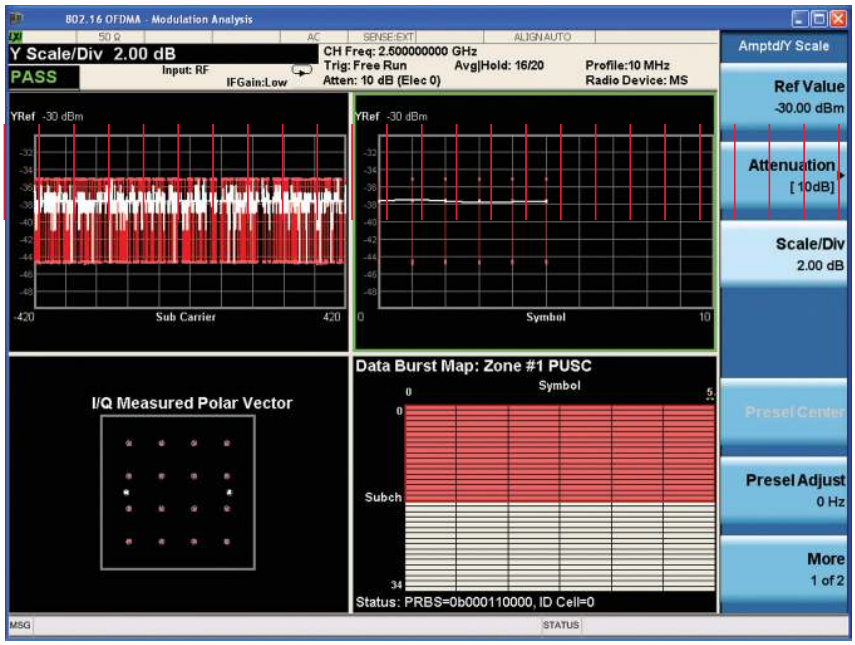
# Keysight Technologies
# N9075A & W9075A 802.16 OFDMA

## X-Series Measurement Application

## Demo Guide




KEYSIGHT TECHNOLOGIES

# Introduction

The Keysight Technologies, Inc. N9075A and W9075A 802.16 OFDMA measurement applications provide one-button measurement and modulation analysis capabilities to help your design, evaluation, and manufacturing of Mobile WiMAX™ devices.

This demonstration guide follows the list on page 2. Each demonstration includes a brief description of its function and the corresponding measurement steps on the signal generator and/or signal analyzer.

## 802.16 OFDMA Test Measurements

- Channel power[1]
- ACP (adjacent channel power)1
- Spectrum emission mask1
- Spurious emissions
- Occupied bandwidth1
- Power versus time
- Modulation analysis (including spectral flatness)
- Power statistics CCDF
- Monitor spectrum1
- IQ waveform

1. *These measurements require a timing trigger to capture the burst power on period. To measure time-gated spectrum analysis for bursted signals, gated LO function is required. "Gate required for valid results" is shown in the status message at the bottom of display when these measurements are running. Use time gating with gate setups under [Sweep/Control] key. Minimum equipment configuration requirements*

## Demonstration Preparation

All demonstrations use an X-Series signal analyzer and the N5182A MXG vector signal generator. Keystrokes surrounded by [ ] indicate front-panel keys; keystrokes surrounded by { } indicate softkeys located on the display.

### Helpful tip:

To measure the analog baseband I/Q OFDMA signal, connect the MXG signal outputs (either single-ended or differential) to the MXA signal analyzer with Option BBA. By switching the input from RF to I/Q, you can make the same modulation analysis in the OFDMA measurement application.

### Helpful tip:

Update your instrument firmware and software to the latest version, at

www.keysight.com/find/xseries_software
www.keysight.com/find/signalstudio

## Minimum equipment configuration requirements

To configure these instruments, connect the MXG's 50 Ω RF output to the X-Series signal analyzer's 50 Ω RF input with a 50 Ω RF cable. Turn on the power in both instruments. Now set up the MXG and Signal Studio for 802.16 WiMAX™ software to generate a OFDMA signal.

| Instruments | Model number | Options (recommended or required) |
|---|---|---|
| MXG vector signal generator | N5182A Firmware revision 1.04 or later | Required:<br>– 503 or 506 – Frequency range at 3 GHz or 6 GHz<br>– 651, 652 or 654 – Internal baseband generator<br>– UNV – Enhanced dynamic range (required for better ACP performance) |
| Signal Studio for 802.16 WiMAX software | N7615B Version 2.0.0.0 or later | – 503, 508, 507 (EXA and CXA), 513 or 526 – 513 and 526 not available on CXA |
| X-Series signal analyzer | N9000A, N9010A, N9020A, or N9030A firmware revision A.06.xx or later | Recommended:<br>– EA3 – Electric attenuator, 3.6 GHz<br>– POx – Preamplifier |
| 802.16 OFDMA X-Series signal analyzer measurement application | N9075A–N9010A, N9020A, N9030A, W9075A–N9000A only | Required:<br>– 2FP: 802.16 OFDMA measurement application, fixed perpetual license OR<br>– 2TP: 802.16 OFDMA measurement application, transportable license |
| Controller PC for Signal Studio for 802.16 WiMAX[1] | | Required:<br>– Install N7615B to generate and download the signal waveform into the MXG via GPIB or LAN (TCP/IP). Please refer to the online documentation for installation and setup |

1. *Or install Signal Studio software on the X-Series signal analyzer if you want to connect the MXG with a cross-over LAN cable.*

# Demonstration Setup

## Connect the PC, X-Series, and MXG

| Instructions | Software operations |
|---|---|
| **On the Signal Studio for 802.16 WiMAX software:** | |
| Start the Signal Studio for 802.16 WiMAX software | Start > Program > Keysight Signal Studio > 802.16 WiMAX |
| Connect the Keysight MXG as hardware via GPIB or LAN (TCP/IP) | Follow the Signal Studio for 802.16 WiMAX instructions to connect to the Keysight MXG N5182A |
| Configure the signal of single antenna | Select **Quick Setups** and double click **M x 1** |
| Set the basic parameters of the signal at center frequency 2.5 GHz, amplitude –10 dBm, RF output turned On, and ALC On | Click **Signal Generator** at the left on the Explorer menu.<br>Instrument model number = N5182A.<br>Press **[Preset]** green button on the top.<br>Frequency = 2.5 GHz, Amplitude = –10 dBm,<br>RF Output = on, ALC = on |
| Confirm the waveform setup from upper level | Click **Waveform Setup** to see the fundamental waveform signal setups.<br>Under Waveform Properties, you can set WiMAX common parameters as follows:<br>Built frames = 1<br>Frame duration (ms) = 5<br>Output mode = downlink only (TDD)<br>Downlink ratio (%) = 61.771<br>Guard period = ⅛<br>Symbol rolloff = 5.0% |
| Configure a test signal for demonstrations | Click **Carrier 1** under Waveform Setup on the left of the Explorer menu.<br>Carrier 1: State = on, Radio format = advanced 802.16 OFDMA, 10 MHz BW, 1024 FFT size,<br>0 Hz frequency offset, power at 0.00 dB.<br>Use the default settings of reference spec |
| Create a single carrier signal including downlink only | Click **Downlink** and check following parameters<br>Preamble index = 0<br>Group bitmask = 111111[Binary], 3F[Hex]<br>Number of symbols = 6<br>Symbol offset = 1<br>Max number of subch = 30 |
| Configure Zone #1, PUSC | Select Zone#1 PUSC to check the following parameters.<br>Zone boost = on<br>Number of symbols = 6<br>Auto allocation = on<br>Auto FCH = on<br>Auto DL-MAP = normal<br>Auto UL-MAP = normal |

# Demonstration Setup, continued

| Instructions (continued) | Software operations |
|---|---|
| **On the Signal Studio for 802.16 WiMAX software:** | |
| Add two more data bursts in Zone #1 PUSC | Press [+] once for regular data burst #2 and 3 |
| Configure MAC messaging | Auto DL-MAP = normal<br>Auto UL-MAP = normal<br>Modulation and coding = QPSK (CC) ½<br>Modulation and coding = QPSK(CC) ½ |
| Configure Burst #1 | Select Burst#1 to check the following parameters.<br>Modulation and coding = 16QAM (CTC) ½<br>Data length [Bytes] = 300 |
| Modify Burst #2 | Change the modulation and coding<br>Modulation and coding = QPSK (CTC) ½<br>Data length [Bytes] = 64 |
| Modify Burst #3 | Change the modulation and coding<br>Modulation and coding = 64QAM (CTC) ¾<br>Data length [Bytes] = 540 |
| Download the signal to MXG | Press **Generate and Download** on the top tool bar. If you encounter any errors, please refer to the online help of Signal Studio for 802.16 WiMAX software |
| Save the setting file for future reuse. This saved .scp file will be used in modulation analysis later | **File > Save As... > OFDMA_Demo1.scp** (Name it as you like) |
| Export the waveform file for future reuse | **File > Export Waveform Data > OFDMA_Demo1.wfm** (Name it as you like) |

| Instructions | |
|---|---|
| **On the Keysight X-Series signal analyzer:** | |
| Connect 10 MHz reference output into X-Series signal analyzer | Reference input at rear panel<br>**[Input/Output] Freq Ref In > External** |
| Connect EVENT 1 output into MXA. This is an external trigger at the OFDMA frame boundary | External trigger 1 at rear panel |

# Demonstrations

## Demonstration 1:

### Channel power

Channel power measures and reports the power in the integrated bandwidth as well as computed power spectral density (the power in the signal is normalized to 1 Hz).

You have the ability to adjust the following channel power measurement parameters:

- Integration bandwidth (defaults to 10 MHz)
- Number of trace averages (default to 200)
- Data points displays, 101 to 20001 (default to 1001)
- Configure RRC filter with flexible filter alpha value (default to Off)
- Trigger source: free run, video, line, external-½, RF burst, and periodic timer (default to free run)
- Time gating with gate source: line, external-½, RF burst, and periodic timer (default to periodic timer with sync source = RF burst)

This measurement requires a timing trigger to capture the burst power on period. To measure time-gated spectrum analysis for burst signals, gated LO function is required. With your burst signals, please use any external trigger or gated LO with the X-Series signal analyzer configured by gated LO setups under [Sweep/Control] key.

If you need to measure the OFDMA burst signal and don't have an external trigger, please use a periodic timer as the gate source with an RF burst as the sync source.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Preset X-Series signal analyzer | **[Mode Preset]** |
| Move to 802.16 OFDMA mode | **[Mode] 802.16 OFDMA (WiMAX/WiBro)** |
| Choose transmitter radio device for base station (downlink) | **[Mode Setup] Radio Device BS MS** |
| Set a center frequency at 2.5 GHz | **[FREQ] [2.5] GHz** |
| Run a channel power measurement | **[Meas] Channel Power** |
| Set the sweep time as Auto | **[Sweep/Control] Sweep Time Auto** |
| Configure time gating with gate source of external trigger 1 at the rear panel. (Figure 1) | **[Sweep/Control]**<br>**Gate = On Gated [LO]**<br>**Gate View = On**<br>**Gate View Sweep Time = 5 ms**<br>**Delay = 71 us**<br>**Length = 50 us**<br>**Gate Source = Periodic timer**<br>**Periodic timer**<br>**Periodic = 5 ms**<br>**Sync Source = RF burst** |

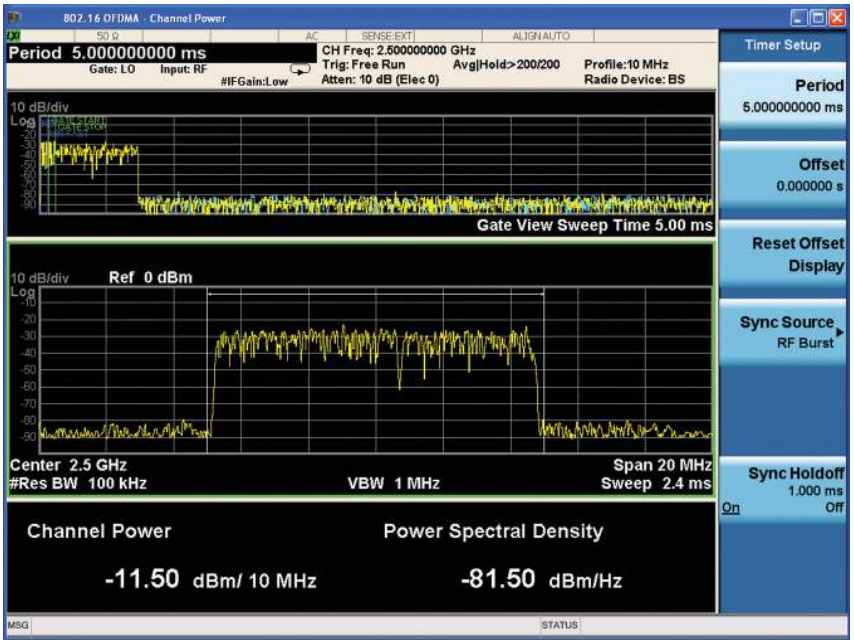



*Figure 1. Channel power in 802.16 OFDMA mode*

# Demonstration 2:

## Adjacent channel power (ACP)

This is a measurement for the power present in adjacent transmit channels. The span is set according to the six available offsets and their associate integration bandwidths defined by users or the selected radio standard.

You have the ability to adjust the following adjacent channel power measurement parameters:

- Measure up to 12 carriers for multi-carrier ACP
- Adjust integration bandwidth
- Select up to six channel offsets
- Choose channel offset frequency
- Adjust and display both absolute and relative power
- View bar graph over spectrum trace
- Use built-in averaging detector (RMS) for speed and accuracy
- RRC filter with flexible filter alpha value
- Noise correction On/Off (default to Off)

This measurement requires a timing trigger to capture the burst power on period. To measure time-gated spectrum analysis for burst signals, gated LO function is required.

"Gate required for valid results" would be seen in the status message at the bottom of display when these measurements are running. Use time gating with gate setup under **[Sweep/Control]** key.

If you need to measure the OFDMA burst signal and don't have an external trigger, please use periodic timer as the gate source with RF burst as the sync source.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Measure ACP | **[Meas] ACP** |
| Check the bar graph over the trace | **[View/Display] Bar Graph On Off** |
| Turn on noise correction | **[Meas Setup] More > Noise correction On Off** |
| Change sweep time | **[Sweep/Control] Sweep Time [10] ms** |
| Check the time gating setup<br>Adjust gate in Gate View if necessary | **[Sweep/Control] Gated [LO]**<br>**Gate View = Off** |
| Restart measurement (Figure 2) | [Restart] |

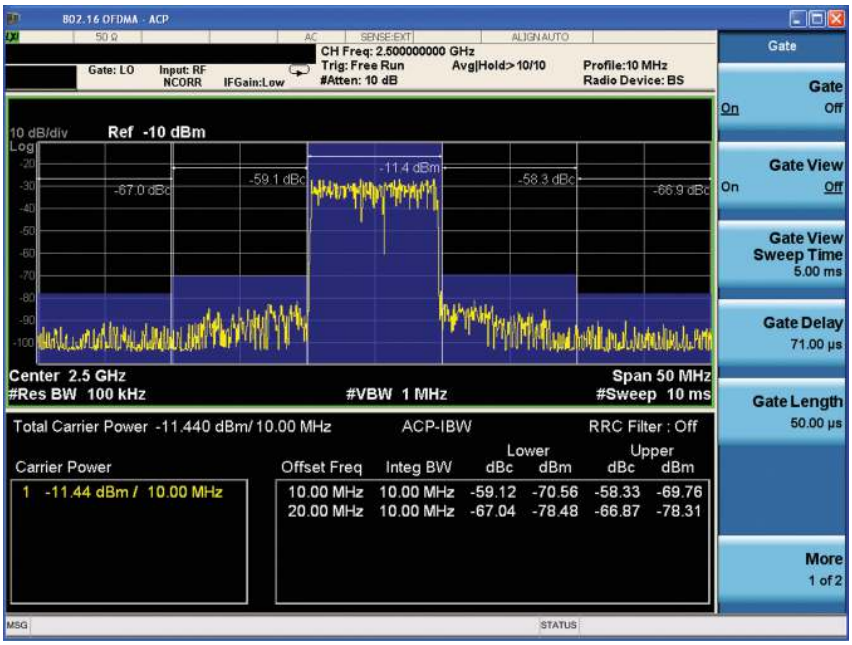



*Figure 2. ACP*

# Demonstration 3:

## Spectrum emission mask (SEM)

The spectrum emission mask measurement includes the in-band and out-of-band spurious emissions. It may also be expressed as a ratio of power spectral densities between the carrier and the specified offset frequency band.

The application includes several pre-defined masks for easy recall, as well as the ability to save custom masks into state file.

Perform the following key steps to find available masks:
**[Recall] > {Data (Import)} > {Mask}** and **{Open...}**. And remember to save customized masks into state files for future reuse.

This measurement requires a timing trigger to capture the burst power on period. To measure time-gated spectrum analysis for burst signals, gated LO function is required.

"Gate required for valid results" would be seen in the status message at the bottom of the display when these measurements are running. Use time gating with gate setup under **[Sweep/Control]** key.

If you need to measure the OFDMA burst signal and don't have an external trigger, please use periodic timer as the gate source with RF burst as the sync source.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Activate a spectrum emission mask measurement | **[Meas] Spectrum Emission Mask** |
| Choose the type of values to display. Observe the measurement values change in the lower window to reflect the selected value type (Figure 3) | **[View/Display] Abs Pwr Freq** or **Rel Pwr Freq** or **Integrated Power** |


*Figure 3. BC3 spectrum emission mask*

# Demonstration 4:

## Spurious emissions

The spurious emissions measurement identifies and determines the power level of spurious emissions in user defined frequency bands. The measurement allows the user to set pass/fail limits and a reported spur threshold value. The results are conveniently displayed in a result table that can show up to 200 values.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Measure the spurious emissions | [Meas] Spurious emissions |
| Confirm how to modify the range table (Figure 4) | [Meas Setup] |

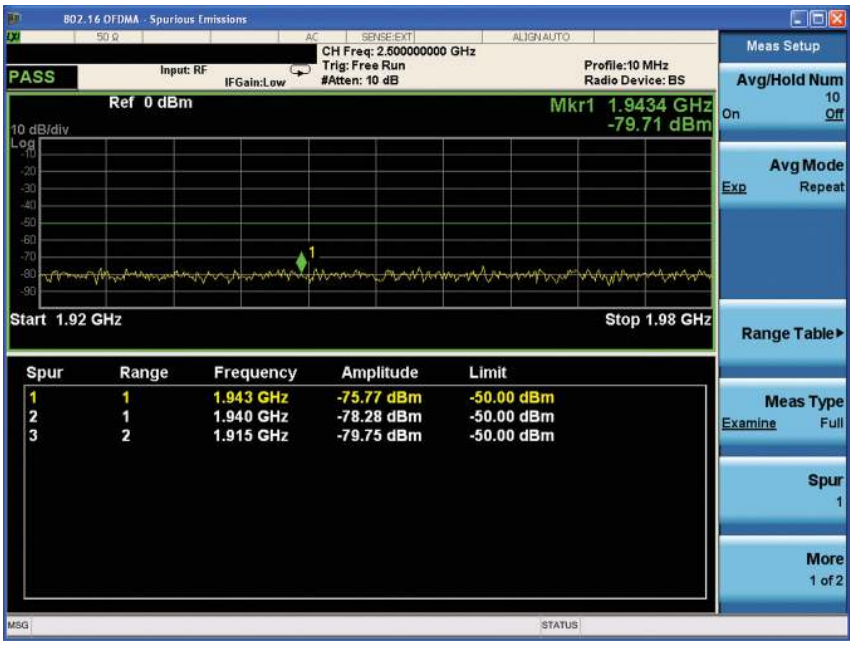



*Figure 4. Spurious emissions*

# Demonstration 5:

## Occupied bandwidth

The occupied bandwidth measurement places markers at the frequencies for which the specified percentage of the power is contained and reports this bandwidth. The measurement defaults to 99% of the occupied bandwidth power.

It also indicates the difference between analyzer center frequency and the center frequency of the channel. The difference is referred to as "transmit frequency error."

You have the ability to adjust the following occupied bandwidth measurement parameters:

– Changeable occupied bandwidth % power

– Measure 99% occupied bandwidth and the user-definable x dB bandwidth as well

This measurement requires a timing trigger to capture the burst power on period. To measure time-gated spectrum analysis for burst signals, gated LO function is required.

"Gate required for valid results" would be seen in the status message at the bottom of display when these measurements are running. Use time gating with gate setup under **[Sweep/Control]** key.

If you need to measure the OFDMA burst signal and don't have an external trigger, please use periodic timer as the gate source with RF burst as the sync source.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Measure the occupied bandwidth | [Meas] Occupied Bandwidth |
| Check the time gating setup. Adjust time gate in gate view if necessary (Figure 5) | [Sweep/Control] Gated [LO]<br>Gate View = On |

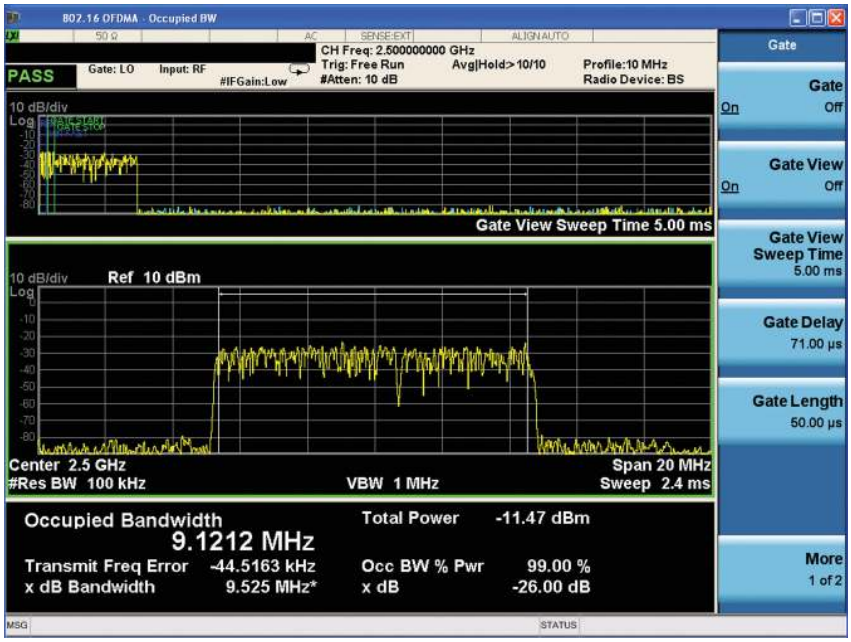



***Figure 5. Occupied bandwidth***

In this measurement, the total power of the displayed span is measured. Then the power is measured inward from the right and left extremes until 0.5% of the power accounted for in each of the upper and lower parts of the span. The calculated difference is the occupied bandwidth. In accordance with the 802.16e-2005 10 MHz preset, the X-Series signal analyzers default to a 10 MHz PASS/FAIL limit values.

# Demonstration 6:

## Power versus time

This measurement examines time domain burst shape if the incoming signal satisfies the test limit profile defined by users. After capturing IQ data in the time domain, this measurement calculates the power vector (magnitude square vector) from the IQ vector. Burst detection parameters will help to search a burst power vector automatically. If you want to verify the signal against an external timing source, the burst auto detection function can be disabled. In addition, the burst detection algorithm searches a burst from the beginning of the captured data and picks up the first one which satisfies the burst detection parameters. For example, if there are two valid bursts in the captured data, the second burst will be disregarded. In WiMAX OFDMA, the captured TDD (time division duplex) signal could contain both downlink and uplink bursts. In this case, you need to use an external trigger with appropriate trigger delay so that the downlink or uplink burst comes to the beginning of the captured data selectively.

Although the 802.16e-2005 standard does not define any conformance test for power versus time mask, pass/fail limit mask test is commonly used to determine the signal quality in burst power on/off. It is highly configurable to define various types of limit mask.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Measure the power versus time with burst signal | [Meas] Power vs Time |
| Check the burst sync source (Figure 6) | [Meas Setup] Burst Sync > RF Amptd |

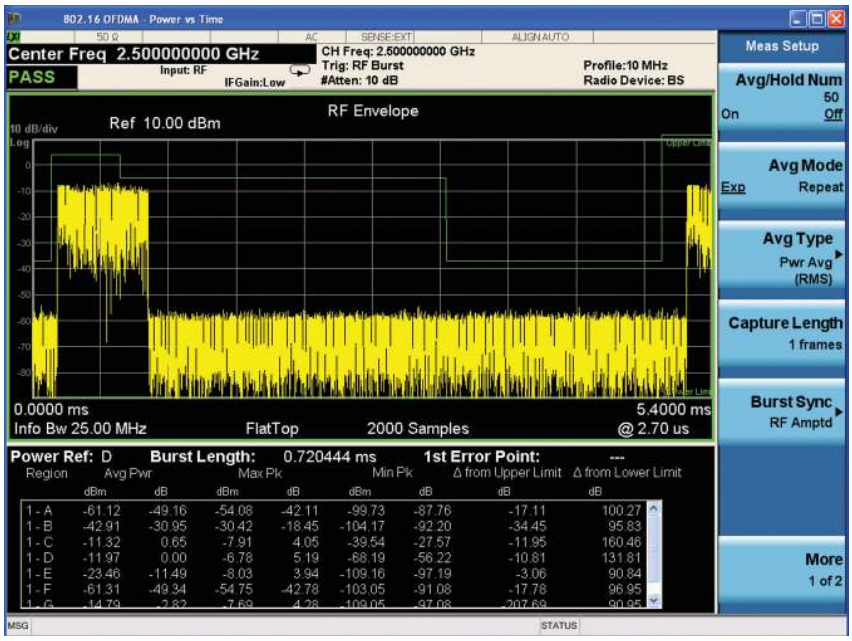



*Figure 6. Power vs. time*

# Demonstration 7:

## Modulation analysis

The modulation analysis measurement provides a full set of demodulation properties that support OFDMA scalable parameters including data tone modulation, frame length, normal bandwidth (BW) ratio, guard interval, and FFT size. Relative constellation error (RCE) is defined in IEEE 802.16 for the same result parameter as error vector magnitude (EVM). EVM is a common modulation quality metric widely used in digital communications.

This measurement takes into account all possible error mechanisms in the entire transmission chain including: baseband filtering, I/Q modulation anomalies, filter amplitude and phase non-linearities, and power amplitude distortions.

Both downlink and uplink subframe modulation analysis can be done with the following metrics:

- IQ measured constellations including multiple formats when present
- Subchannelization
- Available traces: RCE versus time, RCE versus frequency
- Data burst information table modulation format and size

With complex OFDMA frame structure as shown in Figure 7, it is necessary to have the zone and burst map information for correct measurements of RCE (EVM) and other demodulation results.

N9075A has three ways to refer the zone and burst map information:

1. Setup file (.scp) of Keysight N7615B Signal Studio for 802.16 OFDMA
2. Zone definition file (.omf) of Keysight VSA 89601A-B7Y for 802.16 OFDMA
3. DL-MAP/UL-MAP auto detection (preamble index is necessary to decode FCH, DL-MAP, and UL-MAP)

Without having correct map information, modulation analysis measurement would provide results only for FCH (by default).

### DL-MAP/UL-MAP auto-detection

When you try to measure a downlink signal containing FCH (frame control header), DL-MAP, and UL-MAP, zone and burst map can be detected automatically and decoded into a map file to refer to for modulation analysis. This DL-MAP/UL-MAP auto-detect function is added in MXA firmware A.01.10 and EXA firmware A.01.20 or later. It is necessary to have FCH, DL-MAP, and UL-MAP correctly configured in the downlink signal to be measured. And you need to set up general OFDMA signal parameters like radio std and preset profiles including BW, FFT size, BW ratio, guard Interval, frame duration, and downlink radio before using auto-detect function.

When you succeed with UL-MAP detection and decoding with a downlink signal, you can switch radio device from BS to MS and use the detected map in uplink modulation analysis.

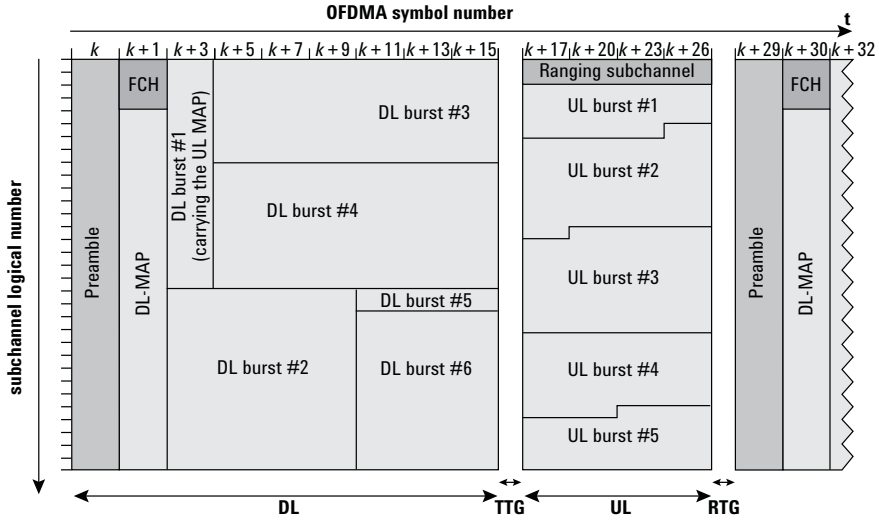



*Figure 7. Example of an OFDMA frame (with only mandatory zone) in TDD mode*

## Modulation analysis, continued

Here's an example procedure for running a DL-MAP/UL-MAP auto-detection with a downlink signal.

In this test signal, the default radio std and preset profile are used. If you would like to measure any downlink signals in different profiles or downlink ratio, for example, please make sure that the profiles are correctly set before playing the auto-detection.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Go to modulation analysis measurement | [Meas] Modulation Analysis |
| Play DL-MAP/UL-MAP auto-detection with the current downlink signal | [Meas Setup] Zone/Data Burst Map > Auto Detect Now |
| View the zone map information with measured RCE results for each burst (Figure 8) | [View/Display] Zone & Data Burst Info |

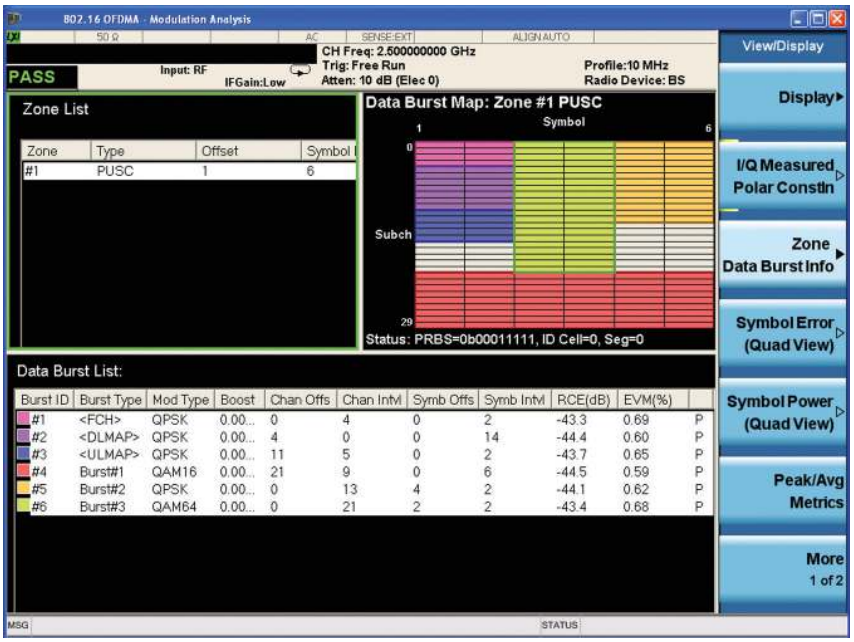



***Figure 8. Data burst summary information***

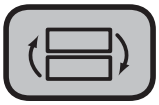
| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Turn on averaging from Off to On, 20 | [Meas Setup] Avg/Hold Num 100 On\|Off [20] [Enter] Avg/Hold Num 20 On\|Off |
| View the result metrics with averaging and peak hold (Figure 9) | [View/Display] Peak/Avg Metrics |
| View the spectral flatness view with pass/fail limits (Figure 10) | [View/Display] Spectral Flatness |


*Figure 9. Modulation analysis in statistic metrics*


*Figure 10. Spectral flatness*

Uplink modulation analysis.

| Instructions | Software operations |
|---|---|
| **On the Signal Studio for WiMAX software:** | |
| Create a new signal configuration | Press [**New**] on the top tool menu |
| Set the basic parameters of the signal at center frequency 2.5 GHz, amplitude –10 dBm | Click Signal Generator and set<br>Frequency = 2.5 GHz and<br>Amplitude = –10 dBm |
| Change the output mode from downlink only to uplink only (TDD) | Click **Waveform Setup** to see the fundamental waveform signal setups. Under Waveform Properties, you can set WiMAX common parameters as follows;<br>Built frames = 1<br>Frame duration = 5 [ms]<br>Output mode = uplink only (TDD) |
| Configure a single carrier signal including uplink | Click **Uplink, Zone#1 PUSC** for signal setup.<br>Permutation base = 0<br>Subchannel rotation = on<br>Number of symbols = 6<br>Auto allocation = on |
| Click Burst #1 | Modulation and coding = 16QAM (CC) ½<br>MAC PDU#1 with Data Length 420 bytes |
| Save the signal file for future reuse and to import in uplink modulation analysis | **File > Save As...> OFDMA_Demo2.scp** (Name it as you like) |
| Download the signal to MXG | Press **Generate and Download** on the top tool bar |

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Change the device from downlink to uplink | **[Mode Setup] Radio Device > BS \| MS** |
| Recall the map file for the correct demodulation | **[Recall] Data > Open**<br>Choose the file name already created by Signal Studio. OFDMA_Demo2.scp is for uplink signal analysis. |
| View the symbol power versus subcarrier, symbol power versus symbol traces with I/Q symbol constellation | **[View/Display] Symbol Power (Quad View)** |
| Change Y scale parameters to see power at each subcarrier in upper left window | **[AMPTD Y Scale] Ref Level [–30] dBm Scale/Div [2] dB** |
| Move the selected window to symbol power trace at upper right with Select Window button under the X-Series signal analyze display |  |
| Change Y scale parameters to see power at each symbol in upper right window | **[AMPTD Y Scale] Ref Level [–30] dBm Scale/Div [2] dB** |

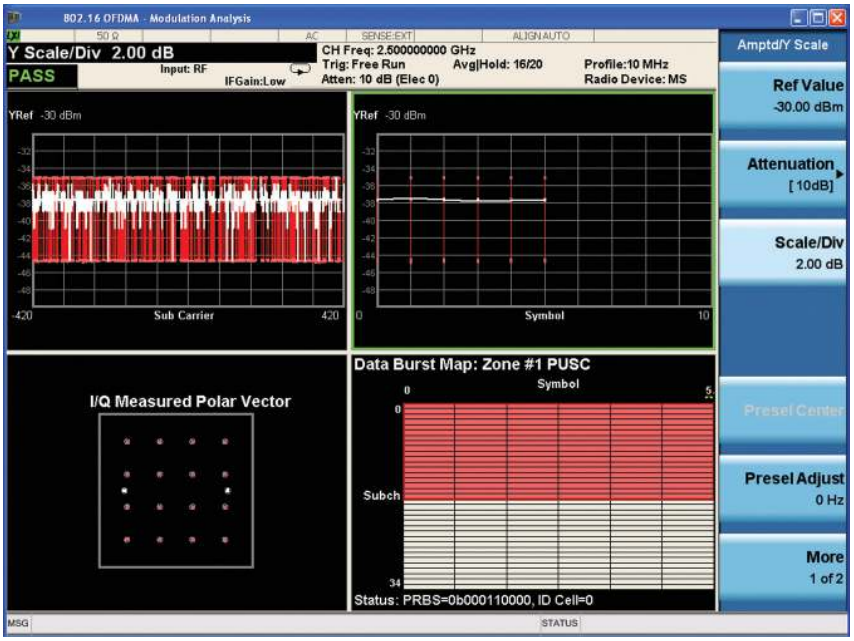



*Figure 11. Symbol power traces in quad view*

# Demonstration 8:

## Power statistics CCDF

The complementary cumulative distortion function (CCDF) is a plot which characterizes the signal's higher level power. It provides the distribution of peak-to-average power ratio (PAR) versus probability and fully characterized the power statistics of a signal. A CCDF curve is defined by how much time the waveform spends at or above the given power level.

Measurement setup parameters:

- Set a reference trace, compare to Gaussian noise trace
- Select measurement bandwidth and measurement interval
- Choose trigger source: video, line, external-½, RF burst, and periodic timer

This exercise illustrates the simplicity of measuring CCDF. Option B25 is required for wider analysis bandwidth up to 25 MHz available on X-Series signal analyzers.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series signal analyzer OFDMA mode:** | |
| Measure the CCDF | **[Meas] Power Stat CCDF** |
| Select external trigger. (Figure 12) | **[Trigger] External 1** |

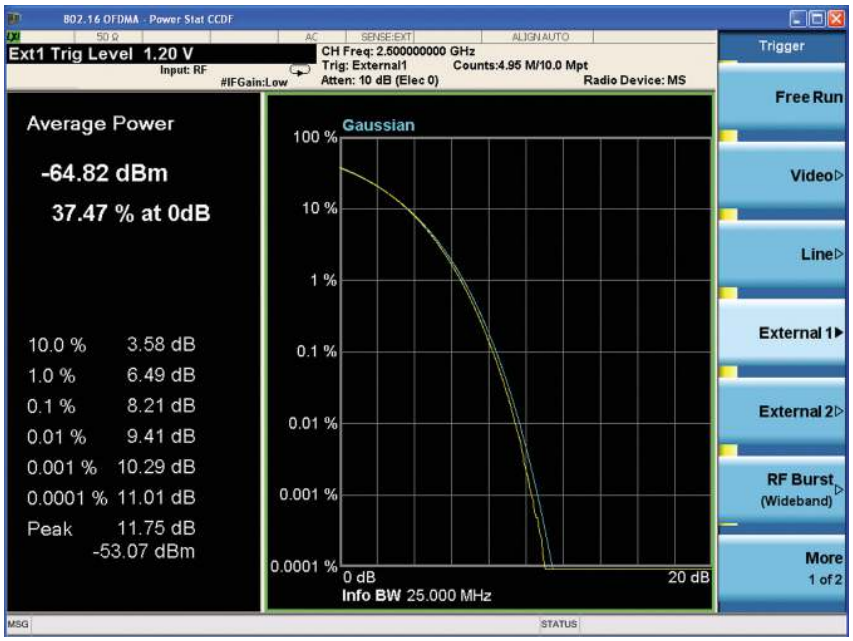



***Figure 12. CCDF***

# Web Resources

Product page:
www.keysight.com/find/n9075a and
www.keysight.com/find/w9075a

X-Series signal analyzers:
www.keysight.com/find/X-Series

X-Series advanced measurement applications:
www.keysight.com/find/X-Series_Apps

Signal Studio software:
www.keysight.com/find/SignalStudio

Signal generators:
www.keysight.com/find/sg

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**www.keysight.com/find/mykeysight**
A personalized view into the information most relevant to you.

**www.lxistandard.org**
LAN eXtensions for Instruments puts the power of Ethernet and the Web inside your test systems. Keysight is a founding member of the LXI consortium.

**www.keysight.com/find/ThreeYearWarranty**
Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.

**Keysight Assurance Plans**
**www.keysight.com/find/AssurancePlans**
Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.

**www.keysight.com/quality**
Keysight Electronic Measurement Group
DEKRA Certified ISO 9001:2008
Quality Management System

**Keysight Channel Partners**
**www.keysight.com/find/channelpartners**
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.



www.keysight.com/find/n9075a

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www.keysight.com/find/contactus

**Americas**

| | |
|---|---|
| Canada | (877) 894 4414 |
| Brazil | 55 11 3351 7010 |
| Mexico | 001 800 254 2440 |
| United States | (800) 829 4444 |

**Asia Pacific**

| | |
|---|---|
| Australia | 1 800 629 485 |
| China | 800 810 0189 |
| Hong Kong | 800 938 693 |
| India | 1 800 112 929 |
| Japan | 0120 (421) 345 |
| Korea | 080 769 0800 |
| Malaysia | 1 800 888 848 |
| Singapore | 1 800 375 8100 |
| Taiwan | 0800 047 866 |
| Other AP Countries | (65) 6375 8100 |

**Europe & Middle East**

| | |
|---|---|
| Austria | 0800 001122 |
| Belgium | 0800 58580 |
| Finland | 0800 523252 |
| France | 0805 980333 |
| Germany | 0800 6270999 |
| Ireland | 1800 832700 |
| Israel | 1 809 343051 |
| Italy | 800 599100 |
| Luxembourg | +32 800 58580 |
| Netherlands | 0800 0233200 |
| Russia | 8800 5009286 |
| Spain | 0800 000154 |
| Sweden | 0200 882255 |
| Switzerland | 0800 805353<br>Opt. 1 (DE)<br>Opt. 2 (FR)<br>Opt. 3 (IT) |
| United Kingdom | 0800 0260637 |

For other unlisted countries:
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