# Keysight X-Series Signal Analyzers

This manual provides documentation for the following Analyzers:

PXA Signal Analyzer N9030A
EXA Signal Analyzer N9010A
MXA Signal Analyzer N9020A
CXA Signal Analyzer N9000A

Notice: This document contains references to Agilent. Please note that Agilent's Test and Measurement business has become Keysight Technologies. For more information, go to www.keysight.com.

# N6153A & W6153A DVB-T/H with T2 Measurement Application Measurement Guide

KEYSIGHT TECHNOLOGIES

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# Table of Contents

# 1 About the DVB-T/H with T2 Measurement Application

The N6153A (for PXA, MXA, EXA) & W6153A (for CXA) DVB-T/H with T2 measurement application offers two options:

a. N6153A–2FP/W6153A-2FP DVB-T/H measurement application

   With this option, the mode name is DVB-T/H and measurements on DVB-T/H signals can be supported.

b. N6153A–3FP/W6153A-3FP DVB-T2 measurement application

   With this option, the mode name is DVB-T/H with T2 and measurements on DVB-T2 signals, which are compliant with ETSI EN 302 755 V1.1.1 or V1.2.1, are supported. Note that the 3FP option must be used together with the 2FP option.

**NOTE**

The "FP" in the option name is short for fixed perpetual, which means you can only install the license key on the specific instruments for which it was created. For PXA, MXA, and EXA, there is another license type called "TP", short for transportable perpetual, which means you can transport this license key between instruments.

The transportable licenses for the two N6153A options are N6153A-2TP and N6153A-3TP. In this document, all the features and functions for N6153A-2FP, N6153A-3FP also apply to N6153A-2TP, N6153A-3TP.

This chapter provides the overall information on the N6153A & W6153A DVB-T/H with T2 measurement application, and describes DVB-T/H and DVB-T2 measurements made by the analyzer.

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

DVB-T2 (Digital Video Broadcasting – Second Generation Terrestrial), is an evolution of DVB-T, which incorporates the latest advanced technologies.

## What Does the DVB-T/H with T2 Application Do?

The DVB-T/H with T2 application allows the analyzer to be used for testing a DVB-T/H/T2 transmitter or exciter and for DVB-T field test in SFN (single frequency network) scenarios. This application is manufactured according to the following standard documents:

- ETSI EN 300 744 Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television
- ETSI EN 302 304 Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H)
- ETSI EN 302 755 V1.1.1 Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)
- ETSI EN 302 755 V1.2.1 Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)
- DVB Document A133 Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)
- 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
- ETSI TR 101 290 Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems

These documents define complex, multi-part measurements used to create and maintain an interference-free environment. For example, the documents include standardized test methods for the measurement of power, spectrum emission mask, and other critical measurements.

The instrument automatically makes these measurements using the measurement methods and limits defined in the documents. The detailed results displayed by the measurements enable you to analyze DVB-T/H and DVB-T2 transmitter's performance. You may alter the measurement parameters for specialized analysis. For an infrastructure test, the analyzer will test transmitters in a non-interfering manner using a coupler or power splitter.

This analyzer makes the following measurements on DVB-T/H and DVB-T2 signals:

- Channel Power
- Adjacent Channel Power (ACP)
- Power Stat CCDF
- Spectrum Emission Mask
- DVB-T/H Modulation Accuracy

- DVB-T2 Modulation Accuracy
- Spurious Emissions
- Monitor Spectrum
- IQ Waveform (Time Domain)

If the option BBA is installed, the ability to analyzer baseband I/Q signal characteristics of mobile and base station transmitters is provided. The Baseband I/Q Input is available in the following measurements:

- DVB-T/H Modulation Accuracy
- DVB-T2 Modulation Accuracy
- Power Stat CCDF
- IQ Waveform (Time Domain)

# 2 Making DVB-T/H with T2 Measurements

This chapter begins with instructions common to all measurements, and then illustrates how to make measurements supported by N6153A/W6153A DVB-T/H with T2 measurement application, including DVB-T/H/T2 transmitter tests and DVB-T field tests in SFN scenarios.

# 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 connector on the front panel.

See the **Input/Output** key menus for details on selecting input ports and **AMPTD Y Scale** menu for details on setting internal attenuation to prevent overloading of 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

Generally speaking, all measurements can be set up using the following three steps in Table 2-1. Table 2-2 shows the main keys and functions that may be used while following the steps.

**NOTE** Press the Help key on the front panel to enter the help system and see the detailed descriptions for the keys you are not familiar with. Press the Cancel (Esc) key on the front panel to exit the help system.

*Table 2-1 The 3 Steps to Set up and Make a Measurement*

| Step | Action | Notes |
|---|---|---|
| **Select and Set Up the Mode** | a. Press **Mode.**<br>b. Press a mode key, like **Spectrum Analyzer**, **IQ Analyzer (Basic)**, or **DVB-T/H with T2**.<br>c. Press **Mode Preset.**<br>d. Press **Mode Setup**. | All licensed, installed modes available are shown under the **Mode** key.<br>Using **Mode Setup**, make any required adjustments to the mode settings. These settings apply to all measurements in the mode. |
| **Select and Set Up the Measurement** | a. Press **Meas.**<br>b. Select the specific measurement to be performed.<br>c. Press **Meas Setup**. | The result data is shown on the display or is available for export.<br>Use **Meas Setup** to make any required adjustment to the selected measurement settings. The settings only apply to this measurement. |
| **Select and Set Up a View of the Results** | Press **View/Display**. Set the display format and select a view for the current measurement data. | Depending on the mode and measurement selected, the graphical and tabular data presentations are available.<br>Use **Span X Scale** and **AMPTD Y Scale** to adjust the display of the measurement graphics. |

**NOTE** You can change settings as needed, and the changes will be in effect on the next measurement cycle or view.

*Table 2-2 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**, **Input/Output** |
| **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, Save**, **Recall**, **File**, **Print** |

**NOTE** 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\Keysight\SignalAnalysis\Infrastructure\Help\bookfiles.

## Common Measurement Steps – Setting up DVB-T/H with T2 Mode

This section lists the steps common to all measurements in DVB-T/H with T2 mode. Whatever measurements you are making, you need to begin with the following steps:

| Step | Notes |
|---|---|
| Press **Mode**, **DVB-T/H with T2.** | If you do NOT have the N6153A-3FP (W6153A-3FP for CXA) license installed in the instrument, the mode name will be **DVB-T/H.** |
| Press **Mode Preset.** | |
| Do one of the following to set center frequency:<br>• Press **FREQ Channel**, **Center Freq**, 474, **MHz.**<br>• Press **FREQ Channel**, **Chan Table**, **PAL-B/G**, **PAL-B/G UHF** and then press **FREQ Channel**, **Channel**, 21. | The first method is to enter the frequency directly.<br>The second method is to set the frequency through channel table. Multiple channel tables are predefined in the instrument, including NTSC-M, NTSC-J, NTSC-Brazil, PAL-M, PAL-I, PAL-B/G, and PAL-D/K.<br>You can change the definition of the channel table following the steps in “Customizing the Channel Table Definition” on page 18. |
| Press **Mode Setup**, **Radio Std**, and choose the standard under test. | The display on the Radio Std menu depends on the licenses installed in your instrument:<br>• If only N6153A-2FP (W6153A-2FP for CXA) is installed, two keys **DVB-T** and **DVB-H** are displayed.<br>• If both N6153A-2FP (W6153A-2FP for CXA) and N6153A-3FP (W6153A-3FP for CXA) licenses are installed, all the three keys **DVB-T**, **DVB-H**, and **DVB-T2** are displayed.<br>Note that if the current measurement is DVB-T/H Mod Accuracy, the **DVB-T2** key under Radio Std menu is grayed out, and if the current measurement is DVB-T2 Mod Accuracy, the **DVB-T** and **DVB-H** keys are grayed out. In this case, switch to other measurements before changing the radio standard. |
| Press **Mode Setup**, **Channel BW** and select the bandwidth of the signal under test. | If the radio standard is set to be DVB-T or DVB-H, four options including 5 MHz, 6 MHz, 7 MHz, and 8 MHz are available.<br>If the radio standard is set to be DVB-T2, six options including 1.7 MHz, 5 MHz, 6 MHz, 7 MHz, 8 MHz, and 10 MHz are available. |

## Customizing the Channel Table Definition

Channel table function enables you to specify the center frequency by entering the channel number under a specific channel table. In a channel table, each channel number corresponds to a center frequency exactly. The predefined channel table complies with industry standards.

A channel table file is used to export, edit, and then import the channel table settings so that you can customize the channel table to satisfy your measurement requirements.

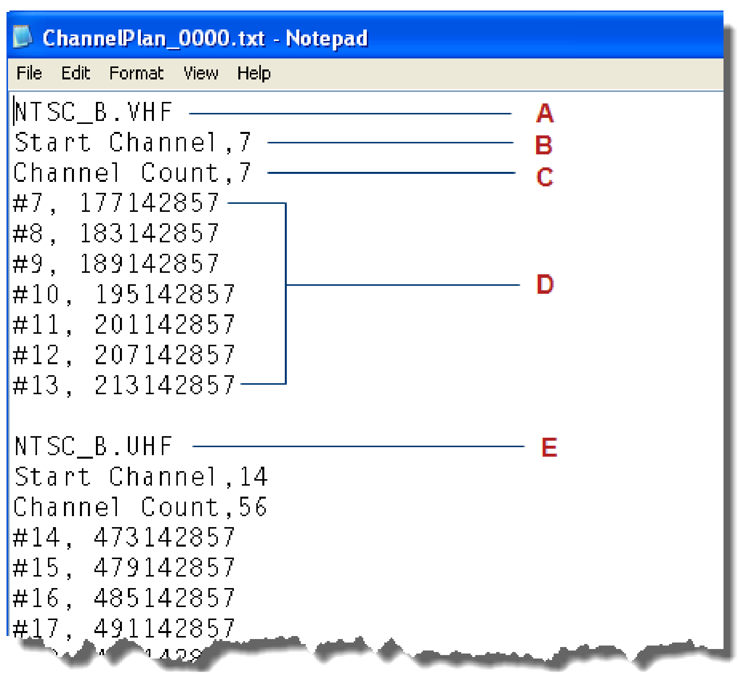
The format of the channel table file is illustrated in Figure 2-1. The channel table file includes channel definitions for all the channel plans, such as NTSC-B, NTSC-J, NTSC-M, PAL-M, PAL-I, PAL-B/G, and PAL-D/K. Each channel plan is separated with a blank line.

File default location: My Documents\Digital Video\data

File type: text file

File extension: .txt

*Figure 2-1* *Format of the Channel Table File*




**A**. Channel plan name. This is the channel plan for NTSC-B VHF;

**B**. Start channel number. Here, the start channel number is 7;

**C**. Channel count in the current channel plan. There are 7 channels in the predefined NTSC-B VHF.

**D**. Channel number and corresponding center frequency, unit Hz. For example, #7, 177142857 means the center frequency for the channel 7 is 177142857 Hz.

**E**. The start of another channel plan NTSC-B UHF.

Perform the following steps to customize the channel table:

| Step | Notes |
|---|---|
| Press **Save**, **Data**, **Channel Table**, and then press **Save As...**, save the current channel table file as ChannelPlan_0000.txt (for example). | This saves the data of the current channel table into a file.<br>You can save the file into the default directory "My Documents\Digital Video\data" or any other locations you like. |
| Open the saved channel table file ChannelPlan_0000.txt, find the channel plan you are going to edit, and then make your desired changes. | You can add your own channel definitions to the channel table file, edit the center frequency value for the predefined channel, or remove the channel definitions unnecessary for your test.<br>▪ Adding channel definitions<br>First, choose and find the channel plan you’re going to edit on, for example, NTSC_B.VHF. Then, add the channel definitions including channel number and corresponding center frequency following the format "# channel number, center frequency". After that, edit the Start Channel and Channel Count values according to your changes.<br>▪ Editing the center frequency value for the channel<br>Choose and find the channel plan you’re going to edit, and then enter the center frequency value for the channel.<br>▪ Removing unnecessary channel definitions<br>Choose and find the channel plan you’re going to edit, and then delete the unnecessary channel definition. After that edit the Start Channel and Channel Count values.<br>Note that the name of the channel plan cannot be changed. If it is changed, the modifications under this channel plan will not work and the default channel settings of the channel plan will work instead. |
| Press **Recall**, **Data**, **Channel Table**, then press **Open...**, and open the channel table file you edited. | |
| Press **FREQ Channel** to specify the center frequency under the new channel table. | If the instrument is restarted, the channel table file needs to be recalled again. |

# DVB-T/H/T2 Transmitter Measurements

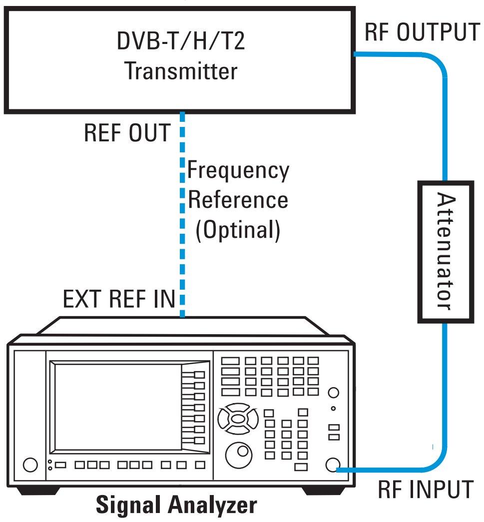
This section describes how to make measurements on DVB-T/H/T2 transmitters. It includes the configurations of the measurement system, the test signal settings, detailed procedure of each measurement, and the measurement results.

## Configuring the Measurement System

Set the DVB-T/H/T2 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 below.

1. Connect the output signal from the DVB-T/H/T2 transmitter to the RF input port of the analyzer using appropriate cables, attenuators, and adapters.
2. (Optional) If there is a frequency reference port on the DVB-T/H/T2 transmitter, connect it to the EXT REF IN port of the analyzer with a cable for frequency synchronization.

*Figure 2-2* *Measurement System Block Diagram*




After finishing the connection, see the **Input/Output** key menus for details on selecting input ports and **AMPTD Y Scale** menu for details on setting internal attenuation to prevent overloading of the analyzer.

## Setting the DVB-T/H/T2 Transmitters (Example for Power Measurements)

Set up the DVB-T/H/T2 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

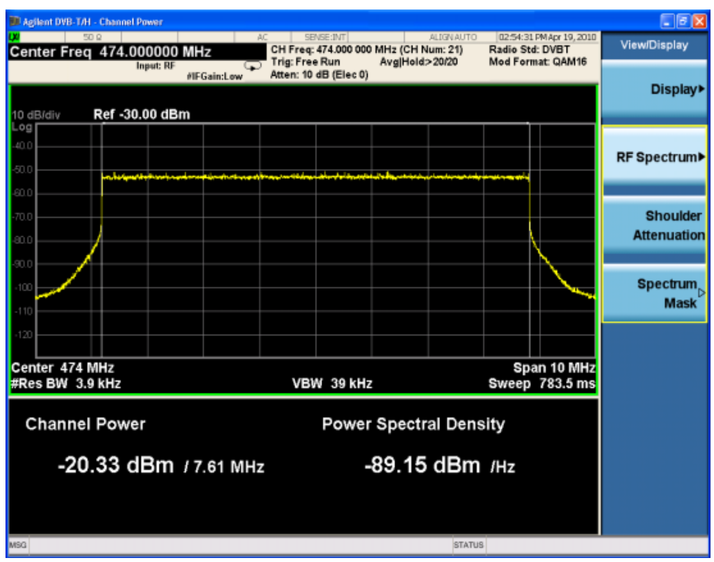
Transmitted Power: 40 dBm (at RF output); -20 dBm (at the analyzer input)

## Channel Power Measurements

This section explains how to make a Channel Power measurement on a DVB-T/H/T2 transmitter/exciter.

This test measures the total RF power and shoulder attenuation present in the channel, and provides a view that compares the input signal against the spectrum mask defined in DVB standard (ETSI EN 300 744) under the condition of an analog TV signal in an adjacent channel.

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to “Common Measurement Steps – Setting up DVB-T/H with T2 Mode” on page 17 | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **Channel Power**. | This selects the Channel Power measurement. |
| Press **View/Display**, **RF Spectrum.** | This selects the RF Spectrum view. |
| View the RF Spectrum results. | In the figure below, the graph window shows the spectrum trace and the text window shows the total power and PSD (power spectral density) level.<br><br>To change the measurement integration bandwidth, press **Meas Setup**, **Integ BW**. |



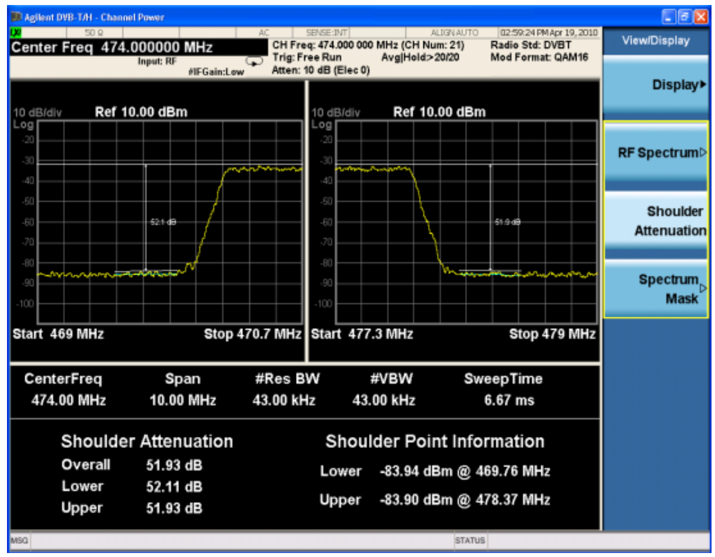

| Step | Notes |
|---|---|
| Press **View/Display**, **Shoulder Attenuation**; | This selects the Shoulder Attenuation view. |

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the shoulder attenuation results.</td><td>

In the figure below, the text window shows the shoulder attenuation value and shoulder points information.

To make the measurement on a specified frequency range, press **Meas Setup** and set the values for **Shoulder Offset Start** and **Shoulder Offset Stop** correspondingly.

To learn more about the measurement method of shoulder attenuation, refer to “Shoulder Attenuation” on page 101.




</td></tr>
<tr><td>Press Input/Output, External Gain, Ext Preamp, -60, dB</td><td>This sets the value for the external attenuator.</td></tr>
<tr><td>

Press **Input/Output**, **More 1 of 2**, **Corrections**, toggle the **Correction** key to **On**, and then do one of the following to specify correction data:

- Press **Edit** and enter the frequency and amplitude data.
- Press **Recall**, **Data (Import) Amptd Cor1**, **Open** to import the correction file.

</td><td>

This applies amplitude correction.

To get the format of the correction file to be recalled, first edit several points using the onscreen editor, then press **Save**, **Data (Export) Correction 1**, **Save As...** to save the correction data to a file. Open the file, and view the format.

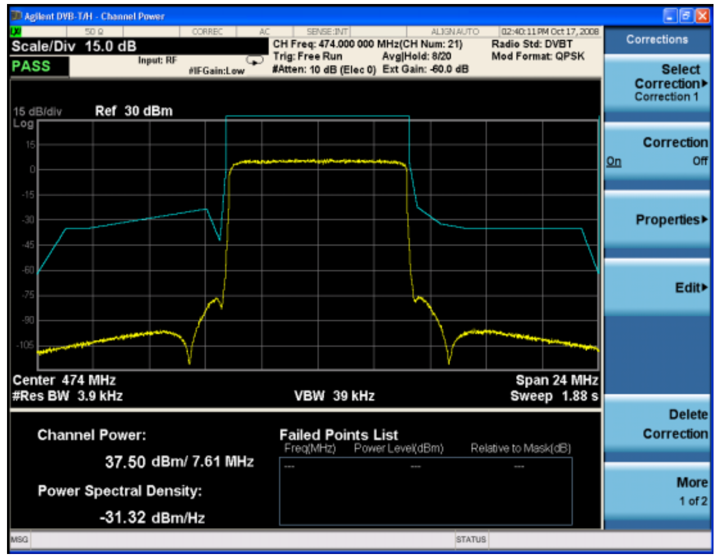
For more information regarding amplitude correction and the definition of correction data, refer to “Amplitude Correction in the Spectrum Emission Mask Measurement” on page 109.

</td></tr>
<tr><td>Press View/Display, Spectrum Mask and then press Spectrum Mask, L/SECAM/NICAM.</td><td>

This selects the Spectrum Mask view and sets the limit mask.

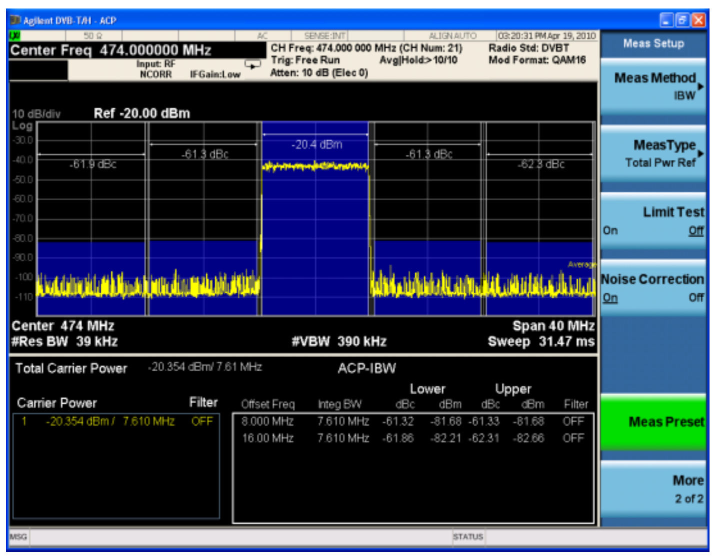
For more details about the definition of the spectrum masks, refer to “Spectrum Mask” on page 101.

</td></tr>
</table>

| Step | Notes |
| --- | --- |
| View the spectrum mask results. | Use this view when an analog TV signal is present in an adjacent channel.  If the channel bandwidth is not 8 MHz, no mask trace will be displayed and a “No Result” message will be displayed, as no spectrum masks for those bandwidths are defined in the specs. |

## ACP Measurements

This section describes the Adjacent Channel Leakage Power Ratio (ACLR or ACPR) measurements on a DVB-T/H/T2 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.

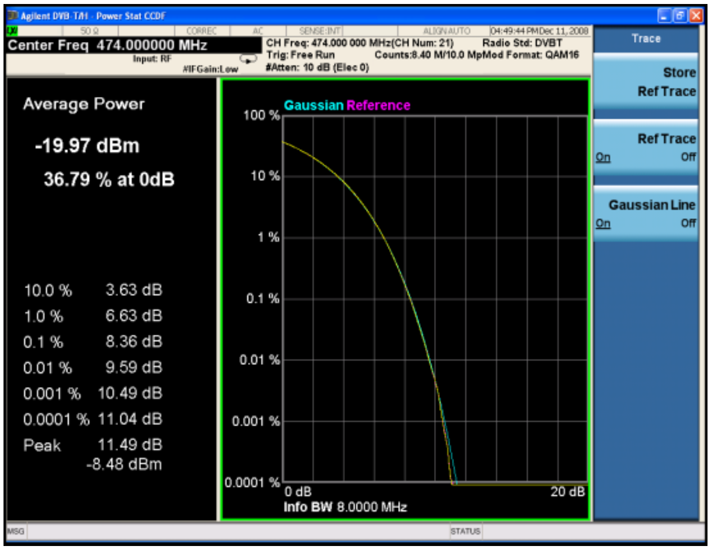
| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to “Common Measurement Steps – Setting up DVB-T/H with T2 Mode” on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **ACP**. | |
| (Optional) Press **Meas Setup**, **More 1 of 2**, **Noise Correction** and toggle it to **On**. | This operation can reduce the noise levels and improve the ACP measurement results. |
| View the ACP measurement results. | In the figure below, the graph window shows the bar graph with the spectrum trace overlay, and the text window shows the total power in reference channel, absolute, and relative power in offset channels.  You can define your own limit mask by configuring the related parameters such as settings under **Meas Setup**, **Carrier Setup** and **Offset/Limits**, and toggle **Limit Test** under **Meas Setup** to **On**. |

## Power Statistics CCDF Measurements

This section outlines how to make the Power Statistics Complementary Cumulative Distribution Function (Power Stat CCDF) measurements on a DVB-T/H/T2 transmitter. Power Stat CCDF measurements characterize the higher level power statistics of a digitally modulated signal.

Power Statistics CCDF measurements can also be used to measure the BBIQ (Baseband I/Q) signals. For the detailed measurement procedure, refer to "Using Option BBA Baseband I/Q Inputs" on page 81.

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Power Stat CCDF**. | |
| View the Power Stat CCDF measurement results. | In the following figure, the statistic data of the peak to average ratio is listed in the text window. In the graph window, 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**. |

| Step | Notes |
|---|---|
| Press **Trace/Detector**, **Ref Trace (On)** to display the user-definable reference trace (violet line). | The reference trace is a measurement trace stored as a reference trace to be compared to a 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.  |



### Troubleshooting Hints

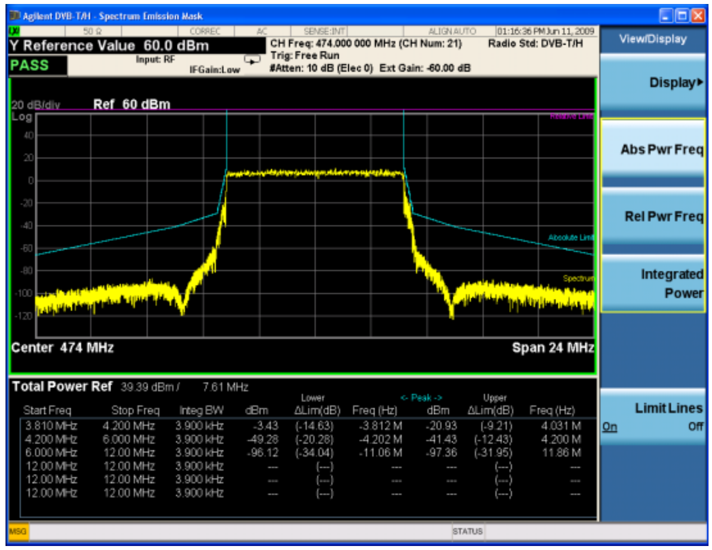
The Power Statistics CCDF measurements are useful in defining the signal power specifications for design criteria for systems, amplifiers, and other components. When the signal power is larger than the limit of the mixer or ADC, the CCDF result trace will deviate from the Gaussian trace.

## Spectrum Emission Mask Measurements

This section describes how to make a Spectrum Emission Mask (SEM) measurement on a DVB-T/H/T2 transmitter. SEM measurements compare the power levels within given offset channels on both sides of the carrier frequency, to the power levels allowed by the standard when there are digital TV signals or other services in adjacent channel. Results of each offset segment measurement can be viewed separately.

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Spectrum Emission Mask**. | This selects the Spectrum Emission Mask measurement. |
| Press **Input/Output**, **External Gain**, **Ext Preamp**, -60, **dB**. | This sets the value for the external attenuator to get the actual transmitting power of the transmitter under test.<br><br>Note that the spectrum mask varies with the change of the transmit power as shown in Table 3-6 on page 108 and Table 3-7 on page 109. |
| Press **Input/Output**, **More 1 of 2**, **Corrections**, toggle the **Correction** key to **On**, and then do one of the following to specify correction data:<br><br>Press **Edit** and enter the frequency and amplitude data.<br><br>Press **Recall**, **Data (Import) Amptd Cor1**, **Open** to import the correction file. | This applies amplitude correction.<br><br>To get the format of the file to be recalled, first edit several points using onscreen editor, then press **Save**, **Data (Export) Correction 1**, **Save As...** to save the correction data to a file. Open the file, and view the format.<br><br>For more detailed information regarding amplitude correction and the definition of correction data, refer to "Amplitude Correction in the Spectrum Emission Mask Measurement" on page 109. |
| Press **Meas Setup**, **Limit Type**, **Non-Critical**. | This selects the non-critical limit mask.<br><br>If the Channel BW is set to 1.7 MHz, 5 MHz, 6 MHz, or 10 MHz, the limit type is set to manual automatically, and the **Non-Critical** and **Critical** keys will be grayed out. You can set the limit line manually through **Meas Setup**, **Offset/Limit**.<br><br>If the Channel BW is set to 7 MHz or 8 MHz, the **Limit Type** key has three options: Manual, Non-critical and Critical. The default value is Non-Critical. The limit masks for non-critical cases and critical cases are listed in Table 3-6 on page 108 and Table 3-7 on page 109. |

| Step | Notes |
|---|---|
| View the Spectrum Emission Mask measurement results. | In the figure below, the top window shows the measured trace together with the limit mask and the bottom window lists the related parameters.<br><br>To make the spectrum emission mask measurement with your own limit mask, press **Meas Setup** and then set the parameters under **Ref Channel** and **Offset/Limit** panel. |




You can zoom on either the graphic window or the text window by pressing the Window Control keys at the left bottom of the front panel.

**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.

## DVB-T/H Modulation Accuracy Measurements

This section describes how to make a DVB-T/H Modulation Accuracy measurement on a DVB-T/H transmitter. DVB-T/H Modulation Accuracy measurements provide 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.

DVB-T/H Mod Accuracy measurements can also be used to measure the BBIQ (Baseband I/Q) signals. For the detailed measurement procedure, refer to "Using Option BBA Baseband I/Q Inputs" on page 81.

### DVB-T/H Signal Settings (Example)

The settings of the DVB-T/H signal under test is as follows (for example):

Standard: DVB-T

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

Channel Bandwidth: 8 MHz

FFT Size: 2 K

Modulation Type: 16 QAM

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 | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect.<br><br>If the Radio Std under Mode Setup is set to DVB-T2, DVB-T/H Mod Accuracy measurement will be grayed out. Use DVB-T2 Mod Accuracy instead to measure the modulation accuracy for the DVB-T2 signals. |
| Press **Meas**, **DVB-T/H Mod Accuracy**. | This selects the DVB-T/H Mod Accuracy measurement. |

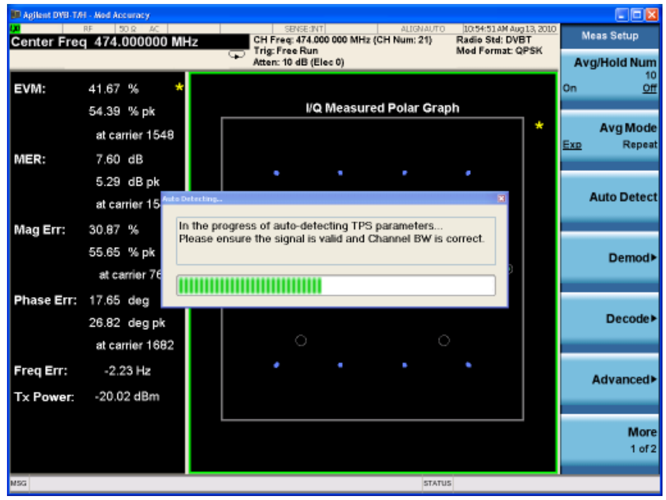
<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>

Do one of the following to set the demodulation settings:

- Press **Meas Setup**, **Auto Detect.**
- Press **Meas Setup**, **Demod**, and then,
  - Press **FFT Size**, **2K.**
  - Press **Modulation Format**, **16QAM.**
  - Press **Alpha**, **Alpha = 1.**
  - Press **Guard Interval**, **1/4.**
  - Toggle the **Hierarchical** key to **On.**
  - Press **More 1 of 2**, **HP Code Rate**, **1/2.**
  - Press **LP Code Rate**, **1/2.**

</td><td>

The first method uses auto-detect functions which detect the modulation parameters from the TPS information of the input signal as shown below.




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

The second method is to set the modulation parameters manually.

</td></tr>
<tr><td>

Press **View/Display**, **I/Q Measured Polar Graph.**

</td><td>

This selects the I/Q Measured Polar Graph view.

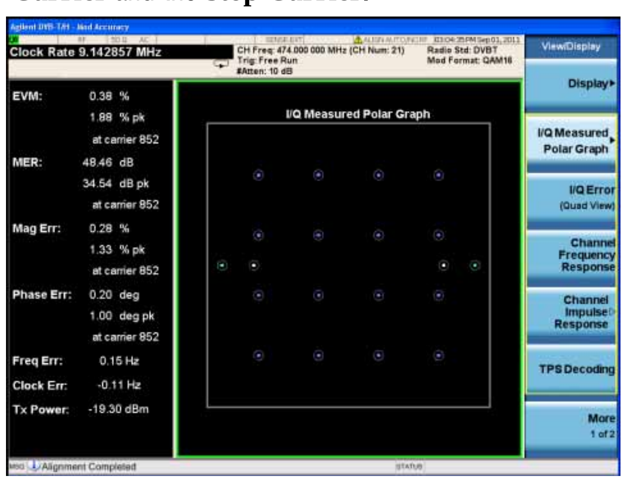
</td></tr>
<tr><td>

View the I/Q Measured Polar Graph results.

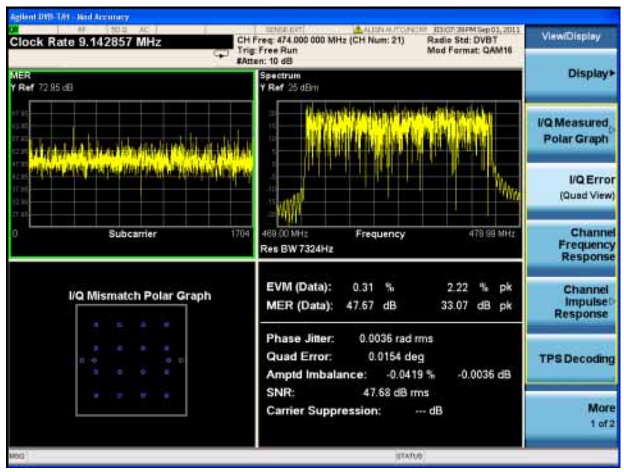
</td><td>

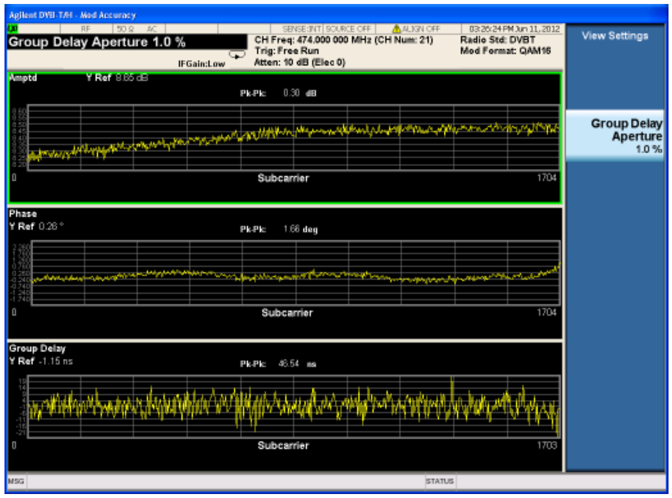
The figure below displays a combination view of the constellation graph and metric result windows. RMS values, peak values, and peak position for EVM, MER, magnitude error, phase error, and frequency error results are listed in the metric result window.

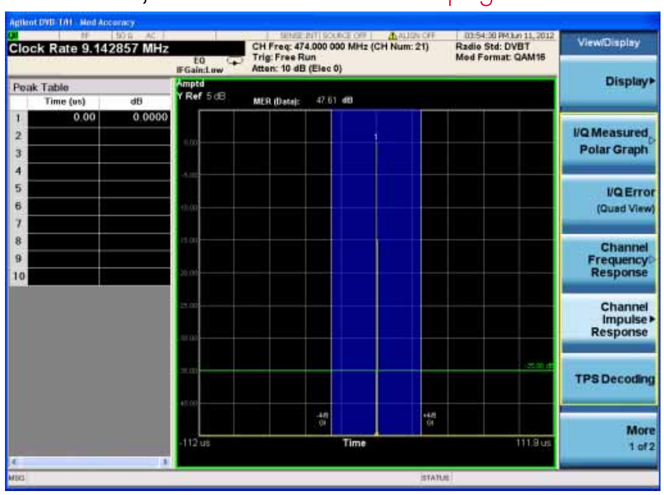
To view the modulation constellation graph for the specified carrier ranges, press **I/Q Measured Polar Graph** again and set the **Start Carrier** and the **Stop Carrier**.

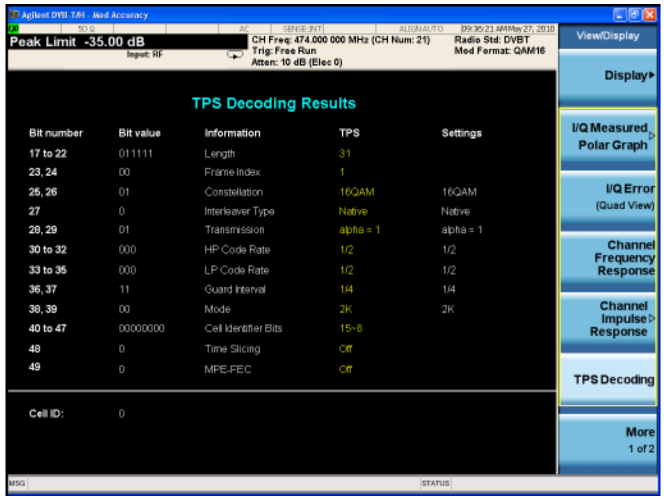
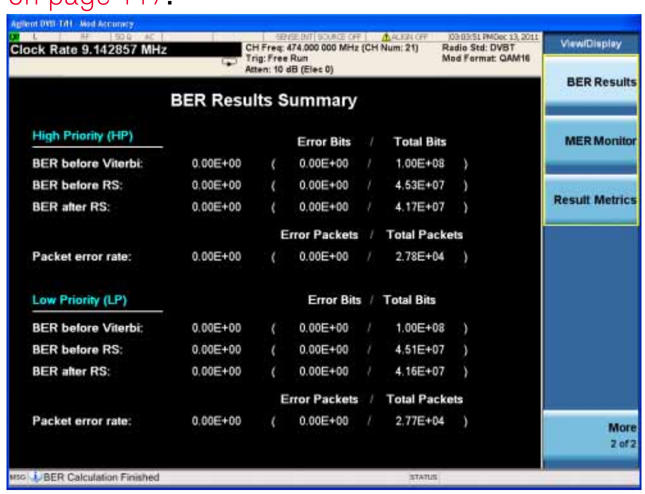



</td></tr>
</table>

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>Press View/Display, I/Q Error.</td><td>This selects I/Q Error (Quad View).</td></tr>
<tr><td>View the I/Q Error results.</td><td>The figure below shows the MER/EVM vs. subcarrier/frequency, spectrum, I/Q mismatch polar graph, and a result summary.<br><br>You can change the scale type for the vertical axis and the horizontal axis in the top left window by setting the Scale Type key under AMPTD Y Scale and Span X Scale menu.<br><br>To display the carrier suppression results in the result summary window, press Meas Setup, Advanced, I/Q Mismatch, and toggle it to Std. For more details about Std and Fast, refer to “Std and Fast Method” on page 119.<br>

</td></tr>
<tr><td>Press View/Display, Channel Frequency Response.</td><td>This selects the Channel Frequency Response view.<br><br>If the currently selected window is the first window, amplitude vs. subcarrier window, you can use the normalize function under Trace/Detector, Normalize menu to measure the frequency response of a device, such as an amplifier or attenuator. For more information, refer to “Using Normalize Function in Channel Frequency Response View” on page 37.</td></tr>
</table>

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the channel frequency response results.</td><td>The figure below displays the amplitude, phase, and group delay on every subcarrier. The Pk to Pk value displayed on the top of each window is the difference between the maximum value and the minimum value in the current window.<br><br>The group delay aperture can be adjusted by pressing View/Display, Channel Frequency Response. Refer to “Group Delay Aperture” on page 121 for more details.<br>
</td></tr>
<tr><td>Press View/Display, Channel Impulse Response, and then press Meas Setup, Advanced, Equalization, toggle it to ON.</td><td>This selects Channel Impulse Response view and turns on the equalizer to get better channel impulse response results.</td></tr>
</table>

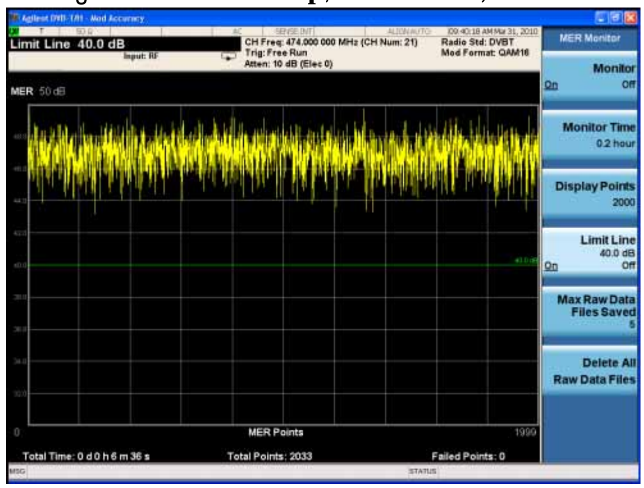
| Step | Notes |
| --- | --- |
| View the Channel Impulse Response results. | In the figure below, the graphic window shows the channel impulse response trace and the text window shows a peak table listing the top 10 peaks on the trace.<br><br>The blue bar with the range of GI indicates that all the paths included are used to reconstruct the signal for measurement. The position of the blue bar will be changed with the FFT Start Position (under Meas Setup, Advanced, More 1 of 2 panel) value. Refer to "SFN Reception Conditions and FFT Start Position" on page 115 for more information.<br><br>The green line with -35 dB above its right side is the peak limit line, which means only peaks above this line can be displayed in the peak table. To adjust the peak limit line, press **Peak Search**, **More 1 of 2**, **Peak Table**, and then enter your desired peak limit value.<br><br>Peak Table window is very useful in multi-path channel. For more information, refer to "Peak Table" on page 121.<br> |
| Press **View/Display**, **TPS Decoding**. | This selects the TPS Decoding view. |

| Step | Notes |
|---|---|
| View the TPS Decoding results. | In the figure below, the results in yellow shows the information conveys in the TPS bits, and the results in white in the rightmost row indicate the current settings under **Mode Setup**, **Demod**.  |
| Press **View/Display**, **More 1 of 2**, **BER Results.** | This selects the BER Results view. If the TS packet under transmission is null TS packets, press **Meas Setup**, **Decode**, **Payload,** and toggle it to **NullPacket**. |
| View the BER results. | Four results including BER before Viterbi, BER before RS, BER after RS, and Packet error rate for HP and LP streams are displayed. Note that if the transmitter under test is NOT in hierarchical mode, the low Priority (LP) part will not be displayed. For more details about the BER calculation methods, refer to “BER” on page 117.  |
| Press **View/Display**, **More 1 of 2**, **MER Monitor**. | This selects the MER Monitor view. |

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the MER Monitor results.</td><td>

The figure below displays the MER results in sequence during the MER monitor process, at the same time, log files and raw data are recorded. For details, refer to “MER Monitor Process” on page 119.

You can customize the MER monitor measurement using the settings under **Meas Setup**, **More 1 of 2**, **MER Monitor**.



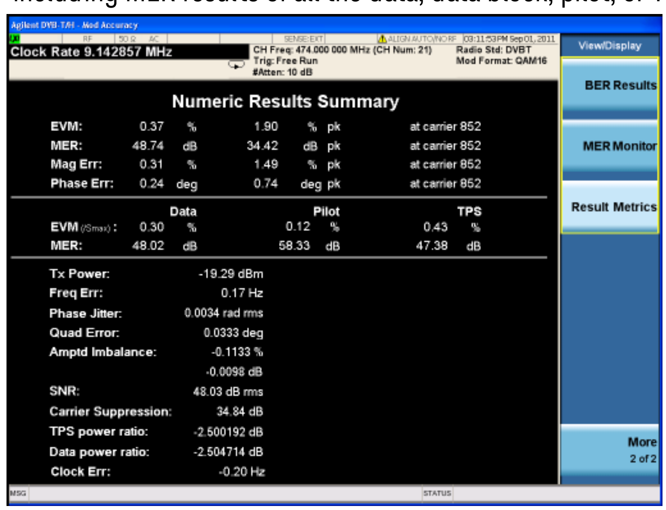

</td></tr>
<tr><td>Press View/Display, More 1 of 2, Result Metrics.</td><td>

This selects the Result Metrics view.

To display BER results on this view, press **Meas Setup**, **Decode**, and toggle **Decoding** to **On**.

</td></tr>
<tr><td>View the summary of the measurement results.</td><td>

The figure below displays a summary of the measurement results, including MER results of all the data, data block, pilot, or TPS bits.




</td></tr>
</table>

### Using Normalize Function in Channel Frequency Response View

Normalize function in channel frequency response view can be used to measure the frequency response of a device, such as an amplifier or attenuator. Here, take an attenuator as an example. The detailed procedure is as below.

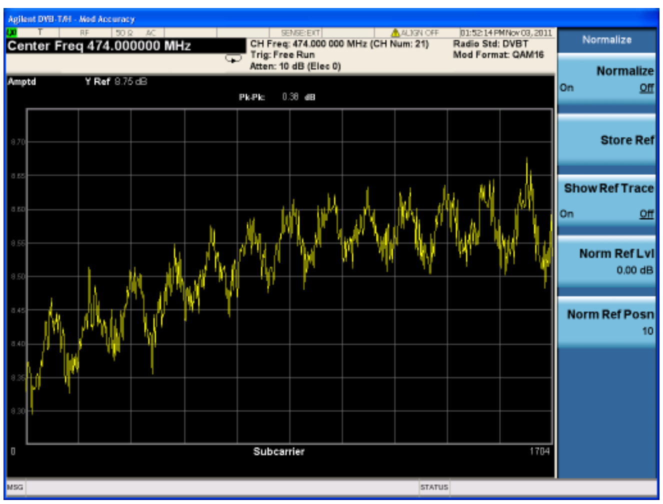
---

**NOTE** To avoid duplication, this section only lists actions directly related to normalize function. For information about how to make channel impulse response measurements, you can refer to the measurement procedures.

---

1. Connect the signal source directly to the signal analyzer to get the frequency response of the test system. In channel frequency response view, press the zoom window key  to zoom in the amplitude vs. subcarrier window.
2. Press **Trace/Detector**, **Normalize**, **Store Ref** to store the current measurement result as reference (TraceRef), as in Figure 2-3.

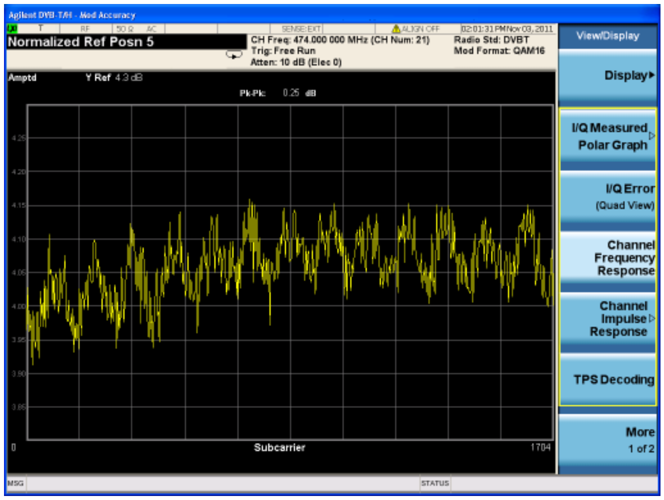
*Figure 2-3 Reference Trace*




3. Connect the device under test between the signal source and the signal analyzer. The measured amplitude vs. subcarrier trace in the channel frequency response view (Tracemeas) is show in Figure 2-4.

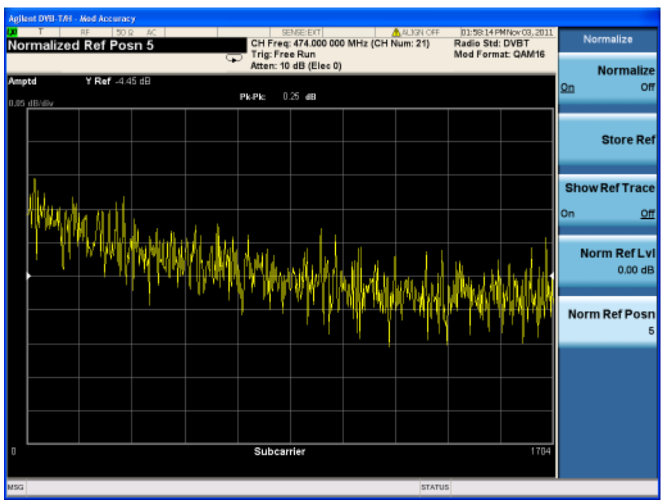
   After the device is connected, if the input power level changes a lot, you may need to adjust the value of attenuator or turn on the preamplifier using keys under AMPTD Y Scale menu.

*Figure 2-4 Amplitude vs. Subcarriers Trace after Connecting the Device*




4. Press **Trace/Detector**, **Normalize**, and toggle **Normalize** to **On**, and set **Norm Ref Posn** to **5**. The displayed trace (TraceNorm), as in Figure 2-5, is the frequency response of the device under test, which is calculated by Tracemeas - TraceRef.

*Figure 2-5 Normalized Trace (Frequency Response of the Device)*




5. (Optional) Press **Trace/Detector**, **Normalize** and toggle **Show Ref Trace** to **On** to show the stored reference trace. You may need to adjust the Ref Value and Scale/Div under AMPTD Y Scale menu to display both the Normalized trace and the reference trace.

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

## DVB-T2 Modulation Accuracy Measurements

This section describes how to make a modulation accuracy measurement on a DVB-T2 transmitter or exciter which is compliant with ETSI EN 302 755 V1.1.1 or V1.2.1. Both single PLP (Physical Layer Pipe), multiple PLPs DVB-T2 signal can be measured, providing results such as EVM, MER, magnitude error, phase error, frequency error, quad error, amplitude imbalance, and so on.

DVB-T2 Mod Accuracy measurements can also be used to measure the BBIQ (Baseband I/Q) signals. For the detailed measurement procedure, refer to "Using Option BBA Baseband I/Q Inputs" on page 81 and "Using BBIQ Inputs in DVB-T2 Mod Accuracy Measurement" on page 84.

**NOTE** Option B40 or DP2 (not upgradeable) is recommended for N9020A MXA/N9010A EXA to speed up the DVB-T2 modulation accuracy measurement.

The measurement procedures for single PLP DVB-T2 signal, multiple PLPs DVB-T2 signal and MISO DVB-T2 signal are slightly different, as follows:

"Measuring SISO Single PLP Signal" on page 40

"Measuring SISO Multi-PLP DVB-T2 Signal" on page 48

"Measuring MISO DVB-T2 Signal" on page 57

### Measuring SISO Single PLP Signal

#### Single PLP Signal Settings (Example)

Version: 1.1.1

P1 Type: SISO

Center Frequency: 474 MHz

Channel bandwidth: 8 MHz

PAPR type: No PAPR

Guard Interval: 1/128

FFT Size: 32K

Pilot pattern: PP7

Carrier mode: Extended

Data symbol number: 7

L1 modulation type: 64QAM

Number of frames per superframe: 2

PLP settings:

Modulation format: 256QAM

Constellation rotation: On

FEC type: 64K

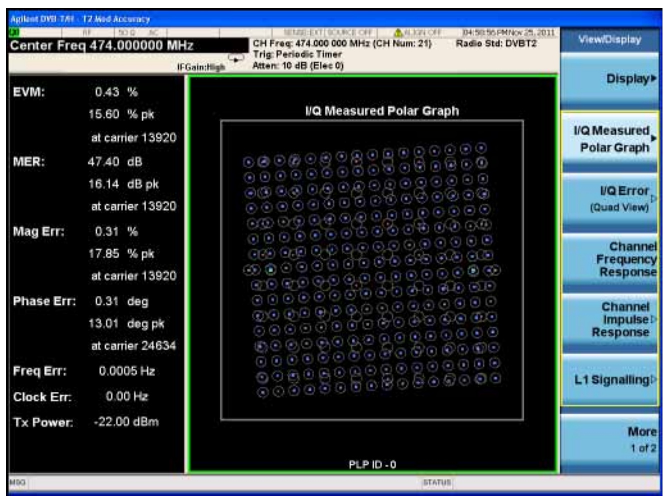
LDPC code rate 3/5

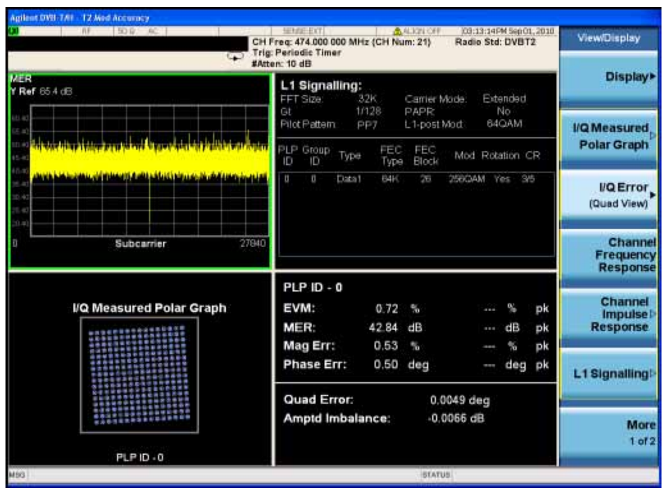
Number of TI (time interleaving) blocks per interleaving frame: 3

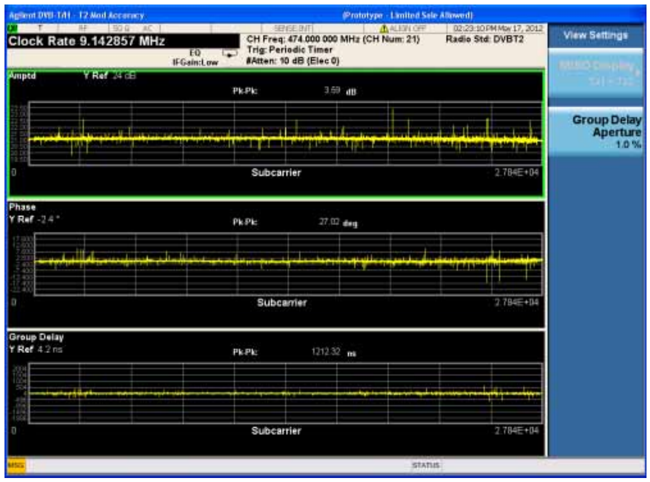
FEC block number: 26

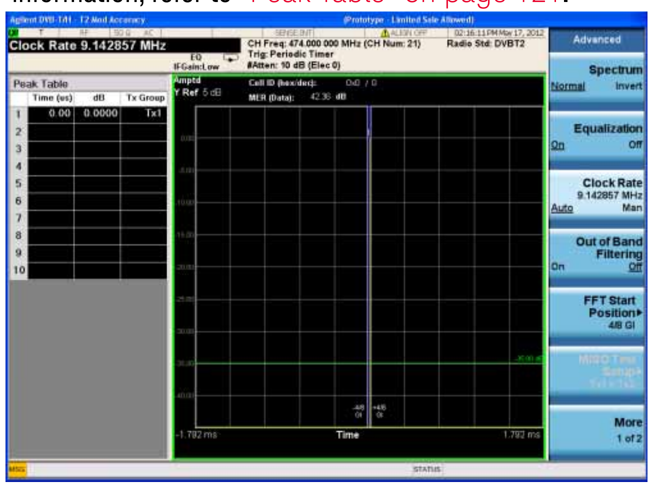
**Measurement Procedure**

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **DVB-T2 Mod Accuracy**. | This selects the DVB-T2 modulation accuracy measurement.<br><br>Note that if the Radio Std (under Mode Setup panel) is set to DVB-T or DVB-H, the DVB-T2 Mod Accuracy key will be grayed out. |
| Press **Meas Setup**, and toggle **Auto Detect** to **On** (default setting). | This sets the instrument to auto-detect the demodulation parameters from L1 signalling data and then demodulates the signal accordingly. The information carried in L1 signalling data can be viewed in L1 signalling view.<br><br>You can also use the following steps to set the demodulation parameters manually.<br><br>a. Press **Meas Setup**, and toggle **Auto Detect** to **Off** to turn off auto detect.<br><br>b. Press **Mode Setup**, **Radio Std**, **DVB-T2**, **Version**, **Version 1.1.1** to select the standard version of the signal under test and toggle the **Transmission Mode** to **SISO**.<br><br>c. Press **Meas Setup**, **Demod** and set the parameters under this menu accordingly. |
| Press **Meas Setup**, **Sync Frame Now**. | When the Sync Frame Now key is pressed, the instrument will synchronize its internal periodic trigger to the start of the T2 frame using the P1 signalling data, and will set the period of the internal trigger to the length of the T2 frame.<br><br>You can find the settings for the periodic trigger by pressing **Trigger**, **More 1 of 2**, **Periodic Timer**.<br><br>For more information on using triggers in this measurement, refer to "Using Triggers in DVB-T2 Mod Accuracy Measurement" on page 127. |

| Step | Notes |
| --- | --- |
| Press **View/Display**, **I/Q Measured Polar Graph**. | This selects the I/Q measured polar graph view, which is the default view. |
| View the I/Q measured polar graph results. | The constellation graph is shown in the graphic window, and EVM, MER, magnitude error, phase error, frequency error, and Tx power results are shown in the text window.<br><br>To set the type of data displayed on the constellation graph, press **I/Q Measured Polar Graph** again, then press **Display Type**, toggle a data type from **On** to **Off** to remove that data type from the constellation graph.<br><br>To view the constellation results in specified carrier ranges, press **I/Q Measured Polar Graph** again, and set values for the **Start Carrier** and **Stop Carrier**. Start Carrier and Stop Carrier keys will be grayed out if there are constellation rotations in the signal under test.<br><br> |
| Press **View/Display**, **I/Q Error**. | This selects the I/Q error view. |

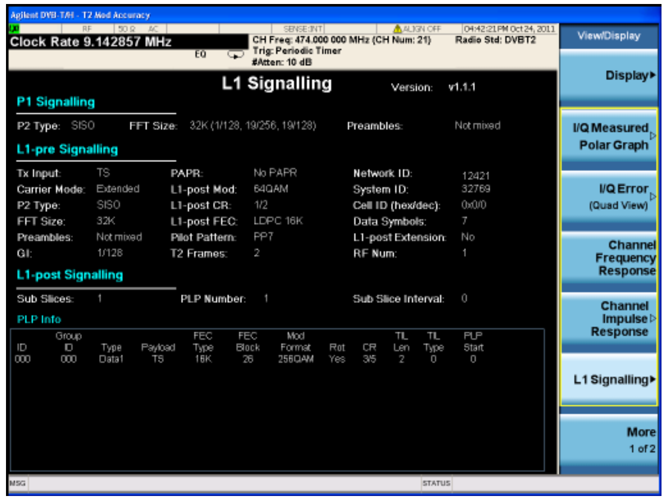
| Step | Notes |
| --- | --- |
| View the I/Q error results. | Four windows are displayed in the I/Q Error results as below.<br>▪ Top left window: MER/EVM vs. subcarrier/frequency. The MER and EVM results are calculated using the overall data.<br>You can change the scale type for the vertical axis and the horizontal axis by setting the Scale Type key under AMPTD Y Scale and Span X Scale menu.<br>▪ Top right window: L1 signalling information.<br>▪ Bottom left window: Constellation graph for the current PLP data.<br>▪ Bottom right window: a summary of results calculated using the current PLP data. If constellation rotation is used in the PLP, the peak results for EVM, MER, Mag Error, and Phase Error are displayed as "---".<br> |
| Press **View/Display**, **Channel Frequency Response**. | This selects the channel frequency response view.<br>If the currently selected window is the first window, amplitude vs. subcarrier window, you can use the normalize function under Trace/Detector, Normalize menu to measure the frequency response of a device, such as an amplifier or attenuator. For more information, refer to “Using Normalize Function in Channel Frequency Response View” on page 37. |

| Step | Notes |
|---|---|
| View the channel frequency response results. | The figure below displays the amplitude, phase, and group delay results on every subcarrier. The Pk to Pk value displayed on the top of each window is the difference between the maximum value and the minimum value in the current window.<br><br>The group delay aperture can be adjusted by pressing **View/Display**, **Channel Frequency Response**. Refer to "Group Delay Aperture" on page 121 for more details.<br><br> |
| Press **View/Display**, **Channel Impulse Response**, and then press **Meas Setup**, **Advanced**, toggle **Equalization** to **On**. | This selects the channel impulse response view, and turns on the equalizer. Turning the equalizer on can gain better channel impulse response results. |

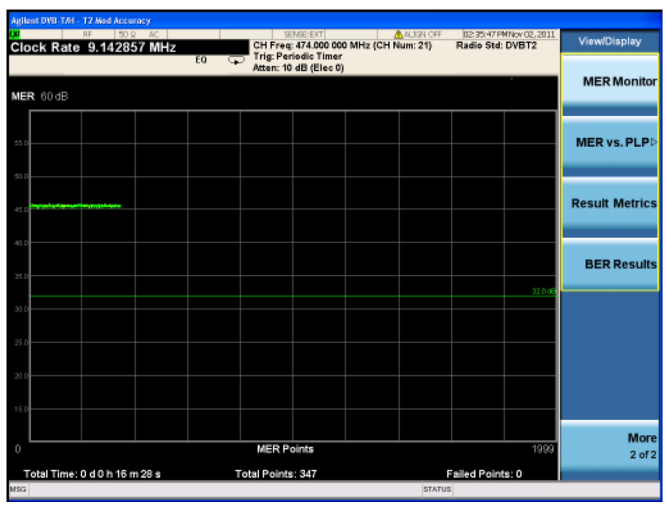
<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the channel impulse response results.</td><td>
The graphic window shows the channel impulse response trace, and the peak table window shows the delay and amplitude of the top 10 peaks on the trace at most.<br><br>
The blue bar with the range of GI indicates that all the paths<br><br>
included are used to reconstruct the signal for measurement. The position of the blue bar will be changed with FFT Start Position (under Meas Setup, Advanced, More 1 of 2 menu) value. Refer to “SFN Reception Conditions and FFT Start Position” on page 115 for more information.<br><br>
The green line with -35 dB above its right side is the peak limit line, which means only peaks above this line can be displayed in the peal table. To adjust the peak limit line, press Peak Search, More 1 of 2, Peak Table, and then enter your desired peak limit value.<br><br>
Peak table window is very useful in multi-path channel. For more information, refer to “Peak Table” on page 121.<br>


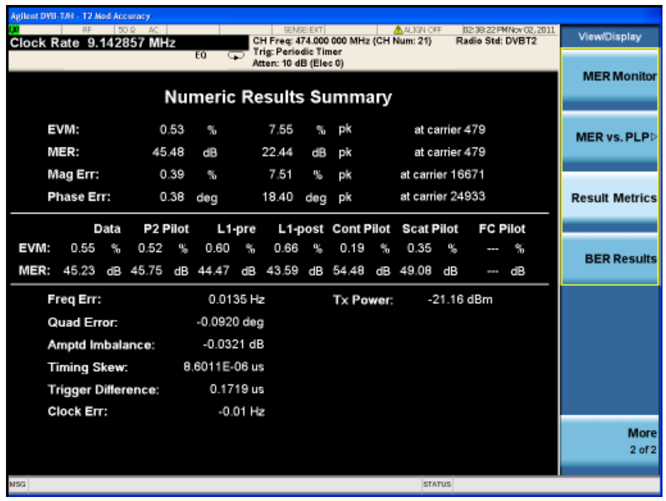
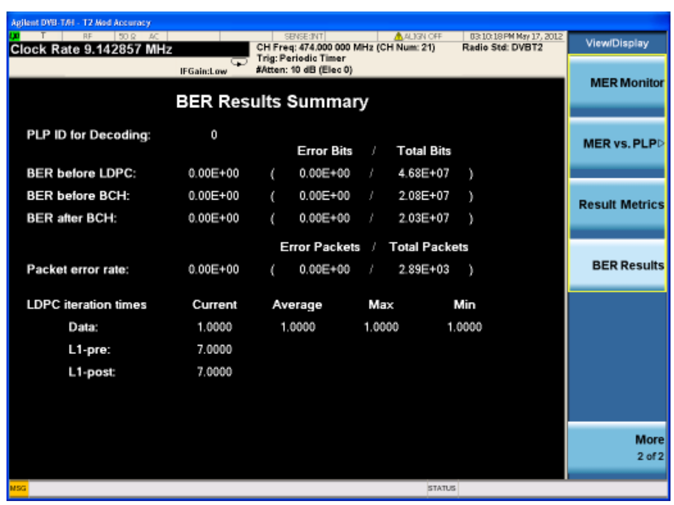
</td></tr>
<tr><td>Press View/Display, L1 Signalling.</td><td>This selects the L1 signalling view.</td></tr>
</table>

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the L1 signalling results.</td><td>The information from the L1 signalling data is displayed in this view.


</td></tr>
<tr><td>Press View/Display, More 1 of 2, MER Monitor.</td><td>This selects the MER monitor view.</td></tr>
<tr><td>View the MER monitor results.</td><td>The figure below displays the MER results in sequence during the monitor period, at the same time, log files and raw data are recorded. For details, refer to “MER Monitor Process” on page 119.

You can customize the MER monitor measurement using the settings under Meas Setup, More 1 of 2, MER Monitor.


</td></tr>
<tr><td>Press View/Display, Result Metrics.</td><td>This selects the result metrics view.</td></tr>
</table>

| Step | Notes |
|---|---|
| View the summary of the results. | This view is a summary of the modulation accuracy measurement results. You can see the EVM and MER results for data, P2 pilot, L1-pre and L1-post signalling, continual pilot, and scattered pilot. The "FC Pilot" results are displayed as "---" because no FC (frame closing) symbols are used in the current signal.<br><br>Clock error result is also provided in this view. For more information about it, refer to “Clock Error” on page 126.<br><br> |
| Press **View/Display**, **More 1 of 2**, **BER Results.** | This selects the BER results view. |
| View the BER results. | Four BER results and LDPC iteration times in the decoding are displayed in this view. The BER results include BER before LDPC, BER before BCH, BER after BCH, and Packet error rate.<br><br> |

### Measuring SISO Multi-PLP DVB-T2 Signal

#### Multi-PLP Signal Settings (Example)

Version: 1.1.1

P1 type: SISO

Center frequency: 474 MHz

Channel bandwidth: 8 MHz

PAPR type: No PAPR

Guard interval: 1/32

FFT size: 8k

L1 modulation type: BPSK

Pilot pattern: PP7

Data symbol number per T2 frame: 108

Sub-slice number: 108

Sub-slice interval: 2400

PLP number: 9

Carrier mode: Extended

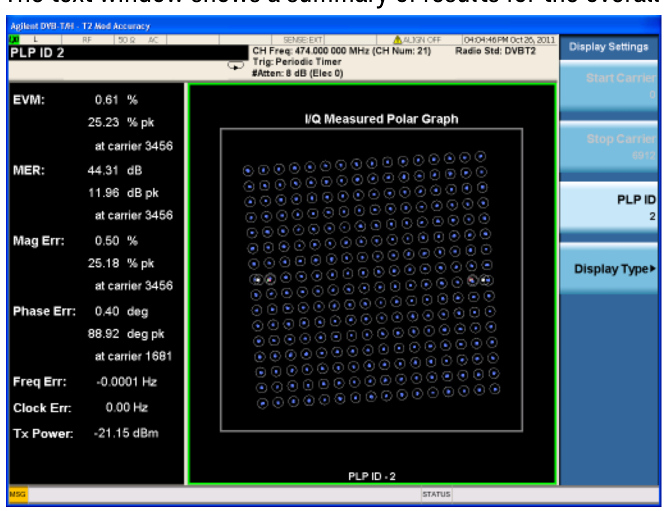
Number of frames per superframe: 12

PLP settings:

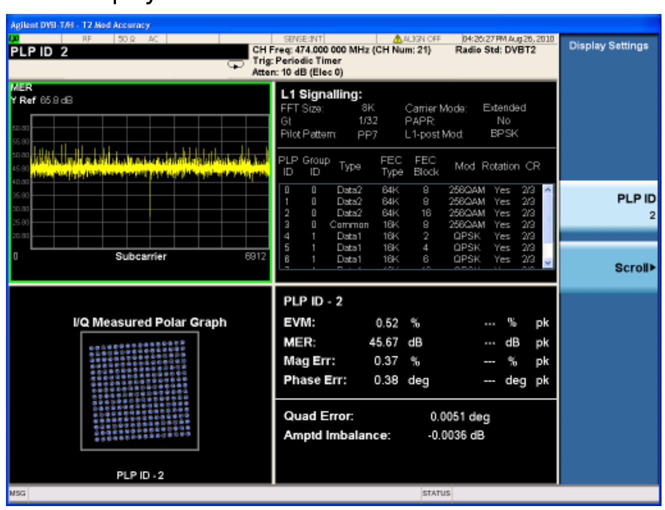
| ID | PLP Type | FEC Type | FEC Block Number | Modulation Format | Constellation Rotation | Code Rate | TI Block Number | TI Type |
|---|---|---|---|---|---|---|---|---|
| 000 | Data2 | 64K | 8 | 256QAM | Yes | 2/3 | 1 | 0 |
| 001 | Data2 | 64K | 8 | 256QAM | Yes | 2/3 | 1 | 0 |
| 002 | Data2 | 64K | 16 | 256QAM | Yes | 2/3 | 1 | 0 |
| 003 | Common | 16K | 8 | 256QAM | Yes | 2/3 | 1 | 0 |
| 004 | Data1 | 16K | 2 | QPSK | Yes | 2/3 | 1 | 0 |
| 005 | Data1 | 16K | 4 | QPSK | Yes | 2/3 | 1 | 0 |
| 006 | Data1 | 16K | 6 | QPSK | Yes | 2/3 | 1 | 0 |
| 007 | Data1 | 16K | 12 | QPSK | Yes | 2/3 | 1 | 0 |
| 008 | Common | 16K | 3 | QPSK | Yes | 2/3 | 1 | 0 |

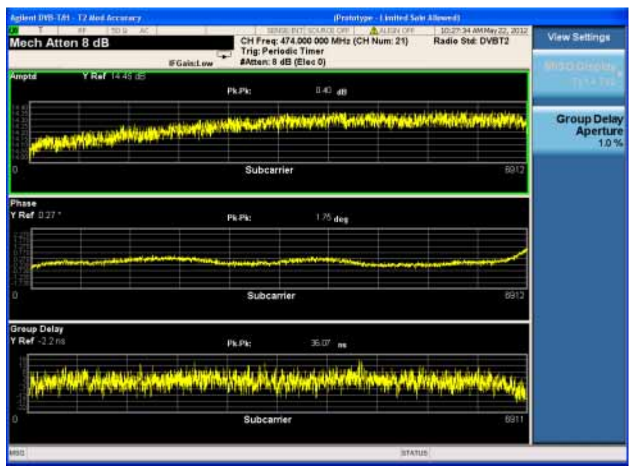
#### Measurement Procedure

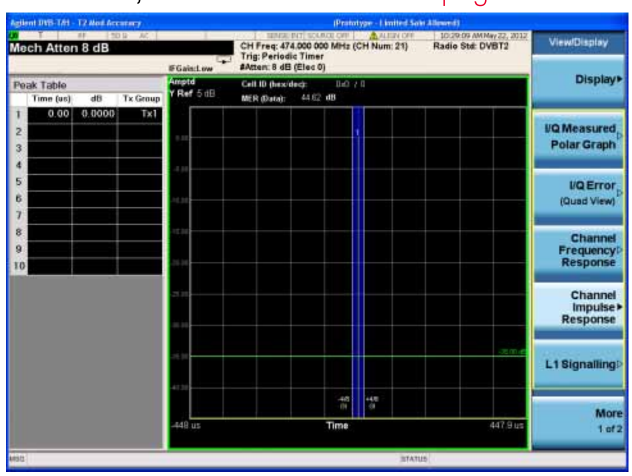
| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **DVB-T2 Mod Accuracy**. | This selects the DVB-T2 modulation accuracy measurement.<br><br>Note that if the radio std (under Mode Setup) is set to DVB-T or DVB-H, the DVB-T2 Mod Accuracy key will be grayed out. |
| Press **Meas Setup**, and toggle **Auto Detect** to **On** (default setting). | This sets the instrument to auto-detect the demodulation parameters from L1 signalling data and then demodulate the signal accordingly. The information carried in L1 signalling data can be viewed in L1 signalling view.<br><br>You can also set the demodulation parameters manually.<br><br>a. Press **Meas Setup**, and toggle **Auto Detect** to **Off** to turn off auto detect.<br><br>b. Import the DVB-T2 configuration file. For more details, refer to "Creating and Importing your own DVB-T2 Configuration File" on page 65.<br><br>If the configuration file you are using is created with previous instrument version (A.10.52 or before), you need to set up the DVB-T2 version and transmission mode manually by pressing **Mode Setup**, **Radio Std**, **DVB-T2**, **Version 1.1.1**, and toggling **Transmission Mode** to **SISO** to select the standard version and transmission mode of the signal under test. |
| Press **Sync Frame Now**. | When this key is pressed, the instrument will synchronize its internal periodic trigger to the start of the T2 frame using the P1 signalling data, and set the period of the internal trigger to the length of the T2 frame.<br><br>You can find settings for the periodic trigger by pressing **Trigger**, **More 1 of 2**, **Periodic Timer**. For more information of using triggers in this measurement, refer to "Using Triggers in DVB-T2 Mod Accuracy Measurement" on page 127. |

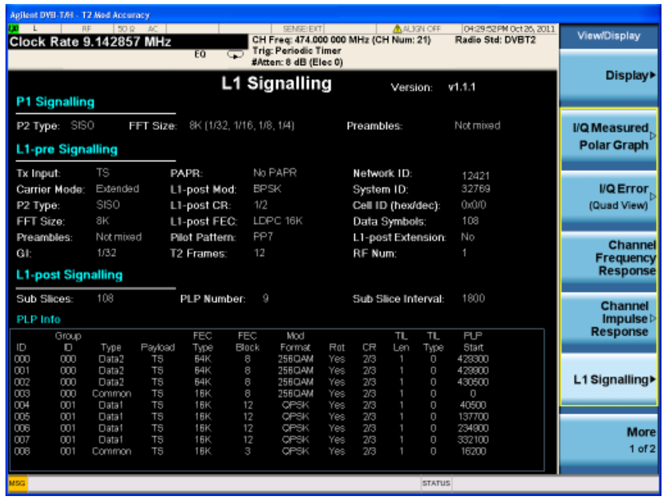
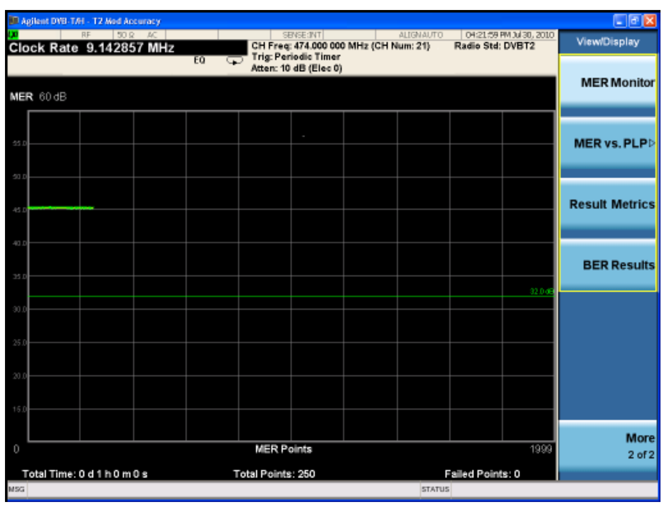
<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>Press View/Display, I/Q Measured Polar Graph, and then press I/Q Measured Polar Graph again, set PLP ID to 2 (example).</td><td>This selects the I/Q measured polar graph view and sets to view the results for PLP 2.<br><br>You can also set the type of data displayed on the constellation graph. Press I/Q Measured Polar Graph again, then press Display Type, toggle a data type from On to Off to remove that data type from the constellation graph.<br><br>Note that the PLP ID key here is identical to the one under I/Q Error. This means if you make changes to either PLP ID key, the other key changes in the same way. Then, if you switch between I/Q Measured Polar Graph view and I/Q Error view, the two views display measurement results for the same PLP ID.</td></tr>
<tr><td>View the I/Q measured polar graph results.</td><td>The graphic window shows the constellation graph for the current PLP data, signalling information, and pilot data. The color of the constellation points and the corresponding data are listed below:<ul><li>Blue () points: PLP data</li><li>Green () points: L1-pre signalling</li><li>Hot pink () points: L1-post signalling</li><li>White () points: P2 pilot</li><li>Sky blue () points: Continued pilot</li><li>Green yellow () points: Scattered pilot</li><li>Purple () points: Frame closing data</li></ul>The text window shows a summary of results for the overall data.<br>
</td></tr>
</table>

| Step | Notes |
| --- | --- |
| Press **View/Display**, **I/Q Error**, and then press **I/Q Error** again, set **PLP ID** to 2 (example). | This selects the I/Q error view and chooses to view results for PLP 2.<br><br>Note that the PLP ID key here is the identical to the one under I/Q Measured Polar Graph view. That means if you make changes to either PLP ID key, the other key changes in the same way. Then if you switch between I/Q Measured Polar Graph view and I/Q Error view, the two views are displaying measurement results for the same PLP ID. |
| View the I/Q error results. | In the figure below, there are four windows:<br><br>▪ Top left window: MER/EVM vs. subcarrier/frequency results. The MER and EVM results are calculated using the overall data.<br><br>Note that you can change the scale type for the vertical axis and the horizontal axis by setting the Scale Type under AMPTD Y Scale and Span X Scale menu.<br><br>▪ Top right window: L1 signalling information. If the PLP settings displayed in this window are more than one page, use the Scroll settings under the I/Q Error menu to view all the results.<br><br>▪ Bottom left window: Constellation graph for the current PLP data.<br><br>▪ Bottom right window: a summary of results calculated using the current PLP data. If constellation rotation is used in the specified PLP, the peak results for EVM, MER, Mag Error, and Phase Error are displayed as "---". |

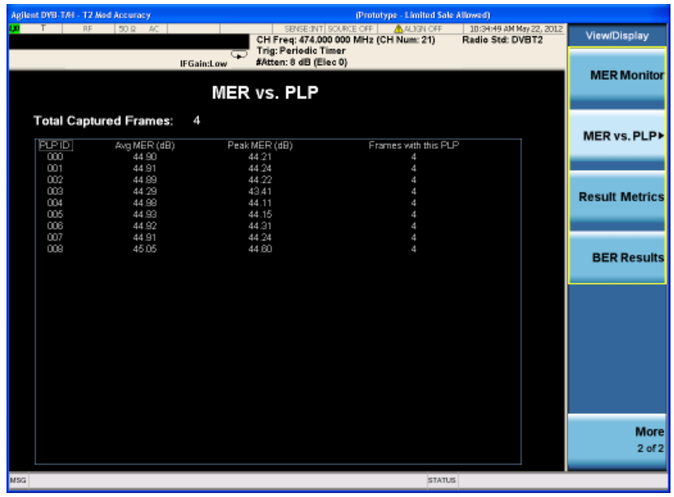


<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>Press View/Display, Channel Frequency Response.</td><td>This selects the channel frequency response view.<br><br>If the currently selected window is the first window, amplitude vs. subcarrier window, you can use the normalize function under Trace/Detector, Normalize menu to measure the frequency response of a device, such as an amplifier or attenuator. For more information, refer to “Using Normalize Function in Channel Frequency Response View” on page 37.</td></tr>
<tr><td>View the channel frequency response results.</td><td>The figure below displays the amplitude, phase, and group delay results on every subcarrier. The Pk to Pk value displayed on the top of each window is the difference between the maximum value and the minimum value in the current window.<br><br>The group delay aperture can be adjusted by pressing View/Display, Channel Frequency Response. Refer to “Group Delay Aperture” on page 121 for more details.<br>

</td></tr>
<tr><td>Press View/Display, Channel Impulse Response, and then press Meas Setup, Advanced, toggle Equalization to On.</td><td>This selects the channel impulse response view, and turns on the equalizer. Turning the equalizer on can gain better channel impulse response results.</td></tr>
</table>

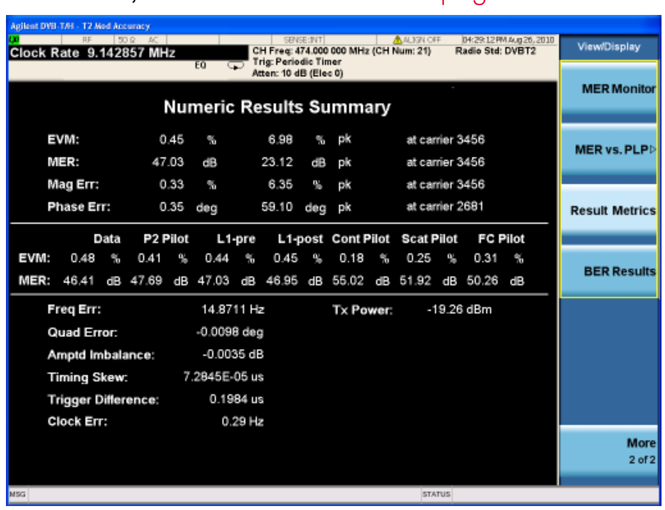
| Step | Notes |
|---|---|
| View the channel impulse response results. | The graphic window shows the channel impulse response trace, and the peak table window shows the delay and amplitude of the top 10 peaks on the trace.<br><br>The blue bar with the range of GI indicates that all the paths included are used to reconstruct the signal for measurement. The position of the blue bar will be changed with FFT Start Position (under **Meas Setup**, **Advanced**, **More 1 of 2** menu) value. Refer to “SFN Reception Conditions and FFT Start Position” on page 115 for more information.<br><br>The green line with -35 dB above its right side is the peak limit line, which means only peaks above this line can be displayed in the peal table. To adjust the peak limit line, press **Peak Search**, **More 1 of 2**, **Peak Table**, and then enter your desired peak limit value.<br><br>Peak table window is very useful in multi-path channel. For more information, refer to “Peak Table” on page 121.<br> |
| Press **View/Display**, **L1 Signalling**. | This selects the L1 signalling view. |

| Step | Notes |
|---|---|
| View the L1 signalling results. | The information from the L1 signalling data is displayed in this view.<br><br>If the PLP Info portion is too long to be displayed in one page, use the Scroll settings under L1 Signalling menu to view all the results.<br><br> |
| Press **View/Display**, **More 1 of 2**, **MER Monitor**. | This selects the MER monitor view. |
| View the MER monitor results. | This view displays the MER results in sequence during the monitor period over time. At the same time, log files and raw data are recorded. For details, refer to "MER Monitor Process" on page 119.<br><br>You can customize the MER monitor measurement using the setting under **Meas Setup**, **More 1 of 2**, **MER Monitor**.<br><br> |
| Press **View/Display**, **More 1 of 2**, **MER vs. PLP** to view the MER results of each PLP. | This selects the MER vs. PLP view. |

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the MER vs. PLP results.</td><td>This view displays the MER results for each PLP. The "Frame with this PLP" result shows the count of frames that transmit this PLP.

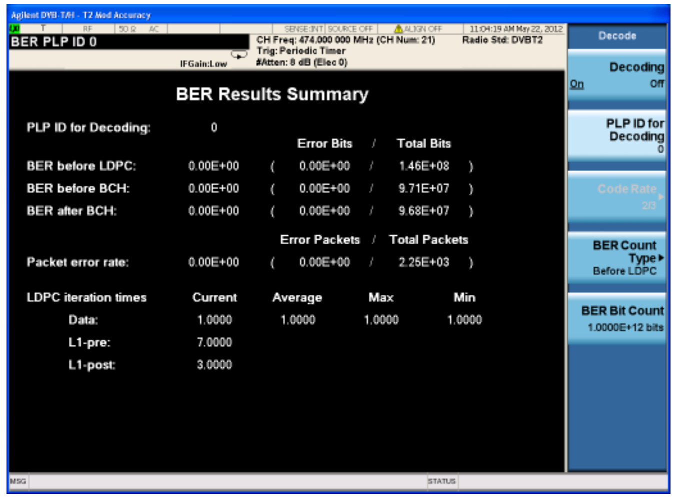

</td></tr>
<tr><td>Press View/Display, More 1 of 2, Result Metrics.</td><td>This selects the result metrics view.</td></tr>
<tr><td>View the summary of the results.</td><td>This view is a summary of the modulation accuracy measurement results. You can see the EVM and MER results for data, P2 pilot, L1-pre and L1-post signalling, continual pilot, scattered pilot, and FC pilot.

Clock error result is also provided in this view. For more details about clock error, refer to “Clock Error” on page 126.


</td></tr>
<tr><td>Press View/Display, More 1 of 2, BER Results and then press Meas Setup, More 1 of 2, Decode, PLP ID for Decoding, 0.</td><td>This selects the BER results view and sets the PLP to test.

Note that, the BER results view can only provide results for one specified PLP.</td></tr>
</table>

| Step | Notes |
|---|---|
| View the BER results. | For the specified PLP, four BER results and LDPC iteration times in the decoding are displayed in this view. The BER results include BER before LDPC, BER before BCH, BER after BCH, and Packet error rate. |



### Measuring MISO DVB-T2 Signal

#### MISO DVB-T2 Signal Settings (Example)

Version: 1.2.1

Transmission mode: MISO

Center frequency: 474 MHz

Channel bandwidth: 8 MHz

PAPR type: L1-ACE&P2-TR

Guard interval: 1/16

FFT size: 32k

L1 modulation type: 16QAM

Pilot pattern: PP7

Data Symbol number per T2 frame: 27

Sub-slice number: 108

PLP number: 4

Carrier mode: Extended

Number of frames per superframe: 2

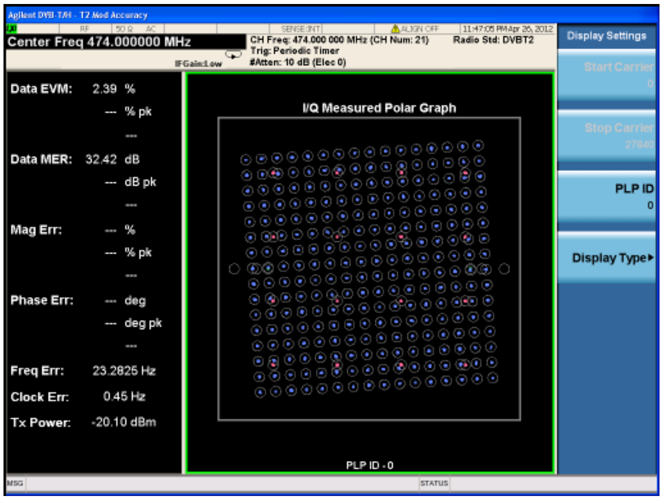
| ID | PLP Type | FEC Type | FEC Block Number | Modulation Format | Constellation Rotation | Code Rate | TI Block Number | TI Type |
|---|---|---|---|---|---|---|---|---|
| 000 | Data2 | 64K | 44 | 256QAM | Yes | 2/3 | 1 | 0 |
| 001 | Data2 | 64K | 18 | 256QAM | Yes | 2/3 | 1 | 0 |
| 002 | Data2 | 64K | 3 | 256QAM | Yes | 2/3 | 1 | 0 |
| 003 | Common | 16K | 17 | 256QAM | Yes | 2/3 | 1 | 0 |

#### Measurement Procedure

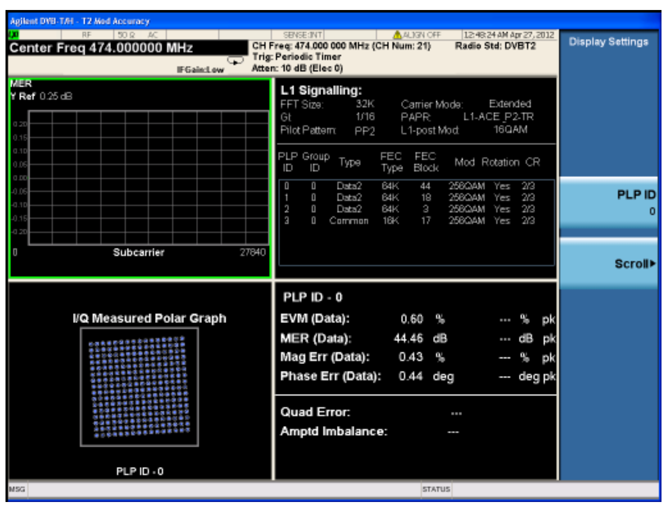
| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **DVB-T2 Mod Accuracy**. | This selects the DVB-T2 modulation accuracy measurement.<br>Note that if the radio std (under Mode Setup) is set to DVB-T or DVB-H, the DVB-T2 Mod Accuracy key will be grayed out. |

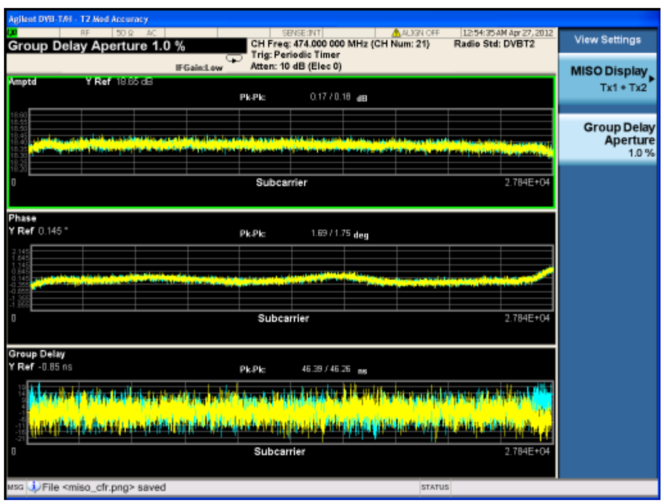
| Step | Notes |
| --- | --- |
| Press **Meas Setup**, and toggle **Auto Detect** to **On** (default setting). | This sets the instrument to auto-detect the demodulation parameters from L1 signalling data and then demodulate the signal accordingly. The information carried in L1 signalling data can be viewed in L1 signalling view.<br><br>You can also set the demodulation parameters manually.<br><br>a. Press **Meas Setup**, and toggle **Auto Detect** to **Off** to turn off auto detect.<br><br>b. Import the DVB-T2 configuration file. For more details, refer to "Creating and Importing your own DVB-T2 Configuration File" on page 65.<br><br>If the configuration file you are using is created with previous instrument version (A.10.52 or before), you need to set up the DVB-T2 version and transmission mode manually by pressing **Mode Setup**, **Radio Std**, **DVB-T2**, **Version 1.2.1**, and toggling **Transmission Mode** to **MISO** to select the standard version and transmission mode of the signal under test. |
| Press **Sync Frame Now.** | When this key is pressed, the instrument will synchronize its internal periodic trigger to the start of the T2 frame using the P1 signalling data, and set the period of the internal trigger to the length of the T2 frame.<br><br>Setting Frame Tracking to On makes the instrument track and compensate the difference between the periodic timer and the start of the T2 frame.<br><br>You can find the settings for the periodic trigger by pressing **Trigger**, **More 1 of 2**, **Periodic Timer**. For more information of using triggers in this measurement, refer to "Using Triggers in DVB-T2 Mod Accuracy Measurement" on page 127. |
| (Optional) Press **Meas Setup**, **Advanced**, **MISO Test Setup**, **Tx1+Tx2.** | This sets the type of MISO signal under test if you know what the transmitted signal consists of. If Tx1 only or Tx2 only signal is transmitted and MISO Test setup is set to Tx1 only or Tx2 only correspondingly, the results displayed in each view will be more complete. |

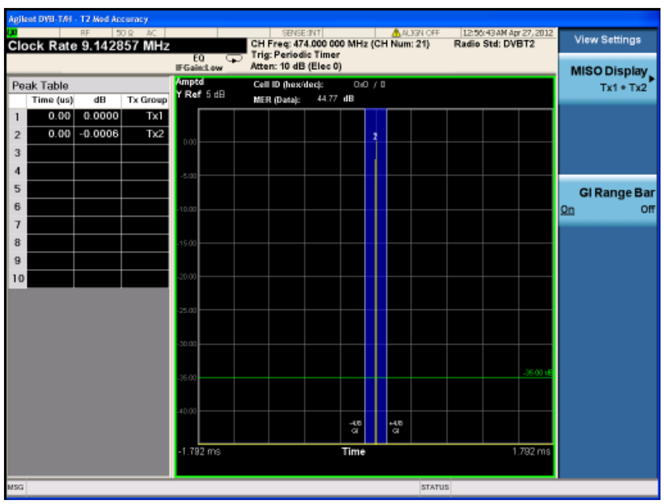
| Step | Notes |
|---|---|
| Press **View/Display**, **I/Q Measured Polar Graph**, and then press **I/Q Measured Polar Graph** again, set **PLP ID** to 0 (example). | This selects the I/Q measured polar graph view and sets to view the results of PLP 0.<br><br>You can also set the type of data displayed on the constellation graph. Press **I/Q Measured Polar Graph** again, then press **Display Type**, toggle a data type from **On** to **Off** to remove that data type from the constellation graph. If the transmission mode is set to MISO and MISO test setup is set to Tx1+Tx2, the Pilot key is greyed out, as no pilot is displayed on the constellation graph in this case.<br><br>Note that the PLP ID key here is identical to the one under I/Q Error. This means if you make changes to either PLP ID key, the other key changes in the same way. Then, if you switch between I/Q Measured Polar Graph view and I/Q Error view, the two views display measurement results for the same PLP ID. |
| View the I/Q measured polar graph results. | The graphic window shows the constellation graph for the current PLP data, signalling information, and pilot data. The color of the constellation points and the corresponding data are listed below:<br><br>▪ Blue ( ) points: PLP data<br>▪ Green ( ) points: L1-pre signalling<br>▪ Hot pink ( ) points: L1-post signalling<br><br>The text window shows a summary of results for the overall data.<br><br>If the MISO signal under test is Tx1+Tx2, the peak value and peak postion for Data EVM, Data MER, magnitude error, and phase error results are displayed as "---". |



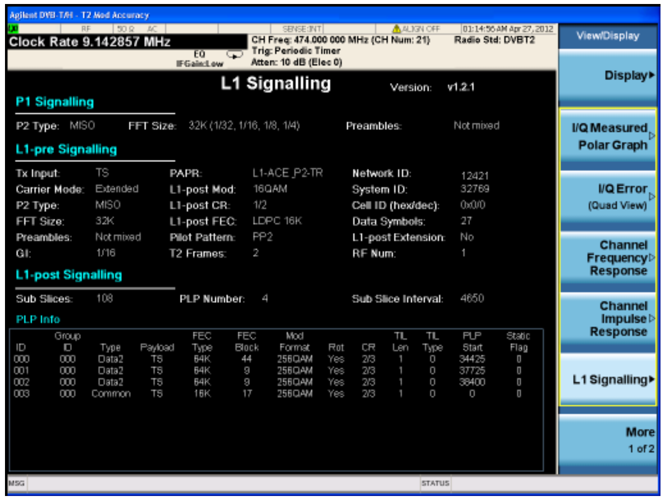
| Step | Notes |
|---|---|
| Press **View/Display**, **I/Q Error**, and then press **I/Q Error** again, set **PLP ID** to 0 (example). | This selects the I/Q error view and chooses to view results for PLP 0.<br><br>Note that the PLP ID key here is the identical to the one under I/Q Measured Polar Graph view. That means if you make changes to either PLP ID key, the other key changes in the same way. Then if you switch between I/Q Measured Polar Graph view and I/Q Error view, the two views are displaying measurement results for the same PLP ID. |
| View the I/Q error results. | In the figure below, there are four windows:<br><br>▪ Top left window: MER/EVM vs. subcarrier/frequency results. The MER and EVM results are calculated using the overall data.<br><br>If the MISO signal under test is Tx1+Tx2, no trace will be displayed in this window.<br><br>▪ Top right window: L1 signalling information. If the PLP settings displayed in this window are more than one page, use the Scroll settings under the I/Q Error menu to view all the results.<br><br>▪ Bottom left window: Constellation graph for the current PLP data.<br><br>▪ Bottom right window: a summary of results calculated using the current PLP data. If constellation rotation is used in the specified PLP, the peak results for EVM, MER, Mag Error, and Phase Error are displayed as "---". If the MISO signal under test is Tx1+Tx2, quad error and amplitude imbalance are displayed as "---". |



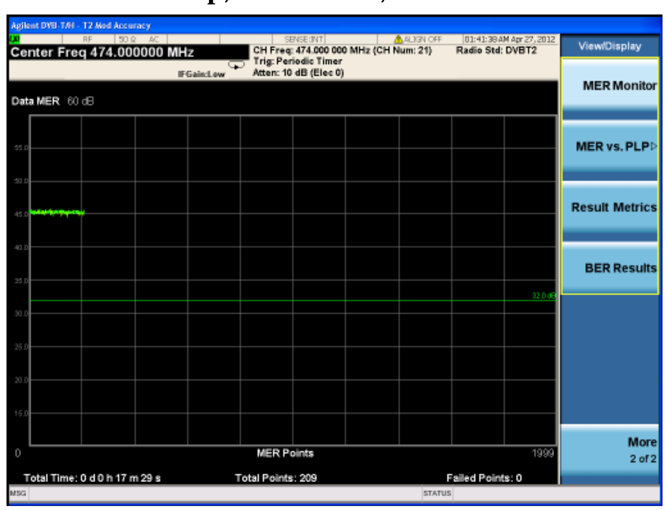
<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>Press View/Display, Channel Frequency Response.</td><td>This selects the channel frequency response view.<br><br>If the currently selected window is the first window, amplitude vs. subcarrier window, you can use the normalize function under Trace/Detector, Normalize menu to measure the frequency response of a device, such as an amplifier or attenuator. For more information, refer to “Using Normalize Function in Channel Frequency Response View” on page 37.</td></tr>
<tr><td>View the channel frequency response results.</td><td>The figure below displays the amplitude, phase, and group delay results on every subcarrier for both Tx1 and Tx2. You can view the channel frequency response for only Tx1 or Tx2 by pressing View/Display, Channel Frequency Response, MISO Display, Tx1 Only or Tx2 Only.<br><br>The group delay aperture can be adjusted by pressing View/Display, Channel Frequency Response. Refer to “Group Delay Aperture” on page 121 for more details.<br><br>The Pk to Pk value displayed on the top of each window is the difference between the maximum value and the minimum value in the current window.<br><br>
</td></tr>
<tr><td>Press View/Display, Channel Impulse Response, and then press Meas Setup, Advanced, toggle Equalization to On.</td><td>This selects the channel impulse response view, and turns on the equalizer. Turning the equalizer on can gain better channel impulse response results.</td></tr>
</table>

| Step | Notes |
|---|---|
| View the channel impulse response results. | The graphic window shows the channel impulse response trace for both Tx1 and Tx2, and the peak table window shows the delay and amplitude of the top 10 peaks on the traces. You can view the channel impulse response for only Tx1 or Tx2 by pressing **View/Display**, **Channel Impulse Response**, **MISO Display**, **Tx1 Only** or **Tx2 Only**.<br><br>The blue bar with the range of GI indicates that all the paths included are used to reconstruct the signal for measurement. The position of the blue bar will be changed with FFT Start Position (under **Meas Setup**, **Advanced**, **More 1 of 2** menu) value. Refer to "SFN Reception Conditions and FFT Start Position" on page 115 for more information.<br><br>The green line with -35 dB above its right side is the peak limit line, which means only peaks above this line can be displayed in the peal table. To adjust the peak limit line, press **Peak Search**, **More 1 of 2**, **Peak Table**, and then enter your desired peak limit value.<br><br>Peak table window is very useful in multi-path channel. For more information, refer to "Peak Table" on page 121.<br><br> |
| Press **View/Display**, **L1 Signalling**. | This selects the L1 signalling view. |

| Step | Notes |
| --- | --- |
| View the L1 signalling results. | The information from the L1 signalling data is displayed in this view.<br><br>If the PLP Info portion is too long to be displayed in one page, use the Scroll settings under L1 Signalling menu to view all the results. |

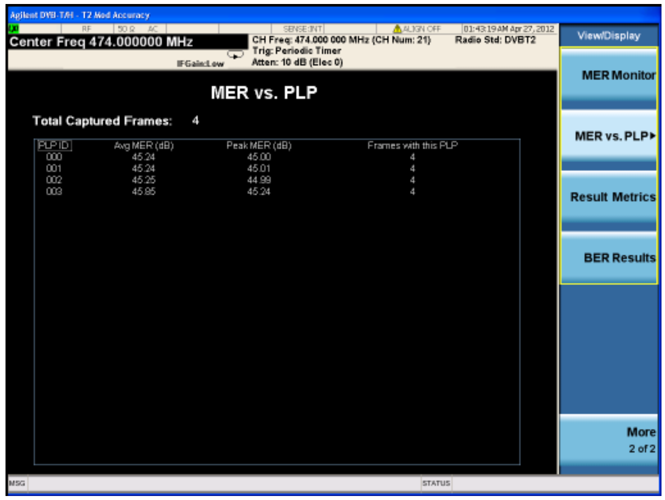



| Step | Notes |
| --- | --- |
| Press **View/Display**, **More 1 of 2**, **MER Monitor**. | This selects the MER monitor view. |
| View the MER monitor results. | This view displays the MER results in sequence during the monitor period over time. At the same time, log files and raw data are recorded. For details, refer to "MER Monitor Process" on page 119.<br><br>You can customize the MER monitor measurement using the setting under **Meas Setup**, **More 1 of 2**, **MER Monitor**. |

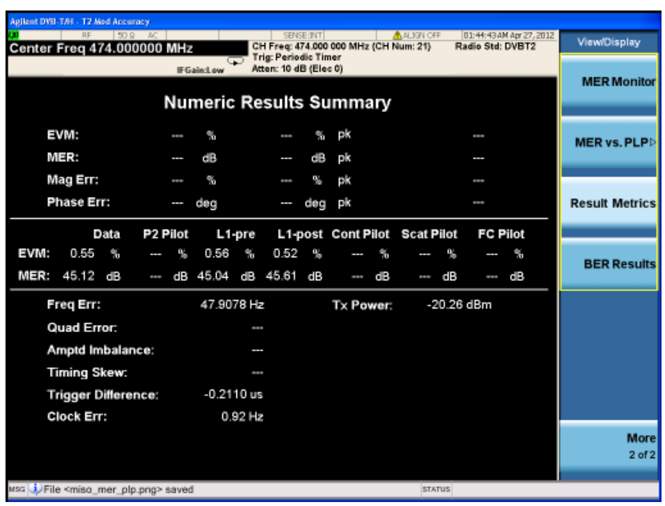



| Step | Notes |
| --- | --- |
| Press **View/Display**, **More 1 of 2**, **MER vs. PLP** to view the MER results of each PLP. | This selects the MER vs. PLP view. |

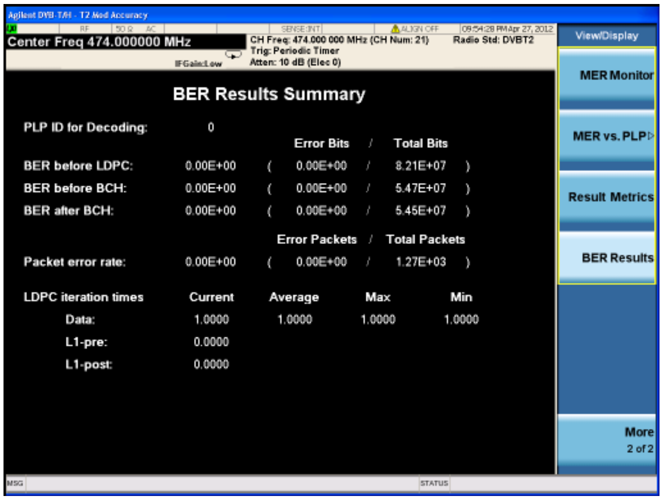
| Step | Notes |
| --- | --- |
| View the MER vs. PLP results. | This view displays the MER results for each PLP. The "Frame with this PLP" result shows the count of frames that transmit this PLP. |




| Step | Notes |
| --- | --- |
| Press **View/Display**, **More 1 of 2**, **Result Metrics.** | This selects the result metrics view. |
| View the summary of the results. | This view is a summary of the modulation accuracy measurement results. You can see the EVM and MER results for data, P2 pilot, L1-pre and L1-post signalling, continual pilot, scattered pilot, and FC pilot.<br><br>If the MISO signal under test is Tx1+Tx2, only EVM/MER for L1-pre and L1-post, Freq Err, Tigger Difference, Clock Error, and Tx Power have values, and other results will be displayed as "---".<br><br>Clock error result is also provided in this view. For more details about clock error, refer to “Clock Error” on page 126. |



| Step | Notes |
|---|---|
| Press **View/Display**, **More 1 of 2**, **BER Results** and then press **Meas Setup**, **More 1 of 2**, **Decode**, **PLP ID for Decoding**, **0**. | This selects BER results view and set the PLP to test. |
| View the BER results. | THe BER results are for the selected PLP. Four results including BER before LDPC, BER before BCH, BER after BCH, and Packet error rate are displayed. |




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

### Creating and Importing your own DVB-T2 Configuration File

In multi-PLP DVB-T2 signal modulation accuracy measurements, the DVB-T2 configurations can NOT be set directly by pressing keys on the instrument. Instead, it can be imported through a configuration file, which contains all the parameters needed to demodulate the signal.

Follow the steps below to create your own DVB-T2 configuration file and import it into the measurement application.

| Step | Action |
|---|---|
| Create your own DVB-T2 configuration files. | a. Press **Save**, **Data**, **DVB-T2 Config**, and then press **Save As...** to save the settings of the current signal into a configuration file and name it as you like.<br>The default directory of the configuration file is "\My Documents\DVB \data\ EVMT2".<br>b. Open the saved file, learn the format of the configuration file, as described in the section "The Format of the DVB-T2 Configuration File" on page 66.<br>c. Create your own configuration file by making edits on the saved file. You need to set the parameters according to the signal under test. After you finish the edits, save and close the file. |
| Import the DVB-T2 configuration file. | Press **Recall**, **Data**, **DVB-T2 Config**, and then press **Open...** to open and import the new configuration file.<br>After the configuration file is imported, the instrument will demodulate the current signal using the settings from the configuration file. |

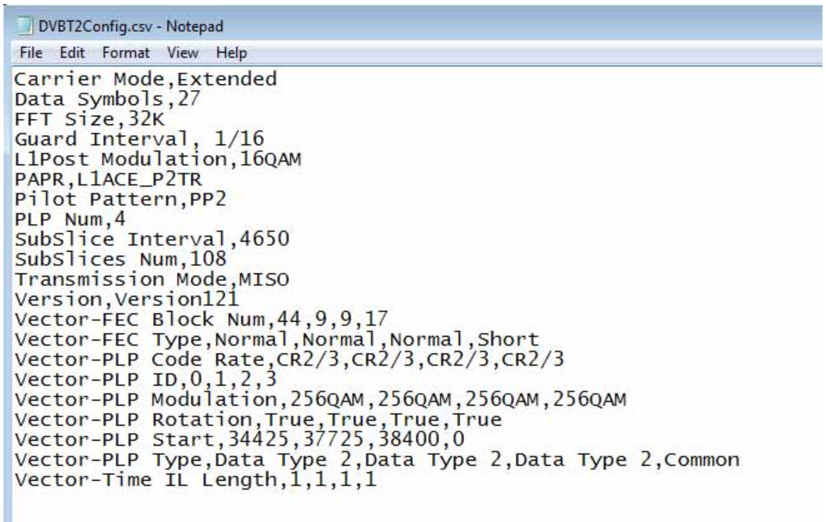
**The Format of the DVB-T2 Configuration File**

The configuration file is located in the directory "\My Documents\DVB\data\EVMT2" by default, in CSV (Comma Separated Values) format. You can edit it easily with notepad.

The format of the configuration file is shown in Figure 2-6. In each line, one parameter is configured following the format "Parameter name, parameter setting".

The first twelve lines for carrier mode, data symbols, FFT size, guard interval, L1 post modulation type, PAPR, pilot pattern, PLP number, subslice interval, subslice number, transmission mode, and version are parameters for the whole T2 frame. Each parameter has one value. The last nine lines for FEC block number, FEC type, PLP code rate, PLP ID, PLP modulation type, PLP rotation, PLP start, PLP type, and Time IL (interleaving) length are parameters for each PLP. The settings for each PLP are appended after the parameter name in sequence, separated by comma.

*Figure 2-6 The Format of DVB-T2 Configuration File*


DVBT2Config.csv - Notepad

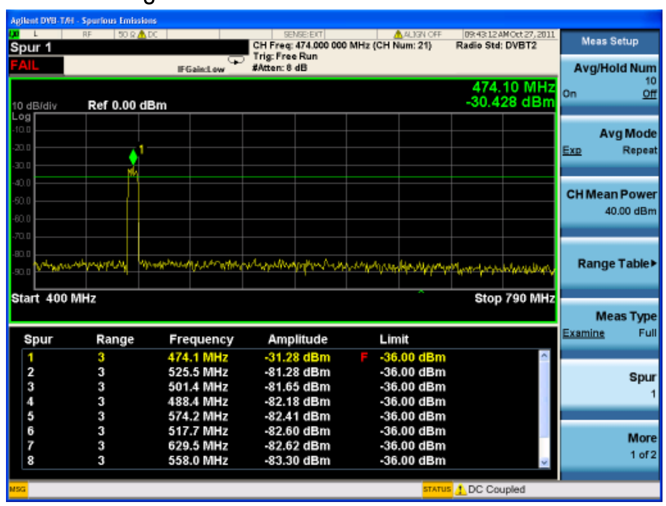
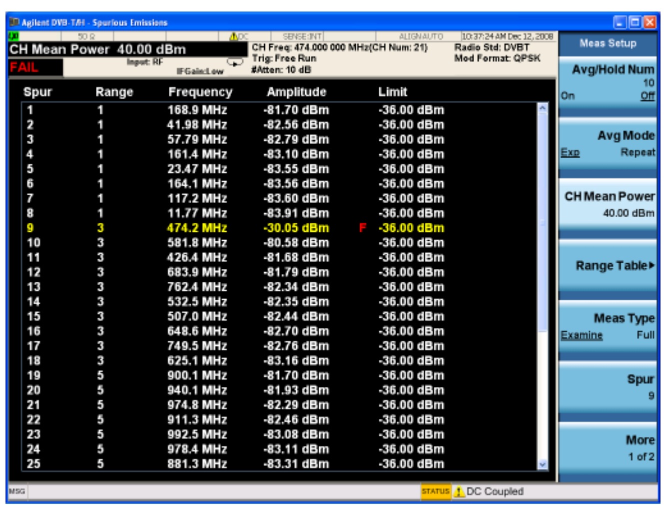
File Edit Format View Help

```
Carrier Mode,Extended
Data Symbols,27
FFT Size,32K
Guard Interval, 1/16
L1Post Modulation,16QAM
PAPR,L1ACE_P2TR
Pilot Pattern,PP2
PLP Num,4
SubSlice Interval,4650
SubSlices Num,108
Transmission Mode,MISO
Version,Version121
Vector-FEC Block Num,44,9,9,17
Vector-FEC Type,Normal,Normal,Normal,Short
Vector-PLP Code Rate,CR2/3,CR2/3,CR2/3,CR2/3
Vector-PLP ID,0,1,2,3
Vector-PLP Modulation,256QAM,256QAM,256QAM,256QAM
Vector-PLP Rotation,True,True,True,True
Vector-PLP Start,34425,37725,38400,0
Vector-PLP Type,Data Type 2,Data Type 2,Data Type 2,Common
Vector-Time IL Length,1,1,1,1
```

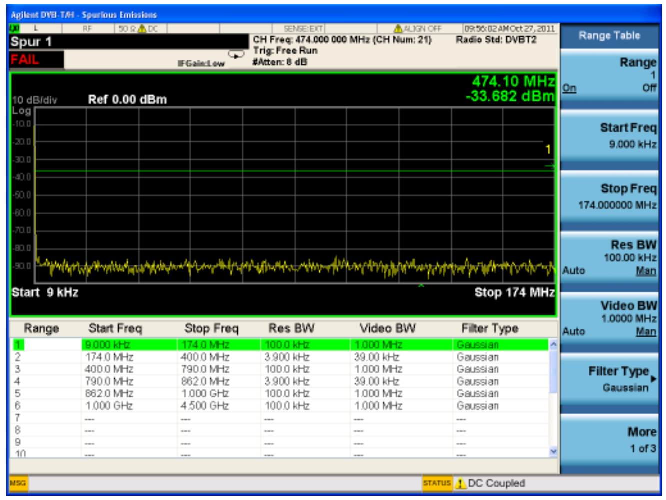
## Spurious Emissions Measurements

This section describes how to make a Spurious Emissions measurement on a DVB-T/H/T2 transmitter. This measurement identifies and determines the power level of spurious emissions in certain frequency bands.

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **Spurious Emissions**. | This selects the spurious emissions measurement. |
| Press **Input/Output**, **RF Input**, **RF Coupling** to toggle the RF Coupling to **DC**. | This sets the RF coupling to DC.<br>Note that 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 the protection of the external mixer by limiting the DC part of the input level to within 200 mV of 0 Vdc. |
| Press **Meas Setup**, **CH Mean Power**, 40, **dBm.** | This sets the mean power of the transmitter. This step is necessary as the limit parameters vary according to the transmit power as listed in Table 3-8 on page 129. |
| Press **View/Display**, **Graph** + **Metrics** to view the spectrum and spur table. | |

| Step | Notes |
|---|---|
| View the Spurious Emissions results. | The graphic window and the text window show the spectrum, frequency, and amplitude of the spurs in the defined frequency ranges. In the text window, spurs that have failed absolute limit have a red "F" beside it and the largest spur is shown in yellow. To select other spurs, press **Meas Setup**, **Spur**, and enter the index.<br><br>The default settings of frequency range and absolute limit are compliant with Table 3-8 on page 129. You can also customize the spurious emissions measurements by setting the parameters under **Meas Setup** manually.<br><br>Note that the failed point in the figure below is the transmitted signal at 474 MHz. To avoid 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 instrument to remove the undesired signal.<br><br> |
| (Optional) Use the Window Control keys  below the screen to zoom the result screen. | The result screen is shown below.<br><br> |

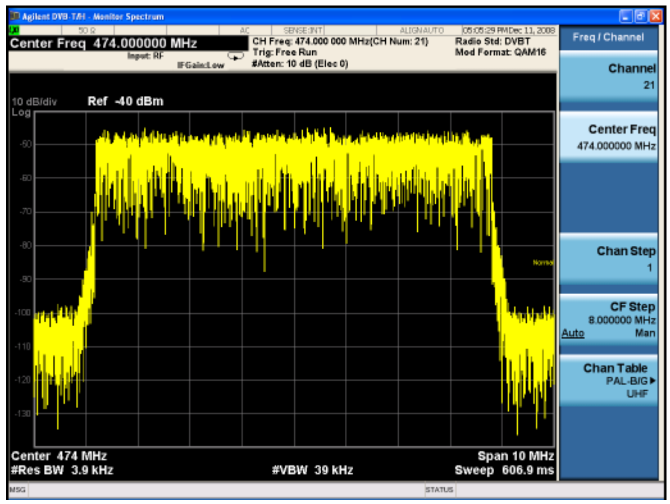
| Step | Notes |
|---|---|
| Press **View/Display**, **Range Table**, and then press **Meas Setup**, **Range Table**, set a value to the Range key to view the range settings. | The graphic window shows the spectrum of the specified range. The text window shows the parameter settings for the ranges while the specified range is shown in green. |



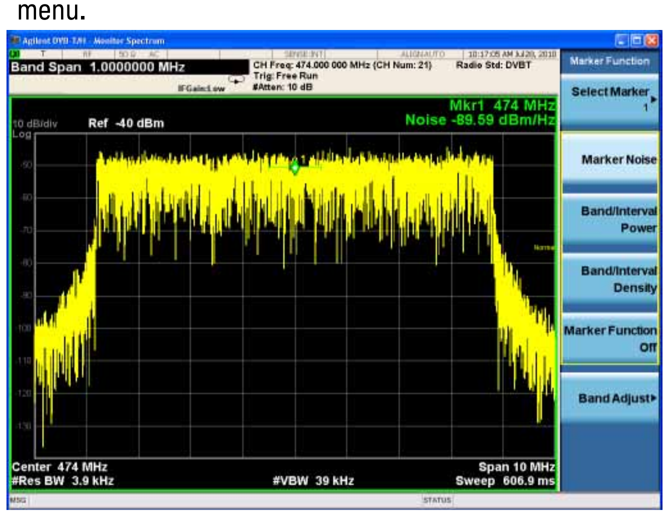
## Monitor Spectrum Measurements

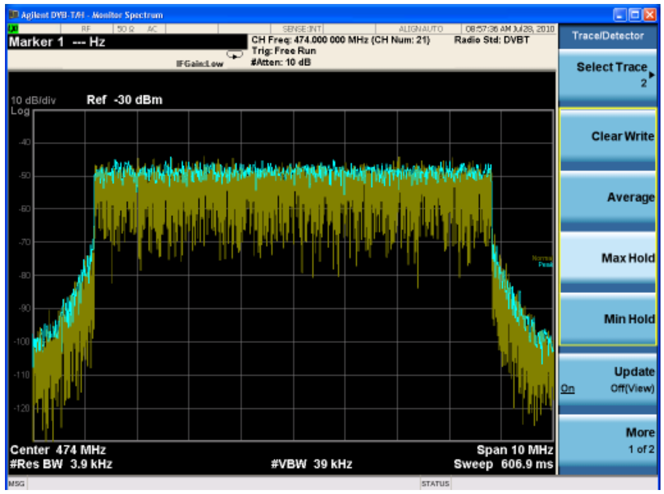
This section describes how to make a Monitor Spectrum measurement on a DVB-T/H/T2 transmitter. Monitor Spectrum measurements show a spectrum domain display of the DVB-T/H/T2 signal.

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to "Common Measurement Steps – Setting up DVB-T/H with T2 Mode" on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **Monitor Spectrum**. | This selects monitor spectrum view. |
| View the monitor spectrum results. | The default display shows the **Current** (yellow trace) data. |




| Step | Notes |
|---|---|
| (Optional) Press **Marker Function**, **Marker Noise**. | This turns on the Marker Function. The figure below is an example for marker noise. You can also select Band/Interval Power and Band/Interval Density to see the power or power density in a specified band, which is set using the keys under the Band Adjust menu. |



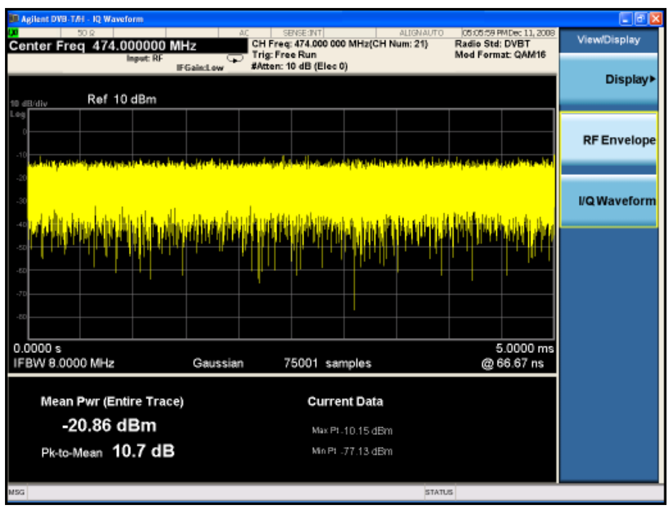
| Step | Notes |
|---|---|
| (Optional) To compare the current trace with the average/max hold/min hold trace, perform the following steps:<br>▪ Press **Trace/Detector**, **Select Trace**, **Trace 1**, and then toggle **Update** to **Off**.<br>▪ Press **Select Trace**, **Trace 2**, press **Max Hold**, and then toggle **Update** to **On**, **Display** to **Show.** | The dark yellow trace is the clear write trace, and the blue trace is the max hold trace. You can also add other traces using the same procedure.<br> |

## IQ Waveform (Time Domain) Measurements

This section explains how to make a Waveform (time domain) measurement on a DVB-T/H/T2 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.

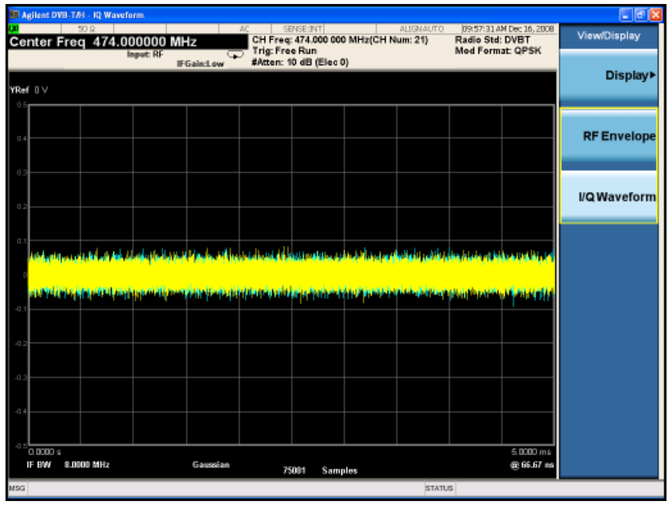
IQ Waveform measurements can be used to measure the BBIQ (Baseband I/Q) signals. For the detailed measurement procedure, refer to “Using Option BBA Baseband I/Q Inputs” on page 81.

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to “Common Measurement Steps – Setting up DVB-T/H with T2 Mode” on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **IQ Waveform.** | This selects the IQ waveform measurements. |
| Press View/Display, | |
| View the RF envelope (default view) results. | The following picture shows the RF envelope results in the graphic windows, and shows the mean power and peak-to-mean power results in the text window. |




| Step | Notes |
|---|---|
| Press **View/Display**, **I/Q Waveform.** | This selects the I/Q waveform view. |

| Step | Notes |
|---|---|
| View the I/Q waveform results. | The I/Q waveform view displays the I (yellow trace) and Q (blue trace) waveforms on the same graph in terms of voltage versus time in linear scale. |




| Step | Notes |
|---|---|
| (Optional) Press **AMPTD Y Scale**, and configure the settings for the Y axis to a convenient scale for viewing. | |
| (Optional) Press **Span X Scale**, and configure the settings for the X axis to a convenient time scale for viewing. | |
| (Optional) Press **Marker Function** and select **Marker Noise**, **Band/Interval Power**, or **Band/Interval Density**. | You can use band adjust to set frequency span for those marker functions. |

# DVB-T SFN Field Measurements

This section describes how to make DVB-T tests in SFN field scenarios. SFN field test generally requires measurement results like power level, MER, channel impulse response, BER, and so on. It is aimed to investigate and verify the SFN network at a certain location.

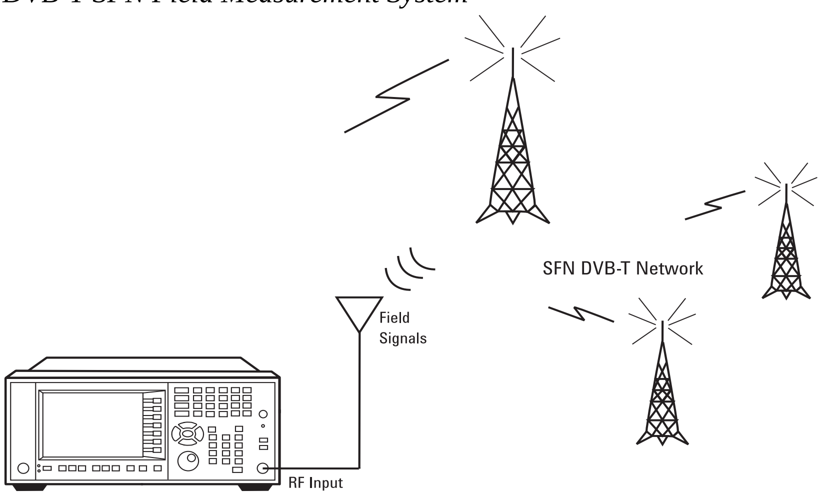
The test system below enables you to test the SFN network in adverse reception conditions. It is robust enough for pre-echoes, post-echoes, and even for the worst case 0 dB echo in the propagation environment, providing stable MER and channel impulse response results. Refer to "SFN Reception Conditions and FFT Start Position" on page 115 for more information.

## Setting Up the Test System

The SFN field measurement is to test the DVB-T over-the-air signals in DVB-T SFN network. The measurement system is shown in Figure 2-7.

To perform the measurement, connect an appropriate antenna to the X-Series signal analyzer. As the power level of the over-the-air signal may be very low, it is recommended to use an antenna with some gain and make sure the impedances of the antenna and the RF input port of the signal analyzer match with each other.

*Figure 2-7 DVB-T SFN Field Measurement System*




## DVB-T Signal Under Test

In this example, Keysight N5182A MXG vector signal generator and N7623B signal studio for digital video are used to simulate DVB-T signals in the SFN network. The detailed parameters are as below.

Power level: -60 dBm

Frequency: 474 MHz

Channel bandwidth: 8 MHz

Mode: 8K (6817 subcarriers)

Modulation type: 16 QAM

Guard interval: 1/4 (224 µs )

S/N: 30 dB

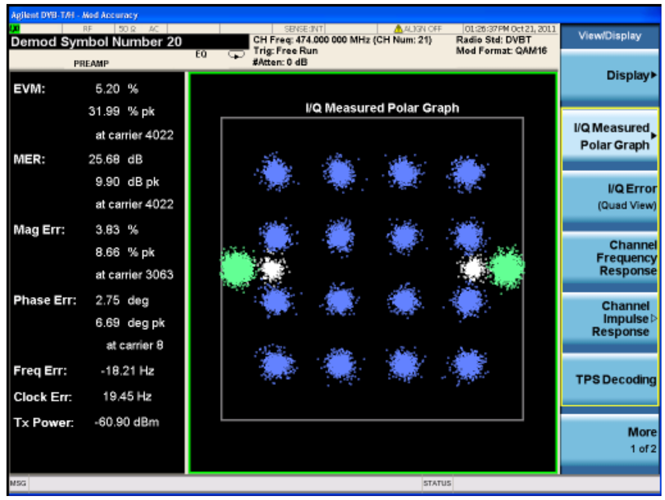
The fading channel used to simulate the SFN propagation environment is shown as below. In the static delay profile, three paths are used, including the main channel, a pre-echo, and a post-echo.

| Tap number | Delay (µs ) | Level (dB) |
|---|---|---|
| 1 | 0 | -10 |
| 2 | 100 | 0 |
| 3 | 200 | -10 |

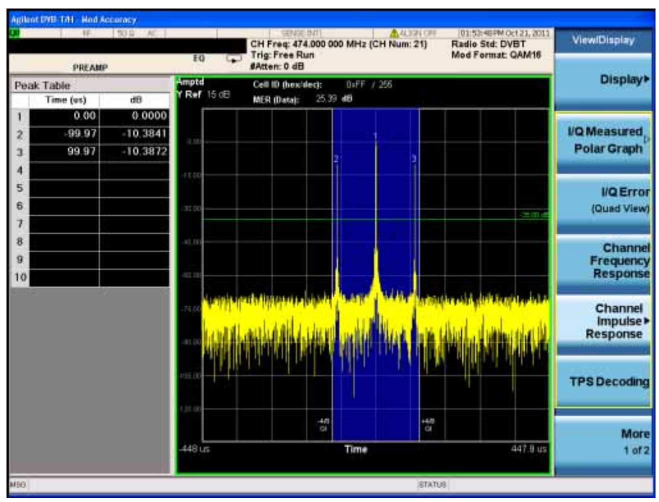
## Measurement Procedure

| Step | Notes |
|---|---|
| Set up the DVB-T/H with T2 mode parameters according to “Common Measurement Steps – Setting up DVB-T/H with T2 Mode” on page 17. | If the DVB-T/H with T2 mode is NOT set up properly, the measurement results will be incorrect. |
| Press **Meas**, **Channel Power** and then<br>• Press **AMPTD Y Scale**, **Attenuation**, set the **Mech Atten** to **0 dB** and toggle **Enable Elec Atten** to **Off**.<br>• Press **AMPTD Y Scale**, **More 1 of 2**, **Internal Preamp**, **Low Band [3.60 GHz]**. | This is to select the channel power measurement and turn off the attenuator and turn on the preamplifier inside the signal analyzer to make it suitable to measure low power level signals.<br>Note that the preamplifier requires option P03 installed in the X-Series signal analyzer. |

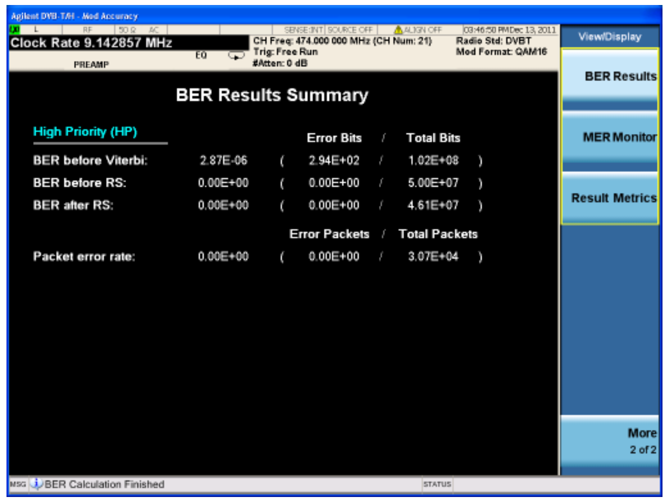
| Step | Notes |
|---|---|
| View the spectrum and the channel power of the signal. | Typically, the signal analyzer can measure signals as low as -80 dBm. If the signal level is about -60 dBm as in the graphic below, the results can be pretty stable.   |
| Press **Meas**, **DVB-T/H Mod Accuracy**. | This selects the DVB-T/H Mod Accuracy measurement to measure MER, Channel Impulse Response, and BER results. |
| Press **View/Display**, **I/Q Measured Polar Graph** (default view). | This selects the I/Q measured polar graph view. |
| Press **Meas Setup**, **Advanced**, and toggle **Equalization** to On. | The recovered I/Q points and MER/BER results can be improved through turning on the equalizer. |
| Press **Meas Setup**, **Auto Detect.** | This is to auto-detect OFDM parameters. Note that you need to perform auto-detect every time you change the RF channel. |
| Press **Meas Setup**, **Advanced**, **More 1 of 2**, **FFT Start Position** and try different options to find the optimal choice with which you can get the largest and the most stable MER result. | This sets the FFT Start Position which will determines the place of the FFT window.<br>For more information, refer to "SFN Reception Conditions and FFT Start Position" on page 115. |

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the constellation graphic and the MER results.</td><td>
</td></tr>
<tr><td>Press View/Display, Channel Impulse Response.</td><td>This is to view the channel impulse response.</td></tr>
<tr><td>Press Meas Setup, Advanced, More 1 of 2, FFT Start Position and try different options to find the optimal choice with which you can get the largest and the most stable MER result.</td><td>This sets the FFT Start Position which is very important in SFN test. While adjusting the FFT Start Position, you can refer to the MER result displayed on the top of the channel impulse response view.<br><br>For more information, refer to “SFN Reception Conditions and FFT Start Position” on page 115.</td></tr>
<tr><td>(Optional) Press Meas Setup, Decode and toggle Decoding to On.</td><td>Turning on decoding slows down the measurement speed obviously. But you can get the following benefits:<br><br>Better results of channel impulse response. By turning on decoding, channel impulse response results can be more accurate, echoes with lower level can be detected, and the image echo caused by echo outside GI range can be eliminated.<br><br>Cell ID for the main path is displayed on the screen.<br><br>For N9020A MXA and N9010A EXA, option DP2 (not upgradeable) or B40 is recommended to improve the measurement speed.</td></tr>
</table>

<table>
<tr><th>Step</th><th>Notes</th></tr>
<tr><td>View the channel impulse response results.</td><td>
In the figure below, the graphic window shows the channel impulse response trace and the table window lists the delay and power level of three paths in the fading channel under test.
The blue bar with the range of GI indicates that all the paths included are used to reconstruct the signal for measurement. The position of the blue bar will be changed with FFT Start Position (under Meas Setup, Advanced, More 1 of 2 menu) value.
The green line with -35 dB above its right side is the peak limit line, which means only peaks above this line can be displayed in the peak table. To adjust the peak limit line, press Peak Search, More 1 of 2, Peak Table and enter your desired peak limit value.
For more information, refer to “Peak Table” on page 121.



</td></tr>
<tr><td>Press View/Display, More 1 of 2, BER Results.</td><td>This is to view the BER results.</td></tr>
</table>

| Step | Notes |
| --- | --- |
| View the BER results. | In the figure below, BER before Viterbi, BER before RS, BER after RS, and Packet error rate are displayed. In this case, the BER before Viterbi is 2.87E-06 and after Viterbi decoder, the BER becomes zero.<br><br>For more details about the BER calculation method, please refer to "BER" on page 117.<br><br> |

# Using Option BBA Baseband I/Q Inputs

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

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

*Table 2-3 BBIQ Supported Measurements vs. Mode*

| Mode | Measurements |
|---|---|
| GSM | IQ Waveform<br>GMSK Phase & Freq<br>EDGE EVM |
| 802.16 OFDMA | IQ Waveform<br>Power Stat CCDF<br>Modulation Analysis |
| TD-SCDMA | IQ Waveform<br>Power Stat CCDF<br>Code Domain<br>Mod Accuracy |
| cdma2000 | IQ Waveform<br>Power Stat CCDF<br>Code Domain<br>Mod Accuracy<br>QPSK EVM |
| DTMB (CTTB) | IQ Waveform<br>Power Stat CCDF<br>Mod Accuracy |
| DVB-T/H with T2 | IQ Waveform<br>Power Stat CCDF<br>DVB-T/H Mod Accuracy<br>DVB-T2 Mod Accuracy |
| CMMB | IQ Waveform<br>Power Stat CCDF<br>Mod Accuracy |
| ISDB-T | IQ Waveform<br>Power Stat CCDF<br>Mod Accuracy |
| Digital Cable TV | IQ Waveform<br>Power Stat CCDF<br>Mod Accuracy |
| IQ Analyzer (Basic) | IQ Waveform<br>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) are ignored. The I and Q ports are in single-ended mode when Differential "Off" is selected.

Differential (balanced) — In this mode, both main and complementary ports are used. To activate this mode, select Differential "On" from the I and Q Setup softkey menus.

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

**NOTE** To avoid duplication, this section describes only the details unique to using the baseband I/Q inputs. For generic measurement details, refer to the previous sections on "Making DVB-T/H with T2 Measurements" on page 13.

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

| Step | Notes |
|---|---|
| Select a measurement that supports baseband I/Q inputs by pressing **Meas**. | Table 2-3 on page 81 lists the measurements that support baseband I/Q inputs in each mode. |
| Select the I/Q Path. Press **Input/Output, I/Q, I/Q Path**, and then select from the choices present on the screen. | The path selected in this step is shown at the top of the measurement screen. |
| Select the appropriate circuit location and probe(s) for measurements. | For details see "Selecting Input Probes for Baseband Measurements" on page 134 in the Concepts chapter. |
| Select baseband I/Q input connectors and connect the I/Q signals to the corresponding I/Q ports on the instrument. | |

| Step | Notes |
| --- | --- |
| If you have set the I/Q Path to **I+jQ** or to **I Only**, press **I Setup.**<br>A. Select whether **Differential (Balanced)** input is **On** or **Off.**<br>B. Select the input impedance, **Input Z**.<br>C. Input a **Skew** value in seconds.<br>D. Set up the I Probe by pressing **I Probe**.<br>a. Select probe **Attenuation**.<br>b. Calibrate the probe. Press **Calibrate...** to start the calibration procedure. Follow the calibration procedure, clicking **Next** at the end of each step. | |
| If you have set the I/Q Path to **I+jQ** or to **Q Only**, press **Q Setup.**<br>A. Select whether **Differential (Balanced)** input is **On** or **Off.**<br>B. Select the input impedance, **Input Z**.<br>C. Input a **Skew** value in seconds.<br>D. Set up the I Probe by pressing **I Probe**.<br>a. Select probe **Attenuation**.<br>b. Calibrate the probe. Press **Calibrate...** to start the calibration procedure. Follow the calibration procedure, clicking **Next** at the end of each step. | |
| 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. |
| If you are using cables that were not calibrated in the probe calibration step, press **I/Q Cable Calibrate...**, follow the calibration procedure, and click **Next** at the end of each step. | |
| After completing the baseband IQ setup procedures, make your desired measurement. | |

### Using BBIQ Inputs in DVB-T2 Mod Accuracy Measurement

To use BBIQ inputs in DVB-T2 Mod Accuracy measurement, besides the procedure listed above, you need to prepare an external trigger, which has a period of the length of the T2 frame under test, and connect it to the TRIGGER 1 IN port on the rear panel of the signal analyzer. After that, set the trigger of the signal analyzer to external 1 by pressing **Trigger**, **External 1**.

For more information on using triggers, refer to "Using Triggers in DVB-T2 Mod Accuracy Measurement" on page 127.

## Measuring Low IF Signals with BBIQ Input

Baseband IQ input can also be used to measure the low IF (intermediate frequency) DVB-T/H/T2 signals. It provides better and clearer measurement results than measuring them from RF input directly. The center frequency of the input signal can be very low, for example, 4 MHz for the 8 MHz signals.

This is helpful when making tests on some low-IF tuners, which down-converts the input TV signal to extremely low IF directly, such as 4 MHz.

**Signal under test (example):**

Radio Standard: DVB-T

Center Frequency: 4 MHz

Channel Bandwidth: 8 MHz

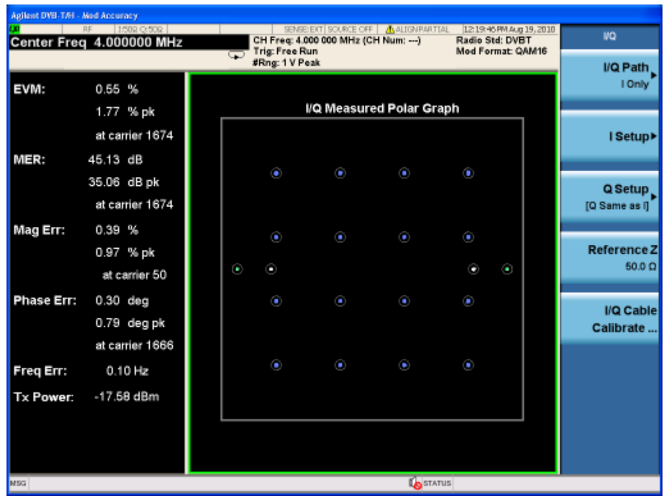
FFT Size: 2K

Modulation Type: 16QAM

**Measurement Procedure**

| Step | Notes |
|---|---|
| Connect the low IF signal under test to the I Input port on the front panel of signal analyzer with appropriate cables and connectors. | |
| On the signal analyzer, press **Meas**, **DVB-T/H Mod Accuracy**. | This selects a measurement that supports BBIQ measurements. You can choose CCDF, IQ Waveform, or DVB-T2 Mod Accuracy as well. |
| Press **Input/Output**, **I/Q**, **I/Q Path**, **I Only**, and then set the parameters under **I Setup**. | This selects the BBIQ input path as I only and sets up the I path. |
| Press **FREQ Channel**, **Center Freq**, **4**, **MHz**. | This sets the center frequency to 4 MHz, and sets up the mode and measurement parameters. |

| Step | Notes |
|---|---|
| Press **Mode Setup**, **Radio Std**, **DVB-T**, **Channel BW**, **8 MHz**, and then press **Meas Setup**, **Auto Detect.** | This sets up the parameters for the mode, and DVB-T modulation accuracy measurement.<br><br>Refer to “DVB-T/H Modulation Accuracy Measurements” on page 30 for more details. |
| View the measurement results. | Here is an example of the I/Q measured polar graph view. The measured MER is 45.13 dB, much higher than the results measured through RF input. |



# 3 Concepts

This chapter provides details about the DVB-T/H and DVB-T2 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.

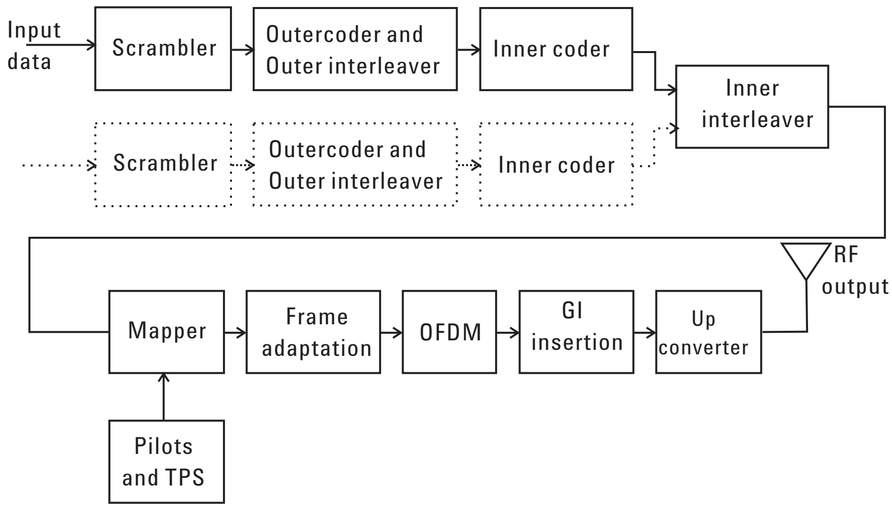
# DVB-T/H Technical Overview

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, defined in ETSI EN 300 744, 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 3-1.

*Figure 3-1 Block Diagram of DVB-T System*




In DVB-T, the capacity for hierarchical modulation can enable two completely separate data streams 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 in 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 are 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

The 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 are 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 of the current transmission parameters.

### OFDM

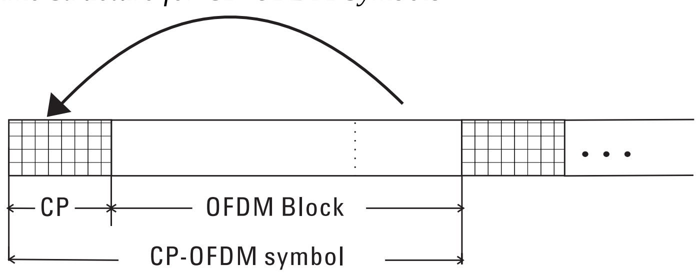
DVB-T/H uses Cyclic Prefix Orthogonal Frequency Division Multiplexing (CP-OFDM) for modulation.

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 into a circular one, hence, the equalization can be performed with much lower complexity. The signal frame structure of CP-OFDM is shown in Figure 3-2.

*Figure 3-2 Signal Frame Structure for CP-OFDM Symbols*



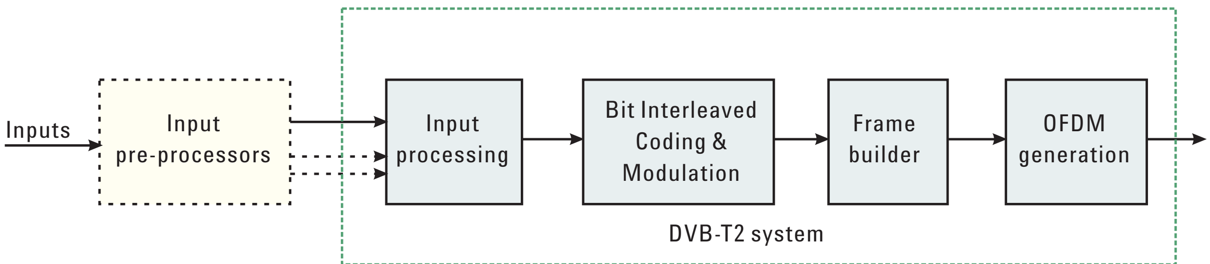

Four GI (guard interval) values are used in DVB-T/H standard, which are 1/4, 1/8, 1/16, 1/32 of the duration of the OFDM block.

# DVB-T2 Technical Overview

DVB-T2 standard, defined in ETSI EN 302 755, is an extension of the existing DVB-T standard, aiming to provide a minimum of 30% capacity increase over the DVB-T, improved single-frequency-network (SFN) performance, service-specific robustness, better error correction ability, and bandwidth and frequency flexibility.

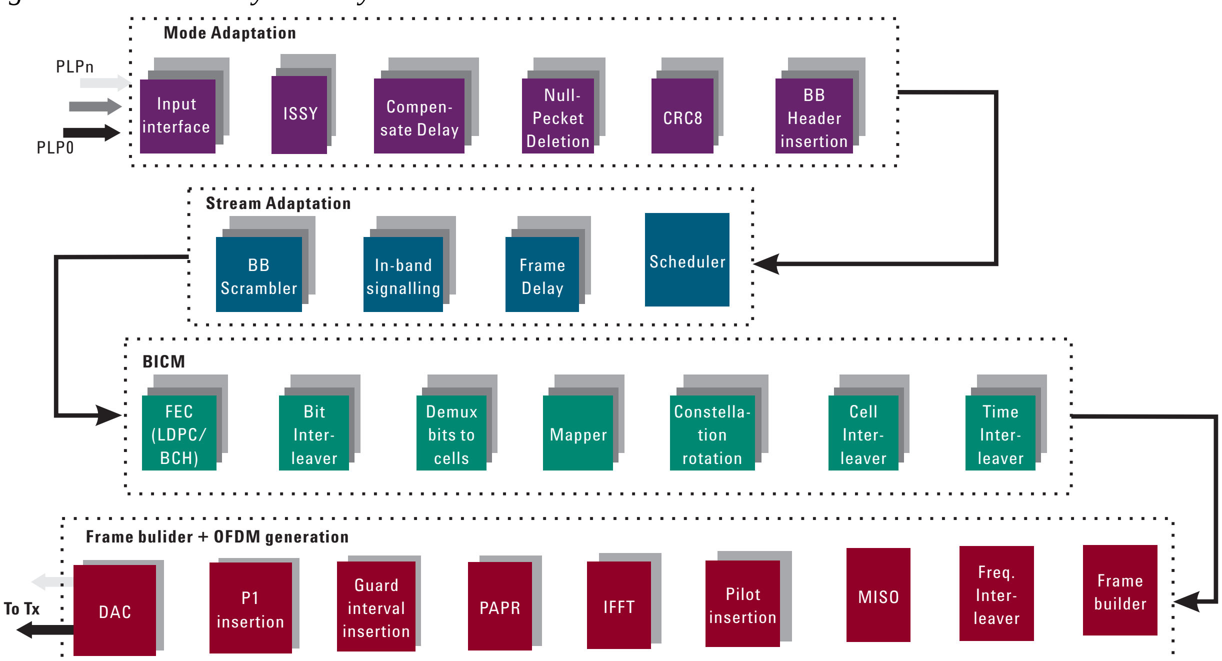
The generic DVB-T2 system block diagram is shown in Figure 3-3. The system inputs may be one or more MPEG-2 transport streams (TS) or one or more generic streams (GS). The input pre-processor, is not part of the T2 system, which is used to separate the input services into T2 system input. The T2 system input includes one or more logical data streams, and will be carried in individual Physical Layer Pipes (PLPs).

*Figure 3-3 DVB-T2 System Block Diagram*




The detailed physical layer architecture in input processing, bit interleaved coding and modulation (BICM), frame builder, and OFDM generation sections is illustrated in Figure 3-4. Refer to [5] and [6] for more details about the DVB-T2 specifications and implementation guidelines.

*Figure 3-4 DVB-T2 Physical Layer Architecture*

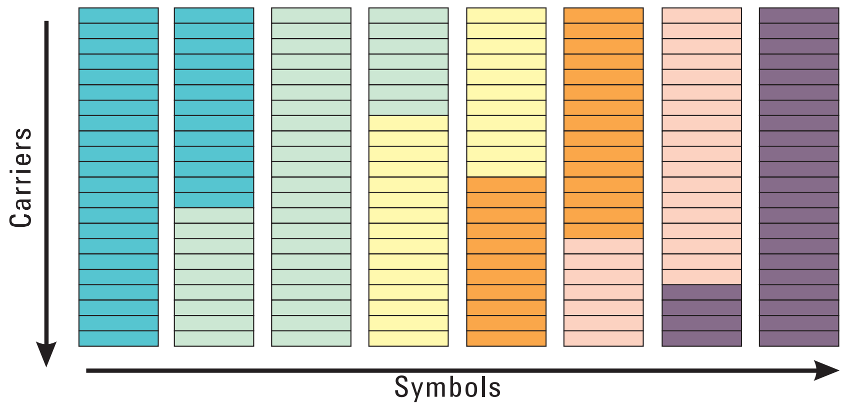


## Key Technologies

### Physical Layer Pipes (PLPs)

The introduction of fully transparent physical layer pipes enable the transport of the service data independently in its own structure, with free selectable, PLP specific physical parameter settings, as shown in Figure 3-5. With this feature, DVB-T2 system has more service-specific robustness.

*Figure 3-5 Different PLPs Transmitted in Different Time Slices*




In each PLP, constellation format, code rate, and interleaving depth can be assigned individually. Furthermore, DVB-T2 also includes a common PLP, shared by all the current PLPs, to transmit the common elements.

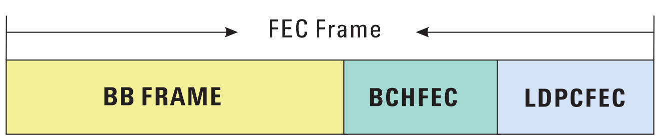
Two input modes are defined: input mode A for single PLP and input mode B for multiple PLPs.

- Input mode A: A single PLP is used, transporting a single transport stream.
- Input mode B: Multiple PLP are used, providing the advantage of service-specific robustness.

### BCH and LDPC Coding

In DVB-T2 specification, concatenated BCH (outer coding) and LDPC (inner coding) are used as FEC (forward error correction) coding, providing better error correction in comparison with convolutional and Reed-Solomon coding implemented in DVB-T.

*Figure 3-6 LDPC and BCH Coding*




The FEC frame is shown in Figure 3-6, in which the parity check bits (BCHFEC) of the BCH outer code and the parity check bits (LDPCFEC) of the LDPC inner code are appended after the BB Frame in sequence.

### Constellation Rotation

A new technique, known as constellation rotation, is implemented in DVB-T2. After the FEC cells are mapped into the I/Q constellation, they are rotated in the complex plane such that each component I or Q after rotation has enough information on its own to identify which constellation point is under transmission. The constellation diagram after rotation is shown in Figure 3-7, which is an example for 64 QAM.

The performance gain obtained through constellation rotation greatly depends on the choice of rotation angle. In DVB-T2, different rotation angles are defined for different modulation formats, as shown in Table 3-1.

The Q part is then cyclically delayed by one cell within a FEC block. This is done to transmit the I and Q parts separately in different carriers. Therefore, if one of them is destroyed by a deep selective fading in the channel, the other can be used to recover the symbol in the receiver. The purpose of this technique to improve the receiver's performance in the propagation channels with deep fades other than Gaussian fadings.

*Figure 3-7 64 QAM Constellation Rotation*

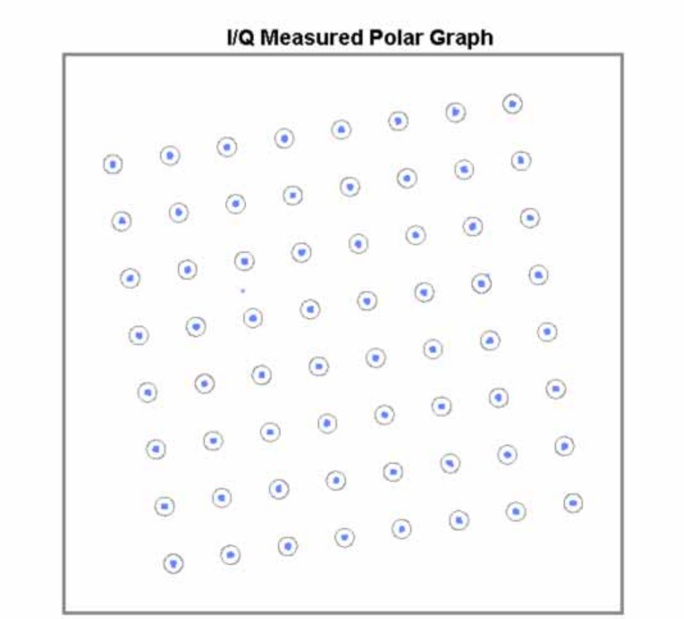


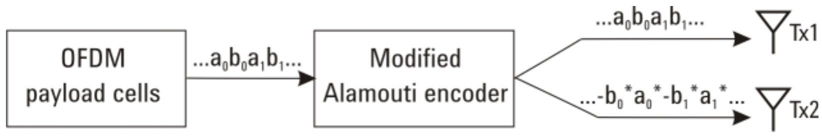

*Table 3-1 Rotation Angle for Each Modulation Format*

| Modulation format | Rotation angle (degrees) |
|---|---|
| QPSK | 29 |
| 16QAM | 16.8 |
| 64QAM | 8.6 |
| 256QAM | atan(1/16) |

### MISO Transmission Scheme

MISO (multiple input single output) transmission scheme for DVB-T2 standard is based on a modified Alamouti coding scheme with two input antennas.

*Figure 3-8*




MISO Encoding Process for OFDM Payload Cells

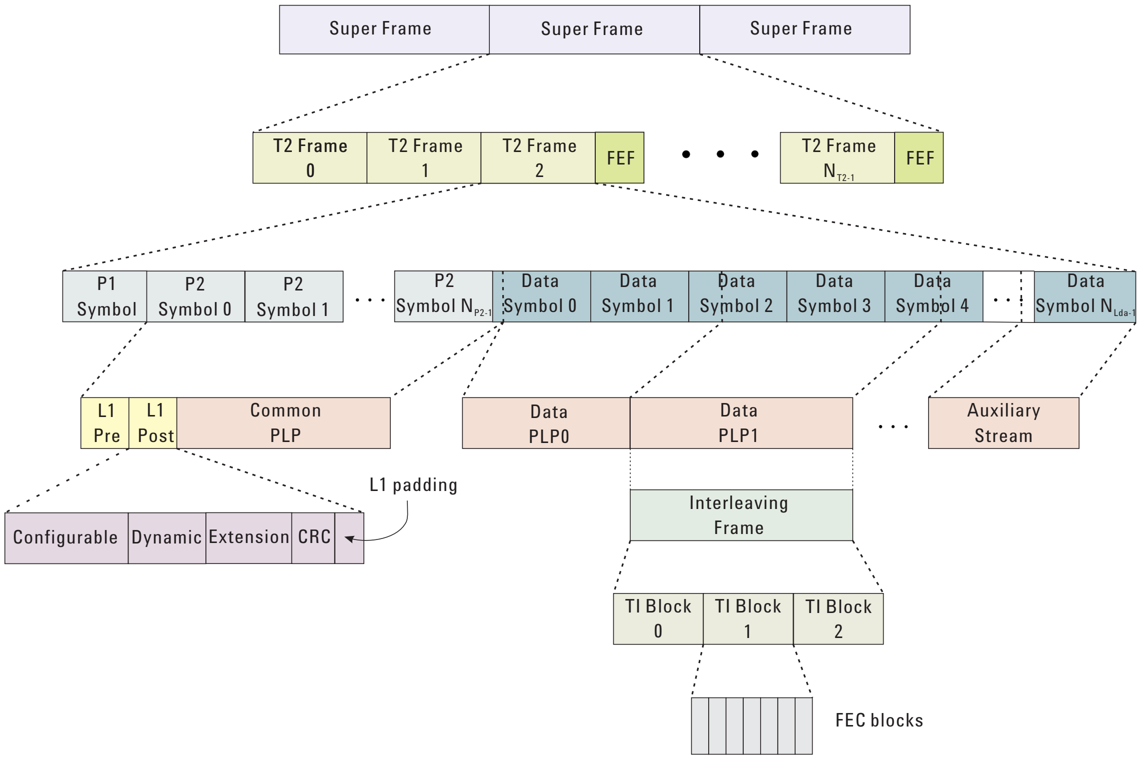
The encoding is performed on pairs of the OFDM payload cells ([$a_0$,$b_0$] for the first pair. Then [a0,b0] will be sent to the first antenna and [-$b_0$*, $a_0$*] to the second one, where * denotes the complex conjugation operation. Note that the encoding process is not applied to preamble symbol P1, so the content of P1 symbol should be identical on the two antennas.

### Frame Structure

The T2 frame structure is illustrated in Figure 3-9. It consists of super frames at the top level, which are then divided into T2 frames and further divided into OFDM symbols. The T2 frame may have FEF parts, which are not compulsory.

A T2 frame includes one P1 preamble symbol, followed by some P2 preamble symbols and a configuration number of data symbols. P1 symbol carries only P1 specific signalling information. P2 symbols carry the remaining L1 signalling information, including the L1-Pre signalling data and L1-Post signalling data. If there is still space left, common PLPs and/or data PLPs can also be carried in P2 symbols. Data symbols carry only common PLPs or data PLPs. P2 or data symbols can be shared between multiple PLPs. If there is free capacity left at the end of the T2-frame, it is filled with auxiliary streams (if any) and dummy cells. In the T2-frame, the common PLPs are always located before the data PLPs.

*Figure 3-9 T2 Frame Structure*

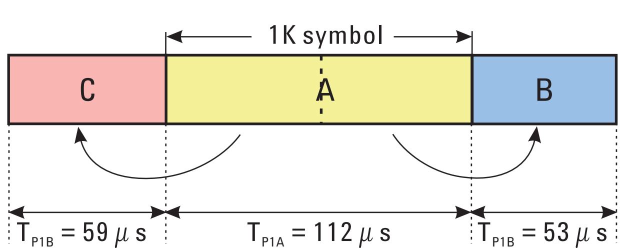



## Layer 1 Signalling

Layer 1 (L1) signalling enables the receiver to access the physical layer pipes within the T2 frame. It includes almost all the transmission parameters required by the receivers to demodulate and decode the input DVB-T2 signals correctly. It contains three sections: P1 signalling, L1-pre signalling, and L1-post signalling.

- P1 signalling is used to indicate the transmission type (T2_SISO, T2_MISO, or Non_T2) and basic transmission parameters (FFT size, mixed status). P1 signalling bits are transmitted through the P1 symbol, which is located at the beginning of a T2 frame. The construction of a P1 symbol is such that it can be used to distinguish itself from other parts in a T2 frame and to achieve timing and frequency synchronization quickly. See the structure of P1 symbols in Figure 3-10. The modulation format is DBPSK.

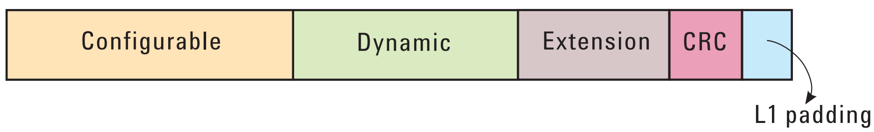
*Figure 3-10 P1 Symbol Structure*



- L1-pre signalling enables the reception and decoding of L1-post signalling by transmitting parameters such as modulation format, code rate, FEC type, etc. L1-pre signalling bits are protected by a concatenation of BCH outer coding and LDPC inner coding, and mapped to BPSK symbols.
- L1-post signalling includes the parameters needed by the receiver to access the physical layer pipes in the T2 frame. See the structure of L1-post signalling in Figure 3-11. It contains two types of parameters, configuration and dynamic, followed by an optional extension field and CRC coding. The configurable field remains the same for the duration of a super-frame, while the dynamic field contains parameters which are specific for the current T2 frame.

  The L1-post signalling bits are also protected by a concatenation of BCH outer coding and LDPC inner coding. The modulation format can be BPSK, QPSK, 16QAM, or 64QAM.

*Figure 3-11 L1-post Signalling Structure*




### Extended Carrier Mode

In DVB-T2, six modes are defined, 1K mode, 2K mode, 4K mode, 8K mode, 16K mode, and 32K mode. Extended carrier mode is defined for 8K mode, 16k mode, and 32k mode in which more subcarrieres can be used for data transmission than in the normal carrier mode. The number of subcarrieres for each mode are listed in Table 3-2.

Extended carrier mode is an optional feature. While increasing the sub-carrier number in the OFDM symbol, the bandwidth is also larger. As a result, more attention needs to be paid to meet the requirements such as spectrum masks and protection ratio.

*Table 3-2 Carrier Number for Each Mode*

| Mode | Carrier Mode | Sub-carrier number |
|---|---|---|
| 1K mode | NA | 853 |
| 2K mode | NA | 1705 |
| 4K mode | NA | 3409 |
| 8K mode | Normal | 6817 |
| | Extended | 6913 |
| 16K mode | Normal | 13633 |
| | Extended | 13921 |

*Table 3-2* *Carrier Number for Each Mode*

| Mode | Carrier Mode | Sub-carrier number |
|---|---|---|
| 32K mode | Normal | 27265 |
| | Extended | 27841 |

### Pilot Pattern

Eight scattered pilot patterns are defined which are used in different combination with the FFT size and guard interval as shown in Table 3-3.

For continual pilots, the use of the "CP groups" also depends on FFT size.

*Table 3-3* *Scatter Pilots Used for Allowed Combination of FFT Size and GI*

| FFT Size | Guard Interval | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1/128 | 1/32 | 1/16 | 19/256 | 1/8 | 19/128 | 1/4 |
| 32K | PP7 | PP4<br>PP6 | PP2<br>PP8<br>PP4 | PP2<br>PP8<br>PP4 | PP2<br>PP8 | PP2<br>PP8 | NA |
| 16K | PP7 | PP7<br>PP4<br>PP6 | PP2<br>PP8<br>PP4<br>PP5 | PP2<br>PP8<br>PP4<br>PP5 | PP2<br>PP3<br>PP8 | PP2<br>PP3<br>PP8 | PP1<br>PP8 |
| 8K | PP7 | PP7<br>PP4 | PP8<br>PP4<br>PP5 | PP8<br>PP4<br>PP5 | PP2<br>PP3<br>PP8 | PP2<br>PP3<br>PP8 | PP1<br>PP8 |
| 4K, 2K | NA | PP7<br>PP4 | PP4<br>PP5 | NA | PP2<br>PP3 | NA | PP1 |
| 1K | NA | NA | PP4<br>PP5 | NA | PP2<br>PP3 | NA | PP1 |

### PAPR Reduction

The high PAPR (peak-to-average power ratio) in the OFDM system can reduce the RF power amplifier efficiency, making it hard and costly to design the RF amplifiers. Two PAPR reduction techniques, active constellation extension (ACE) and tone reservation (TR), are defined in DVB-T2, leading to a substantial reduction of PAPR.

The ACE technique reduces PAPR by extending the outer constellation points in the frequency domain. TR reduces the PAPR by directly cancelling signal peaks in time domain using a set of impulse-like kernels made of the reserved carriers. [6]

The two techniques are complementary and can be used together. ACE performs better in a low order modulation format, while TR performs better in a high order modulation. Note that ACE can NOT be used with constellation rotations.

## DVB-T vs. DVB-T2

A general comparison between DVB-T and DVB-T2 is outlined in Table 3-4.

*Table 3-4 Comparison between DVB-T and DVB-T2*

| Item | DVB-T | DVB-T2 |
|---|---|---|
| FEC | RS + Convolutional | LDPC + BCH |
| Code Rate | 1/2, 2/3, 3/4, 5/6, 7/8 | 1/2, 3/5, 2/3, 3/4, 4/5, 5/6 |
| Constellation | QPSK, 16QAM, 64QAM | QPSK, 16QAM, 64QAM, 256QAM and constellation rotation |
| Guard Interval | 1/4, 1/8, 1/16, 1/32 | 1/4, 19/256, 1/8, 19/128, 1/16, 1/32, 1/128 |
| FFT Size | 2k, 8k | 1k, 2k, 4k, 8k, 16k, 32k |
| Scattered Pilots | 8% of total | 1%, 2%, 4%, 8% of total |
| Continual pilots | 2.6% of total | 0.35% of total |
| Bandwidth | 5, 6, 7, 8 MHz | 1.7, 5, 6, 7, 8, 10 MHz |
| Maximum Capacity | 31.67 Mbits/s | 50.34 Mbits/s |

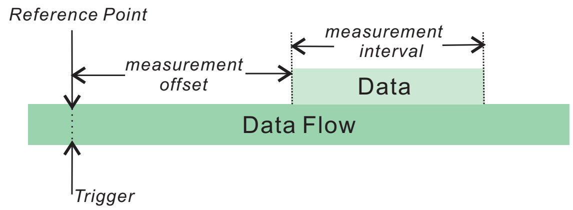
# Capturing Signals for Measurement

The signal analyzer performing vector signal analysis is not a real-time receiver but rather is a block-mode receiver. It captures a time record, and processes and displays the result before capturing the next block of data. Typically the processing and analysis time is longer than the capture time so there may be a gap between the end of one time record and the beginning of the next. Those gaps in time imply that the analyzer is not a real-time processor. This also applies to an analyzer that is configured to trigger on an event such as the change in the amplitude at the beginning of a burst. It may take the analyzer longer to process the current record than the time it takes for the next trigger event to occur.

Here again, the analyzer is not operating in real-time. Fortunately, vector signal analyzers provide a way to get real-time measurements for a limited length of time by using a time capture or recording of the input waveform. Time capturing allows the storage of complete time records with no time gaps produced in the record. The time capture is performed prior to data processing and once the waveform is captured, the signal is played back for analysis.

The signal analyzer captures the time record directly from the measurement hardware and stores the record in memory for immediate analysis or future use. Capturing the time record has the added benefit that the same signal can be analyzed over many different combinations of instrument settings including all the time and frequency measurements discussed in this section.

*Figure 3-12 Signal Capture and Measurement Interval Diagram*




The parameters used in signal capture are shown in Figure 3-12, including:

- Reference Point: This specifies the reference point for measurement offset. Here, the reference point is the time trigger occurs.
- Measurement Offset: Determines the start position of the Measurement Interval.
- Measurement Interval: Determines the length of data that is used for computing and displaying the trace data results.

# Channel Power Measurement Concepts

## Purpose

Channel Power measurement is an important test in the digital video industry to measure the power characteristics of the DVB-T/H/T2 radio signal. First of all, it measures the integrated power and power spectral density (PSD) in DVB-T/H/T2 defined bandwidth. Secondly, it measures and reports the shoulder attenuation. Thirdly, it provides a view comparing the input signal against the spectrum masks defined in ETSI EN 300 744 for the case of analogue 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, 1.7/5/6/7/8/10 MHz for DVB-T2). 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 the 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

Spectrum masks for the case of analogue TV signal in the adjacent channel are given for the following analogue TV systems:

- G/PAL/A2 and G/PAL/NICAM
- I/PAL/NICAM
- K/SECAM and K/PAL
- L/SECAM/NICAM

The spectrum masks for these TV systems are outlined in Figure 3-13, and the breakpoints are listed in Table 3-5.

*Figure 3-13 Spectrum Masks for Analogue TV Signal in Adjacent Channel (Source: ETSI EN 300 744)*

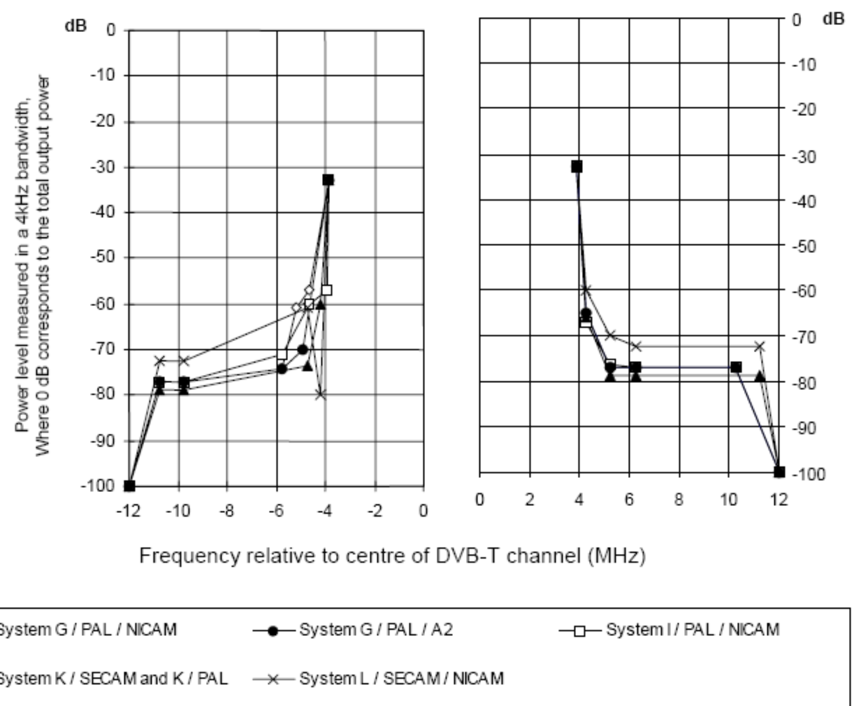



*Table 3-5 Break Points for the Spectrum Masks*

| G/PAL/NICAM | | G/PAL/A2 | | I/PAL/NICAM | | K/SECAM K/PAL | | L/SECAM/NICAM | |
|---|---|---|---|---|---|---|---|---|---|
| Freq. Offset (MHz) | Level (dB) | Freq. Offset (MHz) | Level (dB) | Freq. Offset (MHz) | Level (dB) | Freq. Offset (MHz) | Level (dB) | Freq. Offset (MHz) | Level (dB) |
| -12 | -100 | -12 | -100 | -12 | -100 | -12 | -100 | -12 | -100 |
| -10.75 | -76.9 | -10.75 | -76.9 | -10.75 | -76.9 | -10.75 | -78.7 | -10.75 | -72.4 |
| -9.75 | -76.9 | -9.75 | -76.9 | -9.75 | -76.9 | -9.75 | -78.7 | -9.75 | -72.4 |
| -5.75 | -74.2 | -5.75 | -74.2 | -5.75 | -70.9 | -4.75 | -73.6 | -4.75 | -60.9 |
| -5.185 | -60.9 | -5.185 | NA | -4.685 | -59.9 | -4.185 | -59.9 | -4.185 | -79.9 |

*Table 3-5 Break Points for the Spectrum Masks*

| G/PAL/NICAM | | G/PAL/A2 | | I/PAL/NICAM | | K/SECAM K/PAL | | L/SECAM/NICAM | |
|---|---|---|---|---|---|---|---|---|---|
| **Freq. Offset (MHz)** | **Level (dB)** | **Freq. Offset (MHz)** | **Level (dB)** | **Freq. Offset (MHz)** | **Level (dB)** | **Freq. Offset (MHz)** | **Level (dB)** | **Freq. Offset (MHz)** | **Level (dB)** |
| NA | NA | -4.94 | -69.9 | NA | NA | NA | NA | NA | NA |
| -4.65 | -56.9 | NA | NA | -3.925 | -56.9 | NA | NA | -4.65 | NA |
| -3.9 | -32.8 | -3.9 | -32.8 | -3.9 | -32.8 | -3.9 | -32.8 | -3.9 | -32.8 |
| +3.9 | -32.8 | +3.9 | -32.8 | +3.9 | -32.8 | +3.9 | -32.8 | +3.9 | -32.8 |
| +4.25 | -64.9 | +4.25 | -64.9 | +4.25 | -66.9 | +4.25 | -66.1 | +4.25 | -59.9 |
| +5.25 | -76.9 | +5.25 | -76.9 | +5.25 | -76.2 | +5.25 | -78.7 | +5.25 | -69.9 |
| +6.25 | -76.9 | +6.25 | -76.9 | +6.25 | -76.9 | +6.25 | -78.7 | +6.25 | -72.4 |
| +10.25 | -76.9 | +10.25 | -76.9 | +10.25 | -76.9 | +11.25 | -78.7 | +11.25 | -72.4 |
| +12 | -100 | +12 | -100 | +12 | -100 | +12 | -100 | +12 | -100 |

# Adjacent Channel Power (ACP) Measurement Concepts

## Purpose

Adjacent Channel Power (ACP), as it applies to DVB-T/H/T2, 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 Zo 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.

# 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/T2, 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 3-6 and Table 3-7. [4] Spectrum masks for DVB-T transmitters with output power ≥ 25W are additionally shown in Figure 3-14.

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.

*Figure 3-14 Spectrum emission limits for DVB-T transmitters with output power ≥ 25 W in 8 MHz channels (Source: ETSI EN 302 296)*

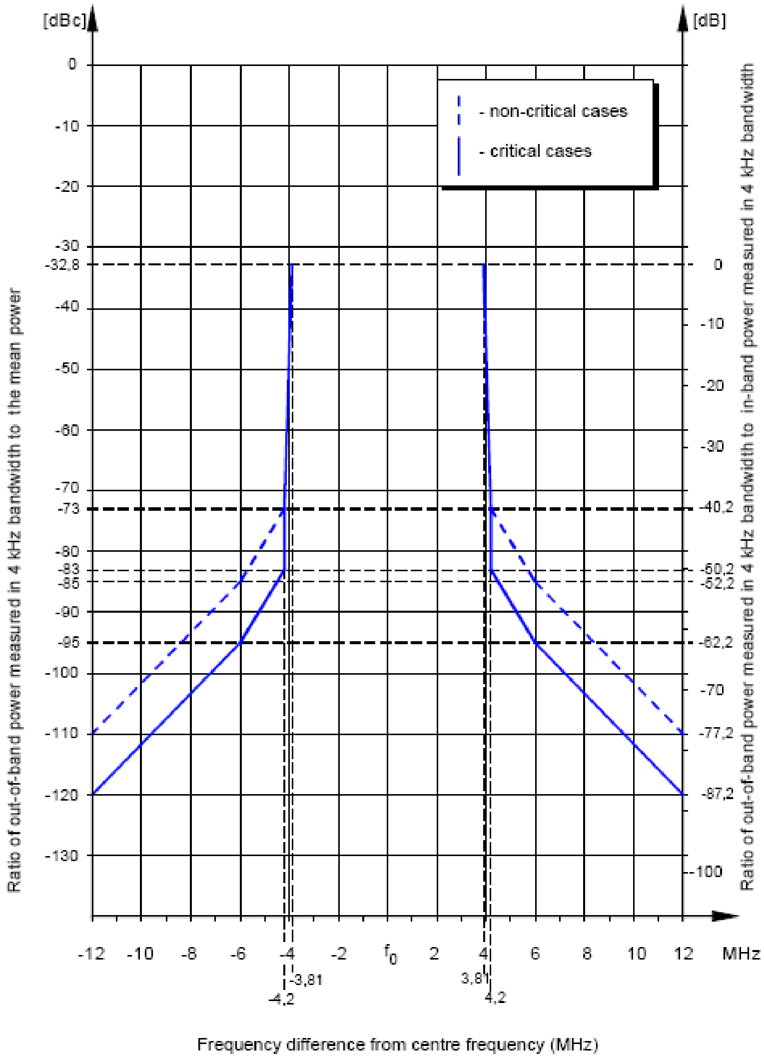



*Table 3-6 Spectrum emission limits for transmitter with output power ≥ 25 W*

| Classification | 7 MHz Channel, frequency offset (MHz) | 8 MHz Channel, frequency offset (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 |

*Table 3-6 Spectrum emission limits for transmitter with output power ≥ 25 W*

| Classification | 7 MHz Channel, frequency offset (MHz) | 8 MHz Channel, frequency offset (MHz) | Relative level (dBc) |
|---|---|---|---|
| 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 3-7 Spectrum emission limits for transmitter with output power < 25 W*

| Classification | 7 MHz Channel, frequency offset (MHz) | 8 MHz Channel, frequency offset (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 |

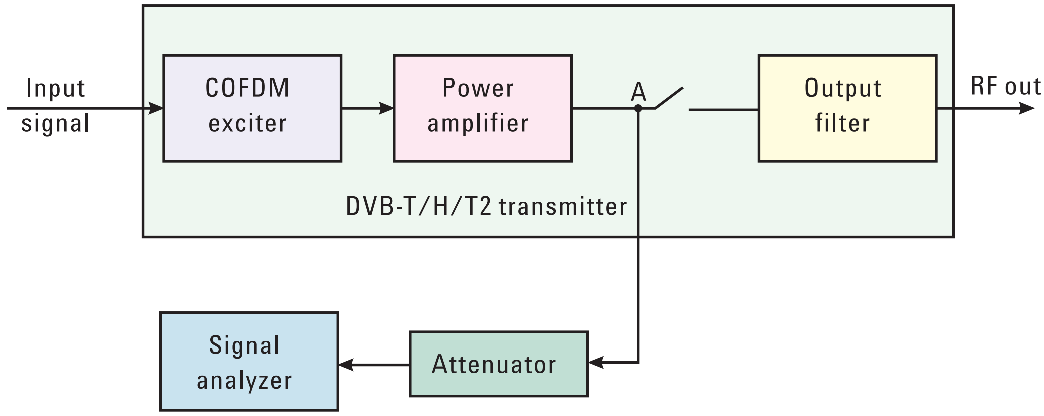
## Amplitude Correction in the Spectrum Emission Mask Measurement

The dynamic range of the RF output of a real DVB-T/H/T2 transmitter typically exceeds that of the analyzer. Therefore, if you measure the spectrum emission mask on the RF output directly, the measurement result is always “FAIL”, which does not reflect the real RF output.

There are two method used to measure the spectrum emission mask of the transmitter’s RF output.

- When the DVB-T/H transmitter has a mask filter that can be disconnected, the diagram for spectrum emission mask measurement is shown in Figure 3-15.

*Figure 3-15 Diagram for the Spectrum Emission Mask Measurement on a DVB-T/H/T2 Transmitter*




Use the following steps to measure the spectrum emission mask.

a.Measure the frequency response of the output filter using a network analyzer or a combination of signal source and signal analyzer.

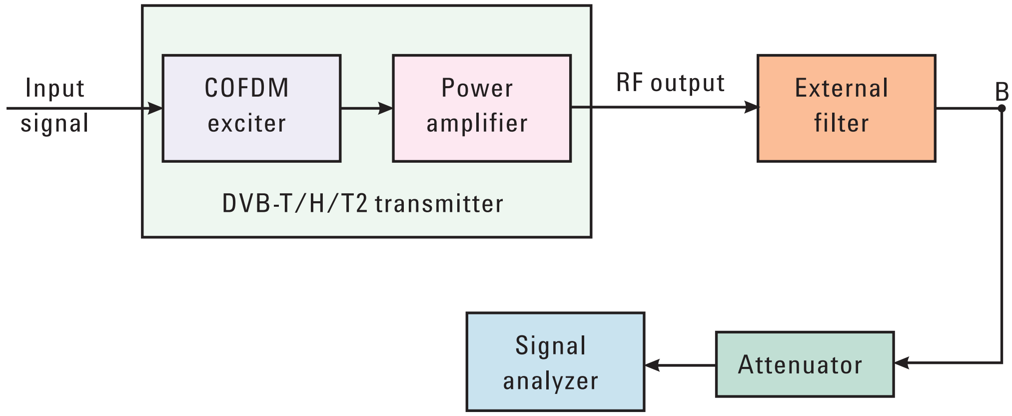
b.Measure the signal transmitted at point A as shown in Figure 3-15.

c.Apply amplitude correction on the 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.

- When the transmitter doesn't have an output filter that can be disconnected, an external filter with a band-block filter frequency response should be added after the transmitter for the measurement arrangement shown in Figure 3-16.

*Figure 3-16 Diagram for the Spectrum Emission Mask Measurement on a DVB-T/H/T2 Transmitter without an Output Filter*




Use the following steps to measure the spectrum emission mask:

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 3-16.

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 value, in dB, at a number of frequency points across the band.

# DVB-T/H 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

The 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 results are 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 following detailed descriptions provide more information on the parameters listed above:

### 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 and $S_{max}$ is the magnitude of the vector to the outermost state of the constellation.

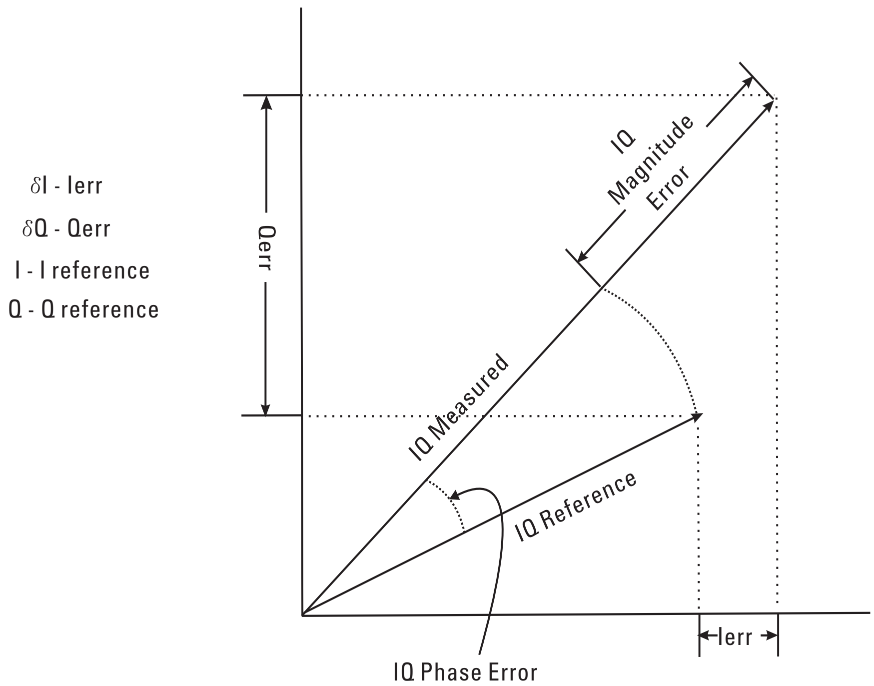
**NOTE** This definition is only used in the broadcast industry. In the wireless industry EVM is defined as the ratio of error vector vs. RMS reference vector.

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

$S_{rms}$ 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 3-17.

*Figure 3-17 Digital Demodulation Error*




### MER

MER (Modulation Error Ratio) is a power ratio expressed in dB of the sum of squares of the magnitude of the ideal symbol vectors to the sum of the squares of the magnitudes of the symbol error vectors.

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

The MER is calculated 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 3-17.

### 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 3-17.

### 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 3-17.

### 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 using 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 isolates the residual carrier. It is calculated as shown 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.

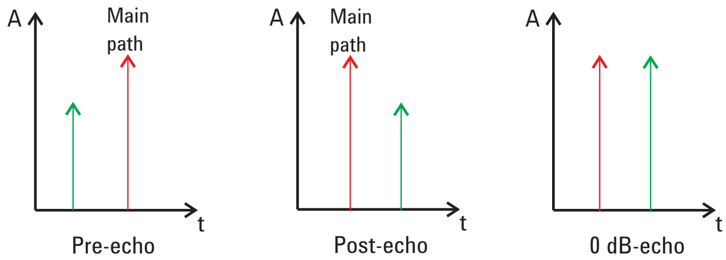
Data power ratio is the power ratio of the measured signal data to the pilots.

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.

### SFN Reception Conditions and FFT Start Position

A single frequency network (SFN) is a broadcast network where several transmitters send the same signal on the same frequency channel simultaneously without causing interference. In SFN, receivers can receive signals from several transmitters at the same time, resulting in complex reception conditions. Generally, three multi-path patterns are considered while analyzing signals from SFN network, which are pre-echo, post echo, and 0 dB echo. See Figure 3-18 for the impulse response of these three pattern, where y-axis is the amplitude of impulse response and x-axis is time.

*Figure 3-18 Pre-echo, Post-echo, 0 dB-echo*




- Pre-echo means the strongest path arrives after a lower path, which usually takes place when using repeaters. The LOS (line of sight) signal arrives first but with lower level than the signal from the repeater.
- Post-echo is the most common case, in which the strongest path is from the nearest transmitter tower and other paths are either from farther transmitters or from reflection.
- 0 dB-echo is the worst case for receiver which consists of two paths with equal level. The two paths may come from two transmitters with equal distance to the receiver or from repeaters.

FFT start position, as shown in Figure 3-19, is defined as the start point of the FFT window used to recover the OFDM carriers. It is crucial for MER and channel impulse response measurements in SFN tests because of complex reception conditions mentioned above. There are eight options from 0/8 GI ~ 8/8 GI with 1/8 GI interval available for choice.

Figure 3-20 illustrates the relationships between the FFT start position and pre-echo/post-echo. The FFT start position should set to make sure the a minimum of inter-symbol interference (ISI) occurs and to include as many echoes as possible within the FFT window. "No ISI range" in Figure 3-20 indicates the FFT start point range with no ISI, where there is no overlap with the preceding and subsequent symbols.

*Figure 3-19 FFT Start Position*

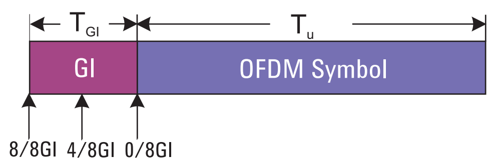
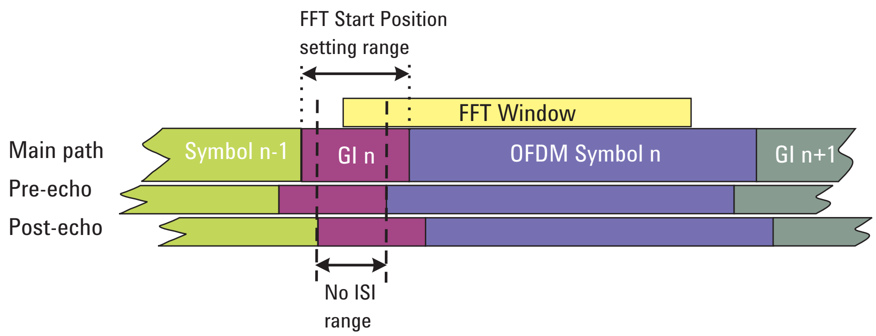


*Figure 3-20 Reception Conditions and FFT Start Position*



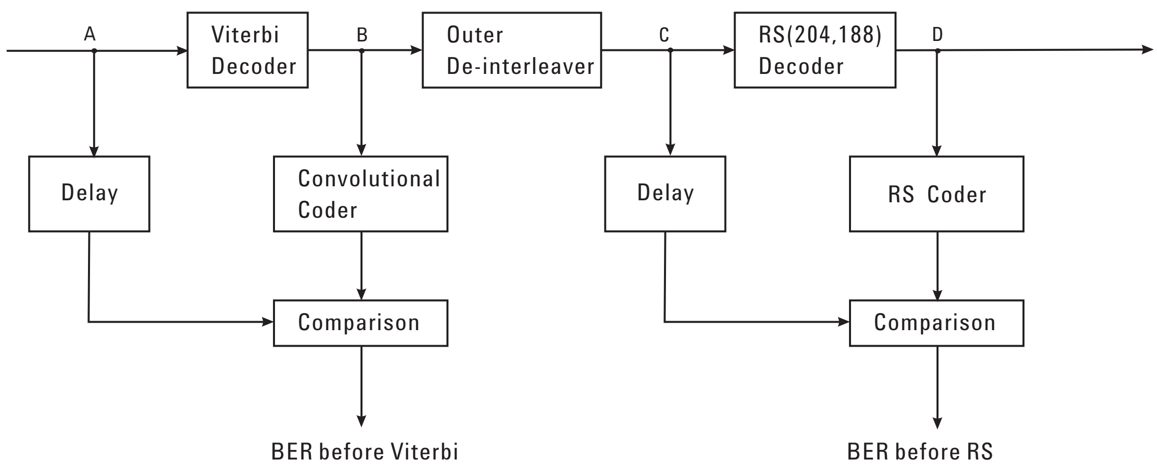

The measurement range for channel impulse response is -1/2 Tu ~ 1/2 Tu, where Tu is the duration of the OFDM symbol. If all the echoes are within GI range, the signals should be well reconstructed by adjusting the FFT start position. If there are echoes outside the GI range, the results would depend on the delay and level of the echo.

To adjust the FFT start position value, it is recommended to begin with 4/8 GI to cover both pre-echoes and post echoes. Then check the MER result with different FFT start position. The optimal FFT start position will lead to best MER result.

**BER**

BER measurement methods for DVB-T/H signals are discussed in this section. There are four results provided: BER before Viterbi, BER before RS, BER after RS, and packet error rate. The BER is defined as the ratio between erroneous bits and the total number of transmitted bits.

*Figure 3-21 Decoding Diagram*




- BER before Viterbi

  As shown in Figure 3-21, the signal after Viterbi decoding at point B is coded again using the same convolutional coding scheme as in the transmitter to produce an estimate of the originally coded data stream. This data stream is compared at bit level with the signal at point A which is before Viterbi decoder to count the erroneous bits. Then BER before Viterbi can be expressed as:

$$before\ Viterbi = \frac{Number\ of\ erroneous}{Number\ of\ transmitted}$$

- BER before and after RS, Packet error rate

  To calculate the BER before RS, BER after RS, and packet error rate, two alternative methods are available, one for "In Service" and the other for "Out of Service" use.

  —In Service

  The transmitter is running under normal operation circumstances.

  BER before RS: For the RS(204,188) decoder used in DVB-T/H, it can correct eight bytes per packet. If there are less than eight byte errors, RS decoder can correct all the errors. Then, the signal after RS decoder at point D as in Figure 3-21 is RS coded and compared with the data at point C at bit-level to count the number of corrected bits.

  If more than eight errors occur with in one TS packet, none of the errors can be corrected by the RS decoder. In this case, it is assumed that the non-correctable packet has nine-byte errors and only one bit error exists in a byte error. So BER before RS can be expressed as:

$$fore\ RS = \frac{Number\ of\ corrected\ bits + 9 \times Number\ of\ non\text{-}corretable}{Number\ of\ bits\ before\ RS\ decoder}$$

  Notice that there are two premises for this method:

  1.BER before RS decoding is much larger than BER after RS decoding;

  2.One bit error exists in one erroneous byte. When there is impulsive noise in the channel, this premise can't be fulfilled.

  BER after RS: The RS(204,188) decoder can correct eight bytes per packet. If there are more erroneous bytes, the whole packet can't be corrected. In this case, it is assumed that in a non-correctable packets contains nine byte errors, and one erroneous bit exists in a byte error. Then BER after RS can be expressed as:

$$after\ RS = \frac{9 \times Number\ of\ non\text{-}corretable\ pa}{Number\ of\ bits\ after\ RS\ decodi}$$

  Packet error rate: If there are nine or more byte error in a packet, the packet can't be corrected. This packet is counted as non-correctable. The packet error ratio can be expressed as:

$$et\ error\ rate = \frac{Number\ of\ non\text{-}correctable\ pa}{Number\ of\ packets\ receive}$$

  —Out of Service

  The basic principle of this method is that a known fixed sequence named "Null TS" packets are transmitted. The "Null TS" sequence is defined in ETSI TR 101 290.

BER before RS: The known "Null TS" packets are RS coded again and compared with the signal before RS decoding at point C as in Figure 3-21 at bit-level. BER before RS can be expressed as:

$$BER\ before\ RS = \frac{Number\ of\ erroneous\ bits}{Number\ of\ bits\ before\ RS\ decoder}$$

BER after RS: The number of erroneous bits are estimated by comparing the TS packets after RS decoding at point D with the known "Null TS" packets. Then BER after RS can be expressed as:

$$after\ RS = \frac{Number\ of\ erroneous\ bits\ after\ RS\ dec}{Number\ of\ bits\ after\ RS\ decoding}$$

Packet Error Ratio: The number of erroneous packets are estimated by comparing the TS packets after RS decoder at point D with the known "Null TS" packets in packets. That is to say, if there is any error in a 188 bytes packet, this packet is marked as erroneous. The packet error ratio can be expressed as:

$$et\ Error\ Ratio = \frac{Number\ of\ erroneous\ pa}{Number\ of\ packets\ rece}$$

### Std and Fast Method

This refers to the I/Q Mismatch settings under the Meas Setup, Advanced menu in the DVB-T/H modulation accuracy measurement.

"Std" means using the formula in the standard to calculate amplitude imbalance, quad error, and carrier suppression, providing results only for 2k mode; "Fast" means using the Keysight internal algorithm to calculate amplitude imbalance and quad error, providing results for the 2k, 4k, and 8k modes.

In the I/Q Error view, the I/Q Mismatch Polar Graph shows only the constellations for the central carrier if I/Q Mismatch is set to Std, and shows the constellation for all carriers if I/Q Mismatch is set to Fast.

### MER Monitor Process

In the DVB-T/H and DVB-T2 modulation accuracy measurement, the MER results can be monitored over time while detailed information and raw data are recorded onto the local hard disk. The actions performed during the MER monitor process are as follows:

- Recording the raw data

  If the limit line (under **Meas Setup**, **MER Monitor**) is turned on and the current MER result is lower than the limit, the corresponding failure raw IQ data for that specific measurement will be saved to the directory “D:\userdata\DVB-TH\rawdata” (for DVB-T2 signals, “D:\userdata\DVB-T2\rawdata”), which can be used by the capture buffer of the X-Series signal analyzers for further research.

The recording file name is “dataIndex_HourMinuteSecond.bin” (Index is the sequence number of the files saved in one monitoring process), such as “data2_155636.bin”.

The maximum number of raw data files saved is controlled by **Max Raw Data Files Saved** (**Meas Setup**, **MER Monitor**). If the failed measurements exceed this number, raw data will not be saved anymore. A message (File Number exceeds MaxRawDataFileSaved. Raw Data are not saved) appears after the MER result in the Log file.

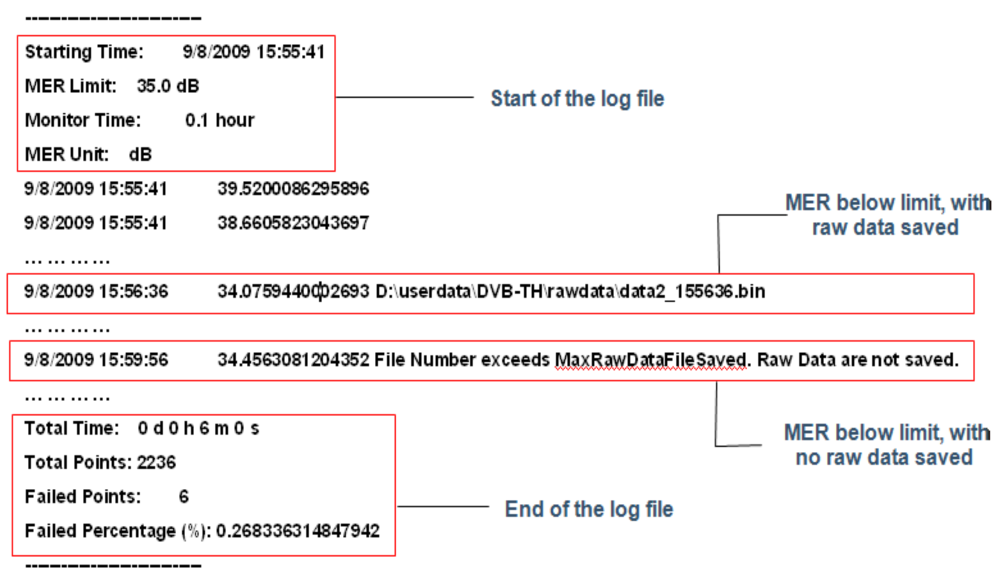
**NOTE** The amount of data included in a failure data file can be set manually. For DVB-T/H signals, set the number of symbols recorded in a failure data file using the Demod Symbols key under **Meas Setup, Advanced** menu. The failure IQ data file can include a maximum of 50 symbols, with the default value as 4. For DVB-T2 signals, the failure IQ data file includes the data of one T2 frame.

- Log file

  During the monitoring process, a log file including all the MER results, along with time information and the failure data file path, is also saved to the directory “D:\userdata\DVB-TH” (for DVB-T2 signals, “D:\userdata\DVB-T2”).

  The format of this file is shown below.

*Figure 3-22 The Format of the Log File*




The failure raw data files and log file will be saved to the local hard disk continually in the MER monitor process. To prevent using up all the hard disk space, make sure there is enough space left (1 GHz recommended) on your hard disk. And it’s recommended to remove the previous useless recorded files before the next measurement.

### Group Delay Aperture

Group delay aperture is used to calculate the group delay value. It is defined as a percentage of the current frequency-domain data. When group delay is calculated for a given point, the aperture is centered at that point. For example, the group delay for 100 Hz maybe calculated by measuring the phase change between 90 Hz and 110 Hz. Larger apertures improves the accuracy of the measured group delay, increases the smoothing of the group delay trace, but decreases resolution.

The formula for group delay is

$$Group\ Delay = [-delta(ph)/delta(f)] \times [1\ cycle/360\ degrees]$$

in which "delta(ph)" is the phase difference (in degrees) of the two frequencies separated by delta(f); "delta(f)" is the difference between two frequencies, in Herz. The units for group delay are in seconds.

"delta(f)" can be adjusted by adjusting the group delay aperture, according to the following formula:

$$delta(f) = Group\ delay\ aperture \times frequency\ span$$

in which "frequency span" is 7.61 MHz for 8 MHz channels.

### Peak Table

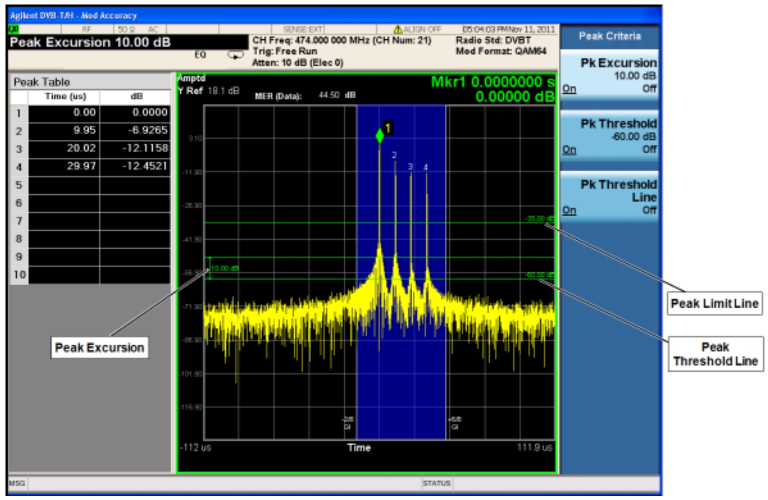
Peak table is very helpful in identifying the amplitude and delay of each path in multi-path channel. Here is an example of a four-path channel impulse response. The delays for each path are 0, 10 us, 20 us, and 30 us, respectively.

You can customize the peak table measurement as following:

— Press **Peak Search**, **More 1 of 2**, **Peak Criteria**, **Pk Excursion**, **10**, **dB**, **Pk Threshold**, **-60**, **dB** and then toggle **PK Threshold Line** to **On** to set the criteria for peak. To see how the Pk Excursion and Pk Threshold affect the peak criteria, refer to “Peak Criteria” on page 122.

The measurement result should look like Figure 3-23, including the peak threshold line, peak excursion, and peak limit line.

*Figure 3-23 Multi-Path Channel Impulse Response*




**Peak Criteria**

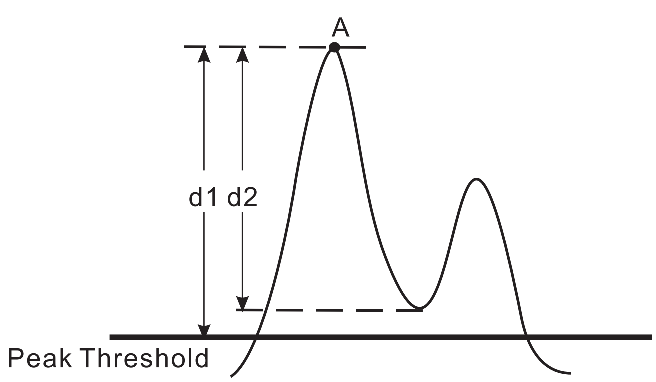
This section describes the criteria for peak, which mainly involves two parameters: Peak Excursion and Peak Threshold.

Peak (Pk) Excursion: This value determines the minimum amplitude variation (rise and fall) required for a signal to be identified as a peak.

Peak (Pk) Threshold: This value defines the minimum signal level that the peak identification algorithm uses to recognize a peak.

If both Pk excursion and Pk Threshold are on, a signal must rise above the Pk threshold value by at least the Peak Excursion value and then fall back from its local maximum by at least the Peak Excursion value to be considered a peak. As shown in Figure 3-24, only when both d1 and d2 are more than, or equal to the value of peak excursion, point A can be identified as a peak.

*Figure 3-24 Peak Criteria*



# DVB-T2 Modulation Accuracy Measurement Concepts

## Purpose

Measurement of modulation accuracy and quality are necessary to meet DVB-T2 defined tests and ensure proper operation of the transmitters or exciters. 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, providing an overall indication of the performance level of the transmitter of the UUT.

## Measurement Method

The DVB-T2 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 results are 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
- L1 signalling decoding results - transmission parameters decoded from L1 signalling bits
- Clock error - The difference between the sample clock of the input signal and the clock rate settings under the Meas Setup, Advanced menu.
- Trigger difference - The trigger difference between the trigger and the start of the T2 frame

The following detailed descriptions provide more information on the parameters listed above:

### 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 and $S_{max}$ is the magnitude of the vector to the outermost state of the constellation.

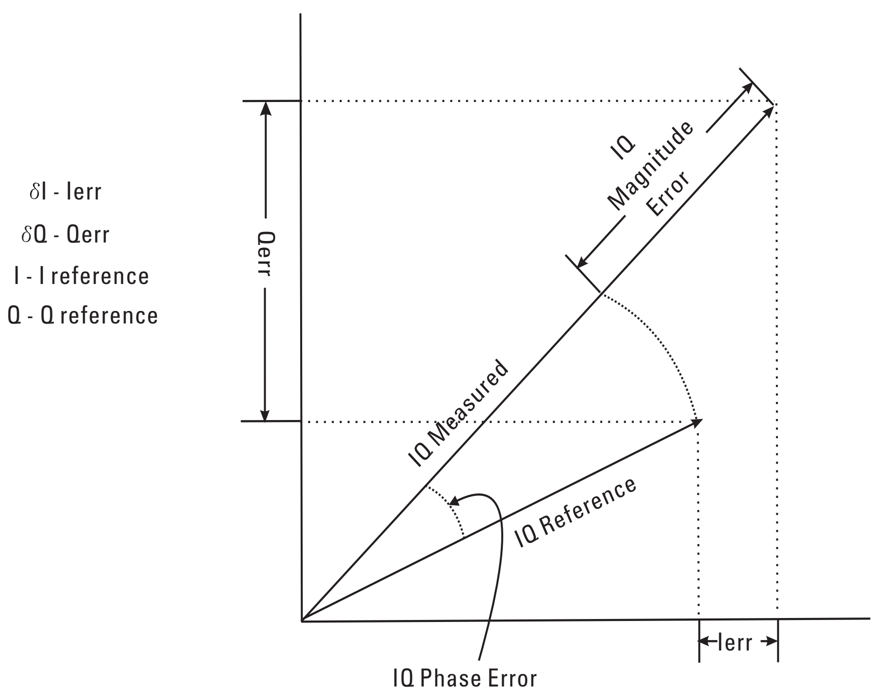
**NOTE** This definition is only used in the broadcast industry. In the wireless industry EVM is defined as the ratio of error vector vs. RMS reference vector.

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

$S_{rms}$ 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 3-25.

*Figure 3-25 Digital Demodulation Error*



### MER

MER (Modulation Error Ratio) is a power ratio expressed in dB of the sum of squares of the magnitude of the ideal symbol vectors to the sum of the squares of the magnitudes of the symbol error vectors.

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

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 3-17.

### 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 3-17.

### 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 3-17.

### 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 using the formula below:

$$AI = 20 \times log_{10}\left(\frac{\nu_I}{\nu_Q}\right) dB$$

Where $\nu_I$ and $\nu_Q$ represent I and Q gain respectively.

### L1 Signalling Results

The L1 signalling information including P1 signalling, L1-pre signalling, and L1-post signalling is provided. Almost all the configuration and modulation parameters of the signal under test can be seen from the L1 signalling results.

### Trigger Difference

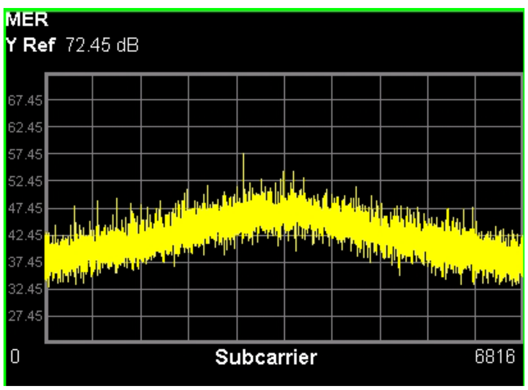
Trigger difference is the time difference between the external or internal periodic trigger and the start of the T2 frame. A positive value means that the trigger is anterior of the start of the T2 frame. A negative value means that the trigger is posterior of the start of the T2 frame.

### Clock Error

Clock error is the difference between the sample clock of the input signal and the settings under the Meas Setup, Advanced menu. The actual clock rate is the sum of the clock rate set on the instrument plus the value of clock error.

If the MER vs. Subcarrier results in the I/Q Error view look like Figure 3-26, where the MER of the subcarrier far from the center frequency are lower than that near the center, the reason of this phenomenon should be clock error. In this case, the clock error can be compensated by adjusting the clock rate under Meas Setup, Advanced panel.

*Figure 3-26 MER vs. Subcarrier Results When Clock Error Exists*



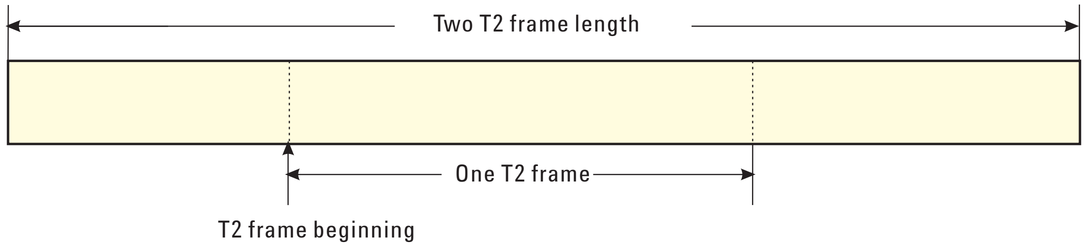
### Using Triggers in DVB-T2 Mod Accuracy Measurement

When making a DVB-T2 Mod Accuracy measurement, you need to use triggers to demodulate the input DVB-T2 signals. This section focuses on the reason for using trigger in a DVB-T2 Mod Accuracy measurement.

See the DVB-T2 frame structure in Figure 3-9 on page 95. A DVB-T2 frame includes P1 symbol, P2 symbols, and multiple PLPs. Each PLP can be configured with different modulation format, code rate, and interleaving depth. The maximum value of a T2 frame duration is 250 ms.

To demod a whole DVB-T2 frame, normally the measurement application needs to capture two T2 frames to get the data of a whole T2 frame, as the captured data does not always start at the beginning of the T2 frame, as shown in Figure 3-27.

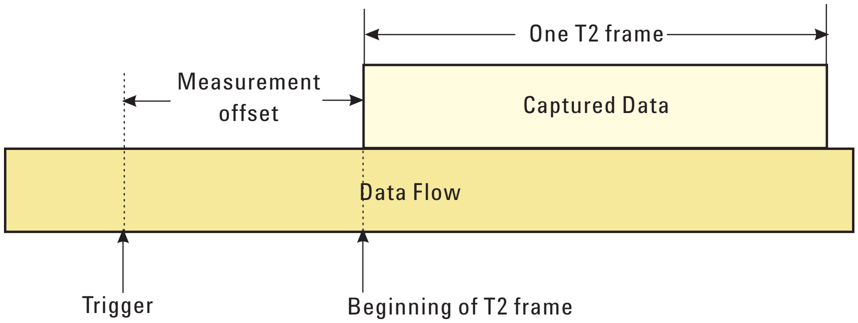
*Figure 3-27 Captured Data Without Trigger*




However, the capture length of one time record in the signal analyzer is not long enough to include two T2 frames, and only enough for one T2 frame. See “Capturing Signals for Measurement” on page 100 for more information about signal capture in signal analyzers.

To solve this problem, a trigger with the period of the length of the T2 frame under test is introduced to provide a reference point for the capturing process, making it possible to capture the data from the very beginning of the T2 frame as shown in Figure 3-28. By identifying the P1 symbol, the beginning of the T2 frame can be recognized. Then an offset is set to the trigger to make the signal analyzer capture data at the beginning of the T2 frame.

*Figure 3-28 Captured Data with Trigger*



# 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, determines which spurs to report.

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

From the spurs in the list, those with peak amplitude greater than the Absolute Limit for that range will be logged as a measurement failure. 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 3-8 for the frequency range 9 kHz to 4.5 GHz. [4]

*Table 3-8* *Spurious emission limits for DVB-T transmitters*

| Frequency range | Limits | Reference BW |
|---|---|---|
| 9 kHz to 174 MHz | -36 dBm (250 nW) | 100 kHz |
| > 174 MHz to 400 MHz | $-82$ dBm, for $P \le 25$ W<br>$-126$ dBc, for $25\,W < P \le 1000$ W<br>$-66$ dBm, for $1000\,W < P$ | 4 kHz |
| > 400 MHz to 790 MHz | -36 dBm (250 nW) | 100 kHz |
| > 790 MHz to 862 MHz | $-76$ dBm, for $P \le 25$ W<br>$-120$ dBc, for $25\,W < P \le 1000$ W<br>$-60$ dBm, for $1000\,W < P$ | 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.

# 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 (CTTB)
- DVB-T/H with T2
- CMMB
- ISDB-T
- Digital Cable TV

## What are Baseband I/Q Inputs?

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

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

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

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

To make a balanced measurement, the two connectors labeled “I” and “Q” are used in conjunction with the I and Q inputs. The terms “I-bar” and “Q-bar” must 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 I-bar connectors for I only signal measurements, while the Q and Q-bar 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 134.

## 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 (CTTB), 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 MΩ impedance input passive probes as well as the Keysight 1153A active differential probe using the InfiniMax probe interface.

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

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

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

**Supported Probes**

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

| Probe Type | Model Number | Description |
|---|---|---|
| Active | 1130A | 1.5 GHz differential probe amp<br>(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 MΩ, 1.5 m |

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

**Probes without Stored Calibration**

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

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

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

## Baseband I/Q Measurement Views

Measurement result views made in the IQ Analyzer (Basic) mode are available for baseband signals if they relate to the nature of the signal itself. Many measurements which relate to the characteristics that baseband I and Q signals have when mixed and upconverted to signals in the RF spectrum can be made as well. However, measurements which relate to the characteristics of an upconverted signal that lie beyond the bandwidth available to the Baseband I/Q Input circuits can not be measured (the limits 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 Keysight 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
  Keysight part number 5965-7160E

- Application Note

  Characterizing Digitally Modulated Signals with CCDF Curves
  Keysight part number 5968-5858E

- Application Note

  BER and Subjective Evaluation for DVB-T/H Receiver Test
  Keysight part number 5989-8446E

Go to http://www.keysight.com/find/digital_video to find more products and literatures on digital video transmitter and receiver measurements.

## Instrument Updates at www.keysight.com

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

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

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

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

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

# 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

[5] ETSI EN 302 755: Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)

[6] DVB Document A133: Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)