

Practical Tips on WiMAX Field Measurements

MT8222A
BTS Master™

Introduction

Worldwide Interoperability for Microwave Access (WiMAX) digital communications technology is based on wireless transmission methods defined by the IEEE-802.16 air interface standard. Intended for wireless metropolitan area networks, it provides broadband wireless access up to 30 miles for fixed stations, and 3 - 10 miles for mobile stations. WiMAX has a range of potential uses including providing high-speed mobile data and telecommunications services (e.g. 4G), as a wireless alternative to cable and DSL for last mile broadband access, and to connect Wi-Fi hotspots with each other and to other parts of the Internet.

The 802.16 air interface standard supports fixed, nomadic, portable and mobile access (Table 1). To meet the requirements of different types of access, two versions of WiMAX have been defined. The first, IEEE 802.16-2004 (Fixed WiMAX), is optimized for Fixed and nomadic broadband wireless access to homes and businesses. This point-to-multipoint version specifies WiMAX for systems in the 10-66 GHz and sub 11-GHz frequency ranges. The second version, IEEE 802.16e (Mobile WiMAX), is designed to support portability and mobility and offers the full mobility of cellular networks at true broadband speeds. Both fixed and mobile applications of WiMAX are engineered to help deliver ubiquitous, high-throughput broadband wireless services at a low cost.

Definition	Devices	Location/Speed	Handoffs	802.16-2004	802.16e
Fixed access	Outdoor and indoor CPEs	Single/Stationary	No	Yes	Yes
Nomadic access	Indoor CPEs, PCMCIA cards	Multiple/Stationary	No	Yes	Yes
Portability	Laptop PCMCIA or mini cards	Multiple/Walking speed	Hard handoffs	No	Yes
Simple mobility	Laptop PCMCIA or minicards, PDAs or smartphones	Multiple/Low vehicular speed	Hard handoffs	No	Yes
Full mobility	Laptop PCMCIA or minicards, PDAs or smartphones	Multiple/High vehicular speed	Soft handoffs	No	Yes

Table 1. Types of access to a WiMAX network*

This application note focuses on the measurement procedures for Fixed WiMAX and Mobile WiMAX networks. Its objective is to present practical field measurement tips and procedures which will help a field-based network technician or RF engineer conduct measurements on WiMAX networks.

*Table 1. Courtesy of the WiMAX Forum, this table demonstrates different types of access to a WiMAX network.

Understanding WiMAX Technology

The 802.16 broadband wireless access (BWA) standard is designed to provide increased bandwidth and range, efficient bandwidth interference avoidance, and stronger encryption. Conformance and interoperability of the standard is overseen by the WiMAX Forum.

In favorable circumstances, wireless connectivity is possible between network endpoints without the need for direct line of sight. Non-line-of-sight propagation (NLOS) performance is also possible and relies on a clever use of multi-path signals.

Some of the main advantages of WiMAX networks include:

- Higher data rates over a longer distance. Thanks to good antenna technology, the WiMAX transmitting station can send data to WiMAX-enabled computers or routers set up within the transmitter's 30-mile radius.
- Operates on both licensed and non-licensed frequencies. Consequently, WiMAX provides a regulated environment and viable economic model for wireless carriers.
- WiMAX offers better coverage, easier self installation, reduced power consumption, frequency re-use and bandwidth efficiency. The mobile version also adds a capability for full mobility support.

Because 802.16 was designed to cover application to diverse markets - from very high bandwidth businesses to SOHO and residential users - it contains allowances for a number of physical layers to accommodate different frequency bands and region-by-region frequency regulatory rules. These options may leave implementers facing some tough decisions. To address this issue and help speed WiMAX adoption in real-world networks, the WiMAX Forum has created a limited number of system profiles. These profiles specify which features (e.g. frequency band, channel bandwidth and duplexing scheme) are mandatory or optional for the various MAC or PHY scenarios that are most likely to arise in the deployment of real WiMAX systems. As a result, vendors addressing the same market can build systems for that market which are interoperable but that do not require the implementation of absolutely every feature.

The choice of profiles is driven by market demand, spectrum availability, regulatory constraints, the services to be offered, and vendor interest. For example, the availability of spectrum for BWA services in several countries motivated the creation of profiles in the 3.5 GHz band. By the same token, the availability of license-exempt spectrum and demand for fixed services drove the creation of a profile in the 2.4 MHz and 5.8 GHz bands.

A list of Fixed WiMAX system profiles is specified in Table 2. Here, the most globally harmonized band is the licensed 3.5 GHz band (3400 - 3600 MHz).

Frequency Band (MHz)	Channelization (MHz)	Duplexing
3400 - 3600	3.5	TDD
3400 - 3600	7.0	TDD
3400 - 3600	3.5	FDD
3400 - 3600	7.0	FDD
5725 - 5850	1	TDD

Table 2. Fixed WiMAX initial profiles (source: WiMAX Forum).

A list of Release-1 Mobile WiMAX profiles is provided in Table 3. These profiles cover a range of channel bandwidths for licensed worldwide spectrum allocations in the 2.3, 2.5, 3.3 and 3.5 GHz frequency bands. Selection of frequency for Mobile WiMAX deployment directly affects the quality and cost of the network. Lower frequency bands are generally preferred as they offer lower attenuation and longer reach which, in turn, leads to a smaller number of required cells to provide mobility coverage. The most preferred bands of many would-be Mobile WiMAX operators today are between 1.9 GHz and 2.1 GHz. These bands though have already been assigned to 3G operators. There is also a growing interest in the 700 - 800 MHz bands traditionally used by analog TV broadcast, but it is unclear when these bands will be completely vacated.

Channelization (MHz)	FFT Size	Frequency Band (GHz)					
		2.3-2.4	2.305-2.32	2.345-2.36	2.496-2.69	3.3-3.4	3.4-3.8
5.0	512	TDD	TDD	TDD	TDD	TDD	TDD
7.0	1024					TDD	TDD
8.75	1024	TDD					
10	1024	TDD	TDD	TDD	TDD	TDD	TDD

Table 3. Release-1 Mobile WiMAX System Profiles (source: WiMAX Forum). For 7 and 8.75 MHz channel bandwidths, sampling factor - instead of FFT size - is made variable.

Fixed WiMAX

The 802.16-2004 Fixed WiMAX standard covers both the Media Access Control (MAC) and the physical (PHY) layer protocols for extending broadband wireless access to the metropolitan area network. Fixed WiMAX is based on Orthogonal Frequency Division Multiplexing (OFDM). It can accommodate either Time Division Duplexing (TDD) or Frequency Division Duplexing (FDD) deployments, allowing for both full and half-duplex terminals in the FDD case. In licensed bands, the duplexing method can be either TDD or FDD. Unlicensed operation is limited to using the TDD format.

As a cost-effective alternative to cable and DSL services, Fixed WiMAX supports scalable channel bandwidths from 1.25 to 20 MHz. The varying channel bandwidth is necessary to address international markets and regional spectrum regulations. It also supports both fixed and nomadic access in line-of-sight and NLOS environments.

• 802.16-2004 PHY

While multiple PHYs are defined for the 802.16-2004 standard, the one which dominates the industry is the 256-carrier OFDM format (Figure 1). With this modulation scheme, basic OFDM symbols are based on a 256 point Fast Fourier Transform (FFT). Out of 256 subcarriers, 55 subcarriers are nulled and set aside for guard bands; the center frequency subcarrier is set to zero, since it is susceptible to carrier leakage; the remaining 200 subcarriers are used for data (192) and pilot (8). Note that pilot subcarriers are always binary phase shift keying (BPSK) modulated, while the data carriers can be BPSK, quadrature phase shift keying (QPSK), 16 quadrature amplitude modulation (16 QAM) or 64 quadrature amplitude modulation (64 QAM). These adaptive modulation and coding (AMC) rate configurations can be used to trade off data rate for system robustness under various wireless propagation and interference conditions.

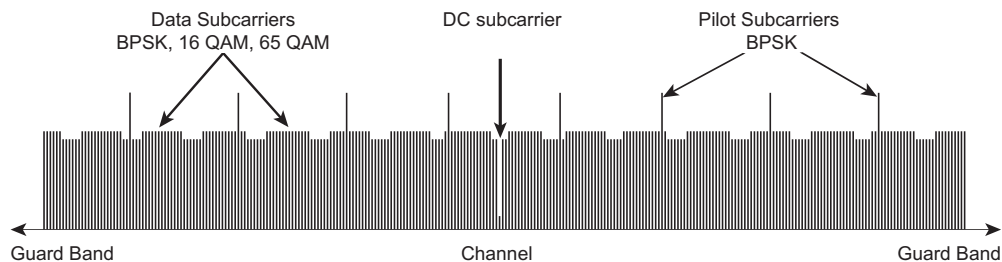


Figure 1. OFDM subcarriers.

In WiMAX systems with narrow bandwidth, the subcarriers are very closely spaced, thereby providing a relatively long symbol period. Note that a symbol period is defined as $1/\text{subcarrier spacing}$ rather than $1/\text{bandwidth}$, thereby providing a relatively long symbol period. Closely spaced subcarriers and long symbols can be quite beneficial as they help overcome channel impairments (e.g. multipath). The long symbol period also offers significant advantages for long distances and non-line-of-sight applications.

• 802.16-2004 MAC

The 802.16-2004 MAC is designed specifically for the point-to-multipoint wireless access environment and supports higher layer or transport protocols such as ATM, Ethernet or Internet Protocol (IP), as well as future protocols. It features very high bit rates (up to 268 mbps each way) of the broadband physical layer, while delivering ATM compatible QoS including: Unsolicited Grant Service (UGS), Real-Time Polling Service (rtPS), Non-Real-Time Polling Service (nrtPS), and Best Effort service.

As compared to other popular wireless network standards (e.g. 802.11 WLAN), the 802.16-2004 MAC uses a scheduling algorithm that enables the SS to only compete once for initial entry into the network. Once it gains entry, the SS is allocated a time slot by the base station. While the time slot can increase or decrease, it remains assigned to the SS. The slot therefore, can not be used other subscribers. The scheduling algorithm is stable under overload and over-subscription, and is bandwidth efficient. It also allows the base station to control Quality of Service (QoS) parameters by balancing the time-slot assignments among the application needs of the subscriber stations.

The typical 802.16-2004 MAC frame structure consists of a downlink (DL) subframe and an uplink (UL) subframe (Figure 2). Currently there are seven supported frame durations in the IEEE 802.16-2004 standard ranging from 2.5 to 20 ms.

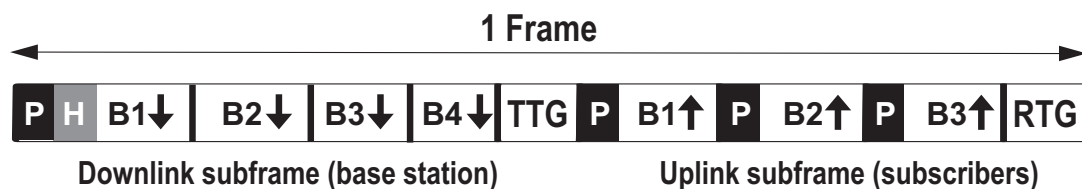


Figure 2. Downlink and uplink subframes.

As an example consider the TDD frame. It consists of one DL subframe followed by one or multiple UL subframes. An adaptive boundary lies between the DL and UL subframes of the TDD signal's flexible frame structure. A short transition gap - the transmit/receive transition gap (TTG) - is placed between the DL and UL subframes. After completion of the UL subframes, another short gap - the receiver/transmit transition gap (RTG) - is added between this subframe and the next DL subframe. The time durations of the transition gaps are a function of the channel bandwidth and the OFDM symbol time and are specified in the 802.16 standard.

In a TDD configuration, the base station and subscriber equipment each transmit on the same RF frequency but are separated in time. Transmissions on both the uplink and downlink always begin with a preamble which allows receivers to synchronize with the transmitter and is used for channel estimation. The DL subframe begins with a long preamble - two OFDM symbols used for synchronization and channel estimation at the SS. It is followed by the frame control header (FCH), which contains decode information for the SS and one or more downlink bursts of payload data. While from burst to burst, the modulation can change, within each burst, the modulation type is constant. Bursts using robust modulation types are required to be transmitted first, followed by less robust modulation types. For example, a downlink subframe containing all four types of modulation would need to be in this order: BPSK followed by QPSK, 16 QAM, and finally 64 QAM. The UL subframe begins with a short preamble - one OFDM symbol that is used at the base station for synchronization to the individual SS. The time duration of the long and short preambles is determined by the specified length of the OFDM symbol.

To simplify transmitter and receiver designs, all symbols in the FCH and DL data bursts are transmitted with equal power. Because the OFDM symbols use four different modulation types it is necessary to scale each, such that the average symbol power from each symbol is approximately equal.

The 802.16-2004 MAC offers a number of key benefits. Its frame structure, for example, allows terminals to be dynamically assigned uplink and downlink burst profiles according to their link conditions. This allows a trade-off between capacity and robustness in real-time, and provides roughly a two times increase in capacity on average when compared to non-adaptive systems, while maintaining appropriate link availability. An efficiency increase comes from the use of, among other things, a variable length Protocol Data Unit (PDU). To save PHY overhead, multiple MAC PDUs may be concatenated into a single burst. Multiple Service Data Units (SDU) for the same service may also be concatenated into a single MAC PDU, to save on MAC header overhead. The overhead and delay of acknowledgements is eliminated due to the MAC's use of a self-correcting bandwidth request/grant scheme.

Mobile WiMAX

Mobile WiMAX specifies air interfaces for broadband wireless access systems and is based on Orthogonal Frequency Division Multiple Access (OFDMA) technology. The inherent advantages of OFDMA in terms of channel bandwidth scalability, throughput, latency, excellent QoS, spectral efficiency, tolerance to multipath and self-interference, and advanced antenna support, enable Mobile WiMAX to provide higher performance than today's wide area wireless technologies. The specification was created to improve support for combined fixed wireless and mobile NLOS operation in frequencies below 6 GHz. It is considered the first 4G next-generation network solution.

Mobile WiMAX supports adaptive modulation and coding in both downlink and uplink with variable packet size. The uplink can support 16QAM modulation (64QAM optional). Although the scheduling overhead is higher to support variable packet size, the overhead for fragmentation and padding is reduced. Specific characteristics of the OFDMA PHY include:

- Downlink modulation: 64QAM, 16QAM, and QPSK
- Downlink code rate: Turbo (CTC) and Convolutional Code (CC), Repetition: 1/12, 1/8, 1/4, 1/2, 2/3, 3/4, and 5/6
- Uplink modulation: 16QAM OFDM, QPSK OFDM, and 64QAM OFDM (optional)
- Uplink code rate - Turbo, CC, Repetition: 1/12, 1/8, 1/4, 1/2, 2/3, 3/4, and 5/6 (optional)
- FFT size: 128, 512, 1024, or 2048
- Cyclic Prefix (G): 1/32, 1/16, 1/8 and 1/4
- Error correcting code: BTC (Block and Convolutional Turbo code), CC, and CTC (Convolutional Turbo Coding)

Some of the specific features of Mobile WiMAX include:

- Applies fast scheduling in both downlink and uplink. WiMAX performs scheduling on a per-frame basis and broadcasts the downlink/uplink scheduling in the MAP messages at the beginning of each frame. With Mobile WiMAX, the scheduling can change very quickly as can the amount of resources allocated ranging from the smallest unit to the entire frame. Therefore, it is well suited for bursty data traffic and rapidly changing channel conditions. Particularly since uplink subchannels are orthogonal. With uplink scheduling, the uplink resource is more efficiently allocated, performance is more predictable, and QoS is better enforced.
- Flexible configuration of zones, bursts and MAC PDUs (Protocol Data Units)
- Variable bandwidths: Mobile WiMAX supports channel bandwidths of 5 MHz, 7 MHz, 8.75 MHz, and 10 MHz and can optionally support channel bandwidths ranging from 1.25 MHz to 20 MHz. With the flexibility to support a wider bandwidth, Mobile WiMAX enjoys high aggregate sector throughput, which allows more efficient multiplexing of data traffic, lower latency and better QoS.
- FCH (Frame Control Header), downlink MAP (which defines the access to the downlink information) and uplink MAP message (which allocates access to the uplink channel) automatically generated
- Standards-based, raw, or fully coded data
- Partial Usage of Subchannels (PUSC), Full Usage of Subchannels (FUSC) and OFUSC Permutation Zone for downlink, PUSC and OPUSC Permutation Zone for uplink. Note that a permutation formula maps the subchannels to physical subcarriers in the OFDMA symbol. The formula varies for uplink and downlink.
- Channel coding: CC and CTC
- Space-Time-Coding (STC) with 2 antennas sources for both downlink and uplink. STC is a method employed to improve the reliability of data transmission in wireless communication systems using multiple transmit antennas.
- SUI channel model, ITU channel model and 3GPP Multiple Input Multiple Output (MIMO) channel model
- CC decoding with soft decision (with channel state information - CSI)

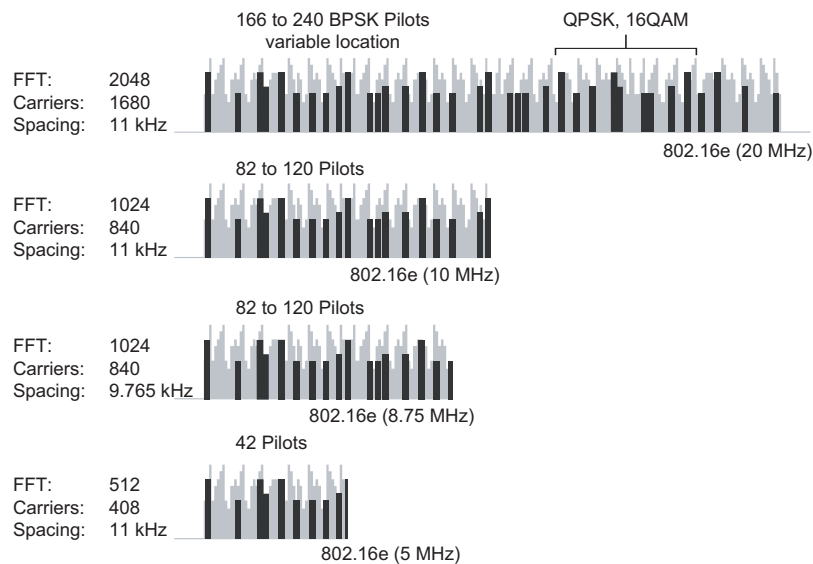


Figure 3. Possible OFDMs for 802.16e OFDMA.

Mobile WiMAX introduces support for an enhanced OFDMA modulation method known as Scalable OFDMA. SOFDMA allows for a variable number of carriers, in addition to the previously-defined OFDM and OFDMA modes (Figure 3). The carrier allocation in OFDMA modes is specifically designed to minimize the effect of the interference on user devices with omni-directional antennas. 802.16e also offers improved support for hard handoffs and features improved power-saving capabilities for mobile devices.

In particular, SOFDMA improves on OFDM 256 for NLOS applications in the following ways:

- Improves coverage via advanced antenna diversity schemes and hybrid-Automatic Retransmission Request (hARQ). To improve packet reception, Chase Combining (CC) is implemented at the receiver to jointly process the packets in error and new retransmission.
- Increases system gain and improves indoor penetration through use of denser sub-channelization.
- Enhances security and NLOS performance by using high-performance coding techniques like Turbo Coding and Low-Density Parity Check (LDPC).
- Allows administrators to trade coverage for capacity or vice versa by introducing downlink sub-channelization.
- Improves coverage by using Adaptive Antenna Systems (AAS) and MIMO technology.
- Eliminates channel bandwidth dependencies on subcarrier spacing, which allow for equal performance under any RF channel spacing (1.25-14 MHz)
- Increases resistance to multipath interference by using an enhanced FFT algorithm which can tolerate larger delay spreads.

Network Deployment (Installation and Maintenance)

As WiMAX network operators join the existing Wireless carriers in the deployment of RF equipment to create a network, they face the challenge of a new undertaking – installation and maintenance of wireless networks. With Fixed WiMAX solutions now being deployed and new trials for Mobile WiMAX beginning each week, adequately addressing that challenge is all the more imperative.

When deploying a base station, the operator must comply with government regulations for radio frequency use, such as transmitter power levels within regulation range, correct frequency use, not causing interference with other users, and assuring correct operation of the network equipment. All this should satisfy both the regulatory agencies as to the correct use of the frequency band as well as, of course, the end users with the provided service quality.

A list of the items which must be tested, and specific test requirements for each, is as follows:

Availability of the Frequency Spectrum

Prior to base station deployment, the engineer must verify the availability of the spectrum via a site survey. This is done to determine whether anything will interfere with the assigned transmit frequency, or if anybody else is transmitting on the base stations assigned receive frequency.

The Interference Analyzer option available in BTS Master MT8222A is specifically designed to assist the engineer in finding signals that can cause problems. Using a spectrogram capture mode, it monitors any transmission across a specified frequency band for a period of time to make sure that the spectrum is clean. When an interfering signal is found, the Interference Analyzer can locate it with a directional antenna based on signal strength.

The Transmit Frequency

Regulatory agencies dictate that a wireless operator deploys its service only on the approved designated frequency. This needs to be verified with a certain level of accuracy, not just for the purpose of compliance, but also to guarantee interoperability with the end users stations. Due to a high accuracy internal clock which verifies its accuracy any time GPS is used, BTS Master can make the required frequency measurement with an accuracy of better than 0.025 ppm.

The Power Level

The power level of a base station greatly affects the usable range. To ensure correct coverage in the designated area, the power level needs to be measured with high precision. The WiMAX standard also requires that the ACPR (adjacent channel power ratio) be verified to make sure that the transmitter does not put out significant power on neighboring channels.

The High Accuracy Power Sensor option of BTS Master features a specified accuracy of better than 0.16 dB. This capability enables the engineer to fine tune the transmit level with great accuracy.

The Signal Quality

Signal quality has many aspects which need to be verified. The main issue, Relative Constellation Error (RCE), is the error vector of the received modulation constellation expressed in dB versus in % as done in the Error Vector Magnitude (EVM) measurement. RCE and EVM are important metrics for measuring the signal quality in the digital communications.

BTS Master offers both of these measurements. They are however only an indication of the total signal quality. The engineer must also look for more detailed quality problems by analyzing the individual Subcarriers and symbols. BTS Master allows the engineer to see the actual EVM versus Subcarrier (frequency domain) and EVM versus Symbols (time domain) displays, as well as the Spectral Flatness of the channel to assure consistent quality for all users. The actual constellation can also be viewed to verify correct placement of the points in a single display with all modulation types.

Once these measurements are complete, the engineer will have confirmed that the WiMAX base station is performing as required. Before it is actually put on the air though, the correct installation and performance of the cabling and antenna system must be verified. This can be accomplished using BTS Master's built-in Cable and Antenna Analyzer. It provides measurement capabilities such as Return Loss, Cable Loss, VSWR, and the ability to find a problem location with the DTF (Distance-To-Fault) function. Thanks to a true 2 port capability (both magnitude and phase), BTS Master's Cable and Antenna analyzer can also be used in situations where verification of duplex filters, amplifiers, repeaters, or an antenna isolation measurement is required.

Understanding WiMAX Measurements

Verifying Fixed and Mobile WiMAX performance requires field technicians to measure many different types of parameters. WiMAX measurements that can be made with BTS Master include:

Channel Power (RSSI)

Channel Power measures the average time domain power within the selected bandwidth and is expressed in dBm. Received Signal Strength Indicator (RSSI) is 'vendor-defined' in the standard and is typically the same as Channel Power.

Occupied Bandwidth (BW)

The Occupied Bandwidth is calculated as the bandwidth containing 99% of the transmitted power in the given RF span.

Adjacent Channel Power Ratio (ACPR)

The filtered power across the bandwidth of the signal is compared with the power in the adjacent upper and lower channels, the differences are measured in dB.

Data Burst Power (Fixed WiMAX only)

Data Burst Power is the RMS power over the data burst part of the downlink frame.

Downlink Burst Power (Mobile WiMAX only)

Downlink Burst Power is the RMS Power over the downlink portion of the burst

Uplink Burst Power (Mobile WiMAX only)

Uplink Burst Power is the RMS Power over the uplink portion of the burst

Preamble Power

Preamble Power is the RMS power over the preamble part of the downlink frame.

Crest Factor (Fixed WiMAX only)

Crest Factor is the ratio of the peak-to-average power over the entire downlink frame.

Freq Error

The Frequency Error is the difference between the received frequency and the specified frequency. This measurement is only as accurate as the frequency reference used. Frequency error is displayed in both Hz and ppm.

Error Vector Magnitude (EVM)

The Error Vector Magnitude is the ratio, in percent, of the magnitude of the error vector (e.g. difference between the measured waveform and the reference waveform) to the magnitude of the reference waveform. From this, the rms and peak EVM can then be derived.

Relative Constellation Error (RCE)

Relative Constellation Error is similar to EVM, but expressed in dB. $RCE = 20 \log(EVM \text{ in } \%/100)$ Both RMS and peak values over an entire frame are displayed.

Carrier Frequency

Carrier Frequency is the measured frequency of the received signal. It is equal to the specified frequency plus the Freq Error described in the same section.

Base Station ID (Fixed WiMAX Only)

Each transmitter has a unique ID. BTS Master displays it as Base Station ID by decoding the FCH part of the downlink frame.

Sector ID (Mobile WiMAX Only)

The BTS Master displays the unique sector ID decoded from the FCH part of the frame

Adjacent Subcarrier Flatness (Peak)

Adjacent Subcarrier Flatness is the absolute difference between adjacent subcarriers.

Making Fixed WiMAX Measurements

The Anritsu BTS Master MT8222A offers two Fixed WiMAX options:

- Fixed WiMAX RF Measurements
- Fixed WiMAX Demodulator

For accurate RF and demodulator measurements on FDD or TDD networks, BTS Master MT8222A can be connected to any Fixed WiMAX base station (BTS). It can measure WiMAX BTS transmitter performance over the air by connecting an antenna, or by connecting the BTS equipment directly to BTS Master. The measurements are more accurate when the BTS Master is directly connected to the base station.

To measure a WiMAX signal over the air, connect the appropriate frequency band antenna to the BTS Master RF In connector. To connect the BTS equipment directly to BTS Master, connect the power amplifier of the BTS equipment to the RF In connector of BTS Master using a coupler or attenuator. Note that the maximum input damage level of the RF In port is +43 dBm. To prevent damage always use a coupler or high power attenuator.

Set-Up

Regardless of whether the measurement will be taken over the air or via a direct connection, making Fixed WiMAX measurements with the BTS Master requires some initial set-up. To begin, configure the MT8222A for Fixed WiMAX mode, as follows:

1. Select the Shift key, then the Mode (9) key.
2. Use the directional arrow keys or the rotary knob to highlight Fixed WiMAX Signal Analyzer and press the Enter key to select.

Next, BTS Master must be configured to tune to the frequency being output by the base station. The user can either enter the center frequency of the channel or select the signal standard and channel which allows BTS Master to automatically set the frequency.

To enter the center frequency:

1. Press the Freq function hard key.
2. Press the Center Freq soft key.
3. Enter the desired frequency using the keypad, the arrow keys or the rotary knob. If entering a frequency using the keypad, the soft key labels will change to GHz, MHz, kHz and Hz. Select the appropriate “units” key. Selecting the Enter key has the same affect as selecting the MHz soft key.
4. Press the Enter key to set the Center Frequency. The current setting is shown on the left side of the display.

To select a signal standard:

1. Press the Freq function hard key.
2. Select the Signal Standard soft key.
3. Using the Up/Down arrow keys or the rotary knob, highlight a signal standard and press Enter to select. When a signal standard is selected, the center frequency for the channel of the selected standard is automatically tuned.
4. Select the Channel soft key and use the Up/Down arrow keys, the keypad or the rotary knob to select a channel number for the selected signal standard. The center of the channel is tuned to the center of the display. The current settings are displayed on the left side of the screen.

Additional Configuration

Additional procedures for configuring BTS Master for the WiMAX measurement include:

Power Offset For Compensating External Loss

To ensure the measurement results are accurate, any external attenuation should be compensated for using power offset. In power offset mode the compensation factor is in dB. External attenuation can be caused by using an external cable or external high power attenuator. To set the power offset:

1. Press the Amplitude function hard key.
2. Select the Power Offset soft key and use the arrow keys, the keypad or the rotary knob to enter the desired offset value. Press the Enter key to set the Power Offset. The value entered is displayed on the left side of the screen.

Bandwidth Setup

The 802.16-2004 standard specifies bandwidth from 1.25 MHz to 20 MHz. BTS Master can set up a variable bandwidth manually. To set the bandwidth:

1. Press the Setup function hard key.
2. Press the Bandwidth soft key to display a set of bandwidths available: 1.25 MHz, 1.5 MHz, 1.75 MHz, 2.50 MHz, 3.0 MHz, 3.5 MHz, 5 MHz, 5.5 MHz, 6.0 MHz, 7 MHz, 10 MHz

1.25 MHz	3.0 MHz	6.0 MHz
1.5 MHz	3.5 MHz	7.0 MHz
1.75 MHz	5.0 MHz	10.0 MHz
2.50 MHz	5.5 MHz	
3. Use the Up/Down arrow keys or the rotary knob to highlight the applicable bandwidth on the list and press the Enter key to set the bandwidth. The selected bandwidth is displayed in the user settable parameters to the left of the display.

CP Ratio (G) Setup

The 802.16-2004 standard specifies CP ratios from 1/4 to 1/32. BTS Master can set up a desired CP ratio manually. It offers support for the following ratios: 1/4, 1/8, 1/16, and 1/32. To set up the CP ratio:

1. Press the Setup function hard key.
2. Press the CP Ratio (G) soft key to display a set of available ratios: 1/4, 1/8, 1/16, and 1/32.
3. Using the Up/Down arrow keys or the rotary knob, highlight the applicable ratio on the list and press the Enter key to select the ratio. The selected ratio is displayed in the user settable parameters to the left of the display.

Span Setup

Span setup controls the span of the Spectrum view only. Also, the span is automatically set based on bandwidth chosen. This setup allows a manual override of the Spectrum Span. To set up the span:

1. Press the Setup function hard key.
2. Press span soft key to display a set of available spans: 5 MHz, 10 MHz, 20 MHz, and 30 MHz.
3. Using the Up/Down arrow keys or the rotary knob, highlight the applicable span on the list and press the Enter key to select the span.

DL Frame Length

BTS Master supports 2.5 ms, 5 ms, and 10 ms down link subframe lengths. Press the Frame Length soft key to cycle through the three values.

Frequency Reference Setup

In order to get the best frequency accuracy measurements, it is important to use an external reference frequency attached to the BTS Master Ext Ref In connector or built-in GPS receiver in BTS Master.

To setup the BTS Master with an External Reference or GPS, please refer to the section on Frequency Reference Setup on page 23.

With the initial set-up complete, you are now ready to begin making WiMAX measurements.

RF Measurements

Fixed WiMAX RF measurements include Spectrum, Power versus Time and Adjacent Channel Power Ratio (ACPR). When making Fixed WiMAX RF measurements, you must first connect BTS Master MT8222A to the base station as explained in the set up section. Then, the desired measurements can be made as follows:

Spectrum

The Spectrum screen displays the input signal's spectrum and the following measurements: channel power in dBm and occupied bandwidth.

1. Select the Shift key, then the Mode (9) key.
2. Using the directional arrow keys or the rotary knob, highlight Fixed WiMAX Signal Analyzer and press the Enter key to select.
3. Press the Freq function hard key.
4. Press the Center Freq soft key and enter the desired frequency manually, or press the Signal Standard soft key and select the applicable standard.
5. Select the Channel soft key and use the Up/Down arrow keys, the keypad, or the rotary knob to select a channel number for the selected signal standard. The center of the channel is tuned to the center of the display.
6. Press the Setup function hard key.
7. Set the bandwidth and CP ratio as described in the measurement setup section (Section 4.2).
8. For the most accurate frequency measurements, press the Ext. Ref. Freq soft key to display a list of the available reference frequencies. Select the desired reference frequency or activate the GPS (if equipped) and synchronize the BTS Master to Internal High Accuracy.
9. Press the Measurements function hard key.
10. Press the RF Measurements soft key.
11. Press the Spectrum soft key to activate the spectrum measurement. The red dot on the soft key indicates it is selected (Figure 4).

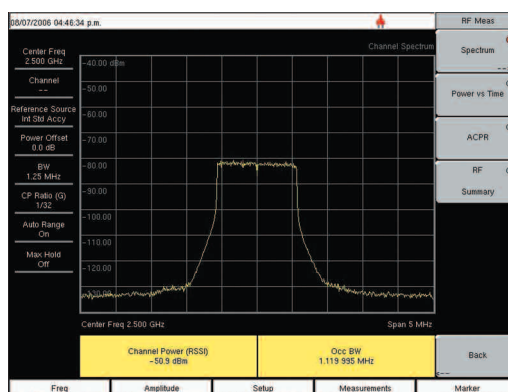


Figure 4. Spectrum view.

Power versus Time

The Power versus Time view shows the time domain view of a WiMAX 802.16-2004 OFDM signal over approximately 1 frame. The preamble is always 3 dB higher than the data. The screen also displays Channel power (RSSI), Data Burst Power, Preamble power and Crest Factor.

1. Follow Steps 1-10 in section on Spectrum above.
2. Press the Power versus Time soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 5).

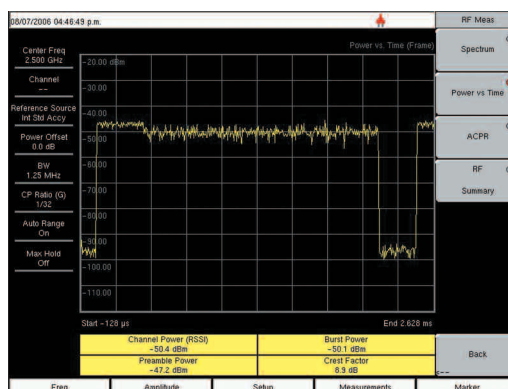


Figure 5. Power versus Time view.

Adjacent Channel Power Ratio (ACPR)

The ACPR view shows 1 main channel and two adjacent channels, and displays the power levels for each channel (both absolute and relative). The channel spacing matches the selected bandwidth and the channels are color coded.

1. Follow Steps 1-10 in section on Spectrum on page 10.
2. Press the ACPR soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 6).



Figure 6. ACPR view.

RF Summary

The RF Summary displays the critical RF transmitter performance measurements in a tabular format, without demodulating the WiMAX signal. The parameters displayed in the RF summary table are Channel Power in dBm, Data Burst power in dBm, Preamble power in dBm, Occupied Bandwidth and Crest Factor.

1. Follow Steps 1-10 in section on Spectrum on page 10.
2. Press the RF Summary soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 7).

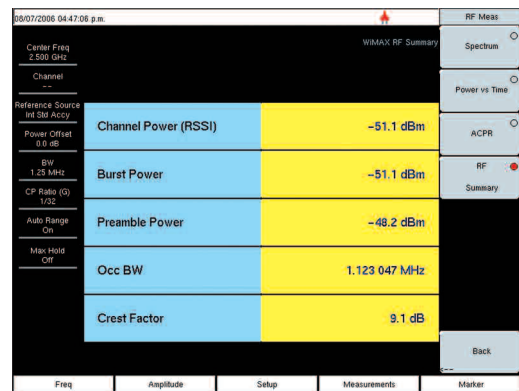


Figure 7. RF Summary view.

Demodulation

Demodulation is the process whereby the changes imposed on the carrier at the receiver are removed to reveal the message at the receiver. BTS Master demodulates WiMAX signals by connecting directly to the BTS equipment. To connect the BTS equipment directly to the BTS Master, connect the power amplifier of the BTS equipment to the RF In connector of the BTS Master using a coupler or attenuator. Demodulation results can be displayed in a Constellation, Spectral flatness, EVM versus Subcarrier, EVM versus Symbol or Modulation Summary Screen.

Constellation

The BTS Master displays the constellation of the demodulated data symbols over 1 downlink frame. Various constellations are color coded as follows:

BPSK is shown in orange

QPSK is shown in purple

16-QAM is shown in green

64-QAM is shown in yellow

The constellation primarily helps in visually identifying IQ impairments. Reference points can be switched on to visually place the measurement. The numerical results displayed in this view are: RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz, and Base Station ID.

To display the constellation:

1. Follow Steps 1-9 in section on Spectrum on page 10.
2. Press the Demodulator soft key.
3. Press the Constellation soft key to activate the measurement. The red dot on the soft key indicates it is selected.
4. Press the Constellation soft key again to activate the reference points menu.
5. Press the Reference Points soft key to switch them On or OFF (Figure 8A and B).

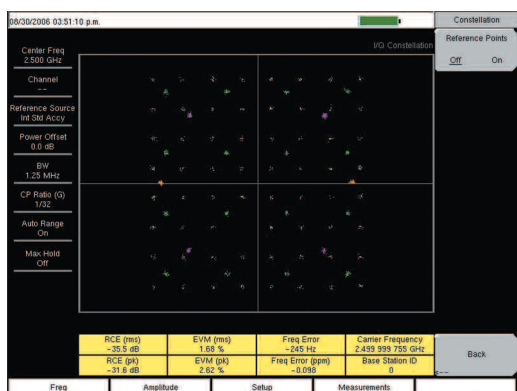


Figure 8A. Constellation with reference points off.

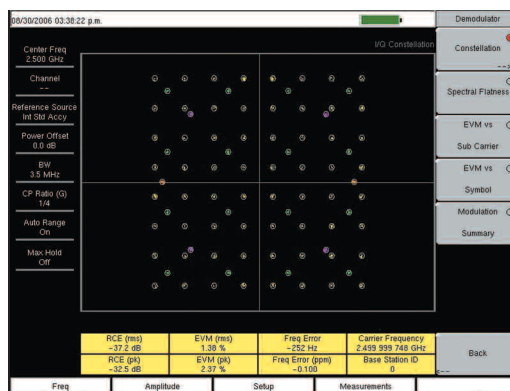


Figure 8B. Constellation with reference points on.

Spectral Flatness

The Spectral Flatness view shows the data collected from the preamble at the channel estimation step. The deviation of the spectral flatness from the average over all the carriers is shown in dB. A mask that conforms to the specification is overlaid on the trace. Green color on the mask indicates pass and red indicates regions of the mask where it fails. The specification for the mask is:

± 0 to 50 subcarriers $< \pm 2$ dB

± 50 to 100 subcarriers $< +2$ dB and -4 dB

This mask is referenced from the average of all 200 subcarrier amplitude values. The numerical result displayed in this view is the adjacent subcarrier flatness (in dB).

To display the spectral flatness:

1. Follow Steps 1-9 in section on Spectrum on page 10.
2. Press the Demodulator soft key.
3. Press the Spectral Flatness soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 9).

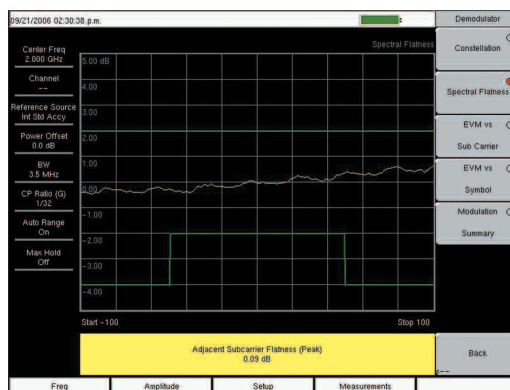


Figure 9. Spectral Flatness view.

EVM versus Subcarrier

This view shows the EVM (rms) values versus OFDM subcarriers. There are eight pilot subcarriers shown in orange and 192 data sub carriers in yellow. The numerical results displayed in this view are: RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz, and Base Station ID.

To display the EVM versus Subcarrier view:

1. Follow Steps 1-9 in section on Spectrum on page 10.
2. Press the Demodulator soft key.
3. Press the EVM vs. Subcarrier soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 10).

The user can also set up Max Hold by selected Shift and Trace (5). The green displayed trace is the Max Hold trace.

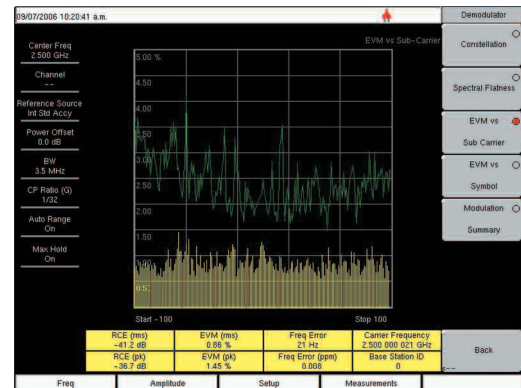


Figure 10. EVM versus Subcarrier view.

EVM versus Symbol

This view shows the EVM (rms) values versus OFDM symbols. The numerical results displayed in this view are: RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz, and Base Station ID.

To display the EVM versus Symbol view:

1. Follow Steps 1-9 in section on Spectrum on page 10.
2. Press the Demodulator soft key.
3. Press the EVM versus Symbol soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 11).

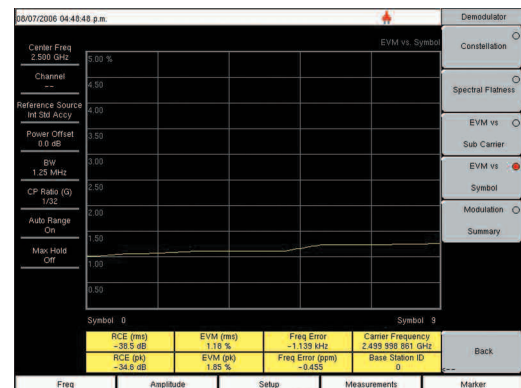


Figure 11. EVM versus Symbol view.

Modulation Summary

The Modulation Summary displays the critical modulation transmitter performance measurements in a tabular format by demodulating the WiMAX signal. The parameters displayed in the Modulation summary table RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz, and Base Station ID.

To display the Modulation Summary view:

1. Follow Steps 1-9 in section on Spectrum on page 10.
2. Press the Demodulator soft key.
3. Press the Modulation Summary soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 12).

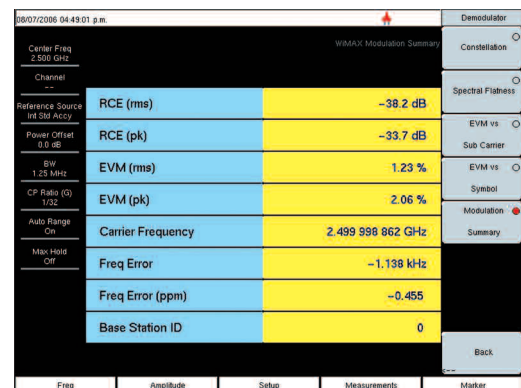


Figure 12. Modulation Summary view.

Pass/Fail

BTS Master MT8222A provides a Pass/Fail mode. Here, a user defined file may be chosen that specifies a list of measurements with pass/fail criteria. This mode will sequence through the appropriate measurements and indicate a pass or fail state based on the criteria. Green color indicates the measurement has passed and red indicates fail. Using Master Software Tools, a custom test list can be created and downloaded into the unit. All critical measurements can be selected for pass fail testing. The results are displayed in tabular format with clear identification of pass/fail results including min/max thresholds and measured results (Figure 13).

To activate the Pass/Fail mode:

1. Follow Steps 1-9 in section on Spectrum on page 10.
2. Step 10. Press the Pass/Fail Mode soft key.
3. Press the Pass/Fail Mode soft key again to activate the sub-menu.
4. Press the Select Pass/Fail Test soft key to view a list of pass/fail test definition files.
5. Use the Up/Down arrow keys or the rotary knob to highlight the applicable pass/fail test on the list and press the Enter key.

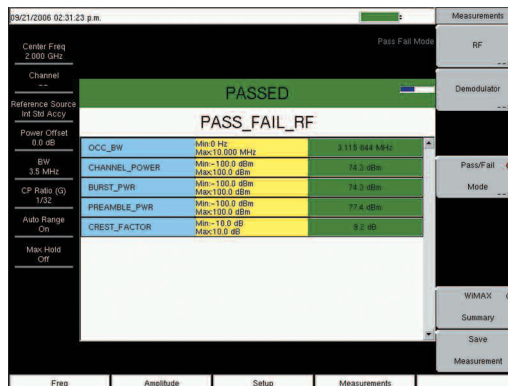


Figure 13. Pass/Fail mode example screen.

Fixed WiMAX Summary

The WiMAX Summary displays all the critical RF and modulation transmitter performance measurements in a tabular format. The parameters displayed in the WiMAX summary table are channel power, Data Burst Power, Preamble power, Crest Factor, occupied bandwidth, RCE (Relative Constellation Error) rms and peak, EVM (Error Vector Magnitude) rms and peak, carrier frequency, frequency error Hz and ppm and Base Station ID.

To display the WiMAX Summary view:

1. Follow Steps 1-9 in section on Spectrum on page 10.
2. Press the WiMAX Summary soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 14).

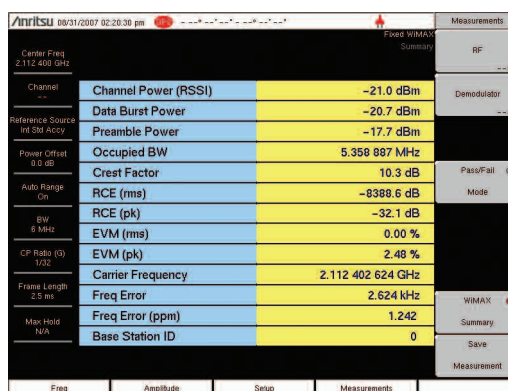


Figure 14. WiMAX Summary screen.

Making Mobile WiMAX Measurements

The Anritsu BTS Master MT8222A offers three Mobile WiMAX options:

- Mobile WiMAX RF Measurements
- Mobile WiMAX Demod Measurements
- Mobile WiMAX Over the Air (OTA) Measurements

For accurate RF and demodulator measurements on FDD or TDD networks, BTS Master MT8222A can be connected to any Mobile WiMAX base station (BTS). It can measure WiMAX BTS transmitter performance over the air by connecting an antenna, or by connecting the BTS equipment directly to BTS Master.

To measure a WiMAX signal over the air, connect the appropriate frequency band antenna to the BTS Master RF In connector. To connect the BTS equipment directly to BTS Master, connect the power amplifier of the BTS equipment to the RF In connector of BTS Master using a coupler or attenuator. Note that the maximum input damage level of the RF In port is +43 dBm. To prevent damage always use a coupler or high power attenuator.

Set-Up

Regardless of whether the measurement will be taken over the air or via a direct connection, making Mobile WiMAX measurements with the BTS Master requires some initial set-up. To begin, configure the MT8222A for Mobile WiMAX mode, as follows:

1. Select the Shift key, then the Mode (9) key.
2. Use the directional arrow keys or the rotary knob to highlight Mobile WiMAX Signal Analyzer and press the Enter key to select.

Next, BTS Master must be configured to tune to the frequency being output by the base station. The user can either enter the center frequency of the channel or select the signal standard and channel which allows BTS Master to automatically set the frequency.

To enter the center frequency:

1. Press the Freq function hard key.
2. Press the Center Freq soft key.
3. Enter the desired frequency using the keypad, the arrow keys or the rotary knob. If entering a frequency using the keypad, the soft key labels will change to GHz, MHz, kHz and Hz. Select the appropriate “units” key. Selecting the Enter key has the same affect as selecting the MHz soft key.
4. Press the Enter key to set the Center Frequency. The current setting is shown on the left side of the display.

To select a signal standard:

1. Press the Freq function hard key.
2. Select the Signal Standard soft key.
3. Using the Up/Down arrow keys or the rotary knob, highlight a signal standard and press Enter to select. When a signal standard is selected, the center frequency for the channel of the selected standard is automatically tuned.
4. Select the Channel soft key and use the Up/Down arrow keys, the keypad or the rotary knob to select a channel number for the selected signal standard. The center of the channel is tuned to the center of the display. The current settings are displayed on the left side of the screen.

Additional Configuration

Power Offset for Compensating External Loss

To ensure the measurement results are accurate, any external attenuation should be compensated for using power offset. In power offset mode the compensation factor is in dB. External attenuation can be caused by using an external cable or external high power attenuator.

To set the power offset:

1. Press the Amplitude function hard key.
2. Select the Power Offset soft key and use the arrow keys, the keypad or the rotary knob to enter the desired offset value.
3. Press the Enter key to set the Power Offset. The value entered is displayed on the left side of the screen.

Bandwidth Setup

The 802.16-2005 standard specifies bandwidth from 1.25 MHz to 20 MHz. BTS Master can set up a variable bandwidth manually.

To set the bandwidth:

1. Press the Setup function hard key.
2. Press the Bandwidth soft key to display a set of bandwidths available:
5 MHz, 8.75 MHz and 10 MHz,
3. Use the Up/Down arrow keys or the rotary knob to highlight the applicable bandwidth on the list and press the Enter key to set the bandwidth. The selected bandwidth is displayed in the user settable parameters to the left of the display.

CP Ratio Setup

The 802.16-2005 standard specifies CP ratios from 1/4 to 1/32. The WiMAX Forum Profile 1 recommends the Base Station to use a CP Ratio of 1/8. The BTS Master is automatically set to this CP Ratio

Span Setup

Span setup controls the span of the Spectrum view only. Also, the span is automatically set based on bandwidth chosen. This setup allows a manual override of the Spectrum Span. To set up the span:

1. Press the Setup function hard key.
2. Press span soft key to display a set of available spans: 5 MHz, 10 MHz, 20 MHz, and 30 MHz.
3. Using the Up/Down arrow keys or the rotary knob, highlight the applicable span on the list and press the Enter key to select the span.

Frame Length

BTS Master supports 5 ms, and 10 ms frame lengths.

1. Press the Setup function hard key.
2. Press the Frame Length soft key to toggle between the available frame lengths: 5ms and 10ms.

Demod

The BTS Master gives the user three different choices to demodulate the signal.

Auto – The BTS Master would automatically decode the DL-MAP of the OFDMA signal once the correct Center Frequency, Bandwidth and the Frame Length is selected.

Manual – This selection allows the user to use a DL-MAP Param (.xml) file stored in the unit. These files can be created and downloaded to the BTS Master using Anritsu Master Software Tools.

FCH – This selection decodes only the FCH portion of the burst. This allows for a quick verification of the transmitted signal.

To set up the Demod method

1. Press the Setup function Hard key
2. Press the Demod button to toggle between Auto, Manual, or FCH.

Note: To select Manual Demod, the user will need to select a pre loaded xml file stored in the instrument first. The user can access these files by pressing the Load Param File button, below the Demod button. Once a file is selected, the user will be able to toggle between Auto, Manual and FCH selections in the Demod button.

Frequency Reference

In order to get the best frequency accuracy measurements, it is important to use an external reference frequency attached to the BTS Master Ext Ref In connector or built-in GPS receiver in BTS Master. To setup the BTS Master with an External Reference or GPS, please refer to the section on Frequency Reference Setup on page 23.

RF Measurements

Mobile WiMAX RF measurements are used to measure the transmitted signal strength and signal shape of the selected BTS transmitter. RF Measurements include Spectrum, Power versus Time and Adjacent Channel Power Ratio (ACPR). When making Mobile WiMAX RF measurements, you must first connect BTS Master MT8222A to the base station as explained in the set up section. Then, the desired measurements can be made as follows:

Spectrum

In the Spectrum screen, technicians can view and examine the selected signal's channel power (in dBm) and occupied bandwidth.

1. Select the Shift key, then the Mode (9) key.
2. Using the directional arrow keys or the rotary knob, highlight Mobile WiMAX Signal Analyzer and press the Enter key to select.
3. Press the Freq function hard key.
4. Press the Center Freq soft key and enter the desired frequency manually, or press the Signal Standard soft key and select the applicable standard.
5. Select the Channel soft key and use the Up/Down arrow keys, the keypad, or the rotary knob to select a channel number for the selected signal standard. The center of the channel is tuned to the center of the display.
6. Press the Setup function hard key.
7. Set the bandwidth as described in the measurement setup section (Page 16).
8. For the most accurate frequency measurements, press the Ext. Ref. Freq soft key to display a list of the available reference frequencies. Select the desired reference frequency or activate the GPS (if equipped) and synchronize the BTS Master to GPS High Accuracy.
9. Press the Measurements function hard key.
10. Press the RF Measurements soft key.
11. Press the Spectrum soft key to activate the spectrum measurement. The red dot on the soft key indicates it is selected (Figure 1).

The user can also set up Max Hold by selected Shift and Trace (5). The green displayed trace is the Max Hold trace.

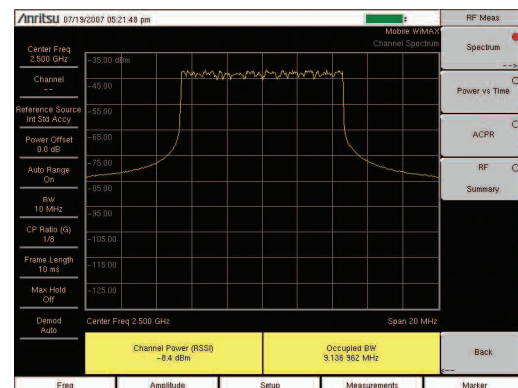


Figure 1. RF Spectrum view.

Power versus Time

The Power versus Time view shows the time domain view of a WiMAX 802.16-2005 OFDMA signal over approximately 1 frame. The preamble is always 3 dB higher than the data. The screen also displays Channel power (RSSI), Uplink Burst Power, Downlink Burst Power and Preamble power.

1. Follow Steps 1-8 in section on Spectrum above.
2. Select the Demod Param as described in the setup section.
3. Press the Measurements function hard key.
4. Press the RF Measurements soft key.
5. Press the Power versus Time soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 2).

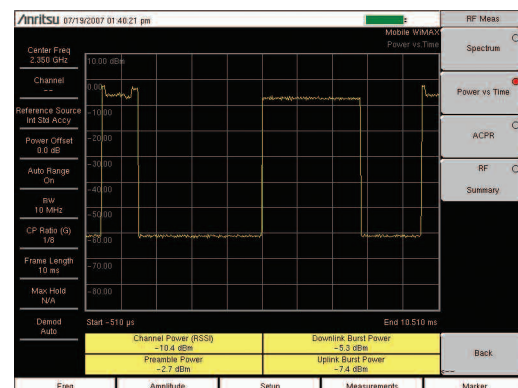


Figure 2. Power versus Time view.

Adjacent Channel Power Ratio (ACPR)

The ACPR view shows 1 main channel and two adjacent channels, and displays the power levels for each channel (both absolute and relative). The channel spacing matches the selected bandwidth and the channels are color coded.

1. Follow Steps 1-10 in the section on Spectrum on page 17.
2. Press the ACPR soft key to activate the measurement.
The red dot on the soft key indicates it is selected (Figure 3).

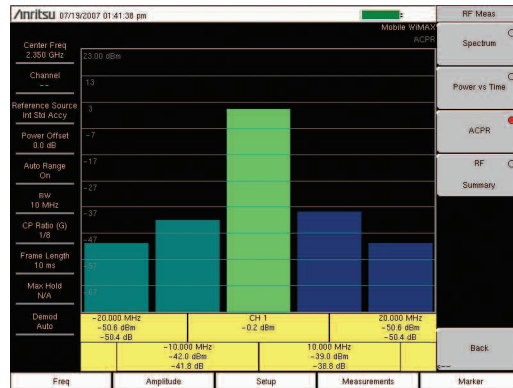


Figure 3. ACPR view.

RF Summary

The RF Summary displays the critical RF transmitter performance measurements in a tabular format, without demodulating the WiMAX signal. The parameters displayed in the RF summary table are Channel Power in dBm, Downlink Burst power in dBm, Uplink Burst Power in dBm, Preamble power in dBm and Occupied Bandwidth.

1. Follow Steps 1-10 in the section on Spectrum on page 17.
2. Press the RF Summary soft key to activate the measurement.
The red dot on the soft key indicates it is selected (Figure 4).

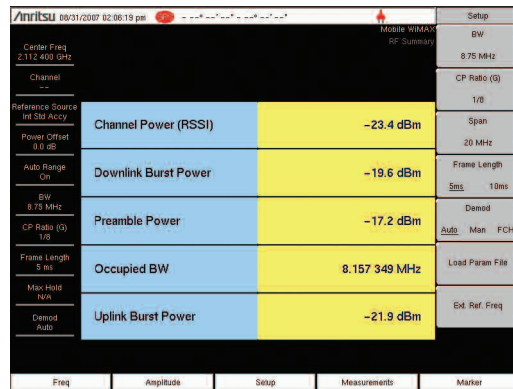


Figure 4. RF Summary view.

Demodulation

Demodulation is the process whereby the changes imposed on the carrier at the receiver are removed to reveal the message at the receiver. BTS Master demodulates WiMAX signals by connecting directly to the BTS equipment. To connect the BTS equipment directly to the BTS Master, connect the power amplifier of the BTS equipment to the RF In connector of the BTS Master using a coupler or attenuator. Demodulation results can be displayed in a Constellation, Spectral flatness, EVM versus Subcarrier, EVM versus Symbol or Modulation Summary Screen.

Constellation

The BTS Master displays the constellation of the demodulated data symbols over 1 downlink frame. Various constellations are color coded as follows:

BPSK is shown in orange

QPSK is shown in purple

16-QAM is shown in green

64-QAM is shown in yellow

The constellation primarily helps in visually identifying IQ impairments. Reference points can be switched on to visually place the measurement. The numerical results displayed in this view are: RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz and Sector ID.

To display the constellation:

1. Follow Steps 1-8 in the section on Spectrum on page 17.
2. Select the Demod Param as described in the setup section.
3. Press the Measurements function hard key.
4. Press the Demodulator soft key.
5. Press the Constellation soft key to activate the measurement. The red dot on the soft key indicates it is selected.
6. Press the Constellation soft key again to activate the reference points menu.
7. Press the Reference Points soft key to switch them On or OFF (Figure 5).

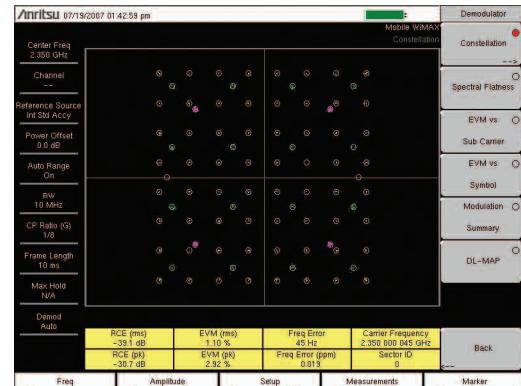


Figure 5. Constellation View with reference points turned ON.

Spectral Flatness

The Spectral Flatness view shows the data collected from the preamble at the channel estimation step. The deviation of the spectral flatness from the average over all the carriers is shown in dB. A mask that conforms to the specification is overlaid on the trace. Green color on the mask indicates pass and red indicates regions of the mask where it fails. The specification for the mask is:

Extreme left quarter and the extreme right quarter subcarriers $< +2\text{dB}$ and -4dB

Center half subcarriers $< \pm 2\text{dB}$

The numerical result displayed in this view is the adjacent subcarrier flatness (in dB).

To display the spectral flatness:

1. Follow Steps 1-4 in Constellation section above.
2. Press the Spectral Flatness soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 6).

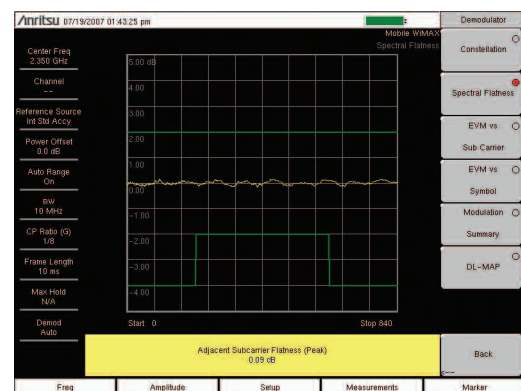


Figure 6. Spectral Flatness view.

EVM versus Subcarrier

This view shows the EVM (rms) values versus OFDMA subcarriers. There are eight pilot subcarriers shown in orange and 192 data sub carriers in yellow. The numerical results displayed in this view are: RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz, and Sector ID.

To display the EVM versus Subcarrier view:

1. Follow Steps 1-4 in Constellation section page 19.
2. Press the EVM vs. Subcarrier soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 7).

The user can also set up Max Hold by selected Shift and Trace (5). The green displayed trace is the Max Hold trace.

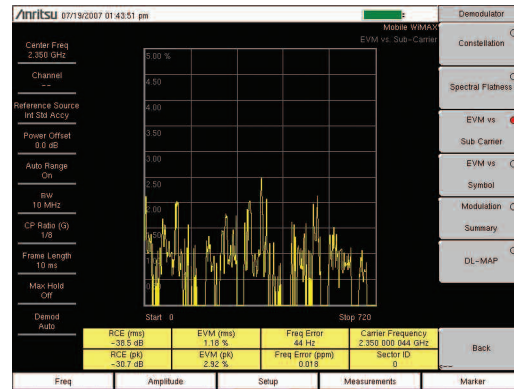


Figure 7. EVM versus Subcarrier view.

EVM versus Symbol

This view shows the EVM (rms) values versus OFDMA symbols. The numerical results displayed in this view are: RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz, and Sector ID.

To display the EVM versus Symbol view:

1. Follow Steps 1-4 in Constellation section page 19.
2. Press the EVM versus Symbol soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 8).

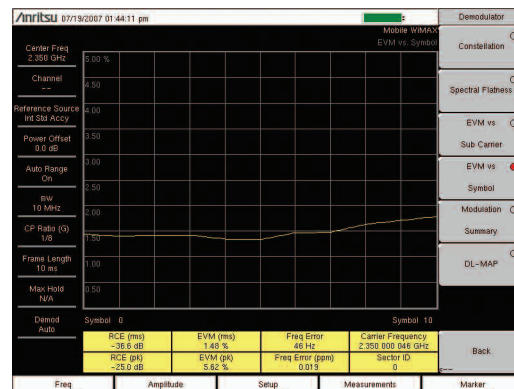


Figure 8. EVM versus Symbol view.

DL-Map

The MT8222A can automatically decode the DL-MAP information from the Mobile WiMAX carrier, thereby simplifying the testing of the demodulated Mobile WiMAX signals. The DL MAP screen displays the decoded DL Map zone information and all relevant data associated with each individual zone.

To display the DL-MAP view:

1. Follow Steps 1-4 in Constellation section page 19.
2. Press the DL-MAP soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 9).

To expand or collapse the DL-MAP tree, select the node and press the right arrow key to expand, or left arrow key to collapse. Also, the tree could be collapsed or expanded by pressing down the twiddle knob.

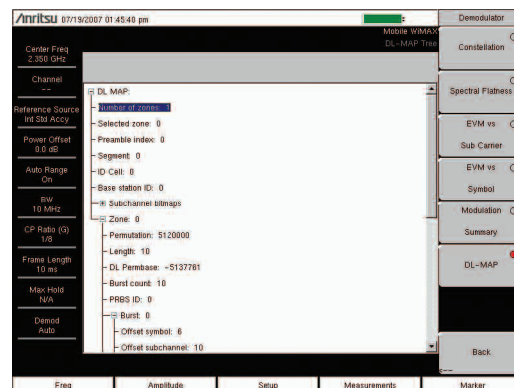


Figure 9. DL-MAP view.

Modulation Summary

The Modulation Summary displays the critical modulation transmitter performance measurements in a tabular format by demodulating the WiMAX signal. The parameters displayed in the Modulation summary table RCE (rms) in dB, RCE (pk) in dB, EVM (rms) in %, EVM (pk) in %, Freq Error in Hz, Freq Error in ppm, Carrier Frequency in Hz, and Sector ID.

To display the Modulation Summary view:

1. Follow Steps 1-4 in Constellation section page 19.
2. Press the Modulation Summary soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 10).

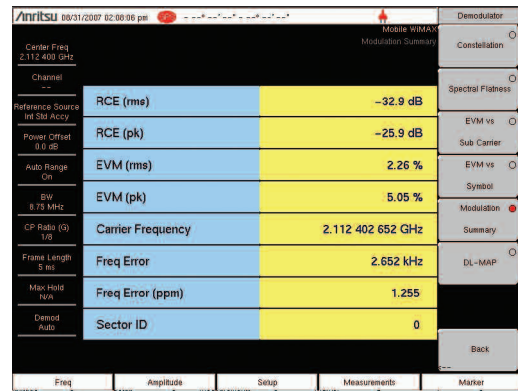


Figure 10. Modulation Summary view.

Over the Air Measurements

The BTS Master has basic drive test capability with its channel monitor measurement that combines the channel power measurement made over time with the GPS location information of the instrument, this information can be saved to either internal or external memory for export to post processing.

Channel Power Monitor

The channel power monitor view captures Mobile WiMAX channel power continuously or for a specified time, the user can also select the time interval to capture measurements and can set the instrument to automatically save the data, if the optional GPS receiver is turned on the captured data will also have the longitude/latitude and time information tagged to each measurement. The BTS Master can also be configured to set how long the user wants to monitor the channel power.

To set up the Channel Power Monitor

1. Follow Steps 1-8 in the section on Spectrum on page 17.
2. Select the Demod Param as described in the setup section.
3. Press the Measurements function hard key.
4. Press the OTA soft key.
5. Press the Channel Power Monitor soft key. The red dot on the soft key indicates it is selected (Figure 11).
6. Press the Channel Power Monitor soft key again to activate the sub-menu.
7. Press the Time Interval soft key to set how often you want to update the measurement.
8. Press the Measure duration soft key to toggle between Continuous and Manual. Selecting Manual, allows the user to monitor the channel power for a specified duration and stop recording data. Selecting continuous monitors channel power for as long as memory is available to store the data.
9. To change the manual measurement duration, press the Manual Duration soft key and enter the time.

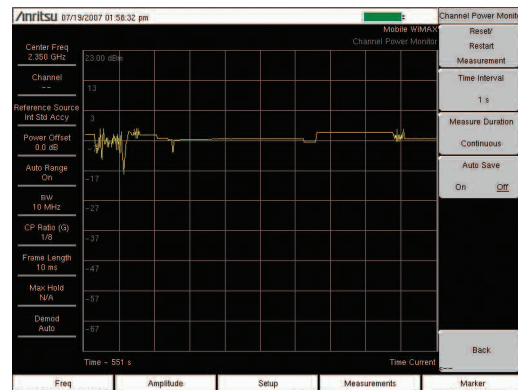


Figure 11. Channel Power Monitor (OTA) screen.

The monitored data can be downloaded into a PC using Master Software Tools. The downloaded measurements can be viewed in a graph format or on a Map in Master Software Tools.

Note: Mapping feature required Microsoft Mappoint installed in the computer.

Pass/Fail

BTS Master MT8222A provides a Pass/Fail mode, where a user defined file may be chosen that specifies a list of measurements with pass/fail criteria. This mode will sequence through the appropriate measurements and indicate a pass or fail state based on the criteria. Green color indicates the measurement has passed and red indicates fail. Using Master Software Tools, a custom test list can be created and downloaded into the unit. All critical measurements can be selected for pass fail testing. The results are displayed in tabular format with clear identification of pass/fail results including min/max thresholds and measured results (Figure 13).

To activate the Pass/Fail mode:

1. Follow Steps 1-8 in the section on Spectrum on page 17.
2. Select the Demod Param as described in the setup section.
3. Press the Measurements function hard key.
4. Press the Pass/Fail Mode soft key. The red dot on the soft key indicates it is selected (Figure 12).
5. Press the Pass/Fail Mode soft key again to activate the sub-menu.
6. Press the Select Pass/Fail Test soft key to view a list of pass/fail test definition files.
7. Use the Up/Down arrow keys or the rotary knob to highlight the applicable pass/fail test on the list and press the Enter key.

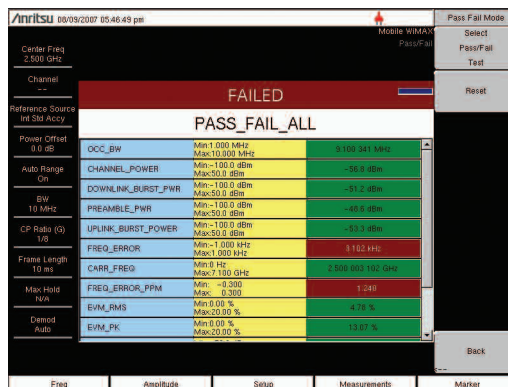


Figure 12. Pass/Fail mode example screen.

Mobile WiMAX Summary

The WiMAX Summary displays all the critical RF and modulation transmitter performance measurements in a tabular format. The parameters displayed in the WiMAX summary table are channel power, preamble power, DL burst power and UL burst power, occupied bandwidth, RCE (Relative Constellation Error) rms and peak, EVM (Error Vector Magnitude) rms and peak, carrier frequency, frequency error Hz and ppm and sector ID.

To display the WiMAX Summary view:

1. Follow Steps 1-3 in Constellation section page 19.
2. Press the WiMAX Summary soft key to activate the measurement. The red dot on the soft key indicates it is selected (Figure 13).

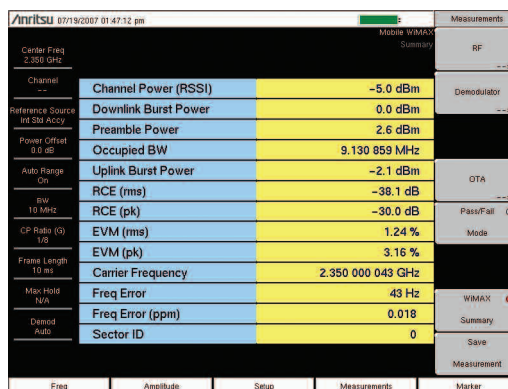


Figure 13. WiMAX Summary screen.

Frequency Reference Setup

External Reference Frequency Setup

Most base stations have a reference frequency available on a BNC connector. To configure BTS Master to use an external reference frequency:

1. Press the Setup function hard key.
2. Press the Select Reference Frequency soft key to display a list of the available reference frequencies:

1 MHz	4.9152 MHz
1.2288 MHz	5 MHz
1.544 MHz	9.8304 MHz
2.048 MHz	10 MHz
2.4576 MHz	13 MHz
4.8 MHz	19.6608 MHz
3. Using the Up/Down arrow keys or the rotary knob, highlight the applicable reference frequency on the list and press the Enter key to select the reference frequency. As the BTS Master locks to the source, the Reference Freq value is displayed in the user settable parameters to the left of the display.

GPS Setup

GPS gives accurate frequency error measurements which comply with the 802.16d frequency error measurement.

To configure BTS Master to use GPS:

1. Install the Anritsu GPS antenna to the GPS antenna connection on the BTS Master connector panel. One antenna now available from Anritsu that is suitable for this purpose is the 2000-1410 Magnet Mount GPS Antenna with 5m (15 ft.) cable. Note that the GPS antenna connection on BTS Master is fitted with a reverse BNC connector to help prevent damage to the GPS circuitry. There is a DC voltage present on this connector. Never connect anything other than the Anritsu GPS antenna to this port.
2. Press the Shift, then System keys, to open the system options.
3. Press the GPS soft key to open the GPS menu.
4. Press the GPS On/Off soft key to turn the GPS feature on or off. When GPS is first turned on, the GPS icon below will be displayed in red: When the GPS receiver is tracking at least three satellites, the GPS icon will change to green as shown:

Note that it may take as long as three minutes for the Ref Freq status to change to GPS High Accuracy in the Status menu displayed on the left side of the screen.
5. Press the GPS Info soft key to view the number of tracked satellites, latitude, longitude, altitude, and UTC timing information, etc...

Within three minutes of satellite acquisition, the reference oscillator will have an accuracy of less than 25 PPB (parts per billion). The OCXO internal standard accuracy is ± 0.3 PPM. The correction factor applied to the internal OCXO allows the instrument to maintain GPS frequency accuracy for three days, even when the instrument is obstructed from receiving signals from the GPS satellites. In order to acquire data from the GPS satellites, the user must have line-of-sight to the satellites or the antenna must be placed outside with out any obstructions. Once GPS High Accuracy is achieved, the internal reference is adjusted and will hold this adjusted value even when GPS satellites can no longer be received. This status will be indicated by "Internal High Accuracy" showing in the Status menu displayed on the left side of the screen. This improved frequency accuracy of better than 50 ppm will hold up to three days.

Note: When the GPS feature is not enabled, the reference source will display either "Internal Standard Accuracy" or a user selected external reference frequency in the Status menu on the left side of the screen.

Note that to reset the GPS, press the Reset soft key. The green GPS icon with a red cross appears when GPS satellite tracking is lost. This occurs after being active (tracking three or more satellites). With the initial set-up complete, you are now ready to begin making WiMAX measurements.

Conclusion

Anritsu's BTS Master MT8222A provides WiMAX measurement capabilities which enable field-based network technicians and RF engineers to quickly, efficiently and cost-effectively conduct Fixed and Mobile WiMAX RF measurements and demodulation. BTS Master's support for these WiMAX measurements is key to ensuring that any potential network performance problems are detected early, when they are easier and less costly to fix.

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