Anritsu Advancing beyond

rateart Product Brochure

# LMR Master™ S412E

## Land Mobile Radio Modulation Analyzer, Signal Generator, Cable & Antenna Analyzer, Spectrum Analyzer

*Now Supporting Auto Test and Alignment for Automated Radio Testing*



# LMR Master S412E

## OVERVIEW








*LMR Master S412E*

### Introduction

The LMR Master S412E is a compact handheld multi-function analyzer that has been specifically developed for technicians and engineers who install and maintain public safety, utility, and private mobile communications systems. LMR Master is a highly-integrated, rugged handheld instrument that offers unmatched measurement breadth, depth, and precision while reducing the number of different instruments needed to verify operation and diagnose problems. LMR Master is the only truly portable solution for analysis and mapping of P25, TETRA, DMR, ITCR and ACSES Positive Train Control (PTC), and FirstNet Public Safety LTE.

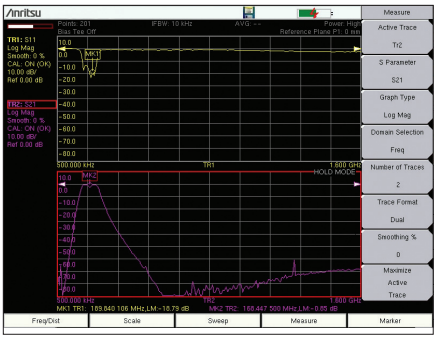
**Standard features are:**

- 2-port Cable & Antenna and distance domain analysis: 500 kHz to 1.6 GHz (user may also select the more flexible vector network analyzer display)
- Spectrum Analyzer: 9 kHz to 1.6 GHz
- CW/FM/AM Signal Generator: 500 kHz to 1.6 GHz
- Power Meter: 9 kHz to 1.6 GHz
- Narrowband FM Analysis: Received power, carrier frequency, frequency error, deviation, modulation rate, SINAD, THD, CTCSS, DCS, and DTMF
- Auto Scan locks on to unidentified FM signal sources between 10 MHz and 1.6 GHz
- Indoor Coverage Mapping of RSSI and transmitter SINAD is standard on the LR Master
- Outdoor Coverage Mapping is available with the optional GPS receiver

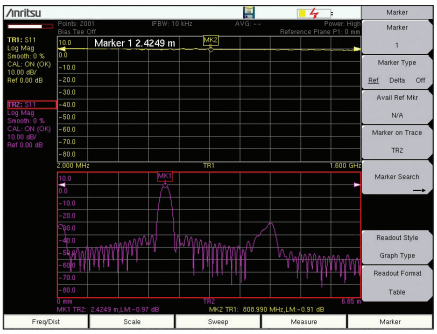
**LMR Master S412E offers many options, including:**

- PIM Hunting
- Extension of Spectrum Analyzer to 6 GHz
- Extension of Vector Network Analyzer to 6 GHz
- Vector Voltmeter
- High Voltage Bias Tee (for both VNA and Spectrum Analyzer applications)
- High Accuracy Power Meter
- Spectrogram Interference Analyzer
- EMF Measurements
- GPS Receiver
- P25 FDMA and Phase 2 TDMA Analyzer and Signal Generator
- NXDN Analyzer and Signal Generator
- ETSI DMR/MOTOTRBO* Analyzer and Signal Generator
- dPMR Analyzer
- ITCR and ACSES PTC Analyzer and Signal Generator
- TETRA Analyzer w/analysis of Base Station ECC and Signal Generator
- Auto Test and Alignment for Automated Testing of Motorola P25 Radios
- Indoor and Outdoor Coverage Mapping of RSSI, BER, and EVM (Modulation Fidelity) for NBFM, P25 (Phase 1 and Phase 2), NXDN, DMR, MOTOTRBO, ITCR and ACSES PTC, and TETRA
- LTE Analyzer (FirstNet) including RF, Modulation Quality, and Over-the-Air (OTA) Measurements
- GSM Measurements for GSM-R railway systems

LMR site technicians and engineers can use the LMR Master to accurately and quickly test and verify the installation and commissioning of base stations, mobiles, and portables. The LMR Master is equally suited for preventative maintenance and troubleshooting to help ensure the operation of wireless network infrastructures, including broadband and microwave backhaul systems.



*Cable & Antenna and VNA Mode in the LMR Master both Provide Simultaneous Measurement of Insertion Loss and Return Loss*



*Distance Domain (DTF) Analysis Allows Simultaneous Viewing of Cable Return Loss and DTF*

## 2-Port Vector Network Analyzer

### 2-Port Cable & Antenna, Vector Network Analyzer, including Distance-to-Fault (DTF)

LMR Master features a 2-port Cable & Antenna analyzer (which can be reconfigured via menu selection to a full vector network analyzer display) to test and verify the performance of feedline, filtering, and antenna components. This includes:

- Connectors
- Cables/Jumpers
- Antenna Isolators
- Multicouplers/Diplexers/Duplexers
- Tower Mounted Amplifiers

Transmission measurements can help identify poor filter adjustment, antenna isolation, and degraded tower mounted amplifiers. DTF shows the location of impairments, without the null/masking effects found in traditional time domain reflections (TDRs). The goal of these measurements is to maximize the system coverage and capacity with problem-free base stations.

### Antenna System Failure Mechanisms

Maintenance is an on-going requirement as antenna system performance can degrade at any point in time due to:

- Loose connectors
- Improperly weatherized connectors
- Pinched cables
- Poor grounding
- Corroded connectors
- Lightning strikes
- Strong winds misaligning antennas
- Water intrusion into cables
- Bullet holes, nails, or rodent damage to coax and feedlines

### Making Measurements Easier

The LMR Master provides features for making measurements easier to perform and for analyzing test results such as:

- Fast sweep speed, measurement point selection, and flexible display formats make it easy to view and adjust base station RF system performance
- High RF Immunity mode for testing in harsh RF environments
- Trace Overlay compares reference traces to see changes over time
- Limit Lines and Alarming for providing reference standards
- High and Low Power output selection to test tower-top components without climbing the tower
- Internal Bias-Tee on VNA ports to power up TMAs for off-line testing
- Internal Bias-Tee on Spectrum Analyzer port for easy powering of pre-amplifiers
- GPS tagging of data to verify location of tests

**Measurements**

1-Port Measurements
- VSWR, Return Loss, Phase, Linear Polar, Log Polar, Smith Chart
- Log/Mag/2 (1-Port Cable Loss)
- DTF Return Loss
- DTF VSWR

Windowing Functions in Distance Domain
- Rectangular
- Normal Side Lobe
- Low Side Lobe
- Minimum Side Lobe

2-Port Measurements
- Log Mag Insertion Loss/Gain, Phase, Linear Polar, Log Polar, Group Delay

**Calibration**
- User-Variable Data Points from 2 to 4001
- Full S11 (Open, Short, Load)
- 1P2P (Open, Short, Load, Through)
- Response $_{S11}$
- Response $_{S21}$

**Sweep Functions**
- Run/Hold, Single/Continuous
- RF Immunity (High/Low)
- Averaging/Smoothing
- Output Power (High/Low)

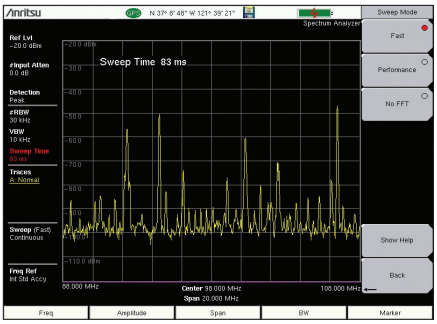
**Trace Functions**
- Save/Recall, Copy to Display Memory
- No Trace Math, Trace ± Memory
- Trace Overlay

**Marker Functions**
- Up to 8 Markers, each with a Delta Marker
- Marker to Peak/Valley
- Marker to/Peak Valley between Markers
- Marker Table

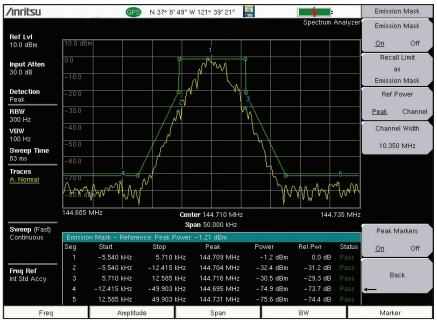
**Limit Line Functions**

Limit Lines
- Single Limit
- Multi-Segment (41)
- Limit Alarm

Limit Line Edit
- Frequency, Amplitude
- Add/Delete Point
- Next Point Left/Right
- Move Limit




*The Spectrum Analyzer Mode in the LMR Master Offers Fast Sweep Speeds for Interference Hunting Intermittent Signals*




*The Spectrum Analyzer Mode in the LMR Master Offers Automated Measurements Including Occupied Bandwidth, Adjacent Channel Power, and Emission Mask, as Shown Above. The Mask can be Quickly Created Using the Standard Limit Line Editor. The Emission Mask Measurement Function Automatically Moves the Trace to Match the Peak of a Modulated Signal to Conform to Common Mask Standards.*

## Spectrum Analyzer

LMR Master features the most powerful handheld spectrum analyzer in its class with unmatched performance in:

- Sensitivity & Dynamic Range
- Phase Noise & TOI
- DSP-based IF Filtering
- Frequency Accuracy
- Resolution Bandwidth (RBW)

The goal of Spectrum Analyzer measurements is to be able to accurately monitor, measure, and analyze RF signals and their environments. It finds rouge signals, measures carriers and distortion, and verifies base stations' signal performance. It validates carrier frequency and identifies desired and undesired signals.

### Simple But Powerful

The LMR Master features dedicated routines for one-button measurements. For more in-depth analysis, the technician has control over settings and features that are not found even on lab-grade benchtop spectrum analyzers. For example, the LMR Master offers:

- Multiple sweep detection methods – Peak, Negative, True RMS, Quasi-Peak, Sample
- Advanced marker functions – noise marker, tracking marker, peak search, sequential peak search, delta markers
- Advanced limit line functions – automatic envelope creation, relative limits, limit mirror, point/segment/line adjustment
- Save-on-Event – automatically saves a sweep when crossing a limit line

The LMR Master offers full control over bandwidth and sweep settings or can be set to automatically optimize for best possible trade-off between accuracy and speed.

### GPS-Assisted Frequency Accuracy

With GPS Option 31 the frequency accuracy is improved to < 50 ppb (parts per billion). Also all measurements can be GPS tagged for exporting to maps.

### Rx Noise Floor Testing

The LMR Master can measure the receive noise floor on a base station's uplink channel using the channel power measurement. An elevated noise floor indicates interference that can lead to call blocking, denial of service, call drops, low data rates, and lowered system capacity.

**Measurements**
- One Button Measurements
  - Field Strength – in dBm/m2 or dBmV/m
  - Occupied Bandwidth – 1% to 99% of Power

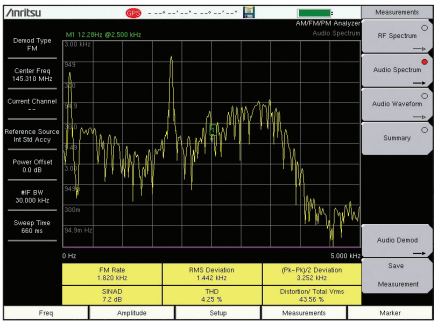
Emission Mask
- Channel Power – in Specified Bandwidth
- Adjacent Channel Power Ratio (ACPR)
- AM/FM/SSB Demodulation – Audio out Only
- Carrier-to-Interference Ratio (C/I)

**Sweep Functions**
- Sweep
  - Single/Continuous, Manual Trigger, Reset, Minimum Sweep Time
- Detection
  - Peak, RMS, Negative, Sample, Quasi-peak
- Triggers
  - Free Run, External, Video, Change Position, Manual

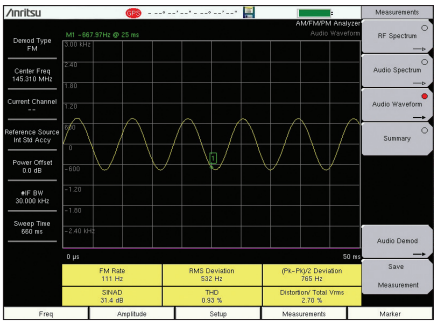
**Trace Functions**
- Traces
  - 1–3 Traces (A, B, C), View/Blank, Write/Hold
- Trace A Operations
  - Normal, Max Hold, Min Hold, Average, Number of Averages, (Always the Live Trace)
- Trace B Operations
  - A → B, B ← → C, Max Hold, Min Hold
- Trace C Operations
  - A → C, B ← → C, Max Hold, Min Hold, A – B → C, B – A → C, Relative Reference (dB), Scale

**Marker Functions**
- Markers
  - 1–6 Markers each with a Delta Marker, or Marker 1 Reference with six Delta Markers
- Marker Types
  - Fixed, Tracking, Noise, Frequency Counter
- Marker Auto-Position
  - Peak Search, Next Peak (Right/Left), Peak Threshold %, To Channel, To Center, to Reference Level, Delta Marker to Span
- Marker Table
  - 1–6 Markers' Frequency & Amplitude Plus Delta Markers' Frequency Offset & Amplitude

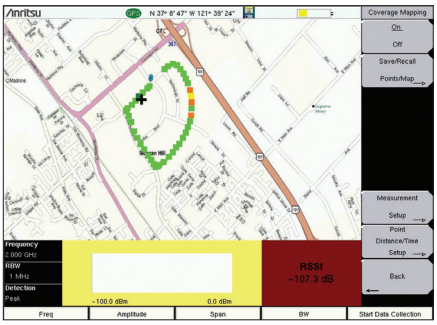
**Limit Line Functions**
- Limit Lines
  - Upper/Lower, Limit Alarm, Default Limit
- Limit Line Edit
  - Frequency, Amplitude, Add/Delete Point, Add Vertical, Next Point Left/Right
- Limit Line Move
  - To Current Center Frequency, by dB or Hz, to Marker 1, Offset from Marker 1
- Limit Line Envelope
  - Create, Update Amplitude, Number of Points (41), Offset, Shape Square/Slope
- Limit Line Advanced
  - Absolute/Relative, Mirror, Save/Recall



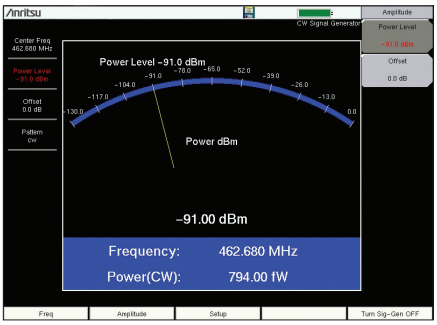

*The AM/FM/PM Option 509 Displays the Demodulated Audio Spectrum vs Frequency with AM (%), Deviation (kHz) or Deviation (rad) for AM/FM/PM, Respectively*




*The AM/FM/PM Option 509 Displays the Demodulated Audio Spectrum vs Time with AM (%), Deviation (kHz), or Deviation (rad) for AM/FM/PM, Respectively*




*The Coverage Mapping Option 0431 Provides Measurement RSSI or ACPR of a Single Channel Along with a User Downloaded Map and GPS Location*




*The LMR Master Includes a Standard Signal Generator with Coverage from 500 kHz to 1.6 GHz and 120 dB Power Control Range*

## AM/FM/PM Analyzer (Option 509)

### AM/FM/PM Modulation Measurements

Option 509 AM/FM/PM Modulation Analyzer provides analysis and graphical display of common analog modulations. The RF Spectrum View displays the RF spectrum with carrier power (power in dB vs frequency) along with center frequency, and occupied BW. Audio Spectrum shows the demodulated audio spectrum along with the audio rate, RMS deviation, Pk-Pk deviation (FM/PM) or depth (AM), SINAD, Total Harmonic Distortion (THD), and Total Distortion. Each demodulation also includes an Audio Waveform display that shows the time-domain demodulated waveform. A summary table shows a tabular list of all the RF and Demod measurement results.

### AM/FM/PM Coverage Measurements

Coverage Mapping Option 431 provides on screen map displays of RSSI and ACPR. Users can convert existing map images to a format compatible with the LMR Master using Anritsu's easyMap Tools™ PC software. RSSI and ACPR measurements can then be superimposed on the maps with the LMR Master. Maps with GPS coordinates can take advantage of the optional GPS receiver to place measurements appropriately. For indoor measurements, without GPS, the user just touches the LMR Master display to place measurements at the proper location. The maps with measurements can be exported through the built-in USB port as JPEG or KML files.

**Measurements**

One Button Measurements
- Field Strength – in dBm/m2 or dBmV/m
- Occupied Bandwidth – 1% to 99% of Power
- Channel Power – in Specified Bandwidth
- ACPR – Adjacent Channel Power Ratio
- AM/FM/SSB Demodulation – Audio out Only
- C/I – Carrier-to-Interference Ratio

**Sweep Functions**

Sweep
- Single/Continuous, Manual Trigger, Reset, Minimum Sweep Time

Detection
- Peak, RMS, Negative, Sample, Quasi-peak

Triggers
- Free Run, External, Video, Change Position, Manual

## Signal Generator

The LMR Master includes a Signal Generator mode for use as a general purpose test signal. The generator can produce CW, modulated AM, and modulated FM signals. Frequency can be adjusted from 500 kHz to 1.6 GHz in 1 Hz steps. Power can be adjusted from 1 to –120 dBm in 0.1 dB steps. The frequency accuracy follows the spectrum analyzer mode and is improved to less than 50 ppb when the GPS is on and locked.

**Setup Parameters**

Generator
- On/Off

Tx Output Level
- –130 dBm to 0 dBm

Tx Pattern

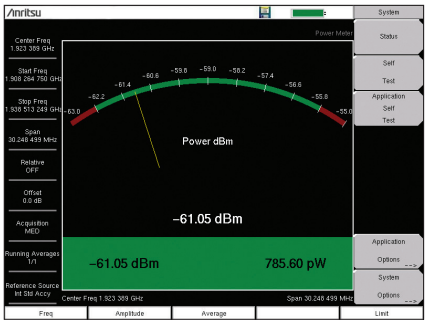
**CW RF Characteristics**

Power Level Accuracy
- 2.0 dB (CW Pattern, Temperature Tange 15 °C to 35 °C, –130 dBm to 0 dBm) Typical

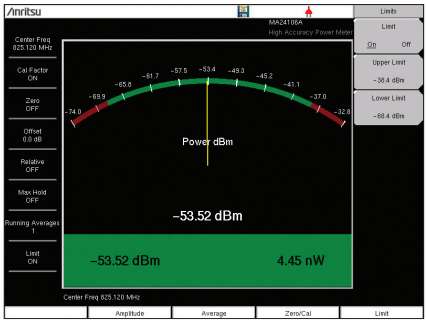
Frequency Range
- 500 kHz to 1.6 GHz

Frequency Accuracy
- Same as Spectrum Analyzer

Modulation Adjustments
- AM Depth
- FM Deviation



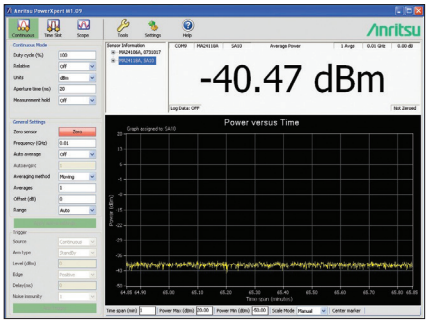

***Power Meter Built-in***
*Power is Displayed in an Analog Type Display and, Supports both Watts and dBm. RMS Averaging can be Set to Low, Medium, or High*




***High Accuracy Power Meter***
*Requires External Power Sensor with Convenient Connection Via a USB A/mini-B Cable. Use Upper/Lower Limit Activation During Pass/Fail Measurements.*



***USB Power Sensor***
*Anritsu Offers a Family of Power Sensors for Your Power Measurement Requirements. They are Compact Enough to Fit in Your Shirt Pocket.*




***PC Power Meter***
*These Power Sensors can be Used with a PC Running Microsoft Windows® via USB. A Front Panel Display Makes the PC Appear Like a Traditional Power Meter.*

## High Accuracy Power Meter (Option 19)

### Power Meters

The LMR Master offers a standard built-in Power Meter utilizing the RF In port, and an optional High Accuracy Power Meter when used with optional external power sensors. Properly setting the transmitter output power of a base station is critical to the overall operation of a wireless network. A 1.5 dB change in power levels indicates a 15% change in coverage area. Too much power means overlapping coverage that translates into cell-to-cell self interference. Too little power, or too little coverage, creates island cells with non-overlapping cell sites and reduced in-building coverage. High or low values will cause dead zones/dropped calls, lower data rates/reduced capacity near cell edges, and cell loading imbalances/blocked calls.

### High Accuracy Power Meter (Option 19)

To address the most accurate power measurement requirements, select the high accuracy measurement option and a choice of sensors with:

- Frequency ranges: 10 MHz to 26 GHz[1]
- Power ranges: –40 dBm to +51.76 dBm[1]
- Measurement uncertainties: ±0.18 dB[2]

[1]Depending on choice of sensor

[2] Under specific conditions

These sensors enable users to make accurate measurements for CW and digitally modulated signals for LMR and cellular wireless networks.

The power sensor easily connects to the LMR Master via a USB A/Mini-B cable. An additional benefit of using the USB connection is that a separate DC supply (or battery) is not needed because the necessary power is supplied by the LMR Master's USB host port.

### PC Power Meter

These power sensors can be used stand-alone with a PC running Microsoft Windows® via USB. They come with the PowerXpert™ application, an advanced data analysis and control software. The application has abundant features, such as data logging, power vs time graph, large numerical display, and many more features, that enable quick and accurate measurements.

**Power Sensors**

**MA24103A**
Inline Peak Power Sensor
25 MHz to 1 GHz, 75 Watts

**MA24105A**
Inline Peak Power Sensor
350 MHz to 4 GHz, +51.76 dBm

**MA24106A**
USB Power Sensor (Average)
50 MHz to 6 GHz, +23 dBm

**MA24108A**
Microwave USB Power Sensor
10 MHz to 8 GHz, +20 dBm

**MA24118A**
Microwave USB Power Sensor
10 MHz to 18 GHz, +20 dBm

**MA24126A**
Microwave USB Power Sensor
10 MHz to 26 GHz, +20 dBm

**MA24208A**
Microwave Universal USB Power Sensor
10 MHz to 8 GHz, +20 dBm to –60 dBm

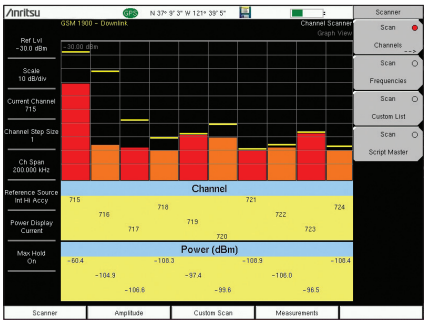
**MA24218A**
Microwave Universal USB Power Sensor
10 MHz to 18 GHz, +20 dBm to –60 dBm

**MA24330A**
Microwave CW USB Power Sensor
10 MHz to 33 GHz, +20 dBm

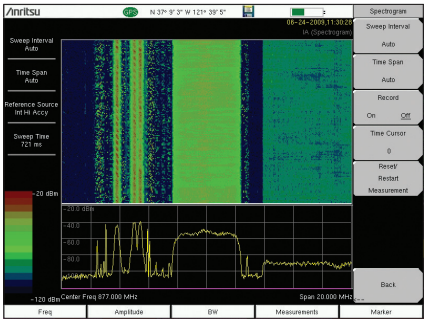
**MA24340A**
Microwave CW USB Power Sensor
10 MHz to 40 GHz, +20 dBm

**MA24350A**
Microwave CW USB Power Sensor
10 MHz to 50 GHz, +20 dBm

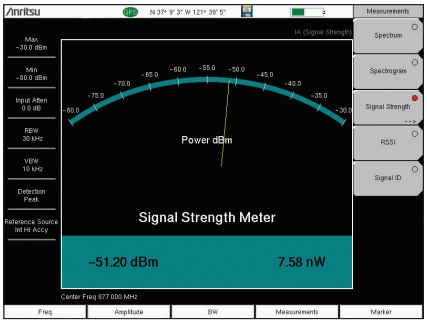
**MA25100A**
RF Power Indicator



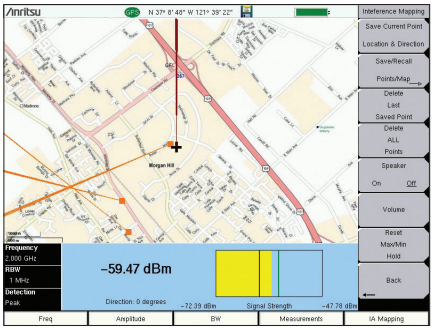

***Channel Scanner***
*Works on any Signal and is Useful When Looking for IM or Harmonics. Can Help Spot Signals Widely Separated in Frequency That Turn On and Off Together.*



***Spectrogram***
*For Identifying Intermittent Interference and Tracking Signal Levels over Time for Up to 72 Hours with an External USB Flash Drive*




***Signal Strength Meter***
*Can Locate an Interfering Signal, by Using a Directional Antenna and Measuring the Signal Strength and by an Audible Beep Proportional to Its Strength*




***Interference Mapping***
*Maps Can be Downloaded to the LMR Master to Help Identify Sources of Interfering Signals. Maps can be Panned and Zoomed to Further Aid the Hunt for Interference.*

## Interference Analyzer (Option 25) Channel Scanner (Option 27)

Interference is a continuously growing problem for wireless network operators. Compounding the problem are the many sources that can generate interference such as:

- Intentional Radiators
- Unintentional Radiators
- Self Interference

Interference causes channel degradation, robbing the network of capacity. In many instances, interference can cause an outage to a sector, a cell, and/or neighboring cells. The goal of these measurements is to resolve interference issues as quickly as possible. LMR Master supports the MA2700A InterferenceHunter handheld direction finding system (sold separately).

### Monitoring Interference

The LMR Master offers many tools for monitoring intermittent interferers over time to determine patterns:

- Spectrogram
- Received Signal Strength Indicator
- Remote Monitoring over the Internet
- Save-on-Event – crossing a limit line

Master Software Tools for your PC features diagnostic tools for efficient analysis of the data collected during interference monitoring. These features include:

- Folder Spectrogram – creates a composite file of multiple traces for quick review
- Movie playback – playback data in the familiar frequency domain view
- Histogram – filter data and search for number of occurrences and time of day
- 3D Spectrogram – for in-depth analysis with 3-axis rotation viewing control

### Identifying Interference

The LMR Master provides several tools to identify the interference – either from a neighboring wireless operator, illegal repeater or jammer, or self-interference:

- Signal ID (up to 12 signals at once)
- Signal Analyzer Over-the-Air Scanners
- Channel Scanner (up to 1200 channels, 20 at a time)

### Interference Mapping

Once interference has been identified, its location can be mapped with the help of the MA2700A InterferenceHunter™ (see separate technical data sheet) and suitable directional antenna. Maps can be created with Anritsu's easyMap Tools™ software and downloaded to the LMR Master.

**Interference Analyzer Measurements**

- Spectrogram
- Signal Strength Meter
- Received Signal Strength Indicator (RSSI)
- Signal ID (up to 12 Signals)
  - FM
  - GSM/GPRS/EDGE
  - W-CDMA/HSDPA
  - CDMA/EV-DO
  - Wi-Fi
- Spectrum
  - Field Strength – in dBm/m2 or dBmV/m
  - Occupied Bandwidth – 1% to 99% of Power
  - Channel Power – in Specified Bandwidth
  - ACPR – Adjacent Channel Power Ratio
  - AM/FM/SSB Audio Monitor
  - C/I – Carrier-to-Interference Ratio

**Channel Scanner**

- Scan
  - 20 Channels at Once, by Frequency or Channel
  - Noncontiguous Channels
  - Different Channel Bandwidths in one Scan
- Display
  - Current Plus Max Hold Display
  - Graph View
  - Table View
- Script Master™
  - Up to 1200 Channels
  - Auto-Repeat Sets of 20 Channels and Total
  - Auto-Save with GPS Tagging

## Distance Domain Analysis

Distance-to-Fault Analysis is a powerful field test tool to analyze cables for faults, including minor discontinuities that may occur due to a loose connection, corrosion, or other aging effects. By using Frequency Domain Reflectometry (FDR), the LMR Master sweeps a user-specified band of full power operational frequencies (instead of fast narrow pulses from TDR-type approaches) to more precisely identify discontinuities.

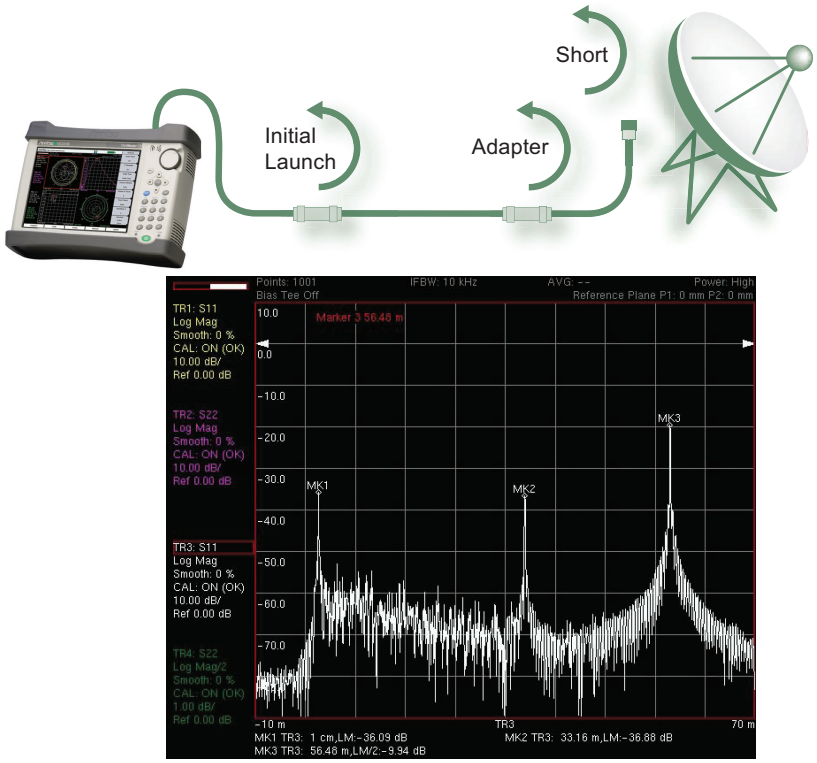
The LMR Master converts S-parameters from frequency domain into distance domain on the horizontal display axis, using a mathematical computation called Inverse Fourier Transform. Connect a reflection at the opposite end of the cable and the discontinuities appear versus distance to reveal any potential maintenance issues. Distance Domain will improve your productivity with displays of the cable in terms of discontinuities versus distance. This readout can then be compared against previous measurements (from stored data) to determine whether any degradations have occurred since installation (or the last maintenance activity). More importantly, you will know precisely where to go to fix the problem and so minimize or prevent downtime of the system.

**Measurements**

- DTF Return Loss
- DTF Insertion Loss
- Full DTF Support in VNA Modes

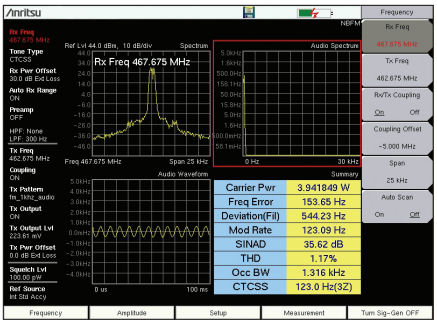
**Setup Parameters**

- Start Distance
- Stop Distance
- Start Frequency (FDR)
- Stop Frequency (FDR)
- Windowing: Rectangular, Nominal Side Lobe, Low Side Lobe, Minimum Side Lobe
- Propagation Velocity
- Cable Loss
- Units: Meters or Feet
- Distance Info Display

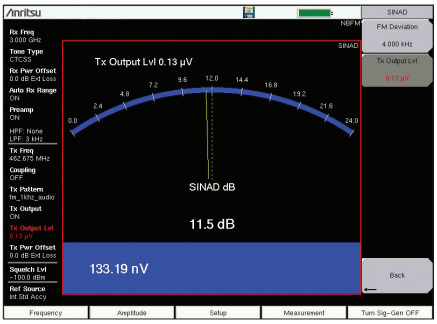



**Distance-to-Fault Analysis**

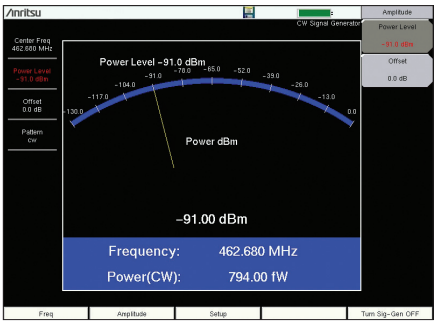
This illustration shows a typical cable measurement scenario with an adapter between the near and far end of the cable. With a short on the far end, the LMR Master can convert frequency domain results into corresponding distance-domain readout. Moving left to right, we can see the initial launch (MK1), the intermediate adapter (MK2), and the short at the far end of the cable (MK3). It is easy to interpret the discontinuities as normal or faults by simply looking at the location and amplitude of the peaks. Since the short shows as –20 dB, this means that the one-way cable loss must be 10 dB.




*When Cabled to a Radio, the NBFM Analyzer Features an Auto Scan Function That can Automatically Determine and Tune to the Carrier Frequency of an Unknown Transmitter*




*Dedicated 20 dB Quieting and SINAD Tools Provide Quick and Accurate Measurement of Analog Receiver Performance*




*The NBFM Analyzer can Generate a CW or FM Carrier with Adjustable Deviation for Modulation Patterns Including 1 kHz, CTCSS/DCS, and DTMF*

## NBFM Analyzer

The NBFM Analyzer is a standard feature on all LMR Master instruments and is designed to analyze the performance of both receivers and transmitters according to guidelines in the TIA-603-D Measurement and Performance Standard.

Auto Scan can be used to identify (and automatically tune to) the center frequency of an unknown transmitter. Once locked to the center frequency, the Summary display shows Received Power, Frequency Error, Deviation, Modulation Rate, Occupied Bandwidth and THD. Standard values for CTCSS, DCS (both Normal and Inverted), and DTMF are decoded and displayed. 20 dB Quieting and SINAD test screens are provided for receiver alignment. Units are adjustable for dBm, Volts, or Watts as needed.

Filters (high-pass, low-pass, pre-emphasis and de-emphasis) allow selection of audio passband components for precise measurements.

The built-in signal generator can provide everything from pure clean CW to modulated FM with test tone and privacy tone at variable deviations.

NBFM Coverage Mapping is also standard on the S412E LMR Master. When GPS signals are available, the optional GPS receiver (Option 31) allows location tagging of RSSI, THD, and SINAD points which are displayed on the S412E's map viewer. Results are then exportable as tab-delimited data, JPEG image, and industry-standard KML for offline analysis in Google Earth™ or other mapping applications. The LMR Master offers the industry's only self-contained indoor mapping solution for land mobile radio — simply load a building floor plan and begin taking measurements by tapping locations right on the instrument's high-resolution touchscreen display.

**RF Measurements**
- Received Channel Power
- Carrier Frequency
- Frequency Error
- Occupied Bandwidth
- (% of Power or > dBc Method)

**Modulation Measurements**
- Deviation
- Modulation Rate
- SINAD from RF Input
- SINAD from Audio Input
- Quieting
- CTCSS/DCS/Inverted DCS/DTMF
- RSSI/THD/SINAD Coverage Mapping

**Filter Types**
- 750 µs Pre-Emphasis
- 750 µs De-Emphasis
- High Pass: 300 Hz, 3 kHz, None
- Low Pass: 300 Hz, 3 kHz, 15 kHz, None

**Analyzer Adjustments**
- Auto Scan (10 MHz – 1.6 GHz)
- RX Frequency
- TX Frequency
- RX/TX Coupling
- RX/TX Duplex Offset
- Channel Span
- Audio Span
- Audio Sweep Time
- RX Units
- TX Units
- Numerical Squelch Level

**Signal Generator Test Patterns**
- CW
- FM + CTCSS
- FM + DCS
- FM + DTMF
- FM + 1 kHz + CTCSS
- FM + 1 kHz + DCS
- AM 10 Hz to 10 kHz, 1 to 100%



*LMR Master Testing from a Service Vehicle*

## Introduction to Signal Analyzers

The LMR Master features Signal Analyzers for the major wireless standards around the world. The Signal Analyzers are designed to test and verify the:

- RF Signal Strength and Quality
- Modulation Quality
- Downlink (Talk-Out) Coverage
- Downlink Channel Capture
- Receiver Sensitivity (excluding WiMAX, and LTE)

### DSP SDR Receiver Enables OTA Coverage Measurements

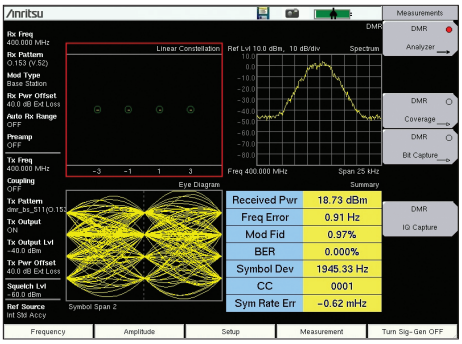
DSP-powered SDR technology in the LMR Master provides accurate and convenient measurement of the RF modulation quality for LMR systems and improved sensitivity for realistic coverage mapping measurements. DSP IF filtering ensures that adjacent channel signals will not cause errors in on-channel measurements. Optional internal GPS provides location information for coverage mapping, and improves the internal reference accuracy to less than 50 ppb.

Coverage mapping options are available to support in-service and out-of-service measurements of FM, P25, TETRA, NXDN, DMR, and PTC systems. LMR Master offers both outdoor (using GPS tagging) and indoor (using on-screen tagging) of critical performance metrics. The signal generator offers a 130 dB power control range to measure receiver sensitivity using CW, modulated FM, modulated AM, and digital LMR modulation test patterns. The signal generator's amplitude, frequency, deviation/depth, and test pattern (digital) are independently adjustable to allow stimulus of a repeater input while observing the transmitter output.

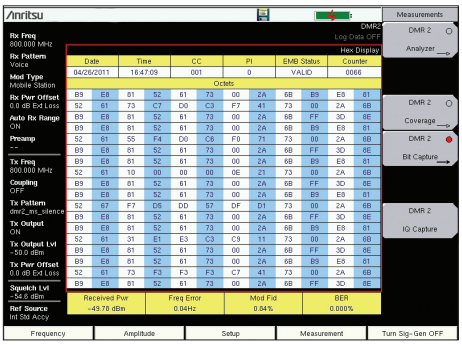
LMR Master's ultra-sensitive receiver combined with Signal Analyzer options support testing and mapping the downlink signals over the air, while powerful DSP filtering ensures that on-channel measurements are not skewed by noise or signals in adjacent channels.

**Signal Analyzers**

Narrowband FM
P25 FDMA Phase 1 and TDMA Phase 2
NXDN™
DMR/MOTOTRBO™/PDT
ITCR and ACSES Positive Train Control (PTC)
TETRA
dPMR
FirstNet Public Safety LTE
WiMAX (IEEE 802.16, Fixed and Mobile)
GSM




*The DMR Analyzer Display Gives a Complete Summary of the RF and Modulation Quality*




*The DMR Bit Capture Display Displays the Uplink Traffic and Exports this to USB Memory*

## DMR Signal Analyzer (Option 591)

The DMR Analyzer, Option 591, is designed to test and verify the performance of DMR radio systems. The DMR Analyzer supports measurement of time-slotted DMR transmitted signals while directly connected to the transmitter (through a power attenuator) or over-the-air with an antenna. The signal analyzer input has the sensitivity to measure DMR signals down to –115 dBm allowing transmitter problems to be analyzed and verified miles away. Separate demodulators are available for Base Station (BS) and Mobile Station (MS) systems. Receive test patterns include the DMR standard 1031 Hz BER pattern, the O.153 PN9 BER pattern, a proprietary voice pattern that estimates BER from audio transmissions.

The built-in DMR signal generator offers over ten DMR test patterns including the standard 1031 Hz voice-framed BER pattern and the O.153 PN9 BER pattern. The generator power level can be controlled over a 130 dB range from 0 to –130 dBm to support receiver sensitivity measurements. The 0 dBm signal level supports amplification to higher levels with an external amplifier for use as a temporary BER test transmitter for coverage assessment. The frequency of the DMR signal generator can be either locked to or controlled independently from the DMR Analyzer frequency.

Bit Capture captures, displays, and stores the uplink data traffic.

A 12.5 kHz channel I-Q capture function is also available to record a channel's baseband data to USB memory as tab delimited data for later analysis and replay.

- RF Quality
- Modulation Quality
- Downlink (Talk-Out) Coverage
- Baseband I-Q Channel Capture
- DMR Test Signal Generator for Receiver Sensitivity and Coverage Measurements

**RF Measurements**

Received Channel Power
Frequency Error
Channel Spectrum
Eye Diagram
Constellation
Linear Constellation
Power Profile

**Modulation Measurements**

Modulation Types: Base Station (BS) and Mobile Station (MS)
Modulation Fidelity
Symbol Deviation
Symbol Rate Error
Symbol Histogram

**Protocol Measurements**

BER and EVM on 1031 Hz, O.153, Voice
Color Code

**DMR Analyzer Patterns**

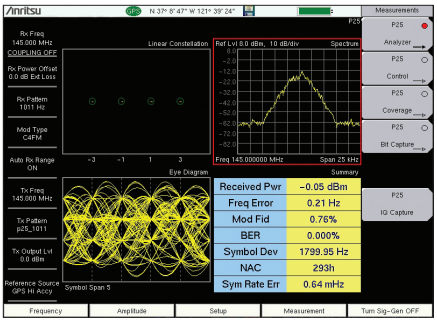
1031 Hz
O.153 (V.52, PN9)
Voice
Silence

**Base Station Test Patterns**

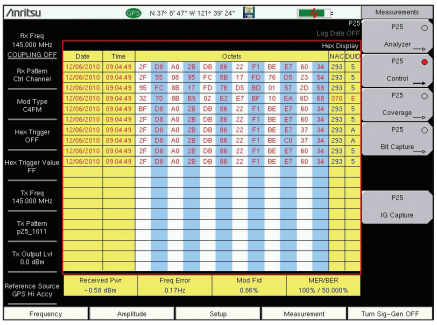
dmr_bs_1031
dmr_bs_511(O.153)
dmr_bs_silence
dmr_bs_1031_1_pcnt_ber
dmr_bs_511(O.153)_1_pcnt_ber
dmr_bs_tscc
cw
am_1khz_audio
fm_1khz_audio

**Mobile Station Test Patterns**

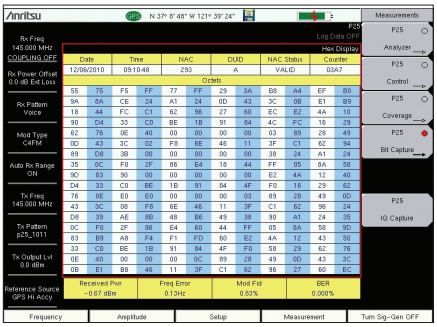
dmr_ms_1031
dmr_ms_511(O.153)
dmr_ms_silence
dmr_ms_1031_1_pcnt_ber
dmr_ms_511(O.153)_1_pcnt_ber
cw
am_1khz_audio
fm_1khz_audio




*The P25 Analyzer Display Gives a Complete Summary of the RF Quality*



*The P25 Control Channel Display Provides a Hex Display of the Trunked Downlink Data in Hex Format. Anritsu Offers a Free Software Script to Convert the Hex Information to Text Messages.*



*The P25 Bit Capture Display Displays the Uplink Traffic and Exports this to USB Memory*

## P25 FDMA and P25 Phase 2 TDMA Signal Analyzer (Option 521)

The P25 Signal Analyzer, Option 521, is designed to test and verify the performance of P25 conventional and trunked radio systems. The P25 Analyzer supports measurement of P25 transmitted signals while directly connected to the transmitter (through a power attenuator) or over-the-air with an antenna. The signal analyzer input has the sensitivity to measure P25 signals down to –115 dBm allowing transmitter problems to be analyzed and verified miles away. Separate demodulators are available for C4FM (Phase 1 P25 systems) and π()/4 DQPSK (LSM and Phase 2 P25 systems). Receive test patterns include the P25 standard 1011 Hz BER pattern, the O.153 PN9 BER pattern, a proprietary voice pattern that estimates BER from audio transmissions, and a control channel pattern that measures the control channel message error rate and estimates the control channel BER based on the forward error correction bits.

The P25 signal generator offers several P25 test patterns including the standard 1011 Hz (Phase 1), 1031 Hz (Phase 2), voice-framed BER pattern, and the O.153 PN9 BER pattern. The generator power level can be controlled over a 130 dB range from 0 to –130 dBm to support receiver sensitivity measurements. The 0 dBm signal level supports amplification to higher levels with an external amplifier for use as a temporary BER test transmitter for inbound coverage assessment. The frequency of the signal generator can be either locked to or controlled independently from the receiver frequency.

Control Channel messages on trunked P25 systems can be captured to the instrument display and exported to USB memory for conversion to standard test messages using a Python script available from the Anritsu website at no charge. Control Channel data can be captured in either free-run mode or triggered based on user-definable hexadecimal values to catch specific messages as they occur. Bit Capture captures, displays, and stores the uplink data traffic.

A 12.5 kHz channel I-Q capture function is also available to record a channel's baseband data to USB memory as tab-delimited data for later analysis and replay.

- RF Quality
- Modulation Quality
- Downlink (Talk-Out) Coverage
- Baseband IQ Channel Capture
- Trunked System Control Channel Messages
- P25 Test Signal Generator for Receiver Sensitivity and Coverage Measurements

**RF Measurements**

Received Channel Power
Frequency Error
Channel Spectrum
Eye Diagram
Constellation

**Modulation Measurements**

Modulation Types (P25 Phase 2):
Base Station (BS) and Mobile Station (MS)
Modulation Fidelity
Symbol Deviation
Symbol Rate Error
Symbol Histogram

**Protocol Measurements**

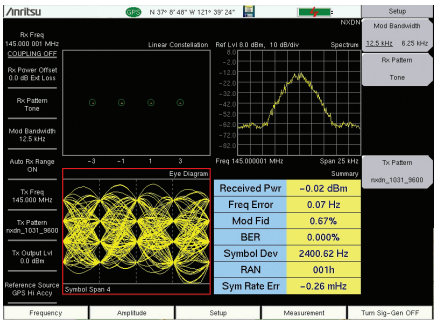
BER and ModFid on 1011 Hz, 1031 Hz
O.153, Voice, or Control Channel
NAC
Color Code (P25 Phase 2)
TDMA Power Profile (P25 Phase 2)

**P25 Analyzer Patterns**

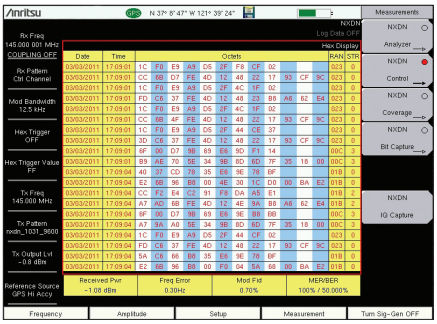
1011 Hz (P25 Phase 1)
1031 Hz (P25 Phase 2)
O.153 (V.52, PN9)
Voice
Control Channel

**P25 Generator Test Patterns**

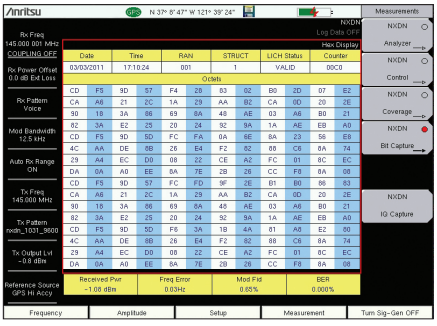
p25_1011
p25_511 (O.153/v.52)
p25_1011_cal
p25_intfr
p25_silence
p25_busy
p25_idle
p25_high_dev
p25_low_dev
p25_fidelity
p25_lsm_1011
p25_lsm_511 (O.153/v.52)
p25_lsm_1011_cal
p25_lsm_intfr
p25_lsm_silence
p25_lsm_busy
p25_lsm_idle
p25_lsm_fidelity
p252_bs_1031
p252_bs_1031_cal
p252_bs_silence
p252_ms_1031_0
p252_ms_1031_1
p252_ms_1031_2
p252_ms_1031_cal_0
p252_ms_1031_cal_1
p252_ms_silence_0
p252_ms_silence_1
cw
am_1khz_audio
fm_1khz_audio




*The NXDN Analyzer Display Gives a Complete Summary of the RF Quality*



*The NXDN Control Channel Display Provides a Hex Display of the Trunked Downlink Data in Hex Format. Anritsu Offers a Free Software Script to Convert the Hex Information to Text Messages.*



*The P25 Bit Capture Display Displays the Uplink Traffic and Exports this to USB Memory*

## NXDN Signal Analyzer (Option 531)

The NXDN Analyzer, Option 531, is designed to test and verify the performance of NXDN conventional and trunked radio systems. The NXDN Analyzer supports measurement of NXDN transmitted signals with a direct connection to the transmitter (through a power attenuator) or over-the-air with an antenna. The signal analyzer input has the sensitivity to measure NXDN signals down to –115 dBm, allowing transmitter problems to be analyzed and verified miles away. Separate demodulators are available for 12.5 kHz and 6.25 kHz NXDN systems. Receive BER test patterns include the NXDN standard 1031 “Tone” BER pattern and the O.153 (PN9) BER pattern. For in-service BER testing, Option 531 offers a proprietary voice pattern that estimates BER from forward error correction bits, and a control channel BER pattern that measures the control channel message error rate, and estimates the control channel BER from the forward error correction bits.

The built-in NXDN signal generator offers over seven NXDN test patterns at both 9600 (12.5 kHz) and 4800 (6.25 kHz) rates including the standard 1031 “Tone” BER pattern and the 511 (O.153) BER pattern.

The generator power level can be controlled over a 130 dB range from 0 to –130 dBm to support receiver sensitivity measurements. The 0 dBm signal level supports amplification to higher levels with an external amplifier for use as a temporary BER test transmitter for coverage assessment. The frequency of the NXDN signal generator is independently settable from the NXDN Analyzer frequency. Control channel messages on trunked NXDN systems can be captured as hex data to the internal display and exported to USB memory for converting to standard test messages using a Python script available from Anritsu at no charge. Bit Capture captures, displays, and stores the uplink data traffic.

A 12.5 kHz channel I-Q capture is also available to capture channel baseband data to USB memory as tab delimited data for later analysis and replay.

- RF Quality
- Modulation Quality
- Downlink (Talk-Out) Coverage
- Baseband I-Q Channel Capture
- Trunked System Control Channel Messages
- NXDN Test Signal Generator for Receiver Sensitivity Measurements

**RF Measurements**

Received Channel Power
Frequency Error
Channel Spectrum
Eye Diagram
Constellation

**Modulation Measurements**

Modulation Fidelity
Symbol Deviation
Symbol Rate Error
Symbol Histogram

**Protocol Measurements**

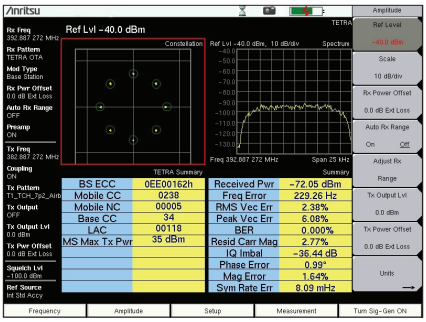
BER on 1031 Hz, O.153, Voice, or Control Channel
RAN

**NXDN Analyzer Patterns**

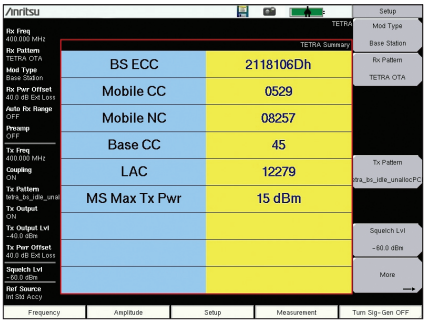
1031 Hz
O.153 (V.52, PN9)
Voice
Control Channel
Traffic (DTS)

**NXDN Generator Test Patterns**

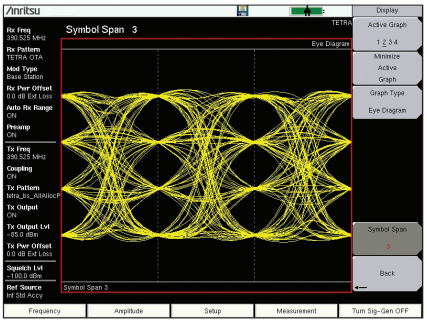
nxdn_1031_4800
nxdn_1031_9600
nxdn_511(O.153)_4800
nxdn_511(O.153)_9600
nxdn_high_dev_4800
nxdn_high_dev_9600
nxdn_low_dev_4800
nxdn_low_dev_9600
nxdn_udch_pat_10_4800
nxdn_udch_pat_10_9600
nxdn_cac_4800
nxdn_cac_9600
nxdn_1031_dts_4800
nxdn_1031_dts_9600
nxdn_facch3_dts_4800
nxdn_facch3_dts_9600
nxdn_pn9_framed_4800
nxdn_pn9_framed_9600
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nxdn_1031_cal_9600
cw
am_1khz_audio
fm_1khz_audio



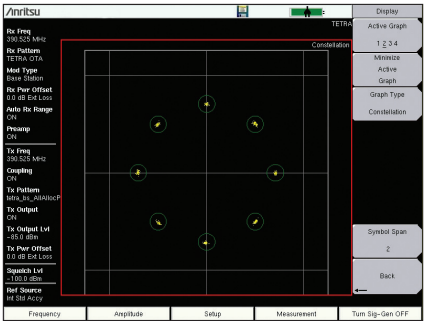

***Configurable Quad Display***
*User-Configurable Display Offers the Ability to Change Screens as Needed to Suit Measurement Needs*




***TETRA Summary Screen***
*Provides Information on Cell Configurations and Maximum Power Directives to Mobile Stations*




***Eye Diagram***
*Distortions in the Eye Diagram will Visually Indicate Variations in Amplitude, Phase, and Inter-Symbol Timing. Summary Screen Allow Numerical Interpretations of Error.*




***Constellation***
*Distortions in the Constellation Reveal Issues Possibly Caused by Transmitter Degradation, Multipath, or Interference*

## TETRA Analyzer (Option 581)

The TETRA Analyzer, Option 581, is designed to test and verify on-the-air performance of Terrestrial Trunked Radio systems. TETRA Analyzer looks at both the physical layer and cell information to give comprehensive insight into real world system performance. Leveraging the LMR Master's high sensitivity receiver, TETRA Analyzer is capable of analyzing system performance at any location. Site technicians or RF engineers can make measurements over-the-air (OTA) to spot-check a transmitter's coverage and signal quality without taking the cell site off-line. When the OTA test results are ambiguous one can directly connect to the base station to check the signal quality and transmitter power.

### RMS and Peak Vector Error

Vector Error is a measurement of the difference between the ideal constellation point and the point measured by the receiver. Vector Error faults will result in poor signal quality to all user equipment. High Vector Error may indicate multipath caused by destructive combining of reflected signals.

### Bit Error Rate (BER)

A proprietary method has been developed to estimate Bit Error Rate (BER) from the TETRA base station's live data stream. This measurement will work on live base stations without the need to transmit a test pattern.

### IQ Imbalance and Magnitude/Phase Errors

IQ Imbalance shows the ratio difference between the phase states. Magnitude and Phase Errors indicate the cause of IQ errors.

### TETRA Summary

Derived from the Base Station control channel, the TETRA Summary screen provides information on the Mobile and Base Color Codes, Network Code, and Location Area Code. It also shows the Mobile Station Maximum Transit Power directive as issued by the base station. Examining these values can help diagnose the causes of user-reported performance issues, and helps ensure that new systems are ready for mission-critical use before wide deployment to users.

### TETRA Base Station Receiver Sensitivity Measurement

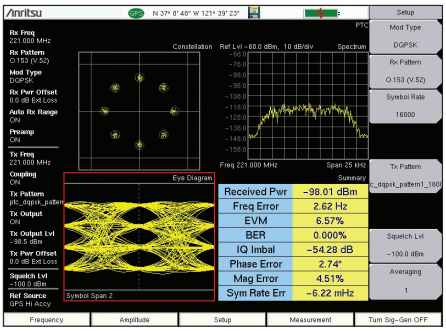
The LMR Master is the first handheld instrument capable of making TETRA Base Station Receiver Sensitivity measurements. This measurement requires the measuring instrument to generate a T1 TCH/7.2 signal that is synchronized to the TETRA Base Station's timing. The LMR Master supports all major TETRA Base Station manufacturers and can synchronize the timing using the base station's downlink signal or by using an external trigger from the base station.

**RF Measurements**
- Received Power
- Frequency Error
- Channel Spectrum
- Constellation
- Eye Diagram

**Modulation Measurements**
- RMS & Peak Vector Error
- Bit Error Rate (BER)
- Residual Carrier Magnitude
- IQ Imbalance
- Magnitude & Phase Error
- Symbol Rate Error

**Protocol Measurements**
- Base Station Extended Color Code
- Mobile Country Code
- Mobile Network Code
- Base Color Code
- Location Area Code
- Mobile Station Maximum Transmit Power

**Base Station Test Patterns**
- tetra_bs_idle_unallocPCH
- tetra_bs_busy_allocPCH
- T1_TCH_7p2




*PTC ITCR Main Screen DQPSK*

## PTC ITCR Analyzer (Option 721)

The PTC ITCR Analyzer, Option 721, is designed to test and verify the performance of Positive Train Control radio systems compliant with the ITC-R standard for FRA Class 1 railways. The PTC ITCR Analyzer supports measurement of PTC transmitted signals with a direct connection to the transmitter (through a power attenuator) or over-the-air with an antenna. The signal analyzer input has the sensitivity to measure PTC signals down to –115 dBm, allowing transmitter problems to be analyzed and verified miles away. Support for analysis of continuous and burst/packet DQPSK data at Half Rate (8 ksps) and Full Rate (16 ksps) symbol rates is provided.

The built-in PTC ITCR signal generator offers three test patterns with various combinations ranging from simple O.153 (PN9) pattern to O.153 patterns with various preambled (as defined by ITCR v1.0 R02).

The generator power level can be controlled over a 130 dB range from 0 to –130 dBm to support receiver sensitivity measurements. The 0 dBm signal level supports amplification to higher levels with an external amplifier for use as a temporary BER test transmitter for coverage assessment. The frequency of the PTC ITCR signal generator is independently settable from the PTC ITCR Analyzer frequency.

Features include analysis of:

- RF Quality
- Modulation Quality
- Channel Quality

**RF Measurements**

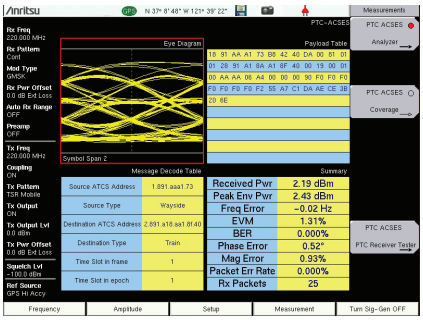
Received channel power
Frequency error
Channel Spectrum
Eye Diagram
Constellation

**DQPSK Modulation Measurements**

Error Vector Magnitude
BER
IQ Imbalance
Magnitude & Phase Error
Symbol Rate Error

**PTC ITCR Analyzer Patterns**

0153_cont_1_8000
0153_cont_2_8000
0153_cont_3_8000
pn9_normal_1_8000
pn9_normal_2_8000
pn9_normal_3_8000
pn9_normal_4_8000
pn9_normal_seq_8000
0153_cont_1_16000
0153_cont_2_16000
0153_cont_3_16000
pn9_normal_1_16000
pn9_normal_2_16000
pn9_normal_3_16000
pn9_normal_4_16000
pn9_normal_seq_16000
cw
am_1khz_audio
fm_1khz_audio

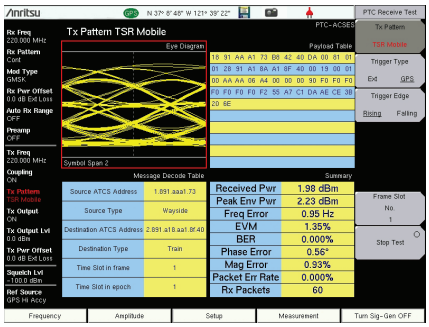



*PTC ACSES Analyzer Payload Table*

## PTC ACSES Analyzer (Options 731 and 733)

The PTC ACSES Analyzer Option 731, is designed to test and verify the performance of Positive Train Control (PTC) – Advanced Civil Speed Enforcement System (ACSES) used in passenger rail safety applications.

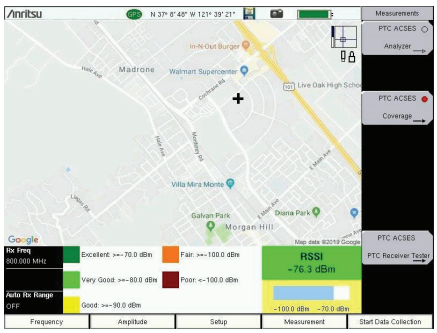
The PTC ACSES Analyzer has many useful RF tools that help determine the performance of the system; constellation diagram, spectrum, eye diagram, message decode table and payload table, will measure Received Power, Peak Envelope Power, Frequency Error, GMSK: Error Vector Magnitude (EVM), BER, Phase Error, Magnitude Error, RS decoder, PTC ACSES Talk Out coverage measurements BER, RSSI, EVM, PER.




*PTC ACSES Receiver Test Signal Generator*

### PTC ACSES Signal Generator (Option 731)

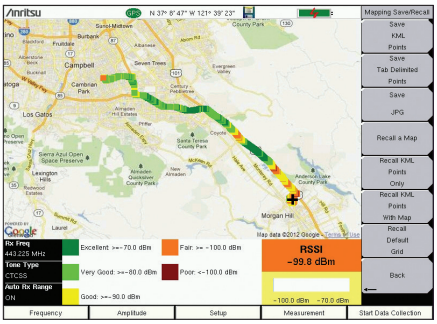
Option 731 also includes a PTC ACSES signal generator (500 kHz to 1.6 GHz) which generates GMSK signal patterns (Generic TSR1, TSR+beacon, Customer pattern, CW, AM, FM) from 0 dBm to –130 dBm, to test both TSR and beacons, and check for appropriate response from the PTC ACSES receiver.




*PTC ACSES Coverage Mapping RSSI, EVM, and BER on Map*

### PTC ACSES Coverage

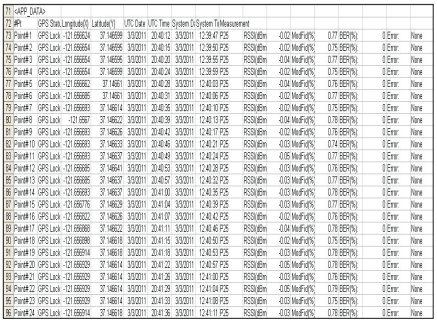
The PTC ACSES coverage Option 733 allows users to check PTC ACSES frequency coverage and quality while traveling different rail routes, users can import maps of the desired area/route and can simultaneously collect and plot RSSI, BER and EVM of the PTC ACSES signal received.




*The LMR Coverage Mapping Options Provide a Map-Based View of Measurement Results along with GPS Status. The Data Points are Color-Coded According to User-Definable Level Bins for the Selected Measurement.*




*The LMR Coverage Mapping Options Generate a Google Earth KML File with Color Push Pins Indicating BER, Modulation Fidelity or EVM, RSSI, THD, or SINAD*



*The LMR Coverage Mapping Options Provide a Tab Delimited Text File for Viewing with Spreadsheet Applications, Custom Post-Processing Scripts, or for Importing into 3rd-Party Coverage Prediction Software*

## LMR Coverage Measurement

The LMR Coverage Measurement options, combined with the GPS Option 31, measures and logs key signal quality parameters of land mobile radio systems. For analog FM systems, RSSI, THD and Transmitter SINAD can be mapped. For digital LMR systems BER, Modulation Fidelity (or Error Vector Magnitude), and RSSI can be mapped. All data points are tagged with a GPS location and time and saved to memory approximately once every two seconds. Two files are exportable; a tab-delimited text file for importing to spreadsheet and custom analysis scripts, or an industry-standard KML file for viewing with geo-mapping software such as Google Earth™. In cases where a GPS signal is not available, the LMR Master allows the user to import a floor plan or other map image and use the high-resolution color touchscreen to record data points.

The RSSI value stored into memory is an average of approximately 50,000 separate samples per second taken during the measurement period.

The EVM or Modulation Fidelity values give a good indication of the amount of multipath on the measured signal.

For in-service channel measurements, the Control Channel pattern measures the message error rate and estimates the BER from analysis of the forward error correction on the control channel data.

The Voice pattern estimates the BER on live voice traffic from analysis of the forward error correction data, eliminating the need to take critical systems off the air for analysis and allowing coverage confirmation without operational disruption.

**Coverage Mapping Parameters**

- Received Channel Frequency
- Receive Signal Pattern
- Auto Receive Range
- Indoor Mapping Repeat Type (Time or Distance)
- Repeat Time
- Repeat Distance
- Distance Units

**Coverage Mapping Types**

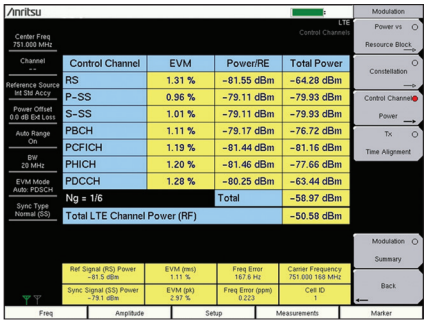
- Analog FM: RSSI, THD, SINAD
- Audio SINAD from External Receiver
- Digital LMR: RSSI, BER, Mod Fid or EVM

**Mapping Color Codes**

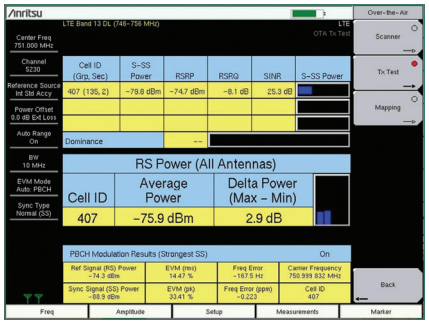
- 5 Levels
- 4 Break Points
- User-Adjustable



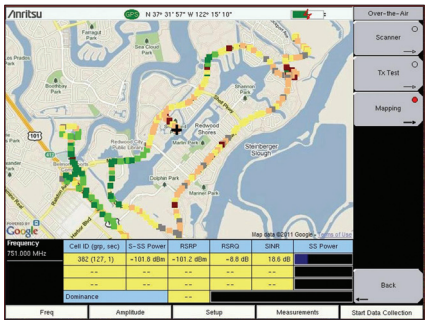

***Modulation Quality – Power vs Resource Block***
*A High Utilization of the Resource Blocks Would Indicate a Cell Site in Nearing Overload and it May be Appropriate to Start Planning for Additional Capacity*




***Modulation Quality – Control Channels***
*High Values will Create Larger Areas of Cell-to-Cell Interference and Create Lower Data Rates Near Cell Edges. Low Values Affect In-Building Coverage.*




***Over-the-Air Measurements – Tx Test***
*By Looking at the Reference Signals of MIMO Antennas One can Determine if MIMO is Working Properly. If the Delta Power is too Large, There is an Issue.*



## FDD/TDD LTE Measurements (Options: FDD LTE 541, 542, 546; TDD LTE 551, 552, 556; 886)

The LMR Master features three LTE measurement modes:

- RF Measurements
- Modulation Measurements
- Over-the-Air Measurements (OTA)

The goal of these measurements is to increase data rate and capacity by accurate power settings, ensuring low out-of-channel emissions and good signal quality. These attributes help to create a low dropped call rate, a low blocked call rate, and a good customer experience.

Cell site technicians or RF engineers can make measurements OTA to spot-check a transmitter's coverage and signal quality without taking the cell site off-line. When the OTA test results are ambiguous, one can directly connect to the base station to check the signal quality and transmitter power.

### Power vs Resource Block

Determination of system capacity is often best done by analyzing the power by resource blocks. Highly utilized LTE systems may be nearing capacity. Understanding resource block performance allows system planners to anticipate crowding and scale systems for future growth.

### Cell ID (Sector ID, Group ID)

Cell ID indicates which base station is being measured OTA. The strongest base station at your current location is selected for measurement. Wrong values for Cell ID lead to inability to register. If the cause is excessive overlapping coverage, it also will lead to poor EVM and low data rates.

### Frequency Error

Frequency Error is a check to see that the carrier frequency is precisely correct. The LMR Master can accurately measure Carrier Frequency Error OTA if the instrument is GPS enabled or in GPS holdover. Calls will drop when terminals travel at higher speed. In some cases, user equipment cannot hand off into or out of the cell.

### Sync Signal Mapping

Sync Signal Scanner can be used with the GPS to save scan results for later display on a map. The EVM of the strongest sync signal available at that spot is also recorded. The Cell, Sector, and Group ID information is also included so that it's easier to interpret the results. Once the Sync Signals are mapped, it becomes much easier to understand and troubleshoot any interference or coverage issues.

**RF Measurements (Options 541, 551)**

Channel Spectrum
- Channel Power
- Occupied Bandwidth

Power vs Time (TDD only; Option 551)
- Frame View
- Sub-Frame View
- Total Frame Power
- DwPTS Power
- Transmit Off Power
- Cell ID
- Timing Error

ACLR

Spectral Emission Mask
- Category A or B (Option 1)

RF Summary

**Modulation Measurements (Options 542, 552)**

Power vs. Resource Block (RB)
- RB Power (PDSCH)
- Active RBs, Utilization %
- Channel Power, Cell ID
- OSTP, Frame EVM by Modulation

Constellation
- QPSK, 16 QAM, 64 QAM, 256 QAM (Option 886)
- Modulation Results
  - Ref Signal Power (RS)
  - Sync Signal Power (SS)
  - EVM – rms, peak, max hold
  - Frequency Error – Hz, ppm
  - Carrier Frequency
  - Cell ID

Control Channel Power
- Bar Graph or Table View
- RS, P-SS, S-SS
- PBCH, PCFICH
- PHICH, PDCCH
- Total Power (Table View)
- EVM

Tx Time Alignment

Modulation Summary
- Includes EVM by Modulation

Antenna Icons
- Detects Active Antennas (1 or 2)

**OTA Measurements (Options 546, 556)**

Scanner – Six Strongest Signals
- Cell ID (Group, Sector)
- S-SS, RSRP, RSRQ, SINR
- Dominance
- Modulation Results – On/Off
- Auto Save – On/Off

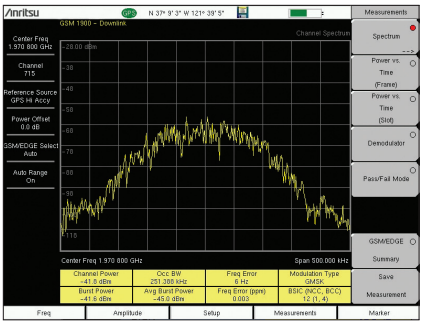
Tx Test
- Scanner – Three Strongest Signals
- RS Power of MIMO Antennas
  - Cell ID, Average Power
  - Delta Power (Max-Min)
  - Graph of Antenna Power
- Modulation Results – On/Off

Mapping (Requires Option 31 GPS)
- On-screen
  - S-SS, RSRP, RSRQ, or SINR

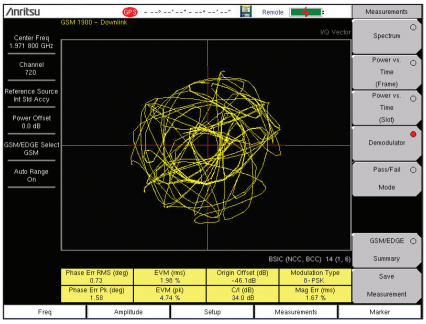
**Pass/Fail (User Editable)**

View Pass/Fail Limits
- All, RF, Modulation

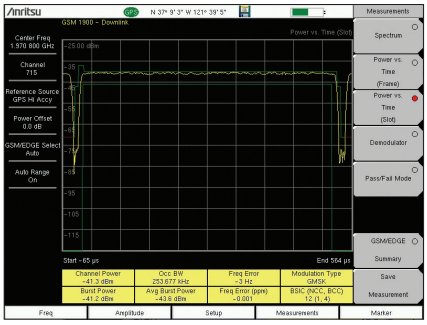
Available Measurements
- Channel Power
- Occupied Bandwidth
- ACLR
- Frequency Error
- Carrier Frequency
- Dominance
- EVM peak, rms
- Frame EVM, rms
- Frame EVM by mod type
- RS, SS Power
- RS EVM
- P-SS, S-SS Power, EVM
- PBCH, PCFICH, PHICH, PDCCH Power, EVM
- Cell, Group, Sector ID
- OSTP
- Tx Time Alignment
- Frame Power (TDD Only; Option 551)
- DwPTS Power (TDD Only; Option 551)
- Transmit Off Power (TDD Only; Option 551)
- Timing Error (TDD Only; Option 551)



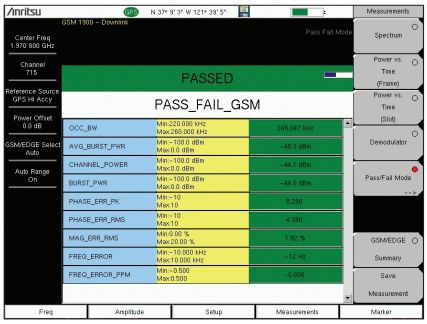
***RF Measurement – Occupied Bandwidth***
*Excessive Occupied Bandwidth can Create Interference with Adjacent Channels or be a Sign of Poor Signal Quality, Leading to Dropped Calls*



***Demodulation – Error Vector Magnitude (EVM)***
*This is the Single Most Important Signal Quality Measurement. Poor EVM Leads to Dropped Calls, Low Data Rate, Low Sector Capacity, and Blocked Calls.*



***RF Measurement – Average Burst Power***
*High or Low Values will Create Larger Areas of Cell-to-Cell Interference and Create Lower Data Rates Near Cell Edges. Low Values Create Dropouts and Dead Zones.*




***Pass/Fail Test***
*Set Up Common Test Limits, or Sets of Limits, for Each Instrument. Inconsistent Settings between Base Stations, Leads to Inconsistent Network Behavior.*

## GSM/EDGE Signal Analyzers (Option 880)

The LMR Master features two GSM/EDGE measurement modes.

- RF Measurements
- Demodulation

The goal of these measurements is to increase data rate and capacity by accurate power settings, ensuring low out-of-channel emissions, and good signal quality. These attributes help to create a low dropped call rate, a low blocked call rate, and a good customer experience.

Cell site technicians or RF engineers can make measurements OTA to spot-check a transmitter's coverage and signal quality without taking the cell site off-line. When the OTA test results are ambiguous one can directly connect to the base station to check the signal quality and transmitter power. For easy identification of which cell you are measuring the Base Station Identity Code (BSIC) gives the base station id, the Network Color Code (NCC) identifies the owner of the network, and the Base Station Color Code (BCC) provides the sector information.

### Carrier-to-Interference (C/I)

C/I indicates the quality of the received signal. It also can be used to identify areas of poor signal quality. Low C/I ratios will cause coverage issues including dropped calls, blocked calls, and other handset reception problems.

### Phase Error

Phase Error is a measure of the phase difference between an ideal and actual GMSK modulated voice signal. High phase error leads to dropped calls, blocked calls, and missed handoffs.

### Origin Offset

Origin Offset is a measure of the DC power leaking through local oscillators and mixers. A high Origin Offset will lower EVM and Phase Error measurements and create higher dropped call rates.

### Power vs Time (Slot and Frame)

Power vs Time (Slot and Frame) should be used if the GSM base station is setup to turn RF power off between timeslots. When used OTA, this measurement can also spot GSM signals from other cells. Violations of the mask create dropped calls, low capacity, and small service area issues.

**RF Measurements**

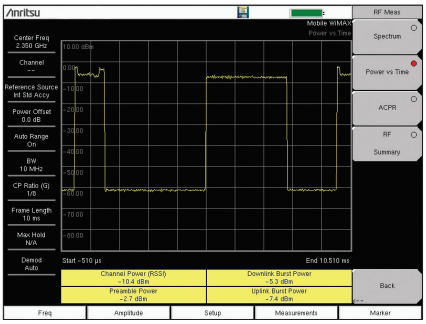
Channel Spectrum
- Channel Power
- Occupied Bandwidth
- Burst Power
- Average Burst Power
- Frequency Error
- Modulation Type
- BSIC (NCC, BCC)

Multi-Channel Spectrum

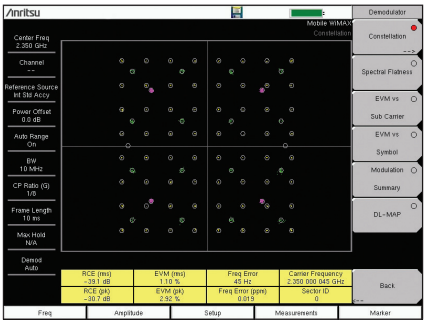
Power vs Time (Frame/Slot)
- Channel Power
- Occupied Bandwidth
- Burst Power
- Average Burst Power
- Frequency Error
- Modulation Type
- BSIC (NCC, BCC)

**Demodulation**

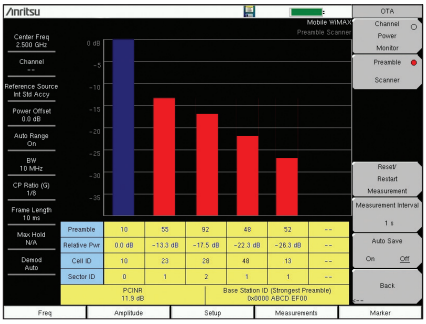
Phase Error
EVM
Origin Offset
C/I
Modulation Type
Magnitude Error
BSIC (NCC, BCC)



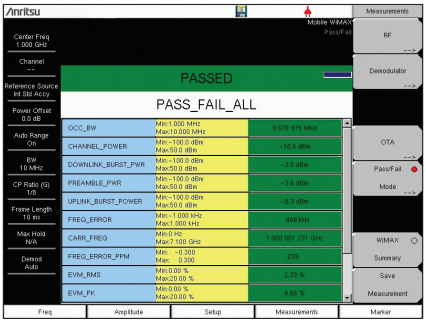
***RF Measurement – Preamble Power***
*High or Low Values will Create Larger areas of Cell-to-Cell Interference and Create Lower Data Rates Near Cell Edges. Low Values Affect In-Building Coverage.*



***Demodulation – Frequency Error***
*Calls will Drop When User's Equipment Travels at High Speed. In Severe Cases, Hand Offs will Not be Possible at Any Speed, Creating Island Cells.*



***Over-the-Air Measurements – PCINR***
*A Low Physical Carrier to Interference Plus Noise Ratio (PCINR) Indicates Poor Signal Quality, Low Data Rate and Reduced Sector Capacity*




## Fixed and Mobile WiMAX Signal Analyzers (Options 46, 47, 66, 67, 37)

The LMR Master features two Fixed WiMAX and three Mobile WiMAX measurement modes:

- RF Measurements
- Demodulation (up to 10 MHz)
- OTA Measurements (mobile only)

The goal of these measurements is to increase data rate and capacity by accurate power settings, ensuring low out-of-channel emissions, and good signal quality. These attributes help to create a low dropped call rate, a low blocked call rate, and a good customer experience.

Cell site technicians or RF engineers can make measurements OTA to spot-check a transmitter's coverage and signal quality without taking the cell site off-line. When the OTA test results are ambiguous one can directly connect to the base station to check the signal quality and transmitter power.

### Cell ID, Sector ID, and Preamble

Cell ID, Sector ID, and Preamble show which cell, sector, and segment are being measured OTA. The strongest signal is selected automatically for the additional PCINR and Base Station ID measurement. Wrong values for cell, sector and segment ID lead to dropped hand offs and island cells. If the cause is excessive coverage, it also will lead to large areas of low data rates.

### Error Vector Magnitude (EVM) Relative Constellation Error (RCE)

RCE and EVM measure the difference between the actual and ideal signal. RCE is measured in dB and EVM in percent. A known modulation is required to make these measurements. High RCE and EVM causes low signal quality, low data rate, and low sector capacity. This is the single most important signal quality measurement.

### Preamble Mapping (Mobile WiMAX)

Preamble Scanner can be used with the GPS to save scan results for later display on a map. PCINR ratio for the strongest WiMAX preamble available at that spot. The Base Station ID and Sector ID information are also included so that it's easier to interpret the results. Once PCINR data is mapped, it becomes much easier to understand and troubleshoot any interference or coverage issues.

**RF Measurements (Option 46/66, Fixed/Mobile)**

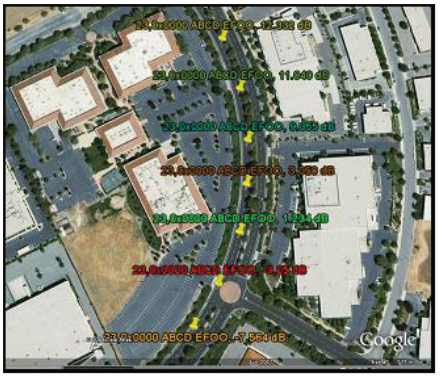
- Channel Spectrum
  - Channel Power
  - Occupied Bandwidth
- Power vs Time
  - Channel Power
  - Preamble Power
  - Downlink Burst Power (Mobile only)
  - Uplink Burst Power (Mobile only)
  - Data Burst Power (Fixed only)
  - Crest Factor (Fixed only)
- ACPR

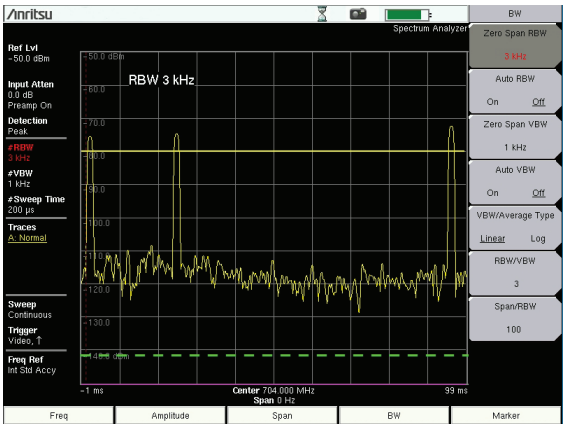
**Demodulation (10 MHz maximum) (Option 47/67, Fixed/Mobile)**

- Constellation
  - RCE (RMS/Peak)
  - EVM (RMS/Peak)
  - Frequency Error
  - CINR (Mobile only)
  - Base Station ID
  - Carrier Frequency
  - Sector ID
- Spectral Flatness
  - Adjacent Subcarrier Flatness
- EVM vs. Subcarrier/Symbol
  - RCE (RMS/Peak)
  - EVM (RMS/Peak)
  - Frequency Error
  - CINR (Mobile only)
  - Base Station ID
  - Sector ID (Mobile only)
- DL-MAP (Tree View) (Mobile only)

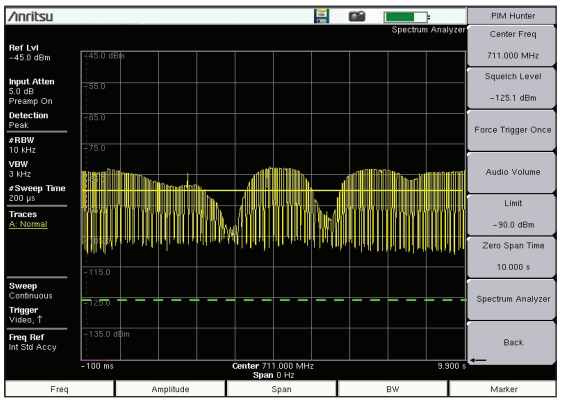
**Over-the-Air (OTA) (Option 37 Mobile Only)**

- Channel Power Monitor
- Preamble Scanner (Six)
  - Preamble
  - Relative Power
  - Cell ID
  - Sector ID
  - PCINR
  - Dominant Preamble
    - Base Station ID
- Auto-Save with GPS Tagging and Logging






*100 ms Zero Span Time*

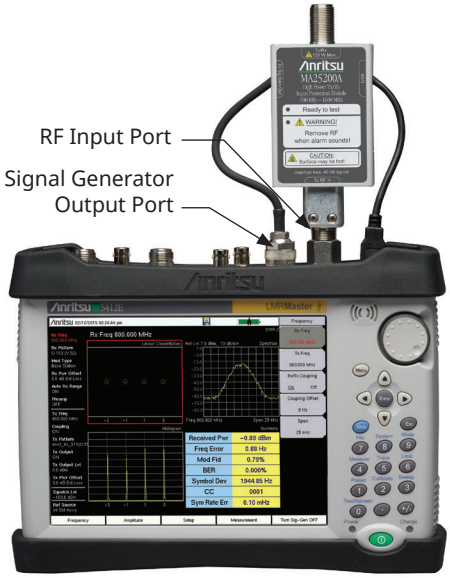



*10 Second Zero Span Time*

## PIM Hunting

Available on Anritsu solutions with spectrum analyzer capabilities, the PIM Hunting measurement is an optimized zero span function that enables users to hunt and find PIM sources. Together with a PIM Hunter™ probe (P/N 200-1884-R), users can quickly and easily sweep suspected areas for PIM while the PIM Master™ MW82119B RF tones illuminate sources. All key controls needed to conduct a PIM hunting exercise are available in this mode, including:

- Center Frequency: Utilizing the IM product frequency generated by the PIM Master test equipment, set the center frequency of the IM product that is being hunted.
- Squelch Level (green dotted line): Equivalent to the video trigger function, this is used to show active traces that are above the set limit while signals below the squelch level will be static.
- Force Trigger Once: Use to reset the squelch and limit line levels if the trace is not moving.
- Audio Volume: As the user is PIM hunting, a variable tone will get higher in pitch as they get closer to the PIM source (i.e., IM signal level rises). The user can adjust the volume as needed.
- Limit (solid yellow line): Use to set the Pass/Fail limit of PIM level being hunted.
- Zero Span Time: This settable time scale is used to show how many IM pulses the user want to see.




## High Power Input Protection Module MA25200A 500 kHz to 1600 MHz

The accessory MA25200A high power protection module is available to safeguard the S412E ports from high power portable, mobile, or base station transmitters. The MA25200A attenuates RF power levels up to +51 dBm (125 W) to safe levels for measurements. The MA25200A connects and mounts to the RF input connector. It has an N(m) coaxial input cable that connects to the Signal Generator output. The top N(f) connector can be connected directly to portable or mobile antenna ports or base station transmit or receive ports. The nominal 40 dB insertion loss applied to the RF input port and signal generator output ports can be compensated in the S412E amplitude offset menus so that the displayed levels match the levels at the input of the MA25200A.

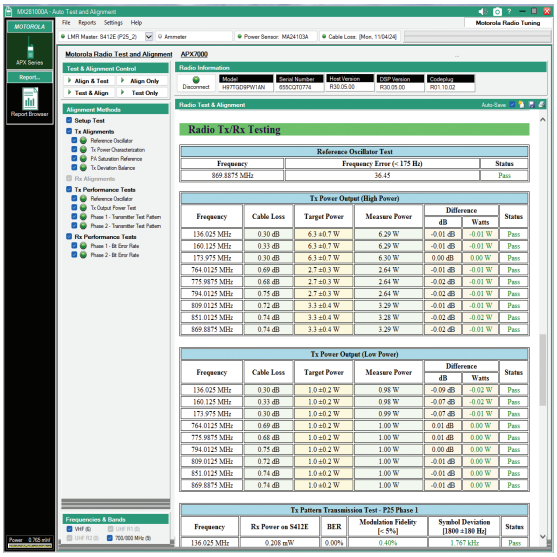
Specification summary.

- Maximum Input Power +51 dBm (125 W)
- Maximum Continuous Input Power +44 dBm (25 W)
- DC Insertion Loss (typical) RF In Port: 40 dB ±1 dB, 500 kHz to 1.6 GHz
- Signal Generator Out: 40 dB ±1 dB 500 kHz to 1.0 GHz, ±2.0 dB > 1.0 GHz to 1.6 GHz
- Size 64 mm x 162 mm x 60 mm (2.5 in x 6.4 in x 2.4 in)
- Weight 583 g (20.6 oz)

## Auto Test and Alignment System

The Auto Test and Alignment (ATA) system is designed for professionals responsible for radio maintenance and repair in critical sectors such as public safety, utilities, transportation, and private security. Reliable communication in these sectors is essential. The Auto Test and Alignment system simplifies and accelerates the maintenance process, automating complex testing and alignment tasks that would otherwise require significant time and manual effort. By providing precise, consistent results with minimal intervention, this system empowers technicians to ensure that radios are always operating at peak performance, reducing downtime and improving the reliability of critical communication networks. This increased efficiency not only saves valuable time but also reduces the risk of errors.





*Example PC Screen Showing Summarized Results for a Motorola P25 Radio*

**The Auto Test and Alignment System Comprises the Following:**

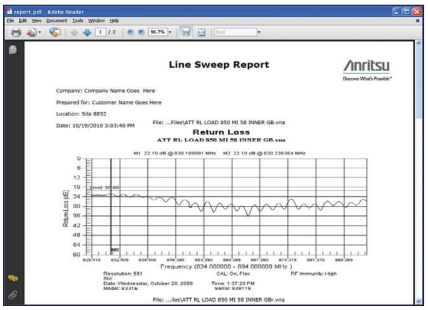
- S412E LMR Master (with P25 options and firmware V4.72 or later)
- MX281000A Auto Test and Alignment Software
- MA25211A Auto Test and Alignment Kit
- A Windows PC (customer supplied) that controls the LMR Master S412E, the ATA accessories, and the radio under test.
- Power Supply (user supplied)

The MX281000A software runs on a standard windows PC which controls the radio under test and the Anritsu S412E LMR Master. A single button initiates execution of an automated test plan that retunes the radio to its optimum state and measures the RF performance. Test reports are created automatically, and a comprehensive library includes historical results for all radios.

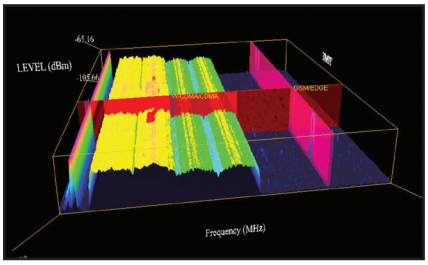
Refer to the ATA Brochure (11410-02961) and TDS (11410-00486) for complete specs and ordering information.




***Trace Validation***
*Marker and Limit Line Presets Allow Quick Checks of Traces for Limit Violations*




***Report Generation***
*Create Reports with Company Logo, GPS Tagging Information, Calibration Status, and Serial Number of the Instrument for Complete Reporting*




***3D Spectrogram***
*For In-Depth Analysis with 3-Axis Rotation Viewing, Threshold, Reference Level, and Marker Control. Turn on Signal ID to See the Types of Signals.*

## Anritsu Tool Box™ (for your PC)

### Line Sweep Tools™

Line Sweep Tools increases productivity for people who deal with dozens of Cable & Antenna traces, or Passive Intermodulation (PIM) traces, every day.

#### User Interface

Line Sweep Tools has a user interface that will be familiar to users of Anritsu's Hand Held Software Tools. This will lead to a short learning curve.

#### Marker and Limit Line Presets

Presets make applying markers and a limit line to similar traces, as well as validating traces, a quick task.

#### Renaming Grid

A renaming grid makes changing file names, trace titles, and trace subtitles from field values to those required for a report much quicker than manual typing and is less prone to error.

#### Report Generator

The report generator will generate a professional looking PDF of all open traces with additional information such as contractor logos and contact information.

### Master Software Tools

Master Software Tools (MST) is a powerful PC software post-processing tool designed to enhance the productivity of technicians in data analysis and testing automation.

#### Folder Spectrogram

Folder Spectrogram – creates a composite file of up to 15,000 multiple traces for quick review, also create:

- Peak Power, Total Power, and Peak Frequency plotted over time
- Histogram – filter data and plot number of occurrences over time
- Minimum, Maximum, and Average Power plotted over frequency
- Movie playback – playback data in the familiar frequency domain view
- 3D Spectrogram – for in-depth analysis with 3-axis rotation viewing control

### easyTest Tools™

easyTest has a few simple tools that allow experienced users to easily share their expertise with novice users. This simplicity allows experienced users to concentrate on their message and not the mechanics of creating a procedure.

### easyMap Tools™

easyMap works with Anritsu handheld spectrum analyzers and interference analyzers. It is focused on supporting Option 25, Interference Analysis, and Option 431, coverage mapping.

**Line Sweep Features**

**Presets**
- 7 Sets of 6 Markers and 1 Limit Line
- Next Trace Capability

**File Types**
- Input: HHST DAT, MNA, and VNA Measurements: Return Loss (VSWR), Cable Loss, DTF-RL, DTF-VSWR, PIM
- Output: LS DAT, MNA, VNA, CSV, PNG, BMP, JPG, PDF

**Report Generator**
- Logo, title, company name, customer name, location, date and time, filename, PDF, HTML, all open traces

**Tools**
- Cable Editor
- Distance-to-Fault
- Measurement Calculator
- Signal Standard Editor
- Renaming Grid

**Interfaces**
- Serial, Ethernet, USB

**Capture Plots**
- Screen, Database, DAT Files, JPEG, Instrument

**Master Software Tools Features**

**Database Management**
- Full Trace Retrieval
- Trace Catalog
- Group Edit
- Trace Editor

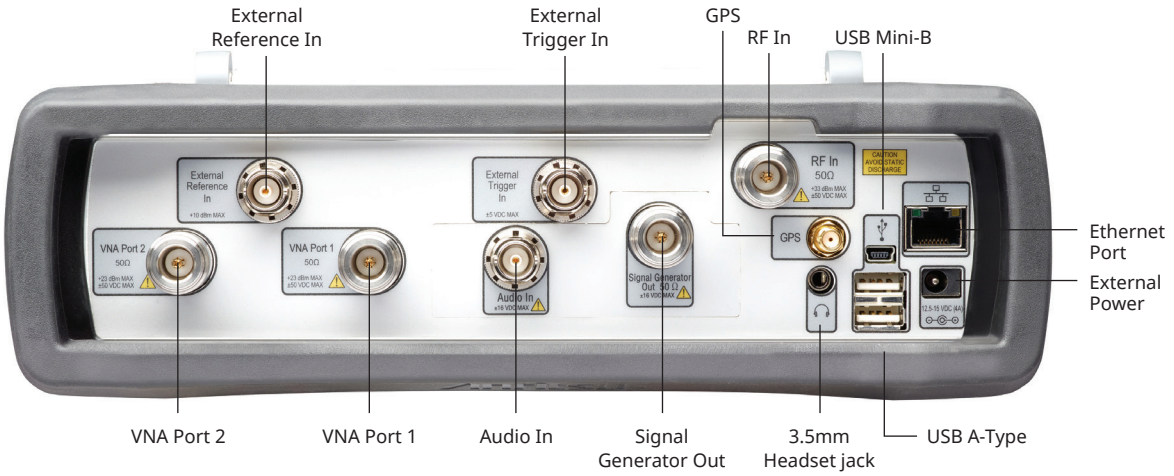
**Data Analysis**
- Trace Math and Smoothing
- Data Converter
- Measurement Calculator

**Mapping (GPS Required)**
- Spectrum Analyzer Mode
- Mobile WiMAX OTA Option
- TS-SCDMA OTA Option
- LTE, both FDD and TDD Options

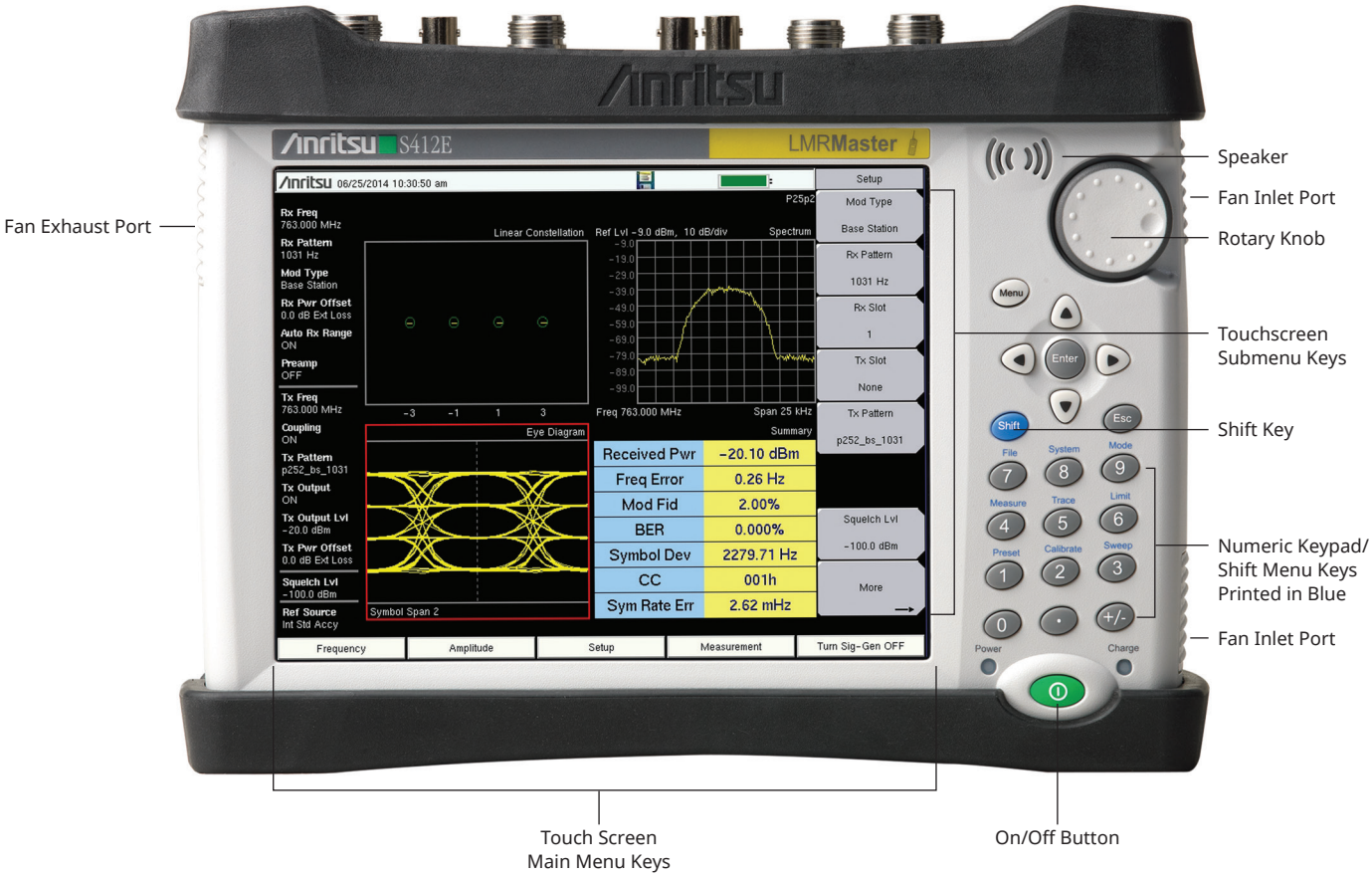
**Folder Spectrogram**
- Folder Spectrogram – 2D View
- Video Folder Spectrogram – 2D View
- Folder Spectrogram – 3D View

**List/Parameter Editors**
- Traces
- Antennas, Cables, Signal Standards
- Product Updates
- Firmware Upload
- Pass/Fail
- VSG Pattern Converter
- Languages
- Mobile WiMAX
- Display

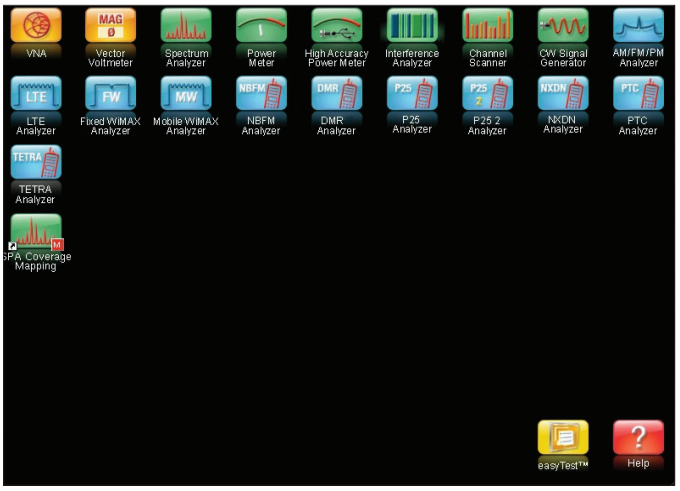
# LMR Master S412E




*All Connectors are Conveniently Located on the Top Panel, Leaving the Sides Clear for Handheld Use*



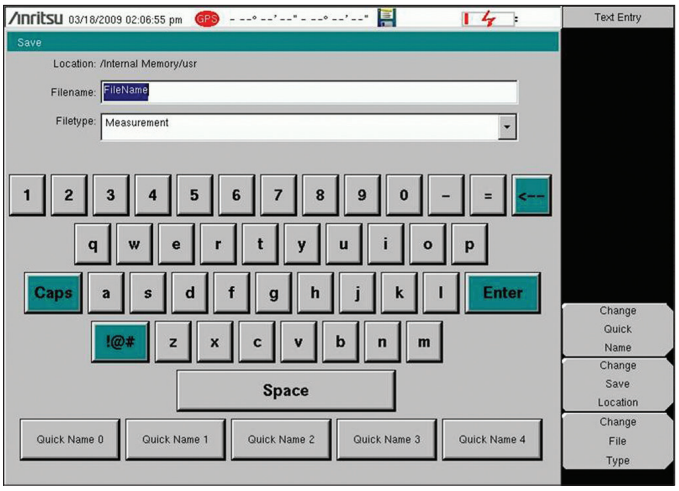

*Handheld Size: 273 x 199 x 91 mm, (10.7 x 7.8 x 3.6 in), Lightweight: 3.6 kg, (7.9 lb)*




### Touchscreen Menu

*The Menu Key Activates the Touchscreen Menu for One Button Access to All of the Analyzers.*

*User Defined Shortcuts Can be Created for One-Button Access to Commonly Used Functions.*




### Touchscreen Keyboard

*A Built-In Touchscreen Keyboard Saves Valuable Time in the Field When Entering Trace Names.*

*For Cable & Antenna Analysis, a Quick Name Matrix Can be Customized for Quickly Naming Your Line Sweeps.*






*Tilt Bails are Integrated into the Case and Soft Case for Better Screen Viewing*

## Ordering Information

| S412E | Description |
|---|---|
| 500 kHz to 1.6 GHz | Vector Network Analyzer |
| 9 kHz to 1.6 GHz | Spectrum Analyzer |
| 10 MHz to 1.6 GHz | Power Meter |
| 500 kHz to 1.6 GHz | CW Signal Generator |
| 10 MHz to 1.6 GHz | NBFM Analyzer |
| **Options** | |
| S412E-0010 | High Voltage Variable Bias Tee |
| S412E-0031 | GPS Receiver (Requires suitable GPS antenna) |
| S412E-0019 | High-Accuracy Power Meter (Requires External Power Sensor) |
| S412E-0025 | Interference Analyzer (Option 31 recommended) |
| S412E-0027 | Channel Scanner |
| S412E-0006 | 6 GHz Coverage on Spectrum Analyzer |
| S412E-0016 | 6 GHz Coverage on Vector Network Analyzer |
| S412E-0015 | Vector Voltmeter |
| S412E-0431 | Coverage Mapping (Requires Option 31) |
| S412E-0444 | EMF Measurements (Requires Anritsu Isotropic Antenna) |
| S412E-0509 | AM/FM/PM Analyzer |
| S412E-0521 | P25/P25p2 Analyzer Measurements |
| S412E-0522 | P25/P25p2 Coverage Measurements (Requires Options 31 and 521) |
| S412E-0531 | NXDN Analyzer Measurements |
| S412E-0532 | NXDN Coverage Measurements (Requires Options 31 and 531) |
| S412E-0573 | dPMR RF Analyzer Measurements |
| S412E-0572 | dPMR Coverage Measurements (Requires Options 31 and 573) |
| S412E-0581 | TETRA Analyzer Measurements |
| S412E-0582 | TETRA Coverage Measurements (Requires Options 31 and 581) |
| S412E-0591 | DMR (MOTOTRBO) Analyzer Measurements |
| S412E-0592 | DMR (MOTOTRBO) Coverage Measurements (Requires Options 31 and 591) |
| S412E-0721 | PTC ITCR Analyzer |
| S412E-0722 | PTC ITCR Coverage Measurements (Requires Options 31 and 721) |
| S412E-0731 | PTC ACSES Analyzer |
| S412E-0733 | PTC ACSES Coverage Measurements (Requires Options 31 and 731) |
| S412E-0541 | FDD LTE RF Measurements |
| S412E-0542 | FDD LTE Modulation Quality |
| S412E-0546 | FDD LTE Over-the-Air Measurements (Requires Option 31) |
| S412E-0886 | LTE 256 QAM Demodulation (Requires Option 542) |
| S412E-0551 | TDD LTE RF Measurements (Requires Option 541) |
| S412E-0552 | TDD LTE Modulation Measurements (Requires Option 542) |
| S412E-0556 | TDD LTE Over-the-Air Measurements (Requires Options 546 and 31) |
| S412E-0880 | GSM/GPRS/EDGE Measurements |
| S412E-0046 | IEEE 802.16 Fixed WiMAX RF Measurements (Requires Option 6) |
| S412E-0047 | IEEE 802.16 Fixed WiMAX Demodulation (Requires Option 6) |
| S412E-0066 | IEEE 802.16 Mobile WiMAX RF Measurements (Requires Option 6) |
| S412E-0067 | IEEE 802.16 Mobile WiMAX Demodulation (Requires Option 6) |
| S412E-0037 | IEEE 802.16 Mobile WiMAX Over-the-Air Measurements (Requires Option 6; Option 31 Required for Full Functionality) |
| S412E-0098 | Standard Calibration to ISO17025 and ANSI/NCSL Z540-1. Includes calibration certificate. |
| S412E-0099 | Premium Calibration to ISO17025 and ANSI/NCSL Z540-1. Includes calibration certificate, test report, and uncertainty data. |

# LMR Master S412E

## Standard Accessories

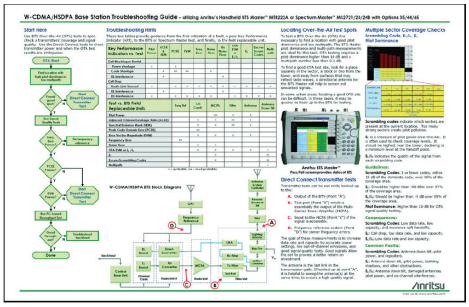


| Part Number | Description |
|---|---|
| 2000-1691-R | Stylus with Coiled Teather |
| 2000-197-R | Screen Protector Film, 8.4 inch (2, one installed) |
| 2000-1654-R | Soft Carrying Case |
| 633-75 | Rechargeable 7500 mAh Li-Ion Battery |
| 40-187-R | AC-DC Adapter |
| 806-141-R | Automotive Power Adapter, 12 VDC, 60 W |
| 3-2000-1498 | USB A-type to Mini USB B-type cable, 3.05 m (10 ft) |
| | Standard Three Year Warranty (one year on battery) |
| | Certificate of Confidence |

## Manuals, Related Literature (soft copy at www.anritsu.com)

| Part Number | Description |
|---|---|
| 10100-00065 | Product Information, Compliance, and Safety |
| 10580-00318 | LMR Master User Guide |
| 10580-00289 | Vector Network Analyzer Measurement Guide |
| 10580-00243 | Land Mobile Radio User Guide |
| 10580-00241 | Cable and Antenna Analyzer Measurement Guide |
| 11410-00349 | Spectrum Analyzer Measurement Guide |
| 10580-00240 | Power Meter Measurement Guide |
| 10580-00234 | 3GPP Signal Analyzer Measurement Guide |
| 10580-00236 | WiMAX Signal analyzer Measurement Guide |
| 10580-00319 | Programming Manual |
| 10580-00498 | MX281000A Auto Test and Alignment User Guide |

## Troubleshooting Guides (soft copy at www.anritsu.com)



| Part Number | Description |
|---|---|
| 11410-00551 | Spectrum Analyzers |
| 11410-00472 | Interference |
| 11410-00566 | LTE eNode Testing |
| 11410-00466 | GSM/GPRS/EDGE Base Stations |
| 11410-00473 | Cable, Antenna, and Component Troubleshooting Guide |
| 11410-00427 | Understanding Cable & Antenna Analysis White Paper |

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