Agilent Technologies

ADS 2008
January 2008
Mobile WiMAX Wireless Test Benches

Acknowledgments
Mentor Graphics is a trademark of Mentor Graphics Corporation in the U.S. and other countries. Microsoft®, Windows®, MS Windows®, Windows NT®, and MS-DOS® are U.S. registered trademarks of Microsoft Corporation. Pentium® is a U.S. registered trademark of Intel Corporation. PostScript® and Acrobat® are trademarks of Adobe Systems Incorporated. UNIX® is a registered trademark of the Open Group. Java™ is a U.S. trademark of Sun Microsystems, Inc. SystemC® is a registered trademark of Open SystemC Initiative, Inc. in the United States and other countries and is used with permission. MATLAB® is a U.S. registered trademark of The Math Works, Inc.. HiSIM2 source code, and all copyrights, trade secrets or other intellectual property rights in and to the source code in its entirety, is owned by Hiroshima University and STARC.

Errata The ADS product may contain references to "HP" or "HPEESOF" such as in file names and directory names. The business entity formerly known as "HP EEsof" is now part of Agilent Technologies and is known as "Agilent EEsof". To avoid broken functionality and to maintain backward compatibility for our customers, we did not change all the names and labels that contain "HP" or "HPEESOF" references.

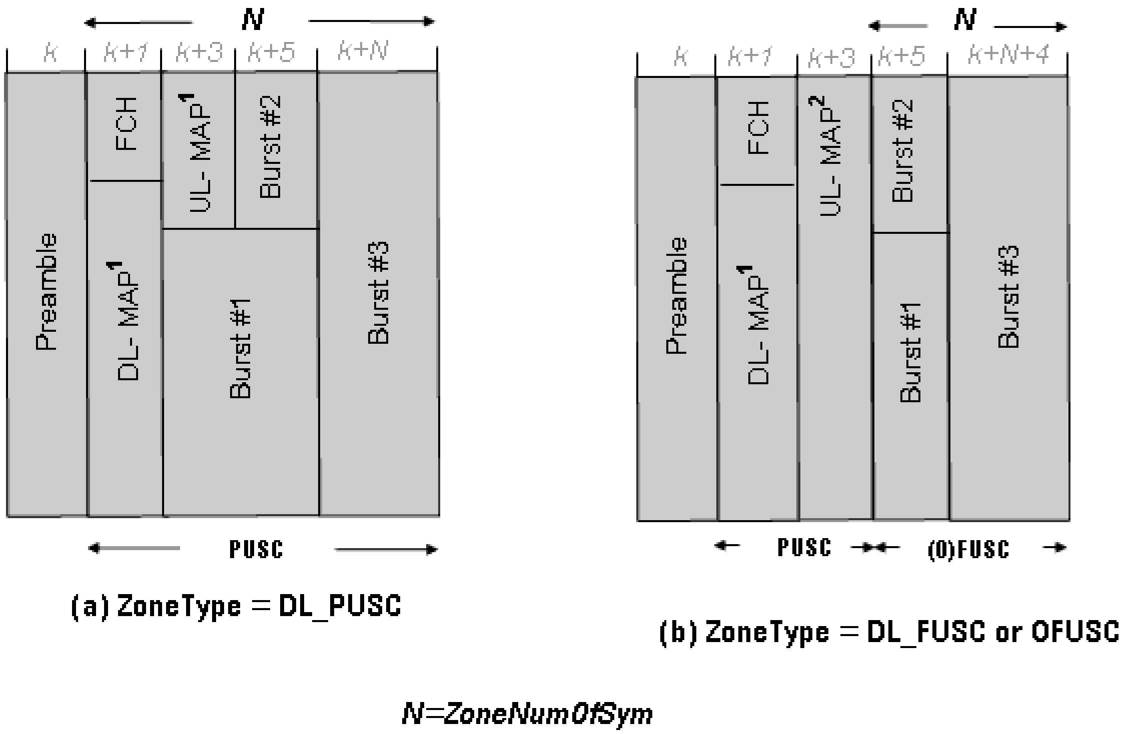
Contents

Mobile WiMAX Downlink Transmitter Test

The WMAN_DL_802_16e_TX transmitter test bench provides a way for users to connect to an RF circuit device under test (RF DUT) and determine its performance by activating various test bench measurements. This test bench provides signal measurements for RF envelope, signal power (including CCDF), constellation, spectrum, and EVM.

The signal and most of the measurements are designed according to References [1] and [2].

The Mobile WiMAX downlink frame structure is illustrated in Mobile WiMAX DL frame structure.



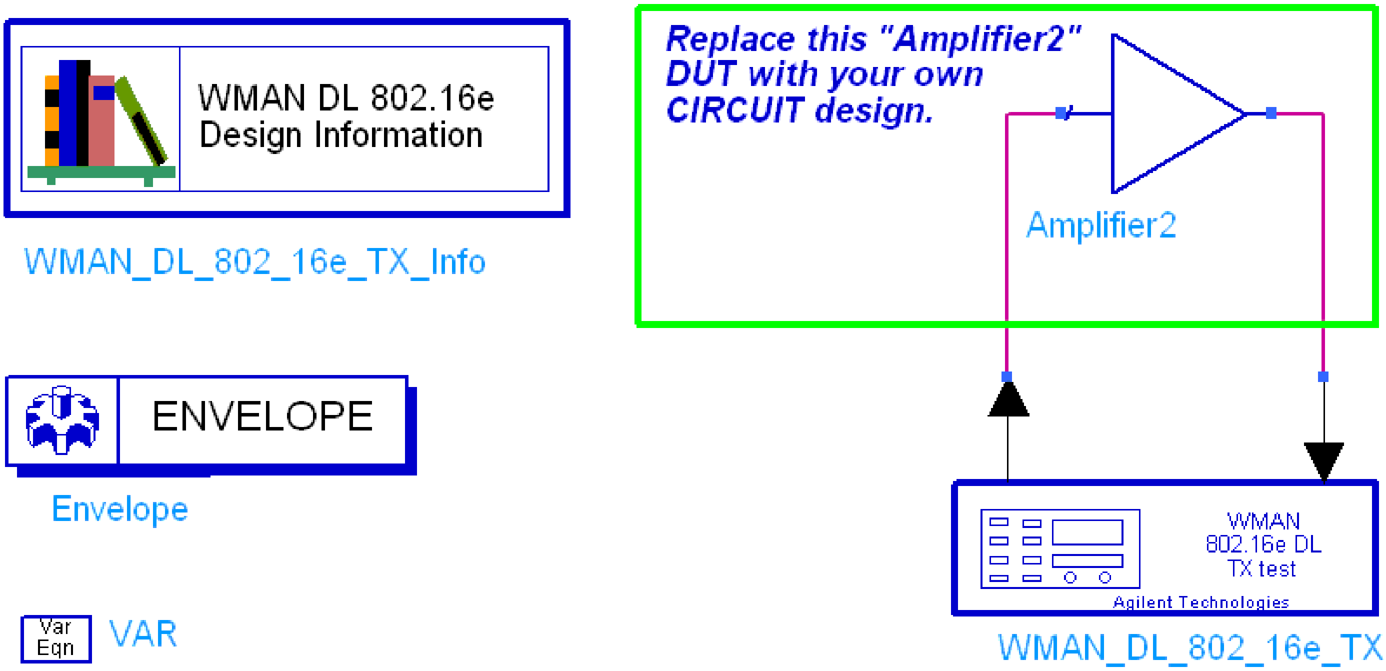
Mobile WiMAX DL frame structure

The downlink subframe starts with one preamble which consists of an OFDM symbol. Then the PUSC zone where FCH, DL-MAP and UL-MAP are allocated. The FCH information will be sent on the first four adjacent subchannels with successive logical subchannel numbers in the PUSC zone. The DL-MAP message immediately follows FCH. The UL-MAP message is always allocated on the third and fourth OFDM symbols if ULMAP_Enable is set to YES.

If ZoneType is DL_PUSC, then a single PUSC zone is defined (a in Mobile WiMAX DL frame structure). If ZoneType is DL_FUSC or DL_OFUSC, then two zones are defined: one is the PUSC zone where FCH is allocated, the other is the FUSC or OFUSC zone for allocating data bursts (b in Mobile WiMAX DL frame structure). ZoneNumOfSym is defined as the number of OFDM symbols for the zone which is allocated data bursts. One downlink frame contains maximum 8 data bursts except FCH, DL-MAP and UL-MAP, and each burst contains only one MAC PDU. Among these bursts, only one burst is FEC-encoded which is randomized, CC coded and interleaved. Other bursts will be provided PN sequences as their coded source respectively.

For DL_PUSC, the total number of symbols in the downlink subframe is (1+ZoneNumOfSym); For DL_FUSC or DL_OFUSC, the total number of symbols in the downlink subframe is (1+2+ULMAP_Enable□2+ZoneNumOfSym), where 1 is for the preamble, the first 2 are for the FCH and DL-MAP, the second 2 are for the UL-MAP, ULMAP_Enable is 1 when set to YES and 0 when set to NO.

Test Bench Basics



Mobile WiMAX DL Transmitter Test Bench

The basics for using the test bench are:

- Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench.
- CE_TimeStep, SourcePower, and FMeasurement parameter default values are typically accepted; otherwise, set values based on your requirements.
- Activate/deactivate measurements based on your requirements.
- Run the simulation and view Data Display page(s) for your measurement(s).

Test Bench Details

The following sections provide details for setting up a test bench, setting measurement parameters for more control of the test bench, simulation measurement displays, and baseline performance.
Open and use the WMAN_DL_802_16e_TX_test template:

1. In an Analog/RF schematic window, choose Insert > Template .

2. In the Insert > Template dialog box, choose WMAN_DL_802_16e_TX_test , click OK ; click left to place the template in the schematic window.

Test bench setup is detailed here.

1. Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench. For information regarding using certain types of DUTs, refer to RF DUT Limitations.
2. Set the Required Parameters.

> Note
> Refer to WMAN_DL_802_16e_TX for a complete list of parameters for this test bench.

Generally, default values can be accepted; otherwise, values can be changed by the user as needed.

- Set CE_TimeStep.
  Cosimulation occurs between the test bench (using ADS Ptolemy Data Flow simulation technology) and the DUT (using Agilent Circuit Envelope simulation technology). Each technology requires its own simulation time step with time-step coordination occurring in the interface between the technologies.
  CE_TimeStep defines the Circuit Envelope simulation time step to be used with this DUT. The CE_TimeStep must be set to a value equal to or a submultiple of (less than) WTB_TimeStep; otherwise, simulation will stop and an error message will be displayed.
  Note that WTB_TimeStep is not user-settable. Its value is derived from other test bench parameter values. The value is displayed in the Data Display pages as TimeStep.
  WTB_TimeStep = 1/(RF_SamplingRate × Ratio)
  where
  The RF_SamplingRate (Fs) implemented in the design is decided by Bandwidth and related sampling factor (N_{factor}) as follows, $F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

  Bandwidth is the user-settable value (default 10 MHz)
  Ratio is the oversampling ratio related to OversamplingOption as Ratio = 2 OversamplingOption .

- Set SourcePower, and FMeasurement.
  - SourcePower defines the power level for FSource. SourcePower is defined as the peak power during the non-idle time of the signal frame.
  - FMeasurement defines the RF frequency output from the DUT to be measured.

3. Activate/deactivate (YES / NO) test bench measurements (refer to WMAN_DL_802_16e_TX). At least one measurement must be enabled:
   - RF_EnvelopeMeasurement
   - Constellation
   - PowerMeasurement
   - SpectrumMeasurement

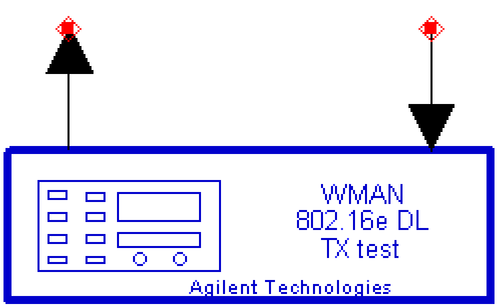
- EVM_Measurement

4. More control of the test bench can be achieved by setting Basic Parameters , Signal Parameters , and parameters for each activated measurement. For details, refer to Setting Parameters.
5. The RF modulator of WMAN_DL_802_16e_TX (shown in the block diagram in Mobile WiMAX DL Transmitter Test Bench) uses SourcePower (Required Parameters), GainImbalance, PhaseImbalance(Signal Parameters).
   The RF output resistance uses SourceR, SourceTemp, and EnableSourceNoise (Basic Parameters). The RF output signal source has a 50-ohm (default) output resistance defined by SourceR.
   RF output (and input to the RF DUT) is with the specified source resistance (SourceR) and with power (SourcePower) delivered into a matched load of resistance SourceR. The RF signal has additive Gaussian noise power set by resistor temperature (SourceTemp) (when EnableSourceNoise=YES).
   Note that the Meas point of the test bench provides a resistive load to the RF DUT set by the MeasR value (50-ohm default) (Basic Parameters).
   The Meas signal contains linear and nonlinear signal distortions and time delays associated with the RF DUT input to output characteristics.
   The DSP block of WMAN_DL_802_16e_TX (shown in the block diagram in Mobile WiMAX DL Transmitter Test Bench) uses other Signal Parameters .
6. More control of Circuit Envelope analysis can be achieved by setting Envelope controller parameters. These settings include Enable Fast Cosim, which may speed the RF DUT simulation more than 10×. Setting these simulation options is described in Setting Fast Cosimulation Parameters and Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation.
7. To run a simulation, choose Simulate > Simulate in the Schematic window.
   For details on Running a Simulation refer to the Wireless Test Bench Simulation documentation.
8. Simulation results will appear in a Data Display window for each measurement. Simulation Measurement Displays describes results for each measurement available for this test bench.

For details on Viewing Results refer to the Wireless Test Bench Simulation documentation.

WMAN_DL_802_16e_TX

This section provides parameter information for Required Parameters, Basic Parameters, Signal Parameters, and parameters for the various measurements.



Setting Parameters

More control of the test bench can be achieved by setting parameters in the Basic Parameters , Signal Parameters , and measurement categories for the activated measurements.

> Note
> For required parameter information, see Set the Required Parameters..

Basic Parameters

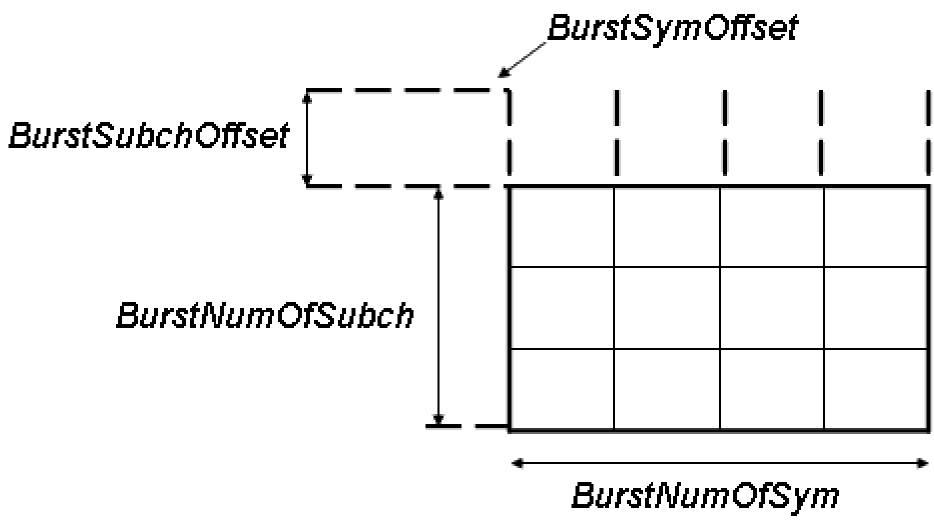
1. SourceR is the RF output source resistance.
2. SourceTemp is the RF output source resistance temperature (oC) and sets noise density in the RF output signal to (k(SourceTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
3. EnableSourceNoise, when set to NO disables the SourceTemp and effectively sets it to -273.15oC (0 Kelvin). When set to YES, the noise density due to SourceTemp is enabled.
4. MeasR defines the load resistance for the RF DUT output Meas signal into the test bench. This resistance loads the RF DUT output; it is also the reference resistance for Meas signal power measurements.
5. TestBenchSeed is an integer used to seed the random number generator used with the test bench. This value is used by all test bench random number generators, except those RF DUT components that use their own specific seed parameter. TestBenchSeed initializes the random number generation. The same seed value produces the same random results, thereby giving you predictable simulation results. To generate repeatable random output from simulation to simulation, use any positive seed value. If you want the output to be truly random, enter the seed value of 0.

Signal Parameters

1. GainImbalance, PhaseImbalance are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
   The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
   $$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$
   where A is a scaling factor that depends on the SourcePower and SourceR parameters specified by the user, V I(t) is the in-phase RF envelope, V Q(t) is the quadrature phase RF envelope, g is the gain imbalance
   $$g = 10^{\frac{GainImbalance}{20}}$$
   and, φ (in degrees) is the phase imbalance.
2. Bandwidth determines the nominal channel bandwidth.
3. OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
4. FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
5. CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
6. FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame.

7. DL_Ratio specifies set the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
8. FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the specification.
9. DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink burst.
10. ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink burst.
11. PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
12. FrameNumber specifies the starting frame number in the downlink subframe.
13. FrameIncreased specifies whether the frame number for the downlink subframe is increased. When FrameIncreased is set to YES, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber , FrameNumber+1 , FrameNumber+2 , FrameNumber+3 . When FrameIncreased is set to NO, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber , FrameNumber , FrameNumber , FrameNumber .
14. DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
15. DCD_Count specifies the DCD count which is used in DL-MAP and DCD messages. This is incremented by one (modulo 256) whenever there is a downlink configuration change.
16. BSID specifies the base station ID which is used in DL-MAP message.
17. PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
18. For DataPattern:
    - if PN9 is selected, a 511-bit pseudo-random test pattern is generated according to CCITT Recommendation O.153.
    - if PN15 is selected, a 32767-bit pseudo-random test pattern is generated according to CCITT Recommendation O.151.
    - if FIX4 is selected, a zero-stream is generated.
    - if x_1_x_0 is selected (where x equals 4, 8, 16, 32, or 64) a periodic bit stream is generated, with the period being 2 x. In one period, the first x bits are 1s and the second x bits are 0s.
    - if S_QPSK, S_16-QAM or S_64-QAM is selected, sequences below are generated. These are test messages for receiver sensitivity measurement.
      S_QPSK = [0xE4, 0xB1, 0xE1, 0xB4]
      S_16-QAM = [0xA8, 0x20, 0xB9, 0x31, 0xEC, 0x64, 0xFD, 0x75]
      S_64-QAM = [0xB6, 0x93, 0x49, 0xB2, 0x83, 0x08, 0x96, 0x11, 0x41, 0x92, 0x01, 0x00, 0xBA, 0xA3, 0x8A, 0x9A, 0x21, 0x82, 0xD7, 0x15, 0x51, 0xD3, 0x05, 0x10, 0xDB, 0x25, 0x92, 0xF7, 0x97, 0x59, 0xF3, 0x87, 0x18, 0xBE, 0xB3, 0xCB, 0x9E, 0x31, 0xC3, 0xDF, 0x35, 0xD3, 0xFB, 0xA7, 0x9A, 0xFF, 0xB7, 0xDB]
19. AutoMACHeaderSetting specifies whether the MAC header is automatically generated or input by users. If it is set to NO, data sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.
20. MAC_Header specifies t 6 bytes of MAC header before the data contents. The cell is only active when the AutoMACHeaderSetting is set to NO.
21. CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU.
22. ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
23. ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
24. GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
25. NumberOfBurst specifies the number of active downlink bursts.
26. BurstWithFEC specifies the downlink burst FEC.

27. BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, see Downlink rectangular burst structure.



Downlink rectangular burst structure

28. DataLength specifies MAC PDU payload byte length for each burst.
29. CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose meaning is shown below.

The meaning of coding type

Coding type	meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

30. Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in the following table.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4

1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

31. RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in the following table.

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4 used on the burst
3	Repetition coding of 6 used on the burst

32. PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
33. DLMAP_CodingType specifies the rate ID for the burst carrying DL-MAP and DCD messages.
34. DLMAP_RepetitionCoding specifies the repetition coding for the burst carrying DL-MAP and DCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in Figure1.
35. ULMAP_CodingType specifies the rate ID for the burst carrying UL-MAP and UCD messages.
36. ULMAP_Rate_ID specifies the rate ID for the burst carrying UL-MAP and UCD messages.
37. ULMAP_RepetitionCoding specifies the repetition coding for the burst carrying UL-MAP and UCD messages. This parameter can be selected from 0 to 3, whose meaning is shown in The meaning of repetition coding.
38. ULMAP_PowerBoosting specifies the power boosting for the burst carrying UL-MAP and UCD messages. This parameter is defined in units of dB.
39. UL_ZoneType specifies the uplink zone permutation. This parameter is used in the UL_Zone_IE() IE.
40. UL_ZoneSymOffset specifies the offset of the OFDMA symbol in which the uplink zone starts, the offset value is defined in units of OFDMA symbols and is relevant to the Allocation Start Time field given in the UL-MAP message. This parameter is used in the UL_Zone_IE() IE.
41. UL_ZoneNumOfSym specifies the Connection Identifier (CID) for each uplink burst. This parameter is used in the OFDMA UL_MAP IE.
42. UL_PermBase specifies the basis of uplink permutation. This parameter is used in the UL_Zone_IE() IE.
43. UL_AllSCIndicator specifies whether all subchannel shall be used. When the UL_AllSCIndicator is set to 0, subchannels indicated by allocated subchannel bitmap in UCD shall be used. Otherwise all subchannels shall be used. This parameter is used in the UL_Zone_IE() IE.
44. UCD_Count specifies the UCD count which is used in the UL_MAP and UCD messages. It is incremented by one (modulo 256) whenever there is an uplink configuration change.
45. UL_NumberOfBurst specifies the number of the uplink bursts. This parameter is used to determine the number of OFDMA UL-MAP IE in UL-MAP message.
46. UL_CID specifies the Connection Identifier (CID) for each uplink burst. This parameter is used in the OFDMA UL-MAP IE.
47. UL_CodingType specifies the coding type for each uplink burst. Each coding type can be selected from 0 to 1, whose meaning is shown in The relation of Coding type and Rate ID (or where 0 is CC and 1 is CTC). This parameter is used in the OFDMA UL-MAP IE.
48. UL_Rate_ID specifies the rate ID for each uplink burst. UL_Rate_ID, along with UL_CodingType, determines the

modulation, coding rate, shown in The relation of Coding type and Rate ID. This parameter is used in the OFDMA UL-MAP IE.

49. UL_BurstAssignedSlot specifies the duration for each uplink burst in units of OFDMA slots. This parameter is used in the OFDMA UL-MAP IE.
50. UL_RepetitionCoding specifies the repetition coding for each uplink burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in The meaning of repetition coding. This parameter is used in the OFDMA UL-MAP IE.

RF Envelope Measurement Parameters

Depending on the values of RF_EnvelopeStart, RF_EnvelopeStop.

1. RF_EnvelopeDisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.
2. RF_EnvelopeStart sets the start time for collecting input data.
3. RF_EnvelopeStop sets the stop time for collecting input data.

For information about TimeStep, see Test Bench Variables for Data Displays.

Constellation Parameters

ConstellationDisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.

Power Measurement Parameters

1. PowerDisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.
2. PowerBursts sets the number of bursts over which data will be collected.

Spectrum Measurement Parameters

The Spectrum measurement calculates the spectrum of the input signal.

In the following, TimeStep denotes the simulation time step, and FMeasurement denotes the measured RF signal characterization frequency.

1. The measurement outputs the complex amplitude voltage values at the frequencies of the spectral tones. It does not output the power at the frequencies of the spectral tones. However, one can calculate and display the power spectrum as well as the magnitude and phase spectrum by using the dBm, mag, and phase functions of the data display window.
   Note that the dBm function assumes a 50-ohm reference resistance; if a different measurement was used in the test bench, its value can be specified as a second argument to the dBm function, for example, dBm(SpecMeas, Meas_RefR) where SpecMeas is the instance name of the spectrum measurement and Meas_RefR is the resistive load.
   The basis of the algorithm used by the spectrum measurement is the chirp-Z transform. The algorithm can use multiple bursts and average the results to achieve video averaging.
2. SpecMeasDisplayPages is not user editable. It provides information on the name of the Data Display pages in which this measurement is contained.
3. SpecMeasStart sets the start time for collecting input data.
4. SpecMeasStop sets the stop time for collecting input data.
5. SpecMeasResBW sets the resolution bandwidth of the spectrum measurement when SpecMeasResBW>0.
   NENBW = normalized equivalent noise bandwidth of the window
   Equivalent noise bandwidth (ENBW) compares the window to an ideal, rectangular filter. It is the equivalent width of a rectangular filter that passes the same amount of white noise as the window. The normalized ENBW (NENBW) is ENBW multiplied by the duration of the signal being windowed. Window Options and Normalized Equivalent Noise Bandwidth lists the NENBW for the various window options.
   The Start and Stop times are used for both the RF and Meas signal spectrum analyses. The Meas signal is delayed in time from the RF signal by the value of the RF DUT time delay. Therefore, for RF DUT time delay greater than zero, the RF and Meas signal are inherently different and some spectrum display difference in the two is expected.
   TimeStep is defined in the Test Bench Variables for Data Displays section.
6. SpecMeasWindow specifies the window that will be applied to each burst before its spectrum is calculated. Different windows have different properties, affect the resolution bandwidth achieved, and affect the spectral shape. Windowing is often necessary in transform-based (chirp-Z, FFT) spectrum estimation in order to reduce spectral distortion due to discontinuous or non-harmonic signal over the measurement time interval. Without windowing, the estimated spectrum may suffer from spectral leakage that can cause misleading measurements or masking of weak signal spectral detail by spurious artifacts.
   The windowing of a signal in time has the effect of changing its power. The spectrum measurement compensates for this and the spectrum is normalized so that the power contained in it is the same as the power of the input signal.
   Window Type Definitions:
   - none:

     $$w(kT_s) = \begin{cases} 1.0 & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

     where N is the window size
   - Hamming 0.54:

     $$w(kT_s) = \begin{cases} 0.54 - 0.46\cos\left(\frac{2\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

     where N is the window size
   - Hanning 0.5:

$$w(kT_s) = \begin{cases} 0.5 - 0.5\cos\left(\frac{2\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size

- Gaussian 0.75:

$$w(kT_s) = \begin{cases} exp\left(-\frac{1}{2}\left(0.75\frac{(2k-N)}{N}\right)^2\right) & 0 \le \left|k - \frac{N}{2}\right| \le \frac{N}{2} \\ 0.0 & otherwise \end{cases}$$

where N is the window size

- Kaiser 7.865:

$$w(kT_s) = \begin{cases} \dfrac{I_0\left(7.865\left[1-\left(\frac{k-\alpha}{\alpha}\right)^2\right]^{1/2}\right)}{I_0(7.865)} & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size, $\alpha = N / 2$, and $I_0(.)$ is the 0th order modified Bessel function of the first kind

- 8510 6.0 (Kaiser 6.0):

$$w(kT_s) = \begin{cases} \dfrac{I_0\left(6.0\left[1-\left(\frac{k-\alpha}{\alpha}\right)^2\right]^{1/2}\right)}{I_0(6.0)} & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size, $\alpha = N / 2$, and $I_0(.)$ is the 0th order modified Bessel function of the first kind

- Blackman:

$$w(kT_s) = \begin{cases} 0.42 - 0.5\cos\left(\frac{2\pi k}{N}\right) + 0.08\cos\left(\frac{4\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size

- Blackman-Harris:

$$w(kT_s) = \begin{cases} 0.35875 - 0.48829\cos\left(\frac{2\pi k}{N}\right) + 0.14128\cos\left(\frac{4\pi k}{N}\right) - 0.01168\cos\left(\frac{6\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size.

Window and Default Constant	NENBW
none	1
Hamming 0.54	1.363

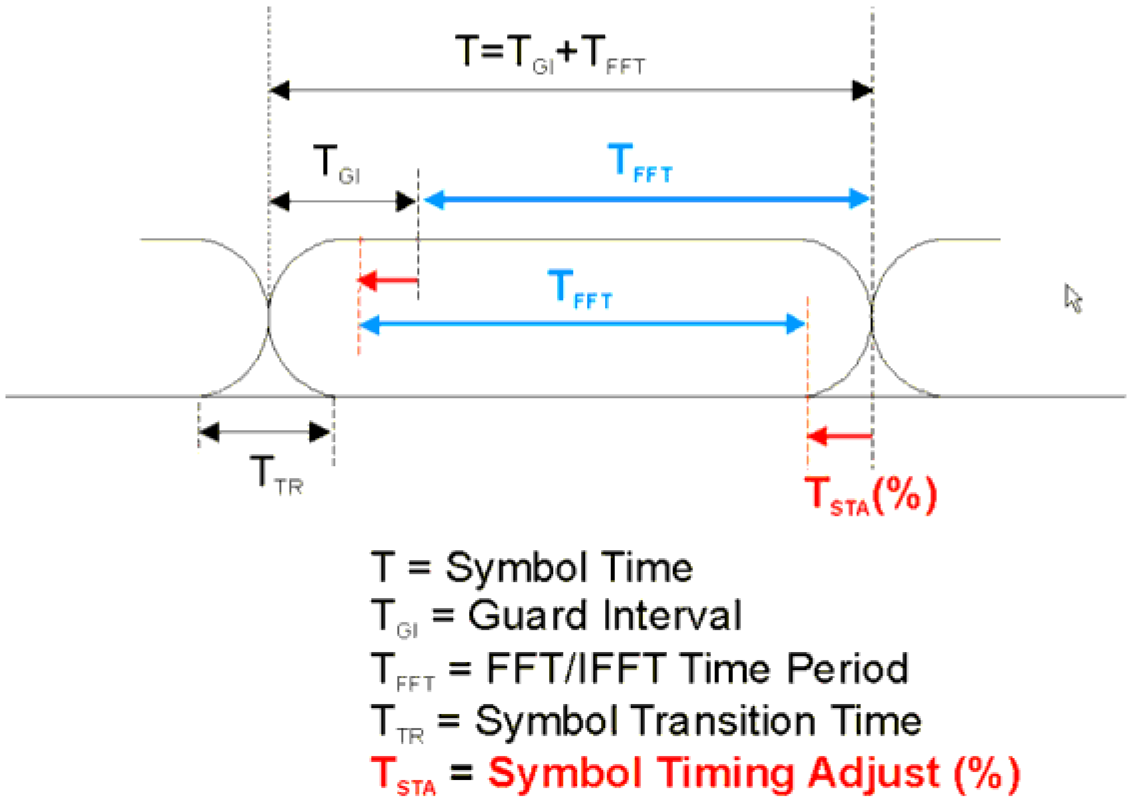
Hanning 0.50	1.5
Gaussian 0.75	1.883
Kaiser 7.865	1.653
8510 6.0	1.467
Blackman	1.727
Blackman-Harris	2.021

EVM Measurement Parameters

The EVM measurement is used to measure the EVM of Mobile WiMAX RF signal source with frequency hopping used, and needs no reference signal provided by the source.

1. EVM_DisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.
2. EVM_Start sets the start time for collecting input data.
3. If EVM_AverageType is set to OFF , only one frame is analyzed. If EVM_AverageType is set to RMS (Video), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 x FrameDuration. A second frame is analyzed and the process repeats until EVM_FramesToAverage frames are processed.
4. EVM_FramesToAverage sets the frame number used for averaging.
5. Starting at the time instant specified by the EVM_Start parameter, the component captures a signal segment of length 2 x FrameDuration. If EVM_PulseSearch is set to YES, this signal segment is searched in order for an RF burst to be detected. If the signal has multiple RF bursts in a FrameDuration then the first one detected is the one that will be analyzed. Some 802.16e OFDMA signals do not have RF burst characteristics, rather they look like a series of bursts with no "off" time between them. These signals resemble a "continually on" signal with embedded preambles. To demodulate signals that do not appear to be made up of RF bursts, EVM_PulseSearch should be set to OFF and EVM_Start should be set to the beginning of the downlink subframe you want to analyze. Otherwise, no pulse will be detected and no measurement will be performed.
   After an RF burst is detected, the I and Q envelopes of the input signal are extracted. The I and Q envelopes are passed to a complex algorithm that performs synchronization, demodulation, and EVM analysis. The algorithm that performs the synchronization, demodulation, and EVM analysis is the same as the one used in the Agilent 89600 VSA.
6. The EVM_SymbolTimingAdjust parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. Normally, when demodulating an OFDMA symbol, the cyclic prefix time (guard interval) is skipped and an FFT is performed on the last portion of the symbol time. However, this means that the FFT will include the transition region between this symbol and the following symbol. To avoid this, it is generally beneficial to back away from the end of the symbol time and use part of the guard interval. The EVM_SymbolTimingAdjust parameter controls how far the FFT part of the symbol is adjusted away from the end of the symbol time. The value is in terms of percent of the used (FFT) part of the symbol time. Note that this parameter value is negative, because the FFT start time is moved back by this parameter.
   EVM_SymbolTimingAdjust Definition. explains this concept. When setting this parameter, be careful to not back away from the end of the symbol time too much because this may make the FFT include corrupt data from the

transition region at the beginning of the symbol time.



EVM_SymbolTimingAdjust Definition.

1. The EVM_TrackAmplitude, EVM_TrackPhase, and EVM_TrackTiming parameters specify whether the analysis will track amplitude, phase, and timing changes in the pilot subcarriers. 802.16e performs demodulation relative to the data in pilot carriers embedded in the signal. These pilot carriers replace data-carrying elements of the signal and allow some kinds of impairments to be removed or "tracked out." Many impairments will be common to all pilot carriers and can be measured as the "common pilot error." When these parameters are set to YES the analysis will track amplitude, phase, and timing changes in the pilot subcarriers and apply corrections to the pilot and data subcarriers.
   The flexibility to allow users to individually enable or disable tracking functions, provides useful troubleshooting capability, since modulation errors can be examined with and without the benefit of particular types of pilot tracking.
2. The EVM_EqualizerTraining parameter sets the type of training used for the equalizer. When demodulating an 802.16e signal, an equalizer is used to correct for linear impairments in the signal path, such as multi-path. When "Chan Estimation Seq Only" is selected the equalizer is trained using the Channel Estimation Sequence in the preamble of the OFDMA burst. After this initialization, the equalizer coefficients are held constant while demodulating the rest of the burst. This equalizer training method complies with the description in the "Transmit constellation error and test method" section (8.4.12.3) of the 802.16-2004 standard. However, for signals whose impairments change during the burst it might result in measured RCE (EVM) values that are higher compared to

if the equalizer were trained over the entire burst.
When "Chan Estimation Seq & Data" is selected the equalizer is trained by analyzing the entire OFDMA burst and using the Channel Estimation Sequence (contained in the preamble) and the all the subcarriers in the Data symbols. This type of equalizer training generally gives a more accurate estimate of the true response of the transmission channel and so results in lower RCE (EVM) measured values. However, it is more complicated and more computationally expensive to implement and therefore less likely to be used in practical receivers.
When "Chan Estimation Seq & Pilots" is selected the equalizer is trained by analyzing the entire OFDMA burst and using the Channel Estimation Sequence (contained in the preamble) and the pilot subcarriers in the Data symbols. This gives results very similar to the "Chan Estimation Seq & Data" option without the excessive computational complexity.

Simulation Measurement Displays

After running the simulation, results are displayed in Data Display pages for each measurement activated.

> Note
> Measurement results from a wireless test bench have associated names that can be used in Data Display Expressions. For more information, refer to Measurement Results for Expressions .

Envelope Measurement

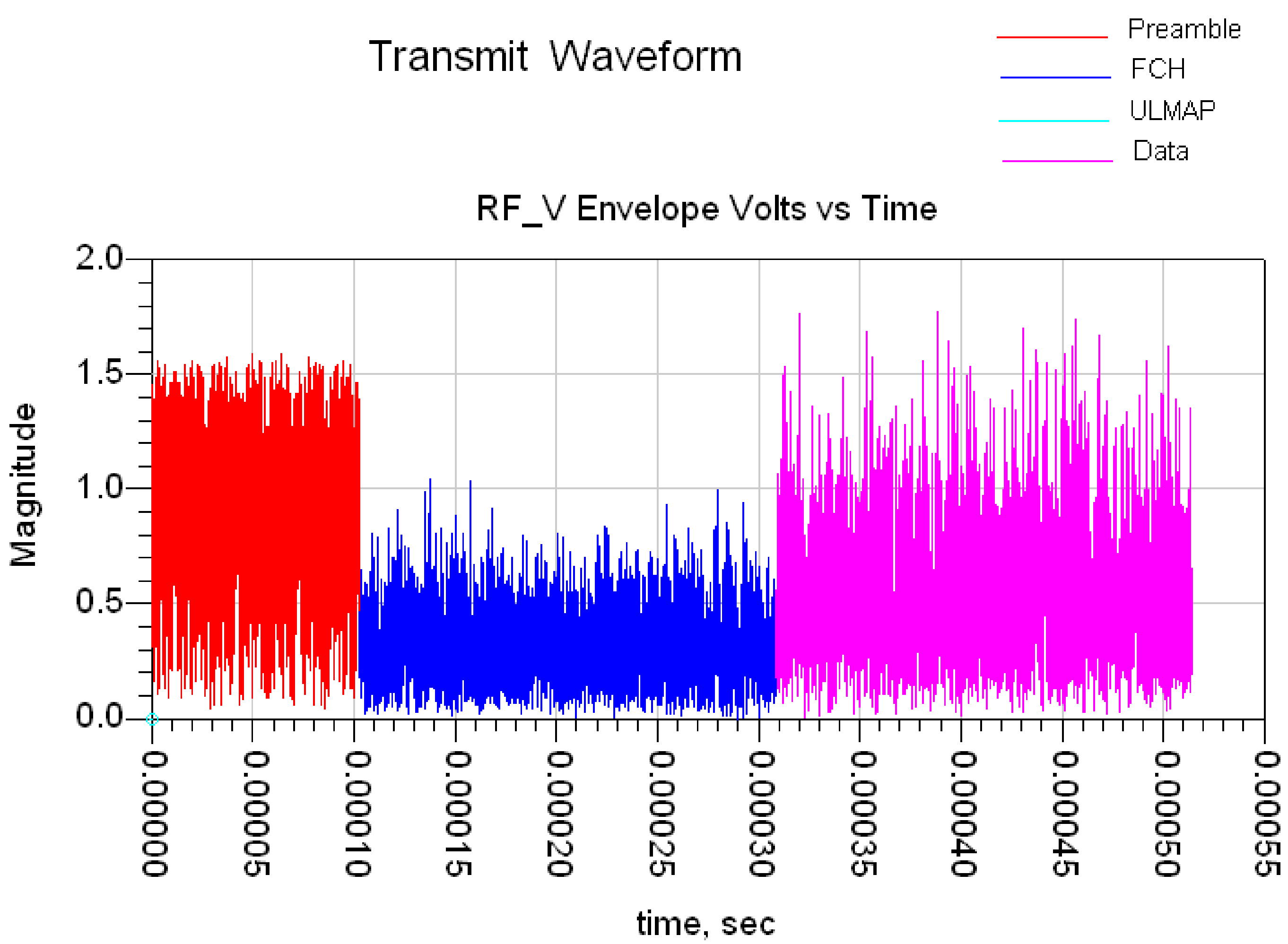
The Envelope measurement shows the envelope of each field in the Mobile WiMAX frame (Preamble, FCH, and DATA fields). Two signals are tested, the RF source signal at the RF DUT input and the Meas signal at the RF DUT output.

For envelope measurement, the default parameter setting is given in Default Parameter Setting for Measurement.

Parameter	Default Setting
RF_FSource	2305.0 MHz
RF_R	50.0 Ohm
RF_Power	10.0 dBm
Bandwidth	10.0 MHz
RateID	5
CyclicPrefix	0.125
Frame_Duration	5.0 msec
TimeStep	44.643 nsec
SamplingFrequency	11.2 MHz
Frame_Mode	TDD

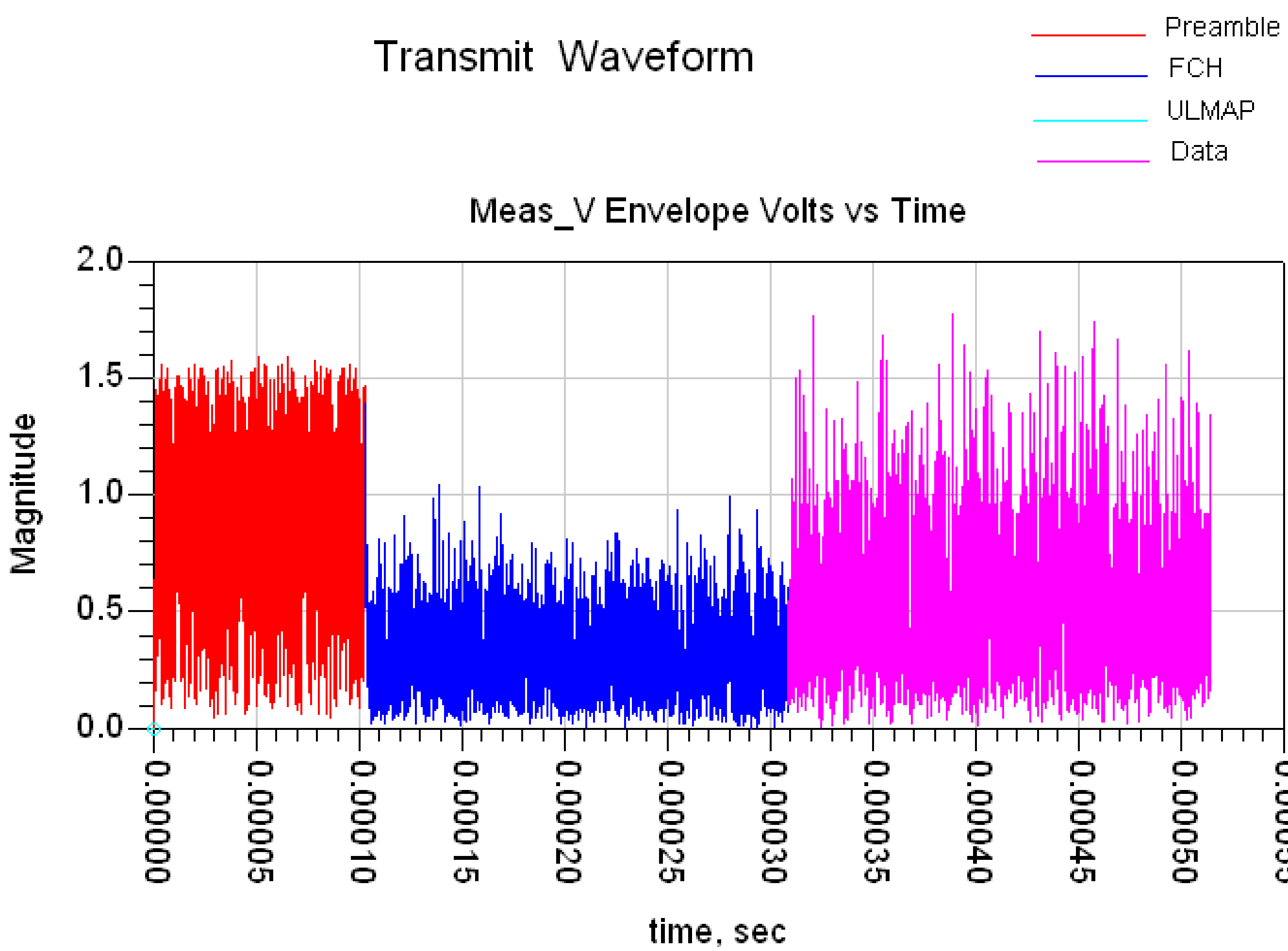
DL_Ratio	0.618
Data_Length	710
Meas_FMeasurement	2305.0 MHz
Meas_R	50.0 Ohm

For the RF signal, the time domain envelope of one complete Mobile WiMAX frame, as well as preamble, FCH, and DATA fields are shown in Time Envelope of Mobile WiMAX RF Signal for Default Settings (one frame).



Time Envelope of Mobile WiMAX RF Signal for Default Settings (one frame)

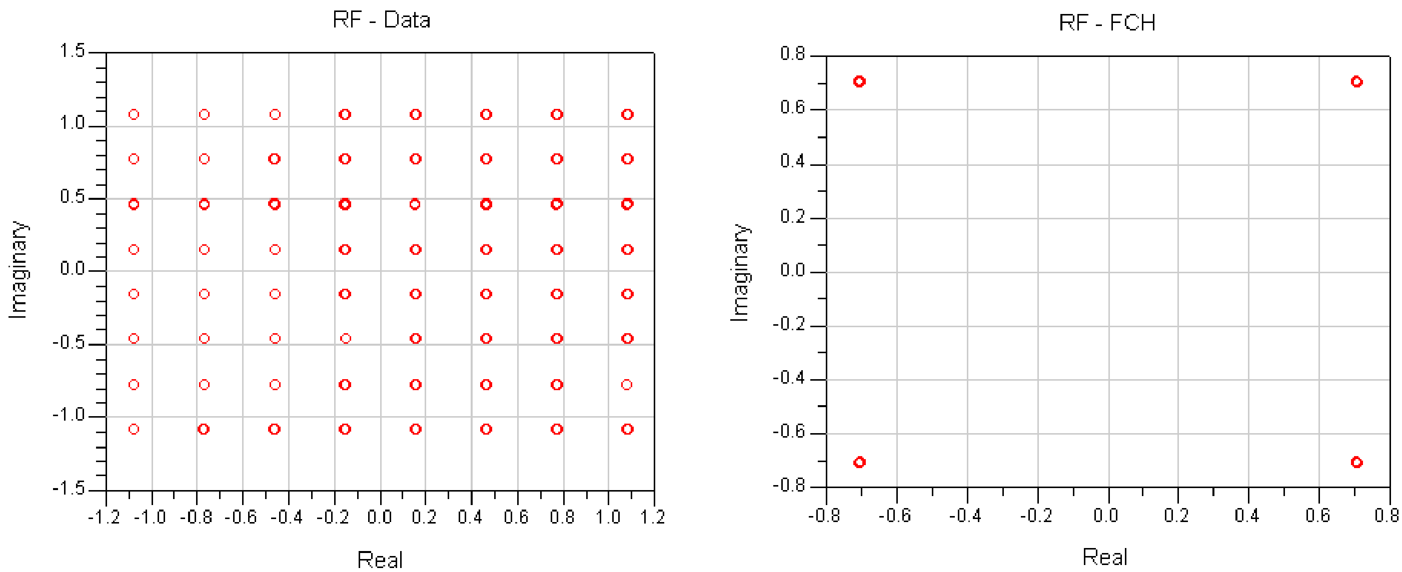
For the Meas signal test, all measurements are the same as RF signal measurements, except the Meas signal will contain any linear and nonlinear distortions. Envelope measurements for Meas signal are shown in Time Envelope of Mobile WiMAX Meas Signal for Default Settings (one frame).



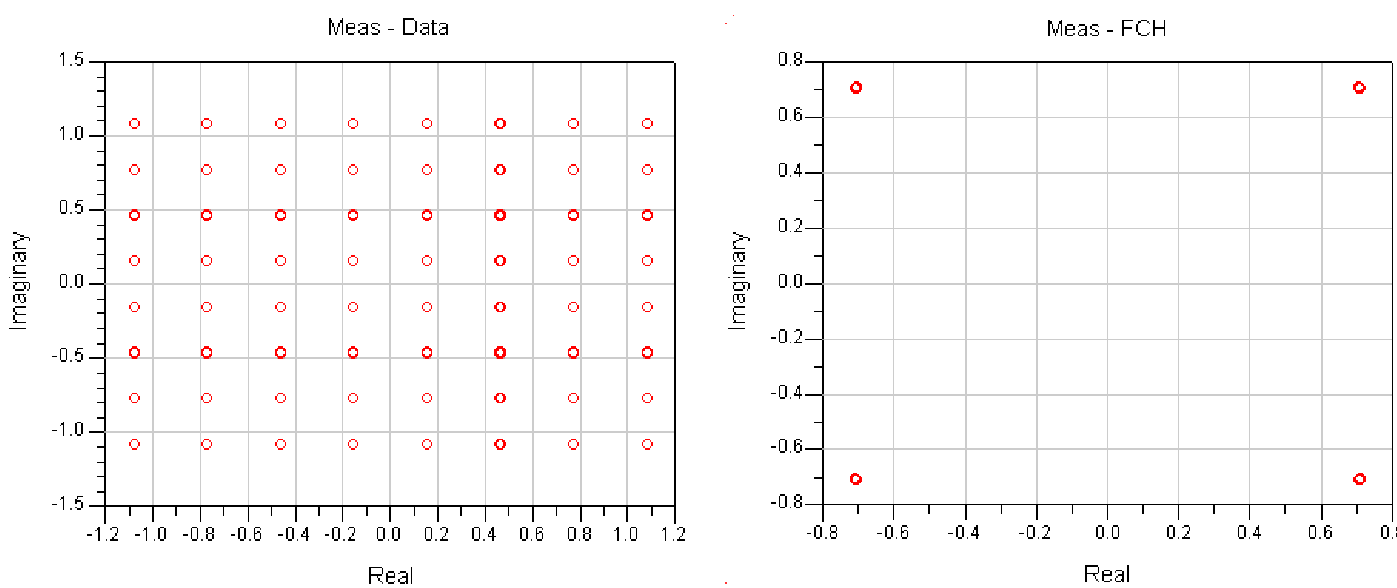
Time Envelope of Mobile WiMAX Meas Signal for Default Settings (one frame)

Constellation Measurement

The constellation measurement shows the RF and Meas signal constellations.



RF Signal Constellation

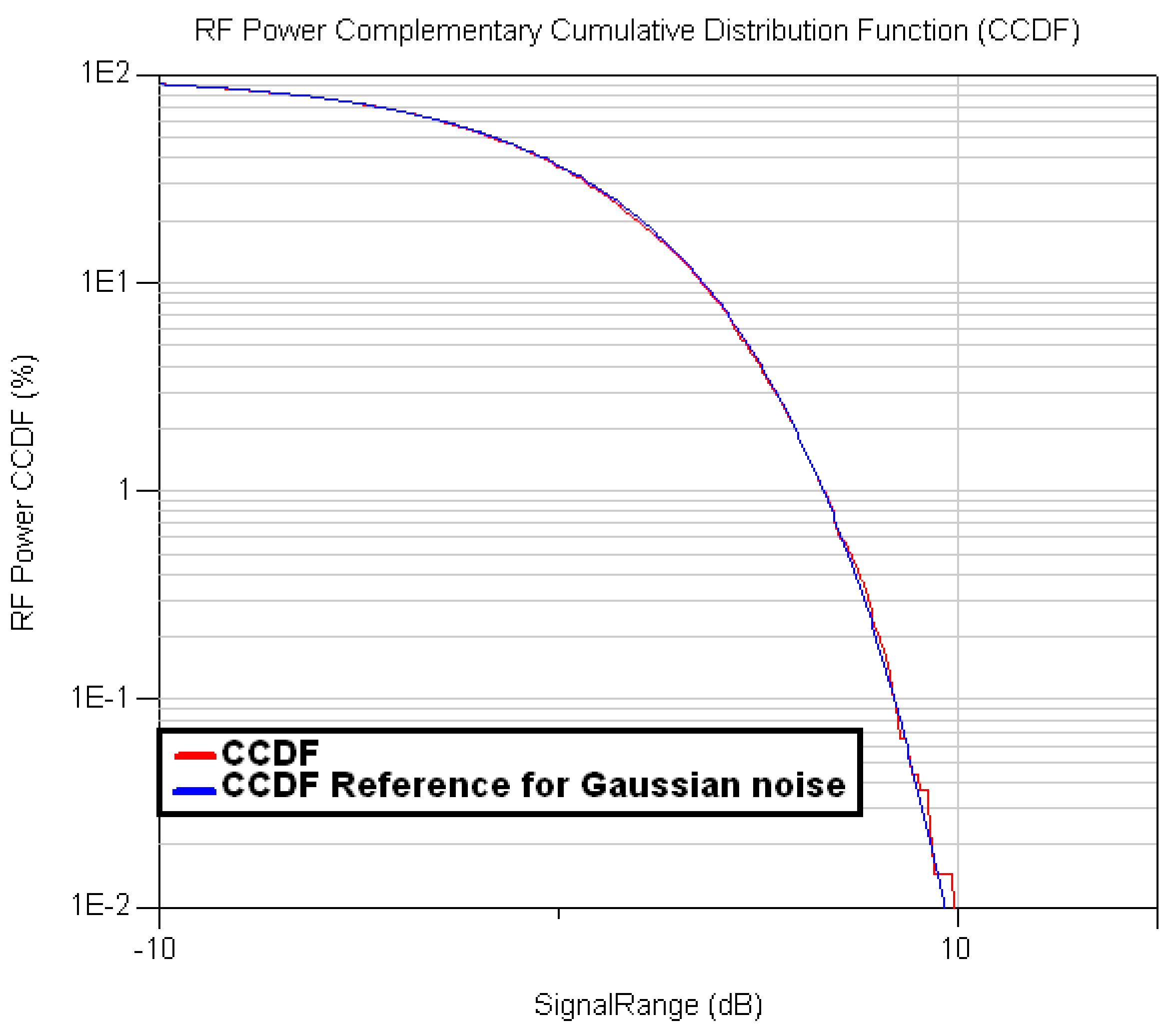


Meas Signal Constellation

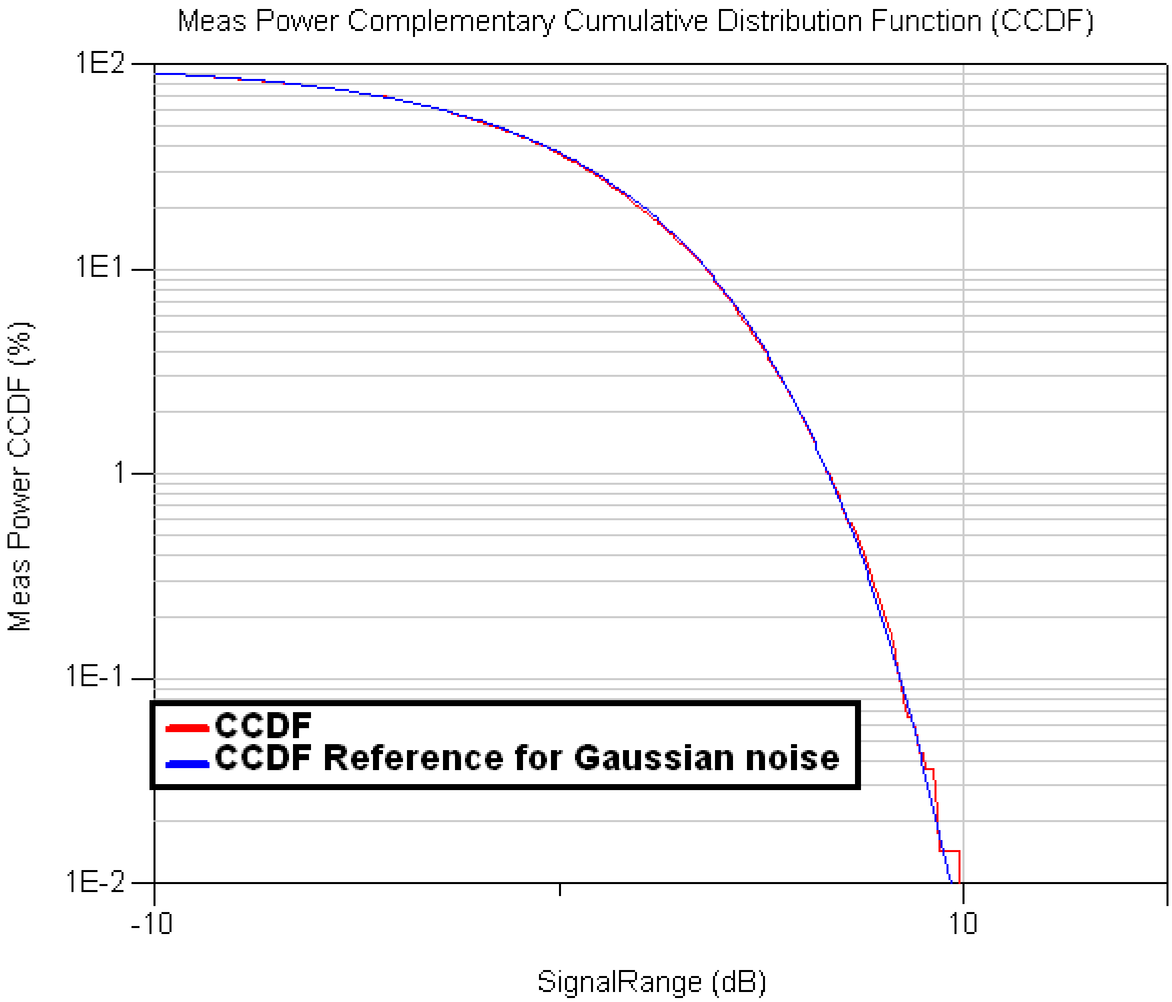
Power Measurement

The power measurement shows the CCDF curves of the transmitter and peak-to-average ratios for the RF and Meas signals.
CCDF measurement results for RF and Meas signals are shown in RF Power CCDF and Meas Power CCDF.

Reference CCDF measurements for Gaussian noise can be calculated by calling the function power_ccdf_ref () in the .dds files directly.
Functions for calculating peak-to-average-ratios and results are shown in RF Signal Peak-to-Average-Ratio and Results and Meas Signal Peak-to-Average-Ratio Results.



RF Power CCDF



Meas Power CCDF

RF_Power.MeanPower_dBm	RF_Power.PeakPower_dBm	RF_Peak_to_Avg_dB
6.101	14.506	8.405

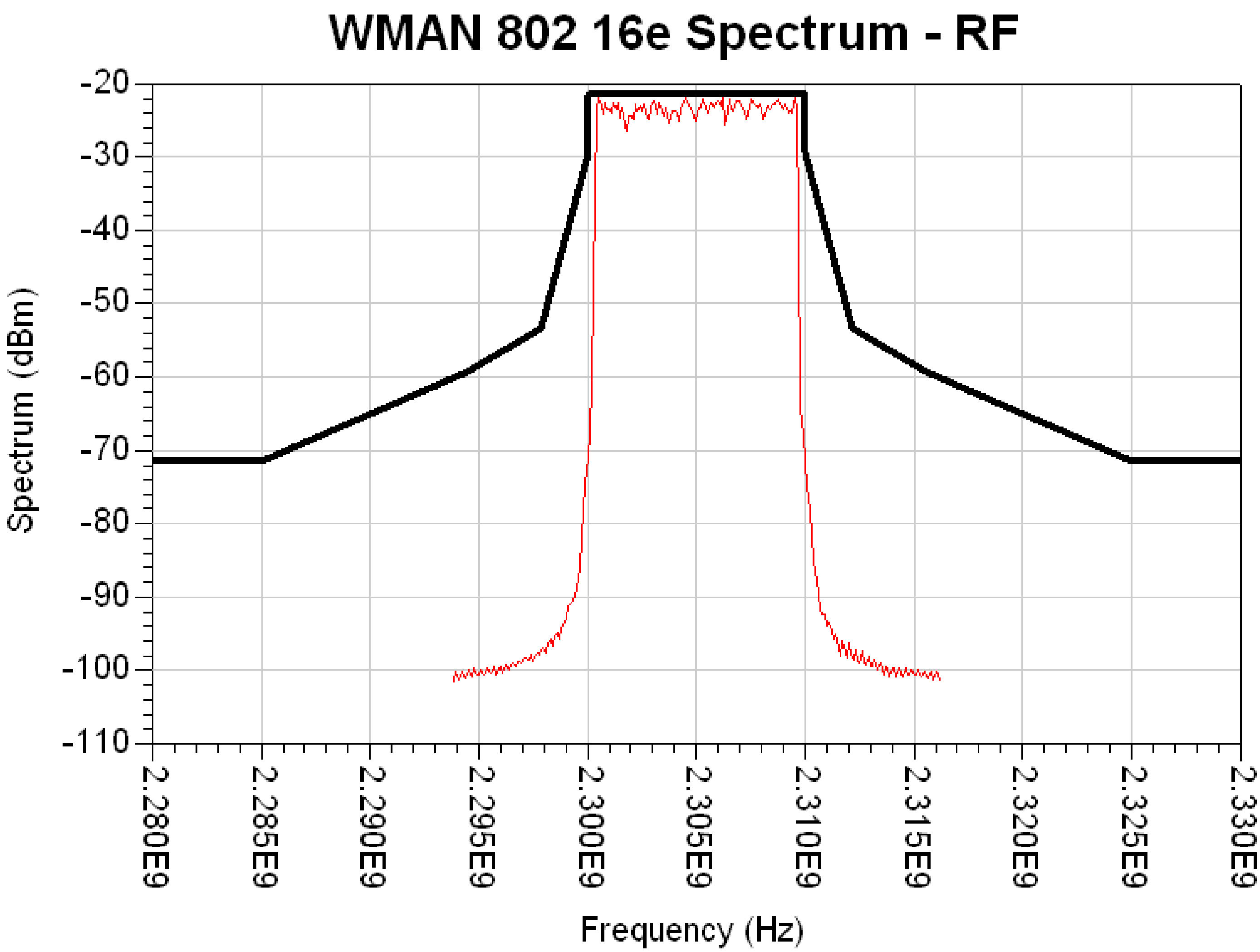
RF Signal Peak-to-Average-Ratio and Results

Meas_Power.MeanPower_dBm	Meas_Power.PeakPower_dBm	Meas_Peak_to_Avg_dB
6.103	14.548	8.445

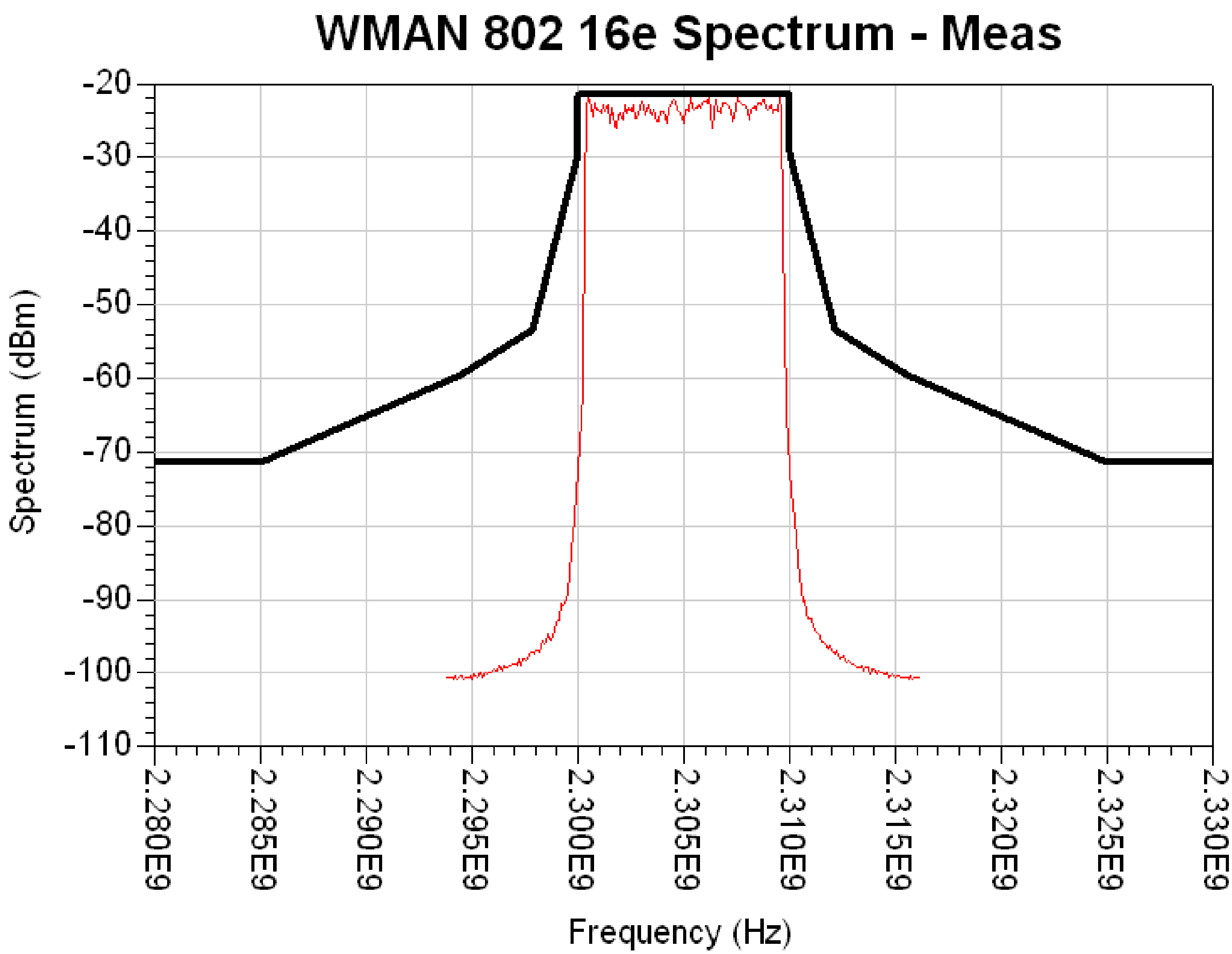
Meas Signal Peak-to-Average-Ratio Results

Spectrum Measurement

The Spectrum measurement is used to verify that the transmitted spectrum meets the spectrum mask according to Reference [3], section 5.3.3. The RF and Meas spectral density must fall within the spectral mask, as shown in RF Spectrum Mask and Meas Spectrum Mask.



RF Spectrum Mask



Meas Spectrum Mask

EVM Measurement

The EVM measurement is a modulation accuracy measurement. EVM measurement results shown in RF Signal EVM and Meas Signal EVM for 64-QAM-2/3 modulation do not exceed -28 dB; therefore the measurements meet the specification requirements.

EVM (RF)

RF_EVM.Avg_RCE_dB	RF_EVM.Avg_Pilot_RCE_dB
-76.411	-78.474

RF_EVM.Avg_DataRCE_dB	RF_EVM.Pilot_RCE_dB
-75.956	-78.348

RF_EVM.DataRCE_dB	RF_EVM.RCE_dB
-76.106	-76.526

RF Signal EVM

EVM (Meas)

Meas_EVM.Avg_RCE_dB	Meas_EVM.Avg_Pilot_RCE_dB
-76.468	-78.530

Meas_EVM.Avg_DataRCE_dB	Meas_EVM.Pilot_RCE_dB
-76.012	-78.402

Meas_EVM.DataRCE_dB	Meas_EVM.RCE_dB
-76.163	-76.582

Meas Signal EVM

Test Bench Variables for Data Displays

Variables listed in Test Bench Variables for Data Displays are used to set up this test bench and data displays.

Data Display Parameter	Equation with Test Bench Parameters

RF_FSource	FSource
RF_Power_dBm	10*log10(SourcePower)+30
RF_R	SourceR
TimeStep	1/SamplingFrequency/(2^OversamplintOption)
SamplingFrequency	Bandwidth*n (n is sampling factor)
Bandwidth	Bandwidth
RateID	Rate_ID
CyclicPrefix	CyclicPrefix
Data_Length	DataLength
Frame_Duration	FrameDuration
Frame_Mode	FrameMode
DL_Ratio	DL_Ratio
Meas_FMeasurement	FMeasurement
Meas_R	MeasR

Baseline Performance

- Test Computer Configuration
  - Pentium IV 2.26 GHz, 1024 MB RAM, Windows 2000
- Conditions
  - Measurements made with default test bench settings.
  - RF DUT is an RF system behavior component.
  - Resultant WTB_TimeStep = 44.643 nsec; Frame_Duration = 5 msec
- Simulation times:

WMAN_DL_802_16e_TX Measurement	Simulation Time (sec)	ADS Processes (MB)
RF_Envelope	181	522
Constellation	176	522
Power	600	565
Spectrum	189	522
EVM	176	522

Expected ADS Performance

Expected ADS performance is the combined performance of the baseline test bench and the RF DUT Circuit Envelope simulation with the same signal and number of time points. For example, if the RF DUT performance with Circuit Envelope simulation alone takes 2 hours and consumes 200 MB of memory (excluding the memory consumed by the core ADS product), then add these numbers to the Baseline Performance numbers to determine the expected ADS performance. This is valid only if the full memory consumed is from RAM. If RAM is less, larger simulation times may result due to increased disk access time for swap memory usage.

References for Mobile WiMAX Downlink Transmitter Test

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. ETSI EN 301 021 V1.6.1 (2003-07): Fixed Radio Systems; Point-to-multipoint equipment; Time Division Multiple Access (TDMA); Point-to-multipoint digital radio systems in frequency bands in the range 3 GHz to 11 GHz

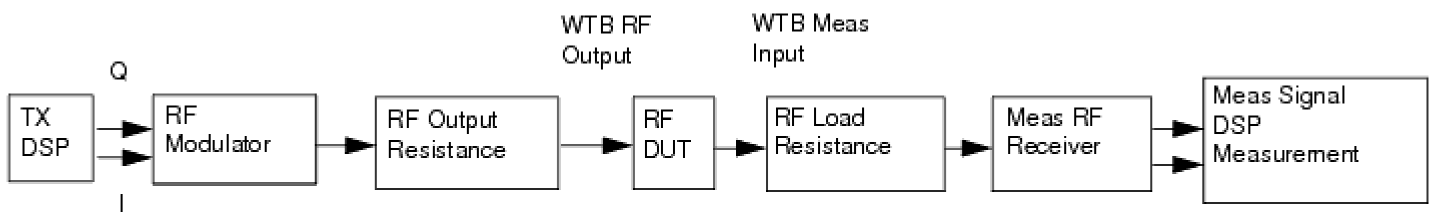
Setting up a Wireless Test Bench Analysis in the Wireless Test Bench Simulation documentation explains how to use test bench windows and dialogs to perform analysis tasks.
Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation explains how to set up circuit envelope analysis parameters such as convergence criteria, solver selection, and initial guess.
Setting Automatic Behavioral Modeling Parameters in the Wireless Test Bench Simulation documentation explains how to improve simulation speed.

Mobile WiMAX Downlink Receiver Sensitivity Test

WMAN_DL_802_16e_RX_Sensitivity_test is the test bench for Mobile WiMAX receiver minimum input level sensitivity testing. The test bench enables users to connect to an RF DUT and determine its performance; signal measurements include BER and PER with minimum input level.

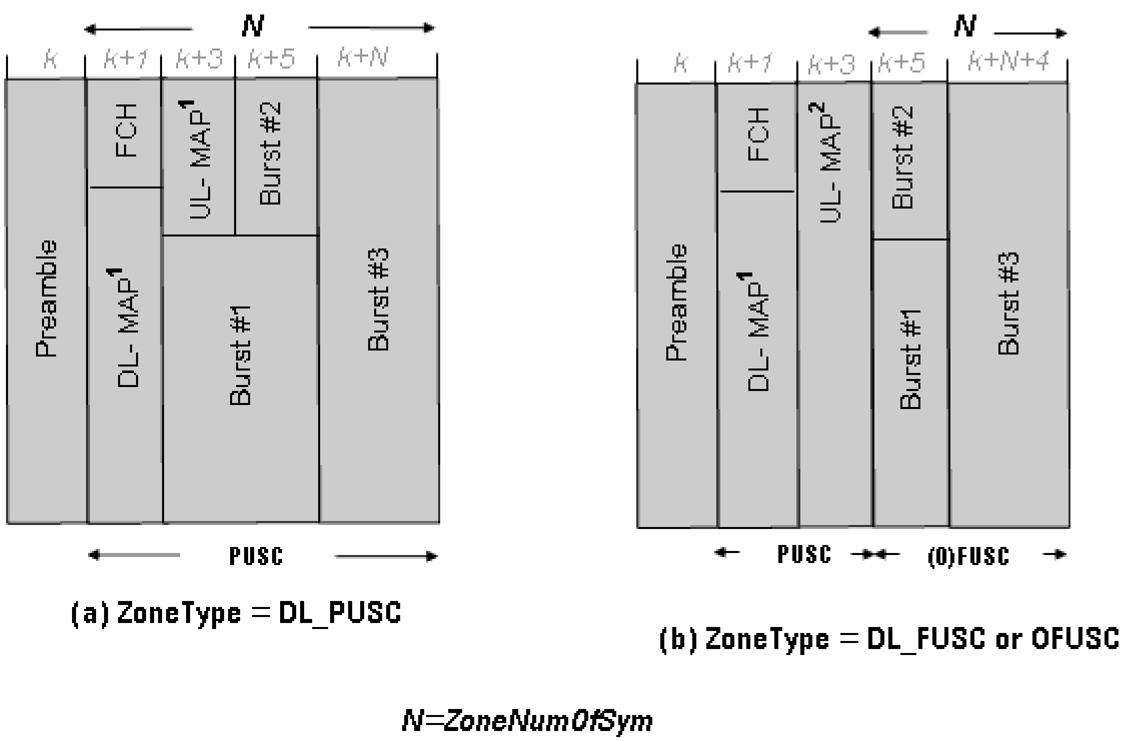
The signal and the measurement are designed according to References [1] and [2].

This test bench includes a TX DSP section, an RF modulator, RF output source resistance, an RF DUT connection, RF receivers, and DSP measurement blocks as illustrated in Receiver Wireless Test Bench Block Diagram. The generated test signal is sent to the DUT.



Receiver Wireless Test Bench Block Diagram

The Mobile WiMAX downlink frame structure is illustrated in Mobile WiMAX DL frame structure.



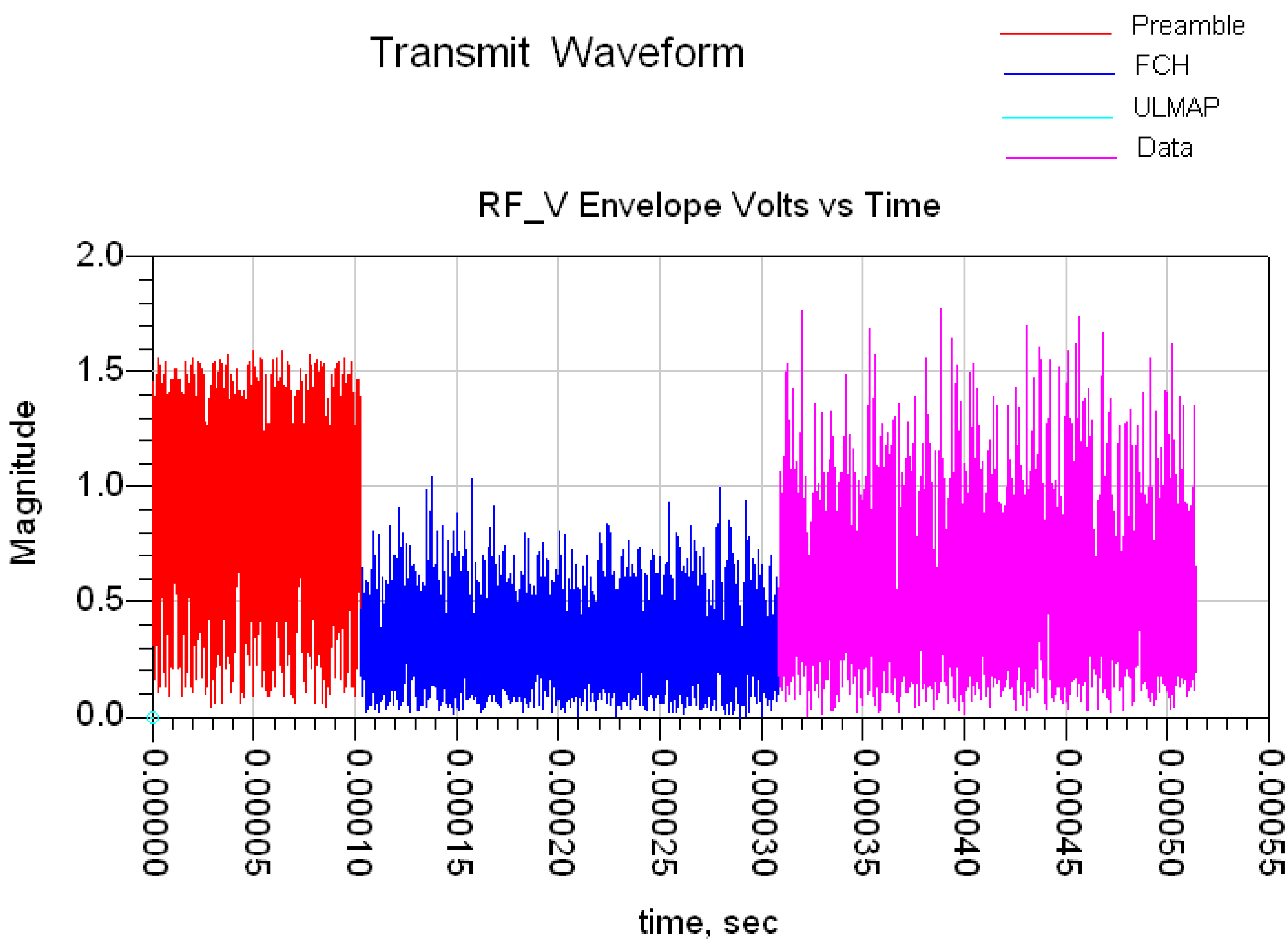
Mobile WiMAX DL frame structure

The downlink subframe starts with one preamble which consists of an OFDM symbol. Then the PUSC zone where FCH, DL-MAP and UL-MAP are allocated. The FCH information will be sent on the first four adjacent subchannels with successive logical subchannel numbers in the PUSC zone. The DL-MAP message immediately follows FCH. The UL-MAP message is always allocated on the third and fourth OFDM symbols if ULMAP_Enable is set to YES.

If ZoneType is DL_PUSC, then a single PUSC zone is defined (a in Mobile WiMAX DL frame structure). If ZoneType is DL_FUSC or DL_OFUSC, then two zones are defined: one is the PUSC zone where FCH is allocated, the other is the FUSC or OFUSC zone for allocating data bursts (b in Mobile WiMAX DL frame structure). ZoneNumOfSym is defined as the number of OFDM symbols for the zone which is allocated data bursts. One downlink frame contains maximum 8 data bursts except FCH, DL-MAP and UL-MAP, and each burst contains only one MAC PDU. Among these bursts, only one burst is FEC-encoded which is randomized, CC coded and interleaved. Other bursts will be provided PN sequences as their coded source respectively.

For DL_PUSC, the total number of symbols in the downlink subframe is (1+ZoneNumOfSym); For DL_FUSC or DL_OFUSC, the total number of symbols in the downlink subframe is (1+2+ULMAP_Enable□2+ZoneNumOfSym), where 1 is for the preamble, the first 2 is for the FCH and DL-MAP, the second 2 is for the UL-MAP, ULMAP_Enable is 1 when set to YES and 0 when set to NO.

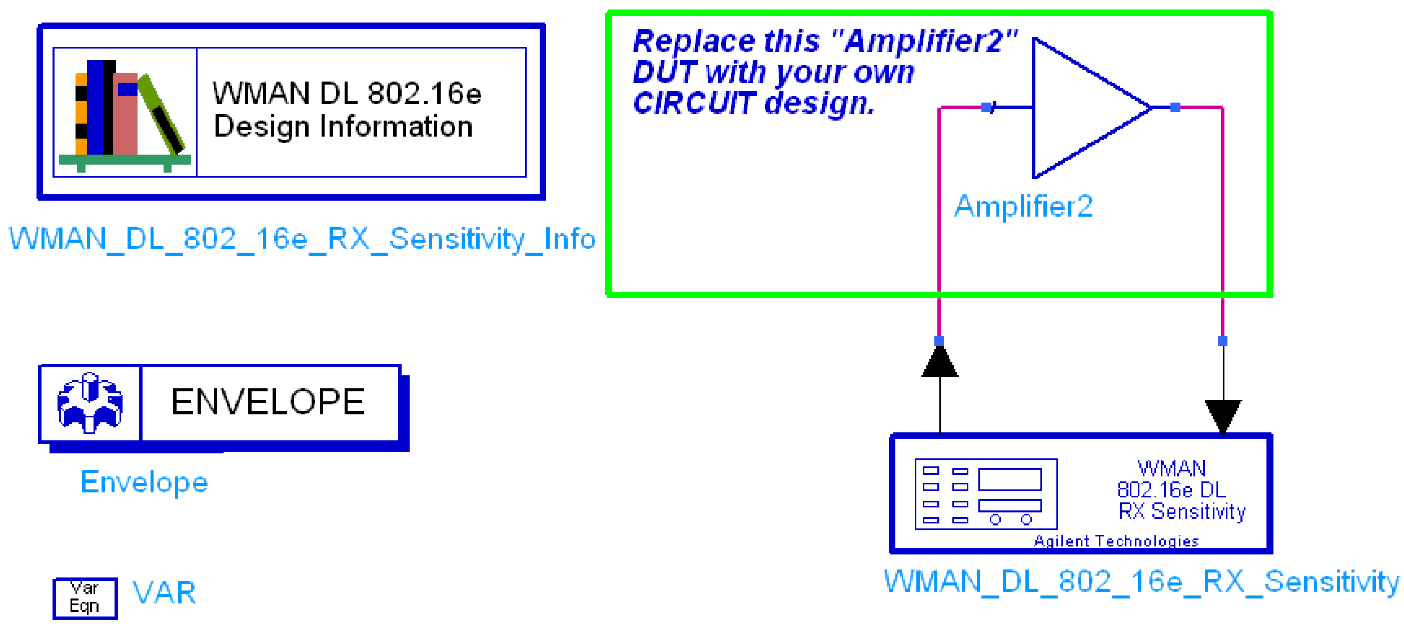
The Mobile WiMAX RF power delivered into a matched load is the average power when all subchannels are occupied. Mobile WiMAX DL RF Signal Envelope shows the RF envelope for an output RF signal with 10 dBm power.



Mobile WiMAX DL RF Signal Envelope

Test Bench Basics

=



Mobile WiMAX DL Receiver Test Bench

The basics for using the test bench are:

- Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench.
- CE_TimeStep, SourcePower, and FMeasurement parameter default values are typically accepted; otherwise, set values based on your requirements.
- Run the simulation and view Data Display page(s) for your measurement(s).

For details, refer to Test Bench Details.

Test Bench Details

The following sections provide details for setting up a test bench, setting measurement parameters for more control of the test bench, simulation measurement displays, and baseline performance.

Open and use the WMAN_DL_802_16e_RX_Sensitivity_test template:

1. In an Analog/RF schematic window, choose Insert > Template .
2. In the Insert > Template dialog box, choose WMAN_DL_802_16e _RX_Sensitivity_test , click OK ; click left to place the template in the schematic window.

Test bench setup is detailed here.

1. Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench. For information regarding using certain types of DUTs, refer to RF DUT Limitations.
2. Set the Required Parameters

> Note
> Refer to WMAN_DL_802_16e_RX_Sensitivity for a complete list of parameters for this test bench.

Generally, default values can be accepted; otherwise, values can be changed by the user as needed.

- Set CE_TimeStep.
  Cosimulation occurs between the test bench (using ADS Ptolemy Data Flow simulation technology) and the DUT (using Circuit Envelope simulation technology). Each technology requires its own simulation time step with time-step coordination occurring in the interface between the technologies.
  CE_TimeStep defines the Circuit Envelope simulation time step to be used with this DUT. The CE_TimeStep must be set to a value equal to or a submultiple of (less than) WTB_TimeStep; otherwise, simulation will stop and an error message will be displayed.
  Note that WTB_TimeStep is not user-settable. Its value is derived from other test bench parameter values. The value is displayed in the Data Display pages as TimeStep.
  WTB_TimeStep = 1/(RF_SamplingRate × Ratio) where
  The RF_SamplingRate (Fs) implemented in the design is decided by Bandwidth and related sampling factor (N_{factor}) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

  The sampling factors are listed in the following table.

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

Bandwidth is the user-settable value (default 10 MHz)
Ratio is the oversampling ratio related to OversamplingOption as Ratio = 2 OversamplingOption .

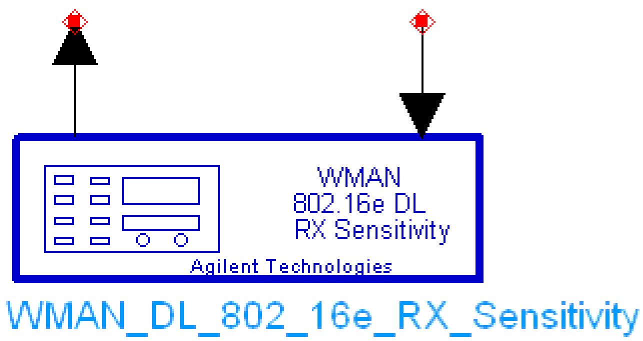
- Set SourcePower, and FMeasurement.
    - SourcePower defines the power level of the source. SourcePower is defined as the average power during the non-idle time of the signal burst.
    - FMeasurement defines the RF frequency output from the DUT to be measured.

3. More control of the test bench can be achieved by setting Basic Parameters , Signal Parameters , and measurement parameters. For details, refer to Setting Parameters.
4. The RF modulator (shown in the block diagram in Receiver Wireless Test Bench Block Diagram) uses SourcePower (Required Parameters), GainImbalance, PhaseImbalance (Signal Parameters).
   The RF output resistance uses SourceR and SourceTemp (Basic Parameters). The RF output signal source has a 50-ohm (default) output resistance defined by SourceR.
   RF output (and input to the RF DUT) is delivered into a matched load of resistance SourceR, with frequency hopping, with the specified source resistance (SourceR) and with power (SourcePower). The RF signal has additive Gaussian noise power set by resistor temperature (SourceTemp).
   Note that the Meas_in point of the test bench provides a resistive load to the RF DUT set by the MeasR value (50-ohm default) (Basic Parameters).
   The Meas signal contains linear and nonlinear signal distortions and time delays associated with the RF DUT input to output characteristics.
   The TX DSP block (shown in the block diagram in Receiver Wireless Test Bench Block Diagram) uses other Signal Parameters .
5. More control of Circuit Envelope analysis can be achieved by setting Envelope controller parameters. These settings include Enable Fast Cosim, which may speed the RF DUT simulation more than 10×. Setting these simulation options is described in Setting Fast Cosimulation Parameters and Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation.
6. To run a simulation, choose Simulate > Simulate in the Schematic window.
   For details on Running a Simulation refer to the Wireless Test Bench Simulation documentation.
7. Simulation results will appear in a Data Display window for each measurement. Simulation Measurement Displays describes results for each measurement available for this test bench.

For details on Viewing Results refer to the Wireless Test Bench Simulation documentation.

WMAN_DL_802_16e_RX_Sensitivity

This section provides parameter information for Required Parameters, Basic Parameters, Signal Parameters, and parameters for the various measurements.



Setting Parameters

More control of the test bench can be achieved by setting parameters in the Basic Parameters , Signal Parameters , and measurement categories for the activated measurements.

Note
For required parameter information, see Set the Required Parameters.

Basic Parameters

1. SourceR is the RF output source resistance.
2. SourceTemp is the RF output source resistance temperature (oC) and sets noise density in the RF output signal to (k(SourceTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
3. MeasR defines the load resistance for the RF DUT output Meas signal into the test bench. This resistance loads the RF DUT output; it is also the reference resistance for Meas signal power measurements.
4. TestBenchSeed is an integer used to seed the random number generator used with the test bench. This value is used by all test bench random number generators, except those RF DUT components that use their own specific seed parameter. TestBenchSeed initializes the random number generation. The same seed value produces the same random results, thereby giving you predictable simulation results. To generate repeatable random output from simulation to simulation, use any positive seed value. If you want the output to be truly random, enter the seed value of 0.

Signal Parameters

1. GainImbalance, PhaseImbalance are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
   The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

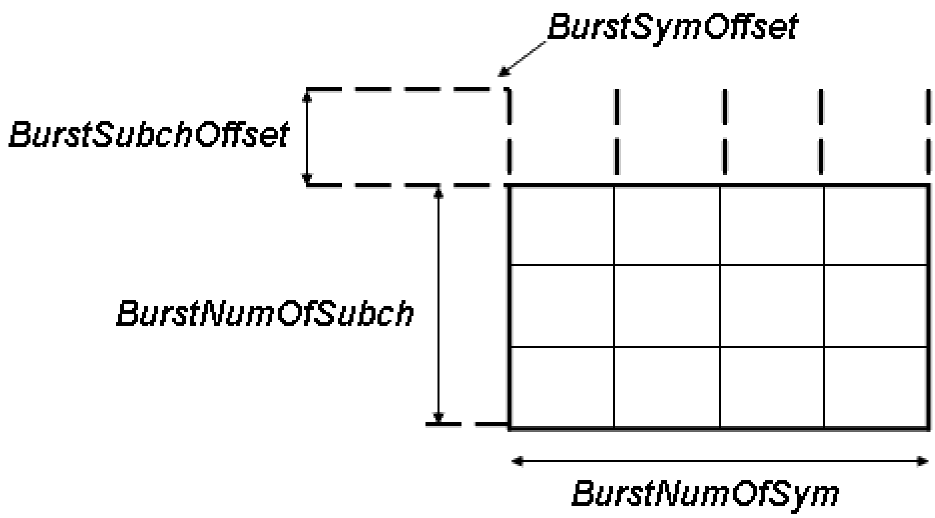
$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

where A is a scaling factor that depends on the SourcePower and SourceR parameters specified by the user, V I(t) is the in-phase RF envelope, V Q(t) is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

and, φ (in degrees) is the phase imbalance.

2. Bandwidth determines the nominal channel bandwidth.
3. OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
4. FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
5. CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
6. FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame.
7. DL_Ratio specifies set the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
8. FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the specification.
9. DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink burst.
10. ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink burst.
11. PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
12. DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
13. BSID specifies the base station ID which is used in DL-MAP message.
14. PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
15. ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
16. ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
17. GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
18. NumberOfBurst specifies the number of active downlink bursts.
19. BurstWithFEC specifies the downlink burst FEC.
20. BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, see Downlink rectangular burst structure.



Downlink rectangular burst structure

21. DataLength specifies MAC PDU payload byte length for each burst.
22. CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose meaning is shown in The meaning of coding type.

The meaning of coding type

Coding type	meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

23. Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in The relation of Coding type and Rate ID.

The relation of Coding type and Rate ID

Coding type	Rate ID	Modulation/Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2

1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

24. RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in The meaning of repetition coding.

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4 used on the burst
3	Repetition coding of 6 used on the burst

25. PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
26. DecoderType specifiers the Viterbi decoder type chosen from CSI, Soft and Hard.
27. StopFrame specifiers the stop burst used for BER and FER calculation.

Measurement Parameters

1. DisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.

Simulation Measurement Displays

After running the simulation, results are displayed in the Data Display pages for each measurement activated.

> Note
> Measurement results from a wireless test bench have associated names that can be used in Data Display Expressions. For more information, refer to Measurement Results for Expressions.

Sensitivity Measurement

The sensitivity measurement shows BER and PER results. The BER measured after FEC shall be less than 10^(-6) at the power levels RSS defined in equation (149b) of section 8.4.13.1 of Reference [2] (assuming 5dB implementation margin and 8dB Noise Figure). Simulation results for "Rate_ID = 5" and SourcePower of -75 dBm are displayed in Simulation Results for "Rate_ID = 5" and -75 dBm SourcePower.

real(RF_FSource) / (1 MHz)	real(RSS_dBm)
2305.000	-75.000

real(TimeStep) / (1 nsec)	real(RF_SourceTemp)
44.643	16.850

real(CyclicPrefix)	real(Data_Length)
0.125	200.000

real(RF_R)	real(Meas_FMeasurement) / (1 MHz)
50.000	2305.000

real(Meas_R)	real(RateID)
50.000	5.000

real(Frame_Duration) / (1 msec)	real(Bandwidth) / (1 MHz)
5.000	10.000

real(SamplingFrequency) / (1 MHz)	real(DL_Ratio)	Frame_Mode
11.200	0.618	TDD

Meas Sensitivity

BER	FER
0.00000000	0.00000000

Simulation Results for "Rate_ID = 5" and -75 dBm SourcePower

Test Bench Variables for Data Displays

Variables listed in Test Bench Variables for Data Displays are used to set up this test bench and data displays.

Test Bench Variables for Data Displays

Data Display Parameter	Equation with Test Bench Parameters
RF_FSource	FSource
RF_Power_dBm	10*log10(SourcePower)+30
RF_R	SourceR
TimeStep	1/SamplingFrequency/(2^OversamplintOption)
SamplingFrequency	Bandwidth*n (n is sampling factor)
Bandwidth	Bandwidth
RateID	Rate_ID
CyclicPrefix	CyclicPrefix
Data_Length	DataLength
Frame_Duration	FrameDuration
Frame_Mode	FrameMode
DL_Ratio	DL_Ratio
Meas_FMeasurement	FMeasurement
Meas_R	MeasR

Baseline Performance

- Test Computer Configuration
  - Pentium IV 2.26 GHz, 1024 MB RAM, Windows 2000
- Conditions
  - Measurements made with default test bench settings.
  - RF DUT is an RF system behavior component.
  - Resultant WTB_TimeStep = 44.643 nsec; Frame_Duration = 5 msec
- Simulation time and memory requirements:

WMAN_DL_802_16e_RX_Sensitivity Measurement	Frames Measured	Simulation Time (hour)	ADS Processes (MB)
RX Sensitivity	100	2	400

Expected ADS Performance

Expected ADS performance is the combined performance of the baseline test bench and the RF DUT Circuit Envelope simulation with the same signal and number of time points. For example, if the RF DUT performance with Circuit Envelope simulation alone takes 2 hours and consumes 200 MB of memory (excluding the memory consumed by the core ADS product), then add these numbers to the Baseline Performance numbers to determine the expected ADS performance. This is valid only if the full memory consumed is from RAM. If RAM is less, larger simulation times may result due to increased disk access time for swap memory usage.

References for Mobile WiMAX Downlink Receiver Sensitivity Test

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

Setting up a Wireless Test Bench Analysis in the Wireless Test Bench Simulation documentation explains how to use test bench windows and dialogs to perform analysis tasks.

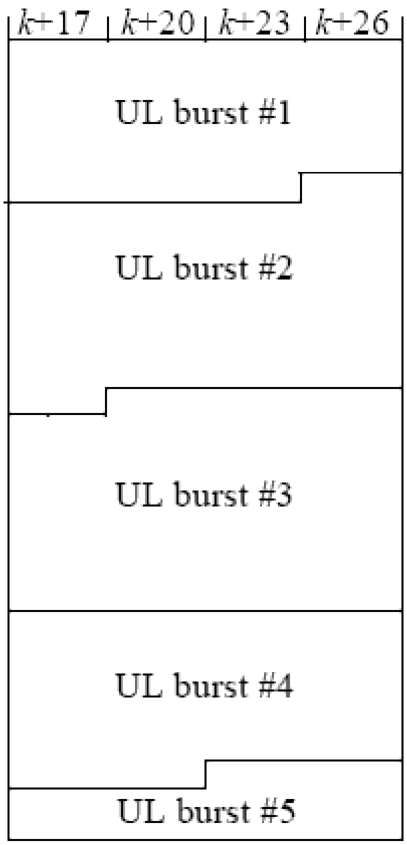
Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation explains how to set up circuit envelope analysis parameters such as convergence criteria, solver selection, and initial guess.

Setting Automatic Behavioral Modeling Parameters in the Wireless Test Bench Simulation documentation to learn how to improve simulation speed.

Mobile WiMAX Uplink Transmitter Test

The WMAN_UL_802_16e_TX transmitter test bench provides a way for users to connect to an RF circuit device under test (RF DUT) and determine its performance by activating various test bench measurements. This test bench provides signal measurements for RF envelope, signal power (including CCDF), constellation, spectrum, and EVM.
The signal and most of the measurements are designed according to References [1] and [2].

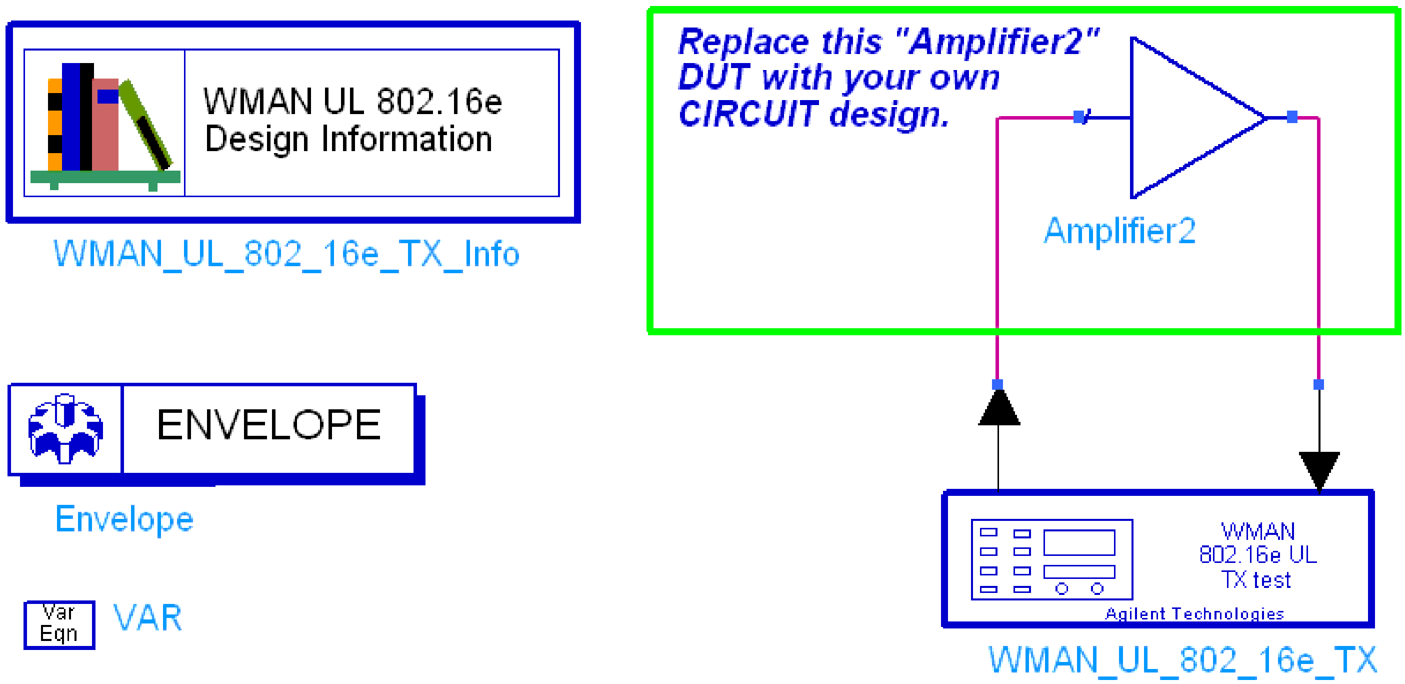
The Mobile WiMAX uplink frame structure is illustrated in Mobile WiMAX UL frame structure.



Mobile WiMAX UL frame structure

The uplink subframe includes only one zone (alternative PUSC or OPUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one FEC-encoded burst is supported whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Both TDD mode and FDD mode can be supported for the uplink source.

Test Bench Basics



Mobile WiMAX UL Transmitter Test Bench

The basics for using the test bench are:

- Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench.
- CE_TimeStep, SourcePower, and FMeasurement parameter default values are typically accepted; otherwise, set values based on your requirements.
- Activate/deactivate measurements based on your requirements.
- Run the simulation and view Data Display page(s) for your measurement(s).

Test Bench Details

The following sections provide details for setting up a test bench, setting measurement parameters for more control of the test bench, simulation measurement displays, and baseline performance.
Open and use the WMAN_UL_802_16e_TX_test template:

1. In an Analog/RF schematic window, choose Insert > Template .
2. In the Insert > Template dialog box, choose WMAN_UL_802_16e_TX_test , click OK ; click left to place the template in the schematic window.
   Test bench setup is detailed here.

3. Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench. For information regarding using certain types of DUTs, refer to RF DUT Limitations.
4. Set the Required Parameters

> Note
> Refer to WMAN_UL_802_16e_TX for a complete list of parameters for this test bench.

Generally, default values can be accepted; otherwise, values can be changed by the user as needed.

- Set CE_TimeStep.
  Cosimulation occurs between the test bench (using ADS Ptolemy Data Flow simulation technology) and the DUT (using Agilent Circuit Envelope simulation technology). Each technology requires its own simulation time step with time-step coordination occurring in the interface between the technologies.
  CE_TimeStep defines the Circuit Envelope simulation time step to be used with this DUT. The CE_TimeStep must be set to a value equal to or a submultiple of (less than) WTB_TimeStep; otherwise, simulation will stop and an error message will be displayed.
  Note that WTB_TimeStep is not user-settable. Its value is derived from other test bench parameter values. The value is displayed in the Data Display pages as TimeStep.
  WTB_TimeStep = 1/(RF_SamplingRate × Ratio)
  where
  The RF_SamplingRate (Fs) implemented in the design is decided by Bandwidth and related sampling factor (N_{factor}) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in sampling factor requirement.

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

Bandwidth is the user-settable value (default 10 MHz)
Ratio is the oversampling ratio related to OversamplingOption as Ratio = 2 OversamplingOption .

- Set SourcePower, and FMeasurement.
  - SourcePower defines the power level for FSource. SourcePower is defined as the peak power during the non-idle time of the signal frame.
  - FMeasurement defines the RF frequency output from the DUT to be measured.

1. Activate/deactivate (YES / NO) test bench measurements (refer to WMAN_UL_802_16e_TX). At least one measurement must be enabled:
   - RF_EnvelopeMeasurement
   - Constellation
   - PowerMeasurement
   - SpectrumMeasurement
   - EVM_Measurement
2. More control of the test bench can be achieved by setting Basic Parameters , Signal Parameters , and parameters for each activated measurement. For details, refer to Setting Parameters.
3. The RF modulator of WMAN_UL_802_16e_TX (shown in the block diagram in Mobile WiMAX UL Transmitter Test Bench) uses SourcePower (Required Parameters), GainImbalance, PhaseImbalance(Signal Parameters).

The RF output resistance uses SourceR, SourceTemp, and EnableSourceNoise (Basic Parameters). The RF output signal source has a 50-ohm (default) output resistance defined by SourceR.
RF output (and input to the RF DUT) is with the specified source resistance (SourceR) and with power (SourcePower) delivered into a matched load of resistance SourceR. The RF signal has additive Gaussian noise power set by resistor temperature (SourceTemp) (when EnableSourceNoise=YES).

Note that the Meas point of the test bench provides a resistive load to the RF DUT set by the MeasR value (50-ohm default) (Basic Parameters).

The Meas signal contains linear and nonlinear signal distortions and time delays associated with the RF DUT input to output characteristics.

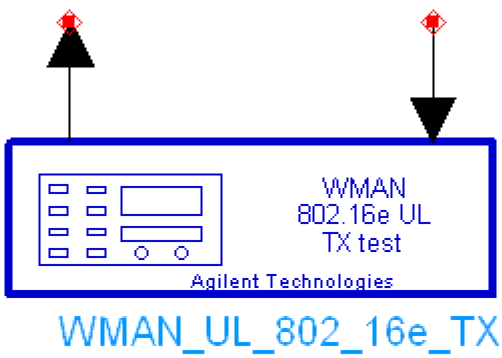
The DSP block of WMAN_UL_802_16e_TX (shown in the block diagram in Mobile WiMAX UL Transmitter Test Bench) uses other Signal Parameters .

1. More control of Circuit Envelope analysis can be achieved by setting Envelope controller parameters. These settings include Enable Fast Cosim, which may speed the RF DUT simulation more than 10×. Setting these simulation options is described in Setting Fast Cosimulation Parameters and Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation.
2. To run a simulation, choose Simulate > Simulate in the Schematic window.
   For details on Running a Simulation refer to the Wireless Test Bench Simulation documentation.
3. Simulation results will appear in a Data Display window for each measurement. Simulation Measurement Displays describes results for each measurement available for this test bench.

For details on Viewing Results refer to the Wireless Test Bench Simulation documentation.

WMAN_UL_802_16e_TX

This section provides parameter information for Required Parameters, Basic Parameters, Signal Parameters, and parameters for the various measurements.



Setting Parameters

More control of the test bench can be achieved by setting parameters in the Basic Parameters , Signal Parameters , and measurement categories for the activated measurements.

> Note
> For required parameter information, see Set the Required Parameters.

Basic Parameters

1. SourceR is the RF output source resistance.
2. SourceTemp is the RF output source resistance temperature (oC) and sets noise density in the RF output signal to (k(SourceTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
3. EnableSourceNoise, when set to NO disables the SourceTemp and effectively sets it to -273.15oC (0 Kelvin). When set to YES, the noise density due to SourceTemp is enabled.
4. MeasR defines the load resistance for the RF DUT output Meas signal into the test bench. This resistance loads the RF DUT output; it is also the reference resistance for Meas signal power measurements.
5. TestBenchSeed is an integer used to seed the random number generator used with the test bench. This value is used by all test bench random number generators, except those RF DUT components that use their own specific seed parameter. TestBenchSeed initializes the random number generation. The same seed value produces the same random results, thereby giving you predictable simulation results. To generate repeatable random output from simulation to simulation, use any positive seed value. If you want the output to be truly random, enter the seed value of 0.

Signal Parameters

1. GainImbalance, PhaseImbalance are used to add certain impairments to the ideal output RF signal. Impairments

are added in the order described here.
The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:

$$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$

where A is a scaling factor that depends on the SourcePower and SourceR parameters specified by the user, V I(t) is the in-phase RF envelope, V Q(t) is the quadrature phase RF envelope, g is the gain imbalance

$$g = 10^{\frac{GainImbalance}{20}}$$

and, φ (in degrees) is the phase imbalance.

2. Bandwidth determines the nominal channel bandwidth.
3. OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
4. FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
5. CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
6. FrameMode determines what will actually be included in the generated waveform. FDD Mode means the entire frame is used for the uplink and the uplink starts at the beginning of the frame. TDD Mode means only the uplink is included in the generated waveform and it starts at some delay from the frame start time based on the Downlink Ratio setting.
7. DL_Ratio set the percentage (1 to 99) of the frame time to be used for the downlink and also set the start time for the uplink. The parameter is only active when the FrameMode is TDD.
8. FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the specification.
9. PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to Table 309 in the specification.
10. FrameNumber specifies the starting frame number in the uplink subframe.
11. FrameIncreased specifies whether the frame number for the uplink subframe is increased. When FrameIncreased is set to YES, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber , FrameNumber+1 , FrameNumber+2 , FrameNumber+3 . When FrameIncreased is set to NO, then the frame numbers in Frame#0, Frame#1, Frame#2, Frame#3 will be FrameNumber , FrameNumber , FrameNumber , FrameNumber .
12. UL_PermBase specifies the permutation base that will be used in this uplink zone. Accepted values are 0 to 69.
13. For DataPattern:
    - if PN9 is selected, a 511-bit pseudo-random test pattern is generated according to CCITT Recommendation O.153.
    - if PN15 is selected, a 32767-bit pseudo-random test pattern is generated according to CCITT Recommendation O.151.
    - if FIX4 is selected, a zero-stream is generated.
    - if x_1_x_0 is selected (where x equals 4, 8, 16, 32, or 64) a periodic bit stream is generated, with the period being 2 x. In one period, the first x bits are 1s and the second x bits are 0s.
    - if S_QPSK, S_16-QAM or S_64-QAM is selected, sequences below are generated. These are test messages for receiver sensitivity measurement.
      S_QPSK = [0xE4, 0xB1, 0xE1, 0xB4]
      S_16-QAM = [0xA8, 0x20, 0xB9, 0x31, 0xEC, 0x64, 0xFD, 0x75]
      S_64-QAM = [0xB6, 0x93, 0x49, 0xB2, 0x83, 0x08, 0x96, 0x11, 0x41, 0x92, 0x01, 0x00, 0xBA, 0xA3, 0x8A, 0x9A, 0x21, 0x82, 0xD7, 0x15, 0x51, 0xD3, 0x05, 0x10, 0xDB, 0x25, 0x92, 0xF7, 0x97, 0x59, 0xF3, 0x87, 0x18, 0xBE, 0xB3, 0xCB, 0x9E, 0x31, 0xC3, 0xDF, 0x35, 0xD3, 0xFB, 0xA7, 0x9A, 0xFF, 0xB7, 0xDB]
14. AutoMACHeaderSetting indicates whether the MAC Header is calculated automatically. If it is set to NO, data

sequences in parameter MAC_Header will be used before data content, otherwise MAC_Header content will be calculated with parameter DataLength and CID and be used before data content.

15. MAC_Header specifies 6 bytes of MAC header before the data contents. The cell is only active when the AutoMACHeaderSetting is set to NO.
16. CRC32_Mode specifies the method for CRC32 calculation appended to MAC PDU.
17. ZoneType specifies the zone type which can be set to PUSC or OPUSC.
18. ZoneNumOfSym specifies the number of symbols in the zone. The value must be a multiple of three because the uplink zone is divided into slots of 3 symbols x 1 subchannel (section 8.4.3.1 in 802.16e-2005). The maximum number of symbols available depends on the Bandwidth , FrameDuration , DL_Ratio , FFTSize , and CyclicPrefix .
19. NumberOfBurst specifies the number of active uplink bursts.
20. BurstWithFEC specifies the uplink burst FEC.
21. BurstSymOffset positions each burst on the horizontal axis (x), if necessary, to avoid any burst overlap. The parameter is an array element.
22. BurstSubchOffset positions each burst on the vertical axis (y), if necessary, to avoid any burst overlap. The parameter is an array element.
23. BurstAssignedSlot specifies the total available slots in each burst. The parameter is an array element.
24. DataLength specifies MAC PDU payload byte length for each burst.
25. CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose meaning is shown in The meaning of coding type.

Coding type	meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

26. Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in The relation of Coding type and Rate ID.

Coding type	Rate ID	<th
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4

1 (CTC)	7	64-QAM CTC5/6

27. RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in The meaning of repetition coding.

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4 used on the burst
3	Repetition coding of 6 used on the burst

28. BurstPowerOffset determines the power offset of each burst in dB. The parameter is an array element.

RF Envelope Measurement Parameters

Depending on the values of RF_EnvelopeStart, RF_EnvelopeStop.

1. RF_EnvelopeDisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.
2. RF_EnvelopeStart sets the start time for collecting input data.
3. RF_EnvelopeStop sets the stop time for collecting input data.

For information about TimeStep, see Test Bench Variables for Data Displays".

Constellation Parameters

ConstellationDisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.

Power Measurement Parameters

1. PowerDisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.
2. PowerBursts sets the number of bursts over which data will be collected.

Spectrum Measurement Parameters

The Spectrum measurement calculates the spectrum of the input signal.
In the following, TimeStep denotes the simulation time step, and FMeasurement denotes the measured RF signal characterization frequency.

1. The measurement outputs the complex amplitude voltage values at the frequencies of the spectral tones. It does not output the power at the frequencies of the spectral tones. However, one can calculate and display the power spectrum as well as the magnitude and phase spectrum by using the dBm, mag, and phase functions of the data display window.
   Note that the dBm function assumes a 50-ohm reference resistance; if a different measurement was used in the test bench, its value can be specified as a second argument to the dBm function, for example, dBm(SpecMeas, Meas_RefR) where SpecMeas is the instance name of the spectrum measurement and Meas_RefR is the resistive load.
   The basis of the algorithm used by the spectrum measurement is the chirp-Z transform. The algorithm can use multiple bursts and average the results to achieve video averaging.
2. SpecMeasDisplayPages is not user editable. It provides information on the name of the Data Display pages in which this measurement is contained.
3. SpecMeasStart sets the start time for collecting input data.
4. SpecMeasStop sets the stop time for collecting input data.
5. SpecMeasResBW sets the resolution bandwidth of the spectrum measurement when SpecMeasResBW>0.
   NENBW = normalized equivalent noise bandwidth of the window
   Equivalent noise bandwidth (ENBW) compares the window to an ideal, rectangular filter. It is the equivalent width of a rectangular filter that passes the same amount of white noise as the window. The normalized ENBW (NENBW) is ENBW multiplied by the duration of the signal being windowed. Window Options and Normalized Equivalent Noise Bandwidth lists the NENBW for the various window options.
   The Start and Stop times are used for both the RF and Meas signal spectrum analyses. The Meas signal is delayed in time from the RF signal by the value of the RF DUT time delay. Therefore, for RF DUT time delay greater than zero, the RF and Meas signal are inherently different and some spectrum display difference in the two is expected.
   TimeStep is defined in the Test Bench Variables for Data Displays section.
6. SpecMeasWindow specifies the window that will be applied to each burst before its spectrum is calculated. Different windows have different properties, affect the resolution bandwidth achieved, and affect the spectral shape. Windowing is often necessary in transform-based (chirp-Z, FFT) spectrum estimation in order to reduce spectral distortion due to discontinuous or non-harmonic signal over the measurement time interval. Without windowing, the estimated spectrum may suffer from spectral leakage that can cause misleading measurements or masking of weak signal spectral detail by spurious artifacts.
   The windowing of a signal in time has the effect of changing its power. The spectrum measurement compensates for this and the spectrum is normalized so that the power contained in it is the same as the power of the input signal.
   Window Type Definitions:
   - none:

     $$w(kT_s) = \begin{cases} 1.0 & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

     where N is the window size
   - Hamming 0.54:

$$w(kT_s) = \begin{cases} 0.54 - 0.46\cos\left(\frac{2\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size

- Hanning 0.5:

$$w(kT_s) = \begin{cases} 0.5 - 0.5\cos\left(\frac{2\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size

- Gaussian 0.75:

$$w(kT_s) = \begin{cases} exp\left(-\frac{1}{2}\left(0.75\frac{(2k-N)}{N}\right)^2\right) & 0 \le \left|k - \frac{N}{2}\right| \le \frac{N}{2} \\ 0.0 & otherwise \end{cases}$$

where N is the window size

- Kaiser 7.865:

$$w(kT_s) = \begin{cases} \dfrac{I_0\left(7.865\left[1 - \left(\frac{k-\alpha}{\alpha}\right)^2\right]^{1/2}\right)}{I_0(7.865)} & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size, α = N / 2, and I 0 (.) is the 0th order modified Bessel function of the first kind

- 8510 6.0 (Kaiser 6.0):

$$w(kT_s) = \begin{cases} \dfrac{I_0\left(6.0\left[1 - \left(\frac{k-\alpha}{\alpha}\right)^2\right]^{1/2}\right)}{I_0(6.0)} & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size, α = N / 2, and I 0 (.) is the 0th order modified Bessel function of the first kind

- Blackman:

$$w(kT_s) = \begin{cases} 0.42 - 0.5\cos\left(\frac{2\pi k}{N}\right) + 0.08\cos\left(\frac{4\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size

- Blackman-Harris:

$$w(kT_s) = \begin{cases} 0.35875 - 0.48829\cos\left(\frac{2\pi k}{N}\right) + 0.14128\cos\left(\frac{4\pi k}{N}\right) - 0.01168\cos\left(\frac{6\pi k}{N}\right) & 0 \le k \le N \\ 0.0 & otherwise \end{cases}$$

where N is the window size.

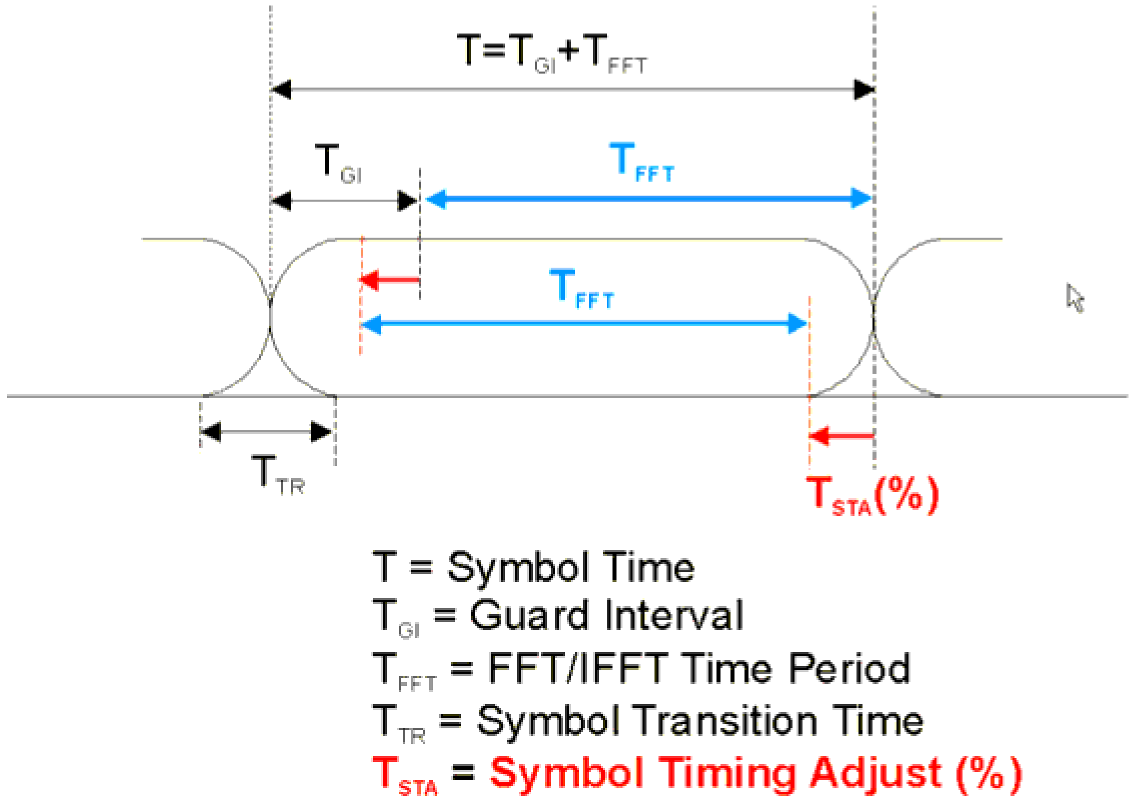
Window and Default Constant	NENBW
none	1
Hamming 0.54	1.363
Hanning 0.50	1.5
Gaussian 0.75	1.883
Kaiser 7.865	1.653
8510 6.0	1.467
Blackman	1.727
Blackman-Harris	2.021

EVM Measurement Parameters

The EVM measurement is used to measure the EVM of Mobile WiMAX RF signal source with frequency hopping used, and needs no reference signal provided by the source.

1. EVM_DisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.
2. EVM_Start sets the start time for collecting input data.
3. If EVM_AverageType is set to OFF , only one frame is analyzed. If EVM_AverageType is set to RMS (Video), after the first frame is analyzed the signal segment corresponding to it is discarded and new signal samples are collected from the input to fill in the signal buffer of length 2 x FrameDuration. A second frame is analyzed and the process repeats until EVM_FramesToAverage frames are processed.
4. EVM_FramesToAverage sets the frame number used for averaging.
5. Starting at the time instant specified by the EVM_Start parameter, the component captures a signal segment of length 2 x FrameDuration. If EVM_PulseSearch is set to YES, this signal segment is searched in order for an RF burst to be detected. If the signal has multiple RF bursts in a FrameDuration then the first one detected is the one that will be analyzed. Some 802.16e OFDMA signals do not have RF burst characteristics, rather they look like a series of bursts with no "off" time between them. These signals resemble a "continually on" signal with embedded preambles. To demodulate signals that do not appear to be made up of RF bursts, EVM_PulseSearch should be set to OFF and EVM_Start should be set to the beginning of the uplink subframe you want to analyze. Otherwise, no pulse will be detected and no measurement will be performed.
   After an RF burst is detected, the I and Q envelopes of the input signal are extracted. The I and Q envelopes are passed to a complex algorithm that performs synchronization, demodulation, and EVM analysis. The algorithm that performs the synchronization, demodulation, and EVM analysis is the same as the one used in the Agilent 89600 VSA.

6. The EVM_SymbolTimingAdjust parameter sets the percentage of symbol time by which we back away from the symbol end before we perform the FFT. Normally, when demodulating an OFDMA symbol, the cyclic prefix time (guard interval) is skipped and an FFT is performed on the last portion of the symbol time. However, this means that the FFT will include the transition region between this symbol and the following symbol. To avoid this, it is generally beneficial to back away from the end of the symbol time and use part of the guard interval. The EVM_SymbolTimingAdjust parameter controls how far the FFT part of the symbol is adjusted away from the end of the symbol time. The value is in terms of percent of the used (FFT) part of the symbol time. Note that this parameter value is negative, because the FFT start time is moved back by this parameter. EVM_SymbolTimingAdjust Definition. explains this concept. When setting this parameter, be careful to not back away from the end of the symbol time too much because this may make the FFT include corrupt data from the transition region at the beginning of the symbol time.



EVM_SymbolTimingAdjust Definition.

7. The EVM_TrackAmplitude, EVM_TrackPhase, and EVM_TrackTiming parameters specify whether the analysis will track amplitude, phase, and timing changes in the pilot subcarriers. 802.16e performs demodulation relative to the data in pilot carriers embedded in the signal. These pilot carriers replace data-carrying elements of the signal and allow some kinds of impairments to be removed or "tracked out." Many impairments will be common to all pilot carriers and can be measured as the "common pilot error." When these parameters are set to YES the analysis will track amplitude, phase, and timing changes in the pilot subcarriers and apply corrections to the pilot and data subcarriers.
The flexibility to allow users to individually enable or disable tracking functions, provides useful troubleshooting capability, since modulation errors can be examined with and without the benefit of particular types of pilot tracking.
8. The EVM_ExtendFrequencyLockRange parameter allows the user to increase the frequency lock range of the

analysis. When set to YES it enables a frequency offset estimation algorithm prior to OFDMA demodulation to increase the frequency lock range of the analysis. This is especially useful when the center frequency drifts more than +/-1 kHz while making multiple measurements or the measurement setup uses multiple DUTs that have a frequency reference variance of greater than +/-1 kHz. The accuracy of the initial frequency offset estimate is dependent on the statistics of the analyzed waveform and may occasionally produce a frequency estimation error beyond the subsequent OFDMA analysis algorithms' capabilities. This will result in a frequency error of multiple kHz and the measurement will be unsynchronized.

9. The EVM_EqualizerTraining parameter sets the type of training used for the equalizer. When demodulating an 802.16e signal, an equalizer is used to correct for linear impairments in the signal path, such as multi-path. When "Chan Estimation Seq Only" is selected the equalizer is trained using the Channel Estimation Sequence in the preamble of the OFDMA burst. After this initialization, the equalizer coefficients are held constant while demodulating the rest of the burst. This equalizer training method complies with the description in the "Transmit constellation error and test method" section (8.4.12.3) of the 802.16-2004 standard. However, for signals whose impairments change during the burst it might result in measured RCE (EVM) values that are higher compared to if the equalizer were trained over the entire burst.
   When "Chan Estimation Seq & Data" is selected the equalizer is trained by analyzing the entire OFDMA burst and using the Channel Estimation Sequence (contained in the preamble) and the all the subcarriers in the Data symbols. This type of equalizer training generally gives a more accurate estimate of the true response of the transmission channel and so results in lower RCE (EVM) measured values. However, it is more complicated and more computationally expensive to implement and therefore less likely to be used in practical receivers.
   When "Chan Estimation Seq & Pilots" is selected the equalizer is trained by analyzing the entire OFDMA burst and using the Channel Estimation Sequence (contained in the preamble) and the pilot subcarriers in the Data symbols. This gives results very similar to the "Chan Estimation Seq & Data" option without the excessive computational complexity.

Simulation Measurement Displays

After running the simulation, results are displayed in Data Display pages for each measurement activated.

> **Note**
> Measurement results from a wireless test bench have associated names that can be used in Data Display Expressions. For more information, refer to Measurement Results for Expressions.

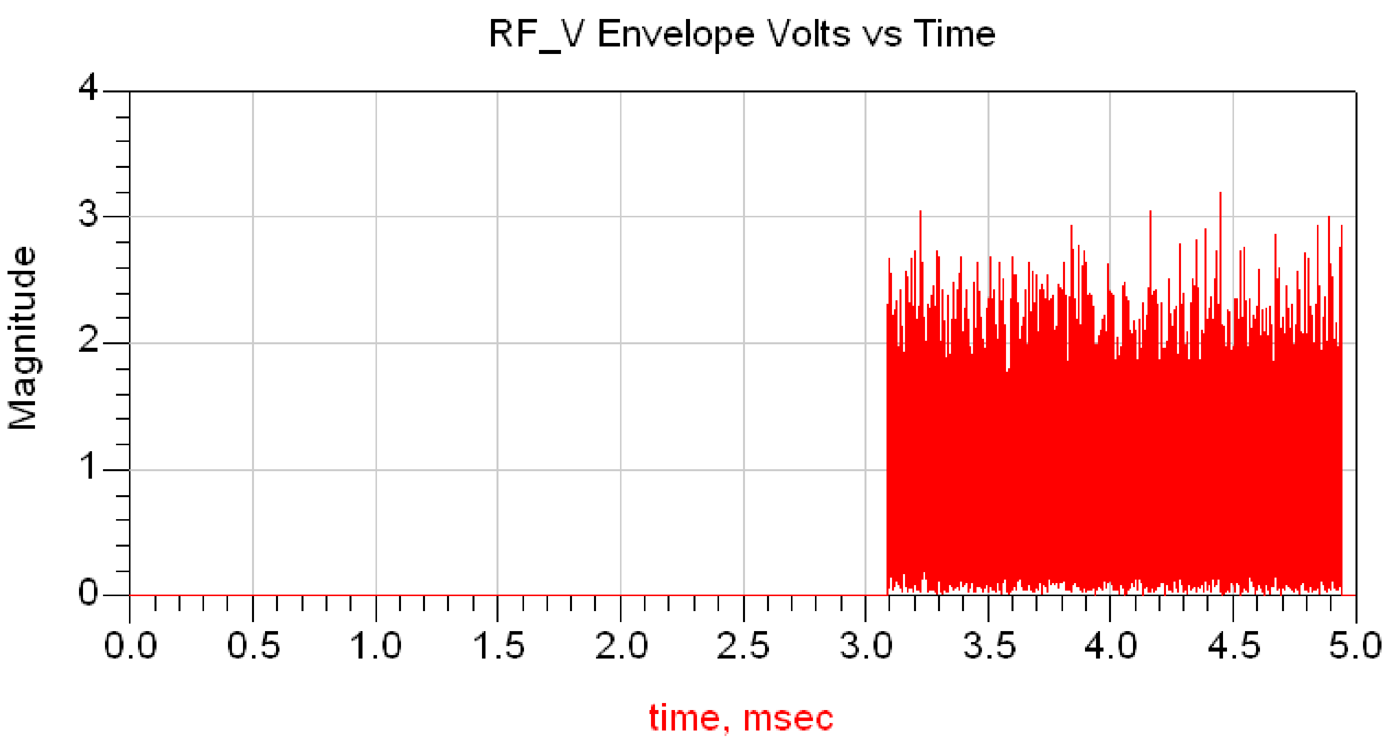
Envelope Measurement

The Envelope measurement shows the envelope of the Mobile WiMAX frame. Two signals are tested, the RF source signal at the RF DUT input and the Meas signal at the RF DUT output.
For envelope measurement, the default parameter setting is given in Default Parameter Setting for Measurement.

Parameter	Default Setting
RF_FSource	2305.0 MHz
RF_R	50.0 Ohm

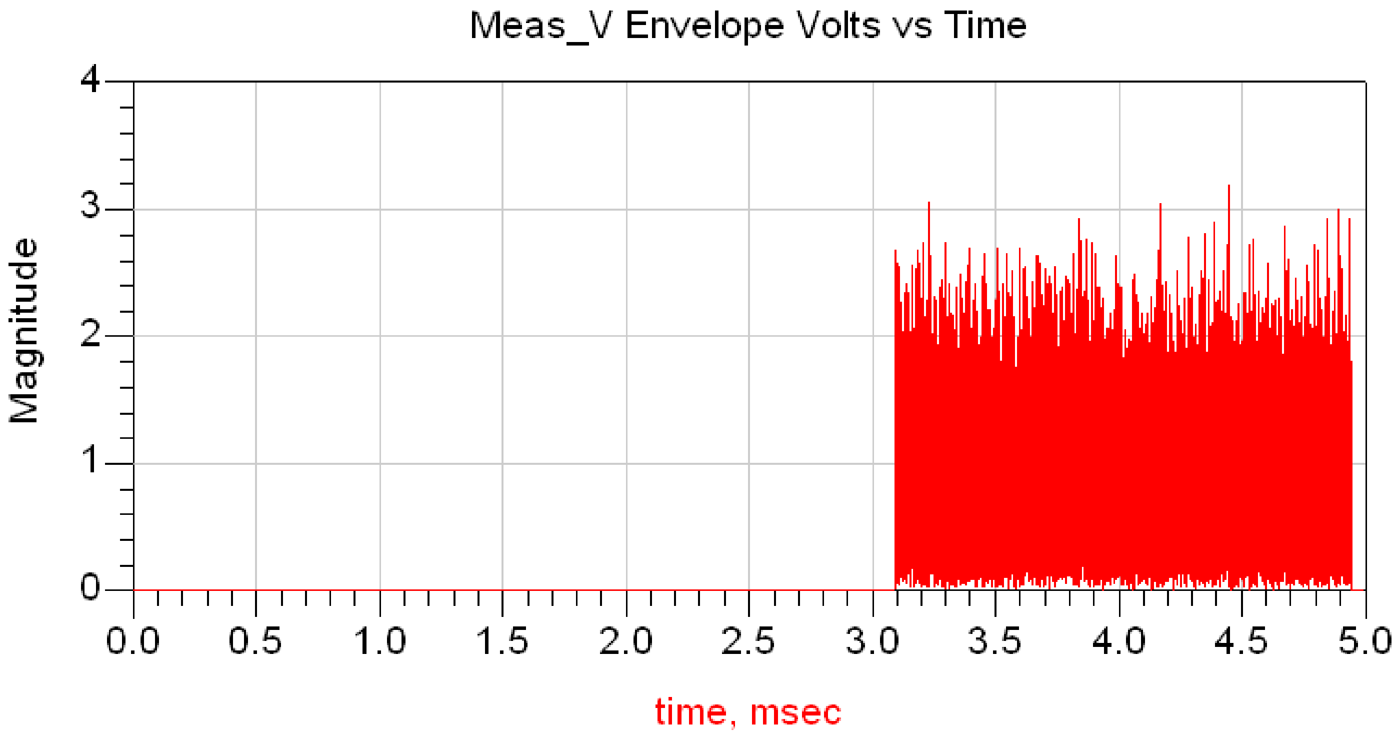
RF_Power	10.0 dBm
Bandwidth	10.0 MHz
RateID	5
CyclicPrefix	0.125
Frame_Duration	5.0 msec
TimeStep	44.643 nsec
SamplingFrequency	11.2 MHz
Frame_Mode	TDD
DL_Ratio	0.618
Data_Length	710
Meas_FMeasurement	2305.0 MHz
Meas_R	50.0 Ohm

For the RF signal, the time domain envelope of one complete Mobile WiMAX frame is shown in Time Envelope of Mobile WiMAX UL RF Signal for Default Settings (one frame).



Time Envelope of Mobile WiMAX UL RF Signal for Default Settings (one frame)

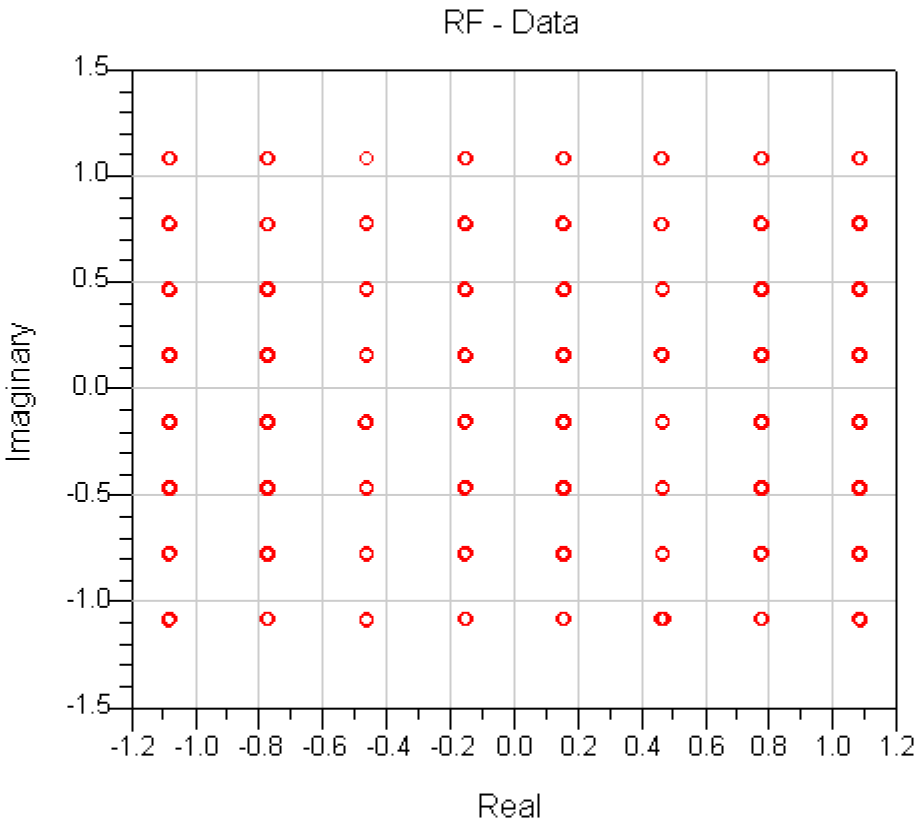
For the Meas signal test, all measurements are the same as RF signal measurements, except the Meas signal will contain any linear and nonlinear distortions. Envelope measurements for Meas signal are shown in Time Envelope of Mobile WiMAX UL Meas Signal for Default Settings (one frame).



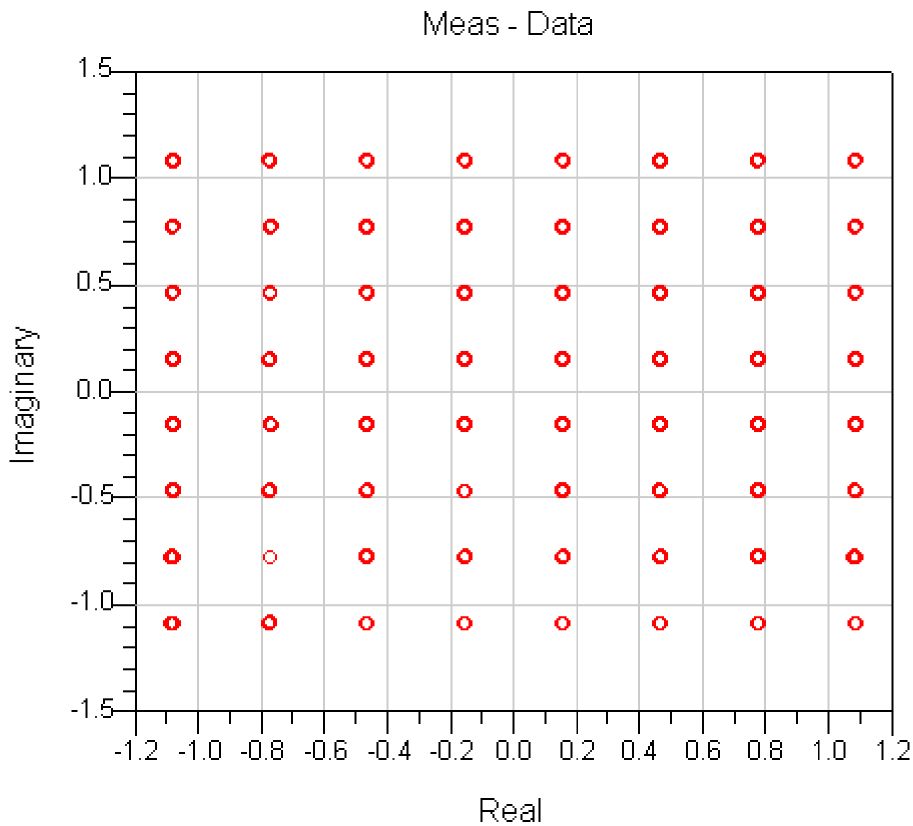
Time Envelope of Mobile WiMAX UL Meas Signal for Default Settings (one frame)

Constellation Measurement

The constellation measurement shows the RF and Meas signal constellations.



RF Signal Constellation

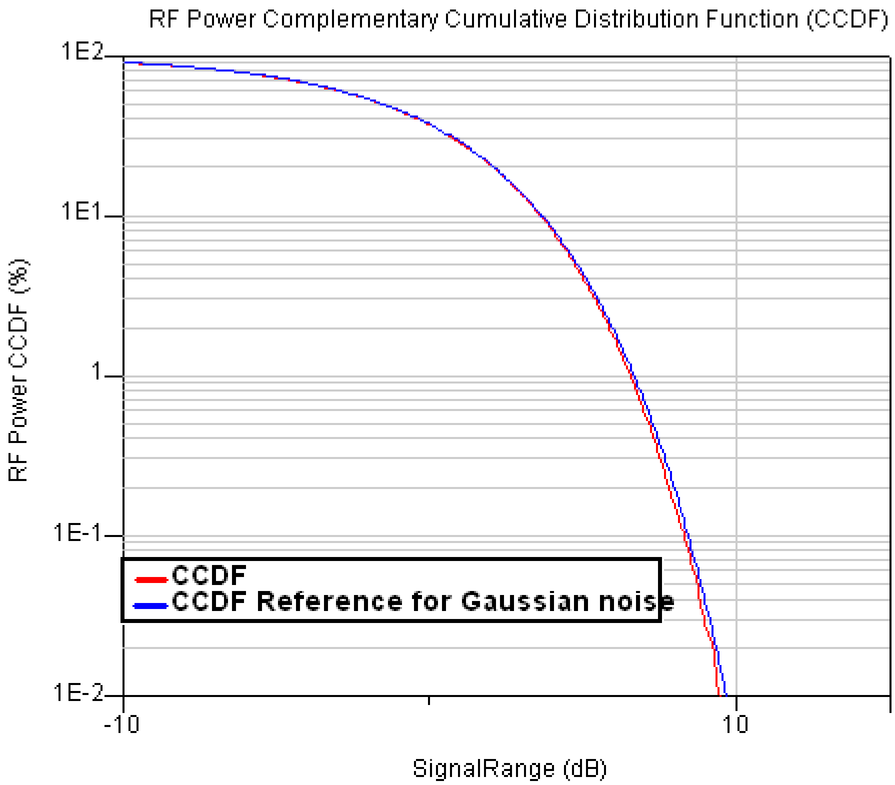


Meas Signal Constellation

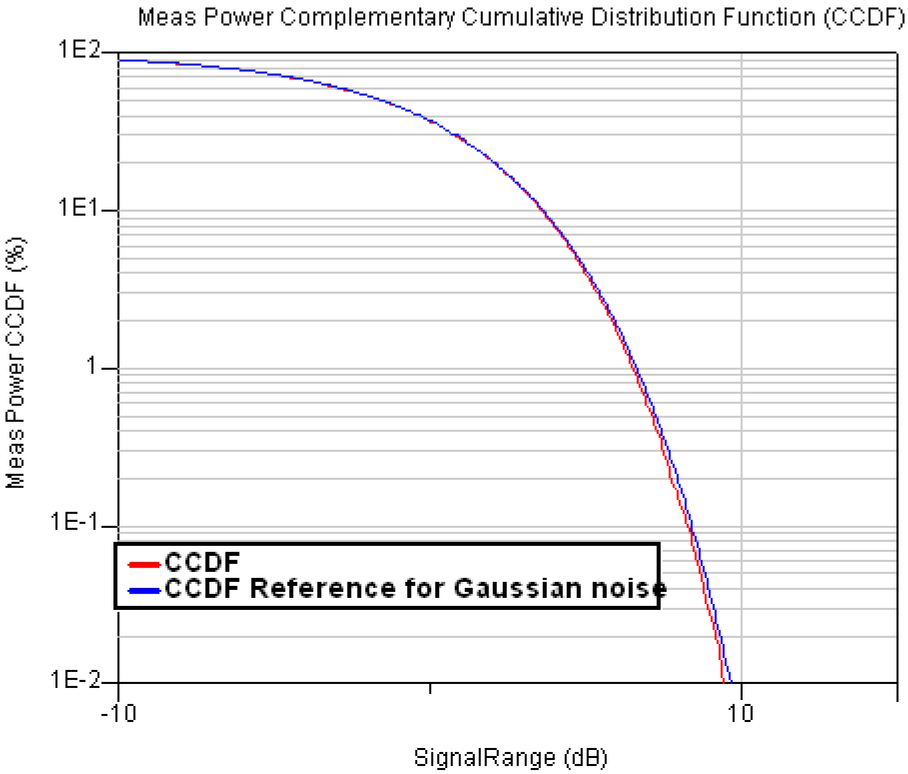
Power Measurement

The power measurement shows the CCDF curves of the transmitter and peak-to-average ratios for the RF and Meas signals.
CCDF measurement results for RF and Meas signals are shown in RF Power CCDF and Meas Power CCDF.

Reference CCDF measurements for Gaussian noise can be calculated by calling the function power_ccdf_ref () in the. dds files directly.
Functions for calculating peak-to-average-ratios and results are shown in RF Signal Peak-to-Average-Ratio and Results and Meas Signal Peak-to-Average-Ratio Results.



RF Power CCDF



Meas Power CCDF

RF_Power.MeanPower_dBm	RF_Power.PeakPower_dBm	RF_Peak_to_Avg_dB
9.982	18.307	8.326

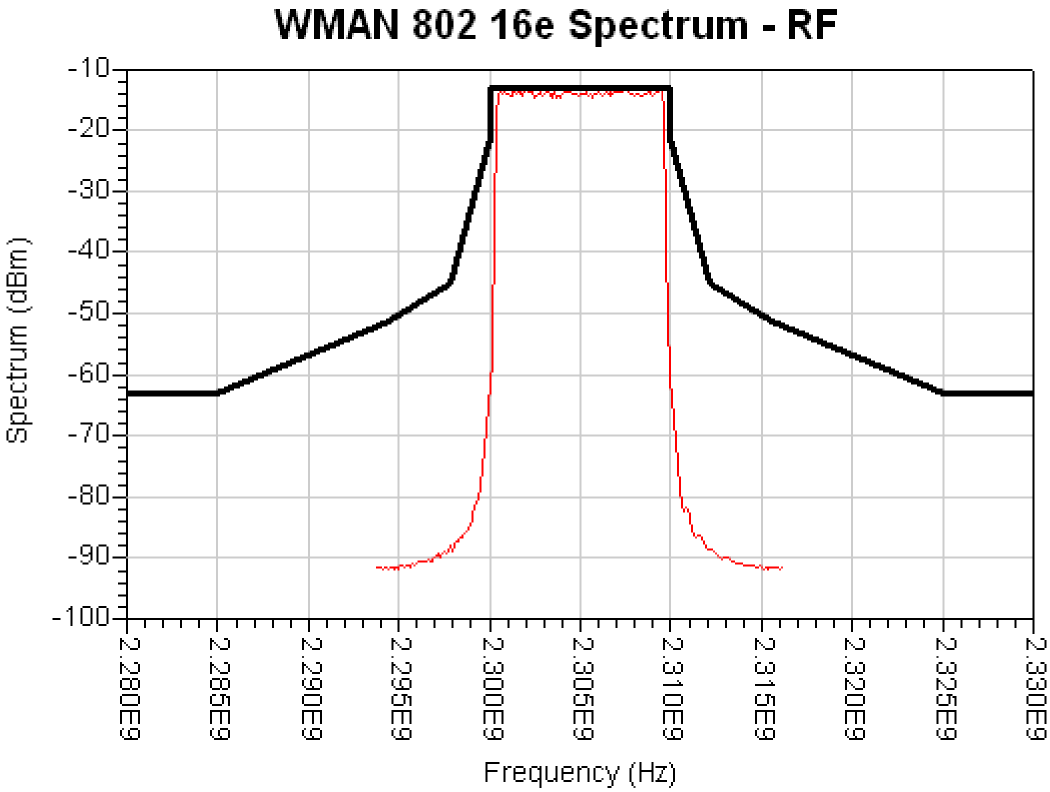
RF Signal Peak-to-Average-Ratio and Results

Meas_Power.MeanPower_dBm	Meas_Power.PeakPower_dBm	Meas_Peak_to_Avg_dB
9.983	18.318	8.335

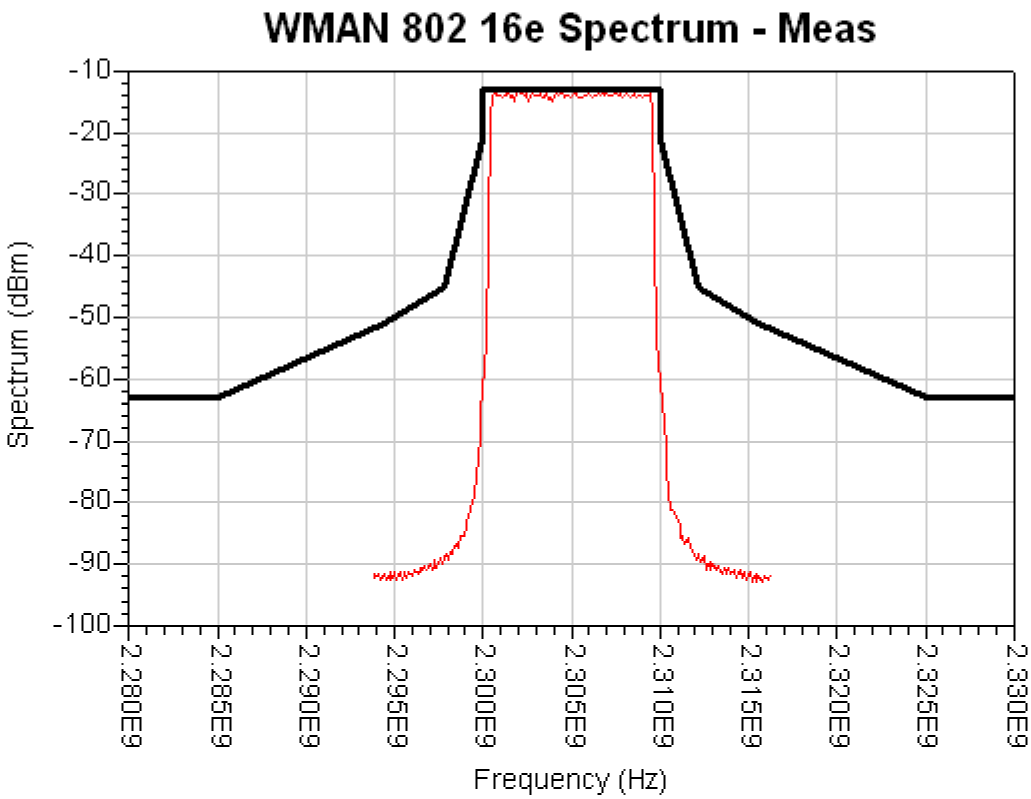
Meas Signal Peak-to-Average-Ratio Results

Spectrum Measurement

The Spectrum measurement is used to verify that the transmitted spectrum meets the spectrum mask according to Reference [3], section 5.3.3. The RF and Meas spectral density must fall within the spectral mask, as shown in RF Spectrum Mask and Meas Spectrum Mask.



RF Spectrum Mask



Meas Spectrum Mask

EVM Measurement

The EVM measurement is a modulation accuracy measurement. EVM measurement results shown in RF Signal EVM and Meas Signal EVM for 64-QAM-2/3 modulation do not exceed -28 dB; therefore the measurements meet the specification requirements.

EVM (RF)

RF_EVM.Avg_RCE_dB	RF_EVM.Avg_Pilot_RCE_dB
-114.710	-114.782

RF_EVM.Avg_DataRCE_dB	RF_EVM.Pilot_RCE_dB
-114.674	-115.001

RF_EVM.DataRCE_dB	RF_EVM.RCE_dB
-115.045	-115.030

RF Signal EVM

EVM (Meas)

Meas_EVM.Avg_RCE_dB	Meas_EVM.Avg_Pilot_RCE_dB
-108.890	-108.938

Meas_EVM.Avg_DataRCE_dB	Meas_EVM.Pilot_RCE_dB
-108.866	-108.573

Meas_EVM.DataRCE_dB	Meas_EVM.RCE_dB
-108.453	-108.493

Meas Signal EVM

Test Bench Variables for Data Displays

Variables listed in Test Bench Variables for Data Displays are used to set up this test bench and data displays.

Data Display Parameter	Equation with Test Bench Parameters
RF_FSource	FSource
RF_Power_dBm	10*log10(SourcePower)+30
RF_R	SourceR

TimeStep	1/SamplingFrequency/(2^OversamplintOption)
SamplingFrequency	Bandwidth*n (n is sampling factor)
Bandwidth	Bandwidth
RateID	Rate_ID
CyclicPrefix	CyclicPrefix
Data_Length	DataLength
Frame_Duration	FrameDuration
Frame_Mode	FrameMode
DL_Ratio	DL_Ratio
Meas_FMeasurement	FMeasurement
Meas_R	MeasR

Baseline Performance

- Test Computer Configuration
  - Pentium IV 2.26 GHz, 1024 MB RAM, Windows 2000
- Conditions
  - Measurements made with default test bench settings.
  - RF DUT is an RF system behavior component.
  - Resultant WTB_TimeStep = 44.643 nsec; Frame_Duration = 5 msec
- Simulation times:

WMAN_UL_802_16e_TX Measurement	Simulation Time (sec)	ADS Processes (MB)
RF_Envelope	181	222
Constellation	176	222
Power	600	265
Spectrum	189	222
EVM	176	222

Expected ADS Performance

Expected ADS performance is the combined performance of the baseline test bench and the RF DUT Circuit Envelope simulation with the same signal and number of time points. For example, if the RF DUT performance with Circuit Envelope simulation alone takes 2 hours and consumes 200 MB of memory (excluding the memory consumed by the core ADS product), then add these numbers to the Baseline Performance numbers to determine the expected ADS performance. This is valid only if the full memory consumed is from RAM. If RAM is less, larger simulation times may result due to increased disk access time for swap memory usage.

References for Mobile WiMAX Uplink Transmitter Test

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.
3. ETSI EN 301 021 V1.6.1 (2003-07): Fixed Radio Systems; Point-to-multipoint equipment; Time Division Multiple Access (TDMA); Point-to-multipoint digital radio systems in frequency bands in the range 3 GHz to 11 GHz

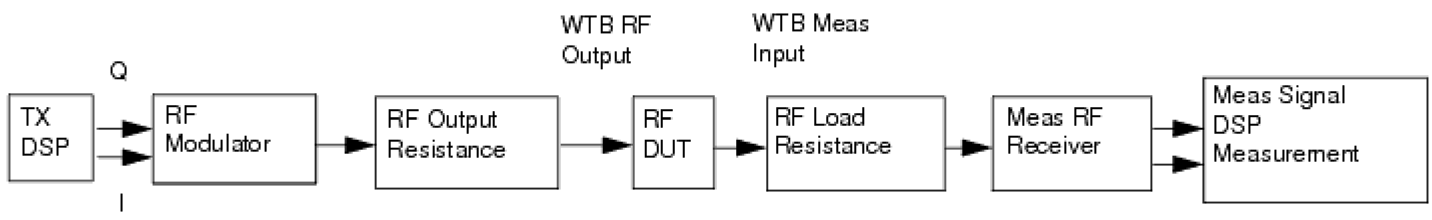
Setting up a Wireless Test Bench Analysis in the Wireless Test Bench Simulation documentation explains how to use test bench windows and dialogs to perform analysis tasks.
Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation explains how to set up circuit envelope analysis parameters such as convergence criteria, solver selection, and initial guess.
Setting Automatic Behavioral Modeling Parameters in the Wireless Test Bench Simulation documentation explains how to improve simulation speed.

Mobile WiMAX Uplink Receiver Sensitivity Test

WMAN_UL_802_16e_RX_Sensitivity_test is the test bench for Mobile WiMAX receiver minimum input level sensitivity testing. The test bench enables users to connect to an RF DUT and determine its performance; signal measurements include BER and PER with minimum input level.

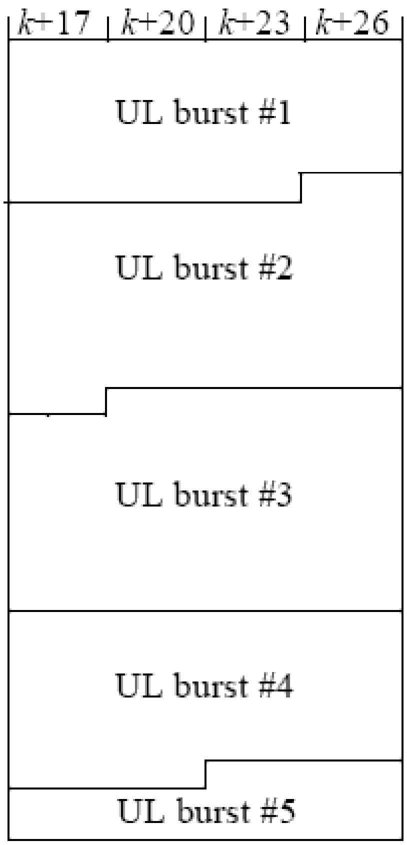
The signal and the measurement are designed according to References [1] and [2].

This test bench includes a TX DSP section, an RF modulator, RF output source resistance, an RF DUT connection, RF receivers, and DSP measurement blocks as illustrated in Receiver Wireless Test Bench Block Diagram. The generated test signal is sent to the DUT.



Receiver Wireless Test Bench Block Diagram

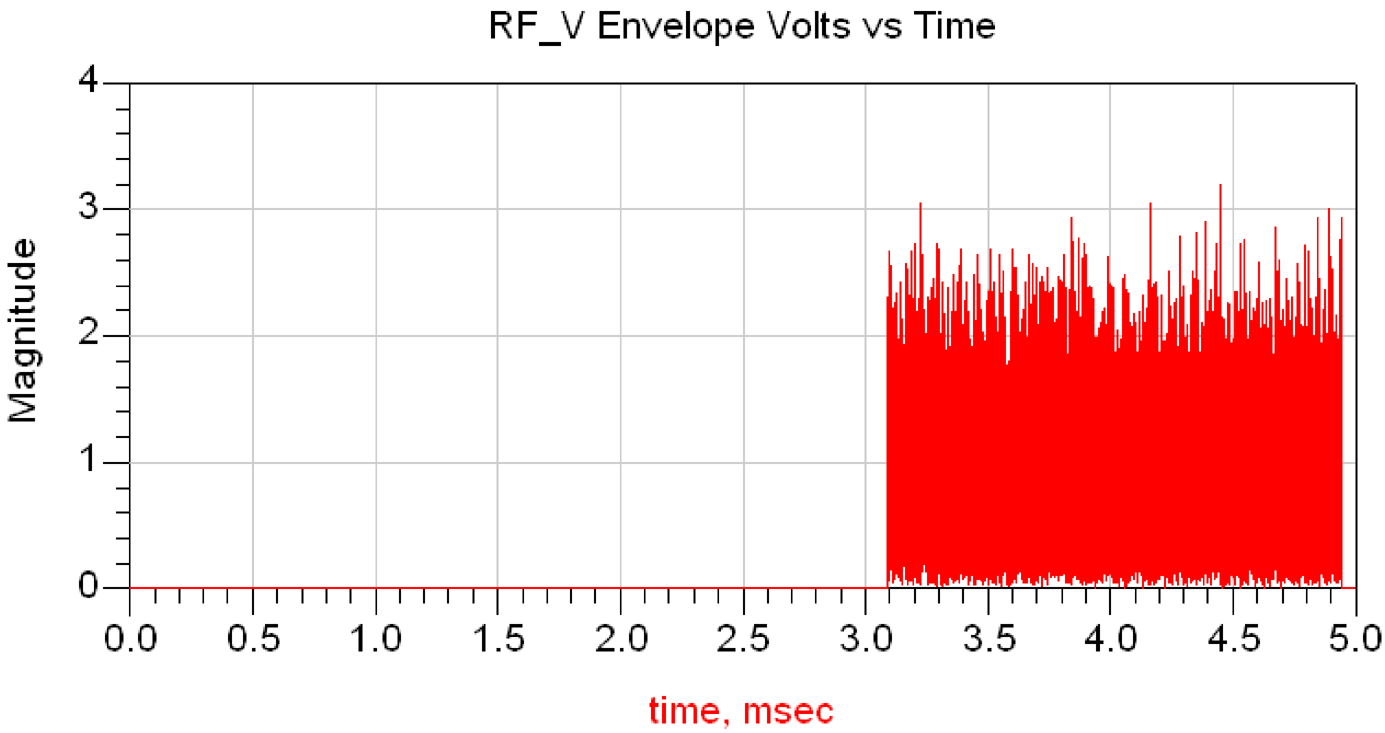
The Mobile WiMAX uplink frame structure is illustrated in Mobile WiMAX UL frame structure.



Mobile WiMAX UL frame structure

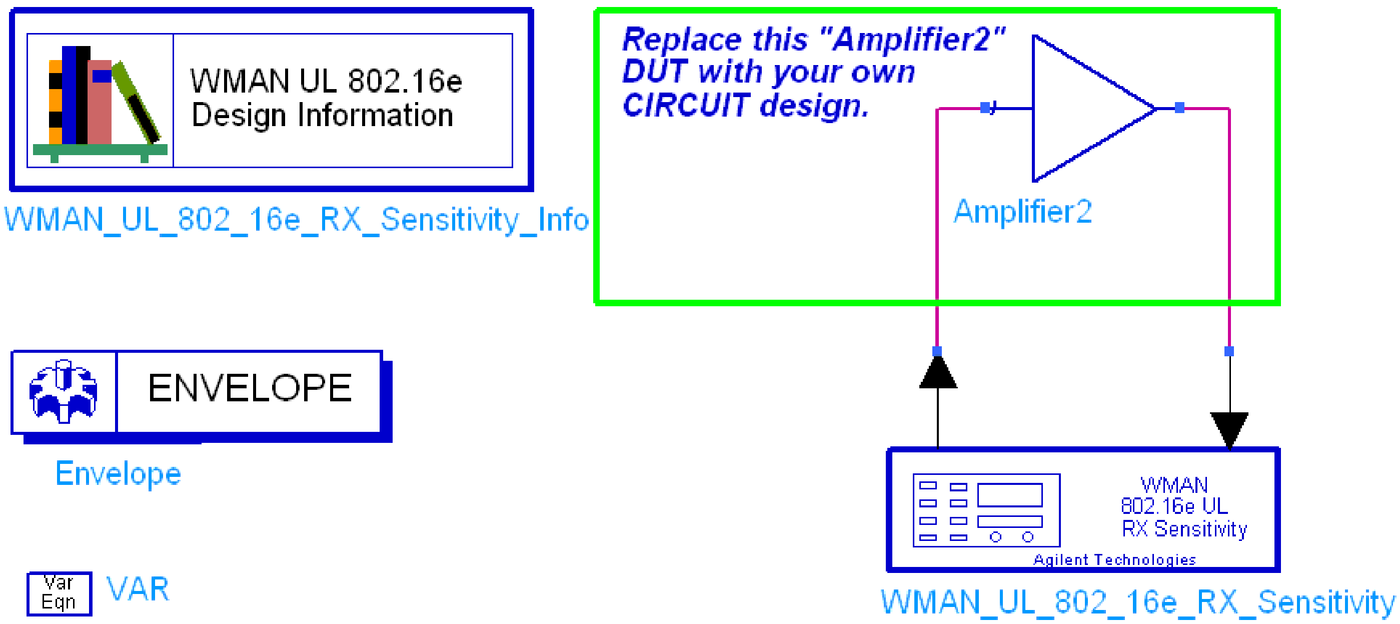
The uplink subframe includes only one zone (alternative PUSC or OPUSC) which contains maximum 8 bursts carrying one MAC PDU each. Among these bursts, only one FEC-encoded burst is supported whose coding type can be set to CC or CTC. Other bursts are provided PN sequences as their coded source respectively. Both TDD mode and FDD mode can be supported for the uplink source.

The Mobile WiMAX RF power delivered into a matched load is the average power when all subchannels are occupied. Mobile WiMAX UL RF Signal Envelope shows the RF envelope for an output RF signal with 10 dBm power.



Mobile WiMAX UL RF Signal Envelope

Test Bench Basics



Mobile WiMAX UL Receiver Test Bench

The basics for using the test bench are:

- Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench.
- CE_TimeStep, SourcePower, and FMeasurement parameter default values are typically accepted; otherwise, set values based on your requirements.
- Run the simulation and view Data Display page(s) for your measurement(s).

For details, refer to Mobile WiMAX Uplink Receiver Sensitivity Test#1247939Test Bench Details.

Test Bench Details

The following sections provide details for setting up a test bench, setting measurement parameters for more control of the test bench, simulation measurement displays, and baseline performance.

Open and use the WMAN_UL_802_16e_RX_Sensitivity_test template:

1. In an Analog/RF schematic window, choose Insert > Template .
2. In the Insert > Template dialog box, choose WMAN_UL_802_16e_RX_Sensitivity_test , click OK ; click left to place the template in the schematic window.

Test bench setup is detailed here.
3. Replace the DUT (Amplifier2 is provided with this template) with an RF DUT that is suitable for this test bench. For information regarding using certain types of DUTs, refer to RF DUT Limitations.
4. Set the Required Parameters

> Note
> Refer to WMAN_UL_802_16e_RX_Sensitivity for a complete list of parameters for this test bench.

Generally, default values can be accepted; otherwise, values can be changed by the user as needed.

- Set CE_TimeStep.
Cosimulation occurs between the test bench (using ADS Ptolemy Data Flow simulation technology) and the DUT (using Circuit Envelope simulation technology). Each technology requires its own simulation time step with time-step coordination occurring in the interface between the technologies.
CE_TimeStep defines the Circuit Envelope simulation time step to be used with this DUT. The CE_TimeStep must be set to a value equal to or a submultiple of (less than) WTB_TimeStep; otherwise, simulation will stop and an error message will be displayed.
Note that WTB_TimeStep is not user-settable. Its value is derived from other test bench parameter values. The value is displayed in the Data Display pages as TimeStep.
WTB_TimeStep = 1/(RF_SamplingRate × Ratio)
where
The RF_SamplingRate (Fs) implemented in the design is decided by Bandwidth and related sampling factor (N_{factor}) as follows,

$$F_s = floor((N_{factor} \times Bandwidth)/8000) \times 8000$$

The sampling factors are listed in sampling factor requirement.

sampling factor n	bandwidth
8/7	For channel bandwidths that are a multiple of 1.75 MHz
28/25	else for channel bandwidths that are a multiple of 1.25 MHz, 1.5 MHz, 2 MHz or 2.75 MHz
8/7	else for channel bandwidths not otherwise specified

Bandwidth is the user-settable value (default 10 MHz)
Ratio is the oversampling ratio related to OversamplingOption as Ratio = 2 OversamplingOption .

- Set SourcePower, and FMeasurement.
  - SourcePower defines the power level of the source. SourcePower is defined as the average power during the non-idle time of the signal burst.
  - FMeasurement defines the RF frequency output from the DUT to be measured.

5. More control of the test bench can be achieved by setting Basic Parameters , Signal Parameters , and measurement parameters. For details, refer to Setting Parameters.
6. The RF modulator (shown in the block diagram in Receiver Wireless Test Bench Block Diagram) uses SourcePower (Required Parameters), GainImbalance, PhaseImbalance (Signal Parameters).

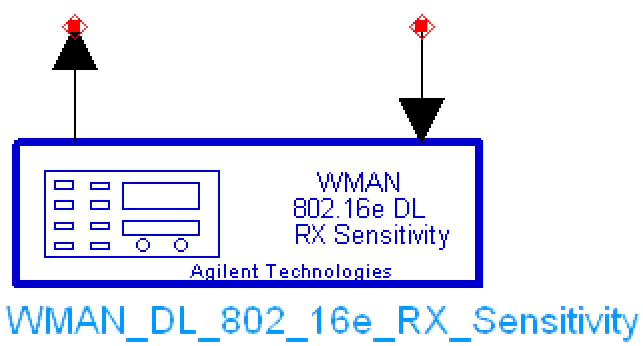
RF output resistance uses SourceR and SourceTemp (Basic Parameters). The RF output signal source has a 50-ohm (default) output resistance defined by SourceR.
RF output (and input to the RF DUT) is delivered into a matched load of resistance SourceR, with frequency hopping, with the specified source resistance (SourceR) and with power (SourcePower). The RF signal has additive Gaussian noise power set by resistor temperature (SourceTemp).
Note that the Meas_in point of the test bench provides a resistive load to the RF DUT set by the MeasR value (50-ohm default) (Basic Parameters).
The Meas signal contains linear and nonlinear signal distortions and time delays associated with the RF DUT input to output characteristics.
The TX DSP block (shown in the block diagram in Receiver Wireless Test Bench Block Diagram) uses other Signal Parameters .

7. More control of Circuit Envelope analysis can be achieved by setting Envelope controller parameters. These settings include Enable Fast Cosim, which may speed the RF DUT simulation more than 10×. Setting these simulation options is described in Setting Fast Cosimulation Parameters and Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation.
8. To run a simulation, choose Simulate > Simulate in the Schematic window.
   For details on Running a Simulation refer to the Wireless Test Bench Simulation documentation.
9. Simulation results will appear in a Data Display window for each measurement. Simulation Measurement Displays describes results for each measurement available for this test bench.

For details on Viewing Results refer to the Wireless Test Bench Simulation documentation.

WMAN_DL_802_16e_RX_Sensitivity

This section provides parameter information for Required Parameters, Basic Parameters, Signal Parameters, and parameters for the various measurements.



Setting Parameters

More control of the test bench can be achieved by setting parameters in the Basic Parameters , Signal Parameters , and measurement categories for the activated measurements.

Note
For required parameter information, see Set the Required Parameters.

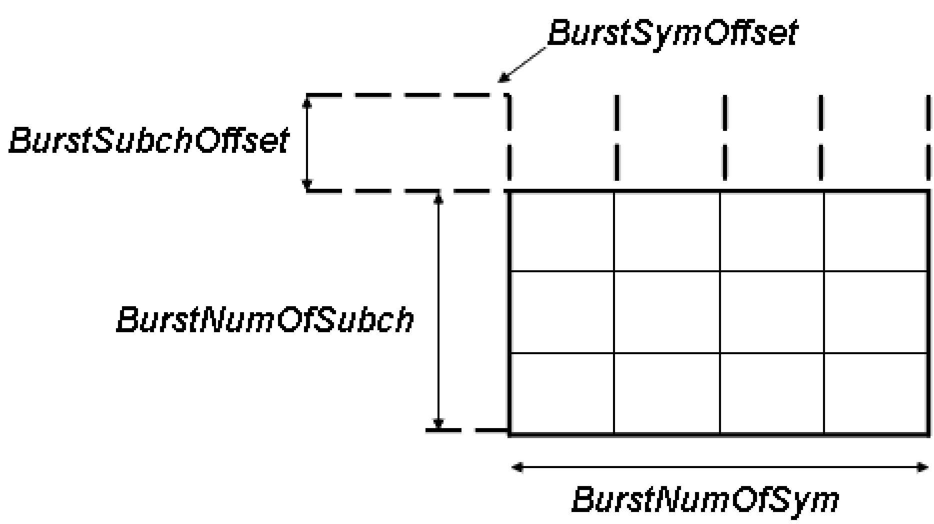
Basic Parameters

1. SourceR is the RF output source resistance.
2. SourceTemp is the RF output source resistance temperature (oC) and sets noise density in the RF output signal to (k(SourceTemp+273.15)) Watts/Hz, where k is Boltzmann's constant.
3. MeasR defines the load resistance for the RF DUT output Meas signal into the test bench. This resistance loads the RF DUT output; it is also the reference resistance for Meas signal power measurements.
4. TestBenchSeed is an integer used to seed the random number generator used with the test bench. This value is used by all test bench random number generators, except those RF DUT components that use their own specific seed parameter. TestBenchSeed initializes the random number generation. The same seed value produces the same random results, thereby giving you predictable simulation results. To generate repeatable random output from simulation to simulation, use any positive seed value. If you want the output to be truly random, enter the seed value of 0.

Signal Parameters

1. GainImbalance, PhaseImbalance are used to add certain impairments to the ideal output RF signal. Impairments are added in the order described here.
   The unimpaired RF I and Q envelope voltages have gain and phase imbalance applied. The RF is given by:
   $$V_{RF}(t) = A\left(V_I(t)\cos(\omega_c t) - gV_Q(t)\sin\left(\omega_c t + \frac{\phi\pi}{180}\right)\right)$$
   where A is a scaling factor that depends on the SourcePower and SourceR parameters specified by the user, V I(t) is the in-phase RF envelope, V Q(t) is the quadrature phase RF envelope, g is the gain imbalance
   $$g = 10^{\frac{GainImbalance}{20}}$$
   and, φ (in degrees) is the phase imbalance.
2. Bandwidth determines the nominal channel bandwidth.
3. OversamplingOption indicates the oversampling ratio of transmission signal. There are six oversampling ratios (1, 2, 4, 8, 16, 32) to support in this source.
4. FFTSize specifies the size of FFT. Sizes 2048, 1024 and 512 are supported.
5. CyclicPrefix specifies the ratio of cyclic prefix time to "useful" time, whose range is from 0 to 1.
6. FrameMode specifies the duplexing method which should be FDD or TDD. In FDD transmission, the downlink occupies the entire frame and the respective gaps (zeros) are automatically adjusted to fill the frame.
7. DL_Ratio specifies set the percentage (1 to 99) of the frame time to be used for the downlink subframe. The parameter is only active when the FrameMode is TDD.
8. FrameDuration determines the frame durations (ms) of the generated waveform.There are eight frame durations (2ms, 2.5ms, 4ms, 5ms, 8ms, 10ms, 12.5ms, 20ms) to be selected as allowed by the specification.
9. DLMAP_Enable specifies whether the DL-MAP burst is inserted in the downlink burst.
10. ULMAP_Enable specifies whether the UL-MAP burst is inserted in the downlink burst.

11. PreambleIndex specifies the preamble index number (0 to 113). The preamble index value determines the ID Cell values (0 to 31) and segment index (0 to 2) according to the standard.
12. DL_PermBase specifies the basis of downlink permutation to be used in initialization vector of the PRBS generator for subchannel randomization in the zone and in STC_DL_Zone_IE() in DL-MAP message.
13. BSID specifies the base station ID which is used in DL-MAP message.
14. PRBS_ID specifies the PRBS ID which may be used in initialization vector of the PRBS generator for subchannel randomization and in STC_DL_Zone_IE() in DL-MAP message.
15. ZoneType specifies the zone type which can be set to PUSC, FUSC or OFUSC.
16. ZoneNumOfSym specifies the symbol number for the zone. The value must be a multiple of two for DL_PUSC, and be a multiple of one for DL_FUSC and DL_OFUSC.
17. GroupBitmask specifies which groups of subchannel are used on the PUSC zone. This parameter uses 1 for assigned groups and 0 for unassigned groups.
18. NumberOfBurst specifies the number of active downlink bursts.
19. BurstWithFEC specifies the downlink burst FEC.
20. BurstSymOffset, BurstSubchOffset, BurstNumOfSym and BurstNumOfSubch specify the position and range for each rectangular burst, see Downlink rectangular burst structure.



Downlink rectangular burst structure

21. DataLength specifies MAC PDU payload byte length for each burst.
22. CodingType specifies the coding type for each burst. Each coding type can be selected from 0 to 1, whose meaning is shown in The meaning of coding type.

The meaning of coding type

Coding type	meaning
0	Convolutional coding (CC)
1	Convolutional turbo coding (CTC)

23. Rate_ID specifies the rate ID for each burst. Rate_ID, along with CodingType, determines the modulation and coding rate, shown in The relation of Coding type and Rate ID.

The relation of Coding type and Rate ID

Coding type	Rate ID	Modulation/Coding rate
0 (CC)	0	QPSK CC1/2
0 (CC)	1	QPSK CC3/4
0 (CC)	2	16-QAM CC1/2
0 (CC)	3	16-QAM CC3/4
0 (CC)	4	64-QAM CC1/2
0 (CC)	5	64-QAM CC2/3
0 (CC)	6	64-QAM CC3/4
1 (CTC)	0	QPSK CTC1/2
1 (CTC)	1	QPSK CTC3/4
1 (CTC)	2	16-QAM CTC1/2
1 (CTC)	3	16-QAM CTC3/4
1 (CTC)	4	64-QAM CTC1/2
1 (CTC)	5	64-QAM CTC2/3
1 (CTC)	6	64-QAM CTC3/4
1 (CTC)	7	64-QAM CTC5/6

24. RepetitionCoding specifies the repetition coding for each burst. Each repetition coding can be selected from 0 to 3, whose meaning is shown in The meaning of repetition coding.

Repetition coding	meaning
0	No repetition coding on the burst
1	Repetition coding of 2 used on the burst
2	Repetition coding of 4 used on the burst
3	Repetition coding of 6 used on the burst

25. PowerBoosting specifies the power boosting for each burst. Each value is defined in units of dB.
26. DecoderType specifiers the Viterbi decoder type chosen from CSI, Soft and Hard.
27. StopFrame specifiers the stop burst used for BER and FER calculation.

Measurement Parameters

1. DisplayPages provides Data Display page information for this measurement. It cannot be changed by the user.

Simulation Measurement Displays

After running the simulation, results are displayed in the Data Display pages for each measurement activated.

> Note
> Measurement results from a wireless test bench have associated names that can be used in Data Display Expressions. For more information, refer to Measurement Results for Expressions.

Sensitivity Measurement

The sensitivity measurement shows BER and PER results. The BER measured after FEC shall be less than 10^(-6) at the power levels RSS defined in equation (149b) of section 8.4.13.1 of Reference [2] (assuming 5dB implementation margin and 8dB Noise Figure). Simulation results for "Rate_ID = 5" and SourcePower of -75 dBm are displayed in Simulation Results for "Rate_ID = 5" and -75 dBm SourcePower.

real(RF_FSource) / (1 MHz)	real(RSS_dBm)
2305.000	-75.000

real(TimeStep) / (1 nsec)	real(RF_SourceTemp)
44.643	16.850

real(CyclicPrefix)	real(Data_Length)
0.125	200.000

real(RF_R)	real(Meas_FMeasurement) / (1 MHz)
50.000	2305.000

real(Meas_R)	real(RateID)
50.000	5.000

real(Frame_Duration) / (1 msec)	real(Bandwidth) / (1 MHz)
5.000	10.000

real(SamplingFrequency) / (1 MHz)	real(DL_Ratio)	Frame_Mode
11.200	0.618	TDD

Meas Sensitivity

BER	FER
0.00000000	0.00000000

Simulation Results for "Rate_ID = 5" and -75 dBm SourcePower

Test Bench Variables for Data Displays

Variables listed in Test Bench Variables for Data Displays are used to set up this test bench and data displays.

Test Bench Variables for Data Displays

Data Display Parameter	Equation with Test Bench Parameters
RF_FSource	FSource
RF_Power_dBm	10*log10(SourcePower)+30
RF_R	SourceR
TimeStep	1/SamplingFrequency/(2^OversamplintOption)
SamplingFrequency	Bandwidth*n (n is sampling factor)
Bandwidth	Bandwidth
RateID	Rate_ID
CyclicPrefix	CyclicPrefix
Data_Length	DataLength
Frame_Duration	FrameDuration
Frame_Mode	FrameMode
DL_Ratio	DL_Ratio
Meas_FMeasurement	FMeasurement
Meas_R	MeasR

Baseline Performance

- Test Computer Configuration
  - Pentium IV 2.26 GHz, 1024 MB RAM, Windows 2000
- Conditions
  - Measurements made with default test bench settings.
  - RF DUT is an RF system behavior component.
  - Resultant WTB_TimeStep = 44.643 nsec; Frame_Duration = 5 msec
- Simulation time and memory requirements:

WMAN_DL_802_16e_RX_Sensitivity Measurement	Frames Measured	Simulation Time (hour)	ADS Processes (MB)

RX Sensitivity	100	2	400

Expected ADS Performance

Expected ADS performance is the combined performance of the baseline test bench and the RF DUT Circuit Envelope simulation with the same signal and number of time points. For example, if the RF DUT performance with Circuit Envelope simulation alone takes 2 hours and consumes 200 MB of memory (excluding the memory consumed by the core ADS product), then add these numbers to the Baseline Performance numbers to determine the expected ADS performance. This is valid only if the full memory consumed is from RAM. If RAM is less, larger simulation times may result due to increased disk access time for swap memory usage.

References for Mobile WiMAX Downlink Receiver Sensitivity Test

1. IEEE Std 802.16-2004, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN-OFDMA PHY, October 1, 2004.
2. IEEE Std 802.16e-2005, Amendment 2: for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1, - Part 16: Air Interface for Fixed Broadband Wireless Access Systems, Section 8.4 WirelessMAN -OFDMA PHY, February 2006.

Setting up a Wireless Test Bench Analysis in the Wireless Test Bench Simulation documentation explains how to use test bench windows and dialogs to perform analysis tasks.

Setting Circuit Envelope Analysis Parameters in the Wireless Test Bench Simulation documentation explains how to set up circuit envelope analysis parameters such as convergence criteria, solver selection, and initial guess.

Setting Automatic Behavioral Modeling Parameters in the Wireless Test Bench Simulation documentation to learn how to improve simulation speed.

RF DUT Limitations for Mobile WiMAX Wireless Test Benches

This appendix describes test bench use with typical RF DUTs, improving test bench performance when certain RF DUT types are used, and improving simulation fidelity. Two sections regarding special attention for Spectum and EVM transmission measurements is also included.
The RF DUT, in general, may be a circuit design with any combination and quantity of analog and RF components, transistors, resistors, capacitors, etc. suitable for simulation with the Agilent Circuit Envelope simulator. More complex

RF circuits will take more time to simulate and will consume more memory.
Test bench simulation time and memory requirements can be considered to be the combination of the requirements for the baseline test bench measurement with the simplest RF circuit plus the requirements for a Circuit Envelope simulation for the RF DUT of interest.
An RF DUT connected to a wireless test bench can generally be used with the test bench to perform default measurements by setting the test bench Required Parameters . Default measurement parameter settings can be used (exceptions described below), for a typical RF DUT that:

- Requires an input (RF) signal with constant RF carrier frequency.
  The test bench RF signal source output does not produce an RF signal whose RF carrier frequency varies with time. However, the test bench will support an output (RF) signal that contains RF carrier phase and frequency modulation as can be represented with suitable I and Q envelope variations on a constant RF carrier frequency.
- Produces an output (Meas) signal with constant RF carrier frequency.
  The test bench input (Meas) signal must not contain a carrier frequency whose frequency varies with time. However, the test bench will support an input (Meas) signal that contains RF carrier phase noise or contains time varying Doppler shifts of the RF carrier. These signal perturbations are expected to be represented with suitable I and Q envelope variations on a constant RF carrier frequency.
- Requires an input (RF) signal from a signal generator with a 50-ohm source resistance. Otherwise, set the SourceR parameter value in the Basic Parameters tab.
- Requires an input (RF) signal with no additive thermal noise (TX test benches) or source resistor temperature set to 16.85 o C (RX test benches). Otherwise, set the SourceTemp (TX and RX test benches) and EnableSourceNoise (TX test benches) parameters in the Basic Parameters tab.
- Requires an input (RF) signal with no spectrum mirroring. Otherwise, set the MirrorSourceSpectrum parameter value in the Basic Parameters tab.
- Produces an output (Meas) signal that requires a 50-ohm external load resistance. Otherwise, set the MeasR parameter value in the Basic Parameters tab.
- Produces an output (Meas) signal with no spectrum mirroring. Otherwise, set the MirrorMeasSpectrum parameter value in the Basic Parameters tab.
- Relies on the test bench for any measurement-related bandpass signal filtering of the RF DUT output (Meas) signal.
  - When the RF DUT contains a bandpass filter with bandwidth that is on the order of the test bench receiver system (~1 times the test bench receiver bandwidth) and the user wants a complete characterization of the RF DUT filter, the default time CE_TimeStep must be set smaller.
  - When the RF DUT bandpass filter is much wider than the test bench receiver system (>2 times the test bench receiver bandwidth), the user may not want to use the smaller CE_TimeStep time step to fully characterize it because the user knows the RF DUT bandpass filter has little or no effect in the modulation bandwidth in this case.

Improving Test Bench Performance

This section provides information regarding improving test bench performance when certain RF DUT types are used.

- Analog/RF models (TimeDelay and all transmission line models) used with Circuit Envelope simulation that perform linear interpolation on time domain waveforms for modeling time delay characteristics that are not an integer number of CE_TimeStep units. Degradation is likely in some measurements, especially EVM.
  This limitation is due to the linear interpolation between two successive simulation time points, which degrades

waveform quality and adversely affects EVM measurements.
To avoid this kind of simulator-induced waveform quality degradation: avoid use of Analog/RF models that rely on linear interpolation on time domain characteristics; or, reduce the test bench CE_TimeStep time step by a factor of 4 below the default CE_TimeStep (simulation time will be 4 times longer).

- Analog/RF lumped components (R, L, C) used to provide bandpass filtering with a bandwidth as small as the wireless signal RF information bandwidth are likely to cause degradation in some measurements, especially Spectrum. These circuit filters require much smaller CE_TimeStep values than would otherwise be required for RF DUT circuits with broader bandwidths.
  This limitation is due to the smaller Circuit Envelope simulation time steps required to resolve the differential equations for the L, C components when narrow RF bandwidths are involved. Larger time steps degrade the resolution of the simulated bandpass filtering effects and do not result in accurate frequency domain measurements, especially Spectrum and EVM measurements (when the wireless technology is sensitive to frequency domain distortions).
  To determine that your lumped component bandwidth filter requires smaller CE_TimeStep, first characterize your filter with Harmonic Balance simulations over the modulation bandwidth of interest centered at the carrier frequency of interest. Though it is difficult to identify an exact guideline on the Circuit Envelope time step required for good filter resolution, a reasonable rule is to set the CE_TimeStep to 1/(double-sided 3dB bandwidth)/32.
  To avoid this kind of simulator-induced waveform quality degradation, avoid the use of R, L, C lumped filters with bandwidths as narrow as the RF signal information bandwidth, or reduce the CE_TimeStep.
- Analog/RF data-based models (such as S-parameters and noise parameters in S2P data files) used to provide RF bandpass filtering with a bandwidth as small as 1.5 times the wireless signal RF information bandwidth are likely to cause degradation in some measurements, especially EVM.
  This limitation is due to causal S-parameter data about the signal carrier frequency requiring a sufficient number of frequency points within the modulation bandwidth; otherwise, the simulated data may cause degraded signal waveform quality. In general, there should be more than 20 frequency points in the modulation bandwidth; more is required if the filter that the S-parameter data represents has fine-grain variations at small frequency steps.
  To avoid this kind of simulator-induced waveform quality degradation, avoid the use of data-based models with bandwidths as narrow as the RF signal information bandwidth, or increase the number of frequency points in the data file within the modulation bandwidth and possibly also reduce the CE_TimeStep simulation time step.
- An additional limitation exists when noise data is included in the data file. Circuit Envelope simulation technology does not provide frequency-dependent noise within the modulation bandwidth for this specific case when noise is from a frequency domain data file. This may result in output noise power that is larger than expected; if the noise power is large enough, it may cause degraded signal waveform quality.
  To avoid this kind of simulator-induced waveform quality degradation avoid the use of noise data in the data-based models or use an alternate noise model.

Improving Simulation Fidelity

Some RF circuits will provide better Circuit Envelope simulation fidelity if the CE_TimeStep is reduced.

- In general, the default setting of the test bench OversamplingRatio provides adequate wireless signal definition and provides the WTB_TimeStep default value.
- Set CE_TimeStep = 1/Bandwidth/OversampingRatio/N
  where N is an integer ≥ 1
- When CE_TimeStep is less than the WTB_TimeStep (i.e., N>1), the RF signal to the RF DUT is automatically

upsampled from the WTB_TimeStep and the RF DUT output signal is automatically downsampled back to the WTB_TimeStep. This sampling introduces a time delay to the RF DUT of 10×WTB_TimeStep and a time delay of the measured RF DUT output signal of 20×WTB_TimeStep relative to the measured RF signal sent to the RF DUT prior to its upsampling.

Special Attention for Spectrum Measurements

The Spectrum Measurement spectrum may have a mask against which the spectrum must be lower in order to pass the wireless specification. The Spectrum measurement itself is based on DSP algorithms that result in as much as 15 dB low-level spectrum variation at frequencies far from the carrier.
To reduce this low-level spectrum variation, a moving average can be applied to the spectrum using the moving_average(<data>, 20) measurement expression for a 20-point moving average. This will give a better indication of whether the measured signal meets the low-level spectrum mask specification at frequencies far from the carrier.

Special Attention for EVM Measurements

For the EVM measurement, the user can specify a start time. The EVM for the initial wireless segment may be unusually high (due to signal startup transient effects or other reasons) that cause a mis-detected first frame that the user does not want included in the RF DUT EVM measurement.
To remove the degraded initial burst EVM values from the RF DUT EVM measurement, set the EVM_Start to a value greater than or equal to the RF DUT time delay characteristic.

Measurement Results for Expressions for Mobile WiMAX Wireless Test Benches

Measurement results from a wireless test bench have associated names that can be used in Expressions. Those expressions can further be used in specifying goals for Optimization and Monte Carlo/Yield analysis. For details on using expressions, see Measurement Expressions. For details on setting analysis goals using Optimization and Monte Carlo/Yield analysis, see Tuning, Optimization, and Statistical Design.

You can use an expression to determine the measurement result independent variable name and its minimum and maximum values. The following example expressions show how to obtain these measurement details where MeasResults is the name of the measurement result of interest:

- The Independent Variable Name for this measurement result is obtained by using the expression `indep(MeasResults)`

- The Minimum Independent Variable Value for this measurement result is obtained by using the expression `min(indep(MeasResults))`
- The Maximum Independent Variable Value for this measurement result is obtained by using the expression `max(indep(MeasResults))`

The following tables list the measurement result names and independent variable name for each test bench measurement.

Expressions defined in a MeasEqn block must use the full Measurement Results Name listed. Expressions used in the Data Display may omit the leading test bench name. You can also locate details on the measurement result minimum and maximum independent variable values by

- Referring to the measurement parameter descriptions when they are available (not all measurement parameter descriptions identify these minimum and maximum values).
- Observing the minimum and maximum independent variable values in the Data Display for the measurement.

WMAN_DL_802.16e_TX Measurement Results

Measurement Results Name	Independent Variable Name
Envelope	
WMAN_DL_802_16e_TX.RF_V	time
WMAN_DL_802_16e_TX.Meas_V	time
Constellation	
WMAN_DL_802_16e_TX.RF_Constellation.Data_Constellation	Index
WMAN_DL_802_16e_TX.RF_Constellation.FCH_Constellation	Index
WMAN_DL_802_16e_TX.Meas_Constellation.Data_Constellation	Index
WMAN_DL_802_16e_TX.Meas_Constellation.FCH_Constellation	Index
Power	
WMAN_DL_802_16e_TX.RF_Power.CCDF	Index
WMAN_DL_802_16e_TX.RF_Power.MeanPower_dBm	Index
WMAN_DL_802_16e_TX.RF_Power.PeakPower_dBm	Index
WMAN_DL_802_16e_TX.RF_Power.SignalRange_dB	Index
WMAN_DL_802_16e_TX.Meas_Power.CCDF	Index
WMAN_DL_802_16e_TX.Meas_Power.MeanPower_dBm	Index
WMAN_DL_802_16e_TX.Meas_Power.PeakPower_dBm	Index

WMAN_DL_802_16e_TX.Meas_Power.SignalRange_dB	Index
Spectrum	
WMAN_DL_802_16e_TX.RF_Spectrum	freq
WMAN_DL_802_16e_TX.Meas_Spectrum	freq
EVM	
WMAN_DL_802_16e_TX.RF_EVM.Avg_RCE_dB	Index
WMAN_DL_802_16e_TX.RF_EVM.Avg_Pilot_RCE_dB	Index
WMAN_DL_802_16e_TX.RF_EVM.Avg_DataRCE_dB	Index
WMAN_DL_802_16e_TX.RF_EVM.Pilot_RCE_dB	Index
WMAN_DL_802_16e_TX.RF_EVM.DataRCE_dB	Index
WMAN_DL_802_16e_TX.RF_EVM.RCE_dB	Index
WMAN_DL_802_16e_TX.Meas_EVM.Avg_RCE_dB	Index
WMAN_DL_802_16e_TX.Meas_EVM.Avg_Pilot_RCE_dB	Index
WMAN_DL_802_16e_TX.Meas_EVM.Avg_DataRCE_dB	Index
WMAN_DL_802_16e_TX.Meas_EVM.Pilot_RCE_dB	Index
WMAN_DL_802_16e_TX.Meas_EVM.DataRCE_dB	Index
WMAN_DL_802_16e_TX.Meas_EVM.RCE_dB	Index

WMAN_DL_802_16e_RX_Sensitivity Measurement Results

Measurement Results Name	Independent Variable Name
RX Sensitivity	
WMAN_DL_802_16e_RX_Sensitivity.BER_FER.BER	Index
WMAN_DL_802_16e_RX_Sensitivity.BER_FER.FER	Index

WMAN_UL_802_16e_TX Measurement Results

Measurement Results Name	Independent Variable Name
Envelope	
WMAN_UL_802_16e_TX.RF_V	time
WMAN_UL_802_16e_TX.Meas_V	time

Constellation	
WMAN_UL_802_16e_TX.RF_Constellation.Data_Constellation	Index
WMAN_UL_802_16e_TX.Meas_Constellation.Data_Constellation	Index
Power	
WMAN_UL_802_16e_TX.RF_Power.CCDF	Index
WMAN_UL_802_16e_TX.RF_Power.MeanPower_dBm	Index
WMAN_UL_802_16e_TX.RF_Power.PeakPower_dBm	Index
WMAN_UL_802_16e_TX.RF_Power.SignalRange_dB	Index
WMAN_UL_802_16e_TX.Meas_Power.CCDF	Index
WMAN_UL_802_16e_TX.Meas_Power.MeanPower_dBm	Index
WMAN_UL_802_16e_TX.Meas_Power.PeakPower_dBm	Index
WMAN_UL_802_16e_TX.Meas_Power.SignalRange_dB	Index
Spectrum	
WMAN_UL_802_16e_TX.RF_Spectrum	freq
WMAN_UL_802_16e_TX.Meas_Spectrum	freq
EVM	
WMAN_UL_802_16e_TX.RF_EVM.Avg_RCE_dB	Index
WMAN_UL_802_16e_TX.RF_EVM.Avg_Pilot_RCE_dB	Index
WMAN_UL_802_16e_TX.RF_EVM.Avg_DataRCE_dB	Index
WMAN_UL_802_16e_TX.RF_EVM.Pilot_RCE_dB	Index
WMAN_UL_802_16e_TX.RF_EVM.DataRCE_dB	Index
WMAN_UL_802_16e_TX.RF_EVM.RCE_dB	Index
WMAN_UL_802_16e_TX.Meas_EVM.Avg_RCE_dB	Index
WMAN_UL_802_16e_TX.Meas_EVM.Avg_Pilot_RCE_dB	Index
WMAN_UL_802_16e_TX.Meas_EVM.Avg_DataRCE_dB	Index
WMAN_UL_802_16e_TX.Meas_EVM.Pilot_RCE_dB	Index

WMAN_UL_802_16e_RX_Sensitivity Measurement Results

Measurement Results Name	Independent Variable Name
RX Sensitivity	

WMAN_UL_802_16e_RX_Sensitivity.BER_FER.BER	Index
WMAN_UL_802_16e_RX_Sensitivity.BER_FER.FER	Index