WaveJudge 5000 LTE

The ultimate authority in wireless testing—your essential tool for troubleshooting wireless development and deployment issues

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Accelerating LTE deployment through advanced troubleshooting

To meet the ever-increasing demand for speed, quality, and reliability in wireless communications, vendors and carriers look to technologies such as Carrier Aggregation, higher-order MIMO, coordinated multipoint and beamforming.

These technologies address the requirements by increasing channels, processing power, or antennas, but at the cost of more complexity in the interaction between the PHY and the upper protocol layers. Troubleshooting functional and interoperability issues becomes that much more challenging. How do you determine what messages were sent, what events occurred, and the associated timing?

Answering these questions can take hours, days, or even weeks, costing time and revenue as certification and deployment are delayed.

A window into the world of wireless

If you could get visibility into what is actually happening and when, from the RF signal to the upper-layer protocol messages, you could reduce the time required for troubleshooting and resolution verification to a fraction of its current cost and go to market sooner with a more reliable solution.

That's where the WaveJudge 5000 comes in. For example, using the WaveJudge 5000 you can:

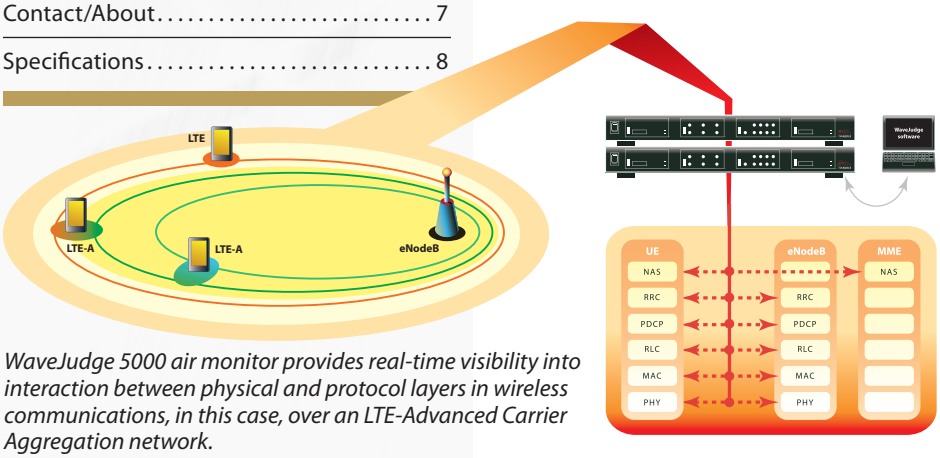
- Understand the interactions at all layers between user equipment (UE) and the evolved node B (eNB).
- Identify complex issues that cause interoperability problems.
- Improve the performance of the overall wireless connection.
- Verify eNB behavior from an over-the-air interface.
- Reveal the nature of complex antenna and modulation schemes.
- Evaluate the impact on performance of MIMO, beamforming, and scheduling.
- Capture wireless conditions in the field for replay in the lab.
- Accurately identify anomalies that affect throughput and delay.

These powerful capabilities are complemented by advanced features including:

- Programmable frequency (from 380 MHz to 6 GHz) to facilitate systems development for multiple markets.
- Internal systemwide master clock to ensure proper sample count and timestamp alignment regardless of module or chassis density and configuration.
- The latest in DSP cores, FPGA density, and technology-specific accelerators to enable real-time testing.

Legacy solutions connect a rack-full of single-purpose instruments to measure a subset of the metrics you need to identify the root cause of an issue. By contrast, the modular nature of the chassis-based WaveJudge 5000 architecture allows you to cost-effectively customize a scalable test solution that fits your needs and provides a wealth of actionable results in a fraction of the footprint, with the ability to scale the solution as your needs change.

Built on years of wireless testing, development, and deployment experience, the WaveJudge 5000 is the essential test and measurement tool for effective troubleshooting and optimization.



WaveJudge 5000 air monitor provides real-time visibility into interaction between physical and protocol layers in wireless communications, in this case, over an LTE-Advanced Carrier Aggregation network.

How the WaveJudge 5000 works

What if you could capture the full conversation of upper-layer messages over the air, including RF signal characteristics? With the WaveJudge 5000 you can.

True air capture

When testing over-the-air, it is difficult to control the wireless environment. Troubleshooting becomes a frustrating and time-consuming exercise when you can't reproduce the conditions that caused an error.

The WaveJudge 5000 captures protocol messages and RF signal characteristics over the air, including the errors, allowing you to quickly and accurately identify the source of an error. The ability to characterize the channel conditions when analyzing application behavior and protocol exchange provides distinct advantages over eNB or UE logging capabilities, which can report false positives when transmitting or false negatives when receiving.

Device logs fail to offer insight at the exact moment when you need it—when an error occurs. Seeing a transmission entry in the log is no guarantee that the message was actually broadcast, only that the device attempted to send it. On the other end, the lack of a received entry in the log is also no guarantee that the message was not received by the antenna, only that it didn't make it to the logging function of the device.

It is in these cases, when a failure occurs and the device log is misleading, that the WaveJudge 5000 can tell you what really happened, or didn't happen, saving you hours of time by showing all the messages correlated across layers. And even if the upper layer message does not show in the WaveJudge 5000 report, IQ capture can reveal whether it was actually sent.

Sits in the middle

A test solution that replaces one of the components in the system under test (SUT) compromises the validity of the test by altering the very thing you are testing. This disruption to the SUT can influence the very behavior you are trying to troubleshoot, sending you down false paths that ultimately lead to dead ends.

The WaveJudge 5000 avoids this problem by tapping into the complete conversation at the RF interface. This ability to test in the middle, not at the ends, means you do not have to modify the system to fit the test tool. The value for you is a quicker time-to-test and more reliable results.

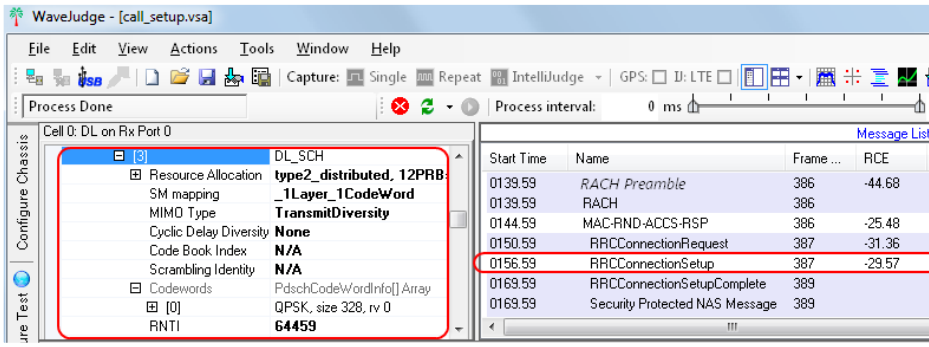
Provides information-dense results through cross-layer correlation

WaveJudge 5000 shows you RF signals time correlated with upper-layer protocol messages. This cross-correlation gives you the power to rapidly investigate and isolate the true root cause of the symptoms or failures you encounter.

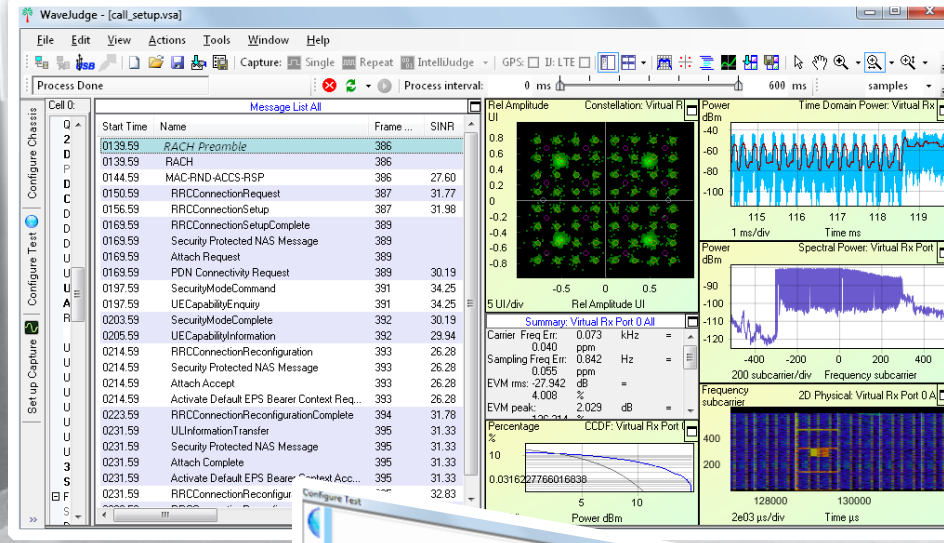
Displaying the relationship is as simple as selecting a protocol message and then viewing a trace of the RF transmission. A WaveJudge 5000 trace contains a wealth of information, such as time domain power and Spectral Power with 2D physical mapping by the scheduler.

Cross-layer correlation also allows you to:

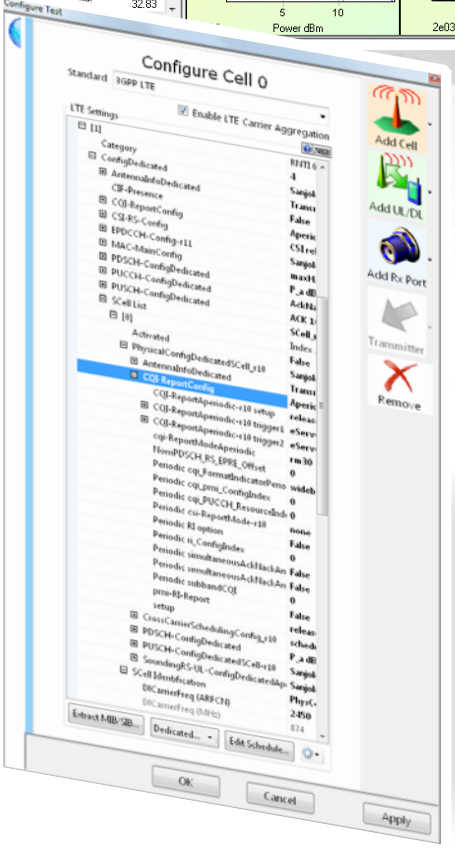
- Verify changes in power, frequency and timing as a UE attaches to the network by visually tracking requests and response while recording the RF channel conditions.
- Analyze UL allocations to detect errors sent in incorrect frame locations.
- Examine the behavior of the eNB and the UE during MIMO handovers.
- Track complete protocol exchange of multiple UEs with eNBs while evaluating the effects of the physical channel characteristics.
- Compare the weight, phase, and amplitude of up to 16 antennas in a beamforming implementation.
- Identify multipath or interference as a source of throughput performance degradation.
- Visually locate eNB scheduling errors and efficiency through advanced views of DL/UL assignments.



The WaveJudge 5000 analyzes multiple layers, captures protocol exchange between eNodeB and UE, and decodes all messages with correlation to the PHY layer.



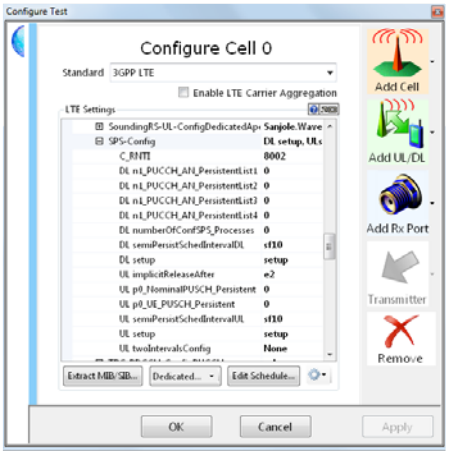
Provides comprehensive test analysis in a single configuration. This includes RF, modulation quality, and protocol analysis.



Carrier Aggregation Serving Cell Information Identified Per UE

Benefits of the WaveJudge 5000 modular architecture

- **FLEXIBLE**
  Tailor the system to your specific test requirements.
- **SCALABLE**
  Start small and add the modules you need when you need them.
- **POWERFUL**
  40 MHz channels allow you to test high-port-density solutions such as MIMO, CA, and beamforming.
- **COST-EFFECTIVE**
  Purpose-built proprietary architecture in a small footprint is more efficient.
- **FUTURE-PROOF**
  Architecture can adapt to the transformation of the wireless industry, protecting your investment.



Uplink and downlink SPS may be configured or extracted from RRC message.

What you can do with the WaveJudge 5000

Wireless protocol analysis

The ability of the WaveJudge 5000 to capture protocol messages for offline analysis brings the power of a protocol analyzer to wireless testing.

- Configure per physical, transport or logical channel or per UE for decoding LTE.
- Capture, filter and decode the entire control-plane/MAC-layer message structure and associated IP source/destination information.
- Sort and filter by message type and subfield (such as MAC message type, DL/UL direction, errors and others).
- Analyze all upper layer protocols including MAC, RLC, PDCP, RRC, and NAS while correlating messages to the PHY layer.
- Store IQ captures to perform post analysis with the WaveJudge 5000 software or export IQ values to other applications.
- Highlight a MAC PDU and view raw HEX and protocol decodes.
- Inspect the UL/DL subframe allocation in a Carrier Aggregation implementation to troubleshoot attach failures.

RF analysis

Now combine your best PHY layer test equipment with your protocol analyzer and you realize the power of the WaveJudge 5000. RF signal testing is available on the WaveJudge 5000 through spectrum-related graphs.

- Identify carrier and sampling clock source mismatch in the Summary view and view channel energy intensity of signals with the Spectrogram view.
- Analyze the FFT of the received signal down to the resource element view along with the scheduled information from the eNB in the 2D physical trace.
- Verify that the signal has the correct waveform, center frequency, and channel bandwidth.
- Evaluate the modulation quality with advanced EVM constellation views and EVM statistics.
- Troubleshoot throughput problems by checking for interference.
- Capture IQ samples over the air and solve the most complex of issues which originate at the PHY and escalate up through the protocol layers.

Burst scheduling performance

Data can be lost when UE transmissions aren't synchronized with the UL grant associated with the eNB. The WaveJudge 5000 simplifies scheduling analysis by displaying a cross-correlated view of the decoded UL grant and DL assignment messages from the eNB and the logical representation of these messages visually plotted against the actual energy detected by the WaveJudge 5000.

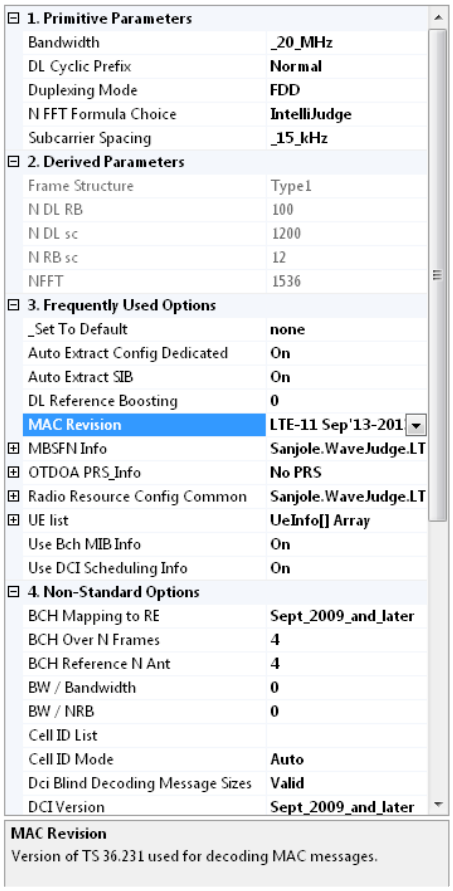
Information is plotted in a 2-D graph showing frames, subframes, and allocated transport blocks. Physical energy overlaid on assignment information creates a powerful visual tool for identification of eNB scheduling performance and regions allocated, including MIMO, feedback and HARQ.

Attach process, HARQ, and MIMO analysis

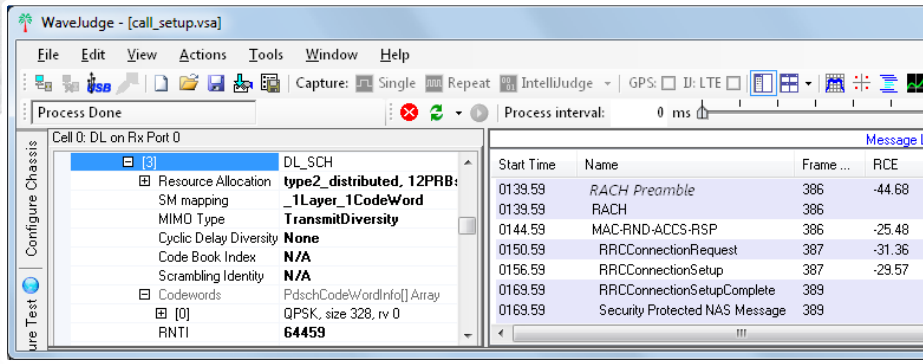
The attach process is a critical step in establishing wireless communications. Parameters established while connecting govern all subsequent transmissions. Problems arising during this step can affect performance, throughput, and availability of features and capabilities, or even prevent communications completely.

In the early days of implementation, attach errors were common, with multiple attempts before connecting. As the technology has matured, user expectations have increased, forcing designers to optimize the attach process to reduce the number of attempts required. The WaveJudge 5000 allows you to monitor and decode all steps of the attach process.

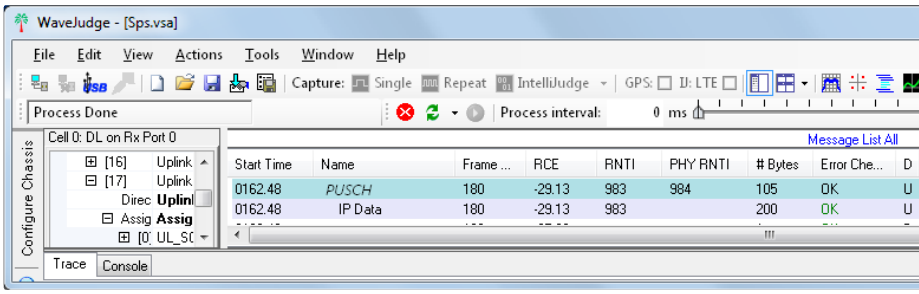
All L1–L3 protocols defined in 3GPP LTE are supported, while advanced testing of both HARQ and MIMO are included. MIMO analysis is possible for up to 8x8 configurations and advanced transmission modes such as DL TM 9, TM 10 and UL TM 2 are supported. Further MIMO analysis includes auto identification of transmit diversity and spatial multiplexing logical transport blocks within the subframe.



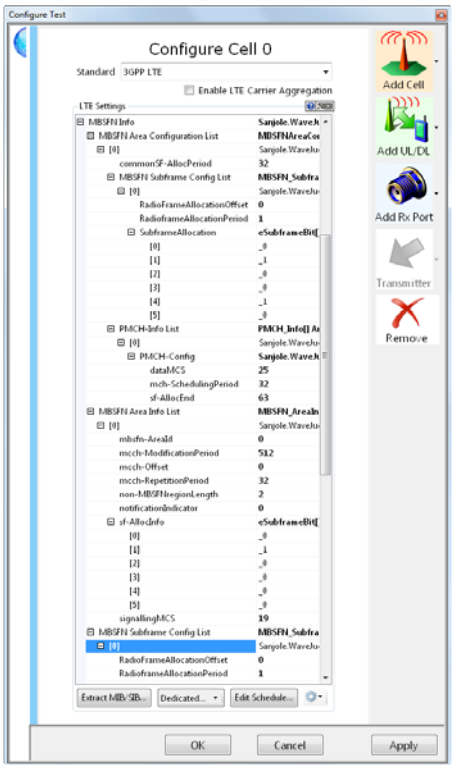
Wavejudge 5000 PHY can be customized for current and future standards.



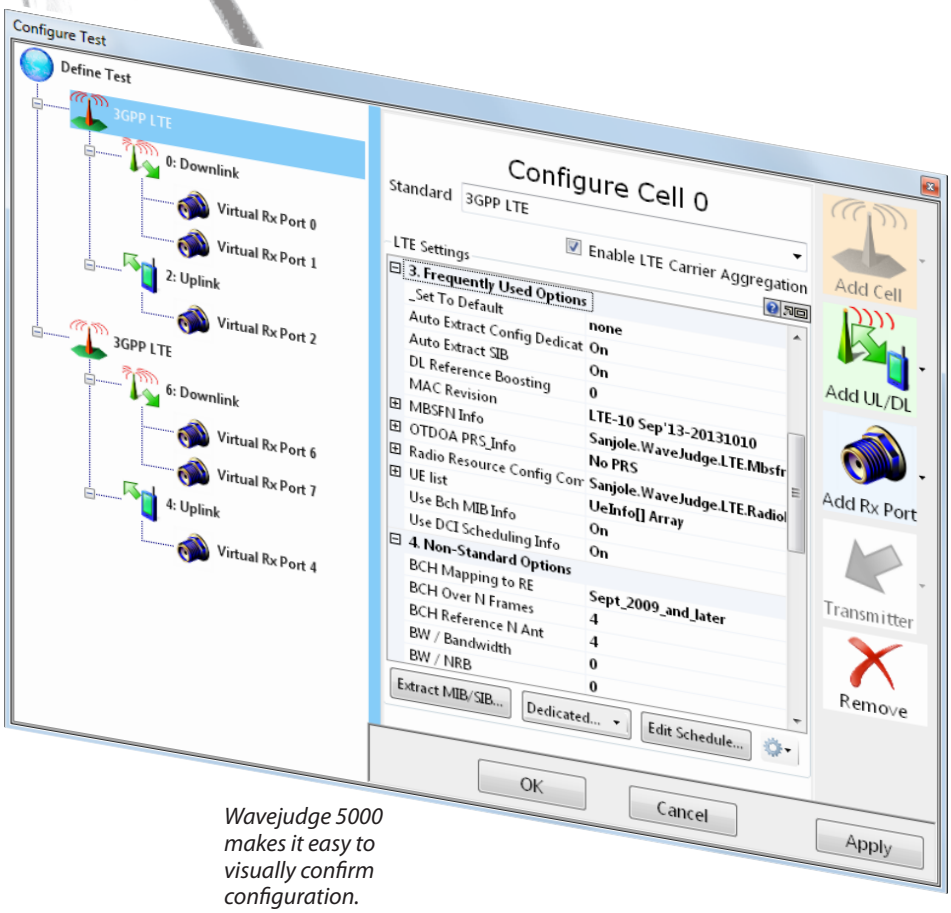
UE attach frame and message list



Tracking SPS traffic based on UEs logical RNTI and Physical RNTI



EMBMS configuration extracted or detected based on mcch_RRC and R9SIB13



Wavejudge 5000 makes it easy to visually confirm configuration.

The power of the WaveJudge 5000 platform

Chassis-based architecture

By moving from a single-use box to a chassis, the WaveJudge 5000 moves the components of the system from fixed motherboards and daughterboards to a selection of modules (cards) that can be installed in or removed from chassis slots as the application requires.

The WaveJudge 5000 uses a proprietary, purpose-built, modular architecture that is much more targeted and cost-effective than a one-size-fits-all standard platform, allowing you to maximize the coverage of your testing budget.

Not only does this modularity give you the ultimate flexibility in customizing a test solution targeted to your specific situation, but it also provides the scalability to expand the solution in terms of ports or memory as your needs change. For large-scale testing up to 64 chassis can be daisy-chained to house up to 256 modules.

In addition, port synchronization is built into the architecture, increasing ease of use and decreasing time to test.

Modules

RX Judge (RF Module)

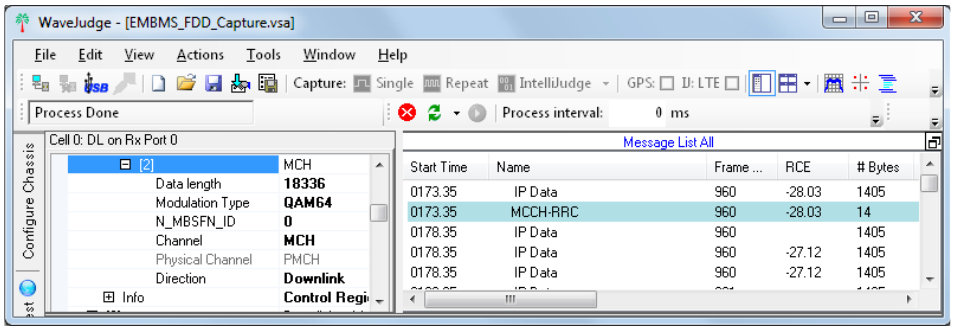
RX Judge modules feature superior sensitivity and dynamic range enabling you to test in the lab and in the field. Each module features four independent, configurable 40 MHz receivers.

All ports in a WaveJudge 5000 system are truly synchronized and are sample- and phased-locked (coherent). By providing synchronized, coherent ports right out of the box, the WaveJudge 5000 does not rely on independent synchronization lock per test device that can drift with respect to a common source. This saves you the time required up front to assure all devices are synchronized, or in the case of some multi-box solutions, calibrated. You also save the time lost in troubleshooting synchronization and coherence issues during testing.

The WaveJudge 5000 provides maximum flexibility in test configurations requiring multiple ports, such as:

- Tower handover
- Beamforming, tracking the weight of up to 16 antennas
- High-order MIMO solutions (up to 8 layers) including transmit diversity and spatial multiplexing with rank measurements
- Frequency division duplex (FDD) wherein ports are used for DL and UL traffic while supporting multiple frequencies simultaneously
- Carrier Aggregation, both FDD and TDD, with up to 5 component carriers and up to 8 layers

PMCH support for EMBMS



IntelliJudge2 (DSP Module)

The latest in DSP cores, FPGA density, dynamic RAM and technology-specific accelerators power the IntelliJudge2 modules and provide real-time testing. Cost-effectively analyze, trigger, filter, log, and chart everything in the wireless channel for any amount of time.

Because the IntelliJudge2 modules are now completely integrated into the WaveJudge 5000 platform, you can configure your system to take advantage of real-time analysis with no time constraints, triggering on lower and upper layer events, errors, messages, and message content. This gives you the powerful ability to isolate problem areas regardless of the layer in which they occur, to detect and eliminate transient errors and bypass the finger pointing between vendors that can delay release dates by weeks or months.

StoraJudge (Memory Module)

You can customize your system for analysis/troubleshooting of short captures or for tracking long-term trends or to isolate intermittent anomalies.

In addition, down-converted analog IQ signals are now stored on the memory modules instead of a fixed 4 GB cache, allowing you to extend the capture timeframe for enhanced troubleshooting. Depending on your application, IQ captures can be invaluable in recreating the wireless channel and providing in-depth physical analysis.

The IntelliJudge2 modules share dynamic RAM for short captures of seconds or minutes depending on your module arrangement, while StoraJudge SSD modules store hours of IQ capture. This flexibility addresses your application requirements without breaking your budget.

SynthJudge (OCXO Module)

Dual-frequency, from 380 MHz to 6 GHz, is particularly useful when developing systems for multiple markets. Leverage your testing investment to cover multiple spectrum bands.

Some test solutions require multiple boxes, which must synchronize to a common external clock (typically 10 MHz) received via cables for sampling. Sample count alignment is typically handled by either field calibration or GPS time-stamp correlation between boxes. In the WaveJudge 5000, there is only one master clock module, which is derived from a selection of internal OCXO, external user

clock, or GPS. This sample clock, along with the exact sample count, is distributed to all chassis and modules in a WaveJudge 5000 system. There is never a need to worry about sample count or timestamp misalignment.

Management

The WaveJudge 5000 is controlled by a laptop or PC running WaveJudge 5000 software connected to the test network via an Ethernet port. The user-friendly software control package, with its strong visual emphasis, greatly simplifies test set up and provides quick graphic confirmation of the test configuration. This feature is very valuable when dealing with complex scenarios.

Call for a Demonstration

To inquire about a demonstration or for more information about the WaveJudge 5000, please call Sanjole at 1-808-457-1452 or email sales@sanjole.com.

About Sanjole

Sanjole is a leader in LTE and WiMAX testing with expertise in innovative wireless technology. Sanjole provides problem solving capabilities from inside the wireless network through over-the-air analysis tools that provide visibility into events spanning multiple layers.

Sanjole has been involved from the very beginning of LTE as a test vendor in the LTE/SAE Trial Initiative (LSTI) events for both fixed and wireless devices. Our work with the WiMAX Forum and 3GPP, participation in the Small Cell Forum, TETRA, and extensive experience in interoperability trials, enable deep insight into the complex technical issues specific to the LTE and 4G community.

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Sanjole's WaveJudge 5000 Feature/Benefit Summary

Identify and Analyze

- DL Assignment and UL grant analysis per RNTI
- Decodes of MAC, RLC, PDCP, RRC, NAS with full correlation to the PHY layer
- ARQ and HARQ process
- Carrier Aggregation DL/UL assignments and messages
- Scheduling errors
- VoLTE (CSFB)
- LTE Advanced features and all transmission modes
- DL/UL timing offsets
- Resource block assignments
- Subcarrier energy usage
- L1–L3 throughput
- MIMO type and rank comparison

Solve

- Interference questions
- Attach process failures
- Cell synchronization problems
- Handover issues
- Optimization and efficiency concerns
- Deployment delays

Features

- Scalable architecture allowing up to 256 modules
- Flexibility of modules include RF, Synth, DSP, and SSD memory
- RF wideband support 380 Mhz to 6 GHz up to 40 MHz BW
- Wide dynamic range supports use in the lab and in the field
- Coherent RF ports up to 16 per set
- Support for all transmission modes up to 8 layers
- CAx5 support with 40 MHz channels
- LTE-specific hardware accelerators
- Real-time streaming analysis of unlimited UEs for any length of time
- IQ storage in expandable SSD for minutes or hours
- Best in class close-in phase noise

Benefits – Executive Level

- Cost effective large scale potential test configurations for complex antenna schemes
- One system covers all RF bands and channels including CA
- Real-time testing at an affordable entry point using less DSPs
- Track intermittent or transient issues in reduced test time
- Accelerate problem solving and time to market
- Dynamic range and sensitivity allows testing in the lab and in the field
- IntelliJudge2 DSP modules provide real-time bidirectional analysis of all interactions at all layers
- Eliminate worries about future technologies obsolescing your test investment
- Decrease test time by quickly locating faulty devices

Benefits – Technical Level

- Close-in phase noise allows 8 layer testing
- Analyze complex antenna schemes including MIMO and beamforming
- Compare expected vs. received frame structure and identify allocation issues
- Visually inspect scheduler performance
- Capture the attach process beginning with UL power
- Understand channel characteristics and their relationship to device behavior
- Test CAx5 with all DL and UL interactions with latest RF port scalability
- Locate complex issues that span LTE layered technology
- Verify eNodeB channel outputs
- Locate eNodeB UL grants and verify UE correct usage
- Identify channel conditions and compare with modulation scheme chosen by eNodeB
- Locate protocol exchange per UE and identify errors
- Trace the bytes as they move through the MAC, RLC, and PDCP layers

WaveJudge 5000 Specifications

WaveJudge 5000 Chassis

- Operating Temperature Range: 0°C to +55°C
- Storage Temperature Range: -40°C to +80°C
- Dimensions: 16.75" width x 1.72" height x 12" depth
- Power, Converter to Chassis: 12V, 15A
- Power, AC to Converter: 110 to 240V, 2.5A, 50 to 60 Hz

Mobility and MIMO

- No. of Ports per Chassis: 8
- No. of Synthesizers per Chassis: 2

Inputs and Outputs

- 1 Gb Ethernet – 20 Gb SRIO
- GPS, ANT IN, PPS IN, PPS OUT (SMA)
- Power Jack

WaveJudge 5000 Analysis

Modulation Formats

- OFDMA/SC-FDMA with BPSK, QPSK, 16QAM, 64QAM, Zadoff-Chu

Traces

- Constellation
- 2D Physical
- Time Domain Power
- EVM vs. Subcarrier
- EVM vs. Symbol Time
- MIMO Rank per Subcarrier
- MIMO Rank per Symbol
- Spectral Flatness (Frequency Domain)
- Amplitude Flatness (Time Domain)
- CCDF, PAPR
- Spectral Power
- Amplitude, Phase, Frequency during synchronization signal
- Impulse Response

Statistics (partial)

- EVM
- EVM Peak
- Reference signal EVM
- Carrier and Sampling Clock Frequency Error
- IQ Offset
- CFI Error Rate
- Payload Bits
- RSSI, RSRP, RSRQ
- MCS
- N Resources
- Modulation type

Protocol Analyzer Decodes

- MAC
- RLC
- PDCP
- RRC
- NAS
- TCP/IP (WireShark supported decodes available)

StoraJudge Memory Module

- SSD-based 128/256/512 GB per module

RXJudge RF Module (380 MHz to 6 GHz)

General Specifications

- No. of Receiver Modules per chassis: 2
- No. of RX per Module: 2 or 4

Amplitude Specifications

- Variable Attenuator: 0 to 60 dB in 2 dB Steps
- Variable Gain Ex. at 2 GHz: -35 to +25 dB
- Measurement Range: DANL to Maximum Input Level
- Maximum Input Level: +22 dBm
- DANL – 1024 pts, 10 MHz channel BW (~15 kHz RBW) Normalized to 1 Hz, -172 dBm
- Absolute Amplitude Accuracy: ±2.5 dB
- Relative Amplitude Accuracy: (adjacent tones ~11 kHz) ±0.2 dB

Sampling System

- A/D Bits: 16 bits
- A/D Clock (Sampling Frequency) ~90 MHz
- 2nd Harmonic Distortion: -70 dBc
- 3rd Harmonic Distortion: -70 dBc
- Two Tone intermodulation: -80 dBc
- Sample Frequency Set (Fs): 1 to 45 MHz (optimized for channel BW)
- Sample Frequency Set Accuracy: 10 Hz

Inputs

- Receive RX 1: MCX female, 50 Ohm
- Receive RX 2: MCX female, 50 Ohm
- Receive RX 3: MCX female, 50 Ohm
- Receive RX 4: MCX female, 50 Ohm

IntelliJudge2 Analysis Module

- Dual TMS320C6670 multi-core DSPs
- 4 GB DDR3 SDRAM per Module
- Gen2 SRIO 8 port switch
  - Per DSP SRIO 1 port @ 5 GHz = 16 Gbps
  - Back plane SRIO 3 ports @ 6 GHz = 60 Gbps
  - Front plane SRIO 1 Port @ 6 GHz = 20 Gbps
- Front Panel SFP support for Gigabit Ethernet PHY
- Charts
  - EVM
  - Power
  - CRC
  - Throughput
  - TB Count
  - SINR, RSSI, RSRP, RSRQ
  - 2D physical
  - RNTI

SynthJudge OCXO Module

Carrier Frequency

- Frequency Range: 380 MHz to 6 GHz
- Center Frequency Set Resolution: 4 Hz
- Frequency Calibration Accuracy: 1 ppm ±4 Hz

Reference Frequency Source

- 100 MHz OCXO
- 10 MHz Ref Input, MCX
- Internal GPS, External 1pps
- Another Sanjole Chassis

OCXO

- Aging per year: <±500 ppb
- Aging over 10-years: ±3 ppm
- Temperature stability (0°C to +50°C): ±50 ppb
- Calibration accuracy: ±1 ppm
- Accuracy: ± (time since last adjust x aging rate) + temperature stability + calibration accuracy

Sideband Phase Noise (normalized to 2 GHz)

- 1 kHz offset: -96 dBc/Hz
- 10 kHz offset: -106 dBc/Hz
- 100 kHz offset: -111 dBc/Hz
- 1 MHz offset: -121 dBc/Hz

Inputs and Outputs

- 10 MHz Reference Input: MCX female, 50 Ohm
- Synth 1: 380 MHz TO 6 GHz, 4x femaie, 50 Ohm
- Synth 2: 380 MHz TO 6 GHz, 4x femaie, 50 Ohm

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