The art of Mobile WiMAX testing

By Eric Hakanson
Product Marketing Manager
Microwave Measurements Division
Anritsu Co.
E-mail: Eric.Hakanson@anritsu.com

The latest version of the WiMAX standard addresses the mobile services required to free users from the tethers of a predetermined location. As with any new technology comes the need to test its hardware—in the research labs, for product qualification and conformance testing to the standard; on the production line; and for troubleshooting and maintenance. Proper and accurate testing helps ensure full interoperability of WiMAX equipment from all manufacturers.

Since WiMAX is intended as a solution for metropolitan broadband wireless access applications, there is a need to address multipath effects from buildings and other obstructions. For this, the OFDM versions of WiMAX were developed and used in fixed WiMAX. Mobile WiMAX employs orthogonal frequency division multiple access (OFDMA), a multiple-user version of OFDM. This allows a more flexible assignment of bandwidth to multiple users than TDMA and provides lower latency.

Mobile WiMAX and fixed WiMAX have similar channel bandwidths and they share modulation types. A key difference between them is that Mobile WiMAX has been designed to hand over user connections and maintain connections across different base stations and coverage areas. A comparison between fixed WiMAX and Mobile WiMAX is shown in **Table 1**.

Parameter	Fixed WiMAX	Mobile WiMAX
Access	Fixed	Fixed, portable, and mobile
Air interface	OFDM/TDMA	OFDMA
Duplex type	TDD or FDD	TDD or FDD
Modulation type	BPSK, QPSK, 16-QAM, 64-QAM	BPSK, QPSK, 16-QAM, 64-QAM
FFT size	256	128, 512, 1024, 2048
Handoffs	No	Yes

Table 1: Mobile WiMAX and fixed WiMAX have similar channel bandwidths and both share modulation types.

In WiMAX systems with OFDM, several modulation formats are used, with the modulation adapted to specific transmission requirements. Using this adaptive modulation approach, raw transmission rates of up to 73Mbit/s are possible for a 20MHz bandwidth. The OFDM symbols used in fixed WiMAX systems are based on an inverse 256-point FFT to make the frequency-to-time conversion, while the OFMDA version uses a variable FFT size from 128 up to 2,048 (except 256).

A single user in an OFDM WiMAX system can use all subcarriers at any given time. In OFDMA, subsets of subcarriers are assigned to multiple users, allowing a number of subscribers to be served simultaneously. Using subchannelization, specific carrier groups are used for each subscriber. These subcarrier assignments change dynamically to overcome the effects of multipath interference.

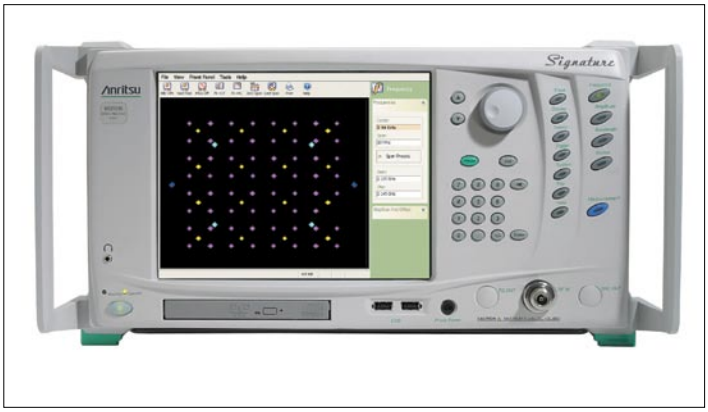

Figure: Devices for Mobile WiMAX requires the use of a signal analyzer such as the Anritsu MS2781B.

WiMAX systems can be used in time-division-duplex (TDD), frequency-division-duplex (FDD) or half-duplex FDD configurations. In a TDD approach, the base station and the subscriber station each transmit on the same frequency although separated in time. The base station transmits a downlink subframe, followed by a short gap called a transmit/receive transition gap and then individual subscribers transmit the uplink subframes. Subscribers are accurately synchronized so that their transmissions do not overlap with each other when they arrive at the base station. Following all uplink subframes, another short gap called a receive/transmit transition gap is allocated before the base station can start transmitting again. The use of preambles at the beginning of each subscriber uplink subframe allows the base station to synchronize on each subscriber station.

Mobile WiMAX in South Korea is known as WiBro, or wireless broadband. WiBro is based on the same IEEE 802.16e-2005 standard as Mobile WiMAX but it is designed to be slightly more robust in terms of the subscriber's speed relative to the base station. WiBro uses TDD only and an 8.75MHz maximum channel bandwidth. WiBro, which uses the 2.3GHz band, is interoperable with WiMAX equipment and is expected to compete with cable, DSL and WLANs in South Korea.

Signal testing

For evaluating WiMAX receivers and components, known test signals from a signal generator take the place of signals from a WiMAX transmitter. To emulate signals for receiver evaluation, the generator must provide the frequency range, modulation types and modulation bandwidth necessary to match the signal requirements of the WiMAX standard for the equipment under test. Because the WiMAX signal has a burst nature, with differences in amplitude level from the start (preamble) of the burst through the burst data, a signal generator for WiMAX receiver testing should also provide programmable power control to mimic the dynamic power characteristics of WiMAX signals. It must also be able to accurately measure BER.

Once WiMAX test signals are generated, they must be analyzed. Testing a base station unit or portable devices for Mobile WiMAX requires the use of a signal analyzer such as the Anritsu MS2781B. The instrument has to emulate the operation of an IEEE 802.16e base station, since the analyzer must be able to detect and record the full range of frequencies and modulation formats used by a WiMAX system.

For production environments aiming to save the space of a separate analyzer and signal generator, there are measurement tools that function as both analyzer and generator such as Anritsu's MS269xA series. Designed for Mobile WiMAX testing, the MS2690A features a fundamental-frequency down conversion scheme that eliminates the need for preselection filtering over its frequency range of 50Hz to 6GHz. A preselector is

Parameter	802.16	802.16-2004	802.16e	WiBro
Bandwidth	1.25 to 28.0 MHz	1.25 to 28.0 MHz	1.25 to 28.0 MHz	8.75 MHz
Modulation	BPSK			
	QPSK	QPSK	QPSK	QPSK
	16-QAM	16-QAM	16-QAM	16-QAM
	64-QAM	64-QAM	64-QAM	64-QAM
FFT size	—	256	128, 256, 512, 1024, 2048	1,024
Duplex type	TDD/FDD	TDD/FDD	TDD/FDD	TDD
Guard period	¼, 1/8, 1/16, 1/32	¼, 1/8, 1/16, 1/32	¼, 1/8, 1/16, 1/32	1/8
MIMO	Yes	Yes	Yes	Yes

Table 2: To avoid interference, transmitted channels must remain within their specified limits and at specified power levels.

included in the MS2691A, which has a frequency range of up to 13.5GHz.

Transmitter measurements

What types of tests are needed for Mobile WiMAX transmitter testing? Transmitter tests as defined by WiMAX standards include maximum output power, transmitter spectral flatness, transmitter relative constellation error (RCE) and error vector magnitude (EVM), transmitter power level control, transmit spectral mask (for unlicensed-band operation), adjacent-channel power ratio, spurious levels and harmonic levels.

Licensing authorities generally establish spectral masks with specific requirements for their areas. Armed with a wideband signal analyzer, all these WiMAX RF transmitter measurements can be made including tests of frequency, power level, interference and modulation quality. Since WiMAX systems are so dependent on accurate digital modulation and demodulation functions, many of the measurements that characterize a Mobile WiMAX device's transmitter relate to modulation quality.

To avoid interference, transmitted channels must remain within their specified limits and at specified power levels. Thus, two of the more basic WiMAX transmitter measurements have to do with characterizing the frequency and power of a WiMAX device's transmitted signal. Because WiMAX signals are transmitted in bursts, transmitter tests for frequency accuracy require a signal analyzer with enough instantaneous bandwidth to capture the full signal of interest. The channel bandwidths for various WiMAX operating frequency ranges and standards are shown in **Table 2**.

Measurements of frequency accuracy require that a WiMAX signal be demodulated before measurement. The WiMAX specifications call for a WiMAX transmitter that is within 2ppm of its set frequency, which is equal to 7kHz for a 3.5GHz WiMAX device. The WiMAX standards also refer to a "mesh-capable" device having looser frequency requirements, with a specification of 20ppm of the set frequency.

In terms of power, note that WiMAX devices send signals in frames in which the amplitude varies from one end of the frame to another. For example, the power at the beginning of the frame (preamble) is generally at least 3dB higher than the power level of the data part of the frame. The WiMAX specifications require relative amplitude accuracy within ±0.5dB for basic WiMAX power measurements.

In a WiMAX burst signal, received-signal-strength indication (RSSI) is used, but only in the preamble part of the burst. Because of the complexity of the WiMAX burst signal, more than just a basic power meter must be used for accurate power measurements. Due to the wide modulation bandwidth of WiMAX signals, it is not possible to evaluate their modulation quality with a conventional spectrum analyzer. Instead, accurate WiMAX transmitter measurements require programmable signal analyzer and application software.

More advanced fixed and Mobile WiMAX transmitter measurements are often presented as a function of time due to the burst nature of the WiMAX signals. Transmitter-quality measurements include received time signals, EVM/RCE, spectral flatness, EVM vs. time, adjacent channel power ratio, adjacent-channel spectral flatness, power spectral density and cumulative complementary distribution functions.

For WiMAX receiver testing, a methodology similar to transmitter testing is used, but a high-performance signal generator is used in place of a WiMAX system's normal transmitter. Typical WiMAX receiver measurements include testing for sensitivity, maximum input level, adjacent-channel and alternate-channel rejection, reference timing accuracy, BER and subscriber station uplink transmit time tracking accuracy, which is similar to reference timing accuracy in that the subscriber station is instructed to change timing.

The best measurement capability is meaningless without the ability to interpret the test results. Due to the complexity of IEEE 802.16e-2005 OFDMA signals and the need for accurate digital demodulation to perform many of the Mobile WiMAX transmitter measurements, it is easy to miss a problem or misinterpret test results. Incorrectly defined data bursts, for example, can cause demodulation during the test process to fail. Attention to detail and sound measurement practices should always be exercised for maximum accuracy in WiMAX measurements.