

Agilent X-Series Signal Analyzer

**This manual provides documentation for the
following analyzers:**

**MXA Signal Analyzer N9020A
EXA Signal Analyzer N9010A**

**N9074A - XFP Single
Acquisition Combined
Fixed WiMAX
Measurement Application
Measurement Guide**



Agilent Technologies

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<http://www.agilent.com/find/mxa>

<http://www.agilent.com/find/exa>

To receive the latest updates by email, subscribe to Agilent Email Updates:

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Information on preventing analyzer damage can be found at:

<http://www.agilent.com/find/tips>

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1

Making Single Acquisition Combined Fixed WiMAX Measurements

This chapter explains how to make combined fixed WiMAX measurements on a 802.16-2004 OFDM signal. Three measurement examples, including SCPI programming commands, are provided for measuring Transmit Power, Transmit Output Spectrum, and Modulation Accuracy of the fixed WiMAX signal.

What Does the Single Acquisition Combined Fixed WiMAX Measurement Application Do?

Single Acquisition Combined Fixed WiMAX adopts the concept of SAMM (Single Acquisition Multiple Measurements). It performs as many measurements as possible on one capture.

Combined Measurement is capture centered and a traditional measurement is measurement centered. In other words, in the combined measurements, all the measurements are based on one capture, there is no switch time among different measurements and in a traditional measurement, measurement controls the capture activity, the capture will restart when the measurement is changed.

The Combined Fixed WiMAX mode includes one measurement, Combined Fixed WiMAX. The following measurement results are presented by this measurement:

- Transmit Power
- Transmit Output Spectrum
- Modulation Accuracy

Measuring Combined Fixed WiMAX on Static Bursts

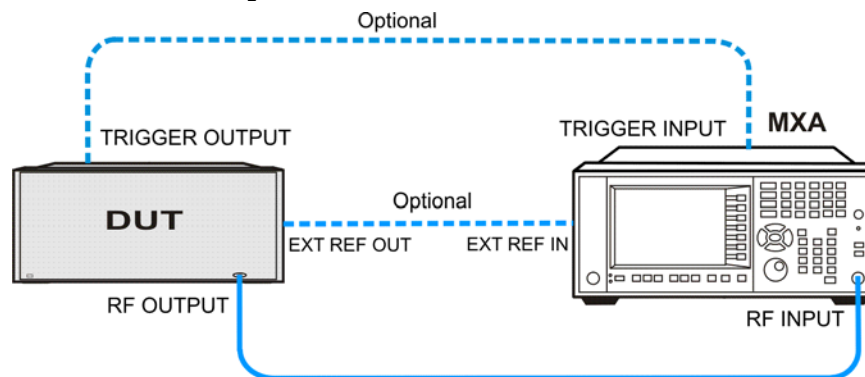
The following example details the measurement procedure and SCPI commands for measuring static bursts which have the same burst settings.

Configuring the Measurement System

Connect the RF OUTPUT of the DUT (Device Under Test) to the RF INPUT of the analyzer. MXA needs LAN or GPIB connection for SCPI control.

Figure 1-1

Measurement Setup



NOTE

If it is available, for time alignment, it is recommended to connect external reference output of the DUT to the external reference input of the analyzer and the trigger output of the DUT to the trigger input of the analyzer.

Measurement Example Signal Settings

Frequency: 1 GHz
Output Power: -7 dBm (at analyzer input)
Fixed WiMAX signal: 802.16d
Bandwidth: 7 MHz
Guard Interval: 1/4
Frame Duration: 2ms Downlink only (TDD)
Data length in the burst: 1.2ms

Measurement Procedure

NOTE

The primary UI for this measurement is SCPI commands. For the SCPI commands of different parameters and the detailed usage of each SCPI command, refer to *N9074A-XFP Single Acquisition Combined Fixed WiMAX Measurement Application User's and Programmer's Reference*.

Step 1. Set up the SCPI communications with the analyzer.

The GPIB or LAN can be used for remote control. The Agilent I/O Library Suite is recommended for connecting the Agilent instruments to the PC and using the instruments from a measurement program. For more detailed information, see the URL: <http://www.agilent.com/find/iolib>.

Step 2. Set the analyzer to the Single Acquisition Combined Fixed WiMAX mode and enable the measurements.

Table 1-1

SCPI Commands for Measuring Combined Fixed WiMAX on Static Bursts (4-1)

SCPI Commands	Notes
INST:SEL CWIMAXOFDM	Select Combined Fixed WiMAX mode.
*RST	*RST is preferred over :SYST:PRES for remote operation. *RST performs a Mode Preset as done by the :SYST:PRES command and it sets the measurement mode to Single measurement rather than Continuous for optimal remote control throughput.
CONF:CFW	Select Combined Fixed WiMAX measurement.
RAD:STAN:W16D:PROF B7M	Configure the system profile (bandwidth).
TRIG:SOUR RFB	Set the trigger type to be RF burst. The default trigger type is RF Burst.
TRIG:RFB:LEV:ABS -20dBm	Set the absolute trigger level.

Step 3. Setup the capture parameters:

Table 1-2

SCPI Commands for Measuring Combined Fixed WiMAX on Static Bursts (4-2)

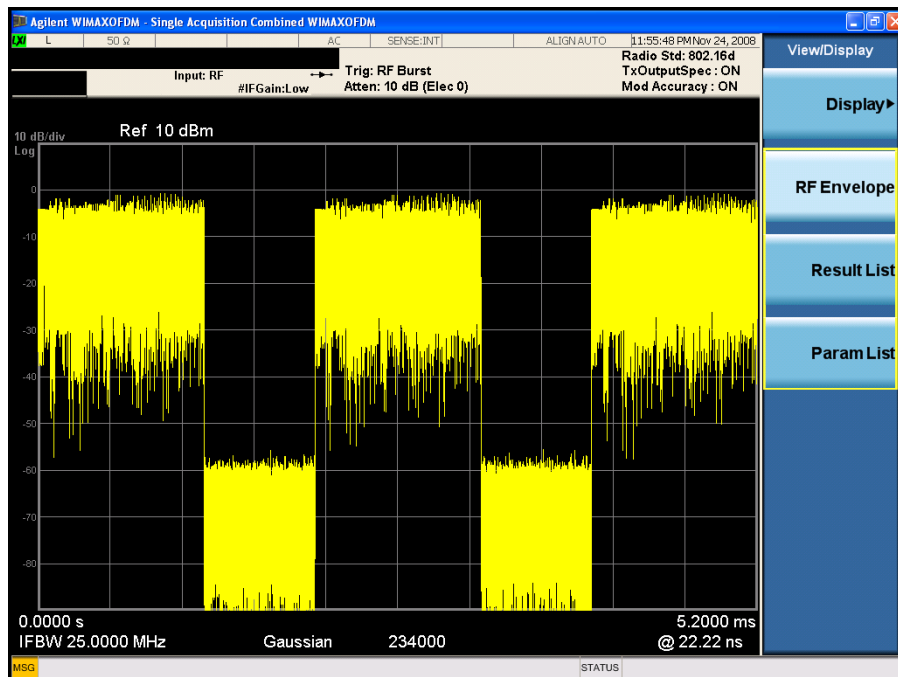
SCPI Commands	Notes
CFW:CAPT:BURS:TYPE STAT	Set the burst type to static.
CFW:CAPT:BURS:NUMB 3	Set the measured burst number.
CFW:CAPT:BURS:FREQ 1e9,1e9,1e9	Set the center frequency of the bursts.

Table 1-2 SCPI Commands for Measuring Combined Fixed WiMAX on Static Bursts (4-2)

SCPI Commands	Notes
CFW:CAPT:BURS:LOAD 0.0012,0.0012,0.0012	Set the time of the data which is captured and calculated for the results.
CFW:CAPT:BURS:PREF 0,0.0008,0.0008	Set the prefix of the burst.
CFW:CAPT:BURS:SUFF 0,0,0	Set the suffix of the burst. There is no suffix in static mode.
INIT:CONT ON	Turn on continuous sweep.
DISP:CFW:VIEW RFEN	Select the RF Envelope View to display the result of signal vs. time. The signal envelope can be checked at this time. Turning off the RF Envelope View during the measurement will produce faster results.

An example of RF Envelope View is shown in [Figure 1-2](#).

Figure 1-2 RF Envelope View for Combined Fixed WiMAX Measurement on Static Bursts



Step 4. Setup the measurement parameters:

Table 1-3 SCPI Commands for Measuring Combined Fixed WiMAX on Static Bursts (4-3)

SCPI Commands	Notes
CFW:TXP:BURS:STAR 1 CFW:TXP:BURS:STOP 3	Set the start and stop burst of transmit power measurement.
CFW:TOSP:BURS:STAR 1 CFW:TOSP:BURS:STOP 3 CFW:TOSP ON	Set the start and stop burst of transmit output spectrum measurement.
CFW:EVM:BURS:STAR 1 CFW:EVM:BURS:STOP 3 CFW:EVM:TIME:RES:LENG 20 CFW:EVM:TIME:RES:MAX 27 CFW:EVM:TIME:INT 20 CFW:EVM:TIME:SEAR 0.0012 CFW:EVM:GINT:RAT R1BY4 CFW:EVM ON	Set the start and stop burst of EVM measurement. Set the result length for the EVM. To determine how many symbols should be set here, refer to “ WiMAX Frequency and Time Parameter Table ” on page 47.
CFW:TXP:AVER ON	Turn on the transmit power average.
INIT:CONT ON	Turn on continuous sweep.
DISP:CFW:VIEW PAR	Select the Parameter List View.

NOTE

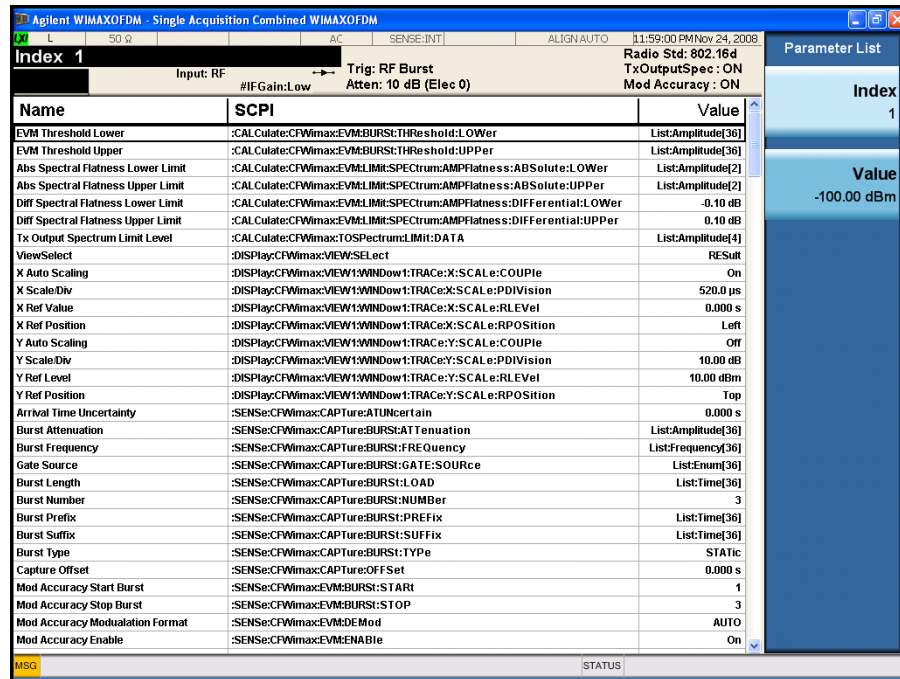
If the error message “Settings conflict: Burst 1 data length is not enough to do EVM measurement” appears, that means the length of burst interval is not enough to calculate the EVM. In this case, you need to enter a larger value.

An example of Parameter List View is shown in [Figure 1-3](#). You may set the parameters using SCPI or you can modify the value of each parameter by selecting the parameter then inputting the value using the mouse and front panel keys. Some parameters, such as Burst Length, that may be “List:Time[36]” in the column of Value, which means this parameter has a maximum of 36 values to set. In this case, enter the index value from 1 to 36.

Figure 1-3 Parameter List View for Combined Fixed WiMAX Measurement on Static

Making Single Acquisition Combined Fixed WiMAX Measurements
Measuring Combined Fixed WiMAX on Static Bursts

Bursts



Step 5. Read the results:

Table 1-4

SCPI Commands for Measuring Combined Fixed WiMAX on Static Bursts (4-4)

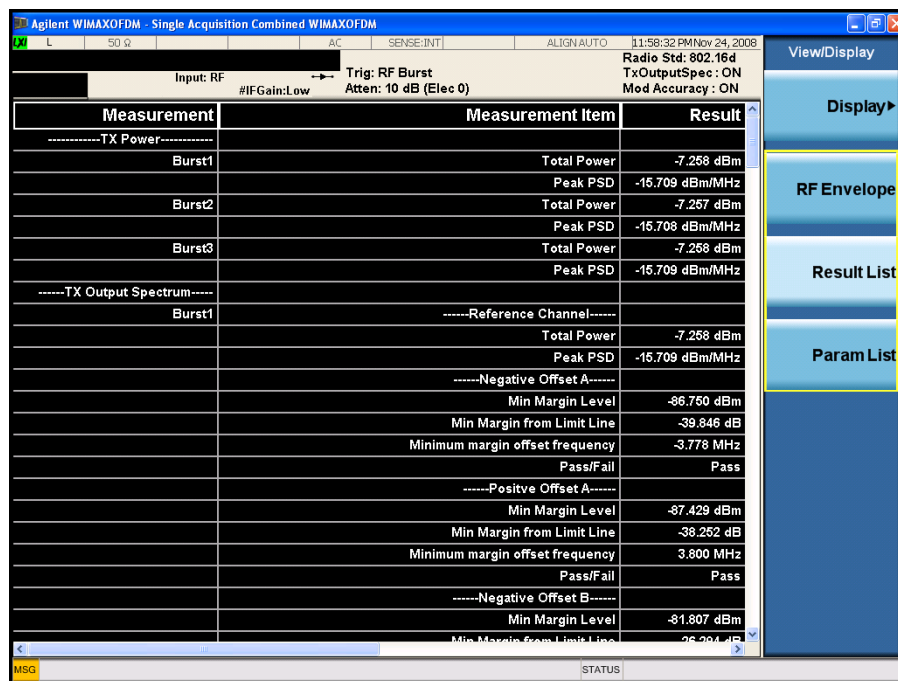
SCPI Commands	Notes
READ:CFW4?	After this command is sent to the analyzer, the transmit power results are returned. For more commands about reading the result, refer to <i>N9074A-XFP Combined Fixed WiMAX Measurement Application User's and Programmer's Reference</i> .
DISP:CFW:VIEW RES	The measurement result is shown in the Result List View.

An example of Result List View is shown below.

Making Single Acquisition Combined Fixed WiMAX Measurements
 Measuring Combined Fixed WiMAX on Static Bursts

Figure 1-4

Result List View for Combined Fixed WiMAX Measurement on Static Bursts



Measuring Combined Fixed WiMAX on Dynamic Bursts

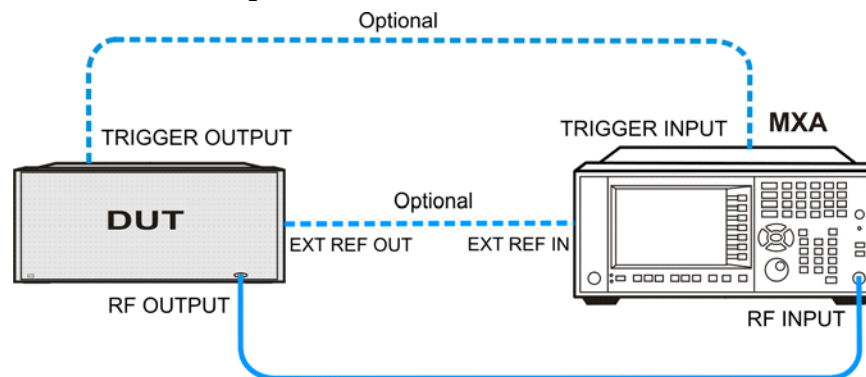
The following example details the measurement procedure and SCPI commands for measuring dynamic bursts which have different settings for each burst.

Configuring the Measurement System

Connect the RF OUTPUT of the DUT (Device Under Test) to the RF INPUT of the analyzer. MXA needs LAN or GPIB connection for SCPI control.

Figure 1-5

Measurement Setup



NOTE

If it is available, for time alignment, it is recommended to connect external reference output of the DUT to the external reference input of the analyzer and the trigger output of the DUT to the trigger input of the analyzer.

Measurement Example Signal Settings

Frequency: 1 GHz
Output Power: -7 dBm (at analyzer input)
Fixed WiMAX signal: 802.16d
Bandwidth: 20 MHz
Guard Interval: 1/16
Frame Duration: 2ms Downlink only (FDD)
Data length in the burst: 1ms

Measurement Procedure

NOTE

The primary UI for this measurement is SCPI commands. For the SCPI commands of different parameters and the detailed usage of each SCPI command, refer to *N9074A-XFP Single Acquisition Combined Fixed WiMAX Measurement Application User's and Programmer's Reference*.

Step 1. Set up the SCPI communications with the analyzer.

The GPIB or LAN can be used for remote control. The Agilent I/O Library Suite is recommended for connecting the Agilent instruments to PC and using the instruments from a measurement program without extra charge. The more detailed information, see the URL: <http://www.agilent.com/find/iolib>.

Step 2. Set the analyzer to the Combined Fixed WiMAX mode and enable the measurements:

Table 1-5

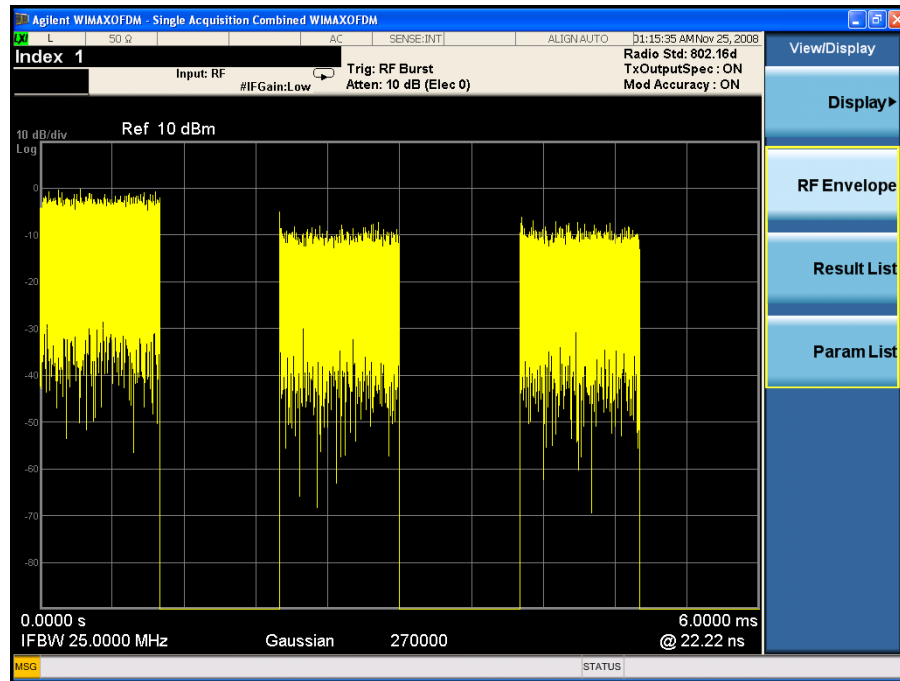
SCPI Commands for Measuring Combined Fixed WiMAX on Dynamic Bursts (4-1)

SCPI Commands	Notes
INST:SEL CWIMAX	Select Combined Fixed WiMAX mode.
*RST	*RST is preferred over :SYST:PRES for remote operation. *RST performs a Mode Preset as done by the :SYST:PRES command and it sets the measurement mode to Single measurement rather than Continuous for optimal remote control throughput.
CONF:CFW	Select Combined Fixed WiMAX measurement.
RAD:STAN W16D:PROF B20M	Configure the system profile (bandwidth).
TRIG:SOUR RFB	Set the trigger type to be RF burst. The default trigger type is RF Burst.
TRIG:RFB:LEV:ABS -20dBm	Set the absolute trigger level. The default trigger type is RF Burst.
CFW:CAPT:BURS:GATE:SOUR RFB,RFB,RFB	After using Gate Source, the SA will begin to capture the data of each burst when it detects the rising side of it.
DISP:CFW:VIEW RFEN	Select the RF Envelope View to display the result of signal vs. time. You can check the signal envelope at this time. In order to obtain more speed, you can turn off the RF Envelope View during the measurement.

An example of RF Envelope View is shown in [Figure 1-6](#):

Figure 1-6

RF Envelope View for Combined Fixed WiMAX Measurement on Dynamic Bursts



Step 3. Setup the capture parameters:

Table 1-6

SCPI Commands for Measuring Combined Fixed WiMAX on Dynamic Bursts (4-2)

SCPI Commands	Notes
CFW:CAPT:BURS:TYPE DYN	Set the burst type to dynamic.
CFW:CAPT:BURS:NUMB 3	Set the measured burst number.
CFW:CAPT:BURS:FREQ 1e9,9.8e8,1.02e9	Set the center frequency of the bursts. Three bursts are needed to measure the transmit output spectrum when the system profile (signal bandwidth) is above 7 MHz. For how to configure the frequency, please refer to the “TX output spectrum configuration guideline” on page 41.
CFW:CAPT:BURS:LOAD 0.001,0.001,0.001	Set the time of the data which is captured and calculated for the results.
CFW:CAPT:BURS:PREF 0,0,0	Set the prefix of the burst.
CFW:CAPT:BURS:SUFF 0.001,0.001,0.001	Set the suffix of the burst.
CFW:METH ACC	Set the measure method to be best accuracy.
INIT:CONT ON	Turn on continuous sweep.

Table 1-6 SCPI Commands for Measuring Combined Fixed WiMAX on Dynamic Bursts (4-2)

SCPI Commands	Notes
DISP:CFW:VIEW PAR	Select the Parameter List View.

Step 4. Setup the measurement parameters:

Table 1-7 SCPI Commands for Measuring Combined Fixed WiMAX on Dynamic Bursts (4-3)

SCPI Commands	Notes
CFW:TXP:BURS:STAR 1 CFW:TXP:BURS:STOP 1	Set the start and stop burst of transmit power measurement.
CFW:TOSP:BURS:STAR 1 CFW:TOSP:BURS:STOP 3 CFW:TOSP ON	Set the start and stop burst of transmit output spectrum measurement. Bursts in triple groups are used in calculating the whole range of output spectrum.
CFW:EVM:BURS:STAR 1 CFW:EVM:BURS:STOP 1 CFW:EVM:TIME:RES:LENG 50 CFW:EVM:TIME:RES:MAX 50 CFW:EVM:TIME:INT 50 CFW:EVM:TIME:SEAR 0.001 CFW:EVM:GINT:RAT R1BY16 CFW:EVM ON	Set the start and stop burst of EVM measurement. Set the result length for the EVM. To determine how many symbols should be set here, refer to “WiMAX Frequency and Time Parameter Table” on page 47.
CFW:TXP:AVER ON	Turn on the transmit power average.
INIT:CONT ON	Turn on continuous sweep.
DISP:CFW:VIEW PAR	Select the Parameter List View.

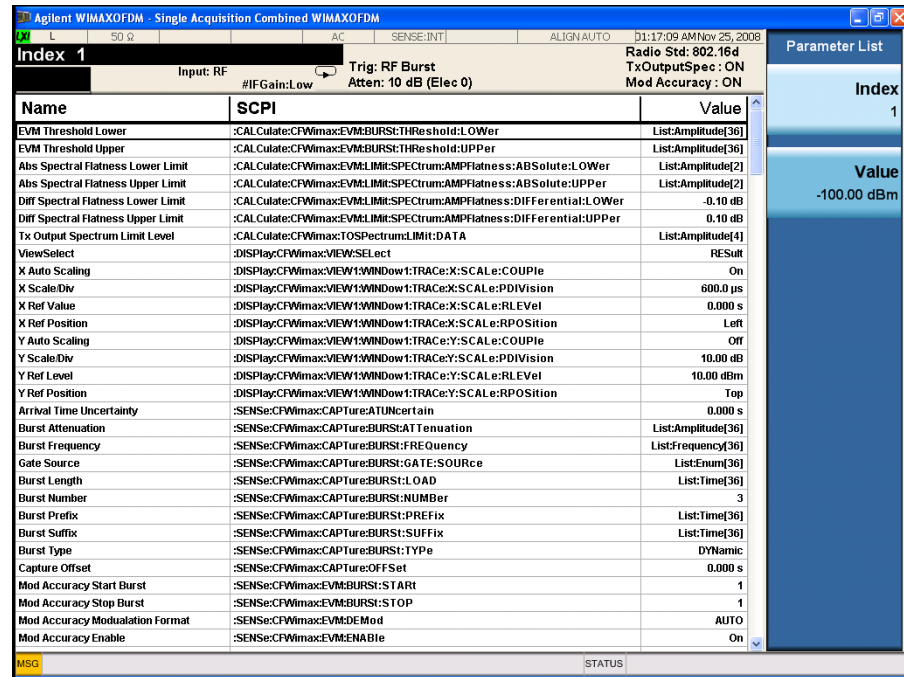
NOTE If the error message “Settings conflict: Burst 1 data length is not enough to do EVM measurement” appears, that means the length of burst interval is not enough to calculate the EVM. In this case, you need to enter a larger value.

An example of Parameter List View is shown in [Figure 1-7](#). You may set the parameters using SCPI or you can modify the value of each parameter by selecting the parameter then inputting the value using the mouse and front panel keys. Some parameters, such as Burst Length, that may be “List:Time[36]” in the column of Value, which means this parameter has a maximum of 36 values to set. In this case, enter the index value from 1 to 36.

Figure 1-7 Parameter List View for Combined Fixed WiMAX Measurement on Dynamic

Making Single Acquisition Combined Fixed WiMAX Measurements Measuring Combined Fixed WiMAX on Dynamic Bursts

Bursts



Step 5. Read the results:

Table 1-8

SCPI Commands for Measuring Combined Fixed WiMAX on Dynamic Bursts (4-4)

SCPI Commands	Notes
READ:CFW4?	After this command is sent to the analyzer, the transmit power results are returned. For more commands about reading the result, refer to <i>N9074A-XFP Combined Fixed WiMAX Measurement Application User's and Programmer's Reference</i> .
DISP:CFW:VIEW RES	the measurement results are shown in the Result List View.

An example of Result List view is shown in [Figure 1-8](#).

Figure 1-8

Result List View for Combined Fixed WiMAX Measurement on Dynamic

Making Single Acquisition Combined Fixed WiMAX Measurements Measuring Combined Fixed WiMAX on Dynamic Bursts

Bursts

Measurement	Measurement Item	Result
-----TX Power-----		
Burst1	Total Power	-7.437 dBm
	Peak PSD	-20.447 dBm/MHz
-----TX Output Spectrum-----		
Burst1	-----Reference Channel-----	
	Total Power	-999.000 dBm
	Peak PSD	-999.000 dBm/MHz
	-----Negative Offset A-----	
	Min Margin Level	-999.000 dBm
	Min Margin from Limit Line	-999.000 dB
	Minimum margin offset frequency	-999 Hz
	Pass/Fail	Not Tested
	-----Positive Offset A-----	
	Min Margin Level	-999.000 dBm
	Min Margin from Limit Line	-999.000 dB
	Minimum margin offset frequency	-999 Hz
	Pass/Fail	Not Tested
	-----Negative Offset B-----	
	Min Margin Level	-999.000 dBm
	Min Margin from Limit Line	-999.000 dB
	Minimum margin offset frequency	-999 Hz
	Pass/Fail	Not Tested
	-----Positive Offset B-----	
	Min Margin Level	-999.000 dBm

NOTE

In this case, if you set the start burst to 1 and stop burst to 3 for EVM measurement, the test result will be shown in Burst3. -999, or Not Tested is shown for Burst1 and Burst2.

Measuring Modulation Accuracy on Frequency Hopping Signal

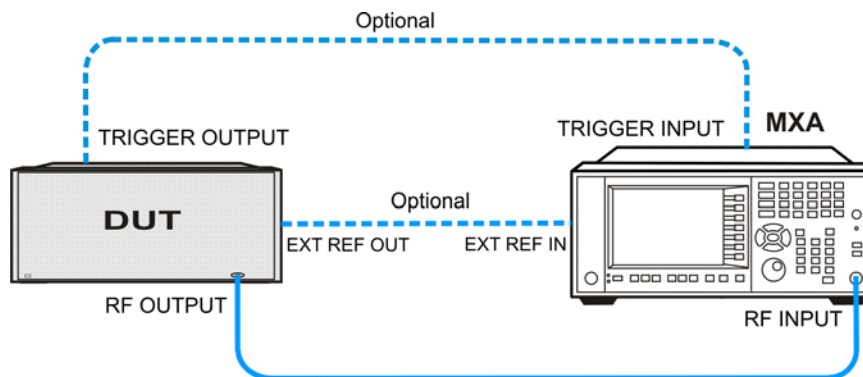
The following example details the measurement procedure and SCPI commands for measuring modulation accuracy on frequency hopping signal.

Configuring the Measurement System

Connect the source RF OUTPUT of the DUT (Device Under Test) to the analyzer RF INPUT as shown in Figure 1-9. MXA needs LAN or GPIB connection for SCPI control.

Figure 1-9

Measurement Setup



NOTE

If it is available, for time alignment, it is recommended to connect external reference output of the DUT to the external reference input of the analyzer and the trigger output of the DUT to the trigger input of the analyzer.

Measurement Example Signal Settings

Frequency: 1 GHz and 1.02 GHz

Output Power: -13 dBm (at analyzer input)

Fixed WiMAX signal: 802.16d

Bandwidth: 7 MHz

Guard Interval: 1/4

Frame Duration: 2ms Downlink only (TDD)

Data length in the burst: 1.2ms

Measurement Procedure

NOTE

The primary UI for this measurement is SCPI commands. For the SCPI commands with different parameters and the detailed usage of each SCPI command, please refer to *N9077A-XFP Combined WLAN Measurement Application User's and Programmer's Reference*.

Step 1. Set up the SCPI communication with the analyzer.

The GPIB or LAN can be used for remote control. The Agilent I/O Library Suite is recommended for connecting the Agilent instruments to PC and using the instruments from a measurement program without extra charge. The more detailed information, see the URL: <http://www.agilent.com/find/iolib>.

Step 2. Set the analyzer to the Combined Fixed WiMAX mode and enable the Combined Fixed WiMAX measurement:

Table 1-9

SCPI Commands for Modulation Accuracy Measurement on Frequency Hopping Signal (4-1)

SCPI Commands	Notes
INST:SEL CWIMAXOFDM	Select Combined Fixed WiMAX mode.
*RST	*RST is preferred over :SYST:PRES for remote operation. *RST performs a Mode Preset as done by the :SYST:PRES command and it sets the measurement mode to Single measurement rather than Continuous for optimal remote control throughput.
CONF:CFW	Select Combined Fixed WiMAX measurement.
RAD:STAN:W16D:PROF B7M	Configure the system profile (bandwidth).
CFW:TRIG:SOUR RFB TRIG:RFB:LEV:TYPE ABS TRIG:RFB:LEB:ABS -35dBm TRIG:DEL 0	Set up the trigger.

Step 3. Setup the capture parameters:

Table 1-10

SCPI Commands for Modulation Accuracy Measurement on Frequency Hopping Signal (4-2)

SCPI Commands	Notes
CFW:CAPT:BURS:NUMB 2	Set the measured Burst Number.
CFW:CAPT:BURS:TYPE DYN	Set the burst type to Dynamic.

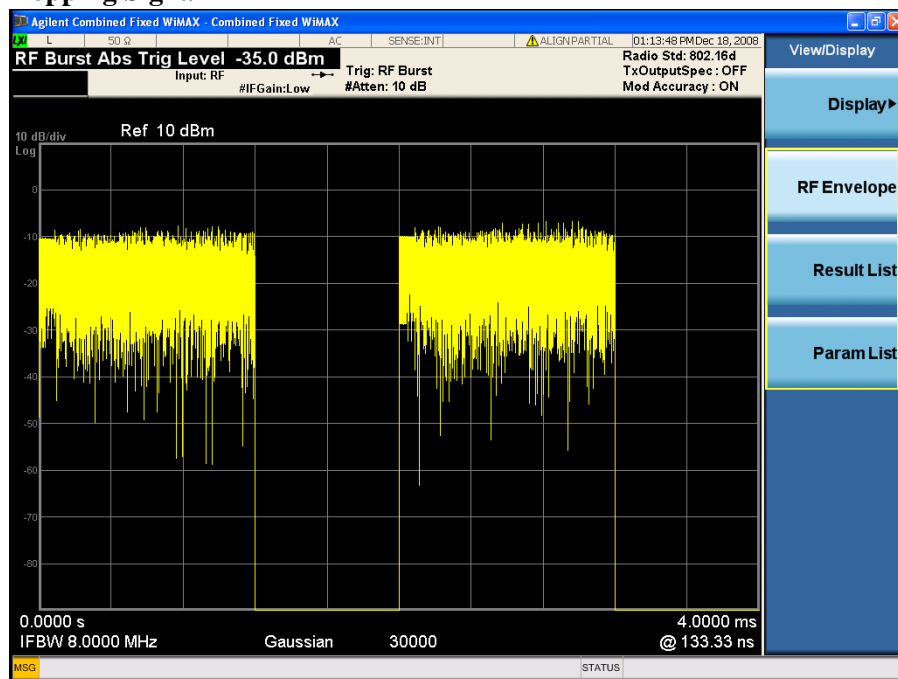
Table 1-10 SCPI Commands for Modulation Accuracy Measurement on Frequency Hopping Signal (4-2)

SCPI Commands	Notes
CFW:CAPT:OFFS 0	Set the Capture Offset.
CFW:METH ACC	Select the measurement method to be Accuracy.
CFW:CAPT:BURS:FREQ 1GHz,1.02GHz	Set the center frequency of the two bursts.
CFW:CAPT:BURS:ATT 0,0	Set the Burst Attenuation.
CFW:CAPT:BURS:LOAD 0.0012,0.0012us	Set the data time of the target burst which is captured and calculated.
CFW:CAPT:BURS:PREF 0,0	Set the prefix of the burst. The prefix needs to be set as zero for modulation accuracy test.
CFW:CAPT:BURS:SUFF 0.00080,0.0008us	Set the suffix of the burst.
CFW:CAPT:BURS:GATE:SOUR RFB,RFB	Set Gate Source for each burst.
INIT:IMM	Resume a sweep.
DISP:CWL:VIEW RFEN	Select the RF Envelope View to display the result of signal vs. time. You can check the signal envelope at this time.

The example of the RF Envelop View is shown below:

Figure 1-10 RF Envelope View for Modulation Accuracy Measurement on Frequency

Hopping Signal



Step 4. Turn on the measurements:

Table 1-11

SCPI Commands for Modulation Accuracy Measurement on Frequency Hopping Signal (4-3)

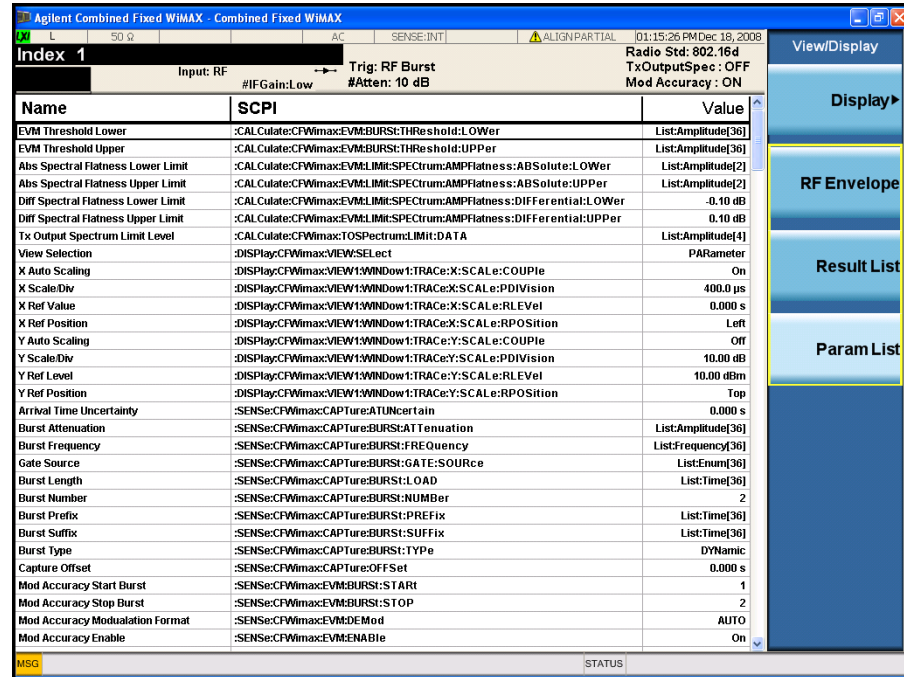
SCPI Commands	Notes
CFW:TXP:BURS:STAR 1 CFW:TXP:BURS:STAR 2	Set the start and stop burst of transmit power measurement.
CFW:EVM:BURS:STAR 1 CFW:EVM:BURS:STOP 2 CFW:EVM:TIME:RES:LENG 10 CFW:EVM:TIME:RES:MAX 25 CFW:EVM:TIME:RES INT 10 CFW:EVM:TIME:SEAR 0.0012 CFW:EVM:TIME:OFFS 0 CFW:EVM:GINT:RAT R1BY4 CFW:EVM ON	Set the start and stop burst of EVM measurement. Set the result length for the EVM. To determine how many symbols should be set here, refer to “WiMAX Frequency and Time Parameter Table” on “WiMAX Frequency and Time Parameter Table” on page 47
INIT:CONT ON	Turn on continuous sweep.
DISP:CWL:VIEW PAR	Select the Parameter List View.

An example of Parameter List View is shown in Figure 1-11. You may set the parameters using SCPI or you can modify the value of each parameter by selecting

the parameter then inputting the value using the mouse and front panel keys. Some parameters, such as Burst Length, that may be “List:Time[36]” in the column of Value, which means this parameter has a maximum of 36 values to set. In this case, enter the index value from 1 to 36.

Figure 1-11

Parameter List View for Modulation Accuracy Measurement on Frequency Hopping Signal



Step 5. Read the results:

Table 1-12

SCPI Commands for Modulation Accuracy Measurement on Frequency Hopping Signal (4-4)

SCPI Commands	Notes
READ:CFW4?	This command is used to see the transmit power results. For more commands on read the result, refer to <i>N9074A-XFP Signal Acquisition Combined Fixed WiMAX Measurement Application User's and Programmer's Reference</i> .
DISP:CFW:VIEW RES	The transmit power measurement results are available in the Result List View.

The Result List View is shown below:

Figure 1-12

Result List View for Transmit Power Measurement on Frequency Hopping

Making Single Acquisition Combined Fixed WiMAX Measurements Measuring Modulation Accuracy on Frequency Hopping Signal

Signal

The screenshot shows the Agilent software interface for a WiMAX signal measurement. The main window displays a table of measurement results. The table has three columns: Measurement, Measurement Item, and Result. The measurements are grouped into sections: TX Power, Mod Accuracy, and another section for Burst2. The right-hand side of the interface has a navigation pane with buttons for View/Display, Display, RF Envelope, Result List, and Param List. The bottom status bar shows MSG and STATUS.

Measurement	Measurement Item	Result
-----TX Power-----		
Burst1	Total Power	-13.414 dBm
	Peak PSD	-21.865 dBm/MHz
Burst2	Total Power	-12.990 dBm
	Peak PSD	-21.441 dBm/MHz
-----Mod Accuracy-----		
Burst1	Frequency Error	0.461 Hz
	Symbol Error	0.147 ppm
	RMS EVM in dB	-42.599 dB
	RMS EVM in percent	0.741 %
	I/Q Offset	-45.749 dB
	Abs Spectrum Flatness Min Margin	-1.917 dB
	Abs Spectrum Flatness Min Margin Level	0.083 dBc
	Abs Spectrum Flatness Min Margin Index	-70
	Abs Spectrum Flatness Min Margin Pass/Fail	Pass
	Diff Spectrum Flatness Min Margin	-0.042 dB
	Diff Spectrum Flatness Min Margin Level	0.058 dB
	Diff Spectrum Flatness Min Margin Index	-48
	Diff Spectrum Flatness Min Margin Pass/Fail	Pass
Burst2	Frequency Error	1.552 Hz
	Symbol Error	0.033 ppm
	RMS EVM in dB	-48.254 dB
	RMS EVM in percent	0.387 %
	I/Q Offset	-59.028 dB

This chapter describes the concepts and theory of 802.16-2004 OFDM signals and explains how Combined Fixed WiMAX measurements are performed by the instrument. Suggestions for optimizing and troubleshooting your setup are provided, along with a list of related Agilent documents that are referenced for further information.

Introduction

This chapter introduces concepts of 802.16-2004 OFDM and Combined Fixed WiMAX measurement to better relate the features and attributes of MXA/EXA Series Spectrum Analyzer option N9074A - XFP.

- “802.16-2004 Standard” on page 29
- “Frame Structure” on page 30
- “Modulation Types” on page 32
- “Orthogonal Frequency Division Multiplexing (OFDM) Concepts” on page 38
- “Combined Fixed WiMAX Measurement Concepts” on page 40
- “Other Sources of Measurement Information” on page 48.
- “References” on page 49

802.16-2004 Standard

The IEEE 802.16-2004 standard, often referred to as WiMAX, defines the physical layer (PHY) and medium access control (MAC) protocol for products that extend broadband wireless access (BWA) from the local area network (LAN) to the metropolitan area network (MAN). The standard contains specifications for licensed and unlicensed BWA operating between 2 and 11 GHz. Initially, licensed operation will cover the frequency ranges from 2.5 to 2.69 GHz and 3.4 to 3.6 GHz and unlicensed operation will use 5.725 to 5.850 GHz. In order to address the international wireless market and regional spectrum regulations, the WiMAX standard includes varying channel bandwidths. The channel bandwidths are selectable from 1.25 to 20 MHz.

The need for inexpensive and flexible commercial deployment of this technology has driven the requirement for multiple user access under non-line-of-sight (NLOS) operation and over distances up to 30 km. The 802.16 specifications define three different PHYs optimized for different wireless operation and conditions. These include a single-carrier modulation, a 256-carrier Orthogonal Frequency Division Multiplexing (OFDM) format and a 2048-carrier OFDM format. The current industry focus is on the 256-carrier OFDM format.

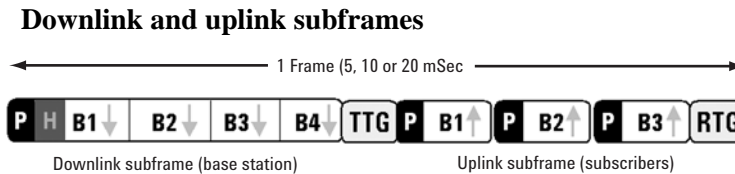
Frame Structure

A WiMAX frame consists of a downlink (DL) subframe (subframes are generally RF bursts) and an uplink (UL) subframe.

WiMAX systems can be deployed as TDD, FDD, or half-duplex FDD. The TDD frame consists of one DL subframe followed by one or multiple UL subframes. There are currently seven supported frame durations in the IEEE 802.16-2004 standard ranging from 2.5 to 20 ms. The flexible frame structure of the TDD signal consists of an adaptive boundary between the DL and UL subframes. A short transition gap is placed between the DL and UL subframes and is called the transmit/receive transition gap (TTG). After the completion of the UL subframes, another short gap is added between this subframe and the next DL subframe. This gap is called the receiver/transmit transition gap (RTG). The time durations of the transition gaps are called out in the 802.16 standard and are a function of the channel bandwidth and the OFDM symbol time.

Figure 2-1 shows a typical frame in a TDD configuration where the base station and subscriber equipment each transmit on the same RF frequency, separated in time.

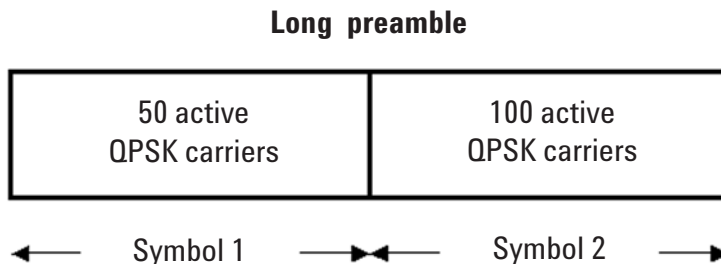
Figure 2-1



Notice that each uplink subframe is preceded by a preamble. This is called a “short preamble” and allows the base station to synchronize on each individual subscriber.

Looking closer at the downlink, a downlink subframe always begins with a preamble, followed by a header, and one or more downlink bursts of data. These downlink bursts are generally made up of multiple symbols within the burst. Within each burst, the modulation type is constant; however, from burst to burst the modulation type can change. Bursts using robust modulation types such as BPSK and QPSK are required to be transmitted first, followed by less robust modulation types (16 and 64 QAM). Downlink subframes containing all four types of modulation would need to be in this order: BPSK followed by QPSK, 16 QAM, and finally 64 QAM.

Figure 2-2 Long preamble



Every transmission on both the uplink and downlink always begins with a preamble. This preamble allows receivers to synchronize with the transmitter and is used for channel estimation. The downlink transmission begins with a long preamble. The long preamble (Figure 3) is made up of two symbols of QPSK modulation. The first symbol uses 50 of the available 200 carriers (every 4th subcarrier) and the second symbol uses 100 of the 200 carriers (all the even numbered subcarriers). These preamble symbols are transmitted with 3 dB more power than all other symbols in the downlink subframe, making them easier for the receivers to demodulate and decode correctly. A “short preamble” is used at the beginning of each uplink bursts. The short preamble is a single symbol of 100 QPSK carriers (all the even numbered subcarriers). When using extremely long downlink bursts that contain many symbols, it may be desirable to insert a midamble (short preamble) in between the downlink bursts. This short preamble helps receivers resynchronize and perform additional channel estimation.

Following the preamble is a frame control header (FCH). This FCH is implemented as a single symbol of BPSK modulation. This symbol contains 88 bits of overhead data that describes critical system information such as base station ID and the downlink burst profile that receivers need to decode the subframe. The FCH does not contain enough information to fully describe the network or downlink profile, but it does contain enough that receivers can start decoding the downlink bursts.

The downlink bursts contain user data as well as control messages. The downlink bursts each contain one or more symbols. Each symbol in the burst contains between 12 and 108 bytes of payload data, depending on the modulation type and coding gain. Table 1 shows the seven different combinations of modulation type and coding gain. For each of these combinations a specific amount of payload data is required for each symbol.

Modulation Types

The IEEE 802.16-2004 standard defines a set of adaptive modulation and coding rate configurations that can be used to trade off data rate for system robustness under various wireless propagation and interference conditions. When the radio link quality is good, the WiMAX system can use a higher-order modulation scheme (more bits/symbol) that will result in more system capacity. When link conditions are poor due to problems such as signal fading or interference, the WiMAX system can change to a lower modulation scheme to maintain an acceptable radio link margin. The allowed modulation types are binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16 quadrature amplitude modulation (16QAM) and 64QAM.

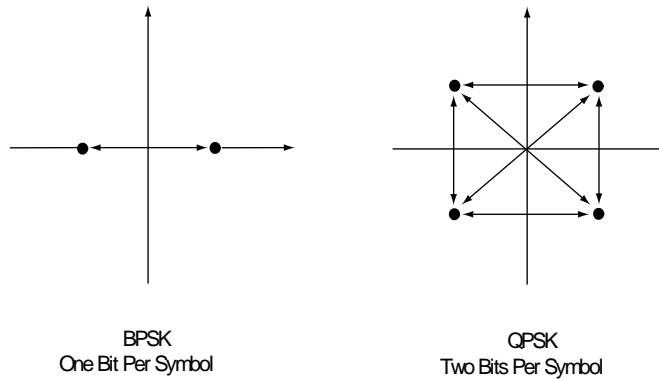
- [“Phase Shift Keying \(PSK\) Concepts” on page 32](#)
- [“Quadrature Amplitude Modulation \(QAM\) Concepts” on page 35](#)

Phase Shift Keying (PSK) Concepts

One of the simplest forms of digital modulation is Binary or Bi-Phase Shift Keying (BPSK). One application where this is used is for deep space telemetry. The phase of a constant amplitude carrier signal moves between zero and 180 degrees. On an I/Q diagram, the I state has two different values. There are two possible locations in the constellation diagram, so a binary one or zero can be sent. The bit rate is one bit per symbol.

A more common type of phase modulation is Quadrature Phase Shift Keying (QPSK). It is used extensively in applications including CDMA (Code Division Multiple Access) cellular service, wireless local loop, and DVB-S (Digital Video Broadcasting — Satellite). Quadrature means that the signal shifts between phase states which are separated by 90 degrees. The signal shifts in increments of 90 degrees from 45 to 135, -45, or -135 degrees. These points are chosen as they can be easily implemented using an I/Q modulator. Only two I values and two Q values are needed and this gives two bits per symbol. There are four states because $2^2 = 4$. It is therefore a more bandwidth-efficient type of modulation than BPSK, potentially twice as efficient.

Figure 2-3 Phase Shift Keying (PSK)

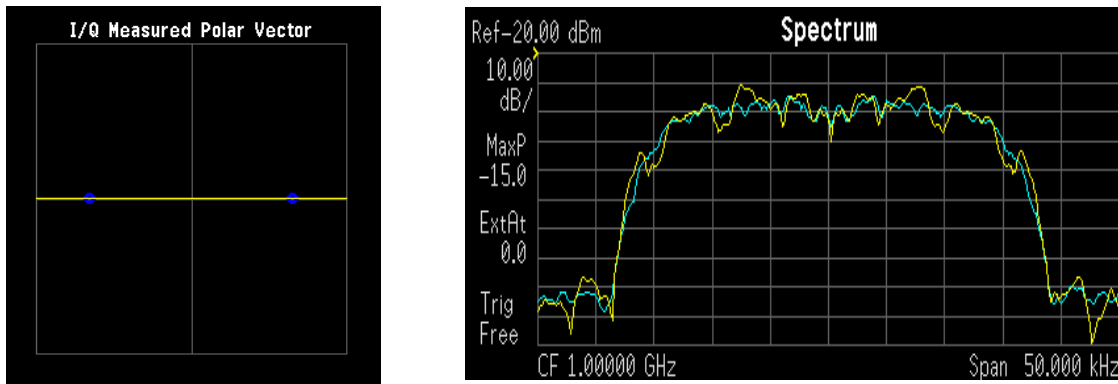


For more information on other types of PSK, see

- [“BPSK Modulation Characteristics” on page 33](#)
- [“QPSK Modulation Characteristics” on page 34](#)
- [“DQPSK Modulation Characteristics” on page 35](#)

BPSK Modulation Characteristics

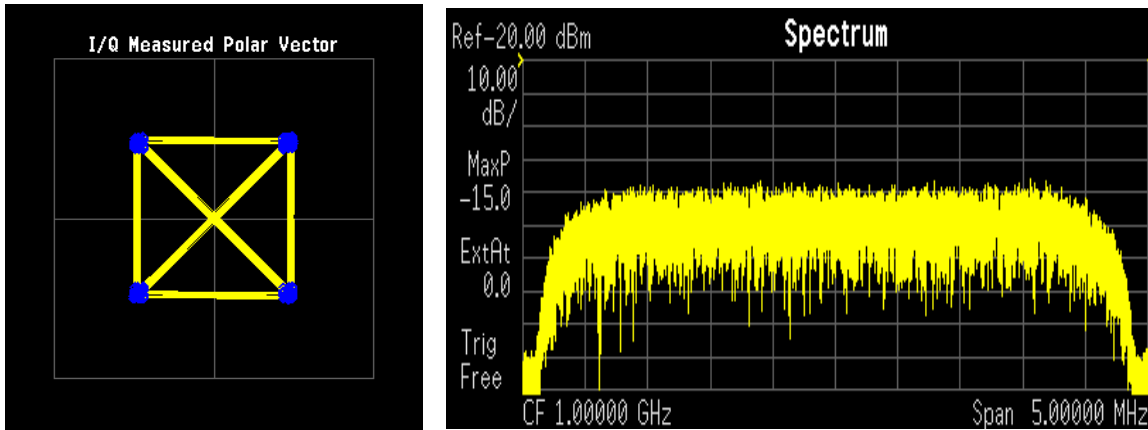
Figure 2-4 BPSK Constellation and Spectrum View



LEFT: BPSK constellation
RIGHT: BPSK spectrum center freq 1 GHz

QPSK Modulation Characteristics

Figure 2-5 QPSK Constellation and Spectrum View



LEFT: QPSK constellation
RIGHT: QPSK spectrum center freq 1 GHz

Differential Modulation Concepts

A variation of standard PSK is differential modulation as used in differential QPSK (DQPSK). Differential means that the information is not carried by the absolute state, it is carried by the transition between states. In some cases there are also restrictions on allowable transitions. This occurs in $\pi/4$ DQPSK where the carrier trajectory does not go through the origin. A DQPSK transmission system can transition from any symbol position to any other symbol position. The $\pi/4$ DQPSK modulation format is widely used in many applications including

CELLULAR

- NADC- IS-54 (North American digital cellular)
- PDC (Pacific Digital Cellular)

CORDLESS

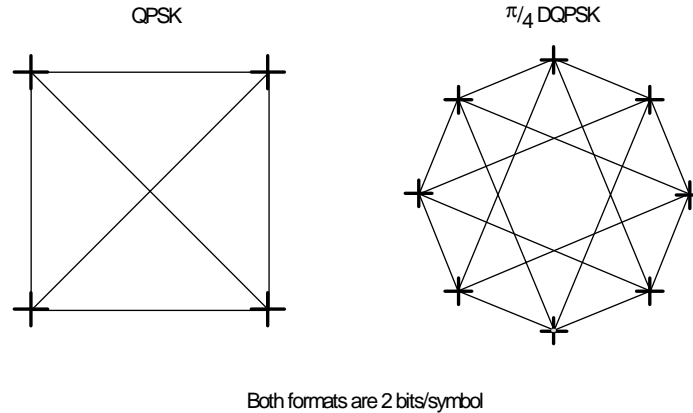
- PHS (personal handyphone system)

TRUNKED RADIO

- TETRA (Trans European Trunked Radio)

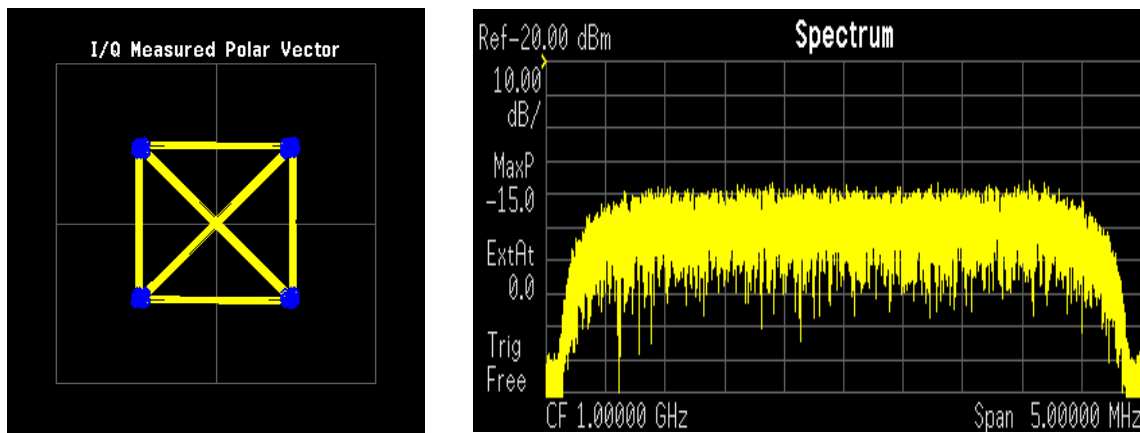
The $\pi/4$ DQPSK modulation format uses two QPSK constellations offset by 45 degrees ($\pi/4$ radians). Transitions must occur from one constellation to the other. This guarantees that there is always a change in phase at each symbol, making clock recovery easier. The data is encoded in the magnitude and direction of the phase shift, not in the absolute position on the constellation. One advantage of $\pi/4$ DQPSK is that the signal trajectory does not pass through the origin, thus simplifying transmitter design. Another is that $\pi/4$ DQPSK, with root raised cosine filtering, has better spectral efficiency than GMSK, the other common cellular modulation type.

Figure 2-6 Differential Modulation



DQPSK Modulation Characteristics

Figure 2-7 DQPSK Constellation and Spectrum View



LEFT: DQPSK constellation
RIGHT: DQPSK spectrum center freq 1 GHz

Quadrature Amplitude Modulation (QAM) Concepts

Quadrature Amplitude Modulation (QAM) is used in applications including microwave digital radio, DVB-C (Digital Video Broadcasting—Cable), and modems.

16 QAM

In 16-state quadrature amplitude modulation (16QAM), there are four I values and four Q values. This results in a total of 16 possible states for the signal. It can transition from any state to any other state at every symbol time. Since $16 = 2^4$ four bits per symbol can be sent. This consists of two bits for I, and two bits for Q. The

Concepts
Modulation Types

symbol rate is one fourth of the bit rate. So this modulation format produces a more spectrally efficient transmission. It is more efficient than BPSK, QPSK, or 8PSK.

QPSK is practically the same as 4QAM.

32 QAM

Another variation of QAM is 32QAM. In this case there are six I values and six Q values resulting in a total of 36 possible states ($6 \times 6 = 36$). This number is too many states for a power of two (the closest power of two is 32). So the four corner symbol states, which take the most power to transmit, are omitted. This reduces the amount of peak power the transmitter has to generate. Since $2^5 = 32$, there are five bits per symbol and the symbol rate is one fifth of the bit rate.

The current practical limits for broadcast transmission of QAM signals are approximately 256QAM, though work is underway to extend the limits to 512 or 1024 QAM. High state QAM formats are better suited to cable delivery where the noise is lessened.

A 256QAM system uses 16 I-values and 16 Q-values, giving 256 possible states. Since $2^8 = 256$, each symbol can represent eight bits. A 256QAM signal that can send eight bits per symbol is very spectrally efficient. However, for a given maximum power, the symbols are closer together than lower-valued QAM's and are thus more subject to errors due to noise and distortion. Such a signal may have to be transmitted with extra power (to effectively spread the symbols out more) and this reduces power efficiency as compared to simpler schemes.

Figure 2-8

Quadrature Amplitude Modulation

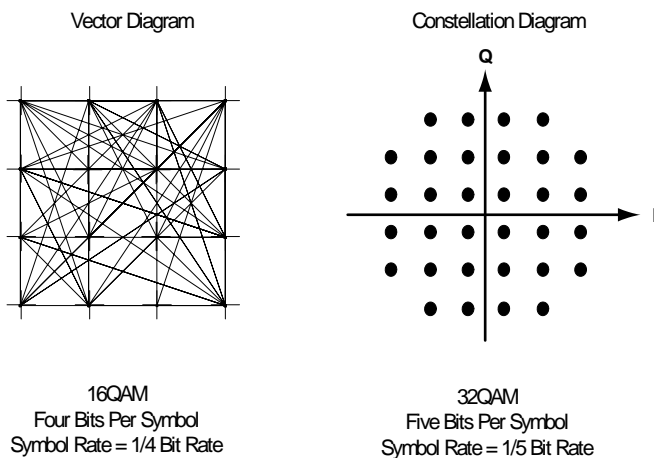


Fig. 14

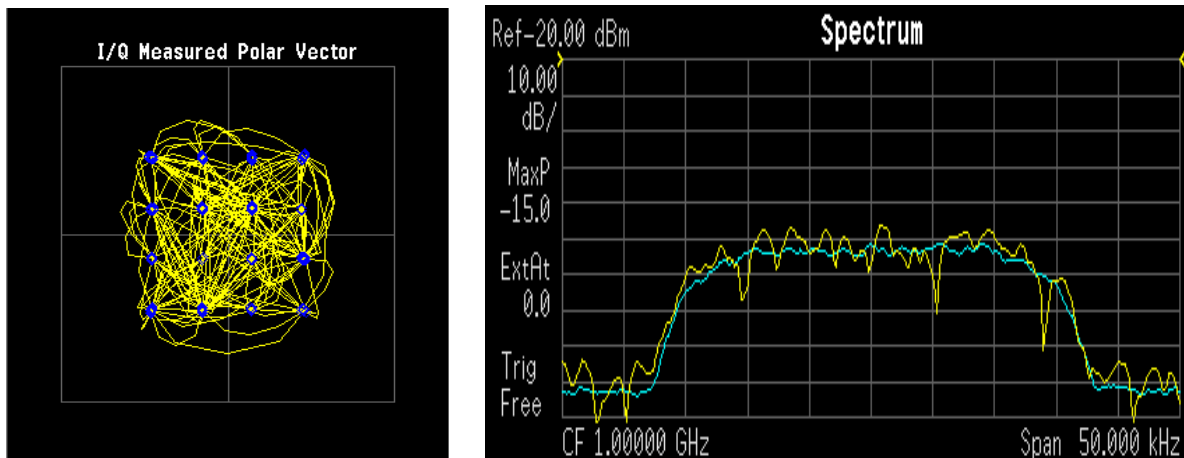
However, bandwidth efficiency is better for higher QAM's. For example, BPSK uses 80 Ksymbols-per-second sending 1 bit per symbol. A system using 256QAM sends eight bits per symbol so the symbol rate would be 10 Ksymbols per second. A 256QAM system enables the same amount of information to be sent as BPSK

using only one eighth of the bandwidth. It is eight times more bandwidth efficient. However, there is a trade-off. The radio becomes more complex and is more susceptible to errors caused by noise and distortion. Error rates of higher-order QAM systems such as this degrade more rapidly than QPSK as noise or interference is introduced. A measure of this degradation would be a higher bit error rate (BER).

In any digital modulation system, if the input signal is distorted or severely attenuated the receiver will eventually lose symbol lock completely. If the receiver can no longer recover the symbol clock, it cannot demodulate the signal or recover any information. With less degradation, the symbol clock can be recovered, but it is noisy, and the symbol locations themselves are noisy. In some cases, a symbol will fall far enough away from its intended position that it will cross over to an adjacent position. The I and Q level detectors used in the demodulator would misinterpret such a symbol as being in the wrong location, causing bit errors. QPSK is not as efficient, but the states are much farther apart for a given power and the system can tolerate a lot more noise before suffering symbol errors. QPSK has no intermediate states between the four corner-symbol locations, so there is less opportunity for the demodulator to misinterpret symbols. QPSK requires less transmitter power than QAM to achieve the same bit error rate.

QAM Modulation Characteristics

Figure 2-9 16 QAM Constellation and Spectrum View



LEFT: 16 QAM constellation
RIGHT: 16 QAM spectrum center freq 1 GHz

Orthogonal Frequency Division Multiplexing (OFDM) Concepts

The WiMAX specifications for the 256-carrier OFDM PHY define three types of subcarriers; data, pilot, and null. Two hundred carriers are used for data and pilot subcarriers. Eight pilot subcarriers are permanently spaced throughout the OFDM spectrum. Data subcarriers take up the remaining 192 active carriers. The remaining 56 potential carriers are nulled and set aside for guard bands and removal of the center frequency subcarrier.

Figure 2-10

OFDM subcarriers

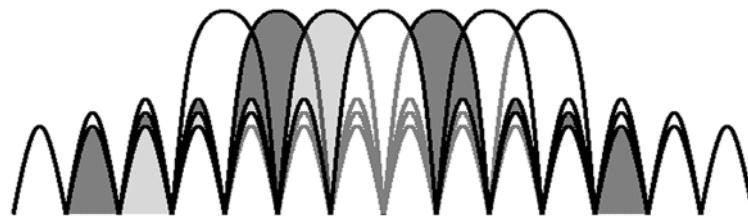


In the WiMAX air interface, the basic OFDM symbols are based on a 256 point FFT. As with other OFDM systems, a portion of these 256 subcarriers are set aside (unused) for guard bands and the center frequency subcarrier is not used because it is easily susceptible to RF carrier feed through. In WiMAX, only 200 subcarriers are actually used. These 200 carriers are allocated as 192 carriers for data and 8 carriers as pilots (see Figure 1). The pilot carriers are always BPSK modulated and the data carriers are BPSK, QPSK, 16 QAM, or 64 QAM.

The OFDM waveform in the frequency domain is created by the inverse Fourier transform of the OFDM symbol in time. The OFDM symbol of duration, T_s , includes the symbol time, T_b ($T_b = 1 \div \text{carrier spacing}$), and the guard interval, T_g . The guard interval or cyclic prefix is a copy of the end of the symbol appended to the beginning. The guard interval is used to collect multipath and improve system performance.

Figure 2-11

OFDM Carriers Separation

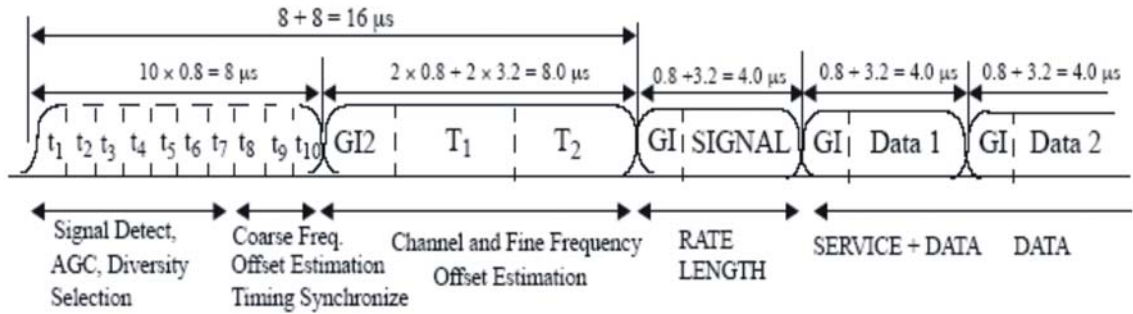


Orthogonal Frequency Division Multiplexing (OFDM) has been formally accepted as the method to achieve high data rates, better than 20 Mbps in the WLAN systems. OFDM provides multiple frequency channels at regular spacing, each modulated by M-ary QAM. An OFDM signal consists of the sum of a number of sub-carriers that are modulated using some form of PSK or QAM. Data interleavers “spread” the information throughout the carriers.

Orthogonal Frequency Division Multiplexing (OFDM) Concepts

As shown in Figure 2-12, “OFDM training structure,” an OFDM burst actually has four distinct regions. The first is the *Short Training Sequence*, followed by a *Long Training Sequence* and finally by the *Signal* and *Data Symbols*. From a RF standpoint, the Signal symbol and the rest of the OFDM symbols are similar.

Figure 2-12 OFDM training structure



Combined Fixed WiMAX Measurement Concepts

This section recommends some guidelines during configuration for easy and quick measurement, it also introduces the timing structure of burst within one acquisition and the measurements in Combined Fixed WiMAX measurement application.

Configuration guidelines

The follow guidelines are recommended in order to optimize the parameter settings and make full use of the potential of the instrument.

1. This software provides user designed setup for the test cases within its own capability. The instrument will just do what it is set to do. You should have full knowledge of the target signals and take full responsibility for making sure that the instrument is properly set.
2. SCPI command (`[[:SENSE]:CFWimax:METHod FAST|BALanced|ACCuracy]`) is used to optimize the measurement as per the need.
3. RF Envelope View is very useful for the time alignment between target signal and the instrument. However, you are encouraged to always use SCPI command (`[[:SENSE]:CFWimax:TRACe:RF[:ENABLE] OFF]`) to turn the trace off once the time alignment is finished. The RF trace gives you an example of what the RF envelope of the signal looks like. The displayed trace is not same as the raw data. You can use the SCPI READ to read the raw data and use it for post-processing.
4. 36 bursts could be set to be captured maximally.
5. The total captured signal time should not exceed 177ms. This includes the capture offset time, all the corresponding prefix time, and burst time.
6. You are encouraged to select “static” burst type if there is no frequency change or e-atten change among different bursts.
7. When applicable, you are encouraged to use the “trigger delay” rather than “capture offset.”
8. The first burst in the burst sequence must be the in-band signal, unless the trigger method is “event trigger.”
9. A suffix is not captured to be present in the raw data. A prefix is captured to be present in the raw data, yet not considered in the result, it is the same with “capture offset”. A “burst” is captured, considered, and calculated in the results.
10. There are no suffixes (considered as 0 no matter what entered) when the burst type is “static”.
11. You are encouraged to use suffixes to make up the empty periods between successive bursts, however, a good practice is to leave 2 ~ 4 us for the successive prefix time of the next burst, especially when the timing of the

bursts can not be exacted to an us level.

12. When the burst type is “dynamic”, follow the formula below to set suffix values.

$$\text{Suffix} \geq |CF_n - CF_{n+1}| * 4 \text{ (us)}$$

CF_n, the center frequency in MHz of the burst in question

CF_{n+1}, the center frequency in MHz of the next burst

13. If TX Output Spectrum is enabled, select "dynamic" burst type, set bursts in triple groups (Penta-groups in case farther offset is on), with the center frequency set as below:

When Preset Profile < 10MHz:

CF_n = in-band center frequency

When 10MHz <= Preset Profile <=24 MHz:

CF_n = in-band center frequency

CF_{n+1} = CF_n - the value of Preset Profile

CF_{n+2} = CF_n + the value of Preset Profile

Currently does not support the Preset Profile of 28 MHz.

14. The maximum sampling points is 4M. If (total capture time * sampling rate) > 4M point, -999.0 will be returned as invalid results.

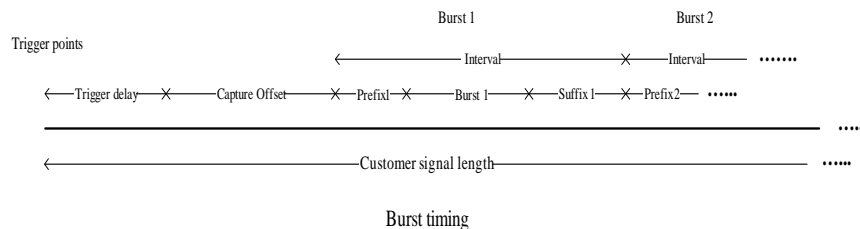
15. For each RF burst, there is no coupling and dependency applied for burst length. But if burst length < 3.769508/RBW, settings conflict (ID -221) message will be posted, and this RF burst will not be measured for power test. If burst length < EVM required length, settings conflict (ID -221) message will be posted, and this RF burst will not be measured for the modulation test.

Algorithm Overview

Signal timing

As shown below, Each **Burst** contains three parts: **Prefix**, **Burst** and **Suffix**.

You are responsible for the exact alignment of the spectrum analyzer and the device under test in terms of these parameters.



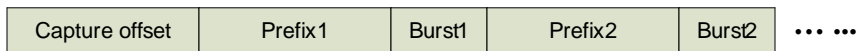
Prefix If burst type is static, prefix is used to define the time spacing between this

Combined Fixed WiMAX Measurement Concepts

burst and the previous burst. If the burst type is dynamic, **Prefix** is used to represent the measurement start time of each burst.

Burst allows you to specify the data time over which the measurement is made.

Suffix is used to define the hardware switching time between this burst and the next burst.



Captured Sequence

Capture starts after the trigger delay lapses; Capture Offset represents the part that you do not want to measure; after Capture Offset, after the Prefix1, comes the Burst 1, which is the target part of the measurement. When Burst 1 lapses, the RF front will suspend and undertake to “hop” the frequency or “reset” the E-attenuation, which will take period of Suffix 1. When the suffix 1 lapses, the RF chain will resume capturing until Burst 2 lapses, of the captured data, prefix1 is the part that somehow you do not want to measure. Burst 1 is the target of the measurements, and so on till all the bust are captured.

It is important to notice that in any case, the specified Suffixes in all bursts (equals to 0 under static burst pattern) correspond to the time the hardware (RF front end) takes changing the Center frequency setting values or E-Atten setting values; so the capturing actually suspends during this time.

In any cases, the total captured length equals the capture offset plus Prefixes and Bursts of all intervals.

Transmit Power Measurement Concepts

Purpose

The Transmit Power measurement is used to find the total power presented in a specified bandwidth. This procedure also measures the power spectral density (the peak power on 1 MHz bandwidth). This measurement is applied to design, characterize, evaluate, and verify transmitters and their components.

Measurement Method

The Transmit Power measurement uses the FFT method to compute signal transmit power. The FFT is done on entire Span set by customer. The transmit power in Integ. BW is computed by adding up the energy of each FFT point in Integ BW around center frequency. The peak power spectral density is defined as the maximum transmit power in 1 MHz bandwidth.

The measurement acquires a number of points representing the input signal in the time domain. It transforms this information into the frequency domain using FFT and then calculates the channel power. The effective resolution bandwidth of the frequency domain trace is proportional to the number of points acquired for the FFT. The fastest FFT process is achieved using a number of acquired points that is a power of 2 (for example: 64, 128, 512).

If you turn the Average on, it will give the average result of all the measured bursts.

Transmit Output Spectrum Measurement Concepts

Purpose

This test measures the spectral profile of the transmitter to verify that the device is not transmitting excessive energy outside its assigned channel bandwidth. Most WiMAX deployments will be in frequency bands that are controlled by local regulations and because these regulations vary widely, the 802.16 specification does not attempt to specify spectral mask for any operation other than “unlicensed.” The measurement procedure defined here is the same, however specific limits must be determined by you and will depend on where the device will be deployed.

Measurement Method

The Transmit Output Spectrum measurement measures spurious signal levels in each of the offset frequency pairs A to C and relates them to the carrier power. PSD (Power Spectral Density) is used for this measurement. Transmit Spectrum Mask measurement is made with both sides centered at the carrier channel frequency bandwidth. The specifications require the reference to be the PSD of the signal. The reference power therefore can be obtained in 100kHz resolution bandwidth as a reference PSD related to 100kHz.

The following table shows the frequency range of the Offset A, B,C:

Table 2-1

Frequency Range for the Offset A/B/C

Offset	Frequency Range (MHz)
A	Preset Profile/10*4.75 – Preset Profile/10*5.45
B	Preset Profile/10*5.45 – Preset Profile/10*9.75
C	Preset Profile/10*9.75 – Preset Profile/10*14.75

The Preset Profile supports bandwidth from 1.25MHz to 24MHz, the bandwidth above 24 MHz is not supported currently.

The measurement provides the following result and Pass/Fail indication for each positive and negative offset.

- Min Margin Level
- Min Margin form Limit Line
- Minimum margin offset frequency

Modulation Accuracy Measurement Concepts

Purpose

This test is a measurement of the transmitter modulation accuracy. Accurate transmitter modulation is necessary to insure the receiver can demodulate the signal with minimal decode errors. This measurement is similar to Error Vector Magnitude (EVM) used in many other digital communication standards. 802.16 introduces a new term - Relative Constellation Error (RCE). A specific algorithm is defined in the standard. This measurement method determines the magnitude error of each constellation point and RMS averages them together across multiple symbols, frames, and packets.

Each of the seven burst profiles (modulation / coding types) has a specification for RCE expressed in dB. The following table shows the allowable RCE for each burst profile.

Table 2-2

Specifications for transmitter constellation error

Burst type	Relative constellation error (dB)
BPSK – 1/2	– 13.0
QPSK – 1/2	– 16.0
QPSK – 3/4	– 18.5
16 QAM – 1/2	– 21.5
16 QAM – 3/4	– 25.0
64 QAM – 1/2	– 28.0
64 QAM – 3/4	– 31.0

During normal system operation, all uplink and downlink transmissions begin with a preamble. The preamble is critical because receivers rely on these preambles to synchronize with the transmitter and perform various channel estimation and equalization processes. The preamble uses QPSK modulation and has no embedded BPSK pilots. Because of this, the preamble is ideally suited to specify spectral flatness across all the subcarriers.

The 802.16-2004 standard states that data shall be taken from the “channel estimation step”, which is the preamble. The specification states, “the absolute difference between adjacent subcarriers shall not exceed 0.1 dB”. In the preamble, because only half or one-fourth of the 200 subcarriers are actually used, adjacent carrier spacing in the preamble is wider than data bursts.

Table 2-3

Specification for transmitter spectral flatness

Spectral lines	Spectral flatness
Spectral lines from –50 to –1 and +1 to +50	±2 dB from the measured energy averaged over all active tones

Table 2-3

Specification for transmitter spectral flatness

Spectral lines	Spectral flatness
Spectral lines from -100 to -1 and +1 to +100	+2dB /-4 dB from the measured energy averaged over all active tones
Adjacent subcarriers	±0.1 dB

Measurement Method

The modulation accuracy measurement is made to get results for a composite error vector magnitude. The error vector is defined as the ratio to the mean power of the reference waveform expressed in dB.

The modulation accuracy measurement provides the following results:

- Frequency Error
- Symbol Error
- RMS EVM in dB – Relative Constellation Error (RCE)
- RMS EVM in percent
- I/Q Offset
- Abs Spectrum Flatness Min Margin – Absolute value for the minimum margin from the limit line
- Abs Spectrum Flatness Min Margin Level – The level of the subcarrier which has the minimum margin from the limit line
- Abs Spectrum Flatness Min Margin Index – The subcarrier which has the minimum margin from the limit line
- Abs Spectrum Flatness Min Margin Pass/Fail flag (1:fail 0:pass)
- Diff Spectrum Flatness Min Margin – The minimum margin of the difference from limit among the adjacent subcarriers
- Diff Spectrum Flatness Min Margin Level – The level of the subcarrier which has the minimum margin from the limit.
- Diff Spectrum Flatness Min Margin Index – The subcarrier which has the minimum margin from the limit
- Diff Spectrum Flatness Min Margin Pass/Fail flag (1:fail 0:pass)

To successfully demodulate a WiMAX signal, most analyzers need the following minimum signal parameters: center frequency, nominal bandwidth, sampling factor, and guard interval. In the 802.16 OFDM modulation scheme, setting the value for Nominal Bandwidth will affect several other parameters. The following table shows the interrelation between the 802.16 OFDM (WiMAX) time and frequency parameters.

Figure 2-13 WiMAX Frequency and Time Parameter Table

Nominal BW	Sampling factor (Fs/BW)	256 carrier BW (Fs)	200 carrier BW (Fs x 200/256)	Carrier spacing ΔF = Fs/256	Symbol time Tb = 1/ΔF	Guard interval G	Guard interval time Tg = G x Tb	OFDM symbol time Ts = Tb + Tg	Long preamble (DL = 2 x Ts)	Short preamble (UL = Ts)
MHz		MHz	MHz	kHz	Sec		Sec	Sec	Sec	Sec
28.00	8/7	32.00	25.00	125.00	8.00	1/4	2.00	10.00	20.00	10.00
						1/8	1.00	9.00	18.00	9.00
						1/16	0.50	8.50	17.00	8.50
						1/32	0.25	8.25	16.50	8.25
24.00	86/75	27.52	21.50	107.50	9.30	1/4	2.33	11.63	23.26	11.63
						1/8	1.16	10.47	20.93	10.47
						1/16	0.58	9.88	19.77	9.88
						1/32	0.29	9.59	19.19	9.59
20.00	144/125	23.04	18.00	90.00	11.11	1/4	2.78	13.89	27.78	13.89
						1/8	1.39	12.50	25.00	12.50
						1/16	0.69	11.81	23.61	11.81
						1/32	0.35	11.46	22.92	11.46
15.00	86/75	17.20	13.44	67.19	14.88	1/4	3.72	18.60	37.21	18.60
						1/8	1.86	16.74	33.49	16.74
						1/16	0.93	15.81	31.63	15.81
						1/32	0.47	15.35	30.70	15.35
14.00	8/7	16.00	12.50	62.50	16.00	1/4	4.00	20.00	40.00	20.00
						1/8	2.00	18.00	36.00	18.00
						1/16	1.00	17.00	34.00	17.00
						1/32	0.50	16.50	33.00	16.50
12.00	86/75	13.76	10.75	53.75	18.60	1/4	4.65	23.26	46.51	23.26
						1/8	2.33	20.93	41.86	20.93
						1/16	1.16	19.77	39.53	19.77
						1/32	0.58	19.19	38.37	19.19
11.00	316/275	12.64	9.88	49.38	20.25	1/4	5.06	25.32	50.63	25.32
						1/8	2.53	22.78	45.57	22.78
						1/16	1.27	21.52	43.04	21.52
						1/32	0.63	20.89	41.77	20.89
10.00	144/125	11.52	9.00	45.00	22.22	1/4	5.56	27.78	55.56	27.78
						1/8	2.78	25.00	50.00	25.00
						1/16	1.39	23.61	47.22	23.61
						1/32	0.69	22.92	45.83	22.92
7.00	8/7	8.00	6.25	31.25	32.00	1/4	8.00	40.00	80.00	40.00
						1/8	4.00	36.00	72.00	36.00
						1/16	2.00	34.00	68.00	34.00
						1/32	1.00	33.00	66.00	33.00
6.00	86/75	6.88	5.38	26.88	37.21	1/4	9.30	46.51	93.02	46.51
						1/8	4.65	41.86	83.72	41.86
						1/16	2.33	39.53	79.07	39.53
						1/32	1.16	38.37	76.74	38.37
5.50	316/275	6.32	4.94	24.69	40.51	1/4	10.13	50.63	101.27	50.63
						1/8	5.06	45.57	91.14	45.57
						1/16	2.53	43.04	86.08	43.04
						1/32	1.27	41.77	83.54	41.77
5.00	144/125	5.76	4.50	22.50	44.44	1/4	11.11	55.56	111.11	55.56
						1/8	5.56	50.00	100.00	50.00
						1/16	2.78	47.22	94.44	47.22
						1/32	1.39	45.83	91.67	45.83
3.50	8/7	4.00	3.13	15.63	64.00	1/4	16.00	80.00	160.00	80.00
						1/8	8.00	72.00	144.00	72.00
						1/16	4.00	68.00	136.00	68.00
						1/32	2.00	66.00	132.00	66.00
3.00	86/75	3.44	2.69	13.44	74.42	1/4	18.60	93.02	186.05	93.02
						1/8	9.30	83.72	167.44	83.72
						1/16	4.65	79.07	158.14	79.07
						1/32	2.33	76.74	153.49	76.74
2.50	144/125	2.88	2.25	11.25	88.89	1/4	22.22	111.11	222.22	111.11
						1/8	11.11	100.00	200.00	100.00
						1/16	5.56	94.44	188.89	94.44
						1/32	2.78	91.67	183.33	91.67
1.75	8/7	2.00	1.56	7.81	128.00	1/4	32.00	160.00	320.00	160.00
						1/8	16.00	144.00	288.00	144.00
						1/16	8.00	136.00	272.00	136.00
						1/32	4.00	132.00	264.00	132.00
1.50	86/75	1.72	1.34	6.72	148.84	1/4	37.21	186.05	372.09	186.05
						1/8	18.60	167.44	334.88	167.44
						1/16	9.30	158.14	316.28	158.14
						1/32	4.65	153.49	306.98	153.49
1.25	144/125	1.44	1.13	5.63	177.78	1/4	44.44	222.22	444.44	222.22
						1/8	22.22	200.00	400.00	200.00
						1/16	11.11	188.89	377.78	188.89
						1/32	5.56	183.33	366.67	183.33

Other Sources of Measurement Information

Additional measurement application information is available in www.agilent.com. The following application notes treat digital communications measurements and WiMAX in much greater detail than discussed in this measurement guide.

- Application Note
WiMAX Concepts and RF Measurements, literature number 5989-2027EN
- Application Note
WiMAX Signal Analysis Part 1 Making Frequency and Time Measurements, literature number 5989-3037EN
- Application Note
WiMAX Signal Analysis Part 2 Demodulating and Troubleshooting the Subframe, literature number 5989-3038EN
- Application Note
WiMAX Signal Analysis Part 3 Troubleshooting Symbols and Improving Demodulation, literature number 5989-3039EN

References

1. IEEE Standard for Local and metropolitan area networks, IEEE Std 802.16-2004

Concepts
References