go to. The time you enter is the Start Time you see in the Message List, in the Connected Time units (Relative time). After entering the time, click the Go button. The selected Message List will search for and highlight the first item on or after the desired time.



IntelliJudge Message List - Go To Specific Time

5. 7. 13 GPS

If you have the GPS option you can get precision time stamps for your data captures. The GPS option is built-in to all WaveJudge 5000 systems. To purchase the GPS option for a WaveJudge 4900, contact *SJ-support@keysight.com*.

To configure the GPS option, you will need to:

1. Have the hardware option factory-installed.
2. If the WaveJudge 4900 chassis has a GPS Active Antenna Sticker by the power supply in the back of it, the GPS port is powered; it will provide +5V DC to your antenna.

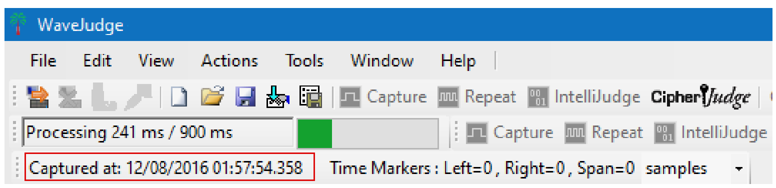
WARNING Powered active antennas are NOT SUPPORTED when your WaveJudge has a GPS Active Antenna sticker. Connecting a powered active antenna to a WaveJudge with an Active Antenna sticker may seriously damage the WaveJudge chassis, antenna, or both. If you are unsure, it is best to contact *SJ-support@keysight.com* for help.

3. If the WaveJudge chassis does not have a sticker, or has a GPS Passive Antenna Sticker near the power supply in the back, the GPS port is unpowered; the antenna must supply the power; use a powered active antenna.

GPS Ports

NOTE Some WaveJudge 4900 units do not support any GPS.

Once the GPS has a lock it is automatically used for precision timestamps on captures. You can see this readily because the time captured indicator (see figure below) will go from three decimal digits after the second (approximately nearest millisecond) to seven digits (nearest 10ths of microseconds).



GPS Time Stamp

5. 7. 13. 1 GPS Satellite Signal Requirements

To achieve a GPS lock, WaveJudge requires visibility of at least four GPS satellites with a high SNR (Signal/Noise Ratio) for a period of approximately 20-30 seconds after powering up, and after the GUI software connects to the WaveJudge chassis.

Once you achieve the initial GPS lock WaveJudge can maintain it so long as at least three GPS satellites remain visible. As long as the lock is maintained all internal timestamps used with captures are marked as Precision, and PPS (pulse per second) output.

If the WaveJudge GUI disconnects and reconnects to the WaveJudge, or if the GPS is reset by clicking the GPS status control, the GPS will go through the initial locking cycle again and must again detect signals for at least four GPS satellites with a high SNR for a period of approximately 20-30 seconds before it can lock.

Tips to Deploy a GPS Antenna

The following considerations apply when considering GPS antenna placement.

- The antenna must be in a location with the greatest feasible access exposed view to the sky.
- An antenna placed in any interior location is likely unable to retrieve the GPS signal since the satellite broadcast signals for GPS are extremely weak.

- An antenna placed where its view of the sky is obstructed in one plane (for example, placement on an exterior window sill) may have impaired visibility of the “constellation” of satellites and reduced ability to lock to the GPS signal.
- An antenna placed where its view is impaired in more than one plane or direction, such as a window facing an interior courtyard or facing a taller building, will have highly impaired visibility of the satellites and may be unable to lock to the GPS signal much of the time.
- Clear visibility of the hemisphere of the sky facing towards the equator (towards the south, in the Northern hemisphere) is particularly important. The GPS satellite orbits are at 55 degrees inclination to the equator, and therefore, when viewed from Northern temperate zone locations, all of the satellites forming the GPS constellation will appear somewhere between the zenith and the southern horizon during most of their period of visibility. (In the Southern hemisphere this is reversed, so visibility of the sky to the north is critical.)
- To reduce signal loss, keep the cable length from the antenna to the WaveJudge to the minimum length necessary.

Connection to GPS Signal Repeater/Amplifier

In a telecommunications laboratory environment, it may be impractical or completely infeasible to connect an antenna with direct line of site to the sky. In this situation, the preferred alternative is to directly connect a cable carrying an amplified GPS signal, as provided by a GPS signal repeater. The GPS signal should be amplifed by 25-28 dBm above its base signal level.

Some laboratories may instead provide an indoor GPS signal re-radiator for test equipment. If you are using a GPS signal re-radiator instead of a direct cable connection WaveJudge will still not be able to receive the GPS signal with a passive or non-powered antenna. However, you may use a powered active GPS antenna in combination with a GPS re-radiator. Engineers who wish to use this combination of equipment are assumed to be able to troubleshoot any resulting signal quality issues.

5. 7. 13. 2 GPS Timestamp Outputs

When the WaveJudge chassis has the correct GPS input attached and has successfully locked to the signal it will automatically capture the GPS referenced time as the capture timestamp for the start of the capture data, or relative to sample 0. This timestamp is converted into an internal timestamp with 100ns resolution (0.1 microsecond) which is saved with the capture file and converts all relative time offsets within the capture to GPS-referenced time in either UTC or local time.

5. 7. 13. 3 GPS PPS Physical Output

The WaveJudge front panel GPS pulse per second (PPS) output is a SMA connector providing a PPS TTL-level signal output, derived from the GPS signal connected to the GPS antenna input. Pulses are transmitted on this output only when the WaveJudge GPS module is successfully locked to the GPS signal.

5. 7. 13. 4 GPS Status Indicator

The main toolbar on the WaveJudge software graphic user interface contains a status indicator labelled **GPS**, which displays a square image similar to a checkbox or colored LED 

. This provides an immediate visible status indicator for the GPS module and signal. Pointing to this indicator with the mouse prompts a floating message or “tool tip” explaining the immediate status of GPS connectivity. This indicator always shows the status at the present moment, not the status when the current capture was taken. You can also double-click the **GPS Status Indicator** while connected to open up the **GPS Status** window.

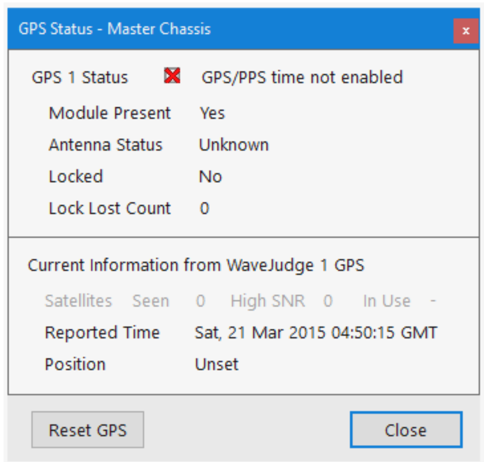
GPS status display messages are:

1. **Software is not connected to a WaveJudge** – The GPS status box is grayed out, visually indicating that it is disabled. The floating description is “No GPS detected”.
2. **Software is connected to a WaveJudge with no GPS module installed** – The GPS status box is grayed out, visually indicating that it is disabled. The floating description is “No GPS detected”.
3. **GPS module detected, but no GPS signal is detected** – The GPS status box appears in black but empty, with a gray interior. The floating description is “Antenna not detected”.
4. **A GPS signal was previously detected and locked, but the GPS has lost the lock** – The GPS status box appears with a red-orange interior. The floating description is “GPS lock lost”.
5. **A GPS signal is currently locked, but the GPS has lost the lock at least once** – The GPS status box appears with a green interior. The floating description is “GPS lock regained”.
6. **A GPS signal is currently locked and stable** – The GPS status box appears with a green interior. The floating description is “GPS locked/stable”.

5. 7. 13. 5 GPS Status Window

For more detailed information while the software is connected to a WaveJudge 5000 or WaveJudge 4900, open the **GPS Status** window, either by double-clicking the **GPS**

Status Indicator or by selecting HelpGPS Status from the WaveJudge main menu. This opens a floating GPS Status window.

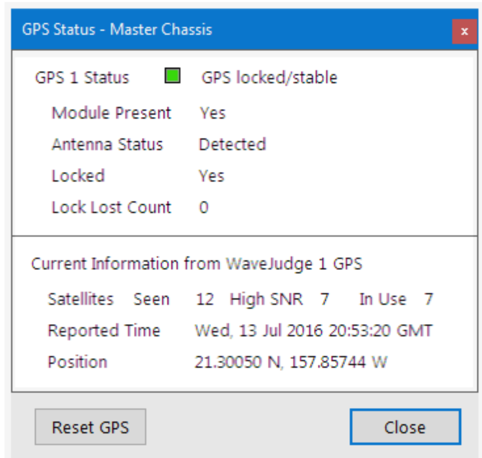


GPS Status Window - GPS Not Enabled

The GPS Status window shows the current GPS status in more detail, divided into two sections. The first section includes:

- Current Status: A graphic GPS Status Indicator and a brief description, such as GPS locked/stable or antenna not detected.
- Module Present: This should authoritatively indicate whether the WaveJudge 5000 or 4900 has an installed and functioning GPS module. For the WaveJudge 5000, this should always indicate “Yes”.
- Antenna Status: Either Unknown, Present, or Detected. The GPS module can generally not determine if the antenna is present in the absence of a signal, so the “Unknown” status does not indicate that the antenna is missing or that the GPS module is malfunctioning.
- Locked: This indicates whether the GPS module has currently succeeded in locking to the GPS signal.

The second section is enabled only when the GPS module is present and the GPS signal is present and being decoded.



GPS Status Window - GPS Enabled

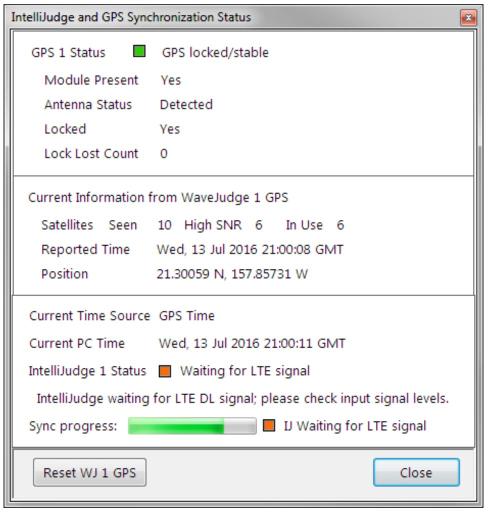
The display messages include:

- **Satellites Seen/High SNR/In Use:** The number of GPS satellites the module believes it should see; those detected with a strong enough signal for the GPS to rely on; and finally those currently in use to supply the GPS signal.
- **Reported Time (UTC):** The current time in UTC, to the nearest second.
- **Position:** The current geographical position (latitude and longitude) reported from the GPS, as a possible check for the accuracy of the other GPS information.

5. 7. 13. 6 IntelliJudge and GPS Synchronization Status Window

The IntelliJudge and GPS Synchonization Status window is normally used only with the IntelliJudge 4900 RT system, although you may use it with the WaveJuge 5000 when IntelliJudge real-time processing is enabled.

To access this option, click the **Help** menu and select **IntelliJudge GPS/Sync Status**. It is only active when connected to a WaveJudge 4900/IntelliJudge system or a WaveJudge 5000 with the IntelliJudge real-time processing option.



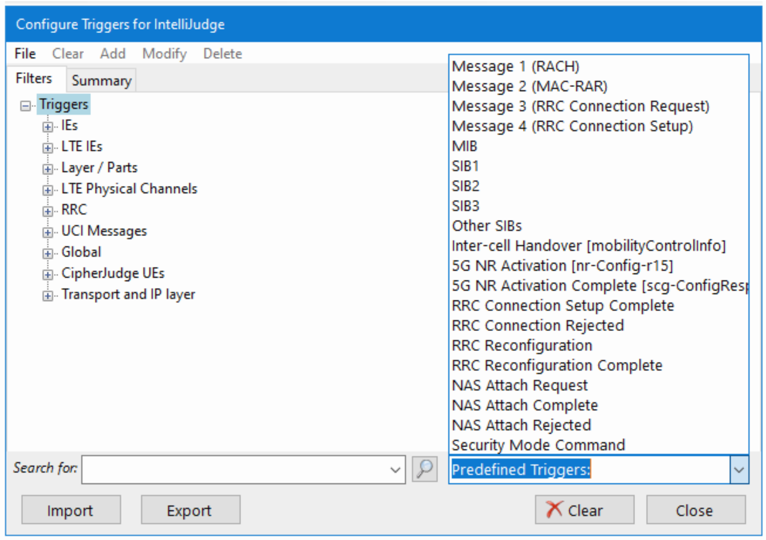
IntelliJudge and GPS Synchronization Status Window

The IntelliJudge GPS/Sync Status window displays combined information on the status of the IntelliJudge and the GPS module including its current status, the GPS input signal status, and the precision of its time signal. They are displayed together in this window because IntelliJudge uses the GPS signal for precise synchronization of dual IntelliJudge 4900 RT systems, as well as for the time information in the message data it reports during a capture.

5. 7. 14 Configure Triggers Window

For WaveJudge users, the **Set Up Capture** window is where you define the triggers to initiate a capture, as well as the length or duration of the capture (Set Up Capture Window on page 162). The maximum duration of a capture depends on the bandwidth, sampling rate settings, and WaveJudge model. The range may be anywhere from 3 to 190 seconds on all Rx ports.

To set the triggers for IntelliJudge captures, click the **Tools** menu and select **IntelliJudge Triggers**; this opens the **Configure Triggers for IntelliJudge Window**.



Configure Triggers Window for IntelliJudge

IntelliJudge triggers are essentially special kinds of filters. They use the filter rules to define a particular type of message or value the software is looking for while processing the IntelliJudge capture. As soon as the software sees the filter, it immediately triggers a WaveJudge capture (RF signal capture) so that that event, or the events following it can be examined in detail once the IntelliJudge capture is complete.

Similar to the previous IntelliJudge filters section, the list of IntelliJudge triggers are the same categories (listed below) and subcategories. To see the triggers for each category, refer to the corresponding windows.

1. LTE Filters - IEs on page 685
2. LTE Filters - LTE IEs on page 689
3. LTE Filters - Layer/Parts on page 696
4. LTE Physical Channels on page 702
5. LTE Filters - RRC on page 703
6. LTE Filters - UCI Messages on page 704
7. LTE Filters - Global on page 704
8. LTE Filters - CipherJudge UEs on page 704
9. LTE Filters - Transport and IP Layer on page 705

Notice the Predefined Triggers drop-down menu box near the bottom of the Configure Triggers Window. These items provide a quick method to rapidly configure some of the most commonly used trigger types. Selecting a message type from this menu expands the Filters tree structure in the body of the window to the corresponding message, jumps to it, and opens the menu to add a ftrigger, ready for you to select any additional options you want on the trigger.

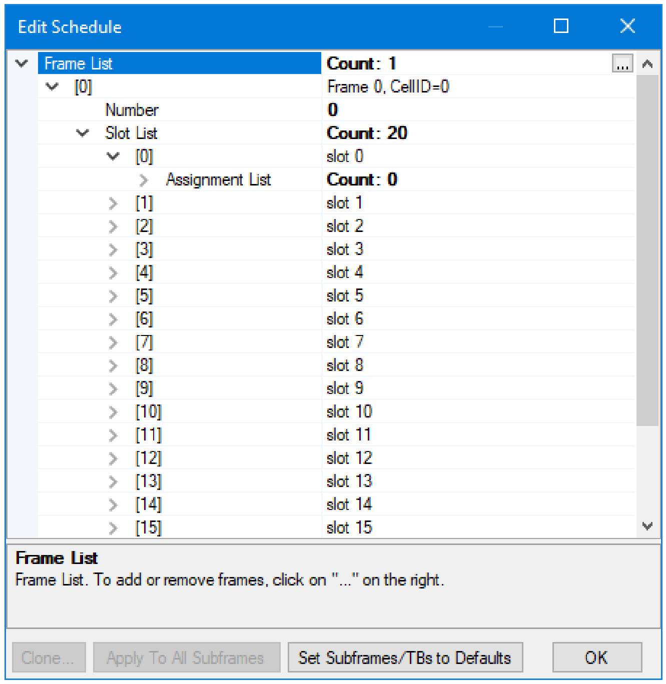
The list of Predefined Triggers are:

1. Message 1 (RACH)
2. Message 2 (MAC-RAR)
3. Message 3 (RRC Connection Request)
4. Message 4 (RRC Connection Setup)
5. MIB
6. SIB1
7. SIB2
8. SIB3
9. Other SIBs
10. Inter-cell Handover [mobilityContrlInfo]
11. 5G NR Activation [nr-Config-r15]
12. 5G NR Activation Complete [scg-ConfigResponseNR-r15]
13. RRC Connection Setup Complete
14. RRC Connection rejected
15. RRC Reconfiguration
16. RRC Reconfiguration Complete
17. NAS Attach Requesst
18. NAS Attach Complete
19. NAS Attach Rejected
20. Security Mode Command

5. 7. 15 5G Edit Schedule

To access the 5G Edit Schedule window

1. Click the vertical Configure Test button Configure Test to open the Configure Test window.
2. In the Define Test tab under the Configure Test Scenario pane, select 5G NR as the Standard from the drop-down menu.
3. In the Cell 1: 5GNR tab, under Configure Cell 1 pane, click Edit Schedule button at the bottom of the window. The Edit Schedule window will open.



5G NR Edit Schedule Window

Elements of the Edit Schedule window are described below.

Frame List: Click to add or remove frames, click the ellipse button on right to open the 5G Frame Info Collection Editor on page 331.

Number: System frame number.

Slot List: List of slots

- Assignment List: To add or remove assignments, click on the ellipse button to the right to open the Assignment Info Collection Editor on page 333.

At the bottom of the Edit Schedule window there are the following buttons.

Clone: Copies a selected slot.

Apply to All Subframes: Applies the settings to all selected subframes.

Set Subframes/TBs to Defaults: Clears new settings and resets all subframes to default settings.

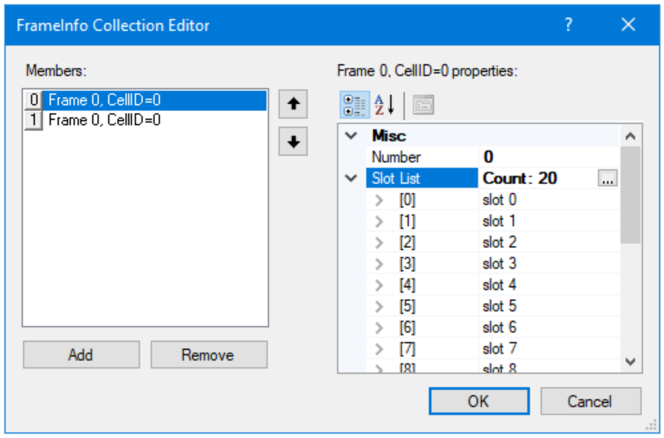
OK Click this button to execute your schedule changes.

5. 7. 16 5G Frame Info Collection Editor

To access the Frame Info Collection Editor

1. Open the 5G Edit Schedule on page 330 window.
2. Click on the Frame List, then click the ellipse button ... on the right side of the

line.



5G NR Frame Info Collection Editor

Elements of this window are described below.

Frame: Each 5G frame has a duration of 10 ms, which consists of 10 subframes, having 1ms duration each (similar to LTE).

Number: System frame number

Slot List: List of slots

Categorized: Sorts and organizes frame cells by category.

Alphabetical: Sorts and organizes frame cells in alphabetical order.

Property Pages: Sorts and organizes frame cells by property.

At the bottom of the window are the following buttons.

Add: Adds frames in the left side Members pane.

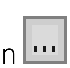
Remove: Deletes the last frame added in the left side Members pane.

OK: Click this button to execute your schedule changes.

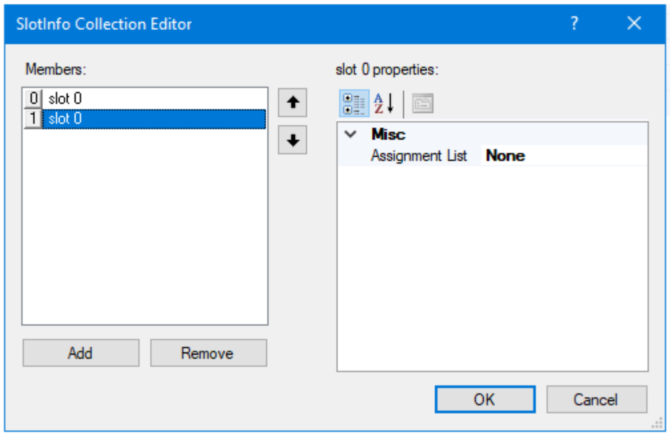
Cancel: Closes out of the window without making any changes.

5. 7. 17 Slot Info Collection Editor

To access the Slot Info Collection Editor

1. Open the 5G Edit Schedule on page 330 window.
2. Click on the Frame List then click the ellipse button  on the right side. This opens the Frame Info Collection Editor.
3. In the Frame Info Collection Editor, click the Slot List line and select the ellipse

button on the right side. This opens the Slot Info Collection Editor window.



5G NR Slot Info Collection Editor

Elements of this window are described below.

Slot: In 5G NR, each frame is divided into 10 subframes of 1 ms each. The 1 ms subframe is then divided into one or more slots (LTE has two slots in a subframe). Slot size is defined based on the Tu value.

Assignment List: Allows you to edit assignments in a subframe. Click the line and select the ellipse button on the right side to open the Assignment Info Collection Editor on page 333, described below.

Categorized: Sorts and organizes slots by category.

Alphabetical: Sorts and organizes slots in alphabetical order.

Property Pages: Sorts and organizes slots by property.

At the bottom of the window are the following buttons.

Add: Adds frames in the left side Members pane.

Remove: Deletes the last frame added in the left side Members pane.

OK: Executes the changes.

Cancel: Closes out of the window without making any changes.

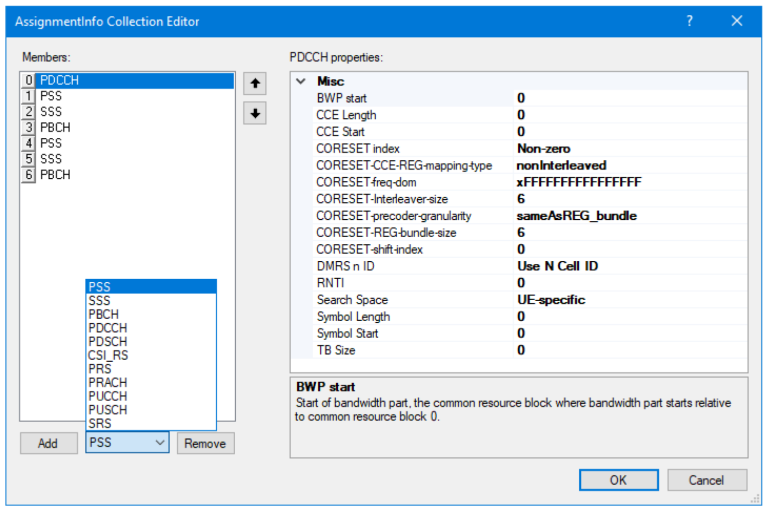
5. 7. 18 Assignment Info Collection Editor

To access the Assignment Collection Editor

1. Open the 5G Edit Schedule on page 330 window.
2. Click on the Frame List then click the ellipse button on the right side. This

opens the Frame Info Collection Editor.

3. In the Frame Info Collection Editor, click the Slot List line and select the ellipse button on the right side. This opens the Slot Info Collection Editor window.
4. In the Slot Info Collection Editor, click on the line item Assignment List and select the ellipse button on the right side. This opens the Assignment Info Collection Editor window.



5G NR Assignment Info Collection Editor

The Assignment Info Collection Editor has the following buttons.

Arrows: Moves the selection up or down in the Members list.

Add: Adds frames in the left side Members pane.

Remove: Deletes the last frame added in the left side Members pane.

OK: Executes the changes.

Cancel: Closes out of the window without making any changes.

The Assignment Info Collection Editor drop-down menu options lists all available TBs:

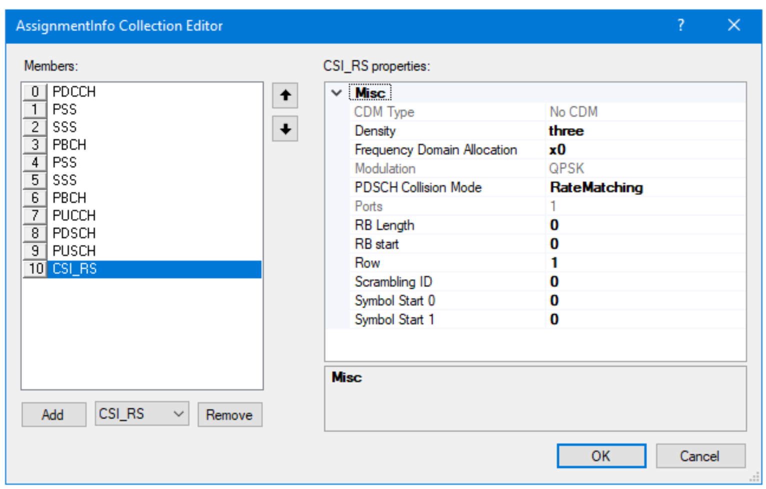
- CSI-RS: Channel State Information Reference Signal (CSI-RS) is a DL-only signal used for DL CSI acquisition.
- PBCH: Physical Broadcast Channel, carries encoded system information required by the UE to access the network.
- PDCCH: Physical Downlink Control Channel, conveys encoded control information and scheduling decisions for PDSCH reception.
- PDSCH: Physical Downlink Shared Channel, carries encoded user data and paging information to the UE.

- PRACH: Physical Random Access Channel
- PRS: Positioning Reference Signal
- PSS: Primary Synchronization Signal
- PUCCH: Physical Uplink Control Channel
- PUSCH: Physical Uplink Shared Channel
- SRS: Sounding Reference Signal
- SSS: Secondary Synchronization Signal

The properties and submenus for each parameter are described in the subsections below.

5. 7. 18. 1 Assignment Info Collection Editor - CSI RS Properties

If CSI RS is not already visible the left side Members list, select CSI_RS from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - CSI RS Properties

In the right side panel, the corresponding CSI RS Properties drop-down menu includes the following parameters.

Misc.

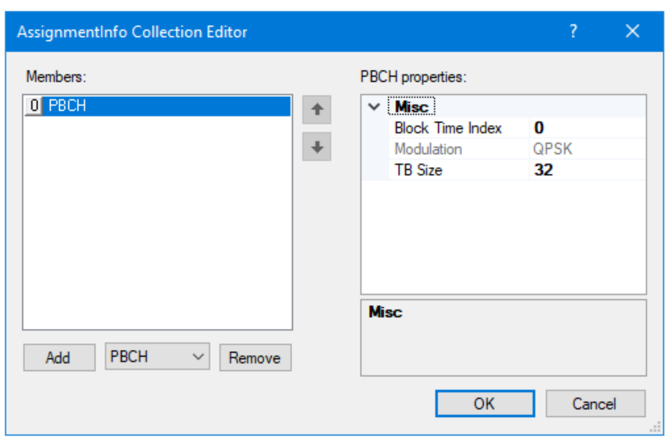
- CDM Type: Type of Code Division Multiplexing (CDM), Frequency Division (FD), and Time Division (TD).
- Density: Frequency domain density. It is 3 for row 1; 1 for rows 4 to 10; and either 1 or 0, 5 for all other rows.
- Frequency Domain Allocation: Bitmap provided by the higher-layer parameter frequencyDomainAllocation. The number of bits is: 4 for row 1; 12 for row 2; 3

for row 4; and 6 for all other rows.

- Modulation: 5G NR supports QPSK, 16 QAM, 64 QAM, and 256 QAM modulation.
- PDSCH Collision Mode: Determines whether a PDSCH that overlaps with the CSI-RS will be rate-matched or punctured around CSI-RS.
- Ports: Number of ports.
- RB Length: Number of Resource Blocks.
- RB Start: First Resource Block.
- Row: Row from 1 to 18 in the table "CSI-RS locations within a slot." It determines the number of ports, the density, CDM type, and location of the CSI-RS.
- Scrambling ID: Value of n_ID used in c_init for scrambled data.
- Symbol Start 0: firstOFDMSymbolInTimeDomain. Parameter 10.
- Symbol Start 1: firstOFDMSymbolInTimeDomain 2. Parameter 11.

5. 7. 18. 2 Assignment Info Collection Editor - PBCH Properties

If PBCH is not already visible the left side Members list, select PBCH from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - PBCH Properties

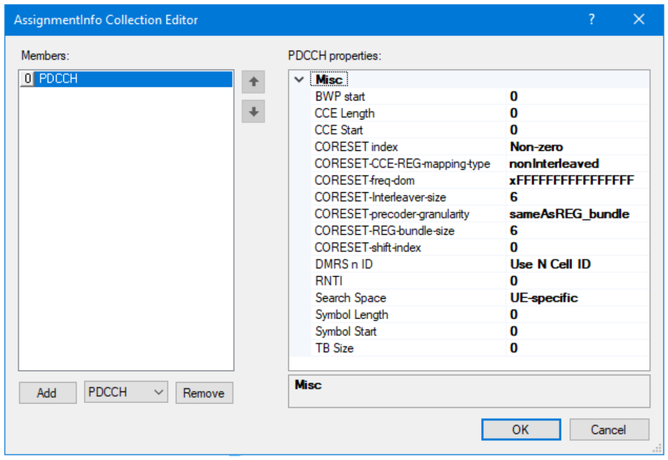
In the right side panel, the corresponding PBCH Properties drop-down menu includes the following parameters.

Misc.

- Block Time Index: Index of the SS/PBCH blocks.
- Modulation: 5G NR supports QPSK, 16 QAM, 64 QAM, and 256 QAM modulation.
- TB Size: Transport Block Size in bits.

5. 7. 18. 3 Assignment Info Collection Editor - PDCCH

If PDCCH is not already visible the left side Members list, select PDCCH from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - PDCCH Properties

In the right side panel for PDCCH Properties, the drop-down menu includes the following parameters.

Misc.

- BWP start: Start of bandwidth part, the common resource block where bandwidth part starts relative to common resource block 0.
- CCE Length: Number of allocated Control Channel Elements, also called aggregation type; can take the values of 1, 2, 4, 8, or 16.
- CCE Start: First allocated Control Channel Element.
- CORESET Index: Indicates whether the CORESET index is zero or non-zero.
- CORESET-CCE-REG-mapping-type: Mapping of Control Channel Elements (CCE) to Resource Elements Group (REG). Corresponds to higher layer parameter cce-REG-Mapping Type.
- CORESET-freq-dom: Frequency domain resources for the CORESET. This is a 45-bit field and each bit corresponds a group of six RBs, with grouping starting from the first RB group in the BWP. The 45th least significatns bit (bit 44) corresponds to the first RB group BWP, and so on.

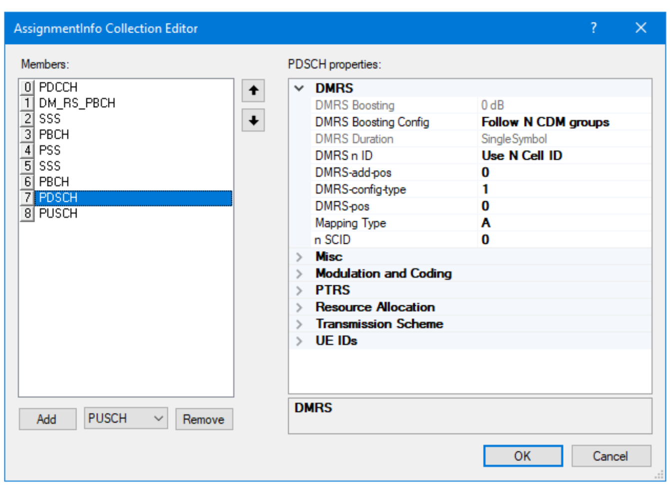
  For example, with the value x0000100000000000 (bit 44 is set), only the first RB group would belong to the frequency domain resources. With the value x0000180000000000 (bit 44 and 43 are set), the first two RB groups would belong to the frequency domain resources. Corresponds to higher layer parameter frequencyDomainResources.
- CORESET-Interleaver-size: Corresponds to higher layer parameter

interleaverSize.

- CORESET-precoder-ganularity: Precoder granularity in frequency domain; corresponds to higher layer parameter precoderGranularity.
- CORESET-REG-bundle-size: Resource Element Groups (REGs) can be bundled to create REG bundles. This parameter defines the size of such bundles; corresponds to higher layer parameter reg-BundleSize.
- CORESET-shift-index: Corresponds to higher layer parameter shift index.
- DMRS n ID: Value of n_ID used in c_init for scrambled data and modulation DM-RS. By default, it is equal to the cell ID, otherwise it corresponds the higher-layer parameters pdcch-DMRS-ScramblingID. Delete the field value and click Enter to set it to "Use N Cell ID".
- RNTI: RNTI value, from 0 to 65535.
- Search Space: Indicates whether the search space is UE-specific or common.
- Symbol Length: Number of symbols.
- Symbol Start: First symbol.
- TB Size: Transport Block Size in bits.

5. 7. 18. 4 Assignment Info Collection Editor - PDSCH Properties

If PDSCH is not already visible the left side Members list, select PDSCH from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - PDSCH Properties

In the right side panel, the corresponding PDSCH Properties drop-down menu includes the following parameters.

DMRS

- DMRS Boosting: Inverse of the ratio of PDSCH/PUSCH EPRE to DM-RS EPRE.
- DMRS Boosting Config: Inverse of the ratio of PDSCH/PUSCH EPRE to DM-RS

EPRE.

- DMRS Duration: Indicates whether DMRS is single-symbol or double-symbol. This is determined by the parameter Antenna Port Config.
- DMRS n ID: Value of n_ID used in c_init for modulation DMRS. By default, it is equal to the cell ID, otherwise it corresponds to the higher-layer parameter scrambling ID0 or scrambling ID1. Delete the field value and click Enter to set it to "Use N Cell ID".
- DMRS-add-pos: dmrs-AdditionalPosition, position for additional DM-RS, from 0 to 3.
- DMRS-config-type: DM-RS Configuration type 1 or 2, corresponding to the higher layer parameter dmrs-Type. Determines ow DMRS are configured in frequency domain.
- DMRS-pos: For mapping type A, dmrs-TypeA-Position, position of (first) DM-RS. For mapping B, increment of the symbol positions.
- Mapping Type: Mapping Type A or B of DM-RS in time domain.
- n SCID: DMRS sequence initialization field in the DCI, equal to 0 or 1.

Misc

- Flags: 1: DMRSSuplink-r16 or DMRSdownlingr-16

Modulation and Coding

- CBG Per TB: Maximum number of code-block-groups (CBG) per TB, configured by higher layer parameter maxCodeBlockGroupsPerTransportBlock. Set to zero to disable code block transmission.
- CBGTI: Code-block-group (CBG) transmission information bitmap, indicated by the DCI field CBGTI. A bit value of 0 in the CBGTI field indicates that the corresponding CBG is not to be transmitted; 1 indicates that it is to be transmitted. The order of CBGTI field bits is such that the CBGs are mapped in order from CBG#0 onwards starting from the MSB.
- CodeWords: List of code words.
  - [0]
    - MCS Index: Modulation and Coding Scheme Index
    - Modulation: Option is QPSK
    - New Data Indicator: New Data Indicator (NDI), toggles between 0 and 1 to indicate a new transmission.
    - Redundancy version: Redundancy version index (RVID), from 0 to 3. Initial transmissions have RVID equal to 0.
    - TB size: Transport Block Size in bits.
- HARQ Process Number: Number that identifies the HARQ processes on which HARQ soft-combining operate. Set this parameter to -1 to disable HARQ soft-combining for that assignment.
- I_LBRM: Indicates whether Limited Buffer Rate Matching is enabled (1) or

disabled (2).

- LBRM MaxMIMO Layers: Maximum number of MIMO layers used in Limited Buffer Rate Matching formulas.
- MCS -Table: Indicates which MCS table shall be used for PDSCH or PUSCH.
- TB Scaling Factor: For P-RNTI and RA-RNTI, scaling factor applied to the computation of the TB size and determined by the TB scaling field in the DCI.
- Xoverhead: Accounts for overhead from CSIK-RS, CORESET, etc.

PTRS Phase Tracking Reference Signal

- K PTRS: K PT-RS equal to 2 or 4, frequency density of PT-RS, is a function of scheduled bandwidth, and is given by the higher-layer parameter frequencyDensity in PTRS-UplinkConfig or PTRS-DownlinkConfig.
- L PTRS: L PT-RS equal to 2 or 4, frequency density of PT-RS, is a function of scheduled MCS, and is given by the higher-layer parameter timeDensity in PTRS-UplinkConfig or PTRS-DownlinkConfig.
- PTRS N Ports: Number of ports allocated to PT-RS.
- PTRS RE offset: Indicates the subcarrier offset for PT-RS and corresponds to the higher-layer parameter resourceElementOffset in the PTRS-UplinkConfig or PTRS-DownlinkConfig IE.

Resource Allocation

- BWP Length: Length of the Bandwidth Part. Only used when VRB to PRB Interleaver is enabled.
- BWP Start: Start of bandwidth part, the common resource block where bandwidth part starts relative to common resource block 0.
- RAT0 Bitmap: Resource allocation type 0 bitmap. The first bit corresponds to the first RB group in the BWP. Click the line and select the ellipse button on the right side to open the Byte Collection Editor on page 351.
- RAT0 P: Resource allocation type 0 nominal RBG size P.
- RAT1 RB Length: Resource allocation type 1 RB length.
- RAT1 RB Start: Resource allocation type 1 RB start.
- Ref RB Offset: Offset from the first common RB. For example, it can be used for PDSCH transmissions scheduled with DCI format 1_0 with the CRC scrambled by SI-RNTI in Type0-PDCCH common search space in CORESET 0.
- Ref RB Offset Enabled: Enables the parameter "Ref RB Offset". Options are Enabled and Disabled.
- Symbol Start: First symbol.
- Symbol Stop: Last symbol.
- VRB to PRB Interleaver: Controls whether the interleaver is enabled or disabled, and the interleaver size. Options are Disabled, Bundle Size 2, Bundle Size 4.

Transmission Scheme

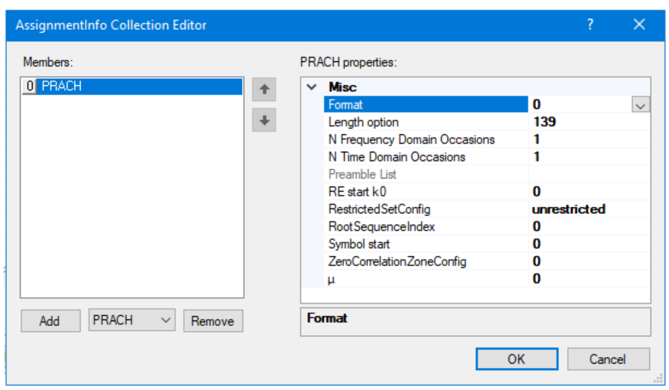
- Antenna Port Config: Corresponds to the values in 3GPP TS 38.212 tables 7.3.1.1.2-6 to 7.3.1.1.2.-23 for PUSCH, and table 7.3.1.2.2-1 to 7.3.1.2..2-4 for PDSCH. This field determines the set of DMRS ports, the value of N DMRS CDM group without data, and DMRS duration.
- DMRS Ports: List of DMRS antenna ports.
- N DMRS CDM Group without Data: Number of DMRS CDM group(s) without data.
- PRB Bundling Size: Precoding granularity.

UE IDs

- Data n ID: Value of n_ID used in c_init for scrambled data. By default, it is equal to the Cell ID, otherwise it corresponds the hogher-layer parameter dataScramblingIdentityPUSCH or dataScramblingIdentityPDSCH. Delete the field value and click Enter to set it to "Use N Cell ID".
- RNTI: RNTI value, from 0 to 65535.

5. 7. 18. 5 Assignment Info Collection Editor - PRACH Properties

If PRACH is not already visible the left side Members list, select PRACH from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - PRACH Properties

In the right side panel, the corresponding PRACH Properties drop-down menus includes the following parameters.

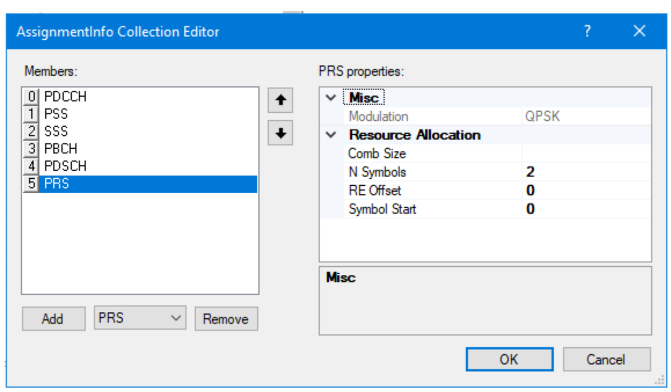
Misc.

- Format: Preamble format. Click the arrow on the right side to access the drop-down menu; options are 0, 1, 2, 3, A1, A2, A3, B1, B2, B3, B4, C0, and C2.
- Length Option: Preamble length (L_RA) option for formats A1-C2. Lengths 571 and 1151 are for μ= 1 and 0 respectively. Click the arrow on the right side to access the drop-down menu; options are 139, 571, and 1151.
- N Frequency Domain Occasions: Number of frequency domain PRACH transmission occasions.

- N Time Domain Occasions: Number of time domain PRACH transmission occasions.
- Preamble List: The Random Access Preamble List will be populated during processing.
- RE start k0: First resource element.
- Restricted SetConfig: Click the arrow on the right side to access the drop-down menu; options are Unrestricted, Restricted to Type A, and Restricted to Type B.
- RootSequenceIndex: Logical root sequence index i used to determine the root sequence number u.
- Symbol Start: First symbol index.
- ZeroCorrelationZoneConfig: The higher-layer parameter ZeroCorrelationZoneConfig maps to the physical layer parameter N_CS which determines the set of cyclic shifts.+
- µ: For formats A1-C2, PRACH subcarrier spacing is 15*2^µ kHz where µ = 0, 1, 2, 3.

5. 7. 18. 6 Assignment Info Collection Editor - PRS Properties

If PRS is not already visible the left side Members list, select PRS from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - PRS Properties

In the right side panel, the corresponding PRS Properties drop-down menus includes the following parameters.

Misc

- Modulation: 5G NR supports QPSK, 16 QAM, 64 QAM, and 256 QAM modulation.

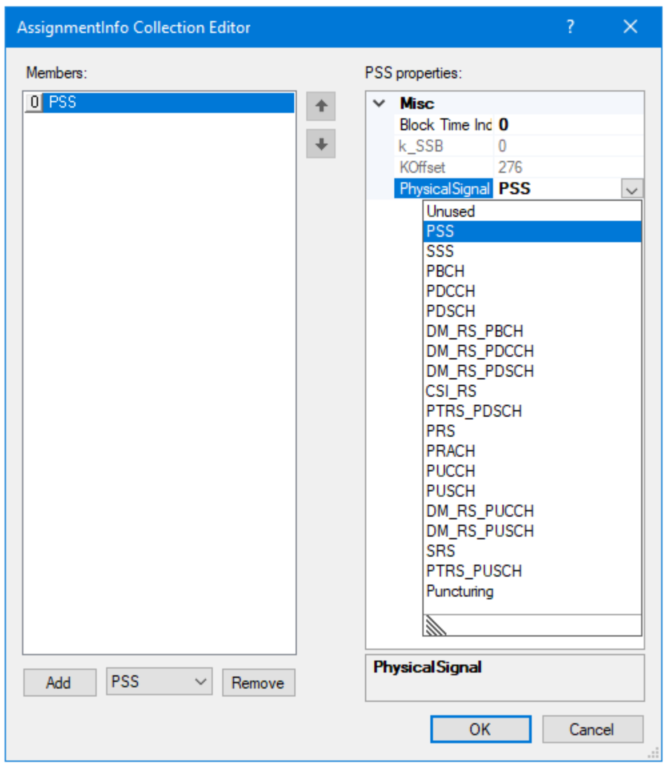
Resource Allocation

- Comb Size: The comb size, equal to 2, 4, 6, or 12, is given by the higher layer parameter dl-PRS-CombSizeN-r16.
- N Symbols: Number of consecutive OFDM symbols. Options are 2, 4, 6, and 12.

- Re Offset: The resource-element offset is given by the higher-layer parameter dl-PRS-ReOffsetr-16.
- Symbol Start: First symbol.

5. 7. 18. 7 Assignment Info Collection Editor - PSS Properties

If PSS is not already visible the left side Members list, select PSS from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - PSS Properties

In the right side panel, the corresponding PSS Properties drop-down menu includes the following parameters.

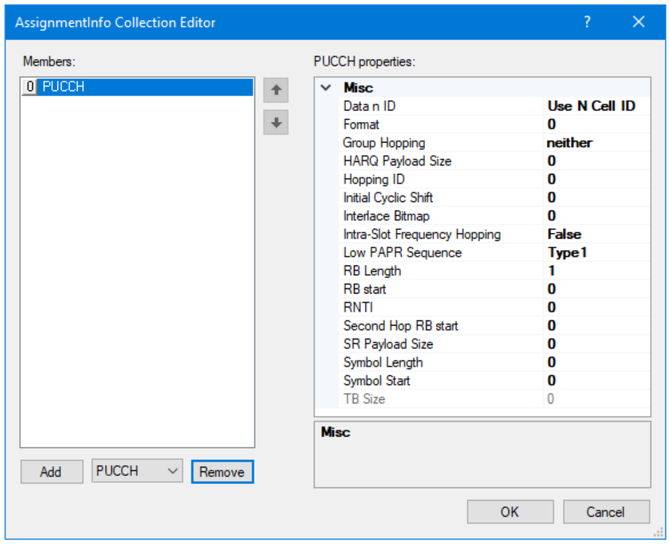
Misc.

- Block Time Index: Index of the SS/PBCH block.
- k_SSB: Subcarrier offset from subcarrier 0 in common resource block N_ CRB^SSB to subcarrier 0 of the SS/PBCH block. For µ {0.1}, k_SSB is in {0, 1, 2,...23} with k_SSB is in {0, 1, 2,..11} with k_SSB expressed in terms of the subcarrier spacing provided by the higher-layer parameter subCarrierSpacingCommon.
- KOffset: Subcarrier offset between the first subcarrier in the band and the first subcarrier in the SSB, expressed in SSB subcarrier spacing.

- **Physical Signal:** Click the right arrow to access the drop-down menu with the following options:
  - **DM_RS_PBCH:** DeModulation Reference Signal for the Physical Broadcast Channel
  - **DM_RS_PDCCH:** DeModulation Reference Signal for the Physical Downlink Control Channel
  - **DM_RS_PDSCH:** DeModulation Reference Signal for the Physical Downlink Shared Channel
  - **PTRS_PDSCH:** Phase Tracking Reference Signal for the Physical Downlink Shared Channel
  - **DM_RS_PUCCH:** DeModulation Reference Signal for the Physical Uplink Control Channel
  - **DM_RS_PUSCH:** DeModulation Reference Signal for the Physical Uplink Shared Channel
  - **PTRS_PUSCH:** Phase Tracking Reference Signal for the Physical Uplink Shared Channel
  - **Puncturing:** Puncturing lets you schedule enhanced mobile broadband (eMBB) traffic on all shared channel resources, without prior reservation of transmission resources for sporadically arriving low-latency communication (LLC) traffic. When LLC traffic arrives, it is immediately scheduled with a short transmission by puncturing part of the ongoing eMBB transmissions.

5. 7. 18. 8 Assignment Info Collection Editor - PUCCH Properties

If PUCCH is not already visible the left side Members list, select **PUCCH** from the drop-down menu and then click **Add**.



5G NR Assignment Info Collection Editor - PUCCH Properties

In the right side panel, the corresponding PUCCH Properties drop-down menus includes the following parameters.

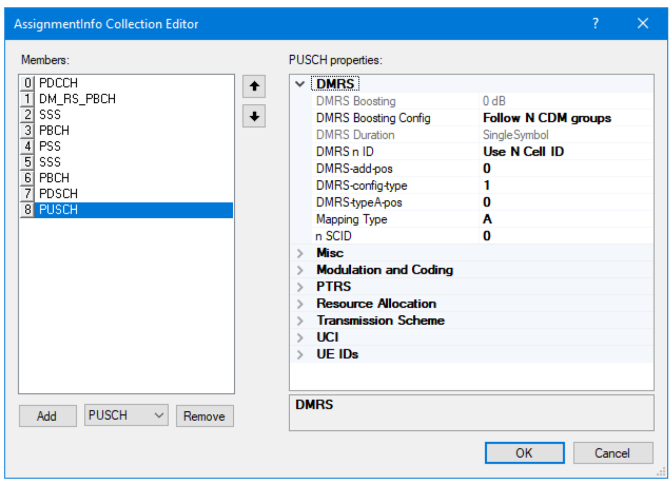
Misc.

– Data n ID: Value of n_ID used in c_init for scrambled data. By default, it is equal to the cell ID, otherwise it corresponds to the higher-layer parameter data ScramblingIdentityPUSCH. Delete the field value and click Enter to set it to "Use N Cell ID".
– Format: Click the line and select the right arrow to access drop-down options: 0, 1, 2, 3, 4.
– Group Hopping: Configuration of group- and sequence hopping for all the PUCCH formats 0, 1, 3, and 4. "Neither" implies neither group or sequence hopping is enabled. "Enable" enables group hopping and disables sequence hopping. "Disable" disables group hopping and enables sequence hopping. Corresponds to higher layer parameter pucch-GroupHopping.
– HARQ Payload Size: HARQ Payload size in bits.
– Hopping ID: Cell-specific scrambling ID, from 0 to 1023, for group hopping and sequence hopping, if enabled. Corresponds to higher layer parameter hoppingId.
– Initial Cyclic Shift: Corresponds to higher layer parameter initialCyclicShift.
– Interlace Bitmap: Bitmap for interlaced resource blocks.
– Intra-Slot Frequency Hopping: Enabling intra-slot frequency hopping. When enabled, the second hop is determined by Second Hop RB start.
– Low PAPR Sequence: Can be type 1 or type 2 (Release 16).
– RB Length: Number of resource blocks.
– RB Start: First resource block.

- RNTI: RNTI value, from 0 to 65535.
- Second Hop RB Start: First Resource Block after frequency hopping, applicable when Intra-Slot Frequency Hopping is enabled.
- SR Payload Size: SR Payload Size in bits.
- Symbol Length: Number of symbols.
- Symbol Start: First symbol.
- TB Size: Transport Block Size in bits.

5. 7. 18. 9 Assignment Info Collection Editor - PUSCH Properties

If PUSCH is not already visible the left side Members list, select PUSCH from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - PUSCH Properties

The PUSCH Properties are the same as the Assignment Info Collection Editor - PDSCH Properties on page 338 described above, except there are few additions.

Misc.

- groupOrSequenceHopping: Parameter(s) for configuring group or sequence hopping. Options include Neither, groupHopping, or sequenceHopping.

Modulation and Coding

- tp-pi2BPSK: Enables pi/2-BPSK modulation with transform precoding.

PTRS

- PTRS N Group/Sample: Number of PT-RS groups and number of samples per PT-RS group. Used only if transform precoding is enabled.
- PTRS-DMRS Association: Determines the ports used for PTRS.

Resource Allocation:

- Intra-Slot Frequency Hopping: When Intra-Slot Frequency Hopping is enabled, resources are allocated in two hops within a slot.

- RAT1 RB Start + BWP Start:
  - **RAT1 RB Start:** Resource allocation type 1 RB start.
  - **BWP Start:** Start of bandwidth part, the common resource block where bandwidth part starts relative to common resource block 0.
- RAT1 RB start second hop: For resource allocation type 1, if intra-slot frequency hopping is enabled, RB start of second hop.

Transmission Scheme

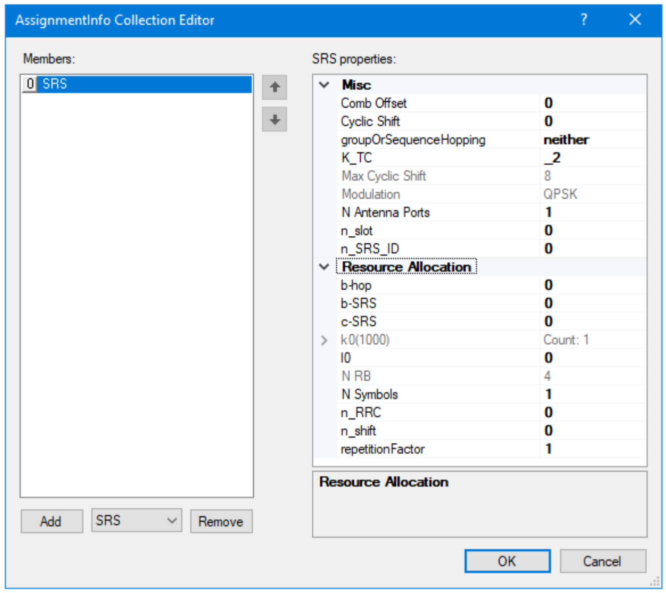
- Rank: MIMO rank, number of layers.
- Transform Precorder Enabled: When enabled, the data is prcoded with a Fourier transform, so the transmission scheme becomes SC-FMDA instead of OFDMA. Corresponds to higher layer parameter transform Precoder.

UCI

- UCI Alpha: Uplink Control Information Alpha, indicates a scaling factor to limit the number or resource elements assigned to UCI on PUSCH configured by higher layer parameter scaling in the UCI-OnPUSCH IE.
- UCI Beta Index ACK: Uplink Control Information Beta Offset for Index ACK, configured by higher layer IE BetaOffsets.
- UCI Beta Index CSI Part 1: Uplink Control Information Beta Offset Index for CSI Part 1, configured by higher layer IE BetaOffsets.
- UCI Beta Index CSI Part 2: Uplink Control Information Beta Offset Index for CSI Part 2, configured by higher layer IE BetaOffsets.
- UCI CSI Part 1 Payload Size: Uplink Control Information CSI Part 1 Payload Size in bits.
- UCI CSI Part 2 Payload Size: Uplink Control Information CSI Part 2 Payload Size in bits.
- UCI HARQ-ACK Payload Size: Uplink Control Information HARQ-ACK Payload Size in bits.

5. 7. 18. 10 Assignment Info Collection Editor - SRS Properties

If SRS is not already visible the left side Members list, select SRS from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - SRS Properties

In the right side panel, the corresponding SRS Properties drop-down menus includes the following parameters.

Misc.

- Comb Offset: Transmission comb offset.
- Cyclic Shift: For multiple SRS transmissions from multiple antennas, cyclic shift multiplexing and different transmission combs may be used.
- groupOrSequenceHopping: Parameter(s) for configuring group or sequence hopping.
- K_TC: Transmission comb number. Options are _2 and _4.
- Max Cyclic Shift: The maximum number of cyclic shifts is 12 if K_TC = 4, and 8 if K-TC = 2.
- Modulation: 5G NR supports QPSK, 16 QAM, 64 QAM, and 256 QAM modulation.
- N Antenna Ports: N Antenna Ports Number of anntenna ports.
- n_slot: For the case of an SRS resource configured as periodic or semi-persistent by the higher-layer parameter resource Type, the quantity n_slot counts the number of candidate slots in which the configured SRS resource may be used for SRS transmission, and is used to compute the frequency domain position when frequency hopping is enabled.
- n_SRS_ID: Sequence ID used to initialize pseudo random group and sequence hopping, given by the higher layer parameter sequenceId in the SRS-Config IE.

Resource Allocation

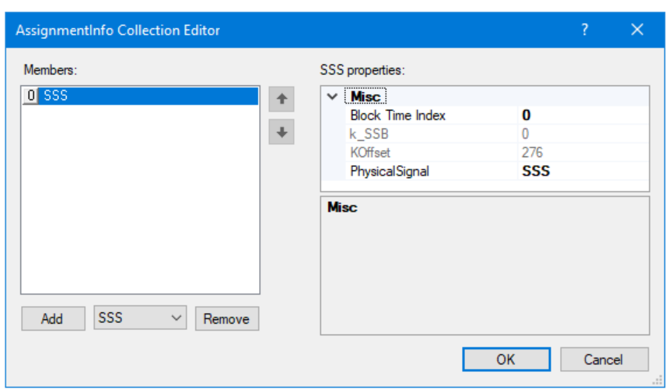
- b-hop: Frequency hopping parameter, from 0 to 3, contained in the higher layer parameter freqHopping.
- b-SRS: SRS bandwidth configuration column index, from 0 to 3, contained in the

higher layer parameter freqHopping.

- c-SRS: SRS bandwidth configuration row index, from 0 to 3, contained in the higher layer parameter freqHopping.
- k0(1000): The starting posisions, listed per symbol, in the frequency domain for antenna ports 1000 and 1002.
- l0: The starting position in time domain.
- N RB: The number of Resource Blocks, denoted m_SRS.b in 3GPP TS 38.211.
- N Symbols: The number of consecutive OFDM symbols, equal to 1, 2, 4, 8, or 12, given by the field nrofSymbols contained in the higher layer parameter resourceMapping.
- n_RRC: Parameter(s) defining frequency domain position and configurable shift to align SRS allocation to 4 PRB grid, given by the higher layer parameter freqDomainPosition.
- n_shift: Parameter defining frequency domain shift in PRBs, contained in the higher layer parameter freqDomainShift in the SRS-Config IE.
- repetitionFactor: Repetition factor, equal to 1, 2 or 4, contained in the higher layer parameter resourceMapping.

5. 7. 18. 11 Assignment Info Collection Editor - SSS Properties

If SSS is not already visible the left side Members list, select SSS from the drop-down menu and then click Add.



5G NR Assignment Info Collection Editor - SSS Properties

In the right side panel, the corresponding SSS Properties drop-down menu includes the following parameters.

Misc.

- Block Time Index: Index of the SS/PBCH block.
- k_SSB: Subcarrier offset from subcarrier 0 in common resource block N_CRB^SSB to subcarrier 0 of the SS/PBCH block. For µ {0.1}, k_SSB is in

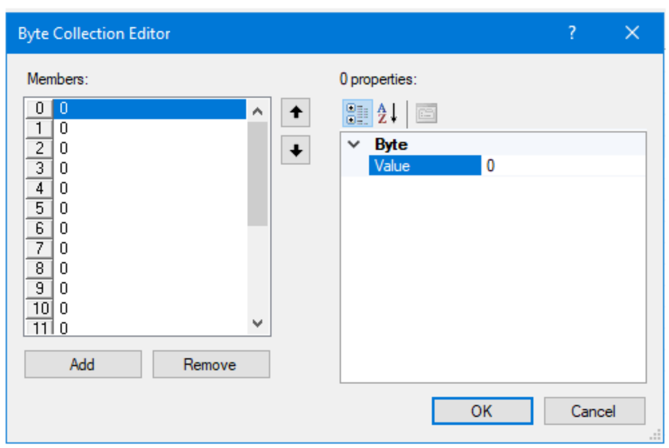
{0,1,2,....23} with k_SSB is in {0,1,2,...11} with k_SSB expressed in terms of the subcarrier spacing provided by the higher-layer parameter subCarrierSpacingCommon.

- KOffset: Subcarrier offset between the first subcarrier in the band and the first subcarrier in the SSB, expressed in SSB subcarrier spacing.
- Physical Signal: Click the right arrow to access the drop-down menu with the following options:
  - Unused
  - PSS: Primary Synchronization Signal
  - SSS: Secondary Synchronization Signal
  - CSI_RS Channel State Information Reference Signal
  - PBCH: Physical Broadcast Channel
  - PDCCH: Physical Downlink Control Channel
  - PDSCH: Physical Downlink Shared Channel
  - PRACH: Physical Random Access Channel
  - PUCCH: Physical Uplink Control Channel
  - PUSCH: Physical Uplink Shared Channel
  - SRS: Sounding Reference Signal
  - DM_RS_PBCH: DeModulation Reference Signal for the Physical Broadcast Channel
  - DM_RS_PDCCH: DeModulation Reference Signal for the Physical Downlink Control Channel
  - DM_RS_PDSCH: DeModulation Reference Signal for the Physical Downlink Shared Channel
  - PTRS_PDSCH: Phase Tracking Reference Signal for the Physical Downlink Shared Channel
  - DM_RS_PUCCH: DeModulation Reference Signal for the Physical Uplink Control Channel
  - DM_RS_PUSCH: DeModulation Reference Signal for the Physical Uplink Shared Channel
  - PTRS_PUSCH: Phase Tracking Reference Signal for the Physical Uplink Shared Channel
  - Puncturing: Puncturing lets you schedule enhanced mobile broadband (eMBB) traffic on all shared channel resources, without prior reservation of transmission resources for sporadically arriving low-latency communication (LLC) traffic. When LLC traffic arrives, it is immediately scheduled with a short transmission by puncturing part of the ongoing eMBB transmissions.

5. 7. 19 Byte Collection Editor

To access the Byte Collection Editor:

1. Open the window 5G Edit Schedule on page 330.
2. Click on the Frame List then click the ellipse button on the right side. This opens the Frame Info Collection Editor.
3. In the Frame Info Collection Editor, click the Slot List line and select the ellipse button on the right side. This opens the Slot Info Collection Editor window.
4. In the Slot Info Collection Editor window, click on the line item Assignment List and select the ellipse button on the right side. This opens the Assignment Info Collection Editor window.
5. In the Assignment Info Collection Editor window, add PDSCH to the Members list if it is not already there.
6. Scroll down the right side PDSCH Properties pane and select the subsection Resource Allocation.
7. Click the line item **RAT0 Bitmap**. Click the ellipse button on the right side of the line, this opens the Byte Collection Editor.



5G NR Byte Collection Editor

Click the Value line and set the parameter. Click the OK button to save and activate the change.

The Byte Collection Editor has the following buttons.

Arrows: Moves the selection up or down in the Members list.

Add: Adds frames in the left side Members pane.

Remove: Deletes the last frame added in the left side Members pane.

OK: Executes the changes.

Cancel: Closes out of the window without making any changes.

5. 8 Hot Keys

Hot keys are keyboard combinations that execute the same command as selecting an item from a menu. Many users find them more efficient to use than the traditional point and click selction method. The list below is a comprehensive list of WaveJudge hot keys.

WaveJudge Hot Keys

Keyboard	Action
Function Keys:	
F1	*Help (context-sensitive)*
Ctrl+F1	*Open Help to Table of Contents*
F2	*(Not Used)*
F3	*Find Again (Find next message)*
F4	*Chart Properties Window*
F5	*Resume processing*
Ctrl+F5	*Stop (stops capture and/or processing)*
F6	*Configure Chassis Window*
F7	*Configure Test Window*
F8	*Set Up Capture Window*
F9	*(Not Used)*
F10	*IntelliJudge Capture*
F11	*Single WaveJudge Capture*
ShftF11	*Repeat WaveJudge Capture*
Control Key for File/Edit Operations:	
Ctrl+N	*New Test Configuration*
Ctrl+O	*Open...*
Ctrl+S	*Save Current Capture...*
Ctrl+ShftS	*Save Test Configuration...*
Ctrl+A	*Select All (Select entire WaveJudge capture time range)*
Ctrl+B	*Save Bookmarks*
Ctrl+D	*Clear Selection (Deselect)*
Ctrl+F	*Find Message (Opens Find Message window)*
Ctrl+G	*Goto Time... (Opens Goto Time window)*
Ctrl+X	*Cut (not used in WaveJudge)*
Ctrl+C	*Copy (not used in WaveJudge)*
Ctrl+V	*Paste (not used in WaveJudge)*

WaveJudge Hot Keys (continued)

Keyboard	Action
Other Operations:	
AltC	*Connect*
AltD	*Disconnect*
AltI	*Reprocess Interval*
AltR	*Reprocess IntelliJudge*
Ctrl+ShftR	*Reprocess WaveJudge*
Ctrl+R	*Reprocess (default/implied target)*
IntelliJudge and WaveJudge Message Lists:	
End	*WaveJudge: Go to end of list; IntelliJudge: Go to end of list and resume automatically scrolling new data, a very important feature*
Ctrl+End	
Ctrl+PgDn	
General:	
Home	*Go to top of list*
Ctrl+Home	
Ctrl+Pg Up	
Pg Up	*Page up*
Pg Dn	*Page down*
Up(Arrow)	*Move current selection up one line*
Down(Arrow)	*Move current selection down one line*
Enter	*Open currently highlighted/selected message in a decode window*
Shift + any arrow or movement key	*Extend current selected range in that direction (like Shift+movement key in Word)*

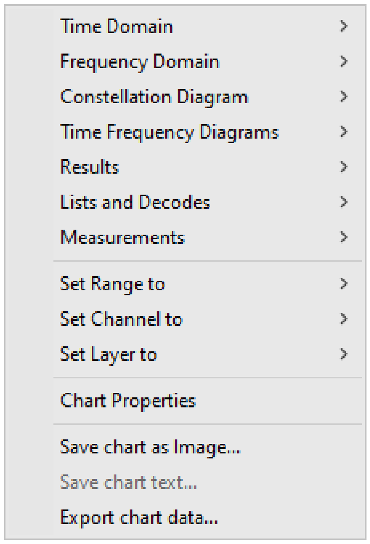
6 Use 5G NR Charts

This section describes how to use WaveJudge charts and context menus. The default charts are for 5G NR, secondary charts are for 4G LTE.

6.1 Chart Context Menu (5G)

Charts represent data as visual graphs, as structured lists such as the WaveJudge Messages List on page 240, as simple text such as the Summary Chart on page 389 or Channel Decoding Chart on page 393 charts, or as hierarchies such as the PHY Frame Lists on page 432 lists. To access the Chart Context Menu, **right-click on any chart** and select an option.

IMPORTANT The chart properties for each chart are different; chart options change according to which chart you select.



5G WaveJudge Chart Context Menu

The first seven items on the Chart Context Menu are charts:

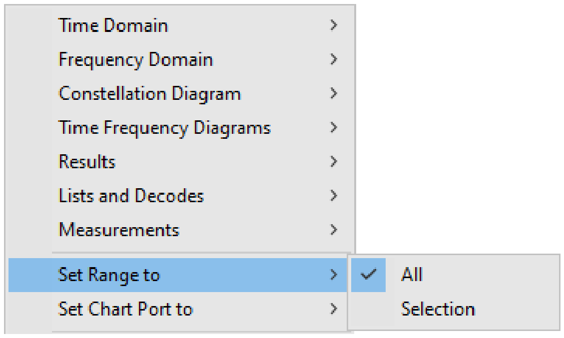
- Time Domain Charts on page 364
- Frequency Domain Charts on page 373
- Constellation Diagram on page 380
- Time Frequency Diagrams on page 381
- Results on page 389
- Lists and Decodes on page 392
- Measurements on page 394

The last six items on the Chart Context Menu are actions.

- Set Range to on page 356
- Set Chart Port to on page 358
- Chart Properties on page 361
- Save Chart as Image on page 360
- Save Chart Text on page 360
- Export Chart Data on page 361

6. 1. 1 Set Range to

The Set Range to submenu in the Chart Context Menu is where you may set a chart's range to either All or Selection.



5G Chart Context Menu - Set Range To Options

You can use all of the data samples collected for the analysis or reduce the measurement to a small number of samples, or units of time. To use all data samples or a selection of samples right-click on a chart, scroll to “Set Range To” and select “All”.

All:

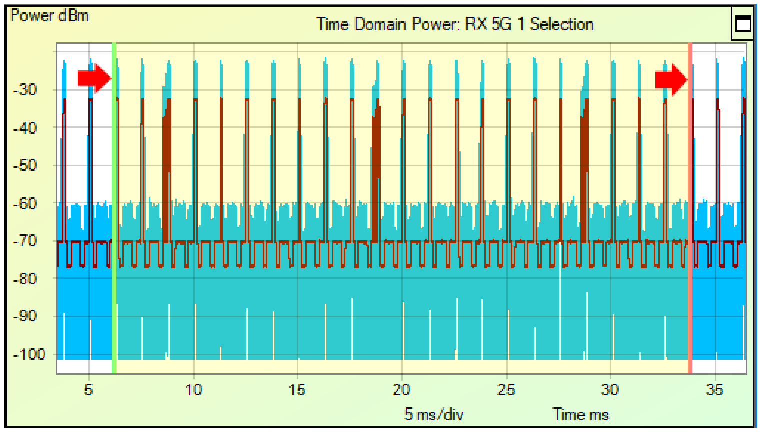
Displays all of the frames captured by WaveJudge. This mode improves averaging since a larger sample of data is used.

Selection:

Set the range to Selection to reflect message data only in the region that represents the selected frame, subframe, or assignment. This option sets the chart to display only the zones or bursts selected on the PHY Frames, the messages selected in the Message List, or the time associated with the gated time markers. All three of these sources send information that is used for the current selection and provide input for cross-probing between charts.

The correlation input to the chart is indicated by colored markers. Click the **Set Markers** icon once to set the left marker (green line), click the icon again to set the right marker (red line). For more information on the cross probing engine, refer to Correlation/Message List Correlation Using the WaveJudge Message List on page 480.

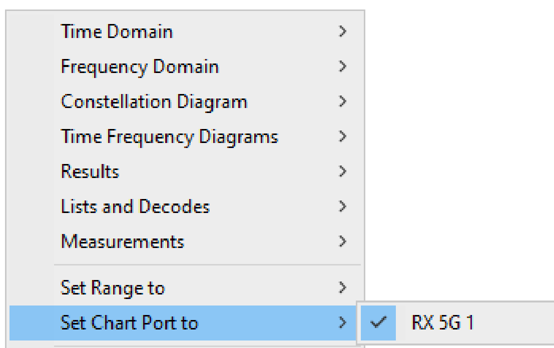
The pane retains the setting and uses this selection on any chart opened in a pane.



Set Range To Selection - Green and Red Markers

6. 1. 2 Set Chart Port to

The Set Chart Port to option is where you designate which port this chart will display data from. Depending on the chart that you right-click to open the Chart Context Menu, the options in the drop-down menu may change.



5G Chart Context Menu - “Set Chart Port to” Drop-down Menu

Use the Configure Test Window or Define a New Test on page 136 to set up the input paths. You can review any of the inputs for any chart, summary table, or frame list. To view an Rx Port in the charts and Summary results table right-click in the chart pane and select Set Chart Port to and a corresponding Rx port.

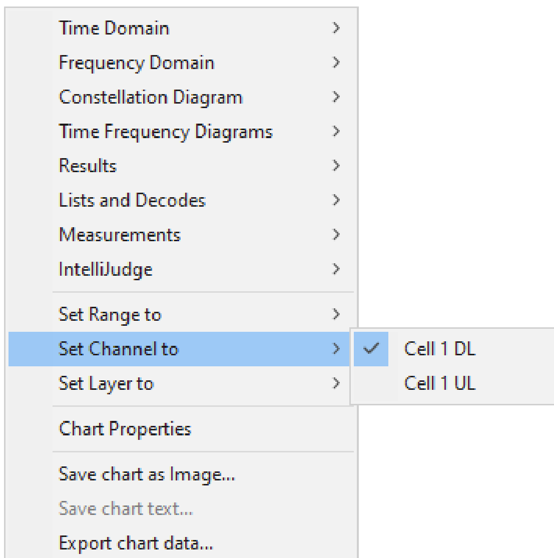
NOTE The pane retains the setting and will use this selection on any chart brought up in this pane. You can only select Rx ports that receive data.

TIP Other analysis options for the charts, such as zoom-in/out, time

TIP gated markers, pointers, and pane sizing, are available; see Chart Views Tool Group on page 225.

6.1.3 Set Channel to (LTE Only)

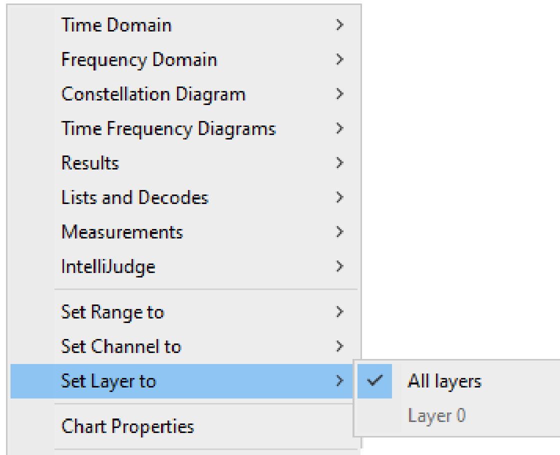
The Set Channel To option is where you designate which channel the chart will display data from. This option is only on the 4G LTE Chart Context menu.



4G LTE Chart Context Menu - "Set Channel To" Drop-down Menu

6.1.4 Set Layer To (LTE Only)

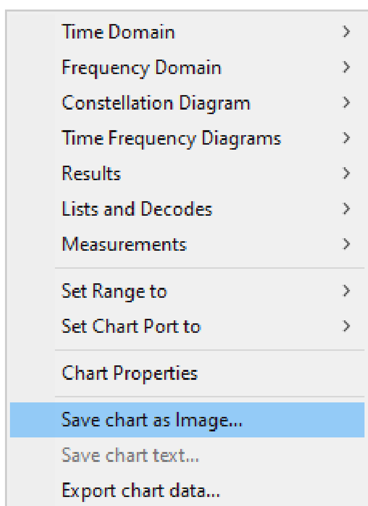
The Set Layer To option is where you designate which layer this chart will display data from. This option is only on the 4G LTE Chart Context menu.



4G LTE Chart Context Menu - “Set Layer To” Drop-down Menu

6. 1. 4. 1 Save Chart as Image

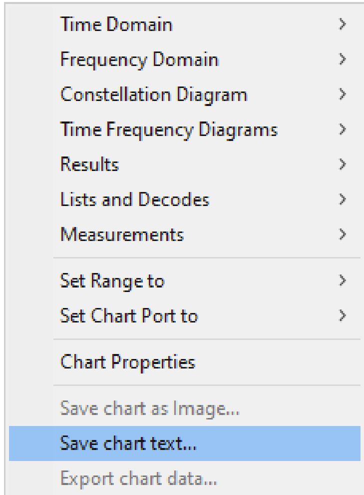
The Save Chart as Image option in the Chart Context Menu opens a window to name and save chart as an image (.GIF, .JPG, .BMP, .TIF, or .PNG) on your computer.



5G Chart Context Menu - Save Chart as Image

6. 1. 4. 2 Save Chart Text

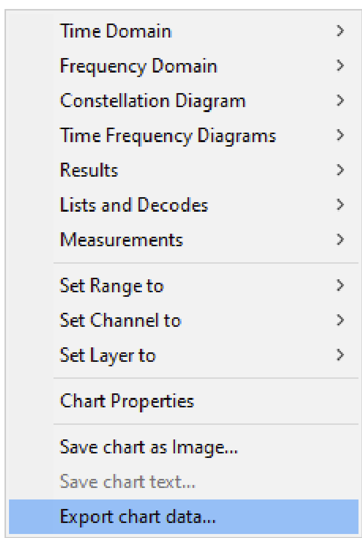
The Save Chart Text option in the Chart Context Menu opens a window to save the chart as .TXT or .CSV format.



5G Chart Context Menu - Save Chart Text

6. 1. 4. 3 Export Chart Data

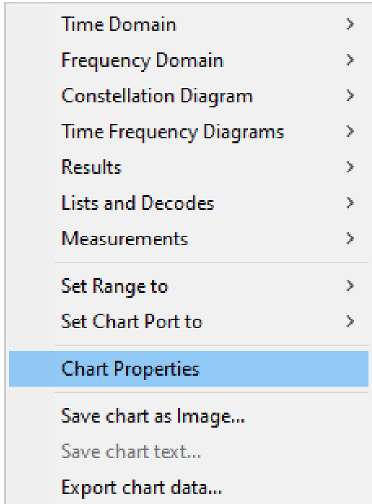
The **Export Chart Data** option in the **Chart Context Menu** opens a window to save the chart as text as .TXT or .CSV format.



5G Chart Context Menu - Export Chart Data

6. 1. 5 Chart Properties

The **Chart Properties** item on the **Chart Context Menu** opens the Chart Properties window. The options in that window will change according to which chart you have open. This topic is discussed in detail in the section Chart Properties Window on page 236.



5G Chart Context Menu - Chart Properties

6. 1. 6 Differences Between 5G and 4G Chart Context Menus

The WaveJudge Chart Context menus for 5G NR and 4G LTE are almost identical. In fact, the LTE Chart Context Menu has everything that the 5G does, plus all the IntelliJudge charts and a few extra options, as indicated in the table below.

Comparison of 5G NR and 4G LTE Chart Context Menus

5G NR Chart Context Menu	4G LTE Chart Context Menu
Time Domain Power	*Time Domain Power*
1. *EVM Per Symbol*	1. *EVM Per Symbol*
2. *Baseband IQ Input*	2. *Baseband IQ Input*
3. *Impulse Response*	3. *Impulse Response*
4. *MIMO Channel Per Symbol*	4. *MIMO Channel Per Symbol*
	5. *Time Domain Phase Noise*
Frequency Diagrams	*Frequency Diagrams*
1. *EVM Per Subcarrier*	1. *EVM Per Subcarrier*
2. *Spectral Power*	2. *Spectral Power*
3. *MIMO Channel Per Subcarrier*	3. *MIMO Channel Per Subcarrier*
4. *Beamforming Phase Per Subcarrier*	4. *Beamforming Phase Per Subcarrier*
5. *Beamforming Power Per Subcarrier*	5. *Beamforming Power Per Subcarrier*
	6. *Phase Noise Relative Power Spectral Density*
Time Frequency Diagrams	*Time Frequency Diagrams*

5G NR Chart Context Menu

1. *2D Power*
2. *Spectrogram*

Results

1. *Summary*

Constellation Diagram

Lists and Decodes

1. *WaveJudge Messages*
2. *Channel Decoding*

Measurements

1. *CCDF*

Set Range To

- *All*
- *Selection*

Set Chart Port To

- *RX1*
- *RX2*
- *RX3*

Chart Properties

Save Chart as Image...

- *Save Chart Text...*
- *Export Chart Data...*

4G LTE Chart Context Menu

1. *2D Power*
2. *Spectrogram*

Results

1. *Summary*
2. *Per User Statistics*

Constellation Diagram

Lists and Decodes

1. *WaveJudge Messages*
2. *Channel Decoding*

Measurements

1. *CCDF*

IntelliJudge

1. *IntelliJudge TB EVM Chart*
2. *IntelliJudge TB Power Chart*
3. *IntelliJudge TB CRC Error Chart*
4. *IntelliJudge Throughput Chart*
5. *IntelliJudge TB Count Chart*
6. *IntelliJudge TB SINR Chart*
7. *IntelliJudge CRS EVM Chart*
8. *IntelliJudge CRS SINR Chart*
9. *IntelliJudge Subframe Power Chart*
10. *IntelliJudge Subframe RSSI Chart*
11. *IntelliJudge Subframe RSRP Chart*
12. *IntelliJudge Subframe RSRQ Chart*
13. *2D Physical IntelliJudge*

Set Range To

- *All*
- *Selection*

Set Chart Port To

- *RX1*
- *RX2*
- *RX3*

Chart Properties

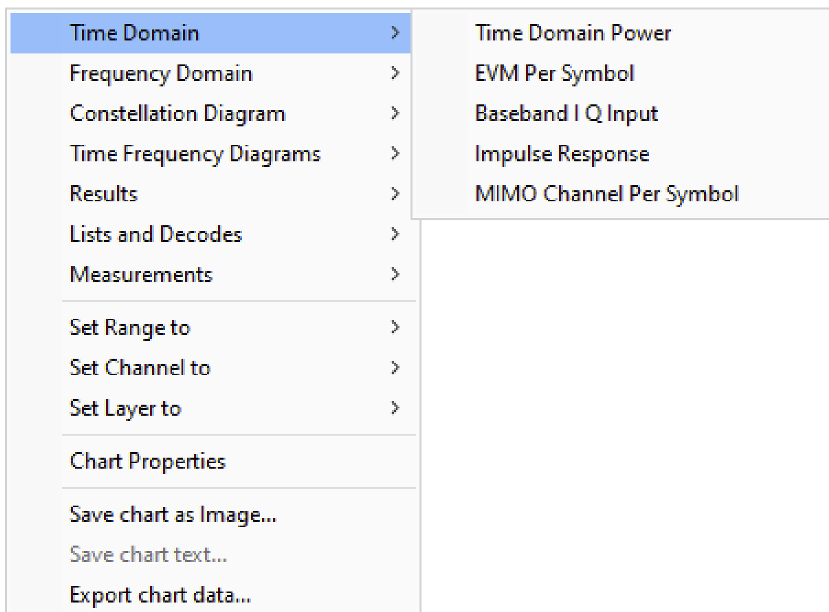
Save Chart as Image...

- *Save Chart Text...*
- *Export Chart Data...*

5G NR Chart Context Menu	4G LTE Chart Context Menu
	Set Chart to Protocol
	– *3GPP LTE*

6. 2 Time Domain Charts

The 5G Time Domain menu has five submenu options: Time Domain Power, EVM Per Symbol, Baseband IQ Input, Impulse Response, and MIMO Channel Per Symbol. However, 4G LTE includes three additional Time Domain charts (CRS SINR Per Subframe, Port Phase Differences per Subframe, and Time Domain Phase Noise) also discussed below.



5G Chart Context Menu - Time Domain Charts

The Time Domain Power chart shows the energy level of the signal over time.

The EVM Per Symbol chart shows the worst or maximum EVM and the average EVM over all subcarriers contained in one symbol.

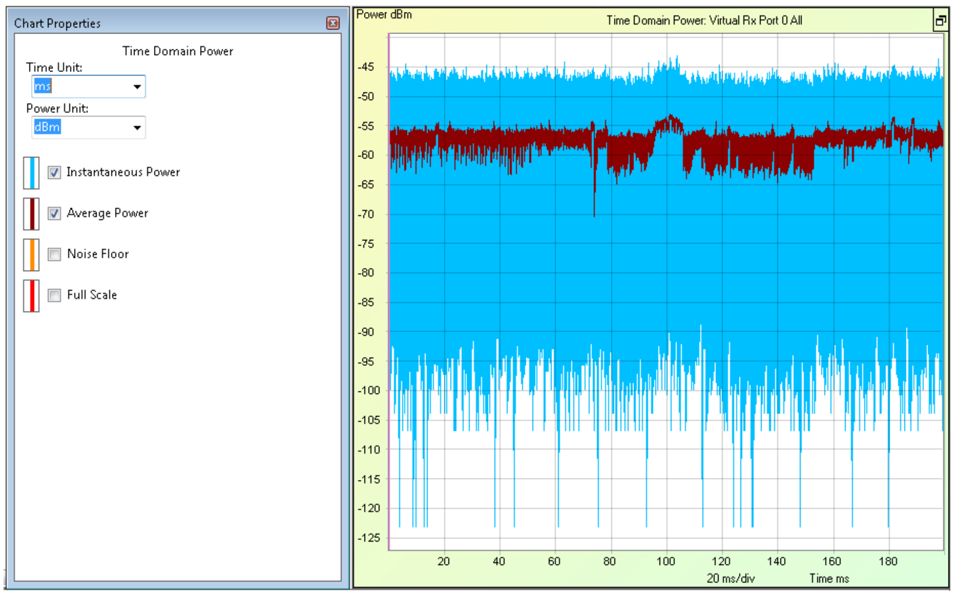
The Baseband IQ Input chart shows the amplitude of the input I and Q values for baseband input. Without baseband inputs to the WaveJudge, this chart displays the WaveJudge’s internal I and Q amplitude values.

The Impulse Response chart is the Fourier transform of the frequency response (shown as a trace in the Spectral Power chart; see Spectral Power on page 375). Use this chart to detect the severity of a multipath. Additional peaks or side lobes to the right of the main peak that are asymmetrical to those on the left side of the main peak provide approximate information relating to the delay profile due to multipath.

The MIMO Channel Per Symbol chart displays the maximum (red) and the average (green) channel rank over all subcarriers contained in each frame, zone, or burst.

6. 2. 1 Time Domain Power

The Time Domain Power chart shows the energy level of the signal over time.



Time Domain Power Chart and Chart Properties Window

This chart is available for 5G, 4G LTE, WiFi, and WiMAX captures. Traces for this chart are:

Instantaneous Power: Power measured per sample.

Average Power: Computed per sample averaged over number of FFT points over a sliding window.

Autocorrelation: Detects the beginning of a burst (WiMAX) or sync signal for a frame (LTE); does not apply to 5G.

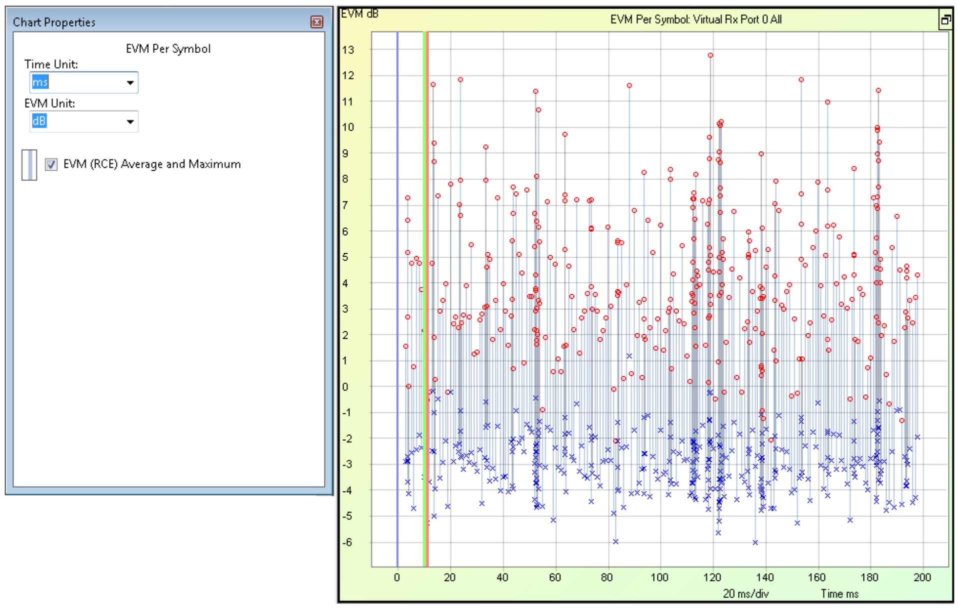
Noise Floor: Indicates where the baseline is.

Full Scale: Adds a bar at the top of the diagram to put the scale into perspective.

Average Power remains visually stable in comparison to Instantaneous Power, due to averaging. PAPR can also be derived from this trace as a ratio between Instantaneous Power and Average Power.

6. 2. 2 EVM Per Symbol

This chart displays the worst or maximum Error Vector Magnitude (red) and the average EVM (green) over all subcarriers contained in one symbol. To display the symbol value and the EVM value, place the Measure tool from the toolbar on any EVM point.



Time Domain Chart "EVM Per Symbol" and Chart Properties Window

This chart is available for 5G, 4G LTE, and WiFi captures. The options and traces for this chart are:

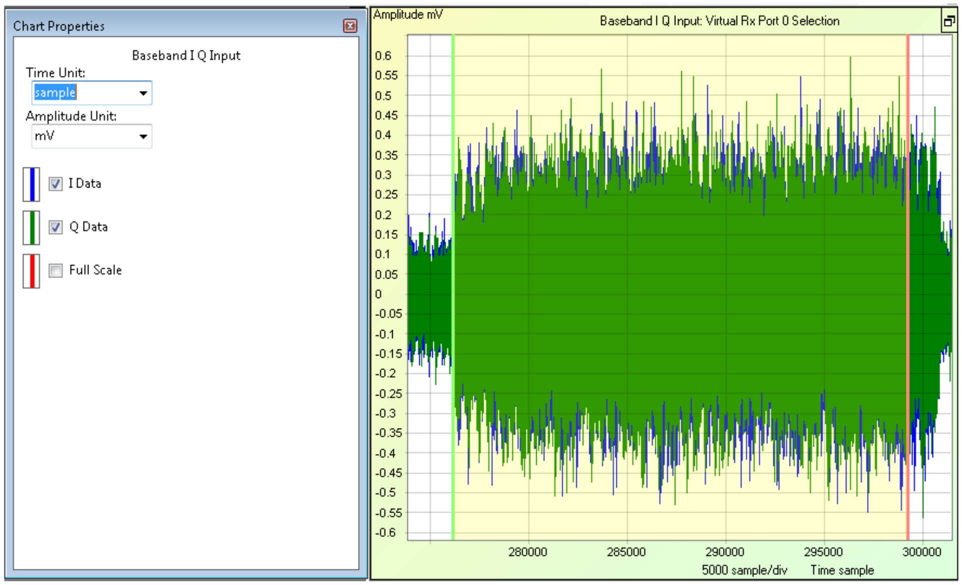
Time Units: Time units available are seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

EVM Units: The measured unit, usually either decibels (dB) or percentage (%).

EVM (RCE) Average and Maximum: Displays the average and maximum EVM of all TBs within the interval.

6. 2. 3 Baseband IQ Input

This chart shows the I/Q sample amplitude values, after format conversion, as captured from the analog digital converter (ADC) hardware. This chart is useful to diagnose physical level RF-related problems, such as DC offset or signal saturation due to incorrect gain settings. The two charts below show amplitude of the input I and Q values for baseband input. Without baseband inputs to the WaveJudge, this chart displays the WaveJudge's internal I and Q amplitude value.



Time Domain Chart "Baseband IQ Input" and Chart Properties Window

This chart is available for 5G, 4G LTE, WiFi, and WiMAX captures. Traces for this chart are as follows.

Time Units: Time units available are seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

Amplitude Unit: Amplitude units are in volts (v), millivolts (mV), microvolts (µv), analog to digital converter (ADC), and unscaled ADC.

I Data: In-phase sample data series.

Q Data: Quadrature sample data series.

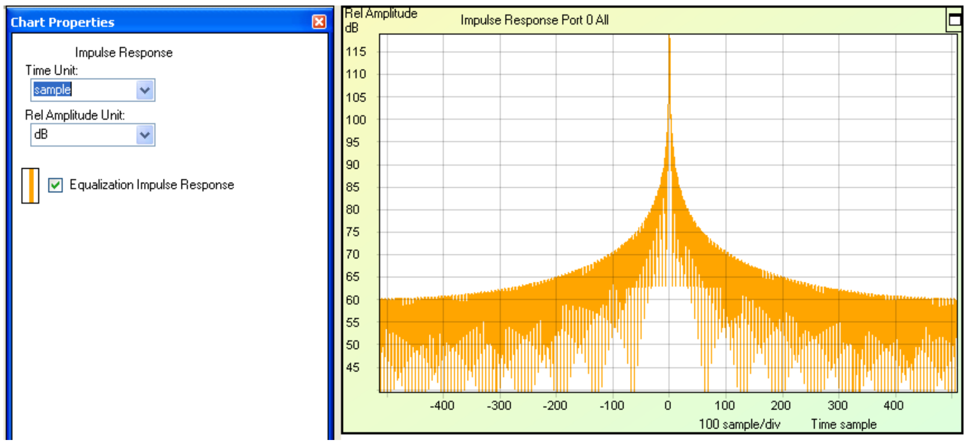
Full Scale: Adds a bar at the top of the diagram to put the scale into perspective; a constant line representing the maximum valid values for the type of ADC hardware used in this capture.

NOTE If the I or Q data regularly reach or are near to the "full scale" line, the captured signal was probably saturated at or before the ADC. In that case the signal probably can not be demodulated reliably; reduce the gain settings or attenuate the signal before trying another capture.

6. 2. 4 Impulse Response

The Impulse Response chart is the Fourier transform of the frequency response (shown as a trace in the Spectral Power chart; see Spectral Power on page 375). Use this chart to detect the severity of multipath. Additional peaks or side lobes to the right of the main peak that are asymmetrical to those on the left side of the main peak provide approximate information relating to the delay profile due to multipath.

This chart provides a measurement for the four up to four DL antennas (Tx0, Tx1, Tx2, and Tx3). The measurement is take on a per ms or subframe boundary; therefore the range is limited to a selection.



Time Domain Chart "Impulse Response" and Chart Properties Window

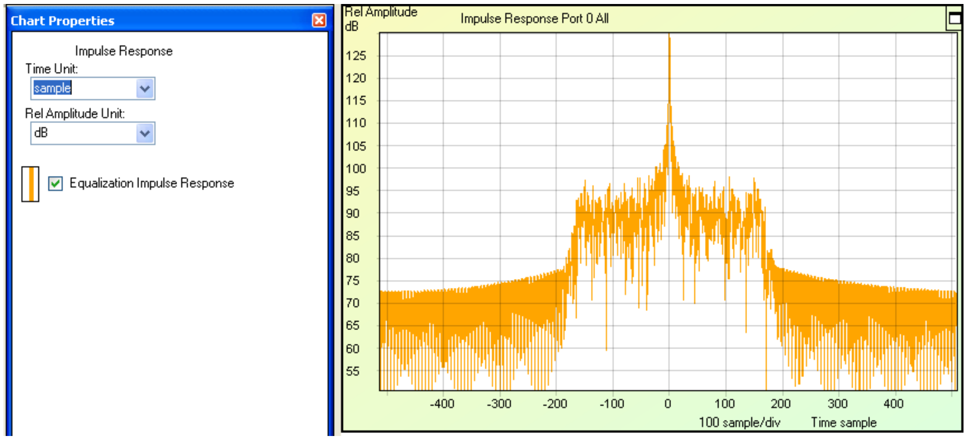
This chart is available for 5G, 4G LTE, and WiFi captures. Traces for this chart are described below.

Time Units: Seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

Relative Amplitude Unit: Decibel (dB), ratio, and percentage (%).

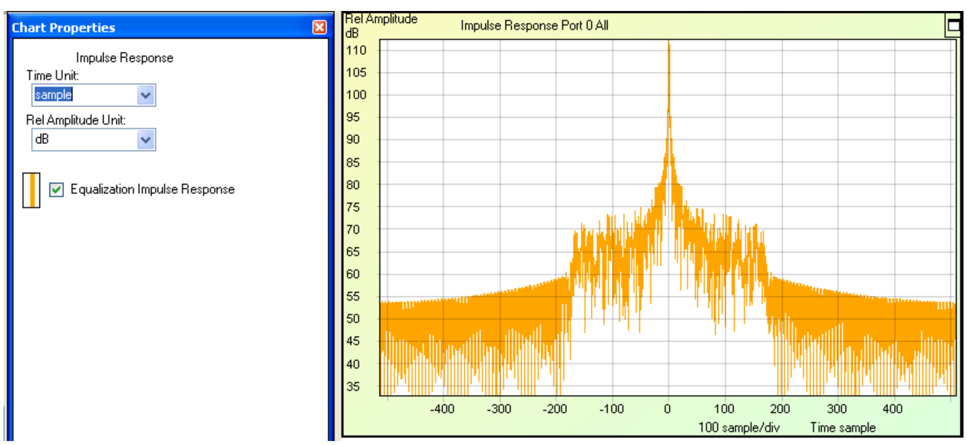
Equalization Impulse Response: Based on the received Cell-specific Reference Signal (CRS).

The cyclic prefix should absorb the effects relating to multipath; thus, a trace that shows additional peaks relating to multipath can be an indication that the cyclic prefix used is too small. The examples below show extra impulses that indicate the presence of multipath.



Time Domain Chart “Impulse Response” Multipath and Chart Properties Window (1)

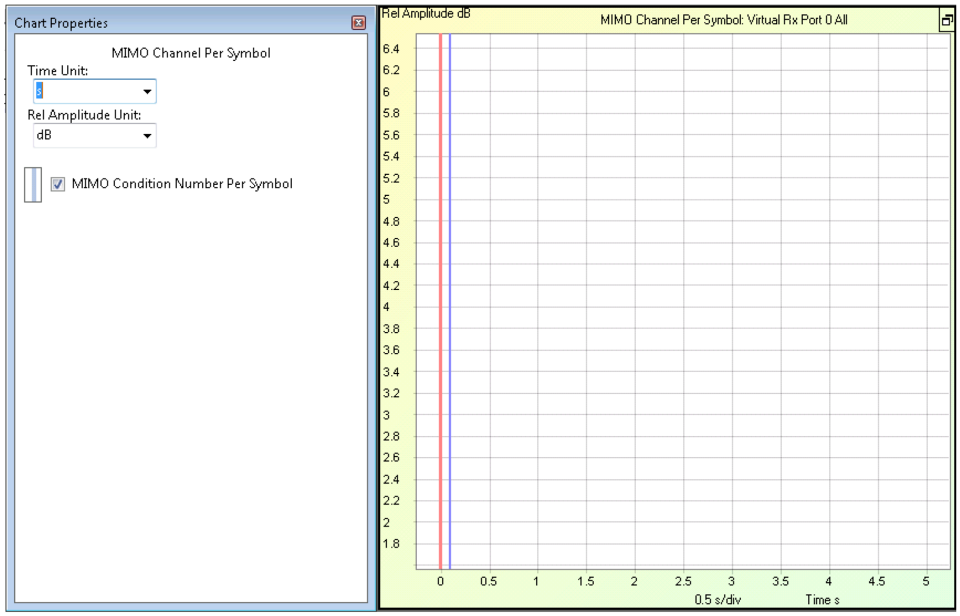
Based on the received Cell-Specific Reference Signal (CRS), each line in this chart shows the magnitude of the impulse response estimated by WaveJudge for the compounded channel from each existent eNodeB’s CRS port to each WaveJudge’s downlink receiving port. The minimum resolution of the chart in time domain is the interval of a WaveJudge sample (e.g., 1 / WaveJudge sampling rate in the unit of second, where the WaveJudge sampling rate equals NFFT choice multiplied by the Subcarrier Spacing chosen on WaveJudge GUI).



Time Domain Chart “Impulse Response” Multipath and Chart Properties Window (2)

6. 2. 5 MIMO Channel Per Symbol

The MIMO Channel Per Symbol chart displays the maximum (red) and the average (green) MIMO channel rank over all subcarriers contained in each frame, zone, or burst. To display the symbol value and the relative amplitude value, place the Measure tool from the toolbar on any channel rank point. The MIMO Constellation is included in the cross-probing of MIMO channel rank, therefore you can show any point on the constellation on a MIMO chart.



Time Domain Chart "MIMO Channel Per Symbol" and Chart Properties Window

This chart is only available for 5G and 4G LTE captures. Traces for this chart are as follows.

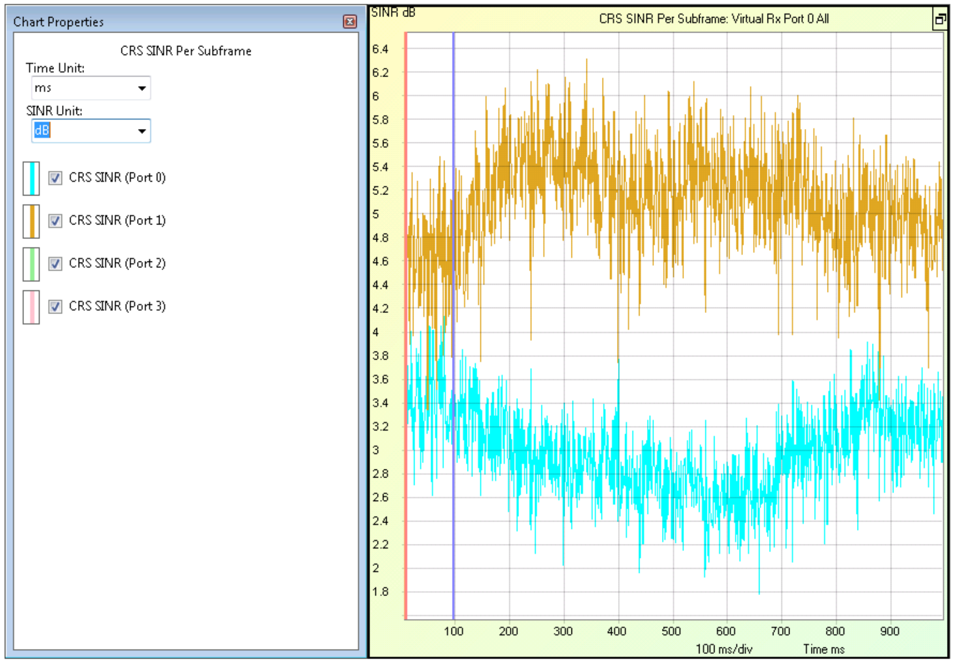
Time Units: Seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

Relative Amplitude Unit: Decibel (dB), ratio, and percentage (%).

MIMO Condition Number Per Symbol: Enables the trace for the MIMO channel rank (condition number).

6. 2. 6 CRS SINR Per Subframe (LTE Only)

WaveJudge includes a chart for CRS SINR by subframe. This chart displays the Signal to Inteference and Noise Ratio (SINR) measurement for the Cell Reference Signal (CRS), which is an indicator of the signal quality for downlink transmissions. This chart is only available for use in LTE, it is not compatible with 5G NR, WiFi, or WiMAX.



Time Domain Chart "CRS SINR Per Subframe" and Chart Properties Window

Traces for this chart are as follows.

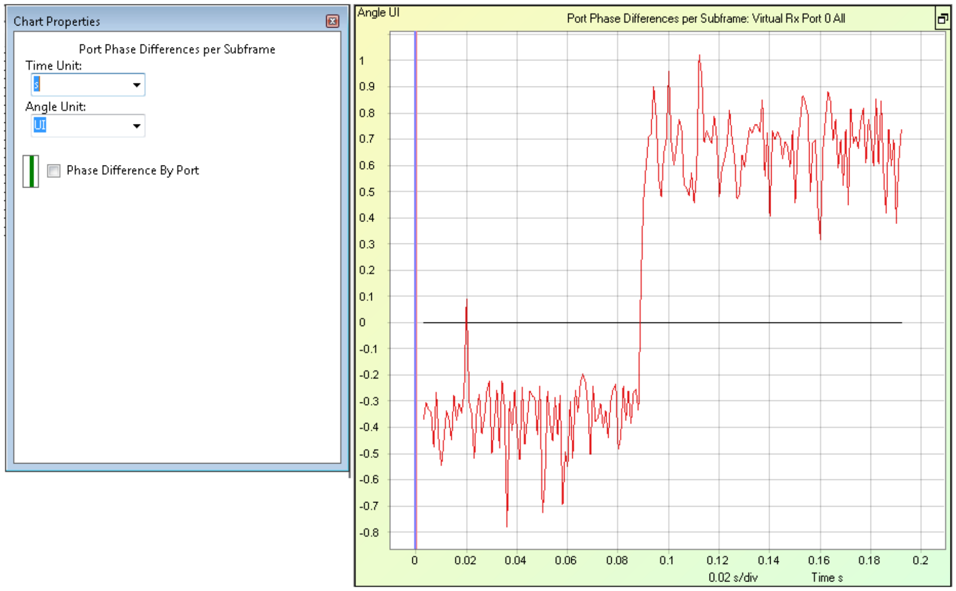
Time Units: Time units available are seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

SINR Units: The units for the measured SINR are either decibels (dB) or ratio.

NOTE The SINR computation in WaveJudge is derived from the EVM of the entity, which is the variance of equalized data in the constellation plane, measured at the WaveJudge itself.; it does not rely on any SINR or EVM calculation by the UE. This SINR measurement therefore is not directly dependent on the channel (or reference signal) power and noise floor measurement. For CRS, the EVM and SINR is calculated compounding all of the CRS tones, including null.

6. 2. 7 Port Phase Differences Per Subframe (LTE Only)

This chart displays the phase of the received Cell-Specific Reference Signal (CRS), where each line in this chart shows the phase difference measured by WaveJudge on each of its downlink receiving port relative to the first logical downlink receiving port. The resolution of the chart in time domain is on a per subframe basis. This chart is only available for use with LTE, it is not compatible with 5G NR, WiFi, or WiMAX.



Time Domain Chart “Port Phase Difference Per Subframe” and Chart Properties Window

Traces for this chart are as follows.

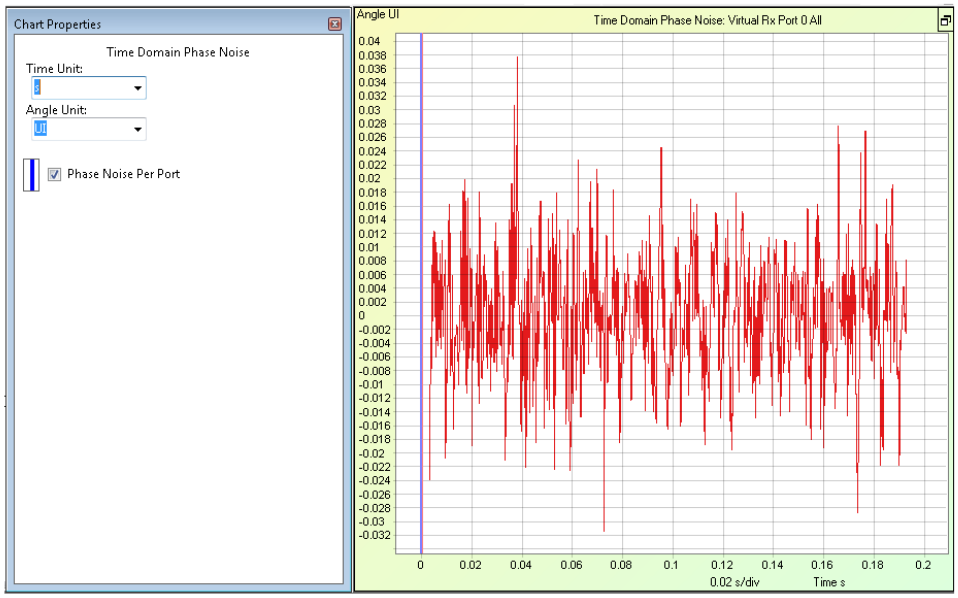
Time Units: Time units available are seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

Angle Units: Angle units are UI, percentage (%), RE, and degree.

Phase Differences by Port: Phase difference measured by WaveJudge on each of its downlink receiving ports relative to the first logical downlink receiving port.

6. 2. 8 Time Domain Phase Noise (LTE Only)

In this chart, the line shows the WaveJudge’s estimation on the compounded phase noise generated by the radios within the communication chain. This measurement is based on the cell-specific reference signal (CRS) and the resolution of the chart in time domain is on a per CRS symbol basis. This chart is only available for use with LTE, it is not compatible with 5G NR, WiFi, or WiMAX.



Time Domain Chart “Time Domain Phase Noise” and Chart Properties Window

Traces for this chart are as follows.

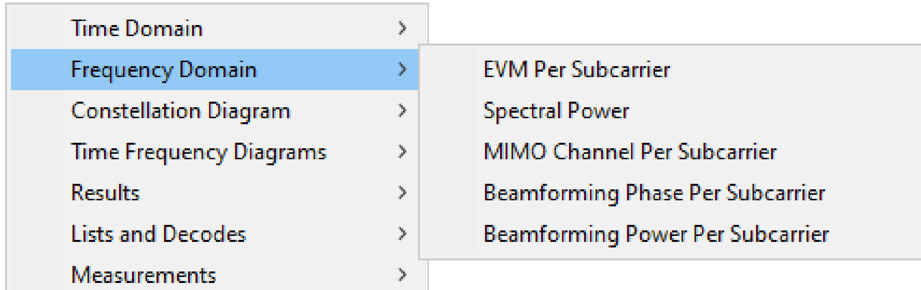
Time Units: Time units available are seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

Angle Units: Angle units are UI, percentage (%), RE, and degree.

Phase Noise by Port: Based on the CRS and the resolution of the chart in time domain is on a per CRS symbol basis.

6. 3 Frequency Domain Charts

The 5G NR **Frequency Domain** menu has five submenu items: EVM Per Subcarrier, Spectral Power, MIMO Channel Per Subcarrier, Beamforming Phase Per Subcarrier, and Beamforming Power Per Subcarrier. The MIMO Channel Per Subcarrier, Beamforming Phase Per Subcarrier, and Power Per Subcarrier are based on the selected PDSCH.

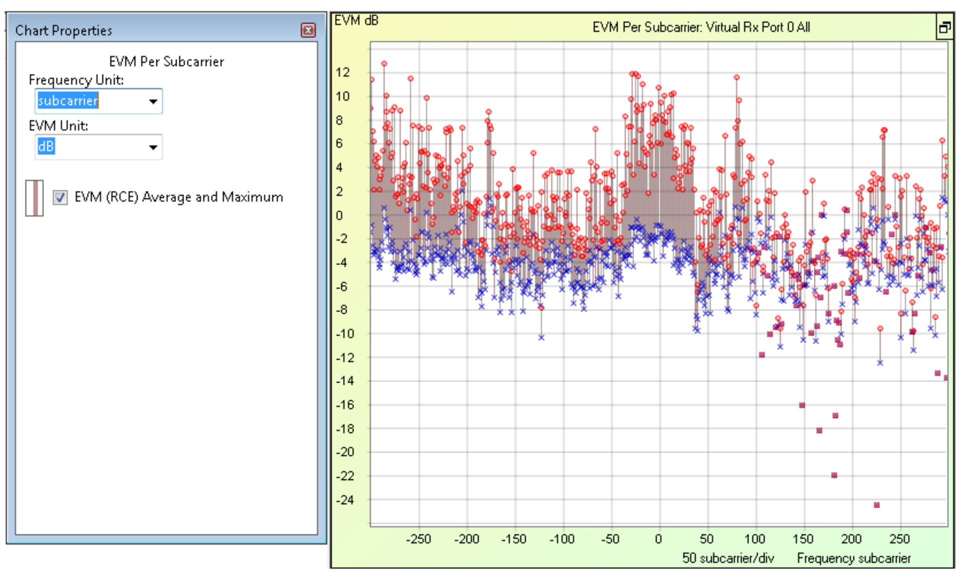


5G NR Frequency Domain Charts

LTE Frequency Domain charts include these same five charts plus a Phase Noise Relative Power Spectral Density.

6. 3. 1 EVM Per Subcarrier

This chart shows the maximum error vector magnitude (EVM) (red) and average EVM (green) for all symbols within each subcarrier. To display the subcarrier value and the EVM value, place the Measure tool from the toolbar on an EVM point.



Frequency Domain Chart "EVM Per Subcarrier" and Chart Properties Window

This chart is available for 5G, 4G LTE, WiFi, and WiMAX captures. Traces for this chart are:

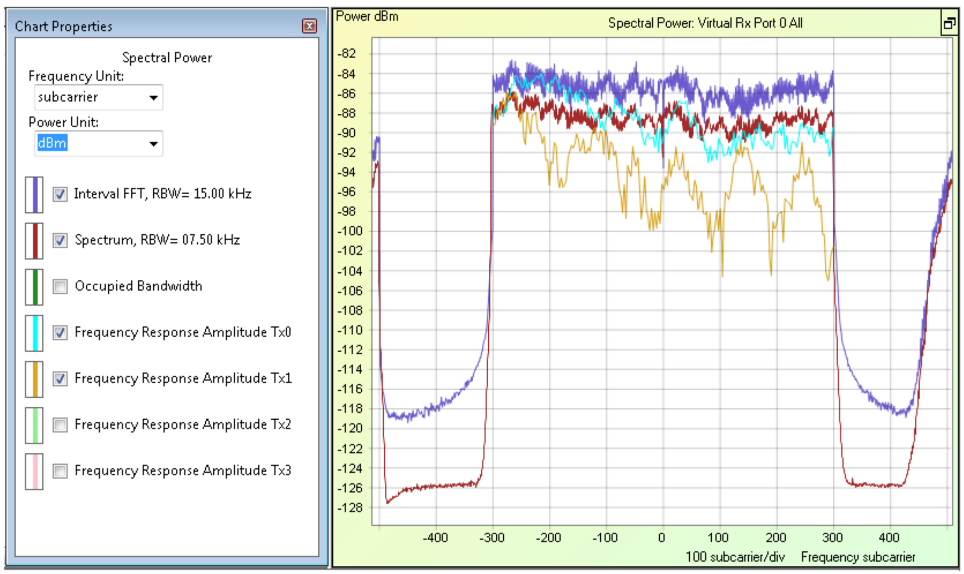
Frequency Units: Subcarrier, gigahertz (GHz), megahertz (MHz), kilohertz (kHz), or hertz (Hz).

EVM Units: Decibels (dB), and percentage (%).

EVM (RCE) Average and Maximum: Displays the average and maximum EVM of all TBs within the interval.

6. 3. 2 Spectral Power

The Spectral Power chart supports measurements from up to four transmit antennas. In addition to the antenna properties, you can apply three filter properties to the signal: Interval FFT with an RBW of 15 kHz, Spectral with an RBW of 11.25 kHz, and Occupied Bandwidth. This chart displays the spectral use on a burst-by-burst basis.



Frequency Domain “Spectral Power” Chart and Chart Properties Window

This chart is available for 5G, 4G LTE, WiFi, and WiMAX captures. Traces for this chart are:

Frequency Units: Subcarrier, gigahertz (GHz), megahertz (MHz), kilohertz (kHz), or hertz (Hz).

Power Units: Decibels per minute (dBm), watts (W), milliwatts (mW), microwatts (μW), and analog to digital converter (ADC).

Interval FFT: Provides the symbol-aligned FFTs. Interval FFT is an effective tool to evaluate frequency response. Using Set Range toAll (see Set Range to on page 356) computes over all captured symbols.

- For example, you can select symbols in any Time Domain chart, such as the 2D Logical chart. For further analysis select a single symbol in the 2D Logical chart and view it in the frequency domain, which isolates subcarriers within the symbol. This provides a view of subcarrier indexing; e.g., when viewing preambles to determine if the correct subcarriers are energized.

Spectrum: Shows the distribution of power across the band. This is a physical measurement that is independent of any standard; it provides a view of the energy without using symbol-aligned FFT.

Occupied Bandwidth: Displays a text box at the lower left corner that indicated the occupied bandwidth.

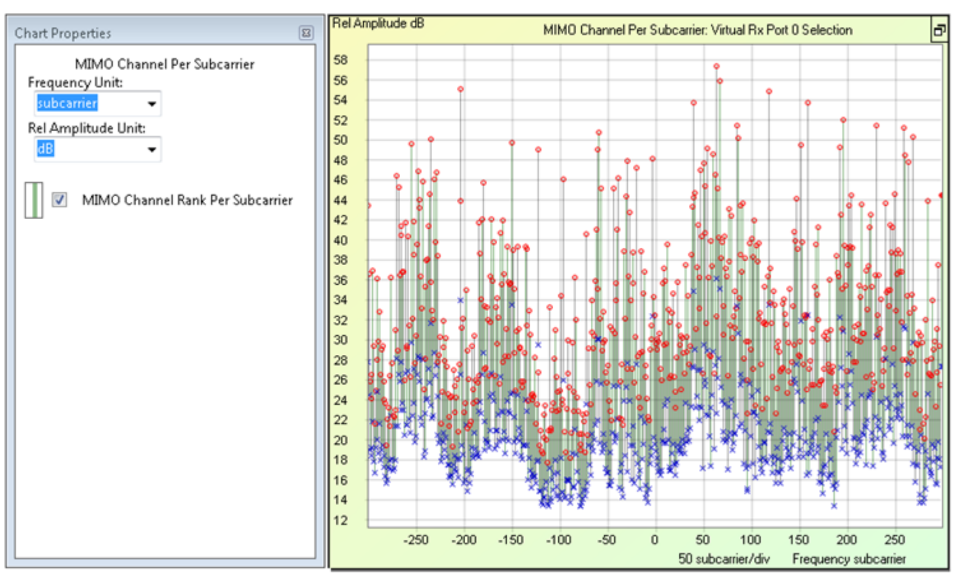
Frequency Response: The combination of phase and amplitude.

6. 3. 3 MIMO Channel Per Subcarrier

MIMO Channel Per Subcarrier is based on the selected PDSCH. It provides a condition number per subcarrier to identify the MIMO signal diversity. The value should be greater than 1.

In 2x2 MIMO (2-input, 2-output; i.e., two transmit antennae, two receive antennae), MIMO rank is a normalized determinant that measures the orthogonality of the 2x2 channel matrix, expressed in unit interval, percent, or dB. A value of 1 in unit intervals, 100%, or 0 dB, means the matrix is orthogonal. A value of 0 unit intervals, 0%, or -inf dB means the determinant is 0 (i.e., the matrix is not invertible). The more orthogonal the channel matrix, the more efficient MIMO is. The MIMO Rank Per Subcarrier chart displays the maximum (red) and the average (green) channel rank for all symbols within each subcarrier.

This type of chart shows the ratio of the maximum eigenvalue to the minimum eigenvalue of the Hermite matrix of the MIMO channel matrix estimated by WaveJudge on each subcarrier. The value of each point ranges from infinity to 0. The channel is estimated based on the received Cell-Specific Reference Signal (CRS).



Frequency Domain Chart "MIMO Channel Per Subcarrier" and Chart Properties Window

This chart is only compatible with 5G NR and 4G LTE. Traces for this chart are:

Frequency Units: Subcarrier, gigahertz (GHz), megahertz (MHz), kilohertz (kHz), or hertz (Hz).

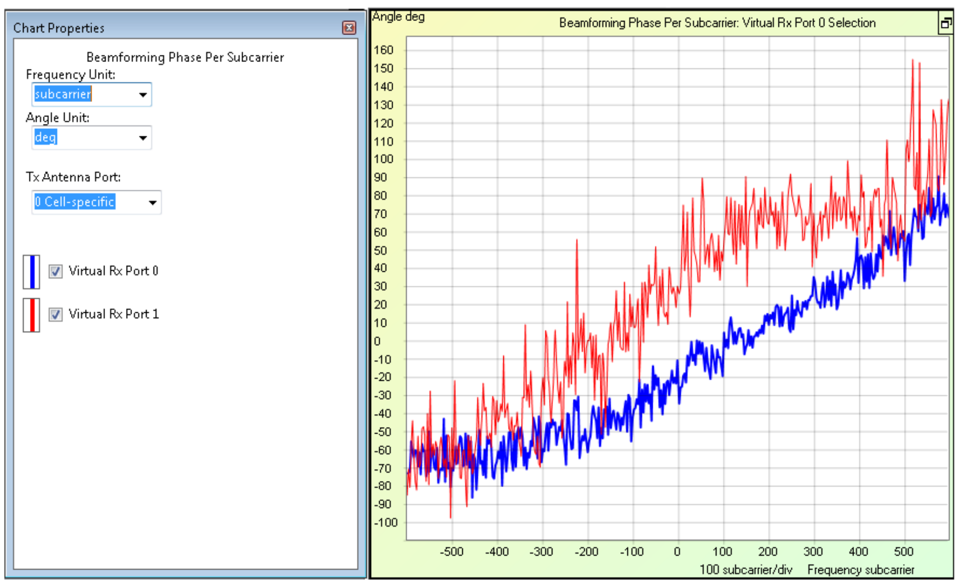
Relative Amplitude Units: Decibels (dB), ratio, or percentage (%).

MIMO Channel Rank Per Subcarrier : Measures the transmission efficiency of a MIMO configuration across different frequencies.

6. 3. 4 Beamforming Phase Per Subcarrier

The Beamforming Phase Per Subcarrier and Beamforming Power Per Subcarrier charts let you identify the transmitter antenna based on the cell through cell-specific signals (0-3) of the UE that are specific to beamforming. Change these views to verify the MIMO signal received at each port.

Based on the respective reference signal, each line in this chart shows the phase of the estimated compounded channel from each enB's transmission port to each WaveJudge's downlink receiving port on each subcarrier.



Frequency Domain Chart - Beamforming Phase per Subcarrier

This chart is only compatible with 5G NR and 4G LTE. Traces for this chart are:

Frequency Units: Subcarrier, gigahertz (GHz), megahertz (MHz), kilohertz (kHz), or hertz (Hz).

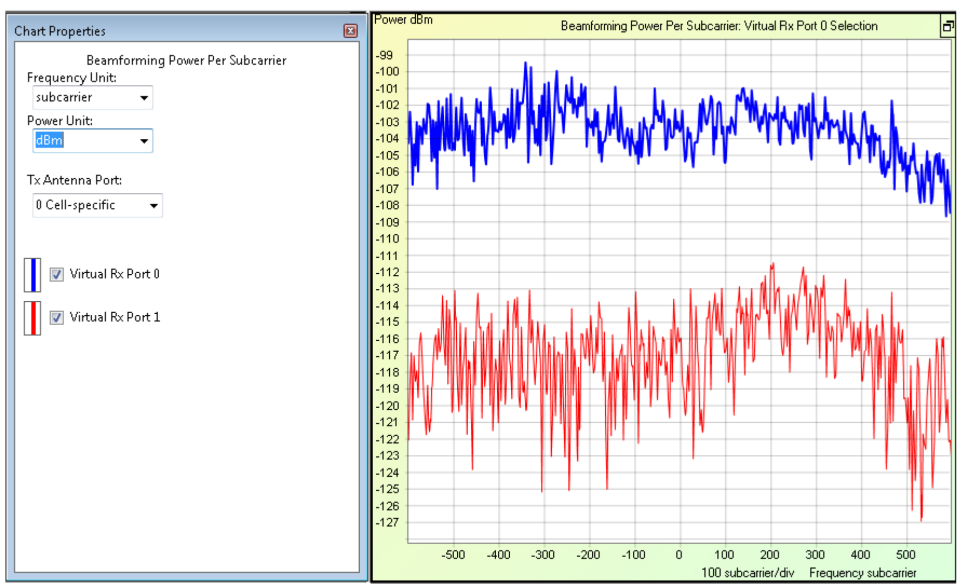
Angle Units: UI (user interface), percentage (%), RD (radians), and degree.

Tx Antenna Port: Transmitter cell-specific ports; options are: 0 Cell-specific, 1 Cell-specific, 2 Cell-specific, 3 Cell-specific, 5 Unspecific TM7, 7 Unspecific TM8+, 8 Unspecific TM8+, 9 Unspecific TM8+, 10 Unspecific TM8+, 0 Uplink.

6. 3. 5 Beamforming Power Per Subcarrier

The **Beamforming Phase Per Subcarrier** chart and the **Beamforming Power Per Subcarrier** charts let you identify the transmitter antenna based on the cell through cell-specific signals (0-3) of the UE that are specific to beamforming. Change these views to verify the MIMO signal received at each port. They basically show the Fourier transform of the impulse response of the channel from each enB’s transmission port to WaveJudge’s receiving port. Due to the nature of LTE (most information is encoded in the frequency domain), the channel estimation in frequency domain is more important than its dual in time domain, the impulse response.

The Beamforming Power Per Subcarrier chart displays power in the frequency domain based on the beamforming analysis. Based on the respective reference signal, each line in this chart shows the power of the estimated compounded channel from each eNodeB’s transmission port to each WaveJudge downlink receiving port on each subcarrier.



Frequency Domain Chart - Beamforming Power per Subcarrier

This chart is only compatible with 5G NR and 4G LTE. Traces for this chart are:

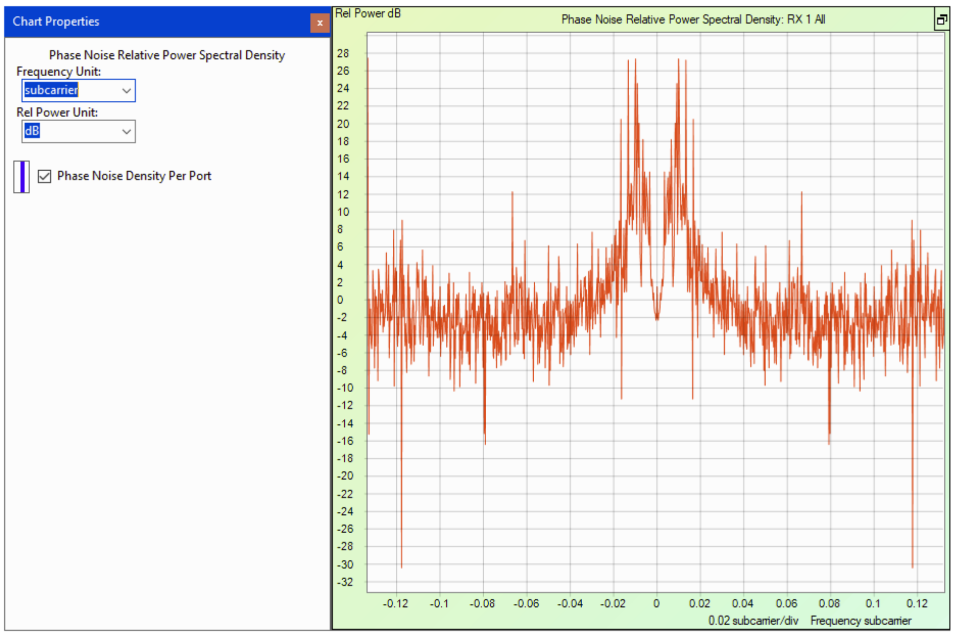
Frequency Units: Subcarrier, gigahertz (GHz), megahertz (MHz), kilohertz (kHz), or hertz (Hz).

Power Units: Decibels per minute (dBm), watts (W), milliwatts (mW), microwatts (µW), and analog to digital converter (ADC).

Tx Antenna Port: Transmitter cell-specific ports, options are: 0 Cell-specific, 1 Cell-specific, 2 Cell-specific, 3 Cel-specific, 5 Unspecific TM7, 7 Unspecific TM8+, 8 Unspecific TM8+, 9 Unspecific TM8+, 10 Unspecific TM8+, 0 Uplink.

6. 3. 6 Phase Noise Relative Power Spectral Density (LTE Only)

This chart displays the estimated relative power density spectrum for the phase noise of the radio.



4G LTE Frequency Domain Chart - Phase Noise Relative Power Spectral Density

This chart is only available for 4G LTE. Traces for this chart are:

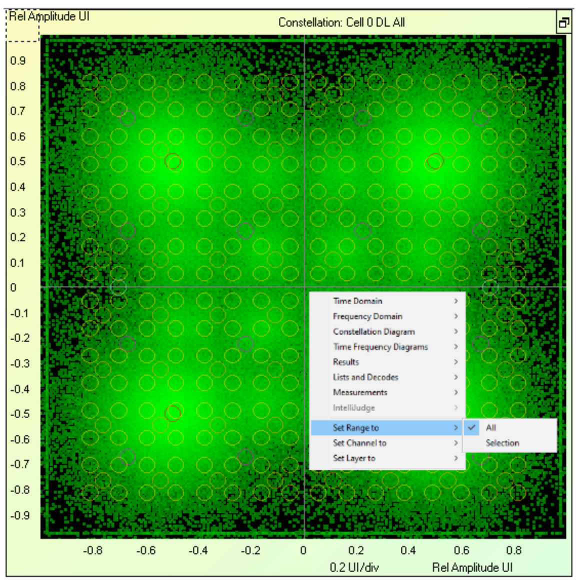
Frequency Unit: Subcarrier, gigahertz (GHz), megahertz (MHz), kilohertz (kHz), or hertz (Hz).

Relative Power Unit: Decibel (dB), ratio, and percentage (%).

6.4 Constellation Diagram

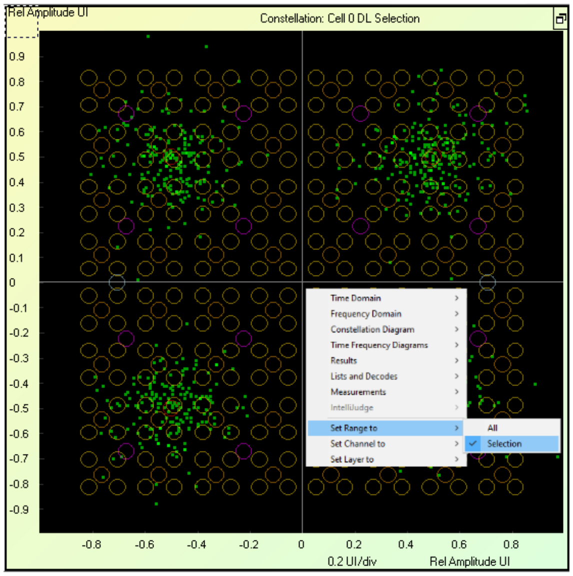
There is only the the one Constellation Diagram in the Chart Context Menu. This chart is available for 5G NR, 4G LTE, WiFi, and WiMAX captures.

The Constellation chart visually displays the modulation quality of the signal. Each modulation type (e.g., BPSK, QPSK, 16-QAM, and 64-QAM) is represented by a set of color-coded circles. When the Constellation diagram is set to the range All, (i.e., right-click in the Constellation chart to open the Chart Context menu, select Set Range To and select All) it provides a view of signal quality for all of the symbols captured and processed so far in the WaveJudge capture. Each new capture refreshes the constellation with a new set of points; the EVM (RCE) calculation in the Summary Chart on page 389 table is performed over the new data.



Constellation Diagram - Set Range to "All"

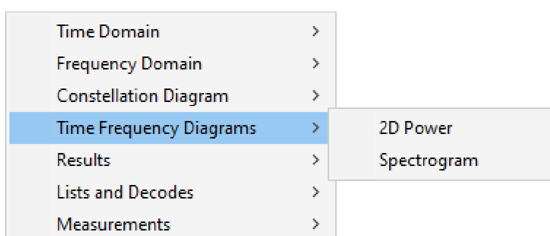
To view the Constellation per burst (message) or per time span (symbol), right-click on the diagram and select Set Range toSelection. This option allows WaveJudge to plot specific bursts in the Constellation. To display the timestamp, subcarrier, and EVM value for any point select the Measure tool on the toolbar and place it over a constellation point.



Constellation Diagram - Set Range to "Selection"

6. 5 Time Frequency Diagrams

5G NR and 4G LTE files show two Time Frequency Diagrams in the Chart Context Menu: 2D Power and Spectrogram. Both charts are available for 5G NR, 4G LTE, WiFi, and WiMAX captures. However, WiMAX includes a 2D Logical chart.

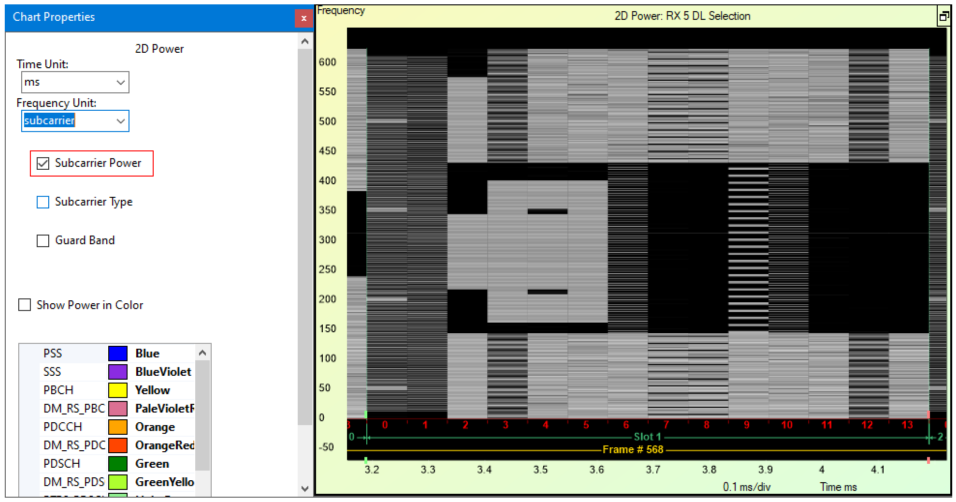


5G and 4G LTE Time Frequency Diagrams - Drop-down Menu Options

6. 5. 1 2D Power Chart for 5G

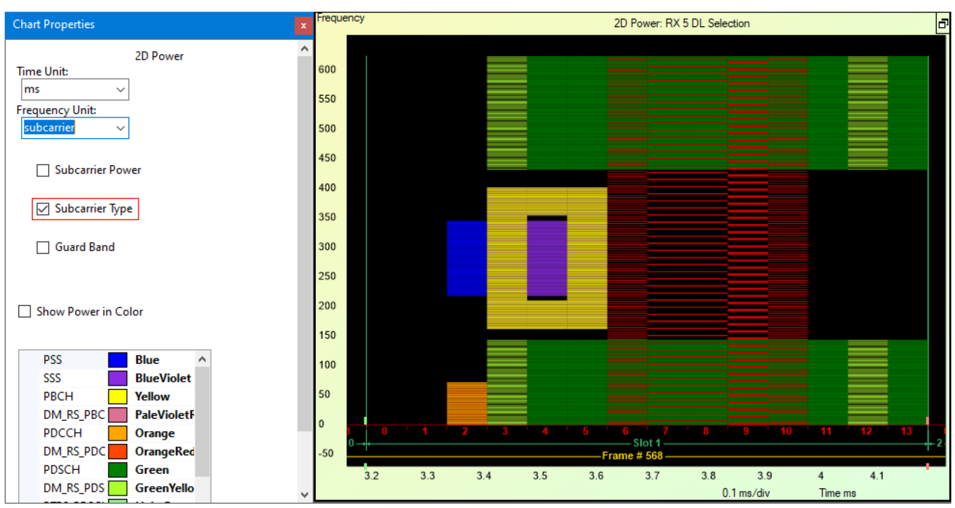
The 2D Power diagram (previously known as the 2D Physical chart) displays all subcarriers in the time-frequency plane; it is one of the most important charts in WaveJudge software. In this chart, the subcarriers are shown in the physical frequency space (as ordered after performing the IFFT of the incoming data), as opposed to the logical frequency space in which bursts are contiguously allocated.

There are two sets of data you can overlay on the chart, Subcarrier Power and Subcarrier Type. The figure below shows a 2D Power chart with only Subcarrier Power option selected. To change the diagram from grey and back, check the box "Show Power in Color".



2D Power Chart: Subcarrier Power

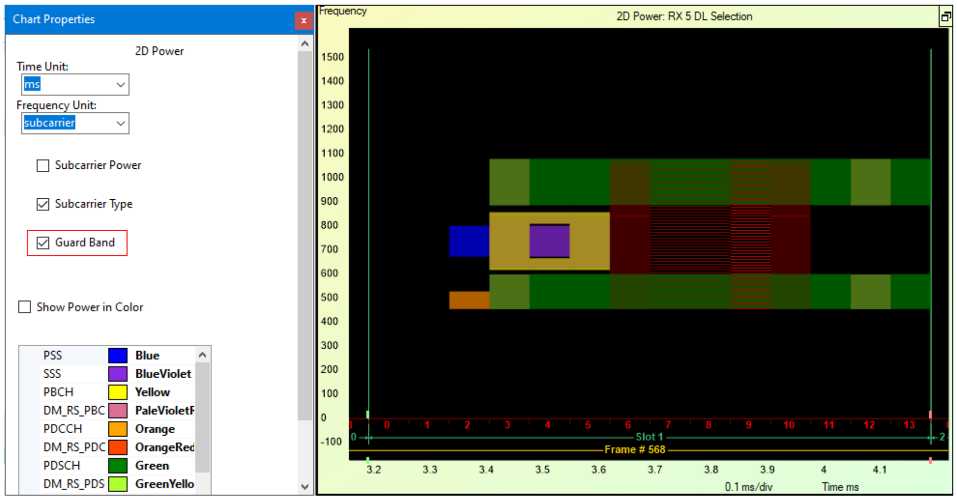
The figure below shows the same 2D Power chart showing the Subcarrier Type. Subcarrier Type is a graph determined by the type of physical channel or reference signal. In the Chart Properties window, there is a color-coded list of physical channels and reference signals. Use the drop-down menu to select the type of physical channel or reference signal to view. You may also select the color for each type of physical channel or reference signal.



2D Power Chart: Subcarrier Type

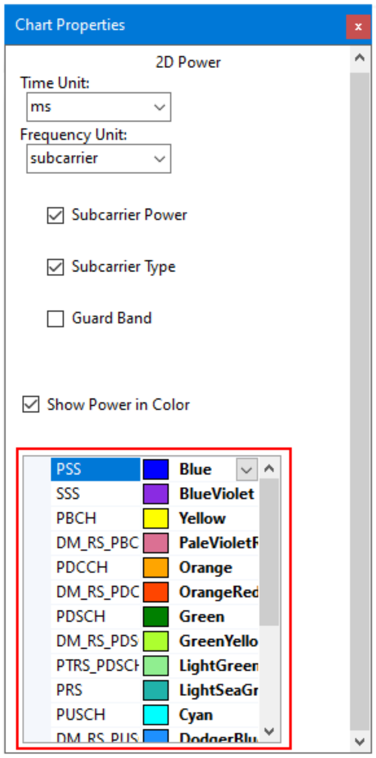
The figure below shows the same 2D Power chart as the one in the figure above except it shows the Subcarrier Type and Guard Band options. Change the Frequency

Unit to Subcarrier otherwise the chart won't show any data. The guard bands are the black borders at the top and bottom; deselect this checkbox to restore the data to full chart size.



2D Power Chart: Subcarrier Type with Guard Band

You can change the color for any message type. The drop-down menu is located in between the checkbox Show Color Options and above the color options window. The figure below shows the channels and provides default colors to illustrate your data.

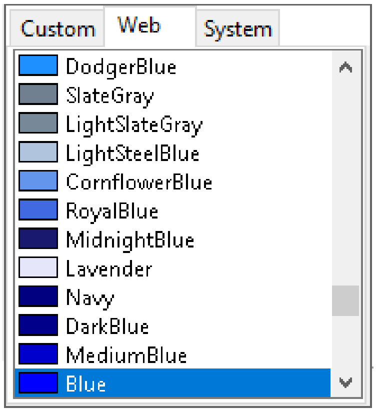


2D Power Chart - 5G Channels and Colors

5G channels in this menu are:

- PSS
- SSS
- PBCH
- DM-RS_PBC
- PDCCH
- DM_RS_PDC
- PDSCH
- DM_RS_PDS
- PTRS_PDSCH
- PRS
- PUSCH
- DM_RS_PUSCH
- PTRS_PUSCH
- PUCCH
- DM_RS_PUCCH
- SRS
- PRACH
- CSI_RS

To change the color for a channel, select the channel and click the arrow to open a drop-down menu. The drop-down menu has three tabs: Custom, Web, and System; that means you can can choose from custom colors, web colors, or system colors.

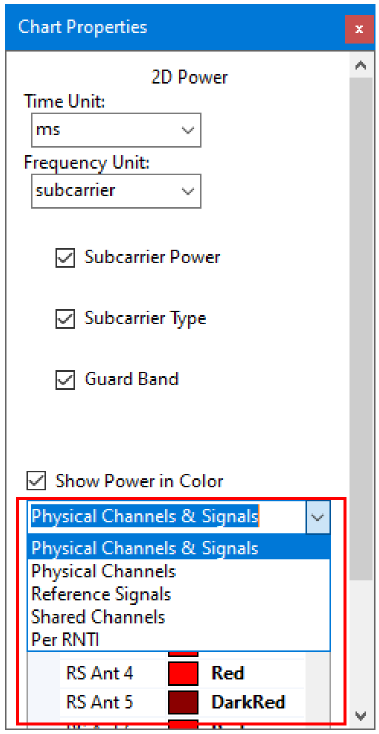


2D Power Chart - 5G Custom Colors Available

6. 5. 2 2D Power Chart for LTE

The 2D Power Chart Properties for4G LTE are very similar to 5G NR described above. The only differences are 1) the drop-down menu for the channels, 2) the list of channels available is expanded, and 3) there are more default colors assigned to the channels.

You can change the color for any message type. The drop-down menu is located in between the checkbox Show Color Options and above the color options window. The menu choices are Physical Channels and Signals, Physical Channels, Reference Channels, Shared Channels, and Per RNTI.



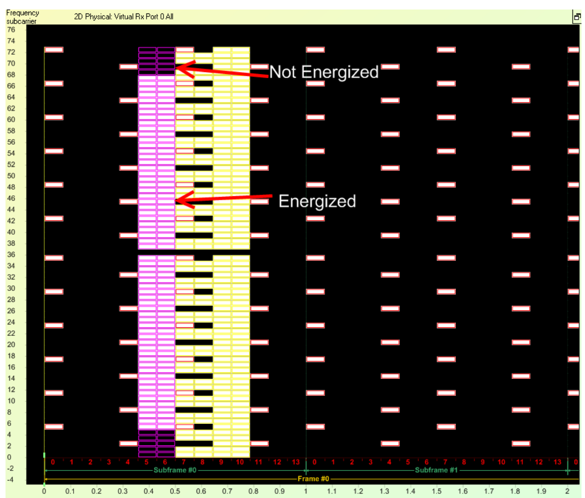
2D Power Chart - LTE

LTE channels in this menu include PSS, SSS, PBCH, PDSCH, PUSCH, PUCCH and PRACH, as well as the following options.

- RS Antennas 0 through 6
- RS Antennas 7, 8, 11, 13
- RS Antennas 9, 10, 12, 14
- CSIRS Antennas 15 though 22
- DMRS Antennas 107 through 110
- SRS
- PCFICH
- PHICH
- PDCCH
- EPDCCH
- MPDCCH
- SPDCCH
- PMCH
- MF_PUCCH
- MF_sPRACH
- PSDCH
- PSCCH
- PDBCH

- PSSS
- SSSS
- NPBCH
- NPDSCH
- NPDCCH
- NPUSCH
- NPSS
- NRS
- NPRACH
- Unused

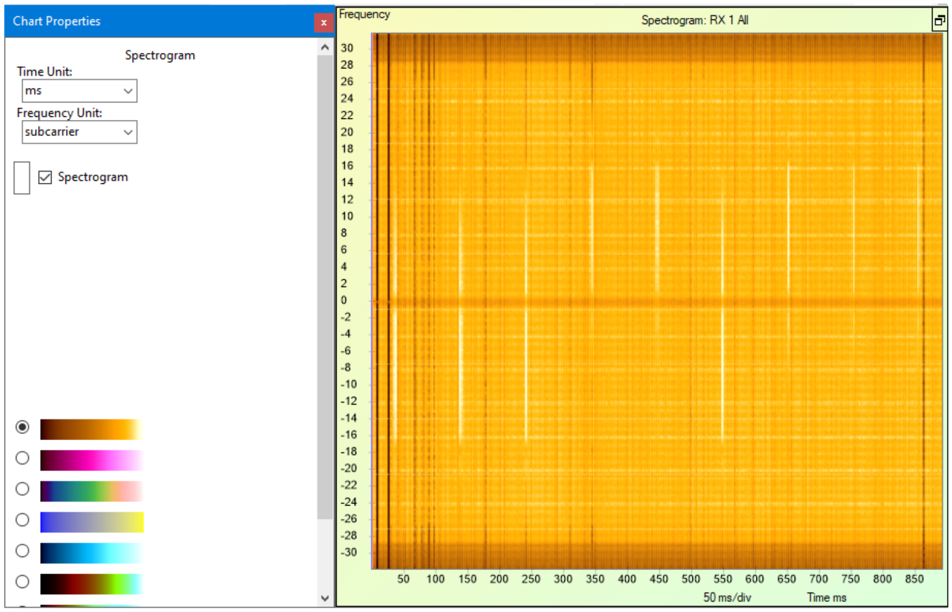
By selecting both Subcarrier Power and Subcarrier Type, you can verify the subcarriers are energized.



2D Power Chart - LTE (Energized)

6. 5. 3 Spectrogram

The Spectrogram is a generic chart that is not specific to any wireless standard. Graphically, it represents the evolution of the spectrum over time. This chart lets you view the energy and density of the spectrum; it is available for 5G, 4G LTE, WiFi, and WiMAX captures.



Spectrogram Chart and Chart Properties Window

This chart indicates whether the energy is modulated on all carriers or by a subchannelized method. The OFDMA example shows how the UL traffic is subchannelized versus the DL traffic. The lighter color in the chart indicates energy; the light band spans the entire channel in the DL direction. Conversely, in the UL direction, the lighter color indicates different subcarriers being energized for each slot across the channel. The Chart Properties window lets you choose from a variety of color swatches to better illustrate data in your capture.

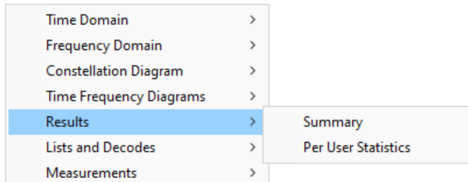
This chart is available for 5G, 4G LTE, WiFi, and WiMAX captures. Traces for this chart are:

Time Unit: Seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), sample, and LTE Ts.

Frequency Unit: Subcarrier, gigahertz (GHz), megahertz (MHz), kilohertz (kHz), or hertz (Hz).

6.6 Results

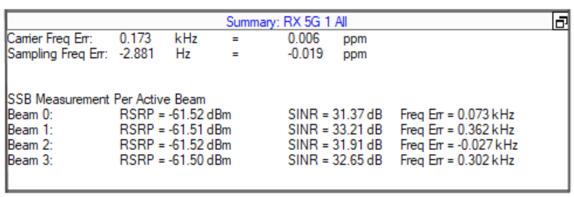
In the 5G NR **Charts Context Menu**, the **Results** option has only one chart, **Summary**. However, a 4G LTE file also lists an option for **Per User Statistics**.



LTE Context Menu: Results - Summary and Per User Statistics

6.6.1 Summary Chart

The Summary Chart presents text results and a summary of measurements for the entire capture or time interval. This chart is available for 5G NR, 4G LTE, WiFi, and WiMAX captures.



Summary Chart - 5G

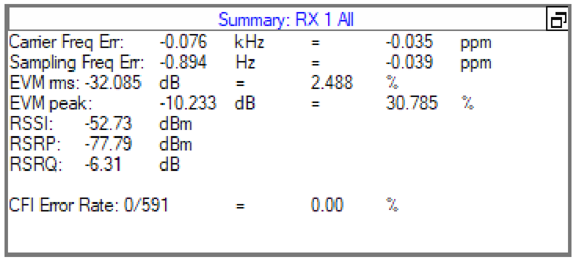
The descriptions for each statistic (i.e., the bold text in first column in the figure above) are as follows.

Carrier Frequency Error: Offset relative to center frequency.

Sampling Frequency Error: Offset relative to the sampling frequency, where sampling frequency is defined as the bandwidth x Sampling Factor.

6.6.1.1 Summary Chart - LTE

The figure below shows an example of the Summary Chart for LTE.



Summary Chart - LTE

Descriptions for each statistic (i.e., the bold text in first column in the figure above) in the LTE Summary table as as follows.

Carrier Frequency Error: Offset relative to center frequency.

Sampling Frequency Error: Offset relative to the sampling frequency, where sampling frequency is defined as the bandwidth x Sampling Factor.

- If the Carrier Frequency Error and the Sampling Frequency Error ppm numbers are significantly different, it indicates that the Carrier clock and the Symbol clock are not tied to the same source, per wireless standards. The Summary above shows only 4 parts per billion difference, which is an insignificant difference.

EVM rms: Also known as RCE; provides the root mean square calculated over all samples, including data and pilot tones

EVM peak: Peak is calculated over the worst individual symbol.

RSSI: Received signal strength indicator.

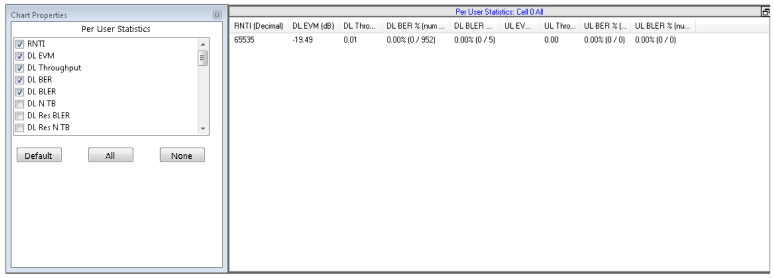
RSRP: Reference signal received power measurement for the subframe.

RSRQ: Reference signal received quality measurement for the subframe.

CFI Error Rate: The number of CFIs with errors.

6. 6. 2 Per User Statistics (LTE Only)

Each user has its own channel quality and communication throughput. Even though the channel of WaveJudge is different from the channel of any other users, WaveJudge still can collect some useful per-user statistics for other users through LTE signalling. Therefore, for some particular application/test, this chart can be very useful.



LTE Per User Statistics Chart and Chart Properties Window

The Per User Statistics Chart Properties Window lists a number of attributes to display in the table header columns. The default columns are as follows.

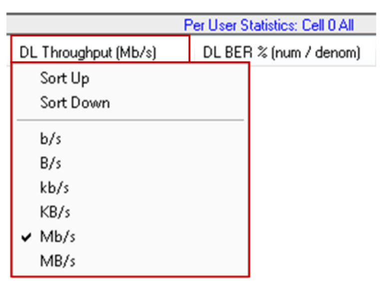
- **RNTI:** Decimal or hexadecimal.
- **DL EVM:** Downlink error vector magnitude; options are decibel (db) and percentage (%).
- **DL Throughput:** Downlink throughput; options are bits per second (b/s), bytes per second (B/s), kilobits per second (kb/s), kilobytes per second (KB/s), megabits per second (Mb/s), and megabytes per second (MB/s).
- **DL BER:** Downlink bit error rate; options are percentage (%) and percentage plus a fraction (% num / denom).
- **DL BLER:** Downlink block error rate; options are percentage (%) and percentage plus a fraction (% num / denom).
- **UL EVM:** Uplink error vector magnitude; options are decibels (db) or percentage (%).
- **UL Throughput:** Uplink throughput; options are bits per second (b/s), bytes per second (B/s), kilobits per second (kb/s), kilobytes per second (KB/s), megabits per second (Mb/s), and megabytes per second (MB/s).
- **UL BER:** Uplink bit error rate; options are percentage (%), and percentage plus a fraction (% num / denom).
- **UL BLER:** Uplink block error rate; options are percentage (%) and percentage plus a fraction (% num / denom).

Additional user statistics are described below.

- **DL N TB:** Total Number of DL TBs transmitted includes Retransmissions.
- **DL Res N TB:** Number of DL TB originally transmitted.
- **DL ReTx>3 BLER % (num / denom):** BLER for DL ReTransmission > 3.
- **DL ReTx>3 N TB:** Number of DL TB with ReTransmissions > 3.
- **DL 1st tx BLER % (num / denom):** BLER of first/orignal DL TB transmission.
- **DL 1st tx N TB:** Number of TBs in first/orignal transmission.
- **DL ReTx 1 BLER % (num / denom):** DL BLER of first retransmission.
- **DL ReTx 1 N TB:** Number of TBs in first retransmission

- **DL ReTx 2BLER % (num / denom):** DL BLER of second retransmission.
- **DL ReTx 2N TB:** Number of TBs in second retransmission.
- **DL ReTx 3 BLER % (num / denom):** DL BLER of third retransmission.
- **DL ReTx 3 N TB:** Number of TBs in third retransmission.
- **UL N TB:** Total Number of UL TBs transmitted (includes retransmissions).
- **UL Res BLER % (num / denom):** BLER for original transmission.
- **UL Res N TB:** Number of UL TB originally transmitted.
- **UL ReTx>3 BLER % (num / denom):** BLER for UL ReTransmission > 3.
- **UL ReTx>3 N TB:** Number of TBs in second retransmission.
- **UL 1st tx BLER % (num / denom):** UL BLER of second retransmission.
- **UL 1st tx N TB:** BLER of first/orignal UL TB transmission.
- **UL ReTx 1 BLER % (num / denom):** UL BLER of first retransmission.
- **UL ReTx 1 N TB:** Number of TBs in first retransmission.
- **UL ReTx 2BLER % (num / denom):** UL BLER of second retransmission.
- **UL ReTx 2N TB:** Number of TBs in second retransmission.
- **UL ReTx 3 BLER % (num / denom):** UL BLER of third retransmission.
- **UL ReTx 3 N TB:** Number of TBs in third retransmission.

Select the Default button to clear all previously selected options and show only the default columns. Click the header to sort up or down, or select the units (shown in parenthesis next to each option above).



LTE Per User Statistics Chart - Right Click a Header to Select Units

6. 7 Lists and Decodes

The Lists and Decodes submenu allows you to select the WaveJudge Messages list or the Channel Decoding chart. If the WaveJudge Messages List is already open, selecting this option will open a copy of it in another pane, which can be used with a different set of options. These options are available for 5G, 4G LTE, WiFi, and WiMAX captures.

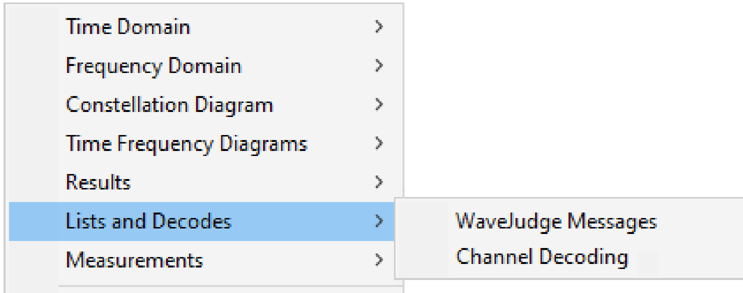


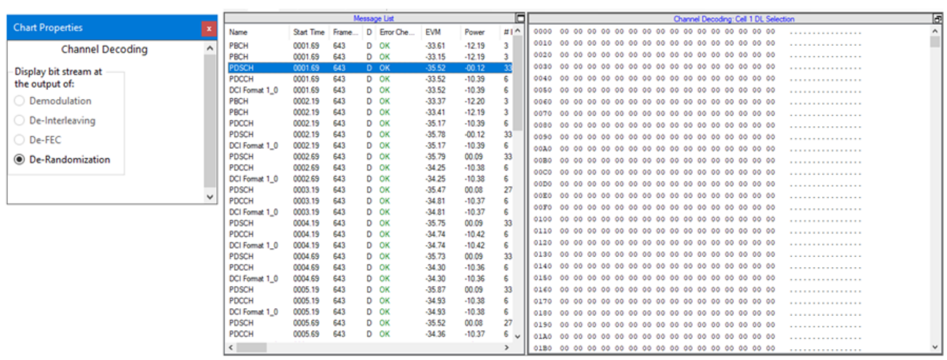
Chart Context Menu - Lists and Decodes

6. 7. 1 WaveJudge Messages

This option opens the WaveJudge Message List with all the default settings in the Chart pane. For a full description, refer to WaveJudge Messages List on page 240.

6. 7. 2 Channel Decoding Chart

The Channel Decoding chart displays a hexadecimal data dump for any selected burst or message. This hex dump is the output of the PHY after all coding, randomization, and interleaving have been removed and includes any padding contained in the burst.



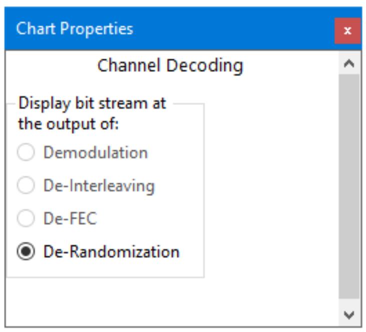
Channel Decoding Chart and Chart Properties Window

To view the Channel Decoding output, it must be set to the range Selection. If it is not, right-click in a chart area and select Set Range toSelection to set the chart range to Selection.

Then whatever message, burst, or other transmission is selected on the PHY Frame Lists on page 432 or WaveJudge Messages List on page 240 is shown in the Channel Decoding pane. The Hex information shown pertains to the entire burst selected in the PHY Frames list. (See Correlation/Message List Correlation Using the WaveJudge Message List on page 480.)

To save a burst Hex dump from the Channel Decoding screen to a file, select the entire Hex dump in the Channel Decoding screen (click in the screen and press CtrlA to select all items), and then press CtrlC to copy the data. The raw data is now in the clipboard and can be pasted into any text editor.

To change parameters, open the corresponding Chart Properties Window. However, for LTE there are currently no selectable options, and output after De-Randomization is the only choice.The Chart Properties can change the display bit stream at the output of demodulation, de-interleaving, de-FEC, and de-randomization.



Channel Decoding Pane - Chart Properties Window

6. 8 Measurements

The Chart Context Menu has an option for Measurements; currently CCDF (Complementary Cumulative Distribution Function) is the only option available.

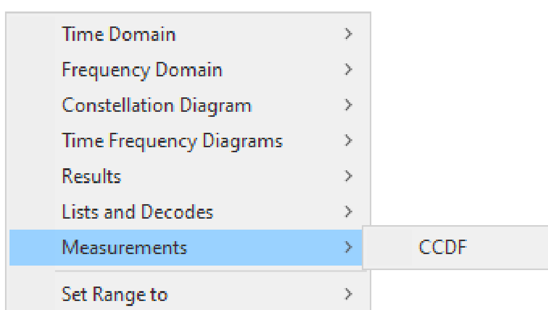
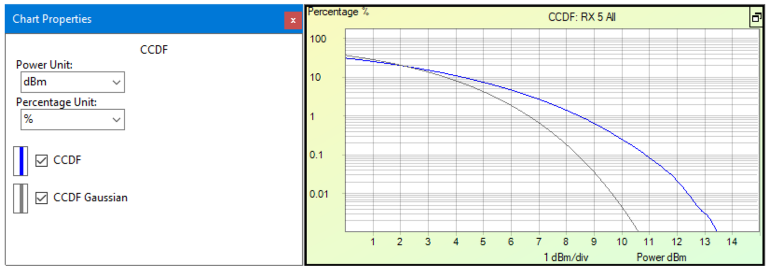


Chart Context Menu - Measurements

6. 8. 1 CCDF

The power (CCDF) measurement is a common measurement performed on wireless signals, it is measured over an interval where power is more or less constant. It is used mainly to detect compression (saturation). The CCDF curve shows the probability that the instantaneous signal power is higher than the average signal power by a certain amount of dB. This chart is available for 5G, 4G LTE, WiFi, and WiMAX captures.

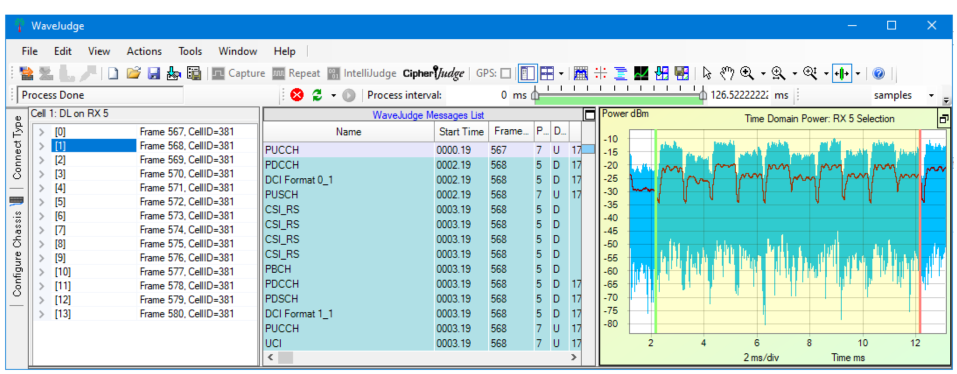


Measurements - CCDF Range Set to "All"

The X-axis is scaled to dB above the average signal power, which means the peak-to-average ratios are actually being measured, as opposed to absolute power levels. The Y-axis is the percent of time the signal spends at or above the power level specified by the X-axis.

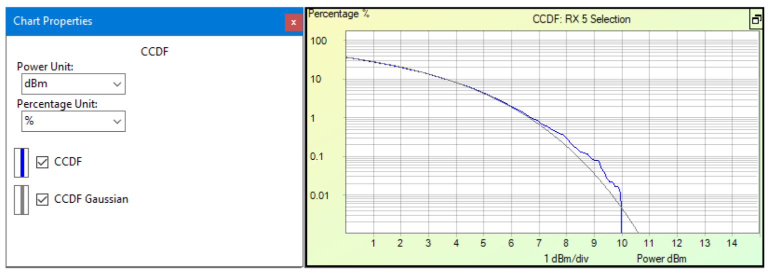
The position of the CCDF curve indicates the degree of peak-to-average deviation, with more stressful signals further to the right. A CCDF curve is a plot of the relative power levels versus probability. The gray line is the Gaussian noise reference line, the blue line is the signal being measured relative to the reference line.

Use the CCDF chart with the time-gated markers located on the toolbar, and the Time Domain Power on page 365 chart. This lets you select the portion of the burst to calculate over the CCDF. Set the time-gated markers to the right of the preamble since the preamble of the burst is typically at a higher level than the remaining portion of the burst and would skew the PAPR (Peak to Average Power Ratio) measurement. The previous figure showed an example of a CCDF chart measured over a burst which has the time-gated markers set correctly, excluding the preamble at the beginning of the burst.



Measurements - CCDF with Chart Properties Window

To set up the CCDF chart, select the Set Markers tool on the toolbar and select Left Marker from the drop-down menu. Place the left marker on the Time Domain Power chart; repeat for the right marker. (Do not include areas of no transmission with areas where transmission is present.) Right-click on the CCDF chart and select Set Range toSelection. This sets the CCDF chart to plot the curve for the time interval set with the markers; the bursts that the CCDF chart is using will be highlighted on the PHY Frame Lists on page 432 as shown above. The interval of relevance increases with the size of the interval computed.



Measurements Chart - CCDF Range Set to "Selection"

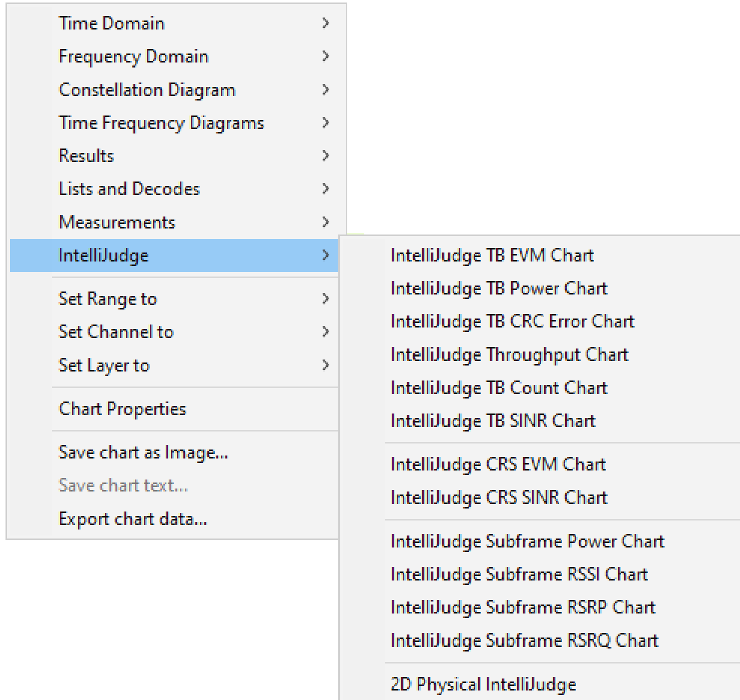
7 Use IntelliJudge2 4G LTE Charts

This section introduces you to the IntelliJudge2 charts and the different ways to use them. IntelliJudge2 charts graph the values from the subframes and transport blocks (TB), which also provide the values displayed in the IntelliJudge Message List.

IMPORTANT IntelliJudge2 charts are only available for 4G LTE, they are not compatible with 5G NR.

There are several ways to access IntelliJudge2 charts.

1. Select the Window menu and then select IntelliJudge + Charts, which will show the IntelliJudge Message List and four default IntelliJudge2 charts: IntelliJudge Subframe RSRQ Chart on page 412, IntelliJudge Subframe RSRP Chart on page 411, IntelliJudge CRS SINR Chart on page 409, and IntelliJudge Throughput Chart on page 406.
2. Click the icon **Apply IntelliJudge2 Chart View** to show the four default IntelliJudge2 charts
3. Right-click on a chart in an IntelliJudge2 capture file to access the Chart Context Menu, then scroll down, click on IntelliJudge2, and click on a specific chart.



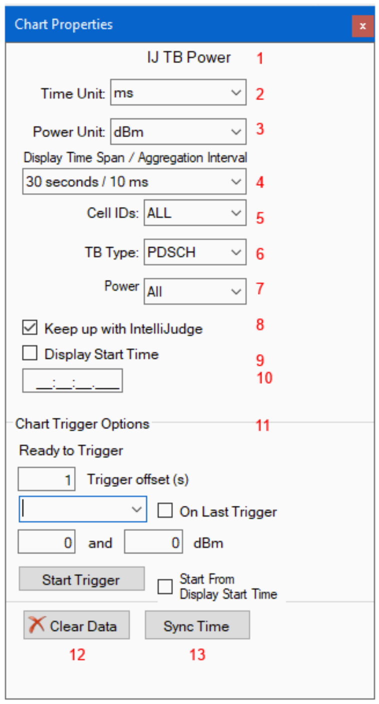
4G LTE - IntelliJudge2 Menu Chart Options

The 13 IntelliJudge2 charts are described in the subsections below:

1. IntelliJudge TB EVM Chart on page 404
2. IntelliJudge TB Power Chart on page 404
3. IntelliJudge TB CRC Error Chart on page 405
4. IntelliJudge Throughput Chart on page 406
5. IntelliJudge TB Count Chart on page 407
6. IntelliJudge TB SINR Chart on page 408
7. IntelliJudge CRS EVM Chart on page 408
8. IntelliJudge CRS SINR Chart on page 409
9. IntelliJudge Subframe Power Chart on page 410
10. IntelliJudge Subframe RSSI Chart on page 410
11. IntelliJudge Subframe RSRP Chart on page 411
12. IntelliJudge Subframe RSRQ Chart on page 412
13. IntelliJudge 2D Physical Chart on page 412

7.1 IntelliJudge2 Chart Properties

Each IntelliJudge Chart Properties window lets you customize how an IntelliJudge2 chart interprets and draws data. The Chart Properties window for most types of IntelliJudge2 charts are almost identical. Of the 13 IntelliJudge2 charts, the majority can be grouped into three formats: TB, subframe, and CRS charts; yet thay all have the same basic parameters The figure below is a typical Chart Properties window for an IntelliJudge2 chart.



Typical Sections of the IntelliJudge2 Chart Properties Window

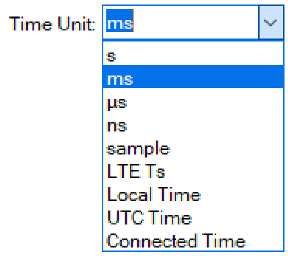
The controls numbered in red text are explained below.

1. Title:

The type and name of the chart.

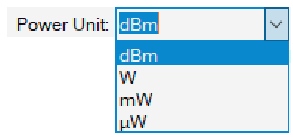
2. Time Unit:

The time unit for the IntelliJudge2 chart. Normally set to milliseconds (ms) or seconds (s); other options include microseconds (µs), nanoseconds (ns), sample, LTE Ts, Local Time, UTC Time, and Connected Time.



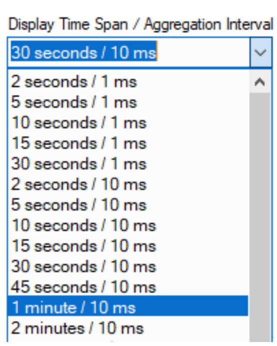
3. EVM/Power Unit:

Depends on the type of chart. The measured unit, usually either decibels (dB) or percentage (%). Other units include megawatts (mW) and microwatts (µw).



4. Display Time Span / Aggregation Interval:

This is the amount of time between points drawn on the chart. The aggregation interval options are 1ms, 10 ms, 100 ms, and 1 second. Change this option according to how frequent you want your data. For example, if you are using the IntelliJudge2 CRC Error Chart there is one CRC error every 10 ms. The menu provides time options all the way up to five hours and one second.

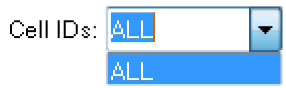


- If you set the interval duration set to 1 ms, you will see 10 points every 10 ms. One point will be at 1 CRC error and the other 9 will be at 0 CRC errors.
- If you set the interval duration to 10 ms, you will see 1 point at 1 CRC error every 10 ms.
- If you set the interval duration to 100 ms, you will see 1 point at 10 CRC errors every 100 ms since there are a total of 10 CRC errors in the 100 ms interval.
- If you set the interval duration to 1 second, you will see 1 point at 100 CRC errors every second since there is a total of 100 CRC errors in the 1 second

interval. An example explaining this is in the Read Data Points in a Real Time Chart on page 422 section.

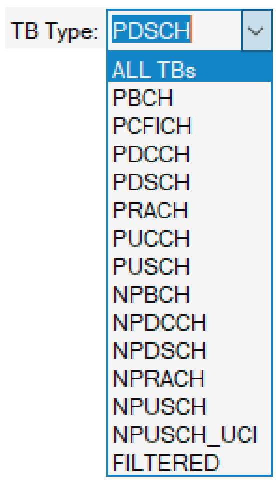
5. Cell IDs:

A cell ID is unique number that identifies each base transceiver station (BTS) or sector of a BTS within a location area code (LAC) if not within a global system for mobile (GSM) phone network.



6. TB Type: (For TB charts only; does not appear for subframe or CRS charts.)

Choose which type or types of transport blocks (TB) will have their data displayed. Different chart types may have different sets of TB types you can choose from.



The TB types (for TB-oriented charts only) in the list are as follows:

All TBs: Chart will show combined values from all TB types.

PBCH: Physical Broadcast Channel

PCFICH: Physical Control Format Indicator Channel

PDCCH: Physical Downlink Control Channel

PDSCH: Physical Downlink Shared Channel

PRACH: Physical Random Access Channel

PUCCH: Physical Uplink Control Channel

PUSCH: Physical Uplink Shared Channel

NPBCH: Narrowband Physical Broadcast Channel

NPDCCH: Narrowband Physical Downlink Control Channel

NPDSCH: Narrowband Physical Downlink Shared Channel

NPRACH: Narrowband Physical Random Access Channel

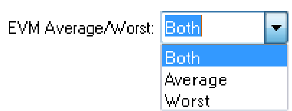
NPUSCH: Narrowband Physical Uplink Shared Channel

NPUSCH_UCI: Narrowband Physical Uplink Shared Channel - Uplink Control Information

Filtered: Filtered messages - Chart will show only values from Transport Blocks which contain filtered messages

7. EVM Average / Worst:

This control applies to a number of IntelliJudge2 chart types where it is possible to chart more than one value per aggregation interval; the name and options will vary according to the chart type. The control title labels the measurement which is being charted, and the pull-down control gives you a range of options appropriate to that measurement.



For example, for the TB EVM chart, this control lets you choose whether to only show the average EVM of all TBs within the interval, the worst EVM of all TBs within the interval, or both values. Assume you have four TBs within the interval with values -20, -25, -25, and -34. If you select “Average” it will draw a point at -26 since -104/4 = -26. If you select “Worst” it will draw a point at -20 since that is the worst EVM value. If you select "Both", it will draw points both at -20 and -26. Details for the EVM chart are explained further in the IntelliJudge TB EVM Chart on page 404 section.

8. Keep up with IntelliJudge2:

☑ Keep up with IntelliJudge When this option is enabled, IntelliJudge2 attempts to draw the graph with the most current data. It will skip any unprocessed data that is past 10 seconds from the last point in the IntelliJudge Message List. If your computer is having a hard time drawing the IntelliJudge2 charts, or if you are loading an IntelliJudge2 capture, you can turn this option off. When turned off, IntelliJudge2 ignores how fast the data is being captured or processed and continues to draw the real-time chart at its own pace without skipping any data intervals.

9. Display Start Time:

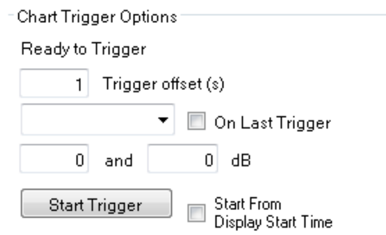
☐ Display Start Time Lets you set IntelliJudge2 chart’s start time to a predefined time and ignores any data outside its time range. This allows you to isolate data in your chart for further analysis. An example is shown in the IntelliJudge Real Time Preset Start Time on page 423 section.

10. Time:

00:00:00.000 The start time value for the preset start time option.

11. Chart Trigger Options:

Lets you set a trigger for the IntelliJudge2 chart. When the IntelliJudge2 chart triggers, it automatically sets the preset start time to the triggered time; this allows you to quickly review the entire IntelliJudge2 capture to look for values. An example is shown in the IntelliJudge Real-Time Chart Trigger Options on page 415 section.



12. Clear Data:

Clears the current set of data points from the chart. Even if you clear the IntelliJudge2 chart, it will automatically try to draw the most recent data available.

13. Sync Time:

You can syncronize the Total Duration, Interval Duration, and Preset Start Time of all IntelliJudge2 charts. This is useful when you have a IntelliJudge2 chart triggered and you want to have all charts with the same time domain to further analyze the problem.

IMPORTANT Setting the Total Duration and Interval Duration determines how many points to draw on the chart. The more points drawn on the chart, the slower the software may respond. There is also a limit to how many points the chart may graph. If you see the chart remove data before the end of the Total Duration, it means you have too many points for the chart. This may occur often if you have an interval duration of 1 ms.

NOTE Changing the X-Axis unit and Y-Axis unit will not lose all the current data in the real tme chart. If you change the total duration or the interval duration, the real time chart may need to clear all data and redraw the chart.

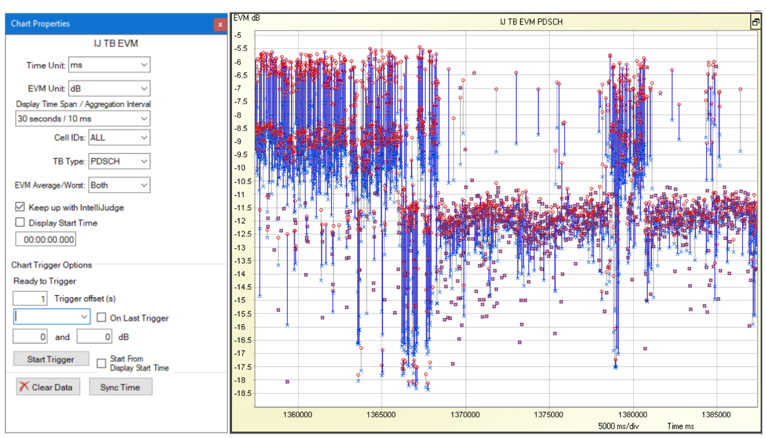
7. 2 IntelliJudge2 Charts

This section describes each IntelliJudge2 chart.

7. 2. 1 IntelliJudge TB EVM Chart

The IntelliJudge TB EVM Chart draws the error vector magnitude (EVM) for all transport blocks (TBs) or TBs of a given type found in the aggregation interval; it can display either the average EVM, the worst EVM, or both. The chart below is a IntelliJudge EVM chart with an interval duration of 1ms and is set to draw both the average and worst EVMs for all TBs. The chart shows some time intervals as a red circle with a superimposed blue x, where the average and worst coincide, and others as a red circle and a blue x connected by a blue line, where the two are different.

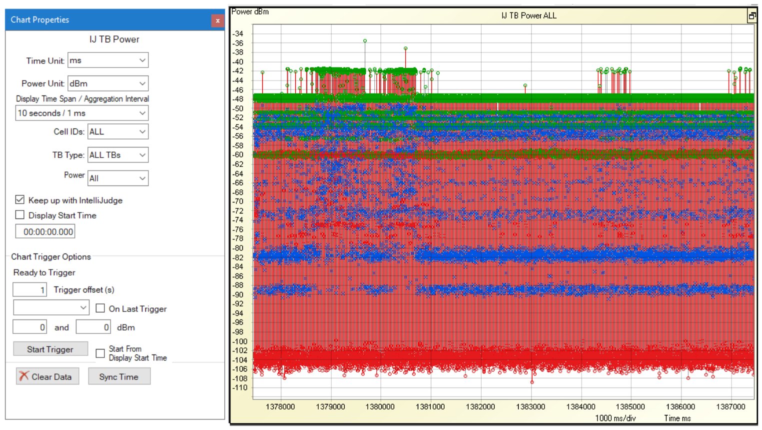
- A single red circle + blue x as a data point means that either all selected TBs in that time interval have the same EVM or there is only 1 TB in the interval duration.
- A red circle and blue x connected by a blue line means that there is more than one selected TB with a different EVM in that time interval.
- The red circle represents the worst EVM for a selected TB in the time interval.
- The blue x represents the average EVM of all selected TBs in the time interval.



IntelliJudge TB EVM Chart Properties Window and Chart

7. 2. 2 IntelliJudge TB Power Chart

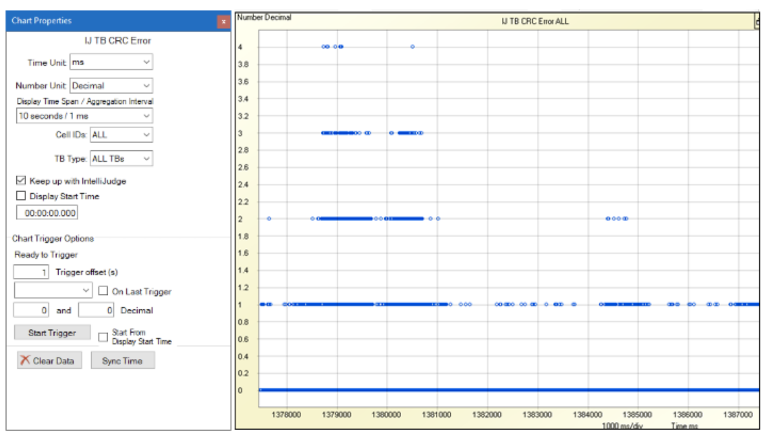
The IntelliJudge TB Power Chart displays the measured power for a given TB type or set of TB types over the time range; it can display either the best (highest) power, the average power, the worst (lowest) power, or all three. Best power is displayed with a green circle, worst power with a red circle, and average power with a blue x.



IntelliJudge TB Power Chart Properties Window and Chart

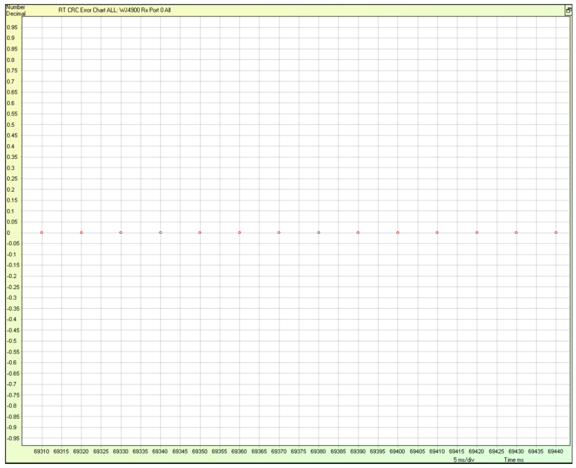
7. 2. 3 IntelliJudge TB CRC Error Chart

The IntelliJudge TB cyclic redundancy check (CRC) Error chart shows the number of CRC errors found from TBs.



IntelliJudge TB CRC Error Chart Properties Window and Chart

Below is a CRC Error chart with a time interval of 10 ms. This chart shows that there are no CRC errors found.

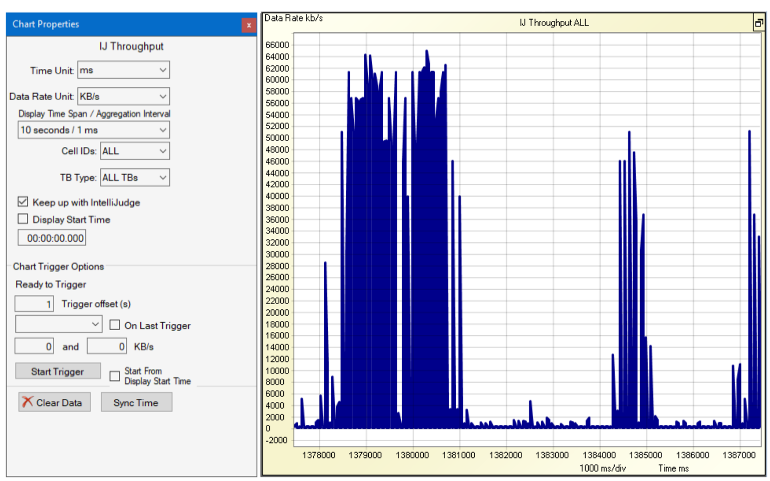


IntelliJudge TB CRC Error Chart - No Errors Found

7. 2. 4 IntelliJudge Throughput Chart

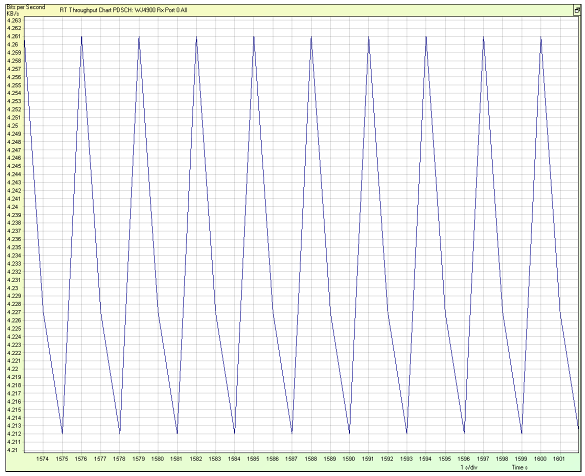
The IntelliJudge Throughput chart shows the rate of data used for a particular TB type or for all TBs. You can right-click on the chart and select **Set Range To** either **All** or **Selection** from the Chart Context menu.

In the figure below, the **TB Type** is set to **All**, and is reflected in the name of the chart (IJ Throughput ALL) on the top of the chart. If you change the TB to something else from the drop-down list, then the data display and the name of the chart will update to reflect the selection.



IntelliJudge Throughput Chart Properties Window and Chart

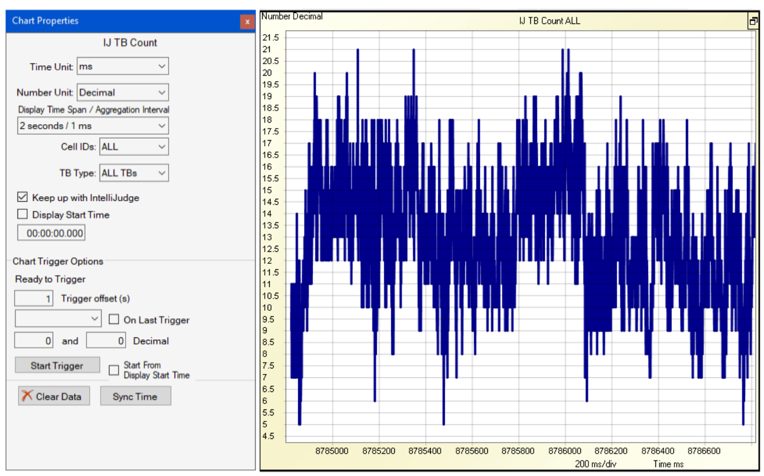
The chart below shows the data rate of a capture where the data rate is varying around 4.2 KB/s.



IntelliJudge Throughput Chart - Data Capture of 4.2 KB/s

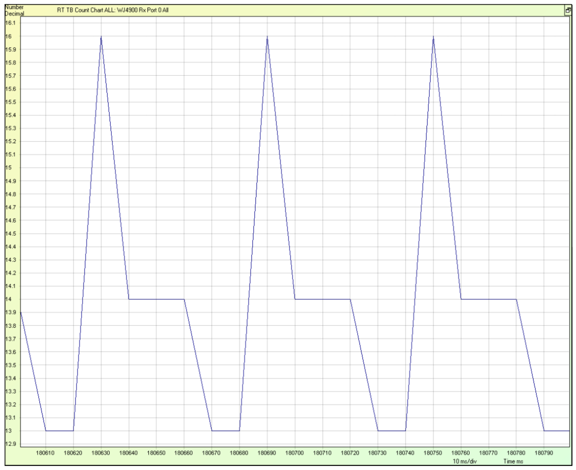
7. 2. 5 IntelliJudge TB Count Chart

The IntelliJudge TB Count chart displays how many TBs (or how many of a given type) are found in the interval.



IntelliJudge Throughput Chart Properties Window and Chart

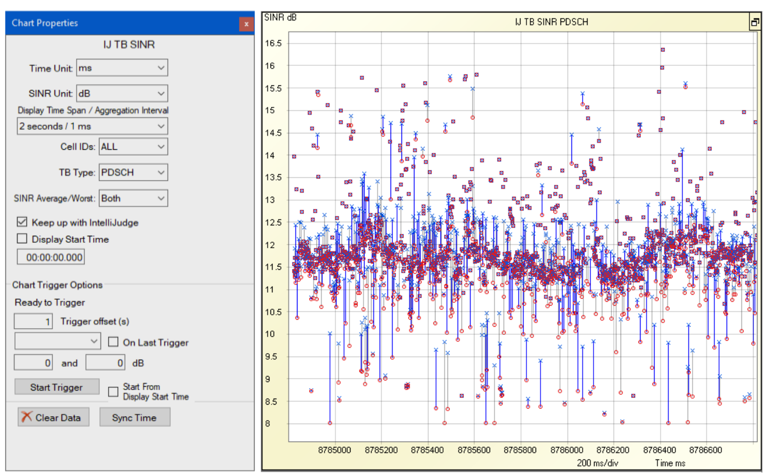
The chart below shows the TBs found in a particular capture.



IntelliJudge Real Time Chart - TB Count

7. 2. 6 IntelliJudge TB SINR Chart

The IntelliJudge TB Signal to Interference plus Noise Ratio (SINR) Chart displays the SINR for all TBs (or TBs of a given type) found in the aggregation interval; it can display either the average SINR, the worst SINR, or both.

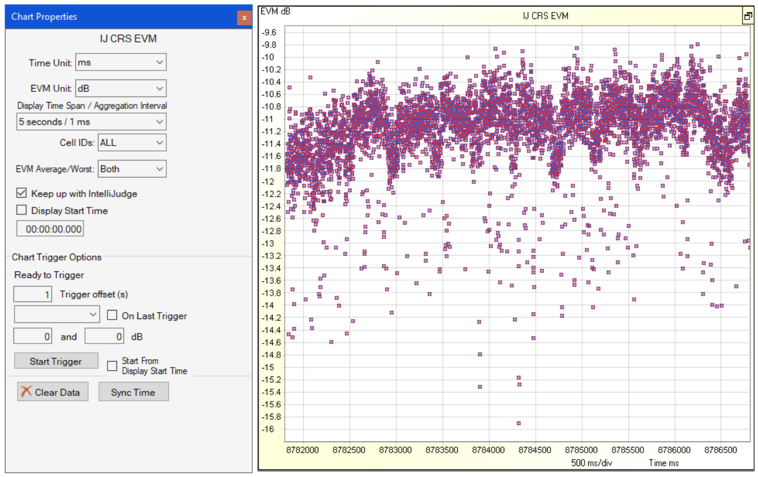


IntelliJudge TB SINR Chart Properties Window and Chart

7. 2. 7 IntelliJudge CRS EVM Chart

The IntelliJudge CRS EVM chart displays the error vector magnitude (EVM) of the Cell Reference Signal (CRS) for all subframes in the aggregation time interval; it can display either the average, the worst, or both.

NOTE If the aggregation interval is 1 ms (the subframe duration) there will only be one value per interval and the average and worst will coincide.

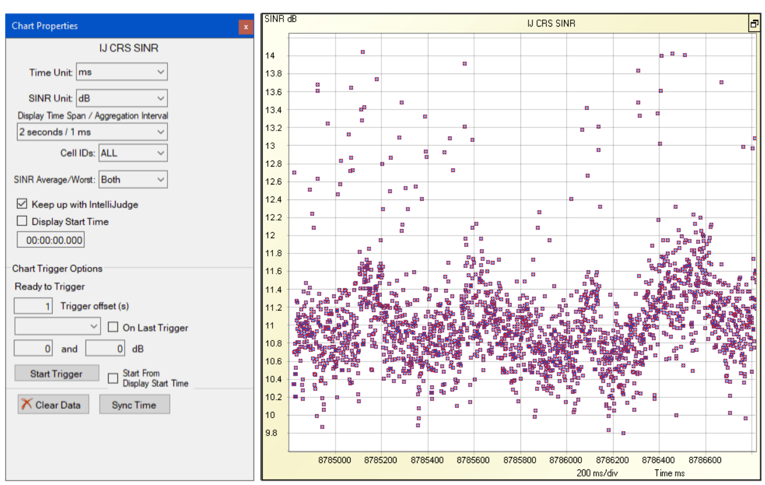


IntelliJudge CRS EVM Chart Properties Window and Chart

7. 2. 8 IntelliJudge CRS SINR Chart

The IntelliJudge CRS SINR chart displays the signal to interference plus noise ratio (SINR) of the Cell Reference Signal (CRS) for all subframes in the aggregation time interval; it can display either the average, the worst, or both.

NOTE If the aggregation interval is 1 ms (the subframe duration) there will only be one value per interval and the average and worst will coincide.

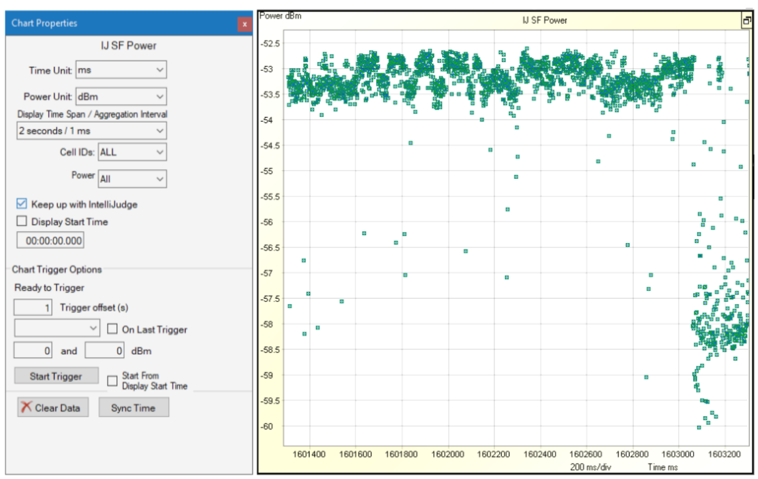


IntelliJudge CRS SINR Chart Properties Window and Chart

7. 2. 9 IntelliJudge Subframe Power Chart

The IntelliJudge Subframe Power Chart shows the average received power level for all transmissions within each subframe in an IntelliJudge capture. For each aggregation interval, the chart can graph the average, minimum, or maximum received subframe power; the default is "All" showing all three. Maximum power is displayed with a green circle, minimum power with a red circle, and average power with a blue x.

NOTE If the aggregation interval is 1ms (the subframe duration) there will only be one value per interval and the average and worst will coincide.

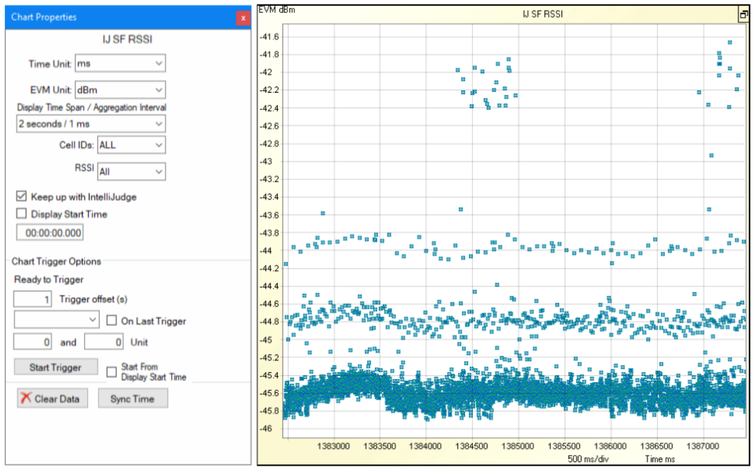


IntelliJudge Subframe Power Chart Properties Window and Chart

7. 2. 10 IntelliJudge Subframe RSSI Chart

The IntelliJudge Subframe Received Signal Strength Indicator (RSSI) Chart graphs the RSSI measurements for each downlink subframe received from IntelliJudge.

NOTE If the aggregation interval is 1ms (the subframe duration) there will only be one value per interval and the average and worst will coincide.

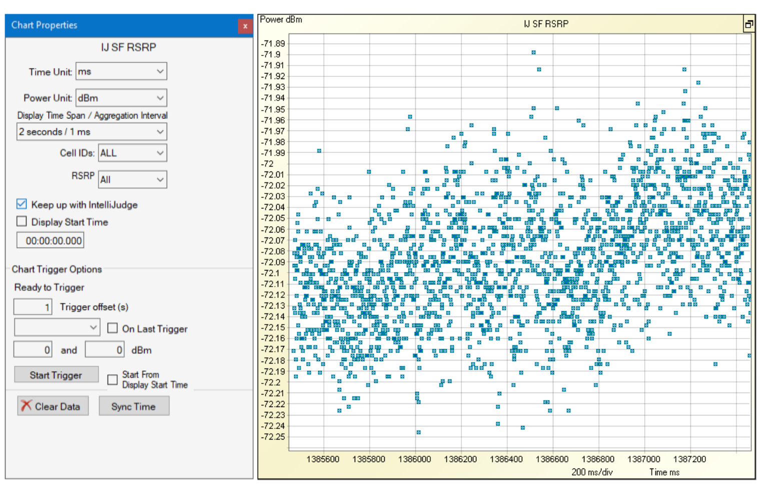


IntelliJudge Subframe RSSI Chart Properties Window and Chart

7. 2. 11 IntelliJudge Subframe RSRP Chart

The IntelliJudge Subframe Reference Signal Received Power (RSRP) Chart graphs the measurements for each downlink subframe received from IntelliJudge. For each aggregation interval, the chart can graph the average, minimum, or maximum subframe RSRP; the default is “All” showing all three. Maximum RSRP is displayed with a green circle, minimum RSRP with a red circle, and average RSRP with a blue x.

NOTE If the aggregation interval is 1 ms (the subframe duration) there will only be one value per interval and the average and worst will coincide.

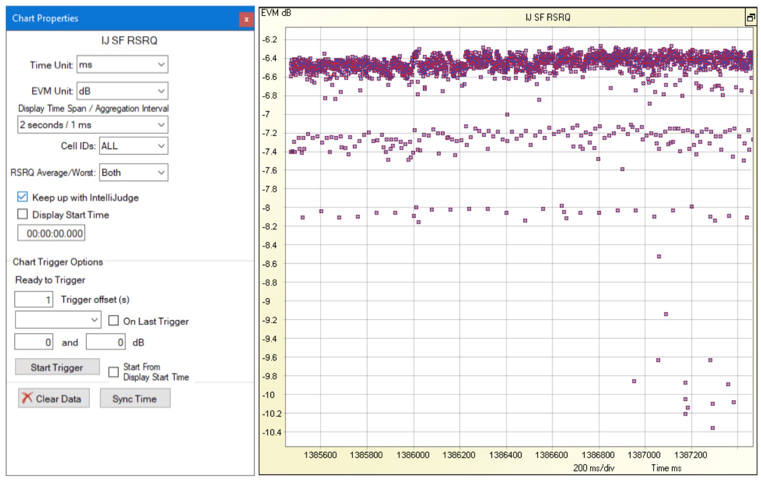


IntelliJudge Subframe RSRP Chart Properties Window and Chart

7. 2. 12 IntelliJudge Subframe RSRQ Chart

The IntelliJudge Subframe Reference Signal Received Quality (RSRQ) Chart graphs the RSRQ measurements for each downlink subframe received from IntelliJudge.

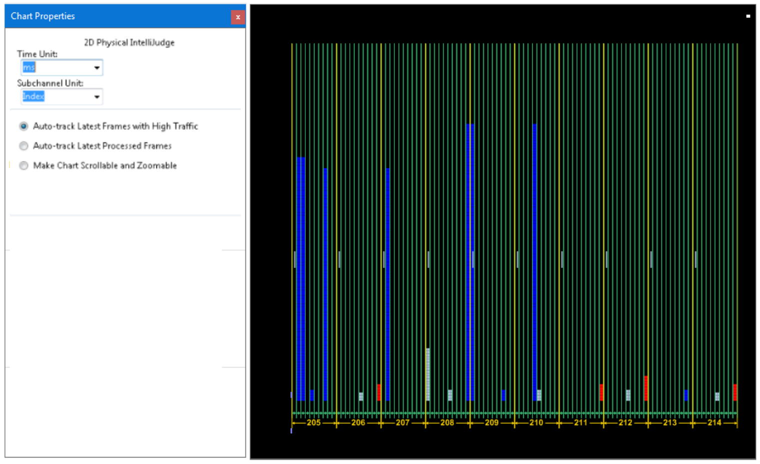
NOTE **If the aggregation interval is 1ms (the subframe duration) there will only be one value per interval and the average and worst will coincide.**



IntelliJudge Subframe RSRQ Chart Properties Window and Chart

7. 2. 13 IntelliJudge 2D Physical Chart

The IntelliJudge 2D Physical chart (known as the 2D Power chart in WaveJudge 5G NR captures) displays scheduling for all subcarriers in the time-frequency plane. In this chart, the subchannels are shown in the physical frequency space (as ordered after performing the IFFT of the incoming data), as opposed to the logical frequency space in which bursts are contiguously allocated. The default behavior is to continually refresh the most recently captured or processed frames which show significant traffic.



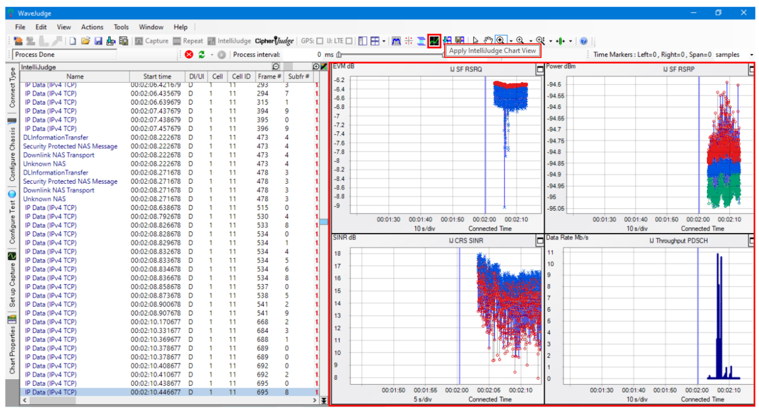
IntelliJudge 2D Physical Chart Properties Window and Chart

7. 3 Using IntelliJudge2 Charts

This section explains how to use different functions available for IntelliJudge2 charts.

7. 3. 1 Apply IntelliJudge Chart View

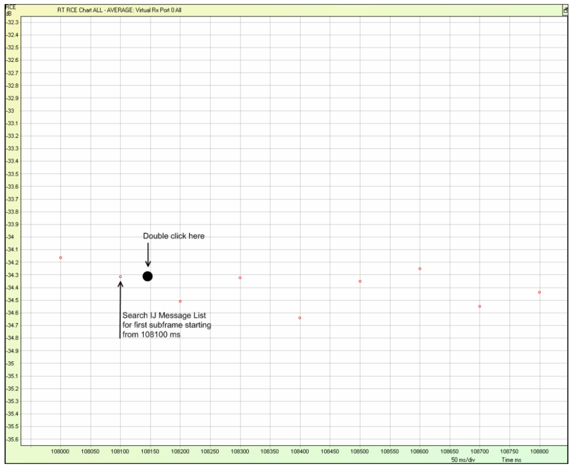
A convenient method to show four default IntelliJudge charts is to click the **Apply IntelliJudge Chart View** icon,  which will open the Subframe RSRQ, Subframe RSRP, CRS SINR, and Throughput PDSCH charts, as shown below.



Apply IntelliJudge Chart View Icon Displays Four Default Charts

7. 3. 2 Open IntelliJudge Message List from an IntelliJudge Chart

Double-clicking on a real time chart prompts WaveJudge to cross-probe from the IntelliJudge Chart to the IntelliJudge Message List. WaveJudge software will find the nearest previous point drawn on the chart, it then searches the IntelliJudge Message List for the first subframe starting from the time of the data point found in the real time chart. The image below shows double-clicking a spot after a data point and where the IntelliJudge message list will highlight.



IntelliJudge Chart - Double Click Data Point Area

7. 3. 3 Use IntelliJudge Charts with Saved Captures

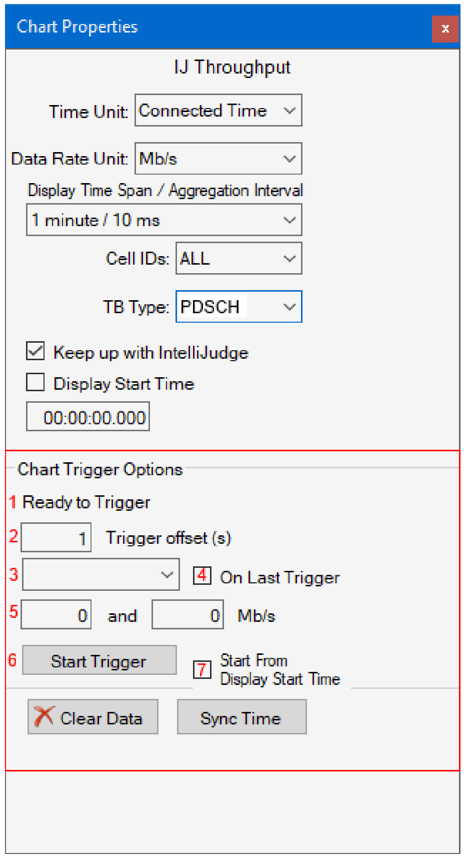
You can use IntelliJudge charts with any previously saved IntelliJudge capture. After setting up your IntelliJudge charts, there are a few ways to use them with a saved IntelliJudge capture.

1. Load the IntelliJudge capture and see the resulting IntelliJudge charts process the saved capture's data.
2. Load the IntelliJudge capture and set the IntelliJudge Real Time Preset Start Time on page 423 to a known problem.
3. Set a chart trigger, load an IntelliJudge capture, and see if the IntelliJudge chart triggers.

NOTE **Reprocessing the IntelliJudge capture will also reprocess the data in the IntelliJudge charts.**

7. 3. 3. 1 IntelliJudge Real-Time Chart Trigger Options

You can set triggers for each IntelliJudge chart. When a chart is triggered, it automatically sets up the Preset Start Time to the trigger **time minus** the Trigger Offset.



IntelliJudge Chart Trigger Options

The red control numbers in the figure above correspond to the descriptions below.

1 - Status:

This is the status, it may have any of the following states:

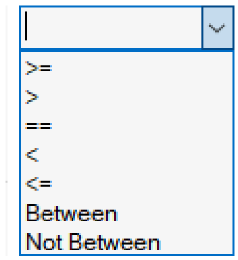
- Ready to Trigger: It is waiting for you to start a trigger.
- Waiting for Trigger: It is comparing values and is waiting for a value that matches your comparison type and value.
- Triggering: It has found a value that matches the comparison type and value but the On Last Trigger option is enabled and is still triggering.
- Last Triggered at <Time>Seconds: This line tells you when the trigger has occured.

2 - Trigger Offset:

The trigger offset value indicates the number of seconds you want to set before the trigger. For example, if you trigger at 30 seconds and set the trigger offset to 5 seconds, it will set the preset start time to 25 seconds. If you set the trigger offset value to 0 seconds, it will set the preset start time to 30 seconds. If you set the preset start time to -5 seconds, it will set the preset start time to 35 seconds.

3 - Comparison Type:

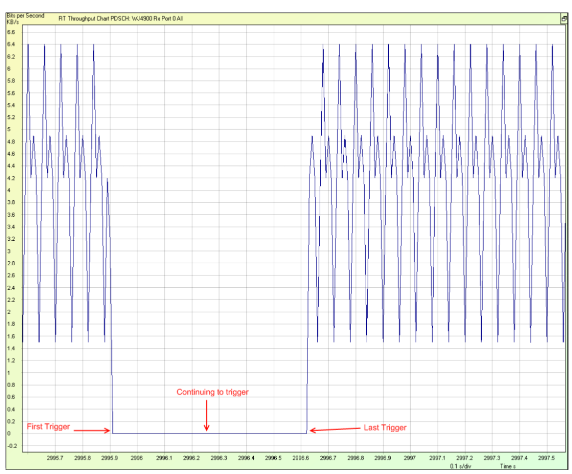
The comparison type lets you set the comparison operative. The operatives **Between** and **Not Between** are inclusive of the values. Other operatives are greater than or equal to (>=), reater than (>), is euqual to (==), less than (<), and less than or equal to (<=).



Comparison Type Drop-down Menu

4 - On Last Trigger:

This checkbox option lets you get the last occurrence of the trigger. The image below shows a capture. If you had set the trigger to 0 KB/s, it would have first triggered at around 2995.91 seconds. If you did not have **On Last Trigger** enabled, it would have triggered at the first trigger point. If you had **On Last Trigger** enabled, it would continue triggering until the last trigger at around 2996.61 seconds.



IntelliJudge Chart - On Last Trigger

5 - Comparison Value:

The values you want to use in conjunction with the comparison type to determine if the chart should trigger. Enter the lower value in the left field and the maximum value in the right field. The frequency is Mb/s.

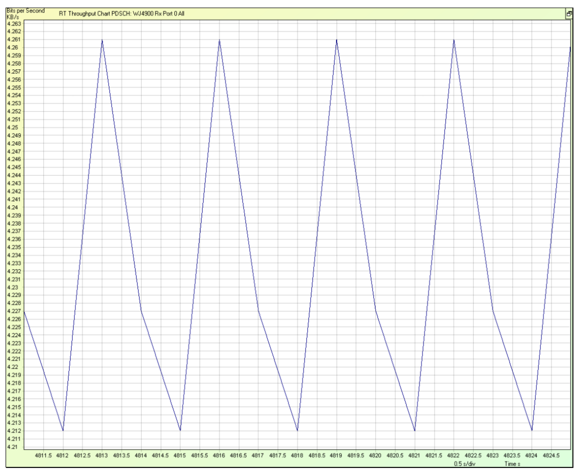
6 - Start Trigger:

Button that starts/stops the current chart trigger.

7 - Start from Display Start Time:

This checkbox lets you search for a trigger starting from the pre-defined start time. This is useful when you want to skip a section of data.

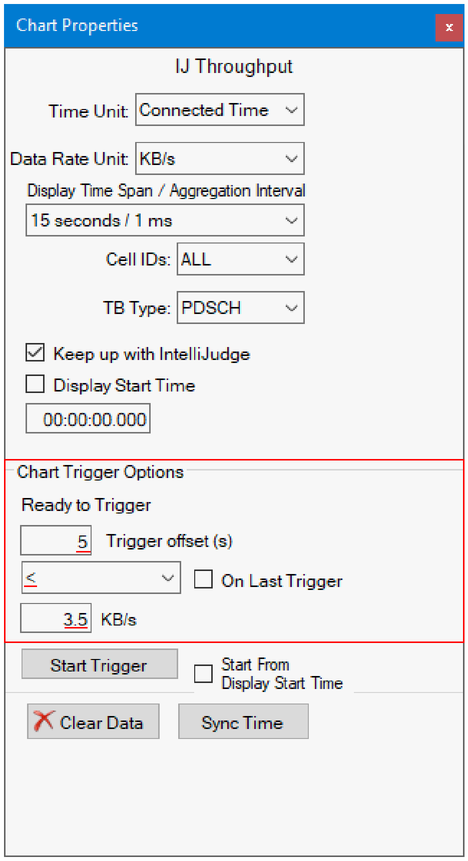
Let’s assume you are taking an IntelliJudge capture. You look at your IntelliJudge Throughput chart and see that the throughput is around 4.2 KB/s. An image of the Real Time Throughput chart with a normal throughput for this capture is below.



IntelliJudge Real Time Throughput Chart

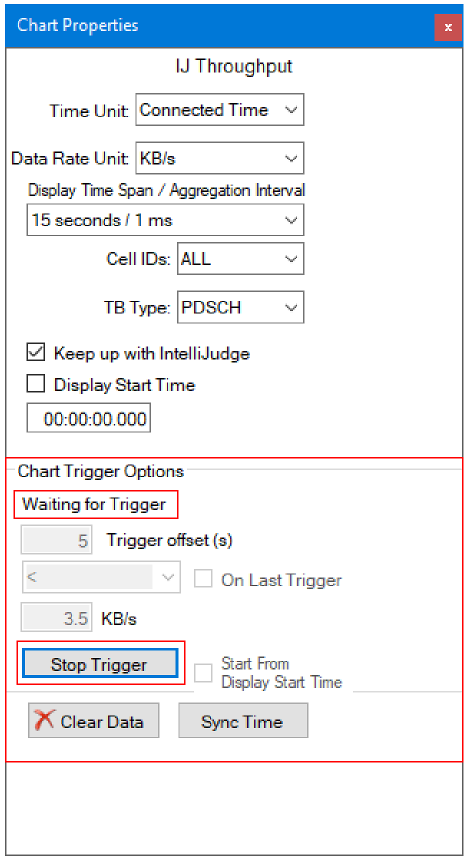
You want to make sure that the **throughput is always above 3.5 KB/**s. Here are the steps to do this, refer to the example below of the Chart Properties Window with these values.

1. Open the Chart Properties window by clicking on the Chart Properties tab and click on the IntelliJudge Throughput chart.
2. Set the trigger offset to **5 seconds**.
3. Set the comparison type to less than ' < '.
4. Set the comparison value to **3.5 KB/s**. This means that if there are any value points that are less than 3.5 KB/s, it will trigger and set the preset start time to 5 seconds before the trigger point.



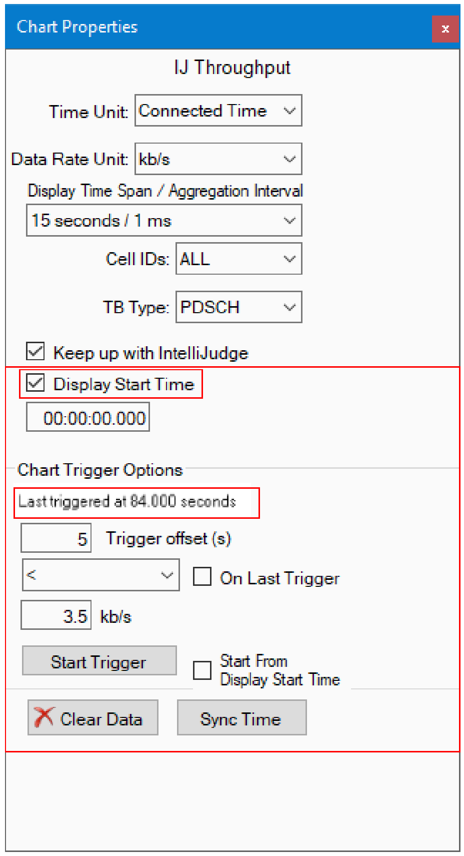
IntelliJudge - Trigger Offsets

Once you have set the values for the triggers, start the trigger by pressing the Start Trigger button. The status line will show the message Waiting for Trigger. Wait for a trigger to occur. You can stop the trigger at any time by pressing the Stop Trigger button. An example of how the Chart Properties window looks like after starting the trigger is shown below.



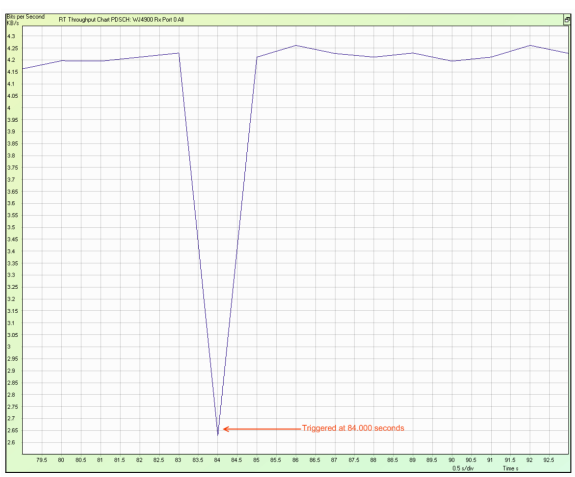
IntelliJudge - Waiting for Trigger

If the chart is triggered, the status line will tell you when the trigger occurred and set the Preset Start Time to the trigger time minus the Trigger Offset. In this example, assume that the chart triggered at 84.000 seconds. Since the Trigger Offset is five seconds, it will set the Preset Start Time to 79.000 seconds; or 00:01:19.000. The figure below shows an example of what the Chart Properties window looks like after a trigger.



IntelliJudge - After Trigger

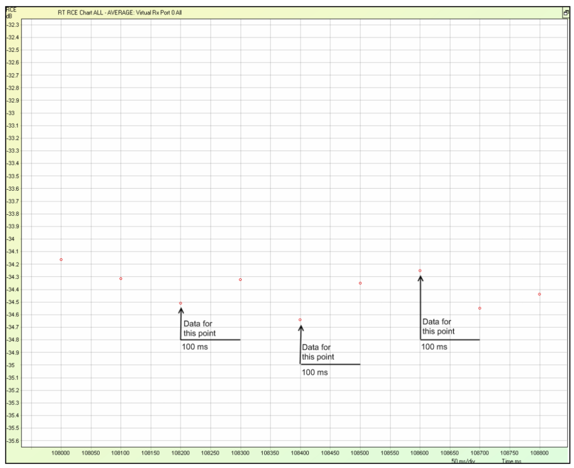
The image below shows the resulting chart in the IntelliJudge real-time Throughput chart.



IntelliJudge Throughput Chart Showing Trigger

7. 3. 3. 2 Read Data Points in a Real Time Chart

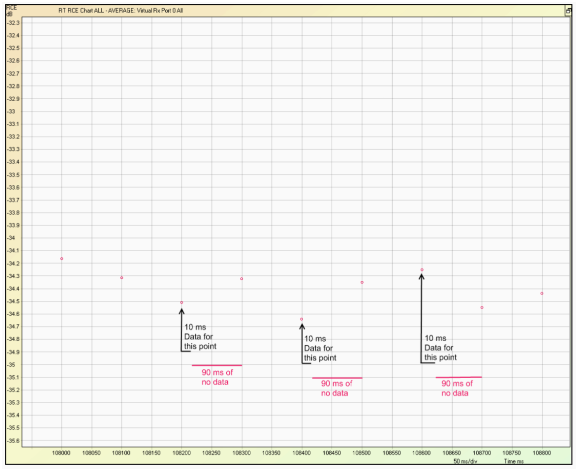
Each point drawn on an IntelliJudge chart is dependent on the Interval Duration. If a point is drawn with an interval duration of 100 ms, the data for that point comes from all data within the next 100 ms. If a point is drawn with an interval duration of 10 ms, the data for that point comes from all data within the next 10 ms.



IntelliJudge EVM Chart Showing Interval Duration of 100 ms

The chart above is an IntelliJudge EVM chart that shows the average of all TBs. Assume that the interval duration is 100 ms for the chart above; the point at 108200ms contains the data for the time period between 108200 (inclusive) to 108300 (non-inclusive). From this chart, you can conclude that the average EVM of all TBs between 108200 (inclusive) and 108300 (non-inclusive) is approximately -34.5 dBm.

In the chart below, the interval duration is 10 ms for the same chart. The black line illustrates where the data point is present. The red line illustrates where the data point is not present. Even though the points are separated by 100 ms, only 10 ms is represented for each data point.



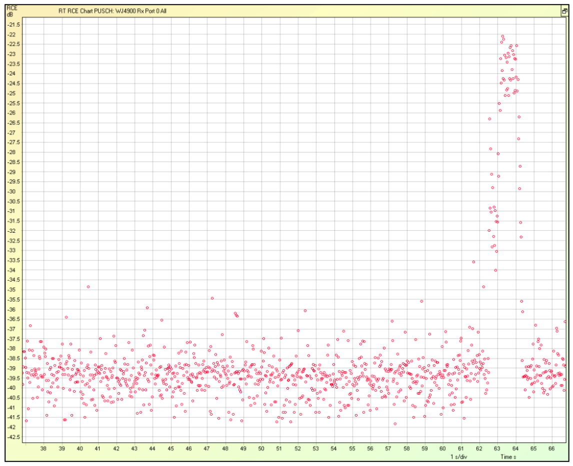
IntelliJudge EVM Chart Showing Interval Duration of 10 ms

For example, the point at 108200 ms only represents data between 108200 (inclusive) to 108210 (non-inclusive). You can conclude from this chart that between 108200 (inclusive) and 108210 (non-inclusive), the average RCE for all TBs is -34.5 dBm. You can also conclude that there are no TBs between 108210 (inclusive) and 108300 (non-inclusive) because there are no data points between 108210 ms (inclusive) and 108300 ms (non-inclusive).

7. 3. 3. 3 IntelliJudge Real Time Preset Start Time

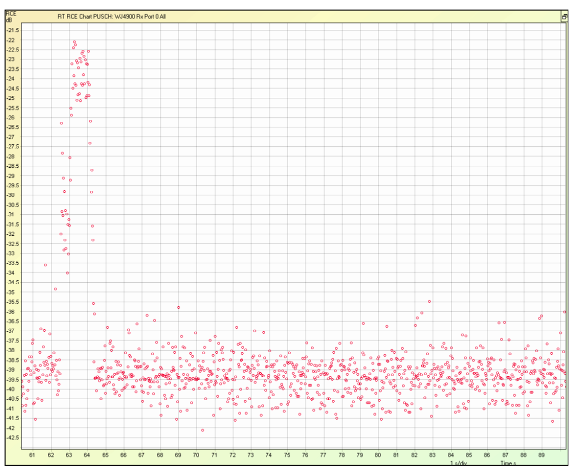
The **IntelliJudge Preset Time** function lets you draw an IntelliJudge chart starting at a predefined time and lock onto that time span. This is very useful to analyze data because if you do not have a preset start time, the data points will eventually be replaced with new data points and you will be unable to view them anymore. An example situation of how to use the preset start time option is explained below.

Say you want to take a capture and observe the **IntelliJudge EVM** chart. You set the total duration to 30 seconds and the interval duration to 10 ms or 1 frame. You connect to the hardware and start an IntelliJudge capture. You see that everything looks fine until around one minute. You see some data points with bad EVM for a few seconds. You want to continue running the IntelliJudge capture and look at the problem area where the EVM suddenly got worse. If you let the IntelliJudge capture continue, the IntelliJudge chart will eventually replace the data points around the poor EVM with new data points from the IntelliJudge capture. The example below shows you how to keep capturing and observe the problem area. You notice (in the chart below) that around 62 seconds the EVM got significantly worse for about two seconds. You start to investigate the problem.



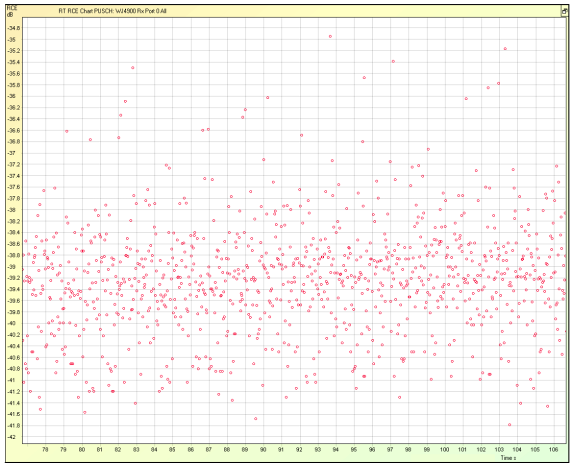
IntelliJudge EVM Chart - Problem at 62 Seconds

Since this is a real-time chart, new data is constantly added to it. In the chart below, 25 seconds has passed. Since the total duration is only 30 seconds, the problem area is quickly replaced with new data points.



IntelliJudge EVM Chart - Problem at 25 Seconds

In the chart below, the problem area is completely removed and replaced by new data points from the IntelliJudge capture.

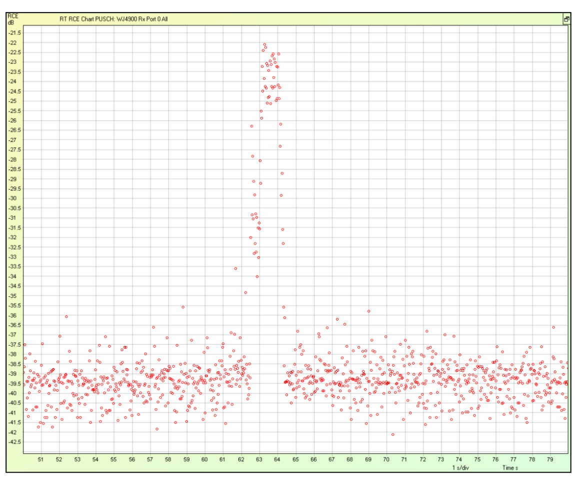


IntelliJudge EVM Chart - Problem Gone

Let's assume you want to continue looking at the problem area. To do this, you need to **set a preset start time**. Open the **Chart Properties** window of this chart and click on the chart. (Alternatively, you can right-click the chart and select **Properties**, this open the Chart Properties window for this chart.)

Since the problem area was around 60 seconds in, you will probably want to observe the time period before the problem area, so set the preset time to 50 seconds.

After setting the time, click the **Preset Start Time** checkbox to redraw the IntelliJudge chart starting at 50 seconds. This will NOT affect any other real time charts running, so you can have other real time charts drawing new data from the capture at the same time. The figure below shows the resulting chart.



IntelliJudge EVM Chart - Preset Start Time Set to 50 Seconds

8 Interpret 5G NR Results

To receive the best results from your WaveJudge and properly analyze them it is important to understand the complexity of the PHY layer and how 5G messages compare to LTE. This section provides an overview of 5G PHY layer communication so the WaveJudge messages, charts, and lists are easier to use.

8. 1 5G PHY Layer

5G radio protocols consist of a user plane (UP) located between the IP layer and the PHY layer, and a control plane (CP), which is the Radio Resource Control (RRC) protocol.

The PHY layer downlink channel has three physical channels:

- **Physical Broadcast Channel (PBCH)** carries encoded system information required by the UE to access the network.
- **Physical Downlink Shared Channel (PDSCH)** carries encoded user data and paging information to the UE.
- **Physical Downlink Control Channel (PDCCH)** conveys encoded control information and scheduling decisions for PDSCH reception.

The data link layer (Layer 2) in 5G NR has four sub-layers:

- Medium access control (MAC),
- Radio link control (RLC),
- Packet data convergence protocol (PDCP), and
- Service data adaptation protocol (SDAP).

The SDAP protocol is new in 5G NR compared to the LTE protocol stack. SDAP handles the new Quality of Service (QoS) framework of the 5G System in the 5G Core. SDAP also applies to LTE when connected to the 5G Core. The introduction of SDAP enables end-to-end QoS framework that works in both directions.

5G NR stack layers provide key enhancements over their LTE counterparts. The PDCP, RLC, and MAC protocols handle tasks such as header compression, ciphering, segmentation and concatenation, and multiplexing and de-multiplexing. PHY handles coding and decoding, modulation and demodulation, and antenna mapping.

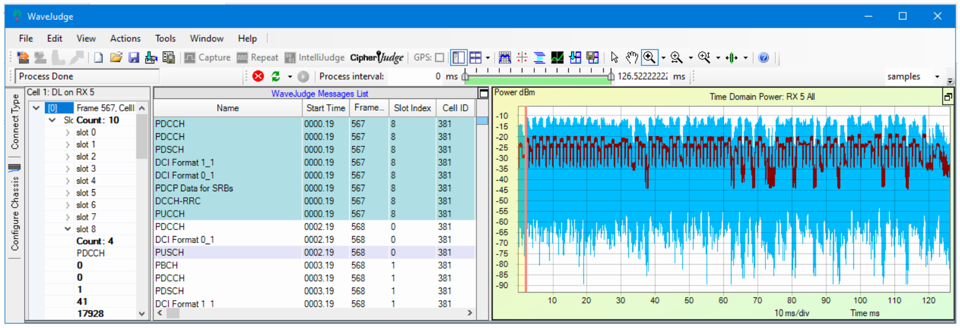
The QoS flows between the UP protocol stack UE and the NR network node (gNB) are the same.

- **SDAP Channels** - SDAP layer in UE stack communicates in both directions with the SDAP layer in gNB.
- **PDPC Channels** - PDPC layer in UE stack communicates in both directions with the PDPC layer in gNB.
- **RLC Channels** - RLC layer in UE stack communicates in both directions with the RLC layer in gNB.
- **Logical Channels** - MAC layer in UE stack communicates in both directions with the MAC layer in gNB.
- **Transport Channels** - PHY layer in UE stack communicates in both directions with the PHY layer in gNB.

8. 2 WaveJudge Messages List

For an introduction to the **WaveJudge Messages List** user interface, refer to WaveJudge Messages List on page 240. The section below explains how to interpret data using different charts and frames.

The correlation feature Correlation LTE on page 479 allows messages to associate with their respective parameters in the frame list on the PHY Frame Lists on page 432. When you select a message in the **Message List**, the parameters that make up that message are highlighted in the **PHY Frames** list, these parameters may contain all or part of message’s content. Conversely, when a parameter, or a group of parameters, is selected in the **PHY Frames** list, any messages that have content in these parameters are highlighted in the **Message List**. You can select multiple parameters in the **PHY Frames** list by pressing the Shift key and clicking on the first and last parameters of the desired series of parameters. You can also select an entire frame in the **PHY Frames** list and all messages that are contained in that frame highlight in the **Message List**.



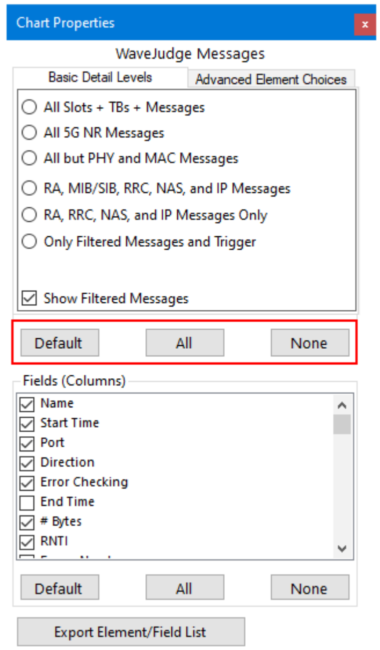
PHY Frame, Message List, and Corresponding Time Domain Power Chart

8. 2. 1 WaveJudge Messages Chart Properties

The chart properties for the WaveJudge Messages List and related message lists are specific to the technology you select. The options change based on the configuration of the standard field in the cell configuration window.

To customize the elements (rows) and fields (columns) in the WaveJudge Messages List, click the WaveJudge Messages List and then click the Chart Properties button; or right-click the WaveJudge Messages List and select Chart Properties from the menu.

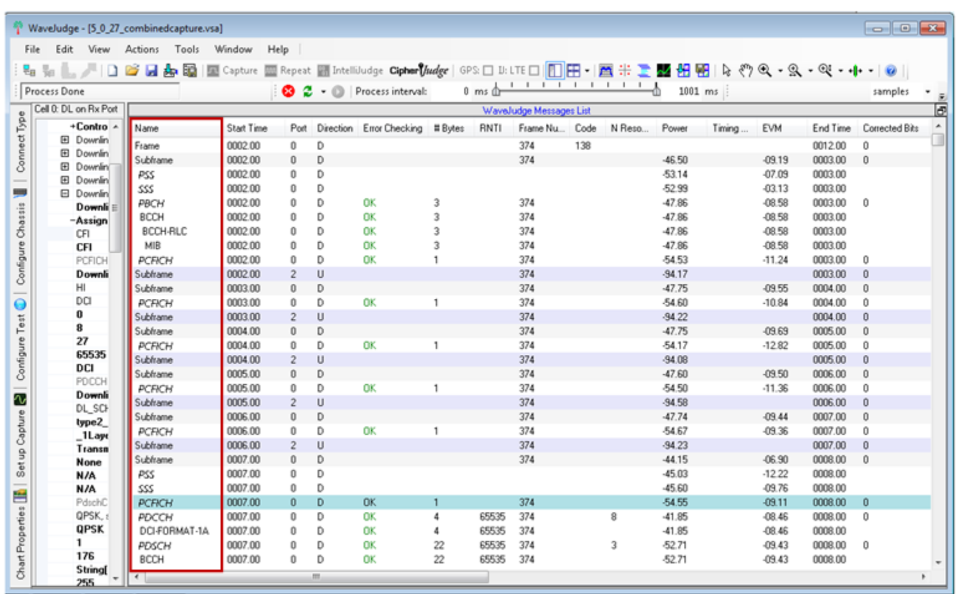
- To select all checkboxes, click All.
- To clear all checkboxes, click None.
- To restore default settings for a category click the Default button. The default settings depend on the protocol chosen and (in the case of WiMAX) the specific list type.



WaveJudge Chart Properties Window - Default, All, None Buttons

8. 2. 2 LTE Chart Properties

The figure below shows the WaveJudge Message List for LTE elements/rows.



WaveJudge Message List - LTE Elements/Rows

LTE element/row properties are described below.

Frame: Wireless standard-defined frame; may contain uplink and/or downlink subframes.

SubFrame: Uplink or downlink subframe

TB: Transport blocks

PRACH Preamble: PRACH transmissions

MAC Padding: Padding PDUs or padding bytes; FF

MAC: Medium access control level messages

RLC: Radio link control messages

DCI: Downlink control information messages

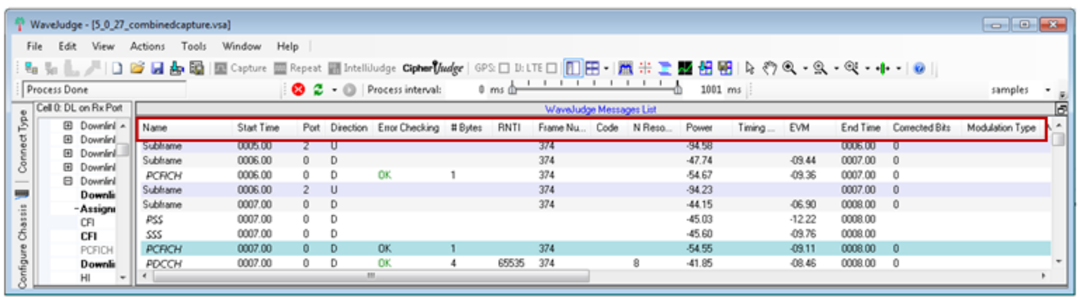
PDCP: Packet data convergence protocol level messages

MIB/SIB: Uplink or downlink transmission

Other: Other message types

Filtered: Filtered messages

The figure below shows the WaveJudge Message List for LTE fields/columns.



WaveJudge Message List - LTE Fields/Columns

LTE field /column options are decribed below.

Name: Message name.

Start Time: Time relative to the start of capture

Port: Receive Rx Port number (0 - 3) that was received from the message

Direction: Direction of captured traffic: U = Uplink (mobile station transmission, color coded blue for quick identification) or D = Downlink (base station transmission)

Error Checking: Any error flag

End Time: End time relative to capture

 # Bytes: Length of a particular item

RNTI: Radio network temporary identifier that identifies a UE

Frame Number: Frame number

Corrected Bits: FEC errors received on a per-burst basis; applicable to frame, subframe, and TB elements

Modulation Type: Applicable to Burst and Sub-burst elements; modulation type (BPSK, QPSK, 16-QAM, or 64-QAM), FEC Type (for example, CTC, RS, or CC), and repetition

Code: RACH and CQI code

N Resources: Represents a resource allocated by eNodeB

Power: Per frame or TB in dBm

Timing Offset:Timing offset of Random Access Preamble for LTE. Timing offset of UL as compared to DL. This value indicates the offset between DL and UL in samples (for example, 10 means that the UL was received with a delay of 10 samples. -20 means that the UL was received 20 samples earlier than expected).

RCE:Relative constellation error; per frame, subframe, or TB

RV: Redundancy bit value

N CodeWords: N codewords for the MIMO type

HARQ Process Number: HARQ process identifier

NDI: HARQ new data indicator

N Layers: N layers for MIMO type

Mimo Type: Mimo type of spatial multiplexing or transmit diversity identified in the TB

8. 3 PHY Frame Lists

The PHY Frame List panels display the hierarchical frame structure of frames captured that correlate to charts and messages. WaveJudge has up to four different ports, or Rx Ports; these paths are configured in panes:

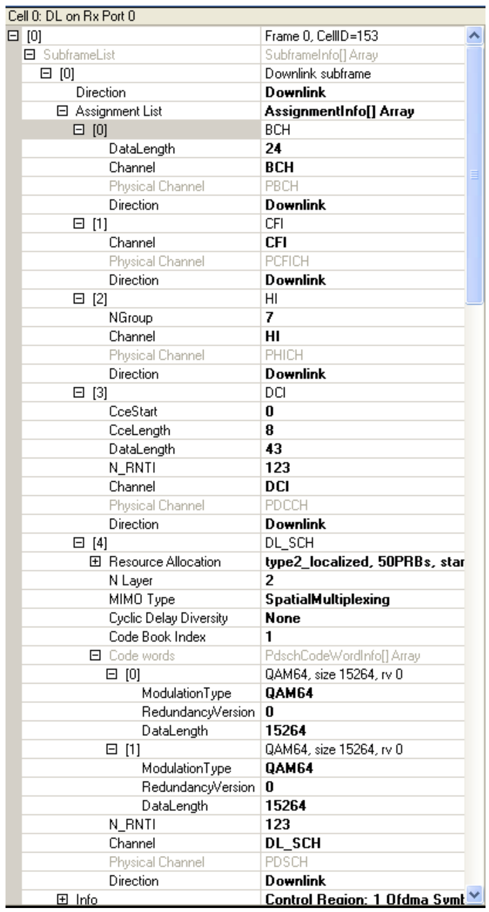
- Configure Test Window or Define a New Test on page 136
- Configure Cells on page 77
- Configure Port Groups/Downlinks on page 85
- Configure Rx Ports on page 86

The captured data appear in a Frame List pane associated with a given cell numbered Cell 0 to Cell 5, depending on the configuration. At most, two frame list panes display regardless of the number of cells; but when there are more than two cells, you can assign each pane to any given cell number.

Each time you perform a capture, or an existing capture is reprocessed, the PHY Frame Lists clear and the lists repopulate with the latest frames captured. The cross-probing feature allows the zones in the PHY Frames Lists to associate with messages in the WaveJudge Messages List on page 240 and most chart and summary screens; see Correlation LTE on page 479 .

8. 3. 1 PHY Frames for LTE

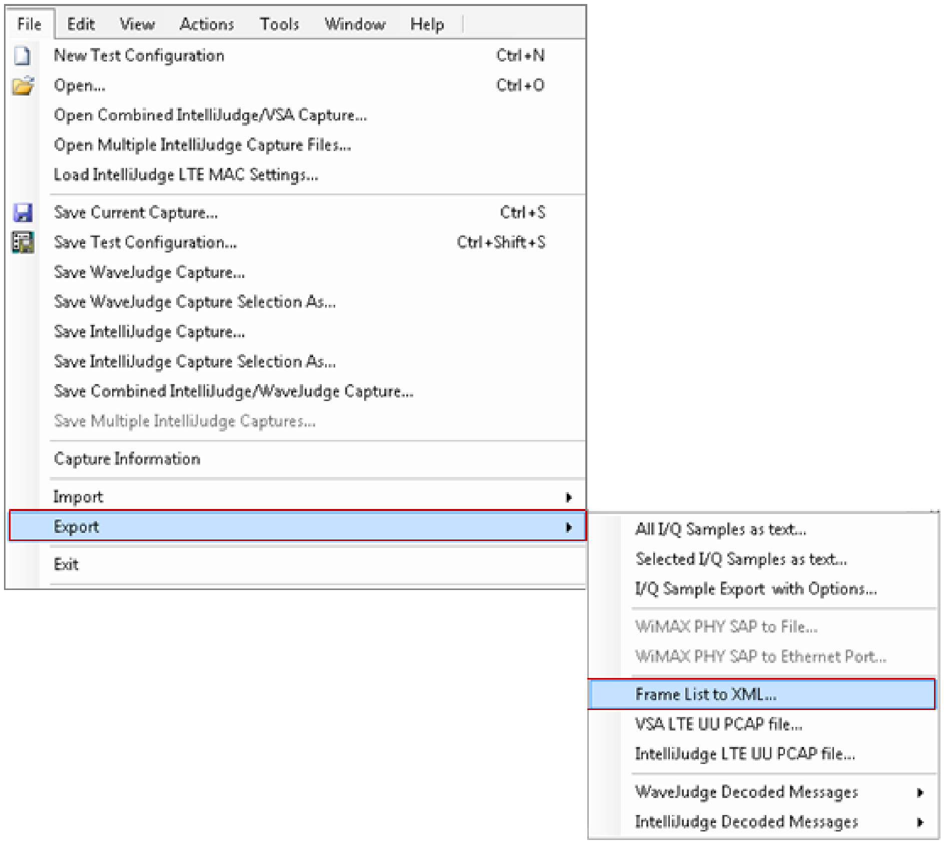
The PHY Frame List for the LTE protocol contains the analyzed data for each frame, subframe, assignment, and assignment's parameters. Each frame contains all the DL and UL subframes set in the Edit Schedule Window on page 141.



WiMAX PHY Frame for LTE

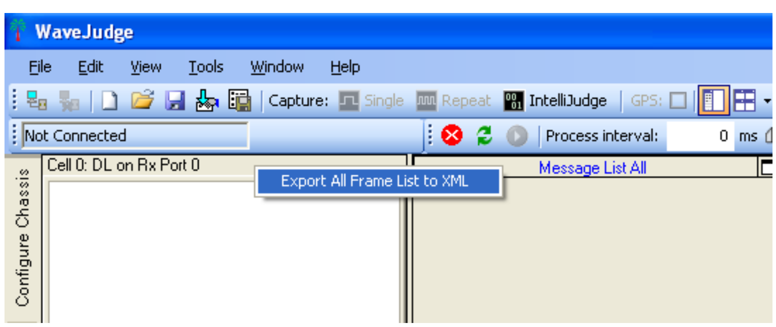
8. 3. 2 Export a Frame List to XML

There are two ways to export the Frame List into an XML format. The first way is through the File menu. Select **File -> Export -> Frame List**.



File Menu - Export Frame List

The second way to save the frame list is by right-clicking the top of the top of the frame list. A menu will appear with the option Export All Frame List to XML. Select Export All Frame List to XML.



Right-Click Frame List to Export

8. 4 Result Views

WaveJudge has many charts and measurements to aid your interpretation and analysis of capture data. To provide correlation between charts and measurements, you can easily review several charts on screen simultaneously. Such a grouping is called a View in WaveJudge.

A View consists of a group of panels (which contain measurement charts) and an optional Side Panel which is usually used to display the WaveJudge Messages List. The possible layouts, selectable in the Window menu, include 1, 4, 5, or 6 panels. You can also select a layout from the Panel Layout button on the toolbar . You can enable/disable the Side Panel by toggling the Side Panel checkbox located in the Window menu identified below, or by clicking the Side Panel button on the toolbar .

To set a specific chart to view results from a specific input port,right-click on a chart to open the chart context menu, select Set Chart Port to on page 358 submenu, and select the **port** from that menu. For convenience, you can simultaneously set all charts to view the same Rx Port by opening the View menu and selecting the ViewSet All Charts To Rx Port... submenu, and choosing the Rx Port from that menu.

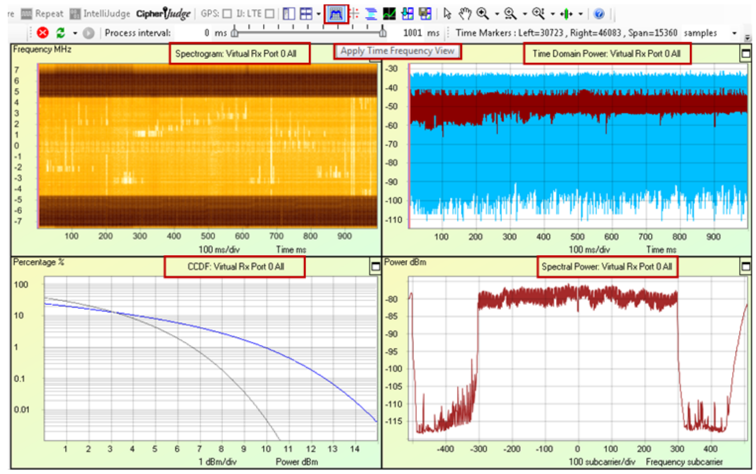
8. 4. 1 Preconfigured Views

The toolbar includes the Chart Views Tool Group on page 225 that have convenient panel layouts for common non-real-time analysis tasks. These views are the Time Frequency View , Demodulation View , and Decode View .

To enable a view click the respective button on the toolbar, or select one from the View menu. The Chart Views Tool Group on page 225 provides another summary of these views.

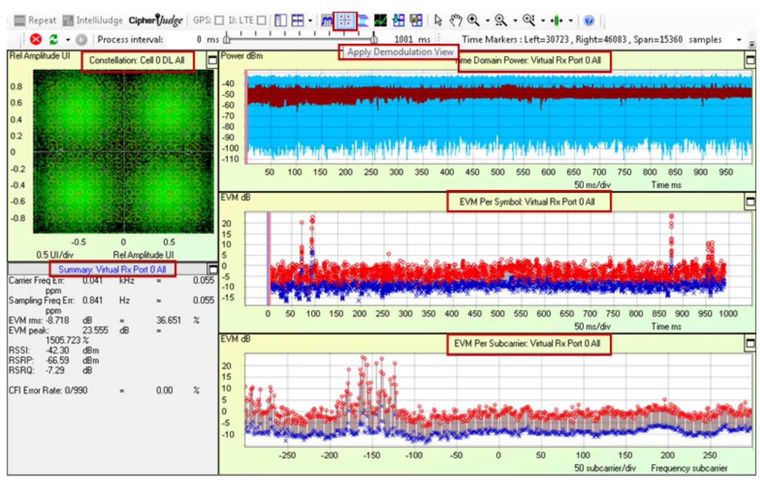
The Time Frequency View aids analysis and verification of RF characteristics and includes charts:

- Spectrogram on page 387
- CCDF on page 394
- Time Domain Power Chart on page 268
- Spectral Power Chart on page 269



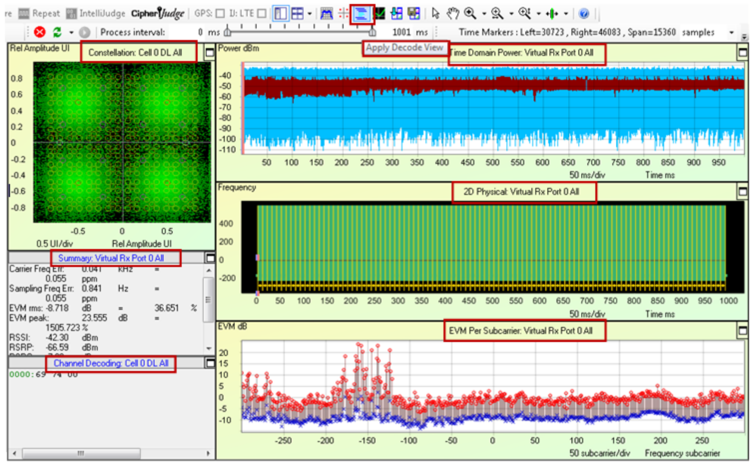
Preconfigured View "Apply Time Frequency"

The **Demodulation View** charts are Constellation Diagram on page 380, Summary Chart on page 389, Time Domain Power on page 365, EVM Per Symbol, and EVM Per Subcarrier. This view helps you to determine the quality of the I/Q demodulation.



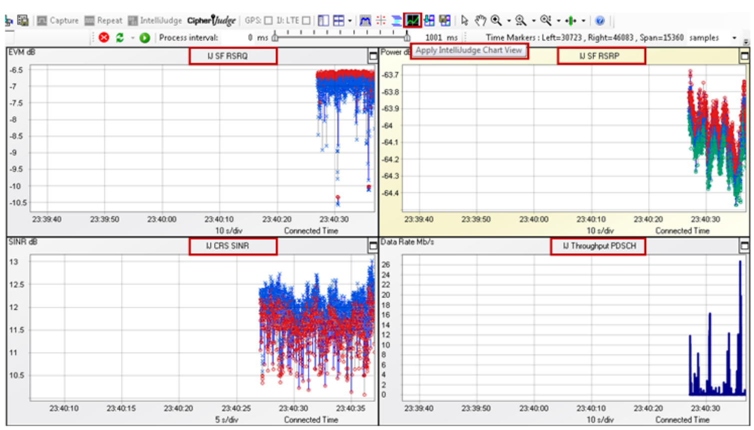
Preconfigured View "Apply Demodulation View"

The **Decode View** includes the Constellation Diagram on page 380, Summary Chart on page 389, Channel Decoding Chart on page 393, Time Domain Power on page 365, 2D Power Chart for 5G on page 381, and EVM Per Subcarrier on page 374. Enable the **Right-Click Context Menu** containing the WaveJudge Messages List on page 240. This view facilitates the correlation between PHY and MAC and helps debug issues that concern both layers.



Preconfigured View "Apply Decode View"

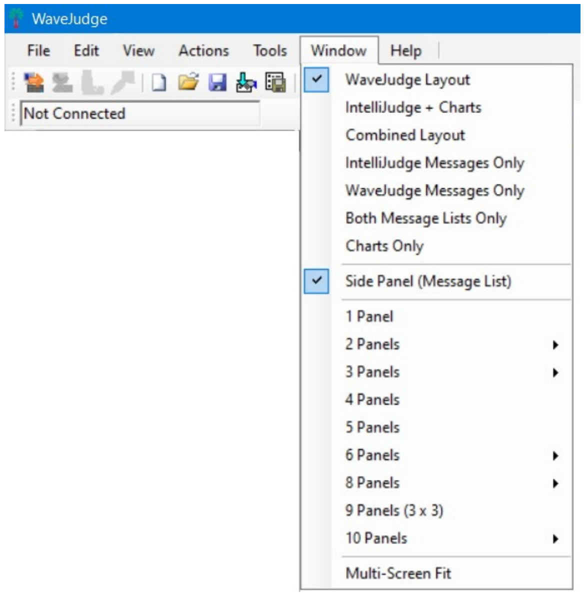
The IntelliJudge Chart View includes the IntelliJudge Subframe RSRQ Chart on page 412, IntelliJudge Subframe RSRP Chart on page 411, IntelliJudge CRS SINR Chart on page 409, and IntelliJudge Throughput Chart on page 406 charts. This view changes all chart displays to a preset IntelliJudge view, suitable for real-time capture analysis while taking and processing an IntelliJudge capture. These charts display an overview of some critical signal quality and signal strength measurements while capturing in real-time.



Preconfigured View "Apply IntelliJudge Chart View"

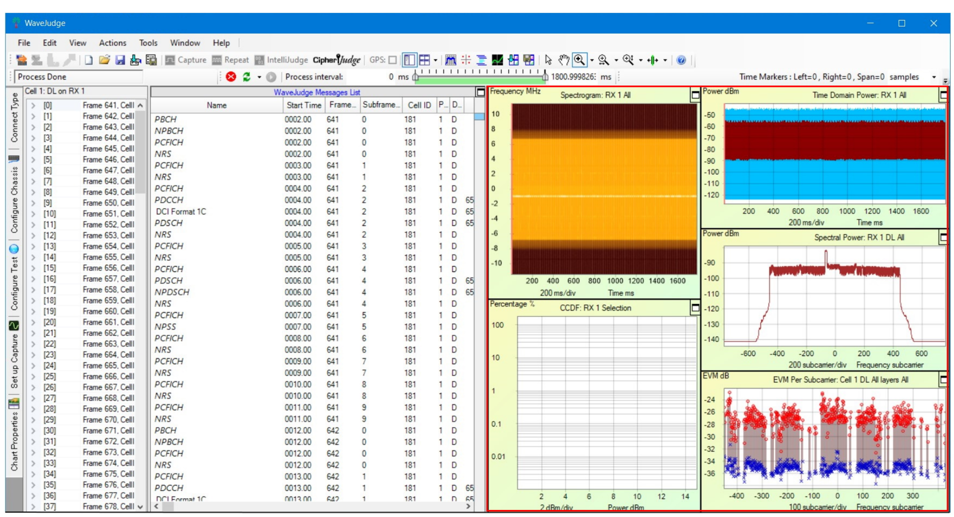
8. 4. 2 Create a Custom View

There are two ways to create a custom view. You can select a panel layout from the Window drop-down menu as shown below; or you can select a layout from an option in the Panel Layout button and the Side Panel button on the toolbar .



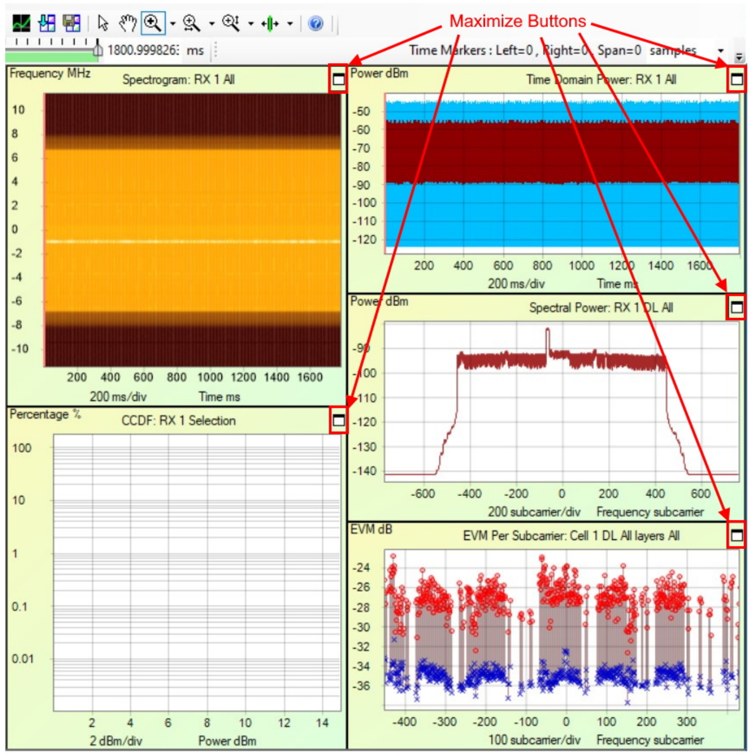
Window Drop-down Menu to Select Panel Layout

The number of panels designates the number of charts shown on the right side of the user interface.



Five Panel View

Each of the configurable panels contain a Minimize / Maximize button. The button maximizes the side panel and hides the chart panes. Use the Maximize buttons to expand charts.



Maximize Buttons Enlarge Lists and Charts

8. 4. 3 Save/Load a Custom View

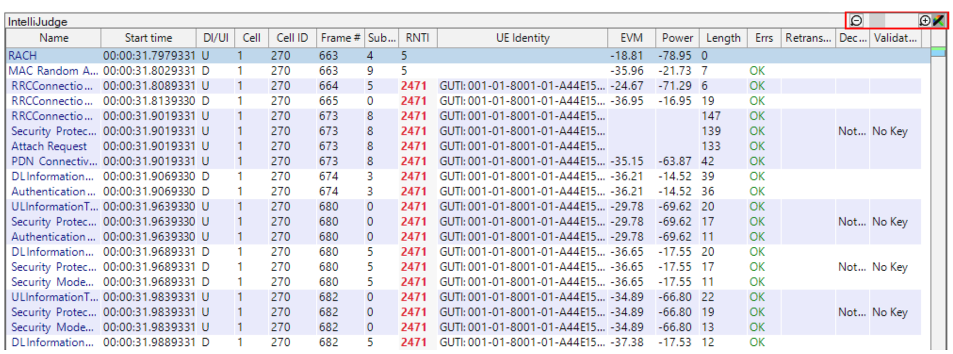
Once you have constructed a custom view of charts and options, you can save the custom view for later use by clicking the Save View button on the toolbar, or select the menu options ViewSave View. To load a previously saved view, select ViewLoad View or click the Load View button . To save a modified loaded view under a different filename, select ViewSave View As from the main menu. The filename extension for saved views is `.vw`.

9 Interpret IntelliJudge2 4G LTE Results

This section describes how to use all of IntelliJudge analysis tools: the IntelliJudge Message List, the IntelliJudge Message List Context Menu, IntelliJudge Chart Properties Window, IntelliJudge Chart Context Menu, and how to use IntelliJudge charts.

9. 1 IntelliJudge Message List

The IntelliJudge Message List displays the 4G LTE real-time data captured by and processed in IntelliJudge and then further decoded in the WaveJudge software on your computer. You can configure the IntelliJudge Message List in many different ways to screen and control how the data display and the level of detail.



IntelliJudge

Name	Start time	DI/UI	Cell	Cell ID	Frame #	Sub...	RNTI	UE Identity	EVM	Power	Length	Errs	Retrans...	Dec...	Validat...
RACH	00:00:31.7979331	U	1	270	663	4	5		-18.81	-78.95	0				
MAC Random A...	00:00:31.8029331	D	1	270	663	9	5		-35.96	-21.73	7	OK			
RRCConnectio...	00:00:31.8089331	U	1	270	664	5	2471	GUTI: 001-01-8001-01-A44E15...	-24.67	-71.29	6	OK			
RRCConnectio...	00:00:31.8139330	D	1	270	665	0	2471	GUTI: 001-01-8001-01-A44E15...	-36.95	-16.95	19	OK			
RRCConnectio...	00:00:31.9019331	U	1	270	673	8	2471	GUTI: 001-01-8001-01-A44E15...			147	OK			
Security Protec...	00:00:31.9019331	U	1	270	673	8	2471	GUTI: 001-01-8001-01-A44E15...			139	OK		Not...	No Key
Attach Request	00:00:31.9019331	U	1	270	673	8	2471	GUTI: 001-01-8001-01-A44E15...			133	OK			
PDN Connectiv...	00:00:31.9019331	U	1	270	673	8	2471	GUTI: 001-01-8001-01-A44E15...	-35.15	-63.87	42	OK			
DLInformation...	00:00:31.9069330	D	1	270	674	3	2471	GUTI: 001-01-8001-01-A44E15...	-36.21	-14.52	39	OK			
Authentication...	00:00:31.9069330	D	1	270	674	3	2471	GUTI: 001-01-8001-01-A44E15...	-36.21	-14.52	36	OK			
ULInformationT...	00:00:31.9639330	U	1	270	680	0	2471	GUTI: 001-01-8001-01-A44E15...	-29.78	-69.62	20	OK			
Security Protec...	00:00:31.9639330	U	1	270	680	0	2471	GUTI: 001-01-8001-01-A44E15...	-29.78	-69.62	17	OK		Not...	No Key
Authentication...	00:00:31.9639330	U	1	270	680	0	2471	GUTI: 001-01-8001-01-A44E15...	-29.78	-69.62	11	OK			
DLInformation...	00:00:31.9689331	D	1	270	680	5	2471	GUTI: 001-01-8001-01-A44E15...	-36.65	-17.55	20	OK			
Security Protec...	00:00:31.9689331	D	1	270	680	5	2471	GUTI: 001-01-8001-01-A44E15...	-36.65	-17.55	17	OK		Not...	No Key
Security Mode...	00:00:31.9689331	D	1	270	680	5	2471	GUTI: 001-01-8001-01-A44E15...	-36.65	-17.55	11	OK			
ULInformationT...	00:00:31.9839331	U	1	270	682	0	2471	GUTI: 001-01-8001-01-A44E15...	-34.89	-66.80	22	OK			
Security Protec...	00:00:31.9839331	U	1	270	682	0	2471	GUTI: 001-01-8001-01-A44E15...	-34.89	-66.80	19	OK		Not...	No Key
Security Mode...	00:00:31.9839331	U	1	270	682	0	2471	GUTI: 001-01-8001-01-A44E15...	-34.89	-66.80	13	OK			
DLInformation...	00:00:31.9889331	D	1	270	682	5	2471	GUTI: 001-01-8001-01-A44E15...	-37.38	-17.53	12	OK			

IntelliJudge Message List

As indicated in the top right corner in the figure above, these controls allow you to adjust settings in the IntelliJudge Message List; these settings as well as all details and column headers are described in the sections below.

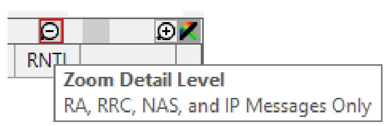
9. 1. 1 IntelliJudge Message Detail Controller

The Message Detail Controller is a convenient way to change the detail level for the IntelliJudge Messages chart without needing to open the IntelliJudge Chart Properties window to adjust it. It is a compact slider control, providing the same level of detail adjustment as the Basic Detail Level tab within the IntelliJudge Chart Properties window. Hover your cursor over the sliderbar or over any of the Zoom Detail Level buttons to see its tool tip.

IntelliJudge Message Detail Controller - Zoom Detail Level: Slider Bar

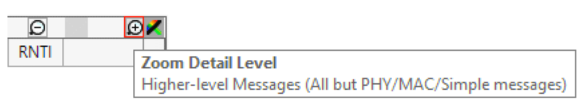
Adjusting the Zoom Detail Level (via the slidebar or the detail level buttons) lets you select any of the following detail levels, from left to right:

1. Filtered Messages Only
2. RA, RRC, NAS + IP Messages Only
3. RA, MIB/SIB, RRC NAS + IP Messages
4. Higher-Level Messages (All but PHY / MAC / Simple Messages)
5. All but PHY and MAC Messages
6. All LTE Message Types
7. All LTE data: Subframes + Transport Blocks + All Messages
    - Click and scroll the Message Detail Controller left to decrease the detail level, or right to increase detail level.
    - Hover the cursor over the Reduce Detail Level button  to show only the lower level messages (RA, RRC, NAS, and IP Messages Only).



IntelliJudge Message Detail Controller - Zoom Detail Level: Minus Sign

    - Hover the cursor over the Increase Detail Level button  to show only the higher level messages (All but PHY/MAC/Simple Messages).



IntelliJudge Message Detail Controller - Zoom Detail Level: Plus Sign

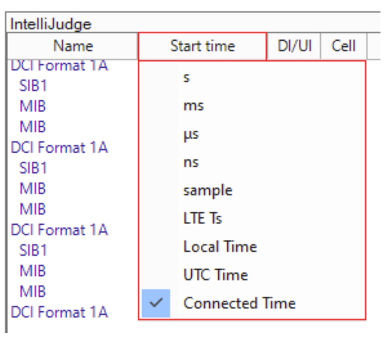
    - The Filtered Messages button  toggles between displaying or not displaying higher-layer messages flagged by the current IntelliJudge filters.

To view or set the filters, either select the Tools menu and click the IntelliJudge Filters item, or open the IntelliJudge Chart Properties window and click the Open IntelliJudge Filters... button. Additional information to set up and use filters is described in the Configure Filters on page 287 section.

9.1.2 IntelliJudge Message List Sorting Features

Each of the column headers and row names in the IntelliJudge Message List are determined by selecting options in the Chart Property Window discussed below.

This section describes the features available if you right-click on the column header. For example, a right-click on the Start Time field opens a drop-down menu to change the format of the start time.



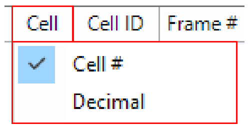
IntelliJudge Message List - Right Click on 'Start Time' Field

The default unit for the Start Time column is the Connected Time, or the time difference from when you connected to the IntelliJudge and the time the message was received. Units for time fields include seconds (s), milliseconds (ms), microseconds (µs), nanoseconds (ns), samples, and a formatted time stamp in UTC or Local Time, if a precision time source such as GPS is available.

- To rearrange the columns, drag any of the column headers to a new position.
- To change the width of the column, click on the right edge of the header and drag it left or right.
- To add a new column to the IntelliJudge Message List, refer to the IntelliJudge Message List Sorting Features on page 443 list in the section below.

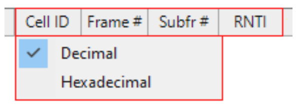
NOTE When you add a field to the IntelliJudge Message List, the field will appear in the third column (pushing the previous third column to the fourth position and moving all following columns to the right by one position).

Right-click on the Cell field header to access a drop-down menu with options to sort by cell number or decimal (if available).



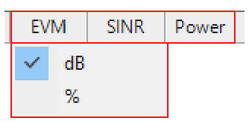
IntelliJudge Message List - Right Click on Cell Field

Right-click on the Cell ID, Frame, Subframe, RNTI, and other fields to access a drop-down menu with options to sort by decimal or hexdecimal.



IntelliJudge Message List - Right Click on Cell ID'Field

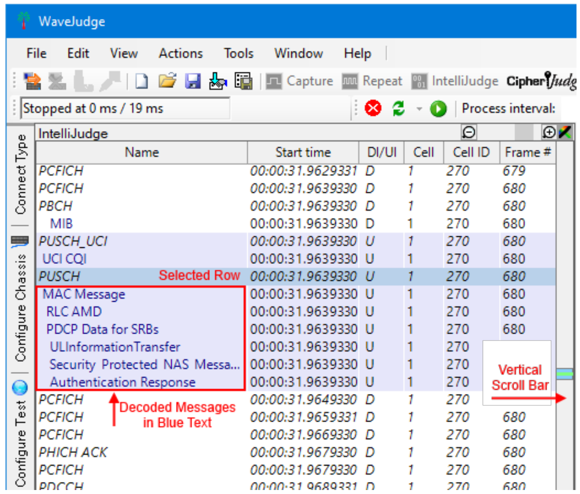
Right-click on the EVM, SINR, Power and other fields to access a drop-down menu with options to sort by decible or percentage.



IntelliJudge Message List - Right Click on EVM, SINR, or Power Field

9. 1. 3 Selecting Messages in IntelliJudge Message List

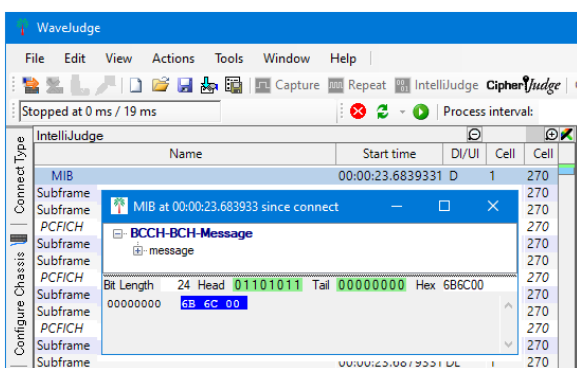
When you select a row IntelliJudge highlights it in a blue background; this marks the current message you are viewing. It is also used to cross-probe to/from triggered IntelliJudge captures.



IntelliJudge Message List - Selecting Messages

Decodable Messages:

Decodable messages are messages where only the name is highlighted in blue (as opposed to the background highlighted in blue). You can decode a message in many different ways. You can double-click the message and click the Enter Key while the row is the Selected Row, or right-click the row and select the Select Message menu item. When the decode window pops up, any item that is highlighted in blue can also be decoded. You can decode those items by double-clicking the item or by pressing the Enter Key while the item is selected. To close the window, click the ESC Key.



IntelliJudge Message List - Decodable Messages are in Blue Text

Vertical Scroll Bar:

The vertical scroll bar lets you quickly scan the message list without moving the selected row. You can quickly move to different parts of the IntelliJudge Message List by dragging the scroller or you can traverse the IntelliJudge Message List by clicking above or below the scroller, moving the IntelliJudge Message List by pages.

You can also use the following keyboard keys to navigate the IntelliJudge Message List.

Up/Down Key:

The Up/Down key moves the selected row Up/Down by one position.

Page Up/Down Key:

The Page Up/Down key moves the selected row Up/Down by the number of viewable rows.

Home Key:

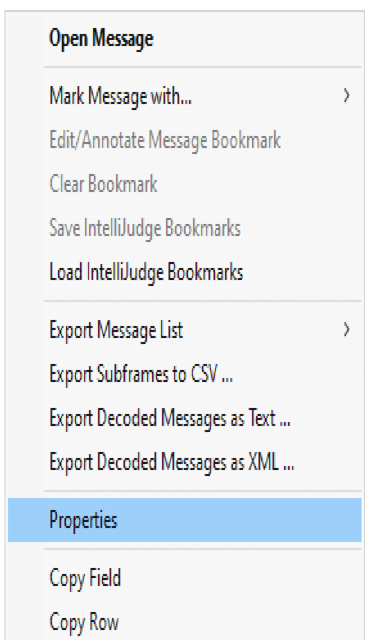
The Home key moves the selected row to the first row.

End Key:

The End key moves the selected row to the last row. It also continuea to move the selected row to the last row if additional messages are added until you take an action that changes the selected row.

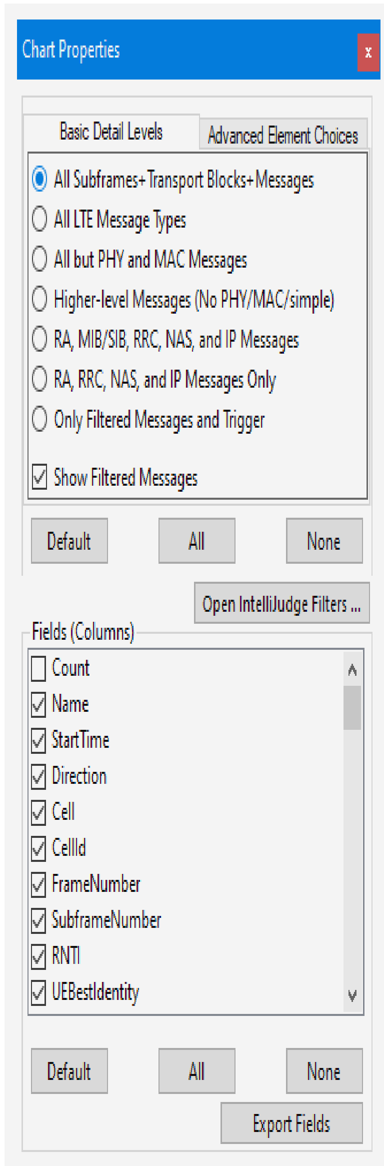
9. 2 IntelliJudge Chart Properties Window

The Chart Properties Window for the IntelliJudge Message List contains most of the options to configure and display data. To access this menu **right-click** anywhere inside the IntelliJudge Message List and and select Properties from the menu options.



Select “Properties” to Open Chart Properties Window

The Chart Properties Window opens as shown here.

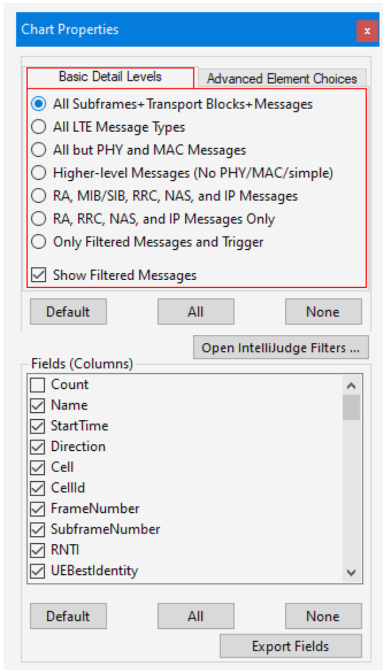


IntelliJudge Message List - Chart Properties Window

Each tab on the Chart Properties Window is described below.

9. 2. 1 Basic Details Levels Tab

The Custom List - Basic Detail Levels Tab has seven radio buttons, however you can only select one at a time.



IntelliJudge Chart Properties Window - Basic Detail Level Tab

Each radio button on the IntelliJudge Chart Properties Window - Basic Details Level Tab is described here.

All Subframes+Transport Blocks+Messages: Displays all frames, subframes, transport blocks (TB), and messages.

All LTE Message Types: Displays all LTE messages.

All But PHY and MAC Messages: Displays everything except physical layer (PHY) and medium access control layer (MAC) messages.

Higher-Level Messages (No PHY/MAC/simple): Displays only higherlayer messages.

RA, MIB/SIB, RRC, NAS, and IP Messages: Displays all random access (RA), master information block (MIB)/system information block (SIB), radio resource control (RRC), non-access stratum (NAS), and internet protocol (IP) messages.

RA, RRC, NAS, and IP Messages Only: Displays all random access (RA), radio resource control (RRC), non-access stratum (NAS), and internet protocol (IP) messages.

Only Filtered Messages and Trigger: Displays only messages configured via the message list Filters dialog and the trigger message.

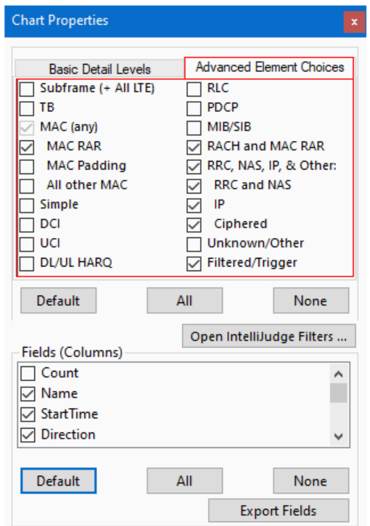
Show Filtered Messages: Lets you add additional messages to the list.

NOTE The only two elements that are in IntelliJudge but not in the WaveJudge Chart Properties are the All Subframes+Transport Blocks+Messages and the Higher-Level Messages (No

NOTE PHY/MAC/simple).

9. 2. 2 IntelliJudge Advanced Element Choices Tab

The Advanced Element Choices Tab has only seven default options compared to the WaveJudge Advanced Tab's 12 default options.



IntelliJudge Chart Properties Window - Advanced Element Choices Tab

9. 2. 2. 1 IntelliJudge Advanced Elements - Default Settings

With the Advanced Element Settings tab open, click the Default button to reset all options to the default settings as follows:

MAC (RAR): Medium access control layer (random access response)

RACH and MAC RAR: Random qccess channel (RACH) and medium access control (MAC) random access response (RAR)

RRC, NAS, IP, and Other: Ratio resource control (RRC), non-access-stratum (NAS), internet protocol (IP) and other messages

RRC and NAS: Radio resource control (RRC), non-access-stratum (NAS) messages only

IP: Internet protocol messages

Ciphered: Ciphered messages

Filtered/Trigger: Filtered and triggered messages

9. 2. 2. 2 IntelliJudge Advanced Elements - Optional Settings

You can also select individual optional Advanced Elements settings, as listed below.

Subframe (+ All LTE): Uplink or downlink subframe

TB: Transport blocks

MAC (Any): Medium access control layer messages

MAC Padding: Padding PDUs or padding bytes; FF

All Other MAC: All other MAC settings

Simple: Simple messages

DCI: Downlink control interface messages

UCI: Unified configuration interface

DL/UL HARQ: Downlink / uplink hybrid automatic repeat request

RLC: Radio link control

PDCP: Packet data convergence protocol level messages

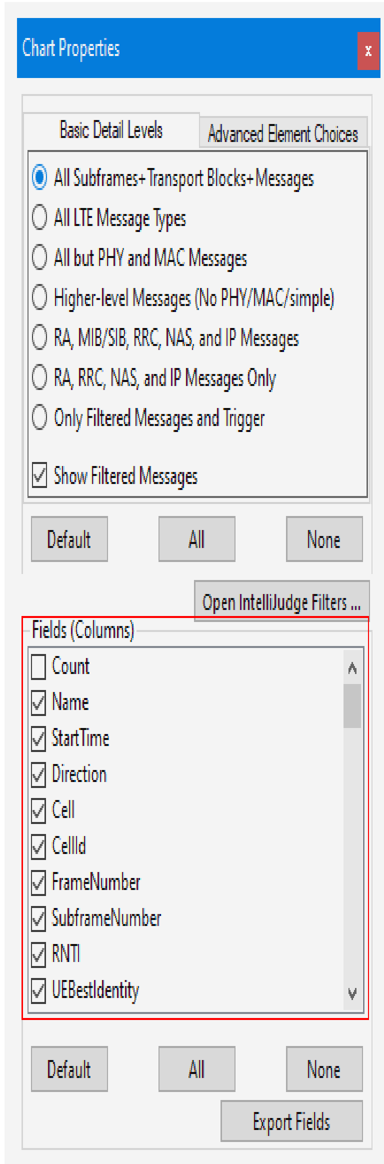
MIB/SIB: Master information block / system information block uplink or downlink transmission

Unknown/Other Unknown or other message types

> **NOTE** WaveJudge Chart Properties only has nine optional advanced elements; IntelliJudge has 13. The options unique to IntelliJudge are **Subframe (+ All LTE)**, **Simple**, **DCI**, **UCI**, and **DL/UL HARQ**.

9. 2. 3 IntelliJudge Fields (Columns)

The **Fields (Columns)** section allows you to select the data you want to display in the IntelliJudge Message List.



IntelliJudge Message List - Chart Properties Window: Fields (Columns) Section

The seven buttons on the Chart Properties window are described below.

The **Default** button selects the default headers.

The **All** button selects all headers.

The **None** button deselects all headers.

The **Open IntelliJudge Filters** button opens the window discussed in Configure Filters for LTE / IntelliJudge Messages on page 309.

The **Export Fields** button opens a “Save As” window to export data as a new file.

9. 2. 3. 1 IntelliJudge Fields (Columns) - Default Settings

The default headers, also known as column titles or field titles, are described below. The first entry in each section is how the column headers appear in the message list; the names in parentheses indicate the column names as they appear in the Chart Properties window, if they are different.

Name: Name of message, transport block, or element (e.g., Subframe)

Start Time: Start time of the transmission for this message or element, in the selected units

Direction: Direction of this message or element (Downlink or Uplink)

Cell: Index in WaveJudge configuration of cell for this message or element (e.g., as shown in Configure Test)

Cell ID: LTE Physical Cell ID of cell for this message or element

FrameNumber: LTE frame number for this message or element, in range 0 to 1023

SubframeNumber: LTE subframe index for this message or element, in range 0 to 9.

NOTE

The frame number and subframe number are commonly used together to identify the time when some particular event of interest occurred.

RNTI: Radio Network Temporary Identifier for this message or element.

Error Checking: Any error flag.

UEBestIdentity (UE Best Identity): Best available information about identity of UE for this message (IMSI if available, or GUTI if that is available, or earlier RNTI if it is possible to reference this message's session to a session on a previous RNTI)

EVM: Error vector magnitude for this message or element, from the physical transmission.

Power: Power level for this message or element, from the physical transmission.

Length: Length of the message content in bytes, if applicable.

Errors: Any errors associated with this message or element, or "OK" if none.

Retransmission: Retransmission.

Decrypted: The decryption status for encrypted messages, if applicable.

Validated: The cryptographic validation status for authenticated messages, if applicable.

NOTE

IntelliJudge default fields are quite different from WaveJudge's default fields; IntelliJudge's default settings do not include Port, #Bytes, Code, N Resources, Timing Offset, and Subframe Index. However, IntelliJudge added Cell, Subframe Number, Length, Errors, and Retransmission to the default list.

9. 2. 3. 2 IntelliJudge Fields (Columns) - Optional

Many other optional columns headers are available in the **Fields (Columns)** section of the Chart Properties Window. The first set of items is how the column headers appear in the message list, the names in parenthesis are the full names as identified in the Chart Properties window.

Count: Rarely used; shows index of the given line within the current displayed list

SINR: Signal to interference plus noise ratio

RSSI: Received signal strength indicator

RSRP: Reference signal received power measurement for the subframe

RSRQ: Reference signal received quality measurement for the subframe

IMSI: International mobile subscriber identity

GUTI: Globally unique temporary identifier

Buffer Length (BufferLength): NOT USED

CrcErr (CrcError): Number of CRC errors, specifically (disregards other error types).

ShortName: Rarely used; shows, in some cases, an abbreviated or shortened version of the message name for MAC or higher layer messages.

CodeWordIndex: Shows the code word index for the message, if applicable; applies only to certain transport block types which may contain two or more codewords within a single TB; shows 0 for all other cases.

DciAggregation: Downlink control information (DCI) aggregation value

DciFormat: Downlink control information (DCI) format code

DciStart: Downlink control information (DCI) start value

Data: Displays actual data content as a series of bytes in hexadecimal or decimal format; not generally useful except when exporting message list content or examining very short messages.

PartCount: For higher layer messages, the number of parts (transport blocks or lower layer messages) which were assembled to create this message's content.

LCID: Logical Channel ID for the message; LCID is used in multiplexing data for different Radio Bearers within the MAC layer for DL-SCH and UL-SCH, controlling how the content within MAC messages will be decoded.

EndTime: End of transmission time of this message or element. For LTE, in most cases it is considered the end of the message's subframe, 1ms after its Start Time.

SyncCounter: Indicates the number of times IntelliJudge had performed a sync to the LTE signal at the time the message was decoded.

NOTE 1 is normal; a value greater than 1 indicates sync was lost at least once, and increasing values mean that IntelliJudge is repeatedly

NOTE losing sync due to a weak signal, interference, or some other reason.

GPSTimeTicks: The unformatted time value associated with this message from the GPS source, using units of MS .Net ticks (100 ns).

ConnectedTimeTicks: The unformatted time value associated with this message from the IntelliJudge sample count, using units of MS .Net ticks (100 ns).

IPSourceAddress: For decoded messages at IP transport layer only, the IPv4 or IPv6 source address of the message. This is only observed if traffic decryption is successful or the network traffic is unencrypted.

IPDestinationAddress: For decoded messages at IP transport layer only, the IPv4 or IPv6 destination address of the message. This is only observed if traffic decryption is successful or the network traffic is unencrypted.

IPProtocol: For decoded messages at IP transport layer only, the IP layer protocol such as TCP, UDP, ICMP, or DHCP. This is only observed if traffic decryption is successful or the network traffic is unencrypted.

ApplicationPort: For decoded messages at IP transport layer only, shows the more meaningful of the IP Source Port or IP Destination Port, if possible translated to a named application protocol such as “HTTP query”, “DNS reply”, or “FTP”. This is only observed if traffic decryption is successful or the network traffic is unencrypted.

IPSourcePort: For decoded messages at IP transport layer only, shows the IP Source Port (sending port number) as a numeric value. This is only observed if traffic decryption is successful or the network traffic is unencrypted.

IPDestinationPort: For decoded messages at IP transport layer only, shows the IP Destination Port (receiving port number) as a numeric value. This is only observed if traffic decryption is successful or the network traffic is unencrypted.

ECID: Enhanced Cell Identity of cell for this message or element.

EARFCN_DL: Evolved Absolute Radio Frequency Channel Number (EARFCN) for downlink (LTE carrier channel numbers).

CorrectedBits: The number of bits corrected by the error correcting algorithms for this transport block or the physical transport block associated with this message.

NRb: The number of Resource Blocks (RBs) allocated for this transport block or the physical transport block associated with this message.

MCS: Modulation and coding scheme code number used for this transport block or the physical transport block associated with this message.

RVID: Redundancy value used in transmitting this transport block or the physical transport block associated with this message.

NLayer: Number of layers per codeword used in transmitting this transport block or the physical transport block associated with this message.

EPRE: Power measurement for this transport block or the physical transport block associated with this message, calculated as power per subcarrier or EPRE (Energy per Resource Element).

NewDataIndicator: Value of the New Data Indicator (NDI) flag used in scheduling and transmitting this transport block or the physical transport block associated with this message. NDI is part of the HARQ processing procedure for LTE.

ModulationType: Displays the modulation type (in readable form) used for this transport block or the physical transport block associated with this message.

HarqProcess: HARQ Process ID value used in scheduling and transmitting this transport block or the physical transport block associated with this message. HARQ Process ID is part of the HARQ processing procedure for LTE.

TbIndex: NOT USED

Transmission Mode: Transmission mode used for this transport block or the physical transport block associated with this message.

TimingOffset: For uplink transport blocks only, indicates uplink timing offset for this transport block or the physical transport block associated with this message.

RAPID: For PRACH/RACH and MAC RAR (random access response) only, indicates the RAPID (Random Access Process ID) for this PRACH transport block or associated with it in the MAC RAR reply.

PHY Rnti: Physical layer radio network temporary identifier (RNTI), where this may differ from the logical RNTI.

CodeValue: PCFICH decoding result, representing the control symbol length for the current subframe.

BandType: Represents the PHY type if the underlying PHY is NB-IoT or eMTC.

RepetitionIndex: Represents the repetition index of a given physical channel in a narrow band PHY (including NB-IoT and eMTC).

NumRepetition: Represents the total number of repetitions for a given physical channel in a narrow band PHY (including NB-IoT and eMTC).

CELevel: When in a common search space of a narrow band PHY (including NB-IoT and eMTC), represents the CE level for a physical channel.

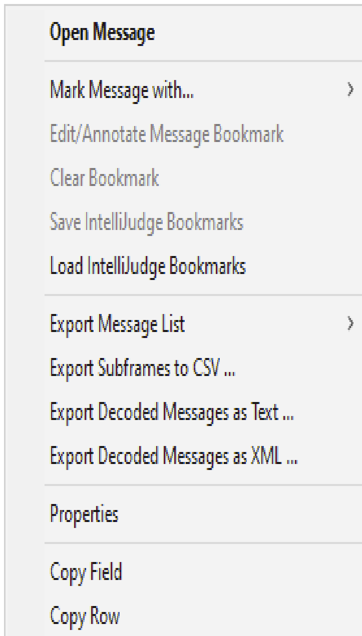
NumResourceUnit: Represents the total number of resource units (RU) for a NPDSCH or NPUSCH.

ResourceUnitIndex: Represents the resource unit (RU) index for the NPDSCH or NPUSCH in the current subframe.

NRe: Represents the number of resource elements (RE) allocated to a NB-IoT PHY entity.

9. 3 IntelliJudge Message List Context Menu

Similar to the WaveJudge Message List, if you right-click in the IntelliJudge Message List a Context Menu opens, as shown here.

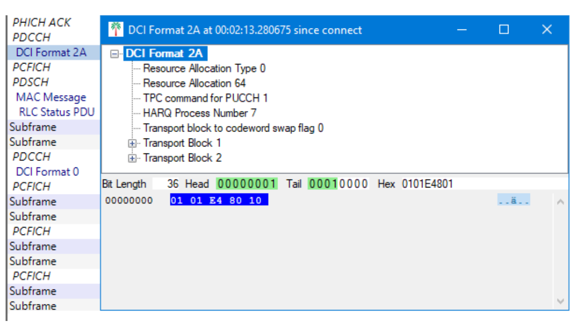


IntelliJudge Message List - Context Menu

Options in this window are described below.

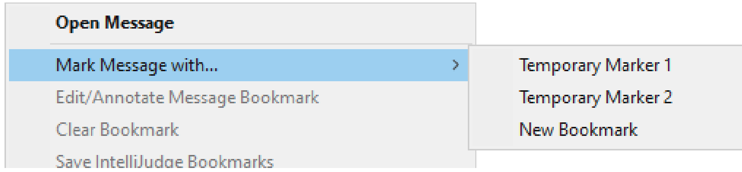
Open Message:

Opens a message in a new window and displays information about a specific message the cursor is on (highlighted in blue).



Mark Message With:

Opens a submenu to mark a message with one of three markers: Temporary Marker 1, Temporary Marker 2, or a New Bookmark. Functions are the same as waveJudge temporary markers; for more information, refer to Mark Message with... on page 249.



Edit/Annotate Message Bookmark:

Allows you to edit or add a message to a bookmark.

Clear Bookmark:

Clears/deletes a bookmark.

Save IntelliJudge Bookmarks:

Saves all IntelliJudge bookmarks to a *.bookmark file.

Load IntelliJudge Bookmarks:

Loads an IntelliJudge bookmark file.

Export Message List:

To export the current data in the IntelliJudge Message List, right-click a line item the message list. A popup menu will appear with several options. To export to an Excel compatible worksheet, select the menu item Export to CSV.

- as CSV...: Opens a Save As window to save the file as .csv.
- as Access MDB...: Opens a Save As window to save the file as .mdb.
- as SQLite...: Opens a Save As window to save the file as .sqlite.

Select the menu item, a Save File window will appear. Choose a name for the file. If the number of rows exceeds 65563 rows, additional files will automatically be created due to compatibility issues using certain programs.

If you are currently in the middle of an IntelliJudge capture, this export function will NOT include any new data captured after you started to export the data. Depending on the length and amount of data exporting, this function may take several minutes.

Export Subframes to CSV...:

Opens a Save As window to save the file as .csv.

Export Decoded Messages as Text...:

Opens a Save As window to save the file as .txt.

Export Decoded Messages as XML ...:

Opens a Save As window to save the file as .xml.

Properties:

This section is described in the next section IntelliJudge Chart Properties Window on page 446.

Copy Field:

Copies the cell of a selected messsage where the cursor is.

Copy Row:

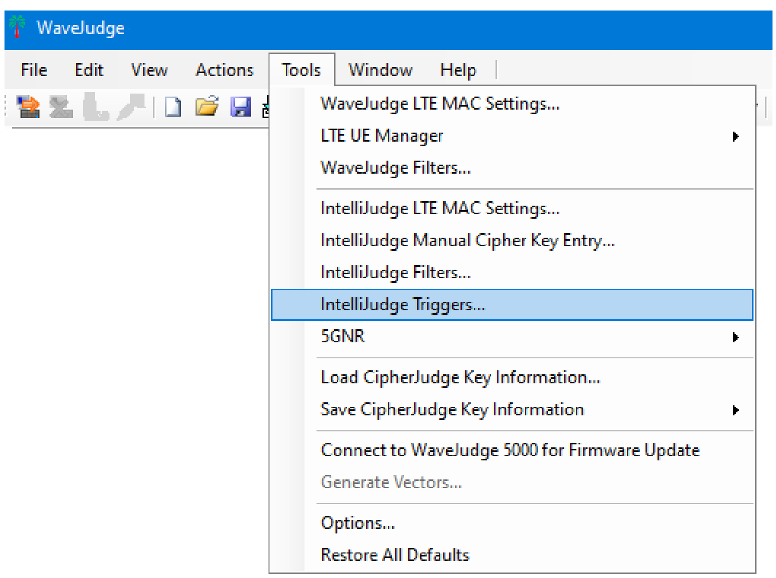
Copies the whole row of a selected message.

9. 4 IntelliJudge Triggered Capture Results

When a triggered event occurs the triggered message highlights in yellow. The capture then downloads into the WaveJudge chassis and is stored. When the capture phase is Data Captured, it is safe to stop the IntelliJudge capture and process the triggered capture. You may stop the capture at any time but if you stop the capture before the capture phase is Data Captured, the triggered capture may not have downloaded into the WaveJudge chassis. After stopping the capture, the data, if available, will automatically be processed. You can cross-probe between the IntelliJudge Message List and the captured results message list.

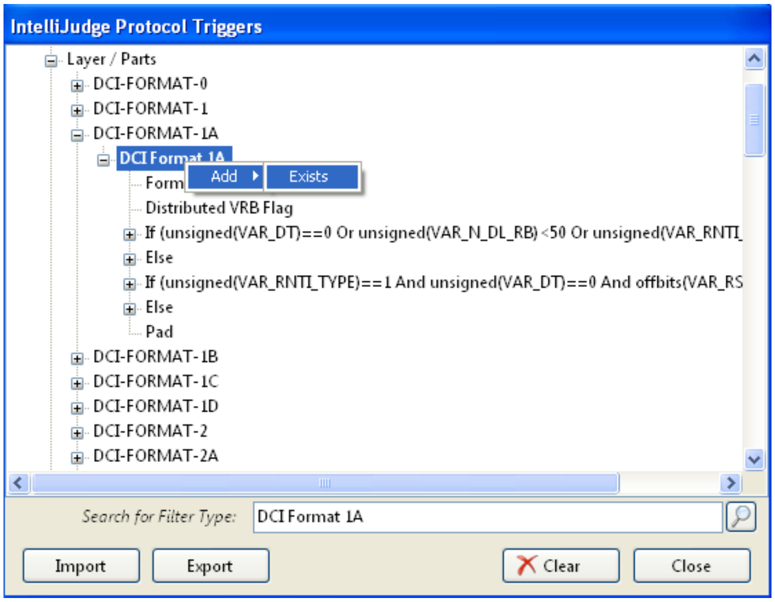
9. 4. 1 Set Up and Take an IntelliJudge Triggered Capture

This section explains how to take an IntelliJudge triggered capture. After setting up your configuration and connecting to the WaveJudge chassis, you will need to set an IntelliJudge trigger. To do this, click the Tools menu and select the menu item IntelliJudge Triggers.



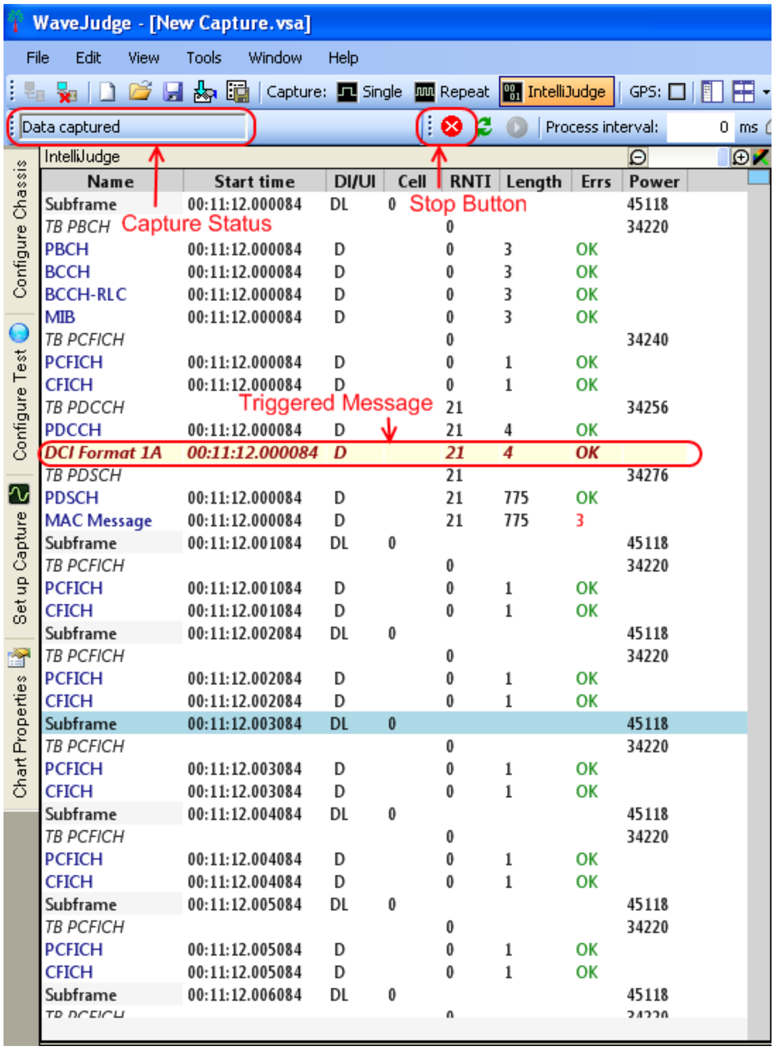
Tools Menu - IntelliJudge Triggers

The IntelliJudge Triggers window will open. Set the triggers you want for the capture. In the example below, DCI-Format 1A messages will trigger a capture. For additional information to set triggers refer to Filtered Messages on page 495. After setting the trigger(s), close the window.



IntelliJudge Message List - Trigger Window "DCI Format 1A"

To start an IntelliJudge capture press the **IntelliJudge** button, a normal IntelliJudge capture will occur. If the IntelliJudge capture is triggered, the message that triggered the capture will highlight in yellow. The triggered capture will download into the WaveJudge chassis. The capture status will change from Waiting for Trigger to Capturing. When the capture status changes to Data Captured the triggered capture has finished downloading. Press the **Stop** button to process the triggered capture.



IntelliJudge Message List - Triggered Capture

After pressing the Stop button, the triggered capture will process. For WaveJudge to cross-probe, you must have a normal WaveJudge Message List open; click the side panel button to open it. Select the type of messages to display in the WaveJudge Message List by setting the WaveJudge Messages Chart Properties on page 429.

To cross-probe between message lists, select a message from either Message List; the other MessageList will highlight the corresponding message if it exists there. If it does not exist, no items will highlight in the other MessageList.

To view the same start time values in the IntelliJudge MessageList and the WaveJudge MessageList, click the Start Time header. A menu will open listing different options to choose from. Select Connected Time; the Start Time is now synchronized.

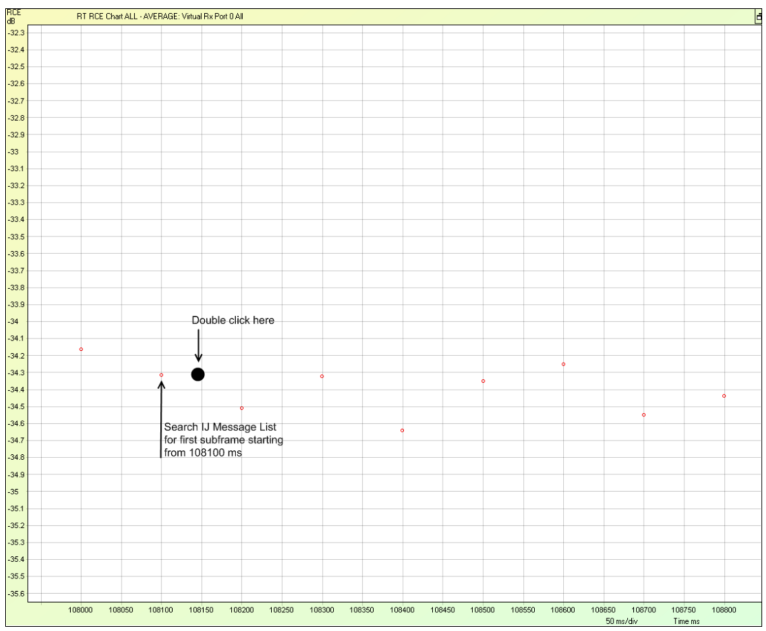
IntelliJudge Message List - Triggered Capture Correlation

9. 5 Using IntelliJudge Charts

This section explains how to use different IntelliJudge chart functions.

9. 5. 1 Open IntelliJudge Message List from an IntelliJudge Chart

Double-clicking on a real-time chart prompts WaveJudge to cross-probe from the IntelliJudge Chart to the IntelliJudge Message List. The WaveJudge software will find the nearest previous point drawn on the chart, it then searches the IntelliJudge Message List for the first subframe starting from the time of the data point found in the real time chart. The image below shows double-clicking a spot after a data point and where the IntelliJudge message list will highlight.



IntelliJudge Chart - Double Click Data Point Area

9. 5. 2 Use IntelliJudge Charts with Saved Captures

You can use IntelliJudge charts with any previously saved IntelliJudge capture. After setting up your IntelliJudge charts there are several ways to use them with a saved IntelliJudge capture.

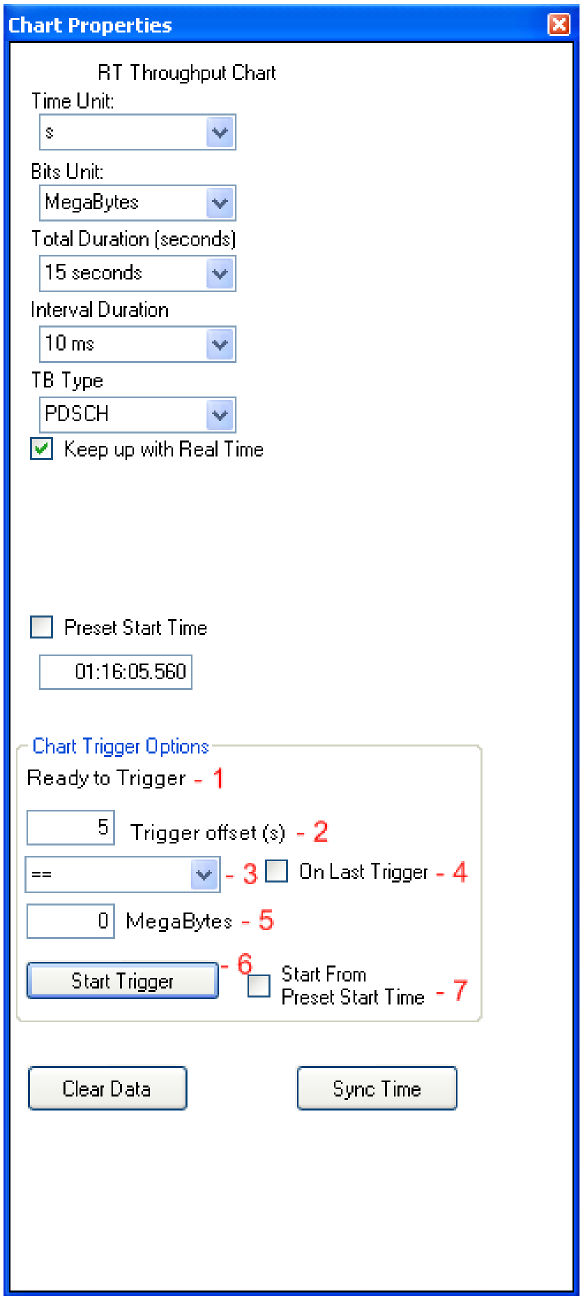
1. Load the IntelliJudge capture and see the resulting IntelliJudge charts process the saved capture's data.
2. Load the IntelliJudge capture and set the IntelliJudge Real Time Preset Start Time on page 423 to a known problem.

3. Set a chart trigger, load an IntelliJudge capture, and see if the IntelliJudge chart triggers.

   NOTE **Reprocessing the IntelliJudge capture will also reprocess the data in the IntelliJudge charts.**

9. 5. 2. 1 Real Time Triggers

You can set triggers for each IntelliJudge chart. When a chart is triggered, it automatically sets up the Preset Start Time to the trigger time minus the Trigger Offset. The image below shows the available options.



IntelliJudge Chart Trigger Options

The red numbers corresponding to the figure above are described below.

1 - Status:

This is the status, it may have any of the following states:

- Ready to Trigger: It is waiting for you to start a trigger.
- Waiting for Trigger: It is comparing values and is waiting for a value that matches your comparison type and value.
- Triggering: It has found a value that matches the comparison type and value but

the **On Last Trigger** option is enabled and is still triggering.

- **Last Triggered at <Time>Seconds:** This line tells you when the trigger has occured.

2 - Trigger Offset:

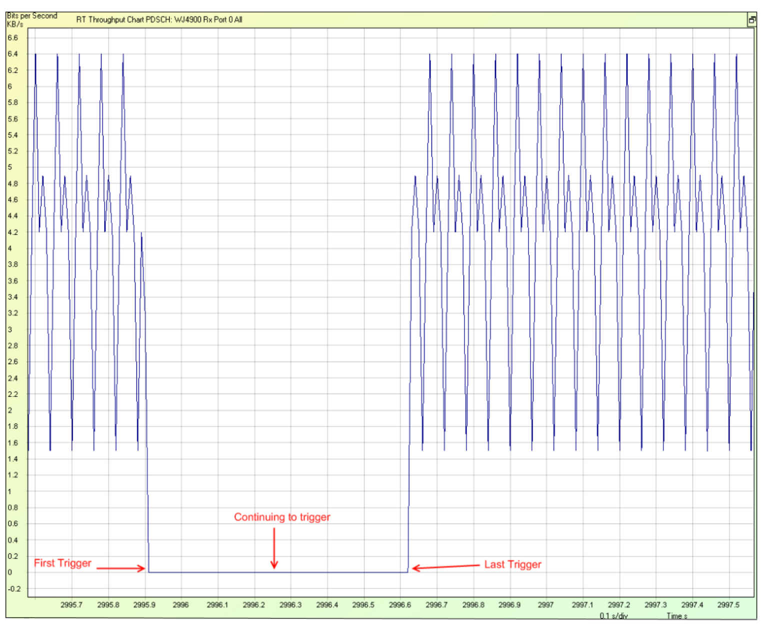
The trigger offset value indicates the number of seconds you want to set before the trigger. For example, if you trigger at 30 seconds and set the trigger offset to 5 seconds, it will set the preset start time to 25 seconds. If you set the trigger offset value to 0 seconds it will set the preset start time to 30 seconds. If you set the preset start time to -5 seconds it will set the preset start time to 35 seconds.

3 - Comparison Type:

The comparison type lets you set the comparison operative. The operatives **Between** and **Not Between** are inclusive of the values.

4 - On Last Trigger:

This option lets you get the last occurrence of the trigger. The image below shows a capture. If you had set the trigger to 0 KB/s, it would have first triggered at around 2995.91 seconds. If you did not have **On Last Trigger** enabled, it would have triggered at the first trigger point. If you had **On Last Trigger** enabled, it would continue triggering until the last trigger at around 2996.61 seconds.



IntelliJudge Chart - On Last Trigger

5 - Comparison Value:

The value you want to use in conjunction with the comparison type to determine if the chart should trigger.

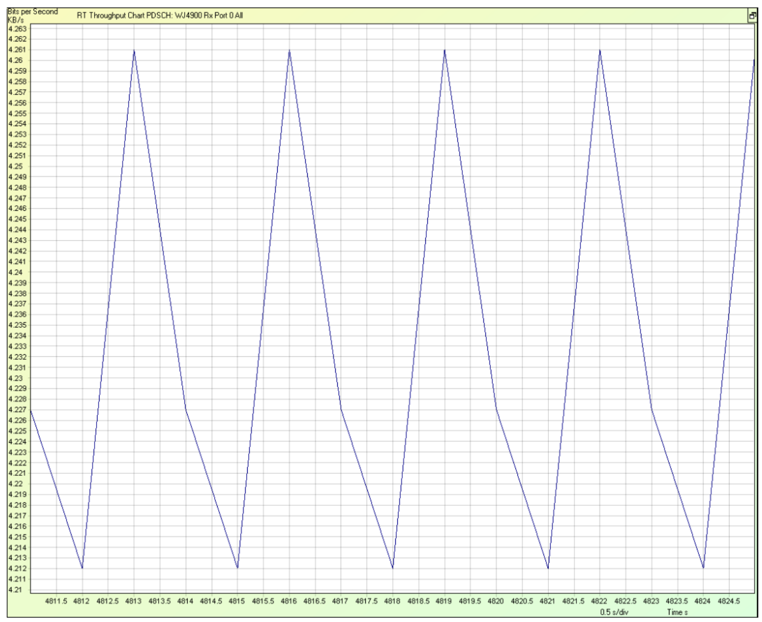
6 - Start Trigger:

Starts/stops the current chart trigger.

7 - Start from Preset Start Time:

This checkbox lets you search for a trigger starting from the pre-defined start time. This is useful when you want to skip a section of data.

Let’s assume you are taking an IntelliJudge capture. You look at your IntelliJudge Throughput chart and see that the throughput is around 4.2 KB/s. An image of the Real Time Throughput chart with a normal throughput for this capture is below.

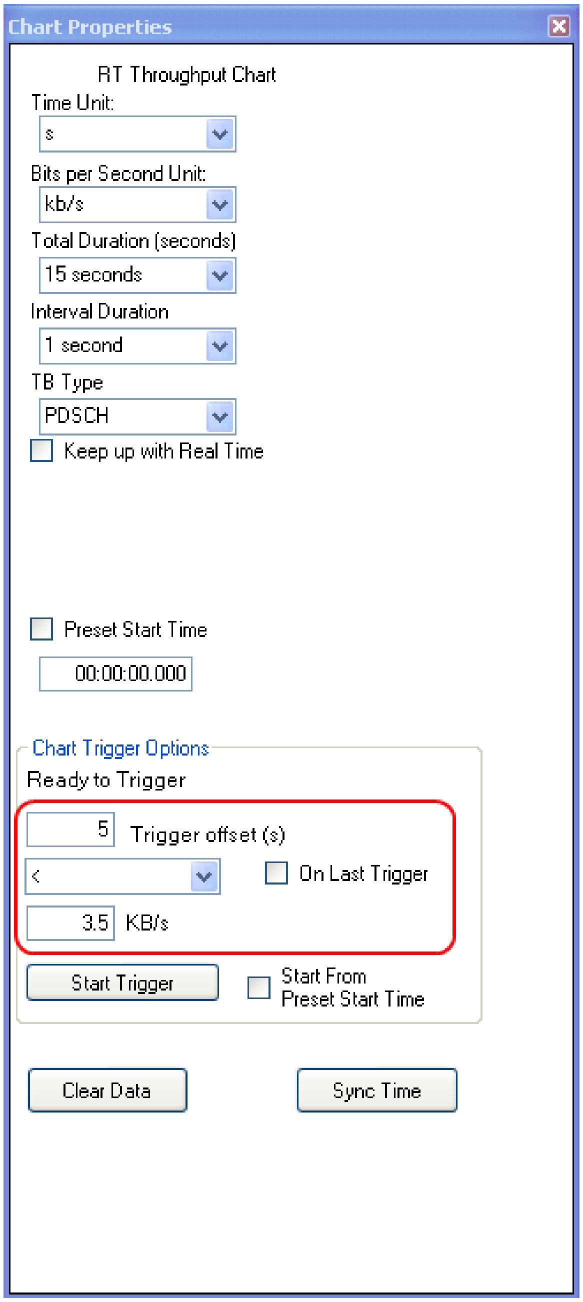


IntelliJudge Real Time Throughput Chart

You want to make sure that the **throughput is always above 3.5 KB/**s. Here are the steps to do this.

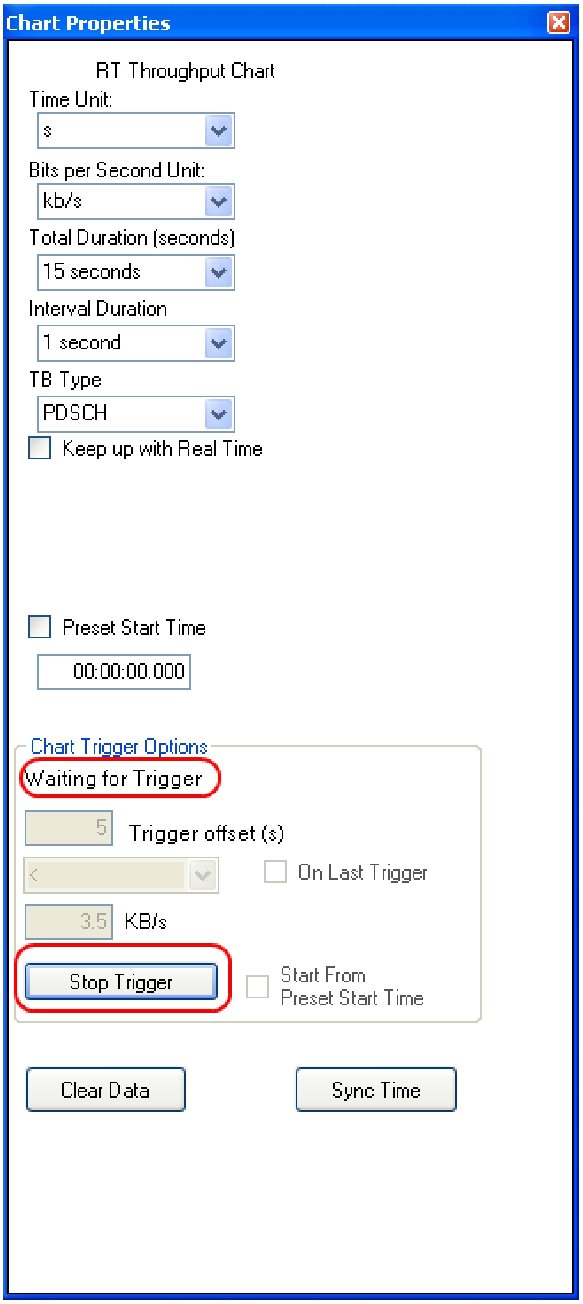
1. Open the Chart Properties window by clicking on the Chart Properties tab and click on the IntelliJudge Throughput chart.
2. Set the trigger offset to 5 seconds.
3. Set the comparison type to less than “ <”.
4. Set the comparison value to 3.5 KB/s. This means that if there are any value points that are less than 3.5 KB/s, it will trigger and set the preset start time to 5 seconds before the trigger point.

An example of the Chart Properties window showing where to input the values is shown below.



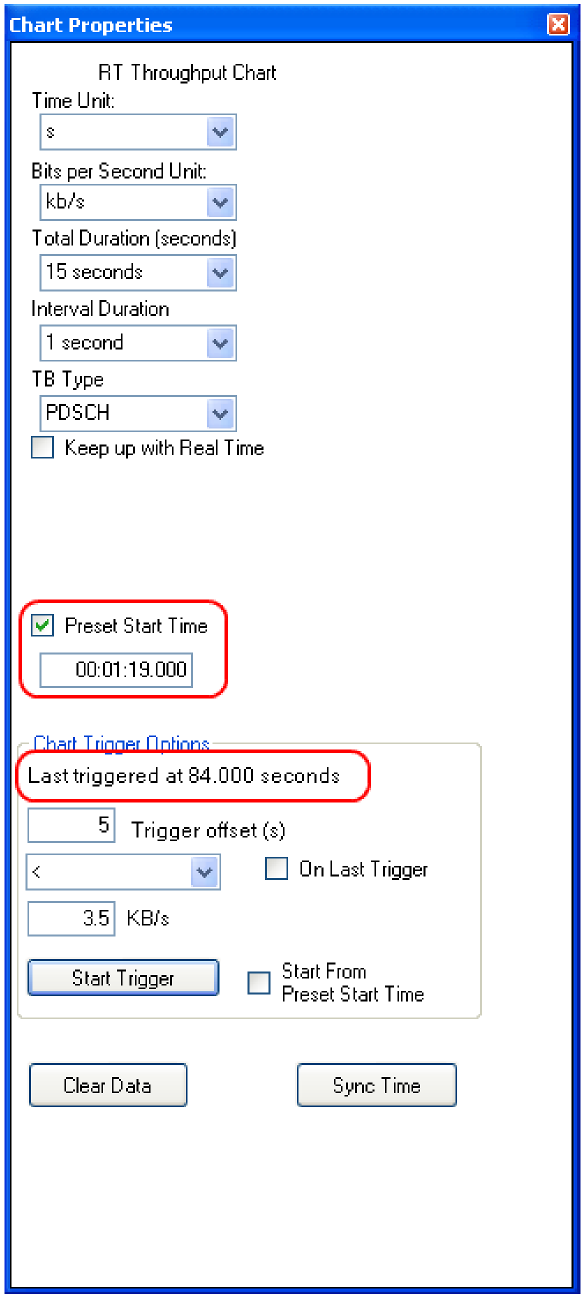
IntelliJudge - Trigger Offsets

Once you have set the values for the triggers, start the trigger by pressing the **Start Trigger** button. The status line will show the message Waiting for Trigger. Wait for a trigger to occur. You can stop the trigger at any time by pressing the **Stop Trigger** button. An example of how the Chart Properties window looks like after starting the trigger is shown below.



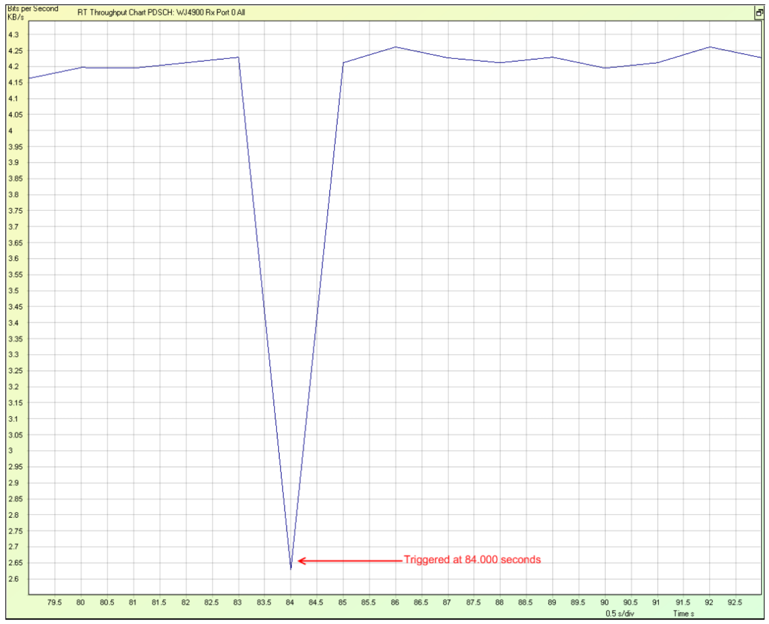
IntelliJudge - Waiting for Trigger

If the chart is triggered, the status line will tell you when the trigger occurred and set the Preset Start Time to the trigger time minus the Trigger Offset. In this example, assume that the chart triggered at 84.000 seconds. Since the Trigger Offset is five seconds, it will set the Preset Start Time to 79.000 seconds; or 00:01:19.000. The figure below shows an example of what the Chart Properties window looks like after a trigger.



IntelliJudge - After Trigger

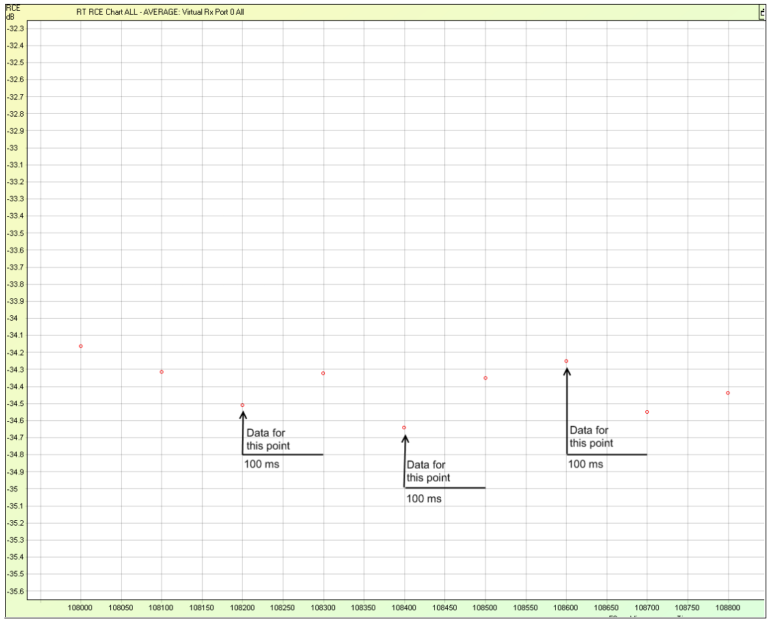
The image below shows the resulting chart in the Real Time Throughput chart.



IntelliJudge Throughput Chart Showing Trigger

9. 5. 2. 2 Read Data Points in a Real Time Chart

Each point drawn on an IntelliJudge chart is dependent on the Interval Duration. If a point is drawn with an interval duration of 100 ms, the data for that point comes from all data within the next 100 ms. If a point is drawn with an interval duration of 10 ms, the data for that point comes from all data within the next 10 ms.



IntelliJudge EVM Chart Showing Interval Duration of 100 ms

The chart above is an IntelliJudge EVM chart that shows the average of all TBs. Assume that the interval duration is 100 ms for the chart above; the point at 108200 ms contains the data for the time period between 108200 (inclusive) to 108300 (non-inclusive). From this chart, you can conclude that the average EVM of all TBs between 108200 (inclusive) and 108300 (non-inclusive) is approximately -34.5 dBm.

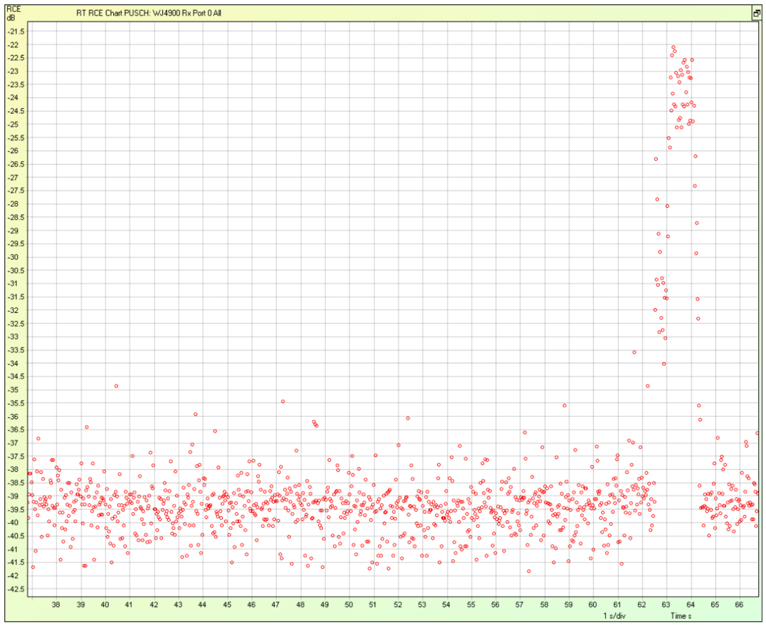
In the chart below, the interval duration is 10 ms for the same chart. The black line illustrates where the data point is present. The red line illustrates where the data point is not present. Even though the points are separated by 100 ms, only 10 ms is represented for each data point. For example, the point at 108200 ms only represents data between 108200 (inclusive) to 108210 (non-inclusive). You can conclude from this chart that between 108200 (inclusive) and 108210 (non-inclusive), the average RCE for all TBs is -34.5 dBm. You can also conclude that there are no TBs between 108210 (inclusive) and 108300 (non-inclusive) because there are no data points between 108210 ms (inclusive) and 108300ms (non-inclusive).

IntelliJudge EVM Chart Showing Interval Duration of 10 ms

9. 5. 2. 3 IntelliJudge Real Time Preset Start Time

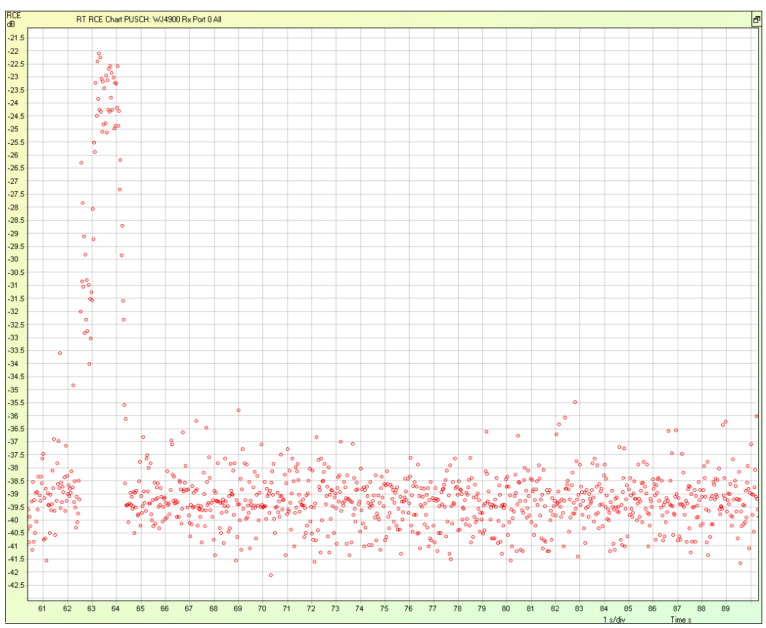
The **IntelliJudge Preset Time** function lets you draw an IntelliJudge chart starting at a pre-defined time and lock onto that time span. This is very useful to analyze data because if you do not have a preset start time, the data points will eventually be replaced with new data points and you will be unable to view them anymore. An example situation of how to use the preset start time option is explained below.

Say you want to take a capture and observe the IntelliJudge EVM chart. You set the total duration to 30 seconds and the interval duration to 10ms or 1 frame. You connect to the hardware and start an IntelliJudge capture. You see that everything looks fine until around one minute. You see some data points with bad EVM for a few seconds. You want to continue running the IntelliJudge capture and look at the problem area where the EVM suddenly got worse. If you let the IntelliJudge capture continue, the IntelliJudge chart will eventually replace the data points around the poor EVM with new data points from the IntelliJudge capture. The example below shows you how to keep capturing and observe the problem area. You notice (in the chart below) that around 62 seconds the EVM got significantly worse for about two seconds. You start to investigate the problem.



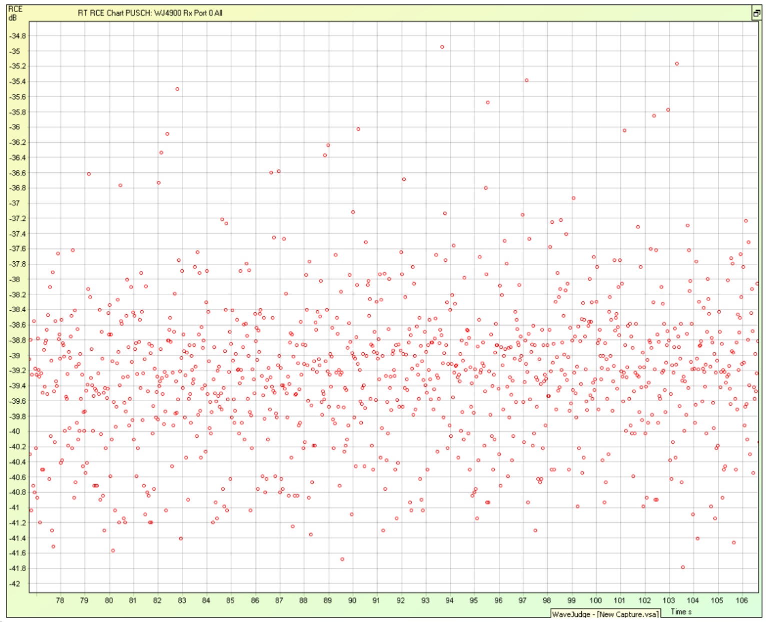
IntelliJudge EVM Chart - Problem at 62 Seconds

Since this is a real-time chart, new data are constantly added to it. In the chart below, 25 seconds has passed. Since the total duration is only 30 seconds the problem area is quickly replaced with new data points.



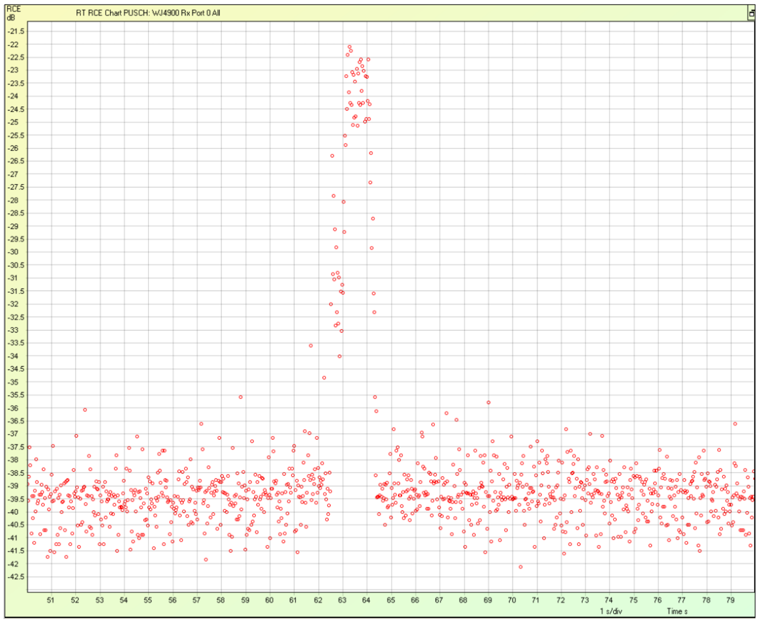
IntelliJudge EVM Chart - Problem at 25 Seconds

In the chart below, the problem area is completely removed and replaced by new data points from the IntelliJudge capture.



IntelliJudge EVM Chart - Problem Gone

Let's assume you want to continue looking at the problem area. To do this, you need to set a preset start time. Open the **Chart Properties** window of this chart by clicking the Chart Properties tab on the left of the GUI and click on the chart. Alternatively, you can right-click the chart and select **Properties**, this opens the Chart Properties window for this chart. Since the problem area was around 60 seconds in, you will probably want to observe the time period before the problem area so set the preset time to 50 seconds. After setting the time, click the **Preset Start Time** checkbox to redraw the IntelliJudge chart starting at 50 seconds. This will NOT affect any other real-time charts running, so you can have other real-time charts drawing new data from the capture at the same time. The figure below shows the resulting chart.



IntelliJudge EVM Chart - Preset Start Time Set to 50 Seconds

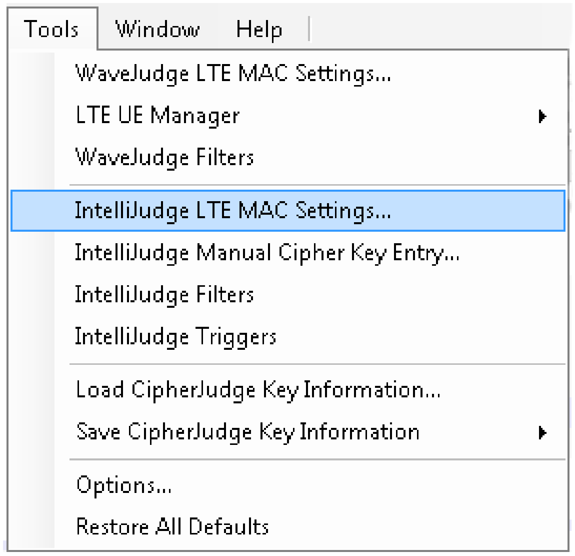
9.6 Radio Link Control (RLC)

This section discusses how to use the RLC settings for an IntelliJudge capture.

9.6.1 Default RLC Settings

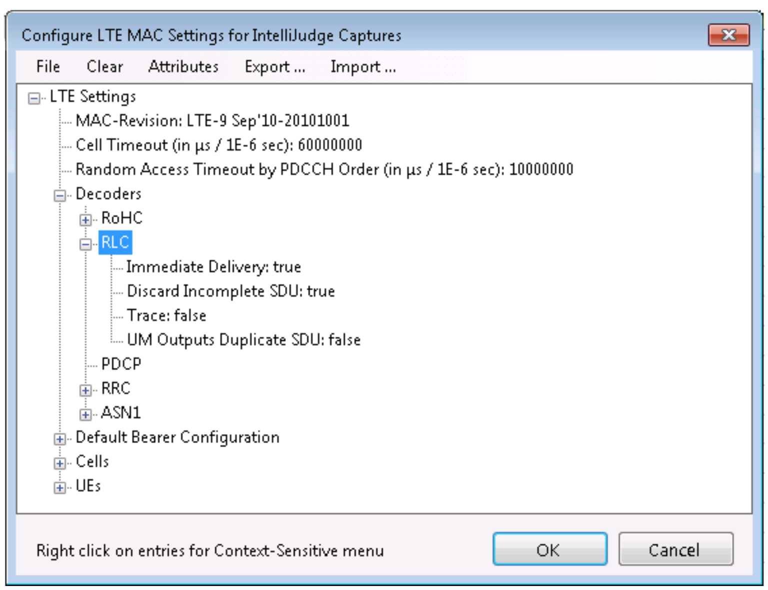
Before you connect to the WaveJudge and IntelliJudge chassis, you can set your default RLC settings. Open the IntelliJudge LTE MAC Settings window from the tools menu.

NOTE Do not load any IntelliJudge capture file prior to setting default RLC settings and taking a new IntelliJudge capture. Any previously defined RLC settings may override default RLC settings.



IntelliJudge Message List - LTE MAC

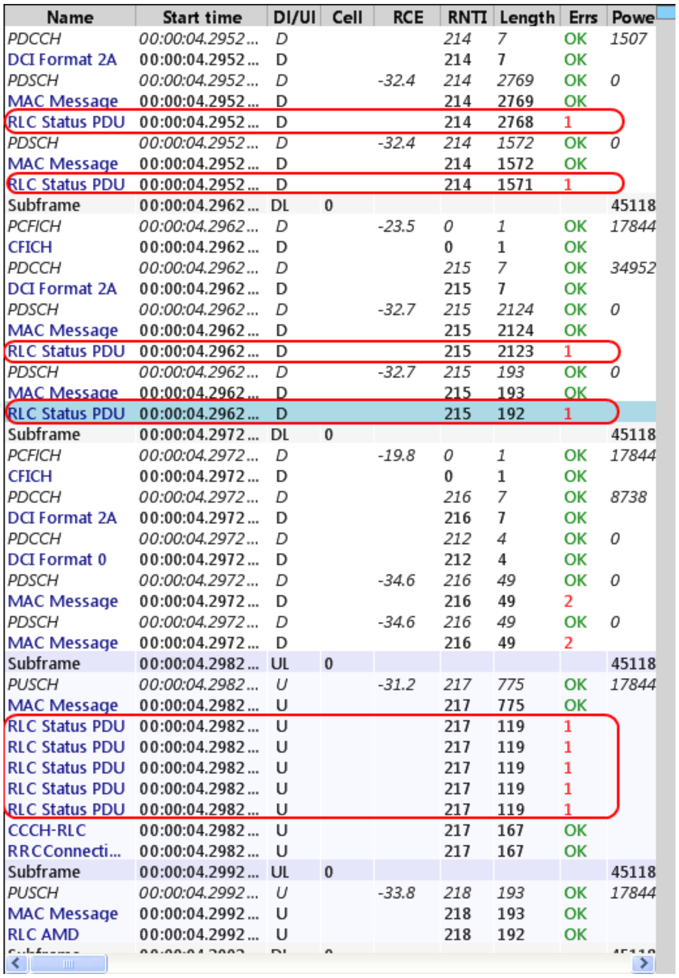
Click the tree to the RLC settings and set your default settings (i.e., select the Tools Menu -> IntelliJudge LTE MAC Settings -> Decoders -> RLC).



IntelliJudge Message List - RLC Default Mode

9. 6. 2 Fix RLC Settings

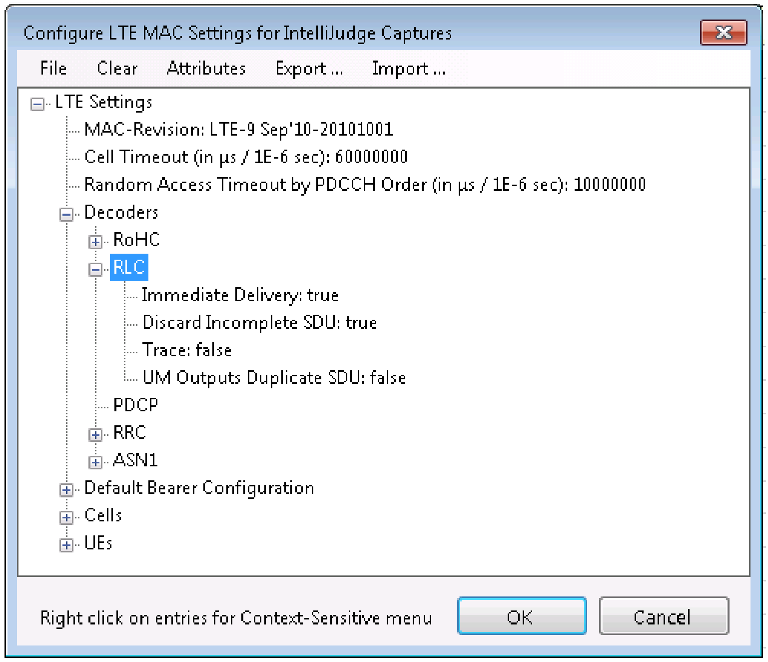
If you have RLC errors due to incorrect RLC messages, you can fix them through the IntelliJudge LTE MAC Settings window. The image below shows incorrect RLC messages in the Message List.



Name	Start time	DI/UI	Cell	RCE	RNTI	Length	Errs	Powe
PDCCH	00:00:04.2952 ...	D			214	7	OK	1507
DCI Format 2A	00:00:04.2952 ...	D			214	7	OK	
PDSCH	00:00:04.2952 ...	D		-32.4	214	2769	OK	0
MAC Message	00:00:04.2952 ...	D			214	2769	OK	
RLC Status PDU	00:00:04.2952 ...	D			214	2768	1	
PDSCH	00:00:04.2952 ...	D		-32.4	214	1572	OK	0
MAC Message	00:00:04.2952 ...	D			214	1572	OK	
RLC Status PDU	00:00:04.2952 ...	D			214	1571	1	
Subframe	00:00:04.2962 ...	DL	0					45118
PCFICH	00:00:04.2962 ...	D		-23.5	0	1	OK	17844
CFICH	00:00:04.2962 ...	D			0	1	OK	
PDCCH	00:00:04.2962 ...	D			215	7	OK	34952
DCI Format 2A	00:00:04.2962 ...	D			215	7	OK	
PDSCH	00:00:04.2962 ...	D		-32.7	215	2124	OK	0
MAC Message	00:00:04.2962 ...	D			215	2124	OK	
RLC Status PDU	00:00:04.2962 ...	D			215	2123	1	
PDSCH	00:00:04.2962 ...	D		-32.7	215	193	OK	0
MAC Message	00:00:04.2962 ...	D			215	193	OK	
RLC Status PDU	00:00:04.2962 ...	D			215	192	1	
Subframe	00:00:04.2972 ...	DL	0					45118
PCFICH	00:00:04.2972 ...	D		-19.8	0	1	OK	17844
CFICH	00:00:04.2972 ...	D			0	1	OK	
PDCCH	00:00:04.2972 ...	D			216	7	OK	8738
DCI Format 2A	00:00:04.2972 ...	D			216	7	OK	
PDCCH	00:00:04.2972 ...	D			212	4	OK	0
DCI Format 0	00:00:04.2972 ...	D			212	4	OK	
PDSCH	00:00:04.2972 ...	D		-34.6	216	49	OK	0
MAC Message	00:00:04.2972 ...	D			216	49	2	
PDSCH	00:00:04.2972 ...	D		-34.6	216	49	OK	0
MAC Message	00:00:04.2972 ...	D			216	49	2	
Subframe	00:00:04.2982 ...	UL	0					45118
PUSCH	00:00:04.2982 ...	U		-31.2	217	775	OK	17844
MAC Message	00:00:04.2982 ...	U			217	775	OK	
RLC Status PDU	00:00:04.2982 ...	U			217	119	1	
RLC Status PDU	00:00:04.2982 ...	U			217	119	1	
RLC Status PDU	00:00:04.2982 ...	U			217	119	1	
RLC Status PDU	00:00:04.2982 ...	U			217	119	1	
RLC Status PDU	00:00:04.2982 ...	U			217	119	1	
CCCH-RLC	00:00:04.2982 ...	U			217	167	OK	
RRCConnecti...	00:00:04.2982 ...	U			217	167	OK	
Subframe	00:00:04.2992 ...	UL	0					45118
PUSCH	00:00:04.2992 ...	U		-33.8	218	193	OK	17844
MAC Message	00:00:04.2992 ...	U			218	193	OK	
RLC AMD	00:00:04.2992 ...	U			218	192	OK	

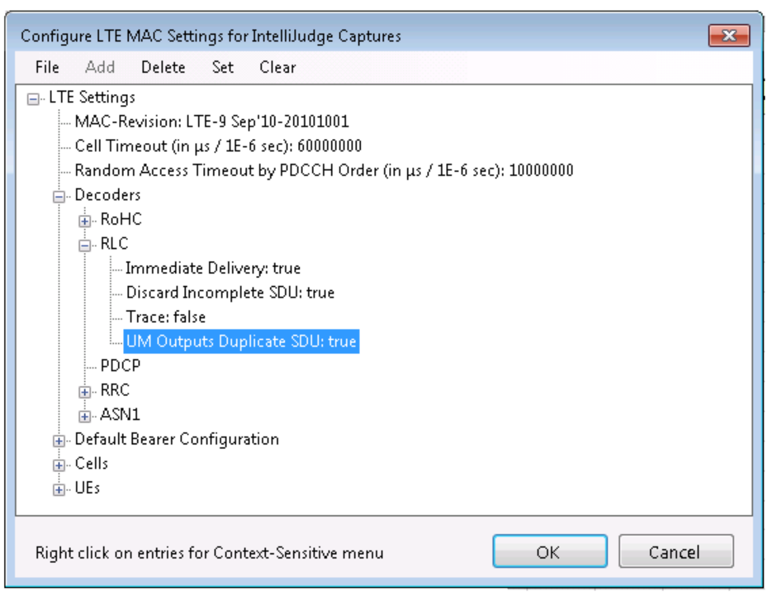
IntelliJudge Message List - RLC Errors

To fix the RLC settings open the IntelliJudge LTE IntelliJudge MAC Settings window from the Tools menu. Under LTE Settings -> MAC Layers, there is a list of RNTIs. Find the subframe RNTI you want to fix and expand the tree to the RLC settings.



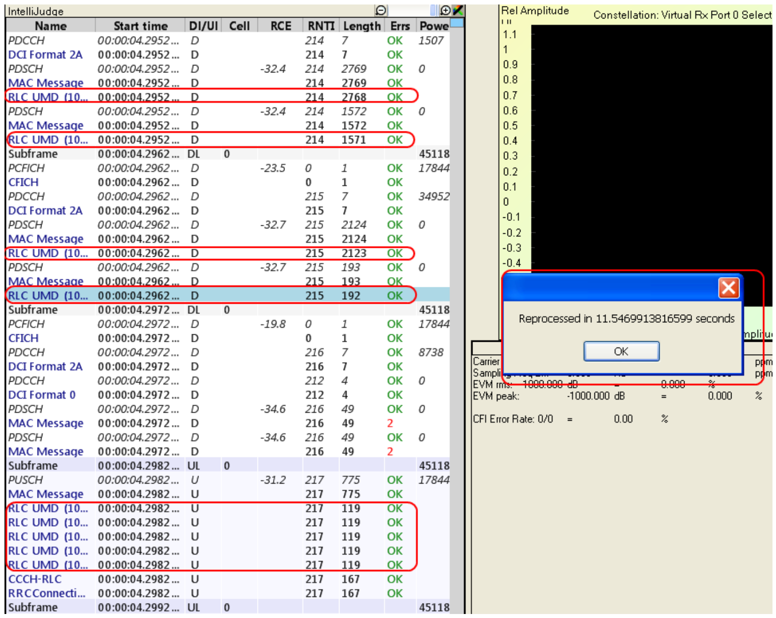
IntelliJudge Message List - RLC

The correct mode for this particular capture is UM, so change the mode to UM.



IntelliJudge Message List - RLC Changed to UM

Repeat this process for all incorrect RNTIs. When you are done, press the OK button. Wait for the IntelliJudge Message List to reprocess. Once it is reprocessed, the RLC messages should be fixed.



IntelliJudge Message List - RLC Fixed Message List

10 Analysis of 4G LTE

10. 1 Correlation LTE

WaveJudge's cross-probing engine requires input from several key charts and lists. The main source of input to the cross-probing engine can come from several sources, the most common sources are the PHY Frames List, WaveJudge Message List, and the Time Domain Power chart

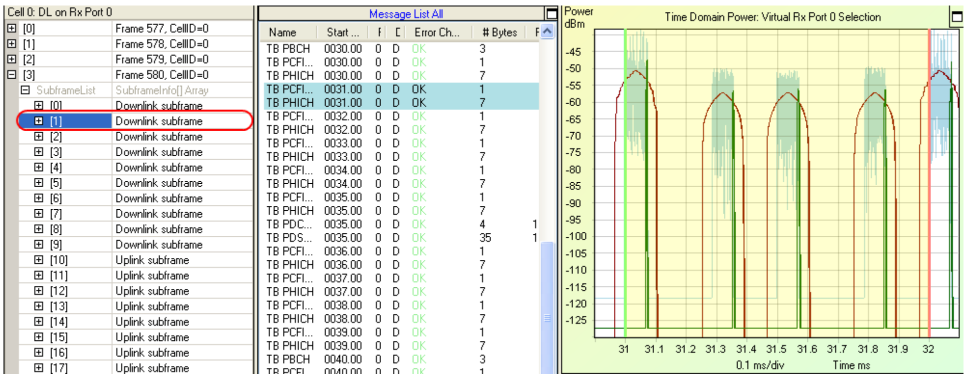
There are also several methods to select events or time intervals to correlate the charts or results. The primary methods are using time gated markers, selecting frames/zones/bursts from the PHY Frames List, and selecting messages; each one of these methods provides global input to the cross-probing mechanism. The cross-probing engine then distributes this input or area of time to all other lists, results, and charts that are set to Selection (see Set Range to on page 356)

10. 1. 1 Correlation Using the PHY Frames List

The correlation feature allows the frames, subframes, and assignments in the PHY Frames List to associate with messages in the WaveJudge Messages List on page 240. When selecting a frame, subframe, or assignment in the PHY Frames List, any messages that have content in these frames, subframes, or assignments are highlighted in the WaveJudge Message List. When a message is selected in the Message List the first assignment correlating to the message selected in the Message List is highlighted in the PHY Frames List

Charts provide additional correlation functions. When selecting a frame, subframe, or assignment in the PHY Frames List, the charts that are set to Selection show green and red vertical lines. The green line represents where the selected frame, subframe, or assignment begins, while the red vertical line represents the end of the selected frame, subframe, or assignment. Using the Selection option in a chart (right-click in a chart pane and select Set Range toSelection) lets you quickly zoom into only the region that represents the selected frame, subframe, or assignment

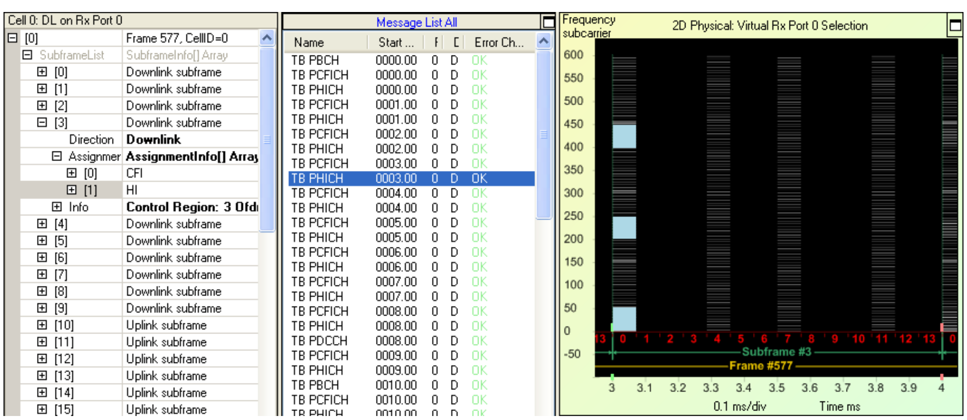
In the example below, a single subframe is selected in the PHY Frames List, with the correlating messages in the WaveJudge Message List; the Time Domain Power graph displays the energy associated with the subframe. The green and red lines in the Time Domain Power chart indicate the beginning and end of the subframe



Correlation Between the PHY Frame List, WaveJudge Message List, and Time Domain Power Chart

10. 1. 2 Correlation Using the WaveJudge Message List

This is the same example using the WaveJudge Message List as the source of input to the cross-probing engine. The image below shows the PHICH transport block selected in the Message List. The **2D Physical** graph highlights the selected transport block. You can see the HI assignment in the PHY Frame is highlighted, this indicates the PHICH transport block correlates to the HI assignment

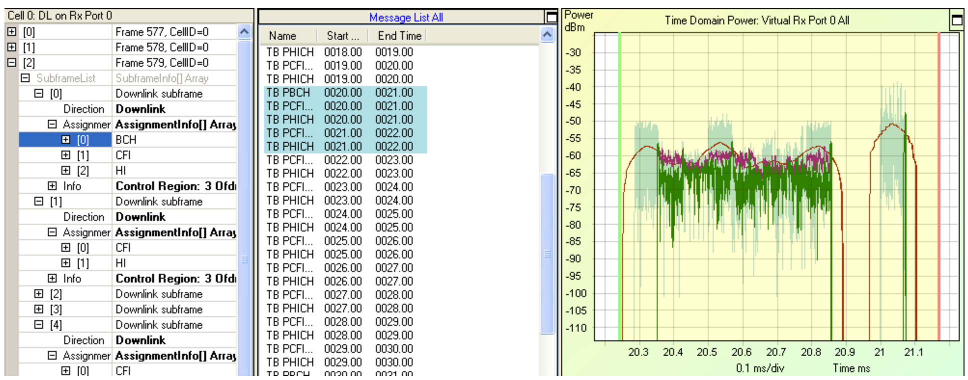


Correlation Between the PHY Frame List, WaveJudge Message List, and 2D Physical Chart

10. 1. 3 Correlation Using Time Gated Markers

In the Time Domain Power chart below, the time gated markers are indicated by green and red vertical lines. The example shows the effect of having the time gated markers set to the portion of the burst that contains data shown in the Time Domain pane. For CCDF measurements this is a common setting, ensuring the preamble is not included so it does not skew the PAPR (peak to average power ratio)

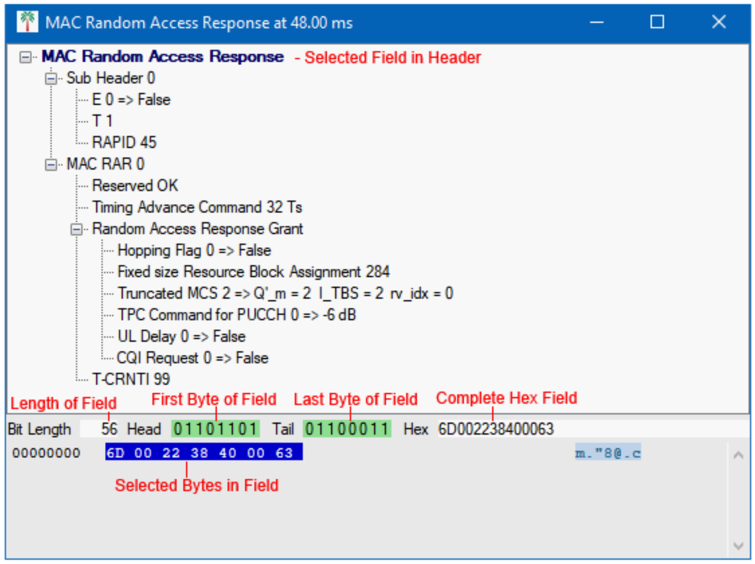
Once the time interval is set the PHY Frames List highlights the first assignment that correlates with the time frame. The Message List shows the messages contained in the time frame. In the PHY Frames List the first assignment is selected. The Message List below shows that the time gated markers contain contain five different assignments. To set the time gated markers, refer to Set Markers on page 227.



Correlation Between PHY Frame List, Message List, and Time Gated Markers on a Time Domain Power Chart

10. 2 Decoded Message

To view a decoded message double-click on a message in the Message List. A protocol decoder window will open containing the decoded message along with the binary and hexadecimal data



Channel Decoding Window

The decoded message is located at the top section of the decoder window; the bottom section contains the byte and hexadecimal representations of the message

Bit Length: Length of the selected field

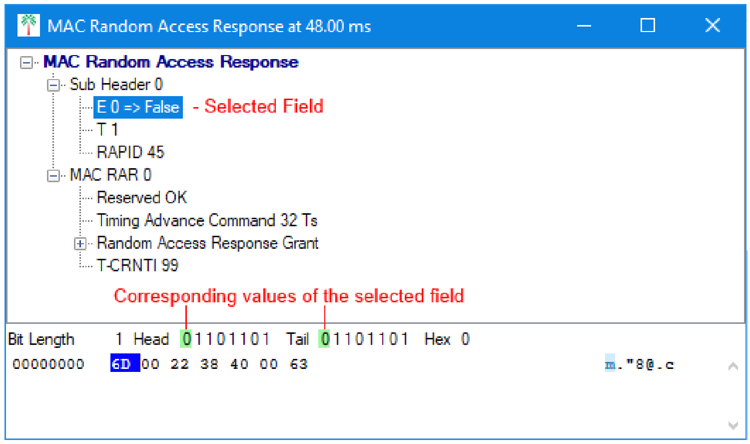
Head: The first byte that contains the selected field in a bit format. The bits of the selected field contained in the Head are highlighted in green

Tail: The last byte that contains the selected field in a bit format. The bits of the selected field contained in the Tail are highlighted in green

NOTE If the selected field is contained in only one byte, the Head and Tail are the same.

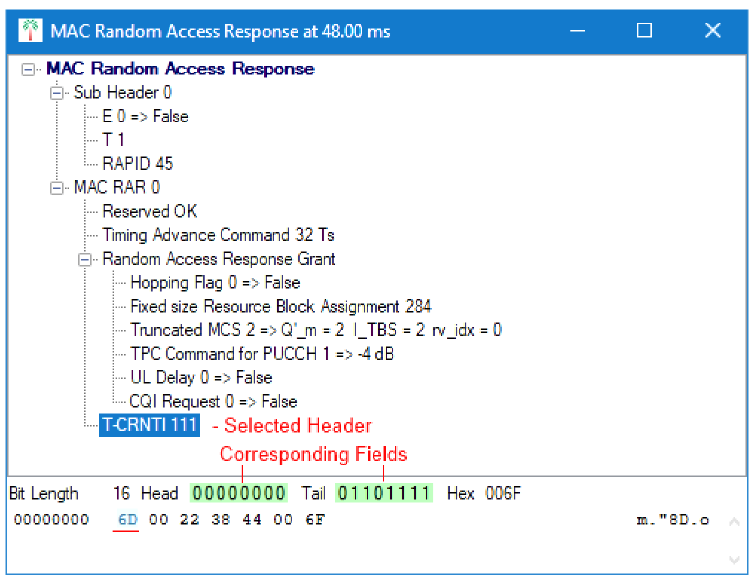
Hex: The complete hexadecimal representation of the selected field

The bytes contained in the selected field are highlighted in blue. The Bit Length, Head, Tail, Hex, and the complete hexadecimal representation of the message help you determine the exact bits corresponding to any decoded field. Below is an example of how to analyze the data using the bit length, head, tail, and hex fields



Channel Decoding - Analyzing Bit Length

In the example below, T-CRNTI 1111 is selected under MAC RAR 0. The corresponding values are the green Head and Tail hex codes, the selected byte is the 6D in the bottom row



\Channel Decoding - Headers and Corresponding Fields

In certain decoded messages some fields are highlighted in blue. These fields are messages contained in the current message. If you double-click the highlighted field a new decoded message window will open containing that message's decoded data

10. 2. 1 IP Decoder

In order to decode and display any IP messages you first need to set up IP Data parameters, then you will be able to see all IP Data messages in the WaveJudge Message List

NOTE Ensure the PHY layer is processed correctly before decoding, particularly for uplink. (See Timing Offset Analysis on page 489.)

10. 2. 1. 1 Set IP Message Parameters

Select the WaveJudge Message List and click on the Chart Properties in the list, the Chart Properties window will open. Select the element Other to populate the Message List with all other elements. In the Advanced Element Choices tab on top, select Unknown/Other. In the Fields (Columns) section, scroll down the list and select IP Protocol

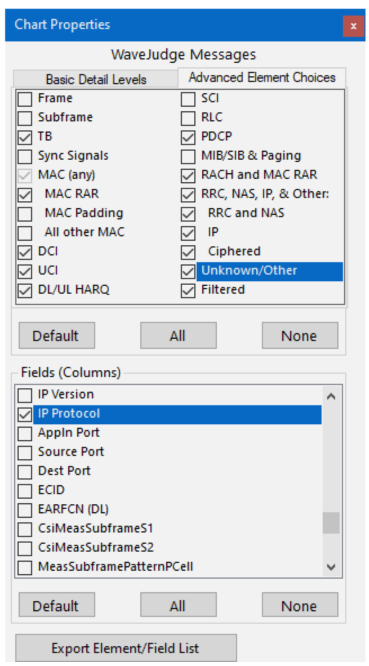
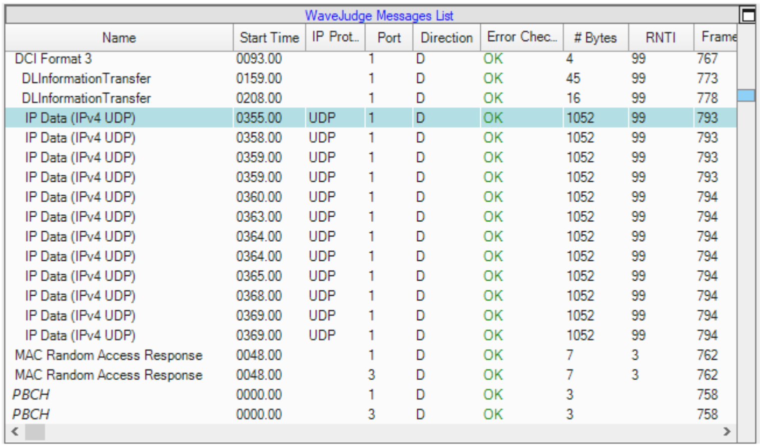


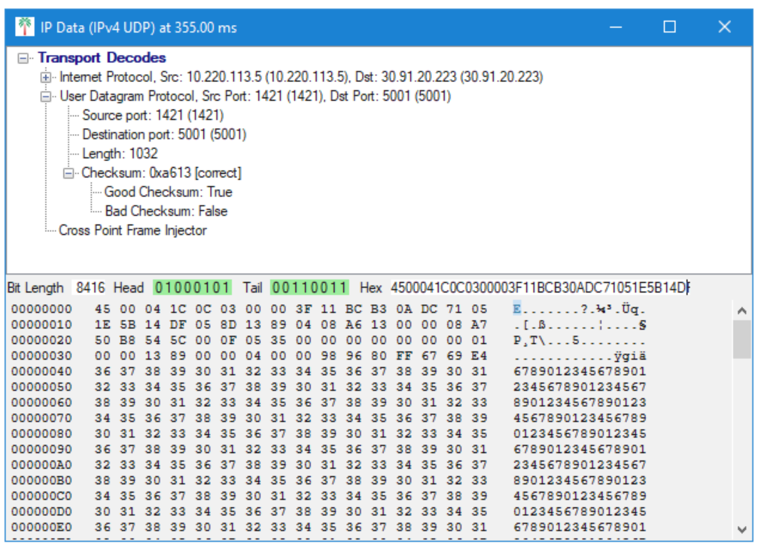
Chart Properties Window - Select "IP Protocol" from Fields

This immediately allows all IP Data messages to populate in the WaveJudge Message List



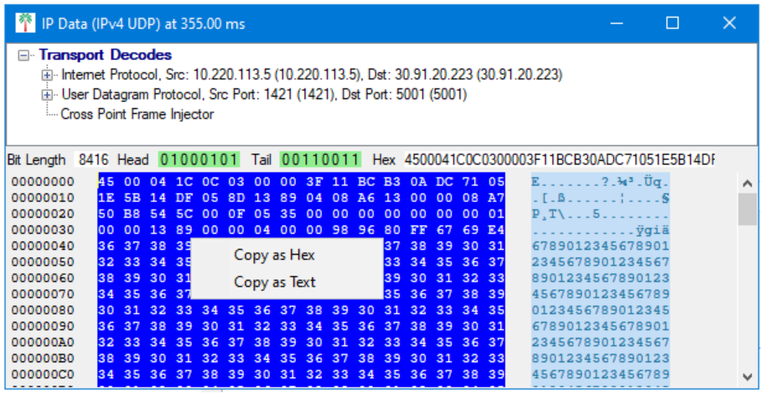
IP Data Messages Populate in the WaveJudge Message List

Double-click the message IP Data in the WaveJudge Message List, the IP Data Decoder window will open and reveal the decoded message



IP Data Decoder Window

To save the raw data to a text file **click and drag your cursor** over the hexadecimal or ASCII notation, then **right-click** and select Copy as Hex or Copy as Text. You can now paste the raw data from the clipboard into any text editor



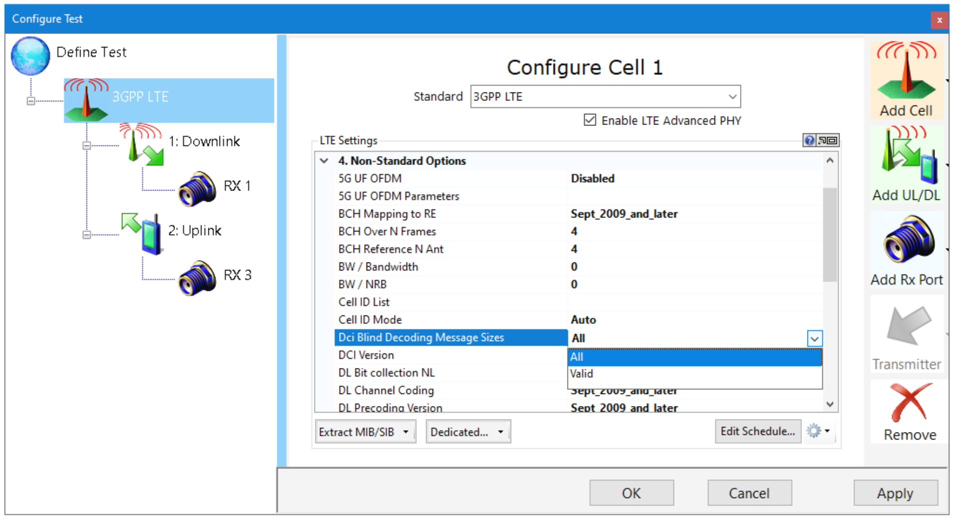
Select Data and Right-Click to Copy as Hex or Text

10. 2. 2 Blind Decoding

Blind decoding finds and decodes downlink control information (DCI) messages, it scans every valid CCE length. To enable blind decoding, set the CCE length to 0 in the **Schedule** window. (See DCI Assignment/Blind Decoding on page 143.

If blind decoding did not find a DCI message that should be there, set the parameter **DCI Blind Decoding Message Sizes** to **All**. To do this:

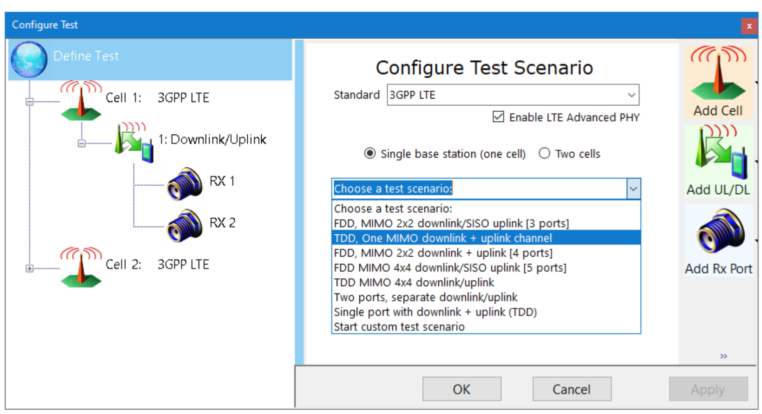
1. Open the **Configure Test** window and click the second link on the left **3GPP LTE** to open the **Configure Cell 0** pane
2. In the **LTE Settings** window, click **4. Non-Standard Options** and scroll down to find **Dci Blind Decoding Message Sizes** and select **All** from the drop-down menu on the right. This will tell the blind decoder to scan all message sizes instead of what is believed to be the valid sizes for this message.
3. Click the **ReProcess** button  to see the results



Set DCI Blind Decoding Message Sizes to "All"

10. 3 MIMO Analysis

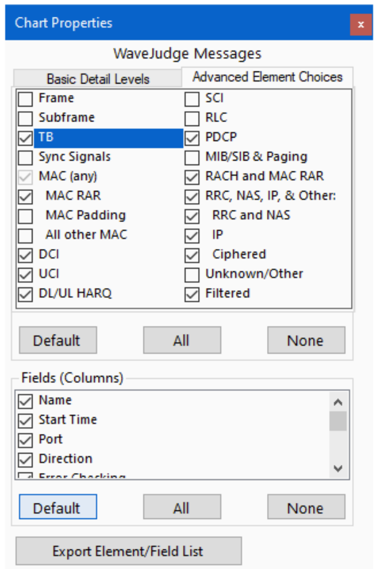
WaveJudge has two ports that enable it to receive 2x2 MIMO transmissions. To set a MIMO configuration, open the Configure Test window; on the left side, select Define a Test Scenario on page 72. In the right pane, select TDD, One MIMO, downlink + uplink channel from the Choose a Test Scenario drop-down menu. WaveJudge will automatically identify and decode MIMO transmissions. You can receive data through a channel emulator or over the air.



Select a MIMO Test Scenario

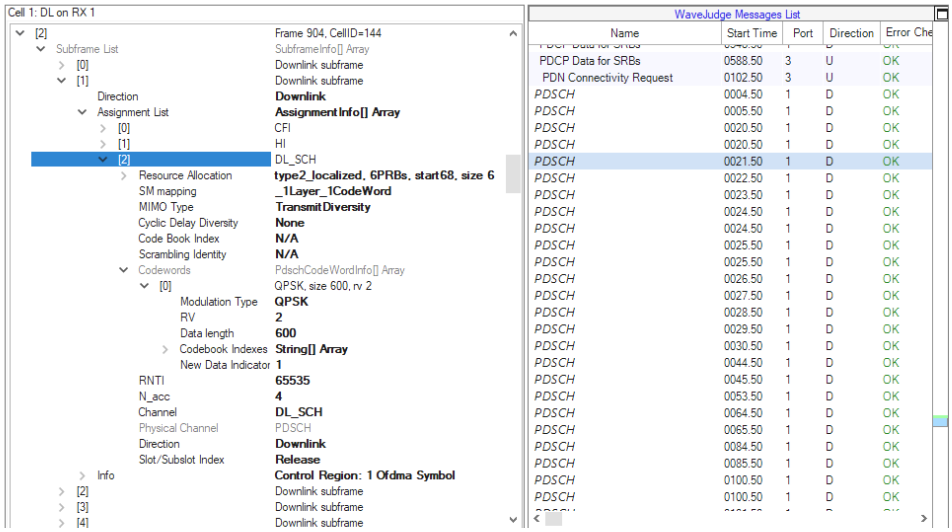
In the Chart Properties window, you can select a TB that uses MIMO and view it's parameters in the PHY Frame. TB is already one of the default Advanced Element

Choices tab settings in the WaveJudge Chart Properties window. Click either the Default button or select the TB checkbox. All TBs will appear in the WaveJudge Message List.



LTE Chart Properties - TB is a Default Advanced Setting

In this example, we will look at PDSCH. In the WaveJudge Message List, select a PDSCH message; this selects the corresponding codewords in the PHY Frame List. In the figure below, a PDSCH message is selected, the corresponding code word in the PHY Frame List is also selected. This specific codeword uses the modulation type QPSK, Redundancy Version 2, and has a data length of 600 bits.



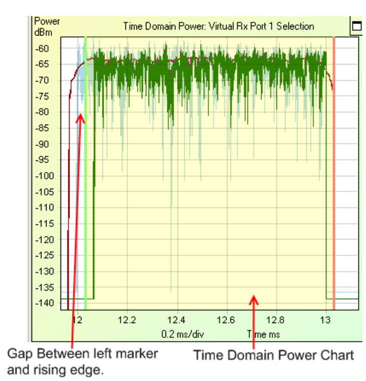
PDSCH Message Automatically Correspond to Codewords in PHY Frame List

Above the code words are the MIMO parameters SM mapping, MIMO Type, Cyclic Delay Diversity, Code Book Index, and Scrambling Identity. These parameters describe the type of MIMO used by this assignment.

10. 4 Timing Offset Analysis

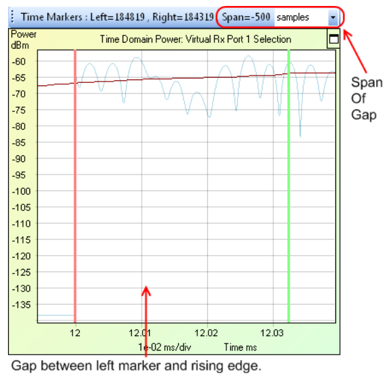
To determine if uplink timing offsets are causing uplink errors, highlight the error in the WaveJudge Message List and compare the rising edge of the burst in the Time Domain Power chart with the green vertical time marker

1. In the Message List click on an error uplink message to highlight it.
2. The scheduled burst is also highlighted in the Time Domain Power chart



Timing Offset in Time Domain Power Chart

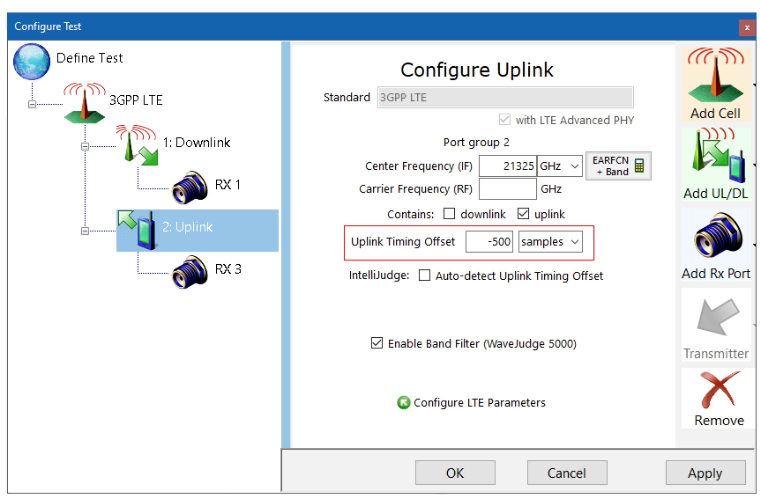
3. On the main menu, select the right Cursor Tool Group on page 226 tool to move the red time marker to the rising edge of the burst
4. Click the Time Units drop-down menu at the right of the Time Markers Span = label, and select samples



Set Time Markers to Samples

5. Add the **Span value** to the current Uplink Timing Offset value on the Configure Downlink/Uplink Port Group window (in the Configure Test window)

   In the example below, Time Span = -500 samples and Uplink Timing Offset = 0 samples. Therefore, the correct Uplink Timing Offset value is -500 + 0 = -500 samples



Enter the Uplink Timing Offset in the Configure Uplink Pane

6. In the Uplink Timing Offset field on the Downlink/Uplink window, enter the correct uplink timing offset value (e.g., -500)

The value is based on the timing delay and the delay in the UL responses to DL transmissions like the RACH and MAC-RAR. Part of the delay is introduced by the TA value that is transmitted in the MAC-RAR. IntelliJudge will use this understanding to automatically configure the uplink timing offset, but it can only work if the RACH/MAC-RAR pair is present

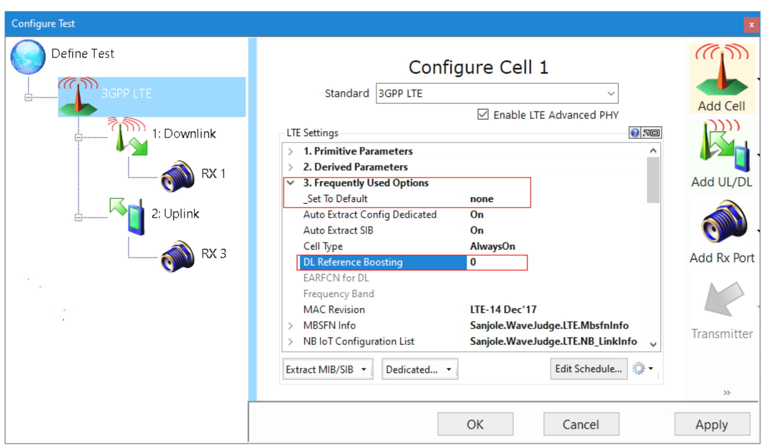
7. Click the Reprocess button on the toolbar to process the data with the uplink timing offset.

10. 5 DL Reference Boosting

Use the DL Reference Boosting scale when the points in a Constellation Chart look compressed or expanded; this occurs when there was no standard set for the power levels used in LTE

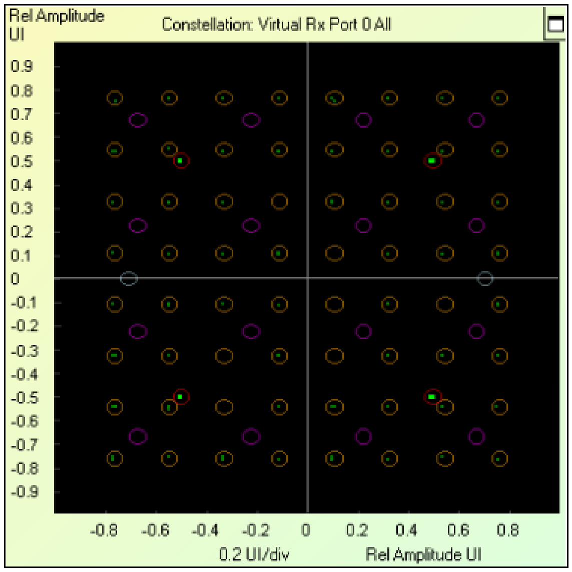
To change the DL Reference Boosting value:

1. Open the Configure Test window and select the second link 3GPP LTE on the left side to open the Configure Cell panel on the right
2. In the LTE Settings window, click on item 3. Frequently Used Options and set the _Set To Default to none
3. Next, scroll down to find DL Reference Boosting. you can change the value. The most common values are 0 and -3



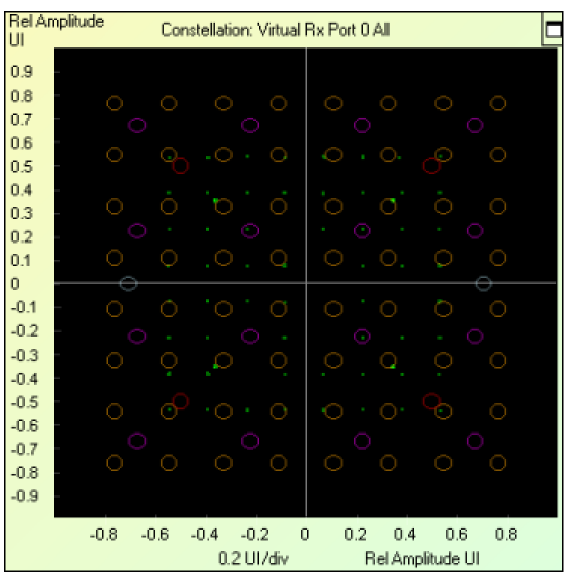
Set Default to "None" then Set a Value for Downlink Reference Boosting

The image below shows a normal 64 QAM constellation. All the constellation points are within the circles.



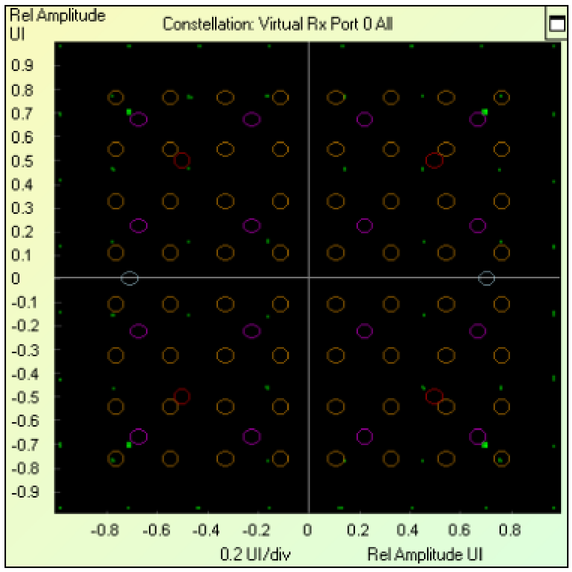
Constellation Chart - Normal Dowlink Reference Boosting

In this next image, the constellation points are compressed. If you look at the image below you can see that the constellation looks like a 64 QAM constellation but does not fall within the circles in the constellation chart. This means that the DL Reference Boosting value is too low, so you should increase it. Try adding three to the DL Reference Boosting value and click the ReProcess button. Adjust the value until the constellation points fall within the circles in the Constellation chart.



Constellation Chrt - Compressed DL Reference Boosting

In the image below, the constellation points are expanded. If you look closely enough, you can see the points are lining up to form a QAM 64 constellation, but is not within the circles. This means that the DL Reference Boosting value is too high. Try subtracting three to the DL Reference Boosting value and click the ReProcess button . Adjust the value until the constellation points fall within the circles

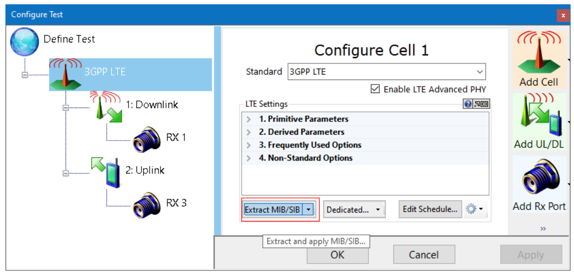


Constellation Chart - Expanded Downlink Reference Boosting

10. 6 Radio Resource Control (RRC)

If you click theExtract MIB/SIB... button and the Extract Dedicated RRC button (located near the bottom of the Configure Test window in the Configure Cell pane) and the SIB and RRC messages are present in the capture, then it's not necessary to configure these parameters

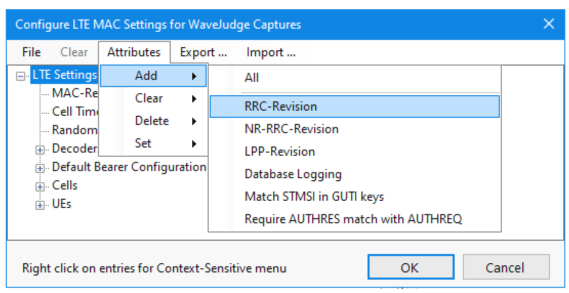
However, SIB is periodic and it may not start at the beginning of the capture. This will prevent some messages from decoding, like the RACH. It may also prevent the proper uplink, downlink, and special subframe configuration in TDD mode from starting at the beginning of the capture. To avoid this situation click the Extract MIB/SIB... button. If the values are not present at all then the default SIB values are used. In this case, you may need to configure these parameters.



Configure Test Window - Extract MIB/SIB Button

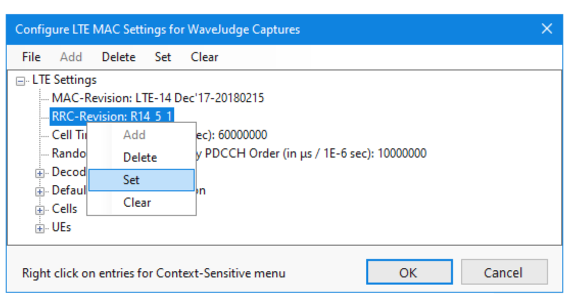
If the default RRC-revision is not what your test is using, you may change the RRC-revision. To set the RRC revision in a cell:

1. Select the Tools menu, then select WaveJudge LTE MAC Settings...
2. The Configure Protocol Analyzer window will open. Right-click the LTE Settings node and select Attributes menu, then click Add, and from the submenu click RRC-Revision



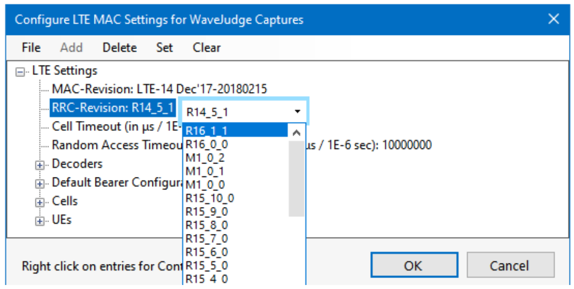
LTE MAC Settings - Add RRC-Revision

3. This will add an RRC-Revision node right below the LTE Settings node. Right-click the RRC-Revision node and select Set



LTE MAC Settings - Right-Click on RRC-Revision and Select "Set"

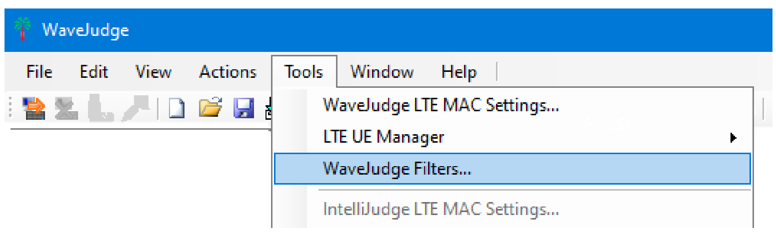
4. A drop-down box will appear. Select the RRC version you wish to set. After clicking the OK button, the revision will apply to all messages in the cell



LTE MAC Settings - Right Click to Select Revision Version

10. 7 Filtered Messages

WaveJudge lets you filter messages by values, you can set which messages you want to see along with any associated values. To access the filter list, click on the Tools menu and select WaveJudge Filters...

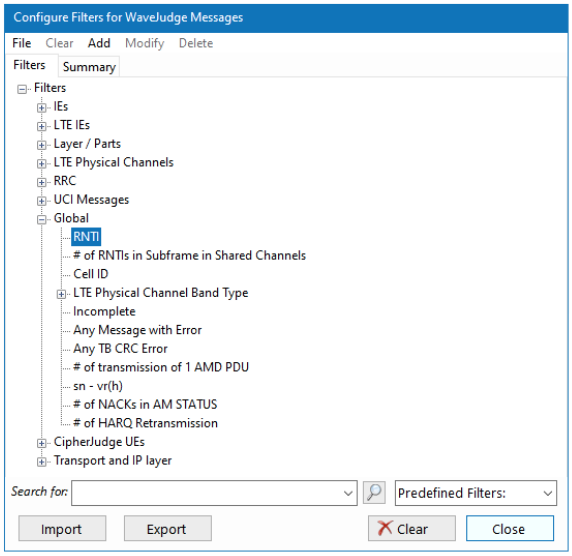


Tools Menu - Select "WaveJudge Filters..."

A popup window will appear showing every type of message for the standard that is currently set. When you start WaveJudge, the filter list is empty. Once you change the filter list it remains there until you exit the program

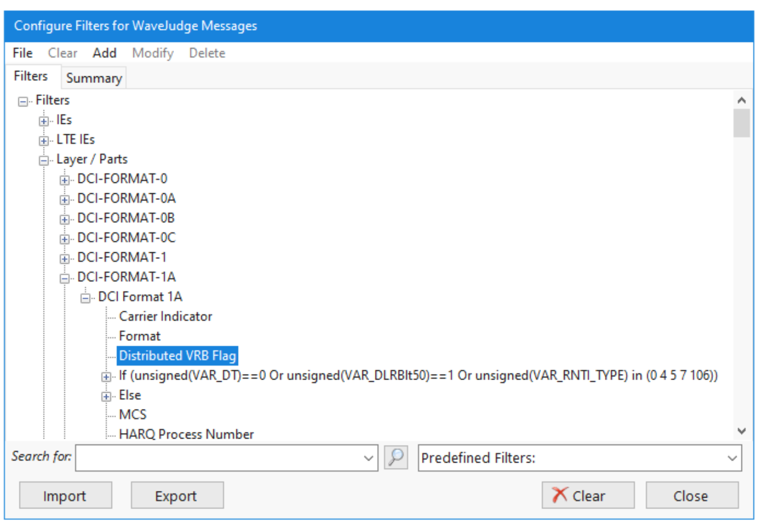
NOTE The filter list and trigger list are **context sensitive**, they are based on the 5G or LTE version

Each standard has it's own filter list. You can select which message and/or values you want to filter. All messages and conditions are compared using an OR operator. This means that if you have multiple requirements on a single parameter, if AT LEAST ONE requirement is met by the filter list the message will display. The most common way to filter RNTI messages is to access Filters then scroll down and select Global then select RNTI



Location of RNTI Filters

After adding a requirement to the filter list, the node that contains the requirement is highlighted and bold. All parent nodes will highlight. In the example below, the Distributed VRB Flag parameter contains at least one filter requirement



Configure Filters for WaveJudge - Distributed VRB Flag

After setting the requirements you want for the filter list click the OK button and then click the ReProcess button to update the filter list

The Chart Properties window includes filtered messages as a default setting in the Advanced Element Choices tab. If Filtered checkbox is not already selected, click it so it is selected

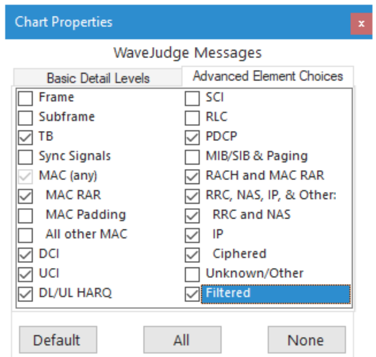
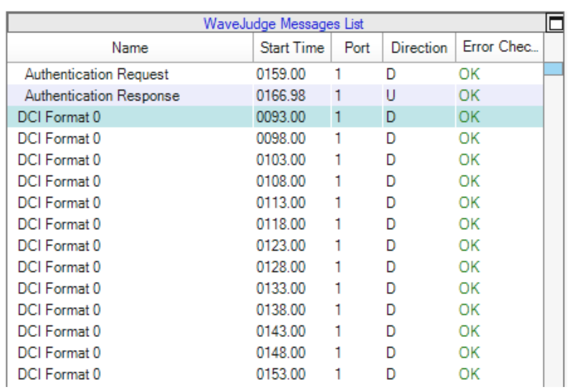


Chart Properties Window - Filtered Messages are Default

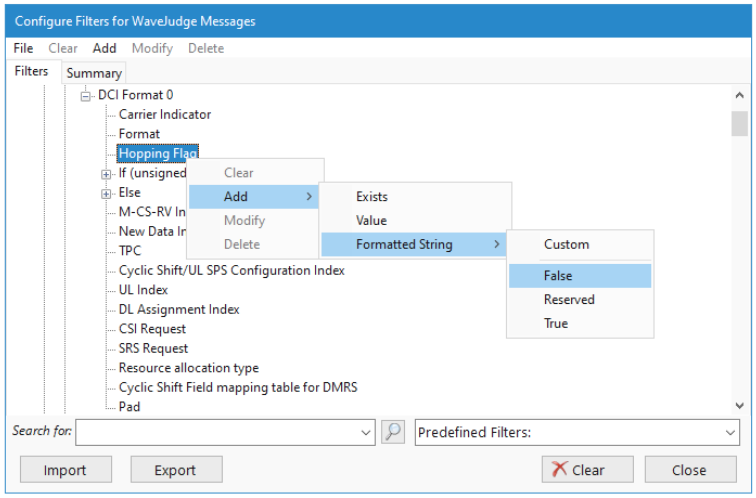
The Message List contains all messages that satisfy at least one condition in the filter list. The example below shows the filtered option used to only show DCI-Format 0messages with a Hopping Flagset to false in the message list



WaveJudge Messages List - Filtered DCI Format 0 Message

When you view the decoded message the value that passed the filter requirement is highlighted in gray. To set Hopping Flag to **False**:

1. Open the WaveJudge Filters window
2. Scroll down to DCI Format 0 and select Hopping Flag
3. Right-click to access the next submenu, select Add
4. Right-click again and select Formatted String
5. Right-click again and select False



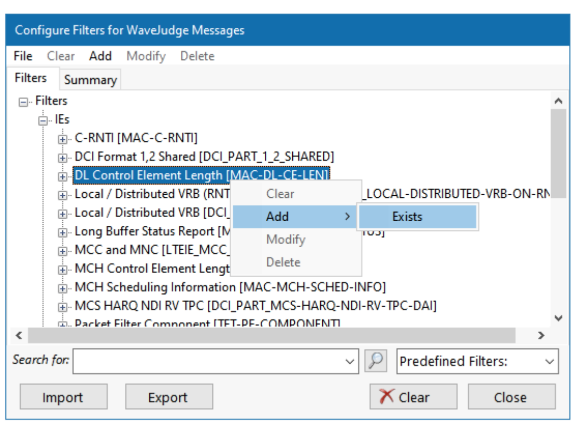
Set Hopping Flag Parameter to False

10. 7. 1 Add Requirements to Filters

There are different ways to add requirements to filters, however all of them require clicking the Tools menu, then accessing the WaveJudge Filters... window. You can add requirements by using any of the following methods:

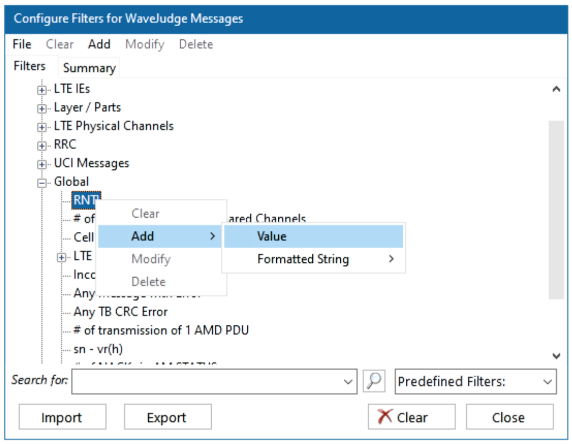
- Add a requirement by selecting a node and click to add
- Add a requirement by value
- Set a formatted string

In the Configure Filters for WaveJudge Messages window, select a message or parameter of the message node, right-click the node, and set it to Add, then right click and select Exists. This adds any message of this type with this parameter to the filter list. In the example below, it adds all DCI-Format 0 messages to the filter list



Configure Filters for WaveJudge - Add Filter, Filter Exists

The second way to add a requirement to the filter list is by value. You can set the operator and value to compare against all messages. If any message meets the requirements it will be added to the filter list. To add a value requirement to the filter list, right-click a node and select Add then click Value. The example below shows how to add a filter for all messages with a RNTI value that meet the requirements

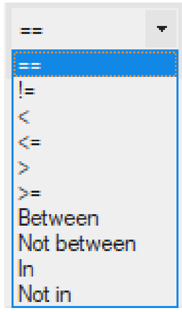


Configure Filters for WaveJudge - Add RNTI Value

After selecting value, choose the value you want to look for. There are different operators you can apply to the value. The operators are:

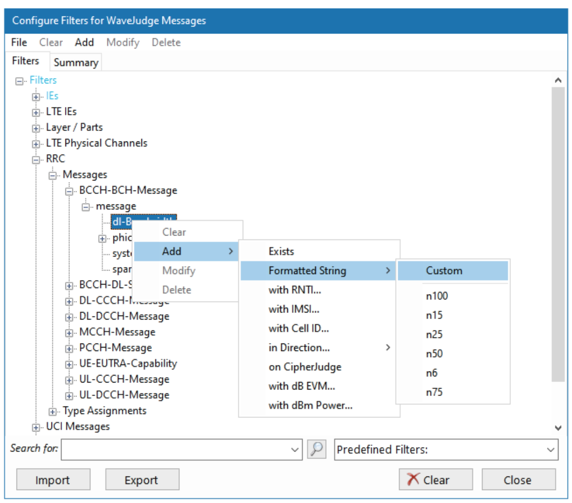
1. == - Equal to the value
2. != - Not equal to the value
3. < - Less than the value
4. <= - Less than or equal to the value
5. > - Greater than the value
6. >= - Greater or equal to the value
7. Between - Greater than or equal to the first value and less than or equal to the second value
8. Not Between - Less than the first value or greater than the second value
9. In - Equal to a list of integers seperated by a space, e.g., 10 20 30 45 52
10. Not in - Not equal to a list of integers seperated by a space, e.g., 10 20 30 45 52

To access the value pop-up options, click on a filter and then click anywhere in the white space, add the requirement to the filter list



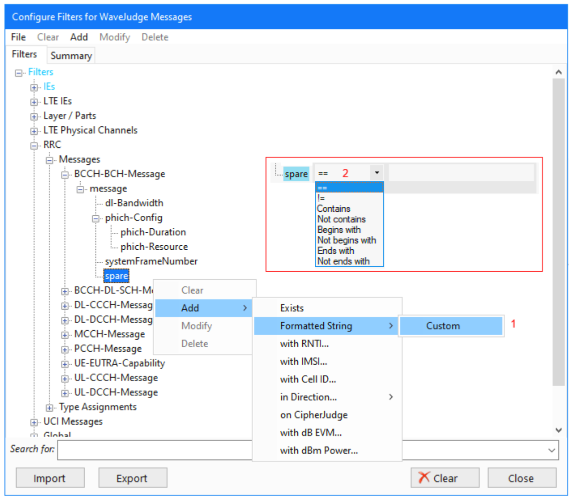
Right-Click Popup Menu with Operator Values

The third way to add a requirement to the filter list is by setting a formatted string. If there are preset values for this parameter, the formatted string option will contain a list of strings that may be set for this parameter. Select a predefined formatted string whenever possible. The example below shows the different formatted strings available for a BCCH-BCH Message's dl-Bandwidth



Configure Filters for WaveJudge - Add Formatted String

If there are no predefined strings, you can create your own custom formatted string. After right clicking on a paramter, select Add ,select Formatted String then click Custom. A text field and drop-down menu will popup next to the paramater,selecte an operator from the menu and type in a string in the grey box.



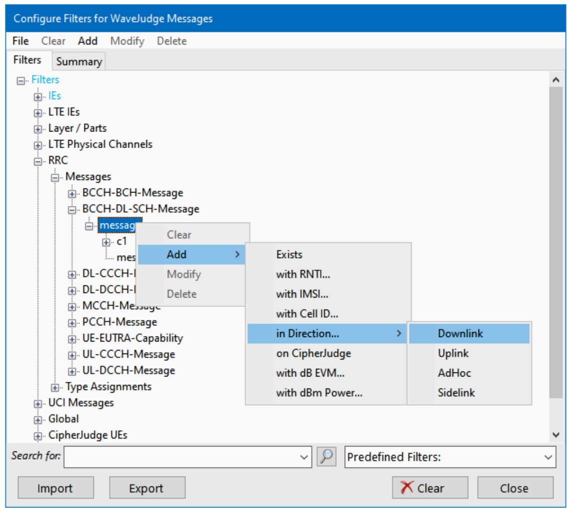
Add Custom Formatted String and Select Options from Menu

There are a few operators you can apply to the custom string. The operators are:

1. == - Equals to the custom string
2. != - Does not equal to the custom string
3. Contains - The custom string is contained somewhere in the parameter
4. Not contains - The custom string is not contained anywhere in the parameter
5. Begins with - The parameter begins with the custom string
6. Not begins with - The parameter does not begin with the custom string
7. Ends with - The parameter ends with the custom string
8. Not ends with - The parameter does not end with the custom string

Clicking anywhere outside of the value and operator section with valid values will add the requirement to the filter list. Click the OK button and press the ReProcess button to update the filter list.

There are many parameter specific menus, one that you may often see is to add a type of message. Right-click on an element, select Add then right click again to find another submenu with options. The in Direction item has it's own submenu with options to set the Downlink,Uplink, Adhoc, or Sidelink described below.



Add Custom Formatted String and Select Options from Menu

To configure the triggers or filters with no further qualifications, select an exit. However, you may wish to have the filter function based on a particular criteria. Normally this is done with an 'AND' operator, which is not available to the filters. For this reason, we provide additional qualifiers of RNTI, IMSI, Cell ID, and Direction. (For CipherJudge, additional operators include CipherJudge UE, db EVM, and dBm Power. As a result option will only be triggered or filtered if it's for the message selected, and it's for RNTI x, or IMSI x, etc.

The additional operators are as follows:

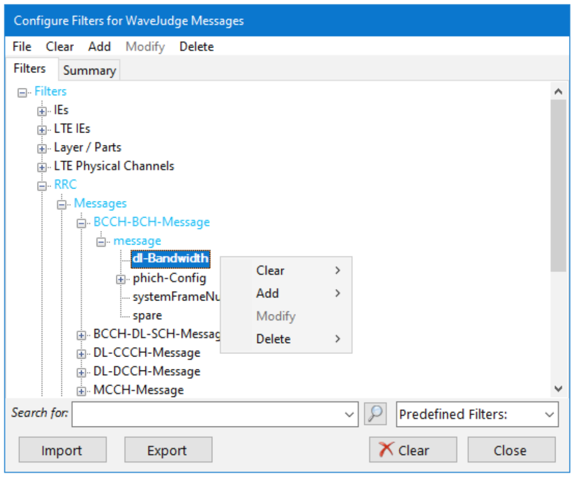
1. Exists
2. with RNTI...
3. with IMSI...
4. with Cell ID...
5. In Direction
   - Downlink
   - Uplink
   - Adhoc
   - Sidelink
6. on CipherJudge
7. with dB EVM...
8. with dBm Power...

10. 7. 2 Delete/Modify Filter Requirements

You can delete or modify any requirement in the filter list. In the Configure Filters for WaveJudge Messages window, after a message is changed, the item and parent line text turn light blue. The current message is highlighted and bold

To access the value popup options, click on a filter and then click anywhere in the white space. In the figure below the user selected **RRC** then **Messages** then **Db-Bandwidth**, to get to the submenu to Clear the change, Add, Modify, or Delete

.



Access a Filter's Value Popup Menu

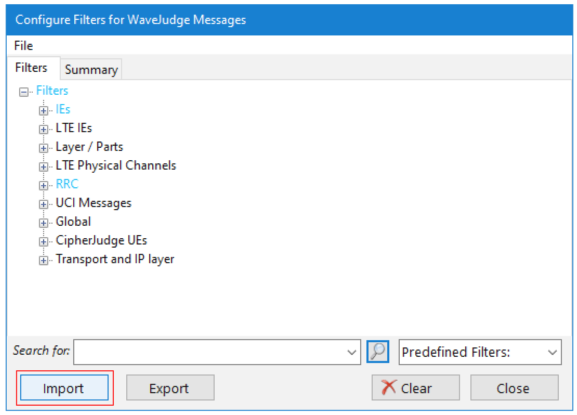
The items in this menu contain all requirements that have been added to this message or parameter:

- To remove the requirement from the filter list, select Delete.
- To change the value and/or operator for the requirement, select Modify.
- To remove all requirements from the filter list, click the Clear button.
- To update the filter list.Click the OK button and click the ReProcess button .

10. 7. 3 Import and Export Filtered Message List Preferences

To import a filter list:

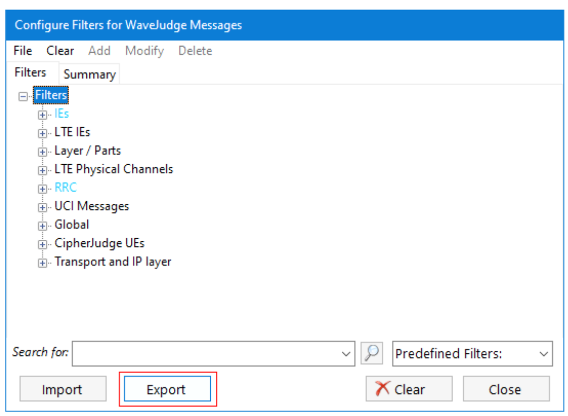
1. Open the Configure Filters for WaveJudge Messages window (Tools menu, then select WaveJudge Filters...).
2. Click the Import button.
3. Select the file to load.
4. Click the OK button and click the ReProcess button to update the filter list



Configure Filters for WaveJudge - Import a Filtered List

To export a filtered list:

1. Open the **Configure Filters for WaveJudge Messages** window (**Tools** menu, then select **WaveJudge Filters...**)
2. Set your desired filter list requirements
3. Click the **Export** button
4. Save the filter list file

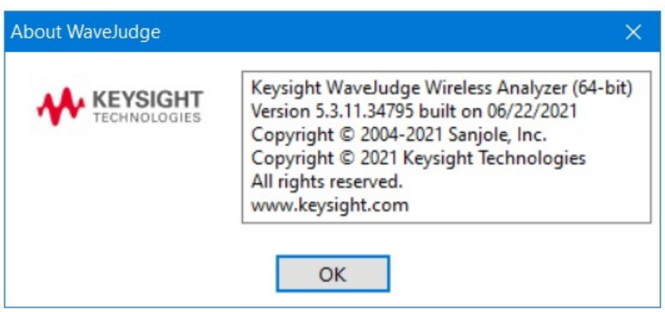


Configure Filters for WaveJudge - Export a Filtered List

11 StoraJudge Module

This section describes a WaveJudge 5000 module called StoraJudge. StoraJudge stores long non-real time captures, which generally take many hours to download. Any time you power cycle, reconnect to the chassis, or start a new capture, any previous capture file is deleted. StoraJudge stores triggered captures to an SSD card mounted into the module. Once captured, you can save the capture data to your PC's storage device. You cannot maintain StoraJudge capture files permanently in the StoraJudge.

IMPORTANT StoraJudge is **only** compatible with WaveJudge version **5.1.x** or later. To see which version of WaveJudge you currently have, click the Help menu and select the option About WaveJudge. In the figure below, the version installed is **5.3.6**.24639, therefore it is compatible with StoraJudge.



View Your WaveJudge Version in the "About WaveJudge" Window

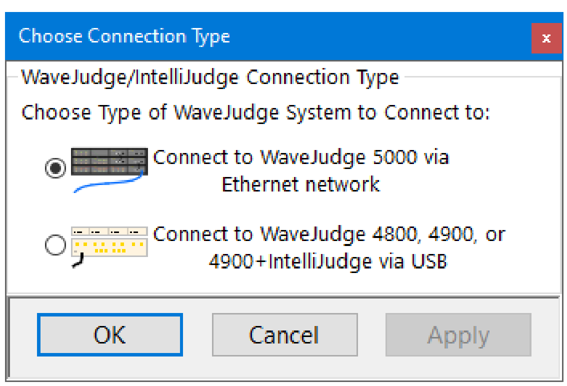
11.1 StoraJudge Card

The StoraJudge consists of a 1 TB SSD module and two SRIO connectors. When paired with the RXJudge 40 MHz module, the SSD may extend capture durations by up to 30 minutes. SRIO connectors function as interconnects between chassis. When paired with the RXJudge 800 MHz module, they function as interconnects only.

StoraJudge Module

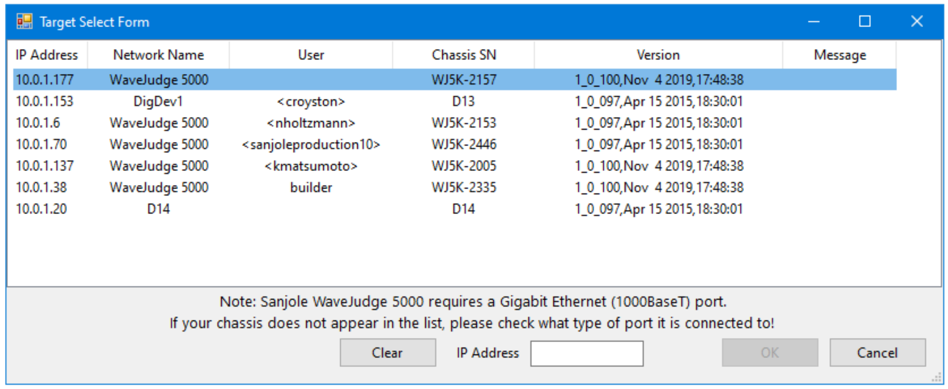
11. 2 Connect StoraJudge

StoraJudge works in conjunction with WaveJudge and IntelliJudge. To access StoraJudge, turn on WaveJudge in the usual manner - start by clicking the Connection Type button located on the vertical button strip on the left side of the GUI. The Choose Connection Type window will open. If you only have one type of chassis in your configuration this window will only offer access to that chassis. Select the radio button for your chassis and click the OK button.



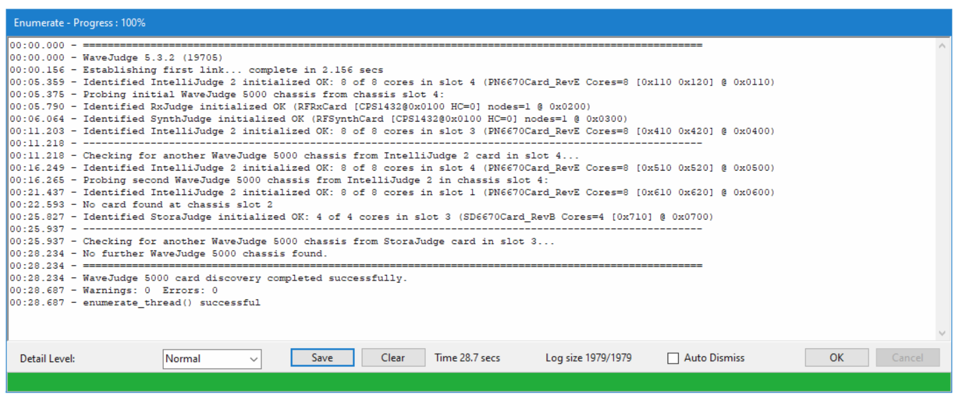
Connect StoraJudge - Choose Connection Type Window

Next, click the Connect button to connect the WaveJudge software to the chassis. The Target Select Form will open, select the line item for the chassis serial number and then click the OK button. If the OK button is grayed out, select the line item so it highlights in blue, then you will be able to click the activated OK button.



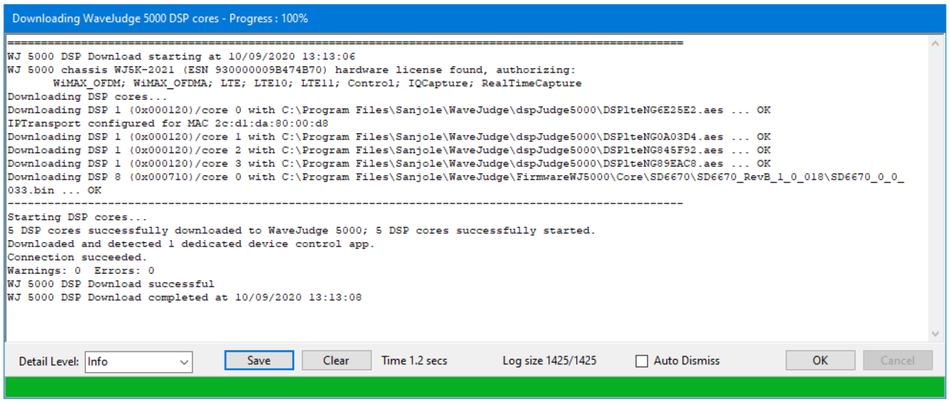
Connect StoraJudge - Target Select Form

Next, the Enumerate - Progress window will open; wait for the green progress bar to complete the download then press the OK button to continue.



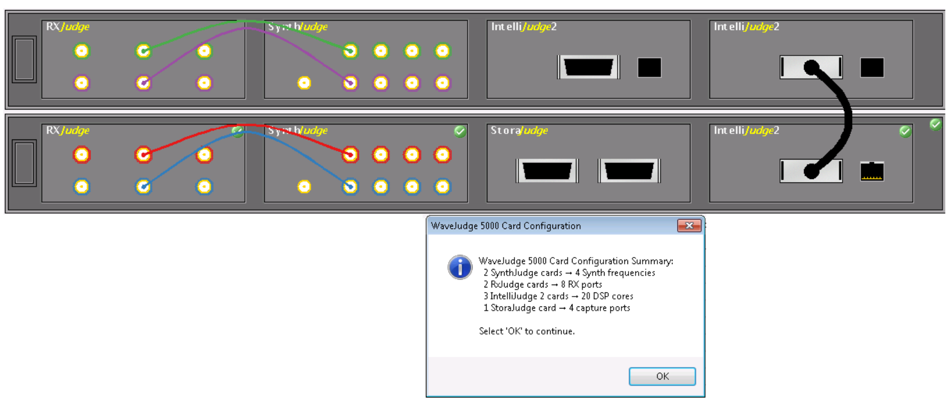
Enumerate Progress Window Shows WaveJudge Chassis Connections

The Downloading WaveJudge 5000 DSP Cores window will open; wait for the green progress bar to complete the download then press the OK button to continue.



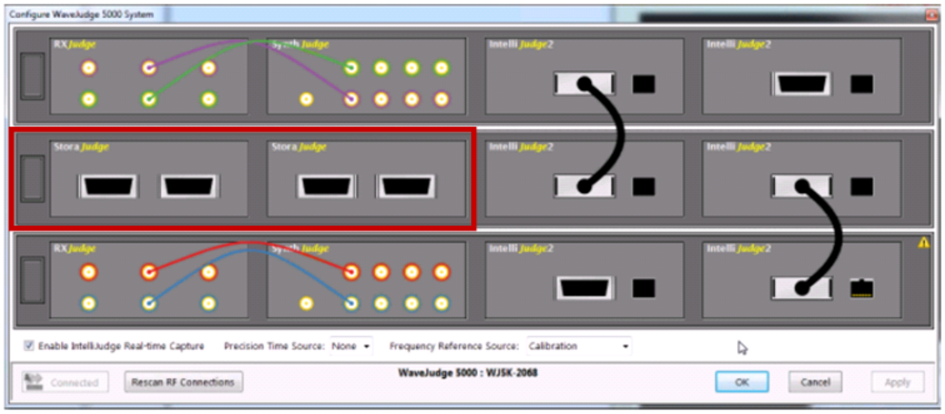
Downloading WaveJudge 5000 DSP Cores Progress Window

When the WaveJudge download is complete you will see a chassis configuration that resembles your setup and a message confirming the configuration. Notice the StoraJudge module in the bottom layer. You are now ready to begin using your WaveJudge, IntelliJudge, and StoraJudge.



StoraJudge Chassis and WaveJudge Setup Configuration Window

The best configuration for StoraJudge is to place the module between the other two IntelliJudge or RxJudge modules so it has a direct connection; do not connect StoraJudge to a chassis too far away from it. You can only use one StoraJudge SRIO port at a time to interconnect two chassis, as with the IntelliJudge2 module; you cannot use both connectors on the StoraJudge.



Three Chassis Configuration - StoraJudge in the Middle

IMPORTANT To capture to StoraJudge, there must be at least one StoraJudge for every four Rx ports used in the current configuration. If the configuration has too many ports, then StoraJudge will not be used for the capture; WaveJudge will capture only to the available RAM in IntelliJudge2 cards, as if StoraJudge were not installed.

11. 3 Using StoraJudge

Once a WaveJudge 5000 with StoraJudge is installed, you can begin using StoraJudge to capture IQ data just as you would normally take WaveJudge or IntelliJudge captures. First, set the trigger; then capture and save the data, then you can reprocess data segments of interest.

Use StoraJudge for captures when the the number of configured RF ports is less than or equal to the number of StoraJudge capture ports (four per unit) and is identified in the WaveJudge 5000 Card Configuration window. You will see a significant increase in the available capture duration identified on the setup capture screen.

Captures stored on the StoraJudge unit are WaveJudge captures, therefore you trigger a capture the same way:

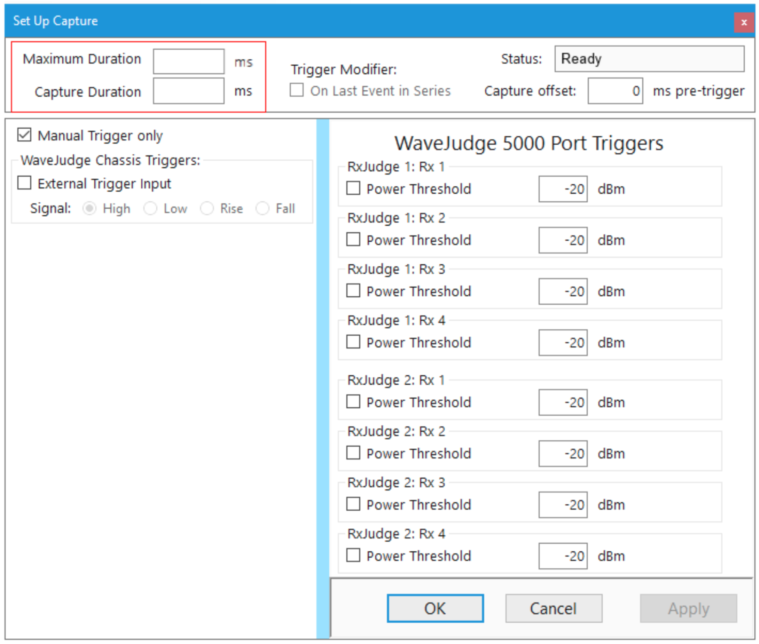
1. Manually – by clicking the Capture button
2. Externally – based on a configured external trigger or a power trigger
3. By the IntelliJudge capture – once the IntelliJudge detects a configured message-based IntelliJudge trigger
4. In the same manner as WaveJudge, you can manually initiate an IntelliJudge capture or StoraJudge capture at any time by clicking the Capture button.

11. 3. 1 Set a Trigger for StoraJudge

You can use StoraJudge with a manual trigger capture or an IntelliJudge capture, however you must first set the trigger. The Set Up Capture window is where you set the trigger's Maximum Duration and Capture Duration. Click the Set Up Capture button located on the vertical button strip on the left side of the GUI.

A maximum duration of 10 mH yields about 20 minutes of capture, a maximum duration of 20 mH yields about 15 minutes of capture. If you specify too large of a maximum duration StoraJudge will adjust it to the right size.

IMPORTANT A 15 minute capture saved to a PC will take all night to save.



Set Maximum and Capture Triggers in the Setup Capture Window

11.3.2 Start Using StoraJudge

To start using StoraJudge:

1. Click the IntelliJudge 

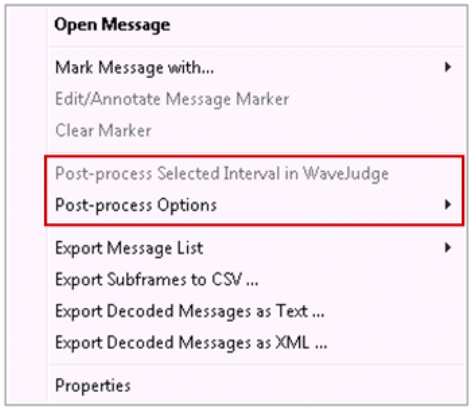
button.
2. Click the Capture 

button.
3. Go to the green status bar and select a segment between the two markers.
4. StoraJudge is set up and ready to use.

11.3.3 StoraJudge Post Processing

Unlike WaveJudge and IntelliJudge, the entire contents of the StoraJudge capture cannot display in the WaveJudge Message List. Since WaveJudge captures are quite large, it is best to access StoraJudge captures over an interval of messages in the **IntelliJudge Message List**.

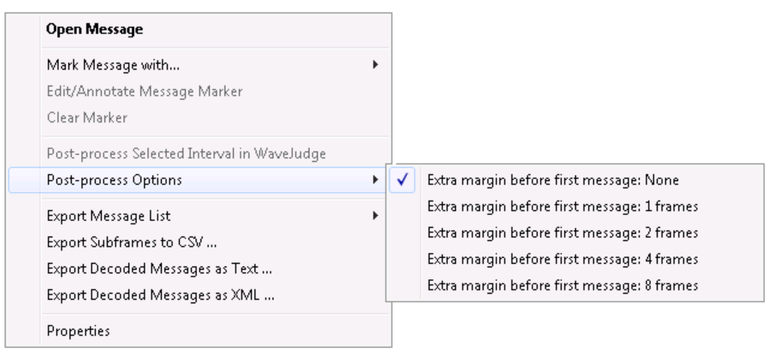
After selecting an interval in the IntelliJudge Message List, right-click and you will see the popup menu has added two new options for post-processing: Post-process Selected Interval in WaveJudge and Post-process Options. These two options are specific to StoraJudge, the rest of the options were previously described in IntelliJudge Message List on page 441.



StoraJudge Post-Process Menu Options

The first item Post-process Selected Interval in WaveJudge lets you review StoraJudge captures taken with WaveJudge when a corresponding IntelliJudge capture is present. The second item, Post-process Options, lets you determine how many extra frames to capture (so you don't miss the data you're trying to acquire). Click the arrow to the right of the text to access the additional options:

- Extra margin before first message: Non
- Extra margin before first message: 1 frame
- Extra margin before first message: 2 frames
- Extra margin before first message: 4 frames
- Extra margin before first message: 8 frames

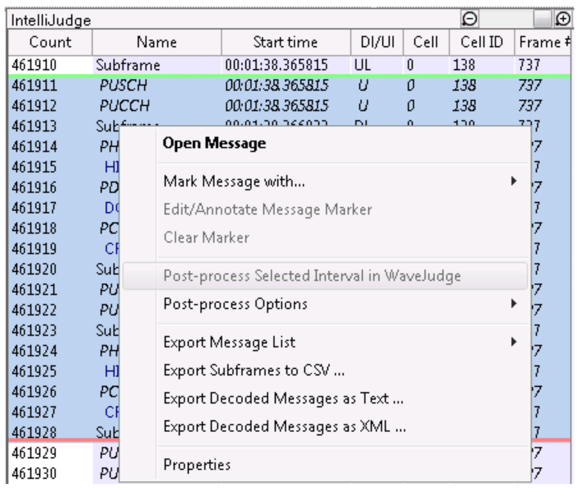


StoraJudge Additional Post-Process Menu Options

A second way to reprocess a StoraJudge capture is to use the WaveJudge Status Toolbar. Use the Reprocess button on the Capture Toolbar in conjunction with a configured Process Interval as you would for a WaveJudge capture only. You cannot process all of the green slider bar, only a segment within it.

Use Proccessing ToolBars for StoraJudge Captures

To select a range of messages **right-click** a message in IntelliJudge, hold the **shift key** down and scroll down to include the messages you want. The selected range will highlight in blue. Select a post-process option from the menu.



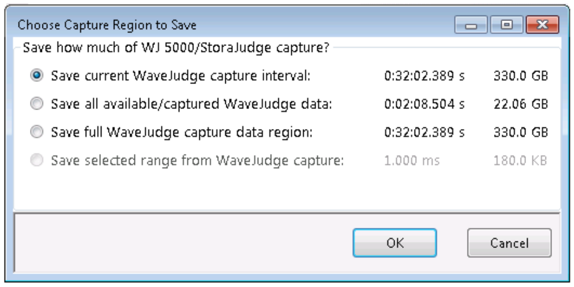
Set a Range of Messages in IntelliJudge List, Right-Click and Select a Post-Process Option

11. 3. 4 Save a StoraJudge Capture

StoraJudge captures are saved when you select any of the following options from the File menu:

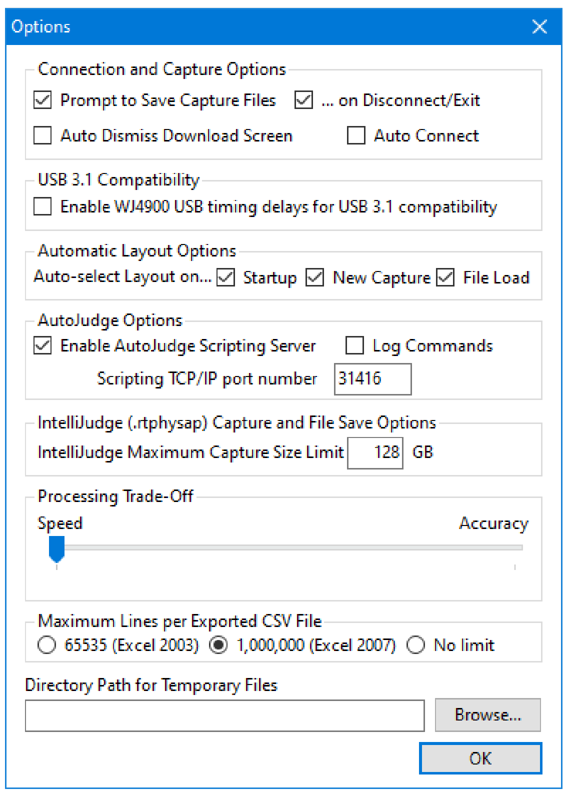
1. Save Current Capture.
2. Save WaveJudge Capture.
3. Save Combined IntelliJudge/WaveJudge capture (when an IntelliJudge capture is present).

To save a StoraJudge capture to your PC’s hard drive select the message in the **IntelliJudge List**, click the **File** menu, and select the option **Save WaveJudge Capture**. The window shown in the figure below will appear, choose the capture region to save to your hard drive.



Choose Capture Region to Save

It's always a good idea to have WaveJudge prompt you to save your capture. To set up this prompt, click the Tools menu and select Options. The Options window will open and you can instruct WaveJudge to always prompt to save your capture as well as when (e.g., on disconnect/exit).



Options Window - Select "Prompt to Save Capture Files"

12 CipherJudge Hardware Kit

This section describes how to use IntelliJudge2 and WaveJudge cipher keys to decode messages during an attach and handover.

A cipher is an algorithm that encrypts and decrypts data necessary to maintain user security and privacy. Ciphers enable private communication across all protocols that encrypt network traffic. A cipher uses a specific parameter that determines the functional output of the algorithm.

A cipher key is the method that encodes and decodes plain text. There are two types of cypher keys: symmetric (for example, private-key cryptography), where the same key is used for encryption and decryption; and asymmetric (for example, public-key cryptography) where two different keys are used for encryption and decryption. Cyphertext is the data output resulting from the data transformation.

CipherJudge is a combined software/hardware package that lets you decode ciphered traffic captured by the IntelliJudge, specific to your device, connected to the CipherJudge hardware. CipherJudge software automatically installs when you install the WaveJudge software. It monitors events between your device and the SIM card that generates the keys required to cipher and decipher traffic. It then forwards the keys to the WaveJudge software and hardware to permit them to decode the traffic.

12. 1 Hardware and Software Installation

This section identifies the components of the CipherJudge hardware and how to assemble it to use with the CipherJudge software. In addition to the hardware assembly it walks you through the one-time setup of CipherJudge software and its USB driver. It is organized to provide a high-level list of all the steps from software installation, hardware assembly, data capture, data, key save, and load. Where necessary it provides a hyperlink to additional information on a particular step.

It is assumed that CipherJudge and WaveJudge are operating in an environment with an optimal signal with no packet loss. If there is packet loss during the connection process between your device and the eNodeB the keys may not be retrieved and the ciphered traffic will not be decoded.

Upon completion of the assembly of the hardware and installation of the software you will be able to repeatedly capture, save, and load deciphered data specific to your device. Traffic is deciphered based on the cipher keys detected during the capture and saved after the capture.

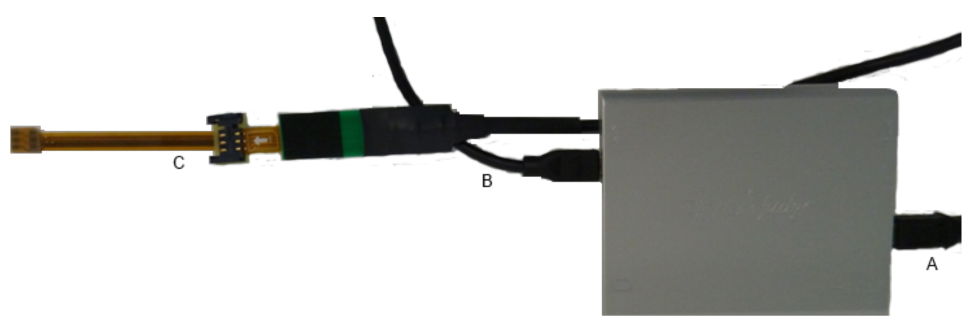
To set up CipherJudge

1. Verify the CipherJudge package contains all of the items in the packing list.
2. CipherJudge Assembly and Connection on page 517
   a. Plug the CipherJudge USB cable into the host PC's USB port.
   b. Start the CipherJudge software by clicking the **CipherJudge** button on the WaveJudge GUI and verify that it detects the CipherJudge hardware.
   c. If the Zadig USB device driver is not present you will be directed to download and Zadig USB Driver Installation on page 519. Repeat the previous step until CipherJudge software is installed.
3. Select the **Broadcast Adapter** used to connect to the WaveJudge in the CipherJudge software.
4. Power down (turn off) the mobile device.
5. Remove the SIM card from the mobile device's SIM tray.
6. CipherJudge Assembly and Connection on page 517
7. Using the appropriate SIM tray, SIM Card Installation on page 521

12. 1. 1 CipherJudge Assembly and Connection

Use the figure below as a reference to set the following connections.

1. Connect the USB to a USB mini-cable to the CipherJudge (A).
2. Connect the CipherJudge SIM Tray Connector (B) to the CipherJudge.



CipherJudge - SIM Tray Connections

3. Connect the SIM Card Extender (C) that fits your device's SIM card tray to the CipherJudge SIM Tray Connector.

CipherJudge - SIM Card Extender

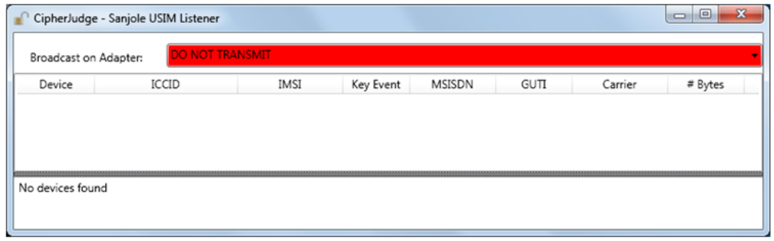
4. Plug the SIM Card Extender into your device's SIM tray. The photo below is an image of a Galaxy S20 with the SIM tray adapter plugged into the phone, as well as a SIM tray with the SIM tray adapter.

CipherJudge - SIM Tray Adaptor Plugged Into Cell Phone

12. 1. 2 CipherJudge Software Status

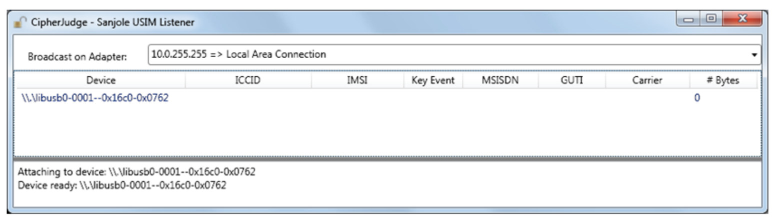
CipherJudge has several software status messages, explained below.

1. CipherJudge hardware not connected.



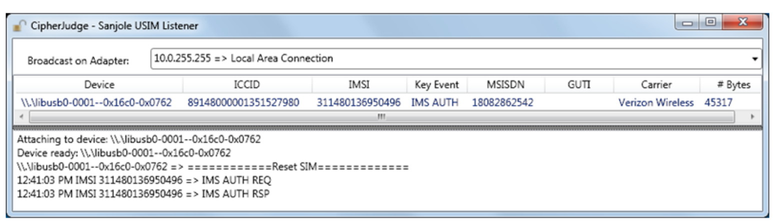
CipherJudge Hardware Not Connected

2. CipherJudge hardware connected and the broadcast adapter is connected to the WaveJudge.



CipherJudge Broadcast Apdaptor

3. Network entry event detection.

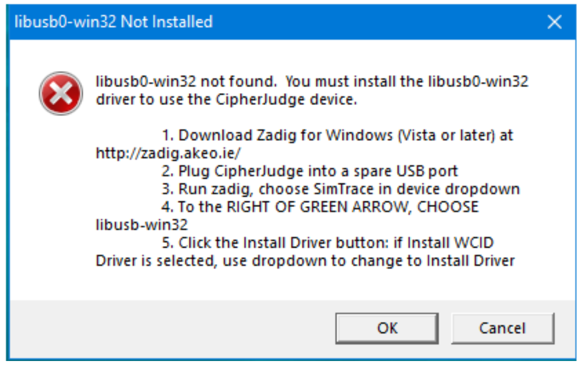


CipherJudge - Network Detected

12. 1. 3 Zadig USB Driver Installation

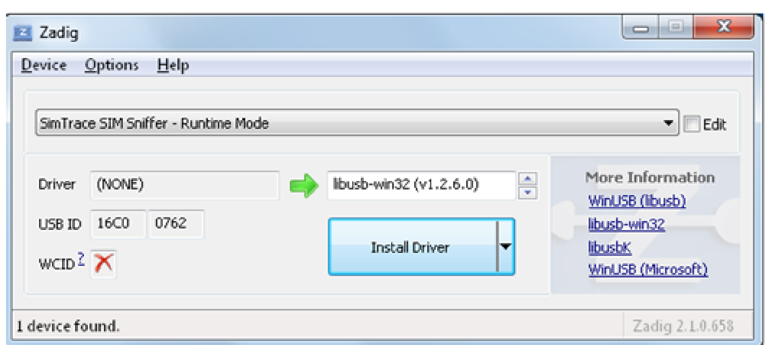
This section provides the steps to install a Zadig USB Driver.

1. If the Zadig USB driver is not found by the CipherJudge software, the following prompt displays. If you click the OK button you'll be redirected to Zadig's website: http://zadig.akeo.ie



CipherJudge - Zadig USB Driver Not Found

2. Once redirected, download Zadig for Windows.
3. If you haven't already done so, plug the CipherJudge into an available USB port.
4. Follow the prompt and select **SIMTrace SIM Sniffer**.
5. Choose libusb-win32.
6. Click the Install Driver button.
7. If the install driver label is not displayed, select it from the drop-down list next to the button. (If the window shown is not working, scroll down the page to Download and click ZADIG 2.5 (or higher version) and download it to your PC.).



CipherJudge - Zadig USB Menu Select "SimTrace SIM Sniffer"

12. 1. 4 SIM Card Installation

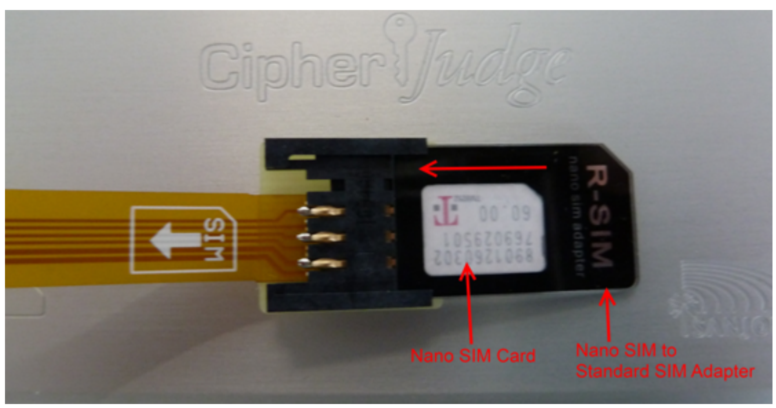
The CipherJudge hardware accepts standard-sized SIM cards. If you have a micro or nano SIM, locate the appropriate adapter tray. While using the trays the SIM card may become lodged in the CipherJudge and impossible to remove without damage.

To avoid damage we recommend using the following procedure

1. Locate the SIM connector adapter that has a standard SIM shaped PCB (printed circuit board).
2. Plug the PCB with the contacts facing down into the CipherJudge SIM.

CipherJudge - PCB Contacts Facing Down

3. If you are using a micro or nano SIM locate the appropriate SIM adapter tray.
4. Place the SIM in the adapter and slide it into the SIM connector adapter.



CipherJudge - Place SIM Card in Adapter

12. 2 Setup, Perform, and Save the Capture

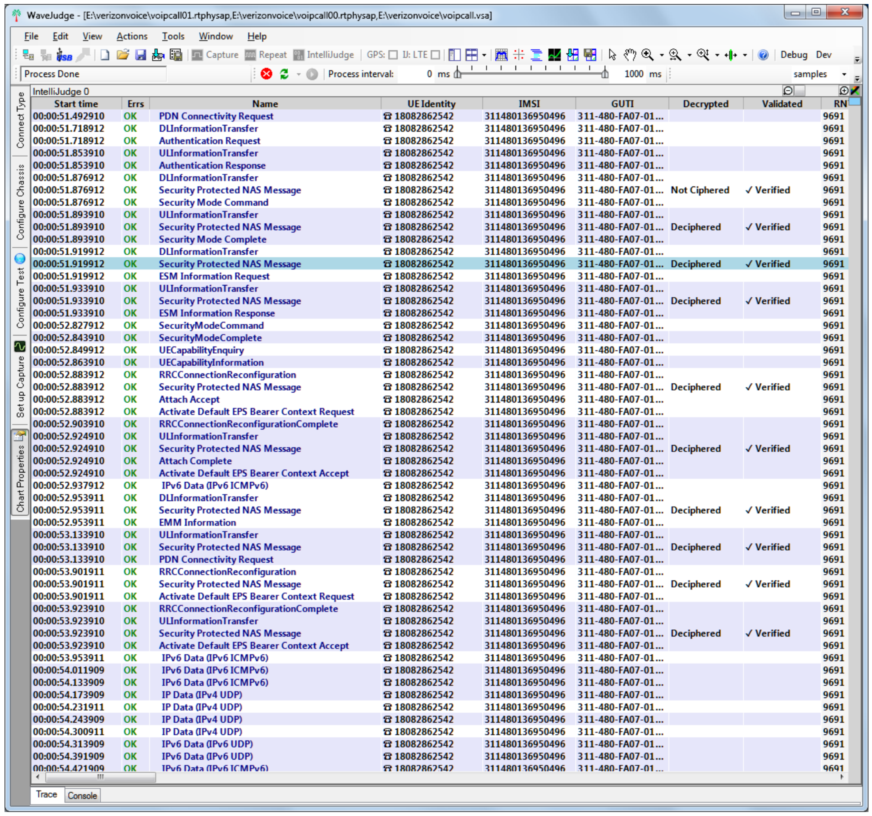
Here are the steps to set up, perform, and save a CipherJudge capture.

1. Configure a cell with the appropriate settings in the WaveJudge software.
2. Start the WaveJudge software and connect to the WaveJudge 5000.

3. Configure the IntelliJudge Filter Configuration for CipherJudge on page 526 to limit the message list to messages specific to your device.
4. Start an IntelliJudge capture.
5. Turn on your device and wait for its status to indicate it is connected to an LTE network.
6. The CipherJudge GUI will now list the Cipher Key Storage and Retrieval Methods on page 544 that occurred during the “Attach Process”.
7. The Show the Capture in CipherJudge on page 522 transferred during the connection process.
8. Save/Load CipherJudge Capture on page 523. Alternatively, generate additional traffic like YouTube then stop and save the capture.
9. Save the CipherJudge Keys.
10. Review the capture at a later date off line by first loading the saved keys followed by the capture file.

12. 2. 1 Show the Capture in CipherJudge

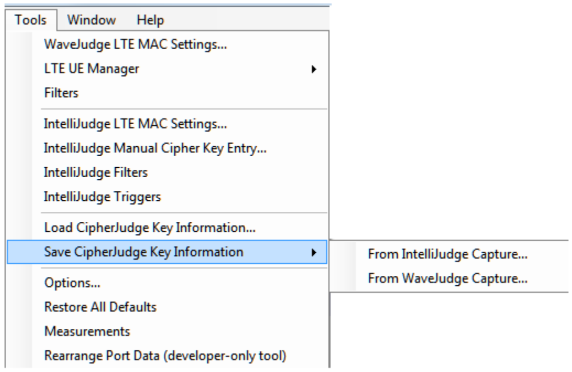
After you’ve connected the CipherJudge hardware, mobile device, and started the CipherJudge software you are now ready to capture. Configure the IntelliJudge message filters, gain levels, start the IntelliJudge capture, and turn on the UE. After the UE indicates that is connected to an LTE network stop the capture. You’ll see a display similar to the following figure if the CipherJudge UE filter is configured for RRC, NAS, and payload messages or IP.



CipherJudge Display

12. 2. 2 Save/Load CipherJudge Capture

The capture is saved in the same manner as any other IntelliJudge capture. Select either Save Current Capture or IntelliJudge capture from the file menu. However, you must take the additional step of saving the Cipher Keys. To do so select Tools? Save CipherJudge Key Information? From IntelliJudge Capture to display the control and store the key set.



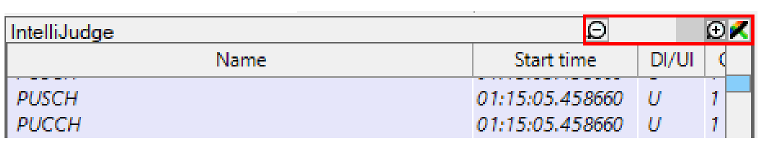
Tools Menu - Save CipherJudge Key Information Options

To analyze the deciphered capture at a later time, perform the opposite steps. First "Load Cipher Key Information", then open the saved capture file.

12. 2. 3 Alternate Message List Views

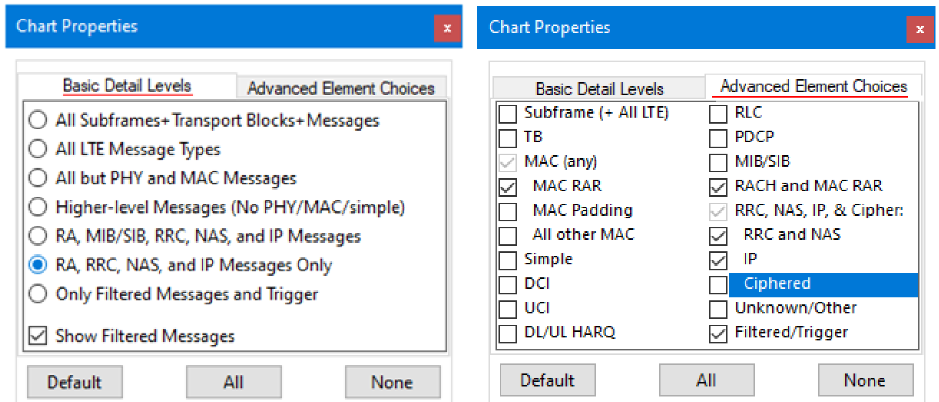
The following options create alternative views of data or adjust the filters

1. Change the layers used by the CipherJudge UE filters.
2. Filter certain messages based on the UE's RNTI.
3. Filter the Message List by changing filter and trigger zoom detail level.



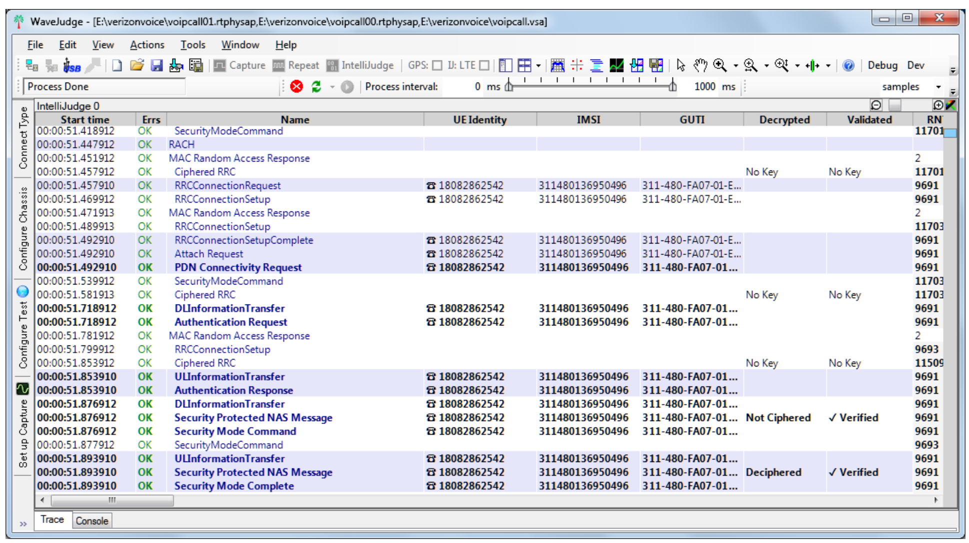
Adjust Message List by Changing Zoom Detail Controls

The CipherJudge display (refer to the figure in previous section Show the Capture in CipherJudge on page 522 began with the PDN Connectivity Request. This occurs because the message that identifies the UE is the Attach Request, which contains the GUTI or IMSI. If you want to see the complete attach sequence, change the Chart Properties Basic Detail Level to RA, RRC, NAS, and IP Message Only. Switch to the Advanced Element Choices and **deselect** Ciphered and Unknown/Other, as identified below.



CipherJudge - Best Chart Properties Selections

The results are shown in the figure below.



CipherJudge - Result from Deselecting Cipher Checkbox

12. 2. 4 CipherJudge History Function

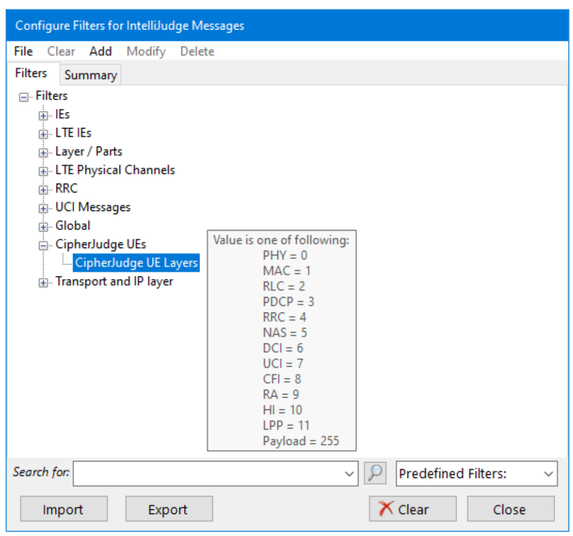
CipherJudge has two new features that work together: a history review and the ability to drag files into the device list. In the System menu, left-click on the window icon (located at the top left corner of a window) and you will see "History…" is a new entry. Click History to see the history of update packets CipherJudge has sent to the network. Select an entry (multiple select, range select, etc.) and click Transmit. Before you click Transmit, you can select the speed of replay - either all packets immediately or at a rate of your choosing (from immediately to at the speed it was transmitted before, upto 1.00x rate). You can also drag sjlusim.sqlite files to the CipherJudge

Device List (CipherJudge main window, top list) and select Replay/History to use the dragged file.

12. 3 Filter Configuration for CipherJudge

While performing your capture multiple UEs may be passing traffic in addition to your device. You can configure IntelliJudge Protocol Filters to display traffic based on the UEs identified by CipherJudge. The UE's are identified by their associated IMSI or GUTI learned by the CipherJudge. To configure IntelliJudge Protocol Filters perform these steps.

1. From the Main Menu select Tools->IntelliJudge Filters.
2. The IntelliJudge Protocol Filter control will display.
3. Expand the CipherJudge UEs branch.
4. Hover over the branch to identify the filterable layers.



CipherJudge - Hover Cursor to See See UE Filters

5. To add values to CipherJudge UE Layers:

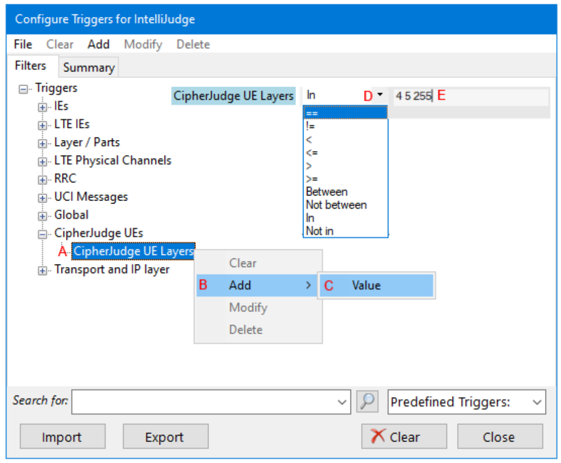
   A. Right-click on CipherJudge UE Layers.

   B. Select Add from the context menu.

   C. Select Value from the context menu.

   D. To identify multiple layers select In from the drop-down menu.

   E. Type the corresponding values from the options shown in the floating window, use a space between numbers.

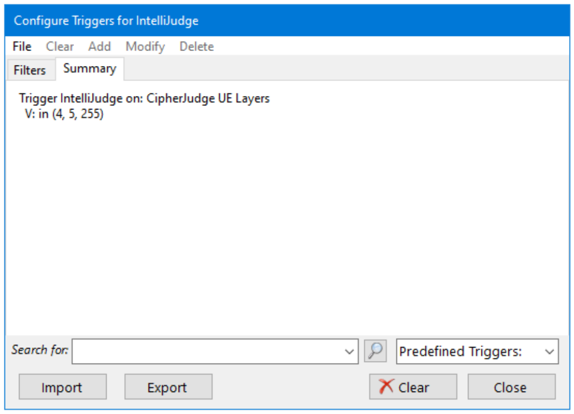


CipherJudge - Hover Cursor to See See UE Filters

F. The CipherJudge UE Layer values shown in the window are:

- PHY = 0
- MAC = 1
- RLC = 2
- PDCP = 3
- RRC = 4
- NAS = 5
- DCA = 6
- UCI = 7
- CFI = 8
- RA = 9
- HI = 10
- LPP = 11
- Payload = 255 (which is often the IP)

Click the Summary Tab to see a list of all triggers that are set. In the figure below, RRC (4), NAS (5), and the Payload (225) are set.



Click the IntelliJudge Triggers Summary Tab to View List of All Set Triggers

12. 4 Cipher LTE MAC Settings

In addition to the Message List and to support ciphering, this section reviews the LTE UE Manager and LTE MAC Settings. Both tools are automatically populated with cells, UEs, and keysets. However you must either populate the UE or its keyset to permit the software to decode ciphered messages. Once populated the decoder will rerun and secure messages may be decoded based on the cipher key.

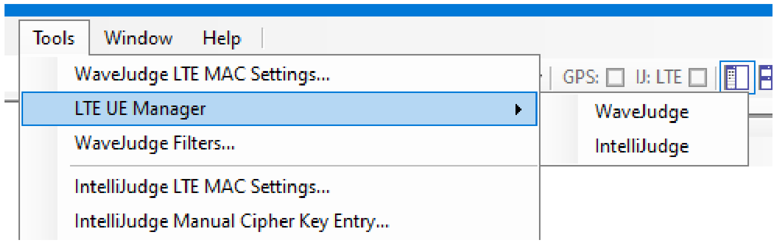
You can provide cipher keys for various points within the derivation structure. It may be the fundamental K(UE) + OP/OPc associated with the UEs SIM cards, the derived K_ASME key associated with each keyset, or the various KeNB, and KNAS keys derived from a K_ASME key. If you configure a derived key it will override key derivation by its parent key. Therefore you would need to configure all of the keys derived from the parent for the current capture.

Consider the K key. Defining the K key allows the highest degree of automation and the least amount of user input. During a capture there could be multiple keysets generated for the UE based on its K key. Each keyset would contain a different K_ ASME. If you define the K_ASME for one keyset, you must define it for the other keysets. If you don't do this, the ciphered messages associated with the keysets that haven't been configured will not decipher. However, if the capture doesn't include a message that is required to derive a K_ASME key, then you may input the key manually into a UE's keyset.

Based on the test configuration, you should use LTE MAC Settings for Cell 0 or 1, and LTE UE Manager Cell 0 or 1. IntelliJudge users will use the IntelliJudge LTE MAC Settings and LTE UE Manager for IntelliJudge.

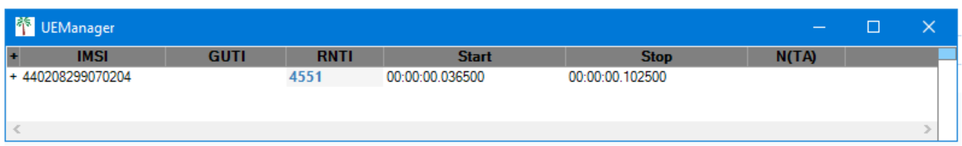
12. 4. 1 LTE UE Manager for CipherJudge

The LTE UE Manager is the exact same window for WaveJudge and IntelliJudge. To access it, click the Tools menu, select LTE UE Manager and select either WaveJudge or IntelliJudge from the submenu.



Tools Menu - LTE UE Manager

The figure below is an example of the LTE UEManager window.



LTE UEManager Window

The columns/fields are as follows:

IMSI: International Mobile Subscriber Identity; detects the UE associated with the connection.

GUTI: Globally Unique Temporary ID; identifies the UE and the MME involved in the connection.

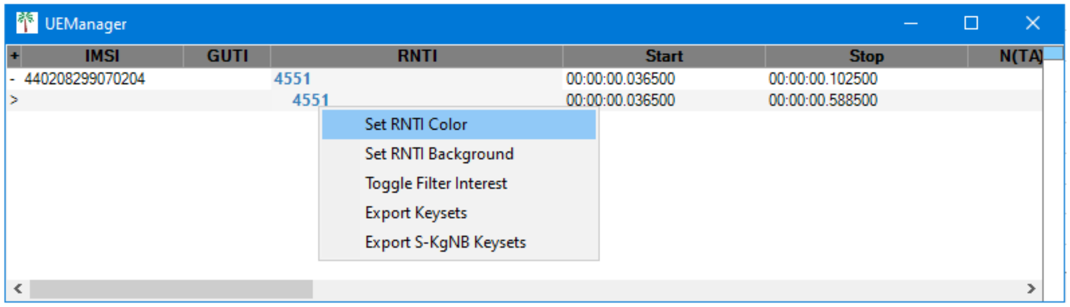
RNTI: Radio Network Temporary Identifier; identifies a connected UE in the cell, a specific radio channel, a group of UEs (for paging), a group of UEs for which power control is issued by the eNB, or system information transmitted for all UEs by 5G gNB.

Start: Starting time of the capture.

Stop: Time the capture ended.

N(TA): Represents the N(Timing Advance) found in the MAC-RAR message.

Right-click on the RNTI to access the UEManager context menu; menu options are described below.



LTE UEManager Window - Right-Click to Access Context Menu

The UEManager context menu options are as follows:

Set RNTI Color: Opens a color picker window to set the color of the RNTI values.

Set RNTI Background: The color applied to RNTI cell background to make it stand out.

Toggle Filter Interest: Toggles the "UE of Interest" user level flag. For example, if you toggle it on a user, and your CipherJudge (IntelliJudge or WaveJudge) filter is set on certain layers (e.g., RRC NAS, IP = "4 5 255"), then when you do a PA level reprocess (open LTE MAC Settings for IntelliJudge/WaveJudge) and click OK (it won't trigger a VSAServer reprocessing), then the message layers you marked to filter would be highlighted.

Export Keysets: Opens a window to export and save the data as file type KeySets (*.keysets.sxl).

Export S-KgNB Keysets: Opens a window to export and save the S-KgNB data as file type KeySets (*.keysets.sxl).

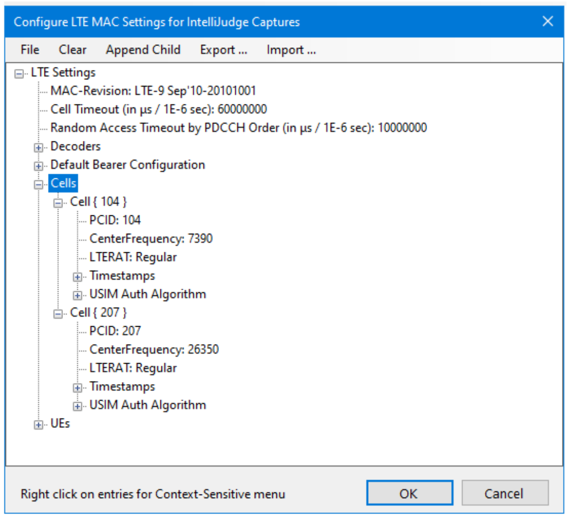
12. 4. 2 IntelliJudge LTE MAC Settings for CipherJudge

Based on the decoded capture data, the **IntelliJudge LTE MAC Settings** may update with branches containing cell and UE data. Cells are detected based on the synchronization signal. The UEs are discovered during connection establishment. The cell branch contains lists of cells. Each cell in the list consists of attributes.

The **Configure LTE MAC Settings for IntelliJudge Captures** window has the following seven layers.

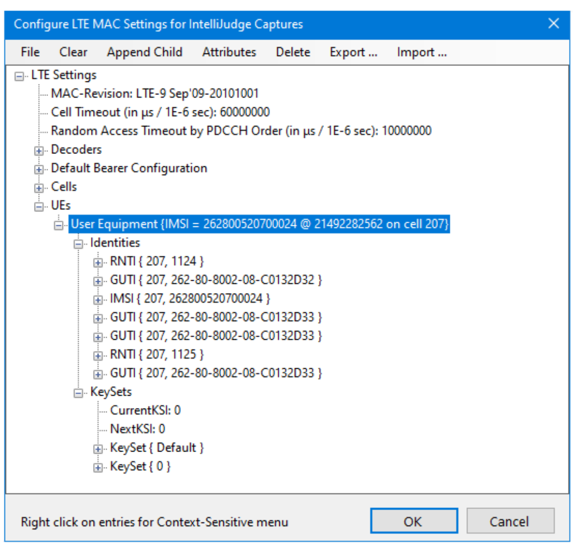
1. MAC-revision
2. Cell Timeout
3. Random Access Timeout by PDCCH Order
4. Decoders
5. Default Bearer Configuration
6. Cells
7. UEs

The Cells layer is where you can locate the the PCID (physical cell identification), Center Frequency, LTERAT (LTE Radio Access Technology), timestamps, and USIM (Universal SIM card) Authentication algorithm.



IntelliJudge LTE MAC Settings Window - Cells Layer

The UE layer is where you can locate and set the KeySets.



IntelliJudge LTE MAC Settings Window - UE Layer Has KeySets

12. 4. 2. 1 User Equipment

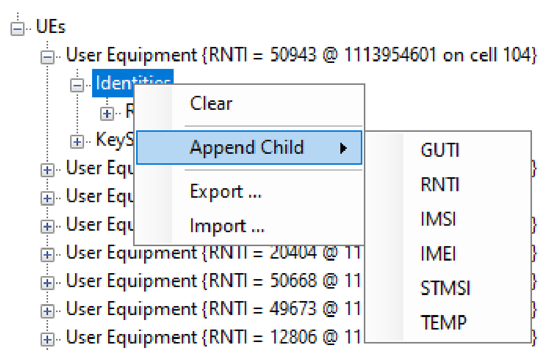
Each UE in the list has the same structure. The structure includes the UE's different identities, cipher keys, integrity, and encryption algorithms used by the UE. The cipher keys may be the K, OP/OPc pair associated with a UE SIM card, the K_ASME derived for each keyset, or KeNB /KNAS derived from the K_ASME.

The key that you configure is dependent on the information in the decoded data. However the K, OP/OPc represents the root of the key derivation tree. Each branch in the key derivation tree begins with the K key. Using the K key will limit the configuration to one entry. If the K_ASME is required then you will need one K_ASME for each keyset derived during the capture. The same method applies for the KeNB and KRRC.

User Equipment Identities: Different identities associated with a UE identified during connection process.

- GUTI
- RNTI
- IMSI
- IMEI
- STMSI
- TEMP

If all of the identities do not appear, you can find and add them by right-clicking on **Identities**, select **Append Child**, and select a value from the drop-down list.



Configure LTE MAC Settings for IntelliJudge - Append UE Identities

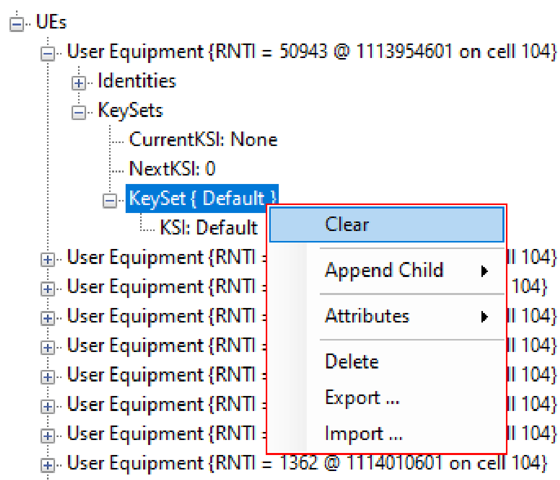
User Equipment Attributes:.

K_UE: Encryption Key used to derive the K_ASME; it's synonymous to the K key stored in UE SIM card.

OP: 128-bit Operator Variant Algorithm Configuration Field that's a component of Milenage functions f1-f5 and f5*.

OPc: 128 bit value derived from K_UE and OP.

Right-click on KeySet to access a context menu and set the parameters.



Right-Click on a KeySet to Access Context Menu

Each branch may have one or all of the following functions; each function is described in a subsection below.

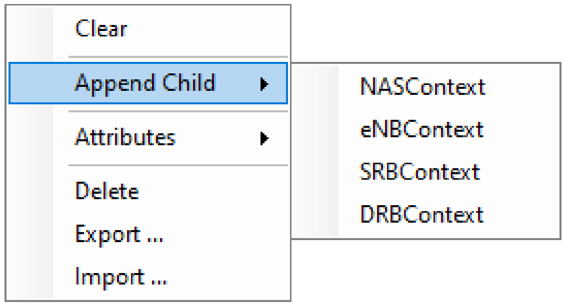
1. Clear on page 533
2. Append Child on page 533
3. Attributes on page 534
4. Delete on page 535
5. Export/Import on page 535

12. 4. 2. 2 Clear

Removes any parameters previously set.

12. 4. 2. 3 Append Child

The Append Child function identifies all branches that have additional branches or attributes associated with it's parents. Items that appear in the Append Child submenus correspond to the parent elements, the list varies according to the parameter.



KeySets Context Menu: Append Child SubMenu

Append Child options allow you to select and append each of the following parameters:

NASContext: Non-access stratum (NAS) layer in the UMTS and LTE protocol stacks.

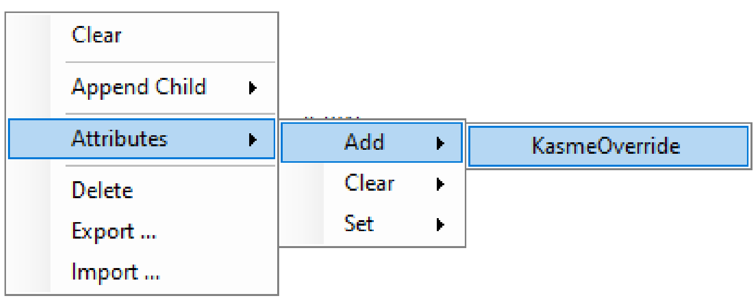
eNBContext: eNodeB.

SRBContext: Signalling Radio Bearer.

DRBContext: Dedicated Radio Bearer.

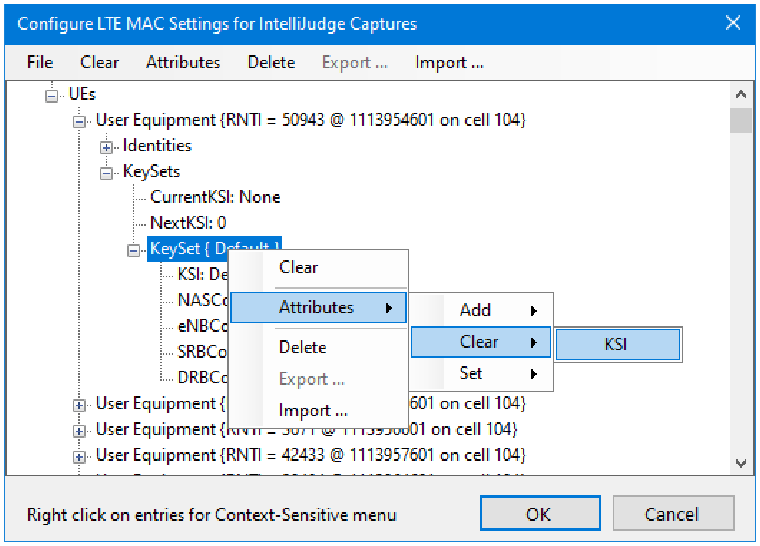
12. 4. 2. 4 Attributes

Attributes that are mandatory are automatically created; however, you may add optional attributes.



KeySets Context Menu: Add Attributes

If you have set the attributes, you can click on a specific one and right-click to clear or set it.



KeySets Context Menu: Clear Attributes

Once you add attributes, you can right click anywhere in the white space and **Set, Clear**, or **Delete** attributes.

12. 4. 2. 5 Delete

Removes a parameter that was previously set.

12. 4. 2. 6 Export/Import

The Export/Import option is available to every node in the IntelliJudge LTE Mac Settings window. Export will export everything under a node. Export opens a Save As window to save the file with an *.sxl extension to the file name. Import opens a window to locat the *.sxl file.

12. 4. 3 Ciphering Process and Logic

This section describes the process of discovering UEs and configuring their K_UE, OP/OPc and kASME_override fields. During the first pass of the captured data through the decoder the RRC Connection Request and RRC Connection Reestablishment Request messages on different RNTI are monitored. Their receipt creates UE entries in the UE manager with an associated color and key code. Next, the RRC Connection Request is checked for the UE-Identity field, which is one of the following:

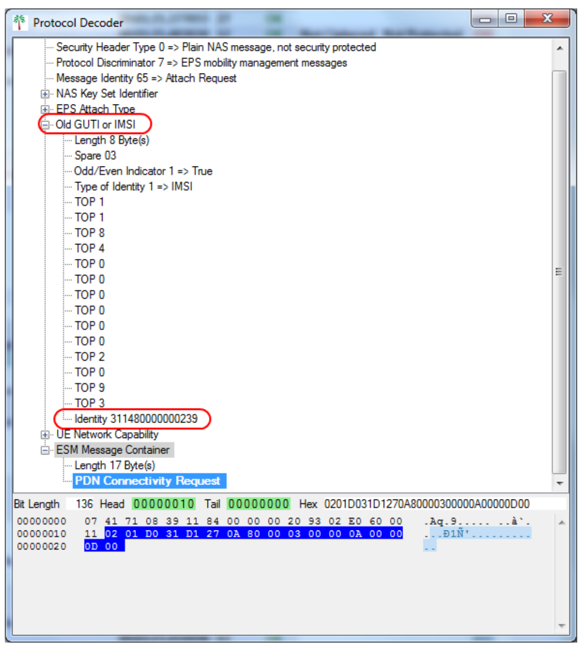
1. 40 bit Random Value
2. S-TMS
3. C-RNTI

If the message includes an S-TMSI field, this information fills in the MMEC and the M-TMSI fields of the GUTI. Otherwise, it creates a blank entry. From this point on all messages received on the associated RNTI display the RNTI using the color configured. Upon receipt of the next RRC Connection request the color associated with the RNTI may change.

4. Attach Request

   Following the RRC Connection request an Attach Request may be received. If a UE doesn't exist for the Attach Request messages' RNTI it creates a UE entry. Next the message's Old GUTI/ IMSI field is checked. If an IMSI value is present it populates the IMSI field, otherwise the GUTI field is populated if it doesn't already exist.

The figure below is an example of a decoded Attach Request. Contained within it is an expansion of the Old GUTI or IMSI field. In it is the IMSI identity field.

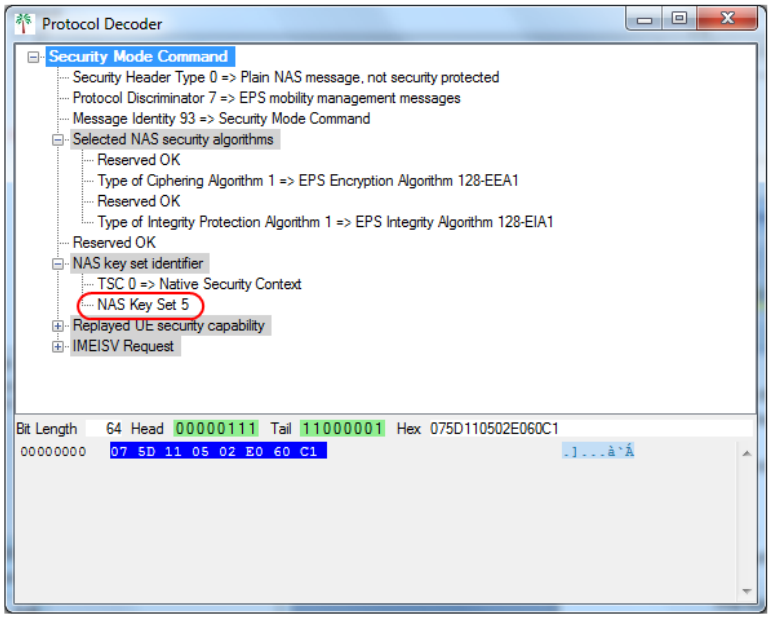


Decoded Attach Request

Once this information is obtained the decoder populates the LTE MAC Configuration window with UEs and the attributes available. This may include Identities (GUTI and IMSI) and KeySets.

KeySets created are containers, they include the Key Set Identifier and place holders for the attributes required. The KeySet is identified in the NAS Security Mode Command. Different Security Mode Commands may identify KeySets, Security Algorithms, and UE security capabilities.

If you provide the K_UE and OP/OPc pair, then you must also provide the authentication key for the key set identified by configuring the kASME_override. If there are problems using either the K_UE, OP/OPc pair, or the kASME_override, you have the option to configure the Cipher Key Override and/or the Integrity Key Override for each of the following: NASContext, ENBContext, SRBContext, or DRBContext. The figure below show an example of a Security Mode Command decode indicating you should use Ciphering Algorithm EEA1, Integrity Algorithm EIA1, and NAS Key Set 5.



Security Mode Command Indicates NAS Key Set 5

12. 5 Cipher Keys and Entities

Below is a list of terms that identify cipher keys:

IMSI: International Mobile Subscriber Identity

DRB: Data Radio Bearer

GUTI: Globally Unique Temporary Identifier

GUMMEI: Globally Unique MME Identifie

KASME: Key Access Security Management Entity. ASME is defined in TS 33.401[1] as the entity in an access network that receives the top level keys from the Home Subscriber Server (HSS). For E-UTRAN access, the MME assumes the role of the Access Security Management Entity (ASME).

MMC: Mobile Country Code

MME: Mobility Management Entity

MMEC: Mobility Management Entity node

MMEG(1): MME Group Identifier

MMEI: MME Identifie

MNC: Mobile Network Code

M-TMSI: MME Assigned Temporary Mobile Subscriber Identity

S-TMSI: SAE Temporary Mobile Subscriber Identity

SRB: Signaling Radio Beare

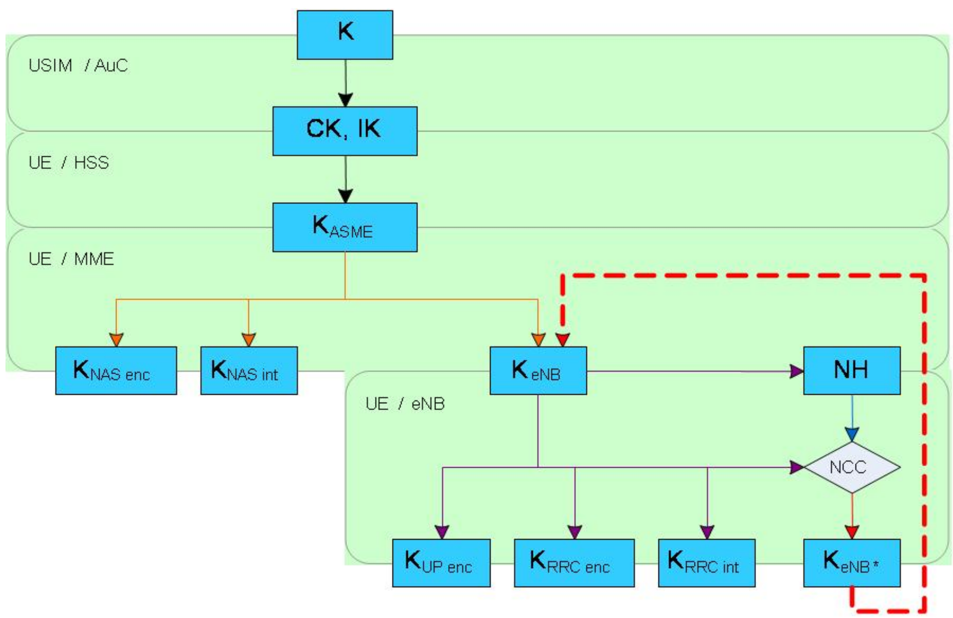
Below are the definitions of the different keys:

Cipher Key Definitions

Key	Purpose	Length	Derived From	Description
K	*Master Base Key for GSM, UNMTS, EPS*	*128*	*-*	*Secret key stored permanently in USIM and AuC*
CK,IK	*Cipher and Integrity Keys*	*128*	*K*	*Pair of keys derive in AuC and USIM during a AKA run. CK and IK should be handled differently for EPS compared to Legacy context.*
K ASME	*MME (ASME) Base/Intermediate Key*	*256*	*CK, IK*	*Intermediate key derived in HHS and UE from CK, IK during AKA. This is sent as part of the EPS AV from HSSS which include RAND, XRES, AUTN, and uniquely identified with ETSI allocated by the MME during AKA process. MME assumes the role of ASME in EPS.*
K eNB	*eNB Base Key*	*256*	*KASME KeNB**	*Intermediate key derived in MME and UE from K ASME when UE transits to ECM-CONNECTED state or by UE and Target eNB from K ENB during Handover.*
*K enb**	*eNB Handover Transition Key*	*256*	*KeNB (H) NH (V)*	*Intermediate key derived in Source eNB and UE during Handover when performing Horizontal (K ENB) or Vertical Kay (NH) Derivation. Used at Target eNB to derive K ENB.*
NH	*Next Hop*	*256*	*KeNB*	*Intermediate key derived in MME and UE used to provide forward security, and forwarded to eNB via the S1-MME interface.*
K NASint	*Integrity Key for NAS Signaling*	*256 (128 LSB)*	*K ASME*	*Integrity key for protection of NAS data derived in MME and UE*
K NASenc	*Encryption Key for NAS Signaling*	*256 (128 LSB)*	*K ASME*	*Encryption key for protection of NAS data derived in MME and UE*

Key	Purpose	Length	Derived From	Description
K UPenc	*Encryption Key for User Plane (DRB)*	*256 (128 LSB)*	*K eNB*	*Encryption key for protection of user plane data derived in eNB and UE*
K RRCint	*Integrity Key for RRC Signaling (SRB)*	*256 (128 LSB)*	*K eNB*	*Integrity key for protection of RRC data derived in eNB and UE*
K RRCent	*Encryption Key for RRC Signaling (SRB)*	*256 (128 LSB)*	*K eNB*	*Encryption key for protection of RRC data derived in eNB and UE*

The figure below shows the key hierarchy in which they are derived.



Cipher Key Hierarchy

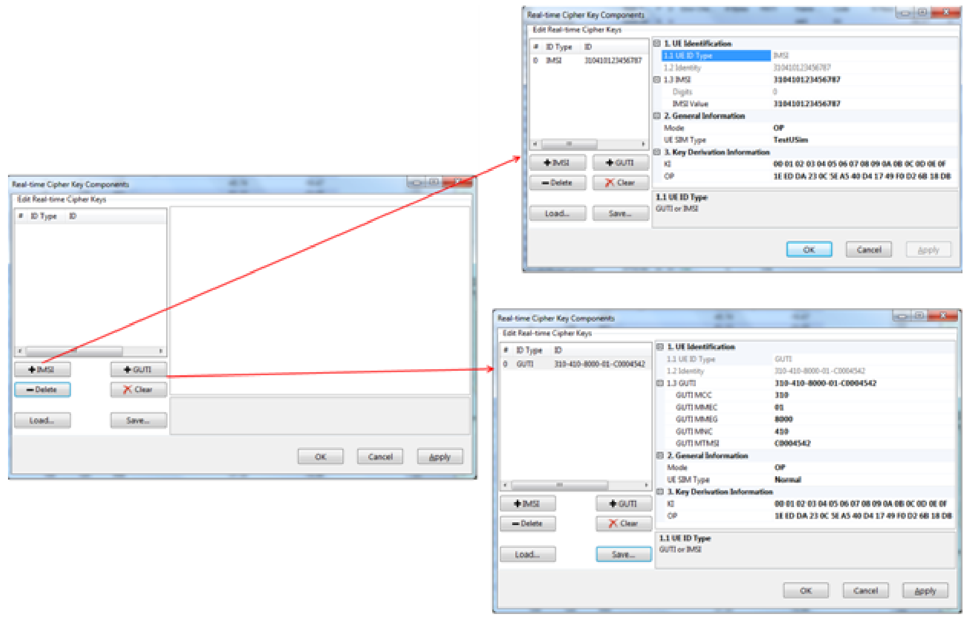
12. 5. 1 IntelliJudge Cipher Keys

The following steps describe how to perform an IntelliJudge and WaveJudge capture and configure the software to reprocess and decipher the ciphered messages.

To decipher in real time you must first enable the RT-Cipher License.

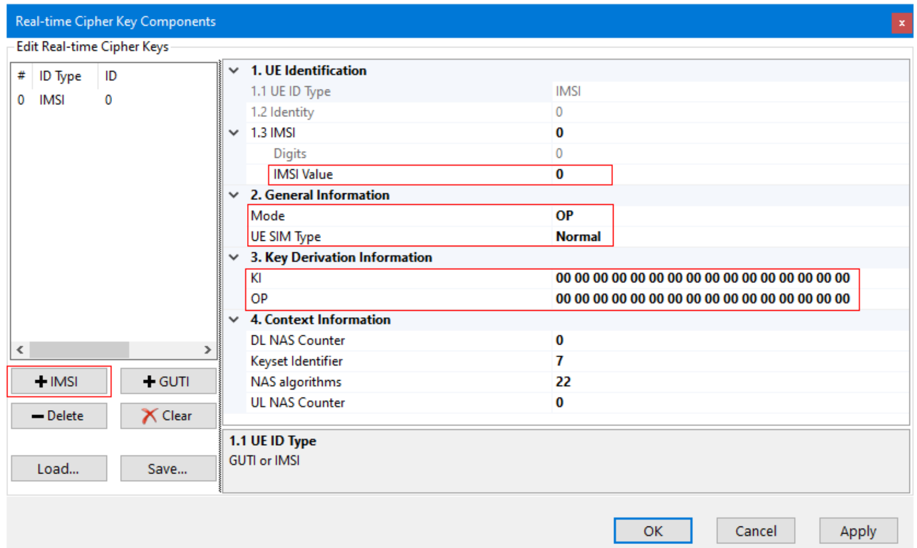
1. Identify the IMSI, K_UE of the SIM card and either OP or OPc, and then turn off the user equipment (UE).

2. On the WaveJudge Tools Menu select IntelliJudge Real-time Cipher keys... .
3. Real-Time Cipher Key Components window will open, you'll see an option to configure the keys based on the IMSI or GUTI.



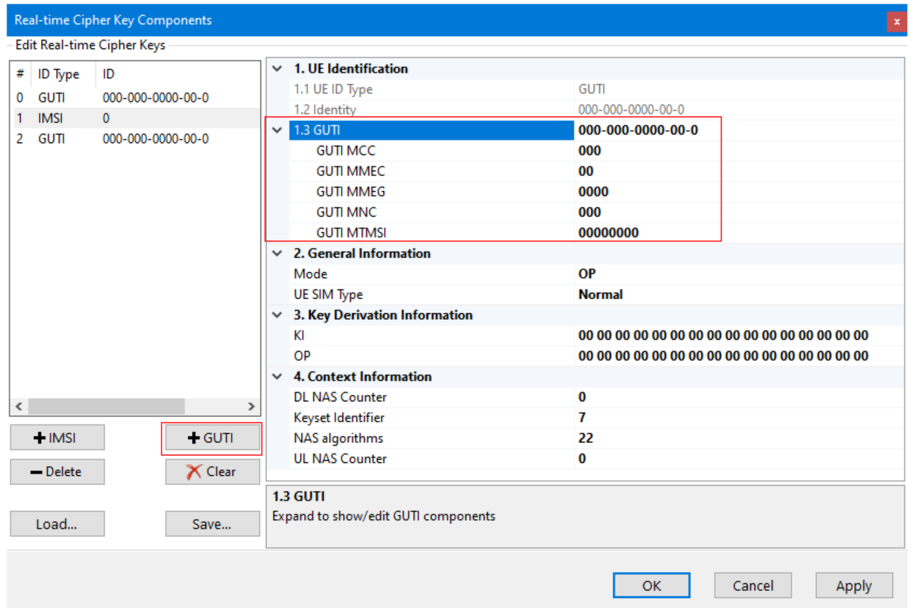
Real Time Cipher Key Components Window - Select IMSI or GUTI

4. Click the + IMSI button to add an IMSI based key set and fill in the fields.
   – IMSI Value: A value of 0 may be used for a TestUESim and may be used regardless of the availability of a GUTI.
   – Mode: OP, OPc, or Kasme with or without NAS.
   – UE SIM Type: Identify the key derivation algorithm: Normal for Mileage, or TestUESim.
   – KI: K_UE value; Enter 16 byte KI value in hexadecimal. K_UE is the secret K key associated with UE/USIM different for every SIM card.
   – OP: Enter 16 byte OP or OPC value in hexadecimal. OP/OPc is the secret Operator key either before or after a (c)ipher algiorithm is applied.



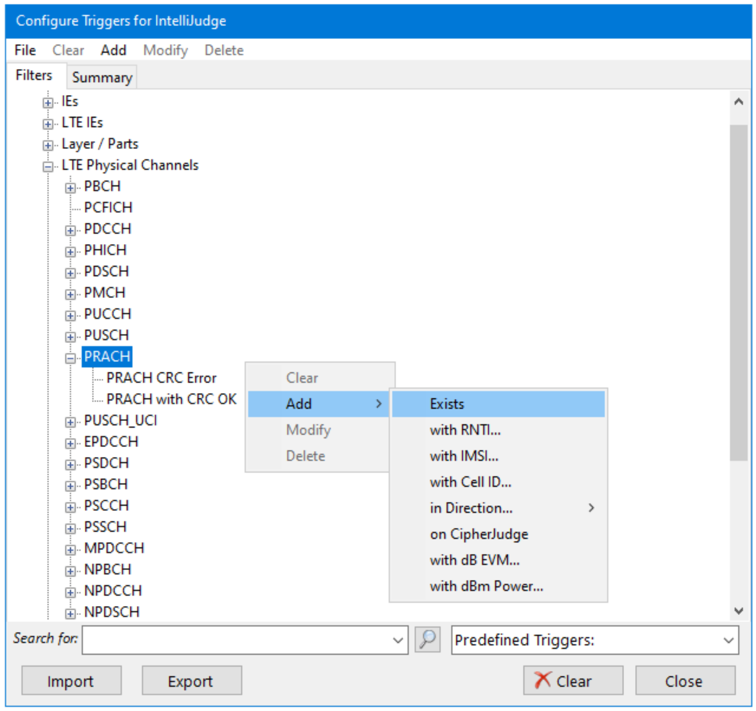
Real Time Cipher Key Components Window - Input IMSI Values

5. If the UE previously entered the network, a GUTI is used to identify the UE the user must key it's component values into the following fields.
   - GUTI MCC: Enter the value of MCC in decimal, as BCD (Binary Coded Decimal); maximum of three digits.
   - GUTI MMEC: Enter the value of MMEC in hexadecimal, maximum of two digits.
   - GUTI MMEG: Enter the value of MMEG in hexadecimal, maximum of four digits.
   - GUTI MNC: Enter the value of MNC in decimal, as BCD; maximum of three digits.
   - GUTI M-TMSI: Enter the value of MTMSI in hexadecimal, upto eight digits.



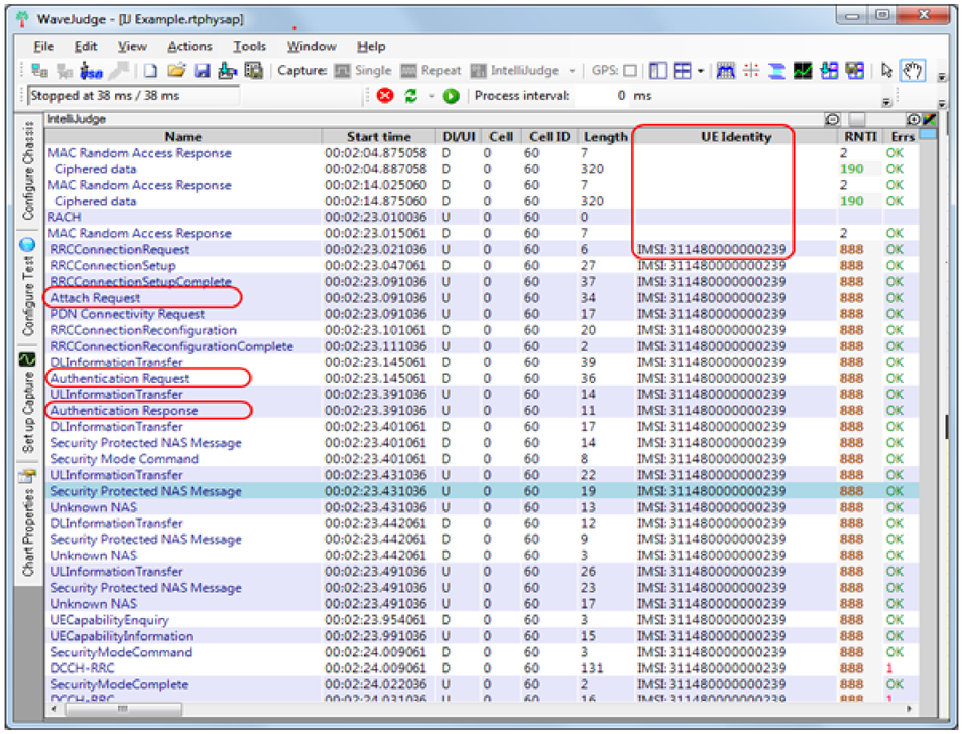
Real Time Cipher Key Components Window – Input GUTI Values

6. Click the Save button to save the configuration for future use.
7. Click either the Apply or OK button to apply the settings.
8. On the Tools Menu select IntelliJudge Triggers and enable LTE Physical Channels then enable Prach.



Set IntelliJudge Triggers to PRACH

9. Click the Setup Capture button Set up Capture. In the Setup Capture window, set the Capture Duration with the maximum duration.
10. Click the IntelliJudge icon IntelliJudge in the menu to start the real-time capture.
11. Turn on the UE and perform the UE Attach.
12. When the WaveJudge capture is complete stop the IntelliJudge by clicking the Stop Processing icon.
13. In the IntelliJudge Message List, verify the following four messages are present. If they are not present then deciphering is not possible. Otherwise a subsequent message should be deciphered.
    - Attach Reques
    - Authentication Request
    - Security Mode Comman
    - Security Mode Complete



CipherJudge - Confirm Four Message Types Are Present

14. The keys you define are not saved with the capture files. Go to the Tools Menu and select IntelliJudge Real-time Cipher keys then load the saved key file either before or after loading the capture file.
15. If you load the keys after loading the capture file, you must reprocess the capture to apply the keys to decode the encrypted data. Click the Reprocess icon.

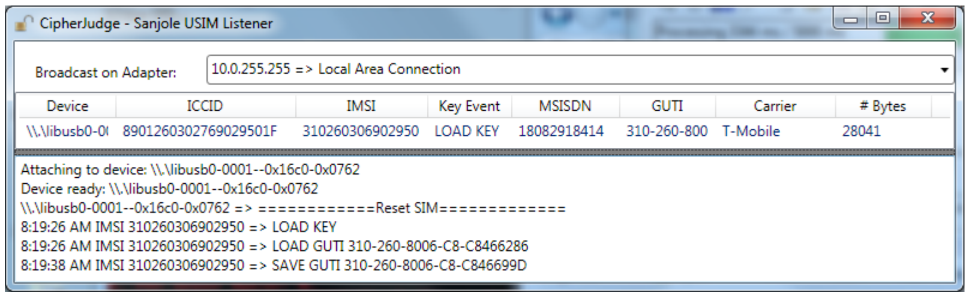
12. 5. 2 Cipher Key Storage and Retrieval Methods

Different devices and their associated service providers store the authentication information used by CipherJudge in one of two locations: 1) stored in the SIM Card's non-volatile RAM, or 2) stored in the device's non-volatile RAM.

How you reset your device, and how CipherJudge obtains the cipher keys depends on where the keys are stored. To identify where the keys are stored check the CipherJudge display when you first power up the phone after it's connected to CipherJudge. Below are examples of the storage methods, key events, and the CipherJudge's display.

1. **Keys stored in SIM Card's non-volatile RAM**.

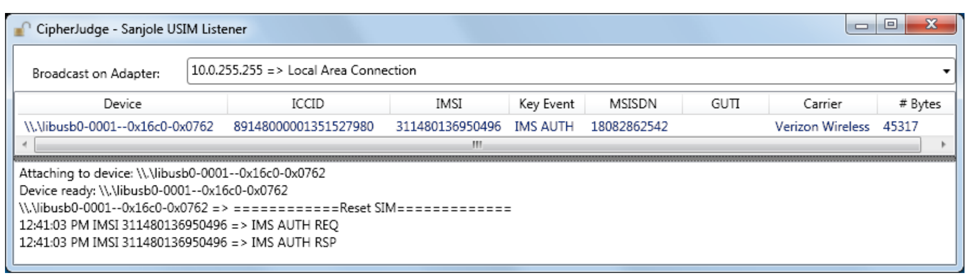
   In the image above, the GUTI provided during the Attach process is loaded from and then saved to the SIM card. If this applies to your device then you don't need to do anything special. Just start the real-time capture and reset your device to decode all of the messages beginning with the attach process.



CipherJudge - Key Stored in SIM Card's Non-volatile RAM

2. **Keys stored in device's non-volatile RAM**.

   If the behavior identified in the image above applies to your device then you likely have two SIM cards with different identities installed. If the SIM cards are from the same carrier you must alternate between them with each new capture. By alternating between the two SIM cards your device will automatically force a complete authentication. If your device does not perform a complete authentication it will use the GUTI stored in the device's non-volatile RAM that the CipherJudge software will not recognize and prevent it from deciphering the traffic.



CipherJudge - Key Stored in Device's Non-volatile RAM

If you have a SIM card from the carrier you are using to test and a SIM card from an alternate carrier, the procedure is slightly different. Use the SIM card from the alternate carrier to reset the phone to force it to re-authenticate. After each capture you must turn off the device, replace the SIM card used to perform the capture with the alternate SIM card, and then turn on the device. After the device has attached to the alternate network turn off the device and change the SIM card. When you are ready to capture again, start the capture and turn on the device.

12. 5. 2. 1 Multi-Frequency Networks

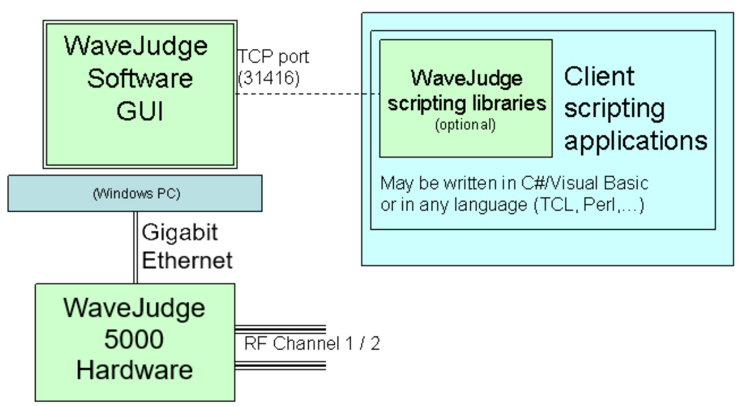
Providers are enhancing their networks with different cell topologies. As an example, our local Verizon network has deployed an overlapping Macro/Small Cell topology. In this configuration, the Macro Cells and the small cells use different frequencies - making it impossible to predict which cell the device will attach to. Therefore, WaveJudge must be configured with two cells to support this configuration. One cell is configured for each frequency with two DL and one UL port. You must know the network topology used to perform these tests.

13 AutoJudge CLI

AutoJudge Command Line Interface (CLI) is a scripting interface that automates wireless testing without using the MS Windows graphic user interface. AutoJudge automatically controls the connection to WaveJudge 5000 hardware, performs data capture and analysis, and configures analysis software and other features. With AutoJudge, you can load or save capture files faster and easier, import or export signal data in ASCII format, and perform protocol decoding and additional capture and analysis functions.

13. 1 AutoJudge Connection Model

AutoJudge's command automation takes place over a TCP/IP socket, in a simple line-oriented (telnet-compatible) protocol. Once you enable AutoJudge, you can connect one or more Windows PCs to WaveJudge via the network connection. From there you can issue commands and receive data. The diagram below provides an overview of the connections.

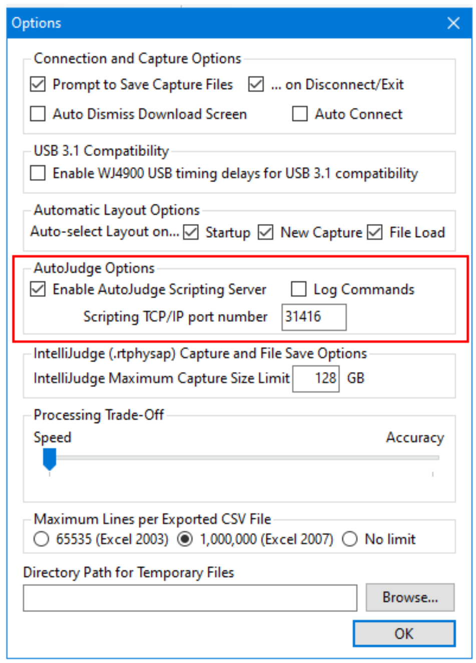


AutoJudge Connection Model and Scripting Diagram

Because AutoJudge interaction takes place in plain text over a TCP/IP connection, you can use AutoJudge to automate wireless testing and analysis from any programming language that can connect to a TCP socket and send and receive strings

13. 1. 1 Enable and Configure AutoJudge Scripting Service

To enable AutoJudge scripting select Options from the Tools menu. Click the Enable AutoJudge Scripting Server checkbox to check. Keysight recommends that you leave the AutoJudge Scripting Port set to its default value of 31416; if it is necessary to change it for your application, you may change it.



Options Window - Enable AutoJudge

After you enable AutoJudge for the first time you must exit and restart WaveJudge to start the AutoJudge scripting service. From then on, AutoJudge's scripting service will enable and listen on the selected port each time you run WaveJudge.

NOTE Before you can enable AutoJudge service or configure the scripting port, you must enable your software license for AutoJudge.

13. 1. 2 Secure the Scripting Configuration

If you enable the AutoJudge scripting service it is your responsibility to configure the Windows firewall and configure your network firewall so that it is impossible to reach the configured scripting port on your WaveJudge installation from outside the network you use for testing.

CAUTION **It is important to understand that AutoJudge has no firewall capabilities. Do not leave the AutoJudge scripting port exposed to access from the public Internet!**

13. 2 AutoJudge Scripting Communications

If you connect directly to the configured port via telnet you will see a router-like “>” prompt. This indicates that WaveJudge is ready to accept a scripting command.

Enter commands as single lines and terminate them with a carriage return. Each command should consist of a named object method or property. The scripting server responds with the return value of the command, or a response beginning with “ERROR” for a command which failed due to an error.

WaveJudge scripting is implemented with an object-oriented model. To access an object’s methods, call them out with a parenthesized parameter list or retrieve its properties by naming them. Properties are set with a method-like syntax via calling `object.set_property(value)`.

Initially, scripts have access to two basic objects:

- Client, a WJScriptingClient object, that provides access to controls over the AutoJudge scripting session itself.
- WaveJudge, a WJScriptable object, is the AutoJudge interface to control WaveJudge’s capture, configuration, and analysis capabilities.

Most of your scripting will involve interaction with the methods and properties of a WaveJudge object or other objects retrieved from it, for example:

```
                       >WaveJudge.Connect
                       >WaveJudge.LoadConfig
(C:\Testing\SavedConfigs\MytestConfig.pfl) True
                       >WaveJudge.set_ConfigCaptureDuration(1000)
                       >WaveJudge.StartCapture
```

You can create new internal scripting objects and interact with them by assigning the object resulting from some property or method to an arbitrary name. The scripting server will return a string with the type of the object you have just created and named, for example:

```
> cell = WaveJudge.Cell[0]
Sanjole.WaveJudge.Cell
> pd = cell.ProtocolDecoder
Sanjole.PAServer.ProtocolDecoder
```

13. 2. 1 AutoJudge Support Library

To simplify using AutoJudge's interface, Keysight provides a Microsoft .Net CLR-compatible AutoJudge support library with some simple scripting examples in Microsoft C# and Microsoft Visual Basic. Full source code for the library is included to help clients who wish to write or extend the library or to use it as a basis for writing AutoJudge automation support in other languages.

13. 2. 2 Starting Points

Some useful starting points to browse the reference documentation are:

- The WaveJudge object within AutoJudge: WJScriptable class and methods.
- The Client object within AutoJudge: WJScriptingClient class and methods.
- The WaveJudge namespace of classes and enumerated types.

14 Troubleshooting

This section is intended to help you troubleshoot problems with WaveJudge 5000 equipment, software, capture files, connection issues, charts, and GUI issues. It includes a section of actual customer questions and answers our support team has received, as well as descriptions of error and warning messages.

14. 1 How to Contact Keysight Support

You are welcome to contact Keysight support team regarding your WaveJudge 5000 system and/or WaveJudge modules at any time. The most efficient way for us to solve your problem is if you send us an email that includes the following items.

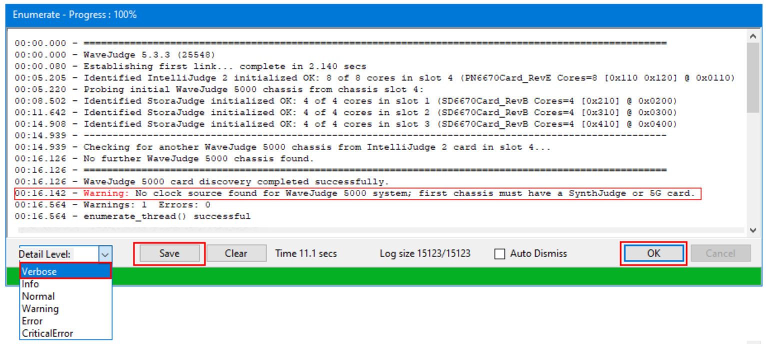
1. **A description of the problem.** – Brief description of what were you trying to do when the issue occurred and what happened instead.
2. **A copy of the Enumerate Progress/Chassis Connection log.** – If you having any connection issue, if you see any warnings or errors during connection, SAVE the **Enumeration Progress** log.

IMPORTANT

The Enumeration Progress Log helps us determine which card, or chassis, the issue may be with; it is one of the most important logs that helps us narrow down the possible causes for the error.

The Save button will save the entire log as a text file with a much higher level of detail than is included in the normal messages. This is extremely valuable for troubleshooting.

When you attempt to connect to the chassis you will see the **Enumerate Progress** window. **If you see an error occur** in the list, select **Verbose** from the **Detail Levels** dropdown menu, then click the Save button. Name and save the file to your computer; leave the default file setting as .txt.



To Save the Log Select "Verbose" and Click 'Save" on Eumerate Progress Window

Below is a screenshot of the saved text log contents; also referred to as the Chassis Connection log.

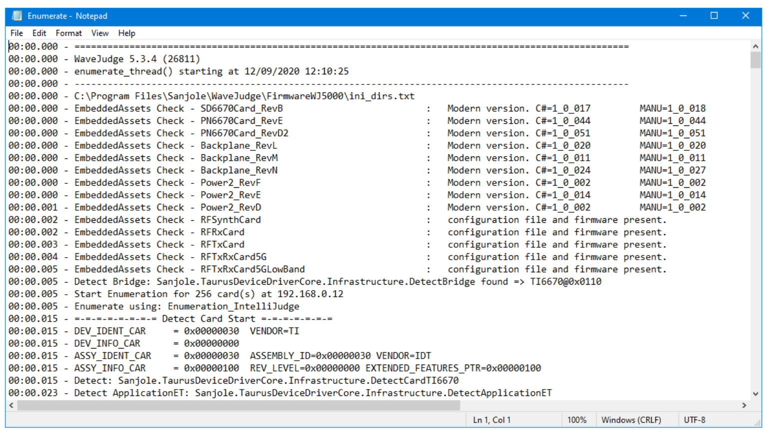


Image of Saved 'Enumerated Progress' Text File

3. **A screenshot of the error message.** - Many error messages seem alike but they appear under different conditions. Knowing which screenshot appeared after which action helps us narrow the error possibilities.

   The following error messages are described in the sections below.

   - Connection Error on page 583
   - WaveJudge 5000 Configuration Error - No Clock Source Found on page 584
   - IntelliJudge Configuration Error on page 585.
   - Invalid Settings Import on page 586
   - File Save/Load Error on page 586.
   - License Update Error on page 586
   - Parsing Error on page 587

- WaveJudge 5000 Card Configuration Warning on page 587
- WaveJudge 5000 Configuration Warning - Sampling Rate or Bandwidth Error on page 588
- WaveJudge 5000 Firmware Update on page 588
- Firmware Update: Power-Cycle WaveJudge 5000 Chassis on page 589
- Firmware Update: Reconnecting to WaveJudge 5000 Chassis on page 589
- WaveJudge 5000 Firmware Update Errors on page 590

4. **A copy of the capture file.** - Providing a copy of the capture file helps us quickly recreate the same scenario and determine if perhaps the settings are missing or improperly set.

If your files are too large to email, zip them in a folder and upload the file to FileZilla. Refer to Upload Captures or Other Files via FileZilla.

Email technical support questions to: *SJ-support@keysight.com*.

14. 2 Troubleshooting Connection Issues

There are many possible reasons why a connection failure may occur. Some of the most common reasons are:

- You closed out of WaveJudge software for the day, but did not power down the chassis. In this case, close out of the software, power down the chassis, restart the chassis, and launch WaveJudge software.
- WaveJudge experienced a power surge due to local power outage/blackout, or even a brown out. In this case, power down the chassis and restart it.
- No internet/unexpected loss of access to the internet. In this case, see if you can open a browser and access Google, for example. If you do not have internet access contact your local internet service provider for support. When your internet is working, try to connect to the chassis again.
- SRIO connections are loose. In this case, check all connections are in the correct ports and all of them are tight.
- Damage or other problem with a card or chassis. Contact support to troubleshoot and determine the issue.

Generally, when the problem is connecting to a WaveJudge chassis, we try to eliminate all potential hardware and firmware issues then we look at the software.

First, with the information we received from you (as noted in the previous section) we review at the enumeration log and determine if the problem is with a card or a chassis. If we suspect the issue is with a card, the log will show us which chassis it failed at.

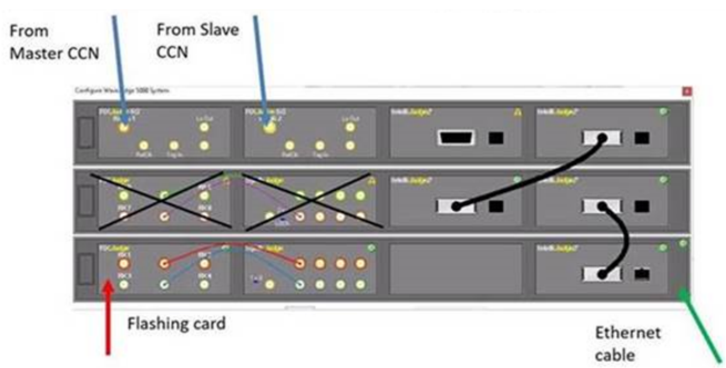
From there, we may recommend that you either firmly press the card in a little more, or remove the card from the slot and place it in a different slot on the same chassis or in a different chassis, then try to connect again.

WARNING **Do not attempt to adjust a card or slot without specific instructions from Keysight support. Moving the card and/or plugging it in different slots too many times may create an adverse affect on the card.**

14. 2. 1 Can't Connect, Card Not Found in Chassis

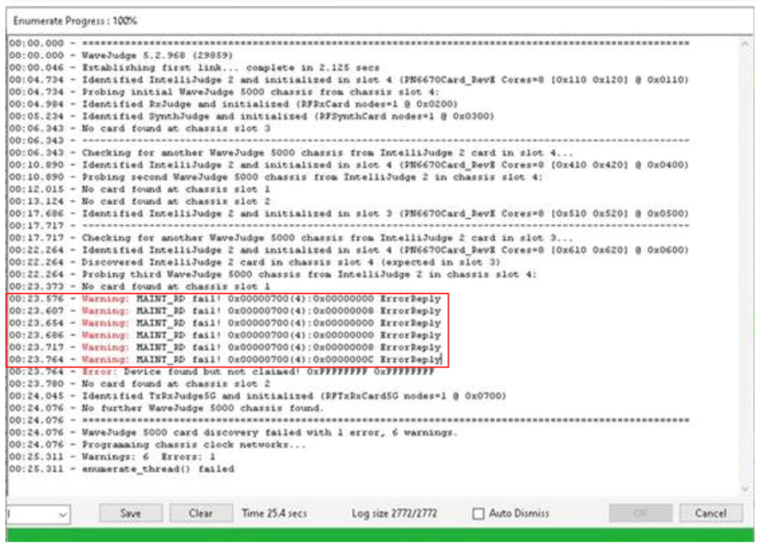
QUESTION:

We are having an issue connecting to WaveJudge, there seems to be an issue with the card not found in the chassis. I have not seen what the physical installation looks like in reality; however, RF cables are connected to top 5G ports as shown in picture.



Error Connecting to WaveJudge - No Card Found

The chassis connection log shows the error message "Warning: MAINT_RD fail! 0x00000700(4):0x00000000 ErrorReply".



Enumerate Progress Log Shows Warning Message "MAINT RD Fail"

ANSWER:

Earlier versions of the RF module firmware had SRIO timing issues which could lead to the “MAINT_RD fail error”. Other errors appear to be from not attending to message prompts, such as cable connections and not power-cycling the chassis when prompted. To remedy these errors, please take the following actions.

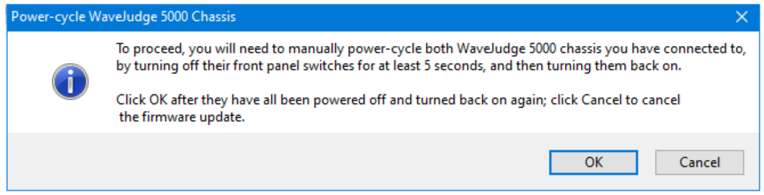
1. Update WaveJudge software to the latest version.
   - This should remove the “MAIN-RD fail error” message.
2. Update WaveJudge firmware.
   - Updating the software will automatically prompt you to update the firmware. If necessary, refer to Updating Firmware.

IMPORTANT

Follow the specific instructions in the dialog boxes that walk you through, do not dismiss the messages without reading them.

On a multi-chassis system, the message instructs that **you must physically power off all chassis in the system, leave them off briefly, turn them all back on,** and only then, connect for the update.

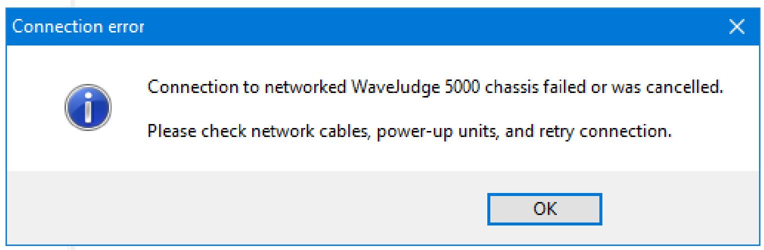
IMPORTANT



If you don't use this procedure then it's quite possible that the update will fail, or will only partially complete, which could then cause further problems.

.

3. Cable connections are incorrect; please heed the warnings and error messages regarding cables.



- The SRIO cable from the second chassis slot 3 should be connected to the DSP module found in the third slot of the third chassis (rather than diagonally to the DSP module in the fourth slot).
- Refer to NSA Chassis Configurations on page 55.

14. 3 Troubleshooting Captures

Problems with capture files, charts, and missing messages are typically due to:

- A missing trigger or filter required for either LTE or 5G.
- Setting an incorrect parameter.
- Inability to save a capture because it is too long and times out.
- A higher level message is missing because a lower message has an error.
- Timing offset is not set correctly, there is not enough time on the uplink.

The following sections provide some of the most common requests for support and our directions to remedy the problems. Most situations require communication back and forth between the client and Keysight support team before the case is closed. For your convenience, the questions and answers are summarized below.

14. 3. 1 How to Detect Channel Saturation in a Non Real-Time Capture Using the CCDF Chart

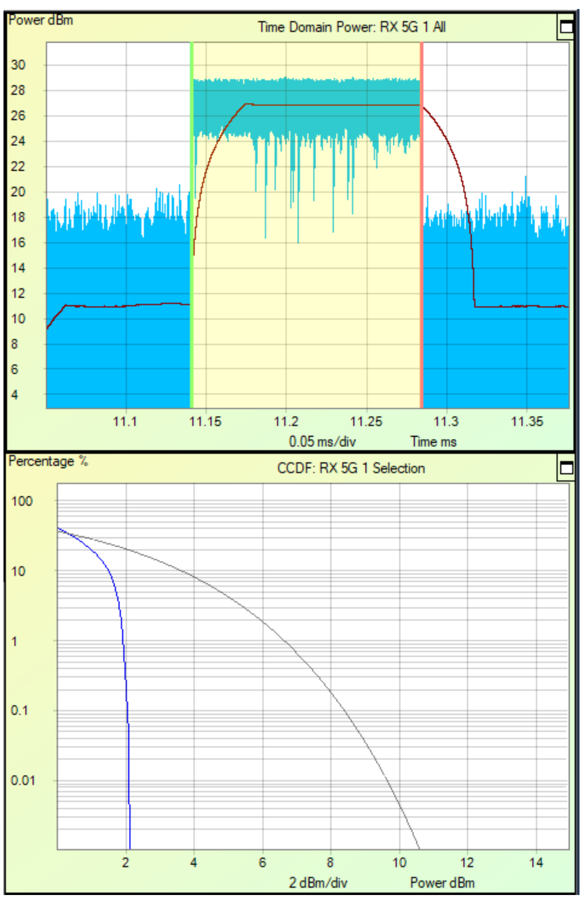
QUESTION:

Which chart should I use to detect channel sauturation on a real-time capture?

ANSWER:

The CCDF (Complementary Cumulative Distribution Function) chart can be used to detect signal saturation on either 4G/LTE or 5G non real-time captures. This means that the CCDF chart is protocol independent.

For example, in the CCDF chart below, the signals present in the SJ.vsa are saturated. When applied to a selected time interval of constant average power, the blue curve in the CCDF chart is supposed to follow the referenced gray curve. However, as seen in the CCDF plot area, the blue curve drops much faster, indicating compression.



Viewing Saturation in CCDF Chart Versus Time Domain Power Chart

14. 3. 2 How to Detect Channel Saturation in a Real-Time IntelliJudge Capture Using Real-Time Charts

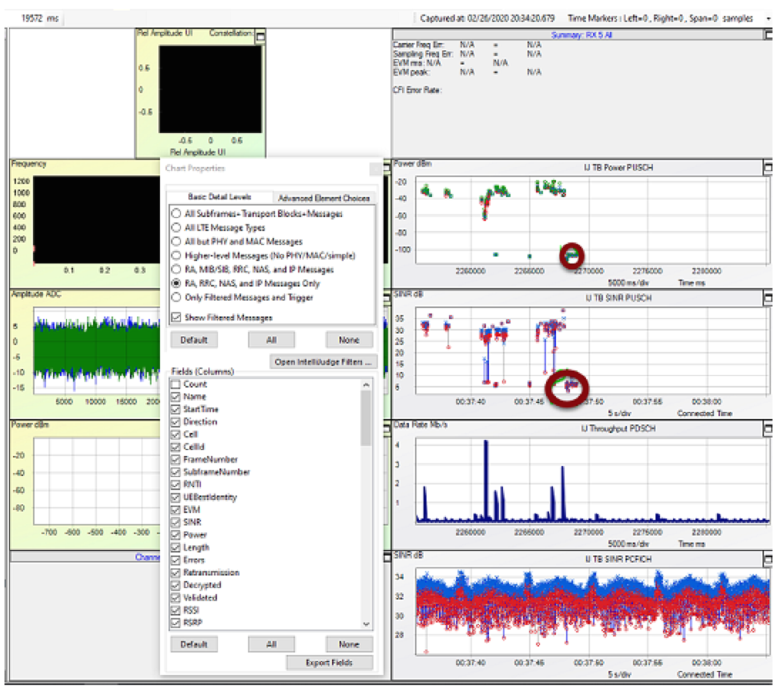
QUESTION:

What charts do you use to detect channel saturation in IntelliJudge capture?

ANSWER:

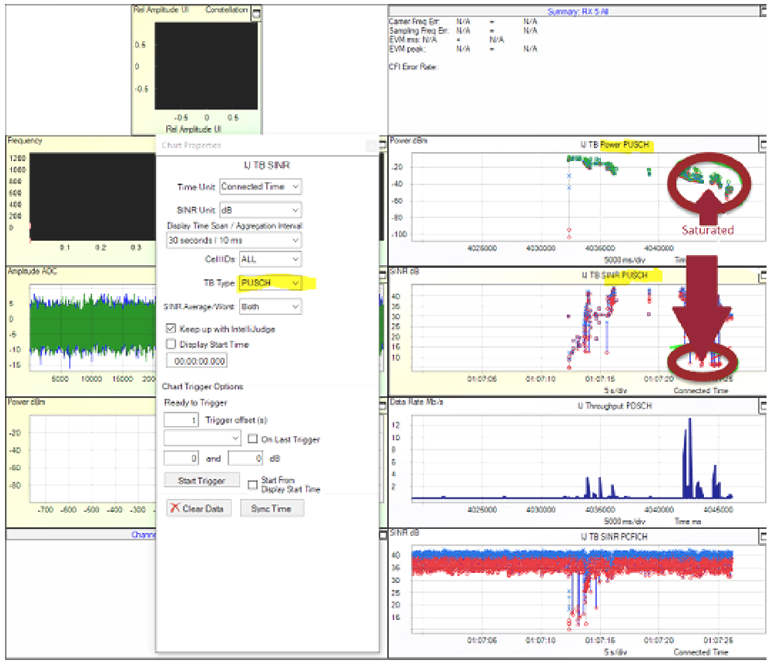
Use the **IntelliJudge TB SINR** chart and **IntelliJudge TB Power** charts together to best detect channel saturation in a real-time capture. Select the display channel as **PUSCH**; as long as you have the UE turned on you will see the PUSCH SNR and power measurements flying on these panels.

For a cabled test, or an OTA test in which the UE is very close to IntelliJudge, you can expect the UL side SNR to be very good in most cases (around or above 30 dB). The two figures below use both charts to illustrate the difference between a saturated channel and a non-saturated channel.



WJ1610 - Nonsaturated Channel

Saturation is indicated once you see that a lot of PUSCH have bad SNR (around or below 10 dB) and very high power.



Saturated Channel Shows PUSCH with Bad SINR and High Power

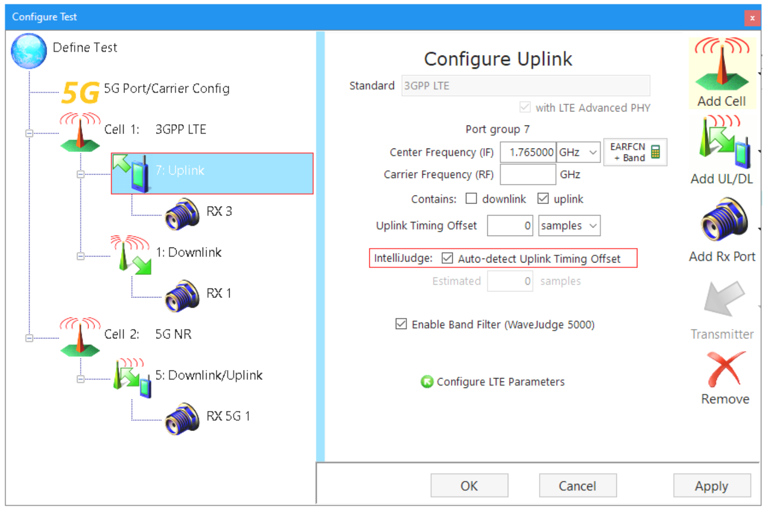
14. 3. 3 How to Fix Incomplete CA Traces

QUESTION:

During CA all of our uplink messages did not show **Attach Request**, but the **Attach Accepted** message is OK.

ANSWER:

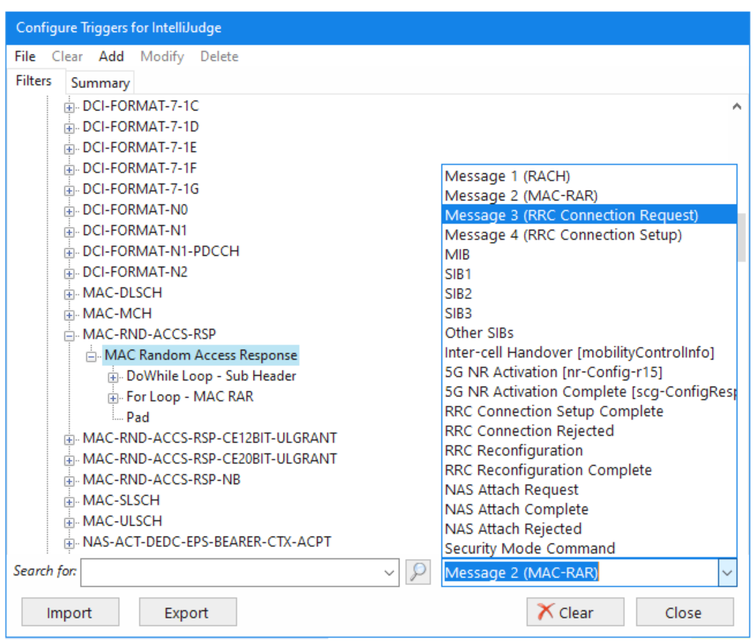
This is probably due to a loss of uplink traffic, which is often due to saturation and uplink timing offsets. IntelliJudge can automatically determine the uplink timing offset based on the RACH and MAC RAR pair. You can enable this by checking the Auto-detect Uplink Timing Offset detection checkbox found on the uplink channel.



Select the Checkbox to Autodetect Uplink Timing Offset

To perform the captures, enable either the **RACH** or **RRC Connection Request** messages as triggers. Go to the Tools menu then select IntelliJudge Triggers. From the Predefined Triggers menu on the lower right corner of the window, select Message 2 (MAC-RAR) to quickly access the MAC triggers.

- The capture pre-trigger should be **200 ms**.
- The capture duration will probably be in the seconds if multiple **RRC Connection Reconfiguration** messages are expected.

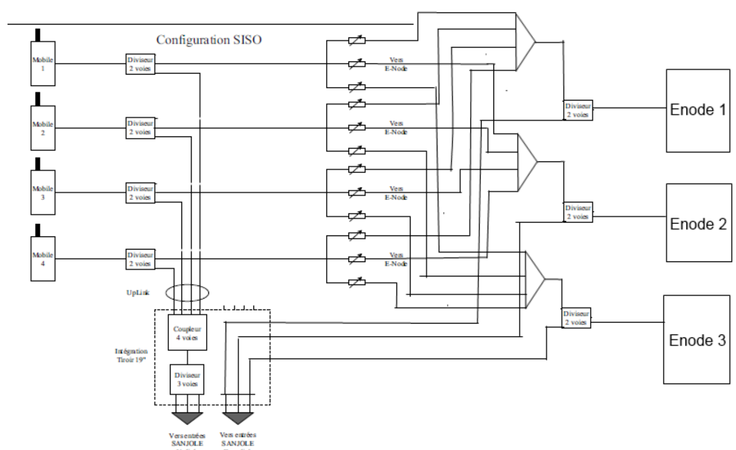


IntelliJudge Triggers Window - Select RACH or RRC Request

WaveJudge is dependent on the signal from the eNodeB to perform its decodes. As the signal between the eNodeB to the WaveJudge system fades, the ability also degrades to detect and decode DCIs - which prevents WaveJudge from scheduling subsequent HARQ, PUSCHs, and PDSCH. Without these messages, higher layer MAC and RRC messages cannot decode. Eventually as the signal continues to fade the synchronization signal is lost and nothing is decoded.

Port configurations should be based on the number of TX antennas utilized by the eNodeB. If the number of DL RX ports are not configured properly then PDSCHs will not decode properly. As the signal strength increases synchronization with the eNodeB is achieved and subsequently the different channels are decoded with their associated messages. None of this is instantaneous if the gain is gradually adjusted. In relationship to the gain adjustment there is a gradual gain and loss of messages.

The wiring schematic below allows WaveJudge to maintain synchronization with the eNodeB and properly decode the signals. You may modify it as you see fit, but **do not** place the attenuators between the eNodeB and the WaveJudge chassis.



Wiring Schematic between WaveJudge and EnodeB

14. 3. 4 How to Automate Timing Advance for 624 Ts

QUESTION:

For TDD, the UE (by specification) advances its transmission by 624 Ts (36.211 Sec. 8.1). In WaveJudge, I have to account for this by setting the UL timing offset. Why doesn't WaveJudge automatically accommodate this task.

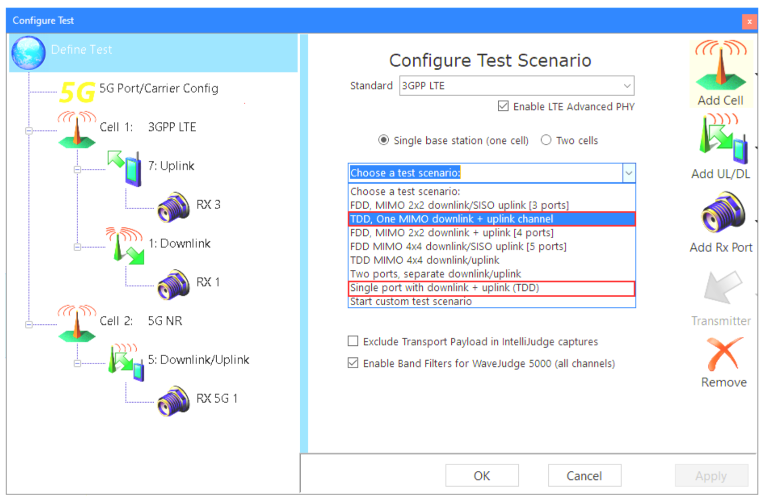
For example, in our full stack setups the timing is typically accurate enough to decode the UL when the UL timing offset is initialized to zero Ts for FDD and 624 Ts for TDD. For TDD, however, if someone accidentally initializes with zero Ts then WaveJudge is not able to decode the uplink. This is especially true with new users who expect

WaveJudge to account for the baseline offset in TDD. Our preference is to have the initial 624 Ts to be automatic, is there a way to do this?

ANSWER:

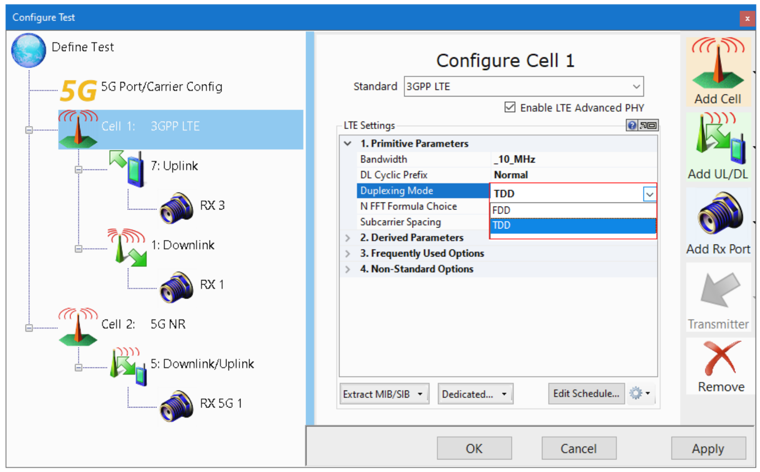
Yes, WaveJudge can automate the baseline offset TDD for you.

1. Create a new TDD test scenario in WaveJudge:
   - Open the Configure Test window.
   - Open the Define Scenario panel.
   - Choose a TDD scenario.



Configure Test Window - Create a TDD Scenario

2. Set the Duplex Setting to TDD and add a new cell. The uplink timing offset for the new configuration, or the newly added cell will automatically be set to 624 Ts for TDD.



Configure Test Window - Change Duplexing Mode to TDD

However, if you take an existing configuration and simply change the duplex from FDD to TDD, WaveJudge does not automatically change the uplink timing offset.

NOTE **If we were to replace a setting that users may have already configured, the potential negative impact of surprising users with an undesired change outweighs the possible benefits.**

14. 3. 5 How to Measure the Uplink Timing Offset and Decode a Capture

QUESTION:

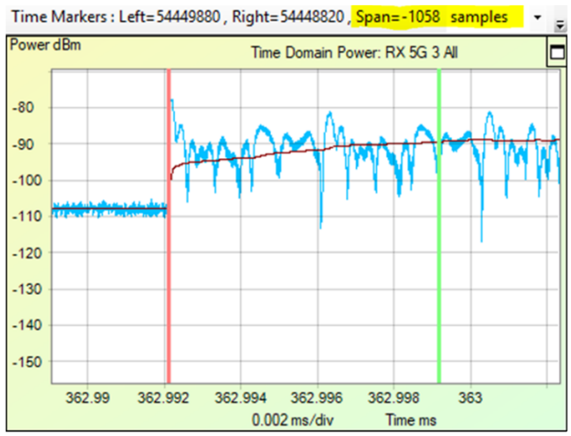
How do you measure the Uplink Timing Offset?

ANSWER:

Setting the WaveJudge 5000 chart parameter is the key to correct decoding. This cannot be automatically preset because it depends upon factors such as the distance between the mobile device and network transmitter, the relative distance of the test equipment, or both.

1. Measure the **Uplink Timing Offset**.
   - Click on the PUSCH in the WaveJudge Message List, which automatically places the left and right time markers at the start and end of the scheduled PUSCH.
   - Next, zoom in the Time Domain Power chart, around the rising edge of the PUSCH.
   - Use the **right marker tool** to place the right marker as close to the rising edge as possible, and read the **span** between the red and green markers.

– Here we set the **Uplink Timing Offset** to **-1058 samples**, the PUSCHs were decoded OK.



Uplink Timing Offset Should be the Same Value as the Sample Span

14. 3. 6 How to Verify the TDD Timing Offset Between P-Cell and S-Cell CA

QUESTION:

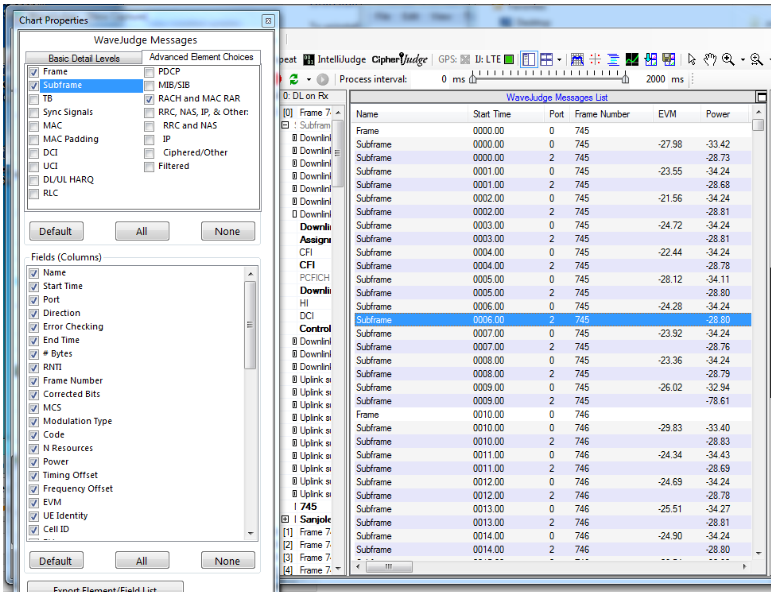
How can I verify the timing offset with WaveJudge between two TDD cells?

ANSWER:

Connect both TDD cells to WaveJudge and perform a capture. The message list will contain messages from both cells and will identify them by the connected ports.

Next, open the WaveJudge Chart Properties window and configure the start time and/or the end time to be in samples, ms, micro and nanoseconds; it could also be local/GPS time if WaveJudge is connected to a GPS antenna. You may also enable frame and subframe numbers. After you've enabled the fields to view, you can limit the message list to just frames and subframes. Once the configuration is complete, verify that the frame and subframe numbers are synchronized.

Next, check the time stamp field for the frame(s) that alternate between the cell to check the offset between cells.



WaveJudge Chart Properties Window - Enable Frames and Subframes

14. 3. 7 How to Fix a Long RACH Message

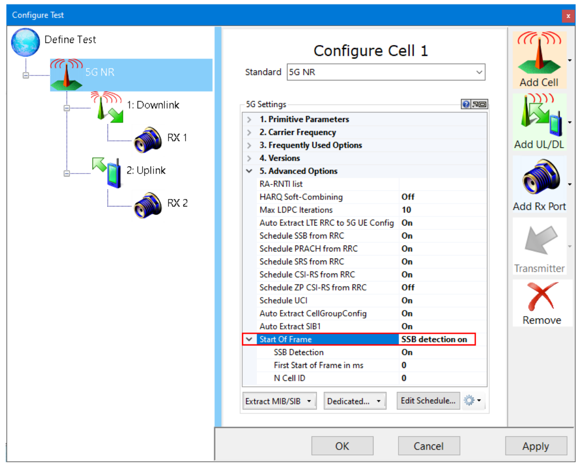
QUESTION:

While performing an LTE and 5G capture (NSA) I noticed here is a RACH message nearly 10 seconds after the last Reconfiguration message, which seems a little long.

ANSWER:

You want to do three things to decrease the time.

1. In the Configure Test window, in the Configure Downlink or Configure Uplink tab, set the **Center Frequency (RF)**.
2. In the Configure Test window, under 5GNR Settings pane, section 5. Advanced Settings, set the **Start of Frame -> SSB Detection** to **On**.



Set the Start of Frame: SSB Detection to On

3. How to Measure the Uplink Timing Offset and Decode a Capture on page 563

14. 3. 8 How to Locate LTE UL/DL SPS Messages

QUESTION:

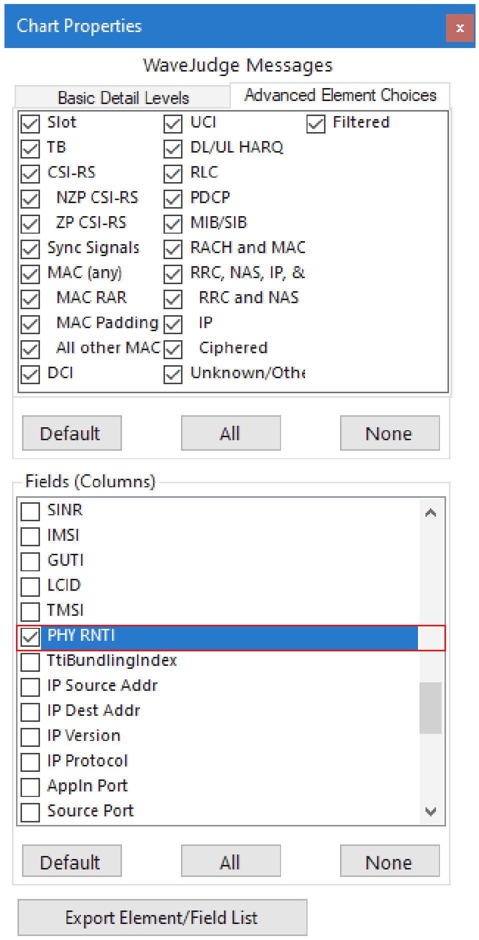
I configured an LTE cell with 2x2 MIMO DL and one UL and am unsure how to handle the UL/DL SPS (Semi-Persistent Scheduling). In the UE array there are many UEs with different RNTIs and in the “Config Dedicated” SPS RNTI is an option. I can trace a VoLTE and confirm in the internal trace that SPS is active (so SPS RNTI is used) but I can only find DL/UL grants with the C-RNTI.

ANSWER:

The differentiation between the C-RNTI and the SPS-RNTI is available in the **non-real time capture only**. To see it you need to enable the non-real time message list field **PHY-RNTI**. The SPS-RNTI is always aggregated under the C-RNTI, and is only identified in the PHY-RNTI field. Although the real time decodes do not currently have the PHY-RNTI field, it will include this property in the succeeding release.

Currently, real time captures only allow you to recognize that there was an occurrence of the SPS RNTI through the UE Manager. It is caused by the activation of the SPS RNTI by a DCI associated with the SPS RNTI. If the SPS Config IE had also been decoded by IntelliJudge then it should also schedule PDSCHs/PUSCH based on the SPS activation.

You can find PHY-RNTI only in WaveJudge Messages Chart Properties Window; it is not an option in the IntelliJudge Chart Properties Window. From the Window menu select either WaveJudge Layout or WaveJudge Messages Only From there you will be able to configure the PHY-RNTI after you select the the WaveJudge Message List.



WaveJudge Message List - Select PHY-RNTI

14. 3. 9 How to Fix Unknown Data Errors and Message Loss During CA

QUESTION:

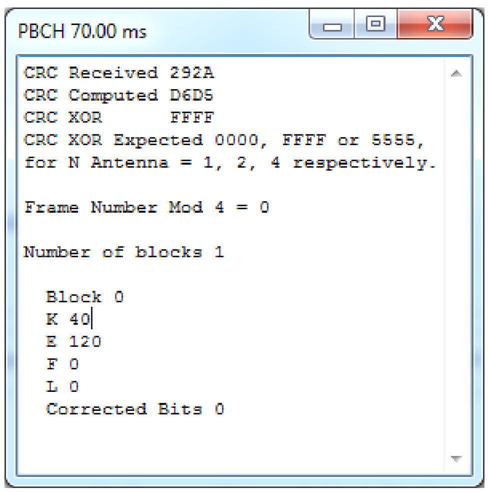
I successfully ran a CA test, and I saw the UE attach to the primary cell, but then the traffic rate doubled (~ 120 Mb/sec instead of 60). I tried to simulate a mobility situation by lowering the primary cell signal to see if UE attaches the secondary cell. Unfortunately, WaveJudge lost lots of messages and shows many ‘Unknown Data’ error messages; I saw no ‘Measurement Reports’ yet I saw incomplete ‘Connection Reconfiguration’. When performing the test, the beginning of the loss situation was synchronized with the decrease of primary cell signal... It is not possible to modify the cabling?

ANSWER:

It is unfortunate that you cannot change the wiring; message loss is unavoidable when the DL signal is attenuated. However, there are two possible solutions. One is to use the external trigger. The external source would have to be the attenuator. The second solution is to monitor the IntelliJudge decode.

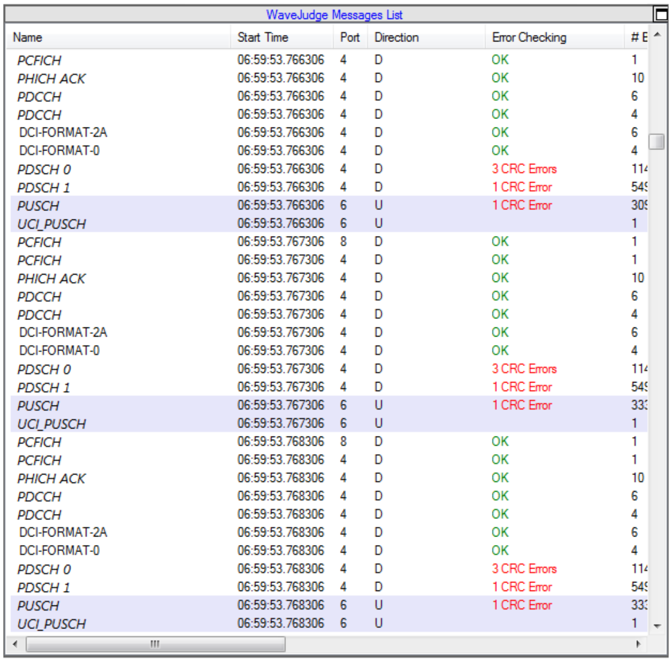
When you see the message loss occur (via a throughput chart) manually trigger the WaveJudge capture. In either scenario, set the capture pre-trigger to multiple seconds so you can capture the initial message-loss events.

In this situation, we identified two configuration problems in the client's test bed. The first was signal attenuators in the WaveJudge signal path; the second was the use of one DL port for both cells. The second cell had just one DL antenna. However, by reviewing the decode for the PBCH, based on the CRC XOR value of FFFF, we found the primary cell had two antennas.



PBCH Message Decoded

Based on the PBCH multiple, DCI 2As were decoded by the WaveJudge as MIMO transmissions and two PDSCH code words were scheduled. This is not possible with a single antenna connected to the WaveJudge and thus resulted in errors.

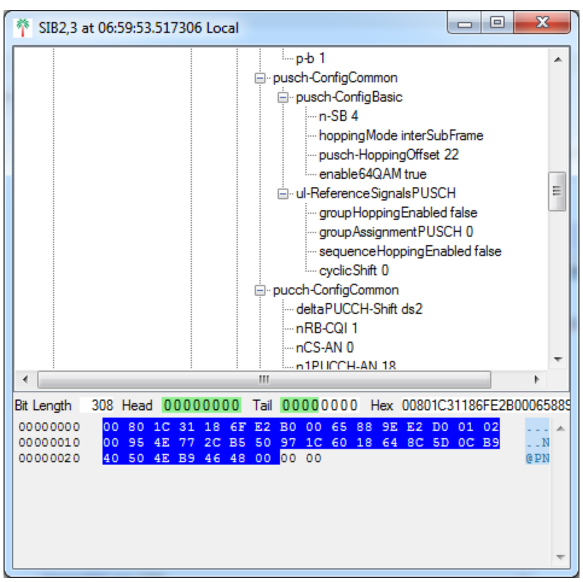


WaveJudge Messages List

Name	Start Time	Port	Direction	Error Checking	# B
PCFICH	06:59:53.766306	4	D	OK	1
PHICH ACK	06:59:53.766306	4	D	OK	10
PDCCH	06:59:53.766306	4	D	OK	6
PDCCH	06:59:53.766306	4	D	OK	4
DCI-FORMAT-2A	06:59:53.766306	4	D	OK	6
DCI-FORMAT-0	06:59:53.766306	4	D	OK	4
PDSCH 0	06:59:53.766306	4	D	3 CRC Errors	114
PDSCH 1	06:59:53.766306	4	D	1 CRC Error	549
PUSCH	06:59:53.766306	6	U	1 CRC Error	309
UCI_PUSCH	06:59:53.766306	6	U		1
PCFICH	06:59:53.767306	8	D	OK	1
PCFICH	06:59:53.767306	4	D	OK	1
PHICH ACK	06:59:53.767306	4	D	OK	10
PDCCH	06:59:53.767306	4	D	OK	6
PDCCH	06:59:53.767306	4	D	OK	4
DCI-FORMAT-2A	06:59:53.767306	4	D	OK	6
DCI-FORMAT-0	06:59:53.767306	4	D	OK	4
PDSCH 0	06:59:53.767306	4	D	3 CRC Errors	114
PDSCH 1	06:59:53.767306	4	D	1 CRC Error	549
PUSCH	06:59:53.767306	6	U	1 CRC Error	333
UCI_PUSCH	06:59:53.767306	6	U		1
PCFICH	06:59:53.768306	8	D	OK	1
PCFICH	06:59:53.768306	4	D	OK	1
PHICH ACK	06:59:53.768306	4	D	OK	10
PDCCH	06:59:53.768306	4	D	OK	6
PDCCH	06:59:53.768306	4	D	OK	4
DCI-FORMAT-2A	06:59:53.768306	4	D	OK	6
DCI-FORMAT-0	06:59:53.768306	4	D	OK	4
PDSCH 0	06:59:53.768306	4	D	3 CRC Errors	114
PDSCH 1	06:59:53.768306	4	D	1 CRC Error	549
PUSCH	06:59:53.768306	6	U	1 CRC Error	333
UCI_PUSCH	06:59:53.768306	6	U		1

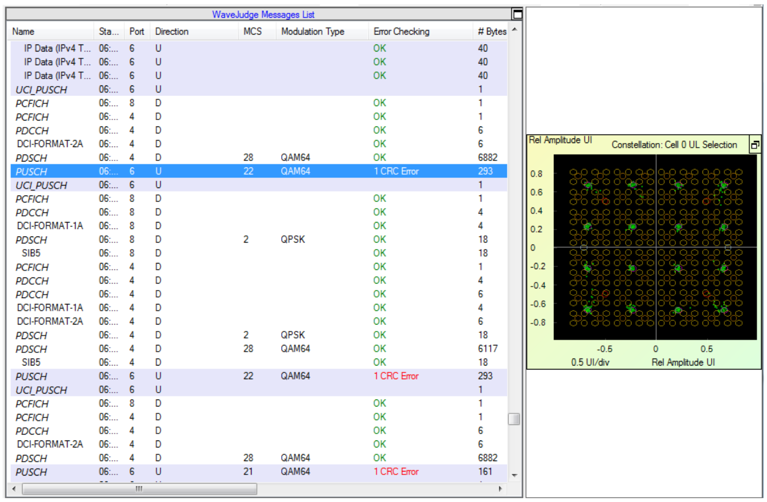
PUSCH Messages Had Errors

It was possible that a number of the PDSCHs flagged with errors carried various RRC messages that weren't decoded and therefore prevented the proper configuration of the UE Capability information. This, in combination with SIB2 that enables 64 QAM UL, was identified in the message window shown here.



SIB2 Enables 64 QAM UL

This caused WaveJudge to schedule a number of 64 QAM PUSCHs when they were 16 QAM, based on the high MCS in the DCI 0 . The results were PUSCHs flagged with errors and may have prevented the Measurement reports (as well as other RRC messages) from being decoded.



64 QAM PUSCHs Visible in Constellation Chart

The client changed the configuration and the problem was solved.

14. 3. 10 How to Set Up Cell ID Mode for CA

QUESTION:

I set up the WaveJudge 5000 demo system for our LTE field test team to show them how to use OTA capture and decode a trial LTE network signal for two center frequencies using CA mode topology. The demo team and trainees met in a meeting room, which had ID coverage for up to six cells. When we made a VoLTE call and went to capture it, the UE handset (HTC m8f) log showed the Cell ID changed a lot - like every few seconds it jumped out even though the next Cell ID was not the strongest one. We couldn’t lock it with same Cell ID with IntelliJudge to the handset, so we couldn’t decode a VoLTE call setup and traffic. Does other FAE also have this kind of problem? How can we decode the multi CC overlap area signal.

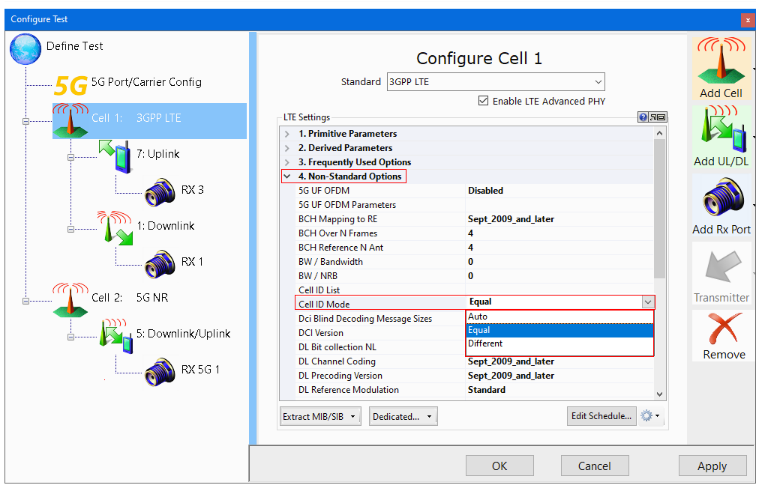
ANSWER:

I understand there are six cells. Each cell has a two CA configuration. If that is the case, then you would need to monitor 12 cells. Regardless of the number of chassis you have available, it won't be enough for you to monitor traffic over the six Cell IDs in the existing location. Are you certain that it’s a two CA and not two cells with different frequencies using the same cell ID? The following is the configuration to monitor traffic on a single cell ID.

- If it's two CA then you need two RXJudge modules with four DL and one UL.
- If it's not two CA and just two cells with different frequencies and the same Cell ID, then you need the RXJudge modules with four DL and two UL. This is the case we have in Hawaii.

In either of these configurations you will need up to three IntelliJudge2 DSP modules per cell, depending on the bandwidth. Three IntelliJudge2 modules are required for real-time capture of 20 MHz on a single cell.

Due to these requirements, it is easiest if you move to where there is a limited number of cells; preferably in a location where there's a single dominant cell that the UE usually locks onto. WaveJudge/IntelliJudge locks onto the first cell it detects; therefore you need to identify the cell the UE synchronizes and locks onto. Once you have that information configure the WaveJudge for the cell. To configure the WaveJudge, set the Cell ID Mode to Equal and configure the Cell ID list as identified below.



Cell ID List - Set Cell ID Mode to "Equal"

14. 3. 11 How to Fix Configuration to Show Correct 5G Ports

QUESTION:

After I upgraded software to V5.3.1, while adding an LTE cell in the "Configure Test", the ports' name were displayed as "RX 5G 1/2/3", which should be "RX 1/2/3". And in this situation, I cannot add RX 5G 1/2/3 for NR use. When I connected it to the chassis, the port name became normal, but if I disconnected it, the port name became abnormal again.

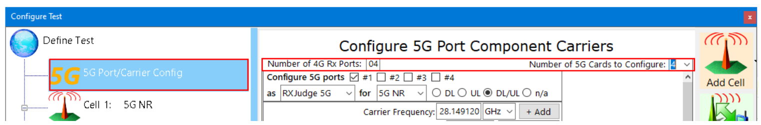
ANSWER:

This can happen sometimes, particularly when starting with a configuration or capture from an earlier version of WaveJudge which did not save the port configuration quite the same way. This siutation comes up sometimes when configuring mixed 4G/5G systems or going back and forth between working with a WaveJudge 5000 5G system and an original WaveJudge 5000 system. (If none of the modules in the system will be 5G modules you'd set the second field to 0, if the system will be all 5G you'd set the first field to 0.)

In WaveJudge 5.3.0 and later, you can correct this problem fairly simply **without** needing to connect to a system by performing the following steps.

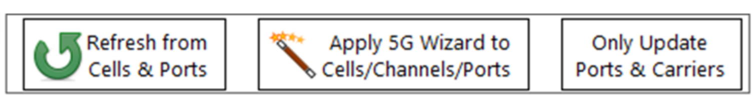
1. Open the Configure Test Window by clicking the button 

2. Om the left side, select the 5G Port/Carrier Config button, which displays the case where it's reporting ports as 5G.



Enter the Number of 4G Rx Ports and the Number of 5G Cards to Configure

3. On the right side panel, in the upper left of the control, there is an entry for Number of 4G Rx Ports which in the case you describe will be set to 00.
4. Set the Number of 4G Rx Ports to match the number of RXJudge ports in the system you are configuring, which is 4 for each RXJudge module. For example, if there is only one of the original 40MHz RXJudge modules, set it to 04.
5. Hit tab or click in the next field Number of 5G Cards to Configure and set to the number of RXJudge 5G modules in the system you are configuring.
6. At the bottom of the panel, click the button Only Update Ports & Carriers. This is one of the scenarios where this button is needed, as you do not want to change the cell configuration.



Click the Button "Only Update Ports and Carriers"

14. 3. 12 How to Configure ULCA for an LTE Signal

QUESTION:

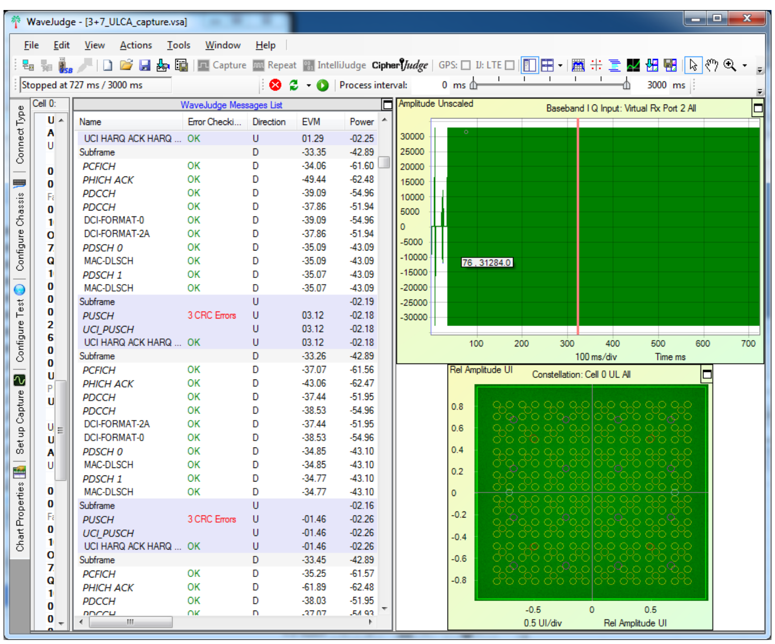
I am trying to configure ULCA on my setup with WaveJudge and but it cannot find the LTE signal. The EARFCN, band, and other configuration seem to be right. IntelliJudge is able to decode the SIBs and WaveJudge decodes the SIBs and MIBs, but I am receiving a message that although the MIB extraction is successful, it cannot decode SIB1 or SIB2. Please advise if there is something wrong with my configuration.

ANSWER:

It's true the IntelliJudge is decoding MIBs and SIBs, but I do not see them in the WaveJudge capture. In the WaveJudge capture I see a clipped MIB, PDCCHs and DCIs. Some of the PDCCHs and DCIs are for the broadcast address of 65535 but I don't see the PDSCH that should be scheduled and decoded based on the DCI. Because they are not present, the SIBs are not decoded. The absence of the PDSCHs is the problem.

I noticed something else in your screenshot. The time domain power chart for port RJ1:RX3 displays a signal level of 7 dBm; that power level is unexpected.

Your configuration is incorrect and cannot support UL CA. Also your uplink signal is completely saturated which results in the CRC errors identified in the image below. The first symptoms I noticed were the unexpectedly high UL power levels. A power level greater than 12 dBm will damage the RXJudge module.

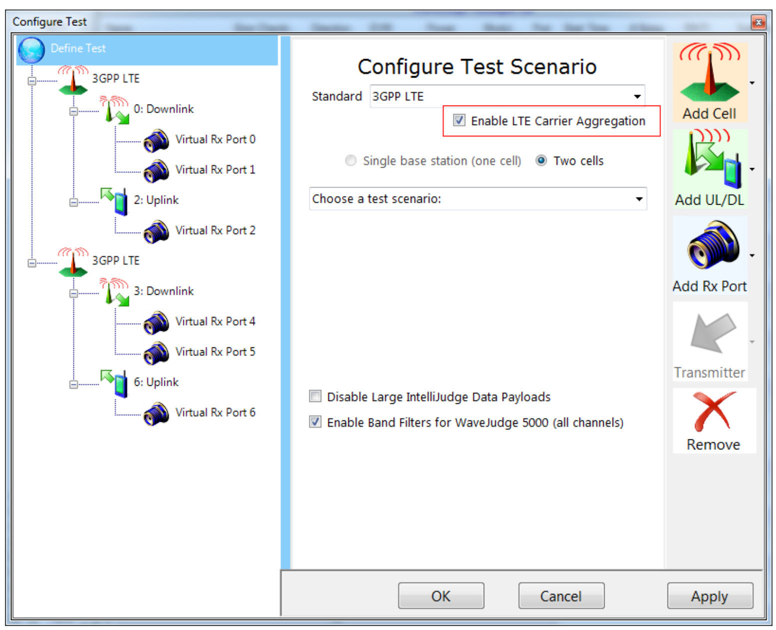


UL CA Capture

In addition to the power, the IQ sample chart configured with an amplitude unit of unscaled ADC indicates a constant amplitude that is greater than 32 K. It indicates the signal has been clipped D-A conversion. Finally the constellation chart is just a cloud - which indicates a poor signal or poor EVM of the signal.

If you expect to analyze the uplink you need to adjust the gain settings.

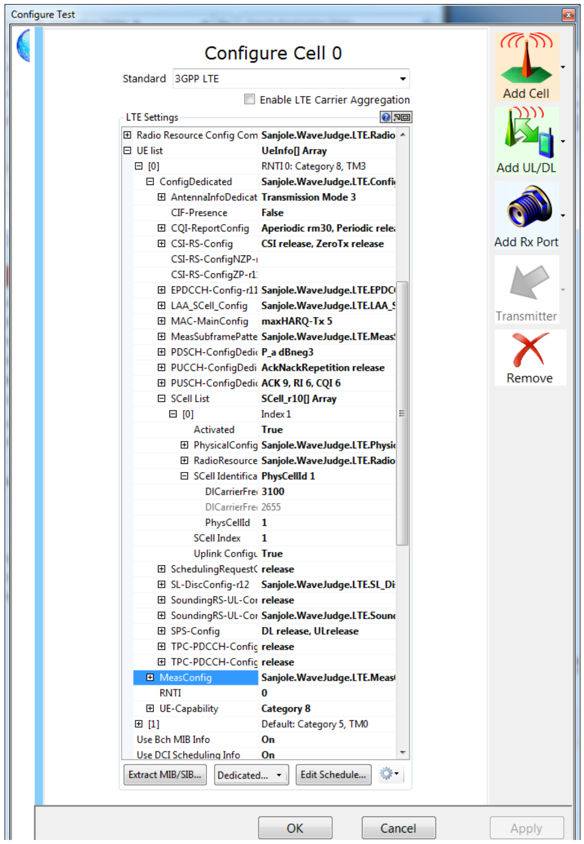
1. Power down the UE.
2. After it’s turned off, open the RF control to allow you to monitor the signal for any saturation.
3. Power up the UE while monitoring the meters.
4. The UE often transmits at a higher power when initially connecting to the eNodeB, and therefore it's important that you monitor the meters during the entire attach process while adjusting the gains as needed. This adjustment process may require multiple iterations of the attach by the UE.
5. If you find the RF meters behave erratically when you are trying to adjust the gains, then it’s possible the RXJudge modules have been damaged by the input power level. In that case, you must RMA the modules.
6. Next, we address your configuration. Since you are testing UL CA, I assume you have two UL carriers. If so, WaveJudge requires the number of configured DL carriers to be greater than or equal to the number of UL carriers. The configuration for two UL carriers is identified below. Also, notice that the Enable LTE Carrier Aggregation checkbox is set.



Configure Test Scenario - Check the Box "Enable LTE Carrier Aggregation"

NOTE For CA the number of DL carriers must be greater than or equal to the number of UL carriers.

7. Configure the second carrier or cell with the frequency band identified by the SCell config dedicated parameters.
8. If I assume the SCell I found in your capture file is valid for this test, then the center frequency should be 2.655 GHz.



Configure Cell Window - SCell and Center Frequency

One problem with the configuration dedicated entry above is the RNTI. **A RNTI with a value of 0 is invalid.** It should be a **C_RNTI which is greater than or equal to 10** to avoid the RA-RNTI range. It should be the RNTI used by the UE.

- If the WaveJuge capture does not include the RRC Messages then the config dedicated parameters must be configured based on the parameters that would be sent in the RRC messages to properly analyze CA.
- If the information is not available then you can obtain it by taking an IntelliJudge capture while the UE Attaches to the network and the carriers are established. After obtaining the IntelliJudge capture, press the dedicated button to extract the information from the IntelliJudge capture. After it is extracted, take additional WaveJudge captures if the same connection is still up between the UE and the eNodeB and the parameters have not changed.

NOTE **Generally, whether it's CA or anything else, you can extract the configuration information from RRC messages while processing a capture in either IntelliJudge or WaveJudge. IntelliJudge always does this and WaveJudge has the option Auto Extract Dedicated by default.**

The ability to decode many of the RRC messages requires the cipher to be turned off, unless you have the CipherJudge package. Generally, the RRC Connection Reconfiguration message will carry the **sCellToAddMod** list to update the UEs physical dedicated information with a carrier as identified in the decode fragment below of an RRC Connection Reconfiguration message. This message is ciphered in a normal network. The RRC messages are:

- nonCriticalExtension
- nonCriticalExtension
- nonCriticalExtension
- sCellToAddModList-r10
- SCellToAddMod-r10
- sCellIndex-r10: 1
- cellIdentification-r10
- physCellId-r10: 458
- dl-CarrierFreq-r10: 1075
- radioResourceConfigCommonSCell-r10
- nonUL-Configuration-r10
- dl-Bandwidth-r10: n50
- antennaInfoCommon-r10
- antennaPortsCount: an2
- phich-Config-r10
- phich-Duration: normal
- phich-Resource: one
- pdsch-ConfigCommon-r10
- referenceSignalPower: 21
- p-b: 1
- radioResourceConfigDedicatedSCell-r10
- physicalConfigDedicatedSCell-r10
- nonUL-Configuration-r10
- antennaInfo-r10
- transmissionMode-r10: tm3
- codebookSubsetRestriction-r10: {2 bits|0x03|Right Aligned}
- ue-TransmitAntennaSelection
- release
- pdsch-ConfigDedicated-r10
- p-a: dB-3
- ul-Configuration-r10
- cqi-ReportConfigSCell-r10

- cqi-ReportModeAperiodic-r10: rm30
- nomPDSCH-RS-EPRE-Offset-r10: 0

After you resolve these different issues you should be able to analyze UL CA. Resolve each item in the following order:

1. Correct the saturation.
2. Using the IntelliJudge capture an **Attach by the UE** (this is just an exercise to try an IntelliJudge capture of the Attach using a simple 1 cell configuration).
3. Modify the configuration to include the second cell.
4. Start IntelliJudge and perform a capture with the UE performing an attach using this configuration and then start data traffic between UE and eNodeB.
5. Stop IntelliJudge capture.
6. Extract the **Dedicated** parameters.
7. Take a WaveJudge capture.

14. 3. 13 How to Fix Missing RRC Reconfig and C-RNTI PDSCH Messages on SA Configuration

QUESTION:

On a SA configuration file, the capture has RRCReconfig PDSCH for auto-detect and decode of other C-RNTI PDSCHs. On the Time Domain Power chart we have C-RNTI scheduling happening, but WaveJudge is not decoding anything outside MIBs/SIBs in the capture.

ANSWER:

In a short capture, the MIBs/SIBs needed to decode are message dependent. They may be in the capture file, but the message of interest precedes them due to the length of the capture and when it's taken.

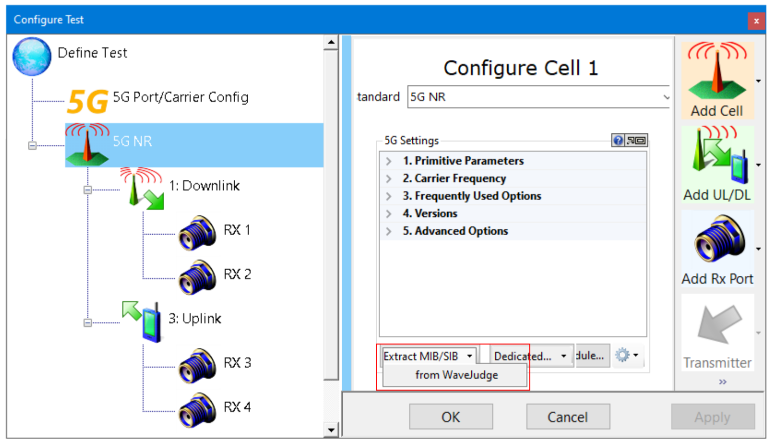
The SIB1 extraction is needed because the first SIB1 is at SFN (subframe number) 288, slot 4, after the RRCReconfiguration, shown in the example. WaveJudge does automatically apply the MIB parameters from the start of the capture, but for SIB1, it is only applied after the first SIB1 was encountered.

Name	Start Time	Error Ch...	Cell ID	Fra...	Slot...
RRCReconfiguration	0007.86	OK	0	287	10
Unsupported NAS	0007.86	Error	0	287	10
MIB	0012.86	OK	0	288	0
SIB1	0014.86	OK	0	288	4
MIB	0032.86	OK	0	290	0
SIB1	0034.86	OK	0	290	4
MIB	0052.86	OK	0	292	0
SIB1	0054.86	OK	0	292	4
MIB	0072.86	OK	0	294	0
SIB1	0074.86	OK	0	294	4

SIB1 Requires Extraction Because It Occurred After the RRCReconfiguration

To fix the problem:

1. Open the Test Configuration window and click the **Extract MIB/SIB** button at the bottom of the Configure Cell 1 pane.



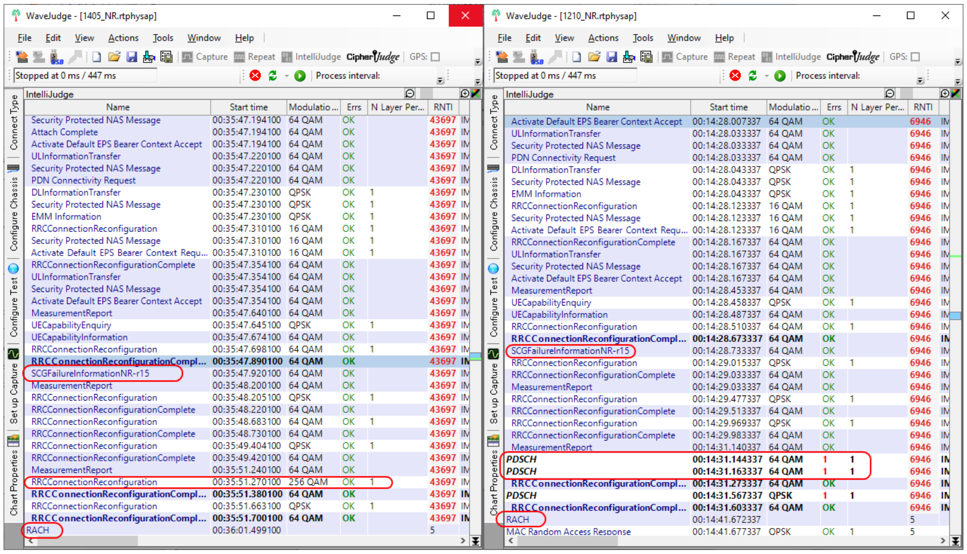
Select "Extract MIB/SIB From WaveJudge" from Dropdown Menu

2. Close out the Configuration Test window.
3. Click the **Reprocess** icon to reprocess the capture. The content is utilized and the messages are decoded.

14. 3. 14 How to Set the NR Config Response Message for an NSA Capture

QUESTION:

Our LTE procedure seemed OK, the MIB/PBCH/SSB/CSI were captured, SINR/EVM of NR seemed OK; but no NR information was captured.



Select 'Extract MIB/SIB From WaveJudge" from Dropdown Menu

ANSWER:

No NR info showed up because the UE returned **SCGFailureInformationNR-r15** message.

After the first **Reconfiguration** and **Reconfiguration Complete** messages **SCGFailureInformationNR-r15** displayed. WaveJudge triggered at this point, but due to the failure, the UE did not transmit anything on the 5G network.

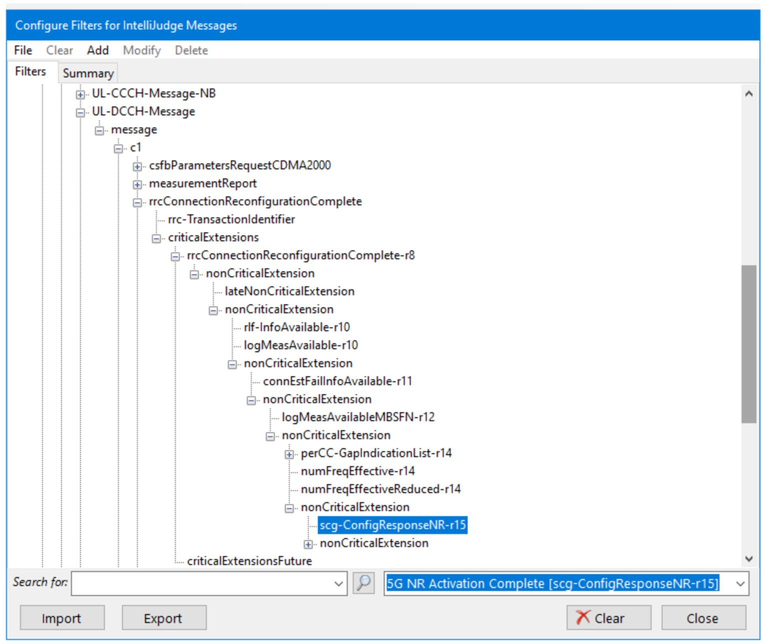
If there was a success you would see a RACH message. Since there was no RACH, the UE may have not joined the 5G network with the other reconfiguration messages.

- Notice in the “1405_nr” capture the first **Reconfiguration Complete** message of the pair is preceded by a Reconfiguration message that is 256 QAM. This is the important message because it contains the serving cell to add information.
- In the “1210_nr” capture, that message is not present because there are PDSCHs flagged as errored and listed as **64 QAM**.
- The next **ReconfigurationComplete** is in response to a reconfiguration message that is **QPSK** because it's a small message with DRX parameters, which is not important to the decode.

WaveJudge can only report on what the UE transmits. Keep in mind WaveJudge is a testing mechanism, therefore we recommend if a test fails at the first attempt, try it again several more times.

To fix the error configure the filter for PDSCHs with errors and the **RRCConnectionReconfigurationComplete** message containing the **scg-ConfigResponseNR-r15 IE**.

Go to **Tools** > **IntelliJudge Filters** > in the **Predefined Filters** window, select **5G Activation Complete [scg-ConfigResponseNR-r15 IE]**. This will automatically open the window to that message where you should set your preferences. After the filters are set, the Message List will display the filtered message in a bold font.



Set IntelliJudge Filter "5G NR Activation Complete"

14. 3. 15 How to Fix Decoding Errors in PBCHs and Abnormal Values of SINR/EVM/Cell ID

QUESTION:

A different problem from the issue above. LTE procedure seemed OK, but aside from PBCH/SSB/CSI, no NR information was captured. There were decode error occurred in all PBCHs and the values of SINR/EVM/Cell ID were abnormal.

Name	Start Time	RSRP	SINR	Cell ID	EVM	Power	Error Checking
CSI_RS	0006.25		-00.24	0	00.24	-125.26	
PBCH	0010.13		03.27	0	-03.27	-125.15	Error
SSS	0010.13		-00.65	0	00.65	-128.70	
PSS	0010.13		00.19	0	-00.19	-128.93	
PSS	0010.13		-00.25	0	00.25	-128.80	
SSS	0010.13		-00.16	0	00.16	-128.68	
PSS	0010.13		-00.39	0	00.39	-128.55	
SSS	0010.13		00.00	0	00.00	-128.89	
PSS	0010.13		00.34	0	-00.34	-128.88	
SSS	0010.13		-00.69	0	00.69	-128.23	
PBCH	0010.13		03.12	0	-03.12	-125.33	Error
PBCH	0010.13		02.88	0	-02.88	-125.25	Error
PBCH	0010.13		03.34	0	-03.34	-125.39	Error

All PBCH Messages Have Errors

ANSWER:

There were decode errors in in PBCHs because the reconfiguration message carrying **nr-Config-r15** was not decoded.

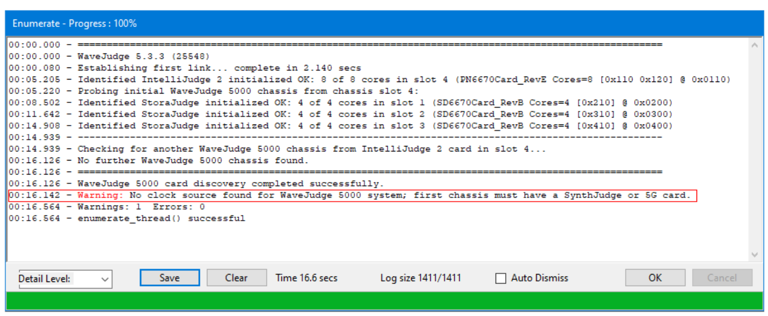
- The message carrying nr-Config-r15 was not decoded because PDSCHs carrying reconfiguration message nr-Config-r15 were flagged with errors.
- They were flagged with errors because the previous reconfiguration message enabled 256 QAM traffic which may have not been properly applied.

To fix the problem, take a combined capture beginning with the initial RRC message through the final reconfiguration message.

14. 3. 16 How to Fix a Clock Synchronization Error

QUESTION:

While connecting to WaveJudge I saw a clock error **Warning: No clock source found for WaveJudge 5000 Systems; first chassis must have a SynthJudge or 5G card**.



Warning: No Clock Source Found for WaveJudge 5000 System

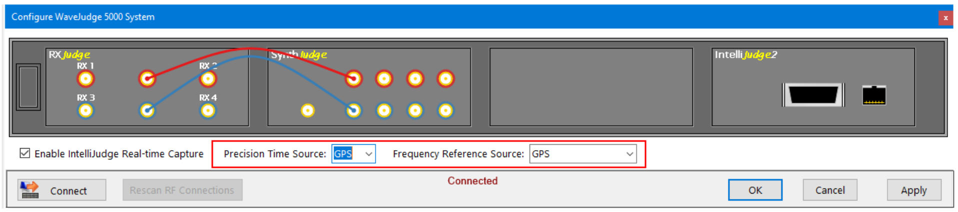
ANSWER:

Generally, clock synchronization occurs after connecting to a system that has just been powered up. If not, there could be errors. An error message during the clock synchronization phase could occur because the clock the software expected is not present. Or, if an external clock is selected but it isn't present, then it will also cause an error.

If you are using IntelliJudge you must:

1. Select the checkbox to the **Enable IntelliJudge Real-Time Capture**.
2. Select a **Precision Time Source** from the dropdown menu:
   - **None:** Indicates there is no clock set up. Synchs the **Frequency Reference Source** with either **Calibration** or **External 10 MHz ref**.

- GPS: Automatically synchs with the GPS in Frequency Reference Source.
- PPS-In: Automatically synchs with the GPS in Frequency Reference Source.



Precision Time Source Auto-Synchs with Frequency Reference Source

14. 3. 17 How to Reset a Lost WaveJudge Message List

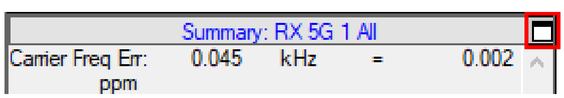
QUESTION:

It may be user error, but I am getting the Summary Pane instead of the WaveJudge Message List, I am unable to access the WaveJudge Message List from any of the usual methods. How can I reset the GUI to the default layout with the Message List?

ANSWER:

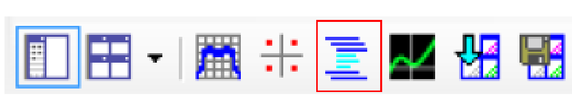
There are two possible ways this has occurred.

1. You may have expanded the Summary chart to the full chart area, in which case resetting its size with the chart restore icon in its upper right (looks sort of like the window restore icon) will shrink it down and make the other charts visible.



Click the Resize Pane Icon to Minimuze the Size

2. You may have accidentally used the chart Context Menu (i.e., the right-click menu) to change what is normally the Message List panel to display the Summary Chart instead. Because whatever layout you pick will be saved for the next run of the program, it will persist when you exit and return to the program until you change it. Either way, pick one of the predefined layouts from the icons in the top toolbar Chart Views Tool Group should fix it. The icon in the middle with the staggered blue lines will specifically include the Message List.



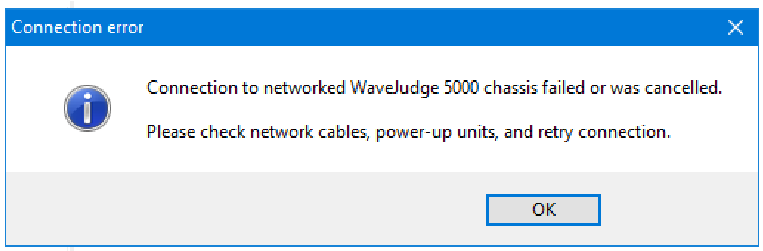
Click the "Decode View" Icon to Reset Default Layout

14. 4 Error Messages

The following sections show common error message windows, describe the issues, and state actions to fix them.

14. 4. 1 Connection Error

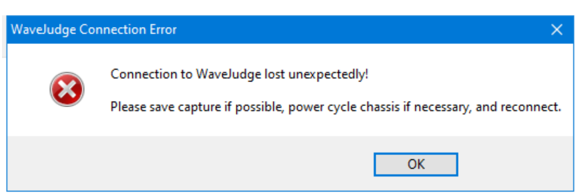
If you press the Connect button before your hardware is set up, or disconnect before you select a chassis from the Target Select Form, you will receive this error message.



Connection Error Message

If you have not used WaveJudge in a while, if you closed out of the software but did not turn off the chassis, then check the network cables, etc., as directed. Turn the chassis off and restart it to clear the connection. If there are no issues with the network cables, etc., it may have been you were working too fast and mistakenly closed a window too soon.

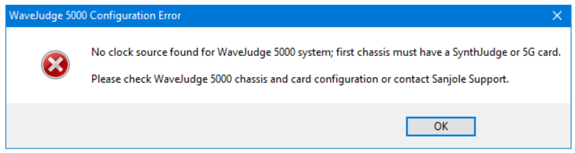
Alternatively, you may receive the following WaveJudge Connection Error message. Similar to the the message above, this message may occur when you have previously closed out of the software but did not turn off the chassis. Follow the instructions in the window and power cycle the chassis then try to reconnect.



WaveJudge Connection Error

14. 4. 2 WaveJudge 5000 Configuration Error - No Clock Source Found

If you were attempting to connect to a chassis and got through the Enumeration Window and/or the Downloading DSP Cores window and then received a configuration error indicating a problem with the clock source, similar to this figure, follow the instructions below to fix the clock source problem.



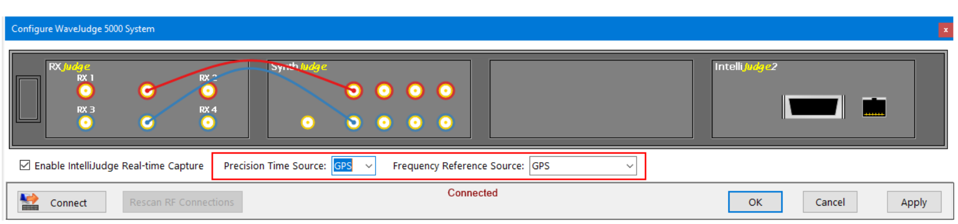
WaveJudge 5000 Configuration Error - No Clock Source Found

The "No clock source found" message shown above indicates either that a module was removed from the system, that the system was incorrectly cabled, or that the Ethernet SFP and cable were installed in the wrong chassis of the system. The primary chassis of the system must always contain either a SynthJudge (for "4G" captures of 40 MHz bandwidth or less) or an RXJudge 5G or RXJudge2 5G for captures of up to 800 MHz bandwidth, and the Ethernet network connection must always be made to this chassis.

Other error messages during the clock synchronization phase could happen because the clock the software expected is not present. For example, if an external reference clock is selected but the signal isn't present, then it may also cause an error during the clock setup phase.

If you are using IntelliJudge you must:

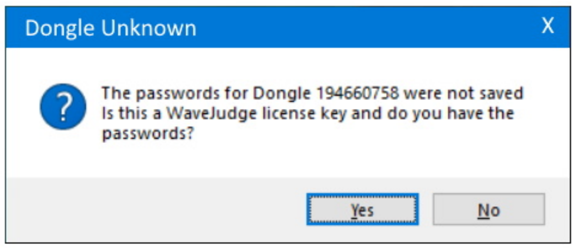
1. Select the checkbox to the Enable IntelliJudge Real-Time Capture.
2. Select a Precision Time Source from the dropdown menu:
   - None: Indicates there is no external precision reference set up. Synchs the Frequency Reference Source with either **Calibration** or **External 10 MHz ref**.
   - GPS: Automatically synchs with the GPS setting in Frequency Reference Source.
   - PPS-In: Automatically synchs with the PPS setting in Frequency Reference Source.



Select a Clock Option from the Precision Time Source Dropdown Menu

14. 4. 3 Dongle Unknown

If you are starting WaveJudge after a recent version upgrade, and are using legacy Sanjole licenses rather than Keysight licenses, you may receive a notice to reset the password.

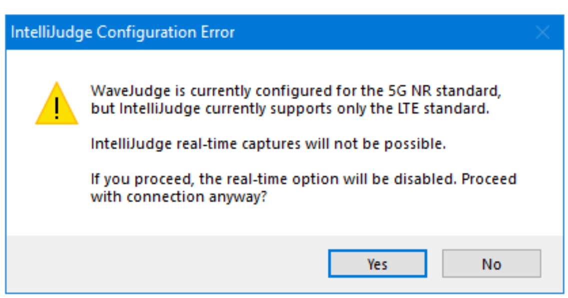


Dongle Unknown Error Message

Enter your unique two passwords in the same field leaving one space between them; e.g., 12345 67890. The password window will disappear and you may continue using WaveJudge.

14. 4. 4 IntelliJudge Configuration Error

By default, WaveJudge remembers the last configuration you used. If you are switching from an LTE to a 5G test and you click the Connect button WaveJudge may interpret your action as a conflict with the previous configuration. You may see the following IntelliJudge Configuration Error message before you can select a chassis from the Target Select Form. Click the Yes to continue with 5G NR; click No if your intention is to use IntelliJudge for 4G LTE.

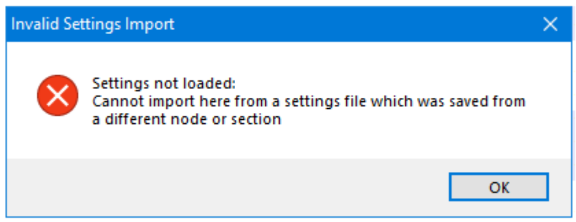


IntelliJudge Configuration Error Message

14. 4. 5 Invalid Settings Import

An Invalid Settings Import error may appear if there is an error loading a settings file, such as .sxl file, into a capture file. Typically, the error is made when the user is using an "import" as opposed to a "load" function.

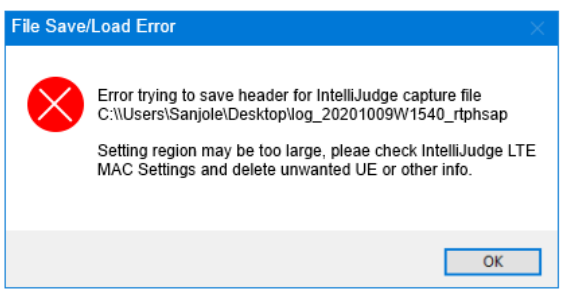
For example, if the user has the Configure 5G NR MAC Settings for WaveJudge Captures window open and has selected the top menu item Import he may see this error. The correct method is to select the File menu, then select Load, and select the file from the browser window.



Invalid Settings Import

14. 4. 6 File Save/Load Error

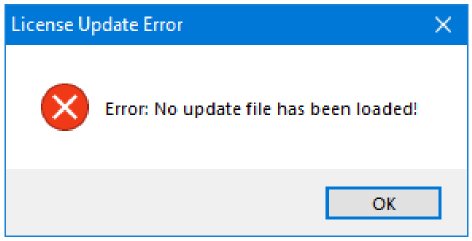
A File Save/Load Error message occurs when an IntelliJudge capture is too long. Delete any unnecessary UE info to prevent WaveJudge from timing out while trying to save or load the file.



File Save/Load Error Message

14. 4. 7 License Update Error

If you are using the Sanjole License Manager to install or update a license and you click the button "Update Dongle" before you have uplodaded the *.dud file, you are going to see the License Update Error message..



License Update Error Message

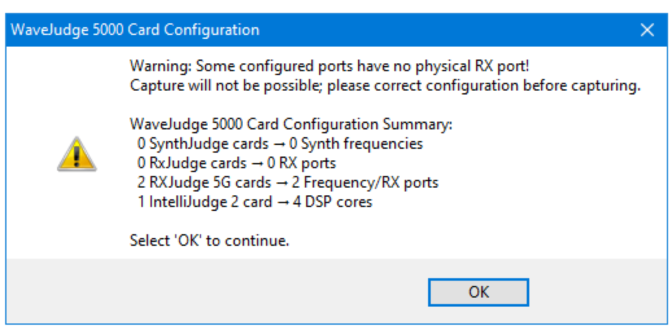
When this occurs, click the OK button on the message to dismiss it. In the Sanjole License Manager click the button Open Update File, which opens a window to locate files on your PC; select the *.dud file and click Open. The Supported Updates window will appear, click OK to dismiss it. The icon in the Sanjole License Manager window will change from a blue question mark to an orange certificate icon; this indicates a successful installation.

14. 4. 8 Parsing Error

If the locale settings on your PC are set incorrectly - such as using a comma (,) instead of a decimal point (.) - this may result in a parsing error. Refer to Troubleshooting on page 551 for instructions to locate and fix the settings.

14. 4. 9 WaveJudge 5000 Card Configuration Warning

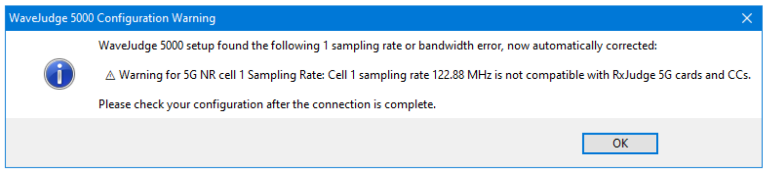
The WaveJudge 5000 Card Configuration warning message below may appear when you are attempting to connect to a chassis before you have setup or completed the configuration.



WaveJudge 5000 Card Configuration Warning

14. 4. 10 WaveJudge 5000 Configuration Warning - Sampling Rate or Bandwidth Error

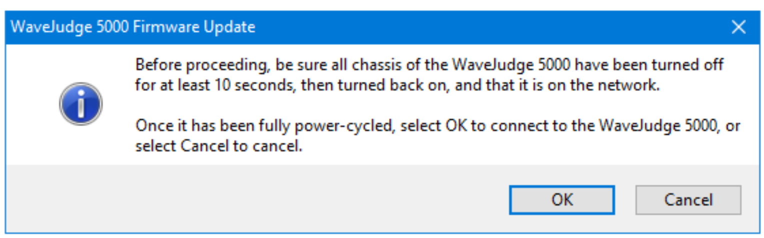
The WaveJudge 5000 Configuration Warning message may appear when you are attempting to connect to a chassis but there is a compatibility issue with the cards, sampling rate, and/or bandwidth. Check your parameters in the Configure Test window.



WaveJudge 5000 Configuration Warning

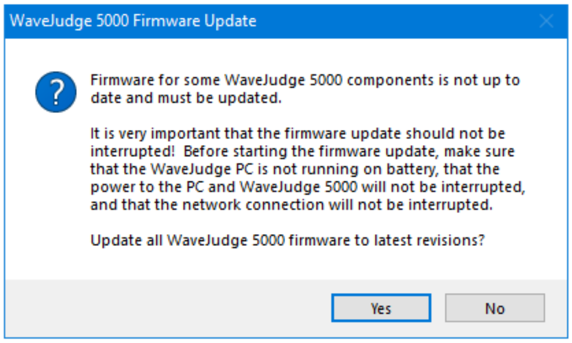
14. 4. 11 WaveJudge 5000 Firmware Update

This window may appear prior to the **Target Select Form** if you have not connected to a chassis in a while; have closed WaveJudge software but have not turned off the hardware, or if Keysight has recently updated the firmware. Power-off and restart the chassis before you try to connect again. Click Cancel then perform the restart. If you see this message again, click the OK to continue.



WaveJudge 5000 Firmware Update Message 1

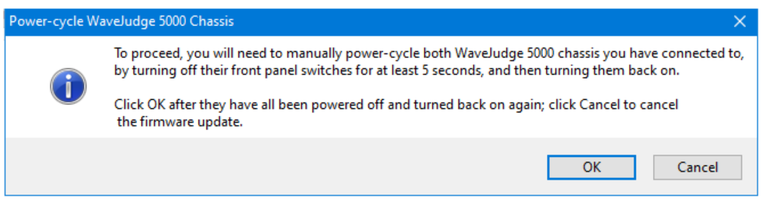
Additionally, the following **WaveJudge 5000 Firmware Update** message may appear when the firmware update is interrupted due to a power interruption, or if your PC battery is low on power. Click Yes to continue. Click No if you intend to check the power settings and attempt to connect again.



WaveJudge 5000 Firmware Update Message 2

14. 4. 12 Firmware Update: Power-Cycle WaveJudge 5000 Chassis

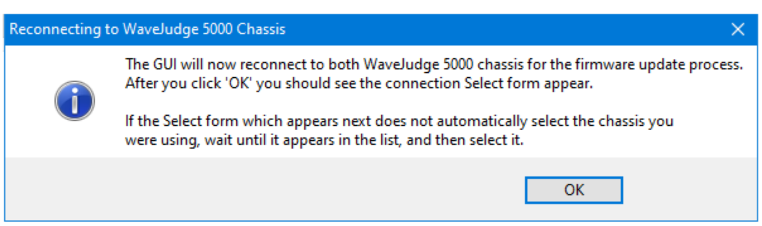
The Power Cycle WaveJudge 5000 Chassis message will appear after the software and/or firmware has been updated. Follow the instructions and manually turn off all WaveJudge chassis you are connected to and keep it off for at least five seconds. **Do not click the Yes button Until AFTER you have power-cycled the chasisis.**



Power-cycle WaveJudge 5000 Chassis Message

14. 4. 13 Firmware Update: Reconnecting to WaveJudge 5000 Chassis

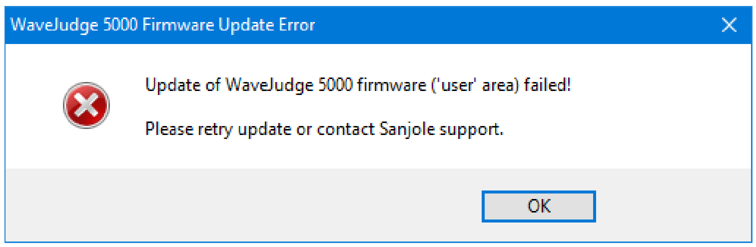
The Reconnecting WaveJudge 5000 Chassis message appears after you have power-cycled all chassis. Click the OK button to access the Target Select Form, which should automatically connect to the same chassis you were previously connected to.



Power-Cycle WaveJudge 5000 Chassis Message

14. 4. 14 WaveJudge 5000 Firmware Update Errors

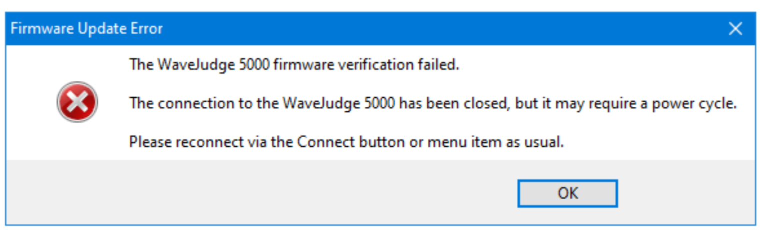
The following WaveJudge 5000 Firmware Update Error message occurs when there is an error updating the firmware. Typically, this message appears if the user clicked the OK button in the Power Cycle WaveJudge 5000 Chassis window without reading the message and turning off all chassis for a minimum of five seconds.



WaveJudge 5000 Firmware Update Error Message 1

Similarly, the following Firmware Update Error will follow, due to the same error of not turning off the chassis earlier when prompted. Click the OK button to close the message.

Then, power cycle all connected WaveJudge chasssis for five seconds and try to connect again.



WaveJudge 5000 Firmware Update Error Message 2

14. 4. 15 RXJudge Error LEDs

Each port on the RXJudge has an LED that indicates an error, otherwise the respective OK LED is lit. Refer to the following RXJudge sections for explanations of error LEDs.

Troubleshooting on page 551

Troubleshooting on page 551

NOTE Ports RX 1 and RX 2 must be set to the same center frequency.
Ports RX 3 and RX 4 must be set to the same center frequency.

14. 4. 16 SynthJudge Error LED

There is only one error LED on the SynthJudge: ERR LED; it indicates the secondary chassis is not receiving a signal from the SYNC IN. Refer to the section on Troubleshooting on page 551 for more information.

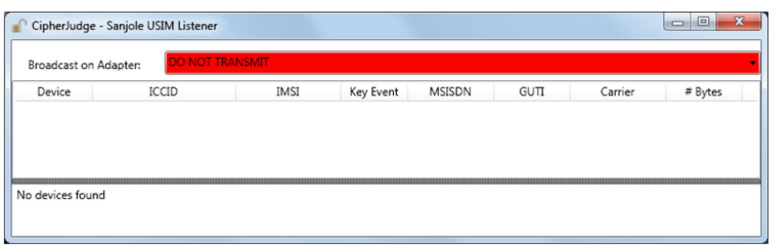
14. 4. 17 IntelliJudge2 Error LED

There is only one error LED on an IntelliJudge2 card: OS Status LED1. The Operating Service Status LEDl blinks to indicate a hardware fault has occurred. For more information, refer to Troubleshooting on page 551.

14. 4. 18 CipherJudge Errors

Do Not Transmit

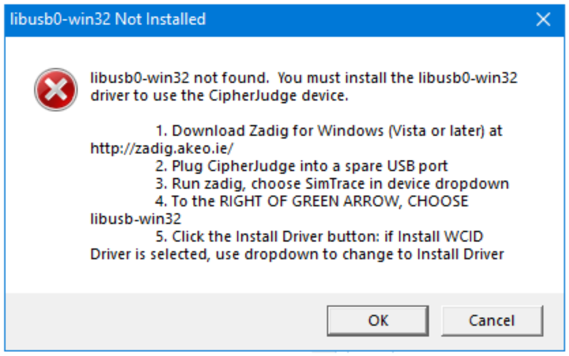
When the CipherJudge status window has a red bar showing "Do Not Transmit" it means CipherJudge hardware is not connected. To connect CipherJudge to the UE, refer to the section Troubleshooting on page 551.



CipherJudge "Do Not Transmit" Status Window

CipherJudge Can't Find Zadig USB Driver

If CipherJudge cannot find the Zadig USB driver, the following window appears. Click the OK button to redirect to Zadig’s website: http://zadig.akeo.ie and install the driver.



During Installation CipherJudge Can't Find Zadig USB Driver

A Glossary

3GPP
: Third Generation Partnership Project

4G
: Fourth Generation (of wireless technology)

5G
: Fifth Generation (of wireless technology)

ACK
: Acknowledgement

ACID
: HARQ Channel Identity

ACK
: Acknowledge

AISN
: HARQ Identification Sequence Number

AMC
: Adaptive Modulation Coding

APT
: Advanced Performance Test

BCH
: Broadcast Channel

BPSK
: Binary Phase Shift Keying

BS
: Base Statio.

CA
: Carrier Aggregation

CC
: Confirmation Code

CCDF
: Complementary Cumulative Distribution Function

CCE
: Control Channel Element

CDMA
: Code Division Multiple Access

CE
: Channel Emulator

CID
: Connection Identifie.

CQI
: Channel Quality Indicator

CQICH
: Channel Quality Information Channe.

CRC
: Cyclic Redundancy Check

CRS
: Cell Reference Signal

CSI
: Channel State Information

CSI-RS
: Cell-Specific Information Reference Signal

CTC
: Convolutional Turbo Codec

dB
: Decibel

dBm
: Decibels (relative to one milliwatt)

DBT
: Device Benchmarking Toolse.

DCCH
: Downlink Control Channe.

DCD
: Downlink Channel Descriptor

DCI
: Downlink Control Informatio.

DHCP
: Dynamic Host Configuration Protocol

DIUC
: Downlink Interval Usage Code

DL
: Downlink

DLFP
: Downlink Frame Prefix

DL-SCH
: Downlink Shared Channel

DMRS
: Demodulation Reference Signal

DSP
: Digital Signal Processor

DUT
: Device Under Test

EARFCN
: Evolved Absolute Radio Frequency Channel Number

EARFCN (DL)
: Evolved Absolute Radio Frequency Channel Number (Downlink)

ECID
: Enhanced Cell Identity

eLTE eNB

Evolved 4G eNode.

eMBB
: Enhanced Mobile Broadband

eNB
: Evolved Node B

EN-DC
: E-UTRAN New Radio - Dual Connectivity

E-UTRAN
: Evolved - UMTS Terrestrial Radio Access Networ.

EVM
: Error Vector Magnitude

FCH
: Frame Control Header

FDD
: Frequency Division Duplex (or Duplexing)

FEC
: Forward Error Correction

FFT
: Fast Fourier Transform

FPGA
: Field Programmable Gate Array

FR1
: Frequency Range 1

FR2
: Frequency Range 2

FTP
: File Transfer Protocol

FWA
: Fixed Wireless Access

GHz
: Gigahertz

gNB
: gNodeB

GSM
: Global System for Mobile

GUTI
: Globally Unique Temporary Identifier

HARQ
: Hybrid Automatic Repeat reQues.

HCS
: Header Check Sequence

HO
: Handove.

Hz
: Hertz

I
: In-phase Component

IMSI
: International Mobile Subscriber Identit.

IMT-2020
: International Mobile Telecommunications - 2020

IP
: Internet Protocol

kHz
: Kilohertz

KPI
: Key Performance Indicator

KSM
: Keysight Software Manager

LCID
: Logical Channel Identity

LM
: License Manager

LNA
: Low Noise Amplifier

LO
: Local Oscillator

LSB
: Least Significant Bit

LTE
: Long Term Evolution

LTE-A
: Long Term Evolution - Advanced

LTE-LAA
: Long Term Evolution - Licensed Assisted Access

M2M
: Machine-to-Machine

MAC
: Medium Access Control (layer)

MC
: Multicarrier

MCH
: Multicast Channe.

MCS
: Modulation and Coding Scheme

MHz
: Megahertz

MIB
: Master Information Block

MIMO

Multiple Input Multiple Output

mmWave
: Millimeter Wave

mMTC
: Massive Machine-Type Communication

MTC
: Machine-Type Communication

MHz
: Megahertz

MS
: Mobile Station

MSIM
: Multiple Subscriber Identity Modules

NACK
: Negative Acknowledgement

NAK
: Negative Acknowledge Character

NAS
: Non Access Stratum (communication layer)

NDI
: New Data Indicator

NES
: Network Emulation Solution.

NGC
: Next Generation Core

NR
: New Radio

NSA NR
: Non-Stand Alone New Radio

OBW
: Occupied Bandwidth

OTA
: Over The Air

OFDM
: Orthogonal Frequency Division Multiplexing

OFDMA
: Orthogonal Frequency Division Multiple Acces.

OCXO
: Oven-Controlled Crystal Oscillato.

PAPR
: Peak to Average Power Ratio

PBCH
: Physical Broadcast Channe.

PCAT
: Protocol Carrier Acceptance Toolset

PCFICH
: Physical Control Format Indicator Channe.

PCI, PCID
: Physical Cell Identification

PCT
: Protocol Conformance Toolset

PDCCH
: Physical Downlink Control Channe.

PDCP
: Packet Data Convergence Protocol (communication layer)

PDSCH
: Physical Downlink Shared Channe.

PDU
: Protocol Data Unit

PHICH
: Physical Hybrid-ARQ Indicator Channel

PHY
: Physical Layer (Layer 1)

PHY RNTI
: Physical Layer Radio Network Temporary Identifier

PMCH
: Physical Multicast Channe.

PPS
: Pulse Per Second

PRACH
: Physical Random Access Channe.

PRBS
: Pseudo-Random Binary Sequence

PRS
: Positioning Reference Signal

PRT
: Protocol Research and Development Toolset

PSS
: Primary Synchronization Signal

PTRS
: Phase Tracking Reference Signal

PUCCH
: Physical Uplink Control Channel

PUSC
: Partial Usage of Subchannels

PUSCH
: Physical Uplink Shared Channel

Q
: Quadrature component

QAM

Quadrature Amplitude Modulation

QoS
: Quality of Service

QPSK
: Quadrature Phase Shift Keyin.

RA
: Random Access (also Receiver Address)

RACH
: Random Access Channel

RAN
: Radio Access Network

RAR
: Random Access Response

RAT
: Radio Access Technolog.

RBW
: Resolution Bandwidth

RCE
: Relative Constellation Error

RCAT
: Radio Frequency/Radio Resource Management Carrier Acceptance Toolset

RCT
: Radio Frequency Conformance Toolset

REG
: Resource Elements Grou.

RF
: Radio Frequency

RFA
: Radio Frequency Automation

RLC
: Radio Link Control (communication layer)

RMS
: Root-mean-square

RNG-REQ
: Ranging Request

RNG-RSP
: Ranging Respons.

RNTI
: Radio Network Temporary Identifier

RRC
: Radio Resource Control (communication layer)

RS
: Reference Signa.

RSRP
: Reference Signal Received Power

RSRQ
    Reference Signal Received Quality
RSSI
    Received Signal Strength Indicator
RT
    Real Time
RTC
    Real Time Connection
RV
    Redundancy Value
Rx
    Receive.
SAP
    Service Access Point
SDAP
    Service Data Adaptation Protoco.
SDU
    Service Data Unit
SFI
    Slot Form Indicator
SIB
    System Information Block
SINR
    Signal to Interference plus Noise Ratio
SISO
    Single Input, Single Outpu.
SMA
    Subminitature version A (a connector type)
SNR
    Signal to Noise Ratio
SRIO
    Serial RapidIO
SRS
    Sounding Reference Signal
SS
    Subscriber Station
SSS
    Secondary Synchronization Signal
TB
    Transport Block
TCP
    Transmission Control Protocol (Internet Protocol)
TDD
    Time Division Duplex (or duplexing)
TMSI

Temporary Mobile Subscriber Identity

TRX
: Transceiver

TTL
: Transistor-Transistor Logic

Tx
: Transmitter

UCCH
: Uplink Control Channel

UCD
: Uplink Channel Descriptor

UIUC
: Uplink Intterval Usage Code

UL
: Uplin.

UMTS
: Universal Mobile Telecommunications Servic.

USCH
: Uplink Shared Channel

V2X
: Vehicle to Everything

B Licenses

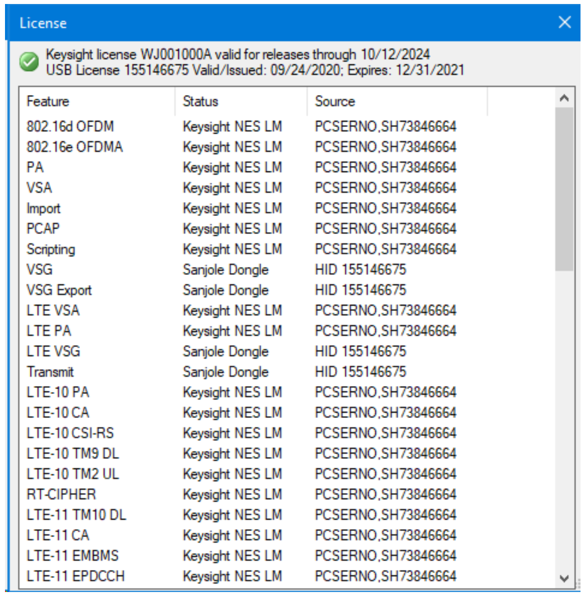
This section provides information for the following:

– Using the WaveJudge License Window on page 603
– Keysight Software Manager (KSM) on page 605
– Keysight Network Emulation Solutions (NES) License Manager (LM) on page 623
– Legacy Sanjole License Manager on page 635

B. 1 Using the WaveJudge License Window

Open the **License** window (via the **HelpLicense** menu selection) to see which WaveJudge software features are enabled and by which type of license.

The License window shows information about the WaveJudge software license but it does not allow you to update or interact with it. Several different types of licenses may appear in this window; more than one type of license may be active at a time.



License Window Shows Expiration Date, with Status and Source for Each Feature

2. **Keysight License:** Keysight licenses are now the primary type of license for the WaveJudge software.

   If you have a Keysight license key of any kind, then for each feature authorized by the license the Status column will show Keysight NES LM and the Source column will show the source of that license, most often a "node-locked" license associated with a specific PC host ID. You may also use the Keysight NES License Manager software to examine or interact with the license.

   A Keysight license should always include the primary WaveJudge application license code, WJ001000A, with a specific support expiration date. You must have this license to use any other license features.

   You can use any WaveJudge software version that was built and released on or before the support expiration date, but you will not be able to use newer versions released after that date. A reminder to purchase additional support will appear when your support is close to the expiration date. You may contact *SJ-support@keysight.com* to extend your support beyond that date, or you may continue to use older versions of WaveJudge software.

   In some cases, if you have bought a time-limited license, there will be an additional "hard" expiration date. In this case, after the expiration date it will not be possible to use the WaveJudge software at all.

3. **Legacy Sanjole USB Dongle License:** A USB license key, also called a “dongle” license, was the most common type of license for Sanjole customers using the WaveJudge software. If you have a USB dongle license key, then for each feature authorized by the license the Status column will show Dongle and the Source column will show an electronic ID number for that license key.

The USB license dongle:

- Requires no installation.
- Contains all license information.
- Can freely move between workstations.
- Starts WaveJudge.
- Has a specific expiration date.

You can use any WaveJudge software version that was built and released on or before the expiration date, but you will not be able to use newer versions after that date. A reminder to purchase additional support will appear when your support is close to the expiration date. You may contact *SJ-support@keysight.com* to extend your support beyond that date, or you may continue to use older versions of WaveJudge software.

4. **Limited-time (trial) License:** Sanjole limited-time or trial licenses are distributed as a license file, tied to a specific Windows PC, with the expiration date shown at the top of the window. If you have a limited-time license then the Status column shows the type of license and the Source column shows the license code as a string of letters and numbers for each authorized feature. After the limited-time license's expiration date you will be unable to use that license file or any of the features it unlocks.

5. **Permanent File License:** In rare cases Sanjole distributed a permanent license as a license file that is tied to a specific Microsoft Windows PC. In this case, for each feature authorized by the license the Status column will show Enabled and the Source column shows the permanent license code as a string of letters and numbers).

NOTE The following only applies when using legacy Sanjole licenses: In this case, your WaveJudge 5000 chassis also requires a unique WaveJudge 5000 hardware license that identifies the major capabilities and protocols supported on that chassis. These licenses cannot be viewed in the Licensewindow because you can only see them while connected to the WaveJudge 5000; however, you can see them in the WaveJudge 5000 Download window or via the Sanjole License Manager.

B. 2 Keysight Software Manager (KSM)

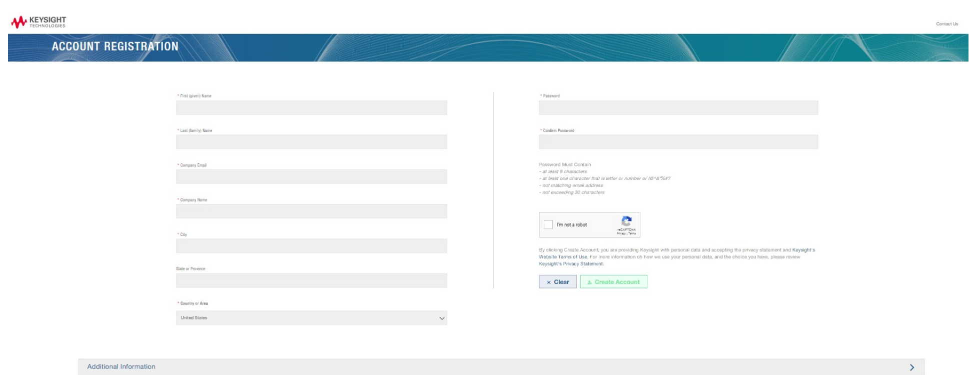
The Keysight Software Manager (KSM) is a website where you can access licenses and software updates for Keysight products you have purchased. You can use this website if you:

- Have received an Keysight entitlement certificate and need to get your license (s)
- Have received email notification of a software update and need to get your update
- Have purchased a subscription renewal and need to apply the renewal to extend your subscription
- Have received email notification that a license is expiring and need to request a new license
- Need to see a summary of your Keysight licenses and subscriptions
- Need to download a license file that you have previously requested
- Need to see details of your licenses and subscriptions that are on a specific host instrument or PC
- Need to update your contact information or other KSM profile settings

B. 2. 1 Create a myKeysight User Account

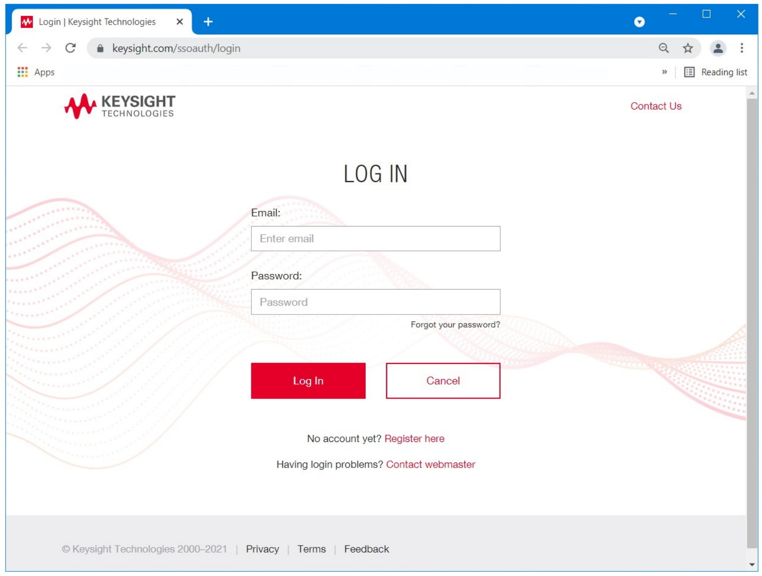
To interact with customer online support, you must have a "myKeysight" account. To create a "myKeysight" account.

1. Visit: User Registration
2. Complete the **Account Registration** form.



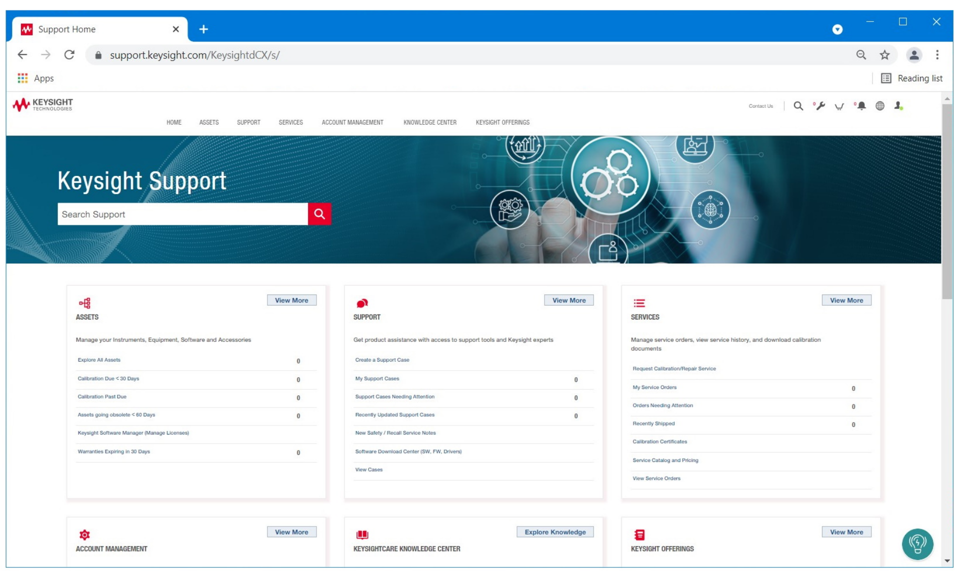
myKeysight - Account Registration Page

3. Click the green $\boxed{\text{Create Account}}$ button.
4. You will receive an automated email, click the link in the email to confirm your account.
5. A webpage will then reconfirm your account is registered. Click the link to login to Keysight Support Login.



Keysight Support Login Page

6. Enter your email and password. Click the red $\boxed{\text{Login}}$ button.



Keysight Support Webpage

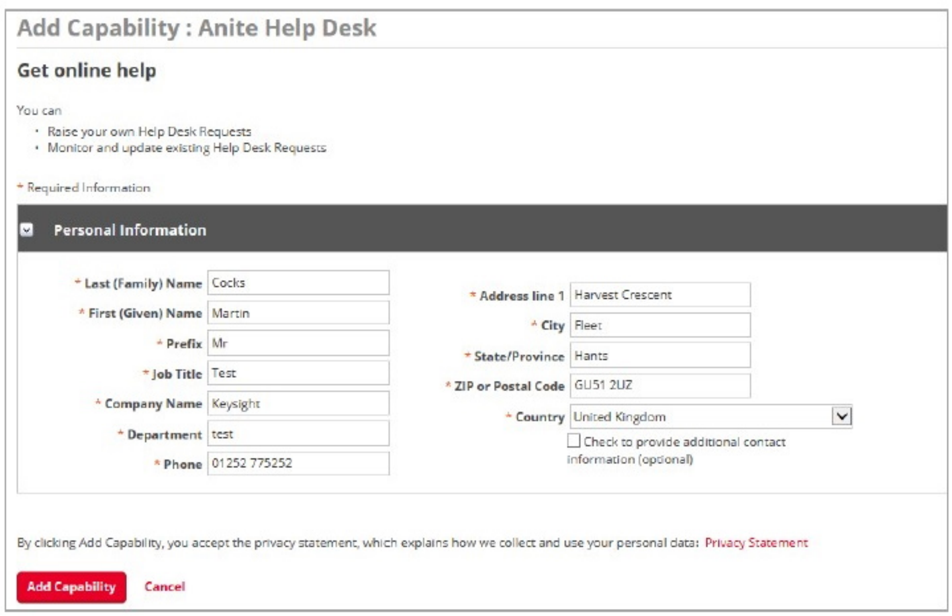
B.2.2 Register as a Customer with an Existing Keysight Account

1. Log out of Keysight.

2. Click the registration link User Registration.

Login to Existing Keysight Customer Account

3. After entering your email address follow the prompt to login.
4. Login with your existing **myKeysight** password.
5. A different form will display with all of your contact details. Click the red button Add Capability to request registration for Help Desk; this action allows you to access and file technical support tickets.

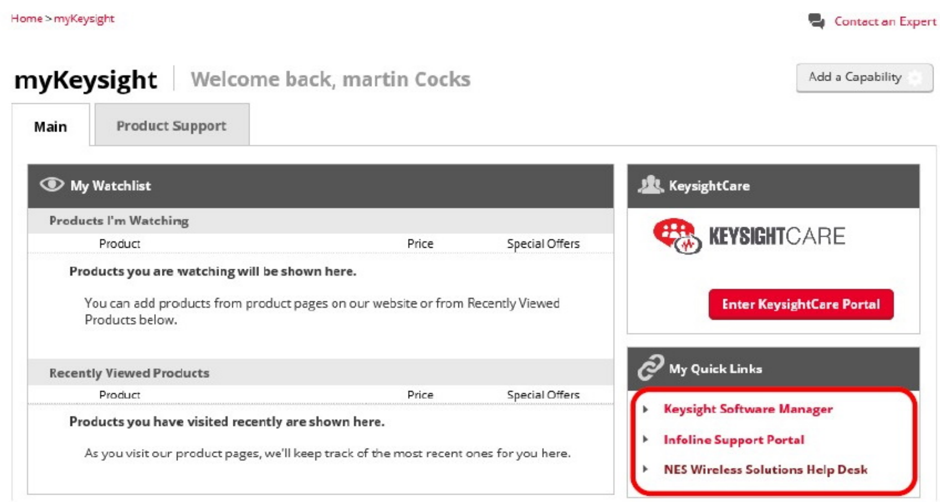


Click Button to "Add Capability" for Help Desk

6. You will receive an automated email, click the link to Confirm Your Registration.

B. 2. 3 Login to myKeysight to Access Software Manager, Help Desk

1. Log into https://www.keysight.com/my/faces/pages_home
2. There are quick links for the KSM, Help Desk, and Infoline.

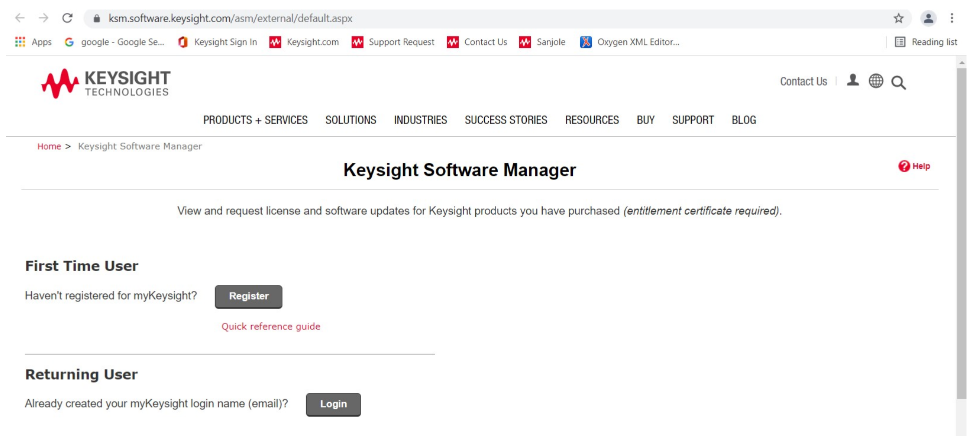


Login to Your myKeysight Account to Access the Software Manager and Help Desk

B. 2. 4 Request a Trial or Temporary License

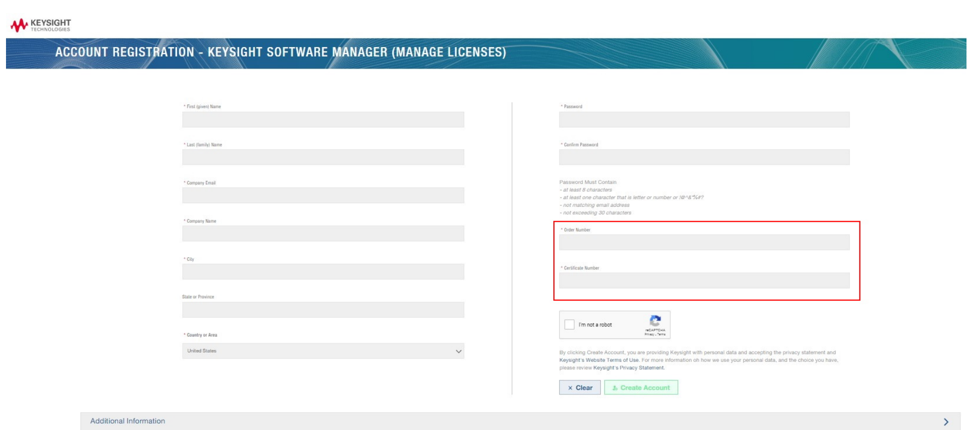
To request a trial or temporary license:

1. Visit the Keysight contact sales webpage for WaveJudge 5000.
2. Click the link for Sales Request.
3. On the next page, complete the Sale Request Form and indicate that you want to request a trial or temporary license.
4. A sales representative will contact you and send an email with a pdf **Entitlement Certificate** attached. Instructions are included at the bottom of the certificate.
5. Visit the Keysight Software Manager webpage and create a new user account for **myKeysight**.
6. Next to First Time User click the button Register.



Keysight Software Manager Webpage - Register as a First Time User

7. The Account Registration - Keysight Software Manager (Manage Licenses) page will open; enter your details in the form. The top portion is mandatory; however, you may click the arrow to the right of Additional Information tab to enter any optional information, such as your job title.
8. In the Account Registration form, there are two fields required to register your license before you can receive and download it. Refer to the **Entitlement Certificate** that you received by email to enter the **Order Number** and **Certificate Number**.

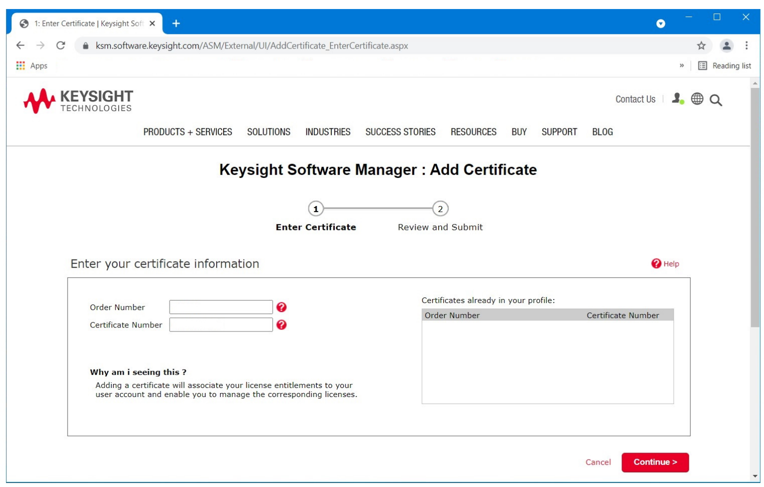


Account Registration Page - Keysight Software Manager

9. Click the button $\boxed{\text{Create Account}}$ to submit the form.
10. You will receive an automated email, click the link to Confirm Your Registration.
11. Download and install the license.

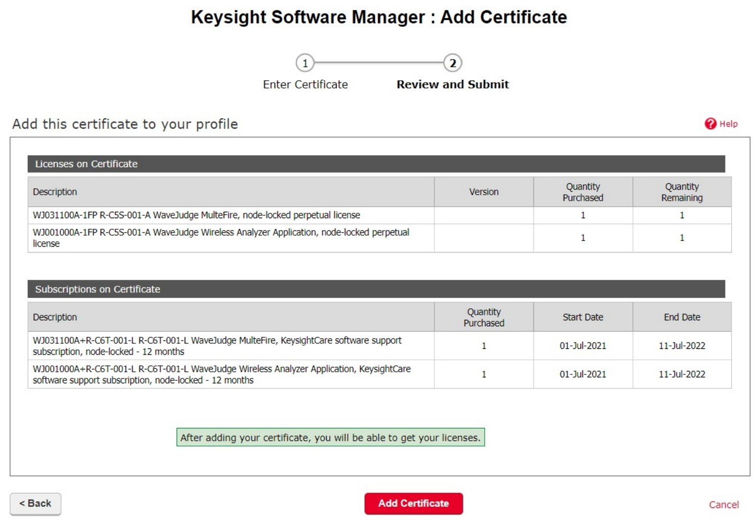
B. 2. 5 Add a License Certificate to KSM

1. Go to http://www.keysight.com/find/softwaremanager, click **Login (Registered User)**, and enter your login email address and password.
2. You will see the **Keysight Support** landing page. Under the **Assets** box, click the link **Keysight Software Manager (Manage Licenses)**.
3. If this is the first time you are accessing the Keysight Software Manager, the **Add Certificate** prompt will appear.
4. Enter the **Order Number** and **Certificate Number** from the **Entitlement Certificate** that you received by email from Keysight, then click the red button Continue.



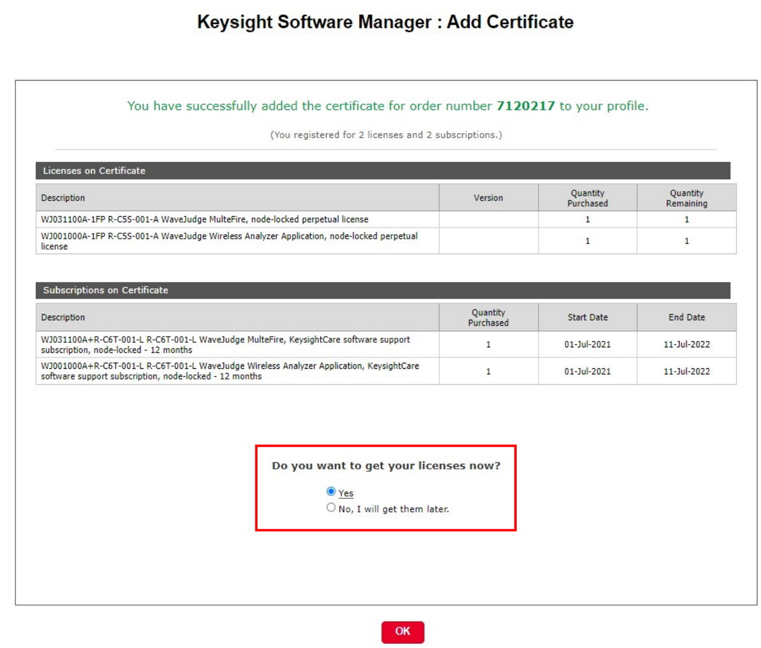
Keysight Software Manager- Enter Your Order and and Certificate Numbers

5. On the next page you will see your licenses populated in the two tables, click the red button Add Certificates.



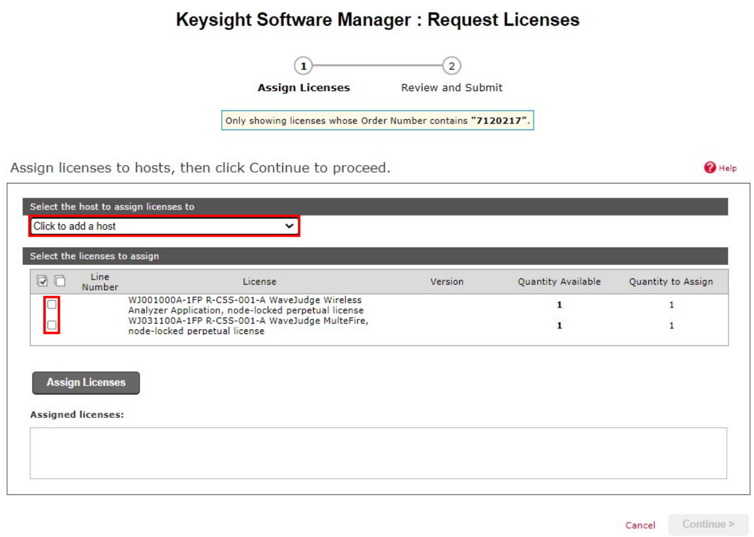
Keysight Software Manager- Click "Add Certificate" Button

6. Next you will see a success message at the top of the page. Select Yes to continue and get your licenses now, then click the OK button.



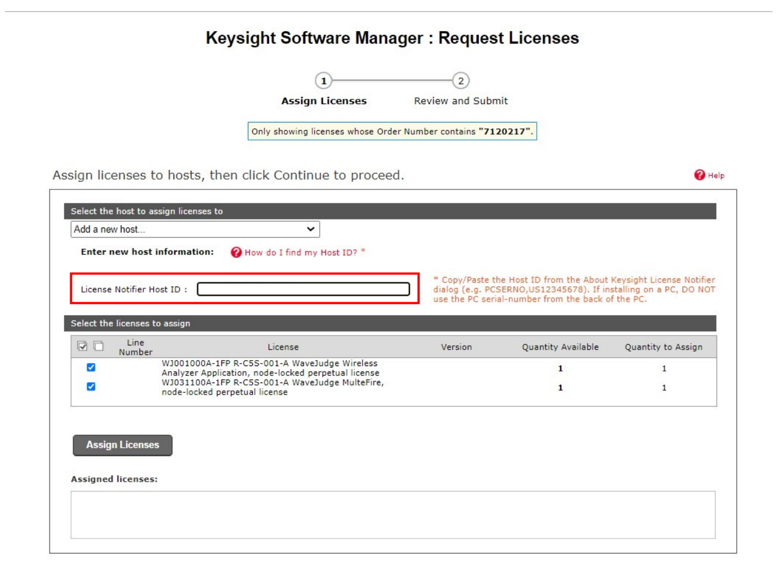
Keysight Software Manager - Select 'Yes' and Click 'OK' Button

7. On the **Request License** page, select Add a New Host from the dropdown menu and check the boxes for each license.



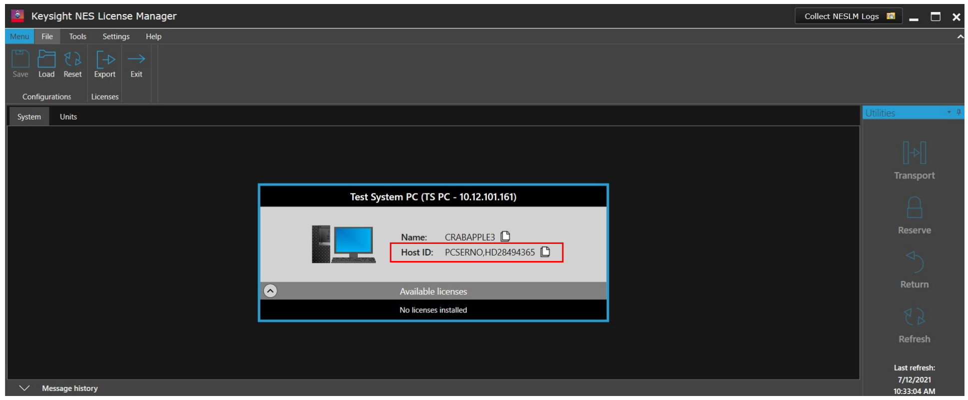
Keysight Software Manager - Add a New Host, Select Licenses

8. Locate the **Host ID** of your computer, enter the number in the field and select the boxes for the licenses.



Keysight Software Manager - Enter Your Host ID

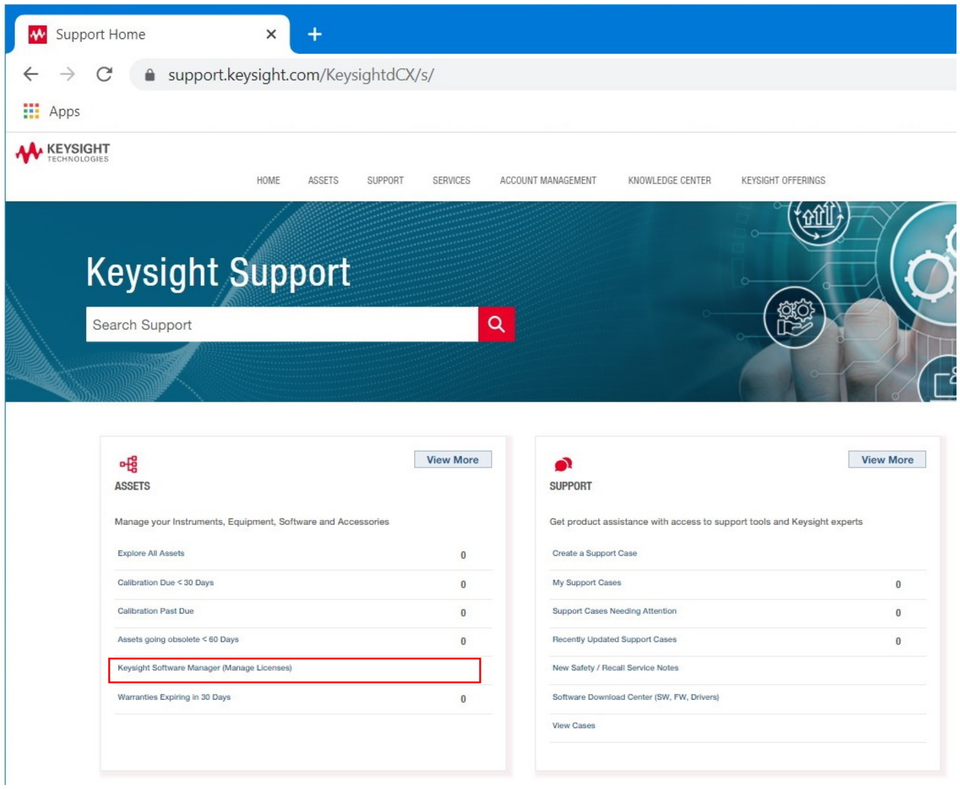
9. **You must install the Keysight NES License Manager to access your Host ID number.** The Host ID is located in the middle of the window when you open the NES License Manager. Refer to Keysight_NES_LM_19_80_00_Installer.exe on page 625.



Keysight NES License Manager - Location of Host ID

B. 2. 6 Renew a License

1. Go to http://www.keysight.com/find/softwaremanager, click Login (Registered User), and enter your login email address and password.
2. You will see the Keysight Support landing page. Under the Assets box, click the link Keysight Software Manager (Manage Licenses).



Click Link for Keysight Software Manager (Manage Licenses)

3. Once inside the KSM, click "**I have an updatable license**." The CPUID of the licenses available to renew will display.
4. Click **Continue**.
5. You will be asked if you want to rehost the license. If you want to use the same CPUID, click **No**, then click **Continue**.
6. Click **Yes (recommended)**, then click **Continue**.
7. Make sure the email address in the email field is correct and click **Request License**. You will receive a new license file from *license_support@keysight.com*.

B. 2. 7 Request Conversion of a Sanjole License to a Keysight License

On May 1, 2021, Sanjole licensing systems began converting to the Keysight licensing systems. As part of this migration to Keysight Sanjole customers were granted replacement Keysight licenses, which offer the equivalent (and in some cases additional) capabilities to the prior dongle-based license. If you were an exisiting customer at that time, you should have received communication from a Keysight representative indicating your order number, certificate number, and instructions to claim your replacement license.

If your Sanjole software support has expired you will need to renew your support before running the new WaveJudge software release (however, you can still install your replacement license withoutt the support).

Complete the License Migration Process on page 616, then contact the Global Renewals Desk at *keysight-global.renewals@keysight.com* for assistance in renewing your software support. You may also choose to take no action and continue to use your existing Sanjole license dongle and WaveJudge software release, however you will not be able to receive new software releases without first migrating to Keysight licensing and renewing your software support.

B. 2. 8 License Migration Process

1. Obtain your replacement license order number(s) and certificate number(s) from your local Keysight representative or Global Renewals Desk contact.
2. Determine the Sanjole Dongle ID(s) for your system(s).

   a. You can determine the Sanjole Dongle ID for your system from the Help > License menu within the WaveJudge software, or from the Sanjole License Manager.

   b. Note: If your entitlement order contains licenses for more than one system (i.e., multiple Sanjole Dongle IDs), multiple users can register the same order into their KSM account and then retrieve the licenses for their particular WaveJudge system, as needed.
3. Go to www.keysight.com/find/softwaremanager (KSM):

   a. If you do not already have a KSM account.

   - Select **Register**.
   - Enter your personal information, Order Number/Certificate Number and select **Create Account**.

   b. If you already have a KSM account:

   - Select **Login**, enter your email and password, and select You can add a new certificate.
   - Enter your Order Number and Certificate Number and select **Continue**, **Add Certificate**, and **OK** to return to the home page.

   c. If you have more than one entitlement order, repeat the You can add a new certificate steps above.
4. View your licenses.

   a. On your KSM home page, from the View menu, select Hosts.

b. From this screen you will be able to see the licenses available for each Sanjole Dongle ID on the order.

5. Download and install the WaveJudge software release.

   a. Select You can get updates.

   b. Select the latest WaveJudge release and follow the instructions to download and install the software on your test system PC (i.e., the PC on which you will install the licenses).

6. Determine your Host ID.

   a. As mentioned above, the Keysight replacement licenses are node-locked perpetual licenses, so as part of the redemption process, you will need to determine the Host ID of your test system PC.

   b. To do so, launch the **NES License Manager**, and select the clipboard icon next to Host ID in the Test System PC window.

7. Send the following information to *SJ-support@keysight.com* with a subject line of **“Sanjole to Keysight license migration"**:

   a. Order number

   b. Dongle ID being replaced

   c. Test system PC Host ID

   d. Email address to send the replacement licenses

8. Install your replacement licenses.

   a. You will receive your replacement licenses via email. When they arrive, launchthe NES License Manager.

   b. Drag and drop the licenses to the location indicated in the bottom right corner of the NES License Manager (or select FileLoad and navigate to the license file location).

   c. Remove your Sanjole license dongle from your test system PC.

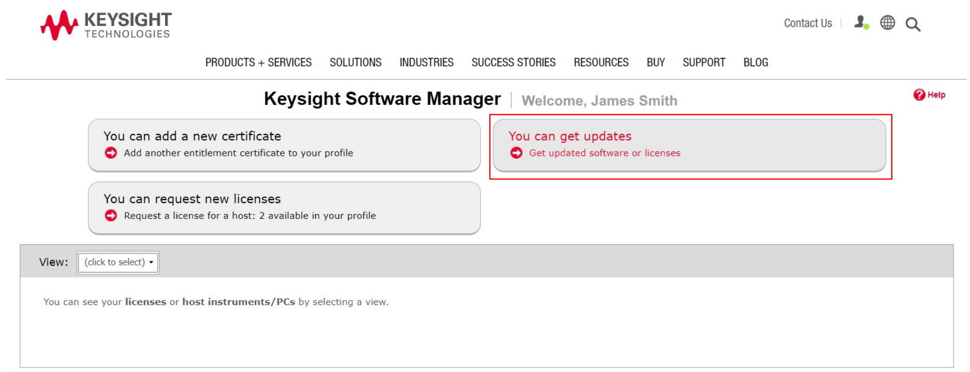
   d. Run the WaveJudge software and ensure that all licensing is operating properly.

9. Return your Sanjole dongle to your local Keysight representative or mail to: Attn: Support, Keysight Technologies, 711 Kapiolani Blvd., Ste 1050, Honolulu, HI 96813.

B. 2. 9 Download and Install Initial and New Releases of WaveJudge Software

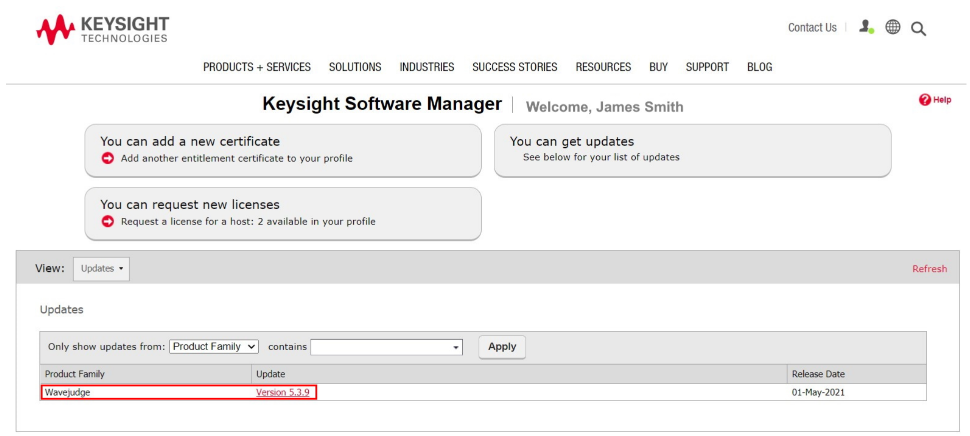
Log into Keysight Software Manager website to access your initial WaveJudge software or to access new releases.

1. Visit Keysight Software Manager.
2. Click the link You can get updates.



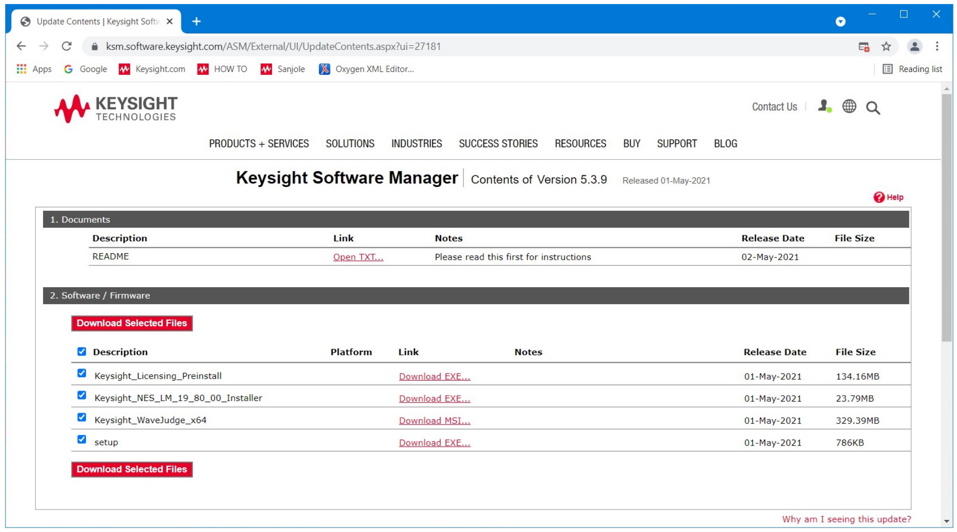
Keysight Software Manager - Click "You Can Get Updates"

3. On the next page, under the **Updates** section, select **Product Family** from the dropdown menu and click the link in the table to access the version of WaveJudge.



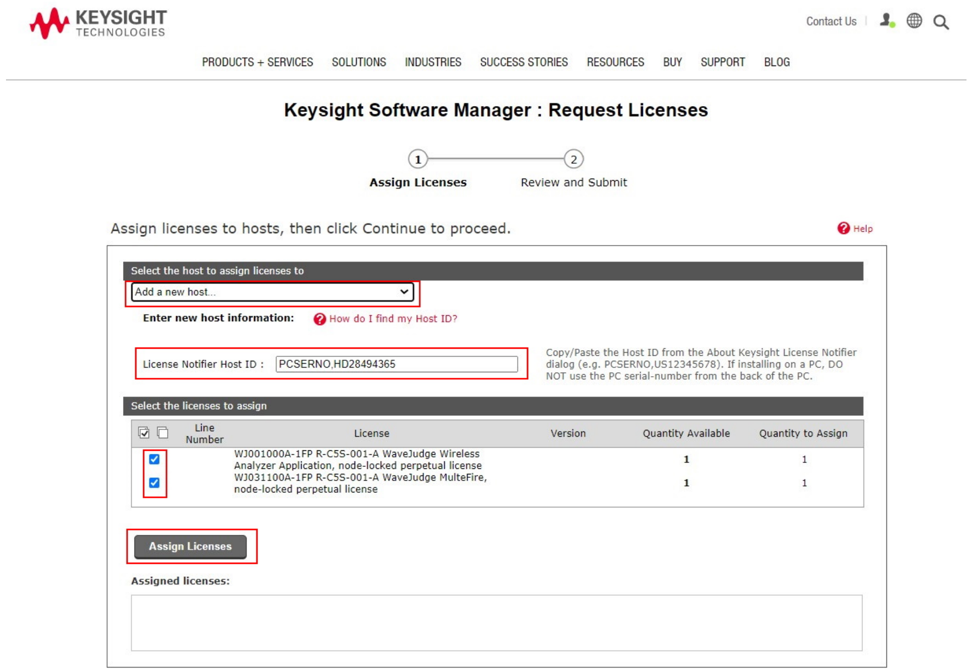
Keysight Software Manager - Click the WaveJudge Version Link

4. A list of all the relevant software packages populates in the table. Under the section **Software/Firmware**, select the checkbox(es) from the list and click the button to $\boxed{\text{Download Selected Files}}$. A Chrome or Firefox browser is recommended.



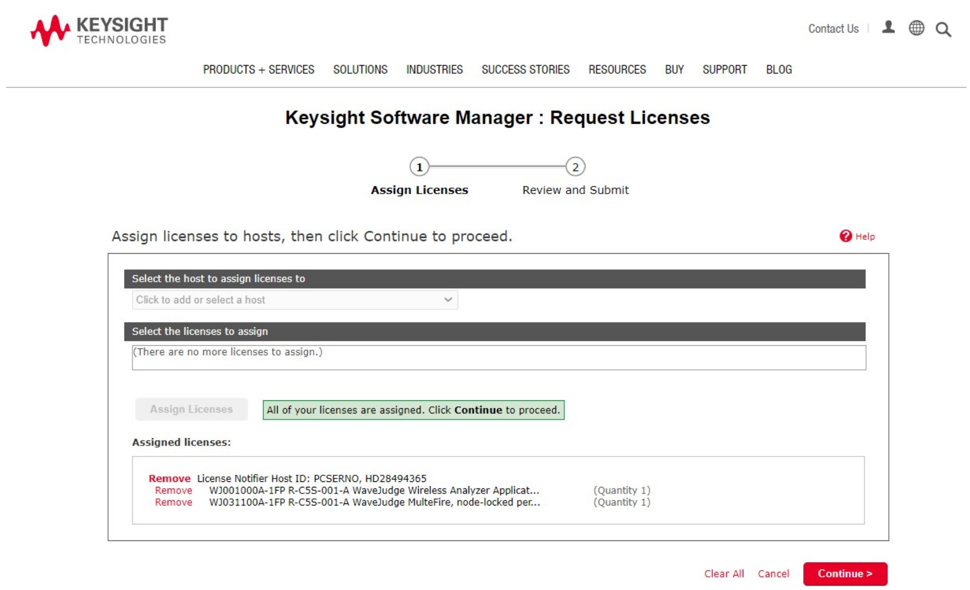
Keysight Software Manager - Download WaveJudge Releases

5. If this is the first time you are accessing WaveJudge files via the Keysight Software Manager, you will have to add a new host. To do this, complete the fields in in the next window:
   - Under the first dropdown menu, select Add a new host....
   - In the **License Notifier Host ID** field, enter your Host ID. (To obtain the Host ID, open the Keysight NES License Manager, it will be in the center of the window.)
   - Select the checkboxes for the licenses to assign.
   - Click the button Assign Licenses.



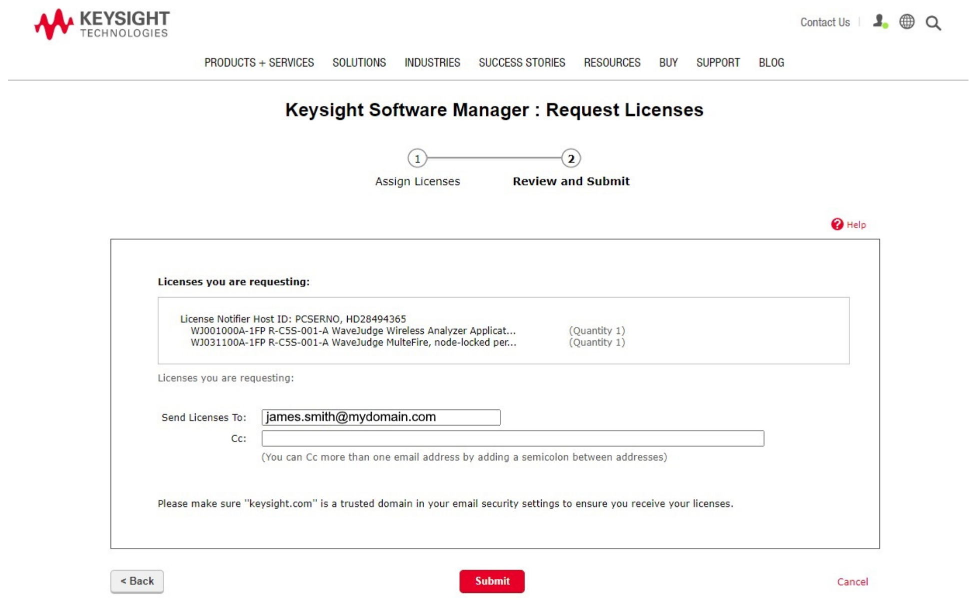
Keysight Software Manager - Select Licenses and Enter Your Host ID

6. Click the red button Continue.



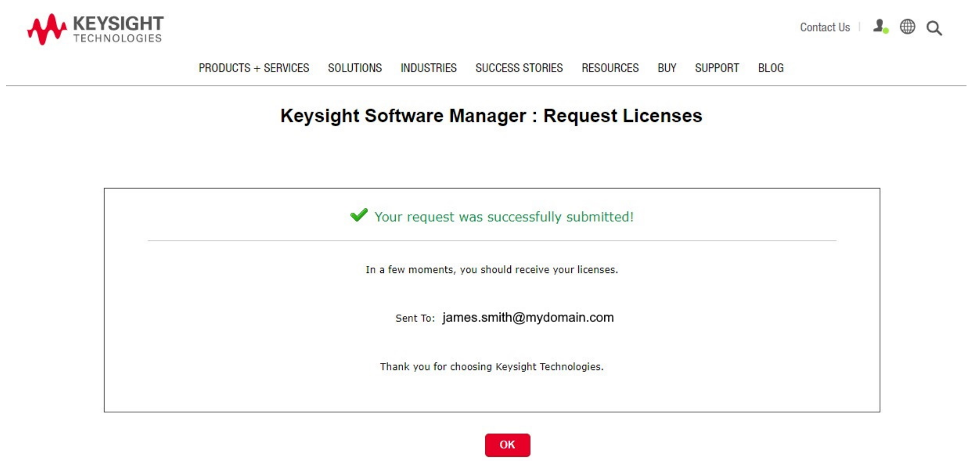
Keysight Software Manager - Select Licenses and Enter Your Host ID

7. Enter your email in the field. Optionally, in the second field, you may add email addresses of other people in your organization who should receive copies of the license(s).



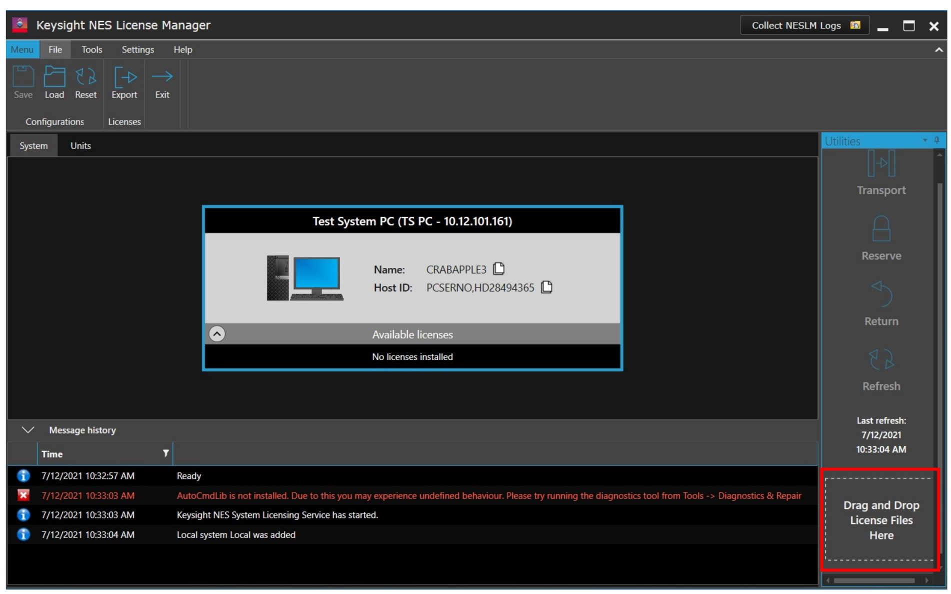
Keysight Software Manager - Enter an Email Address to Receive the Licenses

8. On the next page you will receive a success message indicating an email was sent to you with the license(s).



Keysight Software Manager - Success Message

9. When you will receive the email with the license attachment, save the license file (*lic) to your computer desktop.
10. Open the Keysight NES License Manager; drag and drop the *lic file to the area noted in the bottom right corner of the window.



Keysight NES License Manager - Drag and Drop App Files Here

11. A small window will appear and confirm you have successfully installed the license to the Keysight NES License Manager.

Keysight NES License Manager - Successful License Installation Notice

B. 3 Keysight Network Emulation Solutions (NES) License Manager (LM)

WaveJudge relies on the Keysight Network Emulation Solutions (NES) License Manager (LM), so it automatically installs with your WaveJudge software. The NES LM provides a complete user interface to install, update, and access your Keysight and WaveJudge license features.

If you are a WaveJudge customer and have not transitioned to Keysight NES License Manager, you may need to download and install one or two of the required installers, described below.

B. 3. 1 Keysight NES License Manager Installers

WaveJudge 5000 requires installers for the NES License Manager, which also provides prerequisites for other Keysight software. There are two installers, each one handles different components above and beyond the WaveJudge installer itself.

- `Keysight_Licensing_Preinstall.exe` is for certain prerequisites, which anybody using other Keysight software may already have installed on your system, such as the Keysight Licensing Manager and basic libraries and packages.
- `Keysight_NES_LM_19_80_00_Installer.exe` is the NES License Manager itself.

Your requirements depend on your specific scenario:

- Keysight customers using the UXM test equipment and software already have Keysight NES License Manager installed; no further action is required. Neither one needs to be downloaded or installed.
- Former Sanjole customers and users of WaveJudge who have not yet switched licensing systems, you do not need any of these for a while, as long as you continue using your existing dongles and they have not expired. (However, renewing will require a switch to Keysight licensing.) Neither needs to be downloaded or installed.
- Keysight customers already using other Keysight software on a PC where

WaveJudge is being installed probably already have installed the equivalent of the first installer, but may not have the Keysight NES License Manager installed yet. Thus, you will need to install the Keysight NES License Manager (before or after installing WaveJudge). Download and install ONLY the `Keysight_NES_LM_19_80_00_Installer.exe` file.

– Totally new customers who do not have any Keysight software installed – or none on the PC where you will run WaveJudge – need to download and install both. First, install the `Keysight_Licensing_Preinstall.exe` then install the `Keysight_NES_LM_19_80_00_Installer.exe`.

WaveJudge may be installed either before or after doing this. Once the NES License Manager is installed, WaveJudge will automatically find it.

B. 3. 1. 1 Keysight_Licensing_Preinstall.exe

Legacy Sanjole customers who are new to Keysight software need to download and install the Keysight Licensing Preinstall application, and then the Keysight_NES_LM_19_80_00_Installer.exe on page 625. Once it is installed WaveJudge will automatically find it.

To access the preinstall application:

1. Log into the Keysight Software Manager.
2. As indicated in the section Download and Install Initial and New Releases of WaveJudge Software on page 617, select the box "You can get updates".
3. On the next page, under the Updates section, select Product Family from the dropdown menu and click the link in the table to access the version of WaveJudge.
4. A list of all the relevent software packages populates in the table. Under the section **Software/Firmware**, select the Keysight Licensing Preinstall checkbox from the list and click the button to Download Selected Files.

To install the application

1. Doubleclick on the Keysight_Licensing_Preinstall icon  .
2. The first window is the Keysight Software End-User Agreement, you must click the Accept button to proceed with the installation.
3. In the window, Install required software for Keysight NES License Manager, click the Yes button to allow the app to check for any missing requirements.
4. In the window, Keysight License Manager - InstallShield Wizard you must select the round button **"I accept the terms in the license agreement"** to proceed with the download; then click the Next button.
5. By default, the license manager is installed in the location `C:\Program Files`

`(86)\Agilent\Agilent License Manager`; click the **Next** button to accept this location.

To install the app in a different destination folder click the **Choose** button and browse your PC to select a different location, then click the **Next** button.

6. In the window **Ready to Install the Program**, click the **Install** button.
7. The app will install the files. In the window **InstallShield Wizard Completed** click the **Finish** button to exit the wizard.

B. 3. 1. 2 Keysight_NES_LM_19_80_00_Installer.exe

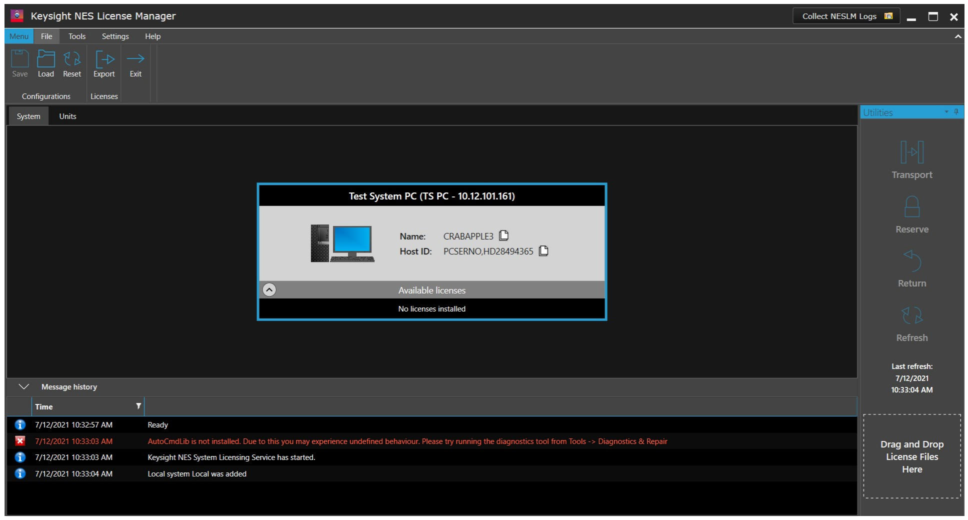
Legacy Sanjole customers who are new to Keysight software need to download and install the Keysight NES LM Installer in addition to the previous Keysight Licensing Preinstall application. Once it is installed WaveJudge will automatically find it.

To access the Keysight NES LM Installer application:

1. Log into the Keysight Software Manager.
2. As indicated in the section Download and Install Initial and New Releases of WaveJudge Software on page 617, select the box **"You can get updates"**.
3. On the next page, under the **Updates** section, select **Product Family** from the dropdown menu and click the link in the table to access the version of WaveJudge.
4. A list of all the relevant software packages populates in the table. Under the section **Software/Firmware**, select the **Keysight NES LM Installer** checkbox from the list and click the button to **Download Selected Files**.

To install the app:

1. Doubleclick on the **Keysight_NES_LM_19_80_00_Installer.exe** icon .
2. The **Install Keysight NES License Manager** window will show a prompt indicating it will install or update the NES License Manager to the latest version. Click the **Yes** button to proceed.
3. The files will quickly install on your computer and an NES License Manager shortcut icon will appear on your desktop . Click the icon to open the Keysight NES License Manager.



Keysight NES License Manager Open

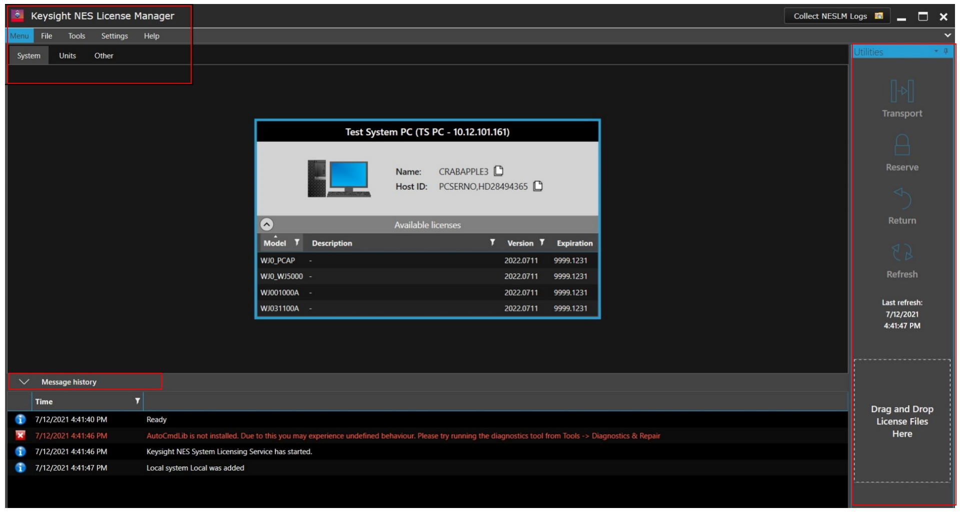
B. 3. 1. 3 Bit-Flip Frequency License

A bit-flip frequency licesnse is assigned to a specific 5G RF module to control the frequency range you may use on that specific module.

B. 3. 2 Keysight NES LM User Interface

The Keysight NES LM has it's own user documentation; however, a brief overview of the user interface is provided in the subsections below. For instructions to access the primary user guide refer to Keysight NES License Manager - Help Menu on page 632.

The Keysight NES LM user interface has three primary sections: the Main Menu at the top left, the Utilities panel on the right side, and Message History at the bottom.



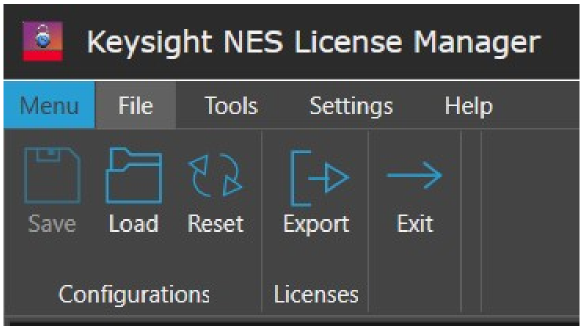
Keysight NES License Manager - User Interface

By default, under System, the Test System window appears in the middle of the window. The system tab displays the hardware unit running the NES License Manager and any license server or connections to other hardware units. Each hardware unit displays the following information:

- Name – the name of the PC or hardware unit on which the NES License Manager is running.
- Host ID – the host ID of the hardware unit that is required when ordering node-locked licenses.
- Available licenses – displays a table listing all of the licenses available on this hardware unit.

B. 3. 3 Keysight NES LM USer Interface - Main Menu

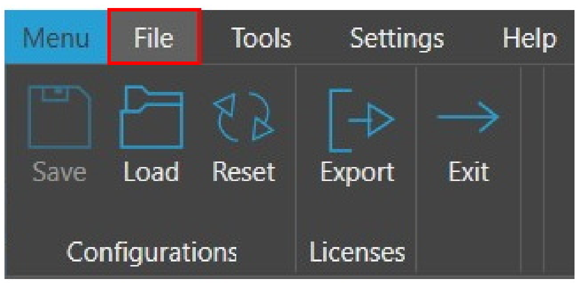
The Main Menu provides buttons to configure and manage licenses and license configurations. It has four menu options: File, Tools, Settings, and Help. The blue Menu option is static, it does not have any function other than to indicate this is the Main Menu.



Keysight NES License Manager - Main Menu

B. 3. 3. 1 Keysight NES License Manager - File Menu

The File menu is where you work with file configurations and licenses.



Keysight NES License Manager - File Menu

The File menu options are described below.

Save (Configurations)

Click to save a file configuration.

Load (Configurations)

Click to load a file configuration.

Reset (Configurations)

Click to reset a file configuration.

Export (Licenses)

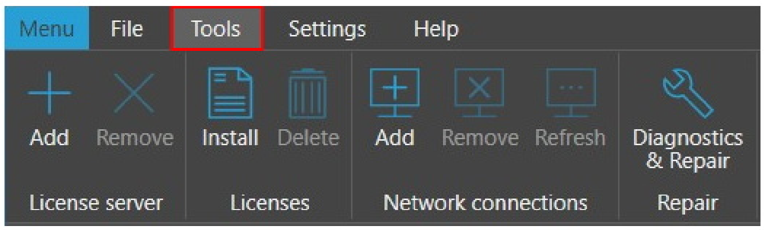
Click to export a license file.

Exit

Click to close the NES License Manager application.

B. 3. 3. 2 Keysight NES License Manager - Tools Menu

The Tools menu is where you can add and remove licenses, server settings, network connections, and access to the diagnostics and repair tool.



Keysight NES License Manager - Tools Menu

The Tools menu options are described below.

Add (License server)

Click to add a license server.

Remove (License server)

Click to remove a license server.

Install (Licenses)

Click to install a license file.

Delete (Licenses)

Click to delete a license file.

Add (Network connections)

Click to add a network connection.

Remove (Network connections)

Click to remove a network connection.

Refresh (Network connections)

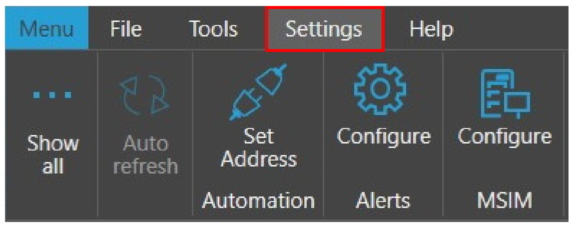
Click to refresh a network connection.

Diagnostics and Repair (Repair)

Click to open the diagnostics and repair wizard.

B. 3. 3. 3 Keysight NES License Manager - Settings Menu

The Settings menu is where you can configure settings such as addresses and alerts.



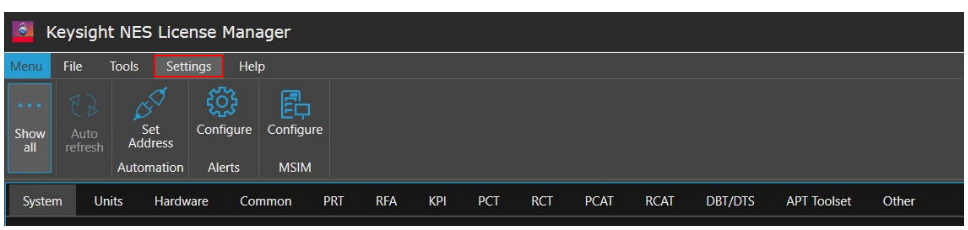
Keysight NES License Manager - Settings Menu

The Settings menu options are described below.

Show All

When selected, NES License Manager displays all of the licenses that can be purchased from Keysight. When deselected, the NES License Manager displays only the licenses that you have installed.

Each tab groups the available and/or installed licenses. Each license tab is briefly described below.



Keysight NES License Manager - Settings Submenu

Show AllSystem

The system tab displays the hardware unit running the NES License Manager and any license server or connections to other hardware units.

Show AllUnits

Click to add a connection.

Show AllHardware

Click to display hardware licenses.

Show AllCommon

Click to display the prerequisite software and test environment licenses.

Show AllPRT

Click to display Protocol R&D Toolset licenses.

Show AllRFA

Click to display RF Automation Toolset licenses.

Show AllKPI

Click to display Functional KPI Toolset licenses.

Show AllPCT

Click to display Protocol Conformance Toolset licenses.

Show AllRCT

Click to display RF Conformance Toolset licenses.

Show AllPCAT

Click to display Protocol Carrier Acceptance Toolset Application.

Show AllRCAT

Click to display RF/RRM Carrier Acceptance Toolset Application.

Show AllDBT/DTS

Click to display Device Benchmarking Toolset Application.

Show AllAPT Toolset

Click to display Advanced Performance Test Toolset Application.

Show AllOther

Displays all licenses that cannot be displayed on any of the other tabs.

Auto Refresh

Click to refresh all data and tables.

Set Address (Automation)

Click to set the Automation PC IP address.

Configure (Alerts)

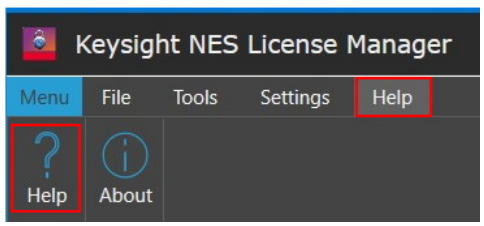
Click to configure alert settings.

Configure (MSIM)

Click to configure Multi-SIM settings.

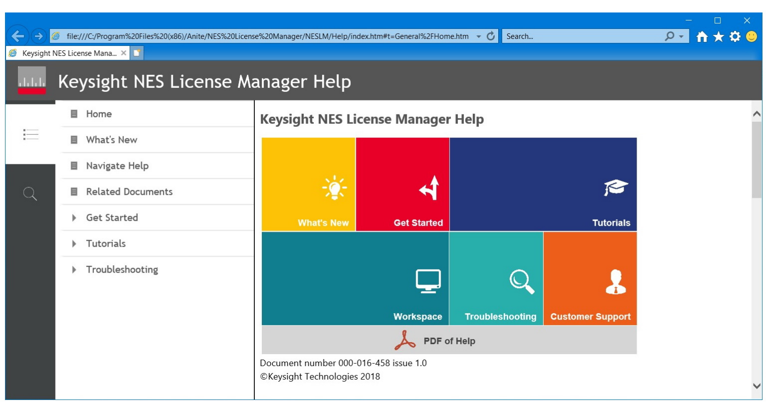
B. 3. 3. 4 Keysight NES License Manager - Help Menu

To access the primary user guidance from within the NES LM interface click Help from the main menu then select the **Help** icon.



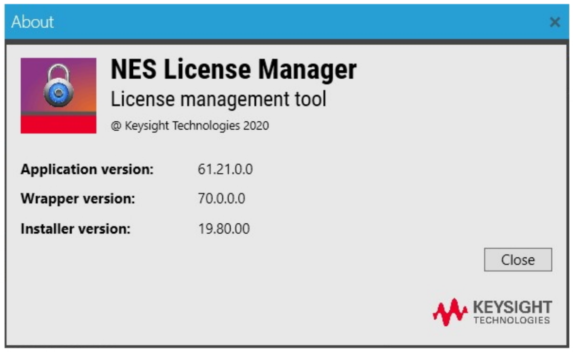
Keysight NES License Manager - Help Menu

A popup alert may appear near the bottom of the window, click the button to **Allow Blocked Content**. When the landing page opens, select the menu icon on the left to show all the high-level help topics.



Keysight NES License Manager - Help Window

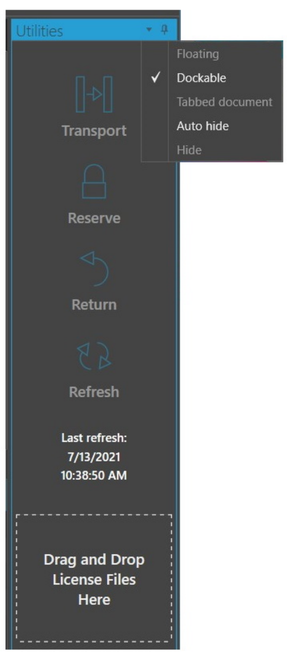
The last option in the Help menu is About, which displays the version number of the NES License Manager application.



Keysight NES License Manager - About Window

B. 3. 3. 5 Keysight NES LM User Interface - Utilities Pane

On the right side of the user interface is the Utilities pane. Options in this menu perform actions on selected licenses. Click the small down arrow (in the blue stripe) to see options to dock or hide the Utilities pane. Click the thumbtack icon to pin it in place.



Keysight NES License Manager - Utilities Pane

Arrow Icon Dropdown Menu

Floating Click to release the pane from the right side of the window

Dockable Click to pin the pane open on the right side of the window.

Tabbed Document Click to allows multiple panels to show within a single window.

Autohide Click to close the pane, only the word Utilities will show in the window.

Hide Click to close and hide the Utilities pane.

The Utilities pane options are described below.

Transport

Select license(s) and click Transport to enable license features.

Reserve

Select license(s) and click Reserve to reserve a software product instance on your PC.

Return

Select license(s) and click Return to return a software product instance on your PC.

Refresh

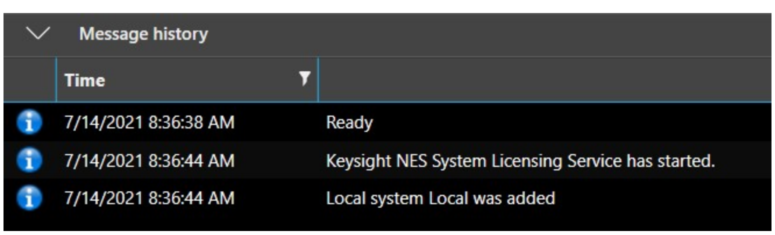
Select license(s) and click Refresh to refresh data a on an offline client computer.

Drag and Drop License Files Here

Drag and drop license (*lic) files to install them in the NES License Manager.

B. 3. 3. 6 Keysight NES LM User Interface - Message History

The Message History panel is at the bottom of the user interface. If you want this section open but do not see it, click the arrow icon next to the words Message History and it will open. This window shows status messages but does not allow you to interact with the content.



Keysight NES License Manager - Message History

B. 4 Legacy Sanjole License Manager

The **Sanjole License Manager** is a standalone window designed to make it easier for users to manage their legacy Sanjole software licenses. It lets you view or update the feature set for your Sanjole USB dongle or hardware licenses in your WaveJudge 5000 without having to return them to Keysight. Unlike the Licenses on page 603 window (listed under the **Help** menu), the **Sanjole License Manager** is only accessible from the Start menu and it has an interactive interface.

NOTE If you are using Keysight licenses, you will never need to use the Sanjole License Manager. You will instead use Keysight's NES License Manager, which you should have installed before or after installing WaveJudge.

The Sanjole License Manager also allows you to connect to a WaveJudge 5000 chassis and view the licenses incorporated into the Primary chassis. In fact, it is the hardware license Control feature that allows it to act as the Primary or "Control" chassis.

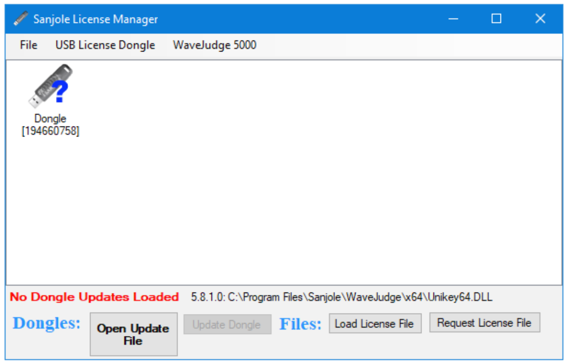
NOTE When using Keysight licenses, the WaveJudge 5000 chassis hardware licenses do not apply and all protocol support and option such as real-time decoding are provided by the Keysight host license. However, some RF frequency or bandwidth options may require specific licenses to be installed on the RF modules.

To access the Sanjole License Manager:

1. Open your **Windows Start Menu**.
2. Scroll down and locate **Sanjole** in the list of programs.
3. Select **Sanjole License Manager**

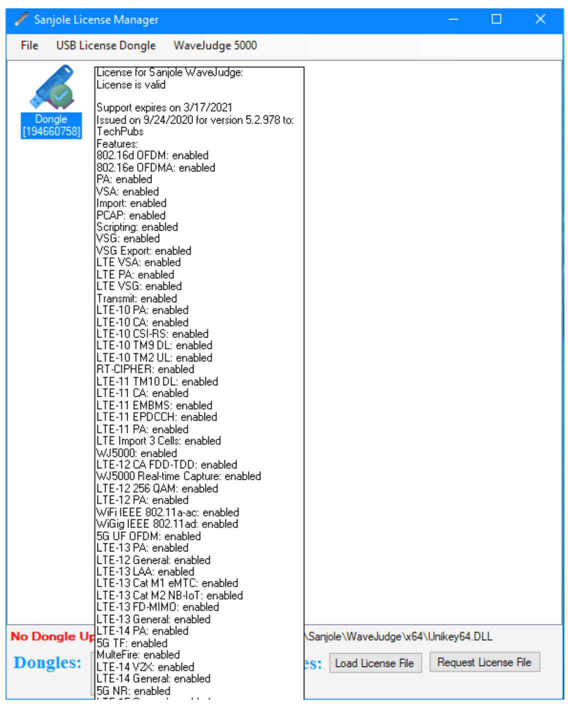
Sanjole License Manager Button

The Sanjole License Manager will open; the main menu has three options **File**, **USB License Dongle**, and **WaveJudge 5000**.



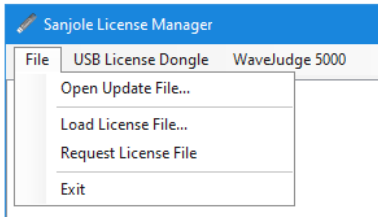
Sanjole License Manager Window

Hover your cursor over the dongle icon and a summary of the license properties will appear.



Hover Your Cursor over the License Icon to View a License Summary

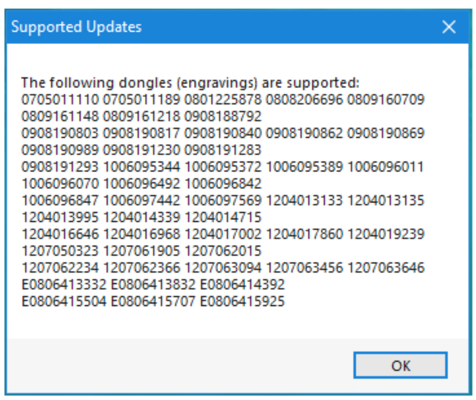
The File Menu has four options Open Update File..., Load License File..., Request License File, and Exit.



Sanjole License Manager - File Menu

Open Update File...: Opens a window to find and select the updated license file for a USB dongle or WaveJudge 5000 Updates, a *.dud file.

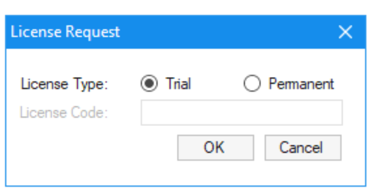
To load the license update click Open Update File which opens a file window. Select the file you received from Sanjole, and select Open. It will display a message like the one on the figure below. The serial number should match the chassis you intend to update; more than one serial number and update may be included in a single license update file.



Sanjole License Manager - Supported Updates Window

Load License File...: Opens a window to find and select the *.license file.

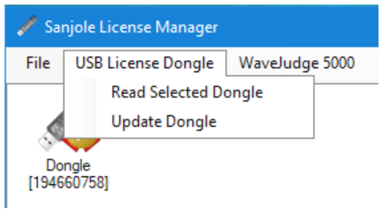
Request License File: Opens a License Request window.



Sanjole License Manager - License Request Window

Exit: Closes the Sanjole License Manager window.

The USB License Dongle menu has two options: Read Selected Dongle and Update Dongle, described below.

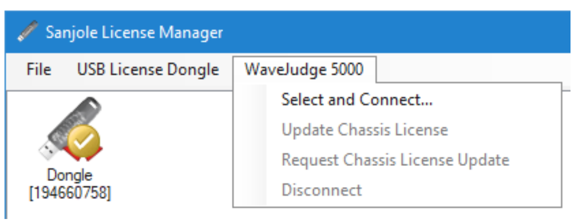


Sanjole License Manager - USB License Dongle Menu

Read Selected Dongle: Opens a window to view dongle properties.

Update Dongle: Opens a window to upload a new dongle license to your PC. You should only have one USB license dongle in the system at any given time.

The WaveJudge 5000 menu has four options: Select and Connect..., Update Chassis License, Request Chassis License Update, and Disconnect, described below.

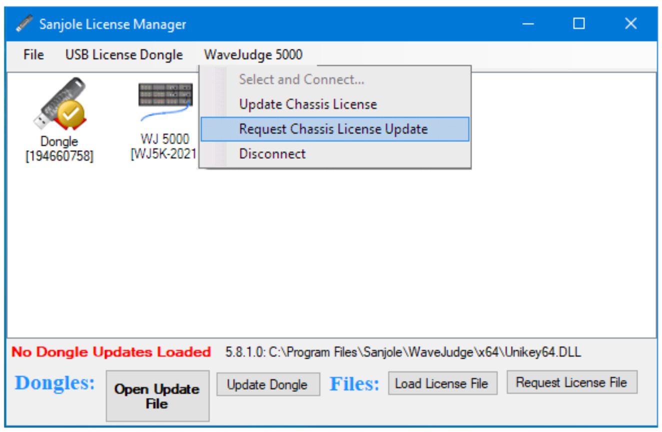


Sanjole License Manager - WaveJudge 5000 Menu

Select and Connect...: Opens the Select Form to connect to any chassis available in the list. Before the software can read the license, it must connect to the WaveJudge 5000 via the network. Select WaveJudge 5000 from the main menu at the top of the program window, then Select and Connect....

Update Chassis License: Once you have connected to the WaveJudge, an icon for the chassis license will appear in the form (shown below). When you click on the WaveJudge icon in the main panel, the menu's Update Chassis License option is enabled. Select that item to apply the license update. The update should be nearly instantaneous; no message will display if the update is applied successfully.

Request Chassis License Update: Requesting a license update begins by running the Sanjole License Manager and connecting to the WaveJudge system you want to upgrade. Once your computer is connected to WaveJudge, a chassis license icon will appear in the form (shown below). Click on the WaveJudge icon to enable the WaveJudge menu's Request Chassis License Update option. Select that item to generate the license update request. You will receive a prompt to save the WaveJudge ID file with a "*.id" extension. After saving the file email it to SJ-support@keysight.com.



Sanjole License Manager - Request Chassis License Update

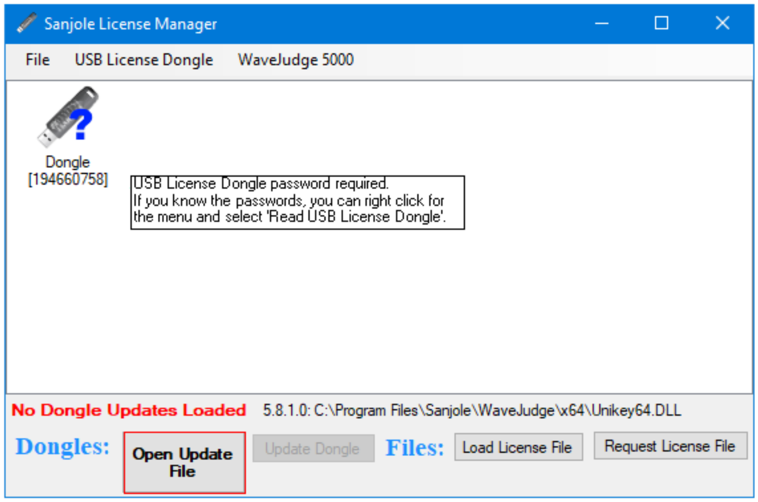
Disconnect: Exits the Sanjole License Manager window.

B. 4. 1 Installing/Updating a Dongle (*dud) License

To Install a Dongle License (*.dud) file:

1. Insert the Sanjole dongle into the PC.
2. Open the Sanjole License Manager. (Go to the Start menu, select Sanjole, select Sanjole License Manager.)
3. At the bottom of the window, click the button Open Update File.
4. Load the file emailed to you (it will be a .dud file).
5. Click the button Update Dongle.

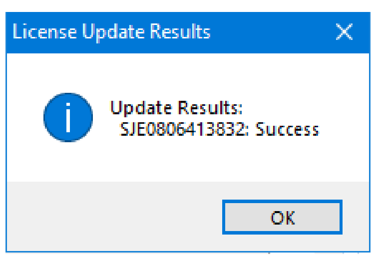
NOTE Hover over the dongle to show the Tool Tip (shown below).



Sanjole License Manager

To Update a Dongle License (.*license):

1. Open the Sanjole License Manager.
   (Go to the Start menu, select Sanjole, select Sanjole License Manager.)
2. Click the Open Update File button and load the dongle update file (*.license).
3. Insert the dongle.
4. Select the dongle icon in the Sanjole License Manager.
5. Click the Update Dongle button.
6. A green status bar will appear; when it completes the process the License Update Results window will appear showing a success message.



License Update Results - Success Message

B.4.2 Renew/Update a License File

To renew or update a license file email the following information to SJ-support@keysight.com. The date of your request should be no later than 90 days after the existing support expiration date.

Option 1:

- The existing license dongle number for a USB dongle-based license (engraved on the USB connector), AN.
- The purchase order number relating to the license renewal order.

Option 2:

- Your existing license file, AND
- Your computer ID generated from Sanjole License Manager (see Generating Your Computer ID File on page 641, AND
- The purchase order number relating to the license renewal order.

Your existing license files should be located in one of the following folders:

- WindowsXP:`C:\Program Files\Sanjole\WaveJudge\*.license`
- Windows 7:`C:\Users\<user name>\AppData\Local\VirtualStore\Program Files (x86)\Sanjole\WaveJudge`

If you have installed WaveJudge in a different location, then use that location; you do not need to use the standard file location: `C:\Program Files\Sanjole\WaveJudge or \Program Files (x86)\Sanjole\WaveJudge`.

B. 4. 3 Generating Your Computer ID File

To generate your computer ID file, you will need to access the Sanjole LicenseManager.

1. Go to Windows Start menu > Sanjole > Sanjole License Manager.
2. In the Sanjole License Manager, click the button Request Trial License.
3. In the License Request window click the Trial button then click the OK button.
4. A "Save As" window will open with the "Save as type - ***.id**" at the bottom. Name the file (e.g., Computer ID.id) and click the Save button. (Save it to your desktop for convenience.)

Email the *.id file to *SJ-support@keysight.com*.

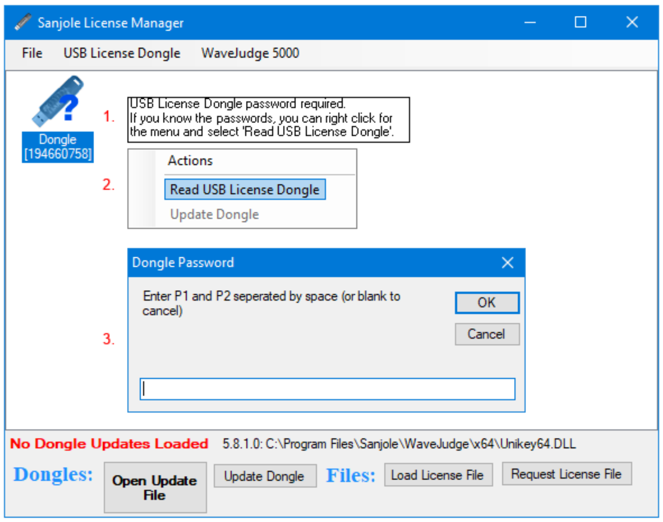
B. 4. 4 Reset USB Dongle License Password

If, when you open the Sanjole License Manager and see the dongle icon has a question mark on it, then you need to enter a password to validate the dongle license. If this is the case, perform the following steps to activate your license.

1. Hover your cursor over the dongle to see the prompt informing you the USB license dongle password is required.
2. Right-click anywhere in the background to open a popup menu, select the

second option Read USB License Dongle.

3. The Dongle Password window will appear.
   - P1 is password number one.
   - P2 is password number two.
   - Enter your unique two passwords in the same field leaving one space between them; e.g., `12345 67890`.



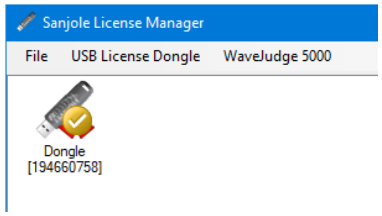
Sanjole License Manager - USB License Dongle Password Reset

IMPORTANT

In a new system, password numbers are provided on the Dongle Key Certificate shipped with the chassis and the USB license dongle.

If you skip this form without entering the password, or answer that it is not a WaveJudge license, WaveJudge will temporarily ignore this license. To enter the password and use the license you will have to exit WaveJudge and open it again to get back to the prompt.

After passwords are entered, WaveJudge will authenticate the license and the dongle license image will update to show an orange circle with a checkmark, indicating the update was sucessful.



Sanjole License Manager - Dongle Icon Changed

B. 5 WaveJudge License File Not Recognized

If a license file is not recognized in Windows 7 through Windows 10, follow these steps.

1. Begin by deleting all existing files ending in `.license` in any of the following folders.
   - `C:\Program Files\Sanjole\WaveJudge\`, if the WaveJudge software is installed into this directory.
   - `C:\Users\<username>\AppData\Local\VirtualStore\Program Files\Sanjole\WaveJudge\*.license` (for all software users.

   NOTE The `C:\Users\<username\AppData` folder is a hidden folder.

   .
2. Copy the license file into the location where the WaveJudge software is installed for the 64-bit version.
   - `C:\Program Files\Sanjole\WaveJudge\`.

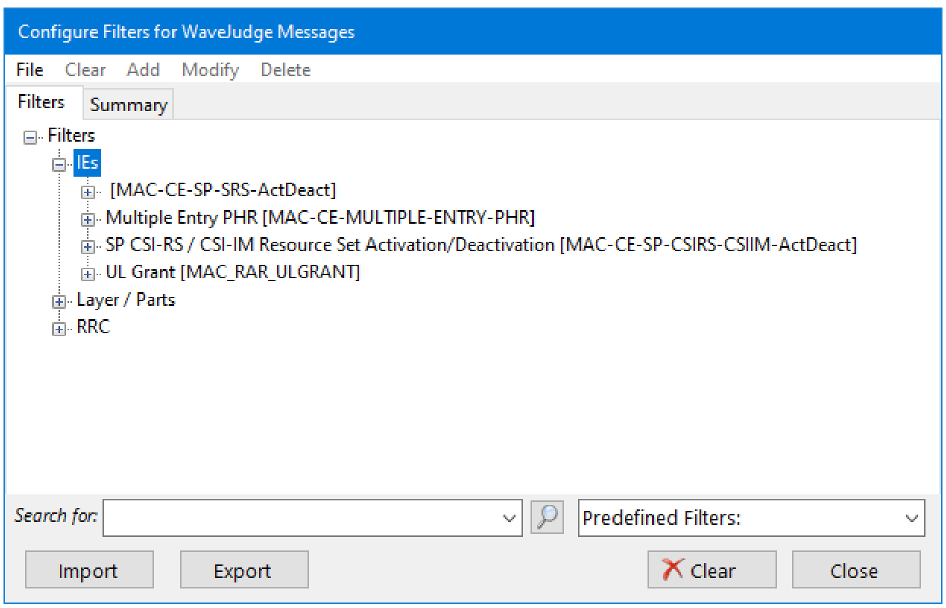
C 5G NR Filter Lists

C. 1 5G NR Default Filters

The following filters are the default sets for 5G NR.

C. 1. 1 Default 5G NR Filters - IEs

The following list of filters are available under ToolsWaveJudge Filters....



Default 5G NR Filters - IEs

[MAC-CE-SP-SRS-ActDeact]

- AD
- SP SRS Resource Set ID
- SRS Resource Set's BWP ID
- Reserved
- C
- SUL
- SP SRS Resource Set ID

- If (unsigned(VAR_AD)==1
  - If (unsigned(VAR_C)==1
    - For Loop – Resource
      - F
      - Resource ID
  - While Loop – Resource/Cell
    - Reserved
    - Resource Serving Cell ID
    - Resource BWP ID
  - Else
    - While Loop –resource
      - F
      - Resource ID

Multiple Entry PHR [MAC-CE-MULTIPLE-ENTRY-PHR]

- While Loop – PHR Entry
  - P
  - V
  - PH
  - If (unsigned(VAR_V)==0)
    - Reserved
    - P_CMAX,f,c

SP CSI-RS / CSI-IM Resource Set Activation/Deactivation [MAC-CE-SP-CSIRS-CSIM-ActDeact]

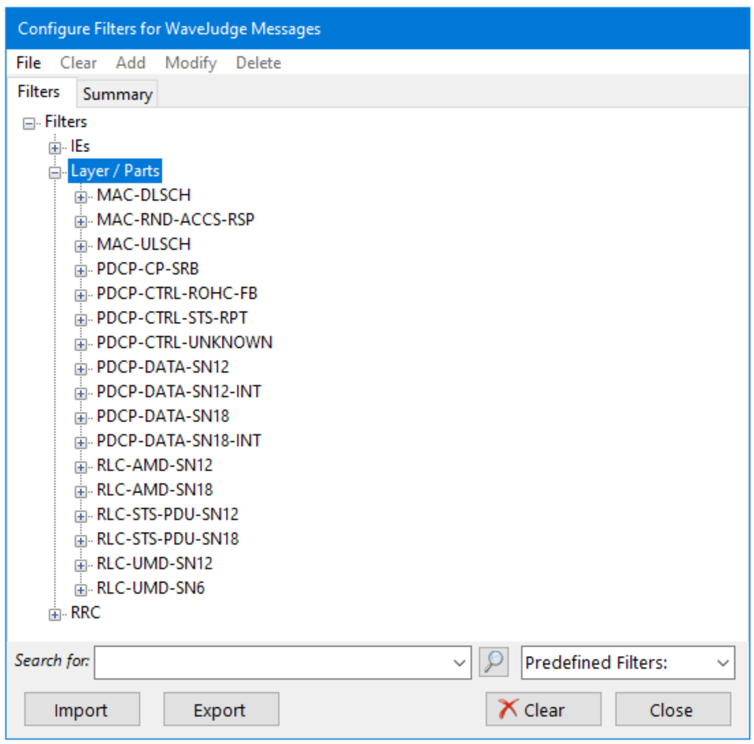
- A/D
- Serving Cell ID
- BWP ID
- Reserved
- IM
- SP CSI-RS Resource Set ID
- If (unsigned(VAR_IM)==1)
  - Reserved
  - SP CSI-IM Resource Set ID
- If (unsigned(VAR_AD)!=0)
  - While Loop – TCI State
    - Reserved
    - TCI State ID

UL Grant [MAC_RAR_ULGRANT]

- Frequency Hopping Flag
- Msg3 PUSCH Frequency Resource Allocation
- Msg3 PUSCH time Resource Allocation
- MCS
- TPC Command for Msg3 PUSCH
- CSI Request

C. 1. 2 Layer/Parts

The following list of filters are available under ToolsWaveJudge Filters....



Default 5G NR Filters - Layer/Parts

MAC-DLSCH

- MAC Message
  - While Loop – SubPDU
    - Reserved
    - F
    - LCID
    - Switch (VAR_LCID)

            - Case 4.
            - Break
                - -- continue through Case 63 --
                - Default
                - Break
        - Switch (VAR_LCID)
            - Case 4.
            - Break
                - -- continue through Case 63 --
            - Default
            - Break

MAC-RND-ACCES-RSP

- MAC Random Access Response
    - DoWhile Loop – Sub Header
        - E
        - T
        - If (unsigned(VAR_T)==0)
            - Reserved
            - BI
    - Else
        - RAPID
        - If (unsigned(VAR_RAPID))
        - Pad

MAC-ULSCH

- MAC Message
    - While Loop – SubPDU
        - Reserved
        - F
        - LCID
        - Switch (VAR_LCID)
            - Case 3.
            - Break
            - Case 5.
            - Break
            - Case 57
            - Break
            - Case 58
            - Break

            - Case 59
            - Break
            - Case 61
            - Break
            - Case 63
                - Pa.
            - Break
                - Default
                    - If (unsigned(VAR_F)==1)
                        - L
                    - Else
                        - .
                - Break
        - Switch (VAR_LCID)
            - Case 4.
            - Break
                - -- continue through Case 63 --
            - Default
            - Break

PDCP-CP-SRB

PDCP-CTRL-ROHC-FB

PDCP-CTRL-STS-RPT

PDCP-CTRL-UNKNOWN

PDCP-DATA-SN12

PDCP-DATA-SN12-INT

PDCP-DATA-SN18

PDCP-DATA-SN18-INT

RLC-AMD-SN12

RLC-AMD-SN18

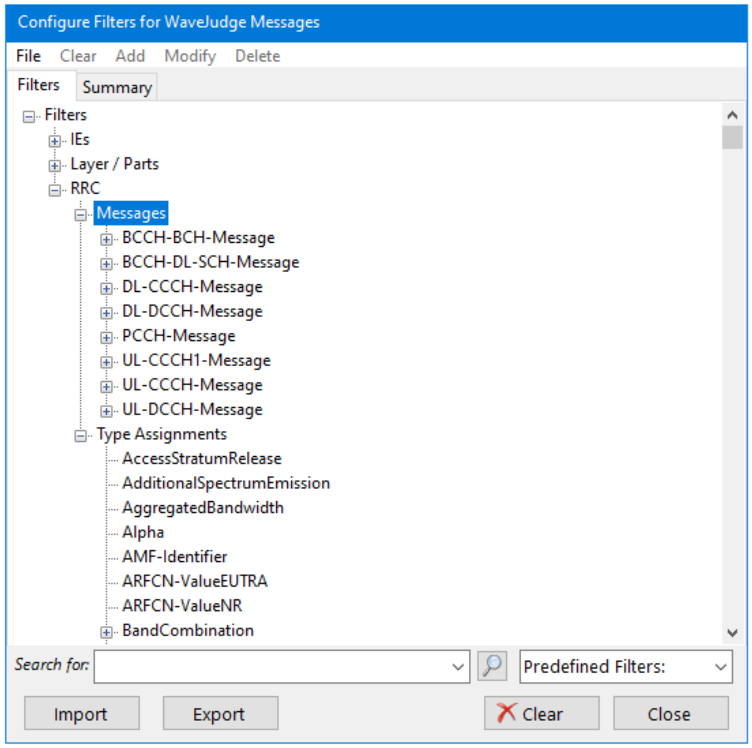
RLC-STS-PDU-SN12

RLC-STS-PDU-SN18

RLC-UMD-SN12

RLC-UMD-SN6

C.1.3 RRC



Default 5G NR Filters - RRC

Messages

- BCCH-BCH-Message
- DL-DCCH-Message
- UL-DCCH-Message

Type Assignments

- AccessStratumRelease
- AdditionalSpectrumEmission
- AggregatedBandwidth
- Alpha
- ARFCN-ValueNR
- BandCombination
- BandCombinationList
- BandNR
- BandParameters
- BCCH-BCH-MessageType
- BeamFailureRecoveryConfig
- BeamManagementSSB-CSI-RS

- BetaOffsets
- BFR-CSIRS-Resource
- BRF-SSB-Resource
- BFR-Config
- BWP
- BWP-Downlink
- BWP-DownlinkCommon
- BWP-DownlinkDedicated
- BWP-Id
- BWP-Uplink
- BWP-UpinkCommon
- BWP-UplinkDedicated
- CA-BandwidthClassEUTRA
- CA-BandwidthClassNR
- CA-ParametersNR
- CellGroupConfig
- CellGroupId
- CellIdentity
- CellsToAddMod
- CEllsToAddModList

CFRA

CFRA-CSIRS-Resource

- CFRA-SSB-Resource
- CG-UCI-OnPUSCH
- CipheringAlgorithm
- CodebookConfig
- ConfiguredGrantConfig
- ControlResourceSet
- ControlResourceSetId
- CrossCarrierSchedulingConfig
- CSI-AperiodicTriggerState
- CSI-AperiodicTriggerStateList
- CSI-AssociatedReportConfigInfo
- CSI-FrequencyOccupation
- CSI-IM-Resource
- CSI-IM-ResourceId
- CSI-IM-ResouceSet
- CSI-IM-ResouceSetId

- CSI-MeasConfig
- CSI-ReportConfig
- CSI-Report-ConfigId
- CSI-ReportFramework
- CSI-ReportPerodicityAndOffset
- CSI-ResourceConfig
- CSI-ResourceConfigId
- CSI-ResourcePeriodicityAndOffset
- CSI-RS-CellMobility
- CSI-RS-ForTrackings
- CSI-RS-IM-ReceptionForFeedback
- CSI-RS-Index
- CSI-RS-ResourceConfigMobility
- CSI-RS-ResourceMapping
- CSI-RS-ResourceMobility
- CSI-SemiPersistentOnPUSCH-TriggerState
- CSI-SemiPersistentOnPUSCH-TriggerStateList
- CSI-SSB-ResourceSet
- CSI-SSB-ResourceSetId
- DL-AM-RLC
- DL-DCCH-MessageType
- DL-UM-RLC
- DMRS-DownlinkConfig
- DMRS-UplinkConfig
- DownlinkConfigCommon
- DownlinkPreemption
- DRB-Identity
- DRB-ToAddMod
- DRB-ToAddModList
- DRB-ToReleaseList
- DRX-Config
- EUTRA-MBSFN-SubframeConfig
- EUTRA-MBSFN-SubframeConfigList
- EventTriggerConfig
- FeatureSet
- FeatureSetCombination
- FeatureSetCombinationId
- FeatureSetDownlink

- FeatureSetDownlinkId
- FeatureSetDownlinkPerCC
- FeatureSetDownlinkPerCC-Id
- FeatureSetEUTRA-DownlinkId
- FeatureSetEUTRA-UplinkId
- FeatureSets
- FeatureSetsPerBand
- FeatureSetUplink
- FeatureSetUplinkId
- FeatureSetUplinkPerCC
- FeatureSetUplinkPerCC-Id
- FilterCoefficient
- FilterConfig
- FreqBandIndicatorEUTRA
- FreqBandIndicatorNR
- FreqBandInformation
- FreqBandList
- FeqSeparationClass
- FequencyInfoDL
- FrequencyInfoUL
- GapConfig
- GeneralparametersMRDS-XDD-Diff
- Hysteresis
- INT-ConfigurationPerServingCell
- IntegrityProtAlgorithm
- LogicalChannelConfig
- LogicalChannelIdentity
- MAC-CellGroupConfig
- MAC-Parameters
- MAC-ParametersCommon
- MAC-ParametersXDD-Diff
- MeasConfig
- MeasGapConfig
- MeasGapSharingConfig
- MeasGapSharingScheme
- MeasId
- MeasIdToAddMod
- MeasIdToRemoveList

- MeasObjectId
- MeasObjectNR
- MeasObjectToAddMod
- MeasObjectToAddModList
- MeasObjectToRemoveList
- MeasParameters
- MeasParametersCommon
- MeasParametersFRX-Diff
- MeasParametersMRDC
- MeasParametersMRDC-Common
- MeasParametersMRDC-FRX-Diff
- MeasParametersMRDC-XDD-Diff
- MeasParametersXDD-Diff
- MeasQuantityResults
- MeasReportQuanity
- MeasResult2NR
- MeasResultCellListSFTD
- MeasResultCellSFTD
- MeasResultList2NR
- MeasResultNR
- MeasResults
- MeasResultSCG-Failure
- MeasResultServMO
- MeasTriggerQuantity
- MeasTriggerQuantityOffset
- MeasurementReport
- MeasurementReport-IEs
- MIB
- MIMO-LayersDL
- MIMO-LayersUL
- MIMO-ParametersPerBand
- ModulationOrder
- MRDC-Parameters
- MultiFrequencyBandListNR
- NR-RS-Type
- NZP-CSI-RS-Resource
- NZP-CSI-RS-ResourceId
- NZP-CSI-RS-ResourceSet

- NZP-CSI-RS-ResourceSetId
- P0-PUCCH
- P0-PUCCH-Id
- P0-PUCCH-AlphaSet
- P0-PUCCH-AlphaSetId
- PCI-List
- PCI-Range
- PCI-RangeElement
- PCI-RangeIndex
- PCI-RangeIndexList
- PDCCH-Config
- PDCCH-ConfigCommon
- PDCCH-ServingCellConfig
- PDCP-Config
- PDCP-Parameters
- PDSCH-CodeBlockGroupTransmission
- PDSCH-Config
- PDSCH-ConfigCommon
- PDSCH-ServingCellConfig
- PDSCH-TimeDomainResourceAllocation
- PDSCH-TimeDomainResourceAllocationList
- PDU-SessionID
- PeriodicalReportConfig
- PHR-Config
- Phy-Parameters
- Phy-ParametersCommon
- Phy-ParametersFR1
- Phy-ParametersFR2
- Phy-ParametersFRZ-Diff
- Phy-ParametersXDD-Diff
- PhysCellId
- PhysicalCellGroupConfig
- P-Max
- PollByte
- PollPDU
- PortIndex2
- PortIndex4
- PortIndex8

- PortIndexFor8Ranks
- PRACH-ResourceDedicatedBFR
- PRB-Id
- PTRS-DensityRecommendationDL
- PTRS-DensityRecommendationUL
- PTRS-DownlinkConfig
- PTRS-UplinkConfig
- PUCCH-Config
- PUCCH-ConfigCommon
- PUCCH-CSI-Resource
- PUCCH-format0
- PUCCH-format1
- PUCCH-format2
- PUCCH-format3
- PUCCH-format4
- PUCCH-FormatConfig
- PUCCH-MaxCodeRate
- PUCCH-PathlossReferenceRS
- PUCCH-PathlossReferencedRS-Id
- PUCCH-PowerControl
- PUCCH-Resource
- PUCCH-ResourceId
- PUCCH-ResourceSet
- PUCCH-ResourceSetId
- PUCCH-SpatialRelationInfo
- PUCCH-SpatialRelationInfoId
- PUCCH-TPC-CommandConfig
- PUSCH-CodeBlockGroupTransmission
- PUSCH-Config
- PUSCH-ConfigCommon
- PUSCH-PathlossReferenceRS
- PUSCH-PathlossReferenceRSId
- PUSCH-PowerControl
- PUSCH-ServingCellConfig
- PUSCH-TimeDomainResourceAllocation
- PUSCH-TimeDomainResourceAllocationList
- PUSCH-TPC-CommandConfig
- QCL-Info

- QFI
- Q-OffsetRange
- Q-OffsetRangeList
- QuanityConfig
- QuanityConfigNR
- QuanityConfigRS
- RACH-ConfigCommon
- RACH-ConfigDedicated
- RACH-ConfigGeneric
- RadioBearerConfig
- RadioLinkMonitoringConfig
- RadioLinkMonitoringRS
- RadioLinkMonitoringRS-Id
- RA-Prioritization
- RateMatchPattern
- RateMatchPatternGroup
- RateMatchPatternId
- RateMatchPatternLTE-CRS
- RAT-Type
- ReconfigurationWithSync
- ReferenceSignalConfig
- ReportConfigId
- ReportConfigToAddMod
- ReportConfigToAddModList
- ReportConfigToRemoveList
- ReportInterval
- ResultsPerCSI-RS-Index
- ResultsPerCSI-RS-IndexList
- ResultsPerSSB-Index
- ResultsPerSSB-IndexList
- RF-Parameters
- RF-ParametersMRDC
- RLC-BearerConfig
- RLC-Config
- RLC-Parameters
- RLF-TimersAndConstants
- RNTI-Value
- RRCReconfiguration

- RRCReconfigurationComplete
- RRCReconfigurationComplete-IEs
- RRCReconfiguration-IEs
- RRC-TransactionIdentifier
- RSRP-Range
- RSRQ-Range
- SCellConfig
- SCellIndex
- SchedulingRequestConfig
- SchedulingRequestId
- SchedulingrequestResourceConfig
- SchedulingRequestResourceId
- SchedulingRequestToAddMod
- ScramblingId
- SCS-SpecificCarrier
- SDAP-Config
- SearchSpace
- SearchSpaceId
- SecurityAlgorithmConfig
- SecurityConfig
- SecCellIndex
- ServingCellConfig
- ServingCellConfigCommon
- SetupRelease
- ShortMAC-I
- SIB1
- SINR-Range
- SlotFormatCombination
- SlotFormatCombinationId
- SlotFormatCombinationsPerCell
- SlotFormatIndicator
- SN-FieldLengthAM
- SN-FieldLengthUM
- SpCellConfig
- SPS-Config
- SRB-Identity
- SRB-ToAddMod
- SRB-ToAddModList

- SRI-PUSCH-PowerControl
- SRI-PUSCH-PowerContolId
- SRS-CarrierSwitching
- SRS-CC-SetIndex
- SRS-Config
- SRS-PerdiocityAndOffset
- SRS-Resource
- SRS-ResourcedId
- SRS-Resources
- SRS-ResourceSet
- SRS-ResourceSetId
- SRS-SpatialRelationInfo
- SRS-TPC-CommandConfig
- SRS-TPC-PDCCH-Config
- SRS-TxSwitch
- SSB-ConfigMobility
- SSB-Index
- SSB-MtC
- SSB-MTC2
- SSB-ToMeasure
- SS-RSSI-Measurement
- SubcarrierSpacing
- SupportedBandwidth
- TAG
- TAG-Config
- TAG-Id
- TCI-State
- TCI_StateId
- TDD-UL-DL-ConfigCommon
- TDD-UL-DL-ConfigDedicated
- TDD-UL-DL-Pattern
- TDD-UL-DL-SlotConfig
- TDD-UL-DL-SlotIndex
- ThresholdNR
- TimeAlignmentTimer
- TimeToTrigger
- T-PollRetransmit
- T-Reassembly

- T-StatusProhibit
- TypeII-Codebook
- TypeII-CodebookPortSelection
- TypeI-MultiPanelCodebook
- Type1-SinglePanelCodebook
- UCI-OnPUSCH
- UE-CapabilityRAT-Container
- UE-CapabilityRAT-ContainerList
- UE-MRDC-Capability
- UE-MRDC-CapabilityAddFRX-Mode
- UE-MRDC-CapabilityAddXDD-Mode
- UE-NR-Capability
- UE-NR-CapabilityAddFRX-Mode
- UE-NR-CapabilityAddXDD-Mode
- UL-AM-RLC
- UL-DataSplitThreshold
- UL-DCCH-MessageType
- UL-UM-RLC
- UplinkConfig
- UplinkConfigCommon
- ZP-CSI-RS-Resource
- ZP-CSI-RS-ResourceId
- ZP-CSI-RS-ResourceSet
- ZP-CSI-RS-ResourceSetId

C. 2 Other 5G Protocol Filters

The following filters are the additional, protocol specific sets for 5G and LTE.

C. 2. 1 Other 5G Protocol Filters - IEs

The following list of filters are available under ToolsWaveJudge Filters....

[MAC –CE-SP-SRS-ActDeact]

- AD
- SP SRS Resource Set ID
- SRS Resource Set's BWP ID
- Reserved
- C
- SUL
- SP SRS Resource Set ID
- If (unsigned(VAR_AD)==1
  - If (unsigned(VAR_C)==1
    - For Loop – Resource
      - F
      - Resource ID
  - While Loop – Resource/Cell
    - Reserved
    - Resource Serving Cell ID
    - Resource BWP ID
  - Else
    - While Loop –resource
      - F
      - Resource ID

Extended Protocol Discriminator [EXT_PROTO_DISCRM]

Multiple Entry PHR [MAC-CE-MULTIPLE-ENTRY-PHR]

- While Loop – PHR Entry
  - P
  - V
  - PH
  - If (unsigned(VAR_V)==0)
    - Reserved
    - P_CMAX,f,c

SP CSI-RS / CSI-IM Resource Set Activation/Deactivation [MAC-CE-SP-CSIRS-CSIM-ActDeact]

- A/D
- Serving Cell ID
- BWP ID
- Reserved
- IM
- SP CSI-RS Resource Set ID
- If (unsigned(VAR_IM)==1)
    - Reserved
    - SP CSI-IM Resource Set ID
- If (unsigned(VAR_AD)!=0)
    - While Loop – TCI State
        - Reserved
        - TCI State ID

UL Grant [MAC_RAR_ULGRANT]

- Frequency Hopping Flag
- Msg3 PUSCH Frequency Resource Allocation
- Msg3 PUSCH time Resource Allocation
- MCS
- TPC Command for Msg3 PUSCH
- CSI Request

C. 2. 2 LTE IEs

The following list of filters are available under **ToolsWaveJudge Filters...**.

LTE IEs

- 5GMM Capability [5GMM_CAPABILITY]
- 5GMM Cause [5GMM_CAUSE]
- 5GS DRX Parameters [5GS_DRX_PARAMETERS]
- 5GS Identity Type [5GS_IDENTITY-TYPE]
- 5GS Mobile Identity [5GS_MOBILITY_IDENTITY]
- 5GS Network Feature Support [5GS_NETWORK_FEATURE_SUPPORT]
- 5GS Registration Result [5GS_REGISTRATION_RESULT]
- 5GS Registration Type [5GS_REGISTRATION_TYPE]
- 5GS Update Type [5GS_UPDATE_TYPE]
- 5GSM Capability [5GSM_CAPABILITY]
- 5GSM Cause [5GSM_CAUSE]

- 5GSM Congestion Re-attempt Indicator [5GSM_CONGESTION_REATTEMPT_IND]
- ABBA [ABBA]
- Access Type [NAS_ACCESS_TYPE]
- Additional 5G Security Information [ADDITIONAL_5G_SEC_INFO]
- Additional Information [ADDITIONAL_INFORMATION]
- Allowed PDU Session Status [ALLOWED_PDU_SESSION_STATUS]
- Allowed SSC Mode [ALLOWED_SSC_MODE]
- Always-on PDU Session Indication [ALWAYS_ON_PDU_SESS_IND]
- Always-on PDU Session Requested [ALWAYS_ON_PDU_SESS_REQ]
- Configuration Update Indication [CONFIG_UPDATE_INDICATION]
- De-registration Type [DEREG_TYPE]
- DNN [DNN]
- EAP Message [EAP_MESSAGE]
- EPS NAS Message Container [EPS_NAS_MESSAGE_CONTAINER]
- Integrity Protection Maximum Data Rate [INTG_PROT_MAX_DATA_RATE]
- LADN Indication [LADB_INDICATION]
- LADN Information [LADN_INFORMATION]
- Mapped EPS Bearer Contexts [MAPPED_EPS_BEARER_CONTEXTS]
- Maximum Number of Supported Packet Filters [MAX_NUM_SUPPORTED_PACKET_FILTERS]
- MICO Indication [MICO_INDICATION]
- NAS Message Container [NAS_MESSAGE_CONTAINER]
- NAS Security Algorithms [NAS_SEC_ALG]
- Network Slicing Indication [NETWORK_SLICING_INDICATION]
- NSSAI [NSSAI]
- NSSAI Inclusion Mode [NSSAI_INCLUSION_MODE]
- Operator-defined Access Category Definitions [OPERATOR_DEFINED_ACCESS_CATEGORY_DEF]
- Payload Container [PAYLOAD_CONTAINER]
- Payload Container Type [PAYLOAD_CONTAINER_TYPE]
- PDU Address [PDU_ADDRESS]
- PDU Session Identity 2 [PDU_SESSION_ID2]
- PDU Session Reactivation Result [PDU_SESSION_REACT_RESULT]
- PDU Session Reactivation Results Error Cause [PDU_SESSION_REACT_ERR_CAUSE]
- PDU Session Status [PDU_SESSION_STATUS]
- PDU Session Type [PDU_SESSION_TYPE]
- QoS Flow Descriptions [QoS_FLOW_DESCRIPTIONS]

- QoS Rules [QOS_RULES]
- Rejected NSSAI [REJECTED_NSSAI]
- Request Type [REQUEST_TYPE]
- Service Area List [SERVICE_AREA_LIST]
- Service Type [NAS_SERVICE_TYPE]
- Session-AMBER [SESSION_AMBR]
- SM PDU DN Request Container [SM_PDU_DN_REQ_CONTAINER]
- SMS Indication [SMS_INDICATION]
- S-NSSAI [S-NSSAI]
- SOR Transparent Container [SOR_TRANSPARENT_CONTAINER]
- SSC Mode [SSC_MODE]
- Tracking Area Identity [5GS_TAI]
- Tracking Area Identity List [5GS_TAI_LIST]
- UE Parameters Update Transparent Container [UE_PARAM_UPD_TRANSPARENT_CONTAINER]
- UE Security Capability [5G_UE_SECURITY_CAPABILITY]
- UE Status [UE_STATUS]
- UE's Usage Setting [UE_USAGE_SETTING]
- Uplink Data Status [UPLINK_DATA_STATUS]

C. 2. 3 Layer/Parts

The following list of filters are available under ToolsWaveJudge Filters....

Layer/Parts

- MAC-DLSCH
- MAC-RND-ACCE-RSP
- MAC-ULSCH
- NAS-5GMM-STAT
- NAS-5GSM-STATUS
- NAS-AUTH-FAIL
- NAS-AUTH-REJ
- NAS-AUTH-REQ
- NAS-AUTH-RSLT
- NAS-AUTH-RSP
- NAS-CONF-UPD-CMD
- NAS-CONF-UPD-CPLT
- NAS-DEREG-ACPT
- NAS-DEREG-REQ
- NAS-DL-NAS-TRANSPORT

- NAS-ID-REQ
- NAS-ID-RSP
- NAS-NOTIFCATION
- NAS-NOTIFICATION-RSP
- NAS-PDU-SESS-AUTH-CMD
- NAS-PDU-SESS-AUTH-CPLT
- NAS-PDU-SESS-AUTH-RSLT
- NAS-PDU-SESS-ESTB-ACPT
- NAS-PDU-SESS-ESTB-REJ
- NAS-PDU-SESSESTB-REQ
- NAS-PDU-SESS-MOD-CMD
- NAS-PDU-SESS-MOD-CMD-REJ
- NAS-PDU-SESS-MOD-CPLT
- NAS-PDU-SESS-MOD-REJ
- NAS-PDU-SESS-MOD-REQ
- NAS-PDU-SESS-REL-CMD
- NAS-PDU-SESS-REL-CPLT
- NAS-PDU-SESS-REL-REJ
- NAS-PDU-SESS-REL-REQ
- NAS-REG-ACPT
- NAS-REG-CPLT
- NAS-REG-REJ
- NAS-REG-REQ
- NAS-SEC-MODE-CMD
- NAS-SEC-MORE-CPLT
- NAS-SEC-MODE-REJ
- NAS-SEC-PROTECTED-MSG
- NAS-SVC-ACPT
- NAS-SVC-REJ
- NAS-SVC-REQ
- NAS-UL-NAS-TRANSPORT
- PDCP-CP-SRB
- PDCP-CTRL-ROHC-FB
- PDCP-CTRL-STS-RPT
- PDCP-CTRL-UNKNOWN
- PDCP-DATA-SN12
- PDCP-DATA-SN12-INT
- PDCP-DATA-SN12-INT

- PDCP-DATA-SN18
- PDCP-DATA-SN18-INT
- RLC-AMD-SN12
- RLC-AMD-SN18
- RLC-STS-PDU-SN12
- RLC-STS-PDU-SN18
- RLC-UMD-SN12
- RLC-UMD-SN6

C. 2. 4 RRC

The following list of filters are available under ToolsWaveJudge Filters....

RRC

- Messages
  - BCCH-BCH-Message
  - BCCH-DL-SCH-Message
  - DL-CCCH-Message
  - DL-DCCH-Message
  - PCCH-Message
  - UL-CCCH1-Message
  - UL-CCCH-Message
  - UL-DCCH-Message
- Type Assignments
  - AccessStratumRelease
  - AdditionalSpectrumEmission
  - AggregateBandwidth
  - Alpha
  - AMF-Identifier
  - ARFCN-ValueEUTRA
  - ARFCN-ValueNR
  - BandCombination
  - BandCombinationList
  - BandCombinationList-v1540
  - BandCombinationList-v1550
  - BandCombinationList-v1560
  - BandCombinationList-v1570
  - BandCombinationList-v1580
  - BandNR

- BandParameters
- BandParameters-v1540
- BCCH-BCH-MessageType
- BCCH-Config
- BCCH-DL-SCH-MessageType
- BeamFailurerecoveryConfig
- BeamManagementSSB-CSI-RS
- BetaOffsets
- BFR-CSIRS-Resource

- – BFR-SSB-Resource
- BRS-Config
- BWP
- BWP-Downlink
- BWP-DownlinkCommon
- BWP-DownlinkDedicated
- BWP-Id
- BWP-Uplink
- BWP-UplinkCommon
- BWP-UplinkDedicated
- CA-BandwidthClassEUTRA
- CA-BandwidthClassNR
- CA-ParametersEUTRA
- CA-ParametersEUTRA-v1560
- CA-ParametersEUTRA-v1570
- CA-ParametersNR
- CA-ParametersNRDC
- CA-ParametersNR-v1540
- CA-ParametersNR-v1550
- CA-ParametersNR-v1560
- CarrierFreqEUTRA
- CarrierFreqListEUTRA
- CarrierInfoNR
- CellAccessRelatedInfo
- CellAccessRelatedInfo-EUTRA-5GC
- CellAccessRelatedInfo-EUTRA-EPC
- CellGroupConfig
- CellGroupId

- CellIdentity
- CellIdentity-EUTRA-5GC
- CellReselectionPriorities
- CellReselectionPriority
- CellResolectionSubPriority
- CellToAddMod
- CellToAddModList
- CFRA
- CFRA-CSIRS-Resource
- CFRA-SSB-Resource
- CGI-InfoNR
- CG-UCI-OnPUSCH
- CipheringAlgorithm
- CodebookConfig
- CodebookParameters
- ConfiguredGrantConfig
- ConnEstFailureControl
- ControlResourceSet
- ControlResourceSetId
- ControlResourceSetZero
- CounterCheck
- CounterCheck-IEs
- CounterCheckResponse
- CounterCheckResponse-IEs
- CrossCarrierSchedulingConfig
- CSI-AperiodicTriggerState
- CSI-AperiodicTriggerStateList
- CSI-AssociatedReportConfigInfo
- CSI-FrequencyOccupation
- CSI-IM-Resource
- CSI-IM-ResourceId
- CSI-IM-ResourceSet
- CSI-IM-ResourceSetId
- CSI-MeasConfig
- CSI-ReportConfig
- CSI-ReportConfigId
- CSI-ReportFramework
- CSI-ReportPeriodicityAndOffset

- CSI-ResourceConfig
- CSI-ResourceConfigId
- CSI-ResourcePeriodicityAndOffset
- CSI-RS-CellMobility
- CSI-RS-ForTracking
- CSI-RS-IM-ReceptionForFeedback
- CSI-RS-Index
- CSI-RS-ProcFrameworkForSRS
- CSI-RS-ResourceConfigMobility
- CSI-RS-ResourceMapping
- CSI-RS-Resource-Mobility
- CSI-SemiPersistentOnPUSCH-TriggerState
- CSI-SemiPersistentOnPUSCH-TriggerStateList
- CSI-SSB-ResourceSet
- CSI-SSB-ResourceSetId
- DataInactivityTimer
- DedicatedNAS-Message
- DelayBudgetReport
- DL-AM-RLC
- DL-CCCH-MessageType
- DL-DCCH-MessageType
- DLInformationTransfer
- DLInformationTransfer-IEs
- DL-UM-RLC
- DMRS-DownlinkConfig
- DMRS-UplinkConfig
- DownlinkConfigCommon
- DownlinkConfigCommonSIB
- DownlinkPreemption
- DRB-CountInfo
- DRB-CountInfoList
- DRB-CountMSB-Info
- DRB-CountMSB-InfoList
- DRB-Identity
- DRB-ToAddMod
- DRB-ToAddModList
- DRB-ToReleaseList
- DRX-Config

- DummyA
- DummyB
- DummyC
- DummyD
- DummyE
- DummyF
- DummyG
- DummyH
- DummyI
- EstablishmentCause
- EUTRA-AllowedMeasBandwidth
- EUTRA-BlackCell
- EUTRA-Cell
- EUTRA-CellIndex
- EUTRA-CellIndexList
- EUTRA-FreqBlackCellList
- EUTRA-FreqNeighCellInfo
- EUTRA-MBSFN-SubframeConfig
- EUTRA-MBSFN-SubframeConfigList
- EUTRA-MultiBandInfo
- EUTRA-MultiBandInfoList
- EUTRA-NS-PmaxList
- EUTRA-NS-PmaxValue
- EUTRA-Parameters
- EUTRA-ParametersCommon
- EUTRA-ParametersXDD-Diff
- EUTRA-PhysCellId
- EUTRA-PhyisCellIdRange
- EUTRA-PresenceAntennaPort1
- EUTRA-Q-OffsetRange
- EUTRA-RSTD-Info
- EUTRA-RSTD-InfoList
- EventTriggerConfog
- EventTriggerConfigInterRAT
- FailureInfoRLC-Bearer
- FailureInformation
- FailureInformation-IEs
- FailureReportsSCG

- FailureReportSCG-EUTRA
- FeatureSet
- FeatureSetCombination
- FeatureSetCombinationId
- FeatureSetDownlink
- FeatureSetDownlinkId
- FeatureSetDownlinkPerCC
- FeatureSetDownlinkPerCC-Id
- FeatureSetDownlink-v1540
- FeatureSetEUTRA-DownlinkId
- FeatureSetEUTRA-UplinkId
- FeatureSets
- FeatureSetsPerBand
- FeatureSetUplink
- FeatureSetUplnkId
- FeatureSetUplinkPerCC
- FeatureSetUplinkPerCC-Id
- FeatureSetUplinkPerCC-V1540
- FeatureSetUplink-V1540
- FilterCoefficient
- FilterConfig
- FreqBandIndicatorEUTRA
- FreqBandIndicatorNR
- FreqBandInformation
- FreqBandInformationEUTRA
- FreqBandInformationNR
- FreqBandList
- FreqPriorityEUTRA
- FreqPriorityListEUTRA
- FreqPriorityListNR
- FreqPriorityNR
- FreqSeparationClass
- FrequencyInfoDL
- FrequencyInfoDL-SIB
- FrequencyInfoUL
- FrequencyInfoUL-SIB
- GapConfig
- GeneralParametersMRCD-XDD-Diff

- Hysteresis
- IMS-Parameters
- IMS-ParametersCommon
- IMS-ParametersFRX-Diff
- InitialUE-Identity
- INT-ConfigurationPerServingCell
- IntegrirtyProtAlgorithm
- InterFreqBlackCellList
- InterFreqCarrierFreqInfo
- InterFreqCarrierFreqList
- InterFreqNeighCellInfo
- InterFreqNeighCellList
- InterRAT-Parameters
- IntraFreqBlackCellList
- IntraFeqNeighCellInfo
- IntraFreqNeighCellList
- I-RNTI-Value
- LocationMeasurementIndication
- LocationMeasurementIndication-IEs
- LocationMeasurementInfo
- LogicalChannelConfig
- LogicalChannerlIdentity
- MAC-CellGroupConfig
- MAC-Parameters
- MAC-ParametersCommon
- MAC-ParametersXDD-Diff
- MasterKeyUpdate
- MCC
- MCC-MNC-Digit
- MeasAndMobParameters
- MeasAndMobParametersCommon
- MeasAndMobParametersFRX-Diff
- MeasAndMobParametersMRDC
- MeasAndMobParametersMRDC-Common
- MeasAndMobParametersMRDC-FRX-Diff
- MeasAndMobParametersMRDC-v1560
- MeasAndMobParametersMRDC-XDD-Diff
- MeasAndMobParametersMRDC-XDD-Diff-v1560

- MeasAndMobParametersXDD-Diff
- MeaseConfig
- MeasGapConfig
- MeasGapSharingConfig
- MeasGapSharingScheme
- MeasId
- MeasIdToAddMod
- MeasIdToAddModList
- MeasIdToRemoveList
- MeasObjectEUTRA
- MeasObjectId
- MeasObjectNR
- MeasObjectToAddMod
- MeasObjectToAddModList
- MeasObjectToRemoveList
- MeasQuanityResults
- MeasQuantityResultsEUTRA
- MeasReportQuantity
- MeasResult2EUTRA
- MeasResulet2NR
- MeasResultCellListSFTD-EUTRA
- MeasResultCellListSFTD-NR
- MeasResultCellSFTD-NR
- MeasResultEUTRA
- MeasResultFreqList
- MeasResultFreqListFailMRDC
- MeasResultList2NR
- MeasResultListNR
- MeasResultsNR
- MeasResults
- MeasResultSCG-Failure
- MeasResultServFreqListEUTRA-SCG
- MeasResultServFreqListNR-SCG
- MeasResultServMO
- MeasResultServMOList
- MeasResultSFTD-EUTRA
- MeasTriggerQuantity
- MeasTriggerQuantityEUTRA

- MeasTriggerQuanitityOffset
- MeasurementReport
- MeasurementReport-IEs
- MIB
- MIMO-LayersDL
- MIMO-LayersUL
- MIM-ParametersPerBand
- MNC
- MobilityFromNRCommand
- MobilityFromNRCommand-IEs
- MobilityStateParameters
- ModulationOrder
- MRDC-Parameters
- MRDC-Parameters-v1580
- MRDC-SecondaryCellGroupConfig
- MultiFrequencyBandListNR
- MutluFrequencyBandListNR-SIB
- NAICS-Capability-Entry
- NextHopChainingCount
- NG-5G-S-TMSI
- NRDC-Parameters
- NRDC-Parameters-V1570
- NR-MultiBankInfo
- NR-NS-PmaxList
- NR-NS-PmaxValue
- NR-RS-Type
- NumberOfCarriers
- NZP-CSI-RS-Resource
- NZP-CSI-RS-Resoourceld
- NZP-CSI-RS-ResourceSet
- NZP-CSI-RS-ResourceSetId
- OtherConfig
- OtherConfig-V1540
- OverheatingAssistance
- OverheatingAssistanceConfig
- P0-PUCCH
- P0-PUCCH-Id
- P0-PUSCH-AlphaSet

- P0-PUSCH-AlphaSetId
- Paging
- PagingCycle
- PagingRecord
- PagingRecordList
- PagingUE-Identity
- PCCH-Config
- PCCH-MessageType
- PCI-List
- PCI-Range
- PCI-RangeElement
- PCI-RangeIndex
- PCI-RangeIndexList
- PDCCH-BlindDetection
- PDCCH-Config
- PDCCH-ConfigCommon
- PDCCH-ConfigSIB1
- PDCCH-ServingCellConfig
- PDCP-Config
- PDCP-Parameters
- PDCP-ParametersMRDC
- PDSCH-CodeBlockGroupTransmission
- PDSCH-Config
- PDSCH-ConfigCommon
- PDSCH-ServingCellConfig
- PDSCH-TimeDomainResourceAllocation
- PDSCH-TimeDomainResourceAllocationList
- PDU-SessionId
- PeriodicalReportConfig
- PeriodicalReportConfigInterRAT
- PeriodicRNAU-TimerValue
- PHR-Config
- Phy-Parameters
- Phy-ParametersCommon
- Phy-ParametersFR1
- Phy-ParametersFR2
- Phy-ParametersFR-Diff
- Phy-ParametersMRDC

- PhysCellId
- PhysicalCellGroupConfig
- PLMN-Identity
- PLMN-Identity-EUTRA-5GC
- PLMN-IdentityInfo
- PLMN-IdentityInfoList
- PLMN-IdentityList-EUTRA-5GC
- PLMN-IdentityList-EUTRA-EPC
- PLMN-RAN-AreaCell
- PLMN-RAN-AreaCellList
- PLMN-RAN-AreaConfig
- PLMN-RAN-AreaConfigList
- P-Max
- PollByte
- PollPDU
- PortIndex2
- PortIndex4
- PortIndex8
- PortIndexFor8Ranks
- PRACH-ResourceDedicatedBFR
- PRB-Id
- ProcessingParameters
- PTRS-DensityRecommendationDL
- PTRS-DensityRecommendationUL
- PTRS-DownlinkConfig
- PTRS-UplinkConfig
- PUCCH-Config
- PUCCH-ConfigCommon
- PUCCH-CSI-Resource
- PUCCH-format0
- PUCCH-format1
- PUCCH-format2
- PUCCH-format3
- PUCCH-format4
- PUCCH-FormatConfig
- PUCCH-MaxCodeRate
- PUCCH-PathlossReferenceRS
- PUCCH-PathlossReferenceRS-Id

- PUCCH-PowerControl
- PUCCH-Resource
- PUCCH-ResourceId
- PUCCH-ResourcesSetId
- PUCCH-SpatialRelationInfo
- PUCCH-SpatialRelationInfoId
- PUCCH-TPC-CommandConfi.
- PUSCH-CodeBlockGroupTransmission
- PUSCH-Config
- PUSCH-ConfigCommon
- PUSCH-PathlossReferenceRS
- PUSCH-PathlossReferenceRS-Id
- PUSCH-PowerControl
- PUSCH-ServingCellConfig
- PUSCH-TimeDomainResourceAllocation
- PUSCH-TimeDomainResourceAllocationList
- PUSCH-TPC-CommandConfig
- QCL-Info
- QFI
- Q-OffsetRange
- Q-OffsetRangeList
- Q-QualMin
- Q-RxLevMin
- QuanitityConfig
- QuantityConfigNR
- QuantityConfigRS
- RACH-ConfigCommon
- RACH-ConfigDedicated
- RACH-ConfigGeneric
- RadioBearerConfig
- RadioLinkMonitoringConfig
- RadioLinkMonitoringRS
- RadioLinkMonitoringRS-Id
- RAN-AreaCode
- RAN-AreaConfig
- RangeToBestCell
- RAN-NotificationAreaInfo
- RA-Prioritization

- RateMatchPattern
- RateMatchPatternGroup
- RateMatchPatternId
- RateMatchPatternLTE-CRS
- RAT-Type
- ReconfigurationWithSync
- RedirectedCarrierInfo
- RedirectedCarrierInfo-EUTRA
- ReducedAggregatedBandwidth
- ReestablishementCause
- ReestabUE-Identity
- ReferenceSignalConfig
- RegisteredAMF
- RejectWaitTime
- ReportCGI
- ReportCGI-EUTRA
- ReportConfigId
- ReportConfigInterRAT
- ReportConfigNR
- ReportConfigToAddMod
- ReportConfigToAddModList
- ReportConfigToRemoveList
- ReportInterval
- ReportSFTD-EUTRA
- ReportSFTD-NR
- ReselectionThreshold
- ReslectionThresholdQ
- ResultsPerCSI-RS-Index
- ResultsPerCSI-RS-IndexList
- ResultsPerSSB-Index
- ResultsPerSSB-IndexList
- ResumeCause
- RF-Parameters
- RF-ParametersMRDC
- RLC-BearerConfig
- RLC-Config
- RLC-Parameters
- RLF-TimersAndConstants

- RNTI-Value
- RRCReconfiguration
- RRCReconfigurationComplete-IEs
- RRCReconfigurationComplete-v1530-IEs
- RRCReconfigurationComplete-v1560-IEs
- RRCReconfigurationComplete-IEs
- RRCReconfiguration-IEs
- RRCReconfiguration-v1530-IEs
- RRCReconfiguration-v1540-IEs
- RRCReconfiguration-v1560-IEs
- RRCReestablishment
- RRCReestablishmentComplete
- RRCReestablishmentComplete-IEs
- RRCReestablishment-IEs
- RRCReestablishmentRequest
- RRCReestablishmentRequest-IEs
- RRCReject
- RRCReject-IEs
- RRCRelease
- RRCRelease-IEs
- RRCRelease-v1540-IEs
- RRCResume
- RRCResumeComplete
- RRCResumeComplete-IEs
- RRCResume-IEs
- RRCResumeRequest
- RRCResumeRequest1
- RRCResumeRequest1-IEs
- RRCResumeRequest-IEs
- RRCResume-v1560-IEs
- RRCSetup
- RRCSetupComplete
- RRCSetupComplete-IEs
- RRCSetup-IEs
- RRCSetupRequest
- RRCSetupRequest-IEs
- RRCSystemInfoRequest
- RRCSystemInfoRequest-IEs

- RRC-TranscactionIdentifier
- RSRP-Range
- RSRP-RangeEUTRA
- RSRQ-Range
- RSRQ-RangeEUTRA
- SCellConfig
- ScellIndex
- SCGFailureInformation
- SCGFailureInformationEUTRA
- SCGFailureInformationEUTRA-IEs
- SCGFailureInformation-IEs
- SchedulingInfo
- SchedulingRequestConfig
- SchedulingRequestId
- SchedulingRequestResourceConfig
- SchedulingRequestResourceId
- SchedulingRequestToAddMod
- ScramblingId
- SCS-SpecificCarrier
- SDAP-Config
- SDAP-Parameters
- SearchSpace
- SearchSpaceId
- SearchSpaceZero
- SecutiryAlgorithmConfig
- SecurityConfig
- SecurityConfigSMC
- SecurityModeCommand
- SecurityModeComman-IEs
- SecurityModeComplete
- SecurityModeCompete-IEs
- SecurityModeFailure
- SecurityModeFailure-IEs
- ServCellIndex
- ServingCellConfig
- ServingCellConfigCommon
- ServingCellConfigCommonSIB
- SetupRelease

- ShortI-RNTI-Value
- ShortMAC-I
- SIB1
- SIB2
- SIB3
- SIB4
- SIB5
- SIB6
- SIB7
- SIB8
- SIB9
- SIB- Mapping
- SIB-TypeInfo
- SINR-Range
- SINR-RangeEUTRA
- SI-RequestConfig
- SI-RequestResources
- SI-SchedulingInfo
- SK-Counter
- SlotFormatCombination
- SlotFormatCombinationId
- SlotFormatCombinationPerCell
- SlotFormatIndicator
- SN-FieldLengthAM
- SN-FieldLengthUM
- S-NSSAI
- SpatialRelations
- SpCellConfig
- SpeedStateScaleFactors
- SPS-Config
- SR-Identity
- SRB-ToAddMod
- SRB-ToAddModList
- SRI-PUSCH-PowerControl
- SRI-PUSCH-PowerControlId
- SRS-CarrierSwitching
- SRS-CC-SetIndex
- SRS-Config

- SRS-PeriodicityAndOffset
- SRS-Resource
- SRS-ResourceId
- SRS-Resources
- SRS-ResourceSet
- SRS-ResourceSetId
- SRS-SpatialRelationInfo
- SRS-SwitchingTimeEUTRA
- SRS-SwitchingTimeNR
- SRS-TPC-CommandConfig
- SRS-TPC-PDCCH-Config
- SSB-ConfigMobility
- SSB-Index
- SSB-MTC
- SSB-MTC2
- SSB-ToMeasure
- SS-RSSI-Measurement
- SubcarrierSpacing
- SupportedBandwidth
- SupportedCSI-RS-Resource
- SuspendConfig
- SystemInformation
- SystemInformation-IEs
- TAG
- TAG-Config
- TAG-Id
- TCA-State
- TCI-State
- TCI-StateId
- TDD-UL-DL-ConfigCommon
- TDD-UL-DL-ConfigDedicated
- TDD-UL-DL-Pattern
- TDD-UL-DL-SlotConfig
- TDD-UL-DL-SlotIndex
- ThresholdNR
- TimeAlignmentTimer
- TimeToTrigger
- T-PollRetransmit

- TrackingAreaCode
- T-Reassembly
- T-Reselection
- T-StatusProhibit
- UAC-AccessCategory1-SelectionAssistanceInfo
- UAC-BarringInfoSet
- UAC-BarringInfoSetIndex
- UAC-BarringInfoSetList
- UAC-BarringPerCat
- UAC-BarringPerCatList
- UAC-BarringPerPLMN
- UAC-BarringPerPLMN-List
- UCI-OnPUSCH
- UEAssistanceInformation
- UEAssistanceInformation-IEs
- UEAssistanceInformation-v1540-IEs
- UECapabilityEnquiry
- UECapabilityEnquiry-IEs
- UECapabiilityEnquiry-V1560-IEs
- UECapabilityInformation
- UECapabilityInformation-IEs
- UE-CapabilityRAT-Container
- UE-CapabilityRAT-ContainerList
- UE-CapabilityRAT-Request
- UE-CapabilityRAT-RequestList
- UE-CapabilityRequestFilterCommon
- UE-CapabilityRequestFilterNR
- UE-CapabilityRequestFilterNR-v1540
- UE-MRDC-Capability
- UE-MRDC-CapabilityAddFRX-Mode
- UE-MRDC-CapabilityAddXDD-Mode
- UE-MRDC-CapabilityAddXDD-Mode-V1560
- UE-MRDC-Capability-v1560
- UE-NR-Capability
- UE-NR-CapabilityAddFRX-Mode
- UE-NR-CapabilityAddFRX-Mode-v1540
- UE-NR-CapabilityAddXDD-Mode
- UE-NR-CapabilityAddXDD-Mode-v1530

- UE-NR-Capability-v1530
- UE-NR-Capability-v1540
- UE-NR-Capability-v1550
- UE-NR-Capability-v1560
- UE-NR-Capability-v1570
- UE-TimersAndConstants
- UL-AM-RLC
- UL-CCCH1-MessageType
- UL-CCCH-MessageType
- UL-DataSplitThreshold
- UL-DCCH-MesasgeType
- ULInformationTransfer
- ULInformationTransfer-IEs
- ULInformationTransferMRDC
- ULInformationTransferMRCDC-IEs
- UL-UM-RLC
- UplinkConfig
- UplinkConfigCommon
- UplinkConfigCommonSIB
- UplinkTxDirectCurrentBWP
- UplinkTxDirectCurrentCell
- UplinkTxDirectCurentList
- ZP-CSI-RS-Resource
- ZP-CSI-RS-ResourceId
- ZP-CSI-RS-ResourceSet
- ZP-CSI-RS-ResourceSetId

D 4G LTE Filter Lists

D. 1 LTE Filters - IEs

- IEs
  - Activation/Deactivation [MAC-ACT-DEACT]
  - Activation/Deactivation [MAC-ACT-DEACT-4BYTES]
  - Activation/Deactivation of CSI-RS Resources [MAC-CE-ACTDEACT-CSIRS-CMD]
  - C-RNTI [MAC-C-RNTI]
    - C-RNTI
  - DAI [DCI_DAI_2_OR_4BITS]
    - If (unsigned(VAR_LEN_DAI)==4)
      - Counter DAI
      - Total DAI
    - Else
      - DL Assignment Index
  - DCI Format 1,2 Shared [DCI_PART_1_2_SHARED]
    - If (unsigned(VAR_DLRBIteq10)==0)
      - Resource Allocation Type
    - If (unsigned(VAR_RSRC_ALLOC_TYPE)==0)
      - Resource Allocation
    - Else
      - Selected Resource Blocks Subset

        - Shift of Resource Allocation Span
        - Resource Allocation
- DCI_7_1_SHARED [DCI_7_1_SHARED]
    - Flag for UL/DL differentiation
    - Resource Allocation
    - MCS
    - HARQ Process Number
    - New Data Indicator
    - Redundancy Version
    - TPC Command for SPUCCH
    - DL Assignment Index
    - Used/Unused SPDCCH Resource Indication
    - SPUCCH Resource Indication
    - Repetition Number
- DL Control Element Length [MAC-DL-CE-LEN]
    - Switch (VAR_LCID)
        - Case 18
        - Break
        - Case 19 **(continue upto Case 30)**
        - Break **(continue upto Break after Case 30)**
        - Case 31
            - If (bit(VAR_E,0)==1)
            - Else
        - Break
        - Default
        - Break
- Dual Connectivity Power Headroom Report [MAC-DC-POWER-HEADROOM]
    - If (unsigned(VAR_PH_SClt8)==1
        - SCell with index 7 reported
        - SCell with index 6 reported
        - SCell with index 5 reported
        - SCell with index 4 reported
        - SCell with index 3 reported
        - SCell with index 2 reported
        - SCell with index 1 reported
        - Reserved
    - Else

    - SCell with index 30 reported **(continue line items to SCell with index 1 reported)**
    - Reserved
  - While Loop - Power Headroom
    - P
    - Value based on Real Transmission
    - Power Headroom
    - If (unsigned(VAR_V)==0
      - Reserved
      - PCMAX,c
- Extended Power Headroom [MAC-XTND-POWER-HEADROOM]
  - If (unsigned(VAR_PH_SClt8)==1
    - SCell with index 7 reported
    - SCell with index 6 reported
    - SCell with index 5 reported
    - SCell with index 4 reported
    - SCell with index 3 reported
    - SCell with index 2 reported
    - SCell with index 1 reported
    - Reserved
  - Else
    - SCell with index 30 reported **(continue line items to SCell with index 1 reported)**
    - Reserved
  - While Loop - Power Headroom
    - P
    - Value based on Real Transmission
    - Power Headroom
    - If (unsigned(VAR_V)==0
      - Reserved
      - PCMAX,c
- Extended/MCH Scheduling Information [MAC-MCH-SCHED-INFO]
  - While Loop
    - LCID
    - If (unsigned(VAR_MCH_LCID))
      - S
    - Else
      - Stop MTCH

        - While Loop
            - LCID
            - S
    - Local / Distributed VRB (RNTI Dependent) [DCI_PART_LOCAL-DISTRIBUTED-VRB-ON-RNTI]
        - Distributed VRB Flag
        - If (unsigned(VAR_DT)==0 Or unsigned (VAR_DLRBlt50)==1 Or unsigned(VAR_RNTI_TYPE) in (0 4 5 7 106))
            - Resource Allocation
        - Else
            - N-gap
            - Resource Allocation
    - Local / Distributed VRB [DCI_PART_LOCAL-DISTRIBUTED-VRB]
        - Distributed VRB Flag
    - Long Buffer Status Report [MAC-LONG-BUFFER-STATUS]
        - Buffer Size #0
        - Buffer Size #1
        - Buffer Size #2
        - Buffer Size #3
    - MCC and MNC [LTEIE_MCC_MNC]
        - Decoded Values
            - ... with 6 component field filters/triggers
        - Interpreted Values
            - ... with 2 component field filters/triggers
    - MCS HARQ NDI RV TPC [DCI_PART_MCS-HARQ-NDI-RV-TPC-DAI]
        - MCS
        - New Data Indicator
        - Redundancy Version
        - TPC Command for PUCCH
    - Packet Filter Component [TFT-PF-COMPONENT]
    - Power Headroom [MAC-POWER-HEADROOM]
        - Power Headroom
    - Random Access Response Grant [MAC-RAR-ULGRANT]
        - Hopping Flag
        - Fixed size Resource Block Assignment
        - Truncated MCS
        - TPC Command for PUCCH

        - UL Delay
        - CQI Request
    - Short Buffer Status Report [MAC-SHORT-BUFFER-STATUS]
        - LCG ID
        - Buffer Size
    - Timing Advance [MAC-TIMING-ADVANCE]
        - Timing Advance Command
    - UE Contention Resolution Identity [MAC-UE-CONTENTION-RESOLUTION-IDENTITY]
        - UE Contention Resolution Identity

D. 2 LTE Filters - LTE IEs

LTE IEs

- Access Point Name [ACCESS_POINT_NAME]
    - Name
        - APN Aggregate Maximum Bit Rate [APN_AGG_MAX_BITRATE]
        - APN-AMBR for downlink
        - APN-AMBR for uplink
- Authentication Failure Parameter [AUTH_FAILURE_PARM]
    - Authentication Failure Parameter Value
- Authentication Parameter AUTN [AUTH_PARM_AUTN]
    - SQN xor AK
    - AMF
    - MAC
- Authentication Parameter RAND [AUTH_PARM_RAND]
    - RAND
- Authentication Response Parameter [AUTH_RESP_PARM]
- – – RES
    - CSFB Response [CSFB_RESPONSE]
        - CS Fallback Response
    - Daylight Saving Time [DAYLIGHT_SAVING_TIME]
        - DST
    - Detach Type [DETACH_TYPE]
    - DRX Parameter [DRX_PARAMETER]
        - Split PG Cycle Code
        - CN Specific DRX cycle length coefficient and DRX value for S1

mode

    - Split pg cycle on CCCH is supported by the mobile station
    - Non-DRX Timer
- EMM Cause [EMM_CAUSE]
    - Cause Value
- EPS Attach Result [EPS_ATTACH_RSLT]
    - EPS Attach Result Value
- EPS Attach Type [EPS_ATTACH_TYPE]
    - EPS Attach Type Value
- EPS Bearer Context Status [EPS_BEARER_CONTEXT_STATUS]
    - EBI(7)-Active
    - EBI(6)-Active
    - EBI(5)-Active
    - EBI(15)-Active
    - EBI(14)-Active
    - EBI(13)-Active
    - EBI(12)-Active
    - EBI(11)-Active
    - EBI(10)-Active
    - EBI(9)-Active
    - EBI(8)-Active
- EPS Mobile Identity [EPS_MOBILE_IDENTITY]
    - Spare
    - Odd/Even Indicator
    - Type of Identity
- EPS Quality of Service [EPS_QoS]
    - QCI
- EPS Update Result [EPS_UPDATE_RSLT]
    - EPS Update Result Value
- EPS Update Type [EPS_UPDATE_TYPE]
    - Active Flag
    - EPS Update Type Value
- ESM Cause [ESM_CAUSE]
    - Cause Value
- ESM Information Transfer Flag [ESM_INFO_TRX_FLAG]
    - Transfer Required
- ESM Message Container [ESM_MESSAGE_CONTAINER]
    - Message Content

- GPRS Timer [GPRS_TIMER]
  - Unit
  - Value
- Identity Type 2 [IDENTITY_TYPE_2]
  - Identity Type Value
- IMEISV Request [IMEISV_REQ]
  - IMEISV Request Value
- KSI and Sequence Number [KSI_AND_SEQ_NUMBER]
  - KSI_asme
  - Sequence Number (5 LSB of NAS Count)
- Linked EPS Bearer Identity [LINKED_EPS_BEARER_IDENTITY]
  - EPS Bearer Identity Value (0-4 are Reserved)
- LLC Service Access Point Identifier [LLC_SAPI]
  - LLC SAPI Value
- Location Area Identification [LOCATION_AREA_IDENTIFICATION]
  - MCC and MNC
  - LAC
- Mobile Identity [MOBILE_IDENTITY]
  - Digit 1/Flags
  - Odd Indicator
  - Type of Identity
- Mobile Station Classmark 2 [MS_CLASSMARK_2]
  - Revision Level
  - Controlled Early Classmark Sending Implemented by MS
  - Encryption algorithm A5/1 not available
  - RF power capability class
  - PS Capability Present
  - SS Screening Indicator
  - SM Capability (MT SMS Pt-2-Pt)
  - VBS capability and notifications wanted
  - VGCS capability and notifications wanted
  - Frequency Capability
  - MS supports options that are indicated in classmark 3 IE
  - Location request notification via CS domain supported
  - UCS2 Treatment
  - MS supports SoLSA
  - Network initiated MO CM connection request

        - A5/3 algorithm supported
        - A5/2 algorithm supported (not used...)
    - Mobile Station Classmark 3 [MS_CLASSMARK_3]
        - Multiband Supported
            - ... with 3 component field filters/triggers
        - R Support
            - ... with 2 component field filters/triggers
        - HSCSD Multi Slot Capability
            - ... with 2 component field filters/triggers
        - UCS2 Treatment
        - The MS supports Extended Measurements
        - MS Measurement Capability
            - ... with 2 component field filters/triggers
        - MS Positioning Method Capability
            - ... with 2 component field filters/triggers
        - ECSD Multi Slot Capability
            - ... with 2 component field filters/triggers
        - 8-PSK Struct
            - ... with 2 component field filters/triggers
        - GSM 400 Bands Supported
            - ... with 2 component field filters/triggers
        - GSM 850 Associated Radio Capability
            - ... with 2 component field filters/triggers
        - GSM 1900 Associated Radio Capability
            - ... with 2 component field filters/triggers
        - UMTS FDD Supported
        - UMTS 3.84 Mcps TDD Supported
        - CDMA 2000 Supported
        - DTM GPRS Multi Slot Class
            - ... with 2 component field filters/triggers
        - Single Band Support
            - ... with 2 component field filters/triggers
        - GSM 750 Associated Radio Capability
            - ... with 2 component field filters/triggers
        - UMTS 1.28 Mcps TDD Supported
        - GERAN Feature Package 1 Supported
        - Extended DTM
            - ... with 2 component field filters/triggers

    - High Multislot Capability
        - ... with 2 component field filters/triggers
    - GERAN Iu Mode Capabilities
        - ... with 2 component field filters/triggers
    - GERAN Feature Package 2 Supported
    - GMSK Multislot Power Profile
    - 8-PSK Multislot Power Profile
    - T-GSM 400 Bands Supported
        - ... with 2 component field filters/triggers
    - T-GSM 900 Associated Radio Capability
        - ... with 2 component field filters/triggers
    - Downlink Advanced Receiver Performance
    - Enhanced DTM CS Establishment/Release Procedures Supported
    - DTM GPRS High Multi Slot Class
        - ... with 2 component field filters/triggers
    - Repeated ACCH Capability
    - GSM 710 Associated Radio Capability
        - ... with 2 component field filters/triggers
    - T-GSM 810 Associated Radio Capability
        - ... with 2 component field filters/triggers
    - Ciphering Mode Setting Capability
    - Additional Positioning Capabilities
    - E-UTRA FDD Support
    - E-UTRA TDD Support
- MS Netowrk Capability [MS_NETWORK_CAPABILITY]
    - GPRS Encryption Algorithm GEA/1
    - SM capabilities via dedicated channels
    - SM capabilities via GPRS channels
    - UCS2 Support/Preference for default alphabet over UCS2
    - SS Screening Indicator
    - SoLSA Capability
    - R99 or later supported
    - PFC feature/BSS packet flow procedures supported
    - GPRS Encryption Algorithm GEA/2
    - GPRS Encryption Algorithm GEA/3
    - GPRS Encryption Algorithm GEA/4
    - GPRS Encryption Algorithm GEA/5
    - GPRS Encryption Algorithm GEA/6

    - GPRS Encryption Algorithm GEA/7
    - LCS VA Capability
    - PS inter-RAT HO to UTRAN Iu mode capability
    - ISR Support
    - SRVCC to GERAN/UTRAN Capability
    - Pad
- NAS Key Set Identifier [NAS_KEY_SET_IDENTIFIER]
    - TSC
    - NAS Key Set
- NAS Message Container [NAS_MESSAGE_CONTAINER]
    - Contents
- NAS Security Algorithms [NAS_SEC_ALG]
    - Type of Ciphering Algorithm
    - Type of Integrity Protection Algorithm
- Network Name [NETWORK_NAME]
    - String
        - ... with 5 component field filters/triggers
- Nonce [NONCE]
    - Nonce Value
- Packet Flow Identifier [PKT_FLOW_IDENTIFIER]
    - Packet Flow Identifier Value
- PDN Address [PDN_ADDRESS]
    - PDN Type Value
    - Address Information
- PDN Type [PDN_TYPE]
    - PDN Type
- PLMN List [PLMN_LIST]
- Protocol Configuration Options [PROTO_CONFIG_OPT]
    - Ext 1
    - Configuration Protocol
- P-TMSI Signature [P-TMSI_SIGNATURE]
    - P-TMSI Signature Value
- Quality of Service [QoS]
    - Delay Class
    - Reliability Class
    - Peak Throughput
    - Precedence Class
    - Mean Throughput

- Radio Priority [RADIO_PRIORITY]
  - Radio Priority Level
- Request Type [REQUEST_TYPE]
  - Request Type Value
- Service Type [SERVICE_TYPE]
  - Service Type Value
- Short MAC [SHORT_MAC]
  - Short MAC Value
- Supported Codecs [SUPPORTED_CODECS]
- Time Zone [TIME_ZONE]
  - Time Zone Value
- Time Zone and Time [TIME_ZONE_TIME]
  - Time Zone and Time
- TMSI Status [TMSI_STATUS]
  - Valid TMSI available
- Tracking Area Identity [TRACKING_AREA_IDENTITY]
  - MCC and MNC
  - TAC
- Tracking Area Identity List [TRACKING_AREA_IDENTITY_LIST]
- Traffic Flow Template [TRAFFIC_FLOW_AGGREGATE]
- Traffic Flow Template [TRAFFIC_FLOW_TEMPLATE]
  - TFT Operation Code
  - E
  - Number of Packet Filters
- Transaction Identifier [TRANSACTION_IDENTIFIER]
  - TI Flag
  - TI Value
- UE Network Capability [UE_NETWORK_CAPABILITY]
  - EPS Encryption Algorithm 128-EEA0 Supported
  - EPS Encryption Algorithm 128-EEA1 Supported
  - EPS Encryption Algorithm 128-EEA2 Supported
  - EPS Encryption Algorithm EEA3 Supported
  - EPS Encryption Algorithm EEA4 Supported
  - EPS Encryption Algorithm EEA5 Supported
  - EPS Encryption Algorithm EEA6 Supported
  - EPS Encryption Algorithm EEA7 Supported
  - EPS Integrity Algorithm 128-EIA1 Supported
  - EPS Integrity Algorithm 128-EIA2 Supported

        - EPS Integrity Algorithm EIA3 Supported
        - EPS Integrity Algorithm EIA4 Supported
        - EPS Integrity Algorithm EIA5 Supported
        - EPS Integrity Algorithm EIA6 Supported
        - EPS Integrity Algorithm EIA7 Supported
        - Pad
    - UE Radion Capability Information Updated Needed [UE_RADIO_ CAPABILITY_UPDATE_NEEDED]
        - Update Needed
    - UE_SECURITY_CAPABILITY [UE_SECURITY_CAPABILITY]
        - EPS Encryption Algorithm 128-EEA0 Supported
        - EPS Encryption Algorithm 128-EEA1 Supported
        - EPS Encryption Algorithm 128-EEA2 Supported
        - EPS Encryption Algorithm EEA3 Supported
        - EPS Encryption Algorithm EEA4 Supported
        - EPS Encryption Algorithm EEA5 Supported
        - EPS Encryption Algorithm EEA6 Supported
        - EPS Encryption Algorithm EEA7 Supported
        - EPS Integrity Algorithm 128-EIA1 Supported
        - EPS Integrity Algorithm 128-EIA2 Supported
        - EPS Integrity Algorithm EIA3 Supported
        - EPS Integrity Algorithm EIA4 Supported
        - EPS Integrity Algorithm EIA5 Supported
        - EPS Integrity Algorithm EIA6 Supported
        - EPS Integrity Algorithm EIA7 Supported

D. 3 LTE Filters - Layer/Parts

Layer / Parts

- DCI-FORMAT-0
    - DCI Format 0
        - with 11 component field filters/triggers
- DCI-FORMAT-1
    - DCI Format 1
        - ... with 11 component field filters/triggers
- DCI-FORMAT-1A

- DCI Format 1A
  - ... with 7 component field filters/triggers
- DCI-FORMAT-1B
  - DCI Format 1B
    - ... with 13 component field filters/triggers
- DCI-FORMAT-1C
  - DCI Format 1C
    - ... with 3 component field filters/triggers
- DCI-FORMAT-1D
  - DCI Format 1D
    - ... with 13 component field filters/triggers
- DCI-FORMAT-2
  - DCI Format 2
    - ... with 11 component field filters/triggers
- DCI-FORMAT-2A
  - DCI Format 2A
    - ... with 12 component field filters/triggers
- DCI-FORMAT-3
  - DCI Format 3
    - ... with 2 component field filters/triggers
- DCI-FORMAT-3A
  - DCI Format 3A
    - ... with 1 component field filter/trigger
- MAC-DLSCH_ULSCH
  - MAC Message
    - ... with 2 component field filters/triggers
- MAC-RND-ACCS-RSP
  - MAC Random Access Response
    - ... with 3 component field filters/triggers
- NAS-ACT-DEDC-EPS-BEARER-CTX-ACPT
  - Activate Dedicated EPS Bearer Context Accept
    - ... with 5 component field filters/triggers
- NAS-ACT-DEDC-EPS-BEARER-CTX-REJ
  - Activate Dedicated EPS Bearer Context Reject
    - ... with 6 component field filters/triggers
- NAS-ACT-DEDC-EPS-BEARER-CTX-REQ
  - Activate Dedicated EPS Bearer Context Request
    - ... with 9 component field filters/triggers

- NAS-ACT-DFLT-EPS-BEARER-CTX-ACPT
  - Activate Default EPS Bearer Context Accept
    - ... with 5 component field filters/triggers
- NAS-ACT-DFLT-EPS-BEARER-CTX-REJ
  - Activate Default EPS Bearer Context Reject
    - ... with 6 component field filters/triggers
- NAS-ACT-DFLT-EPS-BEARER-CTX-REQ
  - Activate Default EPS Bearer Context Request
    - ... with 7 component field filters/triggers
- NAS-ATTACH-ACPT
  - Attach Accept
    - ... with 9 component field filters/triggers
- NAS-ATTACH-CPLT
  - Attach Complete
    - ... with 4 component field filters/triggers
- NAS-ATTACH-REJ
  - Attach Complete
    - ... with 5 component field filters/triggers
- NAS-ATTACH-REQ
  - Attach Request
    - ... with 9 component field filters/triggers
- NAS-AUTH-FAIL
  - Authentication Failure
    - ... with 5 component field filters/triggers
- NAS-AUTH-REJ
  - Authentication Reject
    - ... with 3 component field filters/triggers
- NAS-AUTH-REQ
  - Authentication Request
    - ... with 7 component field filters/triggers
- NAS-AUTH-RSP
  - Authentication Response
    - ... with 4 component field filters/triggers
- NAS-BEARER-RSRC-MOD-REJ
  - Bearer Resource Modification Reject
    - ... with 6 component field filters/triggers
- NAS-BEARER-RSRC-MOD-REQ

    - Bearer Resource Modification Request
        - ... with 8 component field filters/triggers
- NAS-DEACT-EPS-BEARER-CTX-ACPT
    - Deactivate EPS Bearer Context Accept
        - ... with 5 component field filters/triggers
- NAS-DEACT-EPS-BEARER-CTX-REQ
    - Deactivate EPS Bearer Context Request
        - ... with 6 component field filters/triggers
- NAS-DETACH-ACPT
    - Detach Accept
        - ... with 3 component field filters/triggers
- NAS-DETACH-REQ
    - Detach Accept
        - ... with 7 component field filters/triggers
- NAS-DL-NAS-TRANSPORT
    - Security Header Type
    - Protocol Discriminator
    - Message Identity
    - NAS Message Container
        - ... with 1 component field filter/trigger
- NAS-EMM-INFO
    - EMM Information
        - ... with 4 component field filters/triggers
- NAS-EMM-STAT
    - EMM Status
        - ... with 4 component field filters/triggers
- NAS-ESM-INFO-REQ
    - ESM Information Request
        - ... with 4 component field filters/triggers
- NAS-ESM-INFO-RSP
    - ESM Information Response
        - ... with 5 component field filters/triggers
- NAS-ESM-STAT
    - ESM Status
        - ... with 5 component field filters/triggers
- NAS-EXT-SVC-REQ
    - Extended Service Request
        - ... with 7 component field filters/triggers

- NAS-GUTI-REALLOC-CMD
  - GUTI Reallocation Command
    - ... with 5 component field filters/triggers
- NAS-GUTI-REALLOC-CPLT
  - GUTI Reallocation Complete
    - ... with 3 component field filters/triggers
- NAS-ID-REQ
  - Identity Request
    - ... with 5 component field filters/triggers
- NAS-ID-RSP
  - Identity Response
    - ... with 4 component field filters/triggers
- NAS-MOD-EPS-BEARER-CTX-ACPT
  - Modify EPS Bearer Context Accept
    - ... with 5 component field filters/triggers
- NAS-MOD-EPS-BEARER-CTX-REJ
  - Modify EPS Bearer Context Reject
    - ... with 6 component field filters/triggers
- NAS-MOD-EPS-BEARER-CTX-REQ
  - Modify EPS Bearer Context Request
    - ... with 5 component field filters/triggers
- NAS-PDN-CONN-REJ
  - PDN Connectivity Reject
    - ... with 6 component field filters/triggers
- NAS-PDN-CONN-REQ
  - PDN Connectivity Request
    - ... with 7 component field filters/triggers
- NAS-PDN-DISC-REJ
  - PDN Disconnect Reject
    - ... with 6 component field filters/triggers
- NAS-PDN-DISC-REQ
  - PDN Disconnect Reject
    - ... with 7 component field filters/triggers
- NAS-SEC-MODE-CMD
  - Security Mode Command
    - ... with 8 component field filters/triggers
- NAS-SEC-MODE-CPLT

    - Security Mode Complete
        - ... with 4 component field filters/triggers
- NAS-SEC-MODE-REJ
    - Security Mode Reject
        - ... with 4 component field filters/triggers
- NAS-SEC-PROTECTED-MSG
    - Security Protected NAS Message
        - ... with 5 component field filters/triggers
- NAS-SVC-REJ
    - Service Reject
        - ... with 5 component field filters/triggers
- NAS-SVC-REQ
    - Service Request
        - ... with 4 component field filters/triggers
- NAS-TA-UPD-ACPT
    - Tracking Area Update Accept
        - ... with 6 component field filters/triggers
- NAS-TA-UPD-CPLT
    - Tracking Area Update Complete
        - ... with 3 component field filters/triggers
- NAS-TA-UPD-REJ
    - Tracking Area Update Reject
        - ... with 4 component field filters/triggers
- NAS-TA-UPD-REQ
    - Tracking Area Update Request
        - ... with 9 component field filters/triggers
- NAS-UL-NAS-TRANSPORT
    - Uplink NAS Transport
        - ... with 4 component field filters/triggers
- PDCP-CP-SRB
    - PDCP Data for SRBs
        - ... with 4 component field filters/triggers
- PDCP-CTRL-ROHC-FB
    - ROHC Feedback
        - ... with 4 component field filters/triggers
- PDCP-CTRL-STS-RPT
    - PDCP Status Report
        - ... with 4 component field filters/triggers

- PDCP-CTRL-UNKNOWN
  - PDCP Unknown Control Message
    - ... with 4 component field filters/triggers
- PDCP-DATA-12BITSN
  - PDCP Data (12 Bit SN)
    - ... with 4 component field filters/triggers
- PDCP-DATA-7BITSN
  - PDCP Data (7 Bit SN)
    - ... with 3 component field filters/triggers
- PDCP-DATA-MBSFN
  - FFS
- RLC-AMD
  - RLC AMD
    - ... with 9 component field filters/triggers
- RLC-AMD-SEG
  - RLC AMD Segment
    - ... with 11 component field filters/triggers
- RLC-STS-PDU
  - RLC Status PDU
    - ... with 6 component field filters/triggers
- RLC-UMD-10BITSN
  - RLC UMD (10 Bit SN)
    - ... with 7 component field filters/triggers
- RLC-UMD-5BITSN
  - RLC UMD (5 Bit SN)
    - ... with 6 component field filters/triggers

D. 4 LTE Physical Channels

LTE Physical Channels

- PBCH
- PCFICH
- PDCCH
- PHICH
- PDSCH
- PMCH
- PUCCH
- PUSCH

- PRACH
- PUSCH_UCI
- EPDCCH
- PSDCH
- PSBCH
- PSCCH
- MPDCCH
- NPBCH
- NPDCCH
- NPDSCH
- NPUCCH
- NPUSCH
- NPRACH
- NPUSCH_UCI

D. 5 LTE Filters - RRC

Top level messages are listed below.

Messages

- BCCH-BCH-Message
- BCCH-BCH-Message-MBMS
- BCCH-BCH-Message-NB
- BCCH-DL-SCH-Message
- BCCH-DL-SCH-Message-BR
- BCCH-DL-SCH-Message-MBMS
- BCCH-DL-SCH-Message-NB
- DL-CCCH-Message
- DL-CCCH-Message-NB
- DL-DCCH-Message
- DL-DCCH-Message-NB
- MCCH-Message
- PCCH-Message
- PCCH-Message-NB
- SBCCH-SL-BCH-Message
- SC-MCCH-Message-NB
- SC-MCCH-Message-r13
- UE-EUTRA-Capability

- UL-CCCH-Message
- UL-CCCH-Message-NB
- UL-DCCH-Message
- UL-DCCH-Message-NB

Type Assignments

There are hundred of type assignments, refer to the actual filter list.

D. 6 LTE Filters - UCI Messages

UCI Messages

- Any UCI
- CQI
- HARQ ACK
- HARQ NACK
- HARQ Number
- RI
- SR

D. 7 LTE Filters - Global

Global

- RNTI
- # of RNTIs in Subframe in Shared Channels
- Cell ID
- LTE Physical Channel Band Type
- Incomplete
- Any message with Error
- Any TB CRC Error
- # of Transmission of 1 AMD PDU
- sn - vr(h)
- # of NACKs in AM STATUS
- # of HARQ Retransmission

D. 8 LTE Filters - CipherJudge UEs

CipherJudge UEs

- CipherJudge UE Layers

D. 9 LTE Filters – Transport and IP Layer

Transport and IP Layer

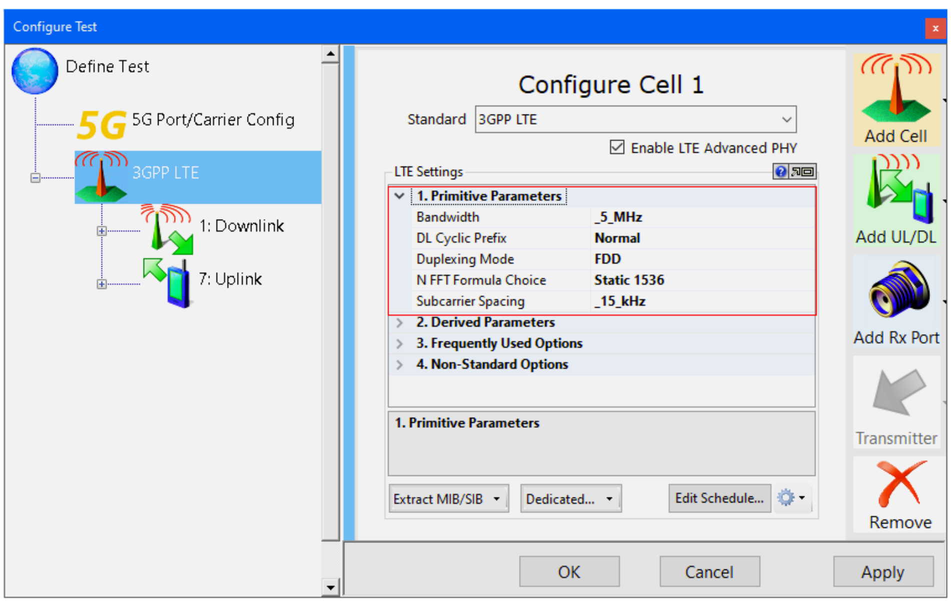
- Unknown Data
- Ciphered Data
- Any IP Data
- IPv4 Data
- IPv6 Data

E 4G LTE Test Settings

This appendix provides a complete list of all LTE settings available in the Configure Test window.

E. 1 Primitive Parameters

Below is the full list of LTE Settings and definitions in section 1. Primitive Parameters of the Configure Test window.



LTE Settings: Section 1. Primitive Parameters

Bandwidth: Nominal channel bandwidth, which is the separation between adjacent center frequencies. Options are: 200 KHz NB-IoT, 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz, Other.

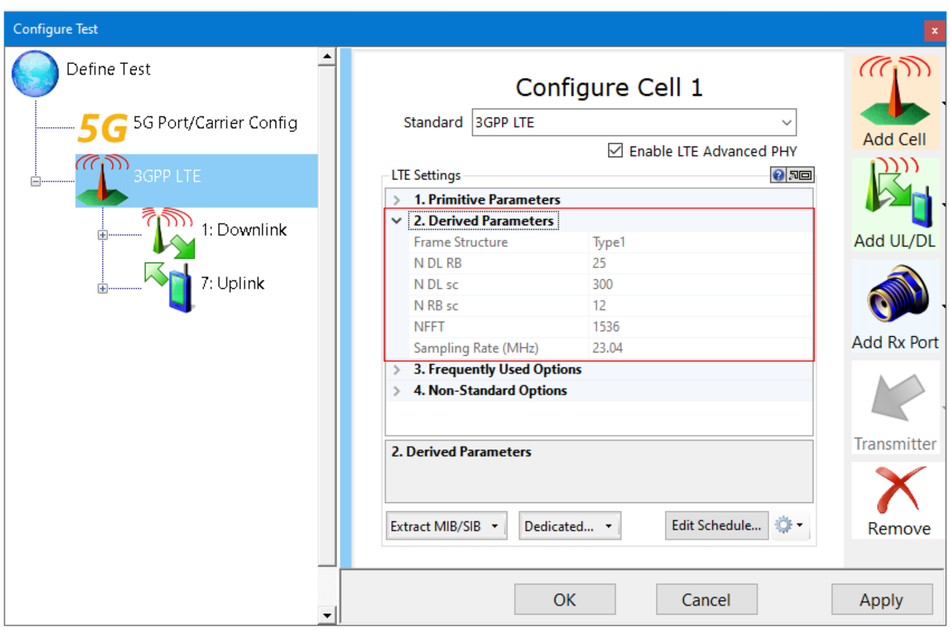
- DL Cyclic Prefix: As specified in TS 36.211, can be either Normal or Extended
- Duplexing Mode: Time division duplexing (TDD) or frequency division duplexing (FDD)
- N FFT Formula Choice: Formula used to derive number of FFT points from

bandwidth; or Sampling Rate.

  - Options are Original, IntelliJudge, Static 256, Static 512, Static 1024, Static 1500 (LTE+ WiFi), Static 1536, Static 512, Static 2048, 3.84 MHz, 7.68 MHz, 15.36 MHz, 22.50 MHz (LTE + WiFi), 23.04 MHz, 30.72 MHz, 45.00 MHz,61.44 MHz, 122.88 MHz, and 150.00 MHz.
  - When set to "Original", N FFT is the smallest power of 2 larger than 12 * N_DL_RB, except for 15 MHz bandwidth, where N FFT = 2048.
  - When set to "IntelliJudge" N FFT is the same as "Original", except for 20 MHz and 15 MHz bandwidth where N FFT is 1536 instead of 2048.
  - When set to "Static_512", "Static_1024", Static_1536" or "Static_2048", NFFT is equal to 512, 1024, 1536, or 2048 respectively, for all bandwidths. Those are useful for automatic bandwidth detection.
  - Please note that the largest value of N FFT which may be used with IntelliJudge or the WJ4900 phase-aligned synthesizer is 1536.
- Subcarrier Spacing: As specified in TS 36.211, can be either 15 kHz or 7.5 kHz

E. 2 Derived Parameters

Below is the full list of LTE Settings and definitions in section 2. Derived Parameters of the Configure Test window.



LTE Settings: Section 2. Derived Parameters

Frame Structure: Type 1 for FDD, Type 2 for TDD

N DL RB: Number of physical resource blocks.

N DL sc: Total number of subcarriers

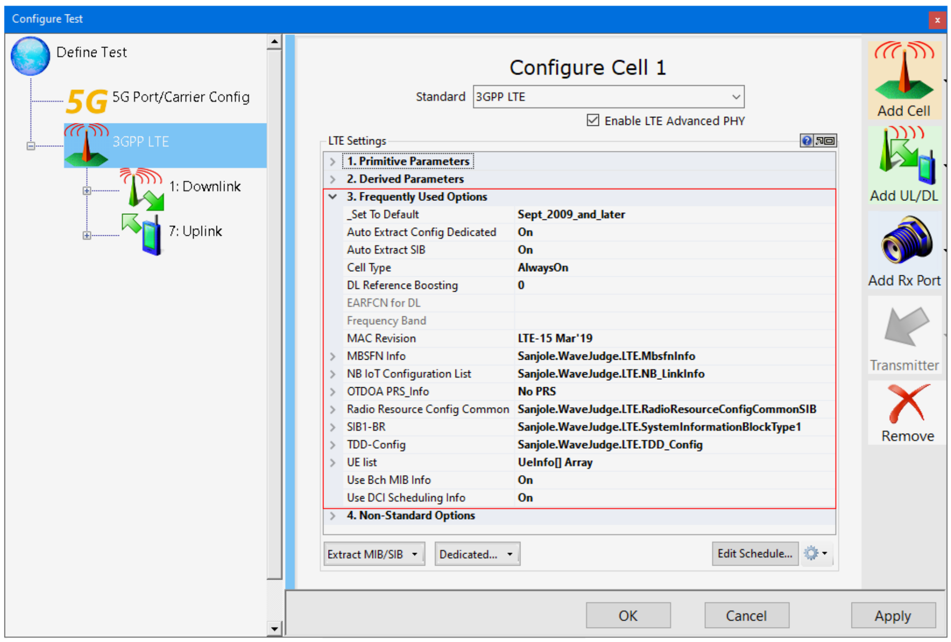
N RB sc: Number of subcarriers per physical resource block

NFFT: Derived number of FFT points

Sampling Rate (MHz): Sampling Rate is in MHz

E. 3 Frequently Used Options

Below is the full list of LTE Settings and definitions in section 3. Frequently Used Options of the Configure Test window.



LTE Settings: Frequently Used Options

Set to Default: Set all advanced options to the default value for a standard version. Dropdown menu options are Sept. 2009 and later, June 2009, March 2009, v850, v840, V830, V820, v819, none, Proprietary1, and Proprietary2.

Auto Extract Config Dedicated: The WaveJudge extracts the Config Dedicated parameters from RRC Connection Setup/Reconfiguration/Re-establishment messahes, and applies them on the fly while processing.

Auto Extract SIB: If "On", the WaveJudge extracts the configuration parameters from SIB messages and applies them on the fly while processing.

Cell Type:

- "Always On" is used for an LTE PCell and most SCells; other values are used for MulteFire or an SCcel which may turn on and off (small cell, LTE-U, LAA). If enabled for IntelliJudge real-time operation, Cell ID Mode must be set to "Equal" and the CellID must also be correctly set in the Cell ID List. When set to

"AlwaysOn", the cell is always on and UE may expect the eNB will always transmit core signals (including PSS/SSS and CRS).
- When set to "OnOff_Licensed" the cell can be turned off and a UE may not expect the eNB will always transmit.
- When set to "OnOff_Unlicensed" a UE shall assume the cell is LAA SCell (Frame Type 3) - also applied to MulteFire.
- When set to "No_Downlink" a UE may expect no eNB DL is present and the only synchronization reference a UE may use is a time-base such as SLSS or GNSS.

DL Reference Boosting: Assumes that all downlink reference signals are boosted by a static number in dB. Its effect is to scale the constellation by the specified number in decibels. A positive number expands the constellation, while a negative number contracts it. It acts globally as the opposite of the UE-specific parameter p-a, defined in TS 36.213. If the UE-specific parameter p-a is provided by RRC messages, or set manually in the 'ConfigDedicated" section, the "DL Reference Boosting" should remain "0".

EARFCN for DL: EARFCN derived from Frequency Band and DL Center Frequency.

Frequency Band: Frequency Bandd Indicator extracted from SIB.

MAC Revision: Version of TS 36.331 used for decoding MAC messages.

MBSFN Info: The collection of parameters to configure Multimedia Broadcast multicast service Single Frequency Network (MBSFN)

- MBSFN Area Configuration List: The list contains the MBMS control information applicable for each MBSFN area.
- MBSFN Area Info List: The IE MBSFN-AreaInfoList (from SIB13) contains the information required to acquire the MBMS control information associated with one or more MBSFN areas.
- MBSFN Sbframe Config List: The IE MBSFN-SubframeConfig (from SIB2) defines subframes that are reserved for MBSFN in downlink.
- MBSFN-AreaInfoList-r16: The IE MBSFN-AreaInfo-r16 List (from SIB13) contains the information required to acquire the MBMS control information associated with one or more MSFBN areas.

NB IoT Configuration List: Configure parameters related to NB IoT.

- **Cell ID for NB IoT:** Cell ID for NB IoT before NSSS is decoded. Taking value from 0 to 503.
- **freqInfo-r13:** freqInfo-r13 configured by SIB2-NB.
  - **UL-CarrierConfigDedicated-NB-r13:** Carrier Frequency related configuration
    - **CarrierFreq-NB is configured:** Indicated this IE is configured by higher layer. Otherwise shall use thet anchor carrier.
    - **CarrierFreqOffset-r13:** Offset of the NB-IoT channel number to EARFCN as defined in TS 36.101 5.7.3F.

    - **CarrierFreq-r13(EARFCN):** The EARFCN applicable for the NB-IoT carrier frequency as defined in TS 36.101 5.7.3F. Taking value from 0 to 262143.
- **LTEDownlinkCarrierCentralFrequency (GHz):** Central frequency (GHz) of the underlying LTE cell's downlink carrier if running under the "Inband_SamePCI" operation mode.
- **MIB/SIB-NB Waveform Format Option:** Waveform Option for physical channels carrying MIB/SIB-NB messages (old format until Release 14.1.0 or new format since Release 14.2.0.
- **NAntennaPort:** Number of antenna ports: 1 or 2.
- **NB-IoT Downlink Anchor Carrier Central Frequency (GHz):** Central frequency (GHz) of NB-IoT downlink anchor carrier. If the EARFCN configuration for the anchor carrier is not configured, the formula to derive this field from the n_PRB index of the Inband support is shown here.

NB-IoT Downlink Anchor Carrier Central Frequency (GHz)

```
if n_PRB >= N_DL_RB / 2 (the PRB is above the LTE DC)
      'NB_IoT_AnchorCarrierCentralFrequency (GHz)' = f0 + ((12 * n_PRB - (N_DL_RB * 6) + 6.5) * 15 / 1000000)

if n_PRB < N_DL_RB / 2 (the PRB is below the LTE DC)
      'NB_IoT_AnchorCarrierCentralFrequency (GHz)' = f0 + ((12 * n_PRB - (N_DL_RB * 6) + 5.5) * 15 / 1000000)

where, 'N_DL_RB' and 'f0' respectively denote the number of PRB and the central carrier frequency of the LTE system.
```

Formula for NB-IoT Downlink Anchor Carrier Central Frequency

- **NB-IoT Downlink Anchor Carrier Configuration:** EARFCN configuration for NB-IoT downlink anchor for Carrier defined in TS 36.101 5.7.3F.
    - **CarrierFreq-NB is confgured:** Indicates this IE is configured by a higher layer. Otherwise, shall use the anchor carrier. Options are True of False.
    - **CarrierFreqOffset-r13:** Offset of the NB-IoT channel number to EARFCN as defined in TS 36.101 5.7.3F.
    - **CarrierFreq-r13 (EARFCN):** The EARFCN applicable for the NB-IoT carrier frequency as defined in TS 36.101 5.7.3F. Taking value from 0 to 262143.
- **NB-IoT UE List:** List of NB-IoT UE specific parameters: N_RNTI, ConfigDedicated from RRC messages (RRCConnectionSetup, RRCConnectionReconfiguration, and RRCConnectionReestablishment).
- **NB-IoT Uplink Anchor Carrier Central Fequencey (GHz):** Central frequency (GHz) of NB-IoT uplink anchor carrier. If the EARFCN for this carrier is not configured, it displays as 0.
- **operationModeInfo-r13:** NB IoT Cell Operation Mode: Inband-SamePCI, Inband-DifferentPCI, Guardband, and Standalone.
- **RadioResourceConfigCommonSIB_NB:** Collection of parameters set in

RadioResourceConfigCommonSIB_NB.

- DL-GapConfig-NB-r13: Used to specify the downlink gap configuration for NPDCCH and NPDSCH (except BCCH).
  - DL_GapConfig_NB is configured: Indicate this IE is configured by higher layer.
  - dl-GapDurationCoeff-r13: Coefficient to calculate the gap duration of a DL transmission as defined in TS 36.211 10.2.3.4,.
  - dl-GapPeriodicity-r13: Periodicity of a DL transmission gap in number of subframes as defined in TS 36.211 10.2.3.4.
  - dl-GapThreshold-r13: Threshold of the maximum number of repetitions configured for NPDCCH before application of DL transmission gap configuration as defined in TS 36.211 10.2.3.4.
- NPRACH-ConfigSIB-NB-r13: Used to specify common parameters needed for the transmission of NPRACH.
  - edt-Parameters-r15: Configuration for early data transmission (EDT).
  - edt-SmallTBS-Subset-r15: Presence indicates only two of the TBS values can be used according to edt-TBS corresponding to the NPRACH resources, as specifed in TS 36.213. When the field is not present, any of the TBS values according to edt-TBS corresponding to the NPRACH resources can be used. This field is applicable for a NPRACH resource only when edt-SmallTBS-Enables is inlcuded for the corresponding NPRACH resource.
  - edt-TBS-InfoList-r15: The list of Largest TBS for Msg3 for a NPRACH resource applicable to aUE performing EDT.
  - nprach-ParametersListEDT-r15: The NPRACH resource in nprach-PrarmetersListEDT are used to initiate EDT. Each NPRACH resource is associated with a TBS signalled in the corresponding entry of edt-TBS-InfoList.
  - nprach-CP-Length-r13: Cyclic prefix length for NPRACH transmission. Value us66dot7 corresponds to 66.7 us, and value us266dot7 corresponds to266.7 us.
  - nprach-ParemtersList-r13: The list of PRACH-ParametersList-NB-r13.
- NPUSCH-ConfigCommon-NB-r13: Used to specify common parameters needed for the transmission on NPUSCH.
  - ack-NACK-NumRepeitions-Msg4-r13: Number of repetitions for ACK/NACK HARQ response to NPDSCH containing Msg4 per NPRACH resource.
  - dmrs-Config-r13: Used to specifiy parameters needed for NPUSCH DMRS.

            - **Configured:** dmrs-Config-r13 is configured by higher later or not.
            - **sixTone-BaseSequence-r13:** Taking a value from 0 to 14. Value 0XFF indicates not configured.
            - **sixTone-CyclicShift-r13:** Taking a value from 0 to 3.
            - **threeTone-BaseSequence-r13:** Taking a value from 0 to 12. Value 0XFF indicates not configured.
            - **threeTone-CyclicShift-r13:** Taking a value from 0 to 2.
            - **twleveTone-BaseSequence-r13:** Taking a value from 0 to 30. Value 0XFF indicates not configured.
        - **srs-SubframeConfig-r13:** SRS SubframeConfiguration. See TS 36.211 Table 5.5.3.3-1.
            - **UL_ReferenceSignalsNPUSCH_NB_r13:** Used to specifiy parameters needed for the transmission on NPUSCH.
                - **groupAssignmentNPUSCH-r13:** Taking a value from 0 to 29.
                - **groupHoppingEnabled-r13:** A boolean value for groupHoppingEnabled-r13.
    - **PCCH-Config-NB-r13:** Used to specify common parameters needed for the transmission of Paging.
        - **defaultPagingCycle-r13:** Default paging cycle, used to derive 'T' in TS 36.304.
        - **nB-r13:** Used as one of the parameters to derive the Paging Frame and Paging Occasion according to TS 36.304.
        - **npdcch-NumRepetitionPaging-r13:** Maximum number of repetitions for NPDCCH common search space (CSS) for paging.
    - **rach-ConfigCommon-r13:** Used to specifiy generic random access parameters for NB-IoT UE.
        - **RACH-InfoList-NB-r13:** The list of RACH-Info-NB-r13.
- **SIB1-NB:** Collection of parameters set in SIB1-NB messages.
    - **downlinkBitmap-r13:** NB-IoT downlink subframe configuration for downlink transmission. If the bitmap is not present the UE shall assume that all subframes are valid.
    - **downlinkBitmap-r13 Length:** The bitmap lengtth can be 10 or 40 bits. Value 0 indicates the downlink bitmap is not present and all DL subframe is valid.
    - **eutraControlRegionSize-r13:** For NB IoT under inband operation mode, indicates the OFDM starting symbol for NPDCCH and NPDSCH. Takes values 1, 2, or 3.
    - **schedulingInfoList-r13:** The list of SchedulingINfoList-NB-r13 for the SIB messages.

  - **si-RadioFrameOffset-r13:** Offset in number of radio frames to calculate the start of the SI window. Can take values from 0 to 15.
  - **si-WindowLength-r13:** Common SI scheduling window for all SIs.

OTDOA PRS_Info: Observed Time Difference of Arrival (OTDOA) Positioning Reference Signals (PRS) parameters.

- **numDL-Frames:** This field specifies the number of consecutive downlink subframes N-PRS with positioning reference signals, as defined as TS36.211. Enumerated values define 1, 2, 4, or 6 consecutive subframes.
- **prs-Bandwidth:** This field specifies the bandwidth that is used to configure the positioning reference signals on. Enumerated values are specified in number of resouce block (n6 corresponds to 6 resources blocks, n15 to 15 resource blocks, etc.) and define 1.4, 3, 5, 10, 15 and 20 MHz bandwidth.
- **prs-ConfigurationIndex:** This field specifies the postioning reference signals configuration index I_PRS and defined in TS36.211.
- **prs-MutingInfo:** This field specifies the PRS muting confiuration of the cell.
- **prs-MutingInfo Periodicity:** This field specifies the periodicity T-REP of the muting sequency and can be 2, 4, 8 or 16.

Radio Resource Config Common: Collection of parameters set in SIB2 messages.

- **FreqHoppingParameters:** Hop rate is the number of frequency changes per second and it is equivalent to the code clock rate.
  - **interval-DLHoppingConfigCommonModeA-r13:** FDD: Takes the values of {int1, int2, int4, int8}. TDD: Takes the values of {int1, int5, int10, int20}.
  - **interval-DLHoppingConfigCommonModeB-r13:** FDD: Takes the values of {int2, int4, int8, int16}. TDD: Takes the values of {int5, int10, int20, int40}.
  - **interval-ULHoppingConfigCommonModeA-r13:** FDD: Takes the values of {int1, int2, int4, int8}. TDD: Takes the values of {int1, int5, int10, int20}.
  - **interval-ULHoppingConfigCommonModeB-r13:** FDD: Takes the values of {int2, int4, int8, int16}. TDD: Takes the values of {int5, int10, int20, int40}.
  - **mpdcch-pdsch-HoppingNB-r13:** The number of narrowbands for MPDCCH/PDSCH frequency hopping. Takes the values of {nb2, nb4}.
  - **mpdcch-pdsch-HoppingOffset-r13:** Frequency hopping offset for MPDCCH/PDSCH. Takes the values of {1 to maxAvailNarrowBands-r13 (16)}.
- **PCCH-Config:** Common configuration for Paging.
  - **defaultPagingCycle:** Default paging cycle, used to derive 'T' in TS 36.304.
  - **mpdcch-Numrepetition-Paging-r13:** Maximum number of repetitions for M-PDCCH common search space (CSS) for paging.
  - **nB:** Parameter: nB is used as a parameter to derive the Paging Frame and Paging Occasion according to TS 36.304.
  - **nB-BR:** nB-BR is used as a parameter to derive the Paging Frame and Paging Occasion according to TS 36.304 for a BL/CE (bandwidth

    reduced-low/coverage enhancement) UE.
  - **paging-narrowBands-r13:** Number of narrowbands used for paging.
- **PDSCH-ConfigCommon:** Common configuration for PDSCH, from SIB2 messages.
  - **Pb:** The Pb parameter determines the relative power of data subcarriers in symbols containing reference signals and other symbols. With the wrong Pb parameter, different symbols can have different constellation scaling. You can visualize it in WaveJudge by applying the constellation chart to "Selection" and select one symbol only.
  - **pdsch-maxNumRepetitionCEmodeA-r13:** Maximum value to indicate the set of PDSCH repetition numbers for CE mode A.
  - **pdsch-maxNumRepetitionCEmodeB-r13:** Maximum value to indicate the set of PDSCH repetition numbers for CE mode B.
  - **ReferenceSignalPower:** Reference Signal Power is the power in dBm per RE of single channel.
- **PRACH-Config:** Configuration for PRACH, from SIB2 messages.
  - **HighSpeedFlag:** "True" corresponds to Restricted set. "False" corresponds to Unrestricted set
  - **mpdcch-startSF-CSS-RA-r13:** Starting subframe configuration for M-PDCCH common search space (CSS), including RAR, Msg3 retransmission, PDSCH with contention resolution and PDSCH with RRCConnectionSetup.
  - **PRACH_Config_v14xy:**
    - **Configured:** Indicates whether PRACH_Config_v14xy is configured or not.
    - **prach-ConfigIndexHighSpeed-r14:** Prach configuration index for the performance enhancement restricted set in high speed scenario. Taking value from 0 to 63.
    - **prach-FreqOffsetHighSpeed-r14:** Prach starting RB index for the performance enhancement restricted set in high speed scenario. Taking value from 0 to 94.
    - **rootSequenceIndexHighSpeed-r14:** This field indicates starting logical root sequence index used to derive the 64 random access preambles based on performance enhancement restricted set in high speed scenario. Taking value from 0 to 837.
    - **zeroCorrelationZoneConfigHighSpeed-r14:** This field indicates NCS configuration for the performance enhancement restricted set in high speed scenario. Taking value from 0 to 12.
  - **prach-ConfigIndex:** PRACH configuration index, from 0 to 63, schedules the PRACH regions.
  - **Prach-FreqOffset:** Parameter: prach-FrequencyOffset, from 0 to 94.

    - **PRACH-ParametersListCE-r13:** Configures PRACH parameters for each CE level.
    - **RootSequenceIndex:** Parameter: RACH_ROOT_SEQUENCE, from 0 to 837.
    - **ZeroCorrelationZoneConfig:** Parameter: N CS configuration, from 0 ro 15.
- **PUCCH-Config-Common:** Common configuration fro PUCCH, from SIB2 messages.
    - **DeltaPUCCH-Shift:** Space between PUCCH formats 1/1a/1b cyclic shifts. Takes the values 1, 2, or 3.
    - **n1PUCCH-AN:** N PUCCH (1), used to schedule HARQ ACK/NACK.
    - **n1PUCCH-AN-InfoList-r13:** Starting offset of the PUCCH resource(s) indicated by SIB1-BR. The first entry in the list is the starting offset of the PUCCH resource(s) of CE level 0, the second entry in the list is the starting offset of the PUCCH resource(s) of CE level 1, and so on.
    - **nCS-AN:** N CS (1), number of cyclic shifts used for PUCCH formats 1/1a/1b in a resource block used for a mix of formats 1/1a/1b and 2/2a/2b.
    - **nRB-CQI:** N RB(2), number of resource blocks reserved for PUCCH formats 2/2a/2b.
    - **PUCCH-ConfigCommon-BR:** PUCCH-ConfigCommon for BL/CE UE.
        - **DeltaPUCCH-Shift:** Speace between PUCCH formats 1/1a/1b cyclic shifts. Takes the values 1, 2, or 3.
        - **n1PUCCH-AN:** N PUCCH (1), used to schedule HARQ ACK/NACK.
        - **nCS-AN:** N CS (1), number of cyclic shifts for PUCCH formats 1/1a/1b in a resource block used for a mix of formats 1/1a/1b and 2/2a/2b.
        - **nRB-CQI:** N RB(2), number of resource blocks reserved for PUCCH formats 2/2a/2b.
    - **pucch-NumRepetitionCE-Msg4-Level0-r13:** Number of repetitions for PUCCH carrying HARQ response to PDSCH containing Msg4 for PRACH CE level 0.
    - **pucch-NumRepetitionCE-Msg4-Level1-r13:** Number of repetitions for PUCCH carrying HARQ response to PDSCH containing Msg4 for PRACH CE level 1.
    - **pucch-NumRepetitionCE-Msg4-Level2-r13:** Number of repetitions for PUCCH carrying HARQ response to PDSCH containing Msg4 for PRACH CE level 2.
    - **pucch-NumRepetitionCE-Msg4-Level3-r13:** Number of repetitions for PUCCH carrying HARQ response to PDSCH containing Msg4 for PRACH CE level 3.
- **PUSCH-Config-Common:** Common configuration for PUSCH, from SIB2

messages.

  - **cyclicShift:** Integer from 0 to 7, used to determine n DMRS (2)
  - **enable64QAM:** Indicates 64QAM modulation PUSCH allowed for UE categories 5 and 8 (TS 36.306).
  - **enable64QAM-v1270:** Indicates that 64QAM is allowed for UL categories indicated in ue-CategoryUL, which support UL 64QAM but cannot fallback category 5 or 8 (TS 36.306).
  - **Group Assignment PUSCH:** DELTA SS
  - **Group Hopping Enabled:** Used to generate reference signals.
  - **Hopping Mode:** Frequency Hopping parameter: Hopping Mode can be inter-subframe or intra-and-inter-subframe.
  - **n-SB:** Frequency Hopping parameter: Number of subbands, from 1 to 4.
  - **pusch-HoppingOffset:** Frequency Hopping parameter: Pusch hopping offset, from 0 to 98.
  - **pusch-maxNumRepetitionCEmodeA-r13:** Maximum value to indicate the set of PUSCH repetition numbers for CE mode A.
  - **pusch-maxNumRepetitionCEmodeB-r13:** Maximum value to indicate the set of PUSCH repetition numbers for CE mode B.
  - **Sequence Hopping Enabled:** Used for generation of the reference signals.
- **RACH-Config-Common:** Common configuration for RACH, from SIB2 messages.
  - **maxHARQ-Msg3Tx:** Maximum number of Msg3 HARQ transmissions in TS 36.321, used for contention based random access.
  - **numberOfRA-Preambles:** Number of non-dedicated random access preambles in TS 36.321.
  - **RACH-CE-LevelInfoList-r13:** The list of RACH-CE-LevelInfo-r13.
- **Sidelink-Config-Common:** Common configuration for Sidelink Channels, from SIB18/SIB19/SIB21/MIB_SL messages
  - **Discovery Reception Pool Config List:** The list specifies the configuration information for each individual pool of resources for sidelink discovery reception.
  - **Discovery Transmission Pool Config List:** The list specifies the configuration information for each individual pool of resources for sidelink discovery transmission.
  - **InCoverage-r12:** Value 'True' indicates that the UE transmitting the MasterInformationBlock-SL is in E-UTRAN coverage
  - **Sidelink Bandwidth:** Sidelink ransmission bandwidth configuration. n6 corresponds to 6 resource blocks, n15 to 15 resource blocks and so on.
  - **SL-V2X-ConfigCommon-r14:** The common configuration for V2X communication defined in SIB-21.

            - **v2x-CommonRxPool-r14:** V2X Communication Resource Pool List of SL - CommResourcePoolv2x-r14
        - **TDD Configuration:** Time Division Duplexing
    - **soundingsRS-UL-Config-Common:** Common configuration for uplink sounding reference signals, from SIB2 messages.
        - **ackNackSRS-SimultaneousTransmission:** Whenever set to false, SRS transmissions cannot be sent in the the same subframe as ACK/NACK or positive SR.
        - **setup:** Setup or Release sounding
        - **Srs_MaxUpPts:** Determines whether SRS is transmitted in all possible RBs of UpPTS symbols in LTE TDD
        - **srs-BandwidthConfig:** Determines the bandwidth reserved for sounding, takes integer values from 0 to 7.
        - **srs-SubframeConfig:** Determines the subframes reserved for sounding, takes integer values from 0 to 15.
    - **UL-CyclicPrefixLength:** Uplink cyclic prefic length can be Normal or Extended.

SIB1-BR: Collection of parameters set in SIB1-BR messages.

- **bandwithReducedAccessRelatedInfo-r13:** Access related information for BL UEs and UEs in CE.
    - **fdd-DownlinkOrTddSubframeBitmapLC Length:** The bitmap length can be 10 or 40 bits. Value 0 indicates the downlink bitmap is not present.
    - **fdd-DownlinkOrTddSubframeBitmapLC-r13:** The set of valid subframes for FDD downlink or TDD transmissions.
    - **fdd-UplinkSubframeBitmapLC-r13:** The set of valid subframes for FDD uplink transmissions for BL UEs.
    - **si-HoppingConfigCommon-r13:** Options are On or Off.
    - **si-RepetitionPattern-r13:** Indicates the radio frames within the SI window used for SI message transmission.
    - **si-WindowLength-BR-r13:** Common SI scheduling window for all SIs.
    - **startSymbolLC-r13:** For BL and UEs in CE, indicates the OFDM starting symbol for any MPDCCH, PDSCH scheduled on the same cell except the PDSCH carrying SystemInformationBlockType1-BR.
- **schedulingInfo:** Indicates scheduling information of SI messages.

TDD-Config: Collection of parameters used to specify the TDD specific physical channel configuration.

- **specialSubframePatterns for SRS with ssp10:** Indicates specialSubframePatterns for SRS when specialSubframePattern is ssp10.
- **specialSubframePatterns-v1450:** Indicates if ssp10-CRS-LessDwPTS is configured for specialSubframePatterns 10.

UE List: List of UE specific parameters: N_RNTI, UE category, ConfigDedicated from RRC messages (RRCConnectionSetup), RRCConnectionReconfiguration and RRCConnectionReestablishment).

- **0:**
  - **ConfigDedicated:** Collection of UE specific configuration parameters.
    - **AntennaInfoDedicated:** UE specific antenna information.
      - **alternativeCodebookEnabledForTX-r12:** Indicates whether alternative code book is being used for deriving CSI feedback and reporting.
      - **maxLayersMIMO:** Indicates the maximum number of layers for spatial multiplexing used to determine the rank indication bit width and Kc determination of the soft buffer size for the corresponding serving cell.
      - **Transmission Mode:** Points to one of Transmission modes defined in TS 36.213, from 1 to 9.
      - **ue-TransmitAntennaSelection mode:** The field indicates whether UE transmit antenna selection control is closed-loop or open-loop.
      - **ue-TransmitAntennaSelection setup:** Setup or Release ue-TransmitAntennaSelection.
    - **AntennaInfoUL:** Specifies the UL antenna configuration.
      - **fourAntennaPortActivated-r10:** Parameter indicates if four antenna ports are used.
      - **transmissionModeUL-r10:** Points to one of UL transmission modes defined in TS 36.213, from 1 to 2.
    - **CE Level:** CE level for BL/CE UE. Takes value 0 or 1 for CeModeA, or takes value 2 or 3 for CeModeB.
    - **CeMode_r13:** Indicates the CE mode as specified in TS 36.213. Takes values of CE-ModeA or CE_ModeB.
    - **ce-pdsch-pusch-enhancementConfig-r14:** Indicates FeMTC support is configured or not.
    - **CIF-Presence:** The field is used to indicate whether carrier indicator field is present (value TRUE) or not (value FALSE) in PDCCH DCI formats.
    - **CQI-Report-Config:** Channel Quality Indication Report Config
      - **altCQI-Table-1024QAM-r15:** Indicates the applicability of the tables supporting 1024-QAM.
      - **altCQI-Table-r12:** Indicates the applicability of the tables supporting 256-QAM.
      - **CQI-ReportAperiodic-r10 setup:** Setup or Release CQI-ReportAperiodic-r10.

- **CQI-ReportAperiodic-r10 trigger1:** Indicates for which serving cell(s) the aperiodic CSI report is triggered when one or more SCells are configured. Trigger1 corresponds to the CSI request field 10; trigger2 corresponds to the CSI request field 11. Each bit has either value 0 (means no aperiodic CSI report is triggered) or value 1 (means the aperiodic CSI report is triggered). At most, 5 bits can eb set to value 1 in the bit string. One value applies for all serving cells (the associated functionality is common, i.e., not performed independently for each cell).
- **CQI-ReportAperiodic-r10 trigger2:** Indicates for which serving cell(s) the aperiodic CSI report is triggered when one or more SCells are configured. Trigger1 corresponds to the CSI request field 10; trigger2 corresponds to the CSI request field 11. Each bit has either value 0 (means no aperiodic CSI report is triggered) or value 1 (means the aperiodic CSI report is triggered). At most, 5 bits can eb set to value 1 in the bit string. One value applies for all serving cells (the associated functionality is common, i.e., not performed independently for each cell).
- **cqi-ReportModeAperiodic:** Aperiodic CQI/PMI/RI reporting mode. Value rm12 corresponds to Mode 1-2; m20 corresponds to Mode 2-0; rm22 corresponds to Mode 2-2, etc. PUSCH reporting modes are described in TS 36.213.
- **csi-ConfigIndex setup:** Setup or Release csi-ConfigIndex.
- **csi-MeasSubframeSet1-r10:** Subframe pattern set 1.
  - Bits 0-31: 32 bits MSB
  - Bits 32-63: 32 bits MSB
  - Bits 64-70: 6 bits MSB
- **csi-MeasSubframeSet2-r10:** Subframe pattern set 2.
  - Bits 0-31: 32 bits MSB
  - Bits 32-63: 32 bits MSB
  - Bits 64-70: 6 bits MSB
- **csi-SubframePatternConfig-r10 Setup:** Controls whether subframe patterns for CSI are configured or not.
- **NomPDSCH_RS_EPRE_Offset:** Parameter Delta offset in TS 36.213, section 7.2.3. Actual value = IE value * 2 [dB].
- **Periodic cqi_FormatIndicatorPeriodic:** Parameter: PUCCH CQI Feedback Type, in TS 36.213, table 7.2.2-1. Depending on transmissionMode, reporting mode is implicitly given from the table.
- **Periodic cqi_PUCCH_ResourceIndex:** Parameter n(2)

PUCCH in TS 36.213.

- **Periodic cqi_pmi-ConfigIndex:** Parameter: CQI/PMI Periodicity and Offset Configuration Index.
- **Periodic cqi_pmi-ConfigIndex2:** Parameter: CQI/PMI Periodicity and Offset Configuration Index.
- **Periodic csi_ReportMode-r10:** Parameter: PUCCH_format1-1_CSI_reporting_mode
- **Periodic PTI Value:** Last value of the periodic PTI value.
- **Periodic RI option:** Indicates whether RI is included in the periodic report or not.
- **Periodic ri-ConfigIndex:** Parameter: RI Config Index I RI, in TS 36.213.
- **Periodic ri-ConfigIndex2:** Parameter: CQI/PMI Periodicity and Offset Configuration Index.
- **Periodic simultaneousAckNackAndCQI:** Simultaneous-AN-and-CQL, in TS 36.213, section 10.1. The value Tru indicates that simultaneous transmission of ACK/NACK and CQI is allowed.
- **Periodic simultaneousAckNackAndCQI-Format3-r11:** Indicates that the UE shall perform simultaneous transmission of HARQ A/N and periodic CQI report multiplexing on PUCCH format 3.
- **Periodic subbandCQI:** Parameter K in TS36.213 used when the periodic reporting mode is subband CQI.
- **periodicityFactor:** Parameter: H' used in the computation of the wideband first precoding matrix indicator report period, when PTI is 0.
- **pmi-RI-Report:** This field configured PMI/RI reporting. EUTRAN configures this field only when transmissionMode is set to tm8, tm9, or tm10.
- **setup:** Setup or Release periodic CQI.

- **CSI-RS-Config:** Channel state information reference signals configuration.
  - **Antenna Ports Count:** Parameter represents the number of antenna ports used for transmission of CSI reference signals where an1 corresponds to 1; an2 corresponds to 2 antenna ports, etc.
  - **DS zero TxPowerCSI RS List:** Parameter for additional zeroTxPowerCSI-RS for a serving cell, concerning the CSI-RS included in discovery signals.
  - **NZP-FrequencyDensity-r14:** Indicates the frequency-

domain density reduction.

- NZP-TransmissionComb-r14: Indicates the transmission combining offset.
- P-C: The parameter P-C is the assumed ration of PDSCH EPRE to CSI_RS EPRE when UE derives CSI feedback.
- Resource Config: CSI referene signal configuration, used for mapping to resource elements.
- Setup: Setup or Release CSI
- Subframe Config: CSI reference signal subframe configuration.
- Zero TxPower Resource Config List: For each bit set to one in the 16-bit bitmap ZeroPower CSI-RS configured by higher layers, the UE shall assume zerotransmission power for the resource elements corresponding to the CSI reference signals. The most significant bit corresponds to the lowest CSI reference signal configuration index and subsequent bits in the bitmap correspond to configurations with indices in increasing order.
- Zero TxPower Setup: Setup or Release ZeroTxPower
- Zero TxPower Subframe Config: CSI reference signal subframe configuration, for qhich the UE shall assume zero transmission power.

- CSI-RS-ConfigNZP-r11 List: List of CSI-RS resource configurations, for which UE assumes non-zero transmission power.
- CSI-RS-Config-v1310: Channel state information reference signals configuration for enhanced MIMO.
  - CSI_RS_ConfigNonPrecoded_r13: CSI RS Configuration for eMIMO Class A.
    - cdmType-r13 and cdmType-r1430: CDMType for CSIRS configuration.
    - nzp-resourceConfigList-r13: The number of resources that may be additionally combined.
  - CSI_RS_ConfigBeamformed-r13: CSI RS Configuration for eMIMO Class B.
  - Setup: Setup or Release eMIMO Type-r13.
- CSI-RS-ConfigZP-rll List: List of CSI-RS resource configurations, for which UE assumes non-zero transmission power.
- EPDCCH-Config-r11: Specifies the subframes and resouce blocks for EPDCCH monitoring.

    - **setConfigList-r11:** List of EPDCCH configuration sets.
    - **Setup:** Setup or release EPDCCH.
    - **startSymbol-r11:** Indicates the OFDM starting symbol for any EPDCCH and PDSCH scheduled by EPDCCH on the same cell.
    - **subframePattern-r11:** Configures the subframes which the UE shall monitor the UE-specific search space on EPDCCH.
        - **Bits 0-31:** 32 bits MSB
        - **Bits 32-63:** 32 bits MSB
        - **Bits 64-70:** 6 bits MSB
    - **subframePattern-r11 Setup:** Setup or release the subframe pattern configuration.
- **LAA_SCell_Config:**
    - **SubframeAllocation:** "1" denotes that the corresponding subframe is allocated for MBSFN. The following mapping applies: The first/leftmost bit defines the MBSFN allocation for subframe #1, the second bit for #2, the third bit for #3, fourth bit for #4, fifth bit for #6, sixth bit for #7, seventh bit for #8, eighth bit for #9.
    - **SubframeStartPosition:** Indicates possible starting position of transmission in the first subframe of the DL transmission burst (s0 normal; s07 can be either Normal or Slot Boundary).
- **MAC-MainConfig:** MAC main configuration. Specifies the MAC main configuration for signalling and data radio bearers.
    - **DRX-Config:** DRX Configuration as specified in TS 36.321.
        - **drx-InactivityTimer:** Specifies the number of consecutive PDCCH-subframe(s) after the subframe in which a PDCCH indicates an initial UL or DL user data transmission for this UE.
        - **drx-RetransmissionTimer:** Specifies the maximum number of consecutive PDCCH-subframe(s) for as soon as a DLretransmission is expected by the UE.
        - **drxShortCycleTimer:** Specifies the number of consecutive subframe(s) the UE shall follow the Short DRX cycle.
        - **longDRX-Cycle:** Specifies the DRX circles length in number of subframes. If shortDRX-Cycle is configured, the value of longDRX-Cycle shall be a multiple of the shortDRX-Cycle value.
        - **onDurationTimer:** Specifies the number of

consecutive PDCCH-subframe(s) at the beginning of a DRX cycle.

      - **Setup:** Setup or release DRX.
      - **shortDRX-Cycle:** Short DRX cycle as specified in TS 36.321. Value in number of sub-frames. Short DRX cycle is not configured for UEs in CE.
      - **StartOffset:** Specifies the subframe where the DRX Cycle starts.
    - **MaxHARQ-Tx:** Maximum number of transmissions for UL HARQ.
    - **shortTTI-Config-r15:** Configuration for shortened Transmission Time Interval (TTI) and processing time for LTE.
      - **dl-TTI-Length-r15:** Indicates the DL short TTI lengths. Value slot corresponds to 7 OFDM symbols and value subslot correspond to 2 or 3 OFDM symbols.
      - **proc-TimeAdv-r15:** Minimum processing time for subslot TA. The UE can indicate support for n+4 and/or n+6 for set 1 and/or n+6, or n+8 for set 2, depending on the SPDCCH configuration.
      - **Setup:** Setup or Release Short TTI Configuration
      - **ul-TTI-Length-r15:** Indicates the UL short TTI lengths. Value slot corresponds to 7 OFDM symbols and value subslot correspond to 2 or 3 OFDM symbols.
    - **skipUplinkTxDynamic-r14:** If configured, the UE skips UL transmissions for an uplink grant other than a configured uplink grant if not data is available for transmission.
    - **skipUplinkTxSPS-r14:** If configured, the UE skips UL transmissions for a configured uplink grant if not data is available for transmission.
    - **ttiBundling:** True indicates that TTI bundling TS 36.321 is enabled while False indicates that TTI bundling is disabled.
  - **MeasSubframePatternPCell-r10:** Time domain measurement resource restriction pattern for the PCell measurements (RSRP, RSRQ, and the radio link monitoring).
    - **MeasSubframePattern-r10:** Time domain measurement resource restriction pattern for the PCell measurements (RSRP, RSRQ, and the radio link monitoring).
      - **Bits 0-31:** 32 bits MSB
      - **Bits 32-63:** 32 bits MSB

        - **Bits 64-70:** 6 bits MSB
    - **Setup:** Setup or Release MeasSubframePatternPCell-r10
- **PDSCH-ConfigDedicated:** UE specific PDSCH configuration
    - **AltMCS-TableScalingConfig-r15:** Presence of the field indicates activation fo 6-bit MCS table for UE indicating support for altMCS-Table. The indicated value configures the parameter altMCS-Table-Scaling.
    - **ce-HARQ-AckBundling-r14:** Activation of PDSCH HARQ-ACK bundling in half-duplex FDD in CE mode A.
    - **ce-pdsch-maxBandwidth-config-14:** Maximum PDSCH channel bandwidth in CE mode A and B. Value bw5 corresponds to 5 MHz; value bw20 corresponds to 20 MHz. If this field is not configured, the maximum PDSCH channel bandwidth in CE mode A and B is set to 1.4 MHz.
    - **ce-PDSCH-TenProcesses-r14:** Configuration of 10 (instead of 8) DL HARQ processes in FDD in CE mode A.
    - **ce-SchedulingEnhancement-r14:** Activation of dynamic HARQ-ACK delay for PDSCH in CE mode A controlled by the DCI. Value range1 corresponds to the first range of HARQ-ACK delays, and value range2 corresponds to second range of HARQ-ACK delays.
    - **DMRS-Config-r11 scramblingIdentity2-r11:** Parameter used for TM1 10.
    - **DMRS-Config-r11 scramblingIdentity-r11:** Parameter used for TM 10.
    - **DMRS-Config-r11 setup:** Setup or Release DMRS-Config-r11.
    - **dmrs-tableAlt-r13 setup:** Setup or Release dmrs-tableAlt-r13.
    - **p-a:** Parameter: P A, in TS 36.213 section 5.2. Value dBneg6 corresponds to -6dB; dBneg4dot77 corresponds to -4.77 dB, etc.
    - **Qcl-Operation:** Quasi-Colocation (QCL) operation
    - **re-MappingQCLCOnfigList-r11:** List of sets of PDSCH parameters related to resource element mapping and quasi co-location.
    - **slotOrSubslotPDSCH-Config-r15:** Parameter indicates resource allocation type for slot-PDSCH or subslot-PDSCH.
    - **tbsIndexAlt2-r14:** Indicates the applicability of the alternative TBS index for ITBS 33B to all subframes scheduled by DCI format 1/1B/2/2A.

  - **tbsIndexAlt3-r15:** Indicates the applicability of the alternative TBS index for the ITBS 37A to all subframes scheduled by DCI format 2C/2D.
  - **tbsIndexAlt-r12:** Indicates the applicability of the alternative TBS index for the ITBS 26 and 33 to all subframes scheduled by DCI format 2C or 2D. Value a26 refers to the alternative TBS index ITBS 26A; a value of a33 refers to the alternative TBS index ITBS 33A.
- **PUCCH-ConfigDedicated:** UE specific PUCCH configuration.
  - **AckNackRepetition Setup:** AckNackRepetition Setup or Release.
  - **ChannelSelection n1PUCCH-AN-CS-List:** Parameter n_ PUCCH for antenna port p0 for PUCCH format 1b with channel selection as specified in TS 36.213 clause 10.1.2.2.1 and 10.1.3.2.1.
  - **ChannelSelection Setup:** ChannelSelection Setup or Release.
  - **codebooksizeDetermination-r13:** Indicates whether HARQ codebook size is determined with downlink assignment indicator based solution or number of configured CCs.
  - **n1PUCCH-AN-Rep:** AckNackRepetition Parameter n PUCCH, ANRep in TS 36.213 for antenna port P0.
  - **n1PUCCH-AN-RepP1-r10:** AckNackRepetition Parameter n PUCCH, ANRep in TS 36.213 for antenna port P0.
  - **n1PUCCH-AN-ListP1-r10:** Parameter n_PUCCH for antenna port P1 for PUCCH format 3 as specified in TS 36.213 Clause 10.1
  - **n1PUCCH-AN-List-r10:** Parameter n_PUCCH for antenna port P0 for PUCCH format 3 as specified in TS 36.213 Clause 10.1
  - **n1PUCCH-Identity-r11:** Parameter n_ID_PUCCH defined in TS 36.211 Clause 5.5.1.5
  - **Pucch_Format4_r13:** Defines whether PUCCH format 4, as specified in TS 36.213, is supported by the UE.

    Collection of parameters for PUCCH format 4.
    - **format4-resourceConfiguration_r13:** Specify an array of 4 frequency resources allocated for PUCCH format 4.
    - **Setup:** Setup or Release Pucch-Format4-r13.
  - **Pucch_Format5_r13:** Defines whether PUCCH format 5, as specified in TS 36.213, is supported by the UE. Collection of

parameters for PUCCH format 5.

  - **format5_resourceConfiguration_r13:** Specifies an array of 4 frequency resources allocated for PUCCH format 5.
  - **Setup:** Setup or Release Pucch-Format5-r13.
- **Pucch_Format_r10:** Format3 or channel selection.
- **pucch-NumRepetisionCE-r13:**
  - **ModeA pucch-NumRepetitionCE-format1-r13:** Number of PUCCH repetitions for PUCCH format 1/1a in CE mode A.
  - **ModeA pucch-NumRepetitionCE-format2-r13:** Number of PUCCH repetitions for PUCCH format 2/2a/2b in CE mode A.
  - **ModeB pucch-NumRepetitionCE-format1-r13:** Number of PUCCH repetitions for PUCCH format 1/1a in CE mode B.
  - **ModeB pucch-NumRepetitionCE-format2-r13:** Number of PUCCH repetitions for PUCCH format 2/2a/2b in CE mode B.
  - **Setup:** Setup or Release pucch-NumRepetitionCE-r13.
- **RepetitionFactor:** AckNackRepetition Parameter N ANRep in TS 36.213, where n2 corresponds to repetition facgtor 2, n4 to 4, n6 to 6.
- **simultaneousPUCCH-PUSCH-r10:** Parameter indicates whether simultaneous PUCCH and PUSCH transmission is configured.
- **spatialBundlingPUCCH-r13:** Indicates whether spatial bundling is enabled or not for PUCCH as specified in TS 36.212 Clause 5.2.3.1.
- **spatialBundlingPUSCH-r13:** Indicates whether spatial bundling is enabled or not for PUSCH as specified in TS 36.212 Clause 5.2.2.6.
- **tdd-AckNackFeedbackMode:** Parameter indicates one of the two TDD ACK/NACK feedback modes used, see TS 36.213 section 7.3 bundling corresponds to use of ACK/NACK bundling whereas, multiplexing corresponds to ACK/NAK multiplexing. The same value applies to both ACK/NACK feedback modes on PUCCH as well as PUSCH. For TDD configuration 5, E-UTRAN should always set this field to bundling.
- **twoAntennaPortActivatePUCCH-Format1a1b-r10:**

Indicates whether two antenna ports are configured for PUCCH format 1a/1b for HARQ-ACK.

    - twoAntennaPortActivatePUCCH-Format3-r10: Indicates whether two antenna ports are configured for PUCCH format 3 for HARQ-ACK as specified in TS 36.213 Clause 10.1

- PUSCH-ConfigDedicated: UE specific PUSCH configuration.
    - betaOffset-ACK-Index: Parameter I HARQ-ACK offset in TS 36.213 takes integer values from 0 to 15.
    - betaOffset-CQI-Index: Parameter I CQI offset in TS 36.213 takes integer values from 0 to 15.
    - betaOffset-RI-Index: Parameter I RI offset in TS 36.213 takes integer values from 0 to 15.
    - ce-pusch-nb-maxTbs-config-r14-On: Indicates the activation of 2984 bits maximum PUSCH TBS in 1.4MHz in CE mode A.
    - dmrs-WithOCC-Activated-r10: Parameter: Activate-DMRS-with OCC, controls the orthogonal cover code for the uplink demodulation reference signal.
    - enable256QAM-r14: Indicates 256QAM is allowed for UE UL categories 16 to 20 indicated in ue-CategoryUL-v14xy.
        - dci-Format0-r14: Indicates 256QAM is allowed for DCI format 0 and tpc subframe set 1, if uplink power control subframe sets are not configured by tpc-SubframeSet.
        - dci-Format4-r14: Indicates 256QAM is allowed for DCI format 4 and tpc subframe set 1, if uplink power control subframe sets are not configured by tpc-SubframeSet.
        - Setup: Setup or Release for 256QAM for UE UL categories 16 to 20 indicated in ue-CategoryUL-v14xy.
        - subframeSet1-DCI-Format0-r14: Indicates 256QAM is allowed for DCI format 0 and tpc subframe set 1, if uplink power control subframe sets are configured by tpc-SubframeSet.
        - subframeSet1-DCI-Format4-r14: Indicates 256QAM is allowed for DCI format 4 and tpc subframe set 1, if uplink power control subframe sets are configured by tpc-SubframeSet.
        - subframeSet2-DCI-Format4-r14: Indicates 256QAM is allowed for DCI format 4 and tpc subframe set 2, if

uplink power control subframe sets are configured by tpc-SubframeSet.

        - **subframeSet2-DCI-Format0-r14:** Indicates 256QAM is allowed for DCI format 0 and tpc subframe set 2, if uplink power control subframe sets are configured by tpc-SubframeSet.
        - **tpc-SubframeSet-Configured-r14:** Indicates if uplink power control subframe sets are configured by tpc-SubframeSet or not.
    - **groupHoppingDisabled-r10:** Parameter: Disable-sequence-group-hopping can disable sequence hopping for PUSCH even if it is enabled on a cell basis.
    - **PUSCH r11-r14:** Collection of dedicated PUSCH configuration parameters introduced from Rel-11 to Rel-14.
        - **nDMRS-CSH-Identity-r11:** Parameter N_ID_csh_DMRS defined in TS 36.211 Clause 5.5.2.1.1.
        - **nPUSCH-Identity-r11:** Parameter N_ID_PUSCH defined in TS 36.211 Clause 5.5.1.5.
        - **TDD-PUSCH-UpPTS-r14:** Configuration parameters for PUSCH in UpPTS.
    - **pusch-EnhancementsConfig-r14:** Indicates that the UE shall transmit in the PUSCH enhancement mode, if setup.
    - **pusch-HoppingConfig-r13:** For BL UEs and UEs in CE, frequency hopping activation/deactivation for unicast PUSCH.
    - **ul-DMRS-IFDMA-r14:** Indicates whether the UE is configured with enhanced UL DMRS.
- **SCell List:** SCell List, for Carrier Aggregation.
- **SchedulingRequestConfig:** Scheduling Request configuration.
    - **DSR-TransMax:** parameter for SR transmission in TS 36.321. The value n4 corresponds to 4 transmissions; n8 corresponds to 8 transmissions, etc.
    - **setup:** Setup or release scheduling request.
    - **SR-ConfigIndex:** Parameter I SR from 0 to 157, in TS36.213.
    - **SR-PUCCH_ResourceIndex:** Parameter n PUCCH, SRI in TS 36.213.
- **SL-DiscConfig-r12:** Specifies the dedicated configuration information for sidelink direct discovery.
    - **DiscTF_IndexList_r12:** List of Disc_TF_Index_Pair_r12
    - **Setup:** Setup or release discTxResources_r12.
    - **SL_HoppingConfigDisc_r12:** Indicates the hopping

configuration used for sidelink

        - **a_r12**: Per cell parameter N_PSDCH_(1) defined in TS 36.213 Clause 14.3.1, taking value from 1 to 200.
        - **b_r12**: Per UE parameter N_PSDCH_(2) defined in TS 36.213 Clause 14.3.1, taking value from 1 to 10.
        - **c_r12**: Per cell parameter N_PSDCH_(3) defined in TS 36.213 Clause 14.3.1, taking value from 1 to 5.
    - **UE dedicated Discovery Transmission Pool Config List:** Specifies the transmission Pool list of the dedicated configuration information for sidelink discovery
- **SL-V2X ConfigDedicated:** Indicates sidelink confifguration for V2X sidelink communication
    - **commTxResouces-r14:** Configuration for the V2X transmission resources for the UE.
        - **List of SL-CommResourcePoolV2X-r14:** V2X Communication Resource Pool List of SL-CommResourcePoolv2X-r14 for this UE.
        - **setup:** Setup or release commTxResources-r14.
        - **sl-V-RNTI-r14:** Indicates the RNTI used for DCI dynamically scheduling sidelink resources for V2X sidelink communication.
    - **Setup:** Setup or release of SL-V2X ConfigDedicated-r14.
- **SoundingsRS-UL-ConfigDedicated:** UE specific Sounding Reference Signal Uplink configuration
    - **CyclicShift:** Parameter n SRS from 0 to 11, for periodic sounding reference signal in TS 36.211.
    - **Duration:** "False" corresponds to single, and value "true" to indefinite, in TS 36.213.
    - **FreqDomainPosition:** Parameter n RRC from 0 to 23, for periodic sounding reference signal in TS 36.211.
    - **Setup:** Setup or release sounding
    - **SRS-Bandwidth:** Parameter B SRS = 0, 1, 2, 3, for periodic sounding reference signal in TS 36.211.
    - **SRS-ConfigIndex:** Parameter I SRS for periodic sounding reference signal in TS 36.213.
    - **SRS-HoppingBandwidth:** Parameter b hop = 0, 1, 2, 3 in TS 36.211.
    - **srs-UpPtsAdd-r13:** Configuration of srs-UpPtsAdd-r13
    - **TransmissionComb:** Parameter k TC = 0 to 3, for periodic sounding reference signal in TS 36.211.

    - **transmissionCombNum-r13:** ParameterK-TC = 2 or 4, for periodic sounding reference signal in TS 36.211.
  - **SoundingsRS-UL-ConfigDedicatedAperiodic-r10:**
    - **setup:** Setup or Release aperiodic sounding
    - **SRS-ActivateAp-r10:** Controls the activation of aperiodic sounding reference signals triggered by DCI formats 0, 1A, 2B, 2C, 2D.
    - **SRS-ConfigApDCI-Format0-r10:** Parameters indicate the resource configurations for aperiodic sounding reference signal transmissions triggered by DCI format 0.
    - **SRS-ConfigApDCI-Format1a2b2c-r10:** Parameters indicate the resource configurations for aperiodic sounding reference signal transmissions triggered by DCI format 0.
      - **CyclicShift:** Parameter n SRS from 0 to 11, for aperiodic sounding reference in TS 36.211.
      - **FreqDomainPositionAp-r10:** Parameter n RRC from 0 to 23, for aperiodic sounding reference in TS 36.211.
      - **SRS-AntennaPortAp-r10:** Indicates the number of antenna ports for aperiodic sounding transmission.
      - **SRS-BandwidthAp-r10:** Parameter B SRS = 0, 1, 2, 3, for aperiodic sounding reference in TS 36.211.
      - **TransmissionCombAp-r10:** Parameter k TC = 0, 1, 2, or 3, for aperiodic sounding reference in TS 36.211.
      - **transmissionCombNum-r13:** Optional paramter K_TC = 2 or 4, for aperiodic sounding reference in TS 36.211.
    - **SRS-ConfigApDCI-Format4-r10:** Parameters indicate the resource configurations for aperiodic sounding reference signal transmission triggered by DCI format 4.
    - **SRS-ConfigIndexAp-r10:** Parameter I SRS for aperiodic sounding reference in TS 36.213.
    - **srs-UpPtsAdd-r13:** Configuration of srs-UpPtsAdd-r13 for aperiodic SRS.
    - **transmissionCombNum-r13:** Parameter K_TC - 2 or 4, for aperiodic sounding reference singal in TS 36.211.
  - **SPDCCH-Config-r15:** Specifies the UE specific SPDCCH configuration.
    - **al-StartingSCCE-forSPDCCH-r15:** Indicates the starting SCCE index for an aggregation level.
    - **dmrs-ScramblingSequenceInt-r15:** The DMRS scrambling sequence initialization parameter. Taking value 0 to 503.

    - **numberRB-InFreq-domain-r15:** INdicates the number of resource-blocks in the frequency domain used for the SPDCCH set. Takes values 2 to 100.
    - **rateMatchingMode-r15:** Indicates, per RB-set, the mode of sPDCCH rate-matching operation defined in TS 36.331.
    - **resourceBlockAssignment-r15:** Indicates the index to a specific combination of physical resource block in frequency for SPDCCH set. First entry for bit 0-63 and second entry for bit 64-98.
    - **Setup:** Setup or Releases Short TTI configuration.
    - **spdcch-L1-ReusedIndication-r15:** For the up to two RB sets configured with the same subframeType applicability, the SPDCCH-L1-ReuseIndication defines the allowed combinations for the two RB sets: {1,1}, {2,0}, or {0,2} corresponding to the values n0, n1, and n2, respectively. In case one RB set is configured, the allowed combination is {2}.
    - **spdcch-NoOfSymbols-r15:** Indicates the number of OFDM symbols that the CRS based SPDCCH is mapped over. Taking a value of 1 or 2.
    - **spdcch-SetConfigId-r15:** Indicates the ID of the SPDCCH set configured in SPDCCH-Config. Takes values 0 to 3.
    - **spdcch-SetRfeferenceSig-r15:** Indicates CRS or DMRS based SPDCCH set.
    - **subframeType-r15:** Indicates applicable subframe type(s) for the SPDCCH set. CRS based SPDCCH is only applied to non-MBSFN subframe.
    - **transmissionType-r15:** Indicates whether distributed or localized SPDCCH transmission mode is used.
- **SPS-Config:** Specifies the semi-persistent scheduling configuration.
    - **C_RNTI:** Semi-persistent Scheduling C-RNTI as defined in TS 36.321.
    - **DL n1_PUCCH_AN_PersistentList1:** First list of parameters of n_PUCCH_1 for antenna port P0 as specified in TS 36.213 Clause 10.1.
    - **DL n1_PUCCH_AN_PersistentList2:** Second list of parameters of n_PUCCH_1 for antenna port P0 as specified in TS 36.213 Clause 10.1.
    - **DL n1_PUCCH_AN_PersistentList3:** Third list of parameters of n_PUCCH_1 for antenna port P0 as specified in TS 36.213 Clause 10.1.

- **DL n1_PUCCH_AN_PersistentList4:** Fourth list of parameters of n_PUCCH_1 for antenna port P0 as specified in TS 36.213 Clause 10.1.
- **DL numberOfConfSPS_Processes:** The number of configured HARQ processes for downlink Semi-Persistent Scheduling defined in TS 36.321.
- **DL semiPersistSchedIntervalDL:** Semi-persistent scheduling interval in downlink as specified in TS 36.321, taking value in number of subframes.
- **DL setup:** Setup or release DL semi-persistent scheduling
- **fixedRV-NonAdaptive-r14:** If this field is present and skipUplink TxSPS is configured, non-adpative retransmissions on configured uplink grant uses redundancy version 0.
- **UL implicitReleaseAfter:** Number of empty UL transmissions before implicit release as specified in TS 36.321 Clause 5.10.2. If skipUplinkTxSPS is configured, the UE shall ignore this field.
- **UL p0_NominaPUSCH_Persistent:** Parameter P_O_ NOMINAL_PUSCH_(0) defined in TS 36.213 Clause 5.1.1.1 Step 1. This field is applicable for persistent scheduling only. If choice setup is used and p0-Persistent is absent, apply the value of p0-NominalPUSCH for p0-NominalPUSCH-Persistent.
- **UL p0_UE_PUSCH_Persistent:** Parameter P_O_UE_PUSCH P_(0) defined in TS 36.213 Clause 5.1.1.1. This field is applicable for persistent scheduling only. If choice setup is used and p0-Persistent is absent, apply the value of p0-UE-PUSCH for p0-UEPUSCH-Persistent.
- **UL semiPersistSchedIntervalUL:** Semi-persistent scheduling interval in uplink as specified in TS 36.321, taking value in number of subframes.
- **UL setup:** Setup or release UL semi-persistent scheduling
- **UL twoIntervalsConfig:** Trigger of two-intervals-Semi-Persistent Scheduling in uplink as specified in TS 36.321 Clause 5.10. If this field is present and the configured Semi-persistent scheduling interval greater than or equal to 10 subframes, two-intervals-SPS is enabled for uplink.

- **TPC-PDCCH-ConfigPUCCH:**
  - **Format:** DCI format 3 or 3A.
  - **Setup:** Setup or release TPC.
  - **TPC Index:** The parameter TPC-Index is provided by higher

layers. If UE has reached maximum power, positive TPC commands shall not be accumulated.

- **TPC RNTI:** RNTI used to transmit DCI 3/3A with TPC.

- **TPC-PDCCH-ConfigPUSCH:**
  - **Format:** TPC PDCCH configuration for PUSCH
  - **setup:** Setup or release TPC
  - **TPC Index:** The parameter TPC-Index is provided by higher layers. If UE has reached maximum power, positive TPC commands shall not be accumulated.
  - **TPC RNTI:** RNTI used to transmit DCI format 3/3A with TPC.

- – MeasConfig: The IE MeasConfig specifies measurements to be performed by the UE.
  - **MeasGapConfig:** Used to setup and release measurement gaps.
    - **Gap Pattern:** Gap Pattern ID.
    - **GapOffset:** Value gapOffset.
  - **MeasObjectEUTRAList:** The IE MeasObjectEUTRA specifies information applicable for intra-frequency or inter-frequency E-UTRA cells.
- – **RNTI:** Radio Network Temporary Identifier. .
  - **SL-Parameters:**
    - **sl-TxDiversity-r15:** INdicates whetehr the UE supports transmit diversity to V2X sidelink communication.
    - **ue-CategorySL-C-RX:** Reception capabilities for sidelink communication and V2X sidelink communication, taking values 1 to 4.
    - **ue-CategorySL-C-TX:** Transmission capabilities for sidelink communication and V2X sidelink communication, taking values 1 to 5.
- – **UE-Capability:** RRC message that UE sends to Network (in most case during initial registration process). It informs on all the details of its capabilities. Collection of messages used to transfer of UE radio access capabilities requested by the E-UTRAN as specified in TS 36.306.
  - **Category:** UE Category as defined in TS 36.306 Table 4.1.-1, taking values 1 to 12. When takng value 0, it denotes DL Category 0. When takng value 128, it denotes DL Category M1. When takng value 129, it denotes DL Category M2. Otherwise, this configuration is invalid and WaveJudge shall take UE category 5 as the default setting.
  - **Maximum number of CC:** Parameter derived from the supported band combinations. Editing this field will automatically populate the supported band combinaitions.
  - **SupportedBandCOmbination-r10:** Includes the supported CA band

combinations, if any, and may include all the supported non-CA bands.

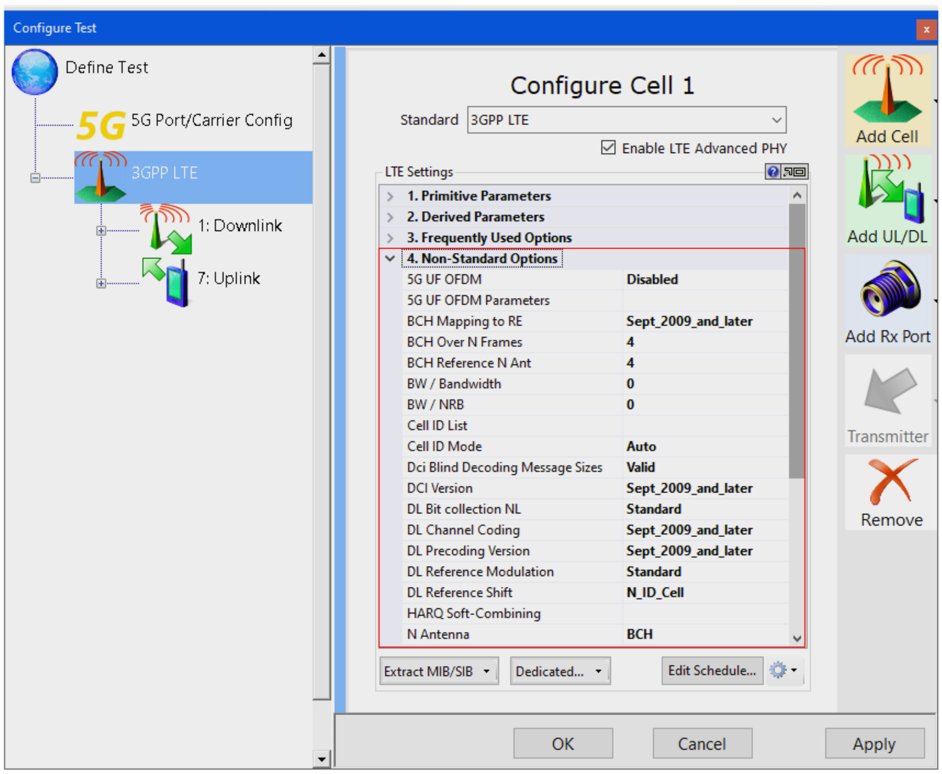
- **ue-CategoryDL:** The field ue-Category DL defines downlink capability.
- **ue-CategoryUL:** The field ue-CategoryUL defines uplink capability.

Use Bch MIB Info: When set to "On", automatically reads the number of PHICH groups and applies it to the right subframes.

Use DCI Scheduling Info: Use DCI info to schedule PDSCH and PUSCH automatically.

E. 4 Non-Standard Options

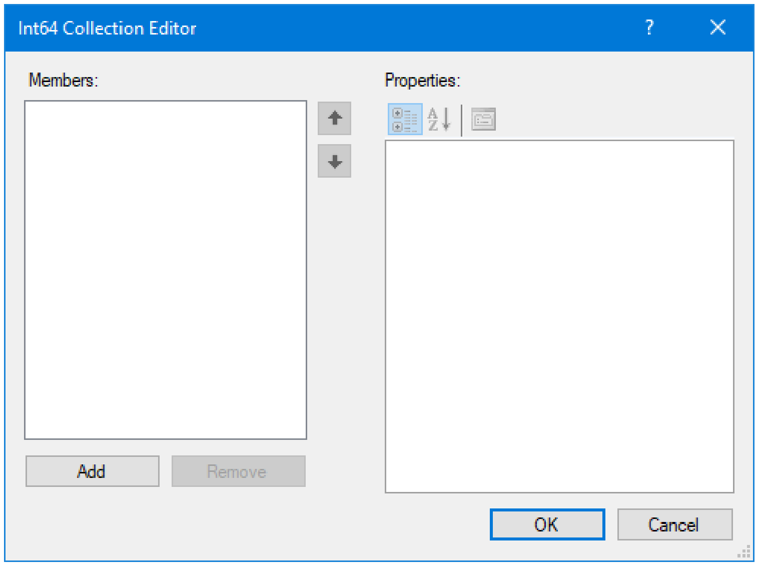
Below is the full list of LTE Settings definitions for section **4. Non-Standard Options** of the Configure Test window.



LTE Settings: Section 4. Non-Standard Options

5G UF OFDM: Enables 5G UFMC extensions to LTE; required corresponding license. Values are Enabled and Disabled.

5G UF OFDM Parameters: 5G UFMC extension parameters. Click the line item ellipse on right side to open the **Int64 Collection Editor.**



Int64 Collection Editor

BCH Mapping to RE: Version of TS 36.211 used for mapping BCH to Resource Elements. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

BCH Over N Frames: Number of frames over which BCH is sent.

BCH Reference N Ant: Number of antenna ports assumed when sending BCH.

BW / Bandwidth: Can be used to define non-standard bandwidths. It is recommended to leave it equal to 0.

BW / NRB: Can be used to define non-standard number of PRBs of the effective LTE BW when PRB Blanking is enabled for the cell. It is recommended to leave it equal to 0 if the value is not known.

Cell ID List: This list specifies the Cell IDs of cells to be analyzed or skipped if “Cell ID Mode” is set to “Equal” or “Different” respectively. It is ignored when “Cell ID Mode” is set to “Auto”. Click the line item ellipse on right side to open the **Int64 Collection Editor.**

Cell ID Mode: The default for this parameter is “Auto”. When set to “Equal”, only cells matching the specified “Cell ID List” are analyzed. When set to “Different”, only cells not matching the specified “Cell ID List” are analyzed. Dropdown list options are Auto, Equal, and Different.

Dci Blind Decoding Message Sizes: “Valid” is the default setting, instructing WaveJudge to detect only DCI messages with valid lengths. When “Dci Blind Decoding Message Size” is set to “All”, WaveJudge looks for DCI of any size, including invalid sizes. This was a useful feature when the LTE specs were changing and not everyone agreed on how to interpret the DCI sizes. If WaveJudge detects an invalid size, it reports is as “Unknown DCI format”. Dropdown menu options are “All” and “Valid”.

DCI Version: Version of TS.36.212 used for DCI detection. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

DL Bit collection NL: NL stands for “Number of Layers”, it is a parameter defined in TS 35.212, section “Bit collection, selection and transmission”. Dropdown menu options are: Standard, NLayerPerBLock, NLayerTotal, _1, and _2. The options “Standard” and “NLayerPerBlock” are equivalent and conform to TS 36.212. The options “_1” and “_ 2” can force NL to be statically set to 1 and 2 respectively.

DL Channel Coding: Version of TS 36.212 used for downlink channel coding. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

DL Precoding Version: Version of TS 36.212 used for precoding downlink transport blocks. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

DL Reference Modulation: Mode for modulating downlink reference signals. Dropdown menu options are Standard, Auto, None, Static, and Diagnostic. It should be set to “Standard” to conform to TS 36.211. When set to “Static” it uses the “DL Reference Static x1” and “DL Reference Static x2” options.

DL Reference Shift: Frequency shift applied for mapping downlink reference signals to resource elements. Dropdown menu options are Zero, N_ID_1, and N_ID_Cell.

HARQ Soft-Combining: This parameter controls the used of soft-combining on HARQ retransmissions. Dropdown menu options are: On, Off, On_Accumulation.

N Antenna: BCH: Extracted from Broadcast Channel CRC. Dropdown menu options are: BCH and UserDefined.

N Control Region Ofdma Symbol: CFI: Extracted from Control Format Indicator. Dropdown menu options are CFI and UserDefined.

NAntenna Port: Number of Antenna Ports: 1, 2, or 4; non needed if N Antenna is set to BCH.

PDCCH Mapping to RE: Version of TS 36.211 used for mapping PDCCH to Resource Elements. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

PHICH: Version of TS 36.211 used for PHICH. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

Proprietary Parameters: Parameters used to configured non-standard, proprietary variants of LTE. Click the line item ellipse on right side to open the **Int64 Collection Editor.**

RNTI Version: Version of TS 36.231 used for RNTI determination. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

SchedulingInfoSIB1-BR: This field contains an index to a table that defines SystemInformationBlockType1-BR scheduling information, which takes Value 0 to 18. Value 0 means that SystemInformationBloclType1-BR is not scheduled.

UE-Specific PDSCH RE Mapping Option: Version of TS 36.211 used for UE-specific PDSCH RE mapping. Dropdown menu options are Latest, Release_8, Release_9, Release_10, Release_11, Release_12, Release_13, Release_14, Release_15, Release_16.

UL Channel Coding: Version of TS 36.212 used for uplink channel coding. Opens a dropdown menu to select a version: September 2009 and later, June 2009, March 2009, v850, v840, v830, v820, v810, none, Proprietary1, Proprietary2, Proprietary3, and Proprietary4.

UL Reference Boosting: Assumes that all uplink reference signals are boosted by a static number in dB. Its effect is to scale the constellation by the specified number in decibels. A positive number expands the constellation, while a negative number contracts it.

UL Reference Modulation: Mode for modulating uplink reference signals. Dropdown menu options are Standard, Auto, None, and Static. It should be set to “Standard” to conform to TS 36.211. When set to “Static” it uses the “UL Reference Static u” option.

UL Reference Static u: Parameter used for modulating uplink reference signals, only when “UL Reference Modulation” is set to “Static”.

Index

Where to Find the Latest Information

Documentation is updated periodically. For the latest information about these products, including instrument software upgrades, application information, and product information, browse to one of the following URLs, according to the name of your product:

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