

Keysight X-Series Signal Analyzers

This manual provides documentation for the following Analyzers:

PXA Signal Analyzer N9030A

MXA Signal Analyzer N9020A

EXA Signal Analyzer N9010A

CXA Signal Analyzer N9000A

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N9076A & W9076A
1xEV-DO
Measurement
Application
Measurement
Guide

Notices

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1 Making 1xEV-DO Measurements

This chapter begins with instructions common to all measurements, then details all the measurements available by pressing the **Meas** key when the **1xEV-DO** mode is selected. For information specific to individual measurements, see the sections at the page numbers below.

- “Channel Power Measurements” on page 15
- “ACP Measurements” on page 21
- “Occupied Bandwidth Measurements” on page 41
- “Power vs. Time (PvT)” on page 85
- “Spectrum Emission Mask Measurements” on page 27
- “Spurious Emissions Measurement” on page 35
- “Power Statistics CCDF Measurements” on page 45
- “Forward Link Code Domain Measurements” on page 51
- “Reverse Link Code Domain Measurements” on page 59
- “Forward Link Modulation Accuracy (Waveform Quality) Measurements” on page 69
- “Reverse Link Modulation Accuracy (Waveform Quality)” on page 77
- “QPSK EVM Measurements” on page 93
- “Monitor Spectrum Measurements” on page 25
- “IQ Waveform (Time Domain) Measurements” on page 81

Setting Up and Making a Measurement

Making the Initial Signal Connection

CAUTION

Before connecting a signal to the analyzer, make sure the analyzer can safely accept the signal level provided. The signal level limits are marked next to the RF Input connectors on the front panel.

See the Input Key menu for details on selecting input ports and the AMPTD Y Scale menu for details on setting internal attenuation to prevent overloading the analyzer.

Using Analyzer Mode and Measurement Presets

To set your current measurement mode to a known factory default state, press **Mode Preset**. This initializes the analyzer by returning the mode setup and all of the measurement setups in the mode to the factory default parameters.

To preset the parameters that are specific to an active, selected measurement, press **Meas Setup, Meas Preset**. This returns all the measurement setup parameters to the factory defaults, but only for the currently selected measurement.

The 3 Steps to Set Up and Make Measurements

All measurements can be set up using the following three steps. The sequence starts at the Mode level, is followed by the Measurement level, then finally, the result displays may be adjusted.

Table 1-1 *The 3 Steps to Set Up and Make a Measurement*

Step	Action	Notes
1 Select and Set Up the Mode	a.Press Mode b.Press a mode key, like 1xEV-DO . c.Press Mode Preset . d.Press Mode Setup	All licensed, installed modes available are shown under the Mode key. Using Mode Setup , make any required adjustments to the mode settings. These settings will apply to all measurements in the mode.
2 Select and Set Up the Measurement	a.Press Meas . b.Select the specific measurement to be performed. c.Press Meas Setup	The measurement begins as soon as any required trigger conditions are met. The resulting data is shown on the display or is available for export. Use Meas Setup to make any required adjustment to the selected measurement settings. The settings only apply to this measurement.

Table 1-1 *The 3 Steps to Set Up and Make a Measurement*

Step	Action	Notes
3 Select and Set Up a View of the Results	Press View/Display . Select a display format for the current measurement data.	Depending on the mode and measurement selected, other graphical and tabular data presentations may be available. X-Scale and Y-Scale adjustments may also be made now.

NOTE A setting may be reset at any time, and will be in effect on the next measurement cycle or view.

Table 1-2 *Main Keys and Functions for Making Measurements*

Step	Primary Key	Setup Keys	Related Keys
1 Select and set up a mode.	Mode	Mode Setup, FREQ Channel	System
2 Select and set up a measurement.	Meas	Meas Setup	Sweep/Control, Restart, Single, Cont
3 Select and set up a view of the results.	View/Display	SPAN X Scale, AMPTD Y Scale	Peak Search, Quick Save, Save, Recall, File, Print

Making 1xEV-DO Measurements
Setting Up and Making a Measurement

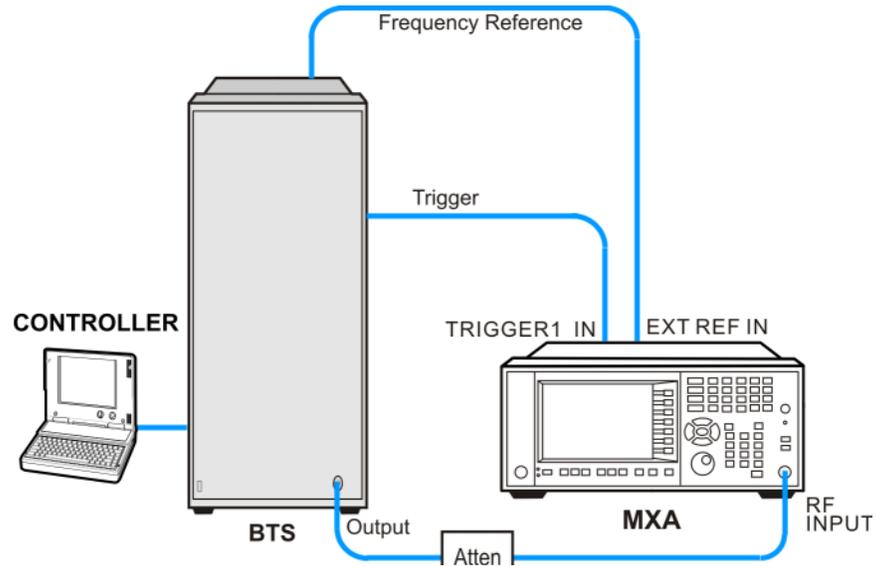
2 Channel Power Measurements

This chapter explains how to make a channel power measurement on a 1xEV-DO base station (BTS, or Access Network, AN). This test measures the total RF power present in the channel. The results are shown in a graph window and in a text window.

Configuring the Measurement System

This example shows a base station (BTS) under test set up to transmit the RF power, and being controlled remotely by a system controller. The transmitting signal is connected to the analyzer RF input port. Connect the equipment as shown.

Figure 2-1 Measurement System



1. Using the appropriate cables and adapters, connect the output signal of the BTS to the RF input of the analyzer.
2. Connect a BNC cable between the 10 MHz OUT port of the BTS and the EXT REF IN port of the analyzer.
3. Using a BNC cable, connect the trigger signal from the BTS to the TRIGGER1 IN port of the analyzer.
4. Connect the system controller to the BTS through the serial bus cable to control the BTS operation.

Setting the BTS (Example)

From the system controller, perform all of the call acquisition functions required for the BTS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the Mode.
- Step 3.** Press **Input/Output, External Gain, BTS** and enter the appropriate attenuation values and **-dB** depending on the external attenuator connected to the analyzer.
- Step 4.** Press **Mode Setup, Radio, Device** and toggle the device to **BTS**.
- Step 5.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 6.** Press **Sweep/Control, Gate** and toggle the **Gate** to **On**. Press **More, Gate Source** and select the desired gate source **External 1**.

If no measurement is performed and a yellow '*' symbol displays on the top right of the screen, you need to check the gate settings. You need the correct gate signal to make the Channel Power measurement.
- Step 7.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 8.** Press **Meas, Channel Power** to initiate the channel power measurement.
- Step 9.** Press **Meas Setup** to see the keys that are available to change measurement parameters from their default condition.
- Step 10.** Press **View/Display**, and toggle the **Bar Graph** key to **Off** to see the spectrum trace graph. The corresponding measured data is also shown in the text window.

If you have a problem, and get an error message, see the "*Instrument Messages Guide*".

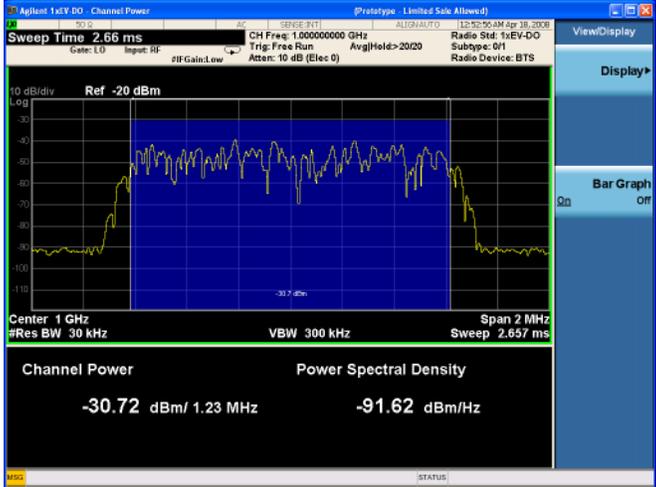
Measurement Results

The Channel Power measurement result should look similar to Figure 2-2. The graph window and the text window show the absolute power and its mean power spectral density values over 2MHz.

Figure 2-2 Channel Power Result – Bar Graph Off



Figure 2-3 Channel Power Result – Bar Graph On



Channel Power Measurements
Measurement Results

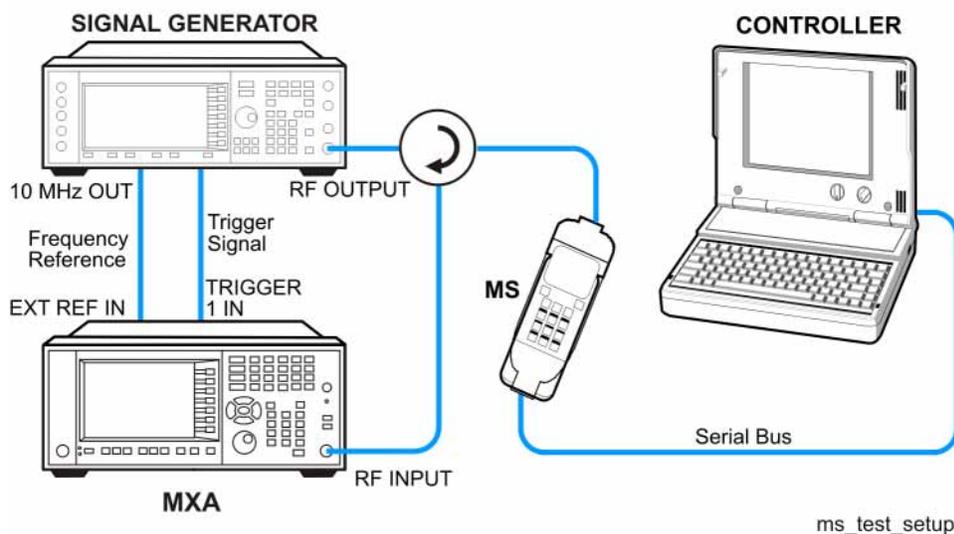
3 ACP Measurements

This chapter explains how to make the adjacent channel leakage power ratio (ACLR or ACP) measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT). ACP is a measurement of the amount of interference, or power, in an adjacent frequency channel. The results are shown as a bar graph or as spectrum data, with measurement data at specified offsets. A Pass or Fail indication is shown in the Measurement Bar.

Configuring the Measurement System

The MS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 3-1 Measurement System



1. Using the appropriate cables, adapters, and circulator, connect the output signal from the MS to the RF input port of the analyzer.
2. Connect the base transceiver station simulator or signal generator to the MS through the circulator to initiate a link constructed with the sync and pilot channels, if required.
3. Connect a BNC cable between the 10 MHz OUT port of the signal generator and the EXT REF IN port of the analyzer.
4. Using a BNC cable, connect the trigger signal from the base transceiver station simulator or signal generator to the TRIGGER1 IN port of the analyzer.
5. Connect the system controller to the MS through the serial bus cable to control the MS operation.

Setting the MS (Example)

From the transceiver station simulator or the system controller, or both, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

Step 1. Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.

Step 2. Press **Mode Preset** to preset the mode.

Step 3. Press **Mode Setup, Radio, Device** and toggle the device to **MS**.

Step 4. Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.

Step 5. Press **Sweep/Control, Gate** and toggle the **Gate** to **On**. Press **More, Gate Source** and select the desired gate source **External 1**.

If no measurement is performed and a yellow '*' symbol displays on the top right of the screen, you need to check the gate settings. You need the correct gate signal to make the ACP measurement.

Step 6. Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.

Or, you can also manually set the reference frequency by pressing **Meas Setup, Carrier Setup, Ref Carrier**, enter the carrier number to be referenced, press **Ref Car Freq**, and enter the carrier frequency.

NOTE When the number of carriers (**Carriers**) is set to 1, the **Ref Carrier** is automatically grayed out and set to 1.

Step 7. Press **Meas, ACP** to initiate the adjacent channel leakage power ratio measurement.

Step 8. Press **View/Display**, and toggle the **Bar Graph** key to **Off** to see the spectrum trace graph. The corresponding measured data is also shown in the text window.

Step 9. Press **Meas Setup** to check the keys available to change the measurement parameters from the default condition.

- Press **Carrier Setup, Carriers** and enter the number of carriers.
- Press **Config Carriers** to adjust the parameter settings for each carrier, or to couple other carriers to Carrier 1 when **Carriers** is set to greater than 1.

Step 10. Press **Meas Setup, Offset/Limits** to adjust the adjacent channel offset and test limits parameters.

NOTE When the measured power is close to the noise floor, turning on the **Noise Correction** under the **Meas Setup** menu can make the measurement more accurate.

Step 11. Press **Meas Setup, Carrier Result** and enter the carrier number to display and highlight the desired carrier power result in the text window.

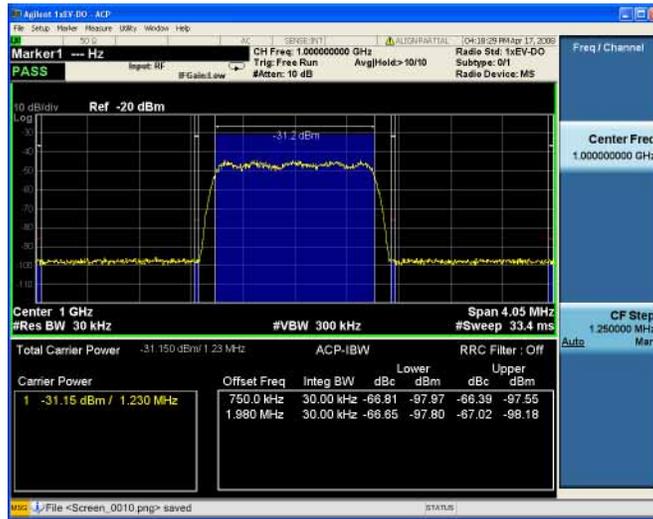
NOTE When Carriers is set to 1, the **Carrier Result** is unavailable (grayed out).

If you have a problem, and get an error message, see the “*Instrument Messages Guide*”.

Measurement Results

The ACP measurement result should look similar to Figure 3-2. The graph window and the text window show the absolute power and its mean power spectral density values over 2MHz.

Figure 3-2 ACP Result – Bar Graph On



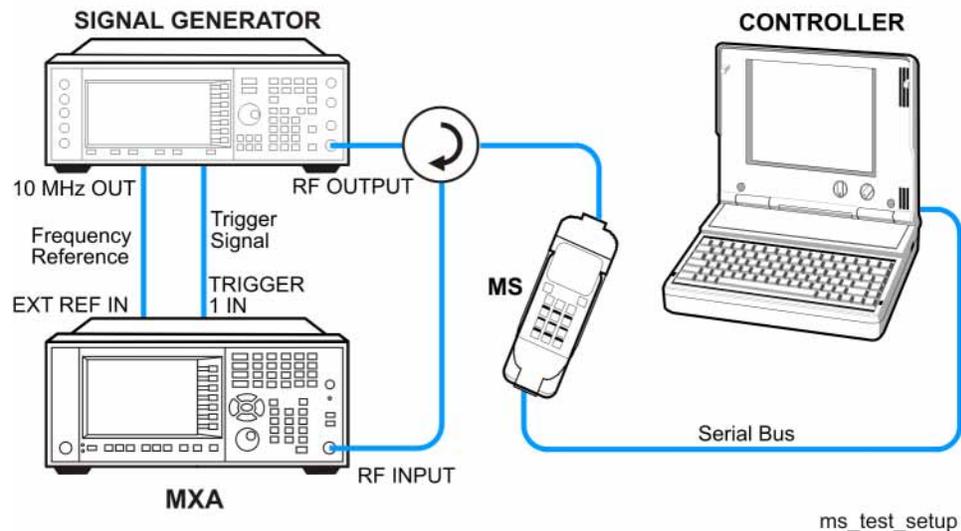
4 Spectrum Emission Mask Measurements

This chapter explains how to make the spectrum emission mask (SEM) measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT) or base transceiver station (BTS, or Access Network, AN). SEM compares the total power level within the defined carrier bandwidth and the given offset channels on both sides of the carrier frequency, to levels allowed by the standard. Results of the measurement of each offset segment can be viewed separately. A Pass or Fail indication is shown in the Measurement Bar.

Configuring the Measurement System

The MS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 4-1 Measurement System



1. Using the appropriate cables, adapters, and circulator, connect the output signal from the MS to the RF input port of the analyzer.
2. Connect the base transceiver station simulator or signal generator to the MS through the circulator to initiate a link constructed with the sync and pilot channels, if required.
3. Connect a BNC cable between the 10 MHz OUT port of the signal generator and the EXT REF IN port of the analyzer.
4. Using a BNC cable, connect the trigger signal from the base transceiver station simulator or signal generator to the TRIGGER1 IN port of the analyzer.
5. Connect the system controller to the MS through the serial bus cable to control the MS operation.

Setting the MS (Example)

From the base transceiver station simulator or the system controller, or both, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz
Output Power: -30 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Mode Setup, Radio, Device** and toggle the device to **MS**.
- Step 4.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 5.** Press **Sweep/Control, Gate** and toggle the **Gate** to **On**. Press **More, Gate Source** and select the desired gate source **External 1**.

If no measurement is performed and a yellow '*' symbol displays on the top right of the screen, you need to check the gate settings. You need the correct gate signal to make the Channel Power measurement.

- Step 6.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 7.** Press **Meas, Spectrum Emission Mask** to initiate the spectrum emission mask measurement.
- Step 8.** Press **Meas Setup** to check the keys available to change the measurement parameters from the default condition.

To select the desired offset pairs, press **Meas Setup, Offset/Limit, Offset, C**. Then press **Start Freq, On**.

NOTE

When there are many offsets to measure, you can increase the Res BW under **Meas Setup, Offset/Limit** to increase the measurement speed.

To make an averaged measurement, press **Avg/Hold Num**, toggle the state to **On**, and enter the number of averages.

To select the power reference, press **Meas Type** key to select from **Total Power Ref, PSD Ref, or Spectrum Pk Ref**.

To adjust the offset parameters, toggle the **Limit State** key to **Manual** and press **Offset/Limits** to change the offset parameters and limit lines.

- Step 9.** Press **View/Display** and select the desired view from **Abs Pwr Freq, Rel Pwr Freq, or Integrated Power**.

You can toggle the **Limit Lines** between **On** and **Off**.

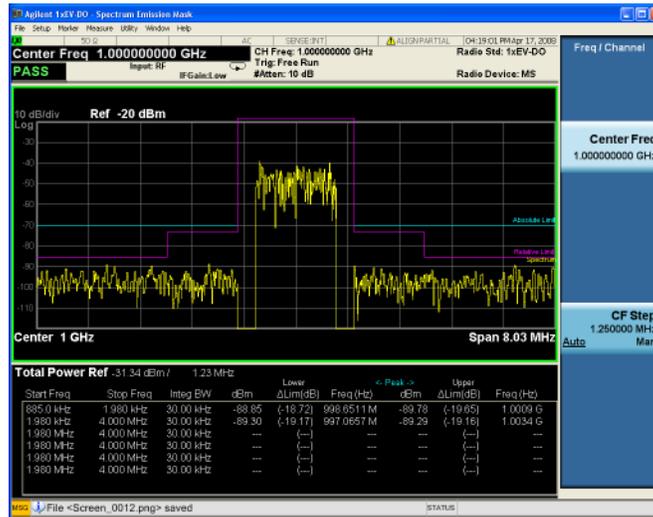
If you have a problem, and get an error message, see the "*Instrument Messages Guide*".

Measurement Results

The Spectrum Emission Mask measurement result should look like Figure 4-2. The text window shows the reference total power and the absolute peak power levels which correspond to the frequency bands on both sides of the reference channel.

Figure 4-2

SEM Result



The Start Freq value (900 kHz for offset A) is the start frequency of the offset to center. The Start Freq in the text window (885 kHz for offset A) is the start frequency of the offset to edge. There is a 15 kHz difference between them. The same as the Stop Freq.

The Lower or Upper Lim is the minimum margin from limit line which is decided by Fail Mask setting. There are four settings for Fail Mask: Absolute, Relative, Abs AND Rel, Abs OR Rel.

- For Absolute mask, the Lower or Upper Lim is compared with the Absolute Limit line.
- For Relative mask, the Lower or Upper Lim is compared with the Relative Limit line.
- For Abs AND Rel mask, the Lower or Upper Lim is compared with the higher Limit line.
- For Abs OR Rel mask, the Lower or Upper Lim is compared with the lower Limit line.

Spectrum Emission Mask Measurements Measurement Results

Figure 4-3 SEM Result - Abs Pwr Freq (Default) View

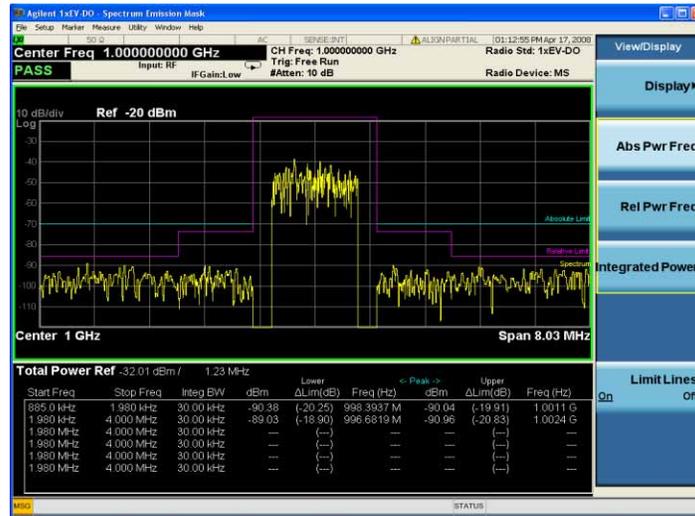


Figure 4-4 SEM Result - Rel Pwr Freq View

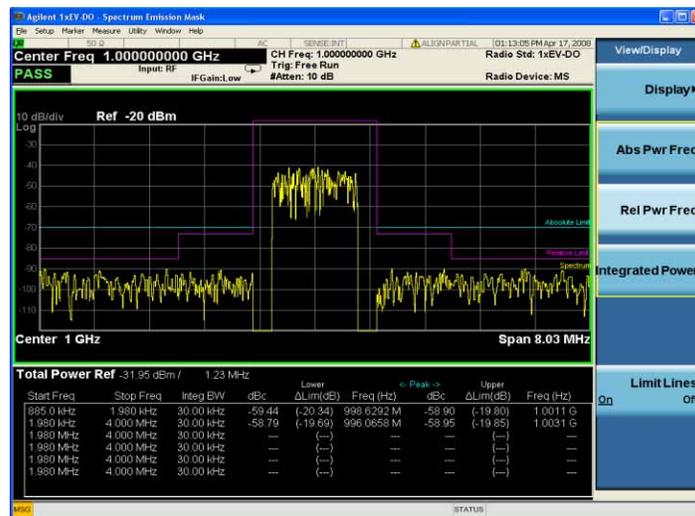
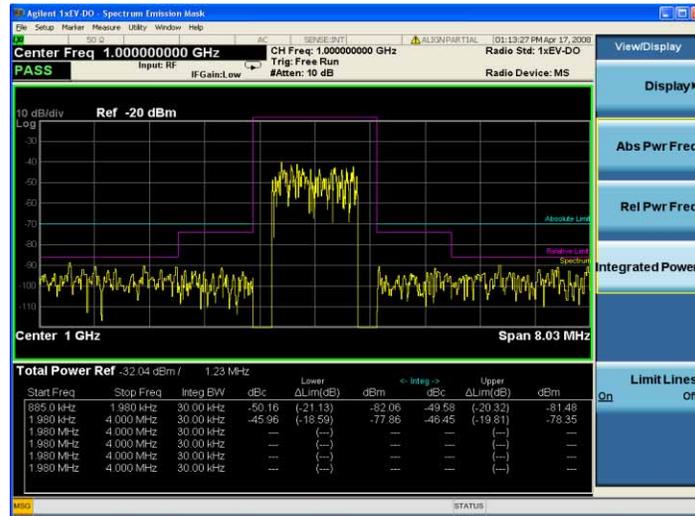


Figure 4-5 SEM Result - Integrated Power View



Troubleshooting Hints

The Spectrum Emission Mask (SEM) measurement can reveal degraded or defective parts in the transmitter section of the unit under test (UUT). The following examples are those areas to be checked further.

- Faulty DC power supply control of the transmitter power amplifier.
- RF power controller of the pre-power amplifier stage.
- I/Q control of the baseband stage.
- Some degradation in the gain and output power level of the amplifier due to the degraded gain control or increased distortion, or both.
- Some degradation of the amplifier linearity or other performance characteristics.

Power amplifiers are one of the final stage elements of a base or mobile transmitter and are a critical part of meeting the important power and spectral efficiency specifications. Since spectrum emission mask measures the spectral response of the amplifier to a complex wideband signal, it is a key measurement linking amplifier linearity and other performance characteristics to the stringent system specifications.

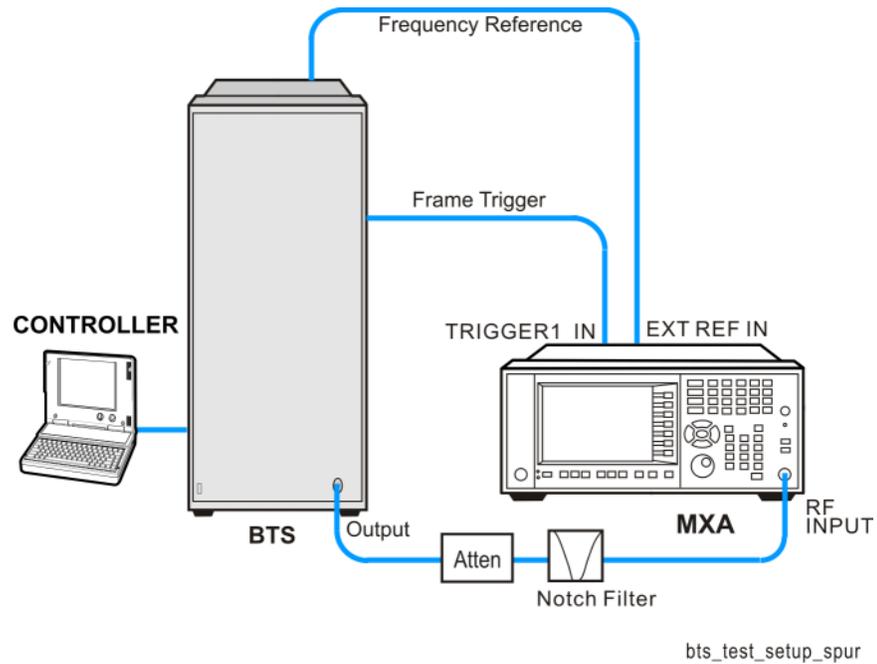
5 Spurious Emissions Measurement

This section explains how to make the spurious emission measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT) or base transceiver station (BTS, or Access Network, AN). This measurement identifies and determines the power level of spurious emissions in certain frequency bands. A Pass or Fail indication is shown in the Measurement Bar.

Configuring the Measurement System

The BTS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 5-1 Measurement System



1. Using the appropriate cables, adapters, notch filter and attenuator, connect the output signal of the BTS to the RF input of the analyzer.
2. Connect a BNC cable between the frequency reference port of the BTS and the EXT REF IN port of the analyzer.
3. Using a BNC cable, connect the trigger signal from the BTS to the TRIGGER1 IN port of the analyzer.
4. Connect the system controller to the BTS through the serial bus cable to control the BTS operation.

Setting up the BTS (Example)

From the system controller, perform all of the call acquisition functions required for the BTS to transmit the RF power as required.

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Input/Output, External Gain, BTS** and enter the number and **-dB** according to the external attenuator connected to the analyzer.
- Step 4.** Press **Input/Output, RF Input, RF Coupling, DC** and toggle the RF Coupling to **DC**.

NOTE

In AC coupling mode, you can view signals less than 10 MHz but the amplitude accuracy is not specified. To accurately see a signal of less than 10 MHz, you must switch to DC coupling.

When operating in DC coupled mode, ensure protection of the External Mixer by limiting the DC part of the input level to within 200 mV of 0 Vdc.

- Step 5.** Press **Mode Setup, Radio, Device, MS** to select the device to **BTS**.
- Step 6.** Press **Meas, Spurious Emission** to initiate the Spurious Emission measurement.

Depending on the current settings, the instrument will begin making the selected measurements. The resulting data is shown on the display.
- Step 7.** Check the spurs reported in the text window and press **Meas Setup, Spur** and enter the spur number to highlight the data of interest. The marker in the graph window will move synchronously.

Toggle the **Meas Type** key between **Examine** and **Full**. The **Examine** type sets the average mode to **Exp** and the **Full** type sets the average mode to **Repeat**.
- Step 8.** Press **More, Spur Report** and toggle the mode from **All** to **LimitTest**. Only spurs above the limit line are displayed.
- Step 9.** If you want to change the measurement parameters from their default condition for a customized measurement, press **Meas Setup, Range Table** to adjust the parameters for your testing.

If you have a problem, and get an error message, see the “*Instrument Messages Guide*”.

Measurement Results

The Spurious Emissions measurement results should look like [Figure 5-2](#). The spectrum window and the text window show the spurs that are within the current value of the Marker Peak Excursion setting of the absolute limit. Any spur that has failed the absolute limit will have an 'F' beside it.

The measurement result of the selected spur in Spur under Meas Setup is shown in yellow. The measurement result of the selected range in Range under Meas Setup, Range Table is shown in yellow.

The analyzer scans the band using the specified Range Table settings. As each band is swept, any signal above the Peak Threshold that has a peak excursion greater than the Peak Excursion will be added to the list of spurs in the text window. A total of 200 spurs can be recorded for one measurement, with a limit of 10 spurs for each frequency range.

If no spurs are reported, but the measured trace exceeds the limit line for any range, a red FAIL indicator will be displayed.

Figure 5-2 Spurious Emissions Result



NOTE If you set the **Meas Type** to **Examine**, the trace is kept updating to show the latest spectrum where the range which has the worst spurious. However, the table is shown the last report. Press Restart to update the table to show the latest result.

For the Meas Type of Examine, if you want to see the measurement result for different ranges, you can press Meas Setup, Range Table, Range, then enter the range number you care.

If you have a problem, and get an error message, see the guide “**Instrument Messages**”.

Spurious Emissions Measurement
Measurement Results

6 Occupied Bandwidth Measurements

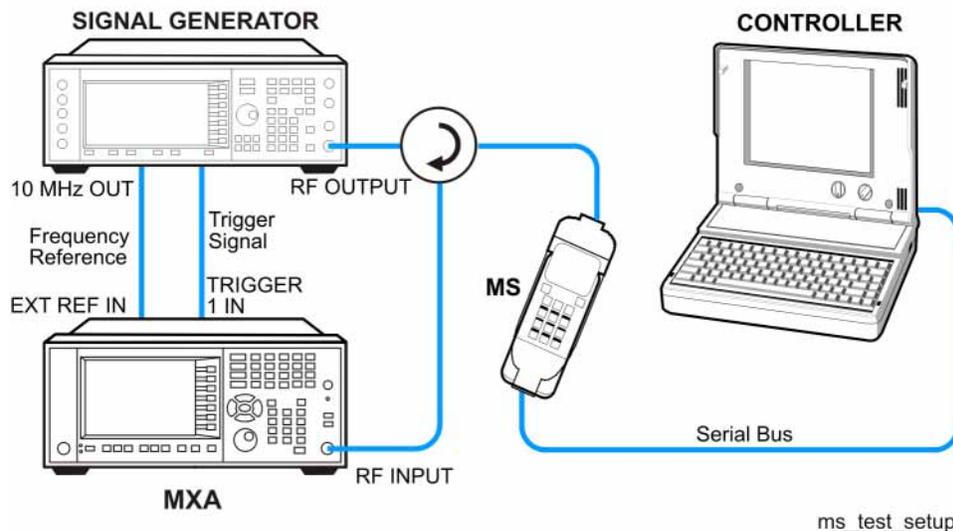
This chapter explains how to make the occupied bandwidth measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT). The instrument measures power across the band, and then calculates its 99.0% power bandwidth.

Setting Up and Making a Measurement

Configuring the Measurement System

The MS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 6-1 Measurement System



1. Using the appropriate cables, adapters, and circulator, connect the output signal from the MS to the RF input port of the analyzer.
2. Connect the base transceiver station simulator or signal generator to the MS through the circulator to initiate a link constructed with the sync and pilot channels, if required.
3. Connect a BNC cable between the 10 MHz OUT port of the signal generator and the EXT REF IN port of the analyzer.
4. Using a BNC cable, connect the trigger signal from the base transceiver station simulator or signal generator to the TRIGGER1 IN port of the analyzer.
5. Connect the system controller to the MS through the serial bus cable to control the MS operation.

Setting the MS (Example)

From the system controller, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm (or other power level for the MS)

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
 - Step 2.** Press **Mode Preset** to preset the mode.
 - Step 3.** Press **Mode Setup, Radio, Device** and toggle the device to **MS**.
 - Step 4.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
 - Step 5.** Press **Sweep/Control, Gate** and toggle the **Gate** to **On**. Press **More, Gate Source** and select the desired gate source **External 1**.
- If no measurement is performed and only a yellow '*' symbol displays on the top right of the screen, you need to check the gate settings. You need the correct gate signal to make the Channel Power measurement.
- Step 6.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
 - Step 7.** Press **Meas, Occupied BW** to initiate the Occupied BW measurement.

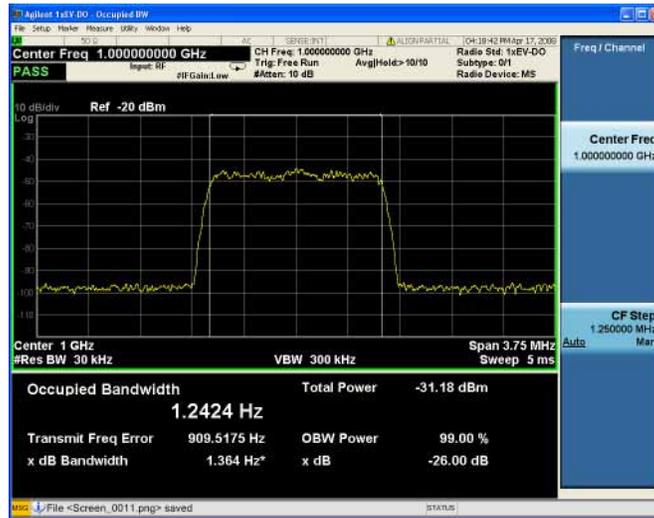
If you have a problem, and get an error message, see the guide “**Instrument Messages**”.

Measurement Results

The Occupied BW measurement result should look like [Figure 6-2](#).

Occupied Band width Measurements Setting Up and Making a Measurement

Figure 6-2 Occupied BW Result



Troubleshooting Hints

Any distortion such as harmonics or intermodulation, for example, produces undesirable power outside the specified bandwidth.

Shoulders on either side of the spectrum shape indicate spectral regrowth and intermodulation. Rounding or sloping of the top shape can indicate filter shape problems.

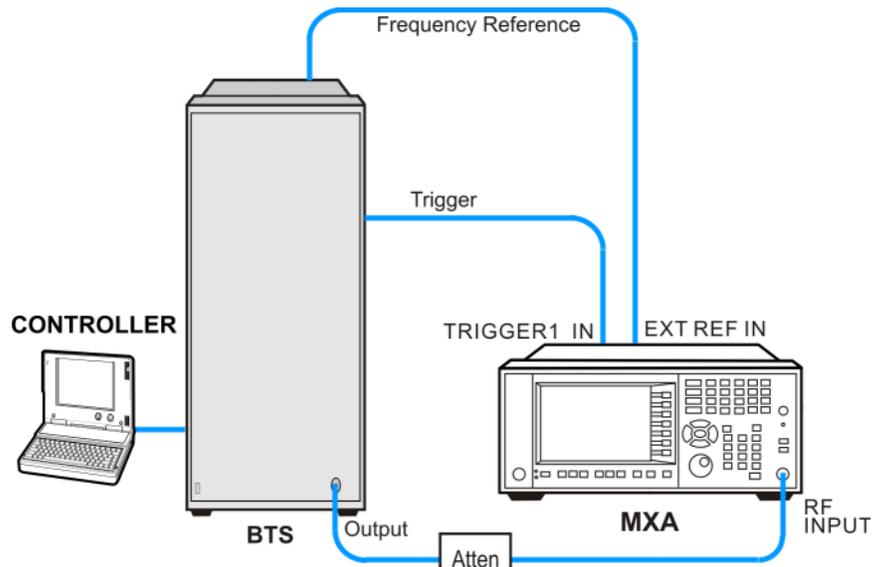
7 Power Statistics CCDF Measurements

This section explains how to make the Power Statistics Complementary Cumulative Distribution Function (Power Stat CCDF) measurement on a 1xEV-DO base station (BTS, or Access Network, AN). Power Stat CCDF curves characterize the higher level power statistics of a digitally modulated signal.

Configuring the Measurement System

This example shows a base station (BTS) under test set up to transmit the RF power, and being controlled remotely by a system controller. The transmitting signal is connected to the analyzer RF input port. Connect the equipment as shown.

Figure 7-1 Measurement System



1. Using the appropriate cables and adapters, connect the output signal of the BTS to the RF input of the analyzer.
2. Connect a BNC cable between the 10 MHz OUT port of the BTS and the EXT REF IN port of the analyzer.
3. Using a BNC cable, connect the trigger signal from the BTS to the TRIGGER1 IN port of the analyzer.
4. Connect the system controller to the BTS through the serial bus cable to control the BTS operation.

Setting the BTS (Example)

From the system controller, perform all of the call acquisition functions required for the BTS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Input/Output, External Gain, BTS** and enter the appropriate attenuation values and **-dB** depending on the external attenuator connected to the analyzer.
- Step 4.** Press **Mode Setup, Radio, Device** and toggle the device to **BTS**.
- Step 5.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 6.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 7.** Press **Trigger** to select the appropriate trigger source **External 1**.

If no measurement is performed and only a yellow '*' symbol displays on the top right of the screen, you need to check the trigger settings. You need the correct trigger signal to make the CCDF measurement.
- Step 8.** Press **Meas, Power Stat CCDF** to initiate the Power Statistics CCDF measurement.
- Step 9.** Press **Trace/Detector, Ref Trace, On** to represent the user-definable reference trace (violet line).

The reference trace is the same as the measurement trace. You can use the Store Ref Trace key to copy the currently measured curve as the reference trace. It will not change until you store the reference trace again or choose the other mode.

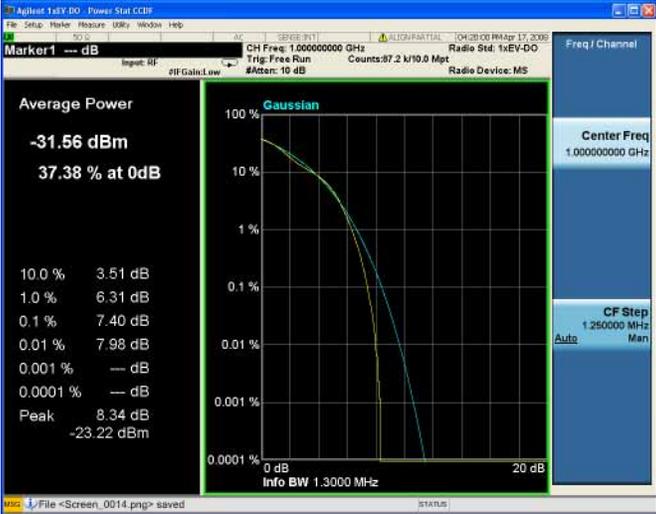
If you have a problem, and get an error message, see the guide "**Instrument Messages**".

Measurement Results

The CCDF measurement result should look like [Figure 7-2](#). The blue line is the Gaussian trace and the yellow line is the measurement result.

The Info BW is the channel bandwidth that will be used for data acquisition, the default value is 1.3MHz. You can manually change the Info BW under the BW menu.

Figure 7-2 Power Statistics CCDF Result



Troubleshooting Hints

The power statistics CCDF measurement can contribute in setting the signal power specifications for design criteria for systems, amplifiers, and other components. For example, it can help determine the optimum operating point to adjust each code timing for appropriate peak or average power ratio throughout the wide channel bandwidth of the transmitter for a 1xEV-DO system.

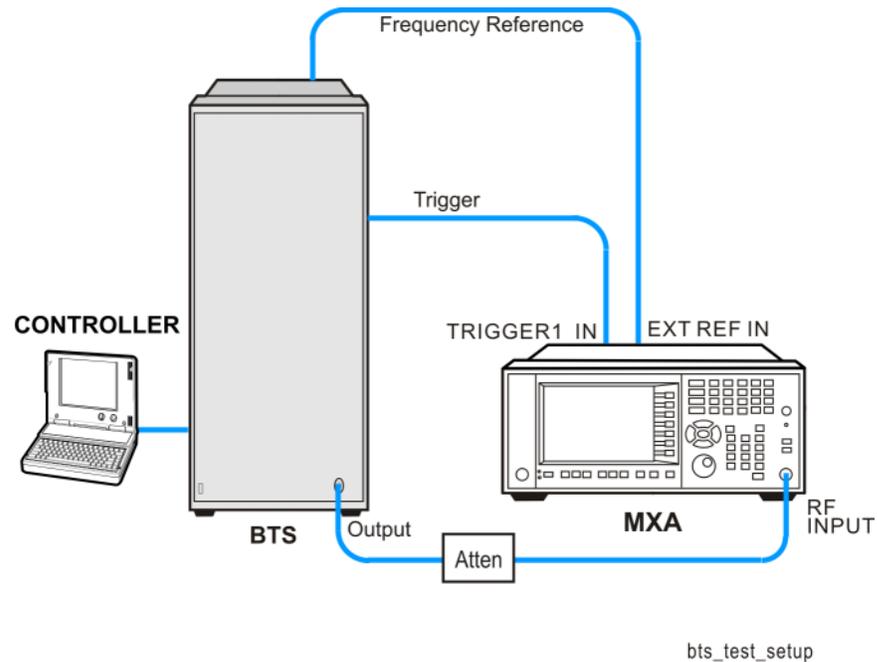
8 Forward Link Code Domain Measurements

This chapter explains how to make a code domain measurement on a 1xEV-DO base transceiver station (BTS, or Access Network, AN). This is the measurement of power levels of the spread code channels across composite RF channels, relative to the total power within the 1.23 MHz channel bandwidth centered at the center frequency.

Configuring the Measurement System

The BTS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 8-1 Measurement System



1. Using the appropriate cables and adapters, connect the output signal of the BTS to the RF input of the instrument.
2. Connect a BNC cable between the 10 MHz OUT port of the BTS and the EXT REF IN port of the instrument.
3. Using a BNC cable, connect the trigger signal from the base transceiver station simulator or signal generator to the TRIGGER1 IN port of the analyzer.
4. Connect the system controller to the BTS through the serial bus cable to control the BTS operation.

Setting the BTS (Example)

From the simulator or the system controller, or both, perform all of the call acquisition functions required for the BTS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

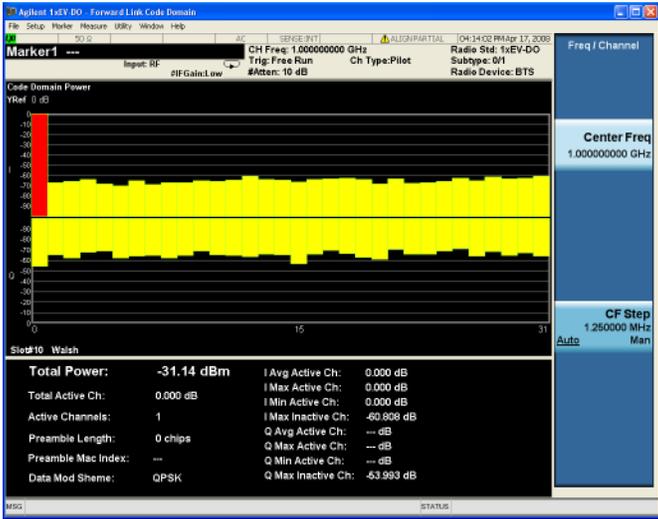
- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Input/Output, External Gain, BTS** and enter the appropriate attenuation values and **-dB** depending on the external attenuator connected to the analyzer.
- Step 4.** Press **Mode Setup, Radio, Device** and toggle the device to **BTS**.
- Step 5.** Press **Mode Setup, Radio, Pre-Defined Interval/Offset** to select the slot of interest.
- Step 6.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 7.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 8.** Press **Meas, Forward Link Code Domain** to initiate the code domain measurement.
- Step 9.** Press **Peak Search** to put a marker on the highest power channel.
- Step 10.** To examine a single channel more closely, set a marker on the channel of interest. Press **Marker ->, Mkr-> Despread** to select this code channel for specific Code Domain Power measurement. The Marker Despread feature automatically determines the Code Domain parameters of the code channel, and sets the analyzer to the appropriate settings for Symbols/sec., Walsh Code Number, and Offset. Any code channel selected by a normal #1 marker can be despread. The measurement data reflects the despread measurement data.

If you have a problem, and get an error message, see the “*Instrument Messages Guide*”.

Measurement Results

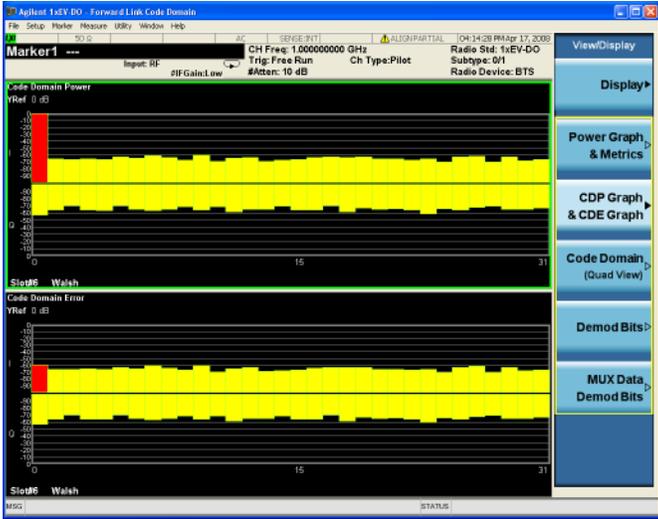
The Forward Link Code Domain measurement result should look similar to [Figure 8-2](#). The graph window is displayed with a text window below it. The text window shows the total power level along with the relative power levels of the various channels.

Figure 8-2 FL Code Domain Result - Power Graph & Metrics (Default) View



Press **View/Display**, **CDP Graph & CDE Graph** to display a combination view of the code domain power and code domain error graph windows. See [Figure 8-3](#). It would be helpful to find which code channels contain errors in code domain.

Figure 8-3 FL Code Domain Result - CDP Graph & CDE Graph View

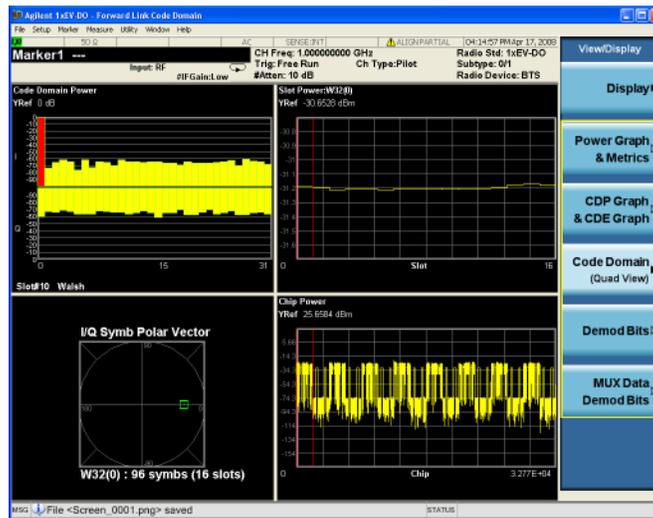


Forward Link Code Domain Measurements Measurement Results

Press **View/Display, Code Domain (Quad View)** to display a combination view of the magnitude error vs. symbol, phase error vs. symbol, and EVM vs. symbol graph windows, with the modulation summary results window. See [Figure 8-4](#). It is visible which modulation type used in the selected channels.

Figure 8-4

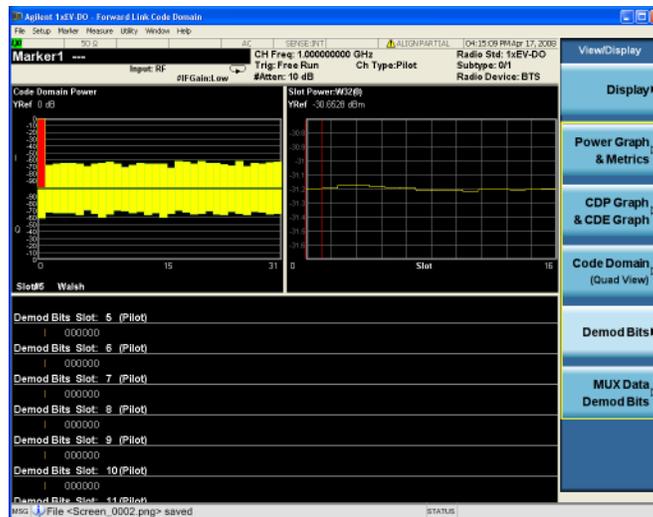
FL Code Domain Result - Code Domain (Quad View)



Press **View/Display, Demod Bits** to display a combination view of the code domain power, symbol power graph windows, and the I/Q demodulated bit stream data for the symbol power slots selected by the measurement interval and measurement offset parameters. Consistently with Code Domain (Quad View), it shows the demodulated data bits of the selected code channel.

Figure 8-5

FL Code Domain Result - Demod Bits View



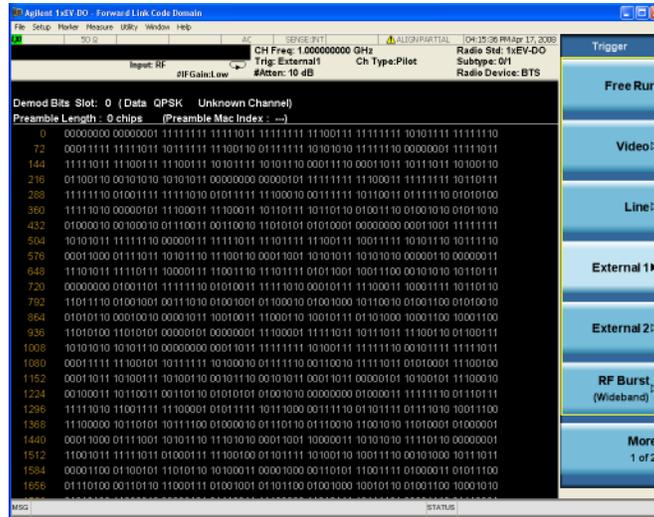
The Demod Bits View displays the same Code Domain Power and Symbol Power windows as the Code Domain (Quad View) shown in [Figure 8-4](#).

The demodulated bit stream displayed is the data contained in the Measurement Interval, slot #1. In the Symbol Power graph, this is the data between the red vertical lines; 1 slot, with no offset, so it is the first slot of the capture interval of 1 frame.

Press **View/Display, MUX Data Demod Bits** to display the I/Q demodulated bit stream data for the symbol power slots selected by the measurement interval and measurement offset parameters.

Figure 8-6

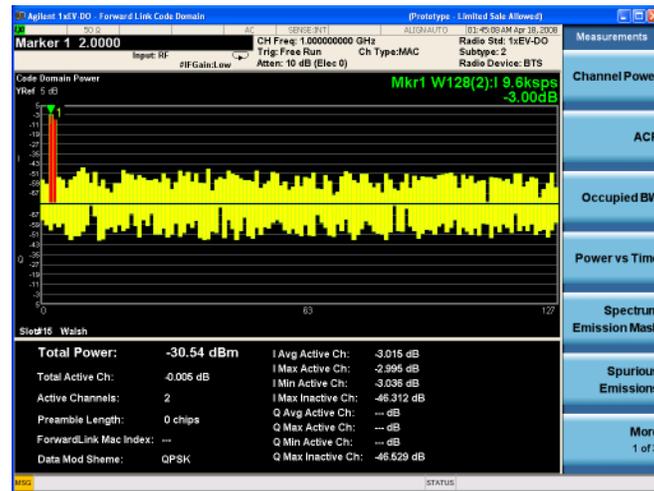
FL Code Domain Result - MUX Data Demod Bits View



The Marker data indicates a Walsh Code position.

Figure 8-7

FL Code Domain Result - Marker



Troubleshooting Hints

Uncorrelated interference may cause CW interference like local oscillator feed through or spurs. Another cause of uncorrelated noise can be I/Q modulation impairments. Correlated impairments can be due to the phase noise on the local oscillator in the upconverter or I/Q modulator of the unit under test (UUT). These will be analyzed by the code domain measurements along with the QPSK EVM measurements and others.

Poor phase error indicates a problem at the I/Q baseband generator, filter, or modulator in the transmitter circuitry of the UUT, or both. The output amplifier in the transmitter can also create distortion that causes unacceptably high phase error. In a real system, poor phase error will reduce the ability of a receiver to correctly demodulate the received signal, especially in marginal signal conditions.

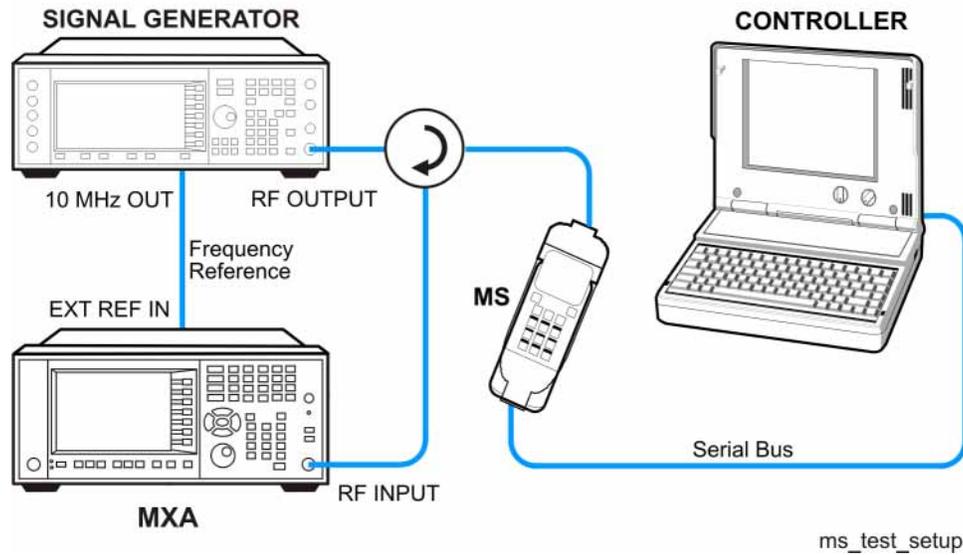
9 Reverse Link Code Domain Measurements

This chapter explains how to make a code domain measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT). This is the measurement of power levels of the spread code channels across composite RF channels. The code power may be measured relative to the total power within the 1.23 MHz channel bandwidth centered at the center frequency. Code Domain measurement examples using a 1xEV-DO uplink (UL) signal are shown in this section.

Configuring the Measurement System

The MS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 9-1 Measurement System



1. Using the appropriate cables, adapters, and circulator, connect the output signal of the MS to the RF input of the instrument.
2. Connect the base transceiver station simulator or signal generator to the MS through the circulator to initiate a link constructed with the sync and pilot channels, if required.
3. Connect a BNC cable between the 10 MHz OUT port of the signal generator and the EXT REF IN port of the instrument.
4. Connect the system controller to the MS through the serial bus cable to control the MS operation.

Setting the MS (Example)

From the mobile station simulator or the system controller, or both, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

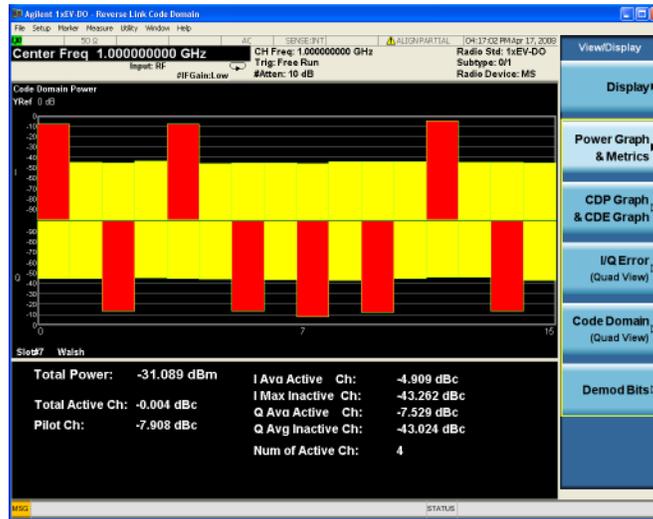
- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 4.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 5.** Press **Meas, Reverse Link Code Domain** to initiate the code domain measurement.
- Step 6.** Press **Meas Setup, More, I Long Code Mask** and enter the Hex long code for I.
Press **Q Long Code Mask** and enter the Hex long code for Q.
- Step 7.** If your 1xEV-DO active channel signal is known, you may be able to take advantage of a predefined Active Channel preset for synchronization.
Press **Meas Setup, More, Active Code Channel, Predefined, Predefined Active chan** and select from the list of predefined Active Channels shown.
- Step 8.** Press **Marker** and rotate the front-panel knob to position the marker. to put a marker on the highest power channel.
- Step 9.** Press **Marker ->, Mkr-> Despread** to initiate the desreading and decoding of the marked channel to allow EVM and other error measurements to be conducted on the channel.
If you have a problem, and get an error message, see the “*Instrument Messages Guide*”.

Measurement Results

The Reverse Link Code Domain measurement result should look similar to [Figure 9-2](#). The graph window is displayed with a text window below it. The text window shows the total power level along with the relative power levels of the various channels.

Figure 9-2

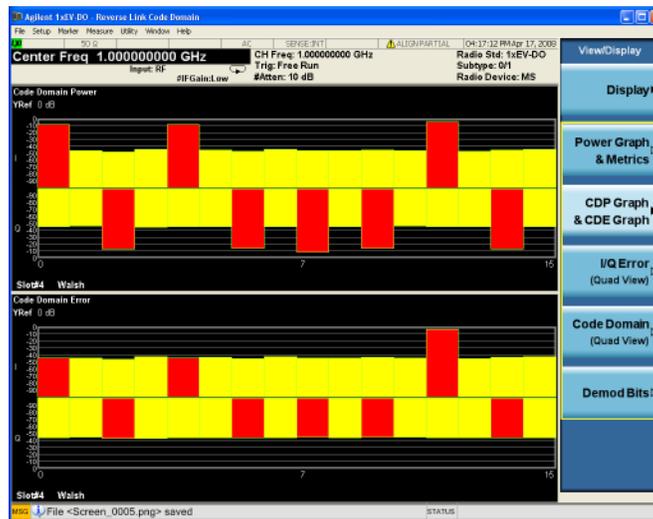
RL Code Domain Result - Power Graph & Metrics (Default) View



Press **View/Display**, **CDP Graph & CDE Graph** to display a combination view of the code domain power window and the code domain error window. See [Figure 9-5](#).

Figure 9-3

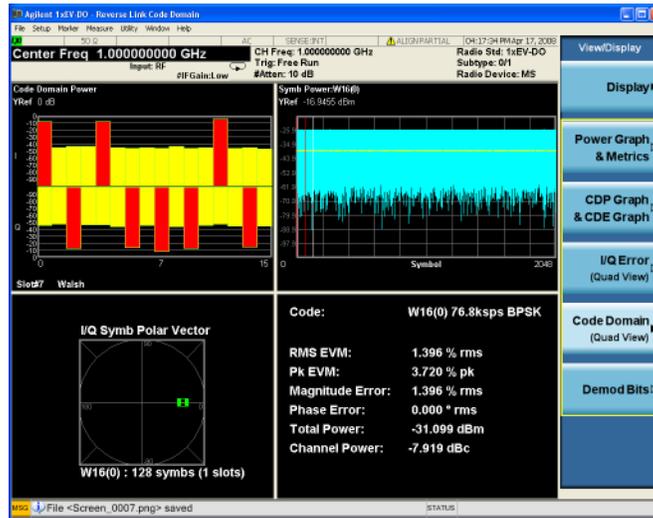
RL Code Domain Result - CDP Graph & CDE Graph



Press **View/Display**, **I/Q Error (Quad View)** to display a combination view of the magnitude error vs. symbol, phase error vs. symbol, and EVM vs. symbol graph windows, with the modulation summary results window. See [Figure 9-4](#).

Reverse Link Code Domain Measurements Measurement Results

Figure 9-4 RL Code Domain Result - I/Q Error (Quad View)

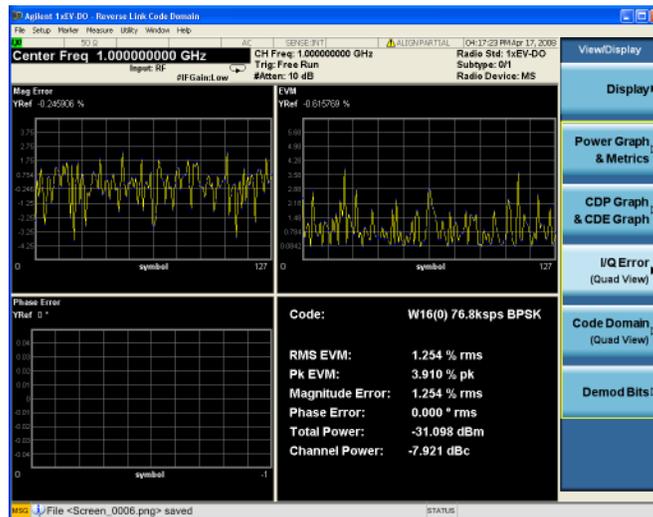


The original Code Domain Measurement is shown at the top left, while the Symbol Power measurement of the marked I-data channel is at the top right.

The summary data at the lower right indicates peak and RMS EVM, magnitude and phase errors, powers of the signal and the channel.

Press **View/Display**, **Code Domain (Quad View)** to display a combination view of the code domain power, symbol power, and I/Q symbol polar vector graph windows, with a summary results window. See Figure 9-5.

Figure 9-5 RL Code Domain Result - Code Domain (Quad View)



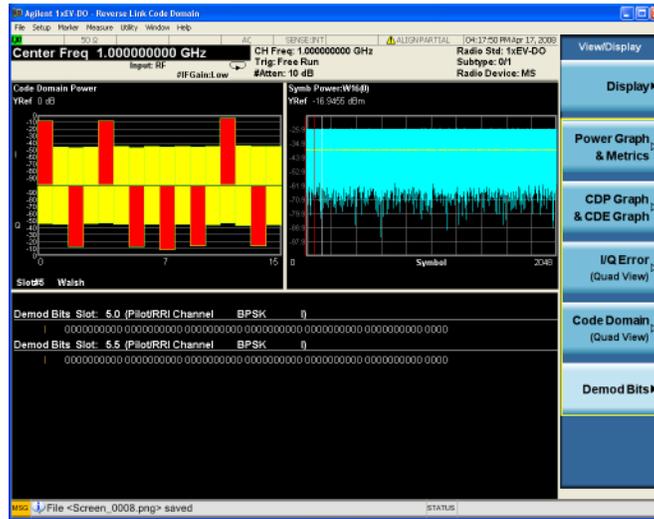
The results screen shows the data for the same code domain channel C2(2) that was selected for despreading by the marker in the Code Domain Quad View in the previous step.

Again, this example uses I-only data that is effectively BPSK modulation for channel C2(2), the phase error must therefore be zero.

Press **View/Display, Demod Bits** to display a combination view of the code domain power, symbol power graph windows, and the I/Q demodulated bit stream data for the symbol power slots selected by the measurement interval and measurement offset parameters.

Figure 9-6

RL Code Domain Result - Demod Bits View



The Demod Bits View displays the same Code Domain Power and Symbol Power windows as the Code Domain (Quad View) shown in [Figure 9-5 on page 64](#).

The demodulated bit stream displayed is the data contained in the Measurement Interval, slot #0. In the Symbol Power graph, this is the data between the red vertical lines; 1 slot, with no offset, so it is the first slot of the capture interval of 1 frame.

The example below shows the marker at the Q channel at W4(2). The marker channel is shown in dark blue, while other Walsh Code channels that are associated with W4(2) are shown in light blue. The marker data indicates Code Domain Power (CDP) and Code Domain Error (CDE) for the channel marked.

Reverse Link Code Domain Measurements Measurement Results

Figure 9-7 RL Code Domain Result - Marker



Troubleshooting Hints

Uncorrelated interference may cause CW interference like local oscillator feed through or spurs. Another cause of uncorrelated noise can be I/Q modulation impairments. Correlated impairments can be due to the phase noise on the local oscillator in the upconverter or I/Q modulator of the unit under test (UUT). These will be analyzed by the code domain measurements along with the QPSK EVM measurements and others.

Poor phase error indicates a problem at the I/Q baseband generator, filter, or modulator in the transmitter circuitry of the UUT, or both. The output amplifier in the transmitter can also create distortion that causes unacceptably high phase error. In a real system, poor phase error will reduce the ability of a receiver to correctly demodulate the received signal, especially in marginal signal conditions.

Reverse Link Code Domain Measurements
Troubleshooting Hints

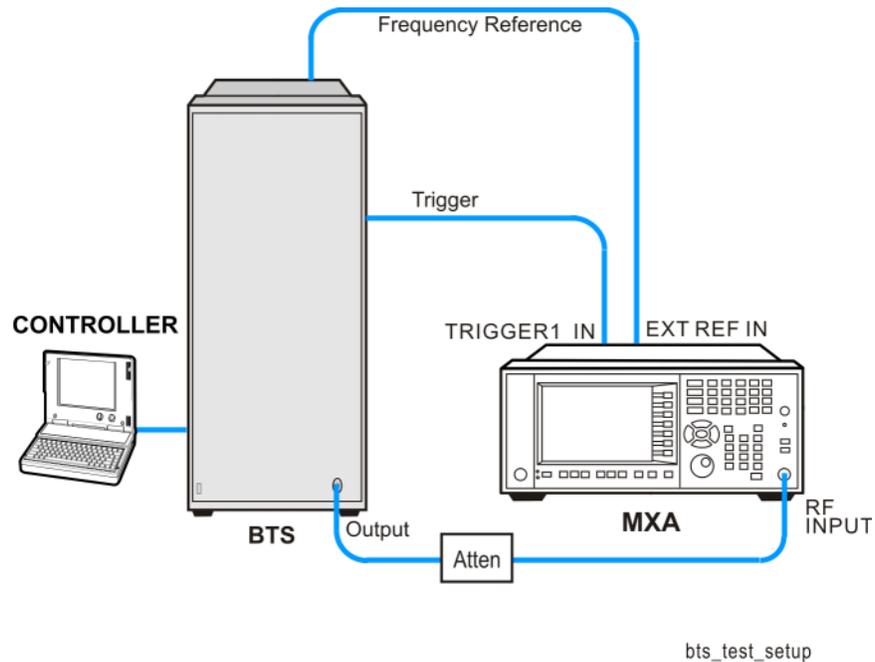
10 Forward Link Modulation Accuracy (Waveform Quality) Measurements

This section explains how to make the modulation accuracy (Waveform Quality) measurement on a 1xEV-DO base station (BTS, or Access Network, AN). Modulation accuracy is the ratio of the correlated power in a multi-coded channel to the total signal power. A Pass or Fail indication is shown in the Measurement Bar.

Configuring the Measurement System

The BTS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 10-1 Modulation Accuracy Measurement System



1. Using the appropriate cables and adapters, connect the output signal of the BTS to the RF input of the analyzer.
2. Connect a BNC cable between the 10 MHz OUT port of the BTS and the EXT REF IN port of the analyzer.
3. Using a BNC cable, connect the trigger signal from the base transceiver station simulator or signal generator to the TRIGGER1 IN port of the analyzer.
4. Connect the system controller to the MS through the serial bus cable to control the BTS operation.

Setting the BTS (Example)

From the system controller, or both, perform all of the call acquisition functions required for the BTS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -20 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Preset** to preset the mode.
- Step 3.** Press **Input/Output, External Gain, BTS** and enter the appropriate attenuation values and **-dB** depending on the external attenuator connected to the analyzer.
- Step 4.** Press **Mode Setup, Radio, Device** and toggle the device to **BTS**.
- Step 5.** Press **Mode Setup, Radio, Pre-Defined Interval/Offset** to select the slot of interest.
- Step 6.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 7.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 8.** Press **Meas, Forward Link Mod Accuracy (Waveform Quality)** to initiate the modulation accuracy measurement.
- Step 9.** Press **Meas Setup, Meas Slot Type** and toggle to the desired type, either **Active** or **Idle**.

Press **More** to check the keys available to change the measurement parameters from the default condition.

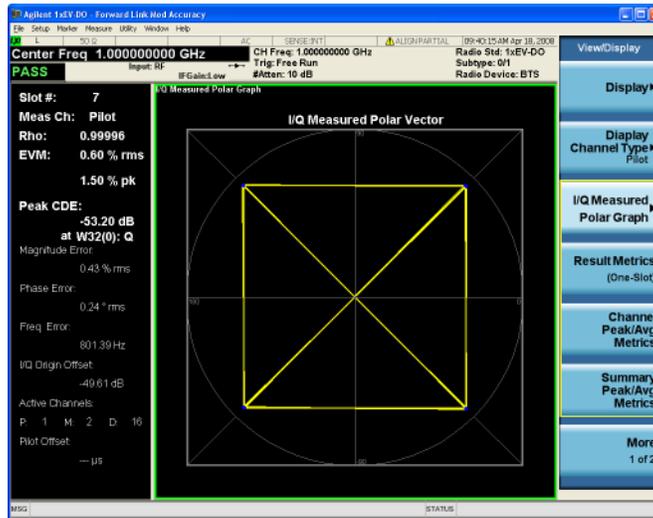
If you have a problem, and get an error message, see the “*Instrument Messages Guide*”.

Measurement Results

The Mod Accuracy I/Q Polar Vector Constellation measurement result should look similar to [Figure 10-2](#).

Figure 10-2

Measurement Result - I/Q Measured Polar Graph (Default) View



The modulation constellation is shown, along with summary data for Rho, EVM, Peak Code Domain Error, and phase and magnitude errors.

Press **View/Display, Channel Peak/Avg Metrics** to display a view of the modulation summary result window.

Figure 10-3

Measurement Result - Polar Constellation View



Press **View/Display, I/Q Error (Quad View)** to display a combination view of the magnitude error, phase error, and EVM graph windows.

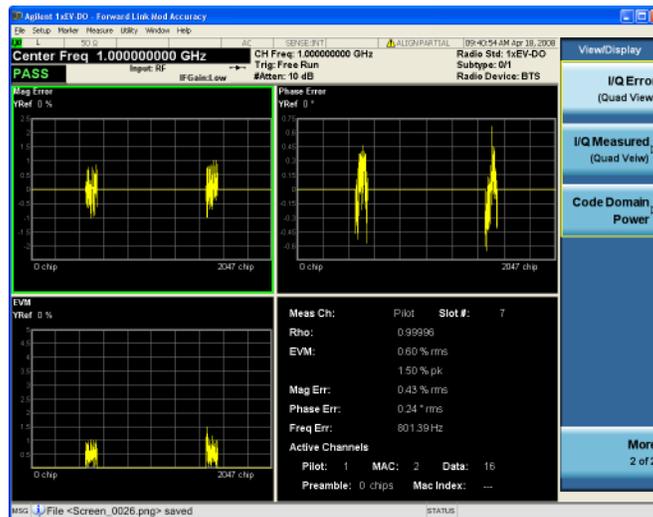
Forward Link Modulation Accuracy (Waveform Quality) Measurements Measurement Results

Figure 10-4 Measurement Result - I/Q Error (Quad View)



Press **View/Display**, **Code Domain Power** to display a combination view of the code domain graph window and the metrics window.

Figure 10-5 Measurement Result - Code Domain Power



Troubleshooting Hints

Poor phase error often indicates a problem with the I/Q baseband generator, filters, or modulator, or all three, in the transmitter circuitry of the unit under test (UUT). The output amplifier in the transmitter can also create distortion that causes unacceptably high phase error. In a real system, a poor phase error will reduce the ability of a receiver to correctly demodulate the received signal, especially in marginal signal conditions.

Forward Link Modulation Accuracy (Waveform Quality) Measurements
Troubleshooting Hints

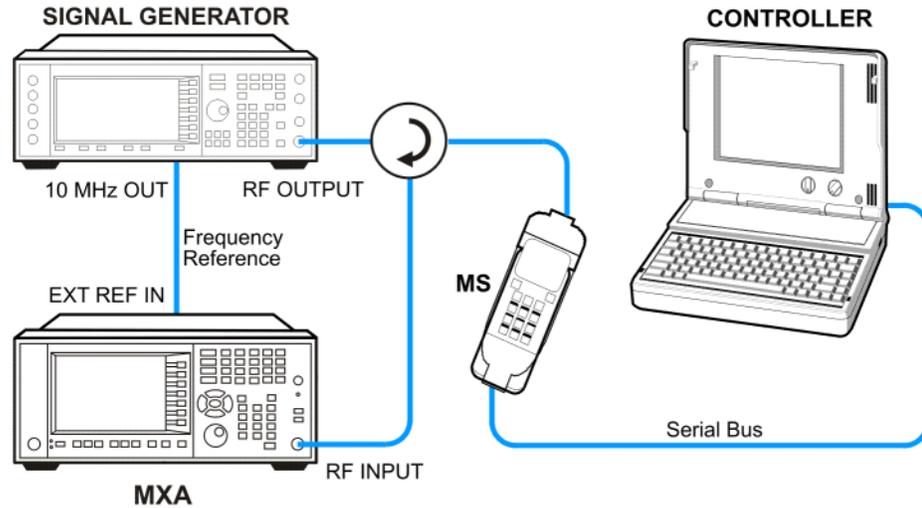
11 Reverse Link Modulation Accuracy (Waveform Quality)

This section explains how to make the modulation accuracy (composite EVM) measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT). Modulation accuracy is the ratio of the correlated power in a multi-coded channel to the total signal power.

Configuring the Measurement System

The MS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 11-1 Modulation Accuracy Measurement System



1. Using the appropriate cables and adapters, connect the output signal of the MS to the RF input of the analyzer.
2. Connect the signal generator to the MS through the circulator to initiate a link constructed with the sync and pilot channels, if required.
3. Connect a BNC cable between the 10 MHz OUT port of the signal generator and the EXT REF IN port of the analyzer.
4. Connect the system controller to the MS through the serial bus cable to control the MS operation.

Setting the MS (Example)

From the system controller, or both, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Mode Setup, Radio, Device** and toggle the device to **MS**.
- Step 4.** Press **Mode Setup, Radio, Pre-Defined Interval/Offset** to select the slot of interest.
- Step 5.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 6.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 7.** Press **Meas, Reverse Link Mod Accuracy (Waveform Quality)** to initiate the modulation accuracy (composite EVM) measurement.
- Step 8.** If your 1xEV-DO active channel signal is known, you may be able to take advantage of a predefined Active Channel preset for synchronization.

Press **Meas Setup, More, Active Code Channel, Predefined, Predefined Active chan** and select from the list of predefined Active Channels shown.
- Step 9.** If your signal has more than 1 Active Channel, you need to press **Meas Setup, More, More, Advanced, More**, and toggle **Multi Channel Estimator** to **On**.

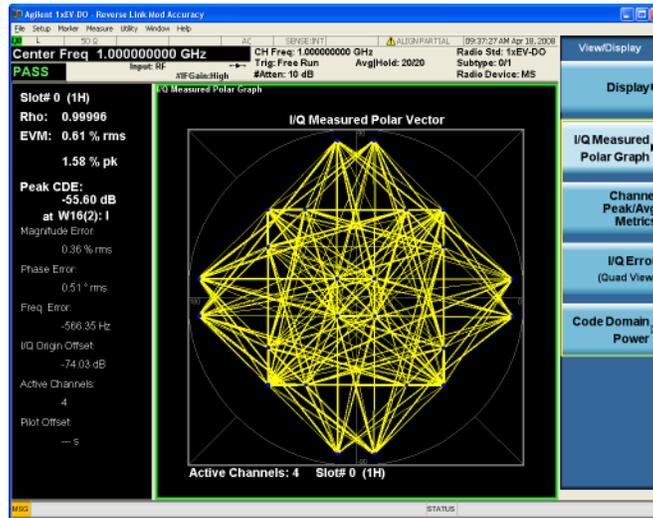
If you have a problem, and get an error message, see the “**Error Messages Guide**”.

Measurement Results

The Mod Accuracy I/Q Polar Vector Constellation measurement result should look similar to [Figure 11-2](#).

Figure 11-2

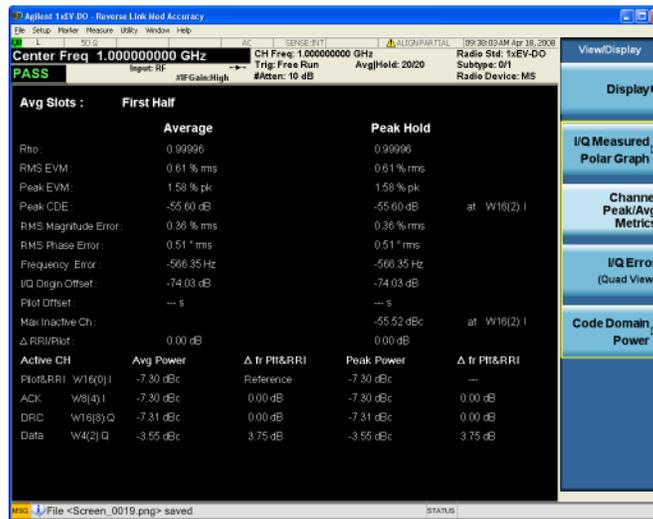
Measurement Result - I/Q Measured Polar Graph (Default) View



The modulation constellation is shown, along with summary data for Rho, EVM, Peak Code Domain Error, and phase and magnitude errors. The number of Active Channels and the Slot Number is shown at the bottom of the Polar Vector window.

Figure 11-3

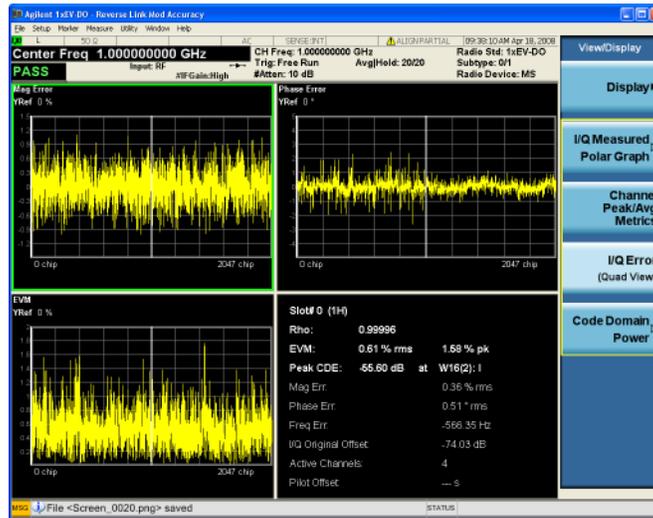
Measurement Result - Channel Peak/Avg Metrics View



Press **View/Display, I/Q Error (Quad View)** to display a combination view of the magnitude error, phase error, and EVM graph windows.

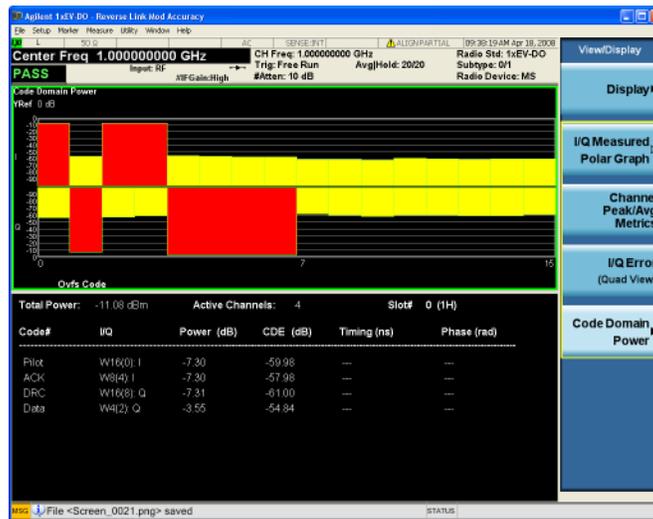
Reverse Link Modulation Accuracy (Waveform Quality) Measurement Results

Figure 11-4 Measurement Result - I/Q Error (Quad View)



Press **View/Display**, **Code Domain Power** to display a combination view of the CDP graph and text windows.

Figure 11-5 Measurement Result - Code Domain Power View



Troubleshooting Hints

A poor phase error often indicates a problem with the I/Q baseband generator, filters, or modulator, or all three, in the transmitter circuitry of the unit under test (UUT). The output amplifier in the transmitter can also create distortion that causes unacceptably high phase error. In a real system, a poor phase error will reduce the ability of a receiver to correctly demodulate the received signal, especially in marginal signal conditions.

Reverse Link Modulation Accuracy (Waveform Quality)
Troubleshooting Hints

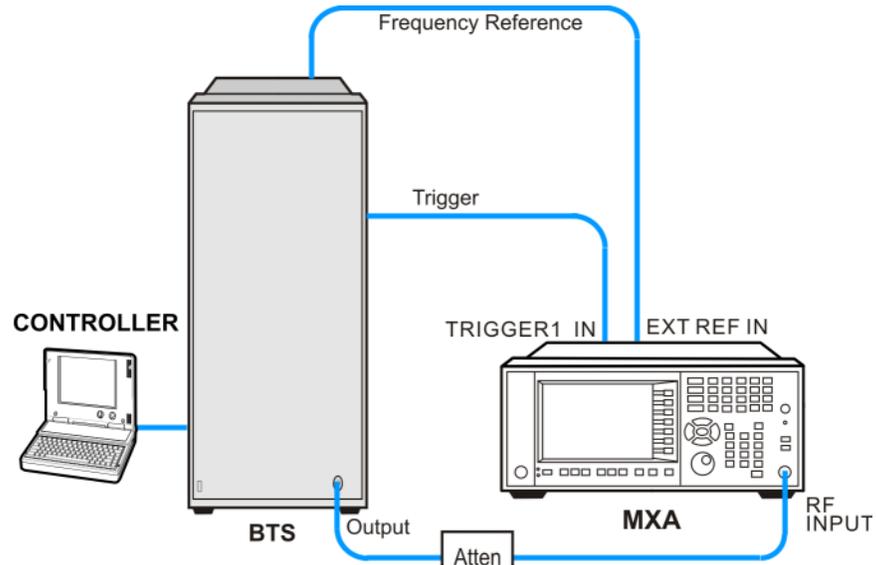
12 Power vs. Time (PvT)

This section explains how to make an 1xEV-DO Power versus Time (PvT) measurement on an 1xEV-DO base station (BTS, or Access Network, AN). Good PvT measurement results verify that the transmitter output power has the correct amplitude, shape, and timing for the 1xEV-DO format. The analyzer, by default, measures the Power vs. Time of the idle slot type signal. A Pass or Fail indication is shown in the Measurement Bar.

Configuring the Measurement System

This example shows a base station (BTS) under test set up to transmit the RF power, and being controlled remotely by a system controller. The transmitting signal is connected to the analyzer RF input port. Connect the equipment as shown.

Figure 12-1 Measurement System



1. Using the appropriate cables and adapters, connect the output signal of the BTS to the RF input of the analyzer.
2. Connect a BNC cable between the 10 MHz OUT port of the BTS and the EXT REF IN port of the analyzer.
3. Using a BNC cable, connect the trigger signal from the BTS to the TRIGGER1 IN port of the analyzer.
4. Connect the system controller to the BTS through the serial bus cable to control the BTS operation.

Setting the BTS (Example)

From the base transmission station simulator and the system controller, set up a call using loopback mode for the BTS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -10 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO mode measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.
- Step 3.** Press **Input/Output, External Gain, BTS** and enter the appropriate attenuation values and **-dB** depending on the external attenuator connected to the analyzer.
- Step 4.** Press **Mode Setup, Radio, Device** and toggle the device to **MS**.
- Step 5.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType.
- Step 6.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 7.** Press **Meas, Power vs Time** to initiate the 1xEV-DO Power vs. Time measurement.
- Step 8.** Press **Trigger** to select the appropriate trigger source **External 1**.

If no measurement is performed and only a yellow '*' symbol displays on the top right of the screen, you need to check the trigger settings and connections.

NOTE

Accurate PvT measurements of burst signals require the analyzer to be perfectly synchronized with the signal of interest. This is usually accomplished through use of the measurement Trigger functions.

- Step 9.** Press **Meas Setup** to check the keys available to change the measurement parameters from the default condition.

Measurement Results

The Power vs. Time measurement result should look similar to [Figure 12-2](#). The burst power, the region masks and limit lines are displayed in the graph window. The average power levels, maximum and minimum peak levels, and delta values to the limit, along with the power reference, the burst length and the first error point are shown in the text window.

Figure 12-2

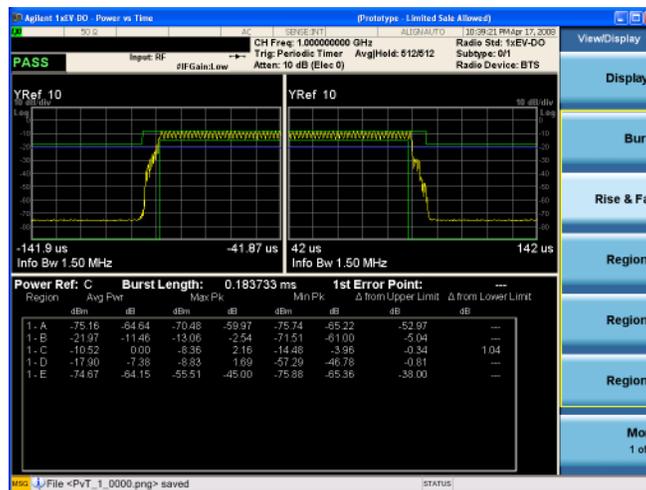
PvT Result - Burst (Default) View



Press **View/Display**, **Rise & Fall** to obtain the horizontally expanded rising and falling edges as shown in [Figure 12-3](#).

Figure 12-3

PvT Result - Rise & Fall View



Press **View/Display**, **Region B** or **Region C** to observe the horizontally expanded regions respectively. See [Figure 12-4](#) and [Figure 12-5](#).

Power vs. Time (PvT)
Measurement Results

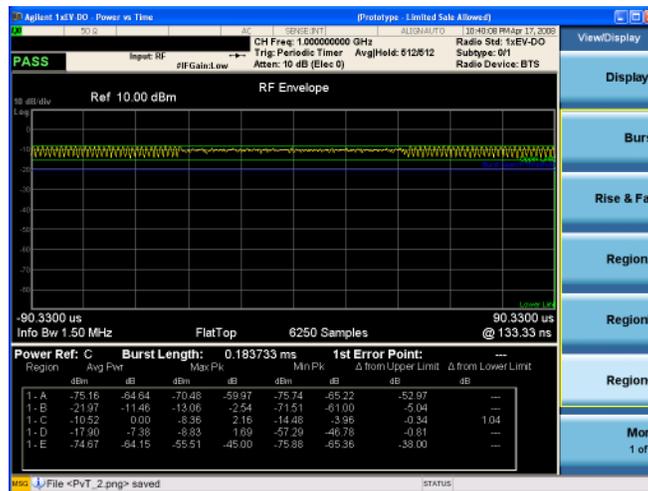
Figure 12-4

PvT Result - Region B View



Figure 12-5

PvT Result - Region C View



The **Scale/Div** key under the **Span/X Scale** menu can also be used to enlarge your view of this signal.

If you have a problem, and get an error message, refer to the *Instrument Messages* manual.

Troubleshooting Hints

The Power vs. Time measurement can reveal degraded or defective parts in the transmitter section of the UUT. The following examples are those areas to be checked further:

- Some problems in the DC power supply control of the transmitter power amplifier, RF power controller of the pre-power amplifier stage, or I/Q control of the baseband stage.
- Some degradation in the gain and output power level of the amplifier due to the degraded gain control and/or increased distortion.
- Some degradation of the amplifier linearity and other performance characteristics.

Power amplifiers are one of the final stage elements of a base or mobile transmitter and are a critical part of meeting the important power and spectral efficiency specifications. Since PvT measures the time domain response of the amplifier to a complex wideband signal, it is a key measurement linking amplifier linearity and other performance characteristics to the stringent system specification.

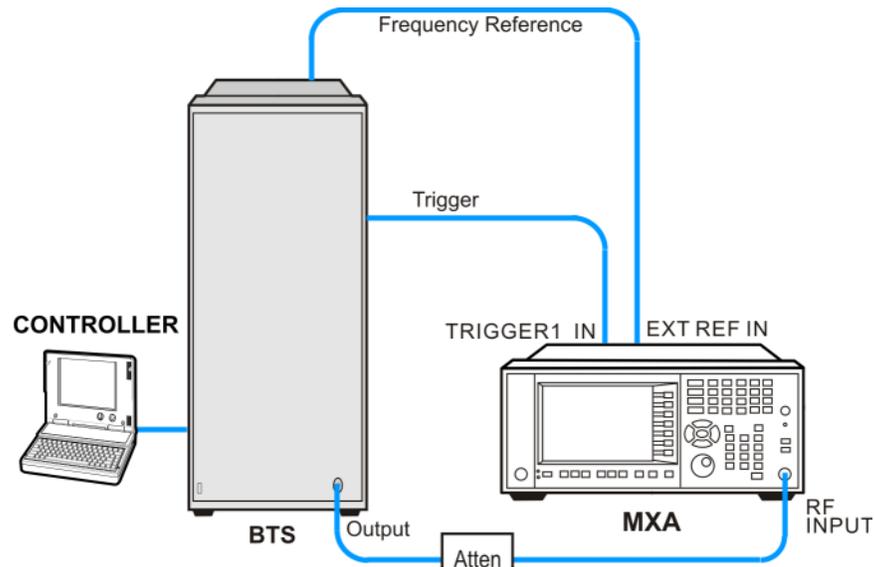
13 QPSK EVM Measurements

This chapter explains how to make a QPSK error vector magnitude (EVM) measurement on a 1xEV-DO base station (BTS, or Access Network, AN). QPSK EVM is a measure of the phase and amplitude modulation quality that relates the performance of the actual signal compared to an ideal signal as a percentage, as calculated over the course of the ideal constellation.

Configuring the Measurement System

The BTS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 13-1 Measurement System



1. Using the appropriate cables and adapters, connect the output signal of the BTS to the RF input of the analyzer.
2. Connect a BNC cable between the 10 MHz OUT port of the BTS and the EXT REF IN port of the analyzer.
3. Using a BNC cable, connect the trigger signal from the BTS to the TRIGGER1 IN port of the analyzer.
4. Connect the system controller to the BTS through the serial bus cable to control the BTS operation.

Setting the MS

From the base transceiver station simulator or the system controller, or both, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Input/Output, External Gain, BTS** and enter the appropriate attenuation values and **-dB** depending on the external attenuator connected to the analyzer.
- Step 4.** Press **Mode Setup, Radio, Device** and toggle the device to **BTS**.
- Step 5.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 6.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 7.** Press **Meas, QPSK EVM** to initiate the QPSK EVM measurement.
- Step 8.** Press **Trigger** to select the appropriate trigger source **External 1**.

If no measurement is performed and only a yellow '*' symbol displays on the top right of the screen, you need to check the trigger settings. You need the correct trigger signal to make the CCDF measurement.

- Step 9.** Press **Meas Setup** to see the keys that are available to change measurement parameters from their default condition.

Press **Meas Offset & Interval**, and input values for **Offset** and **Interval** directly to align the Pilot channel period with the measurement window. Or, you can preset Pilot values by pressing **Mode Setup, Radio, Pre-Defined Interval/Offset** and selecting the appropriate preset Pilot values that will be used in the measurement.

- Step 10.** Press **View/Display, I/Q Error** to display a combination view of the magnitude error, phase error, EVM graph windows, and the modulation summary result window.

NOTE

In the View/Display menu, the **Display** key and the **IQ Measured Polar Graph** key has an arrow in the right middle of the button. If the arrow is hollow, you need to press the key to select the view and the hollow arrow turns solid, If you press the key again, the view settings about this view will be displayed.

If you have a problem, and get an error message, see the guide "**Instrument Messages**".

Measurement Results

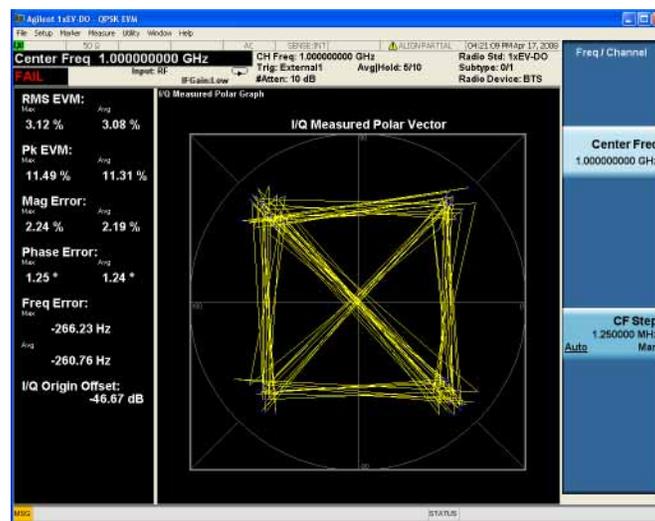
The QPSK EVM I/Q Measured Polar Vector measurement result should look like [Figure 13-2](#). The measurement values for modulation accuracy are shown in the summary result window.

The PASS/FAIL in the top left corner indicates the limit test result. You can manually set the Limits (under Meas Setup menu) of RMS EVM and Freq Error. If some items do not pass the limit test, the related item will be marked with red “F”.

In the Advanced menu, you can use the **EVM Result I/Q Offset** key to include or exclude the I/Q origin offset in the measurement results.

Figure 13-2

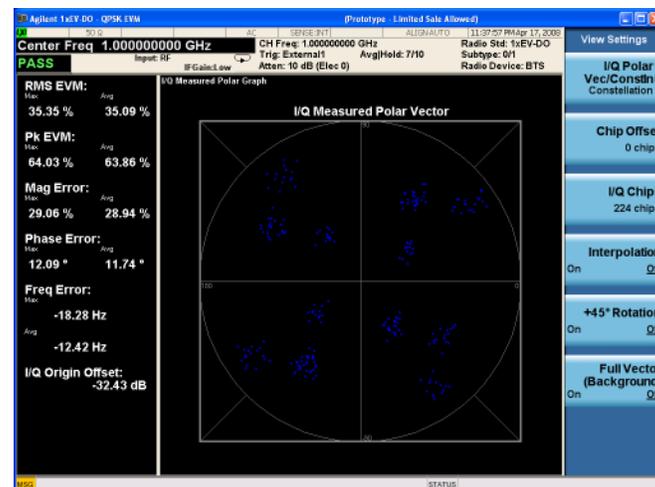
QPSK EVM Result - Polar Vector/Constellation (Default) View



Press **View/Display, I/Q Measured Polar Graph, I/Q Polar Vec/Constln, Constellation** to display a view of the I/Q measured polar constellation graph window and the modulation summary result window.

Figure 13-3

QPSK EVM Result - I/Q Constellation View

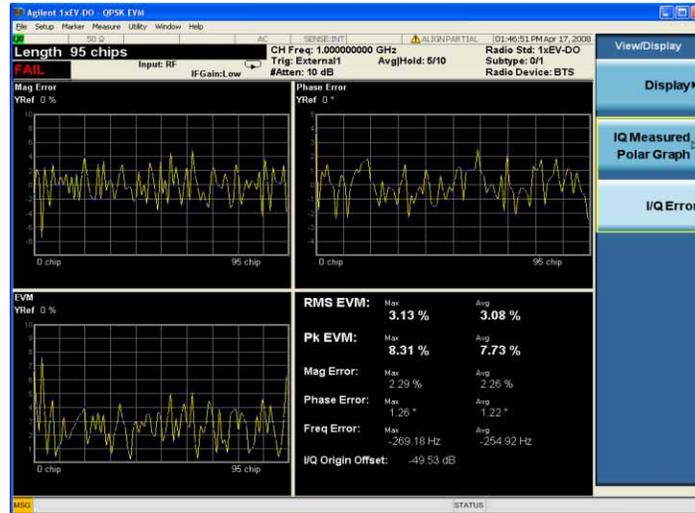


QPSK EVM Measurements Measurement Results

Press **View/Display, I/Q Error** to display a combination view of the magnitude error, phase error, EVM graph windows, and the modulation summary result window.

Figure 13-4

QPSK EVM Result - I/Q Error View



Troubleshooting Hints

Poor phase error indicates a problem with the I/Q baseband generator, filters, or modulator, or all, in the transmitter circuitry of the unit under test (UUT). The output amplifier in the transmitter can also create distortion that causes unacceptably high phase error. In a real system, poor phase error will reduce the ability of a receiver to correctly demodulate the received signal, especially in marginal signal conditions.

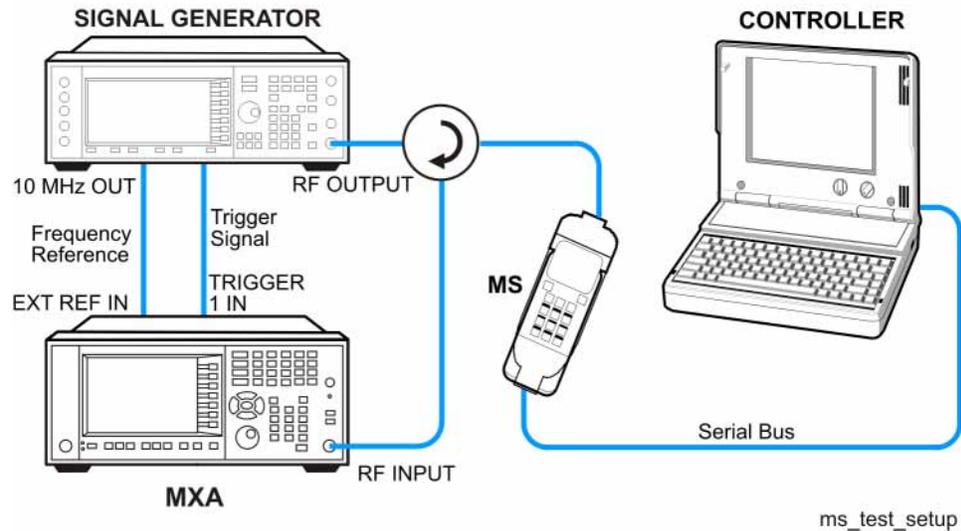
14 Monitor Spectrum Measurements

This chapter explains how to make a Monitor Spectrum measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT). Monitor Spectrum measurements show a spectrum domain display of the 1xEV-DO signal.

Configuring the Measurement System

The MS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 14-1 Measurement System



1. Using the appropriate cables and adapters, connect the output signal from the MS to the RF input port of the analyzer.
2. Connect the base transceiver station simulator or signal generator to the MS through the circulator to initiate a link constructed with the sync and pilot channels, if required.
3. Connect a BNC cable between the 10 MHz OUT port of the signal generator and the EXT REF IN port of the analyzer.
4. Using a BNC cable, connect the trigger signal from the base transceiver station simulator or signal generator to the TRIGGER1 IN port of the analyzer.
5. Connect the system controller to the MS through the serial bus cable to control the MS operation.

Setting the MS (Example)

From the base transceiver station simulator or the system controller, or both, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -20 dBm

Measurement Procedure

- Step 1.** Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.
- Step 2.** Press **Mode Preset** to preset the mode.
- Step 3.** Press **Mode Setup, Radio, Device** and toggle the device to **MS**.
- Step 4.** Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.
- Step 5.** Press **Sweep/Control, Gate** and toggle the **Gate** to **On**. Press **More, Gate Source** and select the desired gate source **External 1**.
- If no measurement is performed and a yellow '*' symbol displays on the top right of the screen, you need to check the gate settings. You need the correct gate signal to make the Channel Power measurement.
- Step 6.** Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.
- Step 7.** Press **Meas, Monitor Spectrum** to initiate the Monitor Spectrum measurement.
- Step 8.** Press **SPAN X Scale**, enter a numerical span using the front-panel keypad, and select a units key, such as **MHz**.

NOTE

A display with a Spectrum window appears when you activate a Spectrum measurement. Changes to the **FREQ, Span**, or **AMPTD** settings will affect only the active window.

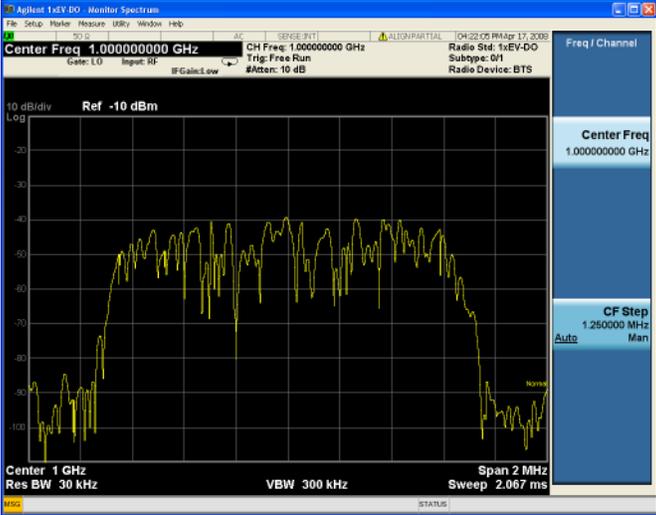
- Step 9.** Press **Trace/Detector, Select Trace** and select the trace(s) desired for display, then toggle **Display** to **Show**.
- Step 10.** Press **Meas Setup** to check the keys available to change the measurement parameters from the default condition.

If you have a problem, and get an error message, see the "*Instrument Messages Guide*".

Measurement Results

The Monitor Spectrum measurement result should look like [Figure 14-2](#).

Figure 14-2 Monitor Spectrum Result



Monitor Spectrum Measurements
Measurement Results

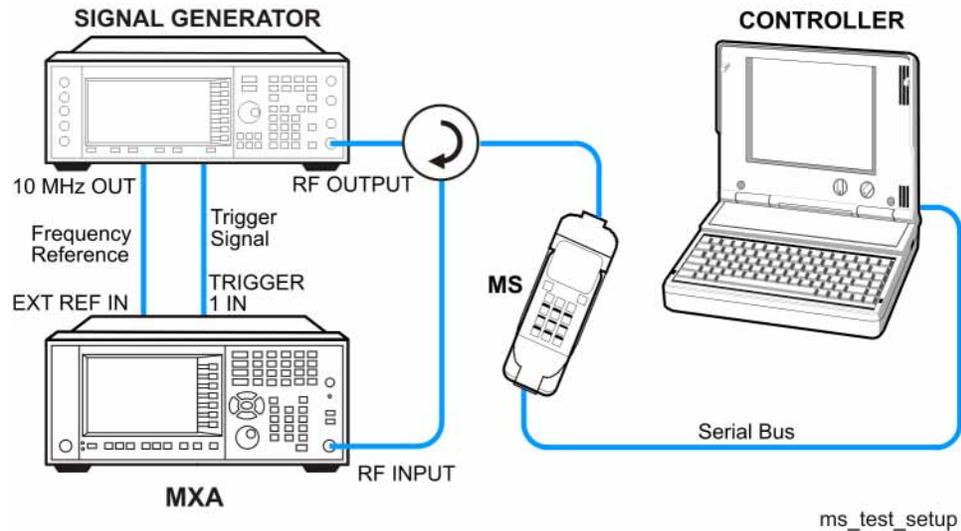
15 IQ Waveform

This chapter explains how to make an IQ Waveform measurement on a 1xEV-DO mobile station (MS, or Access Terminal, AT). The measurement of I and Q modulated waveforms in the time domain disclose the voltages which comprise the complex modulated waveform of a digital signal.

Configuring the Measurement System

The MS under test must be set to transmit the RF power remotely through the system controller. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 15-1 Measurement System



1. Using the appropriate cables and adapters, connect the output signal from the MS to the RF input port of the analyzer.
2. Connect the base transceiver station simulator or signal generator to the MS through the circulator to initiate a link constructed with the sync and pilot channels, if required.
3. Connect a BNC cable between the 10 MHz OUT port of the signal generator and the EXT REF IN port of the analyzer.
4. Using a BNC cable, connect the trigger signal from the base transceiver station simulator or signal generator to the TRIGGER1 IN port of the analyzer.
5. Connect the system controller to the MS through the serial bus cable to control the MS operation.

Setting the MS (Example)

From the base transceiver station simulator or the system controller, or both, perform all of the call acquisition functions required for the MS to transmit the RF power as follows:

Frequency: 1 GHz

Output Power: -30 dBm

Measurement Procedure

Step 1. Press **Mode, 1xEV-DO** to enable the 1xEV-DO measurements.

Step 2. Press **Mode Preset** to preset the mode.

Step 3. Press **Mode Setup, Radio, Device** and toggle the device to **MS**.

Step 4. Press **Mode Setup, Demod, Physical Layer SubType** to select the desired SubType, like **Sub Type 0/1**.

Step 5. Press **FREQ Channel, 1, GHz** to set the center frequency to 1 GHz.

Step 6. Press **Meas, IQ Waveform** to initiate the IQ Waveform measurement.

Step 7. Press **Trigger** to select the appropriate trigger source **External 1**.

If no measurement is performed and only a yellow ‘*’ symbol displays on the top right of the screen, you need to check the trigger settings. You need the correct trigger signal to make the CCDF measurement.

Step 8. Select the view.

Press **View/Display** and toggle the view between **RF Envelope** and **IQ Waveform**.

Step 9. Press the **AMPTD Y Scale**, and down arrow keys until the waveforms are shown at a convenient voltage scale for viewing.

Step 10. Press the **SPAN X Scale**, and down arrow keys until the waveforms are shown at a convenient time scale for viewing.

Step 11. Press **Marker, Select Marker** to activate a marker and press **Properties, Marker Trace** to select the appropriate trace in the current view. Rotate the front-panel knob until the marker is shown at a desired time in the waveform for viewing the trace values at the time position of the marker.

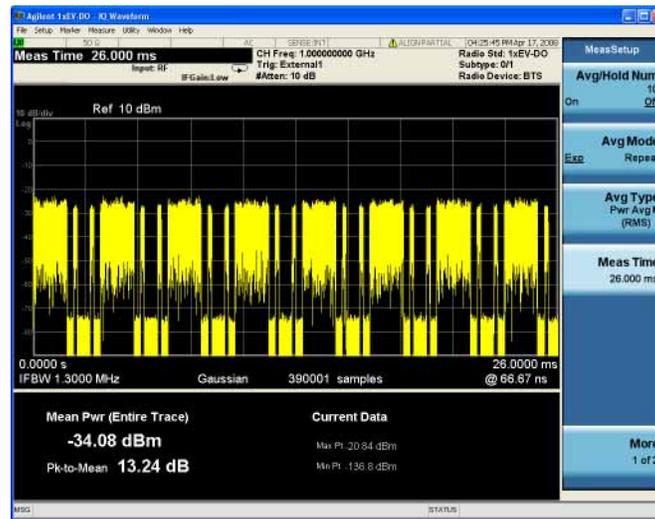
Step 12. Press the **Meas Setup** key to see the keys available to change the measurement parameters from the default condition.

If you have a problem, and get an error message, see the “*Instrument Messages Guide*”.

Measurement Results

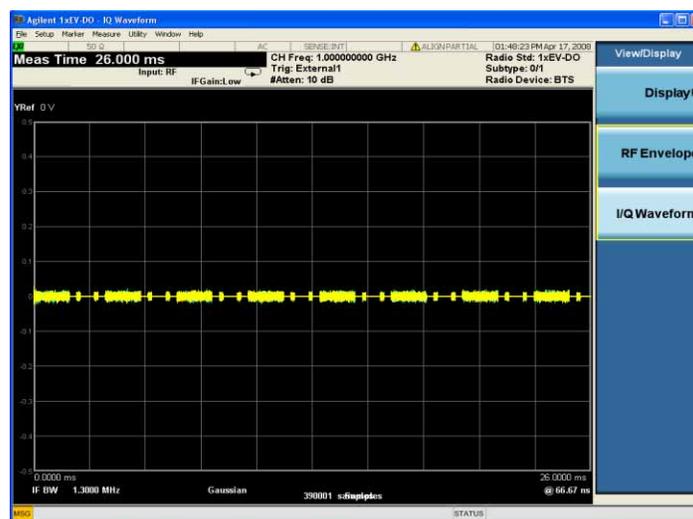
The default display shows the RF Envelope with the current data. The measured values for the Mean Power (entire trace) and Peak-to-Mean power are shown in the text window. See [Figure 15-2](#).

Figure 15-2 Waveform Result - RF Envelope (Default View)



The IQ Waveform window provides a view of the I (yellow trace) and Q (blue trace) waveforms on the same graph in terms of voltage versus time in linear scale. See [Figure 15-3](#).

Figure 15-3 Waveform Result – I/Q Waveform View



IQ Waveform
Measurement Results

16 Using Option BBA Baseband I/Q Inputs

Baseband I/Q Measurements Available for X-Series Signal Analyzers

The following table shows the measurements that can be made using Baseband I/Q inputs:

Table 16-1 *BBIQ Supported Measurements vs. Mode*

Mode	Measurements
GSM	IQ Waveform GMSK Phase & Freq EDGE EVM
802.16 OFDMA	IQ Waveform Power Stat CCDF Modulation Analysis
TD-SCDMA	IQ Waveform Power Stat CCDF Code Domain Mod Accuracy
Cdma2000	IQ Waveform Power Stat CCDF Code Domain Mod Accuracy QPSK EVM
1xEV-DO	IQ Waveform Power Stat CCDF Forward Link Code Domain Reverse Link Code Domain Forward Link Mod Accuracy Reverse Link Mod Accuracy QPSK EVM
IQ Analyzer (Basic)	IQ Waveform Complex Spectrum

Baseband I/Q Measurement Overview

The Baseband I/Q functionality is a hardware option, Option BBA. If the option is not installed in the instrument, the I/Q functionality cannot be enabled.

The Baseband I/Q option provides four input ports and one Calibration Output port. The input ports are I, I-bar, Q, and Q-bar. The I and I-bar together compose the I channel and the Q and Q-bar together compose the Q channel. Each channel has two modes of operation:

Single Ended

(unbalanced)

In this mode, only the main port (I or Q) is used and the complementary ports (I-bar or Q-bar) is ignored. The I and Q ports are in single-ended mode when Differential “Off” is selected.

Differential

(balanced)

In this mode, both main and complementary ports are used. To activate this mode, select Differential “On” from the I and Q Setup softkey menus.

The system supports a variety of input passive probes as well as the Keysight 1153A active differential probe using the infinimax probe interface.

NOTE

To avoid duplication, this section describes only the details unique to using the baseband I/Q inputs. For generic measurement details, refer to the previous “Making Measurements” sections.

To make measurements using baseband I/Q Inputs, make the following selections:

- Step 1.** Select a measurement that supports baseband I/Q inputs.
- Step 2.** Select the I/Q Path
Press **Input/Output, I/Q, I/Q Path**. Select from the choices present on the screen. The path selected is shown at the top of the measurement screen.
- Step 3.** Select the appropriate circuit location and probe(s) for measurements. For details see [“Selecting Input Probes for Baseband Measurements” on page 155](#).
- Step 4.** Select baseband I/Q input connectors.
- Step 5.** If you have set the I/Q Path to **I+jQ** or to **I Only**, press **I Setup**.
 - A. Select whether **Differential (Balanced)** inputs is **On** or **Off**.
 - B. Select the input impedance, **Input Z**.
 - C. Input a **Skew** value in seconds.
 - D. Set up the I Probe by pressing **I Probe**
 - a. Select probe **Attenuation**

- b. Calibrate the probe. Press **Calibrate...** to start the calibration procedure. Follow the calibration procedure, clicking **Next** at the end of each step.

Step 6. If you have set the I/Q Path to **I+jQ** or to **Q Only**, press **Q Setup**

- A. Select whether **Differential (Balanced)** inputs is **On** or **Off**.
- B. Select the input impedance, **Input Z**.
- C. Input a **Skew** value in seconds.
- D. Set up the I Probe by pressing **I Probe**
 - a. Select probe **Attenuation**
 - b. Calibrate the probe. Press **Calibrate...** to start the calibration procedure. Follow the calibration procedure, clicking **Next** at the end of each step.

Step 7. Select the reference impedance by pressing **Reference Z**, and inputting a value from one ohm to one megohm. The impedance selected is shown at the top of the measurement screen.

Step 8. If you using cables that were not calibrated in the probe calibration step, press **I/Q Cable Calibrate...** Follow the calibration procedure, clicking **Next** at the end of each step.

Step 9. After completing the baseband IQ setup procedures, make your desired measurement.

17 Concepts

This chapter provides details about the 1xEV-DO communications system, and explains how the various measurements are performed by the instrument. Suggestions for optimizing and troubleshooting your setup are provided, along with a list of related Keysight documents that are referenced for further information.

What Is the 1xEV-DO System?

1xEV-DO is the name applied to the first single-channel evolution (1xEV) of a 3GPP2 communications system optimized for data only (-DO). As 1xEV-DO has evolved from the cdma2000 voice system and has structural similarity to cdma2000, this discussion will also describe the differences between 1xEV-DO and cdma2000.

RF Characteristics

1xEV-DO uses what is known as High Rate Packet Data, using the same final spread rate of 1.2288 Mcps as does cdma2000 SR1. It also uses the same digital filter to reduce the final modulation bandwidth, with the result that 1xEV-DO is spectrally compatible with cdma2000 SR1. Both 1xEV-DO and cdma2000 SR1 can utilize the same amplifiers, combiners, and antennas to reduce the installation cost of 1xEV-DO.

Although 1xEV-DO is compatible with much existing cdma2000 infrastructure, the two systems may not simultaneously occupy the same channel. Each 1xEV-DO channel requires a paired 1.25 MHz clear channel, therefore it can not be overlaid with cdma2000 channels.

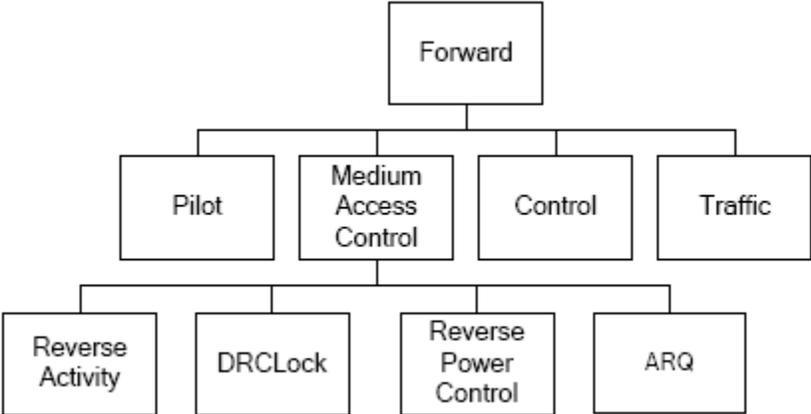
1xEV-DO requires an operator to dedicate a single CDMA channel (1.25 MHz) to the packet-data system. This channel cannot carry any voice. The system uses the exact chip rate and emission filters that are used in cdma2000 and IS-95 CDMA systems, so the new system is spectrally identical to the legacy systems.

Forward Link

1xEV-DO relies on the Global Positioning System (GPS) for intercell synchronization, in the same manner as cdma2000. The 1xEV-DO system is well suited for data transmission in the forward link, as it is optimized for high speed packet data communications from ANs (base stations) to ATs (mobile stations). Average delivery rates of about 600 kbps per sector on a continuous basis have been demonstrated. When compared to the recent IS-95-B design in cdma2000, 1xEV-DO shows about a 6 times improvement in the overall network data rate.

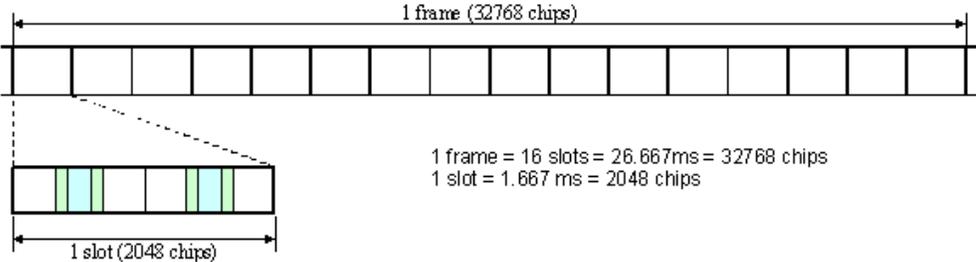
The largest contribution to overall increased data throughput is the ability of 1xEV to negotiate for increased data rates for individual users or mobiles, as only one user is served at a time. This and other contributing factors are described in detail in the Design Elements section below.

Figure 17-1 Forward Link Channel Structure (Rev A)



Frame Structure

The frame structure is different from that used for cdma2000 and IS-95 systems, as they are based on 20 ms frames set by the codec for speech. The frame period for 1xEV-DO is 26.667 ms, which is also the period of one pilot channel. Each frame is divided up into 16 slots of 1.667 ms.



Design Elements

When compared to a voice communication system of cdma2000, the following design elements of the forward link contribute to raise the data rate:

- Full power - The cell is always at full power, resulting in no overhead needed for statistical variations of multiple users.
- Best serving cell - When in soft handoff, the mobile selects the best serving cell and can only request and receive data from that cell.
- Efficient data delivery - The base station can send data to a mobile at times when its rate request is higher than the running average of the base station, and will avoid sending data when the requested rate is lower than the running average.

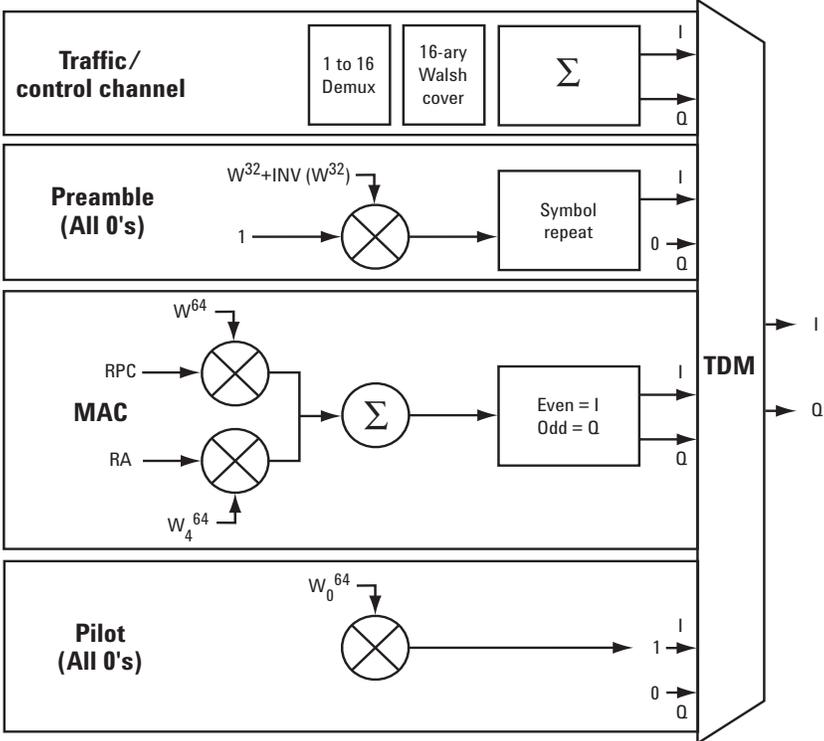
The forward link is always transmitted at its full power, using a rate control scheme instead of a power control scheme, as in cdma2000. The data is TDM (time division multiplexed) to the various users or mobiles, with only one being served at any time. Each mobile measures signal-to-noise ratio (S/N) on the forward link pilot every slot, 1.667 ms, and sends a data rate request to the base station every 1.667 ms. The base station decides which mobile should be served next. The maximum data transfer from the network will be achieved if only the most favorable links get served, however, this is accomplished at the expense of the distant users.

Forward Channel TDM Structure

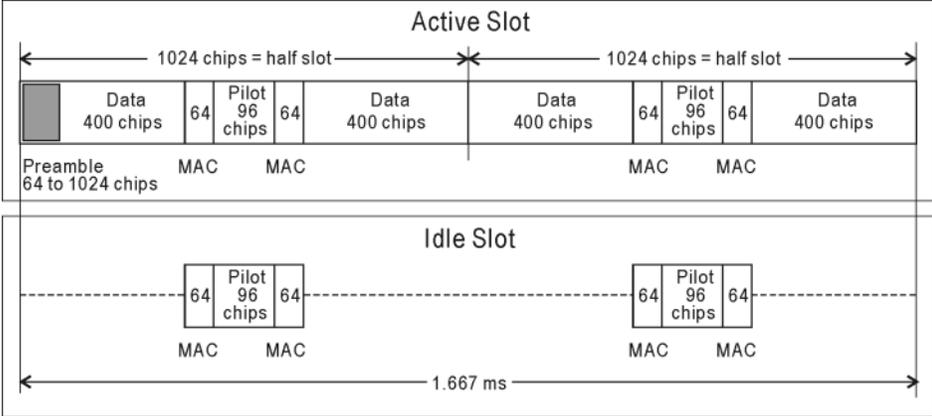
The following four different channels are used and are Time Division Multiplexed (TDM):

- **Traffic Channel** - The data following the turbo coder is scrambled by mixing with a PN sequence, the initial state of which is based on known parameters, and is unique for each user. At the same initial value of the PN sequence, every packet starts. QPSK modulation is used for data rate up to 1.2288 Mbps. Higher order modulation, with either 8PSK with 3 bits per symbol or 16QAM with 4 bits per symbol, is used for higher data rates. The levels of the I and Q symbols are mathematically chosen so that the average power becomes 1. The I and Q channels are mapped into 16 parallel Walsh covers, each of length 16. The I and Q outputs with the Walsh covers signals are added.
- **Preamble** - At the beginning of the transmission to one user, there is a preamble that is embedded in the data. This preamble contains the user ID for the data, and its repeat rate is determined by the data rate; lower data rates require higher repeat values. At its largest, the preamble will fill more than a half the first slot.
- **Medium Access Control (MAC)** - This layer consists of the reverse power control (RPC) and the reverse activity (RA). The power control bits are sent in parallel to all mobiles with an open connection. Each one is assigned a different 64-bit Walsh code which gets transmitted on either the I or Q channel. The codes 0 through 3 are reserved. The Walsh code 4 is the RA cover. The Walsh codes 5 through 63 are allocated to RPC. One Walsh code is allocated for power control to each active reverse link. Power control bits for all of the reverse links are sent in parallel as part of the MAC channel. These are made of 4 repetitions of an assigned Walsh code of length 64. The RA channel is used to indicate that the sector is busy decoding multiple reverse link signals.
- **Pilot** - The pilot signal is gated on for only 192 chips per slot. The differentiator between the cell and the sector is still the PN offset of the pilot channel.

The basic TDM structure of the 1xEV-DO is illustrated below.



The data structure per slot can be illustrated as follows:

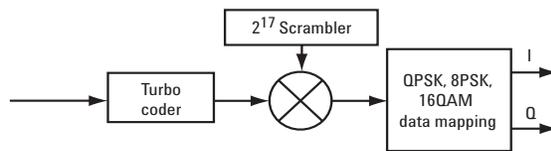


Forward Link Coding

The input data is encoded with a turbo coder, which can provide up to 3 dB better performance than an equivalent convolutional encoder. The data is then scrambled with a code that is unique to each user, providing security. Finally the data is mapped into I and Q values. At lower rates, alternate bits map directly into I and Q with QPSK modulation, which results in two bits per symbol. For higher rates, the mapping is at three bits per symbol, which is 8 PSK. At the highest data rates, the mapping is four bits per symbol, which results in 16 QAM modulation. It should be noted that after modulation the I and Q signals become signed modulation values.

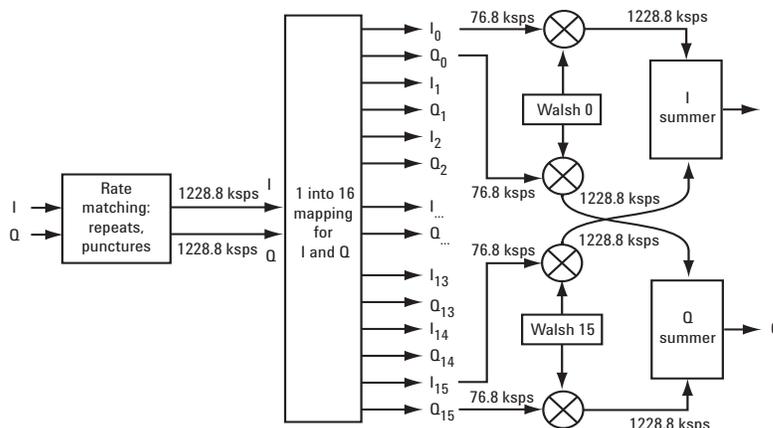
Concepts

What Is the 1xEV-DO System?



The resulting I and Q symbols from the first encode and modulate are then mapped into the process shown in figure 5. First, there is a rate-matching function. In general, this will provide repeats of the input data to the output data so that the output data rate is exactly 1.2288 Msps. The second operation is to demultiplex the I and Q data streams into 16 parallel I and Q data sets. Each of the data sets gets coded with one of the 16 Walsh covers of length 16. Finally, all the I and Q signals are added together as the final baseband signals, ready for passing through band-limiting low-pass filters (the same as is used in IS-95 CDMA) and final I/Q modulation. This final step does not add gain to the system; the signal starts with one complex channel that is multiplexed into 16 parallel paths. Each of these paths gets coded with 16 times the gain of the original signal. However, there are 16 of these channels each with 1/16 the power; so there is 16 times the processing gain, but 1/16 the power, for a net unity gain. This process provides some added time diversity and puts more randomness into the final signal for transmission

The performance of a 1xEV-DO system is anticipated to have an average rate of about 600 kbps from each sector of each cell in a network. This is about three times better than the cdma2000 forward link.



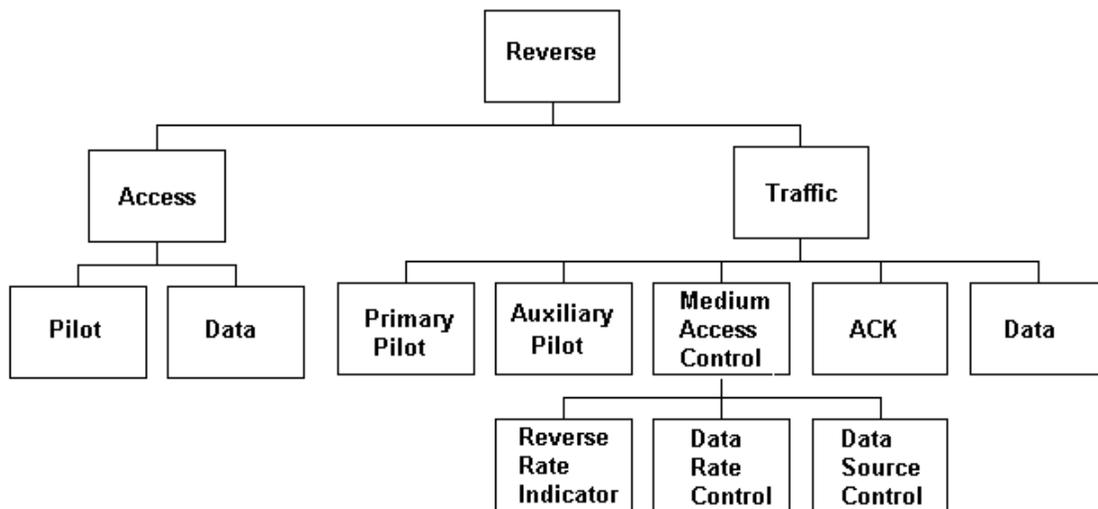
Reverse Link Coding

The reverse link for 1xEV-DO has a structure similar to that for cdma2000, except that in addition to a data channel, the following channels are also included:

- Reverse Rate Indication (RRI) - This replaces with the power control bits to indicate of which data rate is requested by the mobile.

- Data Request Channel (DRC) - This contains a 4 bit word in each slot to allow the choice of up to 16 different transmission rates. Different Walsh covers are used to indicate which PN offset in the active set is preferred for transmission.
- Ack Channel - This acknowledgement channel is only transmitted after the mobile detects a frame with its preamble, meaning the packet is directed to that mobile. The 1 bit on this channel, which is transmitted for a half slot, is used to indicate a successful reception or an erasure.

Figure 17-2 Reverse Link Channel Structure (Rev. A)



The Pilot in 1xEV-DO is still punctured but the information carried is different:

In cdma2000, the Pilot is punctured in a 3:1 ratio (3 Pilot, 1 Data) to carry power control bits. The puncture period is 1 Power Control Group, or 1.25 ms. The data rate for PCB is 16 bits per 20 ms frame.

In 1xEV-DO, the puncture pattern is 7:1 on each slot (7 Pilot, 1 Data). The underlying data is coded, and the transmission rate is 3 bits per 26.667 ms frame.

In 1xEV all signaling is performed on the data channel so there is no Dedicated Control Channel. The data channel can support 5 data rates which are separated in powers of 2 (256 through 4096 bits, or 9.6 through 153.6 kbps). These rates are achieved by varying the repeat factor. The highest rate uses a Turbo coder with lower gain.

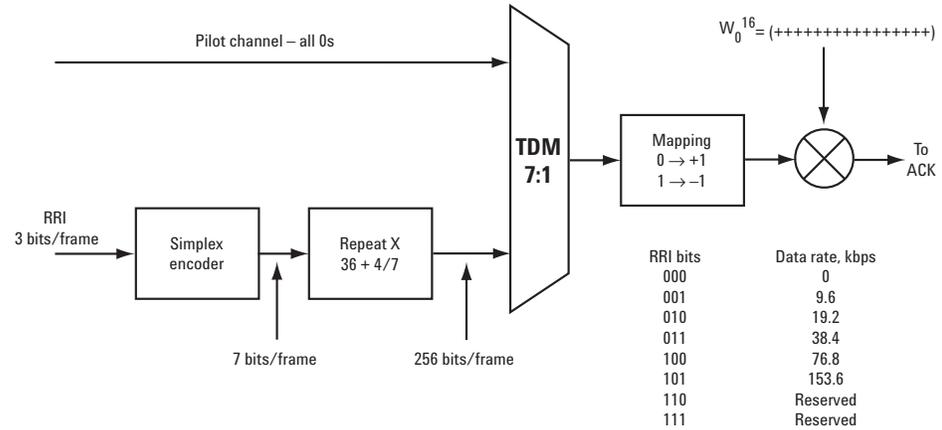
Pilot

In cdma2000, the pilot is punctured in a 3:1 (3 pilot to 1 data) ratio to carry power control bits (PCB). The puncture period is one power control group, or 1.25 μ s. The data rate for power control is 16 bits per 20 μ s frame. In 1xEV-DO, the puncture pattern is 7:1 on each slot. The underlying data is coded, and the transmission rate is

Concepts

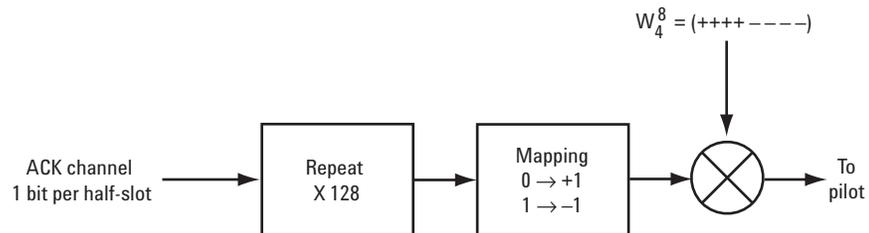
What Is the 1xEV-DO System?

3 bits per 26.67 μ s frame. The pilot is transmitted continuously on the I channel using Walsh cover 0, time division multiplexed with the RRI channel. The pilot/RRI channel coding structure is shown below.



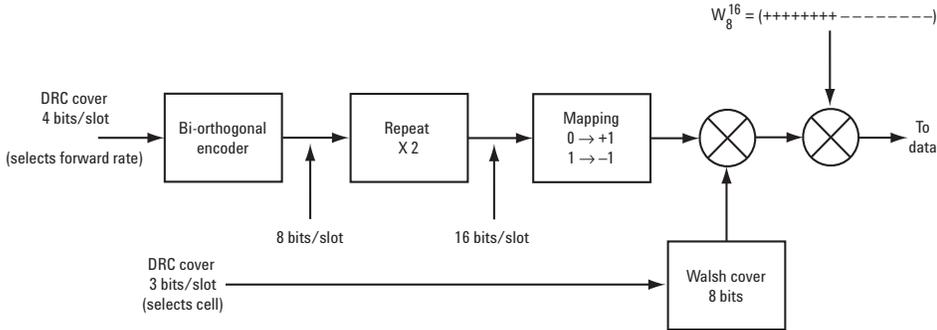
ACK

The ACK channel is transmitted each time the AT successfully detects a frame with a preamble directed to it. It is BPSK modulated, meaning it can have only one of two values indicating a successful reception or an erasure. A 0 bit corresponds to a success (ACK) and a 1 bit corresponds to a failure (NAK). It is transmitted for 1/2 slot on the I channel using Walsh cover 4. The ACK channel coding structure is shown below.



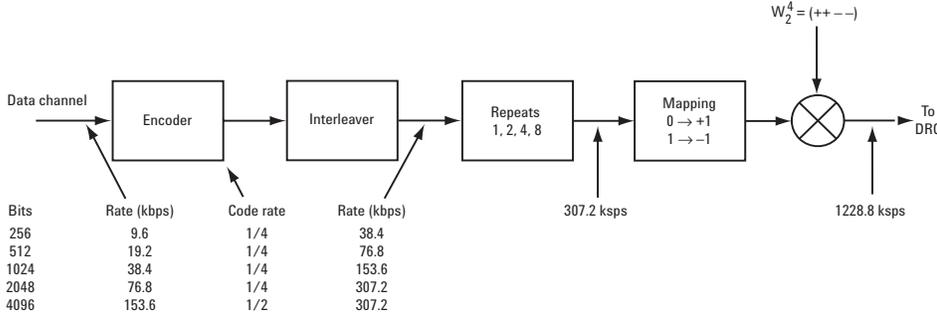
DRC

The DRC channel contains a 4 bit word in each slot. This allows for the choice of up to 16 different transmission rates from the serving AN. Different Walsh covers are used to indicate which PN-offset in the active set is preferred for transmission. In other words, which AN should serve the AT. Figure 8 shows the DRC channel coding structure.



Data

The data channel can support five data rates for reverse link transmission, which are separated in powers of two. Four of these rates are achieved by varying the repeat factor. The highest rate uses a turbo coder with lower gain. Figure 9 shows the data channel coding structure.

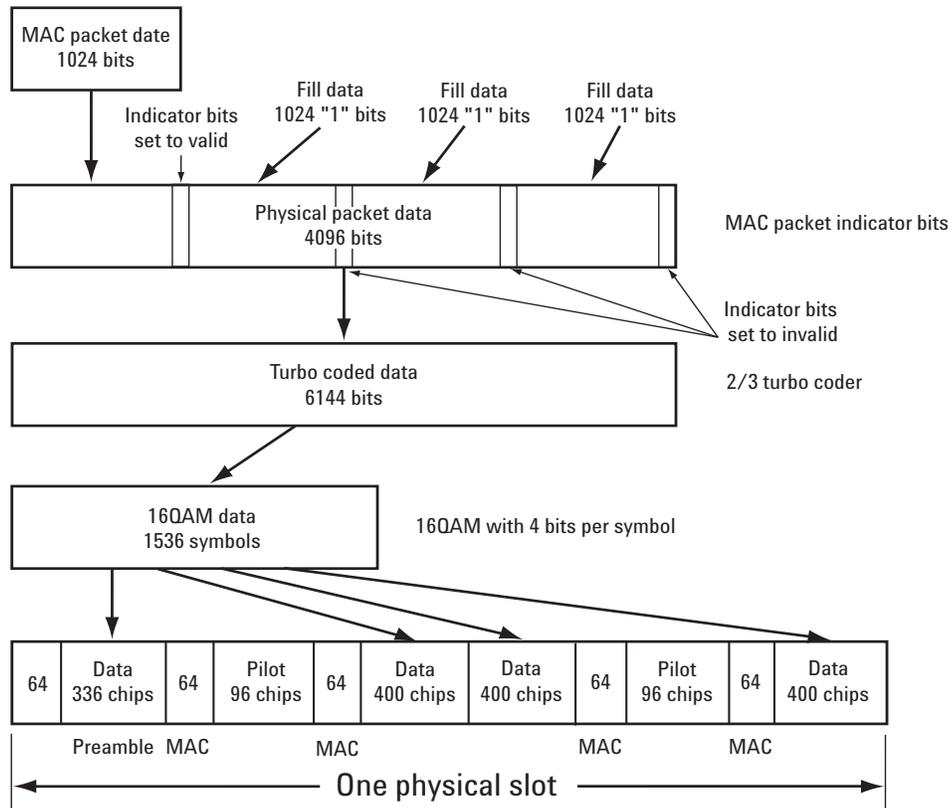


Slot Structure

Physical packets in 1xEV-DO are normally made up of 1024-bit MAC packets. At low data rates, there is a one to one mapping of MAC to physical packets. At high data rates, physical packets incorporate multiple MAC packets for extra throughput. Each physical slot in a 2.4 Mbps signal sent with 16QAM modulation contains four MAC packets of 1024 bits each. This corresponds to one physical packet.

Figure 17-3

Physical Packet Slot Structure

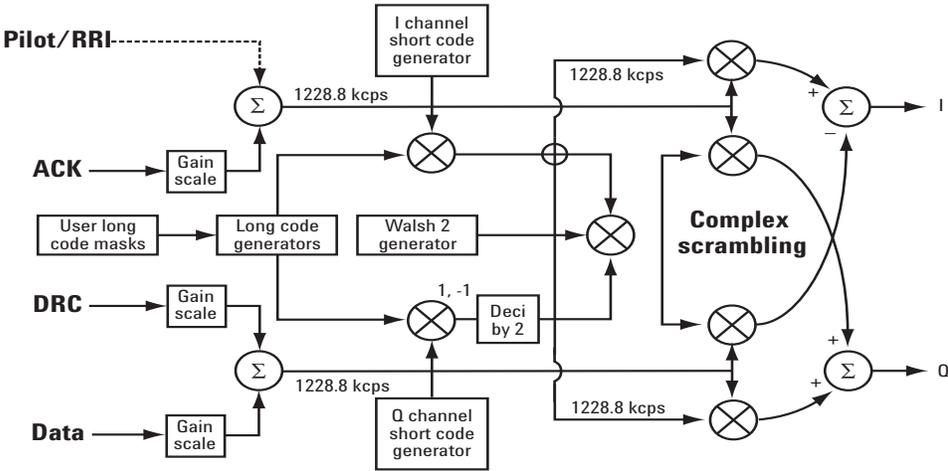


Reverse Link Scrambling

The Pilot, ACK, DRC, and Data channels are added with each other in a manner that maps some into I and some into Q for eventual spreading. The final spreading is made similarly to cdma2000 with HPSK. In 1xEV-DO, the long code used for spreading is seeded with a fixed pattern at the start of every Pilot sequence, every 26.667 ms. There are separate masks, 42 bits long, for the I and Q long spreading codes. In cdma2000, the long code generator is based on system time, or in other words a continuous clock.

The final coding structure is shown below. The first coding and rate matching are not shown.

The performance of the reverse link is expected to be virtually identical to that for cdma2000.



Concepts

What Is the 1xEV-DO System?

Standard Documents

1xEV-DO is defined in the following Telecommunications Industry Association (TIA) and Electronics Industry Alliance (EIA) document:

3GPP2 C.S0024 Revision A cdma2000 High Rate Packet Data Air Interface Specification

3GPP2 C.S0032 Revision A recommended Minimum Performance Standards for cdma2000 High Rate Packet Data Access Network

3GPP2 C.S0033 Revision A recommended Minimum Performance Standards for cdma2000 High Rate Packet Data Access Terminal

TIA/EIA/IS-856 cdma2000 High Rate Packet Data Air Interface Specification

Compatibility with IS-2000

When interpreting TIA/EIA/IS-2000 in the context of TIA/EIA/IS-856, the terms for TIA/EIA/IS-2000 should be mapped as follows:

TIA/EIA/IS-2000	TIA/EIA/IS-856
BS	AN
Base Station	Access Network
BSC	AN
Base Station Control	Access Network
Call	Connection
MS	AT
Mobile Station	Access Terminal

Adjacent Channel Power (ACP) Measurement Concepts

Purpose

Adjacent Channel Power (ACP) is the power contained in a specified frequency channel bandwidth relative to the total carrier power. It may also be expressed as a ratio of power spectral densities between the carrier and the specified offset frequency band.

As a composite measurement of out-of-channel emissions, ACP combines both in-band and out-of-band specifications to provide useful figures-of-merit for spectral regrowth and emissions produced by components and circuit blocks without the rigor of performing a full spectrum emissions mask measurement.

To maintain a quality call by avoiding channel interference, it is important to measure and reduce any adjacent channel leakage power transmitted from a mobile phone. The characteristics of adjacent channel leakage power are mainly determined by the transmitter design, particularly the low-pass filter.

Measurement Method

The ACP measurement analyzes the total power levels within the defined carrier bandwidth and at given frequency offsets on both sides of the carrier frequency. This measurement requires the user to specify measurement bandwidths of the carrier channel and each of the offset frequency pairs up to 6. Each pair may be defined with unique measurement bandwidths.

For Meas Method of RBW, it uses an appropriate RBW and capture all of the power in the carrier channel and the offsets. For Meas Method of Integration BW, the channel integration bandwidth is analyzed using the user defined resolution bandwidth, which is much narrower than the channel bandwidth. The measurement computes an average power of the channel over a specified number of data acquisitions, automatically compensating for resolution bandwidth and noise bandwidth.

ACP is commonly measured using a signal analyzer or measuring receiver. In the measurement, filtering is applied to both the power in the main frequency channel and the power in the adjacent channel. An important factor for ACP is the specification of the measurement filter, including its bandwidth and shape.

If **Total Pwr Ref** is selected as the measurement type, the results are displayed as relative power in dBc and as absolute power in dBm. If **PSD Ref** (Power Spectral Density Reference) is selected, the results are displayed as relative power in dB, and as absolute power in dBm/Hz.

Recommended Offset Frequencies and Reference Bandwidths

While the user sets the specific offsets and reference bandwidths, the radio specifications recommend some common setups as shown in the following table.

Concepts

Adjacent Channel Power (ACP) Measurement Concepts

Table 17-1 ACP Measurement Default Settings

Test Device	Offset Frequency	Integration Band width	Result Reference
Mobile Station (Reverse Link)	765KHz, 1.995MHz, 3.125MHz, 4.000MHz, 7.500MHz, 7.500MHz	30 kHz	Total Carrier Power
Base Station (Forward Link)	765KHz, 1.995MHz, 3.125MHz, 4.000MHz, 7.500MHz, 7.500MHz	30 kHz	

Channel Power Measurement Concepts

Purpose

The Channel Power measurement is a common test used in the wireless industry to measure the total transmitted power of a radio within a defined frequency channel. This procedure measures the total power within the defined channel. This measurement is applied to design, characterize, evaluate, and verify transmitters and their components or devices.

Measurement Method

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

Since the measurement is optimized for speed and accuracy, you are permitted to change only the number of acquired data points in powers of 2, not the actual resolution bandwidth which is shown in gray. However, if absolute sweep time is required, it can be changed to the user's specific value at the expense of reduced speed. At no time will both sweep time and data points be set to manual because of conflicting parameter settings. This flexibility is available through the **Advanced** menu of the channel power measurement.

To improve repeatability, you can increase either the number of averages or the number of data points with longer time record length. The channel power graph is shown in the graph window, while the absolute channel power in dBm and the mean power spectral density in dBm/Hz are shown in the text window.

Code Domain Measurement Concepts

Purpose

Since the code domain measurements despread and descramble the 1xEV-DO signal into its physical channels, the number of active channels of various symbol rates (which are denoted by widths) can be observed. The width of the channel is inversely proportional to the Walsh code length in number of bits. In the code domain, there is a fixed amount of code space for a given chip rate. Therefore, by using the different Walsh codes, the system can dynamically allocate the code space for lower rate voice users versus high speed data users.

This code domain power composite view provides information about the in-channel characteristics of the 1xEV-DO signal. It informs the user of the active channels with their individual channel powers. The composite view also shows which data rates are active and the corresponding amount of code space used. The following are conditions under which a general unlock can occur: the Pilot signal is too low in power or no Pilot signal available, an incorrect long code is used for despreading, the frequency error is too large, or a frequency inversion is present.

When the level of the code domain noise floor is too high, relative to a reference or an expected level, one of the possible causes might be due to CW interference, like local oscillator feedthrough or spurs. I/Q modulation impairments can be another source of this uncorrelated noise. The I/Q demodulation measurements can reveal errors such as I/Q gain imbalance or I/Q quadrature error.

Measurement Method

This procedure measures the power levels of the spread channels in composite RF channels.

The code domain measurement displays the power for each of the spread channels, relative to the total power within the 1.230 MHz channel bandwidth centered at the center frequency. Each spread channel level is displayed as an individual vertical bar with a different width determined by a spread rate. Because this is a relative measurement, the unit of measure is dB (not dBm or watts). This allows a comparison of signal levels between the Pilot and Traffic channels.

If **Device** is set to **MS**, the demodulated I and Q signals are individually shown in the code domain power graph window. Depending on the test equipment for MS, it is recommended that you use the trigger output signal from the instrument for synchronization.

The following displays are available for this measurement:

- Power Graph & Metrics - The transmitted energy associated with each of the symbol rates and Walsh codes is shown in the graph window. The following powers along with the total power are shown in the text window depending on the device selection:

Table 17-2

Code Domain Channel Power Metrics

For BTS	For MS
Total active channel power Pilot channel power Synch channel power Time offset Maximum active channel power Average active channel power Maximum inactive channel power Average inactive channel power Number of active channels	Total active channel power Pilot channel power I average active channel power I maximum inactive channel power Q average active channel power Q maximum inactive channel power

- I/Q Error (Quad View) - The magnitude error, phase error, and EVM graphs are individually shown in the graph windows. The summary data for these parameters are also shown in the text window.
- Code Domain (Quad View) - The graphs of the code domain power, the symbol power for the selected spread channel, and the I/Q symbol power polar vector for the symbol power range selected by the measurement interval and measurement offset parameters, are shown in the graph windows. The symbol EVM summary data is also shown in the text window.
- Demod Bits - In addition to the graphs of the code domain power and the symbol power for the selected spread channel, the demodulated bit stream data can be shown for the selected slots of the symbol power in the text window.

IQ Waveform Measurement Concepts

Purpose

The waveform measurement is a generic measurement for viewing the input signal waveforms in the time domain. This measurement is how the instrument performs the zero span functionality found in traditional spectrum analyzers.

Basic mode waveform measurement data may be displayed using either a Signal Envelope window, or an I/Q window which shows the I and Q signal waveforms in parameters of voltage versus time. The advantage of having an I/Q view available while making a waveform measurement is that it allows you to view complex components of the same signal without changing settings or measurements.

The waveform measurement can be used to perform general purpose power measurements in the time domain with excellent accuracy.

Measurement Method

The instrument makes repeated power measurements at a set frequency, similar to the way a swept-tuned spectrum analyzer makes zero span measurements. The input analog signal is converted to a digital signal, which then is processed into a representation of a waveform measurement. The measurement relies on a high rate of sampling to create an accurate representation of a time domain signal.

Modulation Accuracy (Waveform Quality) Measurement Concepts

Purpose

Rho is one of the primary modulation quality metrics, along with EVM and code domain power. Rho is the ratio of the correlated power in a single coded channel to the total signal power. This is a simplified case of code domain power since this measurement is made on a single coded channel. This measurement takes into account all possible error mechanisms in the entire transmission chain including baseband filtering, I/Q modulation anomalies, filter amplitude and phase non-linearities, and power amplifier distortion.

This measurement conforms to the standard 3GPP2 C.S0024-B. It completely supports subtype0/1, subtype2. But for subtype 3, it only supports No Feedback Mux mode, hence, for short the measurement uses subtype3 (NFM) to indicate this.

Measurement Method

This procedure measures the performance of the transmitter's modulation circuitry.

In a digitally modulated signal, it is possible to predict what the ideal magnitude and phase of the carrier should be at any time, based on the transmitted data sequence. The transmitter's modulated signal is compared to an ideal signal vector. The difference between these two vectors is sampled and processed using DSP. Rho values are in the range of 0 to 1. A value of 1 indicates perfect correlation to the reference (high modulation quality). The 1xEV-DO base station standards require that transmitters have a Rho performance of 0.912 or greater.

Depending on the test equipment for MS, it is recommended that you use the trigger output signal from the instrument for synchronization.

Code Domain Powers of Inactive MAC channels.

Code domain power of an inactive MAC code channel is calculated from slots in which this code channel is inactive. Therefore number of slots used for power of a MAC inactive code channel may not same as the other MAC code channels or other rhos & CDPs. Number of slots used for inactive MAC code domain power is equal to number of slots used for rho Pilot when configuration of MAC code channels is fixed over measurement interval. Maximum value of averaged MAC inactive code domain power might be selected from values averaged using different number of slots when configuration of MAC code channels changes during the measurement.

Slot Type Identification between Active and Idle

Slot type identification is done by comparing powers in a slot. When the slot is Idle, power of Data channel always must be smaller that average power of Pilot and MAC by more than 7dB. On the other hand when the slot is Active, the output power is controlled to be a constant value and power of the slot must be within +/- 2.5dB. Identification of Idle and Active slot is possible by comparing average power of Data of the slot and average power of Pilot and MAC of the slot.

Data Modulation Auto Detection

Modulation schemes of Data code channels are identified by the measurement’s algorithm. The internal algorithm examines code channels and identifies modulation scheme of each code channel separately. Modulation scheme detections of all active code channels in Data channel may not end up with same result especially when input signal is noisy. Since the standard defines that all Data code channels in a slot are encoded using same modulation scheme, ideal reference signal is generated using one modulation scheme for all Data code channels in one slot. The most detected modulation scheme is chosen for Data analysis of the slot. If numbers of detected modulation schemes are same, modulation scheme which has shorter code word length is chosen.

Subtype 0/1, 2 and 3

Modulation Accuracy measurement supports both subtype 0/1, 2 and 3. Base code length of Preamble and MAC changes between subtype 0/1, 2 and 3 as shown in Evaluation of code domain power and code domain error is done based on them.

	Subtype 0/1	Subtype 2	Subtype 3
Pilot	32	32	32
MAC	64	128	128
Data	16	16	16
Preamble	32	64	128

Monitor Spectrum Measurement Concepts

Purpose

The monitor spectrum measurement provides spectrum analysis capability for the instrument. It is used as a quick, convenient means of looking at the entire spectrum. While the look and feel are similar to the Spectrum Analyzer mode, the functionality is greatly reduced for easy operation. The main purpose of the measurement is to show the spectrum. The default span should cover an appropriate frequency range of the application.

Measurement Method

The measurement takes the sweep and acquires the data between the start frequency and stop frequency, then trace is displayed in the measurement window.

Troubleshooting Hints

Changes made by the user to advanced spectrum settings, particularly to ADC range settings, can inadvertently result in spectrum measurements that are invalid and cause error messages to appear. Care needs to be taken when using advanced features.

Occupied Bandwidth Measurement Concepts

Purpose

Occupied bandwidth measurements express the percentage of the transmitted power within a specified bandwidth. This percentage is typically 99%.

The spectrum shape of a 1xEV-DO signal can give useful qualitative insight into transmitter operation. Any distortion to the spectrum shape can indicate problems in transmitter performance.

Measurement Method

The instrument uses sweep mode to capture the data and the total power within the measurement frequency span is integrated for its 100% of power. The frequencies of 0.5% of the total power are then calculated to get 99.0% bandwidth.

Power Statistics CCDF Measurement Concepts

Purpose

Many of the digitally modulated signals appear noise-like in the time and frequency domain. This means that statistical measurements of the signals can be a useful characterization. Power Complementary Cumulative Distribution Function (CCDF) curves characterize the higher-level power statistics of a digitally-modulated signal. The curves can be useful in determining design parameters for digital communications systems.

Long battery life is a key competitive advantage for the mobile phone. cdmaOne uses offset quadrature phase shift keying (OQPSK) as the modulation format for the reverse link. OQPSK minimizes the peak-to-average power ratio by avoiding signal envelope transitions through zero. Peak-to-average power ratio is the ratio of the peak envelope power to the average envelope power of a signal. If the peak-to-average power ratio is small, the headroom required in the amplifier to prevent compression of the signal and interference with the adjacent frequency channels is small. Thus, the amplifier can operate more efficiently.

In 1xEV-DO the handset can transmit multiple channels to accommodate the high data rates. Modulation schemes such as OQPSK or Gaussian minimum shift keying (GMSK) do not prevent zero-crossings for multiple channels and are no longer suitable. Instead, QPSK is used in combination with HPSK (Hybrid Phase Shift Keying) to minimize the peak-to-average power ratio. (For more information on HPSK see [3].) With this technique, the peak-to-average power ratio for the basic configuration (an R-Pilot channel and an R-FCH) is equal to or larger than 4 dB during 0.1 percent of the time (see [Figure 17-4](#)). Even though HPSK reduces the peak-to-average power ratio, it still increases as code channels are activated for higher data rates because the amplitude vectors of each code channel add to each other.

A severe case occurs if two supplemental channels at high data rates are required. In this case, the benefits of HPSK may be lost. This is rarely expected to happen since the forward link will carry most of the high data rate traffic.

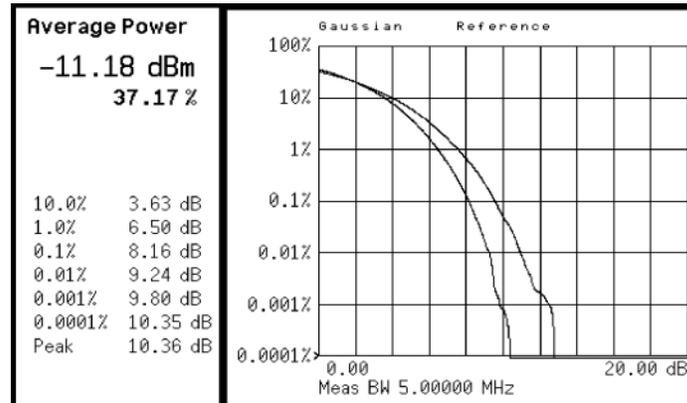
The amplifier must be capable of handling the different peak-to-average power ratios the signal exhibits for the different channel configurations, while maintaining good adjacent channel power (ACP) performance. From the measurement perspective, the statistics of the signal may impact the result of the measurement, particularly in the case of adjacent channel power ratio (ACPR). Therefore, it is important to choose the signal's channel configuration carefully. You need to cover the real-life worst cases, such as those with the most stressful signal configurations or highest peak-to-average power ratios. To do that, you need a way to define the statistics of 1xEV-DO reverse link signals. The complementary cumulative distribution function (CCDF) does that for you.

CCDF measurement fully characterizes the power statistics of the signal. It provides the distribution of particular peak-to-average power ratios versus probability. [Figure 17-4](#) compares the CCDF curves for a signal with R-Pilot and R-FCH, and a signal with R-Pilot, R-FCH, R-SCH1 at 153.6 kbps, and R-SCH2 at

153.6 kbps. For a probability of 0.1 percent, the signal with two supplemental channels has a peak-to-average power ratio 2 dB higher than the signal with only an R-Pilot and an R-FCH. As mentioned earlier, adding code channels, in general, increases the peak-to-average power ratio of the signal.

Figure 17-4

CCDF curves for two 1xEV-DO SRI reverse link signals with different channel configurations.



The power statistics CCDF measurement can be affected by many factors. For example, modulation filtering, modulation format, combining the multiple signals at different frequencies, number of active codes and correlation between symbols on different codes with spread spectrum systems. These factors are all related to modulation and signal parameters. External factors such as signal compression and expansion by non-linear components, group delay distortion from filtering, and power control within the observation interval also affect the measurement.

CCDF curves can help you in several situations:

- To determine the headroom required when designing a component.
- To confirm the power statistics of a given signal or stimulus. CCDF curves allow you to verify if the stimulus signal provided by another design team is adequate. For example, RF designers can use CCDF curves to verify that the signal provided by the digital signal processing (DSP) section is realistic.
- To confirm that a component design is adequate or to troubleshoot your subsystem or system design, you can make CCDF measurements at several points of a system. For example, if the ACLR of a transmitter is too high, you can make CCDF measurements at the input and output of the PA. If the PA design is correct, the curves will coincide. If the PA compresses the signal, the PAR of the signal is lower at the output of the PA (Figure 17-4 on page 140).

Measurement Method

The power measured in power statistics CCDF curves is actually instantaneous envelope power defined by the equation:

$$P = (I^2 + Q^2)/Z_0$$

(where I and Q are the quadrature voltage components of the waveform and Z_0 is the characteristic impedance).

A CCDF curve is defined by how much time the waveform spends at or above a given power level. The percent of time the signal spends at or above the level defines the probability for that particular power level. To make the power statistics CCDF measurement, the instrument uses digital signal processing (DSP) to sample the input signal in the channel bandwidth.

The Gaussian distribution line as the band-limited gaussian noise CCDF reference line, the user-definable reference trace, and the currently measured trace can be displayed on a semi-log graph. If the currently measured trace is above the user reference trace, it means that the higher peak power levels against the average power are included in the input signal.

Power vs. Time Measurement Concepts

Purpose

Power vs. Time measurement examines time domain burst shape if the incoming signal satisfies test limit profile (called limit mask) that is defined based on the selected mode. The limit mask is configurable.

This measurement requires a trigger at the beginning of the frame. A trigger delay between -30 chips to 30 chips is allowed.

Measurement Method

CAUTION

It is imperative that there be no more than $+30$ dBm present at the analyzer input, in order to prevent damage to the internal attenuator.

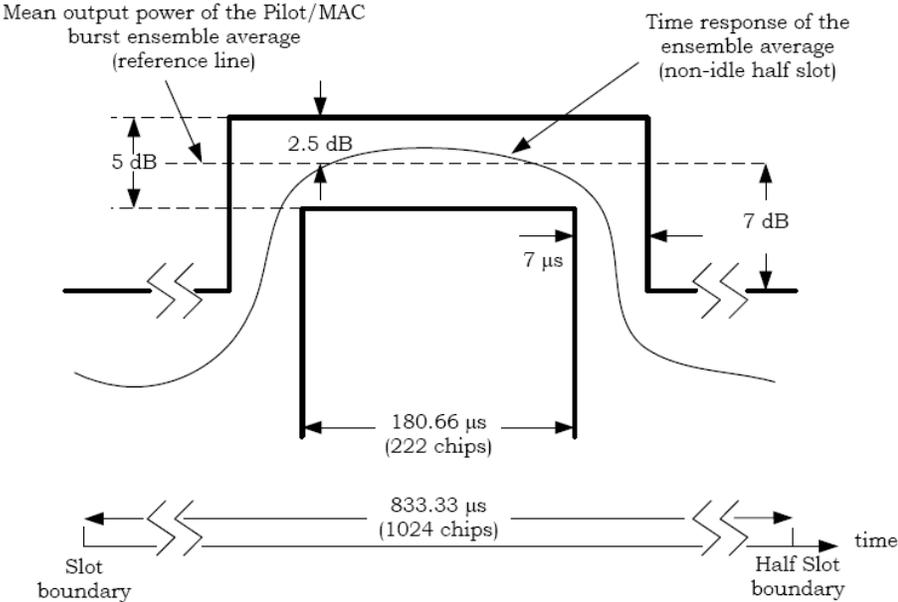
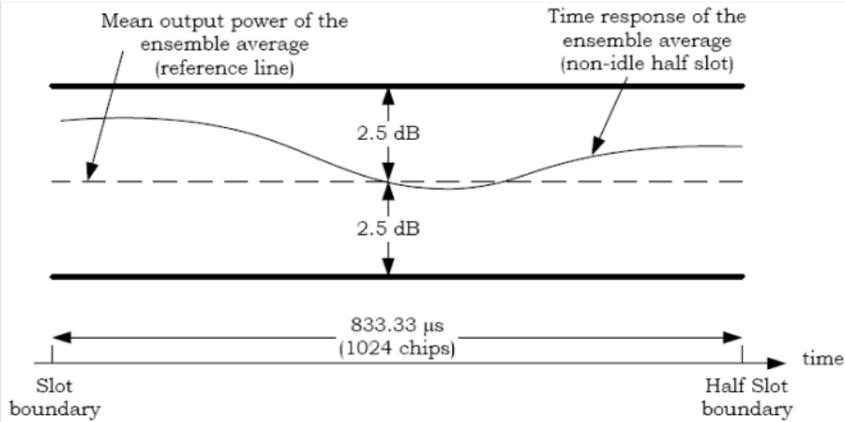
3GPP2 Definition

The 3GPP2 standard, 3GPP2 C.S0032–A v.2.0 described the needs to measure the time response and the mean power of the sector output power over at least 512 half slots to collect ensemble of Waveform and create averaged-waveform. The requirements are as follows:

Given an ensemble of half slots, the time response of the ensemble average that shall be within the 3GPP2 specified limit masks.

The mean power shall remain $+2$ dB to -4 dB of the manufacturer's rated power for the equipment over the specified environmental conditions for active slot.

Slot type identification is done by comparing powers in a slot. Transmission Envelop Masks of Active and Idle slot are shown in Fig 1–1 and Fig 1–2. When the slot is Idle, power of Data channel always must be smaller than average power of Pilot and MAC by more than 7dB. On the other hand when the slot is Active, the output power is controlled to be a constant value and power of the slot must be within ± 2.5 dB. Identification of Idle and Active slot is possible by comparing average power of Data of the slot and average power of Pilot and MAC of the slot.



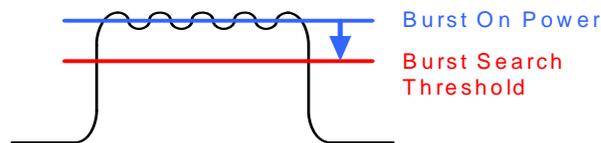
Burst Detection Function

NOTE

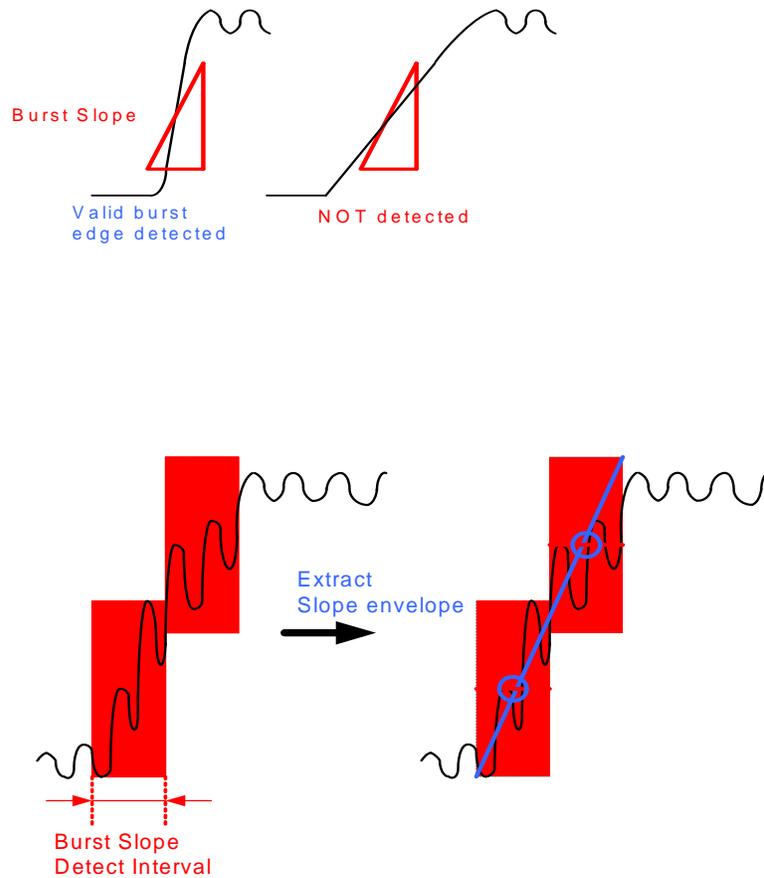
- PvT requires a Preamplifier Option. The measurement will still work without this option present, but you will not be able to reach the dynamic range required by the 1xEV-DO specifications.
 - PvT is set in the single sweep mode. Because of the switching of the Preamp state from on to off, making PvT measurements in the continuous sweep mode is not recommended.
-

When this measurement acquires signal, this measurement algorithm then searches the power vector for a burst that specifies the given burst detection parameters. There are three parameters for detecting Power vs Time burst and its edge.

If the burst on/off ratio exceeds the Burst Search Threshold value, then the measurement detects the burst signal.



And the user can specify the valid burst edge level and interval. If the burst edge is steeper than the Burst Slope Threshold setting, the burst signal can be detected. Burst Slope Detect Interval can set the interval of power integrations in order to find the edge slope envelope. Two integrated (averaged) powers, the lower portion and the upper portion of the edge slope, are compared with each other for extracting the edge slope envelope, then evaluated with the Burst Slope Threshold. Since it can detect the slope envelope of the rising edge, it is effective if the edge slope isn't smooth but noisy or deviated.



Limit Testing Function

Once the burst is detected and its timing is located, the algorithm then applies upper and lower limit masks to the power vector. If the limit mask is defined as the relative power to the reference power, the algorithm calculates the average power of the reference region and draws the limit mask using the reference power. The limit mask is highly configurable to allow various types of limit mask.

After the mask position is determined, the algorithm verifies if the signal's power vector is within the limit mask. If it satisfies the limit for entire capture length, the measurement reports "PASS". If the signal's power vector exceeds the limit mask at least a single sample point, the measurement reports "FAIL" along with the information where the signal exceeds the test limit.

QPSK EVM Measurement Concepts

Purpose

In constant amplitude modulation schemes, such as GMSK, the phase and frequency error are the metrics for modulation quality. However, these metrics are not very effective for non-constant amplitude modulation formats that can also have errors in amplitude.

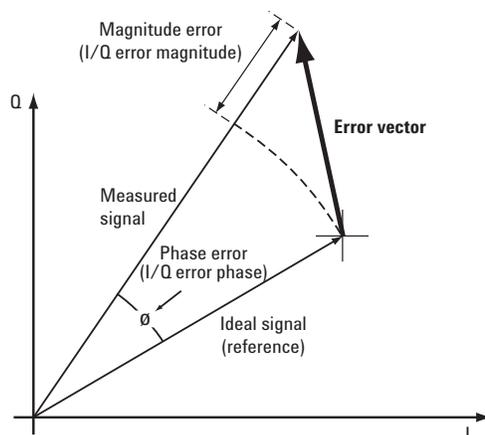
Phase and frequency errors are measures of modulation quality for the 1xEV-DO system. This modulation quality is quantified through QPSK Error Vector Magnitude (EVM) measurements. Since the base stations in 1xEV-DO systems use Quadrature Phase Shift Keying (QPSK) modulation, the phase and frequency accuracies of the transmitter are critical to the communications system performance and ultimately affect range.

1xEV-DO receivers rely on the phase and frequency quality of the QPSK modulation signal in order to achieve the expected carrier to noise ratio. A transmitter with high phase and frequency errors will often still be able to support phone calls during a functional test. However, it will tend to cause difficulty for mobiles trying to maintain service at the edge of the cell with low signal levels or under difficult fading and Doppler conditions.

The accuracy of non-constant amplitude modulation schemes, such as quadrature amplitude modulation (QAM), or quadrature phase shift keying (QPSK), can be assessed very effectively by looking at the constellation of the signal. Signal impairment can be objectively assessed by taking the displacement of each measured symbol from the reference position as an error phasor (or vector), as shown in [Figure 17-5](#).

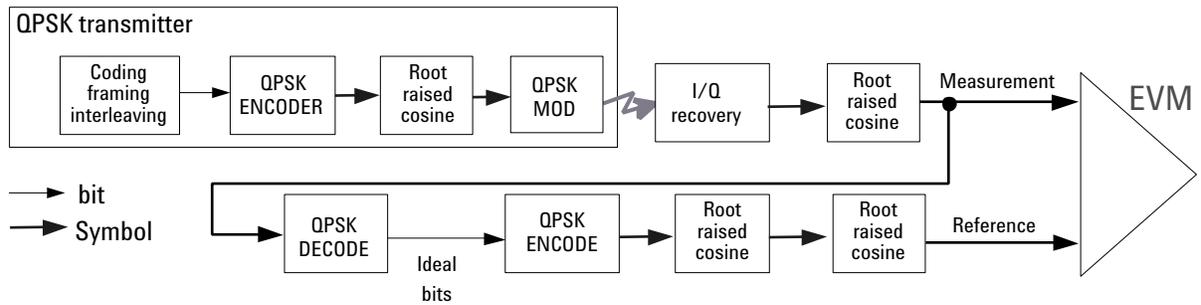
Figure 17-5

Error Vector and Related Parameters



The reference position is determined from a reference signal that is synthesized by demodulating the data bits from the received signal and then re-modulating these bits "perfectly" for a generic QPSK signal, as shown in [Figure 17-6](#).

Figure 17-6 Process to Calculate EVM for a Generic QPSK Signal



The root mean square (RMS) of the error vectors is computed and expressed as a percentage of the square root of the mean power of the ideal signal¹. This is the error vector magnitude (EVM). EVM is a common modulation quality metric widely used in digital communication systems. (See [16] for more information on how to use EVM as a troubleshooting tool.)

For a regular QAM or a phase shift keying (PSK) signal the ideal symbol points always map onto a few specific locations in the I/Q plane. The 1xEV-DO reverse link signal can consist of multiple channels that are I/Q multiplexed. This means the one-bit symbols for each channel are BPSK encoded² for either the I or the Q path. Several channels can be added to the I and/or the Q paths. The resulting I and Q signals are then spread and HPSK scrambled (see Figure 3). The complex-valued chip sequence is then filtered and the result is applied to the QPSK modulator³. The 1xEV-DO MS transmitter in Figure 11 illustrates this process.

The resulting constellation depends on the physical channel configuration. The constellation typically does not look like QPSK or any other known constellation. Except for some very specific channel configurations, for example, a signal with a single R-Pilot (or a single R-FCH) does map onto a QPSK constellation. A signal with both a R-Pilot and a R-FCH at the same amplitude level maps onto a 45°-rotated QPSK constellation [3]. Since the receiver does not care about the absolute phase rotation, it effectively sees a QPSK constellation.

You can use a regular QPSK EVM measurement to evaluate the modulation quality of the transmitter for a single R-Pilot, a single R-FCH, or a signal with both at the same amplitude level. More complex signals cannot be analyzed with this measurement.

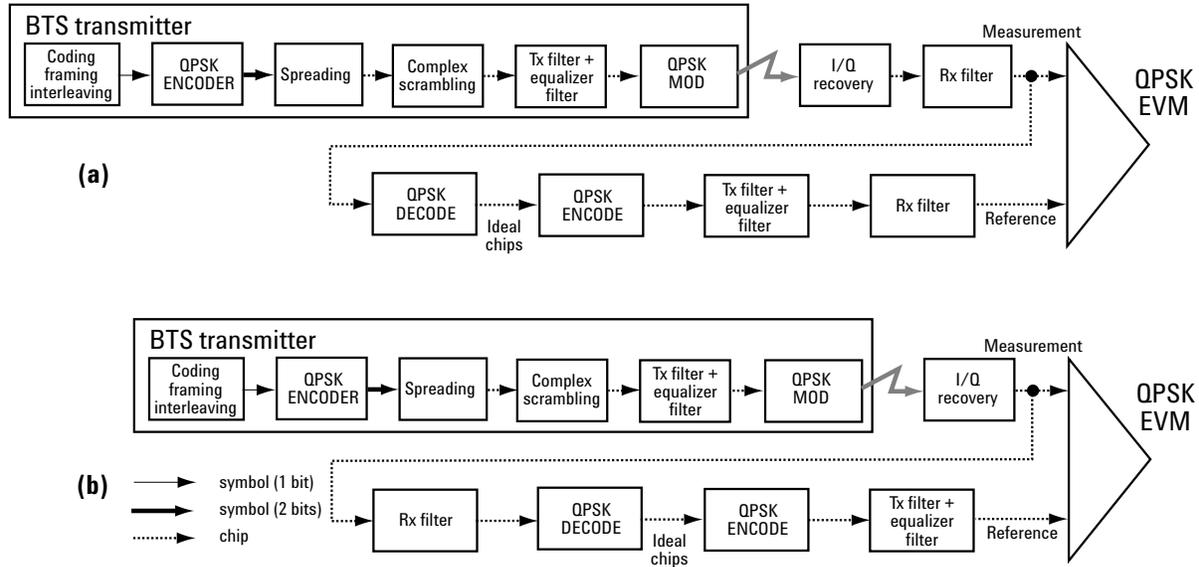
1. The actual calculation method of the percentage depends on the specific standard. The EVM may be normalized to the amplitude of the outermost symbol, the square root of the average symbol power, or the square root of the mean power of the ideal signal. In the case of 1xEV-DO, the specifications require normalization to the square root of the mean power of the ideal signal (see section on Composite EVM).
2. BPSK encoding, in this case, refers to the process of mapping the one-bit symbols for a channel onto the I (or the Q) path in serial. This means the symbols for a channel are directly converted into I (or Q) levels. For example, 1001 would be converted to 1 -1 -1 1.
3. QPSK modulation, in this case, refers to the upconversion process (the process of modulating the radio frequency (RF) carrier with the I/Q baseband signal).

The signal analyzer may use either of the following methodologies to make a QPSK EVM measurement:

- Measure QPSK EVM on the received signal. Filter the recovered I/Q signal with the equalizer and complementary receiver filters and compare it with a reference signal calculated by filtering the demodulated signal with the transmitter, equalizer, and receiver filters. See (a) in [Figure 17-7 on page 149](#).
- Measure QPSK EVM on the transmitted signal. Compare the I/Q recovered signal directly with a reference signal calculated by filtering the ideal chips with the transmitter filter. See (b) in [Figure 17-7 on page 149](#).

Both methods yield similar EVM results and you can use either of them to make valid modulation quality measurements of the MS transmitter; however, the resulting constellation looks different. The first method results in four discrete constellation points. The second method results in a fuzzy constellation, as shown in [Figure 12a](#). The constellations for both methods are correct. The reason for the difference is that, for the first method, the constellation displays what the receiver sees after filtering, while the second method displays the constellation of the transmitted signal before applying any receiver filtering.

Figure 17-7 Process to Calculate QPSK EVM for a 1xEV-DO Forward Link Signal.



Measurement Method

The input signal needs to be a single coded signal, such as a pilot channel.

The phase error of the unit under test is measured by computing the difference between the phase of the transmitted signal and the phase of a theoretically perfect signal. The instrument samples the transmitter output in order to capture the actual phase trajectory. This is then demodulated and the ideal phase trajectory is mathematically derived using detected bits and channel filtering. Subtracting one from the other results in a phase error signal.

This measurement allows you to display these errors numerically and graphically on the instrument display. There are graphs for EVM, Phase Error and Mag Error in the graph windows. In the text window, there are both maximum and average data for Evm: in % rms, in % peak, RMS Mag Error: in %, Phase Error: in degrees, Freq Error: in Hz, and IQ Offset: in dB.

Spectrum Emission Mask Measurement Concepts

Purpose

Spectrum Emission Mask measurements include the in-band and out-of-band spurious emissions. As it applies to 1xEV-DO, it is the power contained in a specified frequency bandwidth at certain offsets relative to the total carrier power. It may also be expressed as a ratio of power spectral densities between the carrier and the specified offset frequency band.

As a composite measurement of out-of-channel emissions, the spectrum emission mask measurement combines both in-band and out-of-band specifications to provide useful figures-of-merit for spectral regrowth and emissions produced by components and circuit blocks without the rigor of performing a full spectrum emissions mask measurement.

Measurement Method

The spectrum emission mask measurement measures spurious signal levels in up to six pairs of offset/region frequencies and relates them to the carrier power. The reference channel integration bandwidth method is used to measure the carrier channel power and offset/region powers. When “Offset” is selected, spectrum emission mask measurements are made, relative to the carrier channel frequency bandwidth. When “Region” is selected, spurious emission absolute measurements are made, set by specifying start and stop RF frequencies. The upper frequency range limit is 3.678 GHz. The measurement screen is titled *Spurious Emission*.

The channel integration bandwidth is analyzed using the user defined resolution bandwidth (RBW), which is much narrower than the channel bandwidth. The measurement computes an average power of the channel or offset/region over a specified number of data acquisitions, automatically compensating for resolution bandwidth and noise bandwidth.

This measurement requires the user to specify measurement bandwidths of the carrier channel and each of the offset/region frequency pairs up to 5. Each pair may be defined with unique measurement bandwidths. The results are displayed both as relative power in dBc, and as absolute power in dBm.

Spurious Emissions Measurement Concepts

Purpose

Spurious signals can be caused by different combinations of signals in the transmitter. The spurious emissions from the transmitter should be minimized to guarantee minimum interference with other frequency channels in the system. Harmonics are distortion products caused by nonlinear behavior in the transmitter. They are integer multiples of the transmitted signal carrier frequency.

This measurement verifies the frequency ranges of interest are free of interference by measuring the spurious signals specified by the user defined range table.

Measurement Method

The table-driven measurement has the flexibility to set up custom parameters such as frequency, span, resolution bandwidth, and video bandwidth.

For each range that you specify and activate, the analyzer scans the band using the specified Range Table settings. Then using the Peak Excursion and Peak Threshold values determines which spurs to report.

As each band is swept, any signal which is above the Peak Threshold value and has a peak excursion of greater than the Peak Excursion value will be added to a list of spurs displayed in the lower results window. A total of 200 spurs can be recorded for one measurement, with a limit of 10 spurs per frequency range. To improve repeatability, you can increase the number of averages.

From the spurs in the list, those with peak amplitude greater than the Absolute Limit for that range will be logged as a measurement failure and denoted by an 'F' in the 'Amplitude' column of the table. If no spurs are reported, but the measured trace exceeds the limit line for any range, the fail flag is set to fail.

This measurement has the ability to display two traces using different detectors on the display simultaneously. All spur detection and limit line testing are only applied to the trace associated with Detector 1, which will be colored yellow. The trace associated with Detector 2 will be colored cyan.

If the sweep time for the range exceeds 2 seconds, a flashing message “Sweeping...Please Wait” will appear in the annunciator area. This advises you that the time to complete the sweep is between 2 and 2000 seconds, and is used as without it the display would appear stagnant and you may think the measurement is not functional.

Other Sources of Measurement Information

Additional measurement application information is available through your local Keysight Technologies sales and service office. The following application notes treat digital communications measurements in much greater detail than is discussed in this measurement guide.

- Application Note 1298
Digital Modulation in Communications Systems - An Introduction
Keysight part number 5965-7160E
- Application Note 1398
Forward Link Measurements for 1xEV-DO Access Networks
Keysight part number 5988-6125EN
- Application Note 1414
Understanding Measurement of 1xEV-DO Access Terminals
Keysight part number 5988-7694E

Instrument Updates at www.keysight.com

These web locations can be used to access the latest information about the instrument, including the latest firmware version.

<http://www.keysight.com/find/pxa>

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

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

<http://www.keysight.com/find/cxa>

Baseband I/Q Inputs (Option BBA) Measurement Concepts

The N9020A Option BBA Baseband I/Q Inputs provides the ability to analyze baseband I/Q signal characteristics of mobile and base station transmitters. This option may be used only in conjunction with the following modes:

- IQ Analyzer (Basic)
- 802.16 OFDMA (WiMAX/WiBro)
- cdma2000
- GSM/EDGE
- TD-SCDMA
- 1xEV-DO

What are Baseband I/Q Inputs?

Option BBA consists of a Baseband Input module, four input connectors, and a calibration output connector. The connectors are at the left side of the front panel. The two ports labeled “I” and “Q” are the “unbalanced” inputs.

An unbalanced or “single-ended” baseband measurement of an I or Q signal is made using a probe connected to the I or Q connector. A simultaneous I/Q unbalanced single-ended measurement may be made using two probes connected to the I and Q input connectors.

If “balanced” signals are available, they may be used to make a more accurate measurement. Balanced signals are signals present in two separate conductors, are symmetrical about ground, and are opposite in polarity, or out of phase by 180 degrees.

Measurements using balanced signals can have a higher signal to noise ratio resulting in improved accuracy. Noise coupled into each conductor equally in a “common mode” to both signals may be separated from the signal. The measure of this separation is “common-mode rejection”.

To make a balanced measurement, the two connectors labeled “I” and “Q” are used in conjunction with the I and Q inputs. The terms “I-bar” and “Q-bar” may be applied to the signals, as well as the inputs themselves. Probes (customer provided) must be used to input balanced baseband I/Q signals. This may be referred to as a balanced measurement.

Balanced baseband measurements are made using the I and connectors for I only signal measurements, while the Q and connectors are used for a Q only signal measurement. Balanced measurements of I/Q require differential probe connections to all four input connectors. For details of probe selection and use, refer to [“Selecting Input Probes for Baseband Measurements” on page 155.](#)

What are Baseband I/Q Signals?

In transmitters, the term baseband I/Q refers to signals that are the fundamental products of individual I/Q modulators, before the I and Q component signals are combined, and before upconversion to IF or RF frequencies.

In receivers, baseband I/Q analysis may be used to test the I and Q products of I/Q demodulators, after an RF signal has been downconverted and demodulated.

Why Make Measurements at Baseband?

Baseband I/Q measurements are a valuable means of making qualitative analyses of the following operating characteristics:

- I/Q signal layer access for performing format-specific demodulation measurements (for example, CDMA, GSM, W-CDMA).
- Modulation accuracy – that is, I/Q plane metrics:
 - rho
 - error vector magnitude; rms, peak, or 95%
 - carrier feed-through
 - frequency error
 - magnitude and phase errors
- Code-domain analysis (including code-specific metrics)
- CCDF of $I^2 + Q^2$
- Single sideband (SSB) metrics for assessing output quality
- Basic analysis of I and Q signals in isolation including: DC content, rms and peak to peak levels, CCDF of each channel

Comparisons of measurements made at baseband and RF frequencies produced by the same device are especially revealing. Once signal integrity is verified at baseband, impairments can be traced to specific stages of upconversion, amplification, or filtering by RF analysis. In addition, impairments to signal quality that are apparent at RF frequencies may be traceable to baseband using baseband analysis.

Selecting Input Probes for Baseband Measurements

The selection of baseband measurement probe(s) and measurement method is primarily dependent on the location of the measurement point in the circuit. The probe must sample voltages without imposing an inappropriate load on the circuit.

The system supports a variety of 1 M Ω impedance input passive probes as well as the Keysight 1153A active differential probe using the InfiniMax probe interface.

The Keysight 1153A active probe can be used for both single-ended and differential measurements. In either case a single connection is made for each channel (on either the I or Q input). The input is automatically configured to 50 Ω single-ended type measurement and the probe power is supplied through the InfiniMax interface. The probe can be configured for a variety of input coupling and low frequency rejection modes. In addition, a wide range of offset voltages and probe attenuation accessories are supported at the probe interface. The active probe has the advantage that it does not significantly load the circuit under test, even with unity gain probing.

With passive 1 M Ω probes, the probe will introduce a capacitive load on the circuit, unless a higher attenuation is used at the probe interface. Higher attenuation helps isolate the probe, however, it reduces the signal level and degrades the signal-to-noise-ratio of the measurement. Passive probes are available with a variety of attenuation values for a moderate cost. Many Keysight passive probes can be automatically identified by the system, setting the input impedance required as well as the nominal attenuation. For single-ended measurements a single probe is used for each channel. Other passive probes can be used, after manually setting the attenuation and probe impedance configurations.

For full differential measurements, the system supports probes on each of the four inputs. The attenuation for each of the probes should be the same for good common mode rejection and channel match.

Supported Probes

The following table lists the probes currently supported by Option BBA:

Table 17-3

Probe Type	Model Number	Description
Active	1130A	1.5 GHz differential probe amp (No probe head)
	1131A ^a	InfiniMax 3.5 GHz probe
	1132A ^a	InfiniMax 5 GHz probe
	1133A ^a	InfiniMax 7 GHz probe
Passive	1161A	Miniature passive probe, 10:1, 10 M Ω , 1.5 m

- a. Probe heads are necessary to attach to your device properly. Probe connectivity kits such as the E2668A, E2669A or E2675A are needed. For more details, refer to the Keysight probe configuration guide, 5968-7141EN and 5989-6162EN.

Probes without Stored Calibration

The following 115xA active probes may be used with the MXA’s baseband IQ inputs and may use the same probe calibration utility software. However, the probe calibration data is not stored in the MXA and will be lost if power is cycled. Use of the E2655B de-skew and calibration kit, including the calibration fixture, is required because of the different physical configuration of the probes. (The physical connections are different mechanically, not electrically.)

Table 17-4

Probe Type	Model Number	Description
Active	1153A	200MHz differential probe
	1156A	Active probe, 1.5 GHz
	1157A	Active probe, 2.5 GHz
	1158A	Active probe, 4 GHz

Refer to the current Keysight probe data sheet for specific information regarding frequency of operation and power supply requirements.

Baseband I/Q Measurement Views

Measurement result views made in the IQ Analyzer (Basic) mode are available for baseband signals if they relate to the nature of the signal itself. Many measurements which relate to the characteristics that baseband I and Q signals have when mixed and upconverted to signals in the RF spectrum can be made as well. However, measurements which relate to the characteristics of an upconverted signal that lie beyond the bandwidth available to the Baseband I/Q Input circuits can not be measured (the limit are dependent on the installed options: Standard – 10 Hz to 20 MHz, Option B25 – 10 Hz to 50 MHz, and Option S40 – 10 Hz to 80 MHz).

At RF frequencies, power measurements are conventionally displayed on a logarithmic vertical scale in dBm units, whereas measurements of baseband signals using Baseband I/Q inputs may be conveniently displayed as voltage using a linear vertical scale as well as a log scale.

Spectrum Views and 0 Hz Center Frequency

To view the Spectrum display of I only or Q only signals, use the Complex Spectrum measurement capability in IQ Analyzer (Basic) Mode.

I only and Q only Spectrum views are conventional, displayed with 0 Hz at the left side of the horizontal axis. When upconverted or multiplied, an I only or Q only signal could ultimately lie above or below the carrier center frequency, but in either case it will only occupy half the bandwidth.

Waveform Views for Baseband I/Q Inputs

For Waveform measurements, two displays are available for baseband I/Q input signals; the I and Q Waveform view, which separates the individual I and Q traces, and the RF Envelope view.

Waveform Signal Envelope Views of I only or Q only

To view the Signal Envelope display of I only or Q only signals, use the Waveform measurement capability in IQ Analyzer (Basic) Mode.

The I and Q Waveform of an I/Q signal is very different from the complex signal displayed in the RF Envelope view. That is because the RF Envelope is a product of both the I and Q modulation waveforms.

However, an I and Q Waveform measurement of an I only or Q only signal is exactly the same signal displayed in the RF Envelope view. That is because an I only or Q only waveform determines the I only or Q only signal envelope. Thus, the RF Envelope view can be used to measure an I only or Q only waveform directly.