



Agilent X-Series Signal Analyzer

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

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

N6153A DVB-T/H Measurement Application Measurement Guide



Agilent Technologies

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Documentation is updated periodically. For the latest information about this analyzer, including firmware upgrades, application information, and product information, see the following URLs:

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

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Information on preventing analyzer damage can be found at:

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

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This chapter focuses on the instructions common to all measurements. For the information specific to individual measurements, see the sections at the page numbers below.

- “Channel Power Measurements” on page 13
- “ACP Measurements” on page 21
- “Power Statistics CCDF Measurements” on page 25
- “Spurious Emissions Measurements” on page 29
- “Spectrum Emission Mask Measurements” on page 35
- “Modulation Accuracy Measurements” on page 43
- “Monitor Spectrum Measurements” on page 55
- “IQ Waveform (Time Domain) Measurements” on page 59

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 maximum 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 mode by returning the mode setup and all of the measurement setups in that 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 type, followed by the Measurement type, then finally, the measurement 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	<ol style="list-style-type: none">Press ModePress a mode key, like Spectrum Analyzer, IQ Analyzer (Basic), or DVB-T/H.Press Mode Preset.Press Mode Setup	<p>All licensed, installed modes available are shown under the Mode key.</p> <p>Using Mode Setup, make any required adjustments to the mode settings. These settings will apply to all measurements in the mode.</p>
2. Select and Set Up the Measurement	<ol style="list-style-type: none">Press Meas.Select the specific measurement to be performed.Press Meas Setup	<p>The resulting data is shown on the display or is available for export.</p> <p>Use Meas Setup to make any required adjustment to the selected measurement settings. The settings only apply to this measurement.</p>

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 . Set display format and select a view 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 changed 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	BW, 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 DVB-T/H Measurements
Setting Up and Making a Measurement

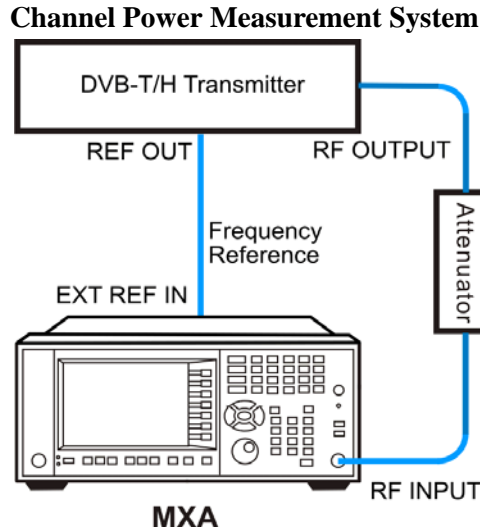
This chapter explains how to make a Channel Power measurement on a DVB-T/H transmitter. This test measures the total RF power and shoulder attenuation present in the channel. This test also provides a measurement that compares the input signal against the DVB-T/H defined spectrum mask under the condition of an analog TV signal in an adjacent channel. The results are shown in a graph window and in a text window.

Setting Up and Making a Measurement

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 2-1



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit the RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

Attenuator: 60 dB

Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

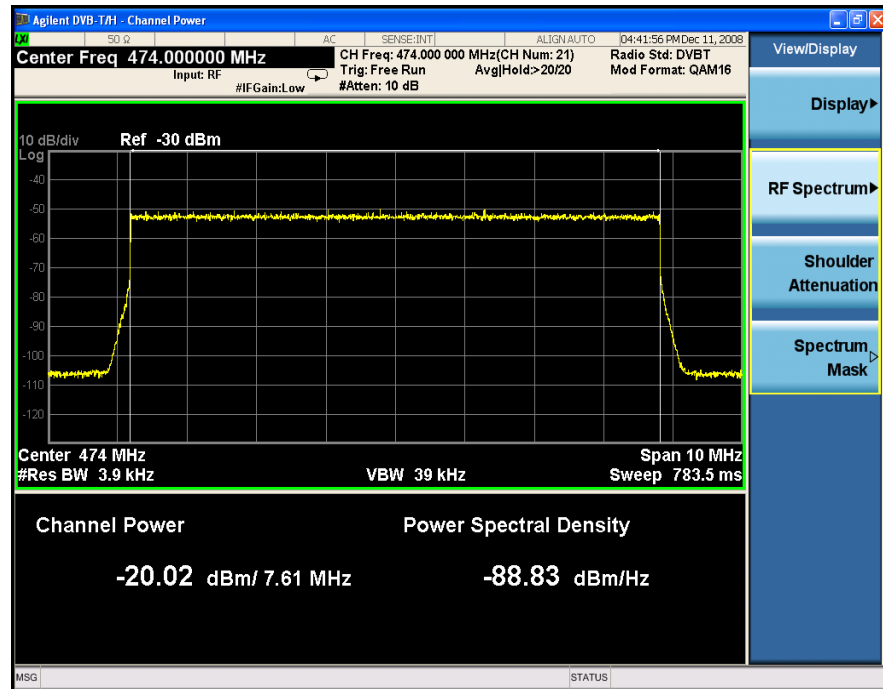
Measurement Procedure

- Step 1.** Press **Mode, DVB-T/H** to enable the DVB-T/H mode measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.

- Step 3.** Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.
- You can also input a channel number under a specific channel table to set the center frequency.
- Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
 - Press **FREQ Channel, Channel** to set the channel number.
- Step 4.** Press **Mode Setup, Radio Std, DVB-T** to select DVB-T standard.
- Step 5.** Press **Mode Setup, Channel BW, 8 MHz** to set the channel bandwidth.
- Step 6.** Press **Meas, Channel Power** to initiate the Channel Power measurement.

Figure 2-2

Channel Power Measurement Result (Default)



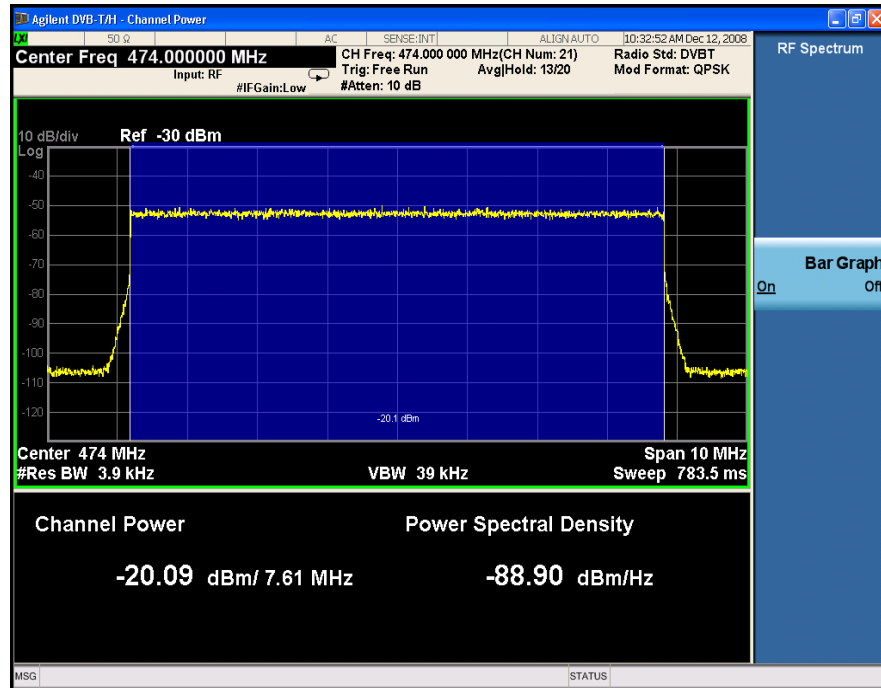
The Channel Power measurement result with RF spectrum view should look like Figure 2-2. The text window shows the total channel power and its mean power spectral density values over 7.61 MHz.

- Step 7.** Press **View/Display, RF Spectrum** and toggle the **Bar Graph** key to **On** to see the bar graph with the spectrum trace graph overlay. The spectrum graph measurement results should look like Figure 2-3.

Channel Power Measurements
Setting Up and Making a Measurement

Figure 2-3

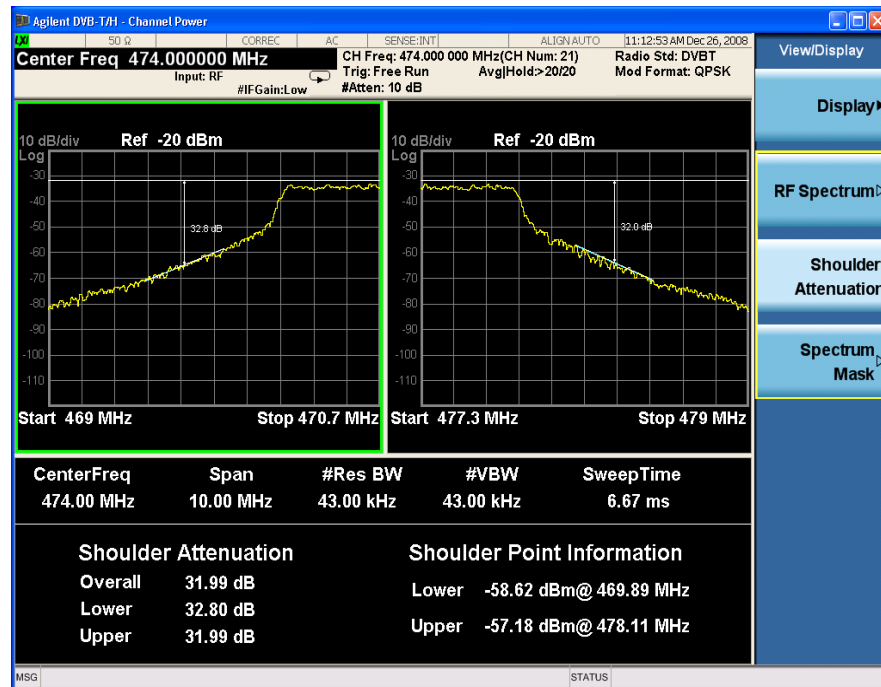
Channel Power Measurement Result-Bar Graph View



Step 8. Press **View/Display, Shoulder Attenuation** to see the DVB-T standard defined shoulder attenuation. The shoulder attenuation measurement should look like [Figure 2-4](#). The text window shows the value of shoulder attenuation and shoulder point information.

Figure 2-4

Channel Power Measurement Result - Shoulder Attenuation View



Step 9. Press **Input/Output, External Gain, Ext Preamp, -60, dB** to input the value of the external attenuator.

Step 10. Press **View/Display Spectrum Mask** to see the channel power spectrum with the DVB-T defined spectrum mask overlay.

- Press **Spectrum Mask** to select the analog TV system in the adjacent channel.

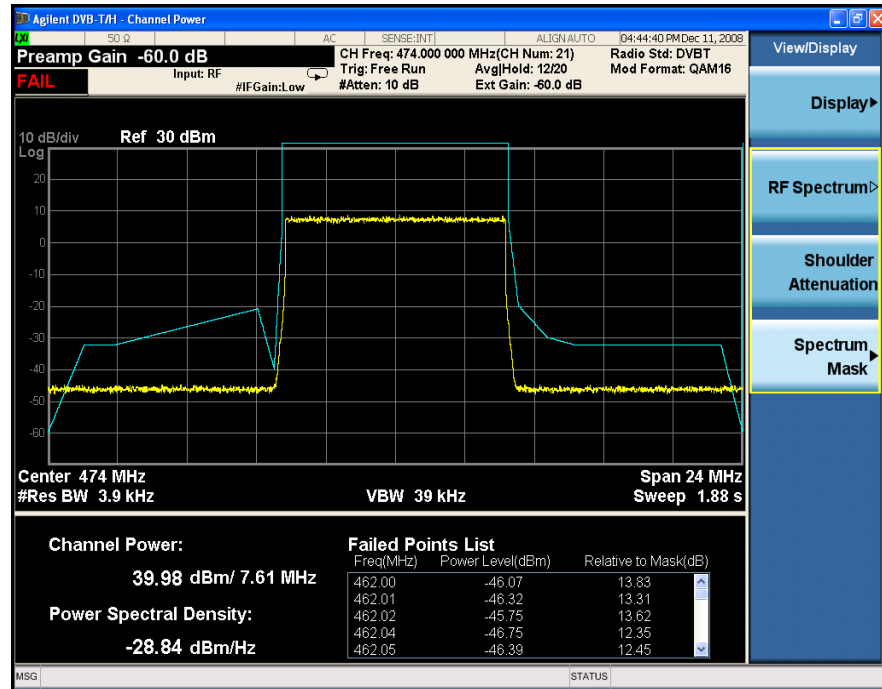
The spectrum mask measurement results should look like [Figure 2-5](#). The text window shows total power, power spectral density and the failed points list.

NOTE

When analog TV signal is used in an adjacent channel, use this measurement to see whether the transmitting signal complies with the spectrum mask specified by the DVB-T standard.

Figure 2-5

Channel Power Measurement Result-Spectrum Mask View



In the spectrum mask view, if the bandwidth is 5/6/7 MHz, the mask trace will not be displayed and a “No Result” message will be displayed, because the spectrum mask is not defined in DVB-T/H standard in those cases.

NOTE

Use the keys under **Spectrum Mask, Scroll** to see the total information of the Failed Point List at the right bottom of the screen.

Step 11. Press **Input/Output, More 1 of 2, Corrections** to use amplitude corrections.

The dynamic range of the RF output of a real DVB-T/H transmitter typically exceeds that of the analyzer, therefore, the direct measurement result is always “FAIL” as shown in [Figure 2-5](#), which does not reflect the actual RF output.

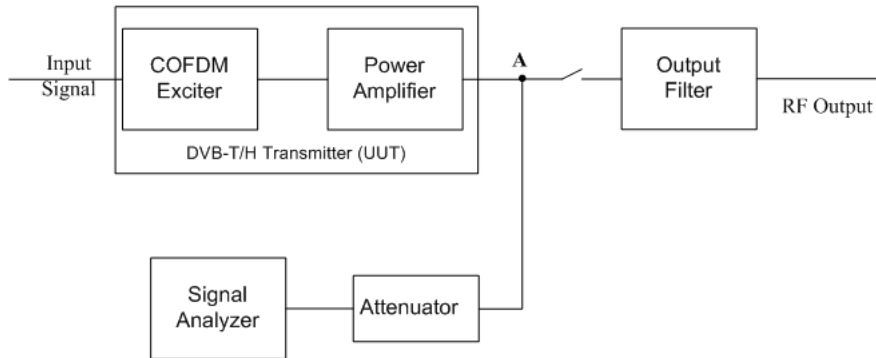
Channel Power Measurements

Setting Up and Making a Measurement

To measure the spectrum mask of the transmitter's RF output, there are two methods.

- When the DVB-T/H transmitter has an output filter, the diagram for spectrum mask measurement is shown in [Figure 2-6](#).

Figure 2-6 Diagram for the Spectrum Mask Measurement on DVB-T/H Transmitter



The steps for measuring the spectrum mask are as follows:

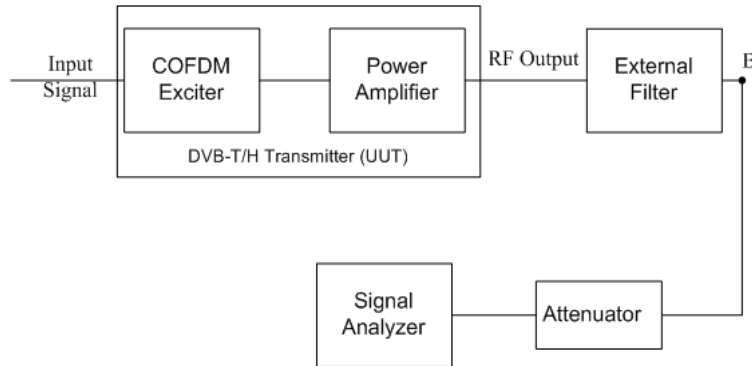
- Measure the frequency response of the output filter using a network analyzer or a combination of signal source and signal analyzer.
- Measure the signal transmitted at point A as shown in [Figure 2-6](#).
- Apply amplitude correction on spectrum value measured in step b using the filter's response from step a.

The correction data is typically a table of the filter's frequency response, in dB, at a number of frequency points across the band.

The operation process for amplitude correction on the signal analyzer is shown as follows:

- Specify the correction data through onscreen editor using **Edit** menu under **Correction**, by sending over SCPI or by loading from mass storage using **Recall, Data (Import) Amptd Cor1, Open**.
 - Toggle the **Correction** key to **On** to apply the corrections.
- When the transmitter doesn't have the output filter, an external filter with a band-block filter frequency response should be added after the transmitter for measurement arrangement as shown in [Figure 2-7](#).

Figure 2-7 Diagram for Spectrum Mask Measurement on DVB-T/H Transmitter without Output Filter



The steps for measuring the spectrum mask is as follows:

- Measure the frequency response of the external filter using a network analyzer or a combination of signal source and signal analyzer.
- Measure the signal transmitted at point B as shown in [Figure 2-7](#).
- Apply amplitude correction on spectrum value measured in step b using the filter's response from step a.

The correction data is typically a table of the negative of filter's frequency response, in dB, at a number of frequency points across the band.

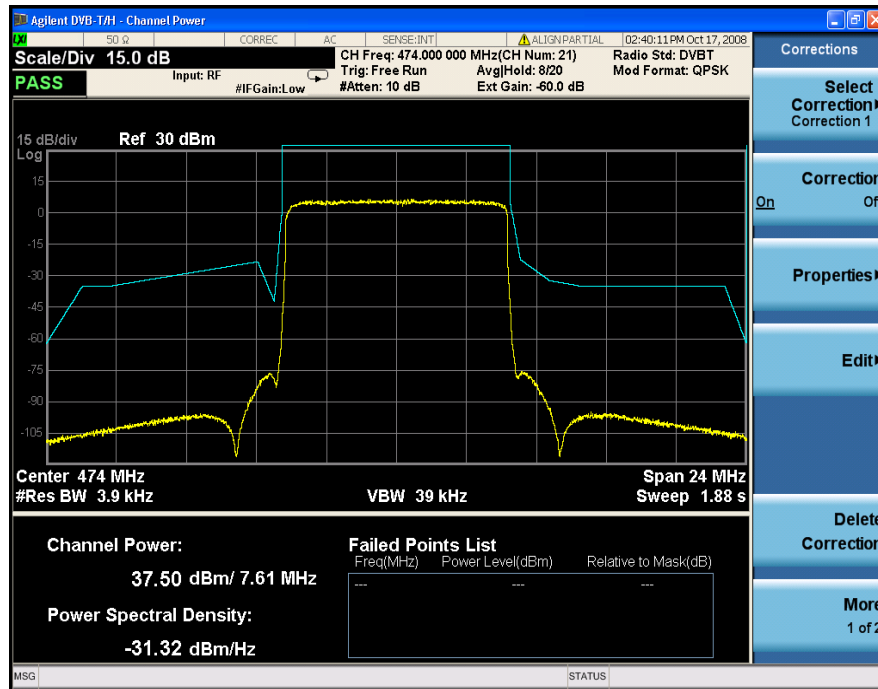
The operation process for amplitude correction on the signal analyzer is shown as follows:

- Specify the correction data through onscreen editor using **Edit** menu under **Correction**, by sending over SCPI or by loading from mass storage using **Recall, Data (Import) Amptd Cor1, Open**.
- Toggle the **Correction** key to **On** to apply the corrections.

The spectrum mask measurement result after amplitude correction should look like [Figure 2-8](#).

Figure 2-8

Channel Power Measurement Result-Spectrum Mask View after Amplitude Correction



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

If you encounter a problem, or get an error message, see the guide “*Instrument Messages*”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Agilent\SignalAnalysis\Infrastructure\Help\bookfiles.

This chapter describes the Adjacent Channel Leakage Power Ratio (ACLR or ACPR) measurement on a DVB-T/H transmitter. ACPR is the measurement of the amount of interference, or power, in adjacent frequency channels. The results are displayed as a bar graph or as spectrum data, with measurement data at specified offsets.

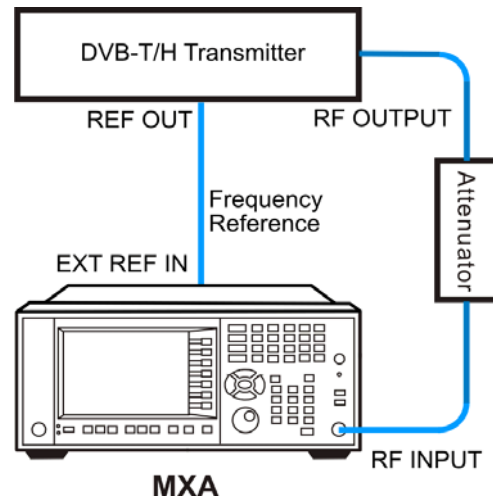
Setting Up and Making a Measurement

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 3-1

Adjacent Channel Power Measurement System



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit the RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

Attenuator: 60 dB

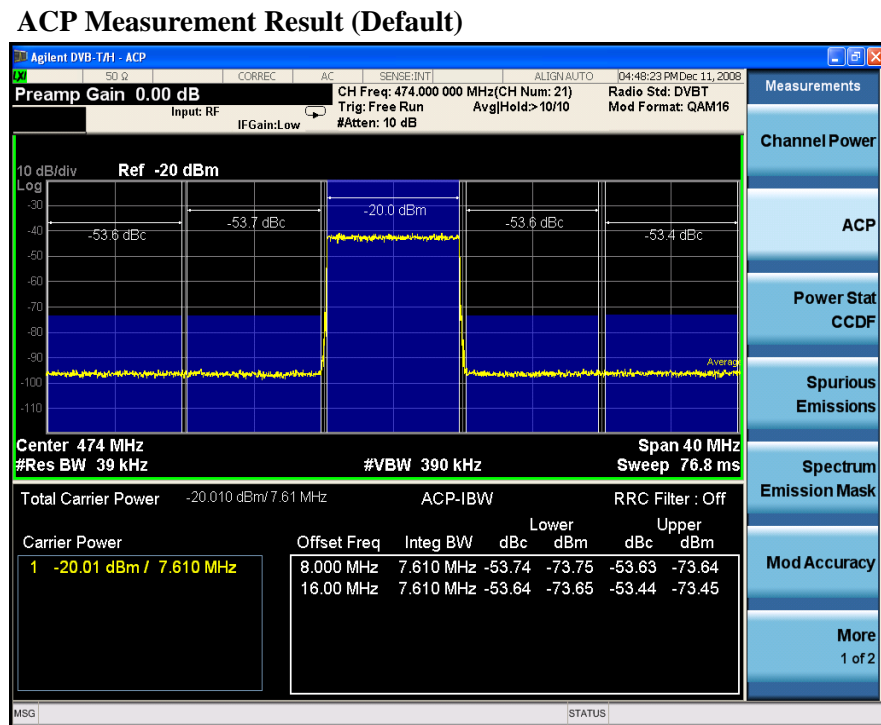
Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

Measurement Procedure

- Step 1.** Press **Mode, DVB-T/H** to enable the DVB-T/H mode measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.

- Step 3.** Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.
- You can also input a channel number under a specific channel table to set the center frequency.
- a. Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
 - b. Press **FREQ Channel, Channel** to set the channel number.
- Step 4.** Press **Mode Setup, Channel BW, 8 MHz** to select the channel bandwidth.
- Step 5.** Press **Mode Setup, Radio Std, DVB-T** to select DVB-T standard.
- Step 6.** Press **Meas, ACP** to initiate the adjacent channel power measurement.

Figure 3-2



The ACP measurement results should look like [Figure 3-2](#). The graph window shows the bar graph with the spectrum trace overlay. The text window shows the total power in reference channel, absolute and relative power in offset channels.

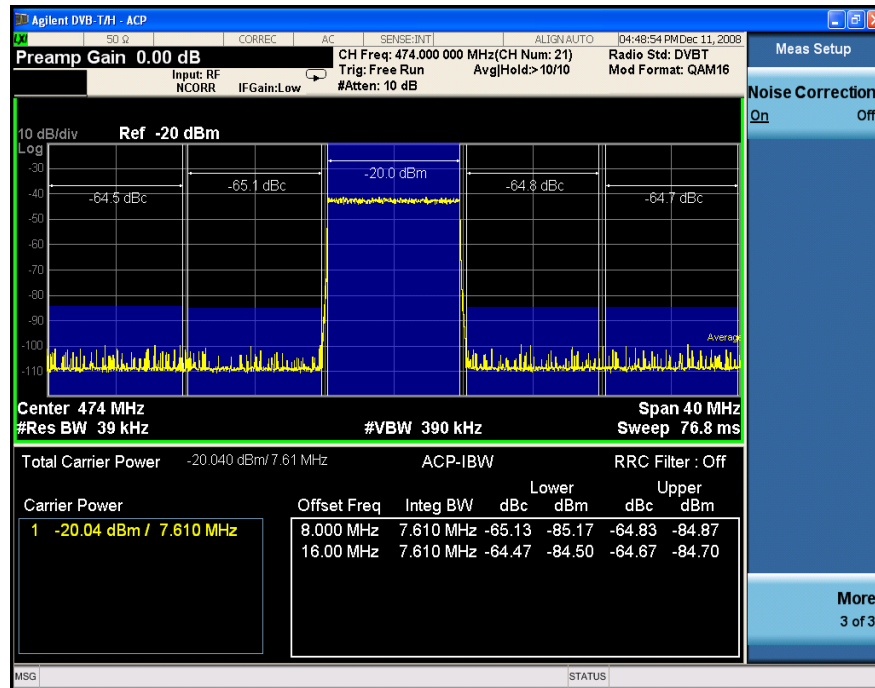
NOTE

You can zoom on either the numeric or the graphic results by pressing the Window Control keys that are at the bottom of the screen.

- Step 7.** Press **Meas Setup, More 1 of 3, More 2 of 3**, and toggle the **Noise Correction** key to **On** to turn on the noise correction to achieve a better ACP results. The ACP view with the Noise Correction should look like [Figure 3-3](#).

Figure 3-3

ACP Measurement Result - Noise Correction



Step 8. Press **Meas Setup** to see the keys that are available to change the measurement parameters from the default condition.

If you encounter a problem, or get an error message, see the guide “*Instrument Messages*”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Agilent\SignalAnalysis\Infrastructure\Help\bookfiles.

This chapter outlines how to make the Power Statistics Complementary Cumulative Distribution Function (Power Stat CCDF) measurement on a DVB-T/H transmitter. Power Stat CCDF measurements characterize the higher level power statistics of a digitally modulated signal.

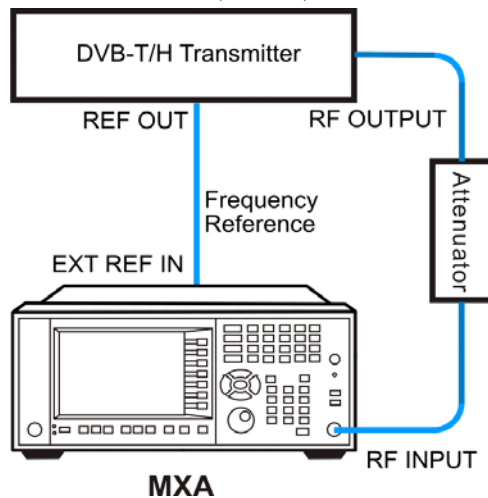
Setting Up and Making a Measurement

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 4-1

Power Statistics (CCDF) Measurement System



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit the RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

Attenuator: 60 dB

Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

Measurement Procedure

- Step 1.** Press **Mode, DVB-T/H** to enable the DVB-T/H mode measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.

Step 3. Press **Input/Output, RF Input** to select the signal inputs for the measurement.

For BBIQ measurement, there will be the I or I-Bar input and the Q or Q-Bar input. Use the procedure in [Chapter 10](#), “Using Option BBA Baseband I/Q Inputs,” on [page 63](#).

Step 4. Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.

You can also input a channel number under a specific channel table to set the center frequency.

- a. Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
- b. Press **FREQ Channel, Channel** to set the channel number.

Step 5. Press **Mode Setup, Radio Std, DVB-T** to select DVB-T standard.

Step 6. Press **Mode Setup, Channel BW, 8 MHz** to select the channel bandwidth.

Step 7. Press **Meas, Power Stat CCDF** to initiate the power statistics CCDF measurement.

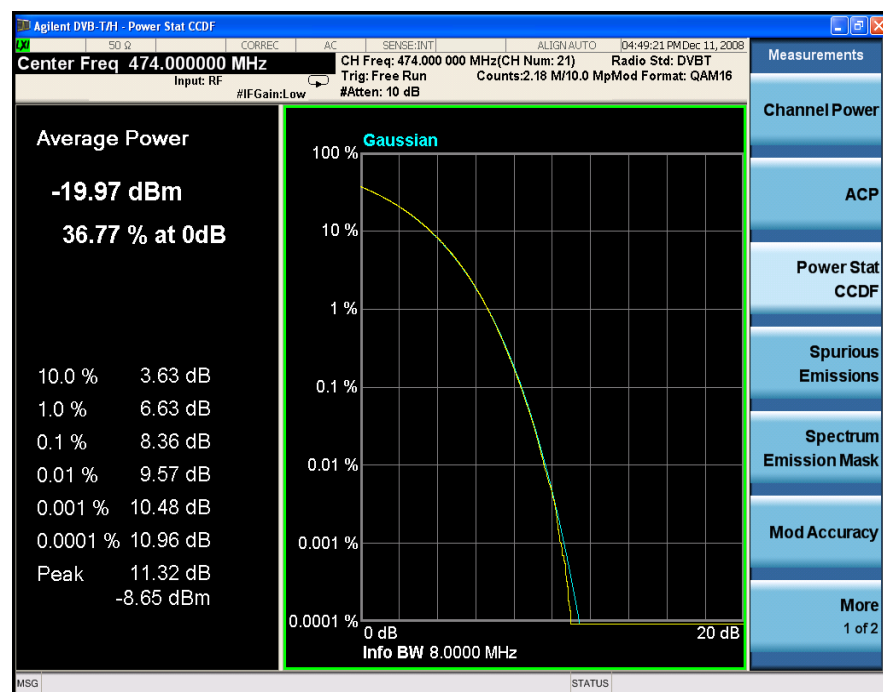
The CCDF measurement result should look like [Figure 4-2](#). The blue line is the Gaussian trace and the yellow line is the measurement result.

The Info BW is the channel bandwidth that will be used for data acquisition, the default value is 8 MHz. You can manually change the Info BW by pressing **BW, Info BW**.

The Counts is the accumulated number of sampling points for data acquisition with default value 10.0 Mpt. You can change the Counts under Meas Setup menu.

Figure 4-2

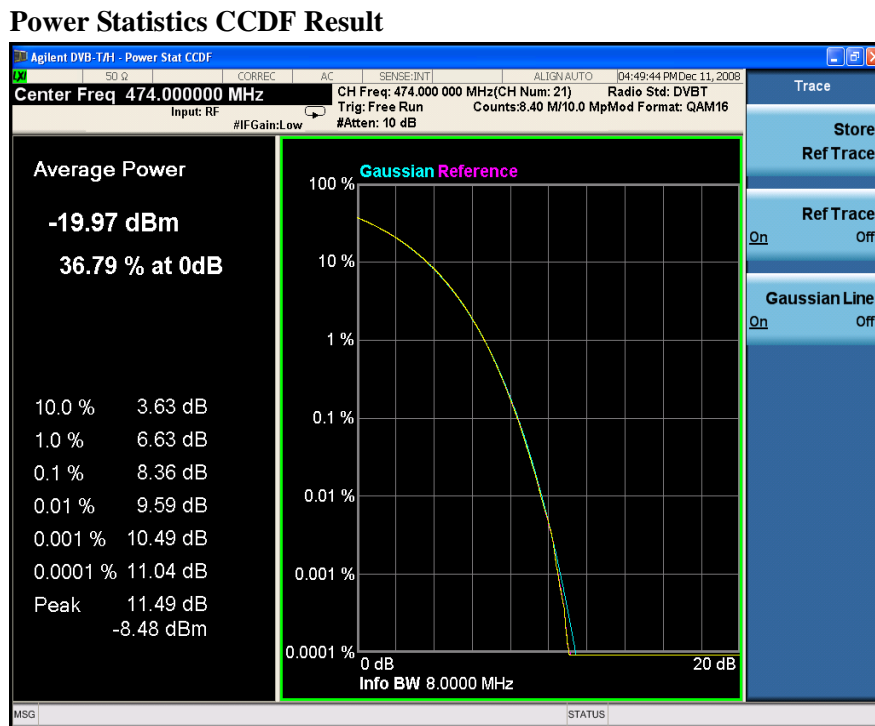
Measurement Results-Power Statistics CCDF Result



Step 8. Press **Trace/Detector, Ref Trace (On)** to display the user-definable reference trace (violet line).

The reference trace is a measurement trace that has been stored to be used as a reference trace to be compared to later measurement. You can use the **Store Ref Trace** key to save the currently measured trace as the reference trace. This reference trace will be lost if you switch between modes or measurements. The CCDF measurement with the reference trace should look like [Figure 4-3](#).

Figure 4-3



If you encounter a problem, or get an error message, see the guide “*Instrument Messages*”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Agilent\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

The power statistics CCDF measurement is useful in defining the signal power specifications for design criteria for systems, amplifiers, and other components. When the signal power is larger than the limit of the mixer or ADC, the CCDF result trace will deviate from the Gaussian trace.

This chapter describes how to make a Spurious Emission Measurement on a DVB-T/H transmitter. This measurement identifies and determines the power level of spurious emissions in certain frequency bands.

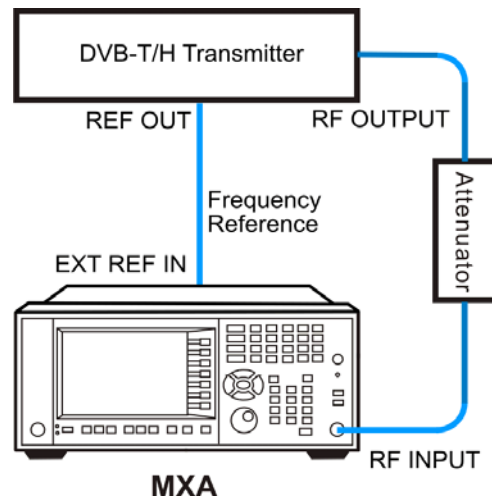
Setting Up and Making a Measurement

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 5-1

Spurious Emissions Measurement System



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

Attenuator: 60 dB

Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

Measurement Procedure

- Step 1.** Press **Mode, DVB-T/H** to enable the DVB-T/H mode measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.

Step 3. Press **Input/Output, RF Input, RF Coupling** to 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 4. Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.

You can also input a channel number under a specific channel table to set the center frequency.

- a. Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
- b. Press **FREQ Channel, Channel** to set the channel number.

Step 5. Press **Mode Setup, Radio Std, DVB-T** to select the DVB-T standard.

Step 6. Press **Mode Setup, Channel BW, 8 MHz** to select the channel bandwidth.

Step 7. Press **Meas, Spurious Emission** to initiate the spurious emission measurement.

NOTE

You should first set the mean power of the transmitter through **Meas Setup, CH Mean Power** before measuring spurious emissions, since the limit parameters are different for different transmit power.

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 and the absolute limit.

The default Meas Type is Examine, in which the average mode is set to exponential and the trace is continuously updating to show the latest spectrum in the range that has the worst spurious. A marker is placed on the frequency of the worst spur.

By pressing **Meas Setup** and toggling the **Meas Type** to **Full**, you can set the Meas Type to Full, in which the average mode is set to repeat and the measurement result of the select spur and range is shown.

NOTE

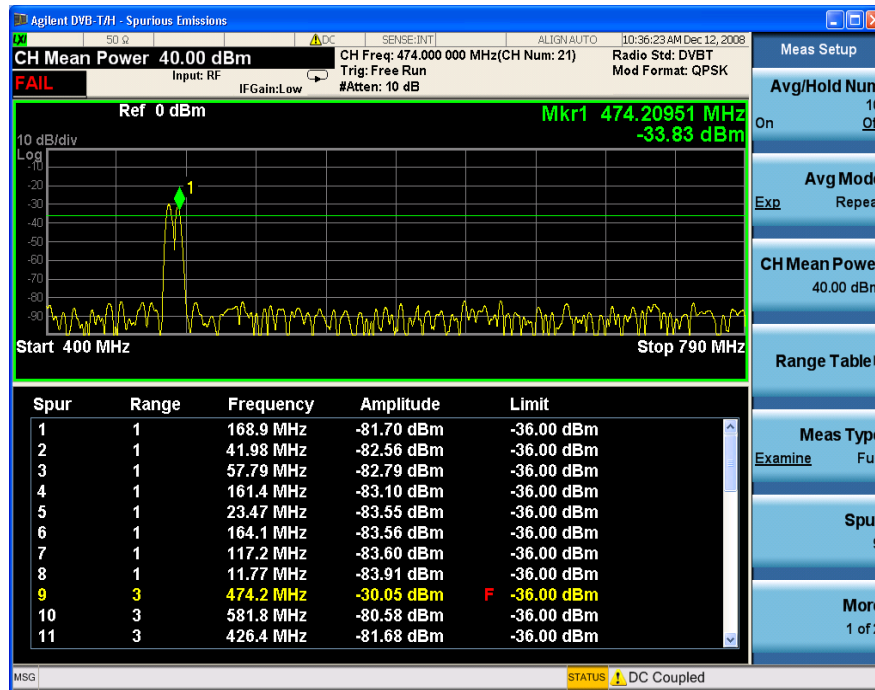
If you set the Meas Type to **Examine**, the trace is continuously updating to show the latest spectrum range that has the worst spurious. However, the table shows the last reported trace information. Press **Restart** to update the table to show the latest result.

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

Spurious Emissions Measurements Setting Up and Making a Measurement

Figure 5-2

Spurious Emissions Measurement



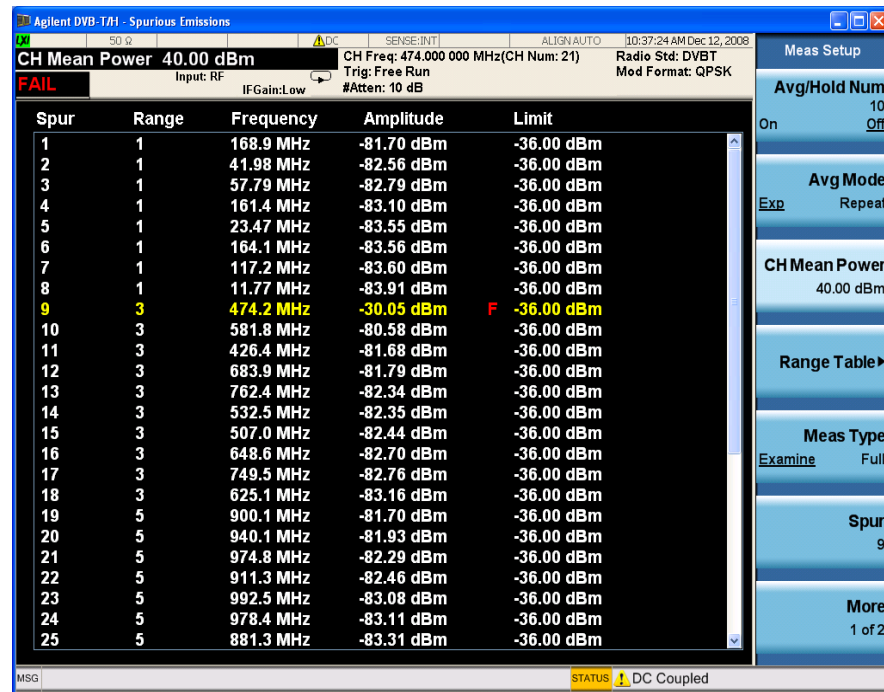
NOTE

The failed point in [Figure 5-2](#) above is the actual transmitted signal with the center frequency of 474 MHz. To avoid seeing this, you can either set the range table not to cover the carrier frequency band or connect a band rejection filter between the transmitter and the instruments to remove the undesired signal.

You can use the window control keys below the screen to zoom the result screen. See [Figure 5-3](#).

Figure 5-3

Spurious Emissions Measurement - Numeric Result Screen



Step 8. Press **Meas Setup**, **Range Table** to setup the range table.

You can enter settings for up to twenty ranges. Press **Meas Setup** to return the screen from range table to spur table.

If you want to change the measurement parameters, press **Meas Setup** to see the parameter keys that are available.

If you encounter a problem, or get an error message, see the guide “*Instrument Messages*”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Agilent\SignalAnalysis\Infrastructure\Help\bookfiles.

Spurious Emissions Measurements
Setting Up and Making a Measurement

Spectrum Emission Mask Measurements

This chapter describes how to make the Spectrum Emission Mask (SEM) measurement on a DVB-T/H transmitter. SEM measurement compares the power level within given offset channels on both sides of the carrier frequency, to the power levels allowed by the standard when there is digital TV signal or other services in adjacent channel. Results of each offset segment measurement can be viewed separately.

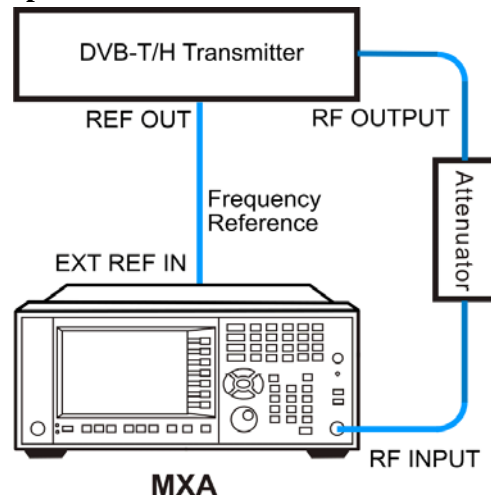
Setting Up and Making a Measurement

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 6-1

Spectrum Emission Mask Measurement System



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit the RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

Attenuator: 60 dB

Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

Measurement Procedure

- Step 1.** Press **Mode, DVB-T/H** to enable the DVB-T/H measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.

Step 3. Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.

You can also input a channel number under a specific channel table to set the center frequency.

- a. Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
- b. Press **FREQ Channel, Channel** to set the channel number.

Step 4. Press **Mode Setup, Radio Std, DVB-T** to select DVB-T standard.

Step 5. Press **Mode Setup, Channel BW, 8 MHz** to select the channel bandwidth.

Step 6. Press **Input/Output, External Gain, Ext Preamp, -60, dB** to input the value of the external attenuator.

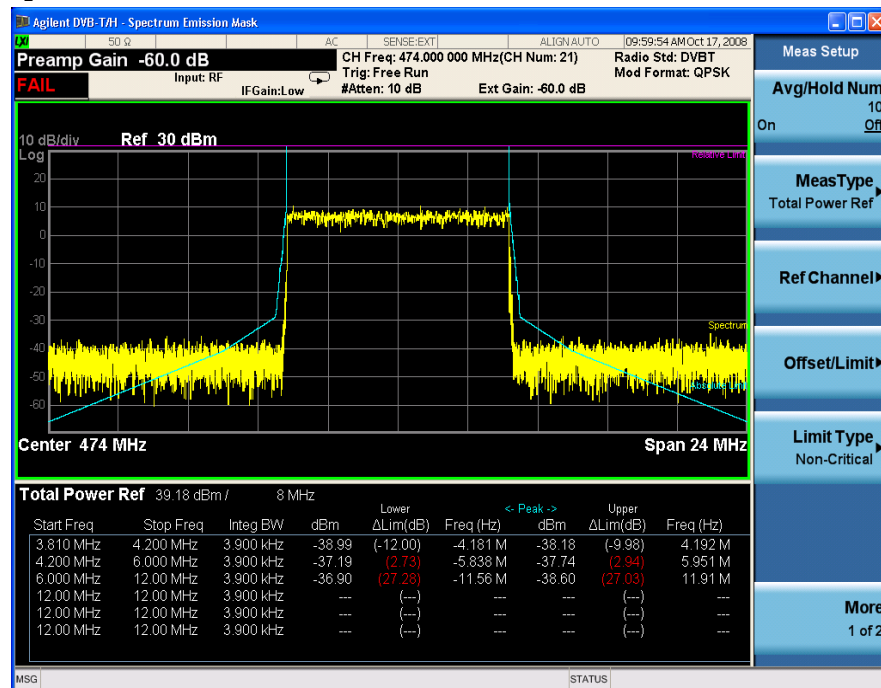
NOTE

Depending on the transmit power levels, the spectrum mask is different as shown in [Table 11-2 on page 81](#) and [Table 11-3 on page 81](#).

Step 7. Press **Meas, Spectrum Emission Mask** to initiate the spectrum emission mask measurement.

Figure 6-2

Spectrum Emission Mask Measurement Result



The Spectrum Emission Mask measurement results should look like [Figure 6-2](#). In this view, Spectrum Emission Mask measurement uses the Non-Critical case.

Step 8. Press **Input/Output, More 1 of 2, Corrections** to use amplitude corrections.

The dynamic range of the RF output of a real DVB-T/H transmitter typically exceeds that of the analyzer, therefore, the direct measurement result is always

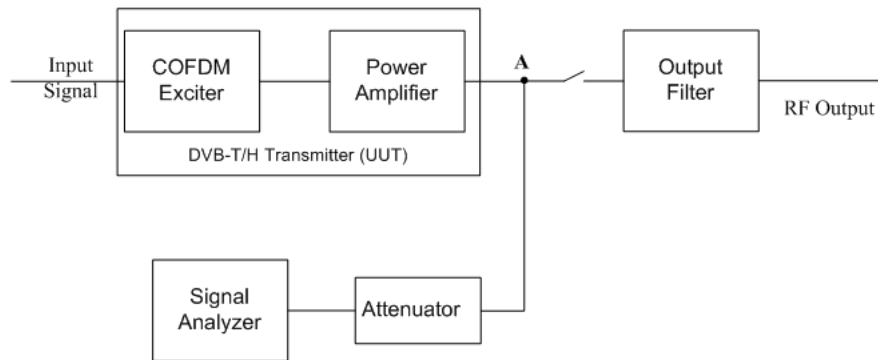
Spectrum Emission Mask Measurements Setting Up and Making a Measurement

“FAIL” as shown in [Figure 6-2](#), which does not reflect the actual RF output.

To measure the spectrum emission mask of the transmitter’s RF output, there are two methods.

- When the DVB-T/H transmitter has an output filter, the diagram for spectrum emission mask measurement is shown in [Figure 6-3](#).

Figure 6-3 Diagram for the Spectrum Emission Mask Measurement on DVB-T/H Transmitter



The steps for measuring the spectrum emission mask are as follows:

- Measure the frequency response of the output filter using a network analyzer or a combination of signal source and signal analyzer.
- Measure the signal transmitted at point A as shown in [Figure 6-3](#).
- Apply amplitude correction on spectrum value measured in step b using the filter’s response from step a.

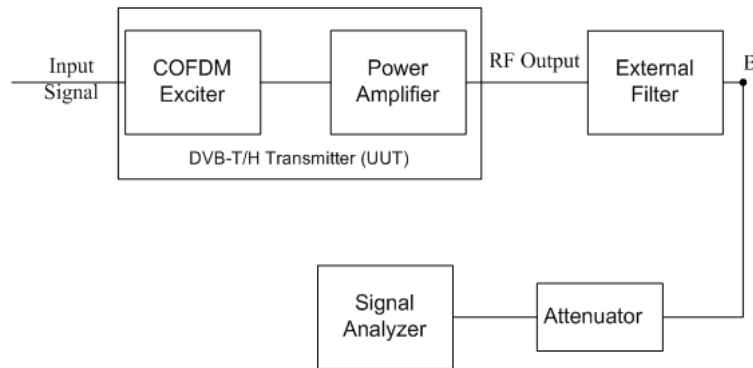
The correction data is typically a table of the filter’s frequency response, in dB, at a number of frequency points across the band.

The operation process for amplitude correction on the signal analyzer is shown as follows:

- Specify the correction data through onscreen editor using **Edit** menu under **Correction**, by sending over SCPI or by loading from mass storage using **Recall, Data (Import) Amptd Cor1, Open**.
 - Toggle the **Correction** key to **On** to apply the corrections.
- When the transmitter doesn’t have the output filter, an external filter with a band-block filter frequency response should be added after the transmitter for measurement arrangement as shown in [Figure 6-4](#).

Figure 6-4

Diagram for Spectrum Emission Mask Measurement on DVB-T/H Transmitter without Output Filter



The steps for measuring the spectrum emission mask is as follows:

- a. Measure the frequency response of the external filter using a network analyzer or a combination of signal source and signal analyzer.
- b. Measure the signal transmitted at point B as shown in [Figure 6-4](#).
- c. Apply amplitude correction on spectrum value measured in step b using the filter's response from step a.

The correction data is typically a table of the negative of filter's frequency response, in dB, at a number of frequency points across the band.

The operation process for amplitude correction on the signal analyzer is shown as follows:

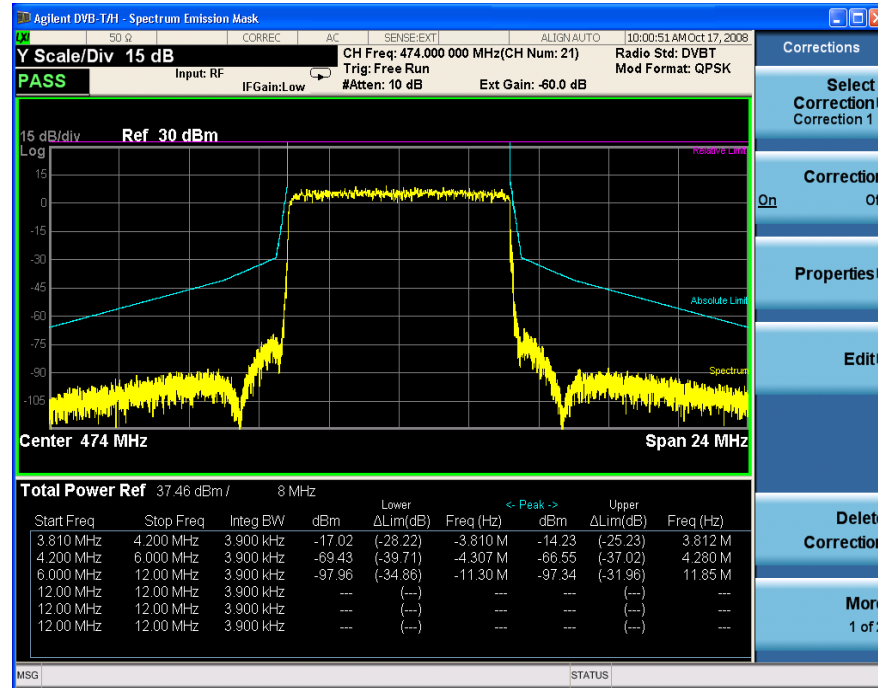
- a. Specify the correction data through onscreen editor using **Edit** menu under **Correction**, by sending over SCPI or by loading from mass storage using **Recall, Data (Import) Amptd Cor1, Open**.
- b. Toggle the **Correction** key to **On** to apply the corrections.

The spectrum emission mask measurement result after amplitude correction should look like [Figure 6-5](#).

Spectrum Emission Mask Measurements Setting Up and Making a Measurement

Figure 6-5

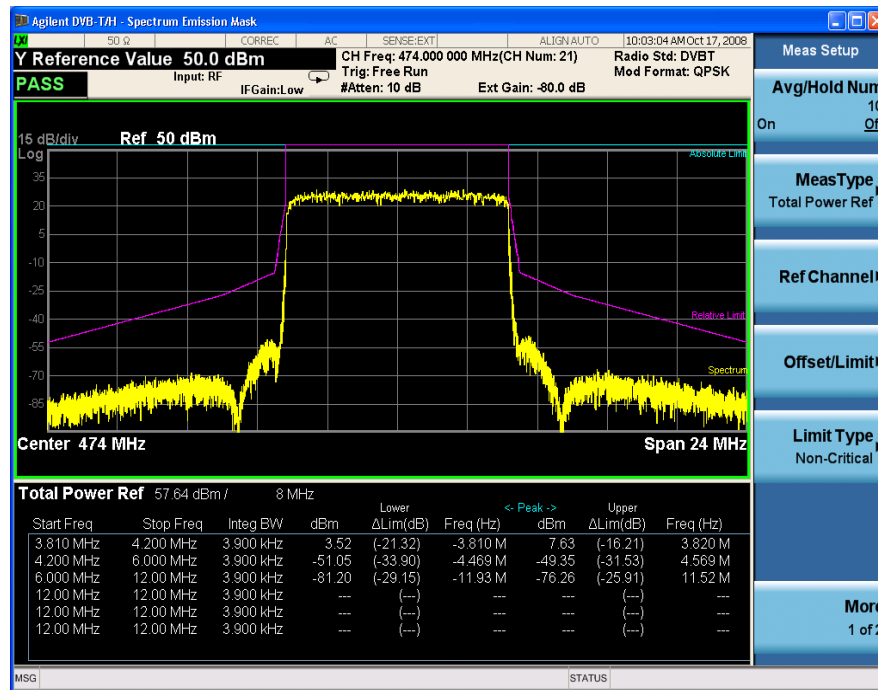
Spectrum Emission Mask Measurement Result after Amplitude Correction



If the total transmitted power is more than 25 W, the limit line turns to a relative limit, as shown in the purple color in Figure 6-6.

Figure 6-6

Spectrum Emission Mask Measurement for Total Power ≥ 25 W

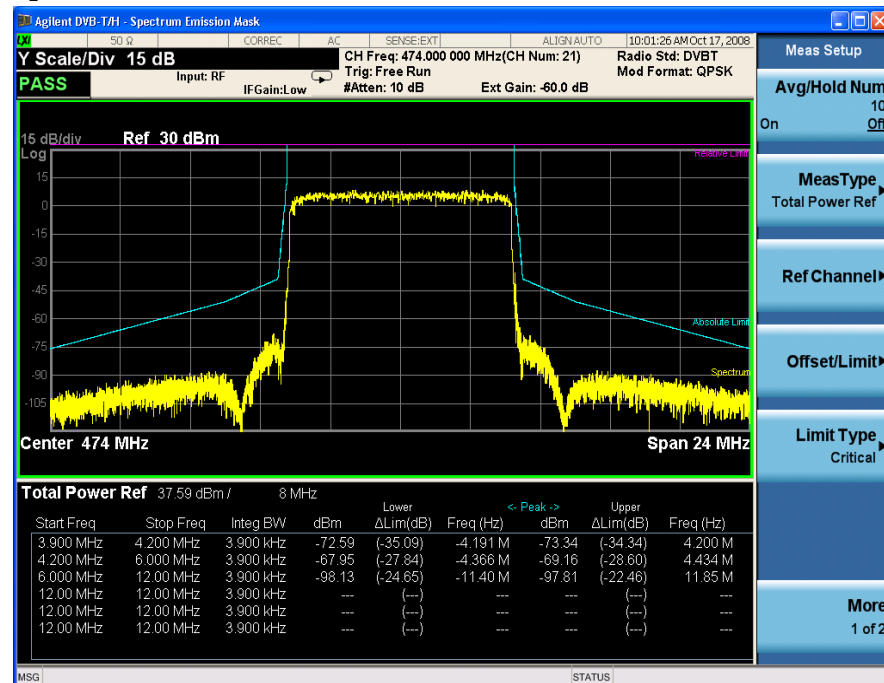


Step 9. Press **Meas Setup, Advanced, Limit Type, Critical** to perform the spectrum emission mask measurement in Critical case, Figure 6-7 shows the measurement

results.

Figure 6-7

Spectrum Emission Mask Measurement in Critical Case



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.

The **Limit Type** key appears differently for the different radio bandwidths.

- When the radio bandwidth is 5MHz or 6 MHz, the **Limit Type** key has only one option: Manual. The **Non-Critical** and **Critical** keys will be grayed out. You should set the limit line manually through **Meas Setup**, **Offset/Limit**.
- When the radio bandwidth is 7 MHz or 8 MHz, the **Limit Type** key has three options: Manual, Non-critical and Critical. The default value is Non-Critical after **Meas Preset**. When the value of the **Limit Type** is set (Critical/ Non-critical), the parameters displayed on the offset/Limits panel will be modified automatically according to [Table 11-2 on page 81](#) and [Table 11-3 on page 81](#).

NOTE

Unless otherwise declared by the manufacturer, use the non-critical limit to measure a transmitting signal; Use the critical limit when the television channels are adjacent to other services (low power or receive only).

If you encounter a problem, or get an error message, see the guide “*Instrument Messages*”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Agilent\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

This spectrum emission mask measurement can reveal degraded or defective parts in the transmitter section of the unit under test (UUT). The following are examples of typical causes for poor performance:

- 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.
- Degradation in the gain and output power level of the amplifier may be due to degraded gain control or increased distortion, or both.
- Degradation of the amplifier linearity or other performance characteristics.

Power amplifiers are one of the final stage elements of a DVB-T/H 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, SEM is a key measurement linking amplifier linearity and other performance characteristics to the stringent system specifications.

This section describes how to make the Modulation Accuracy measurement on a DVB-T/H transmitter. Modulation Accuracy measurement provides methods for measuring the I/Q errors in DVB-T/H transmitter. The results comprise EVM, MER, Magnitude Error, Phase Error, Frequency Error, Phase Jitter, Quad Error, Amplitude Imbalance, SNR, Carrier Suppression, etc.

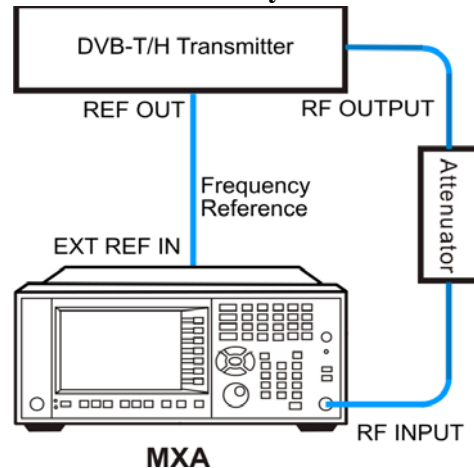
Setting Up and Making a Measurement

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 7-1

Modulation Accuracy Measurement System



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit the RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

FFT Size: 2K

Modulation Type: 16QAM

Alpha: 1

Guard Interval: 1/4

Transmission modes: Hierarchical

HP code rate: 1/2

LP code rate: 1/2

Attenuator: 60 dB

Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

Measurement Procedure

Step 1. Press **Mode, DVB-T/H** to enable the DVB-T/H mode measurements.

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

Step 3. Press **Input/Output, RF Input** to select the signal inputs for the measurement.

For BBIQ measurement, there will be the I or I-Bar input and the Q or Q-Bar input. Use the procedure in [Chapter 10](#), “Using Option BBA Baseband I/Q Inputs,” on [page 63](#).

Step 4. Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.

You can also input a channel number under a specific channel table to set the center frequency.

- a. Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
- b. Press **FREQ Channel, Channel** to set the channel number.

Step 5. Press **Mode Setup, Radio Std, DVB-T** to select DVB-T standard.

Step 6. Press **Mode Setup, Channel BW, 8 MHz** to set the channel bandwidth.

Step 7. Press **Mode Setup, Demod** to set the demodulation options for the transmitter under test.

- Press **FFT Size, 2K** to set the FFT size.
- Press **Modulation Format, 16QAM** to set the modulation format.
- Press **Alpha, Alpha = 1** to set Alpha value.
- Press **Guard Interval, 1/4** to set guard interval.
- Toggle the **Hierarchical** key to **On**.
- Press **More 1 of 2, HP Code Rate, 1/2** to set the HP code rate.
- Press **LP Code Rate, 1/2** to set the LP code rate.

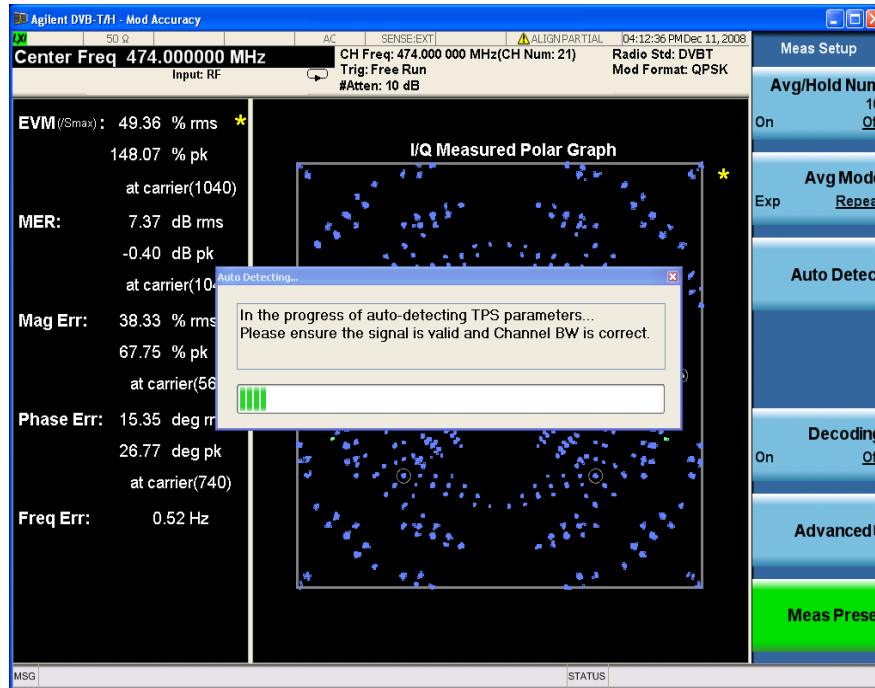
You could also use the **Auto Detect** key under **Meas Setup** menu to auto-detect the modulation parameters from the input signal instead of setting the modulation parameters manually, see [Figure 7-2](#).

NOTE

Before auto-detect, ensure the signal is valid and the channel bandwidth is correct.

Figure 7-2

Modulation Accuracy Measurement - Auto Detect



Step 8. Press **Meas, Mod Accuracy** to initiate the modulation accuracy measurement. The measurement result has a combination view of I/Q measured polar graph and metric windows as shown in [Figure 7-3](#).

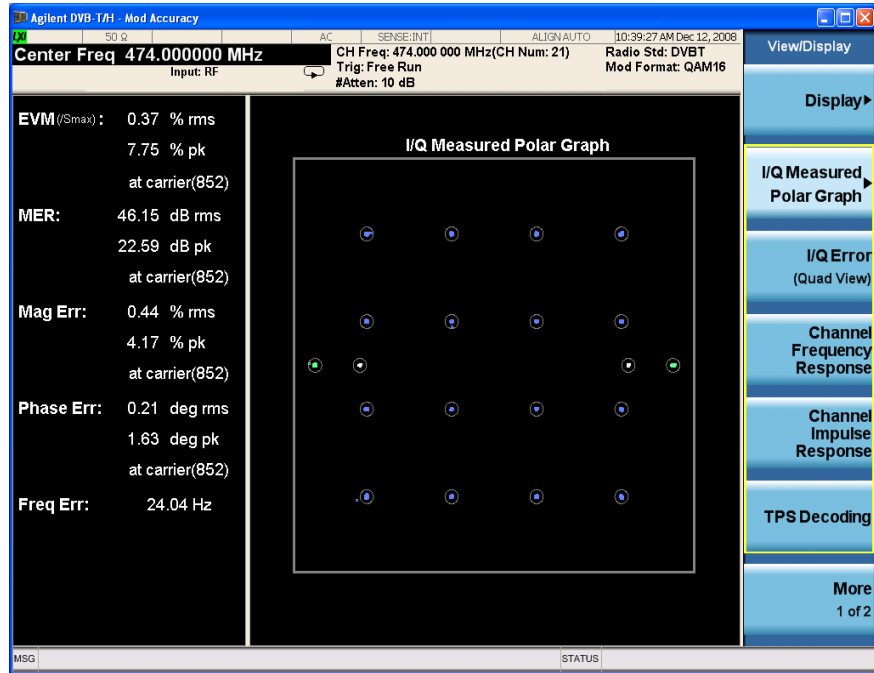
IMPORTANT

If the input power of the instrument is large (e.g., 5 dBm), an “Input Overload; ADC over range” message will be displayed at the bottom of the screen. To get accurate measurement results, you should set an appropriate value to the RF input attenuator through **AMPTD Y Scale, Attenuation** to adjust the signal to enter the mixer at an optimum level.

The modulation constellation is shown, along with EVM, MER, magnitude and phase errors, and frequency error.

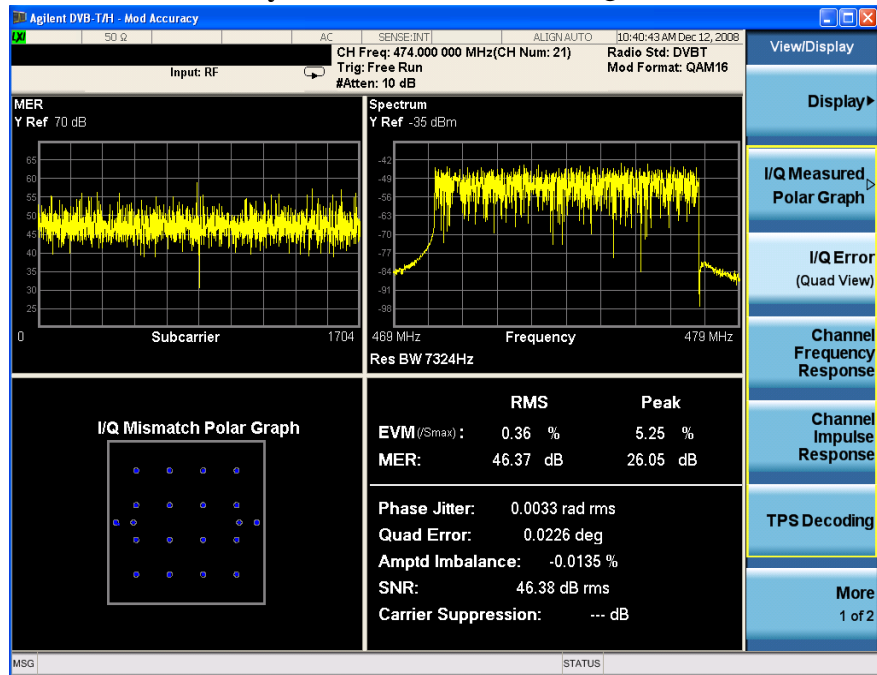
You can view the I/Q Measurement Polar Graph results for specified carriers by setting the **Start Carrier** value and **Stop Carrier** value under the **I/Q Measured Polar Graph** key.

Figure 7-3 Modulation Accuracy Measurement Result - I/Q Measured Polar Graph (Default) View



Step 9. Press **View/Display, I/Q Error (Quad View)** to display a combination view of the MER, spectrum, I/Q mismatch polar graph and result. The I/Q Error measurement result should appear as in [Figure 7-4](#). With this measurement, you can have a global view of the MER on each carrier.

Figure 7-4 Modulation Accuracy Measurement Result - I/Q Error View



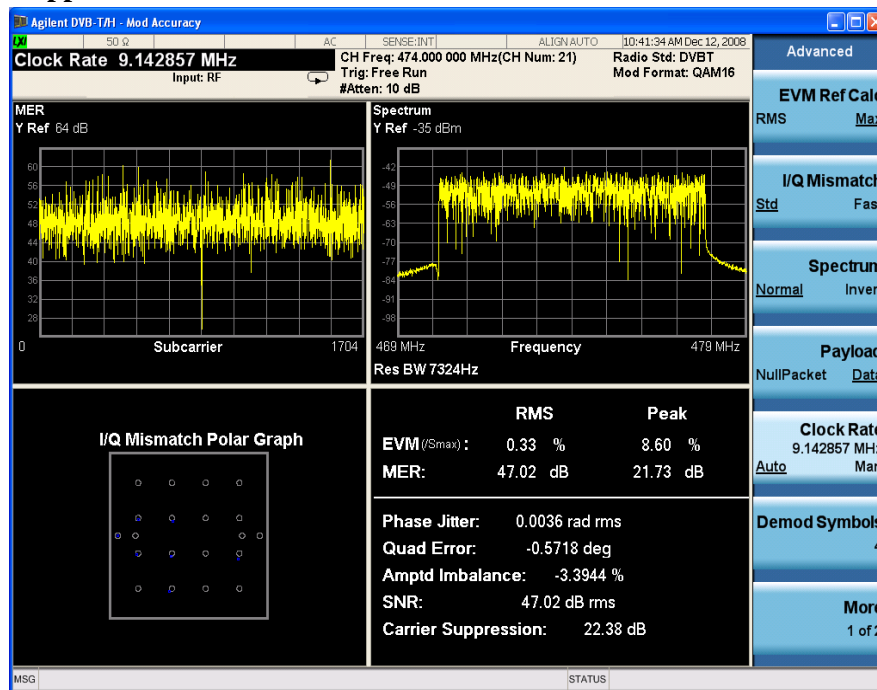
Modulation Accuracy Measurements Setting Up and Making a Measurement

The carrier suppression has no valid value in [Figure 7-4](#), because the default setting uses the “Fast” I/Q Mismatch estimation method. The information of all the carriers are taken into account so that carrier suppression is not able to be calculated.

Press **Meas Setup, Advanced, I/Q Mismatch, Std** to obtain the carrier suppression result, see [Figure 7-5](#).

In the I/Q Mismatch estimation method, “Std” means using the formula in the standard to calculate Amptd Imbalance, Quad Error and Carrier Suppression, providing results only in 2k mode; “Fast” means using Agilent internal algorithm to calculate Amptd Imbalance and Quad Error, providing results in 2k, 4k and 8k mode.

Figure 7-5 Modulation Accuracy Measurement Result - I/Q Error View with Carrier Suppression

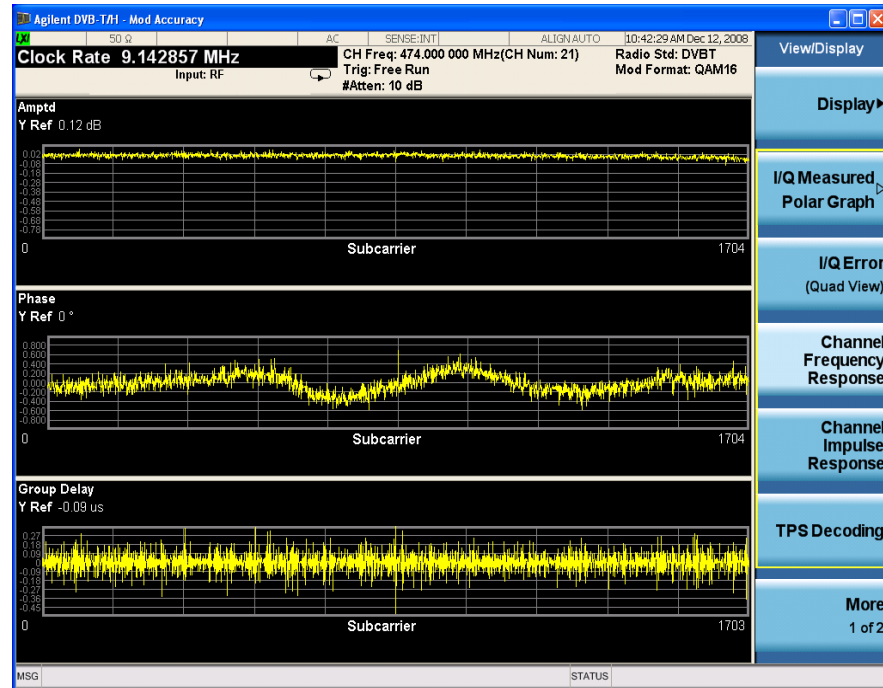


NOTE The I/Q Mismatch Polar Graph in [Figure 7-5](#) only shows the constellations for central carrier if the “Std” method is selected, and shows the constellations for all carriers if the “Fast” method is selected.

- Step 10.** Press **View/Display, Channel Frequency Response** to display the amplitude, phase and group delay of the channel frequency response on every subcarrier. The channel frequency response measurement result should look like [Figure 7-6](#).

Figure 7-6

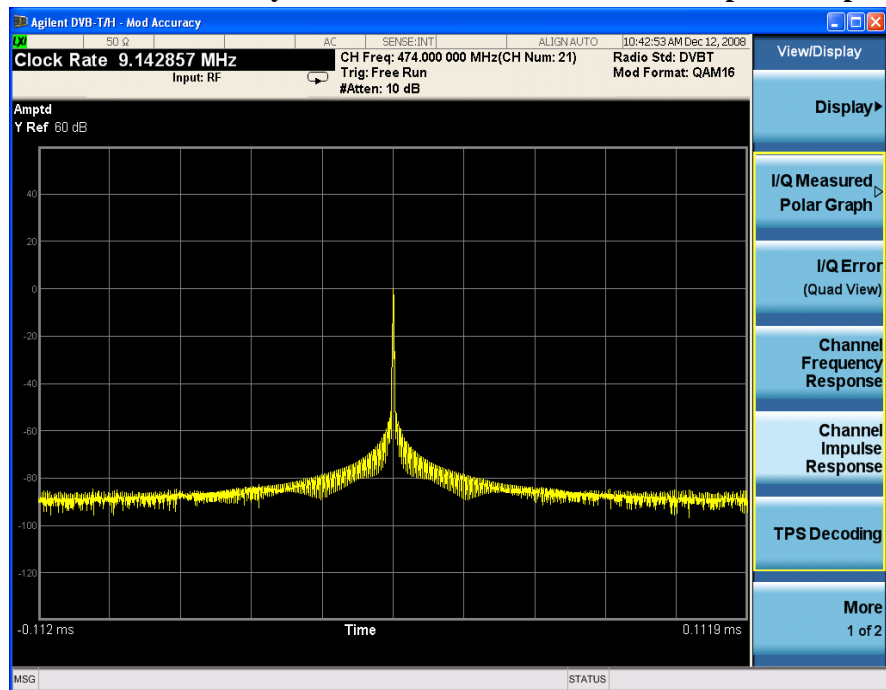
Modulation Accuracy Measurement Result-Channel Frequency Response



Step 11. Press **View/Display, Channel Impulse Response** to display state of channel. The channel impulse response measurement result should look like Figure 7-7.

Figure 7-7

Modulation Accuracy Measurement Result - Channel Impulse Response



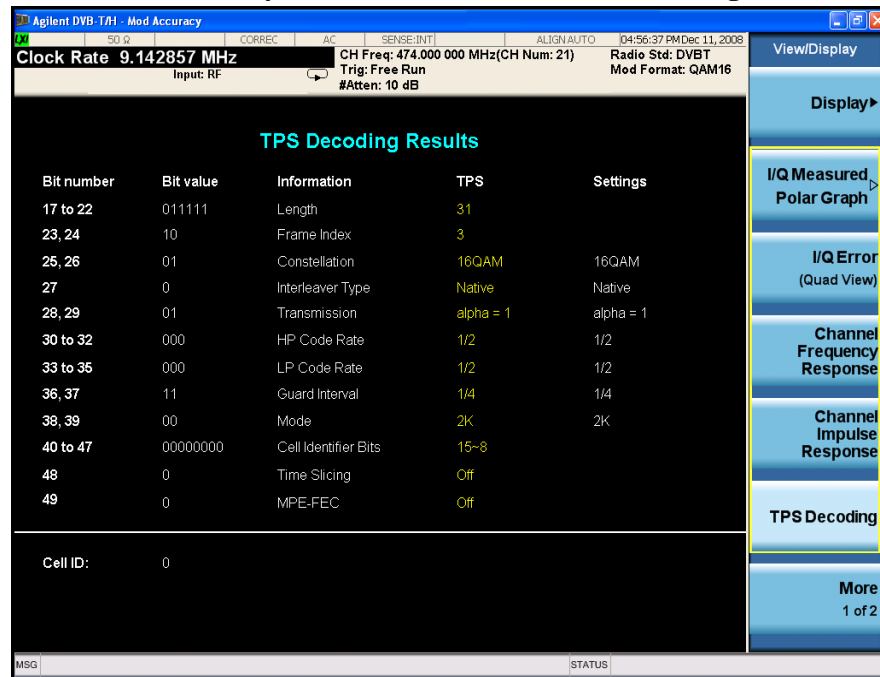
Step 12. Press **View/Display, TPS Decoding** to display the original bits of TPS and information decoded from TPS. The TPS decoding measurement results should

Modulation Accuracy Measurements Setting Up and Making a Measurement

look like [Figure 7-8](#).

Figure 7-8

Modulation Accuracy Measurement Result -TPS Decoding

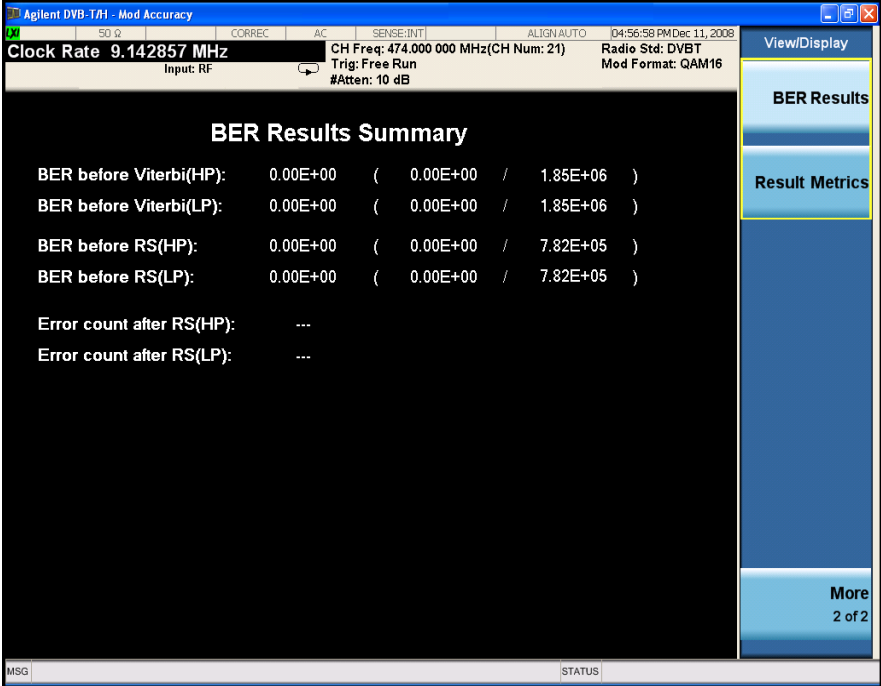


NOTE

In the graph, the results in yellow show TPS measurement results, and the results in white in the rightmost row indicate the current setting under **Mode Setup, Demod**.

- Step 13.** Press **View/Display, More 1 of 2, BER Results** to show the BER results. The BER measurement results should look like [Figure 7-9](#).

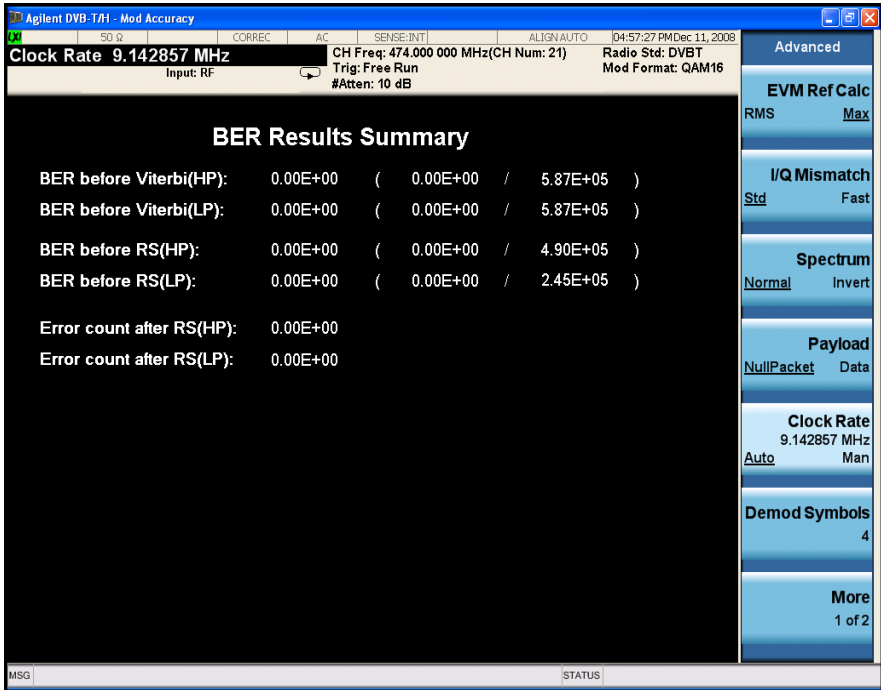
Figure 7-9 Modulation Accuracy Measurement Result -BER Results



When the transmitting signal is TS null, you can set the Payload type to **NullPacket** to measure the error count after RS decoding.

Press **Meas Setup, Advanced, Payload, NullPacket**. The BER measurement results with error count after RS should look like [Figure 7-10](#).

Figure 7-10 Modulation Accuracy Measurement Result -BER Results with Error Count after RS



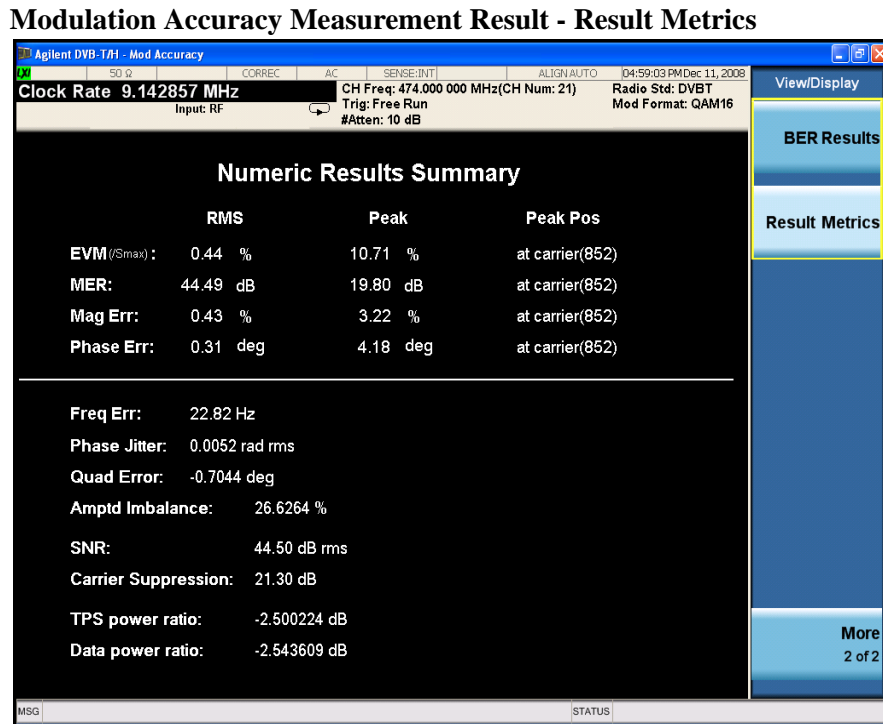
Modulation Accuracy Measurements

Setting Up and Making a Measurement

There are three different BER results, BER before Viterbi, BER before RS and Error count after RS. Each result contains two parts, HP (High Priority stream) and LP (Low Priority stream). If you choose the Non-Hierarchical transmission mode, the results for LP will be shown as "--". Refer to “BER” on page 85 for details of the concepts and measurement methods for BER.

- Step 14.** Press **View/Display, More 1 of 2, Result Metrics** to show the result metrics. The result metrics should look like [Figure 7-11](#).

Figure 7-11



- Step 15.** Press **Meas Setup** to see the keys that are available to change measurement parameters from their default condition.

NOTE

To place a Marker on the different traces of the different views, press **Marker, Properties, Marker Trace**, then select the trace you want to put the marker on. There are 7 traces to select from: Polar Trace, MER vs.Carr, Spectrum, Amptd vs.Carr, Phase vs.Carr, GD vs.Carr, Amptd vs.Time.

If you encounter a problem, or get an error message, see the guide “*Instrument Messages*”, which is provided on the Documentation CD ROM, and in the instrument here:

C:\Program Files\Agilent\SignalAnalysis\Infrastructure\Help\bookfiles.

Troubleshooting Hints

The MER result reflects the quality of digital video signals directly. It indicates the signal deterioration even before the BER result turns bad.

Modulation Accuracy Measurements
Setting Up and Making a Measurement

This chapter describes how to make a Monitor Spectrum measurement on a DVB-T/H transmitter. Monitor Spectrum measurement shows a spectrum domain display of the DVB-T/H signal.

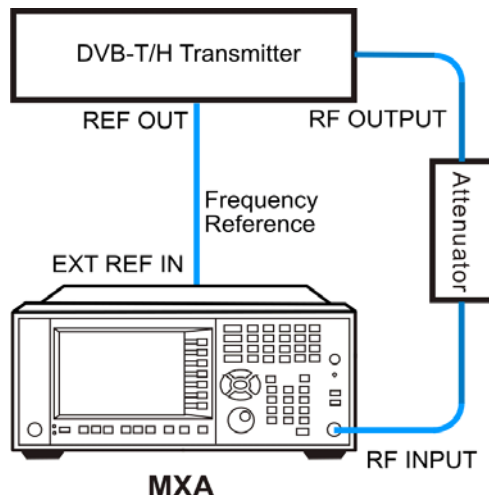
Setting Up and Making a Measurement

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitting signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 8-1

Modulation Accuracy Measurement System



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit the RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

Attenuator: 60 dB

Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

Measurement Procedure

- Step 1.** Press **Mode**, **DVB-T/H** to enable the DVB-T/H mode measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.

Step 3. Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.

You can also input a channel number under a specific channel table to set the center frequency.

- a. Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
- b. Press **FREQ Channel, Channel** to set the channel number.

Step 4. Press **Mode Setup, Radio Std, DVB-T** to select DVB-T standard.

Step 5. Press **Mode Setup, Channel BW, 8 MHz** to set the channel bandwidth.

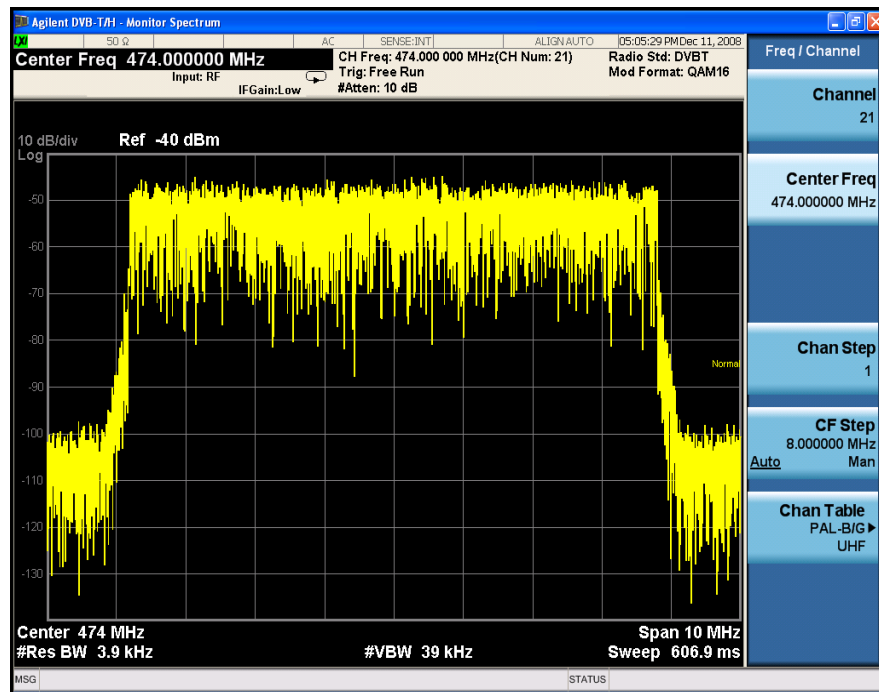
Step 6. Press **Meas, Monitor Spectrum**. The displayed measurement result should look like [Figure 8-2](#).

The default display shows the **Current** (yellow trace) data. To make viewing the display easier, you can view either the **Current** trace or **Average** separately.

- Press **Trace/Detector, Select Trace** and select the trace(s) desired for display, then toggle **Display** to **Show**. Then press **Update** to **On** to see the updated trace.

Figure 8-2

Monitor Spectrum Measurement - Spectrum View



Step 7. Press the **Meas Setup** key to see the keys available to change the measurement parameters from the default condition.

Monitor Spectrum Measurements
Setting Up and Making a Measurement

IQ Waveform (Time Domain) Measurements

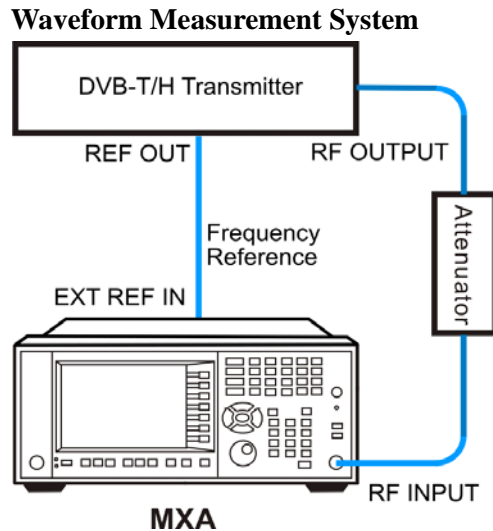
This chapter explains how to make a Waveform (time domain) measurement on a DVB-T/H transmitter. The measurement of I and Q modulated waveforms in the time domain discloses the voltages which comprise the complex modulated waveform of a digital signal.

Setting Up and Making Measurements

Configuring the Measurement System

Set the DVB-T/H transmitter under test to transmit RF power. This transmitted signal is connected to the RF input port of the instrument. Connect the equipment as shown.

Figure 9-1



1. Connect the output signal from the DVB-T/H transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. If there is a frequency reference port on the DVB-T/H transmitter, you can connect a BNC cable between it and the EXT REF IN port of the analyzer for frequency synchronization, if required.

Setting the DVB-T/H Transmitter (Example)

Set up the DVB-T/H transmitter to transmit the RF power as follows:

Standard: DVB-T

Frequency: 474 MHz (Channel Num: 21, Channel Table: PAL-B/G UHF)

Channel Bandwidth: 8 MHz

Attenuator: 60 dB

Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

Measurement Procedure

- Step 1.** Press **Mode**, **DVB-T/H** to enable the DVB-T/H mode measurements.
- Step 2.** Press **Mode Preset** to preset the analyzer.

Step 3. Press **Input/Output, RF Input** to select the signal inputs for the measurement.

For BBIQ measurement, there will be the I or I-Bar input and the Q or Q-Bar input. Use the procedure in [Chapter 10](#), “Using Option BBA Baseband I/Q Inputs,” on [page 63](#).

Step 4. Press **FREQ Channel, Center Freq, 474, MHz** to set the center frequency.

You can also input a channel number under a specific channel table to set the center frequency.

- a. Press **FREQ Channel, Chan Table** to specify a channel table by selecting a video standard.
- b. Press **FREQ Channel, Channel** to set the channel number.

Step 5. Press **Mode Setup, Radio Std, DVB-T** to select the DVB-T standard.

Step 6. Press **Mode Setup, Channel BW, 8 MHz** to set the channel bandwidth.

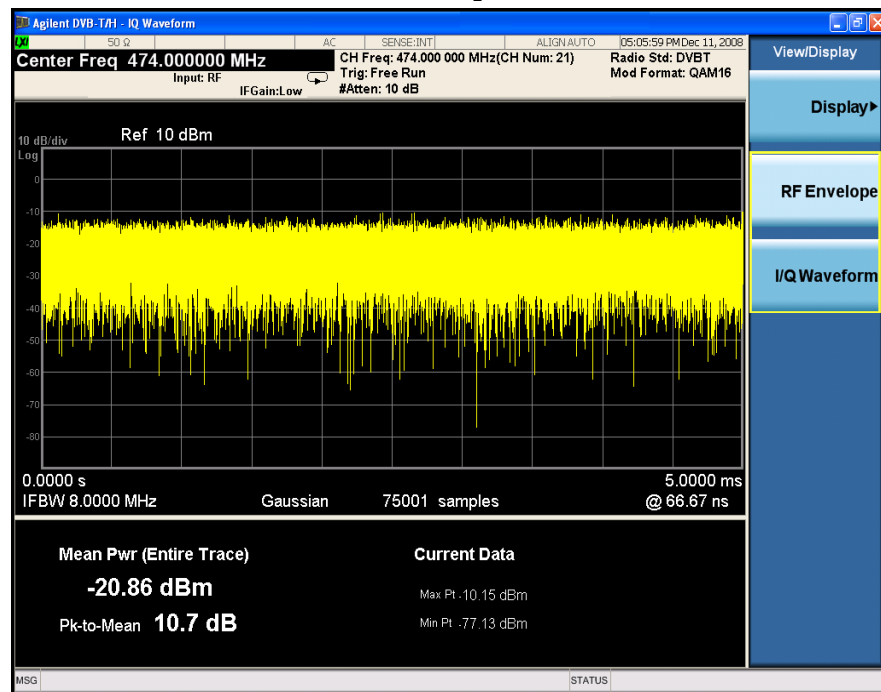
Step 7. Press **SPAN X Scale** key to set the measurement span time, enter a numerical span using the front-panel keypad, and select a units key, for example **ms**.

Step 8. Press **Meas, IQ Waveform** to initiate the IQ Waveform measurement.

The default display shows the RF Envelope with the current data, see [Figure 9-2](#). The measured values for the mean power and peak-to-mean power are shown in the text window.

Figure 9-2

Waveform Measurement - RF Envelope (Default View)



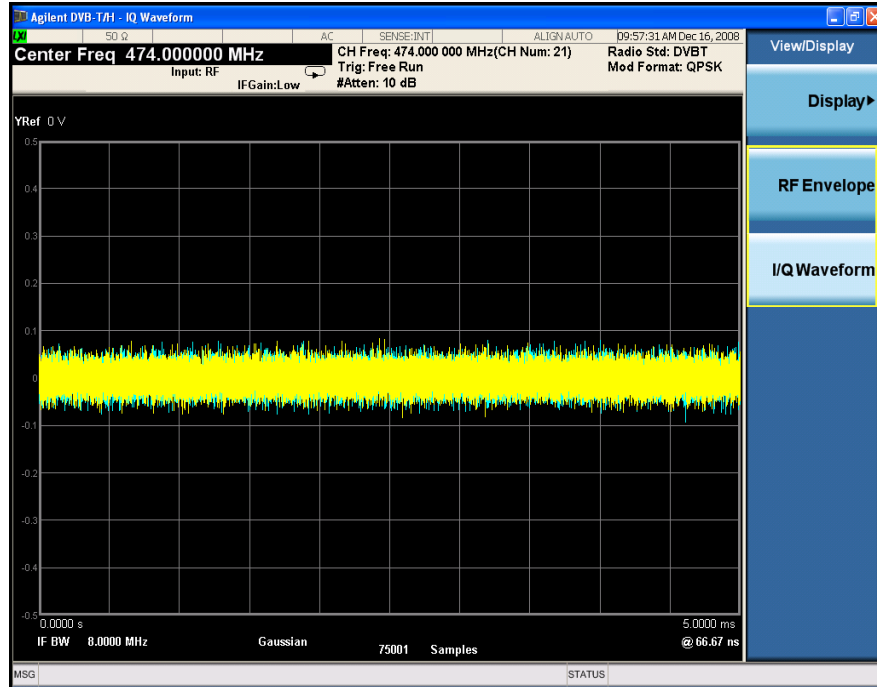
Step 9. Press **View/Display, IQ Waveform** to select the IQ waveform view.

IQ Waveform (Time Domain) Measurements Setting Up and Making Measurements

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 as shown in Figure 9-3.

Figure 9-3

Waveform Measurement - I/Q Waveform View



- Step 10.** Press the **AMPTD Y Scale, Scale/Div**, down arrow keys until the waveforms are shown at a convenient voltage scale for viewing, and set a proper value to the **Ref Value** key for an entire view.
- Step 11.** Press the **SPAN X Scale, Scale/Div**, down arrow keys until the waveforms are shown at a convenient time scale for viewing.
- Step 12.** Press the **Marker, Select Marker**, keys to activate a marker. Rotate the RPG 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 13.** Press the **Meas Setup** key to see the keys available to change the measurement parameters from the default condition.

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 10-1 **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
DTMB	IQ Waveform Power Stat CCDF Mod Accuracy
DVB-T/H	IQ Waveform Power Stat CCDF Mod Accuracy
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 Agilent 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 90” in the Concepts chapter.
- 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**

Using Option BBA Baseband I/Q Inputs
Baseband I/Q Measurement Overview

- 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.

11 **Concepts**

This chapter provides details about the DVB-T/H broadcast systems, 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 documents that are referenced for further information.

Introduction

DVB-T/H concept information is split between these sections as follows:

1. A general introduction for DVB-T/H Broadcast system, see [“What Is the DVB-T/H Broadcast System?”](#) on page 69.
2. Key technologies used in DVB-T/H system, see [“Key Technologies”](#) on page 71.
3. Concepts and measurement methods for each measurement.
 - [“Channel Power Measurement Concepts”](#) on page 73.
 - [“Adjacent Channel Power \(ACP\) Measurement Concepts”](#) on page 75.
 - [“Power Statistics CCDF Measurement Concepts”](#) on page 76.
 - [“Spurious Emissions Measurement Concepts”](#) on page 78.
 - [“Spectrum Emission Mask Measurement Concepts”](#) on page 80.
 - [“Modulation Accuracy Measurement Concepts”](#) on page 82.
 - [“Monitor Spectrum Measurement Concepts”](#) on page 86.
 - [“IQ Waveform Measurement Concepts”](#) on page 87.
4. Concepts and measurement methods for baseband I/Q input, see [“Baseband I/Q Inputs \(Option BBA\) Measurement Concepts”](#) on page 88.
5. Other sources of measurement information is also given, see [“Other Sources of Measurement Information”](#) on page 93.
6. See [“References”](#) on page 94 for references used in this chapter.

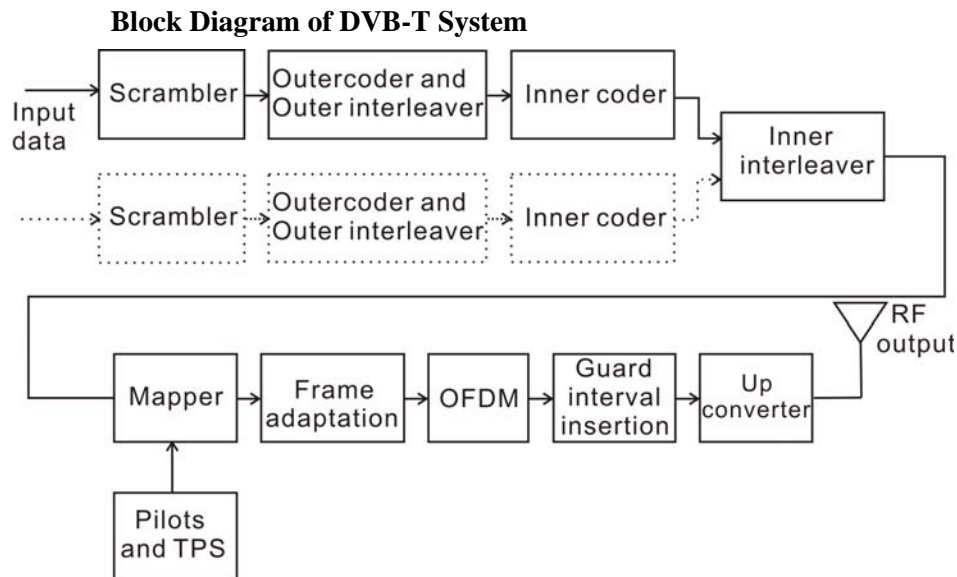
What Is the DVB-T/H Broadcast System?

Digital Video Broadcasting-Terrestrial/Handheld (DVB-T/H) is the European consortium standard for broadcast transmission of digital terrestrial/ handheld television.

DVB-T

DVB-T, compliant with the ETSI EN 300 744 standard, is the most popular digital terrestrial transmission system in the world. It performs the adaptation of the TV transmitted signals from the output of the MPEG-2 multiplexer. A block diagram of typical DVB-T system is shown in [Figure 11-1](#).

Figure 11-1



In DVB-T, the capacity for hierarchical modulation can enable two completely separate data stream to transmit in a single signal which can be used to trade bit rate versus ruggedness. The use of OFDM modulation with appropriate guard interval allows optimal trade-off between network topology and frequency efficiency. DVB-T has the following technical characteristics that make it a very flexible system.

3 modulation options: QPSK/ 16QAM/ 64QAM

5 different FEC rates: 1/2, 2/3, 3/4, 5/6, 7/8

4 Guard interval options: 1/4, 1/8, 1/16, 1/32

2 transmission modes: 2 k/ 8 k

3 channel bandwidth: 6/7/8 MHz

DVB-H

DVB-H is an extension of the DVB-T, which is suitable for handheld portable devices and mobile reception. It has been commercially launched on some European, Asian and African countries, and is being adopted more and more widely in the world.

DVB-H takes into account the properties of the handheld receivers such as small, light weight, portable and battery powered. DVB-H has the following specifications:

- **Time-slicing:** Rather than continuous data transmission as in DVB-T, DVB-H employs a mechanism where bursts of data is received at a time-an IP datacast carousel. This means that the receiver is inactive for much of the time, and can thus, by means of clever control signaling, be “switched off”. The result is a power saving of approximately 90 percent and more in some cases.
- **4 K mode:** With 4 K mode, DVB-H benefits from the compromise between the high-speed small-area SFN capability of 2 K DVB-T and the lower speed but larger area SFN of 8 K DVB-T. In addition, with the aid of enhanced in-depth interleaver in 2 K and 4 K modes, DVB-H has better immunity to ignition interference.
- **MPE-FEC:** The addition of an optional, multiplexer level, forward error correction scheme means that DVB-H transmissions can be even more robust.

Refer to [1] and [2] for more details of the DVB-T/H broadcast system.

Key Technologies

Hierarchical Transmission

DVB-T/H system supports hierarchical transmission, in which there are two transport stream inputs and two FEC blocks.

The stream with a low data rate is fed into the High priority (HP) path and provided with a large amount of error protection. The stream with higher data rate is fed in parallel into the Low priority (LP) path with less error protection.

On the HP path, the modulation type is equal to QPSK, which is a particularly robust type of modulation, while on the LP path, a higher level of modulation is needed due to the higher data rate. In DVB-T/H, the two paths are not modulated with different types of modulation. Instead, each carrier transmits both of LP data and HP data in 16QAM or 64QAM.

Frame Structure

DVB-T/H transmitted signal is organized in frames. Four consecutive frames form one super-frame. One frame contains 68 OFDM symbols, and one symbol has 6817 carriers in 8K mode and has 1705 carriers in 2K mode.

Besides the transmitted data, a Frame also contains scattered pilot cells, continual pilot carriers, and TPS (Transmission Parameter Signalling) carriers. The pilots is useful for frame synchronization, frequency synchronization, time synchronization, channel estimation, transmission mode identification and for following the phase noise. The TPS is used to inform the receiver the current transmission parameters.

OFDM

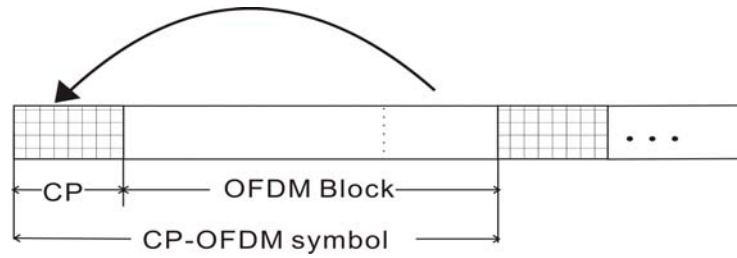
DVB-T/H uses Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFDM) for modulation.

In CP-OFDM, a cyclic prefix (CP) is inserted between two consecutive OFDM symbols as guard interval. The guard interval is designed to be longer than the maximum value of the channel's delay spread.

The cyclic prefix consists a cyclic continuation of the useful OFDM symbol time domain samples. By discarding the CP directly at the receiver, the inter symbol interference (ISI) is then removed.

By introducing CP, the convolution between the transmitting signal and the channel impulse response turns to a circular one, hence, the equalization can be performed with much low complexity. The signal frame structure of CP-OFDM is shown in [Figure 11-2](#).

Figure 11-2 Signal Frame Structure for CP-OFDM Symbols



Four values of GI (guard interval) can be used in DVB-T/H, which is $1/4$, $1/8$, $1/16$, $1/32$ of the duration of the OFDM block.

Channel Power Measurement Concepts

Purpose

The Channel Power measurement is an important test in the digital video industry to measure the channel power characteristics of the DVB-T/H radio signal. First of all, it measures the integrated power and power spectral density (PSD) in DVB-T/H defined bandwidth. Secondly, it measures and reports the shoulder attenuation. Thirdly, it provides a view comparing the input signal against the DVB-T/H defined spectrum mask under the condition of analog TV signal in adjacent channel.

Measurement Method

Channel Power measurement has three views. The measurement methods for each view are described as follows:

RF Spectrum

The RF Spectrum measurement reports the total transmitted power within the channel bandwidth (5/6/7/8 MHz for the DVB-T/H mode). The integration bandwidth (IBW) method is used to determine channel power.

Channel Power is a swept-frequency measurement allowing you to change the RBW and VBW settings manually. To improve repeatability, you can increase the number of averages. 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.

Shoulder Attenuation

For shoulder attenuation view, the measurement includes the following steps [3]:

- a. Find the maximum value of the spectrum by using resolution bandwidth at approximately 10 times the carrier spacing.
- b. Place declined, straight lines connecting the measurement points at 300 kHz and 700 kHz from each of the upper and lower edges of the spectrum. Draw additional parallel to these, so that the highest spectrum value within the respective range lies on the line.
- c. Subtract the power value of the center of the line (500 kHz away from the upper and lower edge) from the maximum spectrum value of step a and note the difference as the “shoulder attenuation” at the upper and lower edge.
- d. Take the worst case value of the upper and lower results from step c as the overall “shoulder attenuation”.

Spectrum Mask

For the spectrum mask which is used to compare with the input signal in the third

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Channel Power Measurement Concepts

view, refer to [2].

Adjacent Channel Power (ACP) Measurement Concepts

Purpose

Adjacent Channel Power (ACP), as it applies to DVB-T/H, 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 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.

Measurement Method

This 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 allows 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.

In this measurement, three methods can be used to calculate power.

- **IBW (Integration BW):** The channel integration bandwidth is analyzed using the user defined resolution bandwidth (RBW), which is much narrower than the channel bandwidth.
- **Filter IBW:** This method is useful for improving dynamic range on the signal because a sharp cutoff band pass filter is used.
- **RBW:** This method uses zero-span and an appropriate RBW setting to capture the power level in the carrier channel and the offsets.

If **Total Pwr Ref** is selected as the measurement type, the reference is the total power in carrier channel, and 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 reference is the PSD in carrier channel, the results are displayed as relative power in dB, and as absolute power in dBm/Hz.

Power Statistics CCDF Measurement Concepts

Purpose

Many 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 Broadcast systems.

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.

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. 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.

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.

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).

Then, to obtain the distribution, make a frequency distribution table in the power calculated above. In this measurement, there are 30001 points range from -200 dBm to 100 dBm by 0.01dB. For example: sampled power = 10 dBm, this means the 21000th index point of this table, so increase the variable that is index by this power.

After that, the CCDF trace vector can be made. The CCDF means a probability distribution more than any power and the trace starts from average power. The trace is obtained by converting the frequency distribution table of more than average power.

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.

Spurious Emissions Measurement Concepts

Purpose

Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions. Spurious emissions from the transmitter should be minimized to guarantee minimum interference with other frequency channels in the system.

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 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, determine 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. 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 selected range exceeds 2 seconds, a flashing message "Sweeping...Please wait" appears in the annunciator area. This message advises you that the time to complete the sweep is between 2 and 2000 seconds, and is used to prevent the display from appearing frozen, and to alert the user that the measurement is still ongoing.

Spurious emission limits for DVB-T transmitter defined by Standard

Spurious emissions shall not exceed the values set out in [Table 11-1](#) for the frequency range 9 kHz to 4.5 GHz. [4]

Table 11-1 Spurious emission limits for DVB-T transmitters

Frequency range	Limits	Reference bandwidth
9 kHz to 174 MHz	-36 dBm (250 nW)	100 kHz
> 174 MHz to 400 MHz	-82 dBm, for $P \leq 25 \text{ W}$ -126 dBc, for $25 \text{ W} < P \leq 1000 \text{ W}$ -66 dBm, for $1000 \text{ W} < P$	4 kHz
> 400 MHz to 790 MHz	-36 dBm (250 nW)	100 kHz
> 790 MHz to 862 MHz	-76 dBm, for $P \leq 25 \text{ W}$ -120 dBc, for $25 \text{ W} < P \leq 1000 \text{ W}$ -60 dBm, for $1000 \text{ W} < P$	4 kHz
> 862 MHz to 1000 MHz	-36 dBm (250 nW)	100 kHz
> 1000 MHz	-30 dBm (1 μW)	100 kHz
Note: P is the mean power of the transmitter		

Spectrum Emission Mask Measurement Concepts

Purpose

Spectrum Emission Mask measurements include the in-band and out-of-band spurious emissions. As it applies to DVB-T/H, 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 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.

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 6. 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.

Spectrum Emission limits defined by Standard

The spectrum emissions shall not exceed the limits specified in [Table 11-2](#) and [Table 11-3](#). [4]

Spectrum emission limits are given as mean power level measured in a 4 kHz bandwidth, where 0 dB corresponds to the mean output power.

For critical cases such as television channels adjacent to other services (low power or receive only), a spectrum mask with higher out-of-channel attenuation may be needed.

Unless otherwise declared by the manufacture, it shall be assumed that the UUT conforms to the non-critical case.

Table 11-2 Spectrum emission limits for transmitter with output power ≥ 25 W

Classification accordingly the frequency assignment	7 MHz Channel, frequency difference from the center frequency (MHz)	8 MHz Channel, frequency difference from the center frequency (MHz)	Relative level (dBc)
Non-critical cases	± 3.4	± 3.81	-32.2/-32.8
	± 3.7	± 4.2	-73
	± 5.25	± 6	-85
	± 10.5	± 12	-110
	± 13.85	-	-126
Critical cases	± 3.4	± 3.81	-32.2/-32.8
	± 3.7	± 4.2	-83
	± 5.25	± 6	-95
	± 10.5	± 12	-120
	± 11.75	-	-126

Table 11-3 Spectrum emission limits for transmitter with output power < 25 W

Classification accordingly the frequency assignment	7 MHz Channel, frequency difference from the center frequency (MHz)	8 MHz Channel, frequency difference from the center frequency (MHz)	Absolute level (dBm)
Non-critical cases	± 3.4	± 3.81	11.8/11.2
	± 3.7	± 4.2	-29
	± 5.25	± 6	-41
	± 10.5	± 12	-66
	± 13.85	-	-82
Critical cases	± 3.4	± 3.9	11.8/11.2
	± 3.7	± 4.2	-39
	± 5.25	± 6	-51
	± 10.5	± 12	-76
	± 11.75	-	-82

Modulation Accuracy Measurement Concepts

Purpose

Measurement of modulation accuracy and quality are necessary to meet DVB-T/H defined tests and ensure proper operation of the transmitters. 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 provides an overall indication of the performance level of the transmitter of the UUT.

Measurement Method

Modulation Accuracy measurement 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.

In the modulation accuracy measurement, the following data is provided:

- EVM - peak and rms error vector magnitude
- MER - distance between measured and theoretical constellation points
- Magnitude Error - rms magnitude error
- Phase Error - rms phase error
- Freq Error - the frequency difference between the transmitter's actual center frequency and the frequency (or channel) that you entered
- Quad Error - the orthogonal error between I and Q signals
- Amplitude Imbalance - a form of IQ gain imbalance
- TPS Decoding results-Original bits of TPS and information decoded from TPS
- BER results

The detailed description of the parameters above is as follows:

EVM

EVM (Error Vector Magnitude) is a modulation quality metric widely used in digital Broadcast systems. It is defined as:

$$EVM = \sqrt{\frac{\frac{1}{N} \sum_{j=1}^N (\delta I_j^2 + \delta Q_j^2)}{S_{max}^2}} \times 100\%$$

Where N is the number of data points in the measurement samples. S_{max} is the magnitude of the vector to the outermost state of the constellation.

NOTE

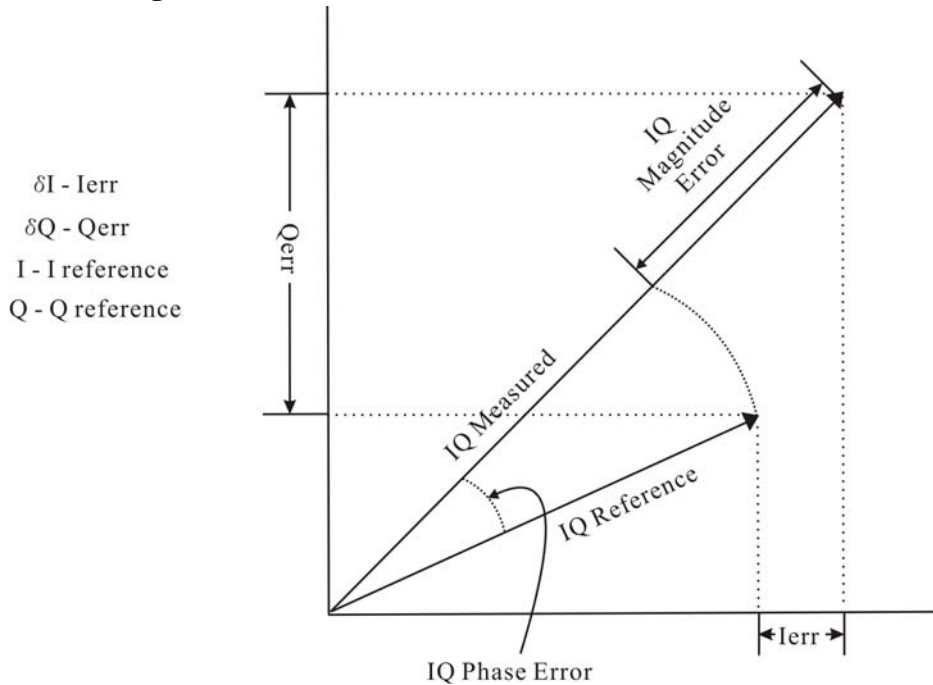
This definition is only used in broadcast industry, and in wireless industry EVM is defined as the ratio of error vector vs. RMS reference vector.

$$EVM = \sqrt{\frac{\frac{1}{N} \sum_{j=1}^N (\delta I_j^2 + \delta Q_j^2)}{S_{rms}^2}} \times 100\%$$

S_{rms} is calculated in the following way: $S_{rms} = \sqrt{\frac{1}{N} \sum_{j=1}^N (I_j^2 + Q_j^2)}$

The representation of other definitions are expressed in [Figure 11-3](#).

Figure 11-3 Digital Demodulation Error



MER

MER (Modulation Error Ratio) is a power ratio expressed in dB of the sum of

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Modulation Accuracy Measurement Concepts

squares of the magnitude of the ideal symbol vectors to the sum of the squares of the magnitudes of the symbol error vectors.

The MER is calculated as below:

$$MER = 10 \log_{10} \left[\frac{\sum_{j=1}^N (I_j^2 + Q_j^2)}{\sum_{j=1}^N (\delta I_j^2 + \delta Q_j^2)} \right] dB$$

N is the number of data points in the measurement samples.

The representations of other definitions are expressed in [Figure 11-3](#).

Magnitude Error

Magnitude Error is the difference in amplitude between the I/Q measured signal and the I/Q reference signal which is shown in [Figure 11-3](#).

Phase Error

Phase error is the difference in phase between the I/Q reference signal and the I/Q measured signal for composite signal. Phase Error is shown in [Figure 11-3](#).

Frequency Error

Frequency Error shows the signal carrier frequency-error relative to analyzer's center frequency. This parameter is displayed in Hz and is the amount of frequency shift, from the analyzer's center frequency, that the analyzer must perform to achieve carrier lock.

Errors in RF frequency, LO frequency, or digitizer clock rate could all appear as carrier frequency error.

Quad Error

Quad Error (Quadrature Skew Error) indicates the orthogonal error between the I and Q signals.

Ideally, I and Q should be orthogonal (90 degrees apart). A quadrature skew error of 3 degrees means I and Q are 93 degrees apart. A quadrature skew error of -3 degrees means I and Q are 87 degrees apart.

Amplitude Imbalance

Amplitude Imbalance is another form of IQ Gain imbalance. It is calculated from the formula below:

$$AI = \begin{cases} \left(\frac{v_I}{v_Q} - 1 \right) \times 100\% & \text{if } v_I > v_Q \\ \left(1 - \frac{v_Q}{v_I} \right) \times 100\% & \text{if } v_Q > v_I \end{cases}$$

Where v_I and v_Q represent I and Q gain respectively.

In order to exclude the interference between sub-carriers, AI is calculated by central carrier only. In 4k or 8k mode, central carrier is pilot (BPSK), then AI is not provided.

SNR

SNR stands for Signal-to-Noise Ratio. It is the power ratio of the measured signal data to the error data between the measured signal data and the reference signal data in dB.

Carrier Suppression

Carrier suppression searches for systematic deviations of all constellation points of the central carrier and isolate the residual carrier. It is calculated as below:

$$CS = 10 \log_{10} \left(\frac{P_{sig}}{P_{RC}} \right) dB$$

Where P_{RC} is the power of the residual carrier and P_{sig} is the power of the central carrier of the OFDM signal (without residual carrier).

TPS power ratio & Data power ratio

TPS power ratio is the power ratio of TPS carriers to the pilots.

Data power ratio is the power ratio of the measured signal data to the pilots.

The pilots are always at amplitude 4/3 (power = 16/9). The TPS carriers are supposed to be at a power of 1 and the expected power for the data is also supposed to be 1.

BER

BER performance of the signal transmitted is measured in the following three aspects.

1. BER before Viterbi (inner) decoder.
2. BER before RS (Outer) decoder.
3. BER after RS (outer) decoder (Bit error count).

Refer to [3] for more detail about measurement principle and method of BER measurement.

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.

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.

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
- DTMB
- DVB-T/H

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 “ \bar{I} ” and “ \bar{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 90.

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 a 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, DTMB, DVB-T/H, W-CDMA).
- Modulation accuracy – that is, I/Q plane metrics:
 - error vector magnitude; rms, peak
 - frequency error
 - magnitude and phase errors
- CCDF of $I^2 + Q^2$
- 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 Agilent 1153A active differential probe using the InfiniMax probe interface.

The Agilent 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 Agilent 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:

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 Agilent 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.)

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 Agilent 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 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.

Other Sources of Measurement Information

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

- Application Note 1298
Digital Modulation in Communications Systems - An Introduction
Agilent part number 5965-7160E
- Application Note
Characterizing Digitally Modulated Signals with CCDF Curves
Agilent part number 5968-5858E
- Application Note
BER and Subjective Evaluation for DVB-T/H Receiver Test
Agilent part number 5989-8446E

Instrument Updates at www.agilent.com

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

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

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

References

- [1] ETSI EN 302 304: Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H)
- [2] ETSI EN 300 744: Digital Video Broadcasting (DVB); Frame structure, channel coding and modulation for digital terrestrial television
- [3] ETSI TR 101 290: Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems
- [4] ETSI EN 302 296: Electromagnetic compatibility and Radio spectrum Matters (ERM); Transmitting equipment for the digital television broadcast service, Terrestrial (DVB-T); Harmonized EN under article 3.2 of the R&TTE Directive