State of the Art WiMAX Test Equipment

Rev 1.0

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This document describes test equipment suitable for WiMAX testing for pre-Certification, Interoperability and System debug.

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1. Introduction

1.1 Document purpose

This document is intended to capture the state of the art test equipment available for WiMAX and continually track new test equipment developments.

1.2 Scope

The document provides summary descriptions of test devices, test applications and contact information for obtaining more information. In addition to static content that will build as new tools are created for the industry, presentations given to the WiMAX Forum will be tracked to allow for a quick reference of past test tool presentations.

1.3 Terminology

- WiMAX - "WiMAX" is an adjective that identifies WiMAX Forum System profiles and products or systems that are designed to operate and to be certified under those profiles.
- ACLR – Adjacent Channel Leakage Ratio
- AMC – Adaptive Modulation and Coding
- AWG – Arbitrary Waveform Generator
- AWGN – Additive White Gaussian Noise
- BF - Beamforming
- BS - Base Station unit.
- BSE – Base Station Emulator
- BW - Bandwidth
- CC – Convolutional Coding
- CCDF – Complementary Cumulative Distribution Function
- CINR – Carrier to Interference and Noise Ratio
- CQI – Channel Quality Indicator
- CW – Continuous Wave
- DL - Downlink
- DSP – Digital Signaling Processor
- ETG – Evolutionary Task Group
- EVM – Error Vector Magnitude
- FCH – Frame Control Header
- FDD – Frequency Division Duplexing
- FFT – Fourier Frequency Transform
- Fixed WiMAX – "Fixed WiMAX" is an adjective that identifies those WiMAX Forum System profiles that support fixed, nomadic and portable usage models and products or systems that are designed to operate and to be certified under those profiles
- HW – Hardware
- IFFT – Inverse FFT
- MIMO – Multiple Input Multiple Output
- Mobile WiMAX – Mobile WiMAX is an adjective that identifies those WiMAX Forum System profiles that support full mobility and products or systems that are designed to operate and to be certified under those profiles
- MTG – Mobility Task Group
- OFDM – Orthogonal Frequency Division Multiplexing

- OFDMA – Orthogonal Frequency Division Multiple Access
- PCT – Protocol Conformance Tester
- PS – Physical Slot
- PUSC – Partial Usage of Subcarriers
- RCE – Relative Constellation Error (EVM)
- RCTT - Radio Conformance Tester
- RS – Reed Solomon
- RSSI – Received Signal Strength Indication
- RTG – BS Receive/Transmit Transition Gap
- RX - Receive
- Sniffer – A passive device, that capture and displays protocol messages
- SISO – Single Input Single Output
- SS - Subscriber Station unit.
- SSE – Subscribe Station Emulator
- SW – Software
- TDD – Time Division Duplexing
- TTG – BS Transmit/Receive Transition Gap
- TX - Transmit
- Testing – any type of testing associated with Conformance Testing, Interoperability Testing, and Certification Testing.
- UL - Uplink
- UUT – Unit-Under-Test, the equipment to be tested for compliance to WiMAX.
- VSA – Vector Signal Analyzer
- VSG – Vector Signal Generator

2. PHY Tools

2.1 General

This section covers tools that encompass the PHY layer, low level radio and other devices. This includes channel emulation, power meters, radio conformance equipment, OFDM(A) generators, attenuators, etc.

2.2 Test Tools

2.2.1 Vector Signal Analyzer (VSA)

2.2.1.1 Purpose

VSAs provide a wide variety of time, frequency and modulation domain measurements, and are used to measure signal characteristics such as modulation quality, envelope shape, burst timing, peak-to-average statistics, and channel power. The most common measure of modulation quality for vector-modulated signals is Error Vector Magnitude (EVM), also called Relative Constellation Error (RCE) in the IEEE-802.16 standard. VSA's often incorporate traditional spectrum analysis, allowing spurious or power measurements in addition to the modulation quality measurements. The input to the VSA is typically an RF signal. However, many VSAs also are capable of analyzing an analog baseband input signal and some a digitized baseband signal.

2.2.1.2 Basic Principles of Operation

Figure 1 gives a VERY basic idea of how the VSA works. The input signal is down-converted to baseband, and then complex-digitized at a sample rate appropriate for the intended measurement span (usually slightly wider than the signal to be measured). The I-Q samples are next calibrated, and then either saved to mass storage as waveform recordings, or passed along to DSP for post-processing into the desired measurement results. The VSA compares the received IQ samples with a perfect (or reference) version of the signal to determine the signal quality of the transmitted waveform. Various linear errors are removed during the measurement process. It is important these are set correctly, to maintain consistency of measurement results.

The details of the VSA measurements for an OFDMA signal are complex and are beyond the scope of this document. For more information, the reader is encouraged to contact the vendors listed Table 3: Available VSA Products.

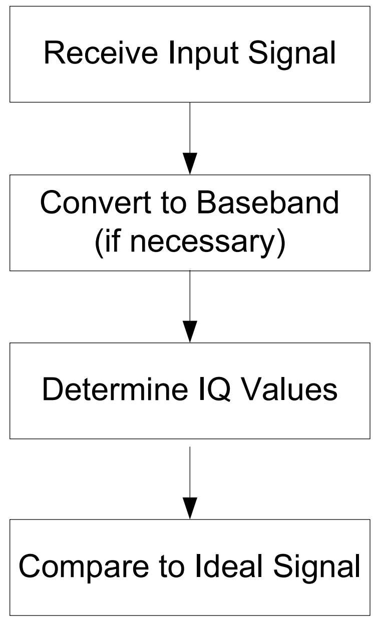

Figure 1: Simplified Vector Signal Analyzer (VSA)

2.2.1.3 Typical VSA Measurements

- Modulation measurements:
  - Constellation diagram
  - Constellation diagram per OFDM carrier
  - I/Q offset, phase skew and imbalance
  - Carrier and symbol clock frequency errors
  - Modulation error (EVM) per OFDM carrier or symbol
  - Peak, average EVM per burst or per frame
  - Amplitude response and group-delay distortion (spectral flatness)
- Amplitude statistics (CCDF) and crest factor
- Transmit spectrum mask
- Adjacent Channel Power (Absolute and Relative)
- Specialized analysis modes, e.g. for preamble, individual bursts, etc.
- Payload bits (without decoding)

2.2.1.4 VSA Measurements Required by Specification

- Frequency Error (8.4.14)
- Relative Constellation Error (Modulated and Unmodulated) (8.4.12.3)
- Spectral Flatness and Absolute Difference (Amplitude and phase) (8.4.12.2)
- Spectral Mask (unlicensed bands)

2.2.1.5 Performance Parameters for Evaluation

The IEEE 802.16 specification describes a superset of possible system features and requirements. Therefore, the WiMAX Forum has defined system profiles for evolutionary and mobile systems, which list the necessary features for a particular WiMAX system. (For example, the 802.16 OFDMA PHY specification gives the possibility of four cyclic prefix values, 1/4, 1/8, 1/16, and 1/32. The MTG system profile document only requires implementation of the 1/8 value for compliance with the MTG profiles.)

These tables map the WiMAX system profile requirements to the IEEE 802.16 reference clause and VSA test equipment coverage.

Feature		Reference (all references to 802.16 specification unless specifically referred to some other document)	Certification Wave Reference				Imple-mented in R&S FSQ with Option K92	Imple-mented in Agilent 89600 VSA w/ B7Y	Imple-mented in Anritsu Signa-ture with Options 41 and 22	Notes
Main Item	Sub item		BS	MS						
				Fixed	Nomadic	Portable				
Profile	profP3_1.75	Section 5 of the Evolutionary System profile	?	?	?	?	Y	Y	Y	
	profP3_3.5		?	?	?	?	Y	Y	Y	
	profP3_5.5		?	?	?	?	Y	Y	Y	
	profP3_7		?	?	?	?	Y	Y	Y	
	profP3_3		?	?	?	?	Y	Y	Y	
	profP3_10		?	?	?	?	Y	Y	Y	
	profP3_2.5		?	?	?	?	Y	Y	Y	
	profP3_5		?	?	?	?	Y	Y	Y	
Duplexing	TDD	8.3.5.1	1	1	1	1	Y	Y	Y	
	FDD	8.3.5.1					Y	Y	Y	
Symbol Parameters	Cyclic Prefix(1/4,1/8,1/16 and 1/32)	8.3.2.4	1	1	1	1	Y	Y	Y	
	DL Short preamble	8.3.3.6	1	1	1	1	Y	Y	Y	
	Preamble and Midamble	8.3.3.6	1	1	1	1	Y	Y	Y	
	Channel bandwidth (1.75, 2.5, 3, 3.5, 5, 5.5, 7 & 10 MHz)	8.3.1					Y	Y	Y	

Feature		Reference (all references to 802.16 specification unless specifically referred to some other document)	Certification Wave Reference				Imple-mented in R&S FSQ with Option K92	Imple-mented in Agilent 89600 VSA w/ B7Y	Imple-mented in Anritsu Signa-ture with Options 41 and 22	Notes
Main Item	Sub item		BS	MS						
				Fixed	Nomadic	Portable				
Frame Parameters	Duration (2.5, 4, 5, 8, 10, 12.5 and 20)	8.3.5.4	1	1	1	1	¤	¤	¤	
Modulation and Coding	DL QPSK	8.3.3.4	1	1	1	1	Y	Y	Y	
	DL 16 QAM	8.3.3.4	1	1	1	1	Y	Y	Y	
	DL 64 QAM	8.3.3.4	1	1	1	1	Y	Y	Y	
	UL QPSK	8.3.3.4	1	1	1	1	Y	Y	Y	
	UL 16 QAM	8.3.3.4	1	1	1	1	Y	Y	Y	
	UL 64 QAM	8.3.3.4	1	1	1	1	Y	Y	Y	
Channel Quality Measure-ment	RSSI	8.3.9.2	2	2	2	2	Y	Y	Y	
	CINR	8.3.9.3	2	2	2	2	Y	Y	Y	
Freq. and Timing Requireme nts	Carrier freq. Error Measure-ment	8.3.12					Y	Y	Y	
	Clock Error measure-ment	8.3.12					Y	Y	Y	
DL subcarrier allocation	All subcarriers		1	1	1	1	Y	Y	Y	
UL subcarrier allocation	All subcarriers	8.3.2.4	1	1	1	1	Y	Y	Y	
	UL Subchan-nelization	8.3.2.4	?	?	?	?	*	*	*	
Control Mechanism	Ranging support	8.3.7.2	2	2	2	2	*	*	*	
	Bandwidth Request	8.3.7.3					*	*	*	

Feature		Reference (all references to 802.16 specification unless specifically referred to some other document)	Certification Wave Reference				Imple-mented in R&S FSQ with Option K92	Imple-mented in Agilent 89600 VSA w/ B7Y	Imple-mented in Anritsu Signa-ture with Options 41 and 22	Notes
Main Item	Sub item		BS	MS						
				Fixed	Nomadic	Portable				
	Open Loop Control Mode	8.3.7.4	?	?	?	?	*	*	*	
Handover	-	6.3.22.2					*	*	*	
MAP Support	Compressed Private MAP	8.3.6.6					*	*	*	
	Reduced Private MAP	8.3.6.7					*	*	*	
STC	Dual DL STC	8.3.6.6					*	*	*	
Concurrent Burst Support	Downlink (16 bursts)	8.3.5.1.1	?	N/A	N/A	N/A	*	*	*	

Table 1: VSA Capabilites for ETG System Profile

Note: "*" in the above table implies that the feature is not available either because it is not implemented or is outside the scope of such equipment. An example of the scope scenario is ranging support while an example of non-availability is Concurrent Burst Support in the table. In either scenario, vendors are interested in working with potential customers in discussing Use Cases and supplying an acceptable solution if possible. "¤" denotes All frame lengths as well as continuous and user defined lengths are supported

Feature	Reference (all references to 802.16	Certification Wave Reference	Implemented in R&S FSQ with Option	Implemented in Agilent 89600 VSA	Implemented in Anritsu Signature

Main Item	Sub item		BS	MS			
Band Class Index	Class 1	4.1.1.2 of the WiMAX Forum Mobile System Profile			Y	Y	Y
	Class 2				Y	Y	Y
	Class 3				Y	Y	Y
	Class 4				Y	Y	Y
	Class 5				Y	Y	Y
Duplexing	TDD	8.4.4.2			Y	Y	Y
	FDD	8.4.4.2			Y	Y	Y
Symbol Parameters	Cyclic Prefix (1/8)	8.4.2.3	1	1	All Cyclic prefixes are supported	All Cyclic prefixes are supported	All Cyclic prefixes are supported
	FFT Size (512 and 1024)	8.4.1	1	1	All FFT sizes (128, 512, 1024, and 2048) are supported	All FFT sizes (128, 512, 1024, and 2048) are supported	All FFT sizes (128, 512, 1024, and 2048) are supported
	Channel Band-width (3.5, 5, 7, 8.75 & 10 MHz)	8.4.1	1	1	All channel bandwidths required in the standard are implemented	Supported BWs include 1.25, 3.5, 4.375, 5, 7, 8.75, 10, 14, 15, 17.5, 20, and 28 MHz	All BWs including 1.25, 1.5, 1.75, 2.50, 3.0, 3.5, 5.0, 6.0, 7.0, 8.75, 10, 12, 14, 15, 17.5, 20, 24 and 28 MHz supported
Frame Parameters	Duration (2, 2.5, 4, 5, 8, 10, 12.5 and 20 ms)	8.4.5.2	1	1	All frame lengths in standard are supported as well as continuous and user defined lengths are supported	All frame lengths in standard are supported as well as continuous and user defined lengths are supported	All frame lengths in standard are supported as well as continuous and user defined lengths are supported
DL	PUSC	8.4.6.1.2.1	1	1	Y	Y	Y

Feature		Reference (all references to 802.16 specifications unless specifically referred to some other document)	Certification Wave Reference		Implemented in R&S FSQ with Option K93	Implemented in Agilent 89600 VSA w/ B7Y	Implemented in Anritsu Signature with Options 41 and 22
Main Item	Sub item		BS	MS			
subcarrier allocation	PUSC w/ all subchannels	8.4.6.1.2.1	1	1	Y	Y	Y
	FUSC	8.4.6.1.2.2	1	1	Y	Y	Y
	AMC 2x3	8.4.6.3	2	2	Y	Y	Y
UL subcarrier allocation	PUSC	8.4.6.2.1	1	1	Y	Y	Y
	AMC 2x3	8.4.6.3	2	2	Y	Y	Y
Ranging & BW request	Initial	8.4.7.1	1	1	*	*	*
	HO	8.4.7.1	1	1	*	*	*
	Periodic	8.4.7.2	1	1	*	*	*
	BW request	8.4.7.2	1	1	*	*	*
Fast-feedback	6-bit	8.4.5.4.10.5	1	1	*	*	*
Channel coding	Repetition	8.4.9	1	1	Y	Y	Y
	Randomization	8.4.9.1	1	1	Y	Y	Y
	CC	8.4.9.2.1	1	1	Y	Y	Y
	CTC	8.4.9.2.3 excluding 8.4.9.2.3.5	1	1	*	*	*
	Interleaving	8.4.9.3	1	1	Y	Y	Y
H-ARQ	Chase Combining with CTC	8.4.15.1	1	1	*	*	*
Synchronization	BS time synchronization	8.4.10.1.1, 6.3.2.3.47	1	N/A	*	*	*
	BS freq synchronization	8.4.10.1.1	1	N/A	*	*	*
	BS-BS freq synchronization	6.3.2.3.47	1	N/A	*	*	*
	SS synchronization	8.4.10.1.2	N/A	1	*	*	*

Feature		Reference (all references to 802.16 specifications unless specifically referred to some other document)	Certification Wave Reference		Implemented in R&S FSQ with Option K93	Implemented in Agilent 89600 VSA w/ B7Y	Implemented in Anritsu Signature with Options 41 and 22
Main Item	Sub item		BS	MS			
Power control	Closed-loop power control	8.4.10.3.1	Y	Y	*	*	*
	Open-loop power control	8.4.10.3.2	1	1	*	*	*
Channel Quality Measurement	Physical CINR using Preamble	6.3.18, 8.4.5.4.12, 8.4.11.3 and 11.8.3.7.9	1	1	Y	Y	Y
	Physical CINR using Pilots	6.3.18, 8.4.5.4.12, 8.4.11.3 and 11.8.3.7.9	Y	Y	Y	Y	Y
	Effective CINR using pilots	6.3.18, 8.4.5.4.12, 8.4.11.3 and 11.8.3.7.9	2	2	*	*	*
	RSSI measurement	8.4.11.2 and 6.3.2.3.50	N/A	1	Y	Y	Y
Modulation	DL QPSK	8.4.9.4.2	1	1	Y	Y	Y
	DL 16 QAM	8.4.9.4.2	1	1	Y	Y	Y
	DL 64 QAM	8.4.9.4.2	1	1	Y	Y	Y
	UL QPSK	8.4.9.4.2	1	1	Y	Y	Y
	UL 16 QAM	8.4.9.4.2	1	1	Y	Y	Y
	UL 64 QAM	8.4.9.4.2			Y	Y	Y
	Pilot modulation	8.4.9.4.3	1	1	Y	Y	Y
	Preamble modulation	8.4.9.4.3.1	1	N/A	Y	Y	Y
	Ranging modulation	8.4.7.3	N/A	1	*	*	*
MAP Support	Normal MAP	6.3.2.3.2 and 6.3.2.3.4	1	1	Y	Y	Y
	Compressed MAP	8.4.5.6	1	1	*	*	*
	Sub-DL-UL MAP	6.3.2.3.60			*	*	*

Feature		Reference (all references to 802.16 specifications unless specifically referred to some other document)	Certification Wave Reference		Implemented in R&S FSQ with Option K93	Implemented in Agilent 89600 VSA w/ B7Y	Implemented in Anritsu Signature with Options 41 and 22
Main Item	Sub item		BS	MS			
MIMO	All IO-MIMO items	8.4.8	2	2	*	*	*
Beam-forming	All IO-BF items	8.4.8	2	2	*	*	*

Table 2: VSA Capabilities for ETG System Profile

Note: "*" in the above table implies that the feature is not available either because it is not implemented or is outside the scope of such equipment. An example of the scope scenario is Power Control while an example of non-availability is MIMO and Beam Forming features. In either scenario, vendors are interested in working with potential customers in discussing Use Cases and supplying an acceptable solution if possible.

2.2.1.6 Available Products

Table 3 gives a list of VSAs that are available for WiMAX measurements.

Product	Company	URL
89600 VSA w/ B7Y	Agilent Technologies	http://www.agilent.com/find/wimax
Signature/MS2781B w/Options 41 and 22	Anritsu Corporation	http://www.us.anritsu.com/Signature/
FSQ w/K92 (OFDM) w/K93 (OFDMA)	Rohde & Schwarz	http://www.rohde-schwarz.com/www/dev_center.nsf/html/wimax_products

Table 3: Available VSA Products

2.2.2 Vector Signal Generator (VSG)

2.2.2.1 Purpose

Vector signal generators are used to generate a repeatable signal with or without known impairment for receiver testing and/or component testing. Typical receiver tests include sensitivity (to measure the ability of a receiver to demodulate a signal at low power levels) and adjacent channel interference (to measure the ability of the receiver to demodulate a signal in the presence of interfering signals). Other important receiver tests measure the ability of the receiver to demodulate a signal in the presence of AWGN, fading, and/or transmitter imperfections such as quadrature error or IQ offset. For component testing, signal generators and signal analyzers are used together to determine, for example, the CCDF (Complementary Cumulative Distribution Function) and ACLR (adjacent channel leakage ratio.)

2.2.2.2 Basic Principles of Operation

Figure 2 provides a VERY high level overview the OFDM generation. Conceptually a VSG consists of a digital baseband, or an arbitrary waveform generator (AWG), a digital to analog converter, a modulator (which is fed by an RF synthesizer) and finally, RF level control and attenuation. In the digital baseband, user bits are coded (e.g. RS-CC) according to the standard, and then converted to symbols. For OFDM signals the mapping to the sub-carriers occurs at this stage. The signal is then baseband filtered. Following an IFFT, the signal is sampled and given a time structure, and guard intervals are added. The digital signal is converted to analog I and Q values, which are typically also made available on BNC ports. These analog baseband signals are up-converted to the desired RF frequency.

Radio communication standards generally specify receiver tests (see next section) which define useful signals and certain environmental conditions (noise, fading, modulated or CW interferer). Therefore, some VSGs simulate these kinds of conditions in the digital baseband section or provide other mechanisms to add fading effects. A number of types of distortions can also effectively be applied to these signals.

2.2.2.3 VSG Measurements

The VSG is used to generate the desired (when no signaling is required) and/or interfering signal for the following receiver tests that are required by the 802.16 standard.

- Sensitivity (8.4.13.1)
- Adjacent Channel and Alternate Adjacent Channel Rejection (8.4.13.2)
- Maximum Input Signal (8.4.13.3)
- Maximum Tolerable Input Signal (8.4.13.4)
- Receiver Image Rejection
- RSSI (8.4.11.2)
- CINR (8.4.11.3)

Since the signal generator does not perform all the tasks for Network entry, tests require the use of some form of test software to control the UUT.

In addition, the VSG may also be used:

- To generate a signal with noise to test the receiver's ability to demodulate the signal in the presence of noise
- To generate a faded signal to test the receiver's ability to demodulate the signal in the presence of noise
- To generate a signal with known imperfections to test the ability of the receiver to demodulate an impaired signal
- To test components, such as amplifiers, mixers, and modulators

2.2.2.4 VSG Performance Parameters

This section provides a table of system features as documented in the WiMAX Forum's system profile document and corresponding information on the availability of the feature in the available VSG WiMAX solutions. A table is provided for the Mobility Task Group's system.

Feature		Reference (all references to 802.16 specifications unless specifically referred to some other document)	Certification Wave Reference		Implemented in R&S SMU	Implemented in Agilent ESG	Implemented in Anritsu MG3700A
Main Item	Sub item		BS	MS			
Band Class Index	Class 1	4.1.1.2 of the WiMAX Forum Mobile System Profile			Y	Y	Y
	Class 2				Y	Y	Y
	Class 3				Y	Y	Y
	Class 4				Y	Y	Y
	Class 5				Y	Y	Y
Duplexing	TDD	8.4.4.2			Y	Y	Y
	FDD	8.4.4.2			Y	Y	Y
Symbol Parameters	Cyclic Prefix(1/8)	8.4.2.3	1	1	All Cyclic prefixes are supported	All Cyclic prefixes are supported	All Cyclic prefixes are supported
	FFT Size (512 and 1024)	8.4.1	1	1	All FFT sizes (128, 512, 1024, and 2048) are supported	All FFT sizes (128, 512, 1024, and 2048) are supported	All FFT sizes (128, 512, 1024, and 2048) are supported
	Channel Bandwidth (3.5, 5, 7, 8.75 & 10 MHz)	8.4.1	1	1	All channel bandwidths required in the standard are supported	Supported BWs include 1.25, 3.5, 4.375, 5, 7, 8.75, 10, 14, 15, 17.5, 20, and 28 MHz	All BWs including 1.25, 1.5, 1.75, 2.50, 3.0, 3.5, 5.0, 6.0, 7.0, 8.75, 10, 12, 14, 15, 17.5, 20, 24 and 28 MHz supported

Feature		Reference (all references to 802.16 specifications unless specifically referred to some other document)	Certification Wave Reference		Implemented in R&S SMU	Implemented in Agilent ESG	Implemented in Anritsu MG3700A
Main Item	Sub item		BS	MS			
Frame Parameters	Duration ((2, 2.5, 4, 5, 8, 10, 12.5 and 20 ms)	8.4.5.2	1	1	All frame lengths in standard are supported as well as continuous and user defined lengths are supported	All frame lengths in standard are supported as well as continuous and user defined lengths are supported	All frame lengths in standard are supported as well as continuous and user defined lengths are supported
	TTG/RTG (as specified in section 4.1.1.6 of the WiMAX Forum's Mobile System Profile)	8.4.5.2	1	1	Y	Y	Y
	No. of DL and UL Symbols (as specified in section 4.1.1.7 of the WiMAX Forum's Mobile System Profile)	8.4.4.2	1	1	The number of symbols is user definable	The number of symbols is user definable	The number of symbols is user definable
DL subcarrier allocation	PUSC	8.4.6.1.2.1	1	1	Y	Y	Y
	PUSC w/ all subchannels	8.4.6.1.2.1	1	1	Y	Y	Y
	FUSC	8.4.6.1.2.2			Y	Y	Y
	AMC 2x3	8.4.6.3				Y	*
UL	PUSC	8.4.6.2.1	1	1	Y	Y	Y

Feature		Reference (all references to 802.16 specifications unless specifically referred to some other document)	Certification Wave Reference		Implemented in R&S SMU	Implemented in Agilent ESG	Implemented in Anritsu MG3700A
Main Item	Sub item		BS	MS			
subcarrier allocation	AMC 2x3	8.4.6.3				Y	*
Ranging & BW request	Initial	8.4.7.1	1	1	Y	Y	*
	HO	8.4.7.1			Y	Y	*
	Periodic	8.4.7.2	1	1	Y	Y	*
	BW request	8.4.7.2	1	1	Y	Y	*
Fast-feedback	6-bit	8.4.5.4.10.5	1	1		Y	*
Channel coding	Repetition	8.4.9	1	1	Y	Y	Y
	Randomization	8.4.9.1	1	1	Y	Y	Y
	CC	8.4.9.2.1	1	1	Y	Y	Y
	CTC	8.4.9.2.3 excluding 8.4.9.2.3.5	1	1	Y	Y	Y
	Interleaving	8.4.9.3	1	1	Y	Y	Y
H-ARQ	Chase Combining with CTC	8.4.15.1				*	*
Synchronization	BS time synchronization	8.4.10.1.1, 6.3.2.3.47	1	N/A	*	*	*
	BS freq synchronization	8.4.10.1.1	1	N/A	*	*	*
	BS-BS freq synchronization	6.3.2.3.47	1	N/A	*	*	*
	SS synchronization	8.4.10.1.2	N/A	1	*	*	*
Power control	Closed-loop power control	8.4.10.3.1	1	1	*	*	*
	Open-loop power control	8.4.10.3.2	1	1	*	*	*

Feature		Reference (all references to 802.16 specifications unless specifically referred to some other document)	Certification Wave Reference		Implemented in R&S SMU	Implemented in Agilent ESG	Implemented in Anritsu MG3700A
Main Item	Sub item		BS	MS			
Modulation	DL QPSK	8.4.9.4.2	1	1	Y	Y	Y
	DL 16 QAM	8.4.9.4.2	1	1	Y	Y	Y
	DL 64 QAM	8.4.9.4.2	1	1	Y	Y	Y
	UL QPSK	8.4.9.4.2	1	1	Y	Y	Y
	UL 16 QAM	8.4.9.4.2	1	1	Y	Y	Y
	UL 64 QAM	8.4.9.4.2			Y	Y	Y
	Pilot modulation	8.4.9.4.3	1	1	Y	Y	Y
	Preamble modulation	8.4.9.4.3.1	1	N/A	Y	Y	Y
	Ranging modulation	8.4.7.3	N/A	1	Y	Y	*
MAP Support	Normal MAP	6.3.2.3.2 and 6.3.2.3.4	1	1	Y	Y	Y
	Compressed MAP	8.4.5.6	1	1	Y	Y	Y
	Sub-DL-UL MAP	6.3.2.3.60			*	*	*
MIMO	All IO-MIMO items	8.4.8	2	2	*	*	*
Beam-forming	All IO-BF items	8.4.8	2	2	*	*	*

Table 4: VSG WiMAX Forum Test Capabilities

Note: "*" in the above table implies that the feature is not available either because it is not implemented or is outside the scope of such equipment. An example of the scope scenario is Power Control support while an example of non-availability is MIMO and Beam Forming features. In either scenario, vendors are interested in working with potential customers in discussing Use Cases and supplying an acceptable solution if possible.

2.2.2.5 Available Products

Table 5 gives a list of VSGs that are available for WiMAX measurements.

Product	**Company**	**URL**
E4438-C w/ N7615B	Agilent Technologies	http://www.agilent.com/find/wimax

MG3700A	Anritsu Corporation	http://www.us.anritsu.com/products/ARO/North/Eng/showProd.aspx?&ID=679
SMU	Rohde & Schwarz	http://www.rohde-schwarz.com/www/dev_center.nsf/html/wimax_products

Table 5: Available VSG Products

2.2.3 Radio Channel Emulator

The inherent complexity of WiMAX communications systems places high demands on test environments. High data rates, multiple channels, wider bandwidth, spectrum availability, and high carrier frequencies all present serious challenges for WiMAX system developers. This subsection presents the features and requirements that are needed from a radio channel emulator to enable system design, environment modeling, and test bench setup for a successful WiMAX MS and BS / network development, deployment, and conformance tests. Some of the performance figures presented in this chapter may not be required in the RCT.

2.2.3.1 Purpose

A wideband radio channel emulator accurately reproduces real-world radio propagation phenomena such as multi-path fading, sliding delays, attenuation, path loss, Doppler shift, and shadowing. It optionally includes integrated AWGN and other interference sources for accurate and repeatable signal-to-noise ratio (S/N) and carrier-to-interference ratio (C/I) emulation.

For MIMO-system testing the accurate and repeatable emulation of complex correlation between the fading channels is required.

A radio channel emulator enables systematic, repeatable laboratory testing of wireless systems under realistic, time variant conditions. In other words, bringing the real world environment into the lab under a controlled set of operational parameters is the primary goal of a radio channel emulator.

2.2.3.2 Basic Principles of Operation

In general, a channel emulator can provide one or more real-time emulations of wireless channels. Typically, RF test system components such as interference generators and AWGN generators may be built-in as part of the fading channel emulator. Testing of receiver is typically done in one direction at a time and the selection to insert fading emulation to downlink or uplink is based on which of the SS or BS is under testing. In system level testing it is also possible to use fading in both UL and DL at the same time. In such case emulator with at least 2 independent fading channels is needed. Figure 2: Channel Emulator & AWGN/Interference generation shows the internal components of a two-channel (uplink and downlink), full-duplex channel emulation test case.

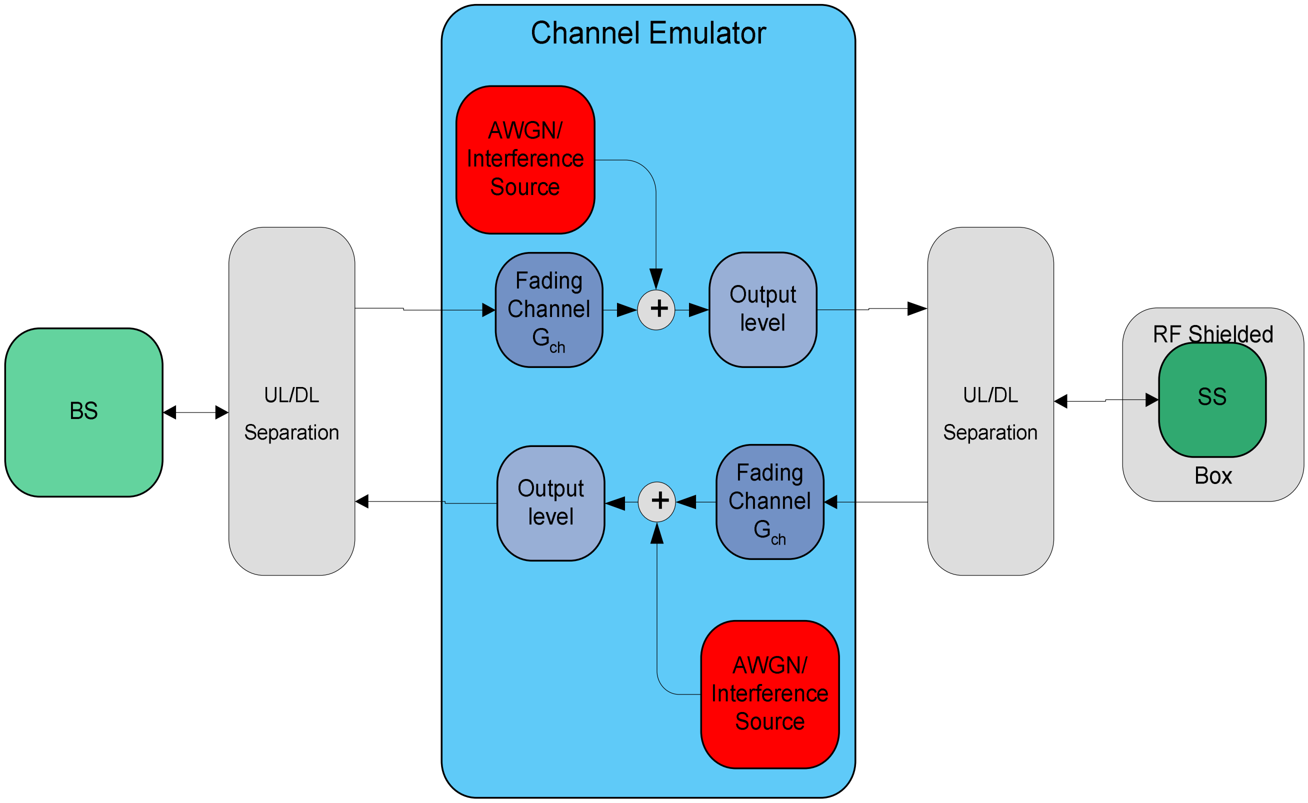

Figure 2: Channel Emulator & AWGN/Interference generation

RF signal comes from the TX antenna connector of BS (DL) or SS (UL) via coaxial attenuator to the emulator input. The signals are converted to digital baseband and inserted to the fading block where the signal is corrupted (typically done in the digital baseband) according to a predefined set of fading parameters. AWGN or interference (if desired) is summed to the carrier after the fading. Internal digital summing on noise or interference provides the best possible accuracy. From emulator output RF signals are connected to the RX antenna connector of SS (DL) and BS (UL). When only one-way link level tests are done the non-faded link (UL or DL) can be fed past the emulator.

2.2.3.3 Features Important for WiMAX Testing

Several channel models have been identified that capture the characteristics of real world impairments that will be encountered by WiMAX devices. These include:

- SUI models for Fixed WiMAX (not required for WiMAX certification)
- ITU Pedestrian and Vehicular models for Mobile WiMAX
- GSM TU Channel models (not required for WiMAX certification)
- ITU Pedestrian and Vehicular with correlation parameters for MIMO (not required for WiMAX certification)
- LTE channel models (not required for WiMAX certification)
- WINNER Channel models (not required for WiMAX certification)

- Simplified WINNER channel models proposed for WiMAX tests (not required for WiMAX certification)

It is important that the channel emulator is capable of precisely generation of these models including the exact spectral shape. Because testing is not limited to these models, the emulator should also have the flexibility to allow creation of custom models in an efficient manner.

In order to support the dense 64-QAM modulation needed for the highest WiMAX data rates, the 802.16 specification notes that the received signal may have a relative constellation error (alternatively referred to as error vector magnitude or EVM) of no more than -31.0dB. It is imperative that the channel emulator exceed this requirement to ensure the integrity and validity of the test results. The channel emulator should only introduce controlled and intended impairments.

2.2.3.4 Test connections – SISO

Figure 3 shows a system configuration with 1 receiver and 1 transmit antennas in BS and 1 receive and 1 transmit antennas in SS, full duplex. This connection is used in Wave 1 Mobile WiMAX Certification tests

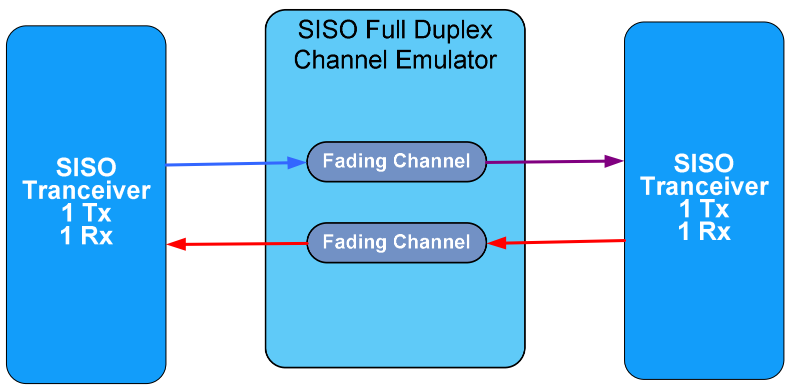

Figure 3: 1x1 Full Duplex SISO channel emulator

2.2.3.5 Test connections – 2x2 MIMO

Figure 4 shows a system configuration with 2 receiver and 2 transmit antennas in BS and 2 receive and 2 transmit antennas in SS (2x2 full duplex). This connection is used in Wave 2 Mobile WiMAX Certification tests.

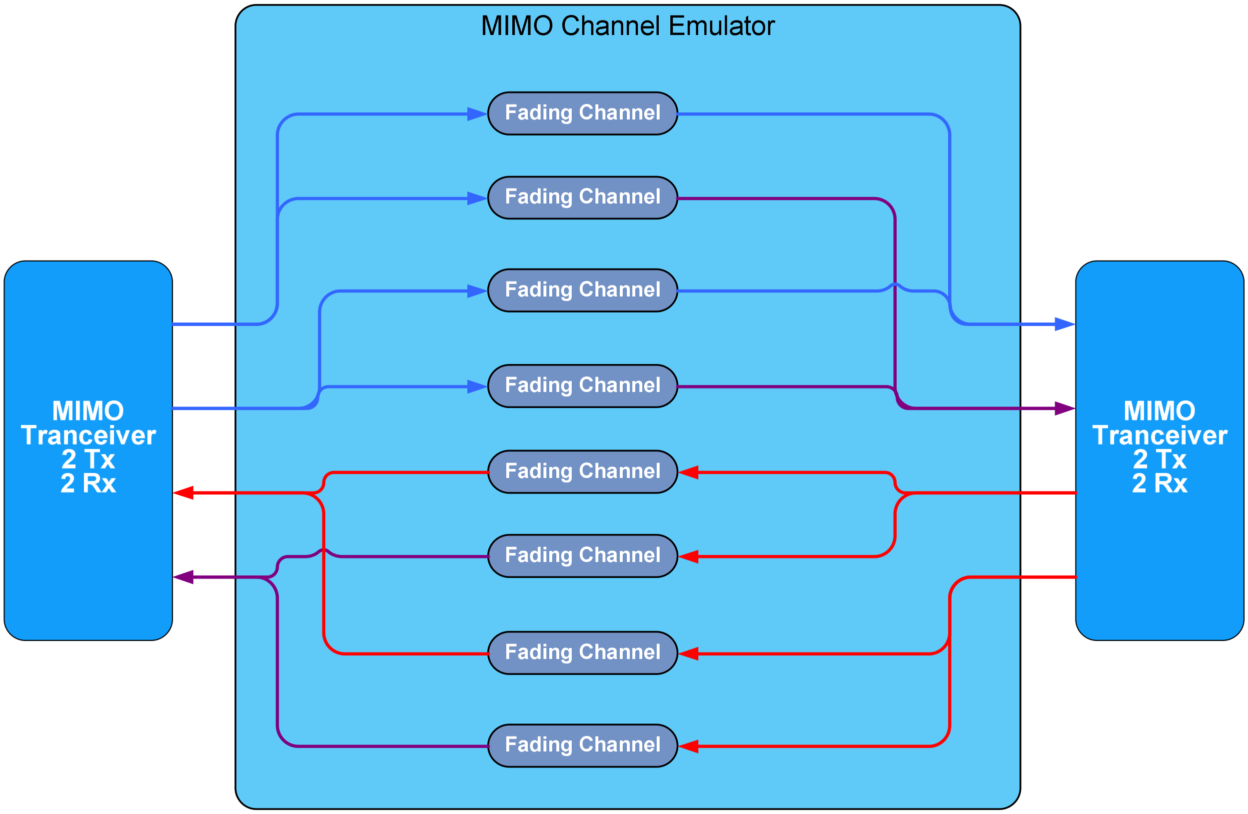

Figure 4: 2x2 Full Duplex MIMO channel emulator

2.2.3.6 Test connections – other MIMO systems (not required for WiMAX Certification)

While Wave 2 specifies test requirements for 2x2 MIMO systems, MIMO systems can also be designed in alternative configurations with different numbers of receiver and transmit antennas. Figure 5 shows an example of a system configuration with 4 receiver and 4 transmit antennas in BS and 2 receive and 2 transmit antennas in SS (2x4 full duplex). This connection can be used in optional 4x2 tests and is shown here as an example. Also other connections can be established in a similar manner.

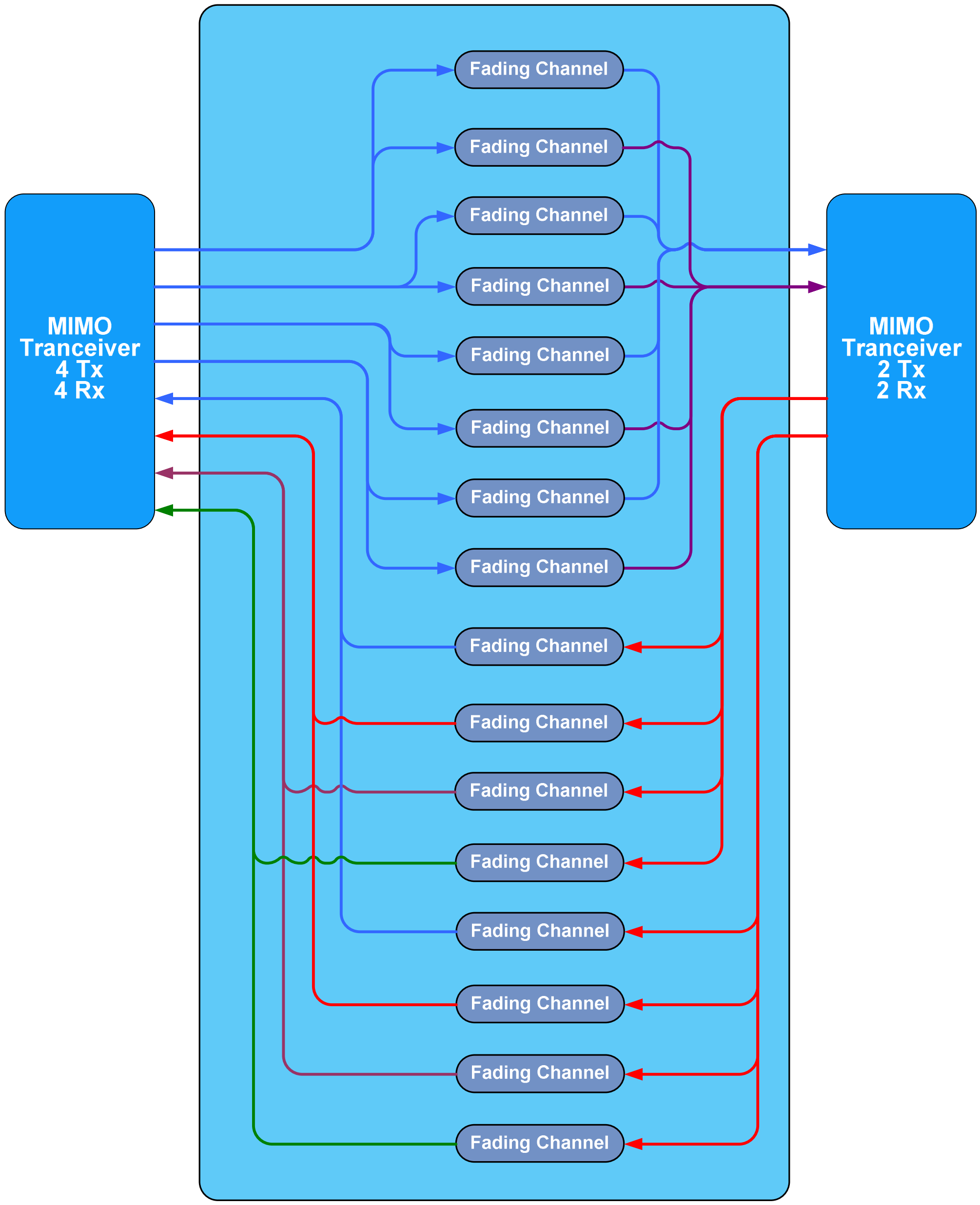

Figure 5: 4x2 Full Duplex MIMO channel emulator

2.2.3.7 Performance Parameters for Evaluation

Table 6 shows the key performance parameters of state-of-the-art channel emulators.

Carrier frequency		Certification Wave Reference		Spirent SR5500 Support	Elektrobit Propsim C8 (also other WiMAX compliant channel emulators available - please contact vendor)	Comment
Main Item	**Sub item**	**BS**	**MS**			
SISO Channel Models	AWGN	1	1	Y	Y	
	Ped. B 3 km/h	1	1	Y	Y	
	Veh. A 50 km/h	1	1	Y	Y	
	User Defined			Y	Y	Not mandatory
MIMO Channel Models	TBD			*	*	
	TBD			*	*	
	TBD			*	*	
	User Defined			*	Y	Not mandatory
Duplexing	TDD	1	1	*	*	
	FDD			*	*	
Carrier frequency	2.3-2.7 GHz	1	1	Y	Y	
	3.3-3.8 GHz			Y	Y	
	5.6-6.0 GHz			Y	Y	
Bandwidth	10 MHz	1	1	Y	Y	
	> 20 MHz			Y	Y	Not mandatory
Number of Channels	2	1	1	Y	Y	
	4			Y	Y	
	8			Y	Y	
	16			*	Y	Not mandatory
Multiantenna Support	MIMO	2	2	Y	Y	
	BF	2	2	Y	Y	
Number of Fading Paths / Channel	6	1	1	Y	Y	
	12			Y	Y	Not mandatory
	24			Y	Y	Not mandatory
Internal Signal Generators	AWGN Noise			Optional	Optional	
	Interference			N	Optional: CW, GMSK, WCDMA, WiMAX	Not mandatory
	RF Local Osc.			Y	Optional	Not mandatory
Modulation and Coding	QPSK,16 QAM,64 QAM			Y	Y	

Table 6: Performance parameters of state-of-the-art channel emulators.

"*" in Table 6 denotes "Contact Vendor". It means that the feature is available, but may have some limitations. Therefore, the customer should contact the equipment manufacturer to receive more detailed explanation.

2.2.3.8 Available Products

Table 7 gives a list of radio channel emulators that are available for WiMAX measurements.

Product	Company	URL
Propsim C8, Propsim C2	Elektrobit	http://www.propsim.com
SR5500	Spirent	http://www.spirentcom.com

Table 7: Available Channel Emulator Products

2.2.4 Radio Conformance Test Tester (RCTT)

2.2.4.1 Purpose

To assist the certification of WiMAX products, some special test systems are required. One of them is the RCT (Radio conformance tester). As the name implies, the RCT tests the base station's and mobile (or subscriber in the case of OFDM) station's physical layer conformance with the standard.

2.2.4.2 Basic Principles of Operation

The RCT main internal architecture could be described with Figure 6.

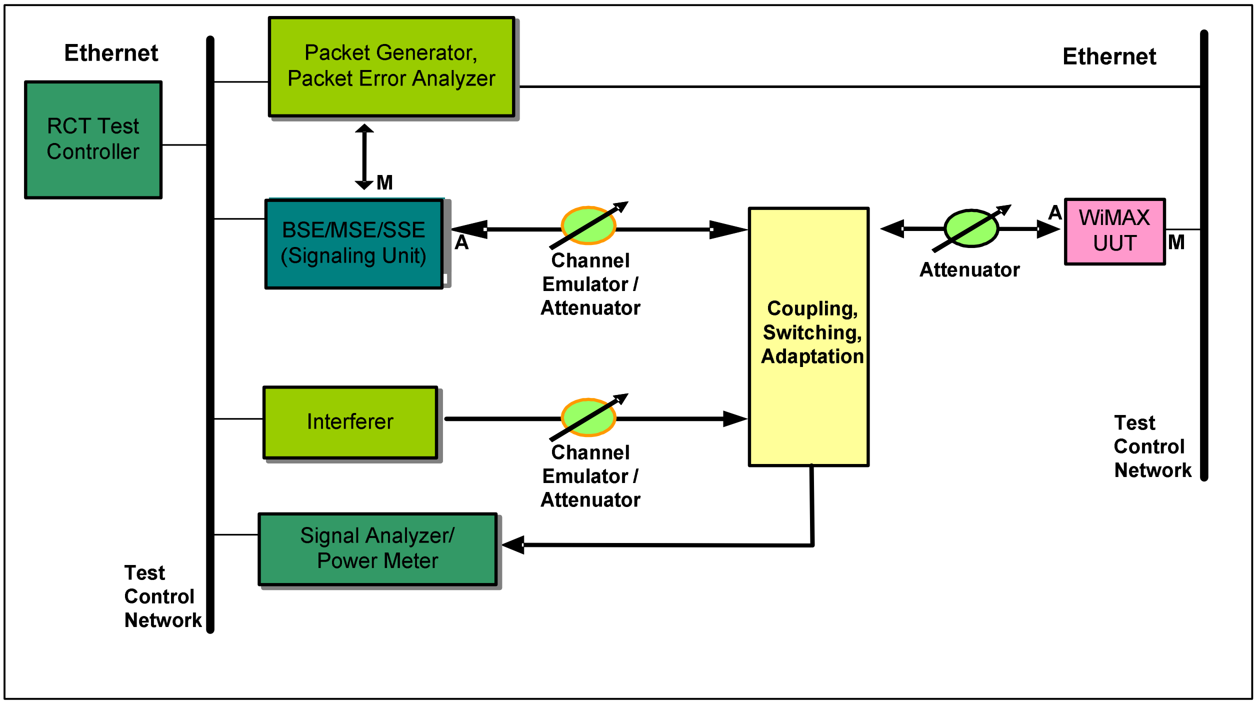

Figure 6: RCTT functional description

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The key building blocks of the WiMAX RCTT system are:

- PC Controller: The PC controller is primarily used to manage the different instruments in the RCTT according to the required test case.
- Vector Signal Analyzer (VSA): the VSA is used to measure the PHY layer characteristics of the UUT such as Frequency, Error Vector Magnitude (EVM), Spectral Flatness and Spectral Mask.
- BSE/MSE/SSE (Signaling Unit): This is a signaling device capable of emulating WiMAX base stations and/or mobile stations. Further, the signaling unit provides the special signaling procedures intended for RCT testing.
- Power Meter: the Power Meter is used to measure accurate power levels within the system.
- IP Traffic Generator: that IP traffic generator is used to generate IP packets with Ethernet format that will be provided to the Test BS/MS system,
- Packet Analyzer: Bit-error-rate and packet-error-rate measurements are done by comparing the originally transmitted IP packets with the received IP packets.
- Vector Signal Generator (VSG) – it is used to generate interfering signals, and can provide defined noise levels
- Channel Emulator: this unit is used to emulate multipath and moving propagation conditions. This is only necessary in a uni-directional way, i.e. in UUTs receive path. (For support of the air (fixed) profiles a channel emulator is not required.)
- Finally, the test setup is completed with an RF Switching Unit which is commanded by the PC controller to provide the necessary RF paths to perform testing.

Other elements of the system are a clock reference that provides the necessary timing accuracy in certain test cases and a DC power supply to be used by the UUT when required.

2.2.4.3 RCTT Requirements

The following are necessary features for an RCTT: The RCTT shall

- Support all mandatory RCTT test cases required to certify a WiMAX BS and/or MS in a specific certification profile.
- Generate a test case result: pass/fail/inconclusive.
- Provide detailed reports on the test case results.
- Support all bands and bandwidths required for the relevant certification profile.
- Be validated by the appropriate validation body.
- Store in hard drive or equivalent the test cases execution results.
- Be compliant with the WiMAX Forum RCT documents.

2.2.4.4 Performance Parameters for Evaluation

To be used for WiMAX device certification, the RCTT must pass validation. The tables in 2.2.4.5 provide information on status of RCTT test case validation.

In addition to the validation requirement for certification, the following parameters may be considered when selecting an RCTT:

- Certification Waves/Releases supported
- Uncertainty levels of the measurements
- Automation of test cases for MS and BS
- Overall test time per test case
- Automatic self test, calibration and path compensation
- Number of optional test cases supported for each family of test cases
- Ability to support PHY modes, bandwidths and bands not required for certification.
- Ability to emulate multiple BSs/MSs at the same time
- Ability to capture trace information and allow for flexible result display. (this is useful if troubleshooting is necessary)

2.2.4.5 Test Cases for Subscriber Stations (Fixed WiMAX)

TTable 8 to Table 13 provide a list of mandatory tests defined in the Radio Conformance Test Document for the OFDM air interface. (The OFDMA test cases can be found in 2.2.4.6)

Test Case	Reference[RCT]	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)
Receiver Maximum Tolerable Signal	8.2.1	V	
Receiver Sensitivity	8.2.2	V	
Cyclic Prefix	8.2.3	V	
Preambles	8.2.4	V	
Frame Timing	8.2.5	V	
Receiver RSSI Measurements	8.2.6		
Receiver CINR Measurements	8.2.7		
Adjacent Channel Rejection	8.2.8	V	
Alternate Channel Rejection	8.2.9	V	
SS Receive Image Rejection	8.2.10	V	

Table 8: OFDM MS Receiver Tests

Test Case	Reference[RCT]	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)
Modulation and coding	8.2.12	V	
Cyclic Prefix and Symbol Timing	8.2.13	V	
Preambles and Midambles	8.2.14	V	
Ranging Support	8.2.15	V	
SS Transmit Power Level Control	8.2.16	V	
Spectral Flatness	8.2.17	V	
Relative Constellation Error	8.2.18	V	
Synchronization	8.2.19		
Spectral Mask	8.2.20		

Table 9: OFDM SS Transmitter Tests

Test Case	Reference[RCT]	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)
SSRTG	8.2.21		
SSTTG	8.2.22		

Table 10: OFDM Performance Tests

Test Case	Reference[RCT]	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)
Receiver Maximum Tolerable Signal	8.3.1	V	
Receiver Sensitivity	8.3.2	V	
Cyclic Prefix	8.3.3	V	
Preambles & Midambles	8.3.4	V	
Frame Timing	8.3.5	V	
Ranging Support	8.3.6		
Adjacent Channel Rejection	8.3.7	V	
Alternate Channel Rejection	8.3.8	V	
Receiver Maximum Input Signal	8.3.9		
BS Receive Image Rejection	8.3.10		

Table 11: OFDM BS Receiver Tests

Test Case	Reference[RCT]	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)
Modulation and coding	8.3.11	V	
Cyclic Prefix and Symbol Timing	8.3.12	V	
Preambles	8.3.13	V	
DL Short Preambles	8.3.13	V	
Power Range	8.3.14	V	
Spectral Flatness	8.3.15	V	
Relative Constellation Error	8.3.16	V	
Spectral Mask	8.3.17	V	

Table 12: OFDM BS Transmitter Tests

Test Case	Reference[RCT]	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)
Reference Frequency Tolerance	8.3.18	V	

Table 13: OFDM BS Performance Test

2.2.4.6 SISO Test Cases for Mobile Stations (OFDMA Air Interface)

The following tables provide a list of the current tests listed in the WiMAX Forum Mobile RCT document along with the availability of the test case in the available RCT products. The Mobile RCT (MRCT) document is still in draft and has not officially been approved. Therefore, the information in the table is subject to change.

(Note: The numbering system for the MRCT test cases are: X.Y.Z where X =9 for mobile station and =10 for base station, Y =1 for wave 1 and =2 for wave2, and Z =test case number.

Test Case	Reference[MRCT]	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)
Rx Maximum Tolerable Signal	9.1.1		
Rx Preambles	9.1.2		
Rx Cyclic Prefix (CP)	9.1.3		
Rx RSSI Measurements	9.1.4		
Rx Physical CINR Measurements	9.1.5		
Rx Receiver Based Effective CINR Measurements	9.1.6		
Rx Adjacent and Non-adjacent Channel Rejection	9.1.7		
Rx Maximum Input Signal	9.1.8		
Rx Sensitivity	9.1.9		
Rx HARQ	9.1.10b		
Receiver PHY Support for Handoff	9.1.11		

Table 14: OFDMA MS Receiver Tests

Test Case	Reference[MRCT]	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)
TX HARQ	9.1.10a		
Tx Modulation and Coding, Cyclic Prefix and Symbol Timing	9.1.12		
Tx Ranging Support	9.1.13		
Tx Power Dynamic Range	9.1.15		
Open Loop & Closed Loop Power Control	9.1.16		
Tx Spectral Flatness	9.1.17		
Tx Relative Constellation Error	9.1.18		
Tx Synchronization	9.1.19		
Performance MSRTG/MSTTG	9.1.20		

Table 15: OFDMA MS Transmitter Tests

Test Case	Reference[MRCT]	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)
Rx Maximum Tolerable Signal	10.1.1		
Rx Cyclic Prefix	10.1.2	Will be incorporated into 10.1.1	
Rx Ranging Support	10.1.3		
Rx Adjacent and Alternate Adjacent Channel Rejection	10.1.4		
Rx Maximum Input Signal	10.1.5		
Rx Sensitivity	10.1.6		

Table 16: OFDMA BS Receiver Tests

Test Case	Reference[MRCT]	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)
Tx Modulation and Coding	10.1.7		
Tx Cyclic Prefix and Symbol Timing	10.1.8		
Tx Preambles	10.1.9		
Tx Power Range Support	10.1.10		
Tx Spectral Flatness	10.1.11		
Tx Relative Constellation Error	10.1.12		

Table 17: OFDMA BS Transmitter Tests

Test Case	Reference[MRCT]	R&S TS8970 (If ✓, then implemented. If V, then the case has been validated.)	Cetecom MINT T2110 (If ✓, then implemented. If V, then the case has been validated.)
BS synchronization	10.1.13		
Rx/Tx HARQ	10.1.14		
BS to neighbor BS synchronization in frequency	10.1.15		
Rx/Tx switching gaps	10.1.16		

Table 18: OFDMA Miscellaneous Tests

2.2.4.6.1. Certification Profiles and Feature support

This section provides information on the certification profiles supported. Details of the profiles can be found in the ETG system profile and the MTG system profile,

(Note: Because of the complexity of the RCTT systems, it is out of the scope of this document to list all features supported by a particular vendor's RCTT. For implementation details and the latest information on feature support, including test interfaces, please contact the vendor).

Certification Profile support	R&S TS8970 (If ✓, then supported)	AT4 Wireless MINT T2110 (Opt. 16e) (If ✓, then supported)
ProfP3_1.75		
ProfP3_3.5		
ProfP3_7		
ProfP3_3		
ProfP3_5.5		
ProfP3_10		
Other bands supported (list in cell)		

Table 19: Certification Profiles - OFDM Air Interface (Fixed)

Certification Profile support	R&S TS8970 (If ✓, then supported)	AT4 Wireless MINT T2110 (Opt. 16e) (If ✓, then supported)
ProfP3_1.75		
ProfP3_3.5		
ProfP3_7		
ProfP3_3		

Certification Profile support	R&S TS8970 (If ✓, then supported)	AT4 Wireless MINT T2110 (Opt. 16e) (If ✓, then supported)
ProfP3_5.5		
ProfP3_10		
ProfP3_2.5		
ProfP3_5		
Other bands supported (list in cell)		

Table 20: Certification Profiles - OFDM Air Interface (ETG)

Certification Profile support	R&S TS8970 (If ✓, then supported)	AT4 Wireless MINT T2110 (Opt. 16e) (If ✓, then supported)
Certification Profile 1.A		
Certification Profile 1.B		
Certification Profile 2.A		
Certification Profile 2.B		
Certification Profile 2.C		
Certification Profile 3.A		
Certification Profile 4.A		
Certification Profile 4.B		
Certification Profile 4.C		
Certification Profile 5.A		
Certification Profile 5.B		
Certification Profile 5.C		
Other bands supported (list in cell)		

Table 21: Certification Profiles - OFDMA Air Interface (MTG)

2.2.4.7 Available Products

Table 22 gives a list of RCTTs that are available for WiMAX measurements. The RCTT is a tool that is validated by a 3rd party. To be listed below requires that the vendor passed this validation process.

Product	Company	URL
MINT T2110	AT4 WIRELESS	http://www.at4wireless.es/web/en/pag/n154#n154
TS8970	Rohde & Schwarz	http://www.TS8970.rohde-schwarz.com/

Table 22: Available WiMAX RCTT

3. MAC Tools

3.1 General

This section covers tools that encompass the MAC layer, protocol conformance testers (PCTs), MAC emulation devices, etc.

3.1.1 WiMAX Protocol Conformance Tester (PCT)

To assist the certification of WiMAX products, some special test systems are required. One such system is the protocol conformance tester (PCT), intended to allow the testing of the MAC layer of BS and M/SS.

3.1.1.1 Purpose

The Protocol Conformance Tester (PCT) is a wireless test system, which has several operation modes:

- One, two or three BSs emulation mode
- One, two or three M/SSs emulation mode
- One BS and one M/SS emulation mode

Each of the operation modes allows MAC testing of an UUT for a certain type of test scenarios. The PCT registers the MAC responses/indications performed by the UUT, and checks whether this behavior is allowed with respect to a set of expected behaviors described by the TSS&TP document. This TTS&TP document reflects all the test purposes and provides a description of each test case, including the test conditions and the required test configuration of the UUT and PCT. The PCT also runs just the test cases applicable to the UUT according with the PICS declaration made by the vendor UUT. The results of the tests allow the UUT to get or not the MAC conformance.

3.1.1.2 Basic Principles of Operation

The PCT main internal operation could be described with the following figure.

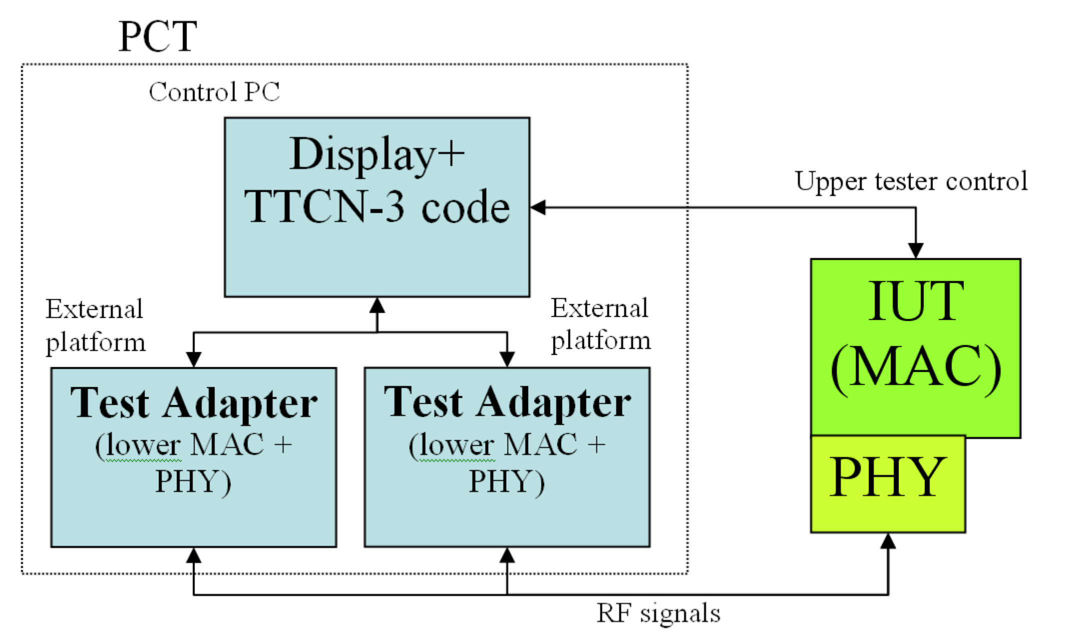

Figure 7: PCT internal description

The PCT has one main element where resides a principal application that manages the PICS, the UUT applicable test cases compilation and execution, the test verdicts and generates reports in different formats. The test cases suite consist in a TTCN-3 code. This code is a standard code derived from the ATS written by ETSI, so is an official and public code. The executable programs derived by the compilation are managed by the referred principal application.

There is also an important piece of SW inside the control PC that it is intended to work directly with the UUT. This SW is also called the Upper Tester application and it is used to trigger the UUT in order to get into the test condition or it is used to retrieve some output from the UUT during or after the test case execution. The output retrieved by the UUT is used to generate the test verdict. The upper tester application should be based on a standardized test interface to send/receive the adequate commands/responses to the UUT.

Another piece of the PCT is the HW platforms where resides the lower MAC and the PHY of the different MAC instances that simulates the TTCN-3 code. The HW platforms allow a scalable system that enables the simulation of several BSs or M/SSs, based upon initial configuration made by the test SW. These elements are intended to exchange the RF WiMAX signals with the UUT.

3.1.1.3 PCT Requirements

The following are necessary features for a PCT: The PCT shall:

- Support all necessary protocol level test cases to validate a WiMAX BS and/or M/SS. This should be possible by inspection of the traces captured by the PCT.
- Generate a test case result: pass/fail/inconclusive.
- Support all bands and bandwidths required for certification.
- Be validated by the appropriate validation body.
- Elaborate reports on the test cases run.
- Store in HHDD or equivalent the test cases execution results.

- Be compliant with protocol test specification.

3.1.1.4 Performance Parameters for Evaluation

The following are parameters that allow to assess the PCT:

- Number of optional test cases supported for each family of test cases
- Number of MAC entities emulated by the PCT, e.g. ability to emulate 2 BSs or 1 M/SS and 1 BS at the same time,…
- Ability for display traces of different levels (PHY, MAC,…) and in different ways.
- Ability to capture the trace into a text/word file (for debugging purpose)
- Ability for capture/display real time traces.
- Amount of time that a PCT is able to capture traces information
- Ability to support PHY modes, bandwidths and bands not required for certification.
- Ability to edit/create new test cases scripts.
- Ability to allow user to remote compiling or editing of test cases.
- Ability to modularize the scenarios/test cases so that one message(structure or field) change does not require massive test case scripts change.
- Certification Waves supported
- Ability to run the test case in automatic batch mode without tester interaction (no manual interaction) Ability to pinpoint reason for test failures

3.1.1.5 Available Products

Table X.X gives a list of PCTs that are available for WiMAX measurements. The PCT is a tool that is validated by a 3rd party. To be listed below requires that the vendor passed this validation process.

Product	Company	Validation	URL
Astro8140	Invenova	Partial	
Astro8140e	Invenova	Pending	
MiNT T2230 AIME/CT; MiNT T2231 AIME/CT	AT4 WIRELESS / Aeroflex	Pending	http://www.at4wireless.com/web_eng/systems/test_solutions/mint/wimax

4. Network Tools

4.1 General

This section covers tools that encompass the network layer, where interconnects between BS, Access Networks, Core Networks, etc. are validated via IP protocols, mechanisms, etc.

5. Emulation Tools

5.1 General

This section covers tools that encompass multiple layers and emulate functions of a WiMAX BS, SS or network component

5.1.1 Multi-Station Emulator

(Placeholder for future test devices)

Appendix A - Past Presentations at WiMAX Forum F2Fs

A.1 General

This sections lists presentation names / products / contact names for test equipment that has been presented at a past WiMAX F2F. This gives forum members an easy way to keep track of past presentation topics / contacts vs. tracking this information down in the F2F archived presentations.

A.2 Previous Vendor Presentations at WiMAX Forum Meetings

Vendor	Date	Topic	Presenter
Agilent	7/15/05	802.16e VSA Status Update	Ken Voelker
Rohde & Schwarz	11/8/05	802.16e VSA Presentation	Ralph Gibbemeyer
Rohde & Schwarz	7/11/06	802.16e SMU Presentation	Jan Prochnow
Spirent	7/11/06	SR5500	Arashk Mahjoubi-Amine
Innowireless / WirelessLogix	8/22/06	SST	Larry Smith, Sungchan Choi, Johnny Koo
Anritsu	8/22/06	Signature, IQProducer	Daljeet Singh and Rod Martin
Sanjole	9/18/06	Wavejudge	John Loia
Agilent	10/17/06	MXA N9020A	Peter Cain, Phil Lorch
Elektrobit	10/17/06	Propsim	Juha Auer

Table 23: Previous Vendor Presentations