Agilent X-Series Signal Analyzer

This manual provides documentation for the following X-Series Analyzers:

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

N6155A & W6155A ISDB-T Measurement Application Measurement Guide

Agilent Technologies

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Information on preventing analyzer damage can be found at:

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

Contents

1 About the N6155A ISDB-T Measurement Application

This chapter provides overall information on the N6155A ISDB-T measurement application. ISDB-T measurement application supports ISDB-T and ISDB-Tsb standard measurements.

ISDB-T (Integrated Services Digital Broadcasting - Terrestrial) is a digital terrestrial broadcasting standard developed in Japan. ISDB-Tsb is a standard for narrow band ISDB-T transmission system, which focuses on audio programs and data programs transmission.

What Does the ISDB-T Measurement Application Do?

The ISDB-T measurement application allows the analyzer to be used for testing an ISDB-T and ISDB-Tsb transmitter.

This application is manufactured according to the following documents:

- ARIB STD-B31 Transmission System for Digital Terrestrial Television Broadcasting
- ARIB STD-B29 Transmission System for Digital Terrestrial Sound Broadcasting
- ABNT NBR 15601 Brazilian Standard: Digital terrestrial television - Transmission System
- JEITA handbook: Methods of Measurement for Digital Terrestrial Broadcasting Transmitters

These documents define complex, multi-part measurements to create an interference-free environment and to ensure high quality transmission. For example, the documents standardize the test methods for transmitting power, shoulder attenuation, ACP, spectrum emission mask, MER, and other critical measurements.

The analyzer automatically makes these measurements according to the methods defined in the documents. The detailed measurement results displayed enable you to analyze the ISDB-T/Tsb transmitter's performance. You can also alter the measurement parameters for specialized analysis.

This analyzer makes the following measurements of ISDB-T/Tsb signals:

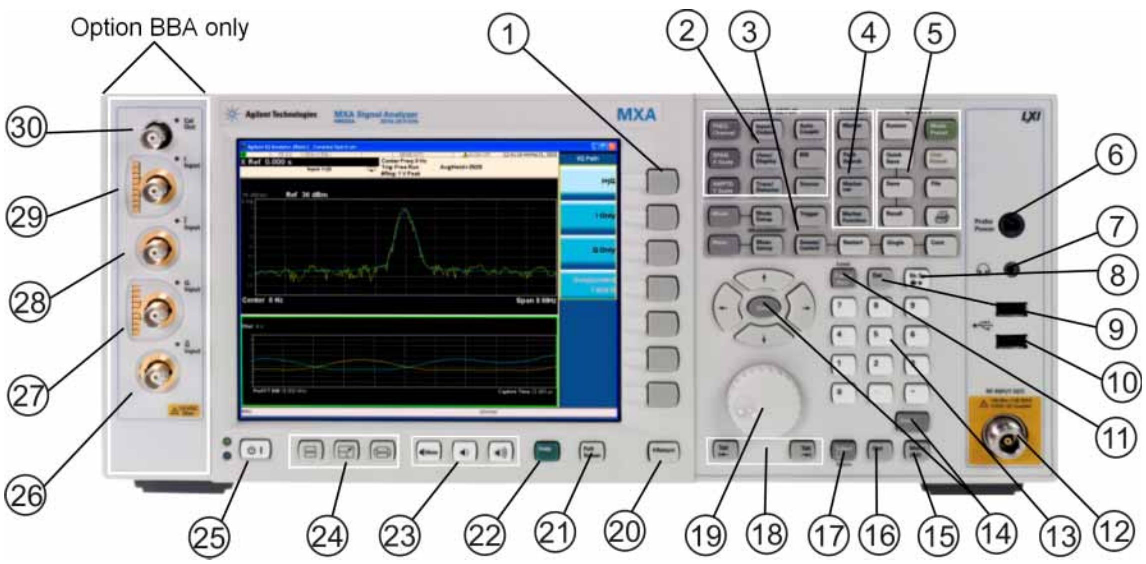
- Channel Power
- ACP
- Power Stat CCDF
- Spectrum Emission Mask
- Mod Accuracy
- Occupied BW
- Monitor Spectrum
- IQ Waveform

If the option BBA is installed, you can analyze baseband I/Q signal characteristics of ISDB-T/Tsb signals. The baseband I/Q analysis is available in the following measurements:

- Power Stat CCDF
- Modulation Accuracy
- IQ Waveform

2 Front and Rear Panel Features

Front-Panel Features



<table>
<tr><th colspan="2">Item</th><th rowspan="2">Description</th></tr>
<tr><th>#</th><th>Name</th></tr>
<tr><td>1</td><td>Menu Keys</td><td>Key labels appear to the left of the menu keys to identify the current function of each key. The displayed functions are dependent on the currently selected Mode and Measurement, and are directly related to the most recent key press.</td></tr>
<tr><td>2</td><td>Analyzer Setup Keys</td><td>These keys set the parameters used for making measurements in the current Mode and Measurement.</td></tr>
<tr><td>3</td><td>Measurement Keys</td><td>These keys select the Mode, and the Measurement within the mode. They also control the initiation and rate of recurrence of measurements.</td></tr>
<tr><td>4</td><td>Marker Keys</td><td>Markers are often available for a measurement, to measure a very specific point/segment of data within the range of the current measurement data.</td></tr>
<tr><td>5</td><td>Utility Keys</td><td>These keys control system-wide functionality such as:
• instrument configuration information and I/O setup,
• printer setup and printing,
• file management, save and recall,
• instrument presets.</td></tr>
<tr><td>6</td><td>Probe Power</td><td>Supplies power for external high frequency probes and accessories.</td></tr>
<tr><td>7</td><td>Headphones Output</td><td>Headphones can be used to hear any available audio output.</td></tr>
<tr><td>8</td><td>Back Space Key</td><td>Press this key to delete the previous character when entering alphanumeric information. It also works as the Back key in Help and Explorer windows.</td></tr>
</table>

Item		Description
#	**Name**	
9	Delete Key	Press this key to delete files, or to perform other deletion tasks.
10	USB Connectors	Standard USB 2.0 ports, Type A. Connect to external peripherals such as a mouse, keyboard, DVD drive, or hard drive.
11	Local/Cancel/(Esc) Key	If you are in remote operation, Local: • returns instrument control from remote back to local (the front panel). • turns the display on (if it was turned off for remote operation). • can be used to clear errors. (Press the key once to return to local control, and a second time to clear error message line.) If you have not already pressed the units or Enter key, Cancel exits the currently selected function without changing its value. Esc works the same as it does on a PC keyboard. It: • exits Windows dialogs • clears errors • aborts printing • cancels operations.
12	RF Input	Connector for inputting an external signal. Make sure that the total power of all signals at the analyzer input does *not* exceed +30 dBm (1 watt).
13	Numeric Keypad	Enters a specific numeric value for the current function. Entries appear on the upper left of the display, in the measurement information area.
14	Enter and Arrow Keys	The Enter key terminates data entry when either no unit of measure is needed, or you want to use the default unit. The arrow keys: • Increment and decrement the value of the current measurement selection. • Navigate help topics. • Navigate, or make selections, within Windows dialogs. • Navigate within forms used for setting up measurements. • Navigate within tables. NOTE The arrow keys cannot be used to move a mouse pointer around on the display.
15	Menu/ (Alt) Key	Alt works the same as a PC keyboard. Use it to change control focus in Windows pull-down menus.
16	Ctrl Key	Ctrl works the same as a PC keyboard. Use it to navigate in Windows applications, or to select multiple items in lists.
17	Select / Space Key	Select is also the Space key and it has typical PC functionality. For example, in Windows dialogs, it selects files, checks and unchecks check boxes, and picks radio button choices. It opens a highlighted Help topic.
18	Tab Keys	Use these keys to move between fields in Windows dialogs.
19	Knob	Increments and decrements the value of the current active function.
20	Return Key	Exits the current menu and returns to the previous menu. Has typical PC functionality.

Item		Description
#	**Name**	
21	Full Screen Key	Pressing this key turns off the softkeys to maximize the graticule display area. Press the key again to restore the normal display.
22	Help Key	Initiates a context-sensitive Help display for the current Mode. Once Help is accessed, pressing a front panel key brings up the help topic for that key function.
23	Speaker Control Keys	Enables you to increase or decrease the speaker volume, or mute it.
24	Window Control Keys	These keys select between single or multiple window displays. They zoom the current window to fill the data display, or change the currently selected window. They can be used to switch between the Help window navigation pane and the topic pane.
25	Power Standby/ On	Turns the analyzer on. A green light indicates power on. A yellow light indicates standby mode. NOTE: The front-panel switch is a standby switch, *not* a LINE switch (disconnecting device). The analyzer continues to draw power even when the line switch is in standby. The main power cord can be used as the system disconnecting device. It disconnects the mains circuits from the mains supply.
26	Q Input	Input port for the Q channel when in differential mode.[a]
27	Q Input	Input port for the Q channel for either single or differential mode.[a]
28	I Input	Input port for the I channel when in differential mode.[a]
29	I Input	Input port for the I channel for either single or differential mode.[a]
30	Cal Out	Output port for calibrating the I, I, Q and Q inputs and probes used with these inputs.[a]

a. Status of the LED indicates whether the current state of the port is active (green) or is not in use (dark).

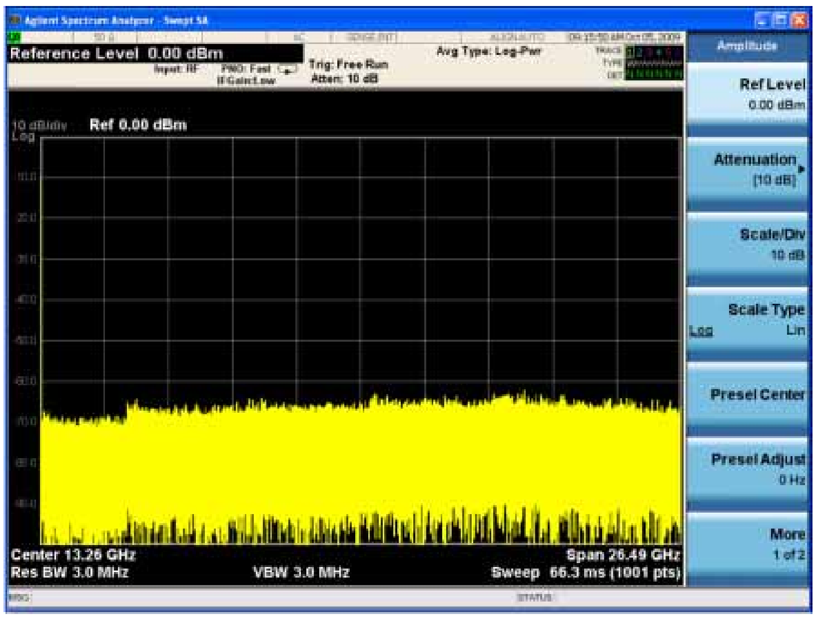
Overview of key types

The keys labeled **FREQ Channel**, **System**, and **Marker Functions** are all examples of front-panel keys.

Most of the dark or light gray keys access menus of functions that are displayed along the right side of the display. These displayed key labels are next to a column of keys called menu keys.

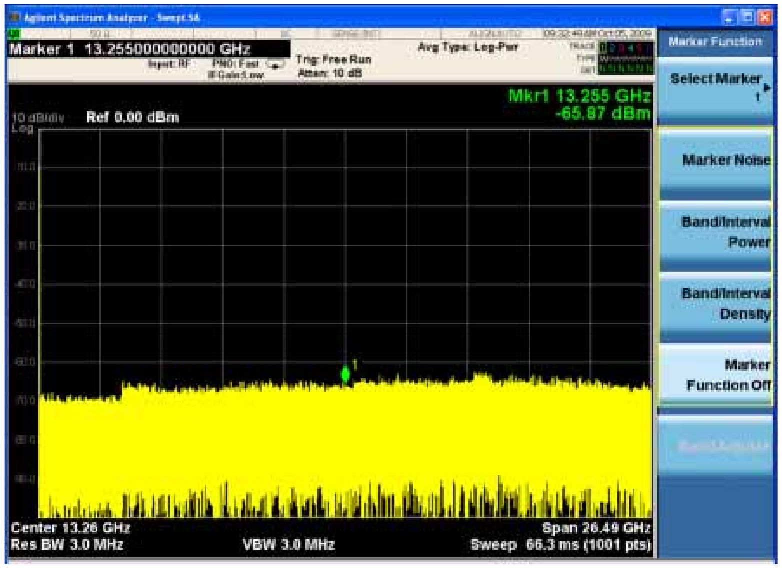
Menu keys list functions based on which front-panel key was pressed last. These functions are also dependant on the current selection of measurement application (**Mode**) and measurement (**Meas**).

If the numeric value of a menu key function can be changed, it is called an active function. The function label of the active function is highlighted after that key has been selected. For example, press **AMPTD Y Scale**. This calls up the menu of related amplitude functions. The function labeled **Ref Level** (the default selected key in the Amplitude menu) is highlighted. **Ref Level** also appears in the upper left of the display in the measurement information area. The displayed value indicates that the function is selected and its value can now be changed using any of the data entry controls.



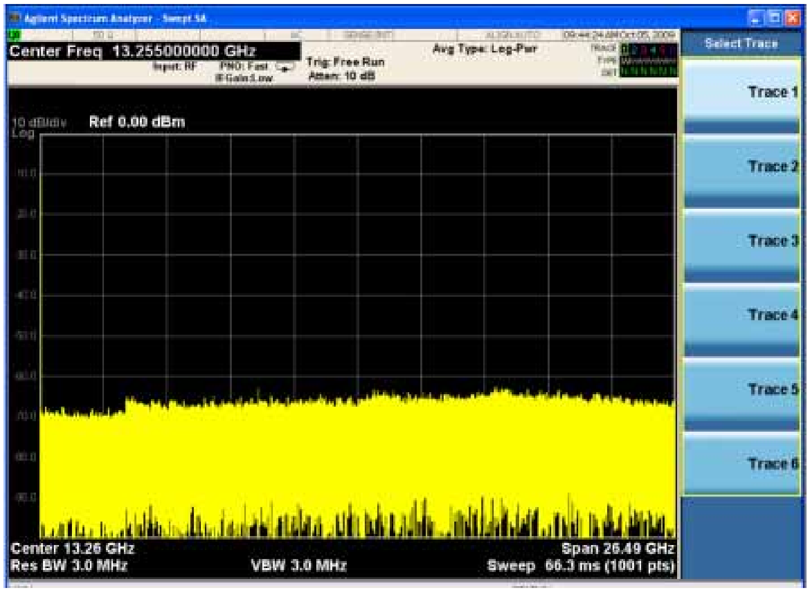
Some menu keys have multiple choices on their label, such as **On**/**Off**, **Auto**/**Man**, or **Log/Lin** (as shown above). The different choices are selected by pressing the key multiple times. For example, the Auto/Man type of key. To select the function, press the menu key and notice that Auto is underlined and the key becomes highlighted. To change the function to manual, press the key again so that Man is underlined. If there are more than two settings on the key, keep pressing it until the desired selection is underlined.

When a menu first appears, one key label is highlighted to show which key is the default selection. If you press **Marker Function**, the **Marker Function Off** key is the menu default key, and is highlighted.

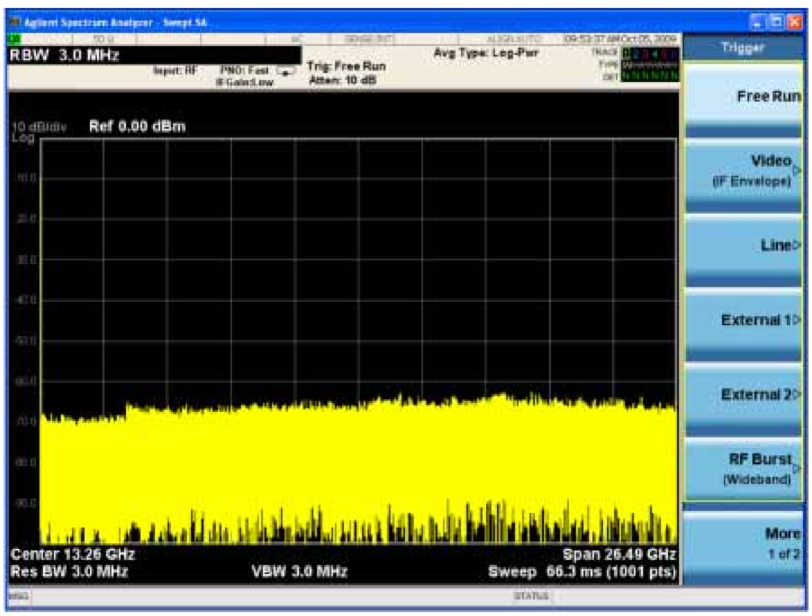


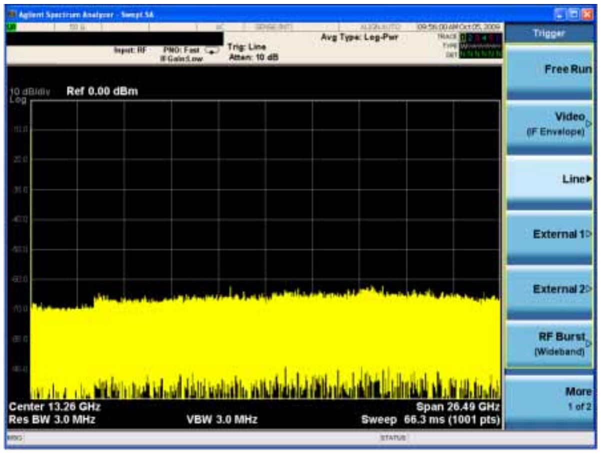
Some of the menu keys are grouped together by a yellow bar running behind the keys near the left side or by a yellow border around the group of keys. When you press a key within the yellow region, such as **Marker Noise**, the highlight moves to that key to show it has been selected. The keys that are linked are related functions, and only one of them can be selected at any one time. For example, a marker can only have one marker function active on it. So if you select a different function it turns off the previous selection. If the current menu is two pages long, the yellow bar or border could include keys on the second page of keys.

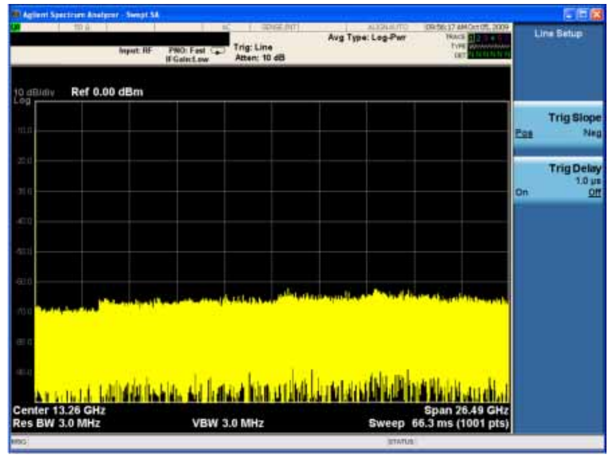
In some key menus, a key label is highlighted to show which key has been selected from multiple available choices. And the menu is immediately exited when you press one of the other keys. For example, when you press the **Select Trace** key (in the **Trace/Detector** menu), it brings up its own menu of keys. The **Trace 1** key is highlighted. When you press the **Trace 2** key, the highlight moves to that key and the screen returns to the **Trace/Detector** menu.



If a displayed key label shows a small solid-black arrow tip pointing to the right, it indicates that additional key menus are available. If the arrow tip is not filled in solid then pressing the key the first time selects that function. Now the arrow is solid and pressing it again brings up an additional menu of settings.

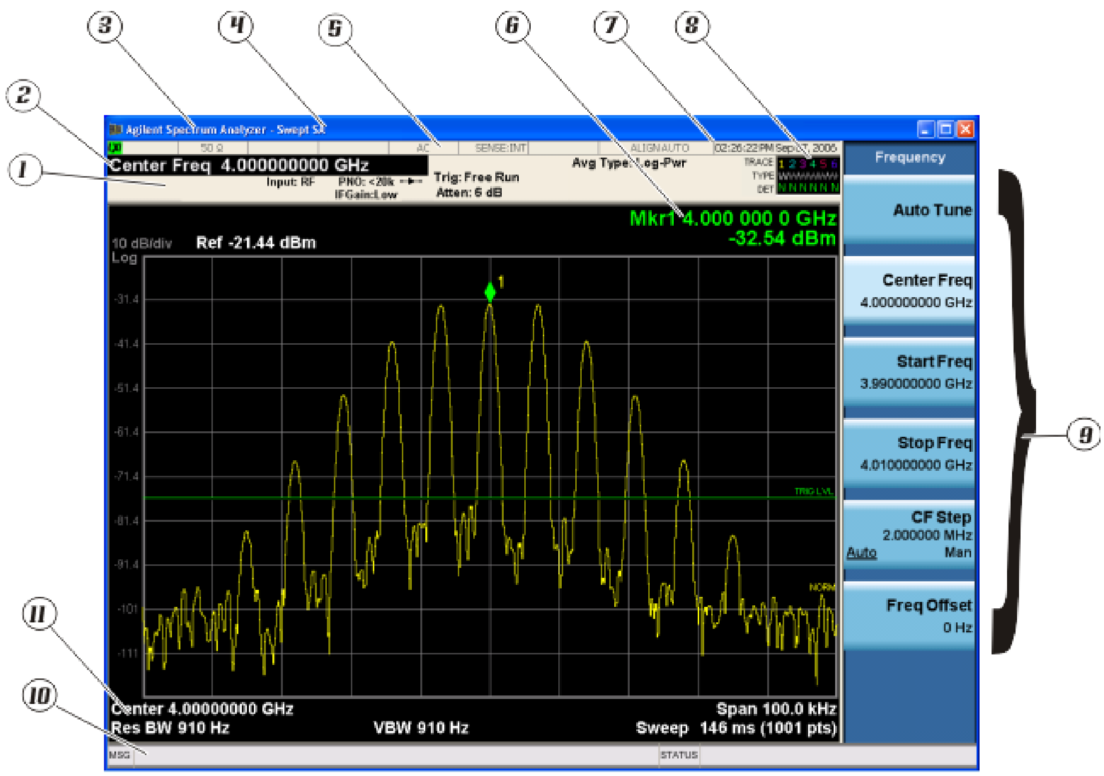


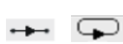

Trigger
Avg Type: Log-Pwr
Trig: Line
Atten: 10 dB
10 dB/div
Ref 0.00 dBm
Free Run
Video
(IF Envelope)
Line
External 1
External 2
RF Burst
(Wideband)
More
1 of 2
Center 13.26 GHz
Res BW 3.0 MHz
VBW 3.0 MHz
Span 26.49 GHz
Sweep 66.3 ms (1001 pts)


Line Setup
Avg Type: Log-Pwr
Trig: Line
Atten: 10 dB
10 dB/div
Ref 0.00 dBm
Trig Slope
Pos
Neg
Trig Delay
1.0 µs
On
Off
Center 13.26 GHz
Res BW 3.0 MHz
VBW 3.0 MHz
Span 26.49 GHz
Sweep 66.3 ms (1001 pts)

Display Annotations

This section describes the display annotation as it is on the Spectrum Analyzer Measurement Application display. Other measurement application modes will have some annotation differences.



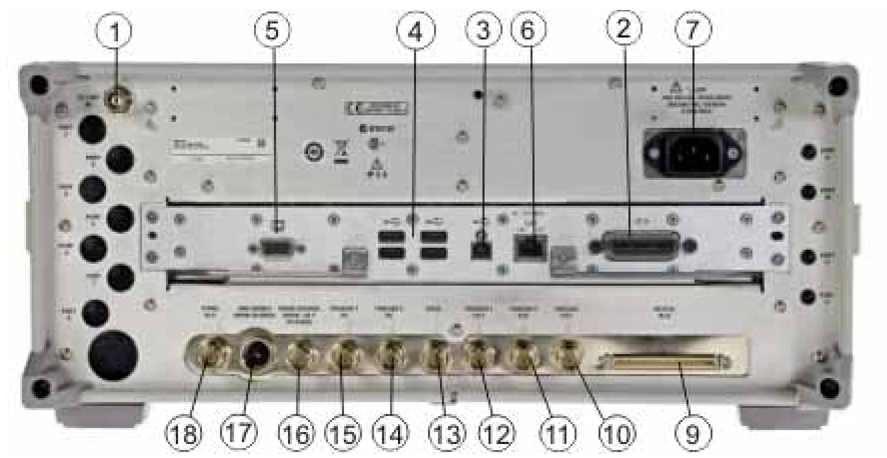
Item	Description	Function Keys
1	Measurement bar - Shows general measurement settings and information.  Indicates single/continuous measurement. Some measurements include limits that the data is tested against. A Pass/Fail indication may be shown in the lower left of the measurement bar.	All the keys in the Analyzer Setup part of the front panel.
2	Active Function (measurement bar) - when the current active function has a settable numeric value, it is shown here.	Currently selected front panel key.
3	Banner - shows the name of the selected measurement application and the measurement that is currently running.	**Mode**, **Meas**

Item	Description	Function Keys
4	Measurement title (banner) - shows title information for the current Measurement, or a title that you created for the measurement.	**Meas** **View/Display**, **Display**, **Title**
5	Settings panel - displays system information that is not specific to any one application. • Input/Output status - green LXI indicates the LAN is connected. RLTS indicate Remote, Listen, Talk, SRQ • Input impedance and coupling • Selection of external frequency reference • Setting of automatic internal alignment routine	**Local** and **System, I/O Config** **Input/Output**, **Amplitude**, **System** and others.
6	Active marker frequency, amplitude or function value.	**Marker**
7	Settings panel - time and date display.	**System**, **Control Panel**
8	Trace and detector information.	**Trace/Detector**, **Clear Write (W) Trace Average (A) Max Hold (M) Min Hold (m)** **Trace/Detector**, **More, Detector, Average (A) Normal (N) Peak (P) Sample (S) Negative Peak (p)**
9	Key labels that change based on the most recent key press.	Softkeys
10	Displays information, warning and error messages. Message area - single events, Status area - conditions.	
11	Measurement settings for the data currently being displayed in the graticule area. In the example above: center frequency, resolution bandwidth, video bandwidth, frequency span, sweep time and number of sweep points.	Keys in the Analyzer Setup part of the front panel.

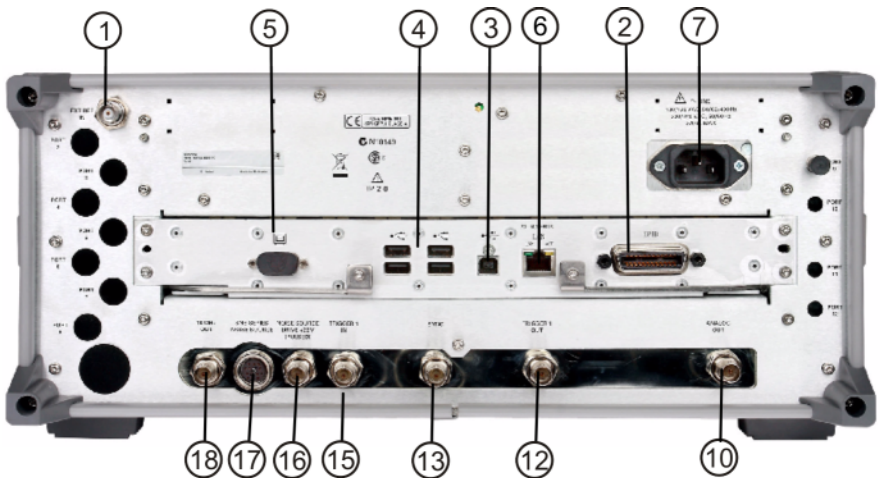
Rear-Panel Features

PXA, MXA and EXA with Option PC2

EXA



CXA



Item		Description
#	Name	
1	EXT REF IN	Input for an external frequency reference signal: For PXA – 1 to 50 MHz For MXA – 1 to 50 MHz For EXA – 10 MHz. For CXA – 10 MHz.
2	GPIB	A General Purpose Interface Bus (GPIB, IEEE 488.1) connection that can be used for remote analyzer operation.
3	USB Connector	USB 2.0 port, Type B. USB TMC (test and measurement class) connects to an external pc controller to control the instrument and for data transfers over a 480 Mbps link.
4	USB Connectors	Standard USB 2.0 ports, Type A. Connect to external peripherals such as a mouse, keyboard, printer, DVD drive, or hard drive.
5	MONITOR	Allows connection of an external VGA monitor.
6	LAN	A TCP/IP Interface that is used for remote analyzer operation.
7	Line power input	The AC power connection. See the product specifications for more details.
8	Removable Disk Drive	Standard on PXA and MXA. Optional on EXA.
9	Digital Bus	Reserved for future use.

Item		Description
#	Name	
10	Analog Out	For PXA option YAV: Screen Video Log Video Linear Video For PXA option EMC: Demod Audio
11	TRIGGER 2 OUT	A trigger output used to synchronize other test equipment with the analyzer. Configurable from the Input/Output keys.
12	TRIGGER 1 OUT	A trigger output used to synchronize other test equipment with the analyzer. Configurable from the Input/Output keys.
13	Sync	Reserved for future use.
14	TRIGGER 2 IN	Allows external triggering of measurements.
15	TRIGGER 1 IN	Allows external triggering of measurements.
16	Noise Source Drive +28 V (Pulsed)	For use with Agilent 346A, 346B, and 346C Noise Sources.
17	SNS Series Noise Source	For use with Agilent N4000A, N4001A, N4002A Smart Noise Sources (SNS).
18	10 MHz OUT	An output of the analyzer internal 10 MHz frequency reference signal. It is used to lock the frequency reference of other test equipment to the analyzer.
19	Preselector Tune Out	Reserved for future use.
20	Aux IF Out	For PXA options: CR3 Second IF Out CRP Arbitrary IF Out ALV Log Video

Front and Rear Panel Symbols

|	This symbol is used to indicate power ON (green LED).
⏻	This symbol is used to indicate power STANDBY mode (yellow LED).
~	This symbol indicates the input power required is AC.
⚠	The instruction documentation symbol. The product is marked with this symbol when it is necessary for the user to refer to instructions in the documentation.
CE	The CE mark is a registered trademark of the European Community.
N10149	The C-Tick mark is a registered trademark of the Australian Spectrum Management Agency.
ICES/NMB-001 ISM GRP.1 CLASS A	This is a marking of a product in compliance with the Canadian Interference-Causing Equipment Standard (ICES-001). This is also a symbol of an Industrial Scientific and Medical Group 1 Class A product (CISPR 11, Clause 4).
	The CSA mark is a registered trademark of the CSA International.
	This symbol indicates separate collection for electrical and electronic equipment mandated under EU law as of August 13, 2005. All electric and electronic equipment are required to be separated from normal waste for disposal (Reference WEEE Directive 2002/96/EC).
40	Indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.
	This symbol on all primary and secondary packaging indicates compliance to China standard GB 18455-2001.

To return unwanted products, contact your local Agilent office, or see http://www.agilent.com/environment/product/ for more information.

3 Making ISDB-T Measurements

This chapter first introduces the instructions common to all measurements, and then, discusses the instructions specific to individual measurements, as follows.

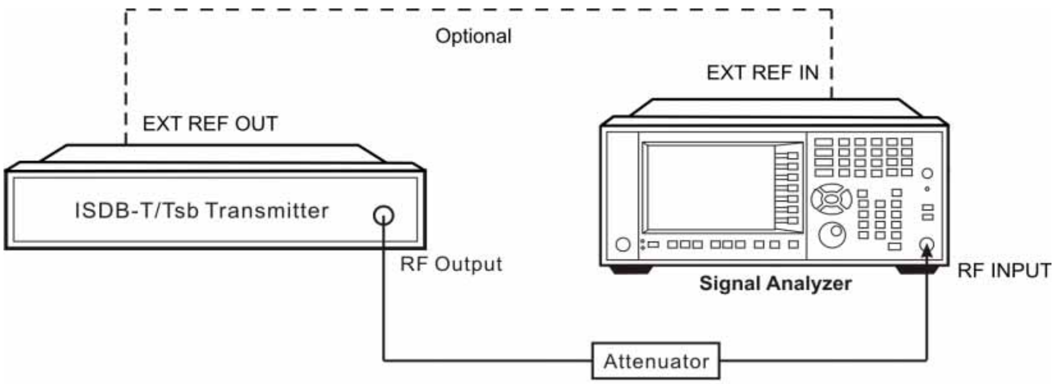
Setting Up and Making a Measurement

Making Initial Connection and Configuring the Measurement System

Step 1. Set the ISDB-T/Tsb 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.

CAUTION Before connecting an ISDB-T/Tsb signal to the analyzer, make sure the analyzer can safely accept the signal level provided. The maximum signal level limits are marked next to the RF Input connectors on the front panel.

Figure 3-1 ISDB-T/Tsb Measurement System



1. Connect the output signal of the ISDB-T/Tsb 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 ISDB-T/Tsb transmitter, connect it to the EXT REF IN port of the analyzer with an cable for frequency synchronization.

Step 2. Select the input port settings using keys under **Input/Output** menu.

NOTE The parameters under **Input/Output** menu can't be reset by pressing **Mode Preset**. Then if you've made any changes to the Input/output parameters which aren't required in another measurement, remember to restore these settings manually.

Setting the ISDB-T/Tsb Transmitter (Example)

Set up the ISDB-T/Tsb transmitter to transmit the RF power as follows:

Standard: ISDB-T

Frequency: 713.142857 MHz

	(Channel Num: 53, Channel Table: NTSC-J AIR)
Mode:	Mode 3 (5617 carriers)
Guard Interval:	1/8
Layer A:	1 Segment; Code Rate = 2/3; QPSK; I (Time Interleaving length) = 4
Layer B:	4 Segment; Code Rate = 3/4; 64 QAM; I = 2
Layer C:	8 Segment; Code Rate = 5/6; 16 QAM; I = 4
Attenuator:	60 dB

Partial Reception (TMCC B27): 1 (Partial Reception Available)

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

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 3-1. Table 3-2 shows the main keys and functions that may be used while following the steps. For the detailed procedures for specific measurement, refer to:

- "Channel Power Measurements" on page 27
- "ACP Measurements" on page 31
- "Power Stat CCDF Measurements" on page 33
- "Spectrum Emission Mask Measurements" on page 37
- "Modulation Accuracy Measurements" on page 43
- "Occupied Bandwidth Measurements" on page 53
- "Monitor Spectrum Measurements" on page 57
- "IQ Waveform (Time Domain) Measurements" on page 59

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

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

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

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

Table 3-2 Main Keys and Functions for Making Measurements

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

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\Agilent\SignalAnalysis\Infrastructure\Help\bookfiles.

Channel Power Measurements

This section explains how to make a Channel Power measurement on an ISDB-T/Tsb transmitter. Channel Power measurements show the spectrum, the total RF power and the shoulder attenuation of the signal.

The Channel Power measurement procedure includes three parts:

a. “Selecting and Setting up the ISDB-T Mode” on page 27

b. “Selecting and Setting up Channel Power Measurement” on page 27

c. “Selecting and Viewing the Measurement Results” on page 28

Selecting and Setting up the ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel**, 53.

Selecting and Setting up Channel Power Measurement

Step 1. Initiate the Channel Power measurement.

Press **Meas**, **Channel Power**.

Step 2. Set up the Channel Power measurement and see the parameters available to change. The default settings are compliant with the specification in ISDB-T standards, so you can use the default settings for most cases.

Press **Meas Setup**.

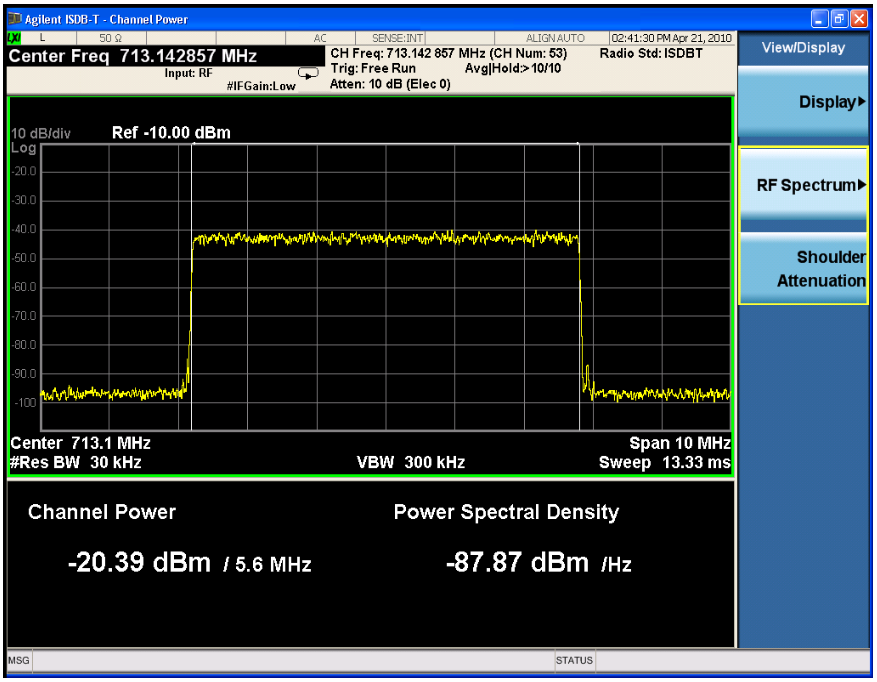
Selecting and Viewing the Measurement Results

Two views are available in the Channel Power measurement. Press **View/Display**, **the name of the view** to display them.

- **RF Spectrum** displays the RF spectrum and power in the channel. The spectrum graph measurement results should look like Figure 3-2. The text window shows the total channel power and its mean power spectral density values over 5.6 MHz.

NOTE To change the measurement bandwidth, press **Meas Setup**, **Integ BW**.

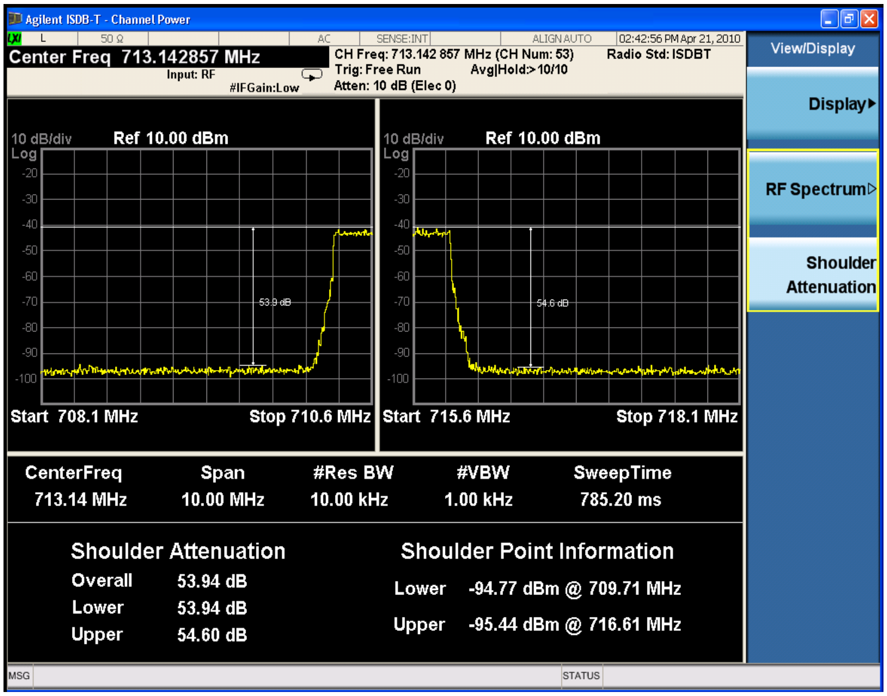
Figure 3-2 Channel Power Measurement Result (Default) - RF Spectrum View



- **Shoulder Attenuation** displays the ISDB-T standard defined shoulder attenuation. The shoulder attenuation measurement should look like Figure 3-3. The text window shows the value of shoulder attenuation and shoulder point information. For the definition of shoulder attenuation of ISDB-T signal, refer to "Shoulder Attenuation" on page 72.

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

Figure 3-3 Channel Power Measurement Result - Shoulder Attenuation View



ACP Measurements

This section describes the Adjacent Channel Leakage Power Ratio (ACLR or ACPR) measurement on an ISDB-T/Tsb 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.

The ACP measurement procedure includes three parts:

a. "Selecting and Setting up the ISDB-T Mode" on page 31

b. "Selecting and Setting up ACP Measurement" on page 31

c. "Viewing ACP Measurement Results" on page 32

Selecting and Setting up the ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel**, 53.

Selecting and Setting up ACP Measurement

Step 1. Initiate the ACP measurement.

Press **Meas**, **ACP**.

Step 2. Set up the ACP measurement and see the parameters available to change. The default settings are compliant with the specification in ISDB-T standards, so you can use the default settings for most cases.

Press **Meas Setup**.

NOTE If you are making ACP measurements on ISDB-Tsb signal, press **Meas Setup** and set the carrier and offset/limits parameters under **Carrier Setup** and **Offset/Limits** menu as needed. No ACP measurement methods are defined in ISDB-Tsb specifications.

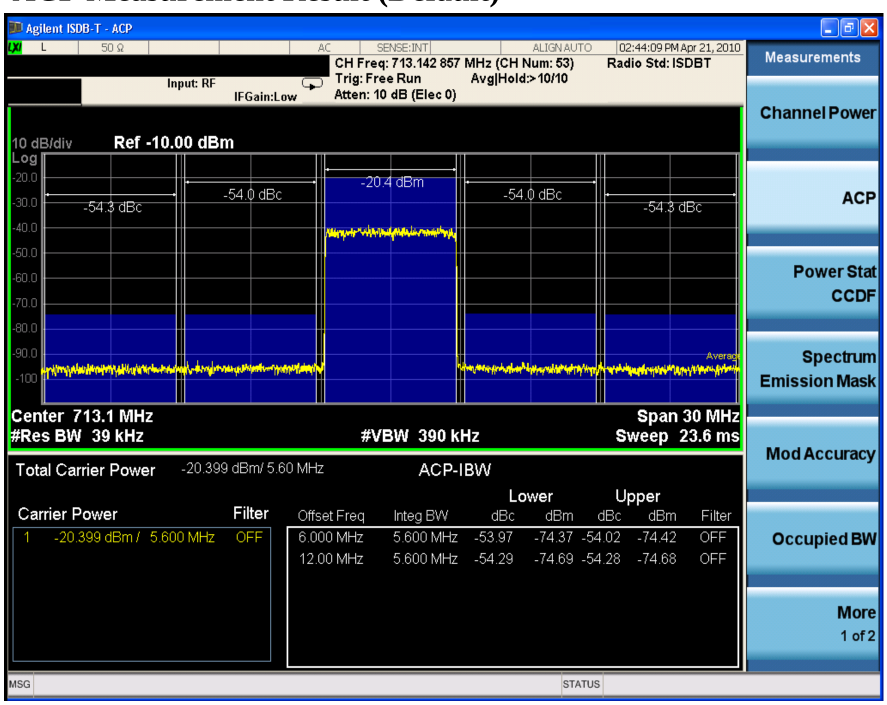
TIP To achieve better ACP results, press **Meas Setup**, **More 1 of 2** and toggle the **Noise Correction** key to **On**.

Viewing ACP Measurement Results

The ACP result should look like Figure 3-4. The graph window shows the bar graph with the spectrum trace overlay. The text window shows the total power in the reference channel, the absolute and relative power in the offset channels.

NOTE 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.

Figure 3-4 ACP Measurement Result (Default)



Power Stat CCDF Measurements

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

The Power Stat CCDF measurement procedure includes three parts:

a. “Selecting and Setting up the ISDB-T Mode” on page 33

b. “Selecting and Setting up Power Stat CCDF Measurement” on page 33

c. “Viewing the Measurement Results” on page 34

Selecting and Setting up the ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel**, 53.

NOTE Power Stat CCDF 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 63.

Selecting and Setting up Power Stat CCDF Measurement

Step 1. Initiate the Power Stat CCDF measurement.

Press **Meas**, **Power Stat CCDF**.

Step 2. Set up the Power Stat CCDF measurement and see the parameters available to change. You can use the default settings for most cases.

Press **Meas Setup**.

TIP

Three key parameters under **Meas Setup** menu are available to set up the Power Stat CCDF measurements.

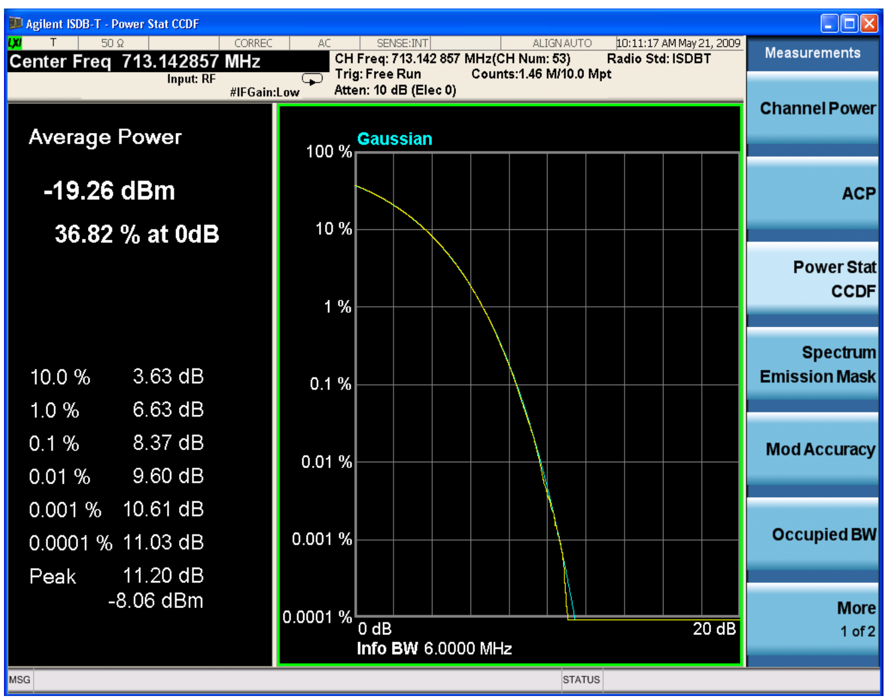
- **Counts** sets the accumulated number of sampling points for data acquisition.
- **Meas Cycles** sets the number of measurement cycles.
- **Meas Interval** sets the measurement time for one cycle.

Viewing the Measurement Results

The Power Stat CCDF measurement result should look like Figure 3-5.

- Press **Trace/Detector**, **Ref Trace (On)** to display the user-definable reference trace (violet line). The CCDF measurement with the reference trace should look like Figure 3-6.

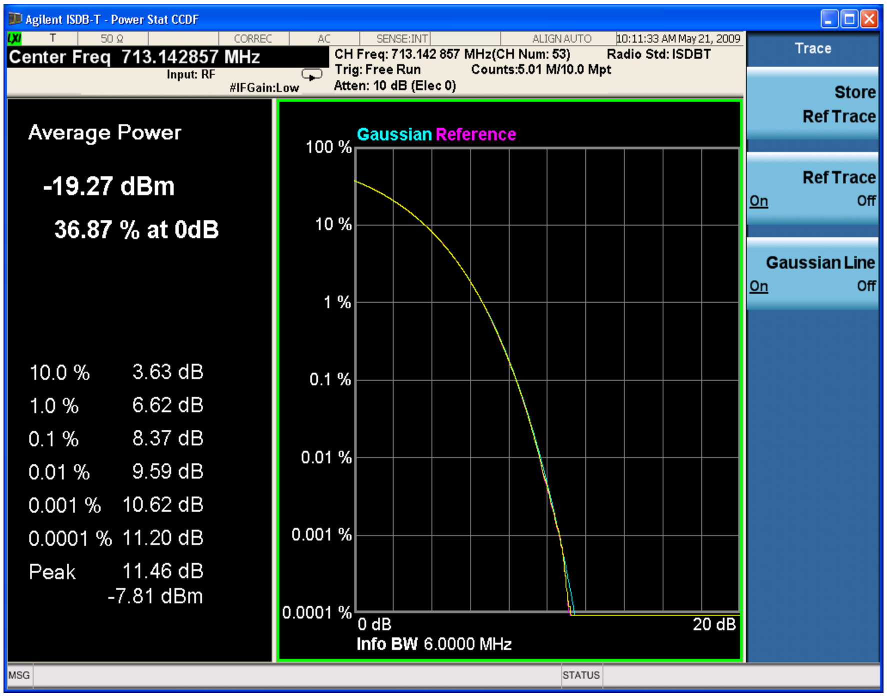
Figure 3-5 Measurement Results-Power Statistics CCDF Result



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 6 MHz. You can manually change the Info BW by pressing **BW**, **Info BW**.

Figure 3-6 Power Statistics CCDF Result



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

Spectrum Emission Mask Measurements

This section describes how to make the Spectrum Emission Mask (SEM) measurements on an ISDB-T/Tsb 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 channels.

The SEM measurement procedure includes four parts:

a. "Selecting and Setting up the ISDB-T Mode" on page 37

b. "Setting up the Input Ports" on page 37

c. "Selecting and Setting up Spectrum Emission Mask Measurement" on page 38

d. "Viewing the Measurement Results" on page 39

Selecting and Setting up the ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel**, 53.

Setting up the Input Ports

Step 1. Input the value of the external attenuator. (In this case, -60 dB)

Press **Input/Output**, **External Gain**, **Ext Preamp**, -60, **dB**.

Step 2. If the dynamic range of the ISDB-T signal under test is less than that of the instrument, omit this step. If not, use amplitude corrections as follows.

Press **Input/Output**, **More 1 of 2**, **Corrections**, then,

a. Specify the correction data using:

- Onscreen editor. Press **Edit**.
- SCPI, or
- A file. Press **Recall**, **Data (Import) Amptd Cor1**, **Open**.

TIP 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.

It is recommended to edit and save the correction data using a file when the correction data has a lot of points.

b. Toggle the **Correction** key to **On** to apply the corrections.

For more details of using amplitude correction and defining correction data, refer to "Amplitude Correction in Spectrum Emission Mask Measurement" on page 80.

Selecting and Setting up Spectrum Emission Mask Measurement

Step 1. Initiate the Spectrum Emission Mask measurement.

Press **Meas**, **Spectrum Emission Mask**.

Step 2. Set up the Spectrum Emission Mask measurement and see the parameters available to change.

Press **Meas Setup.**

To choose the appropriate spectrum mask limit line for your measurement, press **Meas Setup**, **Limit Type**. Six limit types are available. For more information, refer to "Spectrum Emission Limits Defined by Standard" on page 76.

— **Manual**: specify the spectrum mask as needed manually by setting the parameters under **Meas Setup**, **Ref Channel** and **Meas Setup**, **Offset/Limit**.

— **JEITA**: spectrum mask for ISDB-T defined in Japan ARIB STD B31. There are four option under JEITA, which are Auto Sense, 30dB Mask, 40dB Mask, and 50dB Mask.

— **ABNT Non-Critical**: spectrum mask for non-critical case defined in Brazil ABNT NBR 15601.

— **ABNT Sub-Critical**: spectrum mask for sub-critical case defined in Brazil ABNT NBR 15601.

— **ABNT Critical**: spectrum mask for critical case defined in Brazil ABNT NBR 15601.

— **ISDB-Tsb**: spectrum mask for ISDB-Tsb defined in ARIB STD B29.

NOTE To compliant with ARIB-STD B31 Version 1.7 while using JEITA limit type, choose the appropriate limit mask under **JEITA** according to your measurement environment as shown in Table 3-3.

Table 3-3 Actions to Compliant with ARIB-STD B31 Version 1.7 Using JEITA Limit

Channel Power P	Is adjacent channels used for analog TV?	Is the analog TV has more than or equal to 10 times higher than the channel power?	Offset D limit ($\pm(4.36\sim15)$ MHz from carrier frequency)	Mask under JEITA to be used
$P > 2.5W$	Yes/No	Yes/No	-77.4 dB/10kHz	**Auto Sense**
$2.5W \geq P > 0.25W$	No	None	-73.4-10logP [dB/10kHz]	**Auto Sense**
	Yes	Yes	-73.4-10logP [dB/10kHz]	**Auto Sense**
	Yes	No	-77.4 dB/10kHz	**50dB Mask**
$0.25W \geq P > 0.025W$	No	None	-73.4-10logP [dB/10kHz]	**Auto Sense**
	Yes	Yes	-67.4 dB/10kHz	**40dB Mask**
	Yes	No	-77.4 dB/10kHz	**50dB Mask**
$0.025W \geq P$	No	None	-57.4 dB/10kHz	**Auto Sense**
	Yes	Yes	-67.4 dB/10kHz	**40 dB Mask**
	Yes	No	-77.4 dB/10kHz	**50dB Mask**

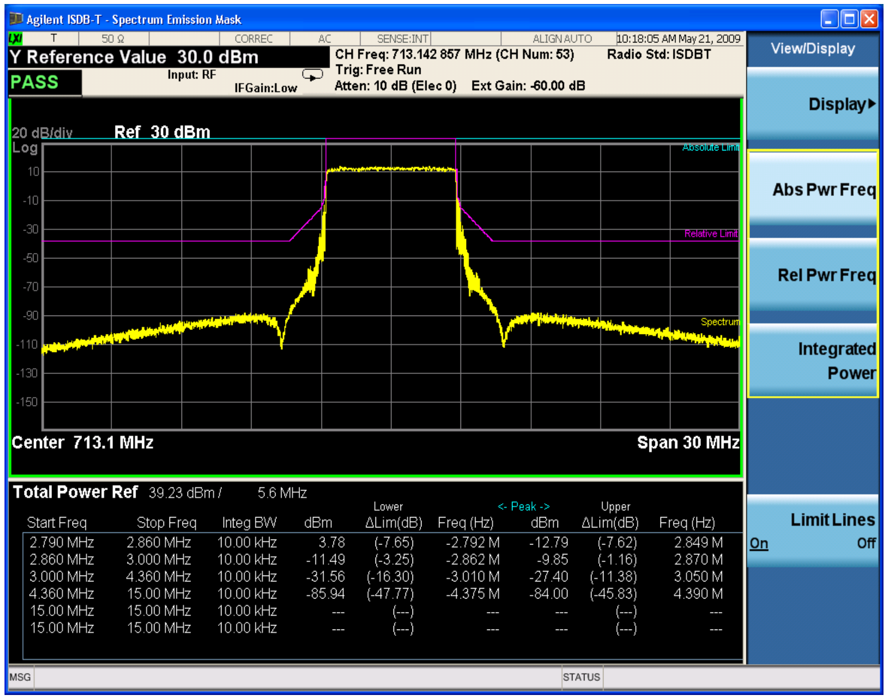
Viewing the Measurement Results

Three views are available in the Spectrum Emission Mask measurement. Press **View/Display**, **the name of the view** to display them. In Spectrum Emission Mask measurement of ISDB-T/Tsb signal, use the first two views: Abs Pwr Freq view and Rel Pwr Freq view.

NOTE 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.

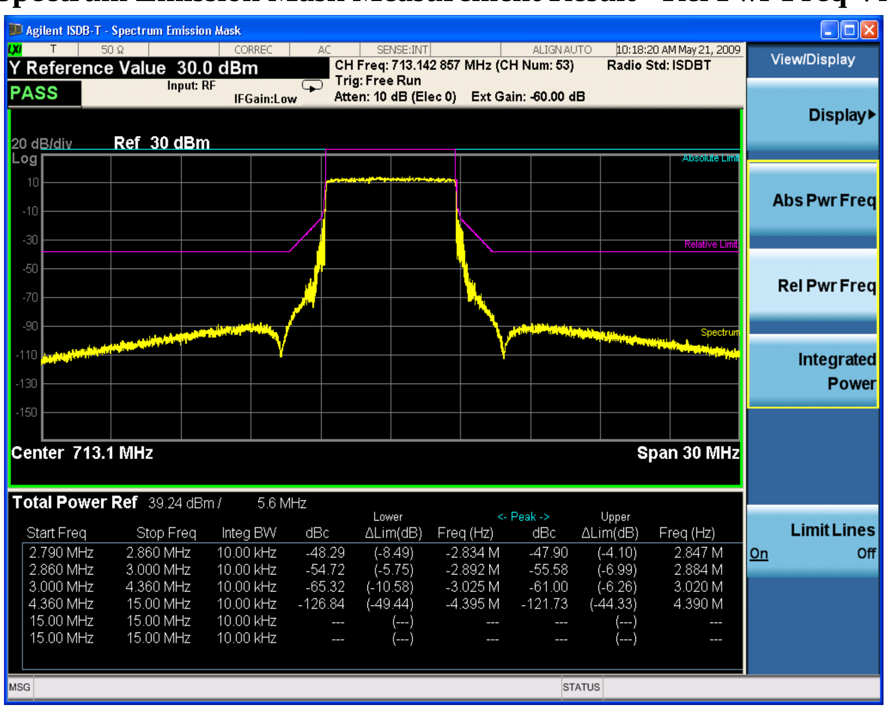
- **Abs Pwr Freq** displays the absolute power levels in dBm and the corresponding frequencies in the text window, as shown in Figure 3-7.

Figure 3-7 Spectrum Emission Mask Measurement Result - Abs Pwr Freq (Default)View



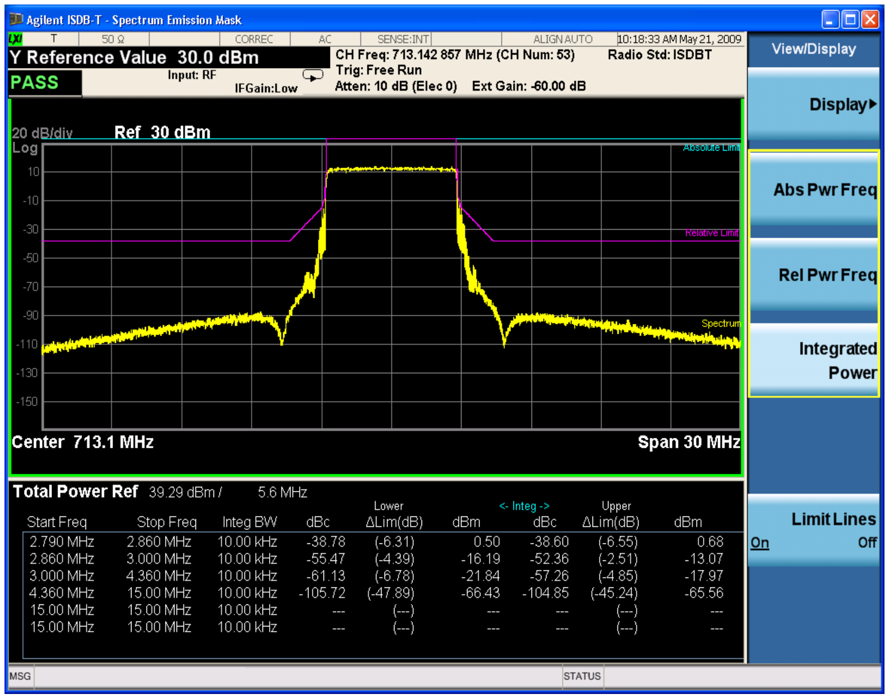
- **Rel Pwr Freq** displays the relative power levels in dBc and the corresponding frequencies in the text window, as shown in Figure 3-8.

Figure 3-8 Spectrum Emission Mask Measurement Result - Rel Pwr Freq View



- **Integrated Power** displays the absolute and relative power levels integrated throughout the bandwidths between the start and stop frequencies in the text window, as shown in Figure 3-9.

Figure 3-9 Spectrum Emission Mask Measurement Result - Integrated Power View



Troubleshooting Hints

The 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 an ISDB-T/Tsb 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.

Modulation Accuracy Measurements

This section describes how to make a Modulation Accuracy measurement on an ISDB-T/Tsb transmitter. Modulation Accuracy measurements provide methods for measuring the I/Q errors in ISDB-T/Tsb transmitter. The results comprise EVM, MER, magnitude error, phase error, frequency error, quad error, amplitude imbalance, TMCC decoding results, etc.

The Mod Accuracy measurement procedure includes three parts:

a. "Selecting and Setting up the ISDB-T Mode" on page 43

b. "Selecting and Setting up Mod Accuracy Measurement" on page 45

c. "Selecting and Viewing the Measurement Results" on page 45

Selecting and Setting up the ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel**, 53.

Step 5. Set the demodulation options for the ISDB-T transmitter under test. There are two methods:

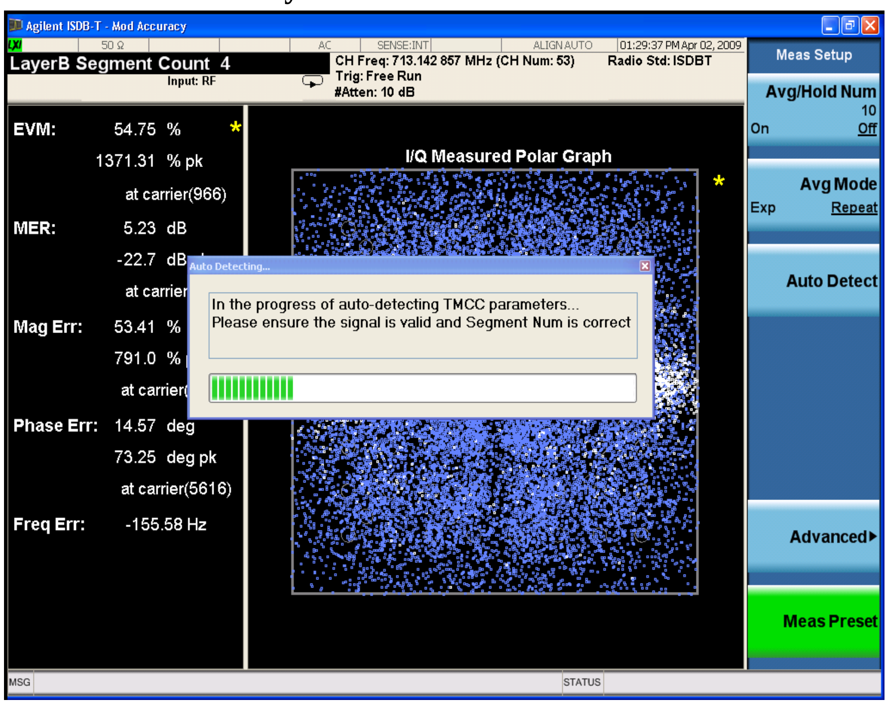
- Auto Detect the modulation parameters from TMCC information of the input signal, see Figure 3-10.

  Press **Meas Setup**, **Auto Detect**.

NOTE Before auto-detect, ensure the signal is valid and the Segment Num is correct.

- Set up the modulation parameters manually. Press **Mode Setup**, **Demod**, then
  - — Press **FFT Size**, **8K**.
  - — Press **Guard Interval**, **1/8**.
  - — Toggle the **Partial Reception** key to **On**.
  - — Press **Layer A**, **Modulation Format, QPSK**.
  - — Press **Layer B**, **Segment Count**, **4**, **Modulation Format**, **64QAM**.
  - — Press **Layer C, Modulation Format, 16QAM**.

Figure 3-10 Modulation Accuracy Measurement - Auto Detect



NOTE Mod Accuracy measurements can be used to measure BBIQ (Baseband I/Q) signals. For the detailed measurement procedure, refer to "Using Option BBA Baseband I/Q Inputs" on page 63.

Selecting and Setting up Mod Accuracy Measurement

Step 1. Initiate the Mod Accuracy measurement.

Press **Meas**, **Mod Accuracy**.

Step 2. Set up the Mod Accuracy measurement and see the parameters available to change. You can use the default settings for most cases.

Press **Meas Setup**.

TIP The following parameters under **Meas Setup**, **Advanced** are available.

- **Spectrum**: Toggle the Spectrum to Inverted when the signal is inverted in frequency domain.
- **Clock Rate**: Set the clock rate.
- **Demod Symbols**: Set the number of symbols used for demodulation.
- **Out of Band Filtering**: Choose whether to use out of band filter or not.
- **Equalization**: Choose whether to enable equalization. When the Equalization state is On, equalization using both SP (Scatterd Pilot) and data is performed. When the Equalization state is Off, equalization using only SP is performed.

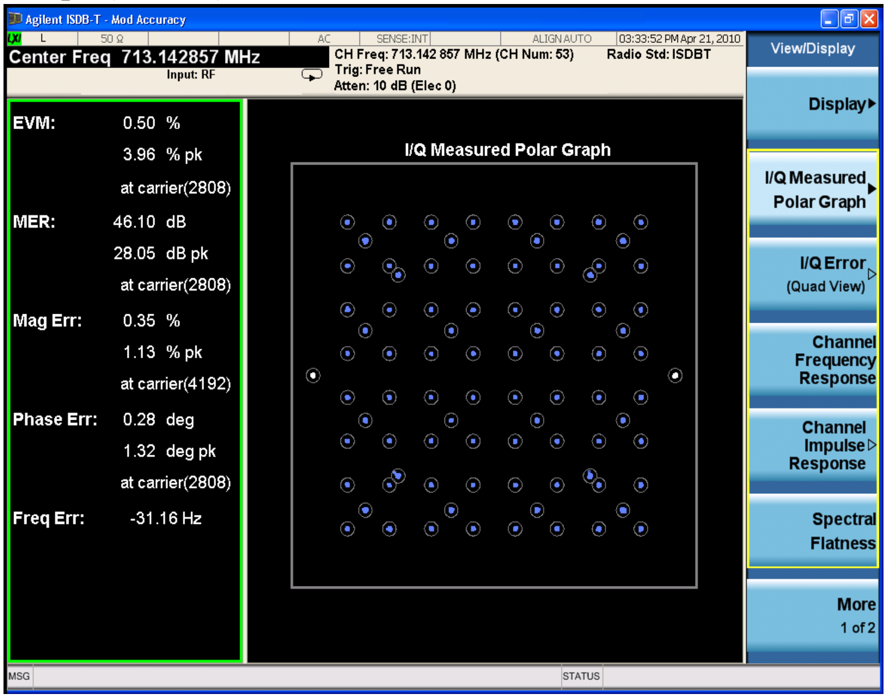
Selecting and Viewing the Measurement Results

Seven views are available in the Mod Accuracy measurement. Press **View/Display**, **the name of the view** to display them.

- **I/Q Measured Polar Graph** displays a combination view of I/Q measured polar graph and metric windows as shown in Figure 3-11. The modulation constellation is shown, along with EVM, MER, magnitude and phase errors, and frequency error.

NOTE View the modulation constellation for specified carriers by setting the **Start Carrier** value and **Stop Carrier** value under the **I/Q Measured Polar Graph** key.

Figure 3-11 Modulation Accuracy Measurement Result - I/Q Measured Polar Graph (Default) View



- **I/Q Error (Quad View)** displays a combination view of the MER, segment map, DataSegment/Layer polar graph and a result summary.

  Press **I/Q Error** again to choose the display type. Three display types are available which enable you to view your measurement result on each layer and segment.

  — View I/Q Error results of Layer B (example) as shown in Figure 3-12.

  Toggle **Display Type** to **Layer**, press **Layer**, and select **Layer B**.

  — View I/Q Error results of Segment 8 (example) as shown in Figure 3-13.

  Toggle **Display Type** to **Seg**, and press **Segment Index**, 8.

  — View I/Q Error results of a frame as shown in Figure 3-14.

  Toggle **Display Type** to **All**.

NOTE Note that, you can set the scale type of the vertical axis to **MER** or **EVM** and that of the horizontal axis to **Carrier** or **Freq** for the top left window in I/Q Error view. If you want to view the MER vs. Subcarrier results,

— press **AMPTD Y Scale**, **More 1 of 2** and toggle the **Scale Type** key to **MER**.

— press **Span X Scale** and toggle the **Scale Type** key to **Carrier**.

Four windows are displayed in Figure 3-12, Figure 3-13, and Figure 3-14. The MER vs. Sub-carrier (top-left) window displays the MER result for the whole frame. The Segment Map window (top right), DataSegment/Layer Polar Graph window (bottom left), and Result Metrics window (bottom right) indicate the results for the selected display data.

Figure 3-12 Modulation Accuracy Measurement Result - I/Q Error View (Layer B)

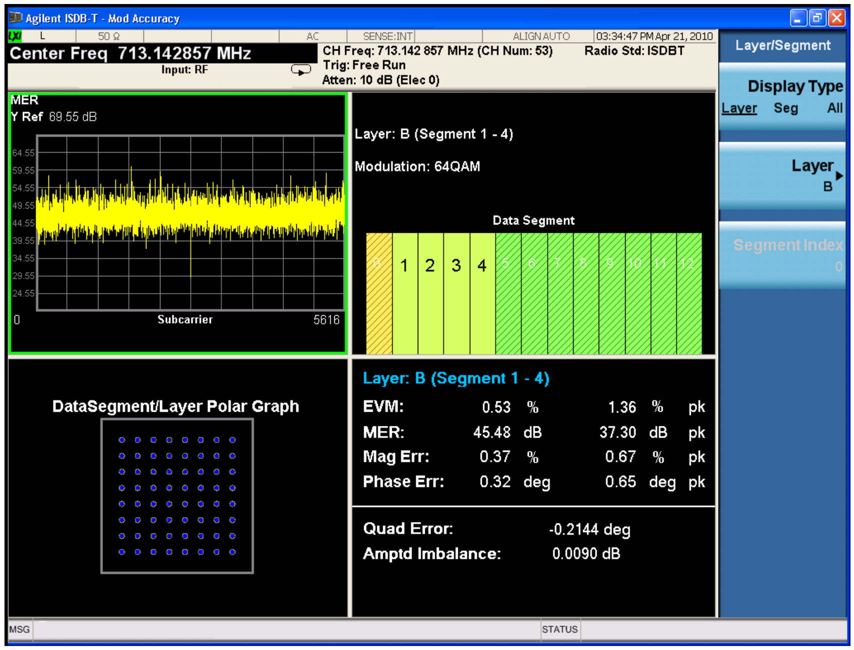


Figure 3-13 Modulation Accuracy Measurement Result - I/Q Error View (Segment 8)

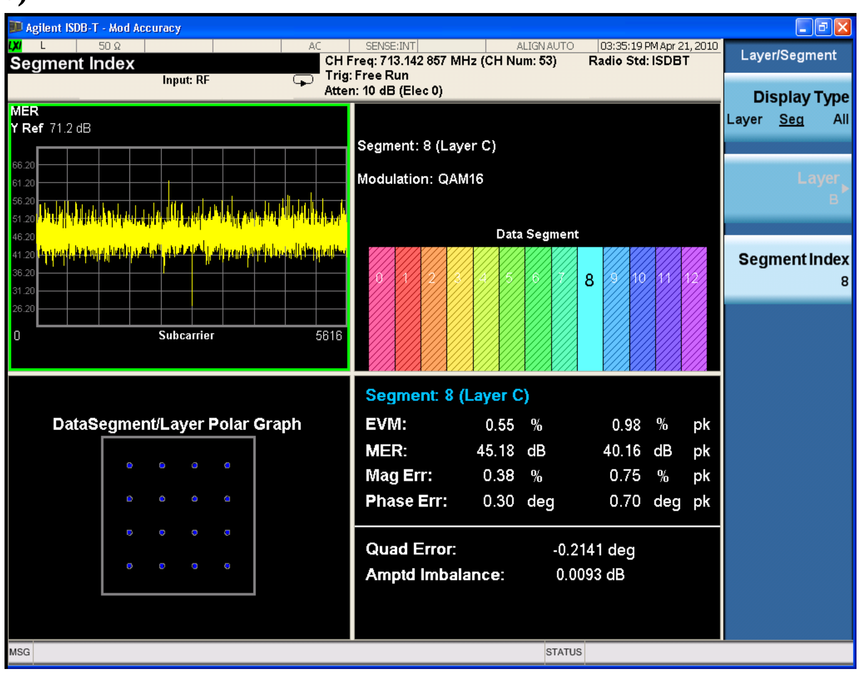
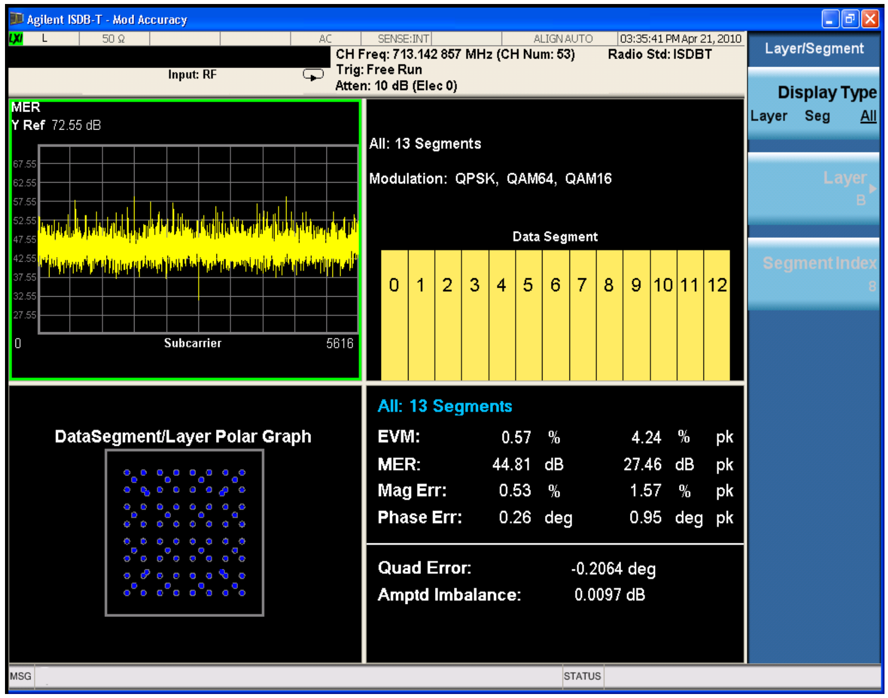
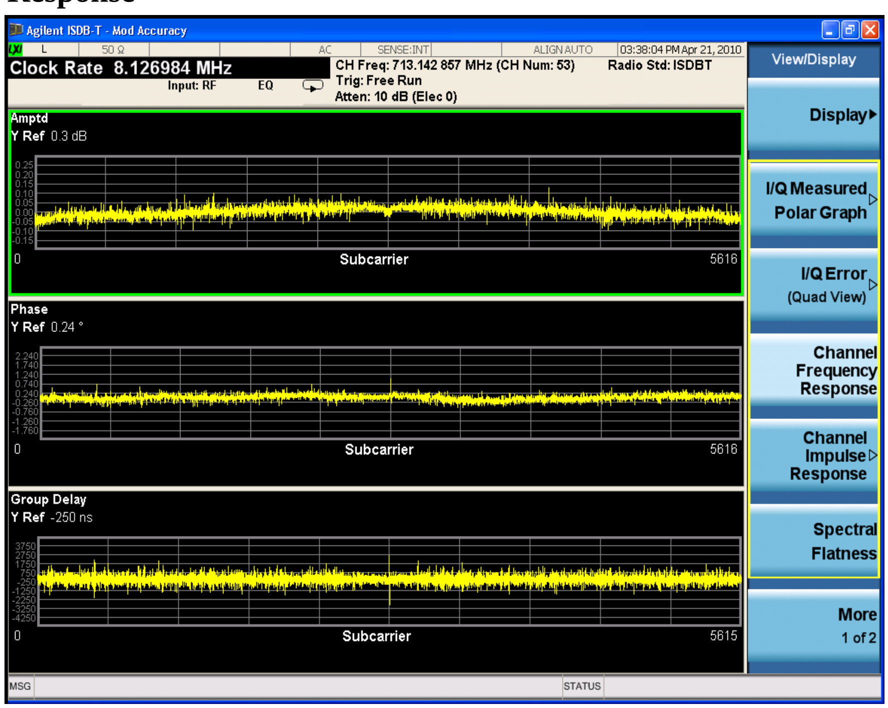


Figure 3-14 Modulation Accuracy Measurement Result - I/Q Error View (ALL)



- **Channel Frequency Response** displays the amplitude, phase and group delay of the channel frequency response on every subcarrier as shown in Figure 3-15.

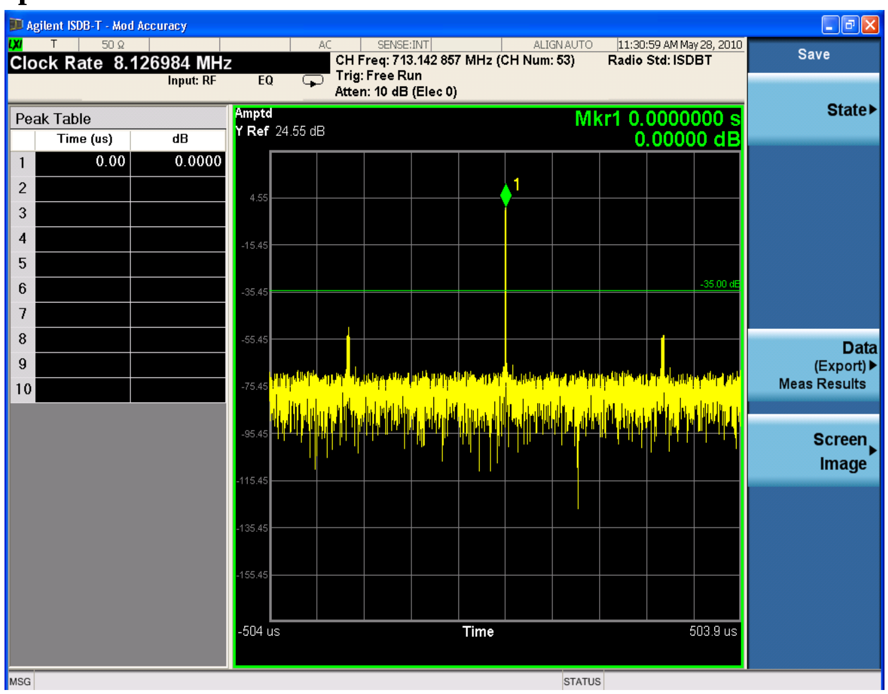
Figure 3-15 Modulation Accuracy Measurement Result - Channel Frequency Response



- **Channel Impulse Response** displays the state and the delay profile of channel. This view has two windows, the graphic window showing the channel impulse response trace and the peak table window showing the delay and amplitude of the top 10 peaks on the trace.

  In this view, equalization need to be turned on to get better result. Press **Meas Setup**, **Advanced**, **Equalization**, and toggle Equalization to **On**. The measurement results should look like Figure 3-16. The green line with -35.00 dB above the 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.

Figure 3-16 Modulation Accuracy Measurement Result - Channel Impulse Response

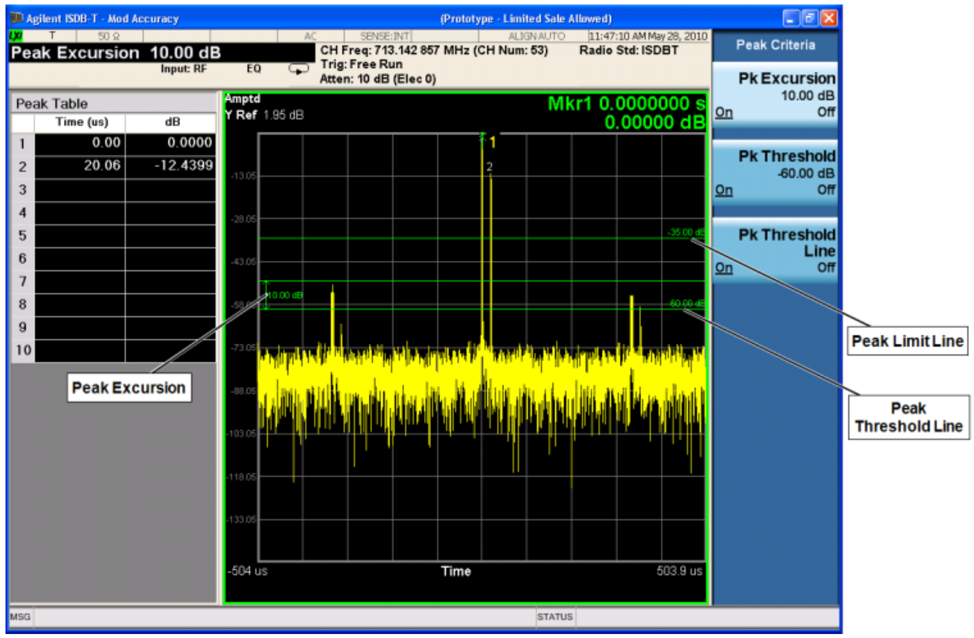


Peak table window is very useful when there are more than one path in the signal channel. Here is an example of channel impulse response of a two-path channel with 0 and 20 us delay respectively. Set the following parameters to make the peak table results meet your requirements:

- Press **Peak Search**, **More 1 of 2**, **Peak Table**, **Peak Sort** and toggle **Peak Sort** to **Amptd** to set the sorting rule.
- 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 85.

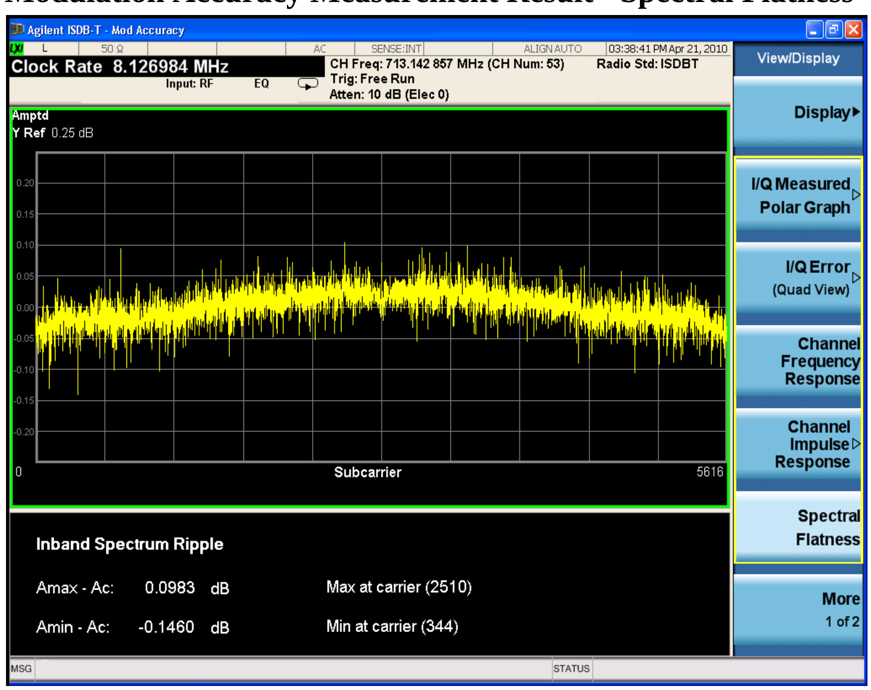
The multi-path measurement result should look like Figure 3-17, including peak threshold line, peak excursion, and peak limit line.

Figure 3-17 Channel Impulse Response of a Two-Path Channel



- **Spectral Flatness** displays the inband spectrum ripple as shown in Figure 3-18.

Figure 3-18 Modulation Accuracy Measurement Result - Spectral Flatness

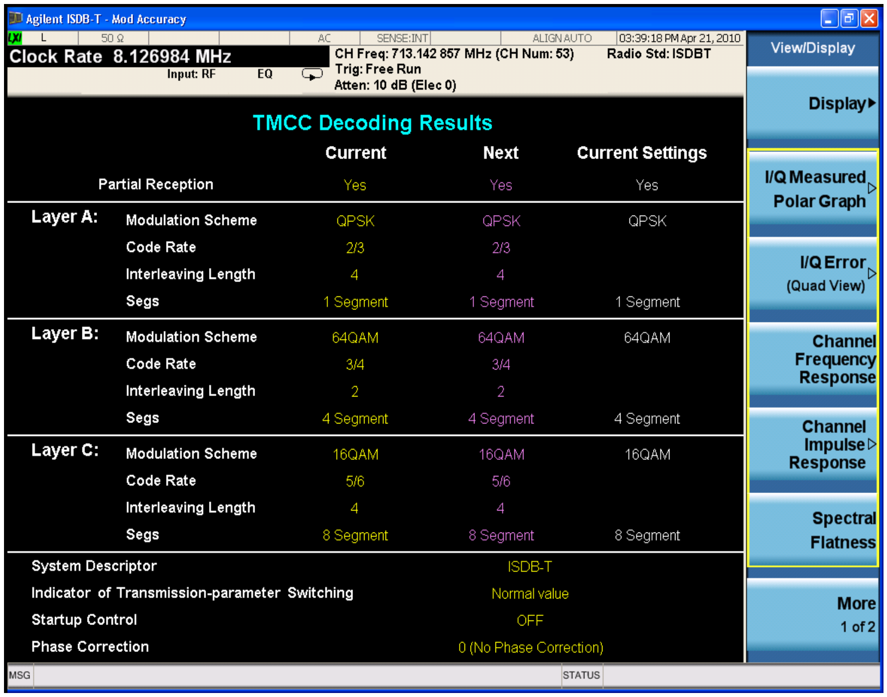


- **More 1 of 2**, **TMCC Decoding** displays the information decoded from TMCC as shown in Figure 3-19.

  The results in yellow with the title ‘Current’ show the current hierarchical configuration and transmission parameters, while the results in purple with the title

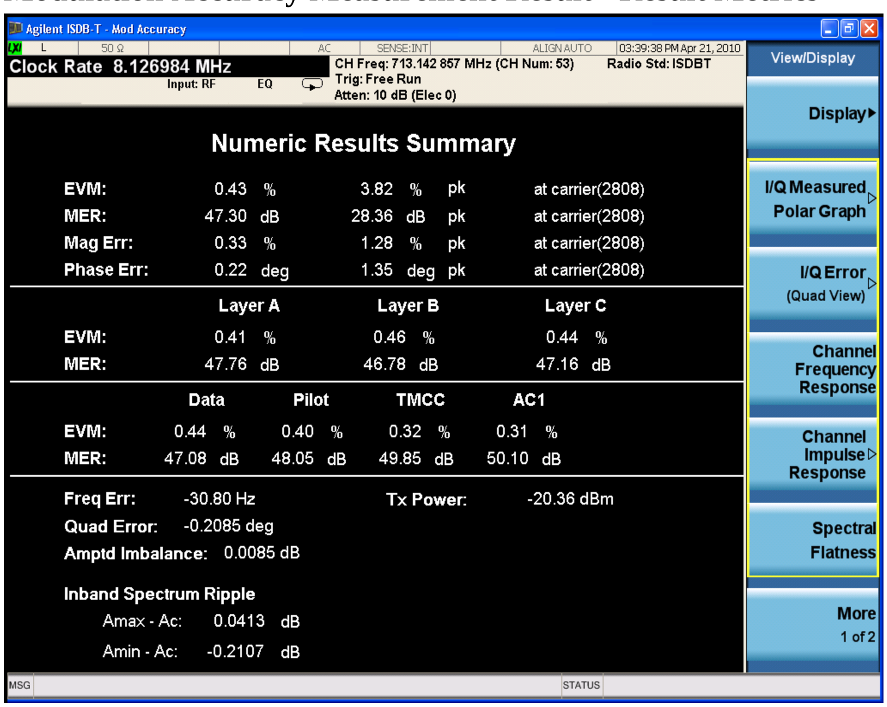
'Next' show the information for the next hierarchical. The results in white in the rightmost row indicate the current settings under **Mode Setup**, **Demod**.

Figure 3-19 Modulation Accuracy Measurement Result -TMCC Decoding



- **More 1 of 2**, **Result Metrics** displays a summary of the measurement results as shown in Figure 3-20.

Figure 3-20 Modulation Accuracy Measurement Result - Result Metrics



You can check the MER results calculated using all the subcarriers, layer A/B/C, data, pilot, TMCC, and AC1 in the Result Metrics view. For more information of calculating MER, refer to “MER Measurement Method” on page 82.

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 6 traces to select from: Polar Trace, MER/EVM vs.Carr/Freq, Amptd vs.Carr, Phase vs.Carr, GD vs.Carr, Amptd vs.Time.

Occupied Bandwidth Measurements

This section explains how to make the Occupied Bandwidth measurement on an ISDB-T/Tsb transmitter. The instrument measures power across the band, and then calculates its 99.0% power bandwidth.

The Occupied Bandwidth measurement procedure includes three parts:

a. "Selecting and Setting up ISDB-T Mode" on page 53

b. "Selecting and Setting up the Occupied BW Measurement" on page 53

c. "Viewing the Measurement Results" on page 54

Selecting and Setting up ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel**, 53.

Selecting and Setting up the Occupied BW Measurement

Step 1. Initiate the Occupied BW measurement.

Press **Meas**, **Occupied BW**.

Step 2. Set up the Occupied BW measurement and see the parameters available to change. The key parameters are shown in Table 3-4.

Press **Meas Setup**.

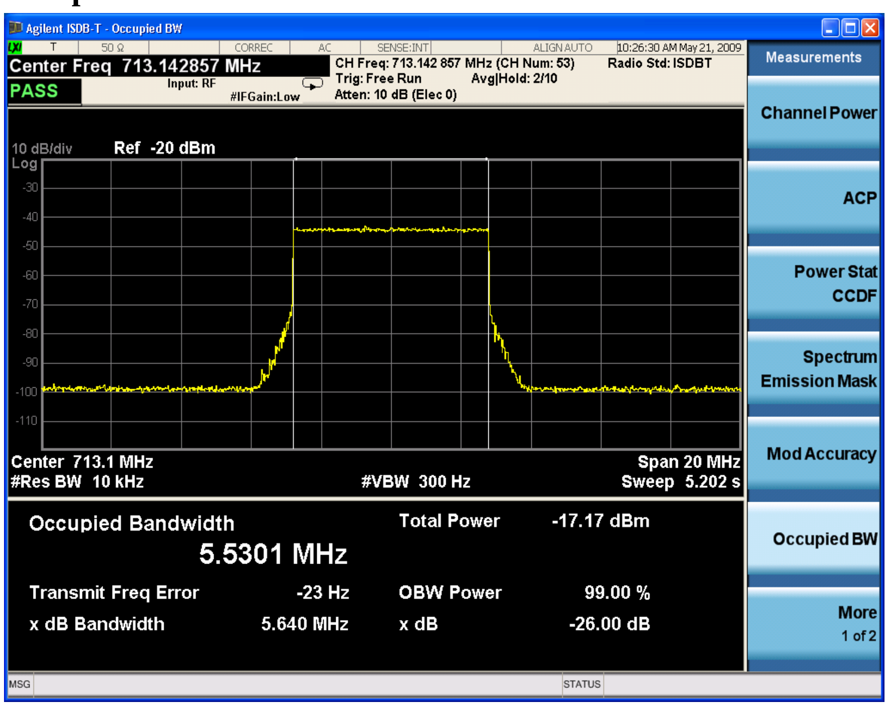
Table 3-4 Key Parameters in Occupied Bandwidth Measurement

Name	Actions (e.g.)	Function
OBW Power	Press **Meas Setup**, **OBW Power**, 99.	Set the percentage of the total power that is measured within the occupied bandwidth.
X dB	Press **Meas Setup**, **x dB**, -26.	Set the x dB value for the 'x dB bandwidth' result.
Limit	• Press **Meas Setup**, **More 1 of 2**, **Limit**, 7.512, **MHz**. • Toggle the **Limit** to **On**.	Turn on the limit checking for the specified frequency.

Viewing the Measurement Results

The Occupied BW measurement result should look like Figure 3-21. The occupied bandwidth of the specified percentage and the x dB bandwidth of the specified x dB are shown in the text window.

Figure 3-21 Occupied Bandwidth Measurement Result



Troubleshooting Hints

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

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

Monitor Spectrum Measurements

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

The Monitor Spectrum measurement procedure includes three parts:

a. "Selecting and Setting up the ISDB-T Mode" on page 57

b. "Selecting and Setting up Monitor Spectrum Measurement" on page 57

c. "Viewing the Measurement Results" on page 58

Selecting and Setting up the ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel, 53**.

Selecting and Setting up Monitor Spectrum Measurement

Step 1. Initiate the Monitor Spectrum measurement.

Press **Meas**, **Monitor Spectrum**.

Step 2. Set up the Monitor Spectrum measurement and see the parameters available to change. You can use the default settings for most cases.

Press **Meas Setup**.

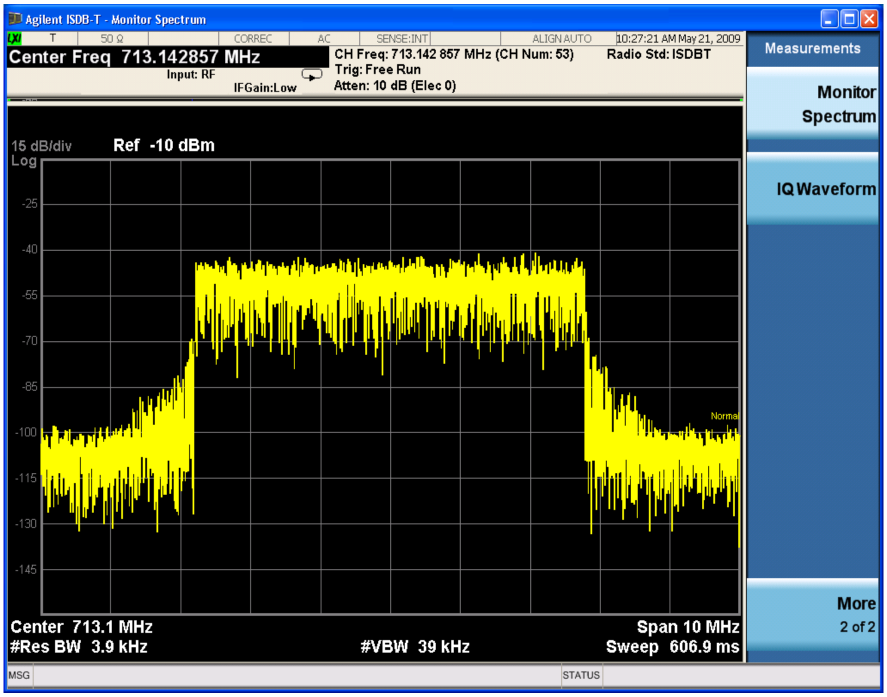
Viewing the Measurement Results

The Monitor Spectrum measurement result should look like Figure 3-22.

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

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

Figure 3-22 Monitor Spectrum Measurement - Spectrum View



IQ Waveform (Time Domain) Measurements

This section explains how to make a Waveform (time domain) measurement on an ISDB-T/Tsb 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.

The IQ Waveform measurement procedure includes three parts:

a. "Selecting and Setting up the ISDB-T Mode" on page 59

b. "Selecting and Setting up IQ Waveform Measurements" on page 59

c. "Selecting and Viewing the Measurement Results" on page 60

Selecting and Setting up the ISDB-T Mode

Step 1. Select ISDB-T mode.

Press **Mode**, **ISDB-T**.

Step 2. Preset the analyzer.

Press **Mode Preset**.

Step 3. Select ISDB-T standard.

Press **Mode Setup**, **Radio Std**, **ISDB-T**.

Step 4. Set the center frequency. There are two methods:

- Enter the center frequency directly.

  Press **FREQ Channel**, **Center Freq**, 713.142857, **MHz**.

- Select the channel number under a specific channel table.

  a. Specify a channel table by selecting a video standard.

     Press **FREQ Channel**, **Chan Table**, **NTSC-J**, **NTSC-J AIR**.

  b. Set the channel number.

     Press **FREQ Channel**, **Channel, 53**.

NOTE 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 63.

Selecting and Setting up IQ Waveform Measurements

Step 1. Initiate the IQ Waveform measurement.

Press **Meas**, **IQ Waveform**.

Step 2. See the keys that are available to change the measurement parameters from their default condition.

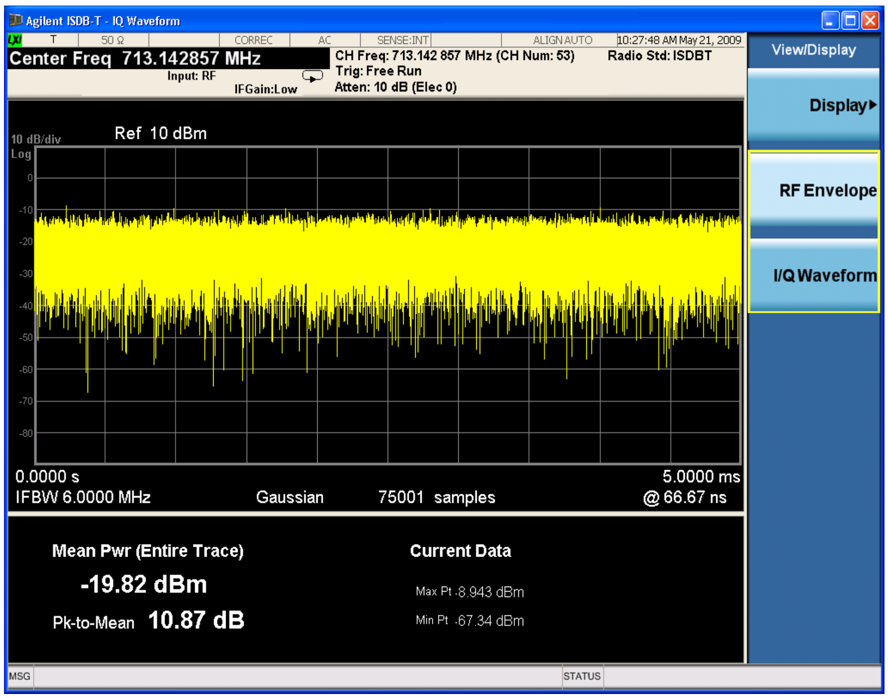
Press **Meas Setup**.

Selecting and Viewing the Measurement Results

Two views are available in the IQ Waveform measurement. Press **View/Display**, **the name of the view** to display them.

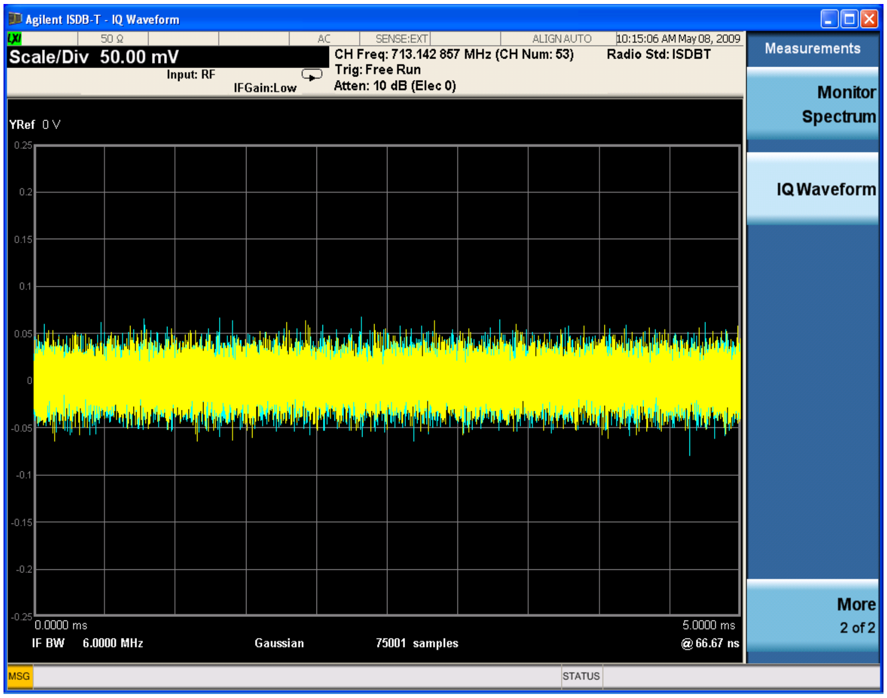
- **RF Envelope** displays the RF envelope with the current data as shown in Figure 3-23. The measured values for the mean power and peak-to-mean power are shown in the text window.

Figure 3-23 Waveform Measurement - RF Envelope (Default View)



- **IQ Waveform** displays a view of the I (yellow trace) and Q (blue trace) waveforms on the same graph in terms of voltage versus time in linear scale as shown in Figure 3-24.

Figure 3-24 Waveform Measurement - I/Q Waveform View



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 3-5 BBIQ Supported Measurements vs. Mode

Mode	Measurements
GSM	IQ Waveform GMSK Phase & Freq EDGE EVM
802.16 OFDMA	IQ Waveform Power Stat CCDF Modulation Analysis
TD-SCDMA	IQ Waveform Power Stat CCDF Code Domain Mod Accuracy
cdma2000	IQ Waveform Power Stat CCDF Code Domain Mod Accuracy QPSK EVM
DTMB (CTTB)	IQ Waveform Power Stat CCDF Mod Accuracy
DVB-T/H	IQ Waveform Power Stat CCDF Mod Accuracy
ISDB-T	IQ Waveform Power Stat CCDF Mod Accuracy
CMMB	IQ Waveform Power Stat CCDF Mod Accuracy
IQ Analyzer (Basic)	IQ Waveform Complex Spectrum

Baseband I/Q Measurement Overview

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

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

Single Ended (unbalanced)
: In this mode, only the main port (I or Q) is used and the complementary ports (I-bar or Q-bar) 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 Agilent 1153A active differential probe using the Infinimax probe interface.

NOTE To avoid duplication, this section describes only the details unique to using the baseband I/Q inputs. For generic measurement details, refer to the previous "Making ISDB-T Measurements" on page 23 sections.

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

Step 1. Select a measurement that supports baseband I/Q inputs.

Step 2. Select the I/Q Path.
Press **Input/Output, I/Q, I/Q Path**. Select from the choices present on the screen. The path selected is shown at the top of the measurement screen.

Step 3. Select the appropriate circuit location and probe(s) for measurements. For details see "Selecting Input Probes for Baseband Measurements" on page 91 in the Concepts chapter.

Step 4. Select baseband I/Q input connectors.

Step 5. If you have set the I/Q Path to **I+jQ** or to **I Only**, press **I Setup.**

A. Select whether **Differential (Balanced)** input is **On** or **Off.**

B. Select the input impedance, **Input Z**.

C. Input a **Skew** value in seconds.

D. Set up the I Probe by pressing **I Probe**.

a. Select probe **Attenuation**.

b. Calibrate the probe. Press **Calibrate...** to start the calibration procedure.

Follow the calibration procedure, clicking **Next** at the end of each step.

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

A. Select whether **Differential (Balanced)** input is **On** or **Off.**

B. Select the input impedance, **Input Z**.

C. Input a **Skew** value in seconds.

D. Set up the I Probe by pressing **I Probe**.

a. Select probe **Attenuation**.

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

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

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

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

4 Concepts

This chapter provides details about the ISDB-T/Tsb 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.

What Is the ISDB-T/Tsb Broadcast System?

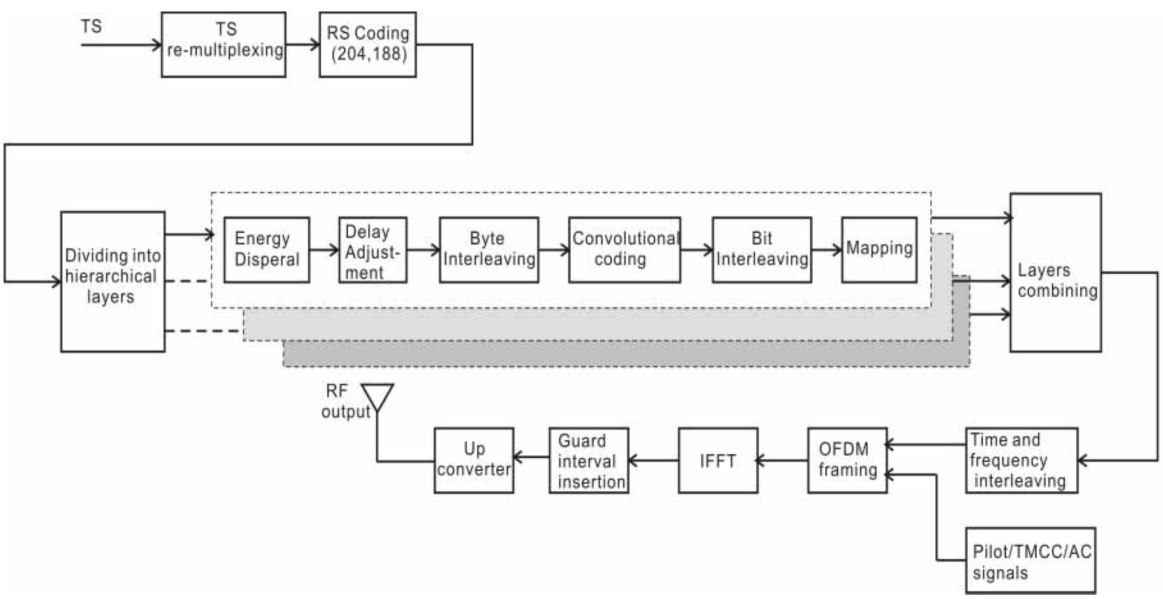
ISDB-T/Tsb standards are the digital terrestrial broadcasting systems developed by the Association of Radio Industries and Business (ARIB) in Japan. ISDB-T, as a terrestrial broadcasting system, is adopted by Japan and Brazil currently. ISDB-Tsb, the narrow-band ISDB-T, is used for audio and data program transmissions. The system and specifications of ISDB-Tsb are almost the same as ISDB-T, except that the bandwidth is narrower and there are only one or three segments in the channel. This chapter mainly focuses on introduction of ISDB-T broadcast system.

The block diagram of ISDB-T system is shown in Figure 4-1.

The multiple TSs (transport stream) from the MPEG-2 output are re-multiplexed to one data stream first. After going through an outer coding (a shortened RS code), the data stream is divided into a maximum of three layers based on the organization information.

Next, the layers are then processed by the parallel processors. The parallel processors mainly include energy dispersal, delay adjustment, byte interleaving, convolutional coding, bit interleaving, and mapping. Note that each layer can have its own error correction, time interleaving length and modulation scheme.

Figure 4-1 Block Diagram of ISDB-T



After that, the data from different layers are combined to one data stream again. The time and frequency interleaving is applied to decrease the transmission errors caused by burst noise and multi-path interference in mobile reception. Then, pilot, TMCC, and AC are inserted to form the OFDM frame. The pilot, TMCC and AC are used to make sure that the receiver can correctly demodulate and decode the data with different transmission configurations in each layer.

After going through the IFFT process and guard interval insertion, the data is upconverted to the RF frequency. The key parameters of ISDB-T are shown in Table 4-1. For more details, refer to [2].

Table 4-1 Key Parameters of ISDB-T

Mode	Mode 1 (2k)	Mode 2(4k)	Mode 3(8k)
Segment Num.	13		
Carrier Spacing	3.968 kHz	1.984 KHz	0.992 kHz
Bandwidth	5.575 MHz	5.573 MHz	5.572 MHz
Total Carriers	1405	2809	5617
Modulation Scheme	QPSK, 16QAM, 64QAM, DQPSK		
Symbol Num Per Frame	204		
Guard Interval	1/4, 1/8, 1/16, and 1/32		
Outer Code	RS(204,188)		
Inner Code	Convolutional Code (1/2, 2/3, 3/4, 5/6, 7/8)		
Data Rate (Mbps)	3.65 ~ 23.2		

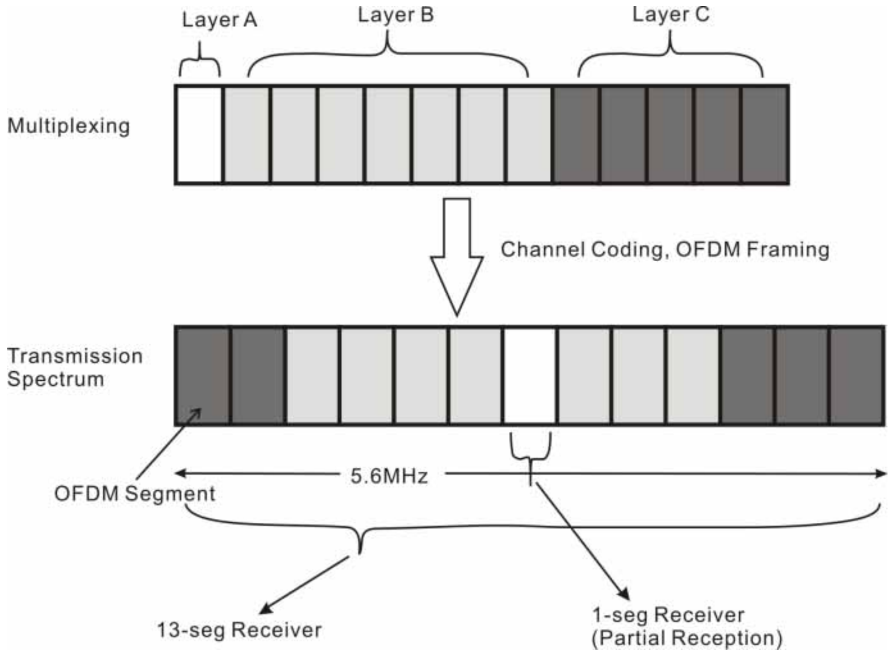
Hierarchical Transmission and Partial Reception

ISDB-T supports hierarchical transmission by introducing hierarchical layers, which means different services, such as HDTV, multi-channel SDTV, and data, can be transmitted in one frequency channel. There are 13 OFDM segments in the ISDB-T transmission channel. Each layer consists one or more segments and has its own transmission parameters (e.g., the inner coding rate, modulation scheme and time interleaving length). A maximum of 3 layers can be provided.

Figure 4-2 presents the general conception of hierarchical transmission and partial reception.

Partial reception relates to the segment at the center of the transmission spectrum. The range of frequency interleaving can be limited within the segment, so that a narrow band (1-seg) receiver can receive the services contained in the segment. Note that the segment used for partial reception is also considered as a hierarchal layer.

Figure 4-2 Hierarchical Transmission and Partial Reception in ISDB-T



Interleaving

As shown in Figure 4-1, four kinds of interleaving are used in ISDB-T system. The effect of each interleaving is discussed below.

- Byte interleaving is used between the RS coding and convolutional coding to randomize the burst errors of the Viterbi decoding output.
- Bit interleaving is used after the convolutional coding to randomize the burst errors before Viterbi decoding.
- Time interleaving is used after mapping and layer combining to randomize the burst errors in time domain caused by the impulse interferences and fadings in mobile reception.
- Frequency interleaving is used after time interleaving to randomize the burst errors of frequency domain caused by multi-path and carrier interferences in mobile reception.

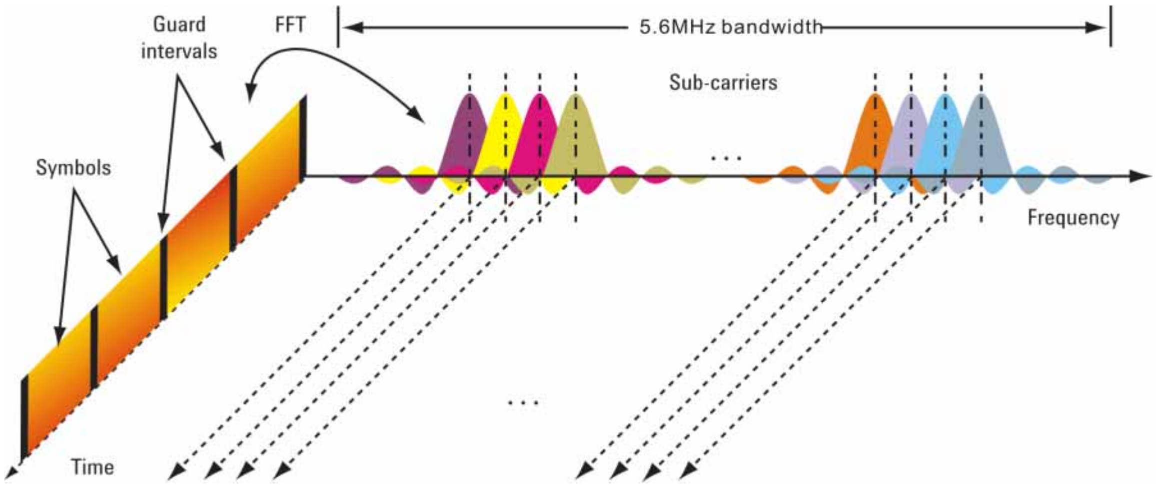
OFDM

ISDB-T uses Orthogonal Frequency Division Multiplexing (OFDM) for modulation. Rather than transmit a high-rate stream of data with a single carrier, OFDM makes use of a large number of closely spaced orthogonal subcarriers that are transmitted in parallel.

Each subcarrier is modulated with a conventional modulation scheme (such as DQPSK, QPSK, 16QAM, 64QAM) at a low symbol rate. The combination of hundreds or thousands of subcarriers enables data rates similar to conventional single-carrier modulation schemes in the same bandwidth.

The diagram in Figure 4-3 illustrates the key features of an OFDM signal in frequency and time. In the frequency domain, multiple adjacent tones or subcarriers are each independently modulated with data. Then in the time domain, guard intervals are inserted between each of the symbols to prevent inter-symbol interference at the receiver caused by multi-path delay spread in the radio channel.

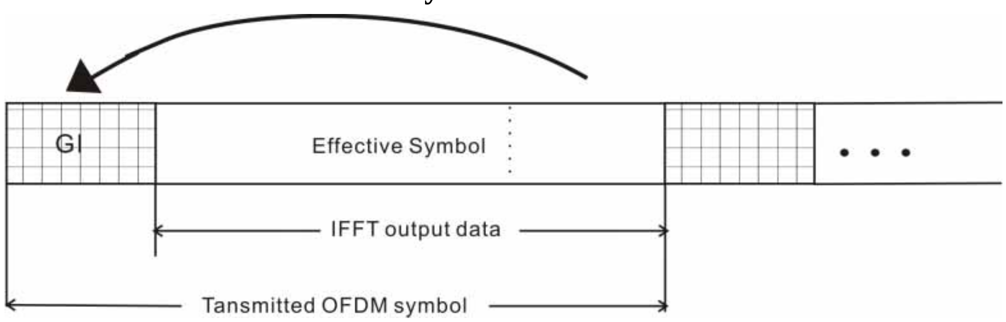
Figure 4-3 OFDM Signal In Frequency and Time Domain



A transmitted OFDM symbol that consists of GI (guard interval) and Effective symbol (the output data of the IFFT) is shown in Figure 4-4. The guard interval is the latter part of effective symbol and inserted without any modification before the effective symbol.

For the GI (Guard interval) in ISDB-T signals, the length can be 1/4, 1/8, 1/16 or 1/32 of the effective symbol length.

Figure 4-4 Structure for OFDM Symbols



Channel Power Measurement Concepts

Purpose

The Channel Power measurement is an important test in the digital video industry to measure the channel power characteristics of the ISDB-T/Tsb radio signal. First of all, it measures the integrated power and power spectral density (PSD) in ISDB-T/Tsb defined bandwidth. Secondly, it measures and reports the shoulder attenuation, which is to measure the intermodulation, one of the causes of the OFDM signal quality degradations.

Measurement Method

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

RF Spectrum

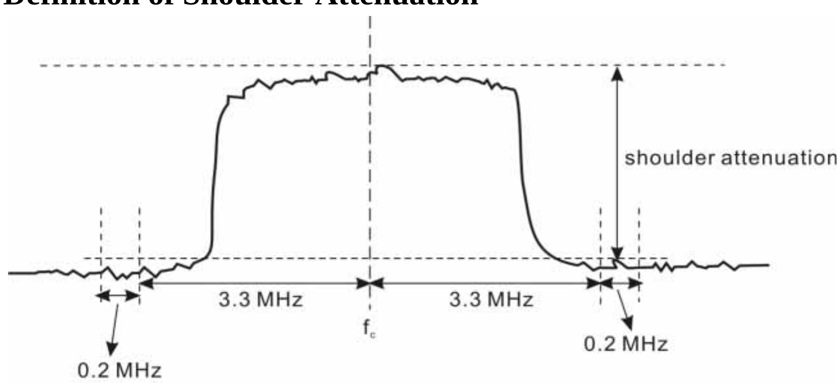
The RF Spectrum measurement reports the total transmitted power within the channel bandwidth (5.6 MHz for ISDB-T). The integration bandwidth (IBW) method is used to determine the channel power.

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

The shoulder attenuation is defined as the difference between the maximum level of the OFDM signal and the maximum level measured at specified frequency range as shown in Figure 4-5. The measurement should be made in the frequency range of -3.3 to -3.5 MHz and +3.3 to 3.5 MHz from the center frequency. [1]

Figure 4-5 Definition of Shoulder Attenuation



Adjacent Channel Power (ACP) Measurement Concepts

Purpose

Adjacent Channel Power (ACP), as it applies to ISDB-T/Tsb, 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.

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 ranging 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 indexed 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 ISDB-T/Tsb, 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 following spectrum masks are available in Spectrum Emission Mask measurement:

- Spectrum Mask for ISDB-T defined in Japan ARIB STD-B31, “Methods of Measurement for Digital Terrestrial Broadcasting Transmitters” is shown in Table 4-2. [1]

Table 4-2 Spectrum Mask for ISDB-T Defined in Japan ARIB STD-B31

Difference from carrier frequency	Attenuation relative to the average power, P	Specification
±2.79 MHz	-27.4 dB/10kHz	upper limit
±2.86 MHz	-47.4 dB/10kHz	upper limit
±3.00 MHz	-54.4 dB/10kHz	upper limit
±4.36 MHz	$-57.4\text{dB}/10\text{kHz} \quad (P \le 0.025\text{W})$ $-(73.4 + 10\log P)\text{dB}/10\text{kHz} \quad (0.025\text{W} < P \le 0.25\text{W}$ $-67.4\ \text{dB}/10\text{kHz} \quad (P = 0.25\text{W})$ $-(73.4 + 10\log P)\text{dB}/10\text{kHz} \quad (0.25\text{W} < P \le 2.5\text{W})$ $-77.4\ \text{dB}/10\text{kHz} \quad (P > 2.5\text{W})$	upper limit

NOTE The limit on ±4.36 MHz frequency offset may differ from the values in Table 4-2 in some special transmission environments. To support these test cases, four limits are available, which are Auto Sense, 30dB Mask, 40dB Mask, and 50dB Mask. Table 3-3 on page 39 lists the cases to use these limits.

— Auto Sense means the limits on ±4.36 MHz frequency offset are the same as the values in Table 4-2, which changes with the channel power automatically.

— 30dB Mask means the limit on ±4.36 MHz frequency offset is -57.4 dB/10 kHz.

— 40dB Mask means the limit on ±4.36 MHz frequency offset is -67.4 dB/10 kHz.

— 50dB Mask means the limit on ±4.36 MHz frequency offset is -77.4 dB/10 kHz.

- Spectrum mask for ISDB-T defined in Brazil ABNT NBR 15601, “Digital terrestrial television - Transmission system” is shown in Table 4-3. [4]

Table 4-3 Spectrum Mask for ISDB-T Defined in Brazil ABNT NBR 15601

Difference from carrier frequency	Minimum attenuation in relation to average power measured at carrier central frequency		
	Non-critical mask	Sub-critical mask	Critical mask
±2.79 MHz	0.0 dB/10kHz	0.0 dB/10kHz	0.0 dB/10kHz
±2.86 MHz	20.0 dB/10kHz	20.0 dB/10kHz	20.0 dB/10kHz
±3.00 MHz	27.0 dB/10kHz	34.0 dB/10kHz	34.0 dB/10kHz

Table 4-3 Spectrum Mask for ISDB-T Defined in Brazil ABNT NBR 15601

Difference from carrier frequency	Minimum attenuation in relation to average power measured at carrier central frequency		
	Non-critical mask	**Sub-critical mask**	**Critical mask**
±3.15 MHz	36.0 dB/10kHz	43.0 dB/10kHz	50.0 dB/10kHz
±4.5 MHz	53.0 dB/10kHz	60.0 dB/10kHz	67.0 dB/10kHz
±9.0 MHz	83.0 dB/10kHz	90.0 dB/10kHz	97.0 dB/10kHz
±15.0 MHz	83.0 dB/10kHz	90.0 dB/10kHz	97.0 dB/10kHz

Three spectrum masks are defined as shown above. The application of the spectrum masks depends on the class of the stations and substations.

According to [4], digital stations are classified in Special Class, Class A, Class B and Class C as shown in Table 4-4.

Table 4-4 Classification of the Digital Stations

Class	Maximum ERP power* (height = 150m) KW	
	VHF high	UHF
Special	16	80
A	1.6	8
B	0.16	0.8
C	0.016	0.08
* ERP power is the effective radiated power		

The criteria for using non-critical, sub-critical and critical spectrum masks are shown in Table 4-5.

Table 4-5 Criteria for Using Non-critical, Sub-critical and Critical Spectrum Masks

<table>
<tr><td>Digital Station class</td><td colspan="5">A, B and C</td><td colspan="2">Special</td></tr>
<tr><td>Distance in relation to the adjacent channel installed in the same location</td><td colspan="2"><400 m</td><td colspan="2">>400m</td><td rowspan="2">Absence of adjacent channel foreseen of installed in the same location</td><td rowspan="2">Presence of adjacent channel foreseen or installed in the same location</td><td rowspan="2">Absence of adjacent channel foreseen of installed in the same location</td></tr>
<tr><td>Type of channel modulation of the adjacent channel foreseen or installed in the same location</td><td>Analog</td><td>Digital</td><td>Analog</td><td>Digital</td></tr>
</table>

Table 4-5 Criteria for Using Non-critical, Sub-critical and Critical Spectrum Masks

Pdigital < Padjacent + 3 dB	Critical	Sub-critical	Critical	Non-critical	Critical
Pdigital > Padjacent + 3 dB		Critical			
Pdigital = ERP Power of the digital station Padjacent = ERP Power of the adjacent channel station					

- Spectrum masks for ISDB-Tsb defined in Brazilian Standard ARIB STD-B29, “Transmission System for Digital Terrestrial Sound Broadcasting” are shown in Table 4-6 and Table 4-7. [3]

  Spectrum mask in Table 4-6 is used when the ISDB-Tsb signal contains 1 segment, and spectrum mask in Table 4-7 is used when the ISDB-Tsb signal contains 3 segments.

Table 4-6 Spectrum Mask for ISDB-Tsb 1-Segment Defined in ARIB STD-B29

Difference from carrier frequency	**Attenuation from the average power**	**Specification**
±220 kHz	-16.3 dB/10kHz	upper limit
±290 kHz	-36.3 dB/10kHz	upper limit
±360 kHz	-46.3 dB/10kHz	upper limit
±1170 kHz	$-52.0\ \mathrm{dB/10kHz}\quad (P \le 0.5\mathrm{W})$ $-(53.6 + 5.6\log P)\mathrm{dB/10kHz}\quad (0.5\mathrm{W} < P \le 5.0\mathrm{W})$ $-57.6\ \mathrm{dB/10kHz}\quad (P > 5.0\mathrm{W})$	upper limit

Table 4-7 Spectrum Mask for ISDB-Tsb 3-Segment Defined in ARIB STD-B29

Difference from carrier frequency	**Attenuation from the average power**	**Specification**
±650 kHz	-21.0 dB/10kHz	upper limit
±720 kHz	-41.0 dB/10kHz	upper limit
±790 kHz	-51.0 dB/10kHz	upper limit
±2220 kHz	$-61.0\ \mathrm{dB/10kHz}\quad (P \le 0.5\mathrm{W})$ $-(45.1 + 10\log P)\mathrm{dB/10kHz}\quad (0.5\mathrm{W} < P \le 5.0\mathrm{W})$ $-71.0\ \mathrm{dB/10kHz}\quad (P > 5.0\mathrm{W})$	upper limit

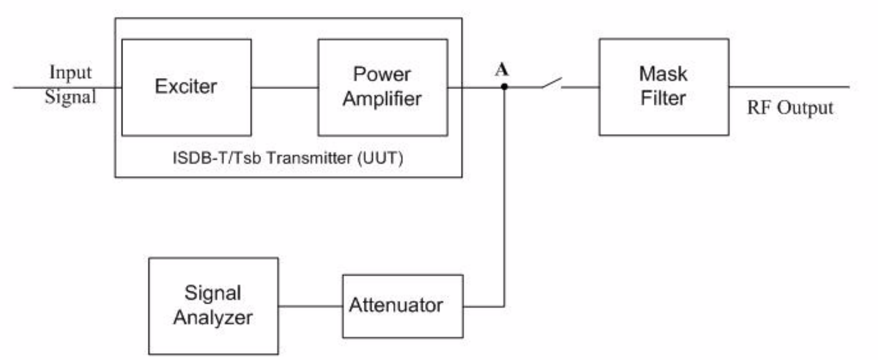
Amplitude Correction in Spectrum Emission Mask Measurement

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

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

- If the ISDB-T/Tsb transmitter has a mask filter, the diagram for Spectrum Emission Mask measurement is shown in Figure 4-6.

Figure 4-6 Diagram for Spectrum Emission Mask Measurement on ISDB-T/Tsb Transmitter



The steps for measuring the Spectrum Emission 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.

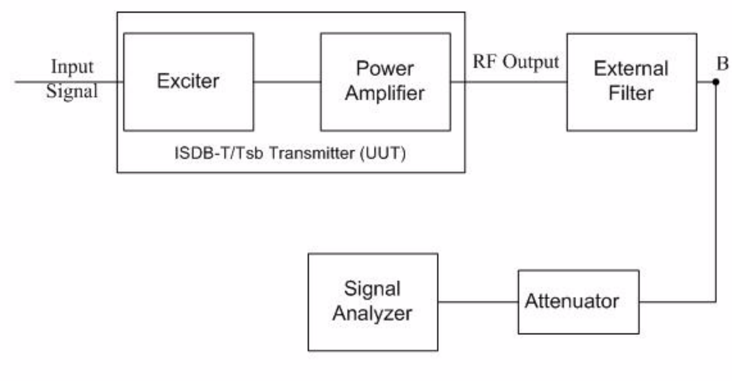
b. Measure the signal transmitted at point A as shown in Figure 4-6.

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 filter’s frequency response values, in dB, at a number of frequency points across the band.

- If the transmitter doesn’t have the mask filter, an external filter with a band-block filter frequency response should be added after the transmitter for measurement arrangement as shown in Figure 4-7.

Figure 4-7 Diagram for Spectrum Emission Mask Measurement on ISDB-T/Tsb Transmitter without Output Filter



The steps for measuring the Spectrum Emission Mask is as follows:

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

b. Measure the signal transmitted at point B as shown in Figure 4-7.

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 including the negative value of the filter's frequency response in dB at a number of frequency points across the band.

Modulation Accuracy Measurement Concepts

Purpose

Measurement of modulation accuracy and quality is necessary to meet ISDB-T/Tsb defined tests and to ensure proper operation of the transmitters. This measurement takes into account all possible error mechanisms in the entire transmission chain including baseband filtering, I/Q modulation anomalies, filter amplitude and phase non-linearities, and power amplifier distortion. This measurement provides an overall indication of the performance level of the transmitter of the UUT.

Measurement Method

Modulation Accuracy measurement measures the performance of the transmitter's modulation circuitry.

In a digitally modulated signal, it is possible to predict what the ideal magnitude and phase of the carrier should be at any time, based on the received data sequence. The transmitter's modulated signal is compared to an ideal signal vector. The difference between these two vectors is sampled and processed using DSP.

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

- EVM - peak and rms error vector magnitude
- MER - power ratio of the sum of squares of the ideal symbol vectors' magnitude to the sum of squares of the symbol error vectors' magnitude
- Magnitude Error - difference in amplitude between I/Q measured signal and I/Q reference signal
- Phase Error - difference in phase between the I/Q measured signal and I/Q reference signal
- Freq Error - the frequency difference between the transmitter's actual center frequency and the analyzer's center frequency
- Quad Error - the orthogonal error between I and Q signals
- Amplitude Imbalance - a form of IQ gain imbalance
- TMCC Decoding Results

MER Measurement Method

The system diagram of the transmitter defined in JEITA handbook is shown in Figure 4-8. The measurement points of MER can be B,C,D, and E.

In the analyzer, the signal is first converted to low IF frequency. After that, AD smpling is performed. And then the sampled data is processed as follows to calculate MER. [1]

a. Detect the OFDM symbol.

b. Detect the carrier frequency offset.

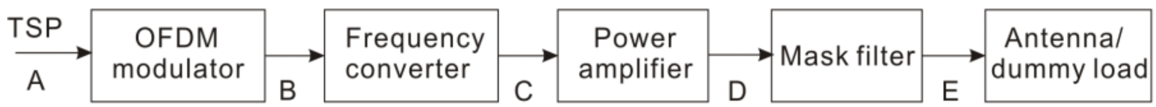
c. Correct the frequency according to the carrier frequency offset.

d. Extract the waveform for each OFDM symbol and perform a FFT.

e. Perform equalization regarding the transmission path using SP (Scattered Pilot) information.

f. Calculate the MER with the formula described in "MER" on page 84.

Figure 4-8 System Diagram of Transmitter



Definition of the Measurement Parameter

The detailed description of the parameters above is as follows:

EVM

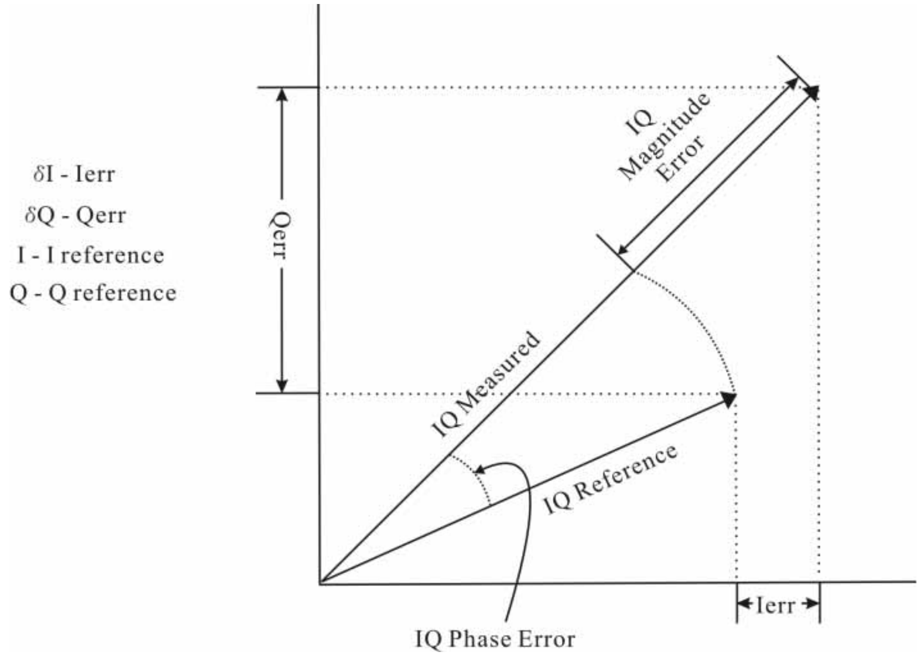
EVM (Error Vector Magnitude) is a modulation quality metric widely used in digital broadcast systems. It is defined as:

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

Where N is the number of data points in the measurement samples. 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 4-9.

Figure 4-9 **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.

The MER is calculated as below:

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

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

The representations of other definitions are expressed in Figure 4-9.

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 4-9.

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 4-9.

Frequency Error

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

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

Quad Error

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

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

Amplitude Imbalance

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

$$AI = 20\log_{10}\frac{v_I}{v_Q}\ dB$$

Where v_I and v_Q represent I and Q gain respectively.

Peak Criteria

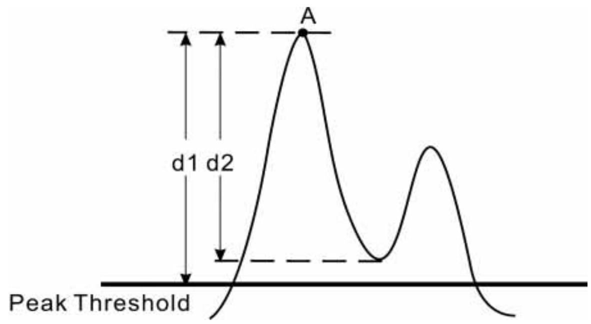
How can a signal be identified as a peak? This section describes the criteria for peak, which involves mainly two parameters: Peak Excursion and Peak Threshold.

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 Peak Excursion value to be considered as a peak. As shown in Figure 4-10, 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 4-10 Peak Criteria



Occupied Bandwidth Measurement Concepts

Purpose

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

The spectrum shape of an ISDB-T/Tsb signal can give useful qualitative insight into transmitter operation. Any distortion to the spectrum shape can indicate problems in transmitter performance.

Measurement Method

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

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 IQ 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
- ISDB-T
- CMMB

What are Baseband I/Q Inputs?

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

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

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

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

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

Balanced baseband measurements are made using the I and connectors for I only signal measurements, while the Q and connectors are used for a Q only signal measurement. Balanced measurements of I/Q require differential probe connections to all four input connectors. For details of probe selection and use, refer to "Selecting Input Probes for Baseband Measurements" on page 91.

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, ISDB-T, CMMB, 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 Agilent 1153A active differential probe using the InfiniMax probe interface.

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

With passive 1 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 Agilent passive probes can be automatically identified by the system, setting the input impedance required as well as the nominal attenuation. For single-ended measurements a single probe is used for each channel. Other passive probes can be used, after manually setting the attenuation and probe impedance configurations.

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

Supported Probes

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

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

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

Probes without Stored Calibration

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

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

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

Baseband I/Q Measurement Views

Measurement result views made in the IQ Analyzer (Basic) mode are available for baseband signals if they relate to the nature of the signal itself. Many measurements which relate to the characteristics that baseband I and Q signals have when mixed and upconverted to signals in the RF spectrum can be made as well. However, measurements which relate to the characteristics of an upconverted signal that lie beyond the bandwidth available to the Baseband I/Q Input circuits can not be measured (the 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 Agilent Technologies sales and service office. The following application notes treat digital communications measurements in much greater detail than discussed in this measurement guide.

- Application Note

  Spectrum Analysis Basics

  Agilent part number 5952-0292E

- Application Note

  Digital Modulation in Communications Systems - An Introduction
  Agilent part number 5965-7160E

- Application Note

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

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

Instrument Updates at www.agilent.com

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

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

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

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

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

References

[1] JEITA handbook: Methods of Measurement for Digital Terrestrial Broadcasting Transmitters

[2] ARIB STD-B31 Transmission System for Digital Terrestrial Television Broadcasting

[3] ARIB STD-B29 Transmission System for Digital Terrestrial Sound Broadcasting

[4] ABNT NBR 15601 Brazilian Standard: Digital terrestrial television - Transmission System