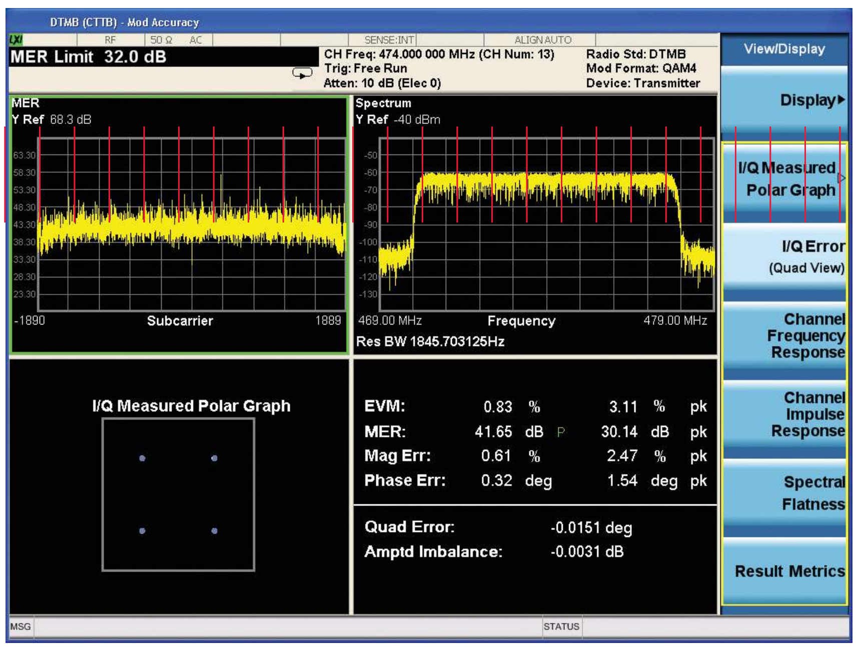
# Keysight Technologies
# N6156A & W6156A DTMB (CTTB) Digital Video

## X-Series Measurement Application

## Demo Guide




KEYSIGHT TECHNOLOGIES

# Introduction

This demonstration guide illustrates how the DTMB (CTTB) measurement application adds convenience to DTMB (CTTB) system development and manufacturing for both multi-carrier and single-carrier schemes with one-button measurements including standard presets and remote SCPI programming capabilities on the X-Series signal analyzers.

# DTMB (CTTB) Digital Video

## Measurement Details

All of the RF transmitter measurements as defined by the DTMB (CTTB) standard, as well as a wide range of additional measurements and analysis tools, are available with a press of a button (Table 2). These measurements are fully remote controllable via the IEC/IEEE bus or LAN, using SCPI commands.

Analog baseband measurements are available on the MXA signal analyzer equipped with BBIQ hardware. Supported baseband measurements include all of the modulation quality plus I/Q waveform and CCDF measurements.

| Technology | DTMB (CTTB) |
| --- | --- |
| **Measurement application** | N6156A, W6156A |
| **X-Series signal analyzer** | PXA, MXA, EXA, CXA |
| Measurements | Channel power<br>RF spectrum<br>Shoulder attenuation<br>Spectrum mask (with analog TV in adjacent channel) |
| | Adjacent channel power |
| | Spectrum emission mask |
| | Monitor spectrum |
| | IQ waveform |
| | Modulation accuracy<br>RMS EVM (%)<br>Peak EVM (%)<br>Position of peak EVM<br>RMS MER (dB)<br>Peak MER (dB)<br>Position of peak MER<br>RMS mag error (%)<br>Peak mag error (%)<br>Position of peak mag error<br>RMS phase error (deg)<br>Peak phase error (deg)<br>Position of peak phase error<br>Frequency error (Hz)<br>Clock error (Hz)<br>Tx power (dBm)<br>Quadrature error (deg)<br>Amplitude imbalance (%)<br>MER/EVM vs. subcarriers/frequency<br>Ampt vs subcarriers (dB)<br>Phase vs subcarriers (deg)<br>Group Delay vs subcarriers (ns)<br>Channel impulse response (dB)<br>MER of data block (dB)<br>MER of system info (dB)<br>MER of header (dB)<br>In-band spectrum ripple Amax-Ac (dB)<br>In-band spectrum ripple Amin-Ac (dB) |

# Demonstration Preparation

## Minimum equipment configuration requirements

All demonstrations use an X-Series signal analyzer and the N5182A MXG vector signal generator.

| Product type | Model number | Required options |
|---|---|---|
| MXG vector signal generator | N5182A (Firmware revision A.01.20 or later) | – 651, 652, or 654 – internal baseband generator (30 M/60 M/125 MSa/s, 8 MSa)<br>– 019 – Upgrade baseband generator memory to 64 MSa (recommended) |
| Signal Studio for digital video | N7623B (Software version 1.6.4.0 or later) | Please check N7623B Signal Studio Web page for the latest version www.keysight.com/find/SignalStudio |
| X-Series signal analyzer | N9000A, N9010A, N9020A, or N9030A[1] firmware revision A.06.xx or later | Recommended:<br>– EA3 – Electric attenuator, 3.6 GHz<br>– P0x – Preamplifier<br>– P0x (P03, P08 (P07 for CXA))<br>– B25, B40 or B1X – Analysis bandwidth up to 25 MHz, 40 MHz or 140 MHz<br>– BBA – Analog baseband IQ inputs (for analog baseband IQ analysis) for N9020A MXA<br>Required:<br>– 503, 508, 507, (EXA and CXA), 513 or 526–513 and 526 not available on CXA |
| DTMB (CTTB) measurement application | N6156A – N9010A, N9020A, N9030A W6156A – N9000A only | Required:<br>– 2FP: DTMB (CTTB) measurement application, fixed perpetual license<br>OR<br>– 2TP: DTMB (CTTB) measurement application, transportable license (For N9010A, N9020A, and N9030A) |
| Controller PC for Signal Studio for digital video[1] | | Install N7623B to generate and download the signal waveform into the MXG via GPIB or LAN (TCP/IP)—please refer to the online documentation for installation and setup |

1. *Keysight X-Series PXA/MXA/EXA/CXA signal analyzers can be used as the controller PC to install the N7623B Signal Studio software and download waveforms into the MXG via LAN or GPIB.*

## Helpful tip:

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

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

# Demonstration Setup

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

Connect a PC (loaded with Keysight N7623B Signal Studio for Digital Video software and Keysight I/O libraries) to the N5182A MXG via GPIB or LAN. Follow the Signal Studio instruction to complete the connection, and then perform the following steps to inter-connect the X-Series signal analyzer and MXG (see Figure 1 for a graphical overview):

A. Connect the MXG RF output port to the X-Series signal analyzer RF input port
B. Connect the MXG 10 MHz out to the X-Series signal analyzer Ext Ref in port (rear panel)

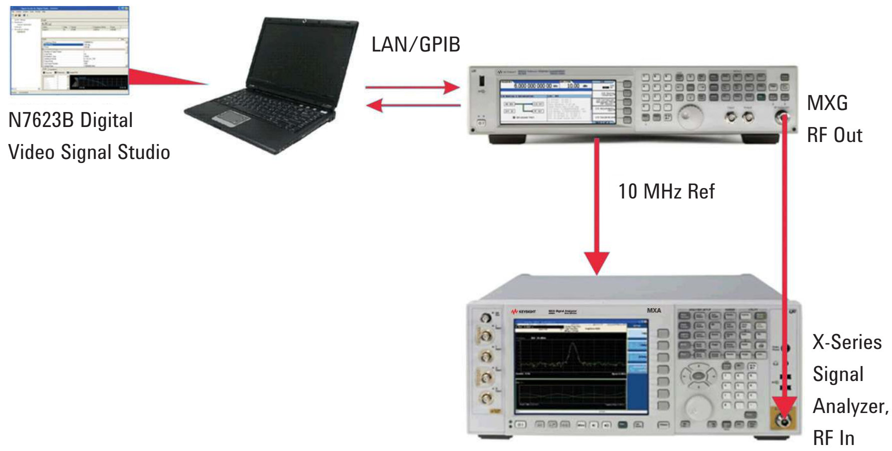



*Figure 1. Demonstration setup*

# Demonstration 1:

## Set up Digital Video Signal Studio on MXG

The Keysight N7623B Signal Studio for Digital Video is a Windows-based utility that simplifies the creation of DTMB (CTTB) signals. These signal parameters are downloaded into the MXG vector signal generator, which creates the desired waveform.

| Instructions | Keystrokes |
|---|---|
| **On the MXG:** | |
| Preset the MXG<br>Check the IP address | **[Preset]**<br>**[Utility] {I/O Config} {LAN Setup}** |
| **On the Signal Studio software:** | |
| Run the Keysight Signal Studio for digital video | Double-click on the Digital Video shortcut on the desk-top or access the program via the Windows start menu |
| Verify the software is communi-cating with the instrument via the GPIB or LAN (TCP/IP) link | To establish a new connection, click on the **{System}** pull-down menu at the top of the Signal Studio program window. Next, select **{Run System Configuration Wizard}** |
| Select the DTMB (CTTB) format | Click on the **{Format}** pull-down menu at the top of the Signal Studio program window. Next, select **{DTMB}** |
| Set the parameters of the signal generator with center frequency 474 MHz, amplitude –20 dBm, RF Output turned on, and ALC On | Click **Signal Generator** at the left on the Explorer menu.<br>Instrument model number: N5162A/N5182A<br>Press **[Preset]** green button at the top.<br>Frequency = 474 MHz, Amplitude = –20 dBm,<br>RF Output = On, ALC = On |
| Confirm the waveform setup from upper level | Click **Waveform Setup** to see the fundamental waveform signal setups, set DTMB (CTTB) common parameters as follows:<br>Oversampling ratio = 2, Mirror Spectrum = Off,<br>Quadrature angle adjustment = 0 deg,<br>I/Q gain balance = 0 dB |
| Set a test signal for demonstrations | Click **Carrier0** under **Waveform Setup** on the left of the explorer menu. Here use the default setting of reference spec. Figure 2 shows the signals setting |
| Download the signal to the MXG | Click on the top tool bar. If you encounter any errors, please refer to the online help of Signal Studio software |
| Save the signal file for future use | **File > Save Setting File > DTMB1.scp** (create filename) |
| Export the waveform file for future use | **File > Export Waveform Data > DTMB.wfm**<br>(create filename) |

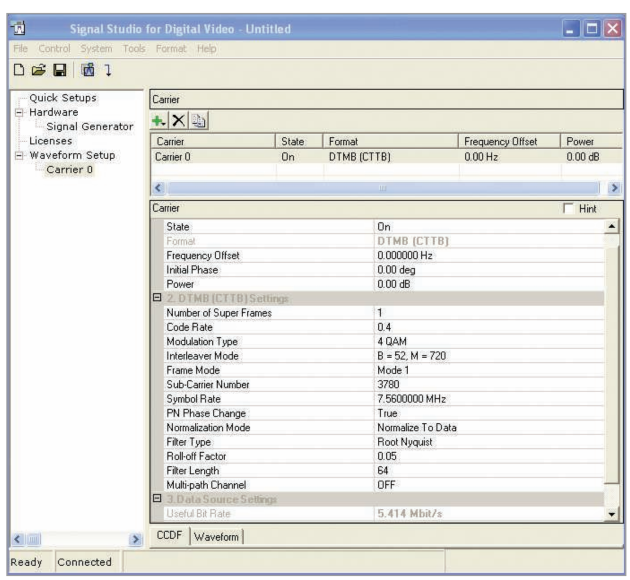



*Figure 2. DTMB (CTTB) signals setup in the Keysight Signal Studio software*

# Demonstration 2:

## Channel power

The channel power measurement has three views: RF spectrum, shoulder attenuation, and spectrum mask.

The RF spectrum view measures and reports the integrated power in a DTMB (CTTB) defined bandwidth and power spectral density (PSD) displayed in dBm/Hz or dBm/MHz.

The shoulder attenuation view measures the power difference between the center frequency (CF) and the shoulder point (4.2 MHz from CF for 8 MHz bandwidth).

The spectrum mask view compares the input signal against the DTMB (CTTB) defined spectrum mask for the condition of analog TV signal in adjacent channel.

*RF spectrum and shoulder attenuation view*

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Preset the MXA/EXA | **[Mode Preset]** |
| Select DTMB (CTTB) mode | **[Mode] {DTMB}** |
| Choose the device under test | **[Mode Setup] {Device Type} {Transmitter}** |
| Set a center frequency at 474 MHz | **[FREQ Channel] {Center Freq} {474} {MHz}** |
| Set channel bandwidth at 8 MHz | **[Mode Setup] {Channel BW} {8 MHz}** |
| Select channel power measurement (RF spectrum default) | **[Meas] {Channel Power}** |
| Switch to shoulder attenuation view | **[View/Display] {Shoulder Attenuation}** |

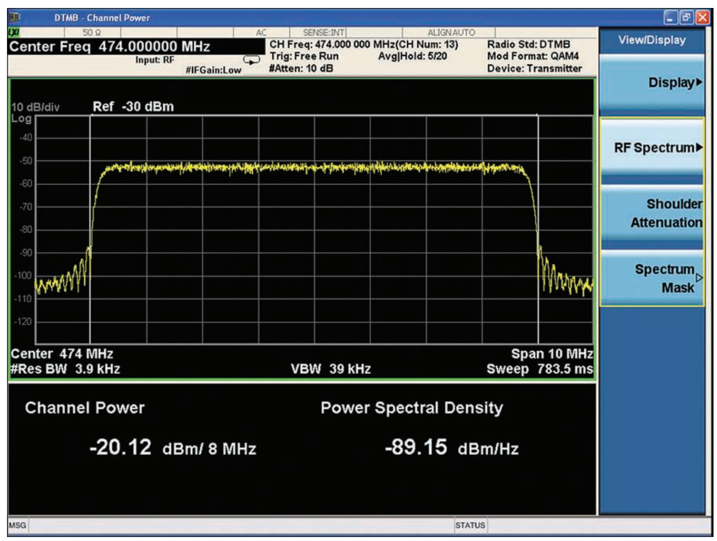



*Figure 3. Channel power measurement with RF spectrum view*

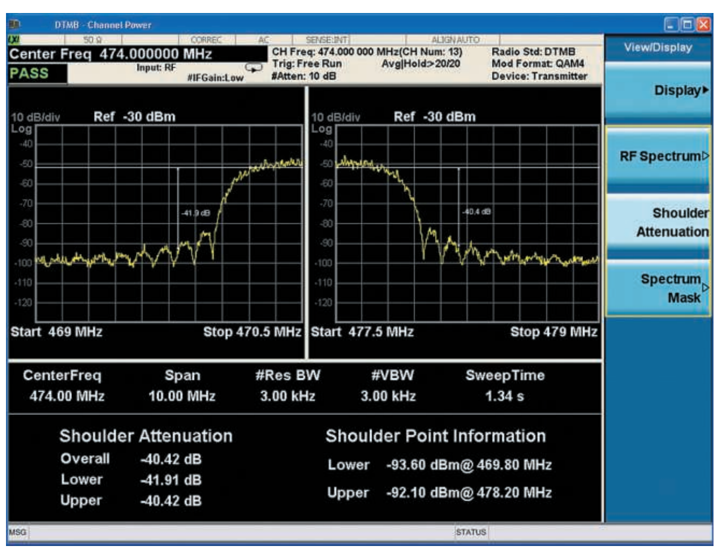



*Figure 4. Channel power measurement with shoulder attenuation view*

## Spectrum mask view

The dynamic range of the RF output of a real DTMB (CTTB) transmitter typically exceeds the dynamic range of the analyzer. Therefore, the direct measurement result is always "FAIL" and cannot reflect the real RF output.

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

### Method 1

When the DTMB (CTTB) transmitter has an output filter, the diagram for the spectrum mask measurement is shown in Figure 5.

Three steps for measuring the spectrum mask are as follows:

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 5.

C. Apply amplitude correction on spectrum value measured in (2) using the filter's response from (1).

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

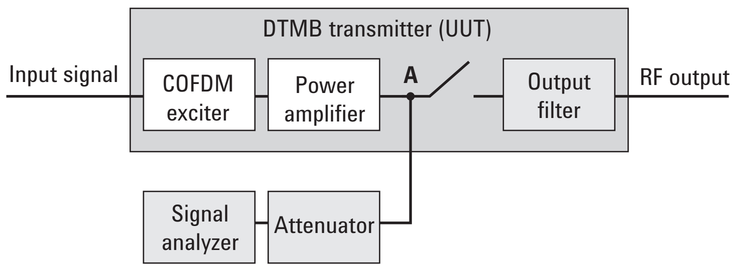



*Figure 5. Diagram for spectrum mask measurement on DTMB (CTTB) transmitter without output filter*

### Method 2

When the transmitter does not have an output filter, an external filter with a band-block filter frequency response should be added after the transmitter for the measurement arrangement shown in Figure 6.

The steps for measuring the spectrum mask are as follows:

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 B as shown in Figure 6.

C. Apply amplitude correction on spectrum value measured in (2) using the filter's response from (1).

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

This spectrum mask measurement is used in case there are analog TV signals in the adjacent channel.

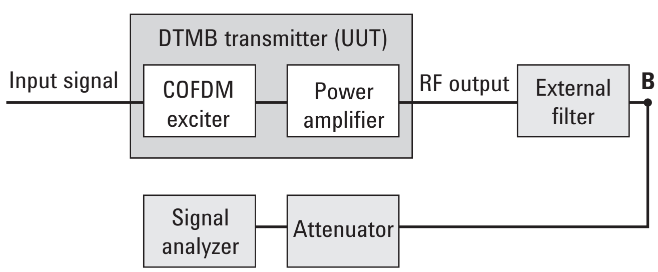



*Figure 6. Diagram for spectrum mask measurement on a DTMB (CTTB) transmitter without an output filter*

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Select the spectrum mask view | **[View/Display] {Spectrum Mask}** |
| Input the value of the attenuator (for real DTMB (CTTB) transmitter) | **[Input/Output] {External Gain} {Ext Preamp}** |
| Recall or edit the correction table | **[Input/Output] {More 1 of 2} {Corrections} {Edit} or [Recall] {Data}** |
| Turn the correction on | **[Input/Output] {More 1 of 2} {Corrections} {On}** |

Note: In spectrum mask view, if the device type is exciter or the bandwidth is 6 MHz, the mask trace will not be displayed and a "No Result" message will be displayed because the spectrum masks for those cases are not defined in the DTMB (CTTB) specifications.

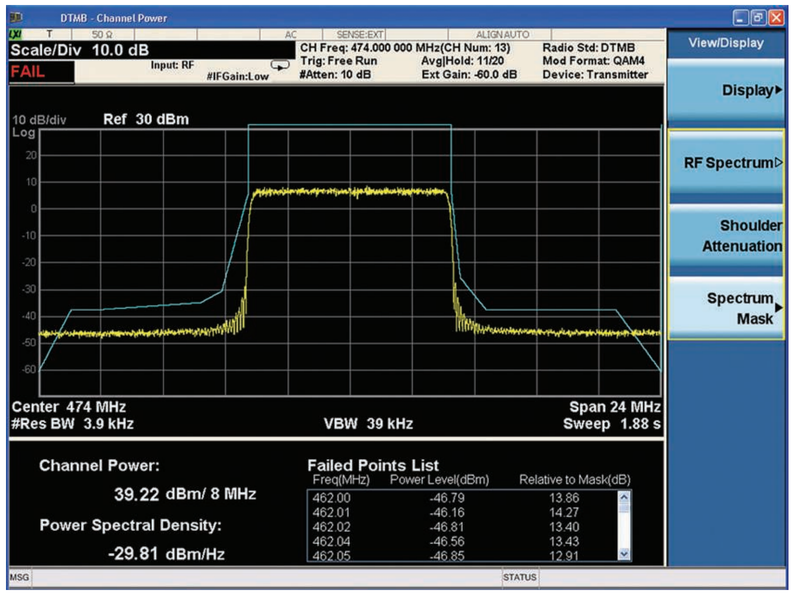



*Figure 7. Channel power measurements using the spectrum mask view*

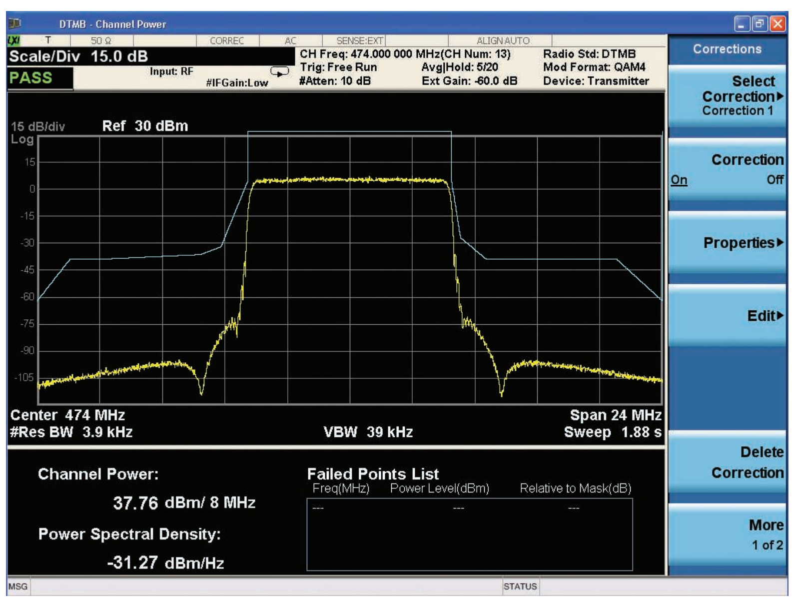



*Figure 8. Channel power measurements using the spectrum mask view after amplitude correction*

# Demonstration 3:

## Adjacent channel power (ACP)

ACP is a measurement of the power in adjacent in-band or out-band channels relative to the transmitted power. The ACP test verifies the ability of the modulator or transmitter to limit the interference produced by the transmitted signal to other receivers operating at the adjacent in-band or adjacent out-band RF channel.

The ACP measurement results should look like Figure 9. The text window shows the power inside adjacent channel and outside adjacent channel as the standard requires.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Activate adjacent channel power measurement | **[Meas] {ACP}** |
| Compare the measurement result with Noise Correction turned on (default is off). A better ACP result is achieved with noise correction on (Figure 9) | **[Meas Setup] {More 1 of 2} {Noise Correction On}** |

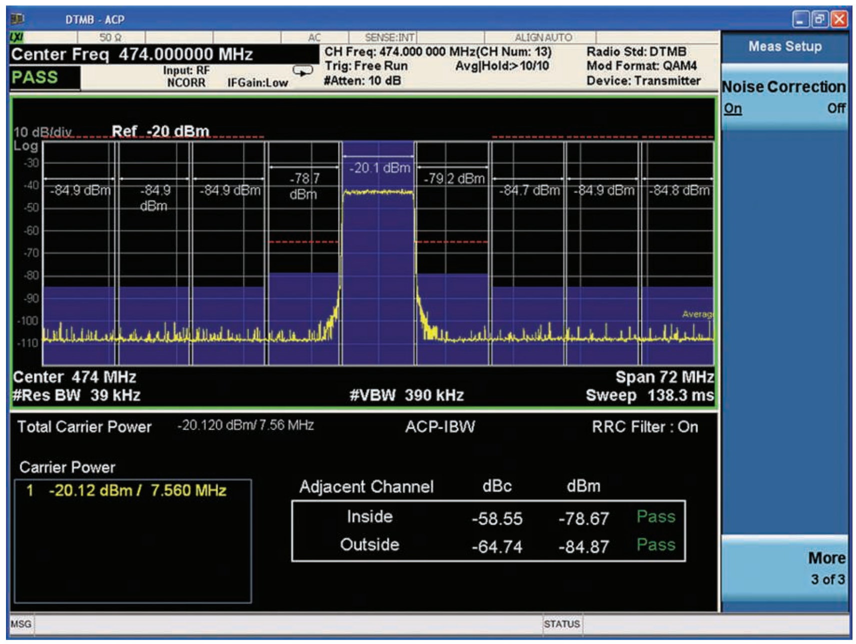



*Figure 9. ACP measurement with noise correction on*

# Demonstration 4:

## Power stat CCDF)

The power stat CCDF (complementary cumulative distortion function) is a statistical method used to interpret the peak-to-average ratio of digitally modulated noise-like signals. It is a key tool for the power amplifier design in DTMB (CTTB) transmitters, which is particularly challenging because the amplifier must be capable of handling the high peak-to-average ratio while maintaining good adjacent channel leakage performance.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Activate the X-Series measurement | **[Meas] {Power Stat CCDF}** |
| Store a reference trace | **[Trace/Detector] {Store Ref Trace}** |
| Turn on reference trace | **[Trace/Detector] {Ref Trace On}** |

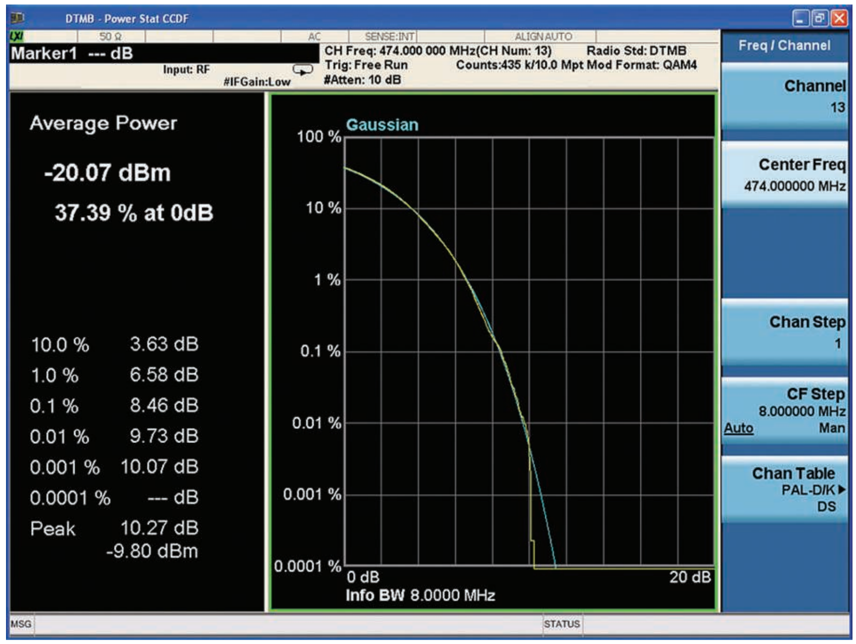



*Figure 10. Power stat CCDF measurement*


*Figure 11. Power stat CCDF measurement with reference trace*

# Demonstration 5:

## Spectrum emission mask

The spectrum emission mask (SEM) measurement can compare the total power level within the defined carrier bandwidth and the given offset channel on both sides of the carrier frequency to levels allowed by the DTMB (CTTB) standard in the strict condition. This measurement refers to the design of the power amplifier in the DTMB (CTTB) transmitter, and it is a key measurement linking amplifier linearity and other performance characteristics to the stringent system specifications.

For a detailed process for making spectrum emission mask measurements, please refer to the descriptions in channel power measurement and spectrum mask view on pages 7 and 8.

Note: In the spectrum emission mask measurement, if the device type is exciter or the bandwidth is 6 MHz, the mask trace will be displayed as a horizontal line on the top of the screen. You can then define the mask trace manually through **[Meas Setup] {Offset/Limit}**.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Activate spectrum emission mask | **[Meas] {Spectrum Emissions}** |
| Input the value of the attenuator (for real DTMB (CTTB) transmitter) | **[Input/Output] {External Gain} {Ext Preamp}** |
| Recall or edit the correction table | **[Input/Output] {More 1 of 2} {Corrections} {Edit} or [Recall] {Data}** |
| Turn correction on | **[Input/Output] {More 1 of 2} {Corrections} {On}** |

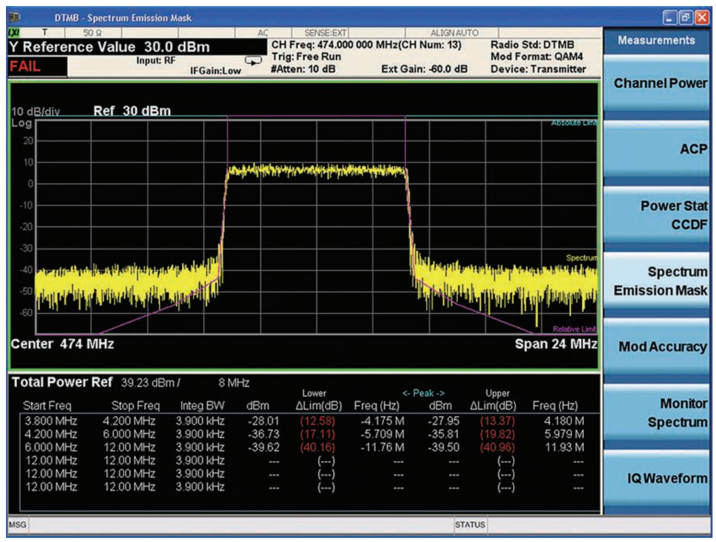



*Figure 12. Spectrum emission mask measurement*


*Figure 13. Spectrum emission mask measurement after amplitude correction*

# Demonstration 6:

## Modulation accuracy

The modulation accuracy measurement is necessary to meet DTMB (CTTB) defined tests and to ensure proper operations of exciters or transmitters. Error vector magnitude (EVM) and modulation error ration (MER) are defined in the DTMB (CTTB) standard to present the total signal degradation including noise, interferences or distortions at the input of a commercial receiver's decision circuits to give an indication of the ability of that receiver to correctly decode the signal. EVM is a measurement parameter for evaluating the quality of a modulation, and it is widely used in digital communications. MER is a representation of the distance between measured and theoretical constellation points, which is an indicator of noise, interferences, or distortions on a signal. MER is usually used in broadcasting applications. MER and EVM can convert each other.

In the Keysight X-Series DTMB (CTTB) application, the modulation accuracy measurement provides many methods for measuring and analyzing modulation quality. In this measurement, you can measure the EVM, MER, magnitude error, phase error, freq error, quadrature error, amplitude imbalance etc.

**Available views and traces in modulation accuracy:**

- **I/Q measured polar graph** view (Figure 14): This is a two-window view. For multi-carrier mode, I/Q measured polar data trace can be calculated on selected sub-carriers.
  - Results metrics (left)
  - I/Q measured polar graph (right)
- **I/Q error** view (Quad view) (Figure 15): This is a four-window view which includes:
  - MER/EVM vs. sub-carrier/ frequency view (top left and only available for multi-carrier mode)
  - Spectrum (top right and only available for multi-carrier mode)
  - I/Q measured polar graph (bottom left)
  - Results metrics (bottom right)
- **Channel frequency response** view (Figure 16): This is a three-window view only available for multi-carrier mode which includes:
  - Amplitude vs. sub-carrier (top)
  - Phase vs. sub-carrier (middle)
  - Group delay vs. sub-carrier (bottom)
- **Channel impulse response** view (Figure 17): This two-window view displays the state of the channel in time domain which the signal has gone through.
  - Peak table window (left)
  - Amplitude vs. time trace (right).
- **Spectrum flatness** view (Figure 18): This two-window view can be used to verify whether the spectrum flatness meets the transmitter or exciter device standard with a PASS/FAIL indicator.
  - Amplitude vs. sub-carrier (top)
  - Results metrics (bottom)
- **Result metrics** view (Figure 19): This view displays the summary of all the detailed numeric result metrics.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Select demodulation options | **[Mode Setup] {Demod}** Select the demodulation options under this menu according to the transmitted signal's format |
| Activate modulation accuracy measurement (I/Q measured polar graph default, Figure 14) | **[Meas] {Mod Accuracy}** |
| Switch to the IQ error view (Figure 15) | **[View/Display] {I/Q Error (Quad View)}** |
| View the channel frequency response (Figure 16) | **[View/Display] {Channel Frequency Response}** |
| View the channel impulse response (Figure 17) | **[View/Display] {Channel Impulse Response}** |
| View the spectrum flatness (Figure 18) | **[View/Display] {Spectrum Flatness}** |
| View result metrics (Figure 19) | **[View/Display] {Result Metrics}** |

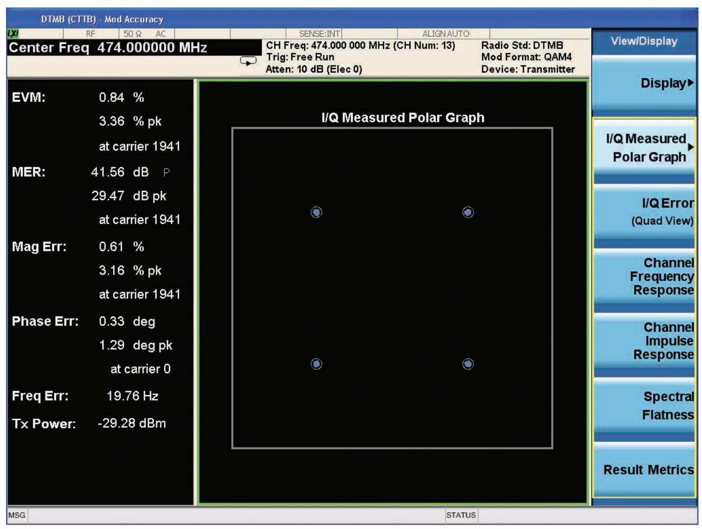



*Figure 14. Modulation accuracy measurement with I/Q measured polar graph view*

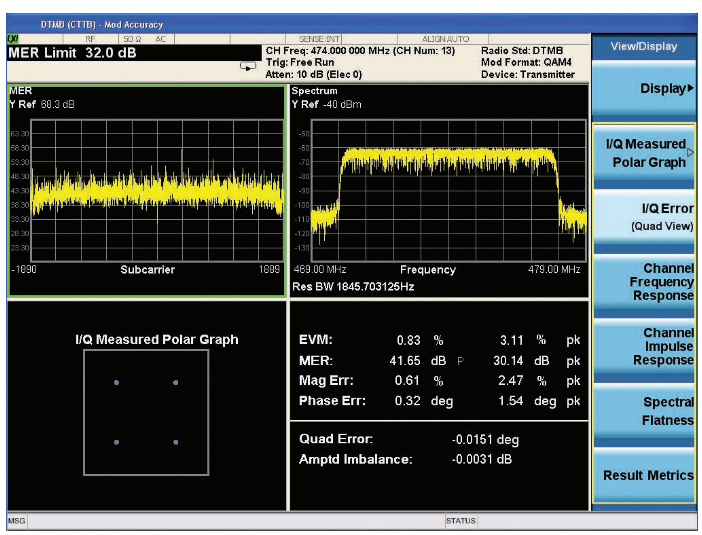



*Figure 15. Modulation accuracy measurements with I/Q error view (Quad view)*

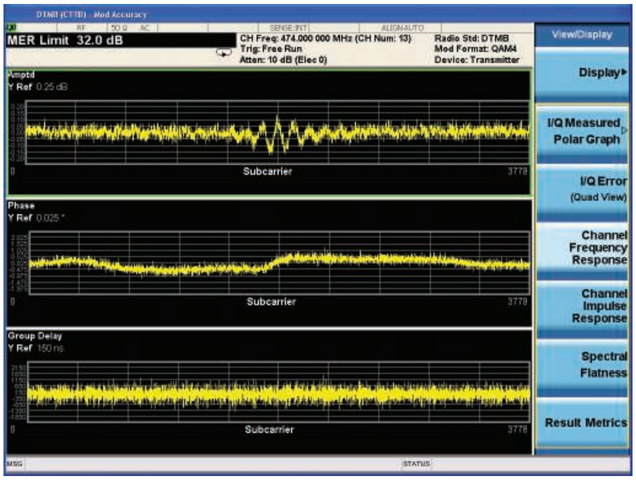


Figure 16. Modulation accuracy measurement with channel frequency response view

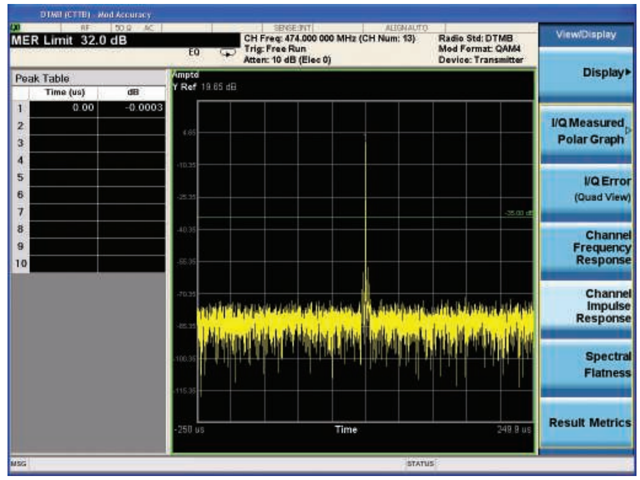


Figure 17. Modulation accuracy measurement with channel impulse response view

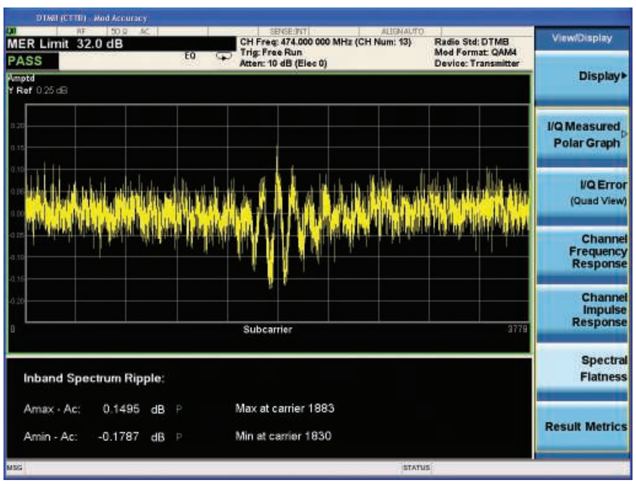


Figure 18. Modulation accuracy measurement with spectrum flatness view

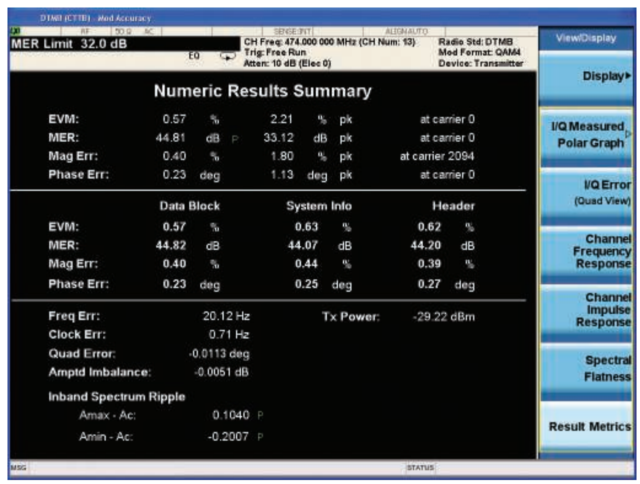


Figure 19. Modulation accuracy measurement with result metrics view

# Demonstration 7:

## Monitor spectrum

The monitor spectrum measurement is used as a quick, convenient means of looking at the entire spectrum. While it is 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.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Activate monitor spectrum measurement | **[Meas] {Monitor Spectrum}** |

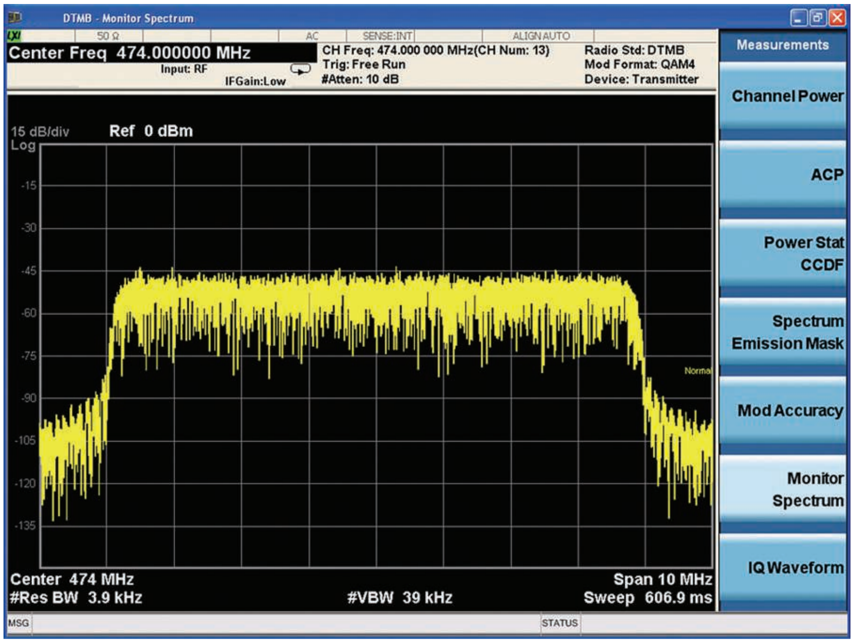



*Figure 20. Monitor spectrum measurement*

# Demonstration 8:

## IQ waveform

The waveform measurement is a generic measurement for viewing the input signal waveforms in the time domain. Under this measurement there is also an I/Q Waveform window, which shows the I and Q signal waveforms in parameters of voltage versus time to disclose the voltages, which comprise the complex modulated waveform of a digital signal.

The waveform measurement can also be used to perform general purpose power measurements to a high degree of accuracy.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Activate IQ waveform measurement (RF envelope default) | **[Meas] {IQ Waveform}** |
| View the I/Q waveform | **[View/Display] {I/Q Waveform}** |

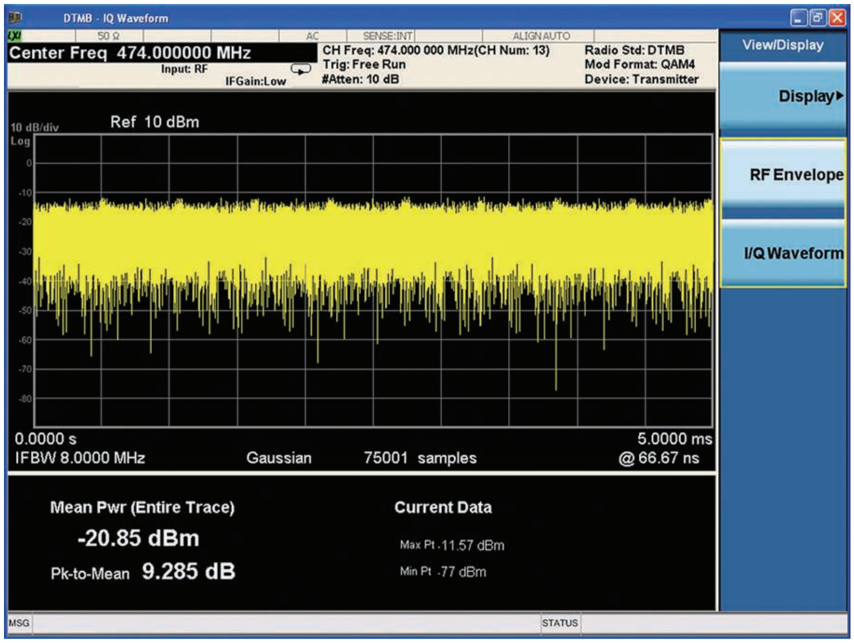



*Figure 21. Waveform measurement with RF envelope view*

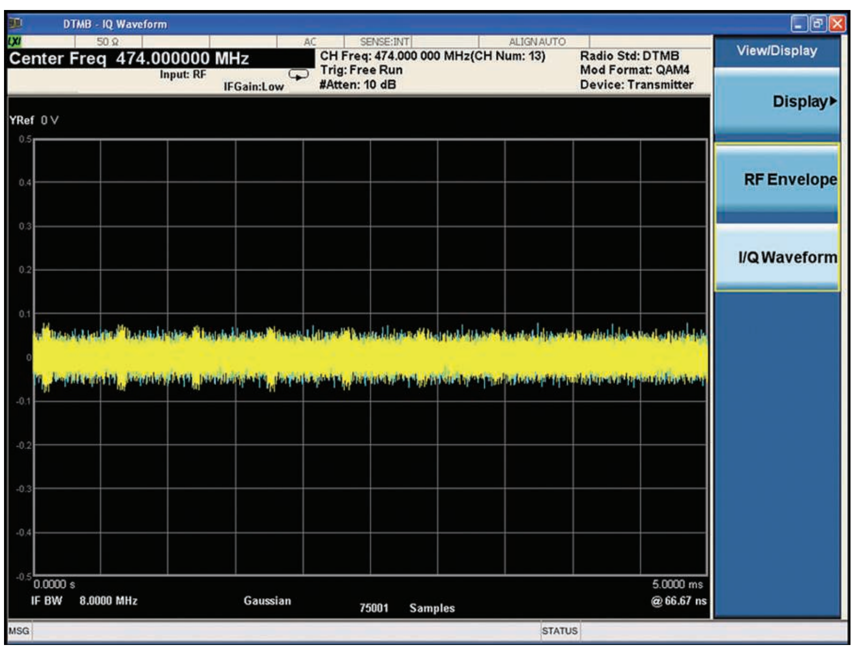



*Figure 22. Waveform measurement with I/Q waveform view*

# Demonstration 9:

## Making DTMB (CTTB) signal measurement in single carrier mode

The N6156A & W6156A measurement applications also support the measurement of single mode DTMB (CTTB) signals. Set up Signal Studio for Digital Video and PXA/MXA/EXA/CXA as follows (this example shows the DTMB (CTTB) signal in single carrier mode with pilot insertion):

| Instructions | Keystrokes |
| --- | --- |
| **On the Signal Studio software:** | |
| Configure a test signal for demonstrations | Click **Carrier0** (DTMB Settings) under **Waveform Setup** on the left of the explorer menu<br><br>Carrier0: Sub-Carrier Number = 1, Insert Pilot = True. For other parameters, use the default settings of reference spec |

### Channel power

The channel power measurement shows the spectrum of the signal. The two vpeak values on each side of the spectrum is the inserted dual-pilot. The frequency distance between the two pilots should be equal to the symbol rate.

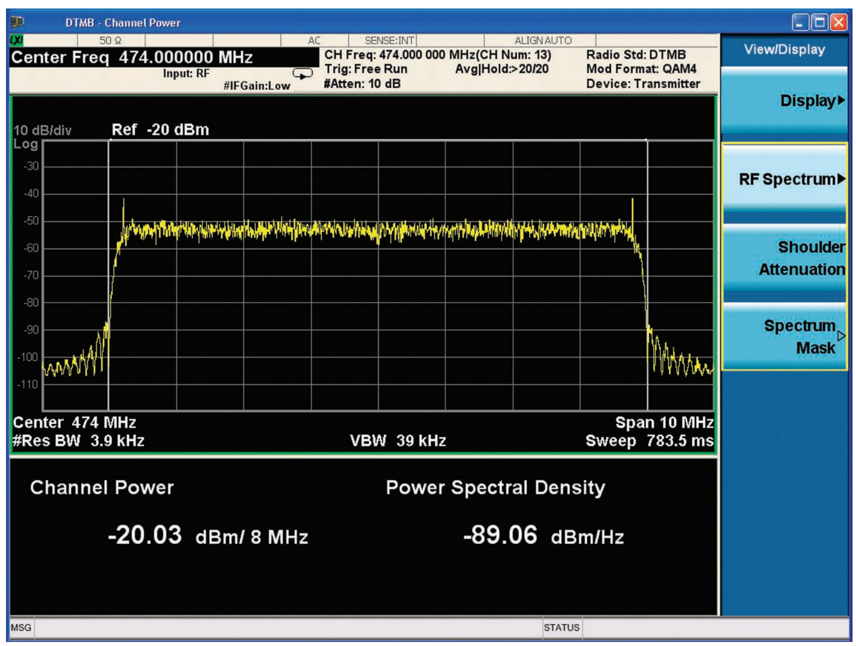



*Figure 23. Channel power measurement on a DTMB (CTTB) signal in single carrier mode*

## Modulation accuracy

In single carrier mode, the insertion method of the dual-pilot is to add 1+j*0 to the odd symbol and add -1+j*0 to the even symbol, counted from the first symbol of a day frame. The constellation diagram is shown in Figure 24.

| Instructions | Keystrokes |
|---|---|
| **On the X-Series in DTMB (CTTB) mode:** | |
| Select demodulation options | **[Mode Setup] {Demod} {Carrier Format} {Single Carrier} {Pilot Insertion} {On}** |
| Activate modulation accuracy measurement (I/Q measured polar graph default, Figure 24) | **[Meas] {Mod Accuracy}** |

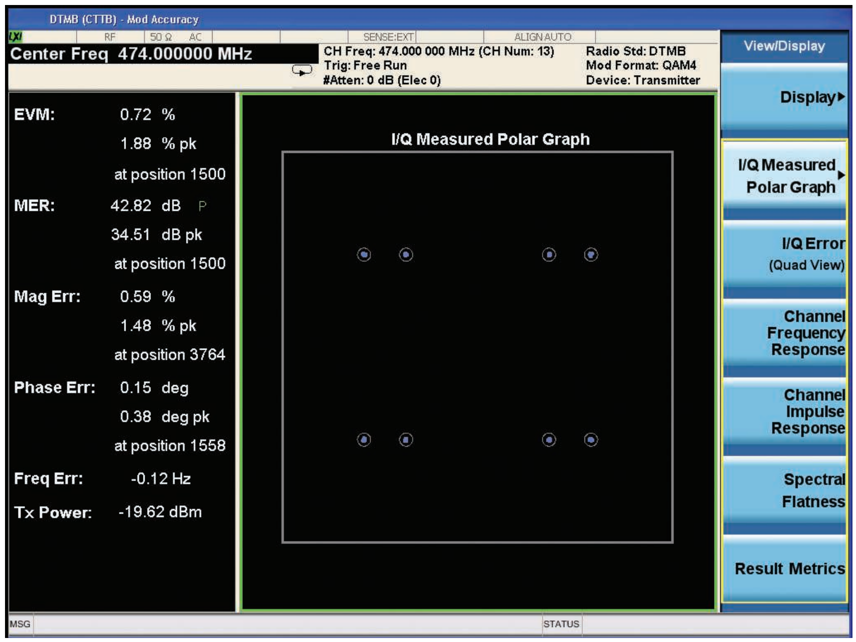



*Figure 24. Constellation diagram of a DTMB (CTTB) signal in single carrier mode*

# Web Resources

Product page:
www.keysight.com/find/n6156a and
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