WaveJudge
4900A WiMAX

Essential Test and Measurement Tools

SANJOLE

WaveJudge 4900A
Wireless Test System

Port 0

RF BASE-I BASE-Q RF
TX RX TX RX

Port 1

RF BASE-I BASE-Q RF
RX TX RX TX

Port 2

RF BASE-I BASE-Q RF
TX RX TX RX

Port 3

RF BASE-I BASE-Q RF
RX TX RX

USB

Trigger
INPUT OUTPUT AUX

Clocks
GPS ANT GPS PPS REF IN

SRIO

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Troubleshooting WiMAX technology: discovering root causes

Whether you are developing, certifying or implementing WiMAX technology, troubleshooting functional and interoperability issues can be a challenge. This is because wireless communication works through a complex interaction between the PHY and upper layers. It can be difficult to determine what messages were sent, what events occurred, and the timing of those messages and events. Consequently, diagnosing the root causes of problems between layers often takes hours, days or even weeks. This results in delays in certification, late deployment, reduced credibility, added costs and lost revenue.

The breakthrough

Sanjole's WaveJudge 4900A provides more information than any other tool about all aspects of wireless communications particularly upper layers through PHY activity.

For example, using the WaveJudge, you'll be able to understand the interactions between mobile station (MS) and the base station (BS) at all layers, identify complex issues that cause interoperability problems, and improve the performance of the overall wireless connection.

You'll also be able to verify BS behavior from an over-the-air interface, including complex antennae and modulation schemes, and evaluate the impact on performance of MIMO, beamforming and scheduling. And you'll be able to capture wireless conditions in the field for replay in the lab.

With its ability to provide such insights, Sanjole's WaveJudge 4900A will help you reduce troubleshooting time from hours to minutes. The WaveJudge is clearly an essential test and measurement tool for effective WiMAX troubleshooting and optimization.
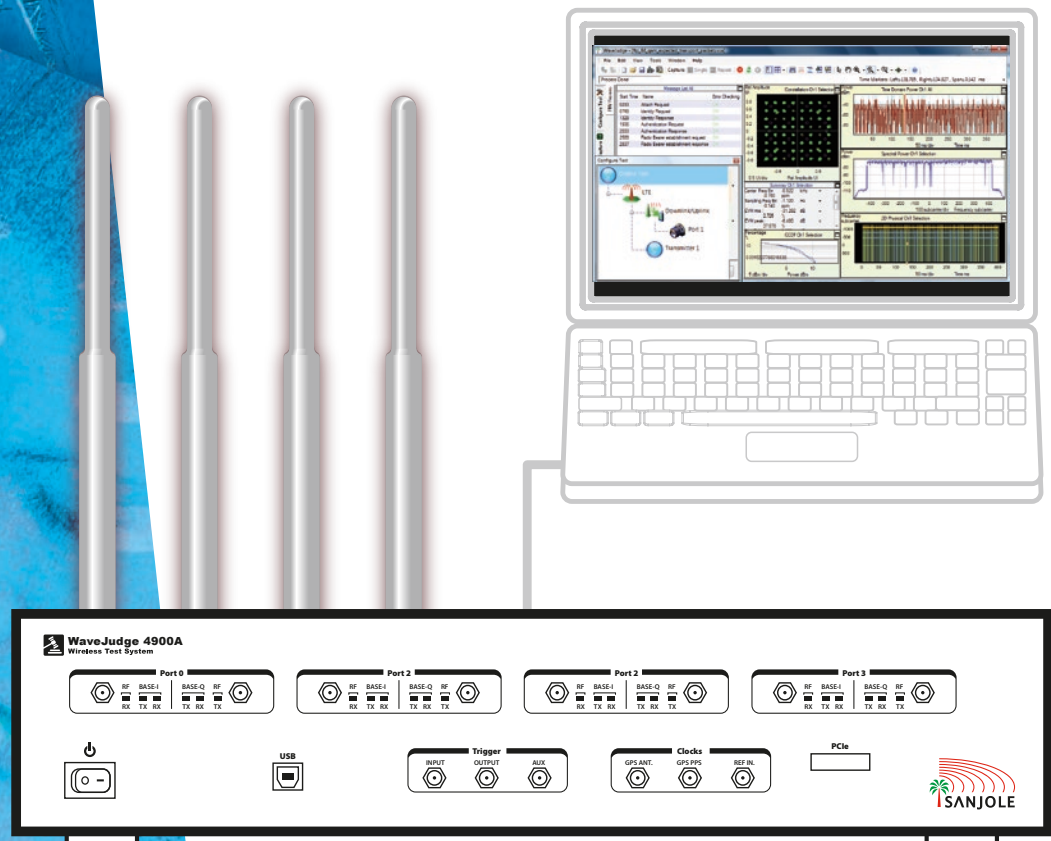
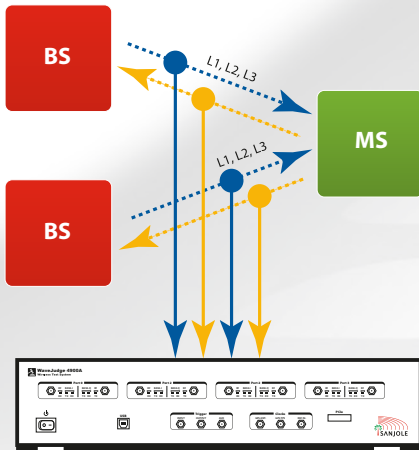*WaveJudge 4900A WiMAX over-the-air test system.*

Understanding the analytical power of the WaveJudge 4900A

The WaveJudge acts as a wireless protocol sniffer, capturing the full over-the-air conversation of upper-layer messages, including RF signal characteristics, for off-line analysis.
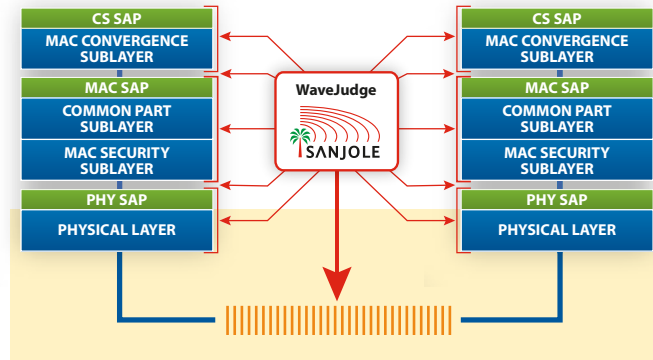

WaveJudge enables decoding and analysis of the full WiMAX protocol stack.

Probing and cross-layer correlation

There are two primary reasons the Wave-Judge provides unparalleled visibility into the interaction between wireless devices.

First, unlike legacy test tools, which replace actual endpoints in the system under test, the WaveJudge taps 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. Not only does this improve ease of testing, it avoids disruption to the system that can change or influence the very behavior you are trying to troubleshoot. You get more reliable results and fewer troubleshooting dead ends.

Second, the WaveJudge 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 trace contains a wealth of information, such as time domain power and spectral FFT with logical and physical mapping by the scheduler.

Cross-layer correlation also allows you to:
- Verify changes in power, frequency and timing as a mobile station enters the network by visually tracking requests and responses.
- Analyze UL allocations to detect errors and identify resulting bursts sent in incorrect frame locations.
- Examine the behavior of the BS and MS during MIMO handovers.
- Track complete protocol exchange of multiple MSs with BS.
- Reveal timing offset violations by viewing the position of MS messages relative to the allocation start time assigned by the BS.

- Identify subchannels and sub carriers used for each slot within a protocol message to determine proper zone permutation assignments.
- Visually locate BS scheduling errors through advanced logical views of DL/UL assignments.

The value of true air capture

Traditionally, one of the problems of over-the-air 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 the WaveJudge, protocol messages and RF signal characteristics, errors included, are captured over the air. This true air capture promotes testing integrity resulting in accurate identification of error source.

The ability to characterize the channel conditions when analyzing application behavior and protocol exchange provides distinct advantages over BS logging capabilities.

True air capture lets the WaveJudge test in the middle, not at the ends.
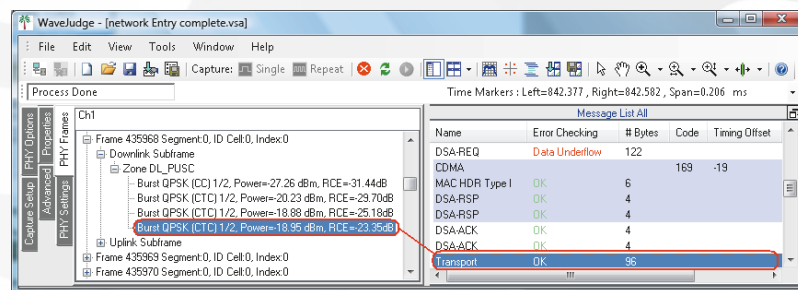
The WaveJudge analyzes multiple layers, captures protocol exchange between BS and MS, and decodes all messages with correlation to the PHY layer.

Powerful hardware-based features

Four independent configurable ports

The WaveJudge 4900A architecture supports four completely independent ports. Each can be configured as either a receive (RX) or transmit (TX) port, allows accurate reception of DL/UL signals with a wide range of power levels, and has its own radio and internal resources.

In addition, the ports can be driven either from the same or from separate low-noise highly accurate oven-controlled crystal oscillators (OCXOs), providing maximum flexibility in test configurations requiring multiple ports, such as:
- Tower handover
- Multiple-input multiple-output (MIMO) solutions including Matrix A, Matrix B and UL Collaborative with rank measurements
- Co-channel interference across multiple sectors
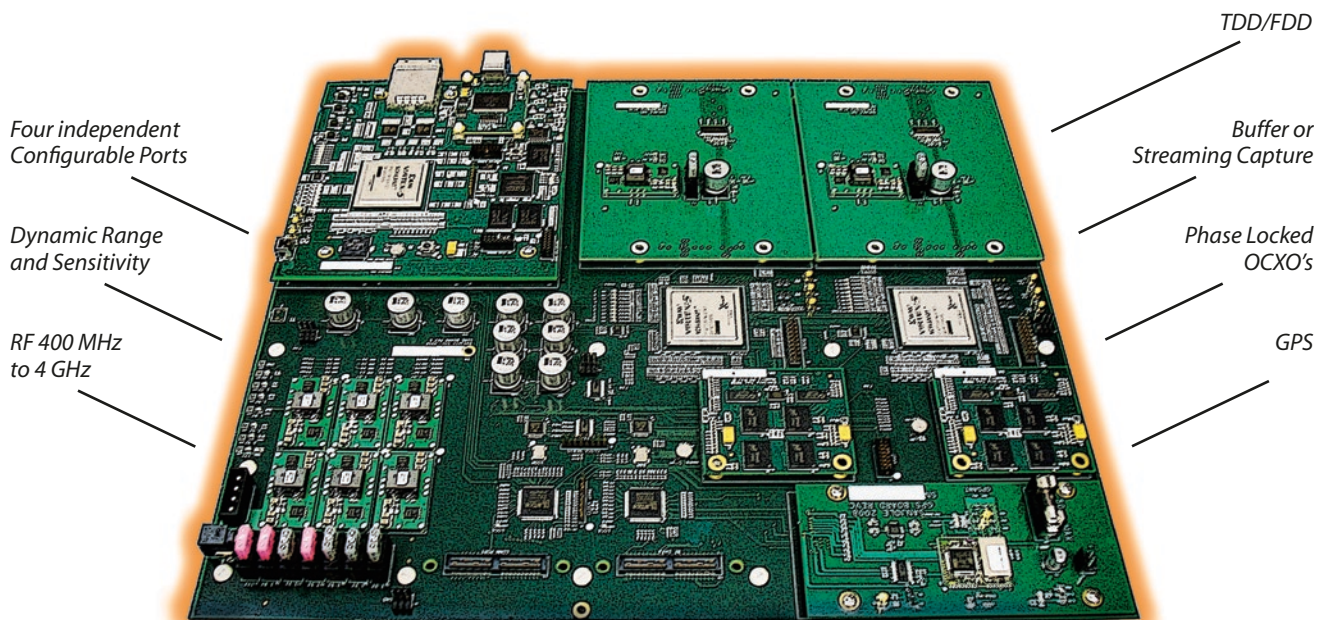
Support for 400 MHz to 4 GHz

If you are developing systems for multiple markets, you will appreciate the wide range of frequencies supported by the WaveJudge 4900A. This capability allows you to leverage your testing investment to cover multiple spectrum bands, including the 2.3 GHz band opened in the US in 1997, the 2.5 GHz band, the 3.5 GHz band opened up from satellite operators, and the 700 MHz spectrum released from television broadcasting.

Superior dynamic range and sensitivity

Not only does the WaveJudge support a wide range of frequencies, it can accept a wide range of power levels for each spectrum. This means you no longer have to adjust your system to accommodate the test tool. If the system under test has a strong (or weak) signal, the WaveJudge adjusts to accurately and reliably read the signal.

Buffer or streaming capture

The WaveJudge 4900A offers two modes of message capturing. Capture up to 25 seconds @ 10 MHz of wireless communication for analysis or troubleshooting, or stream to an external storage device to track long-term trends or to isolate intermittent anomalies.

Four independent
Configurable Ports

Dynamic Range
and Sensitivity

RF 400 MHz
to 4 GHz

TDD/FDD

Buffer or
Streaming Capture

Phase Locked
OCXO's

GPS

*The advanced design of the WaveJudge 4900A.*

PHY and test configuration

Keeping up with PHY

In order to test leading-edge technology, analyzers must be able to keep up with frequent changes in PHY specifications. Because of this, the WaveJudge defines the PHY in software rather than hardware enabling you to quickly customize the WiMAX PHY to meet specifications.
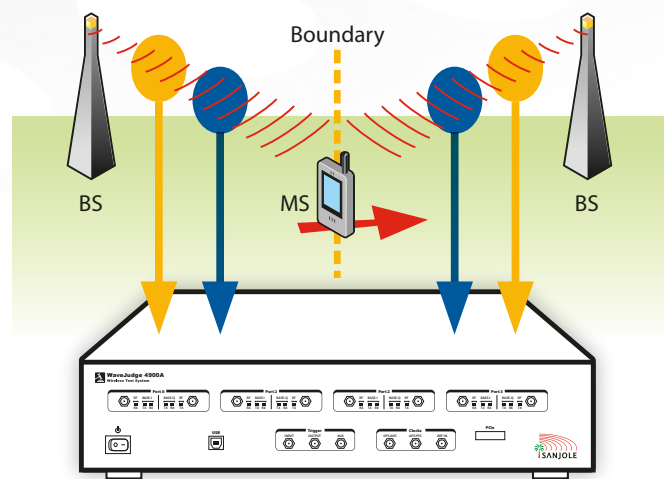
Configuring tests

The WaveJudge 4900A is controlled by a laptop or PC running WaveJudge software. An exciting feature of the software is the user-friendly test configuration GUI. With its strong visual emphasis, the GUI greatly simplifies WiMAX test set up and provides quick graphic confirmation of the test configuration. This is very valuable when dealing with complex scenarios.

With the WaveJudge, the WiMAX PHY can be customized to follow current and future specifications.
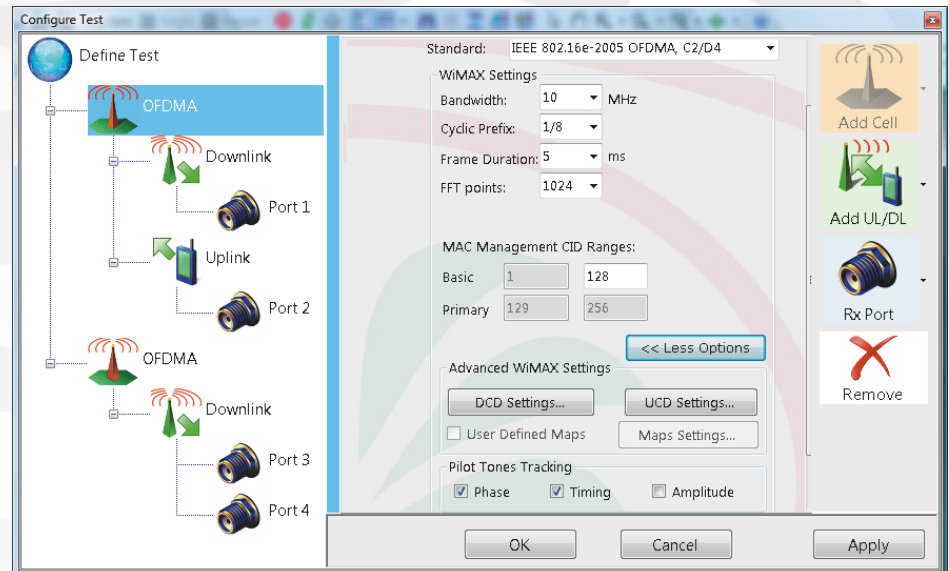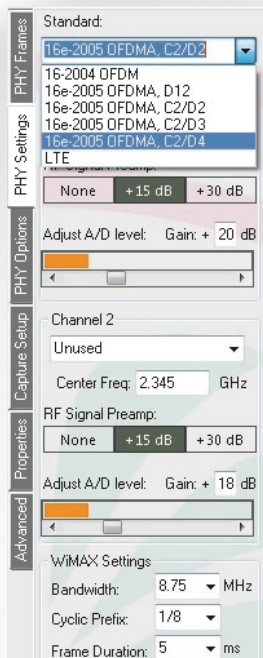
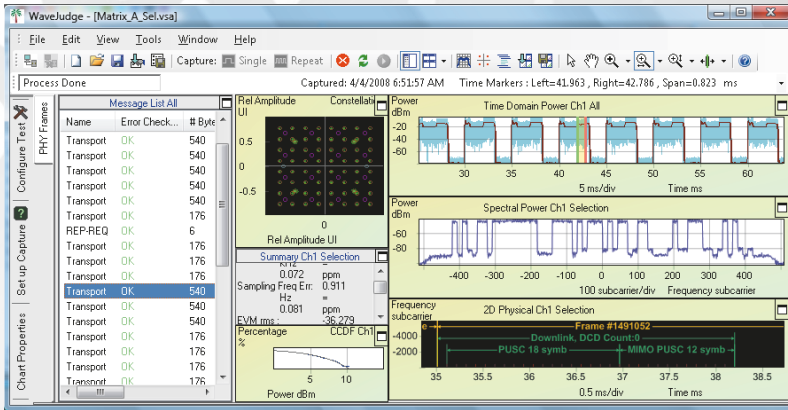*The WaveJudge makes it easy to set up and visually confirm complex test configurations.*

The WaveJudge can be configured to capture and analyze handover behaviors such as when a MS traverses BS cell boundaries.

Tests & measurements

The WaveJudge 4900A provides comprehensive test analysis in a single configuration. This includes RF, modulation quality, and protocol analysis.

Wireless protocol analyzer

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

- Track messages per CID at the PDU level and expand to view all type-length-value tuples (TLVs) and information elements (IEs).
- Capture, filter and decode the entire MAC-layer message structure and associated IP source/destination information.
- Sort & Filter by message type and subfield (such as CID, MAC message type, UL/DL direction, errors and others).
- Highlight a MAC PDU and view raw HEX and protocol decodes.
- Locate reported problems such as incorrect values and FCH, HCS, PDU packing and fragmenting errors.

RF analysis

RF signal testing is available on the Wave-Judge 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. Verify that the signal has the correct waveform, center frequency, and channel bandwidth.

Modulation-quality analysis

The preset windowing capability of the WaveJudge allows you to quickly perform digital demodulation analysis. All modulation formats are automatically detected and are displayed as an overlay on the constellation graph showing all DL and UL frames.

Cross probing of the traces allows you to select a point on the constellation and simultaneously view relative constellation errors (RCE) by symbol and by subcarrier. This provides quick location of the larger error vector magnitude (EVM) points on the constellation and the associated subcarrier, along with burst and frame information. Additionally, peak and average values are displayed on the RCE graphs for quick identification of problems.

The summary screen provides numerical EVM statistics (peak, rms, pilot) along with other vitals including fundamental channel error rates. The channel decoding screen displays the raw bytes, allowing true correlation to bytes inserted prior to the interleaving and randomization process.

Burst scheduling performance

Data can be lost when MS transmissions aren't synchronized with the UL allocation associated with the BS. The WaveJudge simplifies scheduling analysis by displaying a cross-correlated view of the decoded DL/UL map messages from the BS and the

logical representation of these messages visually plotted against the actual energy detected by the WaveJudge.

Information is plotted in a 2-D graph showing frames, subframes, and allocated bursts. Logical assignment information overlaid on physical energy measured with the WaveJudge creates a powerful visual tool for identification of BS scheduling performance and regions allocated, including MIMO, feedback and HARQ. Permutation issues can be quickly identified by mapping subcarrier energy and subchannel usage to each slot of a MAC PDU.

Network entry, HARQ and MIMO Analysis

Network entry is a critical step in establishing WiMAX communications. Parameters established at entry govern all subsequent transmissions. Problems arising during network entry can affect performance, throughput, and availability of features and capabilities, or even prevent communications completely. The Wave-Judge allows you to monitor and decode all steps of network entry, including synchronization, initial ranging, capabilities negotiation, service flow provisioning/activation, and registration. All MAC-layer PDUs defined in IEEE 802.16d and IEEE 802.16e are supported, including Fast Feedback, Physical CINR support, ARQ, HARQ, Power Support, Security exchange, sleep mode, idle mode and MIMO.

MIMO analysis is possible with up to four inputs on the WaveJudge receiving signals from the antennae of the transmitting WiMAX entity. Further MIMO analysis includes auto identification of Matrix A and B bursts, logical description within the subframe and rank comparison.
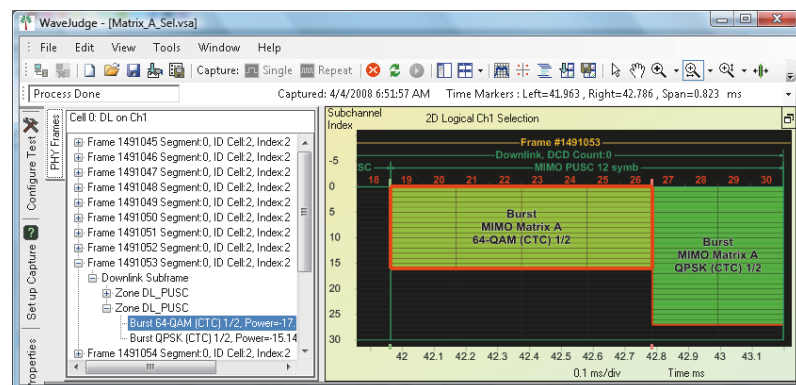
2-D logical and physical diagrams enable verification of subcarrier allocation and usage.

WaveJudge 4900A WiMAX Summary

Sanjole's WaveJudge 4900A can identify and analyze:
- DL/UL grant allocation
- Scheduling errors
- DL/UL timing offsets
- Slot assignments
- Subcarrier energy usage
- L1–L3 usage
- MIMO Type and Rank comparison
- MIMO decodes
- HandOver issues
- L1–L3 layer decodes
- Synchronization and reference signal errors
- Network entry failures

Features
- Decodes of upper layers including TCP/IP, UPD, IP with full correlation to the PHY layer
- L1/L2/L3 analysis of DL/UL via RF Interface
- Customized Control and Data plane viewer
- Analysis of all WiMAX modulation formats and modulation sequences: BPSK, QPSK, 16QAM, 64QAM
- Support for all DL/UL channels and signals
- RF and digital demodulation
- Constellation per Symbol and bursts overlaid with received energy
- Time Domain power with ultra zoom
- FFT Interval analysis
- ARQ and HARQ analysis and summary

Benefits
- Locate complex issues that span WiMAX layered technology
- Validate complete RF, demodulation and decoding
- Verify BS channel outputs
- Track scheduling decisions along with optimization within subframes
- Locate BS UL allocations and verify MS correct usage
- Identify channel conditions and compare with modulation scheme chosen by BS
- Analyze complex antennae schemes including MIMO and beamforming
- Locate protocol exchange per MS and identify errors
- Trace the bytes as they move through L1–L3
- Compare expected vs. received frame structure & identify allocation issues
- Visually inspect scheduler performance
- Capture Network Entry beginning with UL power
- Accelerate problem solving and time to market

Newest WaveJudge Features

Four independent, configurable ports
Ideal for testing MIMO handovers and MIMO or beamforming on TDD/FDD systems.

Each port assignable as TX or RX
Configure any port as a TX or RX with a firmware download.

WiMAX and 3GPP LTE support
Test one technology or a combination.

Support for 400 MHz to 4 GHz
Test in multiple spectrum bands.

Superior dynamic range and sensitivity
Accepts a wide range of power levels for each spectrum and adjusts sensitivity to accurately and reliably read strong or weak signals.

Buffer or streaming true air capture
Capture up to 25 seconds @ 10 MHz of wireless communication for analysis or troubleshooting, or stream to an external storage device to track long-term trends or to isolate intermittent anomalies.

Flexible channel BW support
Test at any channel BW up to 20 MHz.

Call for a demonstration

To inquire about a demonstration or for more information about the Wave-Judge 4900A, please call Sanjole at 1-808-457-1452 or email sales@sanjole.com. We believe it will be well worth your time. The unique and revolutionary capabilities of the WaveJudge make it an essential tool for fixed and mobile WiMAX wireless solutions. The WaveJudge offers analysis well beyond the reach of legacy test tools and is the most cost-effective wireless test instrument available.

About Sanjole

Sanjole is a leader in wireless testing with expertise in innovative wireless technology. Sanjole provides problem solving capabilities from inside the wireless network through deep analysis tools that provide visibility into events spanning multiple layers. Sanjole has been involved from the very beginning of WiMAX and LTE as a test vendor in the first plugfests for wireless devices. Our work with the WiMAX Forum and 3GPP, and extensive experience in interoperability trials, gives Sanjole insight into the complex technical issues specific to the wireless community.

Sanjole Inc.
2800 Woodlawn Drive, Suite 271
Honolulu, Hawaii 96822

e-mail: sales@sanjole.com
call: 808-457-1452

www.sanjole.com

WaveJudge 4900A WiMAX Specifications

Frequency Specifications

General Frequency Specifications
- Frequency Range: 400 MHz to 4 GHz
- Center Frequency: Resolution 4 Hz

Reference Frequency
- External Input (optional): 10 MHz SMA
- Source: 10 MHz OCXO
- Aging per year: <±1 ppm
- Aging over 10-years: ±5 ppm
- Temperature stability (0°C to 70°C) ±0.4 ppm
- 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

Carrier Frequency
- Frequency Range: 400 MHz to 4 GHz
- Center Frequency Set Resolution: 4 Hz
- Frequency Calibration Accuracy: 1 ppm ±4 Hz

Sampling Frequency
- Sample Frequency Set (Fs): 1 to 20 MHz (optimized for channel BW)
- Sample Frequency Set Accuracy: 10 Hz

FFT/OFDM/OFDMA Noise Floor, 3.5 GHz
(Displayed Average Noise Level)
- 1024 pts, 10 MHz channel BW (~15 kHz RBW)
- PreAmp 2 - ON: 0 Attenuation – -131 dBm
- Normalized to 1 Hz, PreAmp 1 - ON: -172 dBm

64 MHz Digitizer Harmonic Distortion
- 2nd Harmonic Distortion: -70 dBc
- 3rd Harmonic Distortion: -70 dBc
- Two Tone intermodulation: -80 dBc

Baseband Receiver
- No. of Channels: 4
- Variable Attenuator: 0 to 63 dB in Idle Steps
- A/D Bits: 16 bits
- A/D Clock (Sampling Frequency): 60 to 64 MHz
- I/Q Memory: 2 Gbyte per 2 ports

Amplitude Specifications

General Amplitude Specifications
- Gain Range: -10 to +87 dB
- Preamp1: ~32 dB
- Preamp2: ~16 dB
- Variable Gain: -10 to +55 dB
- Measurement Range: DANL to Maximum Input Level
- Maximum Input Level: +22 dBm
- Typical 1 dB Gain Compression: +7 dBm
- Absolute Amplitude Accuracy: 2.5 dB
- Relative Amplitude Accuracy: (adjacent tones ~11 kHz) ±0.2 dB

General Specifications

- Operating Temperature Range: 0°C to +55°C
- Storage Temperature Range: -40°C to +80°C
- Dimensions: 16.75°± width x 3.5°± height x 14°± depth
- Power, Converter to Chassis: 12V, 100W
- Power, AC to Converter: 110 to 230V, 100W

Mobility and MIMO
- # of TX/RX Ports per Chassis: 4
- # of Synthesizers per Chassis: 2

Inputs and Outputs
- USB 2 / SRIO
- Receive Channel 1: SMA female, 50 Ohm
- Receive Channel 2: SMA female, 50 Ohm
- Receive Channel 3: SMA female, 50 Ohm
- Receive Channel 4: SMA female, 50 Ohm
- 10 MHz Reference Input: SMA female, 50 Ohm
- Aux. Input (Trigger In): SMA female, LVCMOS (TTL tolerant)
- Aux. Output (Trigger Out): SMA female, LVCMOS (TTL tolerant)
- Power Jack

Modulation Formats
- OFDM/OFDMA with BPSK, QPSK, 16QAM, 64QAM

Capture
- Sample Size up to 2 GB

Port Triggers
- Manual Trigger
- External Trigger
- Trigger on Boolean Phrase (Ex. Power > -20 dBm)

Traces
- Constellation
- 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
- RCE
- RCE Peak
- Pilot Signal RCE
- Carrier and Sampling Clock Frequency Error
- IQ Offset
- DLFP Error Rate
- Payload Bits
- PHY Throughput, Transport Throughput

Protocol Analyzer Decodes
- Network Entry
- Service Flows
- AAS
- Security
- ARQ
- HARQ
- MIMO
- TCP/IP (WireShark supported decodes available)

Specifications subject to change without notice.