W-CDMA Measurement Guide

Agilent Technologies E4406A VSA Series Transmitter Tester

Agilent Technologies

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1 Understanding W-CDMA

What Is the W-CDMA Communication System?

Wideband code division multiple access (W-CDMA) is one of the popular air interface technologies for the third generation RF cellular communications systems. In this system, the cells operate asynchronously, hence it makes the mobile synchronization more complex, but offers the advantage of flexibility in placement of the base stations. Both reverse and forward transmitter power controls are implemented with 0.625 ms intervals. W-CDMA is a direct sequence spread-spectrum digital communications technique that supports wider RF bandwidths, typically from 5 to 20 MHz. The main advantages of W-CDMA over other types of communication schemes are:

- greater capacity
- immunity to signal loss and degradation in the presence of high-level broadband interference
- immunity to signal loss and degradation due to multipath, scattering, and fading
- power consumption of mobile stations is strictly minimized by both base station and mobile controls
- supports variable data rates up to 144 kbits/second for mobile (vehicular) data rate, up to 384 kbits/second for portable (pedestrian) data rate, and up to 2 Mbits/second for fixed installations
- provides increased security

W-CDMA uses correlative codes to distinguish one user from another. Frequency division is still used, as is done with Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA), but in a much larger bandwidth such as 5 MHz or greater. An initial baseband data rate is spread to a transmitted bit rate of 4.096 Mcps, which is also called chip rate or spread data rate. W-CDMA realizes increased capacity from 1:1 frequency reuse and sectored cells. The capacity limit is soft. That is, capacity can be increased with some degradation of the error rate or voice quality.

In W-CDMA, a single user's channel consists of a specific frequency combined with a unique code. Correlative codes allow each user to operate in the presence of substantial interference. The interference is the sum of all other users on the same W-CDMA frequency, both from within and outside of the home cell, and from delayed versions of these signals. It also includes the usual thermal noise and atmospheric disturbances. Delayed signals caused by multipath are separately received and combined in W-CDMA. One of the major differences in access is that any W-CDMA frequency can be used in all sectors of all cells. This is possible because W-CDMA is designed to decode the proper signal in the presence of high interference.

What Does the Agilent Technologies E4406A VSA Series Transmitter Tester Do?

This instrument can help determine if a W-CDMA transmitter is working correctly. When configured for W-CDMA, the instrument can be used for the testing of a W-CDMA transmitter, according to documents such as ARIB 1.0-1.2, Trial 1998 (the trial W-CDMA system originated in Japan), and 3GPP (3rd Generation Partnership Project). These documents define complex, multi-part measurements used to maintain an interference-free environment. For example, the documents include measuring the power of a carrier.

The E4406A Transmitter Tester automatically makes these measurements using the measurement methods and limits defined in the documents. The detailed results displayed by the measurements allow you to analyze W-CDMA system performance. You may alter the measurement parameters for specialized analysis.

For infrastructure test, the instrument will test base station transmitters in a non-interfering manner by means of a coupler or power splitter.

This instrument makes the following measurements:

- Channel Power
- Adjacent Channel Power Ratio (ACPR)
- Power Statistics CCDF
- Code Domain
- QPSK EVM
- Modulation Accuracy (Rho)
- Spectrum (Frequency Domain)
- Waveform (Time Domain)

Other Sources of Measurement Information

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

- Application Note 1298

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

- Application Note 1311

  Understanding CDMA Measurements for Base Stations and Their Components
  part number 5968-0953E

Instrument Updates at www.agilent.com/find/vsa/

This web location can be used to access the latest information about the transmitter tester.

2 Setting Up the W-CDMA Mode

W-CDMA Mode

You may want to install a new personality, reinstall a personality that you have previously uninstalled, or uninstall a personality. Instructions for installing and uninstalling personality options are under "Installing Optional Measurement Personalities" on page 35.

At initial power up, the transmitter tester will come up in the Basic mode, with the Spectrum (frequency domain) measurement selected and the **Measure** menu displayed.

To access the W-CDMA measurement personality, press the **Mode** key and select the **W-CDMA** key.

If you want to set the W-CDMA mode to a known, factory default state, press **Preset**. This will preset the mode setup and all of the measurements to the factory default parameters.

NOTE Pressing the **Preset** key does not switch instrument modes.

How to Make a Measurement

Follow the three-step procedure shown in the table below:

Step	Primary Key	Setup Key	Related Key
1. Select & setup a mode.	**Mode**	**Mode Setup**, **Input**, **Frequency Channel**	**System**
2. Select & setup a measurement.	**Measure**	**Meas Setup**	**Meas Control**, **Restart**
3. Select & setup a view.	**View/Trace**	**Span X Scale**, **Amplitude Y Scale**, **Display**, **Next Window**, **Zoom**	**File**, **Save**, **Print**, **Print Setup**, **Marker**, **Search**

Step 1. Select & setup a mode as follows, for example:

- Press the **Mode** key and select **W-CDMA**.
- Press the **Frequency Channel** key and enter the channel frequency to be measured.
- Press the **Mode Setup** key and change the **Radio**, **Input**, and **Trigger** conditions from those default settings.

Refer to "Changing the Mode Setup" on page 12 and "Changing the Frequency Channel" on page 17 for further explanation.

Refer to "Mode Setup / Frequency Channel Key Flow" on page 19 for the key flow diagrams.

Step 2. Select & setup a measurement as follows, for example:

- Press the **Measure** key to select either **Channel Power**, **ACPR**, **Power Stat CCDF**, **Code Domain**, **Spectrum (Freq Domain)**, **Waveform (Time Domain)**, **QPSK EVM**, or **Mod Accuracy (Perch Only)** to make its measurement.
- Press the **Meas Setup** key to change any of the measurement parameters from the default settings. These parameters such as Span, Resolution Bandwidth, Trigger Source, Average, Limit Test and Limits, are decided according to the measurement selected.

Refer to "Channel Power Measurement Key Flow" on page 20 and to "Waveform (Time Domain) Measurement Key Flow (1 of 2)" on page 33 for the key flow diagrams.

Step 3. Select & setup a view as follows, for example:

- Press the **View/Trace** key to select the desired view for the current measurement.
- Press the **Next Window** key to select a window, then press the **Zoom** key to expand the window to the full display area.
- Press the **Span X Scale**, **Amplitude Y Scale**, **Display**, and/or **Marker** keys for your desired display. These keys are not always available for each view.

Refer to "Channel Power Measurement Key Flow" on page 20 and to "Waveform (Time Domain) Measurement Key Flow (1 of 2)" on page 33 for the key flow diagrams.

Entering a Numeric Value

Three methods are available to enter a numeric value for an active softkey, however, its resolution can be different depending on the method selected and the range, if any. The highest resolutions are described throughout this guide.

- **Numeric keys** - Allows you to enter a value with the highest resolution by pressing the numeric keys. The entry is terminated by pressing the **Enter** key or one of the unit softkeys shown.
- RPG knob - Allows you to continuously change the value shown on the softkey with the medium or highest resolution defined to the parameter by rotating this knob.
- **Step (Up/Down arrow) keys** - Allows you to change the value shown on the softkey with the fixed-step resolution defined to the parameter activated. While the ⇑ (up arrow) key is pressed down, for example, the value increases in multiple steps defined to the parameter.

Changing the Mode Setup

Numerous settings can be changed at the mode level by pressing the **Mode Setup** key. This will access the menu with the selections listed below. The factory default settings are shown in tables. These settings affect only the measurements in the W-CDMA mode.

Configuring the Radio Setting

The **Radio** key accesses the menu as follows:

- **Device** - Allows you to toggle the test device between **BTS** (Base Transmission Station) and **MS** (Mobile Station).
- **MS-BTS Offset** - Allows you to specify the frequency space between MS and BTS. The range is –500.000 MHz to 500.000 MHz with 1 kHz resolution.
- **Standard** - Allows you to access the menu to select one of the standards as follows:

  ARIB 1.0-1.2 - Allows you to make measurements compliant to the ARIB 1.0-1.2 document submitted to 3GPP.

  3GPP - Allows you to make measurements compliant to the evolving third generation partnership project document.

  Trial 1998 - Allows you to make measurements compliant to the W-CDMA trial system that originated in Japan.

Radio Default Settings	
Device	BTS
MS-BTS Offset	190.000 MHz
Standard	Trial 1998

Configuring the Input Setting

The **Input** key accesses the menu as follows: (You can also access this menu from the **Input** front-panel key.)

- **RF Input Range** - Allows you to toggle the RF input range control between **Auto** and **Man** (manual). If **Auto** is chosen, the instrument automatically sets the attenuator based on the carrier power level, where it is tuned. Once you change the **Max Total Pwr** or **Input Atten** value with the RPG knob, for example, the **RF Input Range** key is automatically set to **Man**. If there are multiple carriers present, the total power might overdrive the front end. In this case you need to set the **RF Input Range** to **Man** and enter the expected maximum total power by activating the **Max Total Pwr** key. **Man** is also useful to hold the input attenuation constant for the best relative power accuracy. For single carriers it is generally recommended to set this to **Auto**.

- **Max Total Pwr** - Allows you to set the maximum total power level from the UUT (Unit Under Test). The range is –200.00 to 100.00 dBm with 0.01 dB resolution. This is the expected maximum value of the mean carrier power referenced to the output of the UUT; it may include multiple carriers. The **Max Total Pwr** setting is coupled together with the **Input Atten** and **Ext Atten** settings. Once you change the **Max Total Pwr** value with the RPG knob, for example, the **RF Input Range** key is automatically set to **Man**.
- **Input Atten** - Allows you to control the internal input attenuator setting. The range is 0 to 40 dB with 1 dB resolution. The **Input Atten** key reads out the actual hardware value that is used for the current measurement. If more than one input attenuator value is used in a single measurement, the value used at the carrier frequency will be displayed. The **Input Atten** setting is coupled to the **Max Total Pwr** setting. Once you change the **Input Atten** setting with the RPG knob, for example, the **RF Input Range** key is automatically set to **Man**.
- **Ext Atten** - Allows you to access the following menu to enter the external attenuation values. Either of the **Ext Atten** settings is coupled together with the **RF Input Range** setting, however, pressing **Ext Atten** does not switch the **RF Input Range** key to **Man**. This will allow the instrument to display the measurement results referenced to the output of the UUT.

  MS - Allows you to set an external attenuation value for MS tests. The range is –50.00 to +50.00 dB with 0.01 dB resolution.

  BTS - Allows you to set an external attenuation value for BTS tests. The range is –50.00 to +50.00 dB with 0.01 dB resolution.

Input Default Settings	
RF Input Range	Auto[a]
Max Total Pwr	–15.00 dBm[b]
Input Atten	0.00 dB[b]
Ext Atten:	
MS	0.00 dB
BTS	0.00 dB

a. Auto is not used for Spectrum measurements.
b. This may differ if the maximum input power is more than –15.00 dBm, or depending on the previous measurements.

NOTE The **Max Total Pwr** and the **Input Atten** settings are coupled together. When you switch to a different measurement, the **Max Total Pwr** setting is kept constant, but the **Input Atten** setting may change if the two measurements have different mixer margins. Thus, you can directly set the transmitter tester input attenuator, or you can set it indirectly by specifying the expected maximum power at the UUT (Max Total Pwr setting).

Configuring the Trigger Condition

The **Trigger** key allows you: (1) to access the trigger selection menu to specify each triggering condition, (2) to modify the default trigger holdoff time using the **Trig Holdoff** key, (3) to modify the auto trigger time and to activate or deactivate the auto trigger feature using the **Auto Trig** key, and (4) to modify the period of the frame timer using the **Frame Timer** key.

NOTE The actual trigger source is selected separately for each measurement under the **Meas Setup** key.

- **RF Burst**, **Video (IF Envlp)**, **Ext Front** and **Ext Rear** - Pressing one of these trigger keys will access each triggering condition setup menu. This menu is used to specify the **Delay**, **Level** and **Slope** settings for each trigger source as follows:

  Delay - Allows you to enter a numerical value to modify the trigger delay time. The range is –100.0 to +500.0 ms with 1 µs resolution. For trigger delay use a positive value, and for pre-trigger use a negative value.

  Level - Allows you to enter a numerical value to adjust the trigger level depending on the trigger source selected.

  For **RF Burst** selection, the key label reads as **Peak Level**. The RF level range is –25.00 to 0.00 dB with 0.01 dB resolution, relative to the peak RF signal level. The realistic range can be down to –20 dB.

  For **Video (IF Envlp)** selection, the video level range is –200.00 to +50.00 dBm with 0.01 dB resolution at the RF input. The realistic range can be down to around –50 dBm depending on the noise floor level of the input signal.

  For **Ext Front** or **Ext Rear** selection, the level range is –5.00 to +5.00 V with 1 or 10 mV resolution.

  Slope - Allows you to toggle the trigger slope between **Pos** at the positive-going edge and **Neg** at the negative-going edge of the burst signal.

There are other keys under the **Trigger** key as follows:

- **Trig Holdoff** - Allows you to set the period of time before the next trigger can occur. The range is 0.000 μs to 500.0 ms with 1 μs resolution.
- **Auto Trig** - Allows you to specify a time for a trigger timeout and toggle the auto trigger function between **On** and **Off**. The range is 1.000 ms to 1.000 ks with 1 μs resolution. If no trigger occurs by the specified time, a trigger is automatically generated.
- **Frame Timer** - Allows you to access the menu to manually control the frame timer:

  Period - Allows you to set the period of the frame clock. The range is 0.000 ns to 559.0000 ms with 1 ps resolution.

  Offset - Allows you to set the offset of the frame clock. The range is 0.000 to 10.00 s with 100 ns resolution over 1.000 μs range.

  Reset Offset Display - Allows you to display without any offset of the frame clock.

  Sync Source - Allows you to access the menu to select one of the sources to be synchronized with.

    Off - Allows you to turn the synchronizing source off for asynchronous tests.

    RF Burst (Wideband) - Allows you to select the RF burst signal as the synchronizing source.

    Ext Front - Allows you to select the external input signal from the front-panel input port as the synchronizing source.

    Ext Rear - Allows you to select the external input signal from the rear panel input port as the synchronizing source.

Trigger Default Settings	
RF Burst:	
Delay	0.000 µs
Peak Level	–6.00 dB
Slope	Pos
Video (IF Envlp):	
Delay	0.000 µs
Level	–6.00 dBm
Slope	Pos
Ext Front:	
Delay	0.000 µs
Level	2.00 V
Slope	Pos
Ext Rear:	
Delay	0.000 µs
Level	2.00 V
Slope	Pos
Trig Holdoff	0.000 ms
Auto Trig	100.0 ms, On
Frame Timer:	
Period	10.00000 ms
Offset	0.000 ms
Sync Source	Off

Changing the Frequency Channel

After selecting the desired mode setup, you will need to select the desired center frequency and the center frequency step. The selections made here will apply to all measurements in the mode. Press the **Frequency Channel** key to access the following menu:

- **Center Freq -** Allows you to enter a frequency that corresponds to the desired RF channel to be measured. This is the current instrument center frequency. The range is 1.000 kHz to 4.32140 GHz with 1 Hz resolution.
- **CF Step** - Allows you to enter a center frequency step to shift the measurement segment, and to toggle the step function between **Auto** and **Man**. If set to **Auto**, the **CF Step** value automatically changes according to the selection of the standard. The range is 1.000 kHz to 1.00000 GHz with 1 Hz resolution.

Frequency Channel Default Settings	
Frequency Channel: Center Freq CF Step	 1.00000 GHz 5.00000 MHz, Auto

W-CDMA Measurement Key Flow

The key flow diagrams, shown in a hierarchical manner on the following pages, will help grasp the overall functional relationships for the front-panel keys and the softkeys displayed at the extreme right side of the screen. The diagrams are:

"Mode Setup / Frequency Channel Key Flow" on page 19,

"Channel Power Measurement Key Flow" on page 20,

"ACPR Measurement Key Flow" on page 21,

"Power Stat CCDF Measurement Key Flow" on page 22

"Code Domain Measurement Key Flow (1 of 3)" on page 23

"QPSK EVM Measurement Key Flow (1 of 2)" on page 26

"Modulation Accuracy Measurement Key Flow (1 of 2)" on page 28

"Spectrum (Freq Domain) Measurement Key Flow (1 of 3)" on page 30

"Waveform (Time Domain) Measurement Key Flow (1 of 2)" on page 33

Use these flow diagrams as follows:

- There are some basic conventions:

View/Trace	An oval represents one of the front-panel keys.
QPSK EVM	This box represents one of the softkeys displayed.
<for EVM>	This represents an explanatory description on its specific key.
Avg Number 10 On|Off	This box shows how the softkey default condition is displayed. Default parameters or values are underlined wherever possible.

- Start from the extreme upper left corner of each measurement diagram to the right direction, and go from the top to the bottom.
- When defining a key from auto with underline to manual, for example, just press that key one time.
- When entering a numeric value of **Frequency**, for example, use the numeric keypad by terminating with the appropriate unit selection from the softkeys displayed.
- When entering a numeric value of **Avg Number**, for example, use the numeric keypad by terminating with the **Enter** front-panel key.
- Instead of using the numeric keypad to enter a value, it may be easier to use the RPG knob or **Up/Down** keys depending on the input field of a parameter.

Figure 2-1 Mode Setup / Frequency Channel Key Flow

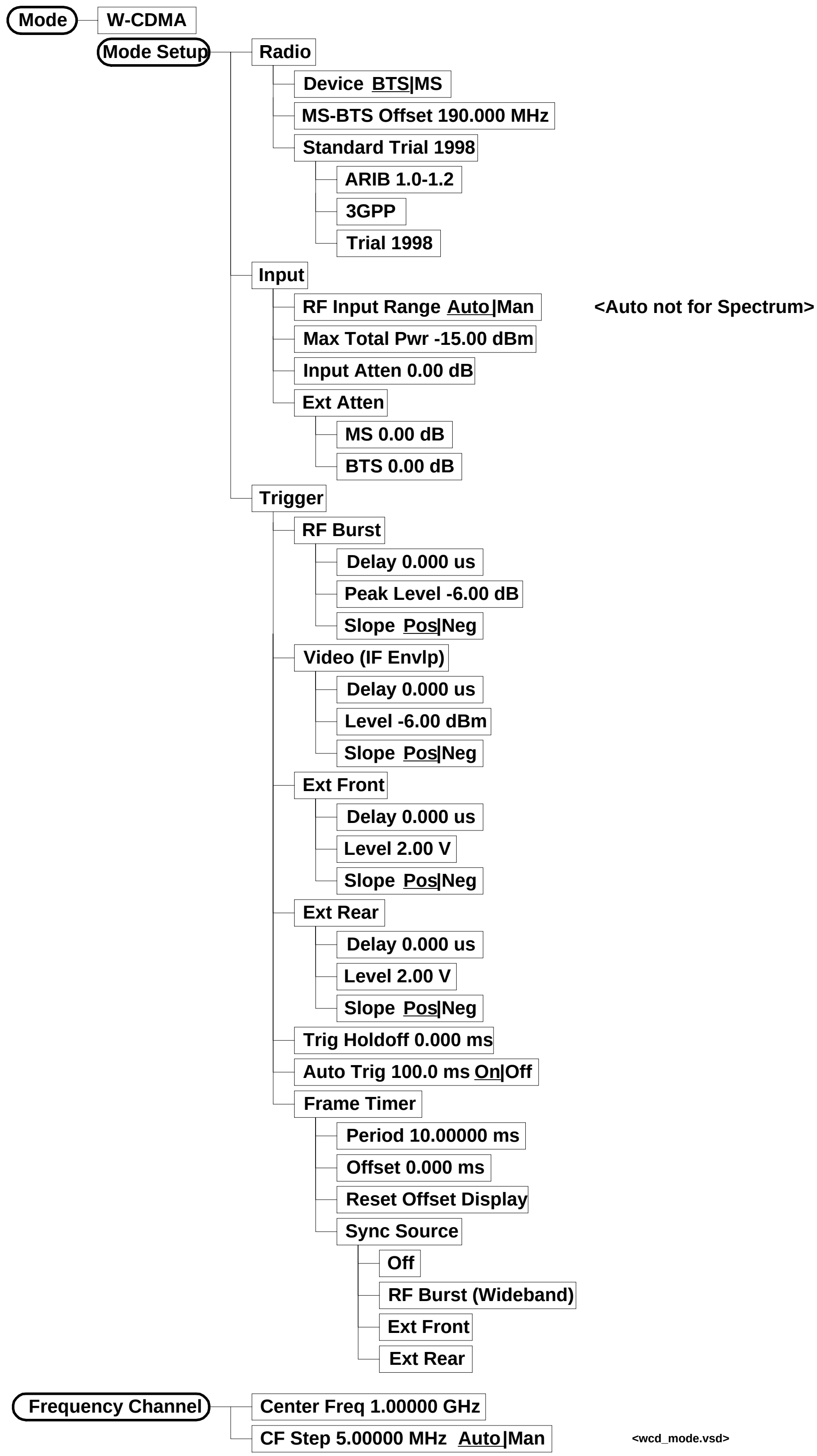


Figure 2-2 Channel Power Measurement Key Flow

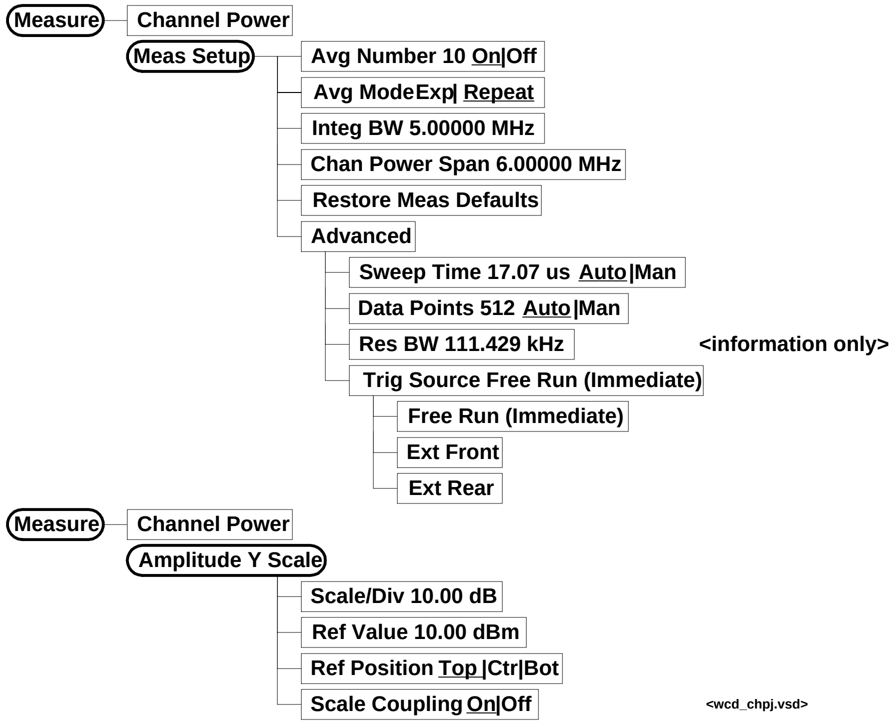


Figure 2-3 ACPR Measurement Key Flow

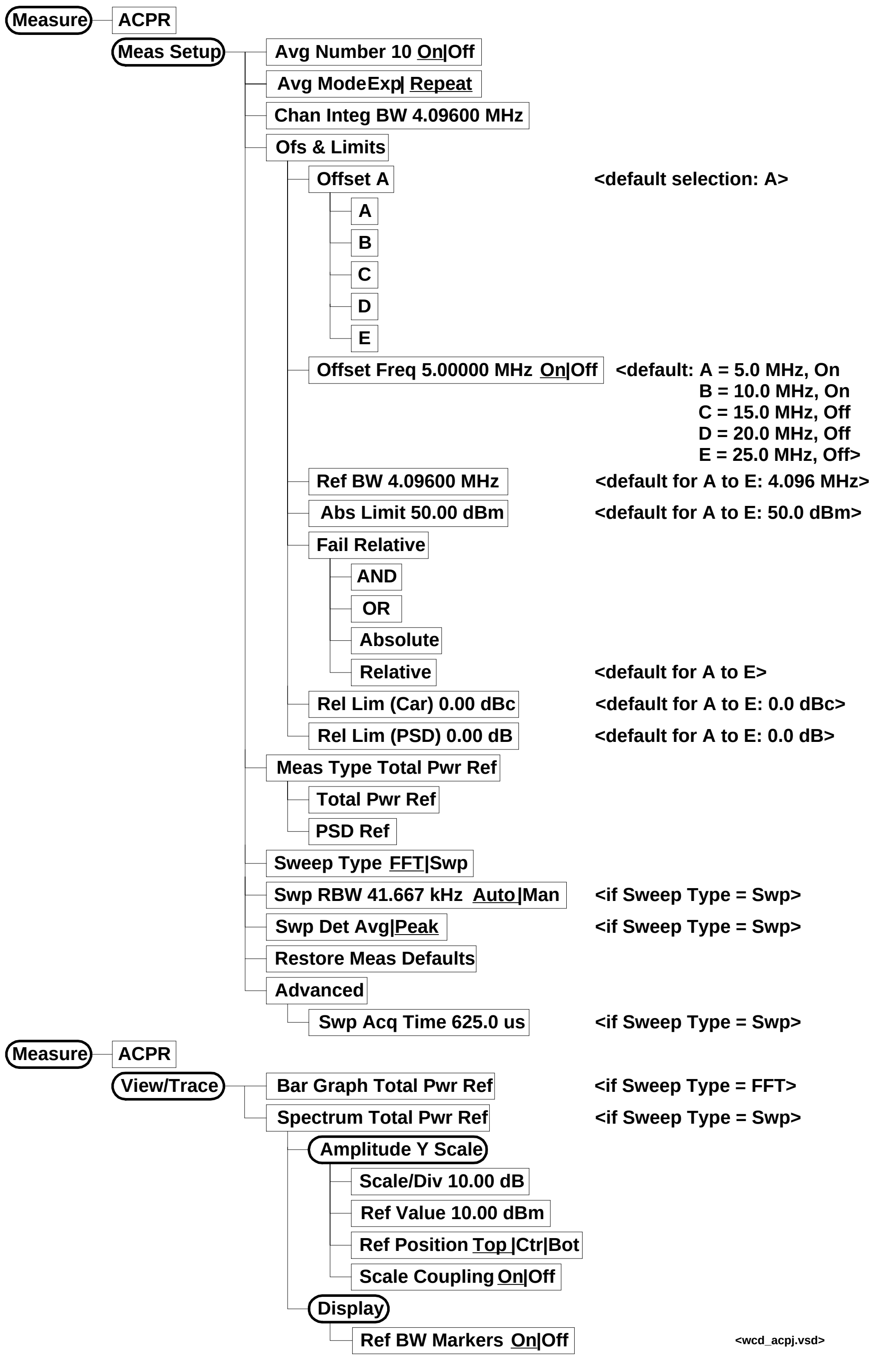


Figure 2-4 Power Stat CCDF Measurement Key Flow

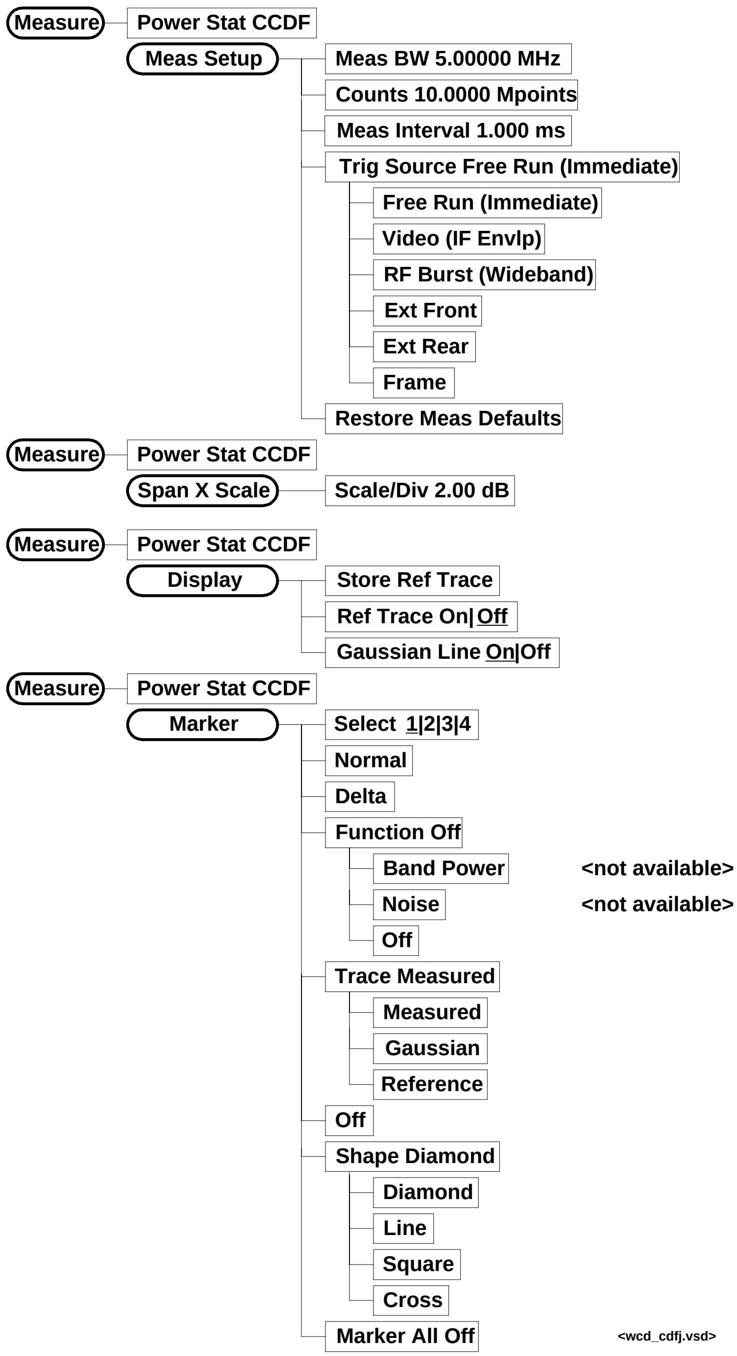


Figure 2-5 Code Domain Measurement Key Flow (1 of 3)

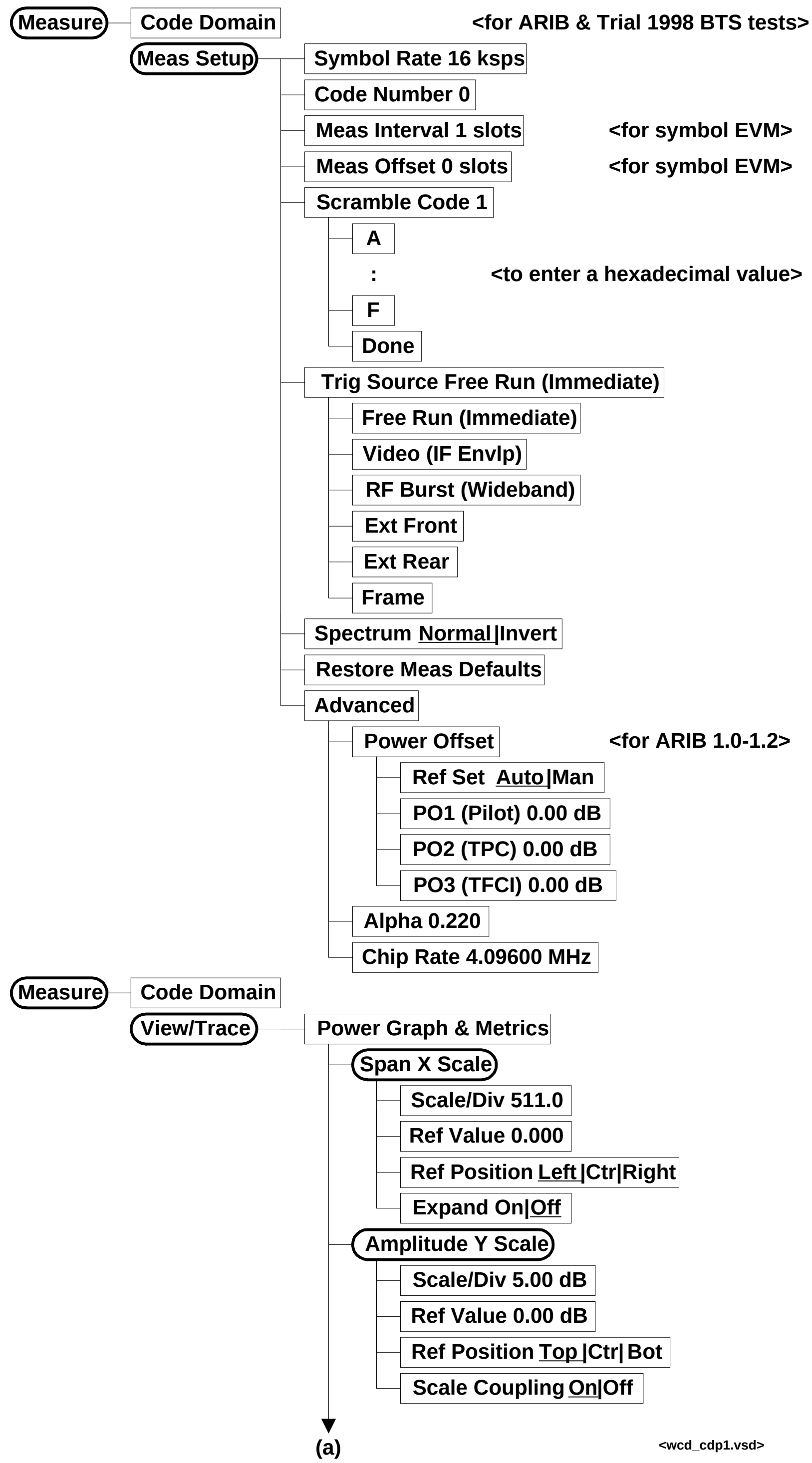


Figure 2-6 Code Domain Measurement Key Flow (2 of 3)

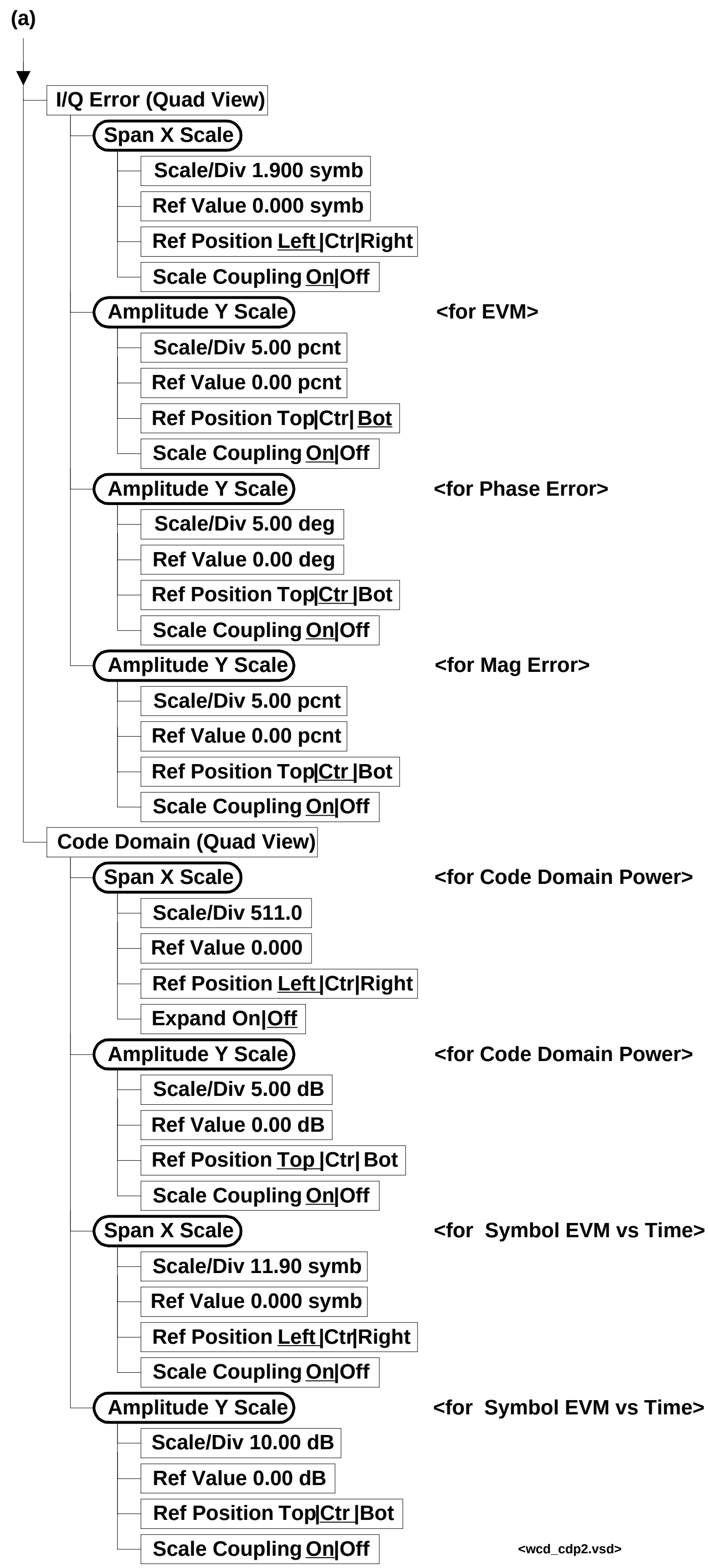


Figure 2-7 Code Domain Measurement Key Flow (3 of 3)

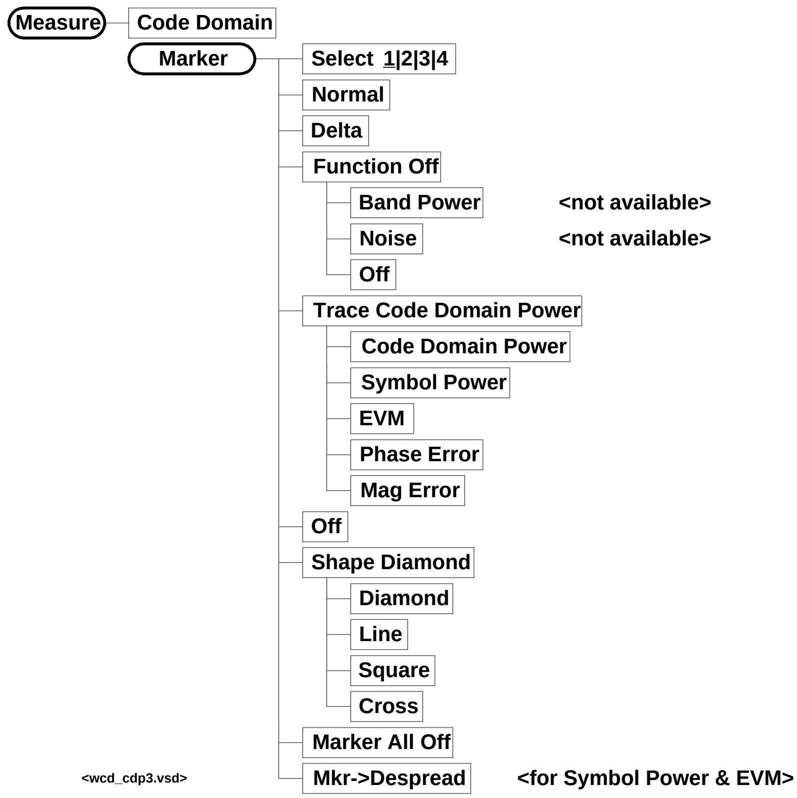


Figure 2-8 QPSK EVM Measurement Key Flow (1 of 2)

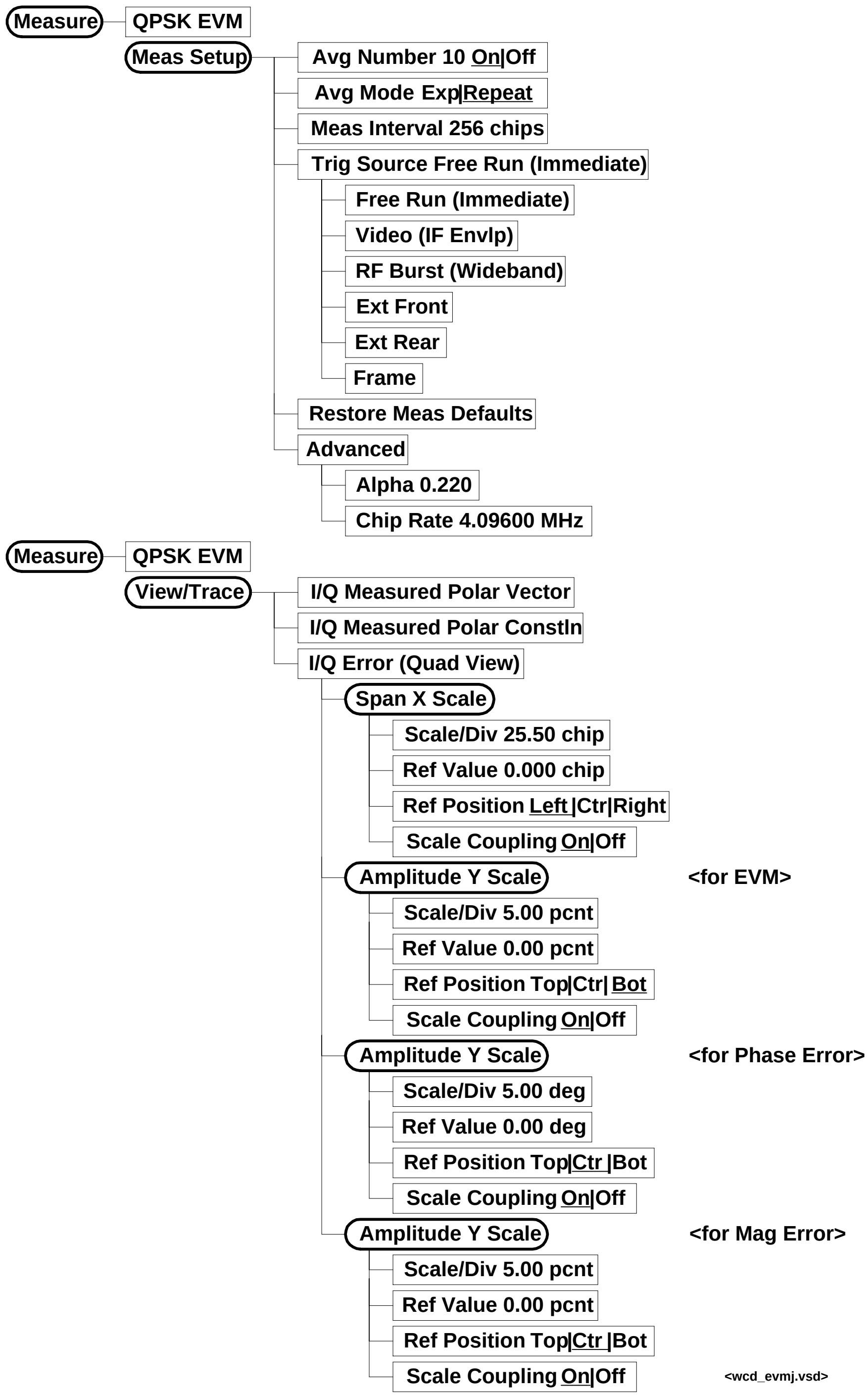


Figure 2-9 QPSK EVM Measurement Key Flow (2 of 2)

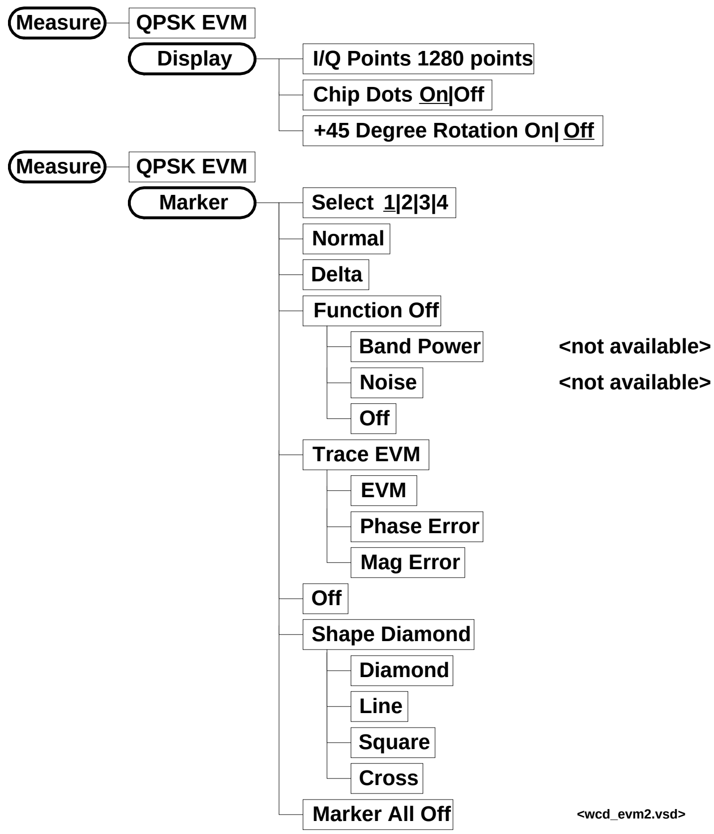


Figure 2-10 Modulation Accuracy Measurement Key Flow (1 of 2)

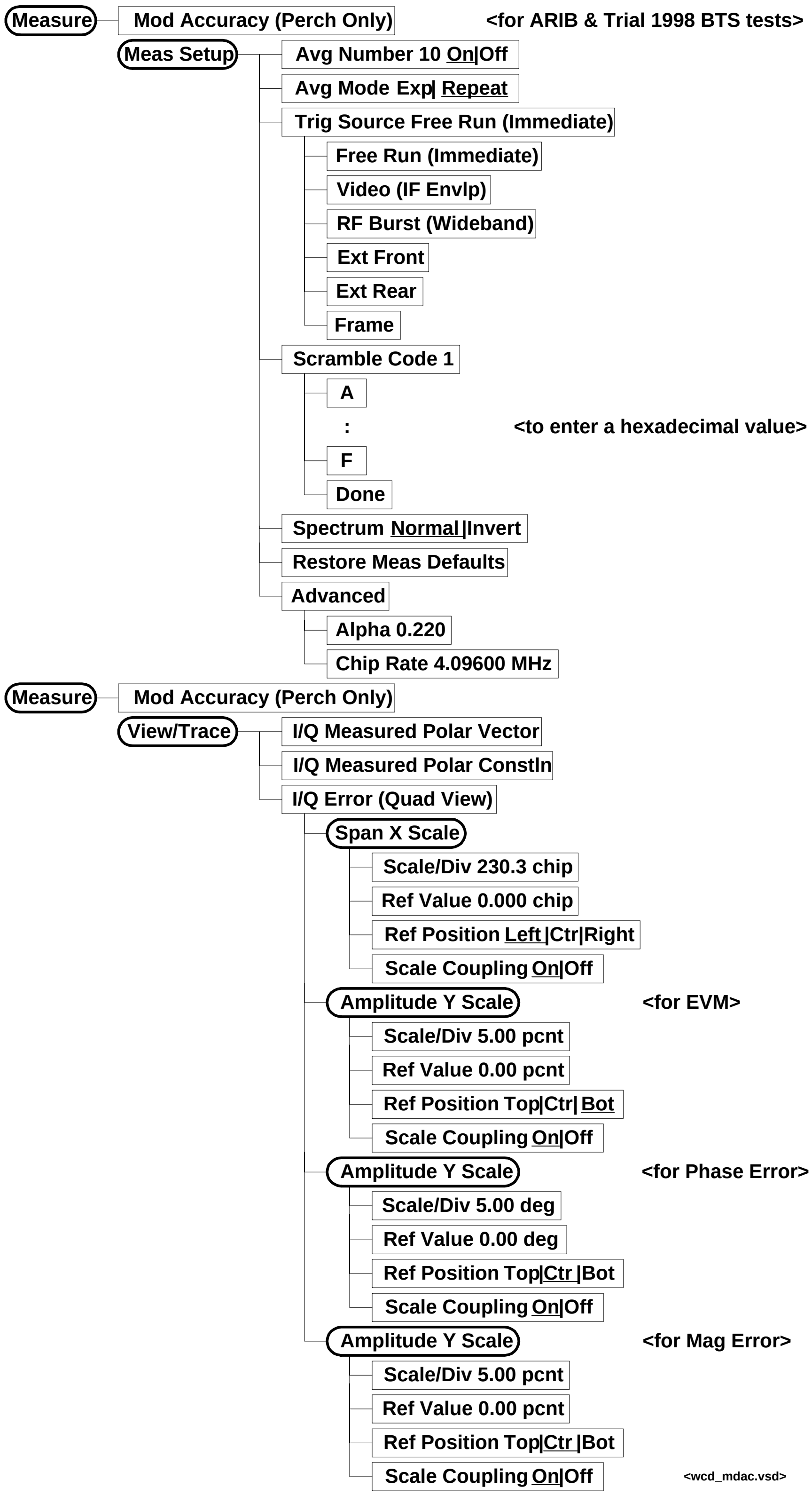


Figure 2-11 Modulation Accuracy Measurement Key Flow (2 of 2)

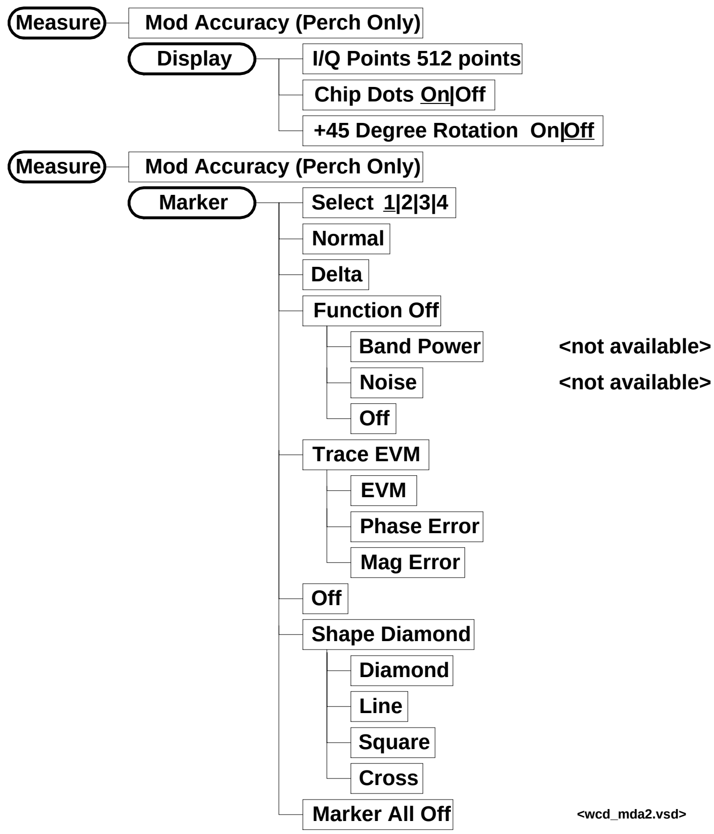


Figure 2-12 Spectrum (Freq Domain) Measurement Key Flow (1 of 3)

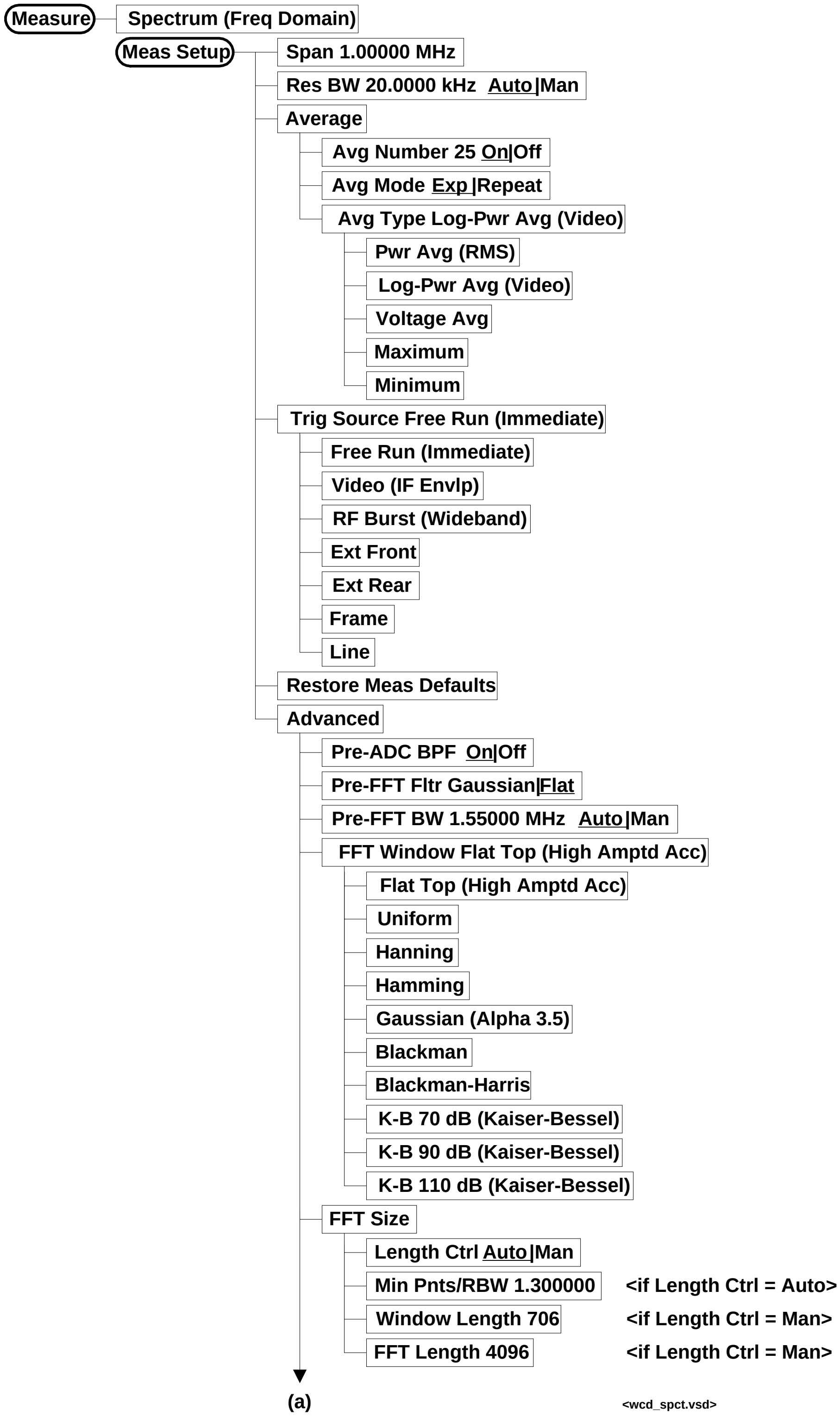


Figure 2-13 Spectrum (Freq Domain) Measurement Key Flow (2 of 3)

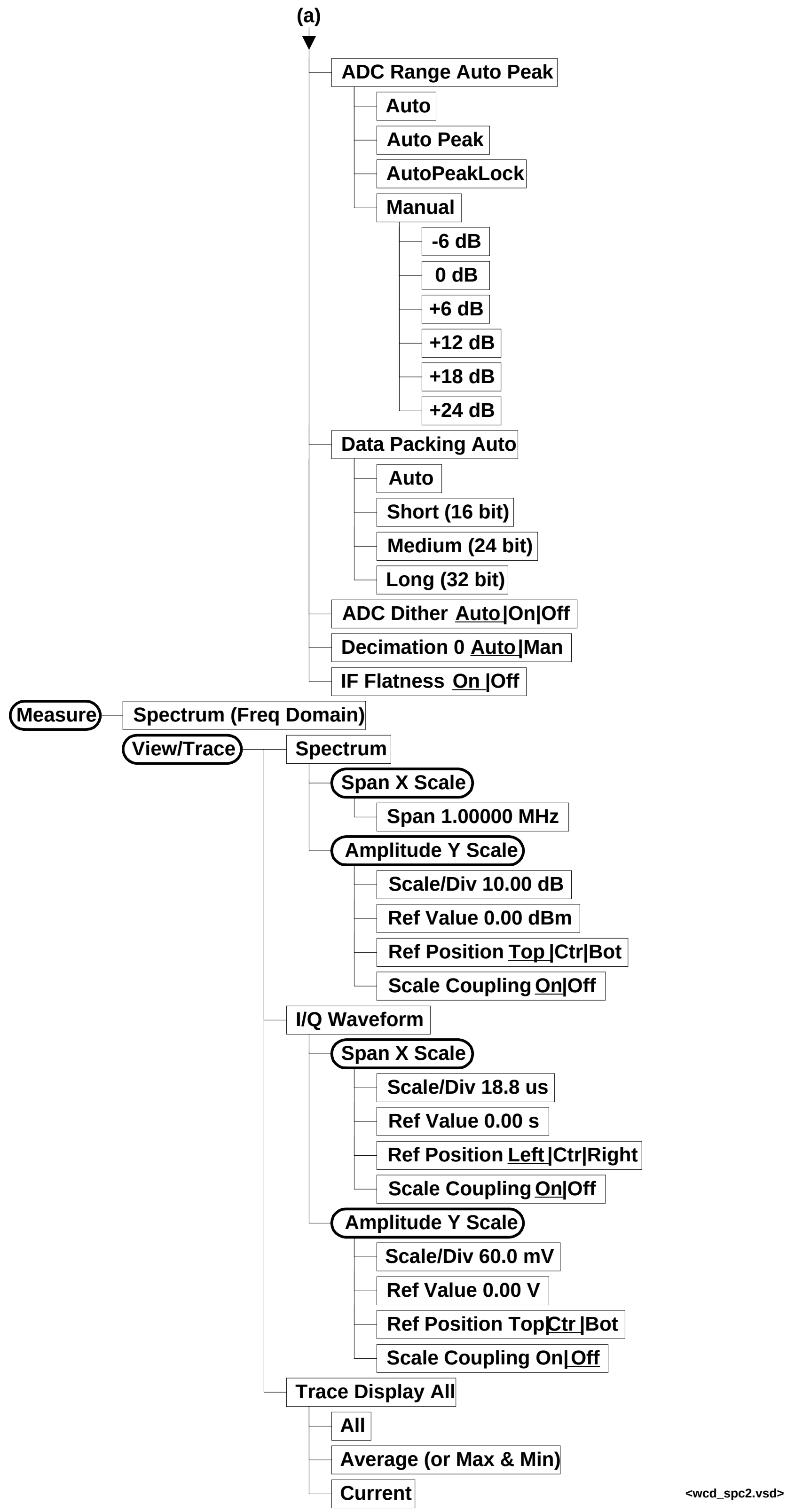


Figure 2-14 Spectrum (Freq Domain) Measurement Key Flow (3 of 3)

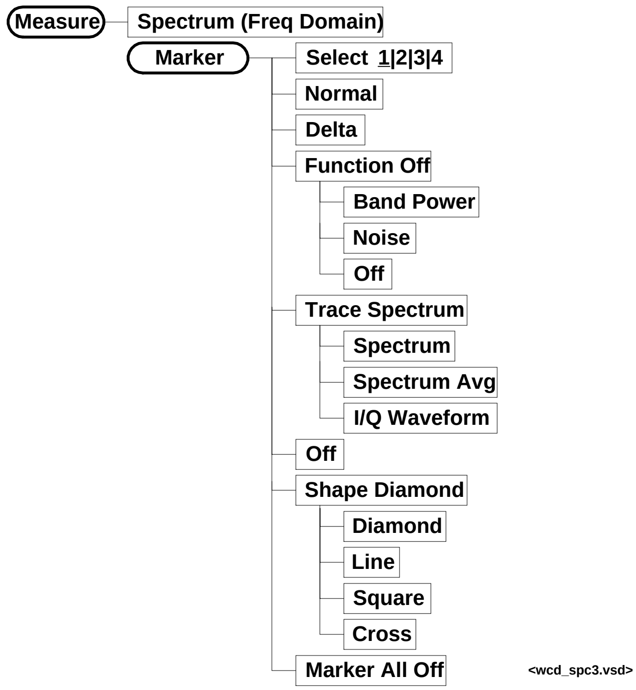


Figure 2-15 Waveform (Time Domain) Measurement Key Flow (1 of 2)

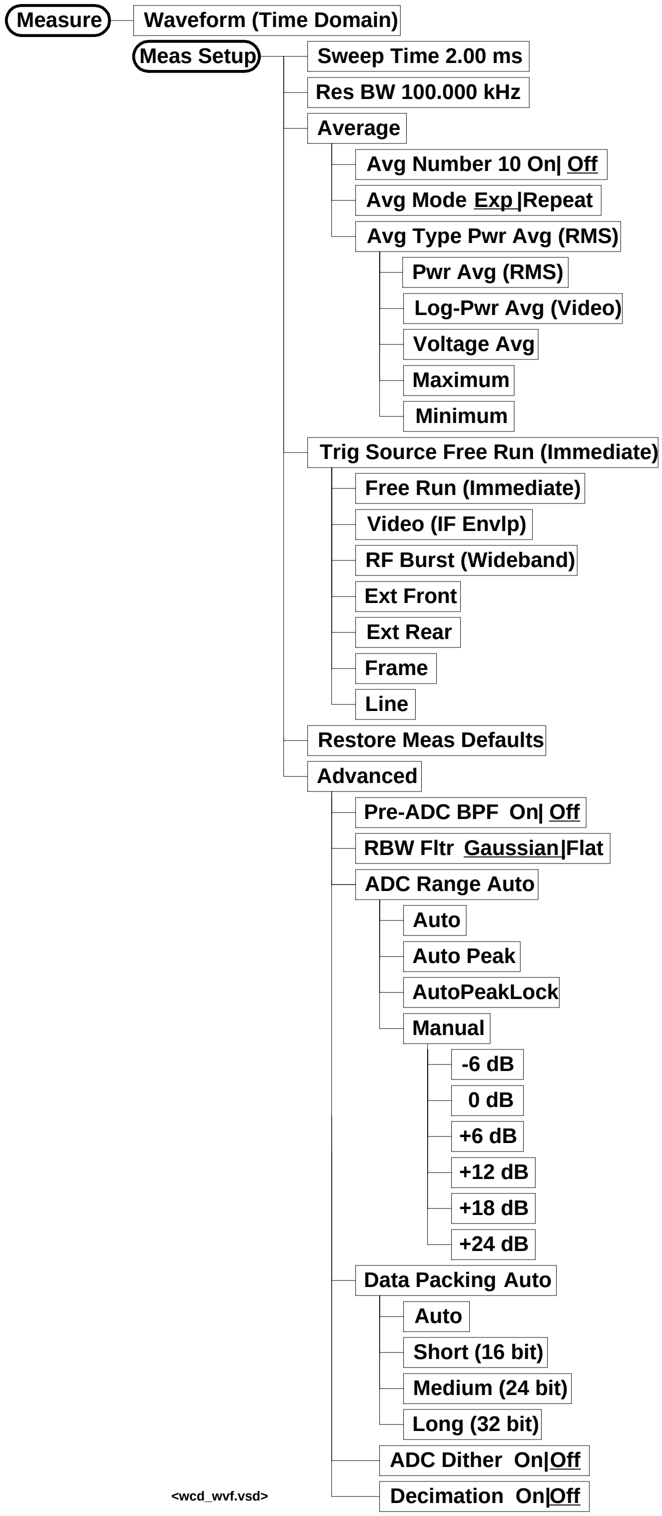
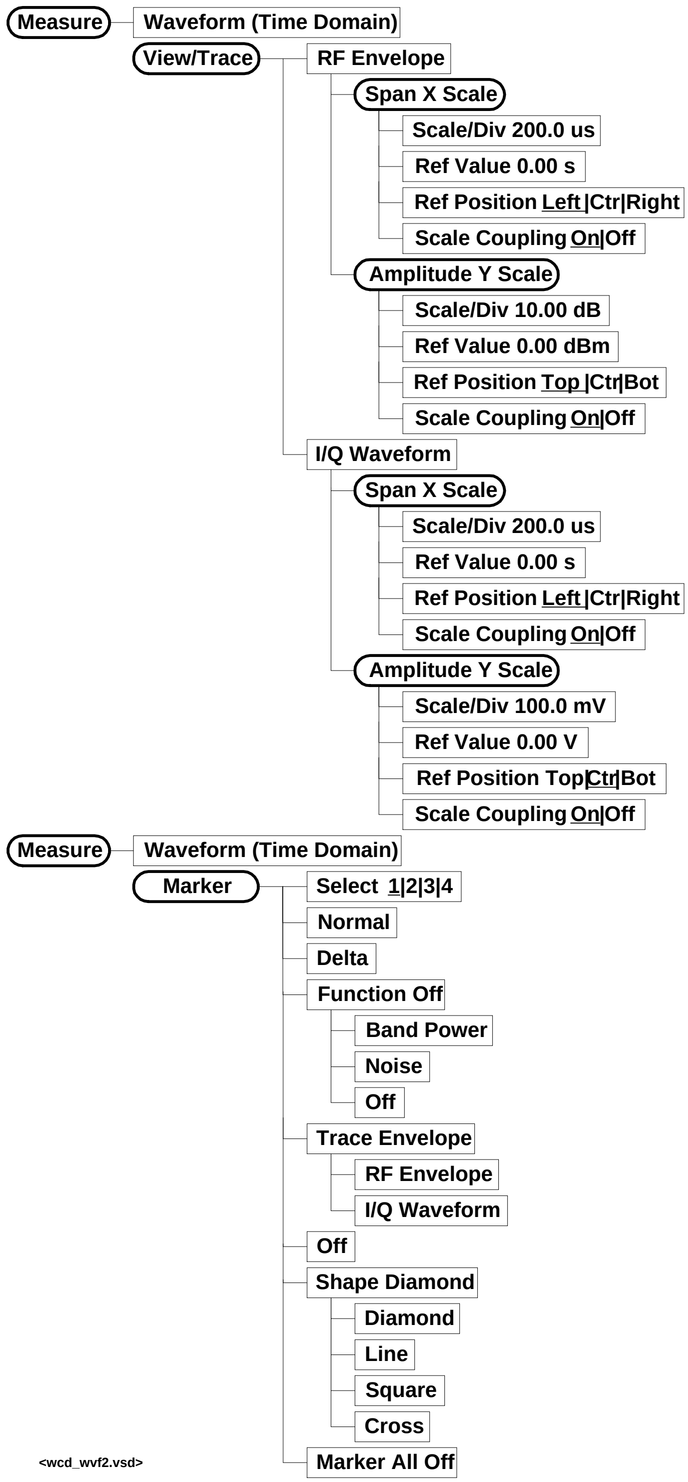


Figure 2-16 Waveform (Time Domain) Measurement Key Flow (2 of 2)



Installing Optional Measurement Personalities

Installing a measurement personality is a two step process.

1. The measurement personality firmware must be installed into the instrument.
2. A license key number must be entered which enables the measurement personality to run. (Refer to the “License Key Numbers” section.)

Adding additional measurement personalities requires purchasing a retrofit kit for the desired option. The retrofit kit includes the measurement personality firmware, usually supplied on a zip disk. The license key certificate, included in the kit, contains the license key number. Every retrofit kit will have installation instructions.

The installation instructions require you to know three pieces of information about your instrument; the amount of memory installed, the Host ID, and the instrument serial number.

To find:	Key Path:
Instrument Memory: ________________	**System**, **File System** (the amount of memory in your instrument will be the sum of the Used memory and the Free memory)
Host ID: ________________	**System**, **Show System**, **Host ID**
Instrument Serial Number: ________________	**System**, **Show System**, **Serial Number**

Exit Main Firmware key. This key is only for use when you want to update firmware using a LAN connection. The **Exit Main Firmware** key halts the operation of the resident firmware code so you can install an updated version of firmware using a LAN connection. Instructions for loading future firmware updates are available at the following URL: **www.agilent.com/find/vsa/**

Available Options

The option designation consists of three characters, as shown in the **Option** column of the table below.

Available Personality Options[a]	Option
GSM measurement personality	**BAH**
cdmaOne measurement personality	**BAC**
NADC, PDC measurement personalities	**BAE**
iDEN measurement personality	**HN1**
W-CDMA measurement personality	**BAF**
cdma2000 measurement personality	**B78**

a. As of the print date of this measurement guide.

License Key Numbers

The measurement personality you have purchased with your instrument has been installed and enabled at the factory. With the purchase of the measurement personality, and with any future purchase of a new personality, you will receive a unique license key number. The license key number is a hexadecimal number that is for your specific measurement personality and instrument serial number. The license key enables you to install, or reactivate any personality you have purchased.

Follow these steps to locate the unique license key number for the measurement personality that has come installed in your instrument:

1. Press **System**, **More (1 of 3)**, **More (2 of 3)**, **Install**, **Choose Option.** When you press the **Choose Option** key the alpha editor will be activated. Use the alpha editor to enter the letters (upper-case) and the front-panel numeric keyboard to enter the numbers (if required) for the personality option that has been installed in the instrument.
2. Press the **Done** key on the alpha editor menu. The unique license key number for your instrument will now appear on the **License Key** softkey.

You will want to keep a copy of your license key number in a secure location. Please enter your license key numbers in the box provided below for future reference. If you should lose your license key number, call your nearest Agilent Technologies service or sales office for assistance.

License Key Numbers for Instrument with Serial # _______
For Option_____________ the license key number is ___________________
For Option_____________ the license key number is ___________________
For Option_____________ the license key number is ___________________
For Option_____________ the license key number is ___________________
For Option_____________ the license key number is ___________________
For Option_____________ the license key number is ___________________

If you purchase an option later, you will receive a certificate which displays the unique license key number that you will need to install that option.

NOTE You will need to use a license key number only if you purchase an additional measurement personality, or if you want to reactivate a measurement personality that has been deactivated.

Installing a License Key Number

NOTE Follow this procedure to reinstall a license key number which has been deleted during the uninstall process, or lost due to a memory failure.

To install a license key number for the selected option, use the following procedure:

1. Press **System**, **More(1 of 3)**, **More(2 of 3)**, **Install**, **Choose Option**. Pressing the **Choose Option** key will activate the alpha editor menu. Use the alpha editor to enter the letters (upper-case) and the front-panel numeric keyboard to enter the numbers (if required) for the option designation, then press the **Done** key. As you enter the option, you will see your entry in the active function area of the display.

2. Press **License Key**. Entering the license key number will require entry of both letters and numbers. Use the alpha editor to enter letters. Use the front-panel numeric keyboard to enter numbers. You will see your entry in the active function area of the display. When you have completed entering the license key number, press the **Done** key.

3. Press the **Install Now** key after you have entered the active license key number and the personality option. When pressed, a message may appear in the function area of the display which reads, "`Insert disk and power cycle the instrument`". Press the **No** key only if you wish to cancel the installation process. If you want to proceed with the installation, press the **Yes** key and cycle the instrument power off and then on.

NOTE Not all personality installations require an installation disk. If the personality upgrade kit does not include a disk, disregard the `Insert disk` portion of the message that may appear in the active function area when the **Install Now** key is pressed.

Using the Uninstall Key

The following procedure removes the license key number for the selected option. This will make the option unavailable for use, and the message "`Application Not Licensed`" will appear in the Status/Info bar at the bottom of the display. Please write down the 12-digit license key number for the option before proceeding. If that measurement personality is to be used at a later date you will need the license key number to reactivate the personality firmware.

NOTE Using the **Uninstall** key does not remove the personality from the instrument memory, and does not free memory to be available to install another option. If you need to free memory to install another option, refer to the instructions for loading firmware updates located at the URL: **www.agilent.com/find/vsa/**

1. Press **System**, **More(1 of 3)**, **More(2 of 3)**, **Uninstall**, **Choose Option**. Pressing the **Choose Option** key will activate the alpha editor menu. Use the alpha editor to enter the letters (upper-case) and the front-panel numeric keyboard to enter the numbers (if required) for the option, then press the **Done** key. As you enter the option, you will see your entry in the active function area of the display.

2. Press the **Uninstall Now** key after you have entered the personality option. Press the **No** key only if you wish to cancel the uninstall process. Press the **Yes** key if you want to continue the uninstall process.

3. Cycle the instrument power off and then on to complete the uninstall process.

3 Making W-CDMA Measurements

W-CDMA Measurements

Once in the W-CDMA mode, the following measurements are available by pressing the **Measure** key:

- Channel Power on page 46
- ACPR (Adjacent Channel Power Ratio) on page 52
- Power Statistics CCDF (Complementary Cumulative Distribution Function) on page 60
- Code Domain Analysis on page 65
- QPSK EVM on page 79
- Modulation Accuracy (Rho) on page 87
- Spectrum (Frequency Domain) on page 95
- Waveform (Time Domain) on page 103

These are referred to as one-button measurements. When you press the key to select one measurement it will become the active measurement, using settings and a display unique to that measurement. Data acquisitions will automatically begin when trigger requirements, if any, are met.

Preparing for Measurements

If you want to set the W-CDMA mode to a known, factory default state, press **Preset**. This will preset the mode setup and all of the measurements to the factory default parameters. You should often be able to make a measurement using these defaults.

NOTE Pressing the **Preset** key does not switch instrument modes.

To preset only the parameter settings that are specific to the selected measurement, press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults**. This will reset the measurement setup parameters, for the currently selected measurement only, to the factory defaults.

Initial Setup

Before making a measurement, make sure the mode setup and frequency channel parameters are set to the desired settings. Refer to the sections "Changing the Mode Setup" on page 12 and "Changing the Frequency Channel" on page 17.

Measurement Selection

The **Measure** front-panel key accesses the menu to select one of the following measurements:

- **Channel Power** - Press this key to make channel power measurements. This is the in-channel power measurement. The channel power graph is displayed in the graph window and both the absolute channel power and mean power spectral density are shown in the text window.
- **ACPR** - Press this key to make adjacent channel power ratio (ACPR) measurements. This is the out-of-channel measurement. The following displays are available:

    Bar graph display to show a histogram of powers within the integration bandwidth

    Spectrum display to show a power distribution curve, like a swept-frequency spectrum analyzer, relative to the center frequency power of the carrier signal
- **Power Stat CCDF** - Press this key to make power statistics, Complementary Cumulative Distribution Function (CCDF) measurements. This is helpful to observe the time domain characteristics of a spread spectrum signal that can significantly affect the ACPR measurement results for a given UUT.

- **Code Domain** - Press this key to make code domain power (CDP) measurements when **Standard** is set to either **Trial 1998** or **ARIB 1.0-1.2**, and also when **Device** is set to **BTS**. The amount of power in each code channel is displayed. The following displays are available:

  Power graph and metrics to show the code domain power and the summary data

  Quad view for the I/Q errors in graphs for the spread rate selected, and the summary data

  Quad view for the code domain power, the selected symbol power vs. symbol rate, and the selected symbol EVM polar vector graphs, and the summary data

- **QPSK EVM** - Press this key to make QPSK error vector magnitude (EVM) measurements. The following displays are available:

  Polar vector graph of the I/Q demodulated signal and the summary data

  Polar constellation graph of the I/Q demodulated signal and the summary data

  Quad view for the I/Q errors in graphs and the summary data

- **Mod Accuracy (Perch Only)** - Press this key to make modulation accuracy (rho) measurements when **Standard** is set to either **Trial 1998** or **ARIB 1.0-1.2**, and also when **Device** is set to **BTS**. The input signal should contain only the Perch channel. This is essentially a code domain power measurement with one active channel. The following displays are available:

  Polar vector graph of the I/Q demodulated signal and the summary data

  Polar constellation graph of the I/Q demodulated signal and the summary data

  Quad view for the I/Q errors in graphs and the summary data

- **Spectrum (Freq Domain)** - Press this key to make frequency domain spectrum measurements. Spectrum and I/Q waveform displays are available.

- **Waveform (Time Domain)** - Press this key to make time domain waveform measurements. RF envelope and I/Q waveform displays are available.

Measurement Control

The **Meas Control** front-panel key accesses the menu to control processes that affect the running of the current measurement.

- **Restart -** Press this key to repeat the current measurement from the beginning, while retaining the current measurement settings. This is equivalent to the **Restart** front-panel key.
- **Measure -** Press this key (not to be confused with the **Measure** front-panel key which has a different function) to toggle the measurement state between **Single** and **Cont** (continuous). When set to **Single**, the measurement will continue until it has reached the specified number of averages set by the average counter. When set to **Cont**, the measurement will run continuously and execute averaging according to the current average mode, either repeat or exponential. The default setting is **Cont** excepting the code domain measurement which is defaulted to **Single**.
- **Pause** - Press this key to pause the current measurement until you reactivate the measurement. Once toggled, the label of the **Pause** key changes to read **Resume**. The **Resume** key, once pressed, continues the active measurement from the point at which it was paused.

Measurement Setup

The **Meas Setup** key accesses the features that enable you to adjust parameters of the current measurement, such as span and resolution bandwidth, according to the measurement function. You will also use the **Meas Setup** menu to access the **Average**, **Limit Test**, **Advanced** and other feature menus.

The following measure setup features can be used with many or all measurements:

- **Restore Meas Defaults** - Allows you to preset only the settings that are specific to the selected measurement by pressing **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults**. This will set the measure setup parameters, for the currently selected measurement only, to the factory defaults.

Averaging

Selecting one of the averaging keys in the **Meas Setup** menu will allow you to modify the average number and averaging mode you use for the currently selected measurement. For spectrum (frequency domain) and waveform (time domain) measurements the **Average** key activates the following menu:

- **Avg Number** - Allows you to change the number of N averages to be made.

- **Avg Mode** - Allows you to toggle the averaging mode between **Exp** (exponential) and **Repeat**. This selection only effects on the averaging result after the number of N averages is reached. The N is set using the **Avg Number** key.

  Normal averaging: Normal (linear) averaging is always used until the specified number of N averages is reached. When the **Measure** key under **Meas Control** is set to **Single**, data acquisition is stopped when the number of N averages is reached, thus **Avg Mode** has no effect in the single measurement mode.

  Exponential averaging: When **Measure** is set to **Cont**, data acquisition will continue indefinitely. Exponential averaging is used with a weighting factor of N (the displayed count of averages stops at N). Exponential averaging weights new data more heavily than old data, which allows tracking of slow-changing signals. The weighting factor N is set using the **Avg Number** key.

  Repeat averaging: When **Measure** is set to **Cont**, data acquisition will continue indefinitely. After the number of N averages is reached, all previous result data is cleared and the average count displayed is set back to 1. This is equivalent to being in **Measure Single** and pressing the **Restart** key each time the single measurement finishes.

- **Avg Type** - Allows you to access the menu of the following average types only for making spectrum (frequency domain) and waveform (time domain) measurements:

  Pwr Avg (RMS) - Executes the true power averaging which is equivalent to taking the rms of the voltage. This is the most accurate type.

  Log-Pwr Avg (Video) - Simulates the traditional spectrum analyzer type of averaging by calculating the log of the power.

  Voltage Avg - Executes the voltage averaging.

  Maximum - Executes the maximum voltage averaging by capturing peak data.

  Minimum - Executes the minimum voltage averaging.

Selecting a Trigger Source

Changing the selection in the **Trig Source** menu alters the trigger source for the selected measurement only. Not all of the selections are always available for all measurements. Also, some W-CDMA measurements do not require a trigger. Choose one of the following trigger sources:

NOTE The **RF Burst**, **Video (IF Envlp)**, **Ext Front** and **Ext Rear** keys found under the **Trigger** menu enable you to change the default settings of the delay, level and slope for each of these trigger sources.

- **Free Run (Immediate)** - A trigger occurs at the time the data is requested, completely asynchronous with the RF or IF signal.
- **Video (IF Envlp)** - An internal IF envelope trigger that occurs at the absolute threshold level of the IF signal level.
- **RF Burst (Wideband)** - An internal wideband RF burst trigger that has the automatic level control for burst signals. It triggers at the level that is set relative to the peak RF signal (12 MHz bandwidth) input level.
- **Ext Front** - Activates the front-panel external trigger input (**EXT TRIGGER INPUT**) port. The external signal must be between –5.00 and +5.00 V with 1 or 10 mV resolution.
- **Ext Rear** - Activates the rear-panel external trigger input (**TRIGGER IN**) port. The external signal must be between –5.00 and +5.00 V with 1 or 10 mV resolution.
- **Frame** - Uses the internal frame clock to generate a trigger signal. The clock parameters are controlled under the **Mode Setup** key or the measurement firmware, but not both. See the specific measurement for details.
- **Line** - Sets the trigger to the internal line mode. Sweep triggers occur at intervals synchronous to the line frequency. This trigger source is available for spectrum (frequency domain) and waveform (time domain) measurements.

Using the Trigger Outputs

The rear panel **TRIGGER 1 OUT** and **TRIGGER 2 OUT** connectors are coupled to the selected trigger source. These trigger outputs are always on at the rising edge with a pulse width of at least 1 μs.

Making the Channel Power Measurement

Purpose

Channel power measurement is a common test used in the wireless industry to measure the total transmitted power of a radio within a defined frequency channel. This procedure measures the total power within the defined channel for W-CDMA. This measurement can be used to design, characterize, evaluate, and verify transmitters and components or devices for base stations and mobile stations.

Measurement Method

The channel power measurement reports the total power within the channel bandwidth, 4.096 MHz for the ARIB 1.0-1.2 and Trial 1998 modes or 3.840 MHz for the 3GPP mode. The transmitter tester acquires a number of points representing the input signal in the time domain. It transforms this information into the frequency domain using FFT and then calculates the channel power. The effective resolution bandwidth of the frequency domain trace is proportional to the number of points acquired for FFT. The fastest FFT process is achieved using a number of acquired points that is a power of 2 (for example: 64, 128, 512).

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

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

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

Select the desired center frequency as described in "Changing the Frequency Channel" on page 17.

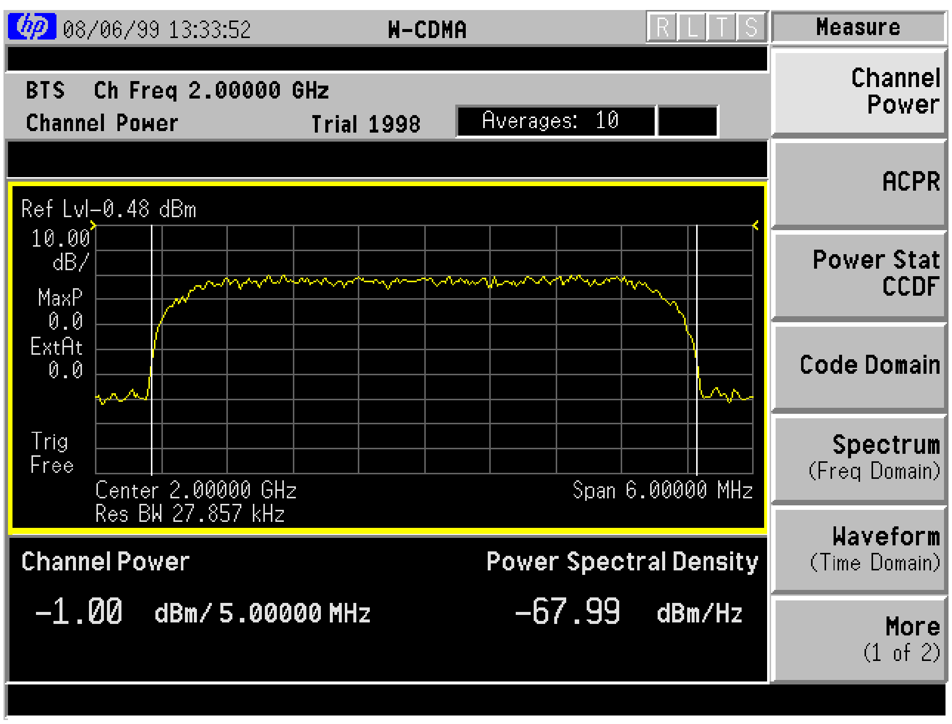
Press **Measure**, **Channel Power** to immediately make a channel power measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 48 for this measurement.

Results

The next figure shows an example result of `Channel Power` measurements. The channel power graph is shown in the graph window. The absolute channel power and its mean power spectral density are shown in the text window.

Figure 3-1 Channel Power Measurement



Changing the Measurement Setup

The next table shows the factory default settings for channel power measurements.

Table 3-1 Channel Power Measurement Defaults

Measurement Parameter	Factory Default Condition
Meas Setup:	
Avg Number	10, On
Avg Mode	Repeat
Integ BW[a]	5.00000 MHz
Chan Power Span[a]	6.00000 MHz
Advanced	
Sweep Time	17.07 μs, Auto[b]
Data Points	512, Auto[b]
Trig Source	Free Run (Immediate)

a. The Integ BW setting proportionally changes the Chan Pwr Span setting up to 10 MHz.
b. These are mutually interlinked to be set to either Man/Auto or Auto/Man.

NOTE Parameters under the **Advanced** key seldom need to be changed. Any changes from the factory default values may result in invalid measurement data.

Make sure the **Channel Power** measurement is selected under the **Measure** menu. The **Meas Setup** key accesses the menu which allows you to modify the average number and average mode for this measurement as described in “Measurement Setup” on page 43.

The following parameters can be changed according to your measurement requirement:

- **Integ BW** - Allows you to specify the integration bandwidth in which the power is measured. The range is 1.000 kHz to 10.0000 MHz with 1 or 10 Hz resolution. Since **Integ BW** is coupled to **Chan Pwr Span** in the factory default condition, if you change the integration bandwidth setting, the channel power span setting changes by a proportional amount until a limit value is reached.
- **Chan Power Span** - Allows you to set the frequency span for the channel power measurement. The range is 1.000 kHz to 10.0000 MHz with 1 or 10 Hz resolution. This span is used for the current integration bandwidth setting. Since **Chan Power Span** is coupled to **Integ BW** in the factory default condition, if you change the integration bandwidth setting, the channel power span setting changes by a proportional amount, 1.2 times the integration bandwidth, until a limit value is reached. However, the channel power span can be individually set.

In addition, the following parameters for channel power measurements can be modified by pressing the **Advanced** key:

- **Sweep Time** - Allows you to toggle the sweep time control between **Auto** and **Man** (manual), and also to manually change the sweep time if set to **Man**. The range is 1.000 μs to 50.00 ms with 1 or 10 μs resolution. If set to **Auto**, the sweep time derived from the data points setting is shown on this key label regardless of the manual entry range.
- **Data Points** - Allows you to toggle the data point control between **Auto** and **Man** (manual), and also to manually change the data points if set to **Man**. The range is 64 to 65536 with the acceptable entry in powers of 2 (for example: 64, 128, 512). If set to **Auto**, the data point derived from the sweep time setting is shown on this key label regardless of the manual entry range.
- **Res BW** - Shows information on the resolution bandwidth derived from the sweep time.
- **Trig Source** - Allows you to change the trigger source from free run (immediate) to the external input signal supplied to either **Ext Front** or **Ext Rear** port.

Changing the Display

The **Amplitude Y Scale** key accesses the menu to set the desired vertical scale and associated parameters.

- **Scale/Div -** Allows you to enter a numeric value to change the vertical display sensitivity. The range is 0.10 to 20.00 dB with 0.01 dB resolution. The default setting is 10.00 dB, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Value -** Allows you to enter a numeric value to change the absolute power value as the display reference. The range is –250.00 to 250.00 dBm with 0.01 dB resolution. The default setting is 10.00 dBm, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Position -** Allows you to set the display reference position to either **Top**, **Ctr** (center), or **Bot** (bottom). The default setting is **Top**.
- **Scale Coupling -** Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

Troubleshooting Hints

If an external attenuator is used, be sure to include its attenuation in the measurement of the channel power. Use the **Ext Atten** key.

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

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

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

Making the Adjacent Channel Power Ratio (ACPR) Measurement

Purpose

Adjacent Channel Power Ratio (ACPR), as it applies to W-CDMA, 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.

As a composite measurement of out-of-channel emissions, ACPR 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 ACPR measurement measures up to five pairs of offset channels and relates them to the carrier power. An integration bandwidth (IBW) method is used to measure the carrier channel power and offset powers.

The IBW method performs a time domain data acquisition and applies FFT to get a frequency domain trace. In this process, the channel integration bandwidth is analyzed using the automatically defined resolution bandwidth (RBW), which is much narrower than the channel bandwidth. The measurement computes an average power of the channel over a specified number of data acquisitions, automatically compensating for resolution bandwidth and noise bandwidth.

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

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

Select the desired center frequency as described in "Changing the Frequency Channel" on page 17.

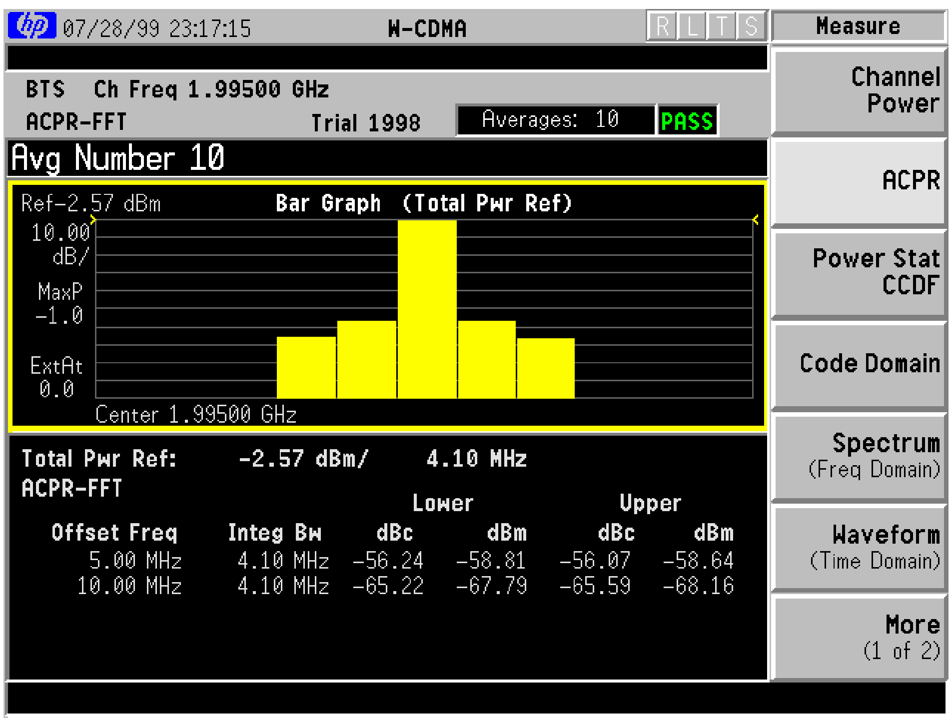
Press **Measure**, **ACPR** to immediately make an adjacent channel power ratio (ACPR) measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 54.

Results

The next figure shows an example result of `ACPR-FFT Bar Graph (Total Pwr Ref)` measurements in the graph window. The absolute and relative power levels on both sides of the carrier frequency are displayed in the text window.

Figure 3-2 ACPR Measurement - FFT Bar Graph View



Changing the Measurement Setup

The next table shows the factory default settings for adjacent channel power ratio measurements.

Table 3-2 Adjacent Channel Power Ratio Measurement Defaults

Measurement Parameter	Factory Default Condition
View/Trace	FFT Bar Graph (Total Pwr Ref)
Meas Setup:	
Avg Number	10, On
Avg Mode	Repeat
Chan Integ BW:	
for ARIB & Trial 1998	4.09600 MHz
for 3GPP	3.84000 MHz
Ofs & Limits:	
Offset	A
Offset Freq:	
A	5.00000 MHz, On
B	10.0000 MHz, On
C	15.0000 MHz, Off
D	20.0000 MHz, Off
E	25.0000 MHz, Off
Ref BW:	
A to E	
for ARIB & Trial 1998	4.09600 MHz
for 3GPP	3.84000 MHz
Abs Limit:	
A to E	50.00 dBm
Fail:	
A to E	Relative
Rel Lim (Car):	
A to E	0.00 dBc
Rel Lim (PSD):	
A to E	0.00 dB
Meas Type	Total Pwr Ref
Sweep Type	FFT
Advanced	
Swp Acq Time (if Sweep Type is Swp)	625.0 µs

Make sure the **ACPR** measurement is selected under the **Measure** menu. The **Meas Setup** key accesses the menu which allows you to modify the average number and average mode for this measurement as described in "Measurement Setup" on page 43. In addition, the following parameters for adjacent channel power ratio measurements can be modified.

- **Chan Integ BW** - Allows you to specify the channel integration bandwidth in which the carrier power is measured. The range is 300.000 kHz to 20.0000 MHz with 1 Hz resolution.
- **Ofs & Limits** - Allows you to access the menu to change the following parameters for offset frequency settings and pass/fail tests:

  Offset - Allows you to access the memory selection menu from **A** to **E** to store 5 sets of values for **Offset Freq**, **Ref BW**, **Abs Limit** and so forth. Only one selection at a time (A, B, C, D, or E) is shown on this key label.

  Offset Freq - Allows you to enter an offset frequency value, and to toggle the offset frequency function between **On** and **Off**, according to each offset key selected. The range is 0.0 Hz to 100.000 MHz. While this key is activated, enter an offset frequency value from the numeric keypad by terminating with one of the frequency unit keys shown. One offset frequency value selected from the **Offset** menu is shown on this key label.

  Ref BW - Allows you to enter a reference bandwidth ranging from 1.000 kHz to 20.0000 MHz with 1 Hz resolution. When this parameter is changed, the integration bandwidth `Integ BW` in the summary data window changes to that value.

  Abs Limit - Allows you to enter an absolute limit value ranging from –200.00 to +50.00 dBm with 0.01 dB resolution.

  Fail - Allows you to access the following menu to select one of the logic keys for fail conditions between the measurement results and the test limits:

    AND - Fail is shown if one of the relative ACPR measurement results is larger than **Rel Lim (Car)** or **Rel Lim (PSD)** AND one of the absolute ACPR measurement results is larger than **Abs Limit**.

    OR - Fail is shown if one of the relative ACPR measurement results is larger than **Rel Lim (Car)** or **Rel Lim (PSD)** OR one of the absolute ACPR measurement results is larger than **Abs Limit**.

    Absolute - Fail is shown if one of the absolute ACPR measurement results is larger than **Abs Limit**.

Relative - Fail is shown if one of the relative ACPR measurement results is larger than **Rel Lim (Car)** or **Rel Lim (PSD)**.

Rel Lim (Car) - Allows you to enter a relative limit value of the carrier level ranging from –200.00 to +50.00 dBc with 0.01 dB resolution.

Rel Lim (PSD) - Allows you to enter a relative limit value of the power spectral density level ranging from –200.00 to +50.00 dB with 0.01 dB resolution.

- **Meas Type** - Allows you to access the menu to select one of the measurement reference types.

  Total Pwr Ref - Sets the reference to the total carrier power and the measured data is shown in dBc and dBm.

  PSD Ref - Sets the reference to the mean power spectral density of the carrier and the measured data is shown in dB and dBm/Hz.

- **Sweep Type** - Allows you to toggle the sweep type between **FFT** and **Swp** (swept). If set to **Swp**, the measurement is made by the swept spectrum method like the traditional swept frequency spectrum analysis to have better correlation to the input signal with a high crest factor (peak/average ratio). However, it may take a longer time. Also, only the **Spectrum** view is available.

- **Swp RBW** - Allows you to enter the sweep resolution bandwidth, and to toggle this function between **Auto** and **Man** (manual), when **Sweep Type** is set to **Swp**. If set to **Auto**, the sweep resolution bandwidth is set automatically, according to the sweep span derived from **Offset Freq** and **Ref BW**. If set to **Man**, the sweep resolution bandwidth is manually changed. The range is 1.000 kHz to 1.00000 MHz with 1 Hz resolution. The default setting is 41.667 kHz and **Auto**.

- **Swp Det** - Allows you to toggle the sweep detector type between **Avg** (average) and **Peak**, when **Sweep Type** is set to **Swp**. The default selection is **Peak**.

- **Advanced** - Allows you to access the menu to set the following parameter:

  Swp Acq Time - Allows you to set the data acquisition time when **Sweep Type** is set to **Swp**. The range is 500.0 μs to 10.00 ms with 1 μs resolution.

Changing the View

The **View/Trace** key accesses the menu to select the desired view of the measurement result as follows when **Sweep Type** is set to **FFT**. When **Sweep Type** is set to **Swp**, the **Bar Graph** key is not available only to show the spectrum display.

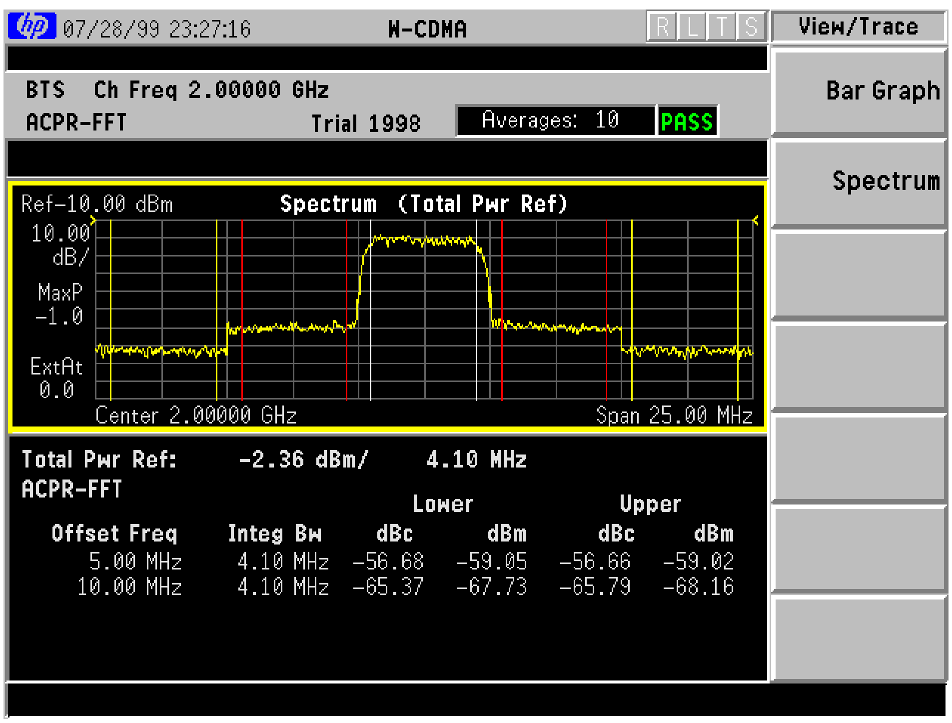
- **Bar Graph** - In the factory default condition, 5 of the total integration power levels, centered at the carrier frequency and ±5.0 MHz and ±10.0 MHz offset frequencies, are shown in the graph window. The corresponding measured data is shown in the text window as shown in Figure 3-2 on page 53. Depending on the **Meas Type** setting, one of the two following displays is obtained:

  `Bar Graph (Total Pwr Ref)` - A histogram of powers referenced to the total carrier power

  `Bar Graph (PSD Ref)` - A histogram of powers referenced to the mean power spectral density of the carrier in dBm/Hz

- **Spectrum** - In the factory default condition, the frequency spectrum with the FFT sweep type is displayed with the bandwidth marker lines in the graph window. The corresponding measured data in the text window is the total integration power levels within the defined bandwidth as shown in the figure below.

Figure 3-3 ACPR Measurement - FFT Spectrum View



Depending on the **Meas Type** setting, one of the two following displays is obtained with either **FFT** or **Swp** mode:

`Spectrum (Total Pwr Ref)` - A spectrum display referenced to the total carrier power

`Spectrum (PSD Ref)` - A spectrum display referenced to the mean power spectral density of the carrier in dBm/Hz

NOTE If **Sweep Type** is set to **FFT**, the spectrum graph does not show the actual power level measured at each of the offsets. Select **Swp** for the more accurate spectrum graph.

While in this view, you can change the vertical scale by pressing the **Amplitude Y Scale** key. You can also activate or deactivate the reference bandwidth markers and the spectrum grid by pressing the **Display** key.

Changing the Display

When the spectrum graph window is selected, the **Amplitude Y Scale** key accesses the menu to set the desired measurement scale and associated parameters:

- **Scale/Div** - Allows you to enter a numeric value to change the vertical display sensitivity. The range is 0.10 to 20.00 dB with 0.01 dB resolution. The default setting is 10.00 dB, however, since the **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Value** - Allows you to set the absolute power reference value ranging from –250.00 to 250.00 dBm with 0.01 dB resolution. The default setting is 10.00 dBm, however, since the **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Position** - Allows you to set the reference position to either **Top**, **Ctr** (center), or **Bot** (bottom). The default setting is **Top**.
- **Scale Coupling** - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

The **Display** key also accesses the menu to control the markers on the display as follows:

- **Ref BW Markers** - Allows you to toggle the reference bandwidth markers function between **On** and **Off**. If set to **On**, the line markers with the reference bandwidth are shown on the measurement result display.

Troubleshooting Hints

If an external attenuator is used, be sure to include its attenuation in the ACPR measurement. Use the **Ext Atten** key.

This adjacent channel power ratio measurement can reveal degraded or defective parts in the transmitter section of the UUT. The following examples are those areas to be checked further.

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

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

Making the Power Stat CCDF Measurement

Purpose

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

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

Measurement Method

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

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

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

A CCDF curve is defined by how much time the waveform spends at or above a given power level. The percent of time the signal spends at or above the level defines the probability for that particular power level. To make the power statistics CCDF measurement, the transmitter tester 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.

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

Select the desired center frequency as described in "Changing the Frequency Channel" on page 17.

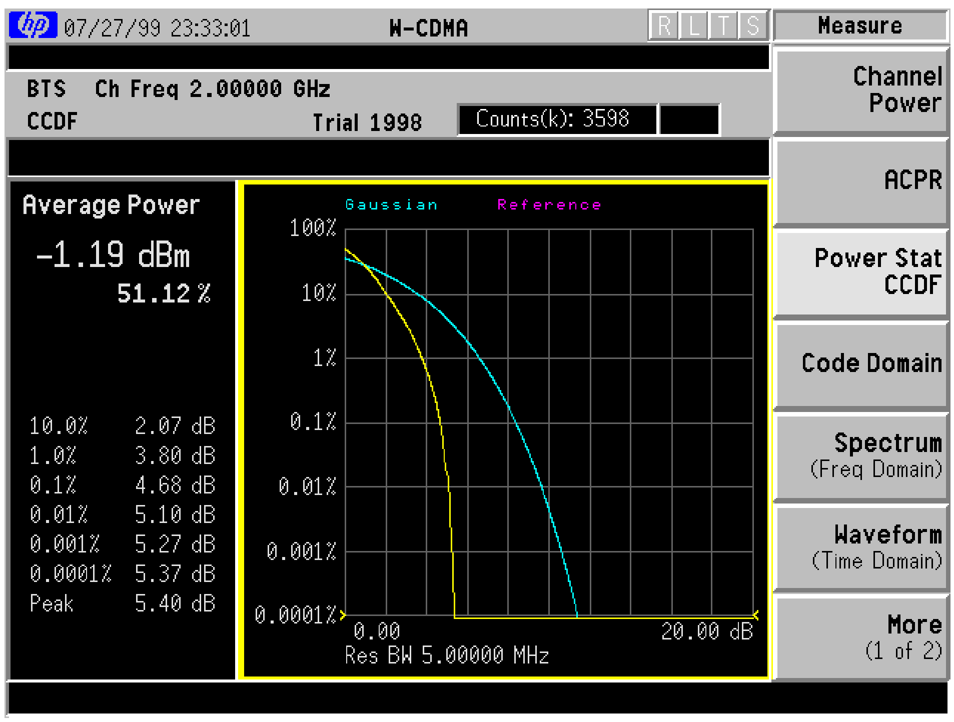
Press **Measure**, **Power Stat CCDF** to immediately make a power statistics CCDF measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 62.

Results

The next figure shows an example result of `Power Stat CCDF` measurements in the graph window. The average power and its probability are shown in the text window.

Figure 3-4 Power Statistics CCDF Measurement



Changing the Measurement Setup

The next table shows the factory default settings for power statistics CCDF measurements.

Table 3-3 Power Statistics CCDF Measurement Defaults

Measurement Parameter	Factory Default Condition
Meas Setup:	
Meas BW	5.00000 MHz
Counts	10.0000 Mpoints
Meas Interval	1.000 ms
Trig Source	Free Run (Immediate)
Display:	
Ref Trace	Off
Gaussian Line	On

Make sure the **Power Stat CCDF** measurement is selected under the **Measure** menu. Press the **Meas Setup** key to access the menu which allows you to modify the trigger source for this measurement as described in “Measurement Setup” on page 43. In addition, the following parameters can be modified.

- **Meas BW** - Allows you to set the measurement bandwidth according to the channel bandwidth. The range is 10.000 kHz to 6.70000 MHz with 0.1 kHz resolution.
- **Counts** - Allows you to set the accumulated number of sampling points for data acquisition. The range is 1.000 kpoints to 2.000 Gpoints with 1 or 10 kpoints resolution. While this key is activated, enter a value from the numeric keypad by terminating with one of the unit keys shown.
- **Meas Interval -** Allows you to specify the time interval over which the measurement is made. The range is 100.0 µs to 10.00 ms with 1 µs resolution.

Changing the View

The **View/Trace** key is not available for this measurement.

Changing the Display

The **Display** key allows you to control the desired trace and line displays of the power statistics CCDF curves. The currently measured curve is always shown.

- **Store Ref Trace** - Allows you to copy the currently measured curve as the user-definable reference trace. The captured data will remain until the other mode is chosen. Pressing this key refreshes the reference trace.
- **Ref Trace -** Allows you to toggle the reference trace display function between **On** and **Off**.
- **Gaussian Line -** Allows you to toggle the Gaussian line display function between **On** and **Off**.

The **Span X Scale** key accesses the menu to set the desired horizontal scale.

- **Scale/Div -** Allows you to enter a numeric value to change the horizontal display sensitivity. The range is 0.10 to 20.00 dB with 0.01 dB resolution. The default setting is 2.00 dB.

Using the Markers

The **Marker** front-panel key accesses the menu to configure the markers.

- **Select** - Allows you to activate up to four markers with the corresponding numbers, respectively. The selected number is underlined and its function is defined by pressing the **Function** key. The default selection is 1.
- **Normal** - Allows you to activate the selected marker to read the power level and probability of the marker position on the selected curve, for example, which is controlled by the RPG knob.
- **Delta** - Allows you to read the differences in the power levels and probabilities between the selected marker and the next.
- **Function** - Allows you to set the selected marker function to **Band Power**, **Noise**, or **Off**. The default setting is **Off**. The **Band Power** and **Noise** functions are not available for this measurement.
- **Trace** - Allows you to place the selected marker on the **Measured**, **Gaussian**, or **Reference** curve. The default setting is **Measured**.
- **Off** - Allows you to turn off the selected marker.
- **Shape** - Allows you to access the menu to set the selected marker shape to **Diamond**, **Line**, **Square**, or **Cross**. The default setting is **Diamond**.
- **Marker All Off -** Allows you to turn off all of the markers.

Troubleshooting Hints

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

As this measurement is a new method, there will be some correlations between CCDF curve degradation and digital radio system measurement parameters such as BER, FER, code domain power, and ACPR. Some studies will help set standards for radio design by specifying the maximum allowed CCDF curve degradation for specific systems.

Making the Code Domain Measurement

Purpose

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

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

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

Measurement Method

This procedure measures the power levels of the spread channels in a single RF channel when **Standard** in the **Radio** menu is set to **ARIB 1.0-1.2** or **Trial 1998**, and also when **Device** is set to **BTS**. One uniqueness from other measurements is that **Measure** in the **Meas Control** menu is defaulted to **Single**.

The code domain measurement displays the power for each of the spread channels, relative to the total power within the 4.096 MHz channel bandwidth centered at the center frequency. Each spread channel level is displayed as an individual vertical bar with a different width determined by a spread rate. Because this is a relative measurement, the unit of measure is dB (not dBm or watts). This allows a comparison of signal levels between the Perch and Traffic channels.

The following displays are available for this measurement:

- Power Graph & Metrics - The transmitted energy associated with each of the symbol rates and codes is shown in the graph window. The following powers along with the total power are shown in the text window:
  - — Total active channel power
  - — Perch channel power
  - — Number of active channels
  - — Maximum active channel power
  - — Average active channel power
  - — Maximum inactive channel power
  - — Average inactive channel power
- I/Q Error (Quad View) - The magnitude error, phase error, and EVM graphs are shown in the graph window. The summary data for these parameters are also shown in the text window.
- Code Domain (Quad View) - The graphs of the code domain power, the symbol power for the selected spread channel, and the symbol EVM polar vector for the symbol power range selected by the measurement interval and measurement offset parameters, are shown in the graph windows. The summary data is also shown in the text window.

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

Select the desired center frequency as described in "Changing the Frequency Channel" on page 17.

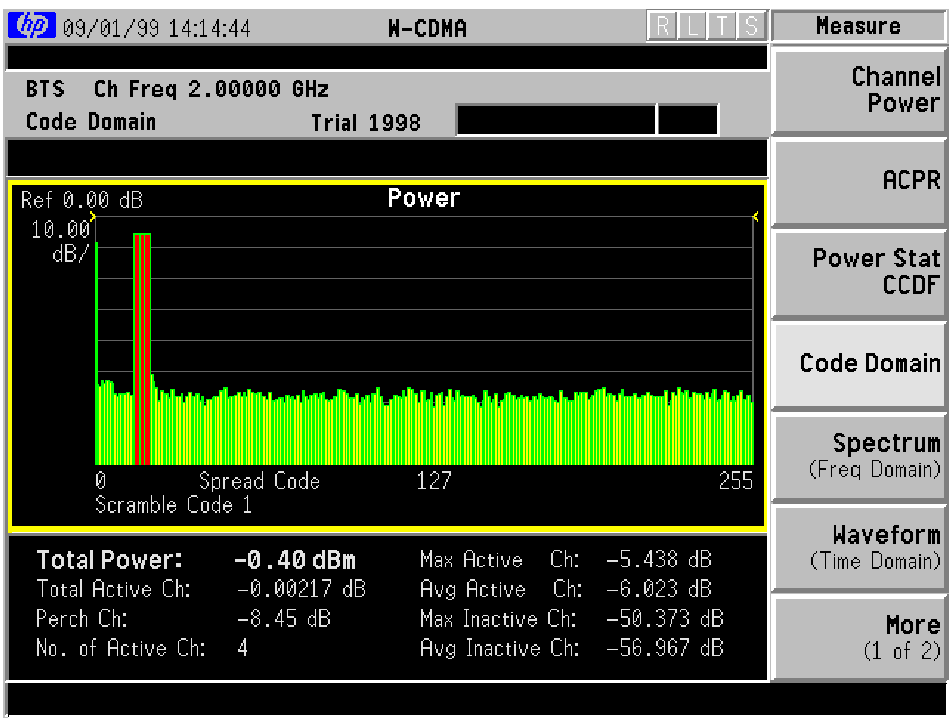
Press **Measure**, **Code Domain** to immediately make a code domain power measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 68.

Results

The next figure shows an example result of `Code Domain Power` measurements. In the graph window, the active channel symbol rates are shown with those widths of the bars and the measured channel powers are shown with those heights. Also, the summary data are shown in the text window.

Figure 3-5 Code Domain Measurement - Power Graph View



Changing the Measurement Setup

The next table shows the factory default settings for code domain power measurements.

Table 3-4 Code Domain Power Measurement Defaults

Measurement Parameter	Factory Default Condition
View/Trace	Power Graph & Metrics
Meas Setup:	
Symbol Rate	16 ksps
Code Number	0
Meas Interval	1 slots
Meas Offset	0 slots
Scramble Code	1
Trig Source	Free Run (Immediate)
Spectrum	Normal
Meas Control: Measure	Single
Advanced	
Power Offset: (for ARIB only) Ref Set	Auto
Alpha	0.220
Chip Rate	4.09600 MHz

Make sure the **Code Domain** measurement is selected under the **Measure** menu. Press the **Meas Setup** key to access the menu which allows you to modify the trigger source for this measurement as described in “Measurement Setup” on page 43. Also, press the **Meas Control** key to access the menu which allows you to change **Measure** from single to continuous as described in “Measurement Control” on page 43. In addition, the following parameters can be modified.

- **Symbol Rate** - Allows you to set the symbol rate ranging from 8 to 1024 ksps. The parameter automatically sets the maximum value for **Code Number** when appropriate. If **Symbol Rate** is set to 16 ksps and **Code Number** is set to 0, the Perch channel is automatically selected as the channel type. When the channel type is set to Perch, the search code portion is not included in the symbol EVM calculation. In other cases, the channel type is set to DPCH which enables power offset measurements.

- **Code Number** - Allows you to set the code number. The range is 0 to 511 depending on the **Symbol Rate** setting as follows:

Symbol Rate	Code Number	Description
8 ksps	0 to 511	Not available for Trial 1998
16 ksps	0 to 255	
32 ksps	0 to 127	
:	:	
512 ksps	0 to 7	
1024 ksps	0 to 3	

- **Meas Interval** - Allows you to set the time interval in slots over which the symbol EVM measurement is made. The range is 32 to 1 slots in conjunction with the **Meas Offset** value. The maximum value is 32 minus the **Meas Offset** value. The marker lines of which width varies with this number of slots are displayed in the symbol power graph of the **Code Domain (Quad View)** display.

- **Meas Offset** - Allows you to set the number of offset slots to make the symbol EVM measurement. The range is 0 to 31 slots in conjunction with the **Meas Interval** value. The maximum value is 32 minus the **Meas Interval** value. The marker lines shift to right by this number of slots in the symbol power graph of the **Code Domain (Quad View)** display.

- **Scramble Code** - Allows you to enter a hexadecimal value for the scramble code. Pressing this key reveals the keys labeled **A** to **F** and **Done**. The range is 0000 to 3FFFF. Use the numeric keypad and these keys to create a hexadecimal value by terminating with the **Done** key.

- **Spectrum** - Allows you to toggle the spectrum function between **Normal** and **Invert**. This key, when set to **Invert**, conjugates the spectrum, which equivalently negates the quadrature component in demodulation. The correct setting (**Normal** or **Invert**) depends on whether the signal being given to the transmitter tester has a high or low side mix.

- **Advanced** - Allows you to access the menu to set the following parameters.

  Power Offset - Allows you to access the menu with the following parameters. (This key is not available for the Trial 1998 mode.)

    Ref Set - Allows you to toggle the power offset reference setting function between **Auto** and **Man** (manual). If set to **Auto**, the symbol EVM is computed with the measured average power for that power region. If set to **Man**, the symbol EVM is computed with the measured average power for data plus the power offset specified.

    PO1 (Pilot) - Allows you to specify the power offset value of the pilot bits. The range is –20.00 to +50.00 dB with 0.01 dB resolution.

    PO2 (TPC) - Allows you to specify the power offset value of the transmit power control bits. The range is –20.00 to +50.00 dB with 0.01 dB resolution.

    PO3 (TFCI) - Allows you to specify the power offset value of the transport format control indicator bits. The range is –20.00 to +50.00 dB with 0.01 dB resolution.

  Alpha - Allows you to specify the alpha value of the root-raised cosine filter. The range is 0.01 to 0.50.

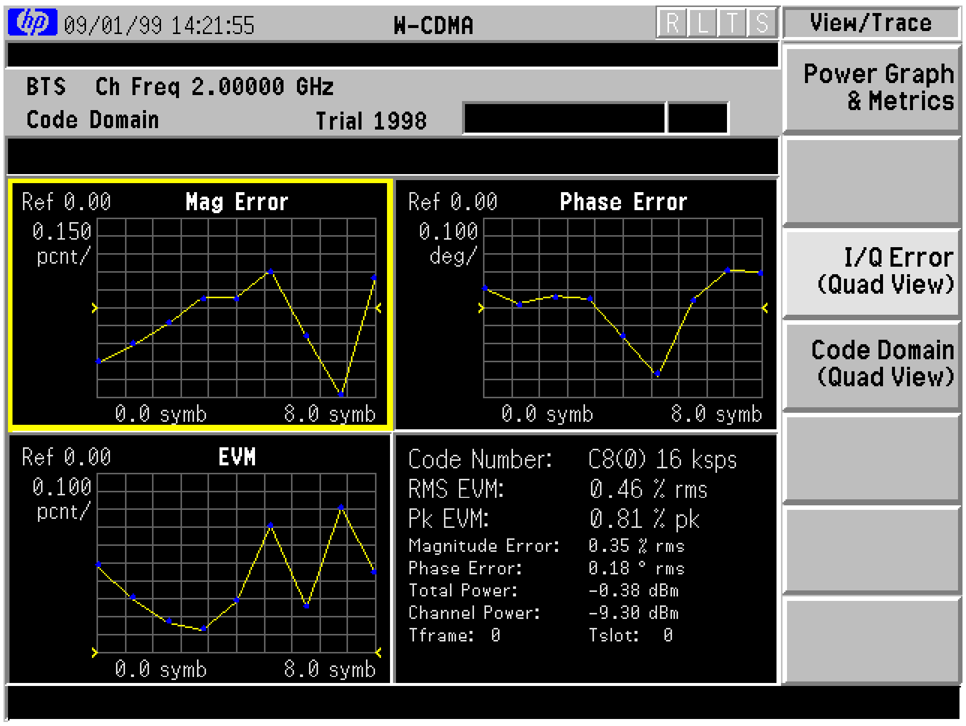
  Chip Rate - Allows you to change the chip rate. The range is 3.68640 to 4.50560 MHz.

Changing the View

The **View/Trace** key will allow you to select the desired view of the measurement from the following. Each of these views contains multiple windows that can be selected using the **Next Window** key and made full size using the **Zoom** key.

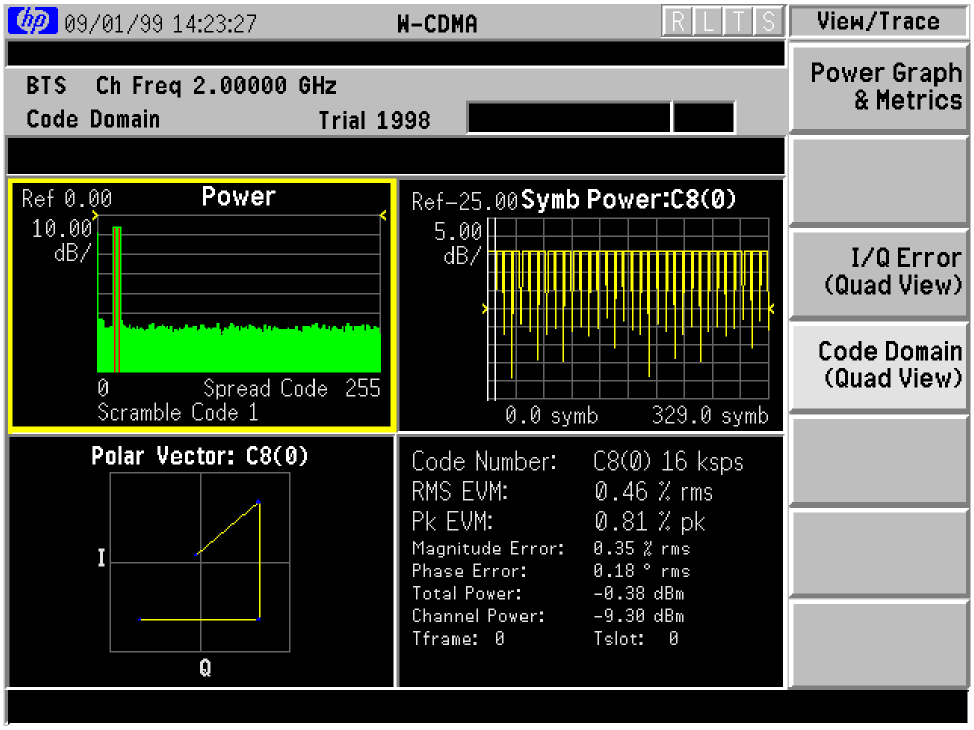
- **Power Graph & Metrics -** Provides a combination view of the code domain power graph and the summary data as shown in Figure 3-5 on page 67.
- **I/Q Error (Quad View) -** Provides a combination view of the magnitude error, phase error, EVM graphs, and the summary data.

Figure 3-6 Code Domain Measurement - I/Q Error Quad View



- **Code Domain (Quad View)** - Provides a combination view of the code domain power, symbol power, symbol EVM polar vector graphs, and the summary data.

Figure 3-7 Code Domain Measurement - Code Domain Quad View



While the `Code Domain Power` graph is activated, press the **Marker** key to place a marker on any active spread channel. Then, press the **Mkr->Despread** key to observe the `Symbol Power` and the `Symbol EVM Polar Vector` graphs with the spread code number for that active channel in other graph windows. The symbol EVM polar vector graph is displayed for the symbol power specified by the measurement interval and measurement offset.

Changing the Display

The **Display** key is not available for the code domain measurement because there is no meaning in phase trajectories between constellation points for symbol EVM measurements. Therefore, the points per chip is always set to 1 and **Chip Dots** is set to On.

- While the **Power Graph & Metrics** display is selected, the **Span X Scale** and **Amplitude Y Scale** keys access the menus to allow the following settings:
  - The **Span X Scale** key accesses the following menu:

    Scale/Div - Allows you to set the horizontal scale by changing a spread code value. The range is 64.00 to 256.0 (for Trial 1998), or to 512.0 (for ARIB 1.0-1.2), spread codes with 0.01 or 0.1 spread code resolution. The default setting is 256.0 (for Trial 1998), or 512.0 (for ARIB 1.0-1.2), spread codes.

    Ref Value - Allows you to set the spread code reference value. The range is 0.000 to 192.0 (for Trial 1998), or to 448.0 (for ARIB 1.0-1.2), spread codes with the scale at least 64 spread codes. The default setting is 0.000 spread code.

    Ref Position - Allows you to set the reference position to either **Left**, **Ctr** (center) or **Right**. The default setting is **Left**.

    Expand - Allows you to toggle the expanding function of the code domain power graph between **On** and **Off**. If set to **On**, the CDP graph is expanded horizontally to show 64 spread codes centered at the scale or the marker position. Upon toggling back to **Off**, the spread code range returns to the previous setting.
  - The **Amplitude Y Scale** key accesses the following menu:

    Scale/Div - Allows you to set the vertical scale by changing the value per division. The range is 0.10 to 20.0 dB per division. The default setting is 5.00 dB, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.

    Ref Value - Allows you to set the reference value ranging from –250.00 to 250.00 dB. The default setting is 0.00 dB, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.

    Ref Position - Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). The default setting is **Top**.

    Scale Coupling - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

- While the **I/Q Error (Quad-View)** display is selected, the **Span X Scale** and **Amplitude Y Scale** keys access the menus to allow the following settings depending on the active window.

  — If either `EVM`, `Phase Error`, or `Mag Error` window is active, the **Span X Scale** key accesses the following menu:

  Scale/Div - Allows you to set the horizontal scale by changing a symbol value per division. The range is 1.00 to 100.00 symbols per division with 0.01 symbol resolution. The default setting is 1.900 symbols, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.

  Ref Value - Allows you to set the symbol reference value ranging from 0.00 to 1000.0 symbols. The default setting is 0.00 symbol, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.

  Ref Position - Allows you to set the reference position to either **Left**, **Ctr** (center) or **Right**. The default setting is **Left**.

  Scale Coupling - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

  — If either `EVM` or `Mag Error` window is active, the **Amplitude Y Scale** key accesses the following menu:

  Scale/Div - Allows you to set the vertical scale by changing the value per division. The range is 0.100 to 50.0% per division. The default setting is 5.00%, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.

  Ref Value - Allows you to set the reference value ranging from –500.00 to 500.0%. The default setting is 0.00%, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.

  Ref Position - Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). For the `EVM` graph, the default setting is **Bot**. For the `Mag Error` graph, the default setting is **Ctr**.

  Scale Coupling - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

— If the `Phase Error` window is active, the **Amplitude Y Scale** key accesses the following menu:

Scale/Div - Allows you to set the vertical scale by changing the value per division. The range is 0.0100 to 3600.0 degrees. The default setting is 5.00 degrees, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.

Ref Value - Allows you to set the reference value ranging from –36000.0 to 36000.0 degrees. The default setting is 0.00 degrees, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.

Ref Position - Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). The default setting is **Ctr**.

Scale Coupling - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

- While the **Code Domain (Quad-View)** display is selected, the **Span X Scale** and **Amplitude Y Scale** keys access the menus to allow the following settings depending on the active window.

— If the `Code Domain Power` window is active, the **Span X Scale** key accesses the following menu:

Scale/Div - Allows you to set the horizontal scale by changing a spread code value. The range is 64.00 to 256.0 (for Trial 1998), or to 512.0 (for ARIB 1.0-1.2), spread codes with 0.01 or 0.1 spread code resolution. The default setting is 256.0 (for Trial 1998), or 512.0 (for ARIB 1.0-1.2), spread codes.

Ref Value - Allows you to set the spread code reference value. The range is 0.000 to 192.0 (for Trial 1998), or to 448.0 (for ARIB 1.0-1.2), spread codes with the scale at least 64 spread codes. The default setting is 0.000 spread code.

Ref Position - Allows you to set the reference position to either **Left**, **Ctr** (center) or **Right**. The default setting is **Left**.

Expand - Allows you to toggle the expanding function of the code domain power graph between **On** and **Off**. If set to **On**, the CDP graph is expanded horizontally to show 64 spread codes centered at the scale or the marker position. Upon toggling back to **Off**, the spread code range returns to the previous setting.

— If `Symbol Power` window is active, the **Span X Scale** key accesses the following menu:

Scale/Div - Allows you to set the horizontal scale by changing a symbol value per division. The range is 1.000 to 100.0 symbols per division with 0.01 symbol resolution. The default setting is 11.90 symbols, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.

Ref Value - Allows you to set the symbol reference value ranging from 0.000 to 1000.0 symbols. The default setting is 0.000 symbol, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.

Ref Position - Allows you to set the reference position to either **Left**, **Ctr** (center) or **Right**. The default setting is **Left**.

Scale Coupling - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

— If `Code Domain Power` window is active, the **Amplitude Y Scale** key accesses the following menu:

Scale/Div - Allows you to set the vertical scale by changing the value per division. The range is 0.10 to 20.0 dB per division. The default setting is 5.00 dB, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.

Ref Value - Allows you to set the reference value ranging from –250.00 to 250.00 dB. The default setting is 0.00 dB, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.

Ref Position - Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). The default setting is **Top**.

Scale Coupling - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

— If the `Symbol Power` window is active, the **Amplitude Y Scale** key accesses the following menu:

Scale/Div - Allows you to set the vertical scale by changing the value per division. The range is 0.10 to 20.00 dB. The default setting is 5.00 dB, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.

Ref Value - Allows you to set the reference value ranging from –250.00 to 250.00 dB. The default setting is 0.00 dB, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.

Ref Position - Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). The default setting is **Ctr**.

Scale Coupling - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

Using the Markers

The **Marker** front-panel key accesses the menu to configure the markers depending on the display selected.

- **Select** - Allows you to activate up to four markers with the corresponding numbers, respectively. The selected number is underlined and its function is defined by pressing the **Function** key. The default setting is 1.
- **Normal** - Allows you to activate the selected marker to read the power level and symbol code with the code layer of the marker position, for example, which is controlled by the RPG knob.
- **Delta** - Allows you to read the differences in the power levels and symbols codes between the selected marker and the next.
- **Function** - Allows you to set the selected marker function to **Band Power**, **Noise**, or **Off**. The default setting is **Off**. The **Band Power** and **Noise** functions are not available for this measurement.
- **Trace** - Allows you to place the selected marker on the **Code Domain Power**, **Symbol Power**, **EVM**, **Phase Error**, or **Mag Error** trace. The default setting is **Code Domain Power**.
- **Off** - Allows you to turn off the selected marker.
- **Shape** - Allows you to access the menu to set the selected marker shape to **Diamond**, **Line**, **Square**, or **Cross**. The default setting is **Diamond**.
- **Marker All Off** - Allows you to turn off all of the markers.
- **Mkr–>Despread** - While a maker is set on any active spread channel of the code domain power graph in **Code Domain (Quad View)**, allows you to observe the `Symbol Power` and the `Symbol EVM Polar Vector` graphs with the spread code number for that active channel in other graph windows. The symbol EVM polar vector graph is displayed for the symbol power specified by the measurement interval and measurement offset.

Troubleshooting Hints

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

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

Making the QPSK EVM Measurement

Purpose

Phase and frequency errors are measures of modulation quality for the W-CDMA system. This modulation quality is obtained through QPSK Error Vector Magnitude (EVM) measurements. Since the W-CDMA system uses the Quadrature Phase Shift Keying (QPSK) modulation technique, the phase and frequency accuracies of the transmitter are critical to the communications system performance and ultimately affect range.

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

Measurement Method

The phase error of the unit under test is measured by computing the difference between the phase of the transmitted signal and the phase of a theoretically perfect signal.

The instrument samples the transmitter output in order to capture the actual phase trajectory. This is then demodulated and the ideal phase trajectory is mathematically derived using detected bits and root-raised cosine channel filtering. Subtracting one from the other results in a phase error signal.

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

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

Select the desired center frequency as described in "Changing the Frequency Channel" on page 17.

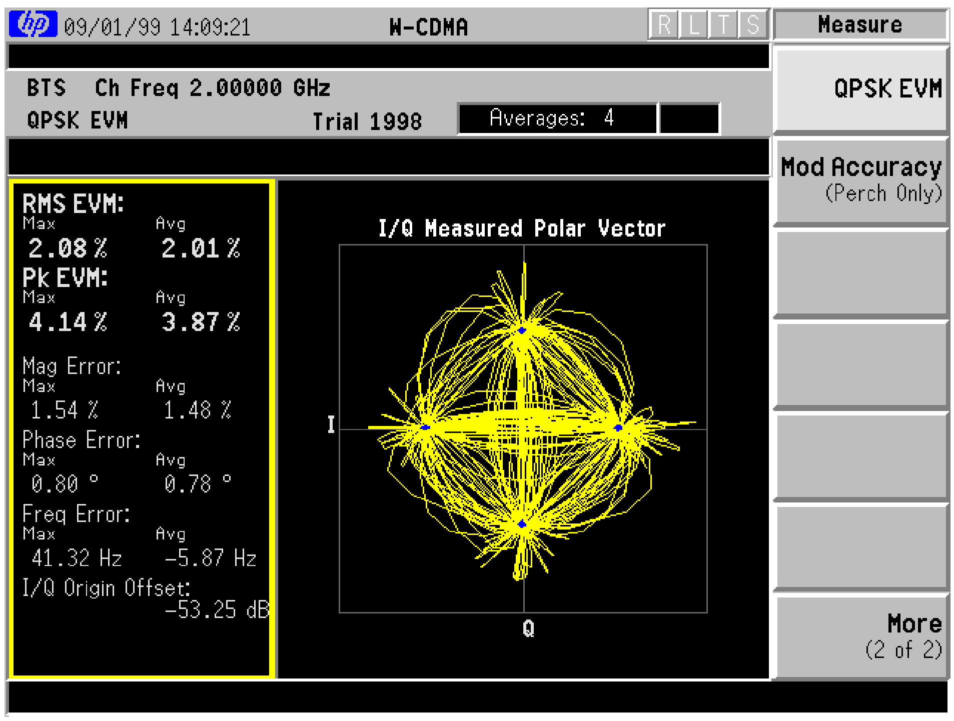
Press **Measure**, **QPSK EVM** to immediately make a QPSK error vector magnitude (EVM) measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 81.

Results

The next figure shows an example result of `I/Q Measured Polar Vector` for the QPSK EVM measurements in the graph window. The measured values for EVM and other parameters are shown in the text window.

Figure 3-8 QPSK EVM Measurement - Polar Vector View



Changing the Measurement Setup

The next table shows the factory default settings for QPSK EVM measurements.

Table 3-5 QPSK EVM Measurement Defaults

Measurement Parameter	Factory Default Condition
View/Trace	I/Q Measured Polar Vector
Meas Setup:	
Avg Number	10, On
Avg Mode	Repeat
Meas Interval	256 chips
Trig Source	Free Run (Immediate)
Advanced	
Alpha	0.220
Chip Rate: for ARIB & Trial 1998 for 3GPP	 4.09600 MHz 3.84000 MHz

Make sure the **QPSK EVM** measurement is selected under the **Measure** menu. Press the **Meas Setup** key to access the menu which allows you to modify the average number, average mode, and trigger source as described in "Measurement Setup" on page 43. In addition, the following QPSK error vector magnitude measurement parameters can be modified.

- **Meas Interval** - Allows you to set the time interval over which the measurement is made. The range is 128 to 512 chips.
- **Advanced** - Allows you to access the menu to change the following parameters:

  Alpha - Allows you to change the alpha value of the root-raised cosine filter. The range is 0.01 to 0.50.

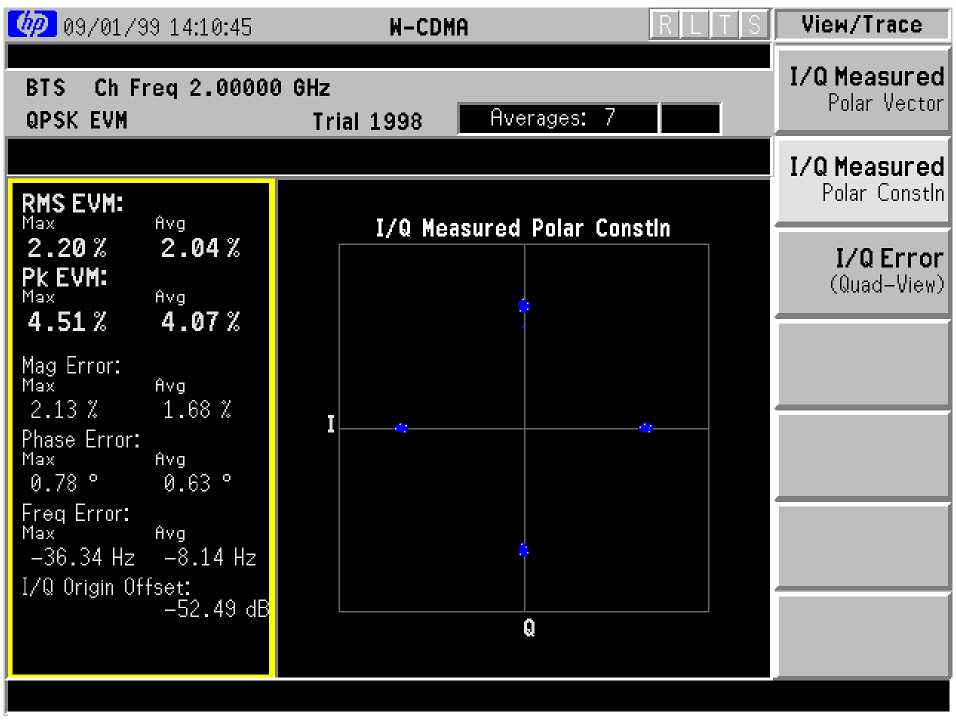
  Chip Rate - Allows you to change the chip rate. The range is 3.68640 to 4.50560 MHz for ARIB 1.0-1.2 and Trial 1998, or 3.45600 to 4.22400 MHz for 3GPP.

Changing the View

The **View/Trace** key will allow you to select the desired view of the measurement from the following:

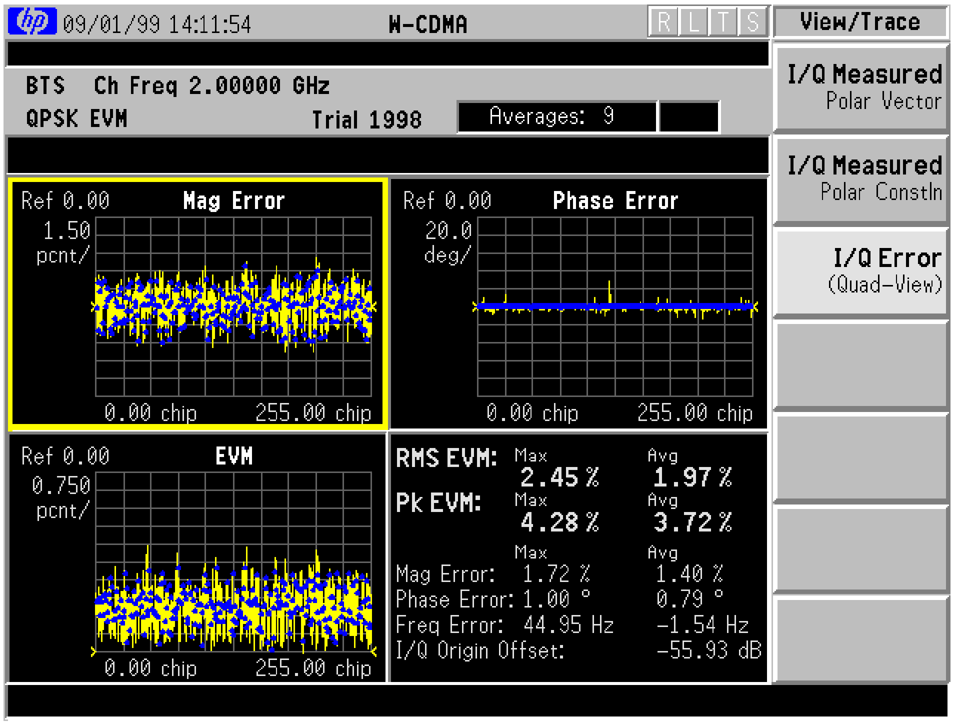
- **I/Q Measured Polar Vector** - Provides a combination view of an I/Q measured polar vector graph and the maximum and average summary data as shown in Figure 3-8 on page 80.
- **I/Q Measured Polar Constln** - Provides a combination view of an I/Q measured polar constellation graph and the maximum and average summary data as shown below.

Figure 3-9 QPSK EVM Measurement - Polar Constellation View



- **I/Q Error (Quad-View)** - Four display windows show Mag Error, Phase Error and EVM graphs and the maximum and average EVM summary data in the text window as shown below.

Figure 3-10 QPSK EVM Measurement - I/Q Error Quad View



Any of these windows can be selected using the **Next Window** key and made full size using the **Zoom** key.

Changing the Display

The **Display** key accesses the menu to allow the following selections for changing the graph displays of `I/Q Measured Polar Vector`, `I/Q Measured Polar Constellation` and `I/Q Error (Quad-View)`:

- **I/Q Points** - Allows you to specify the number of displayed chips for the I/Q waveforms. The range is 1 to 2560 points with the points per chip fixed to 5, depending on the **Meas Interval** setting. The default setting is 1280 points.

- **Chip Dots** - Allows you to toggle the chip dot display between **On** and **Off**. The default setting is **On**.

- **+45 Degree Rotation** - Allows you to toggle the display rotation function between **On** and **Off**. If this is set to **On**, the I/Q polar constellation graph is rotated by +45 degrees to see a rectangular display. The default setting is **Off**.

When either EVM, Phase Error, or Mag Error window is active in the **I/Q Error (Quad-View)** display, the **Span X Scale** key accesses the menu to allow the following settings:

- **Scale/Div** - Allows you to set the horizontal scale by changing a chip value per division. The range is 1.00 to 512.00 chips per division with 0.01 chip resolution. The default setting is 25.50 chips per division, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Value** - Allows you to set the chip reference value ranging from 0.000 to 1000.0 chips. The default setting is 0.000 chip, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.
- **Ref Position** - Allows you to set the reference position to either **Left**, **Ctr** (center) or **Right**. The default setting is **Left**.
- **Scale Coupling** - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

When either EVM or Mag Error window is active in the **I/Q Error (Quad-View)** display, the **Amplitude Y Scale** key accesses the menu to allow the following settings:

- **Scale/Div** - Allows you to set the vertical scale by changing the value per division. The range is 0.100 to 50.0% per division. The default setting is 5.00%, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Value** - Allows you to set the reference value ranging from 0.00 to 500.0%. The default setting is 0.00%, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.
- **Ref Position** - Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). For the EVM graph, the default setting is **Bot**. For the Mag Error graph, the default setting is **Ctr**.
- **Scale Coupling** - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

When the `Phase Error` window is active in the **I/Q Error (Quad-View)** display, the **Amplitude Y Scale** key accesses the menu to allow the following settings:

- **Scale/Div** - Allows you to set the vertical scale by changing the value per division. The range is 0.01 to 3600 degrees. The default setting is 5.00 degrees per division, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Value** - Allows you to set the reference value ranging from –36000 to 36000 degrees. The default setting is 0.00 degrees, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement results.
- **Ref Position** - Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). The default setting is **Ctr**.
- **Scale Coupling** - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

Using the Markers

The **Marker** front-panel key accesses the menu to configure the markers depending on the display selected.

- **Select** - Allows you to activate up to four markers with the corresponding numbers, respectively. The selected number is underlined and its function is defined by pressing the **Function** key. The default setting is 1.
- **Normal** - Allows you to activate the selected marker to read the magnitude or phase error and the number of chips of the marker position on the selected trace, for example, which is controlled by the RPG knob.
- **Delta** - Allows you to read the differences in the magnitude or phase errors and the number of chips between the selected marker and the next.
- **Function** - Allows you to set the selected marker function to **Band Power**, **Noise**, or **Off**. The default setting is **Off**. The **Band Power** and **Noise** functions are not available for this measurement.
- **Trace** - Allows you to place the selected marker on the **EVM**, **Phase Error**, or **Mag Error** trace. The default setting is **EVM**.
- **Off** - Allows you to turn off the selected marker.
- **Shape** - Allows you to access the menu to set the selected marker shape to **Diamond**, **Line**, **Square**, or **Cross**. The default setting is **Diamond**.
- **Marker All Off** - Allows you to turn off all of the markers.

Troubleshooting Hints

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

Making the Modulation Accuracy (Rho) Measurement

Purpose

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

Measurement Method

This procedure is to measure the performance of the transmitter's modulation circuitry when **Standard** in the **Radio** menu is set to **ARIB 1.0-1.2** or **Trial 1998**, and when **Device** is set to **BTS**.

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

With the Rho measurement, the following data is provided:

- Rho - modulation quality representing the ratio of the correlated power in a single coded channel to the total signal power
- Frequency Error - the frequency difference between the transmitter's actual center frequency and the frequency (or channel) that you entered
- EVM - peak and rms Error Vector Magnitude
- Mag Error - rms Magnitude Error
- Phase Error - rms Phase Error
- I/Q Origin Offset

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

Select the desired center frequency as described in "Changing the Frequency Channel" on page 17.

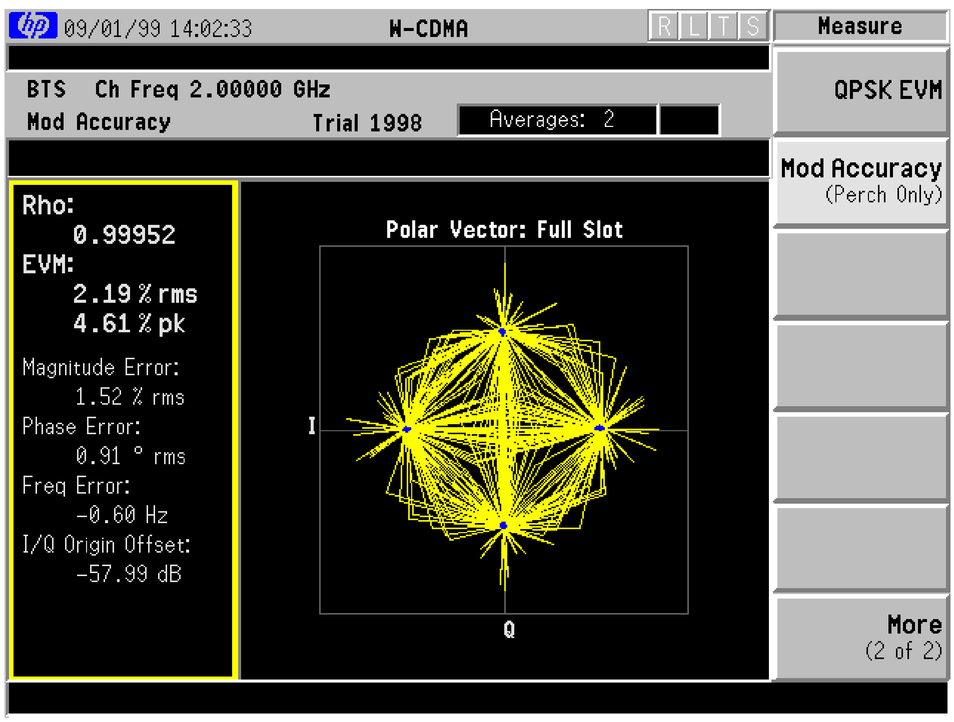
Press **Measure**, **Mod Accuracy (Rho)** to immediately make a modulation accuracy measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 89.

Results

The next figure shows an example result of `I/Q Measured Polar Vector (Full Slot)` for the modulation accuracy measurements in the graph window. The measured values for Rho, EVM, and other parameters are shown in the text window.

Figure 3-11 Modulation Accuracy Measurement - Polar Vector View



Changing the Measurement Setup

The next table shows the factory default settings for modulation accuracy (rho) measurements.

Table 3-6 Modulation Accuracy (Rho) Measurement Defaults

Measurement Parameter	Factory Default Condition
View/Trace	I/Q Measured Polar Vector
Meas Setup:	
Avg Number	10, On
Avg Mode	Repeat
Trig Source	Free Run (Immediate)
Scramble Code	1
Spectrum	Normal
Advanced	
Alpha	0.220
Chip Rate	4.09600 MHz

Make sure the **Mod Accuracy (Rho)** measurement is selected under the **Measure** menu. Press the **Meas Setup** key to access a menu which allows you to modify the average number, average mode, and trigger source as described in "Measurement Setup" on page 43. Since the rho is always calculated from the whole Perch slot with 2304 chips excepting the search code symbol, there is no need to set the measurement interval in this measurement. In addition, the following modulation accuracy measurement parameters can be modified.

- **Scramble Code** - Allows you to enter a hexadecimal value for the scramble code. Pressing this key reveals the keys labeled **A** to **F** and **Done**. The range is 0000 to 3FFFF. Use the numeric keypad and these keys to create a hexadecimal value and terminate with the **Done** key.
- **Spectrum** - Allows you to toggle the spectrum function between **Normal** and **Invert**. This key, when set to **Invert**, conjugates the spectrum, which equivalently negates the quadrature component in demodulation. The correct setting (**Normal** or **Invert**) depends on whether the signal being given to the transmitter tester has a high or low side mix.

- **Advanced** - Allows you to access the menu to change the following parameters:

  Alpha - Allows you to change the alpha value of the root-raised cosine filter. The range is 0.01 to 0.50.

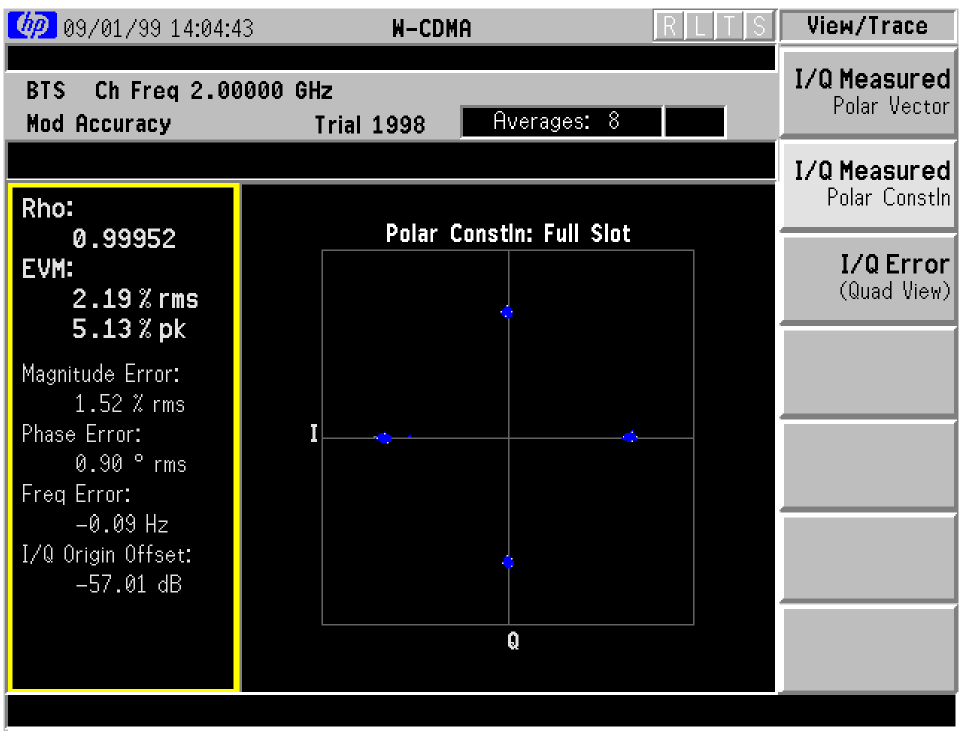
  Chip Rate - Allows you to change the chip rate ranging from 3.68640 to 4.50560 MHz.

Changing the View

The **View/Trace** key will allow you to select the desired measurement view from the following selections:

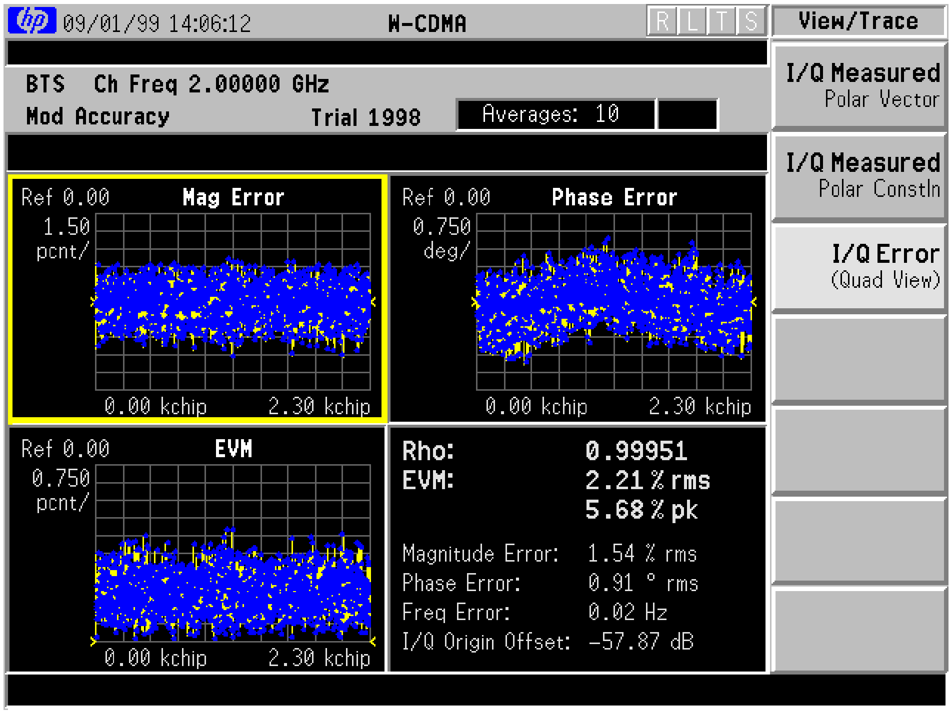
- **I/Q Measured Polar Vector (Full Slot)** - Provides a combination view of an I/Q measured polar vector graph and the summary data as shown in Figure 3-11 on page 88.
- **I/Q Measured Polar Constln (Full Slot)** - Provides a combination view of an I/Q measured polar constellation graph and the summary data as shown below.

Figure 3-12 Modulation Accuracy Measurement - Polar Constellation View



- **I/Q Error (Quad-View)** - Four display windows show Mag Error, Phase Error, and EVM graphs, and the modulation accuracy summary data as shown below.

Figure 3-13 Modulation Accuracy Measurement - I/Q Error Quad View



Any one of these windows can be selected using the **Next Window** key and made full size using the **Zoom** key.

Changing the Display

The **Display** key accesses the menu to allow the following selections for changing the graph displays of `I/Q Measured Polar Vector` and `I/Q Error (Quad-View)`:

- **I/Q Points** - Allows you to specify the number of displayed points for the I/Q waveforms. The range is 1 to 4608 points with the points per chip fixed to 2. The default setting is 512 points.
- **Chip Dots** - Allows you to toggle the chip dot display between **On** and **Off**. The default setting is **On**.
- **+45 Degree Rotation** - Allows you to toggle the display rotation function between **On** and **Off**. If this is set to **On**, the I/Q polar constellation graph is rotated by +45 degrees to see a rectangular display. The default setting is **Off**.

When either `EVM`, `Phase Error`, or `Mag Error` window is active in the **I/Q Error (Quad-View)** display, the **Span X Scale** key accesses the menu to allow the following settings:

- **Scale/Div** - Allows you to set the horizontal scale by changing a chip value per division. The range is 1.000 to 256.00 chips per division with 0.001 chip resolution. The default setting is 230.30 chips per division, however, since **Scale Coupling** is defaulted to **On,** this value is automatically determined by the measurement results.
- **Ref Value** - Allows you to set the chip reference value ranging from 0.000 to 2560.0 chips. The default setting is 0.000 chip, however, since **Scale Coupling** is defaulted to **On,** this value is automatically determined by the measurement results.
- **Ref Position -** Allows you to set the reference position to either **Left**, **Ctr** (center) or **Right**. The default setting is **Left**.
- **Scale Coupling** - Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

When either `EVM` or `Mag Error` window is active in the **I/Q Error (Quad-View)** display, the **Amplitude Y Scale** key accesses the menu to allow the following settings:

- **Scale/Div** - Allows you to set the vertical scale by changing the value per division. The range is 0.100 to 50.0% per division. The default setting is 5.00%, however, since **Scale Coupling** is defaulted to **On**, this value is automatically determined by the measurement result.
- **Ref Value** - Allows you to set the reference value ranging from 0.00 to 500.0%. The default setting is 0.00%, however, since **Scale Coupling** is defaulted to **On,** this value is automatically determined by the measurement results.
- **Ref Position -** Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). For the `EVM` graph, the default setting is **Bot**. For the `Mag Error` graph, the default setting is **Ctr**.
- **Scale Coupling -** Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

When the `Phase Error` window is active in the **I/Q Error (Quad-View)** display, the **Amplitude Y Scale** key accesses the menu to allow the following settings:

- **Scale/Div -** Allows you to set the vertical scale by changing the value per division. The range is 0.01 to 3600 degrees. The default setting is 5.00 degrees per division, however, since **Scale Coupling** is defaulted to **On,** this value is automatically determined by the measurement results.
- **Ref Value -** Allows you to set the reference value ranging from –36000 to 36000 degrees. The default setting is 0.00 degrees, however, since **Scale Coupling** is defaulted to **On,** this value is automatically determined by the measurement results.
- **Ref Position -** Allows you to set the reference position to either **Top**, **Ctr** (center) or **Bot** (bottom). The default setting is **Ctr**.
- **Scale Coupling -** Allows you to toggle the scale coupling function between **On** and **Off**. The default setting is **On**. This function automatically determines the scale per division and reference values by the measurement results.

Using the Markers

The **Marker** front-panel key accesses the menu to configure the markers depending on the display selected.

- **Select** - Allows you to activate up to four markers with the corresponding numbers, respectively. The selected number is underlined and its function is defined by pressing the **Function** key. The default setting is 1.
- **Normal** - Allows you to activate the selected marker to read the magnitude or phase error and the number of chips of the marker position on the selected trace, for example, which is controlled by the RPG knob.
- **Delta** - Allows you to read the differences in the magnitude or phase errors and the number of chips between the selected marker and the next.
- **Function** - Allows you to set the selected marker function to **Band Power**, **Noise**, or **Off**. The default setting is **Off**. The **Band Power** and **Noise** functions are not available for this measurement.
- **Trace** - Allows you to place the selected marker on the **EVM**, **Phase Error**, or **Mag Error** trace. The default setting is **EVM**.
- **Off** - Allows you to turn off the selected marker.
- **Shape** - Allows you to access the menu to set the selected marker shape to **Diamond**, **Line**, **Square**, or **Cross**. The default setting is **Diamond**.
- **Marker All Off** - Allows you to turn off all of the markers.

Troubleshooting Hints

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

Making the Spectrum (Frequency Domain) Measurement

Purpose

Excessive amounts of spectrum energy spilling into an adjacent frequency channel could interfere with signals being transmitted to other mobile stations or base stations.

The spectrum measurement is a generic measurement for viewing spectrums in the frequency domain. The instrument uses Fast Fourier Transform (FFT) to provide the spectrum measurement. The measurement control is designed to be familiar to those who are accustomed to using general swept frequency spectrum analyzers.

The FFT-specific parameters are located in the **Advanced** menu on page 98. Also available is an I/Q waveform window, which shows the I and Q signals in parameters of voltage and time. The advantage of having an I/Q waveform view available in spectrum measurements is that it allows you to view complex components of the same signal without any changing settings or measurements.

Measurement Method

The transmitter tester uses digital signal processing (DSP) to sample the input signal and convert it to the frequency domain. With the instrument tuned to a fixed center frequency, samples are digitized at a high rate, converted to I and Q components with DSP hardware, and then converted to the frequency domain with FFT software.

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

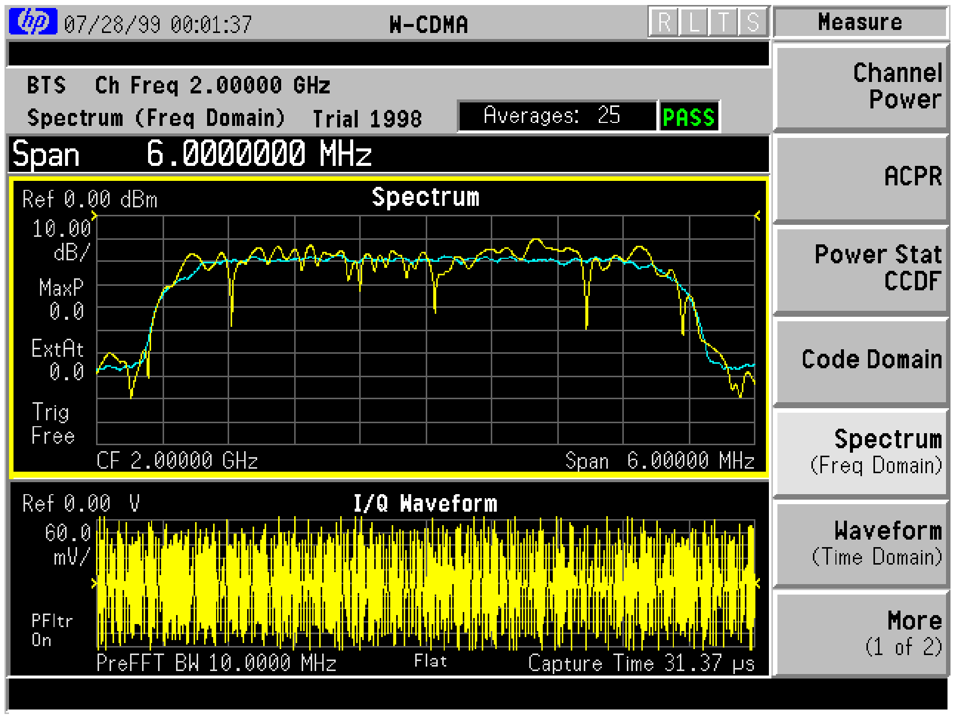
Press **Measure**, **Spectrum (Freq Domain)** to immediately make a spectrum (frequency domain) measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 97 for this measurement.

Results

A display with both a `Spectrum` window and an `I/Q Waveform` window will appear when you activate a spectrum measurement. Use the **Next Window** key to select a window, and the **Zoom** key to enlarge it. Figure 3-14 shows an example of the spectrum measurement.

Figure 3-14 Spectrum Measurement - Spectrum and I/Q Waveform View



Changing the Measurement Setup

The next table shows the factory default settings for spectrum (frequency domain) measurements.

Table 3-7 Spectrum (Frequency Domain) Measurement Defaults

Measurement Parameter	Factory Default Condition
Meas Setup:	
Res BW	20.0000 kHz, Auto
Trig Source	Free Run (Immediate)
Average:	
Avg Number	25, On
Avg Mode	Exp
Avg Type	Log-Pwr Avg (Video)
Spectrum Window	
Meas Setup:	
Span	1.00000 MHz
Amplitude Y Scale:	
Scale/Div	10.00 dB
I/Q Waveform Window (major items)	
Meas Setup:	
Capture Time	188.00 µs
Amplitude Y Scale:	
Scale/Div	60.0 mV
Advanced	
Pre-ADC BPF	On
Pre-FFT Fltr	Flat
Pre-FFT BW	1.55000 MHz, Auto
FFT Window	Flat Top (High Amptd Acc)
FFT Size:	
Length Ctrl	Auto
Min Pnts/RBW	1.300000
ADC Range	Auto Peak
Data Packing	Auto
ADC Dither	Auto
Decimation	0, Auto
IF Flatness	On

NOTE Parameters under the **Advanced** key seldom need to be changed. Any changes from the default advanced values may result in invalid measurement data.

Make sure the Spectrum (Freq Domain) measurement is selected under the **Measure** menu. Press the **Meas Setup** key to access a menu which allows you to modify the averaging function and trigger source for this measurement as described in "Measurement Setup" on page 43. In addition, the following parameters can be modified:

- **Span** - Allows you to modify the frequency span in which the FFT measurement is made. The range is 10.0 Hz to 10.0000 MHz with 1 or 10 Hz resolution. Changing the span causes the bandwidth to change automatically, and will affect data acquisition time.
- **Res BW** - Allows you to toggle the resolution bandwidth control between **Auto** and **Man** (manual), and to specify the resolution bandwidth value if set to **Man**. In manual, the range is 100.0 mHz to 3.00000 MHz. A narrower bandwidth will result in a longer data acquisition time but you will be able to examine the signal more closely. In auto, the resolution bandwidth is set to **Span**/50 (2% of the span).
- **Advanced** - Allows you to access the following selection menu. The FFT advanced features should be used if you are familiar with their operation. Changes from the default settings may result in invalid data.

  Pre-ADC BPF - Allows you to toggle the pre-ADC bandpass filter between **On** and **Off**. The pre-ADC bandpass filter is useful for rejecting nearby signals, so that sensitivity within the span range can be improved by increasing the ADC range gain.

  Pre-FFT Fltr - Allows you to toggle the pre-FFT filter type between **Flat** (flat top) and **Gaussian**. The default setting provides the best amplitude accuracy. The Gaussian filter has better pulse response.

  Pre-FFT BW - Allows you to toggle the pre-FFT bandwidth control between **Auto** and **Man**. In auto, this bandwidth is nominally 50% wider than the span. In manual, the bandwidth ranges from 1.0 Hz to 10.0000 MHz with 1 or 10 Hz resolution. This bandwidth determines the ADC sampling rate.

  FFT Window - Allows you to access the following selection menu. If you are familiar with FFT windows, you can use other digital filters but the use of the flat top filter is recommended.

    Flat Top (High Amptd Acc) - Select this filter for best amplitude accuracy by reducing scalloping error.
    Uniform - Select this filter to have no active window.
    Hanning - Press this key to activate the Hanning filter.

Hamming - Press this key to activate the Hamming filter.
Gaussian (Alpha 3.5) - Press this key to activate the Gaussian filter with an alpha of 3.5.
Blackman - Press this key to activate the Blackman filter.
Blackman-Harris - Press this key to activate the Blackman-Harris filter.
K-B 70dB/90dB/110dB (Kaiser-Bessel) - Allows you to select one of the Kaiser-Bessel filters with sidelobes at –70, –90, or –110 dB.

FFT Size - Allows you to access the following selection menu to set the FFT size:

Length Ctrl - Allows you to toggle the FFT length and window length controls between **Auto** and **Man**.

Min Pnts/RBW - Allows you to set the minimum number of data points that will be used inside the resolution bandwidth. The range is 0.10 to 100.00 points with 0.01 or 0.1 resolution. This key is available if **Length Ctrl** is set to **Auto**.

Window Length - Allows you to enter the FFT window length in the number of captured samples ranging from 8 to 1048576. The default setting is 706. This length represents the actual quantity of I/Q samples that are captured for the FFT processing. This key is available if **Length Ctrl** is set to **Man**.

FFT Length - Allows you to enter the FFT length in the number of captured samples ranging from 8 to 1048576. The default setting is 4096. The FFT length setting is automatically limited to equal to or greater than the FFT window length setting. Any amount greater than the window length is implemented by zero-padding. This key is available if **Length Ctrl** is set to **Man**.

ADC Range - Allows you to access the following selection menu to set one of the ADC ranging functions.

Auto - The ADC range is automatically set. For most FFT spectrum measurements, the auto feature should not be selected. An exception is when measuring a “bursty” signal, in which case auto can maximize the time domain dynamic range, if FFT results are less important to you than time domain results.

Auto Peak - The ADC range is automatically set to the highest peak signal level. Auto peak is a compromise that works well for both CW and bursted signals.

Auto Peak Lock - The ADC range is automatically adjusted to and held at the peak signal level, even when that peak signal is no longer present. Auto peak lock is more stable than auto peak for CW signals, but should not be used for “bursty” signals.

Manual - Allows you to access the selection menu: –**6 dB**, **0 dB**, **+6 dB**, **+12 dB**, **+18 dB**, **+24 dB**, to set the ADC range level. Also note that manual ranging is best for CW signals.

Data Packing - Allows you to access the following selection menu to set one of the data packing methods.

Auto - Data is automatically packed. This is the default setting and most recommended.

Short (16 bit) - Data is packed by every 16 bits.

Medium (24 bit) - Data is packed by every 24 bits.

Long (32 bit) - Data is packed by every 32 bits.

ADC Dither - Allows you to set the ADC dither function to **Auto**, **On**, or **Off**. When set to auto, ADC dither will be activated when a narrow bandwidth is being measured, and deactivated when a wide bandwidth is being measured. “ADC dither” refers to the introduction of noise to the digitized steps of the analog-to-digital converter; the result is an improvement in amplitude accuracy. Use of ADC dither, however, reduces the dynamic range by approximately 3 dB.

Decimation - Allows you to toggle the decimation function between **Auto** and **Man**, and to enter a decimation value ranging from 0 to 1000 if set to **Man**. The default setting is the preferred setting, and the only setting that guarantees aliasing-free FFT spectrum measurements. If you are familiar with the decimation feature you can change the decimation value by setting to **Man**, but be aware that aliasing can result in higher values.

IF Flatness - Allows you to toggle the IF flatness feature between **On** and **Off**. When toggled to **On**, the IF flatness feature causes background amplitude corrections to be performed on the FFT spectrum. The **Off** setting is used for adjustment and troubleshooting the transmitter tester.

Changing the View

The **View/Trace** key is used to activate a measurement view with preset X and Y scale parameters, called a "window". Using the **Span X Scale** and **Amplitude Y Scale** keys you can then modify these settings. You can also activate one specific trace using the **Trace Display** key.

Windows Available for Spectrum Measurements

The spectrum and I/Q waveform windows can be viewed at the same time or individually. You can use the **Next Window** and **Zoom** keys to move between these views.

Spectrum - Select this window if you want to analyze frequency and power. Changes to frequency span or power will sometimes affect data acquisition.

I/Q Waveform - Select this window to view the I and Q signal characteristics of the current measurement in parameters of voltage and time.

NOTE For the widest spans, such as 4.5 MHz and greater, the I/Q waveform window becomes just "ADC time domain samples", because the I/Q down-conversion is no longer in effect.

Using the Markers

The **Marker** front-panel key accesses the menu to configure the markers. If you want to use the marker function in the I/Q waveform window, press **View/Trace**, **I/Q Waveform**, **Marker**, **Trace**, **IQ Waveform**.

- **Select** - Allows you to activate up to four markers with the corresponding numbers, respectively. The selected number is underlined and its function is defined by pressing the **Function** key. The default setting is 1.
- **Normal** - Allows you to activate the selected marker to read the frequency and amplitude of the marker position on the spectrum trace, for example, which is controlled by the RPG knob.
- **Delta** - Allows you to read the differences in frequencies and amplitudes between the selected marker and the next.
- **Function** - Allows you to set the selected marker function to **Band Power**, **Noise**, or **Off**. The default setting is **Off**. If set to **Band Power**, you need to select **Delta**. If set to **Noise**, you need to select **Normal**.
- **Trace** - Allows you to place the selected marker on the **Spectrum**, **Spectrum Avg**, or **I/Q Waveform** trace. The default setting is **Spectrum**.
- **Off** - Allows you to turn off the selected marker.

- **Shape** - Allows you to access the menu to set the selected marker shape to **Diamond**, **Line**, **Square**, or **Cross**. The default setting is **Diamond**.
- **Marker All Off** - Allows you to turn off all of the markers.

Example: Band Power Measurement

A band power measurement using the markers calculates the average power between two adjustable markers. To make a band power measurement:

Step 1. Press the **Marker** key.

Step 2. Press **Trace**, **Spectrum** to activate a marker on the instantaneous spectrum trace.

Step 3. Press **Function** and select **Band Power**.

Step 4. Two marker lines are activated at the extreme left side of the horizontal scale. Press **Normal** and move marker 1 to the desired place by rotating the RPG knob.

Step 5. Press **Delta** to bring marker 2 to the same place as marker 1.

Step 6. Move marker 1 to the other desired position by rotating the RPG knob. Example: “`Pwr Mkrs: 1, 2: 4.084 MHz –10.61 dBm`” displayed in the upper right corner of the spectrum window.

For a full description of the marker features see the user’s guide for your instrument.

Troubleshooting Hints

The spectrum measurement, along with the error vector magnitude measurements, can reveal several faults in the transmitter section, such as the I/Q baseband generator, filters, modulators and power amplifier, of the UUT.

Making the Waveform (Time Domain) Measurement

Purpose

The waveform measurement is a generic measurement for viewing waveforms in the time domain. This measurement is how the instrument performs the zero span functionality found in traditional spectrum analyzers. Also available under the basic waveform measurement is an I/Q waveform window that shows the I and Q signals with voltage and time parameters. The advantage of having an I/Q view available during waveform measurements is that it allows you to view complex components of the same signal without changing settings or measurements.

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

Measurement Method

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

Making the Measurement

NOTE The factory default settings provide a good starting point. For special requirements, you may need to change some of the settings. Press **Meas Setup**, **More (1 of 2)**, **Restore Meas Defaults** at any time to return all parameters for the current measurement to their default settings.

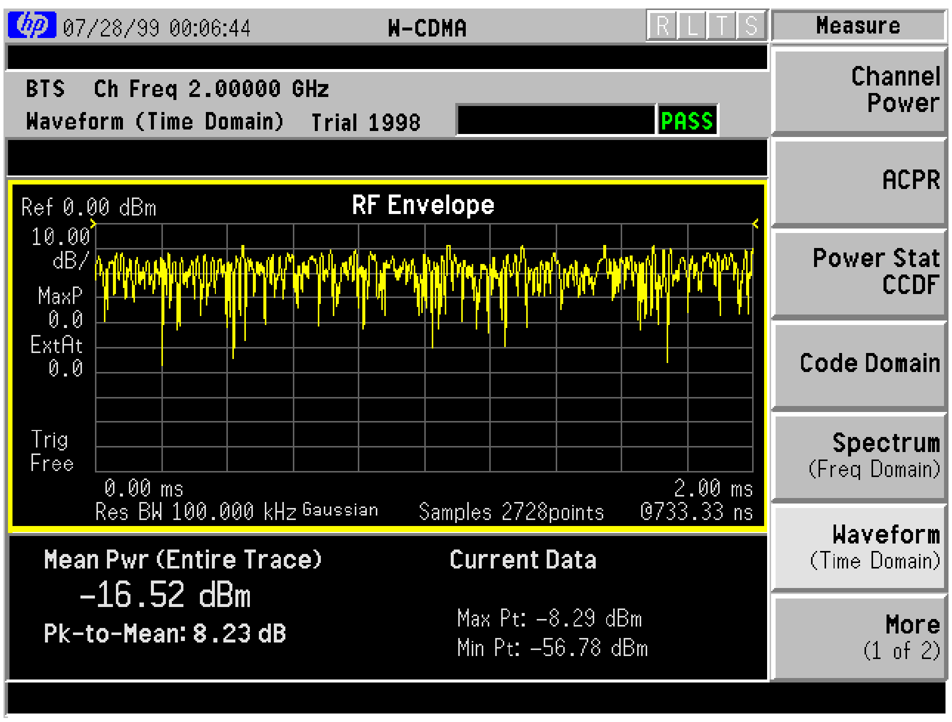
Press **Measure**, **Waveform (Time Domain)** to immediately make a waveform (time domain) measurement.

To change any of the measurement parameters from the factory default values, refer to "Changing the Measurement Setup" on page 105 for this measurement.

Results

A display with the RF Envelope window and measured data window will appear when you activate a waveform (time domain) measurement. Figure 3-15 shows an example of the waveform (time domain) measurement.

Figure 3-15 Waveform Measurement - RF Envelope Window



Changing the Measurement Setup

The next table shows the factory default settings for waveform (time domain) measurements.

Table 3-8 Waveform (Time Domain) Measurement Defaults

Measurement Parameter	Factory Default Condition
View/Trace	RF Envelope
Meas Setup:	
Sweep Time	2.00 ms
Res BW	100.000 kHz
Average: Avg Number Avg Mode Avg Type	 10, Off Exp Pwr Avg (RMS)
Trig Source	Free Run (Immediate)
RF Envelope	
Amplitude Y Scale: Scale/Div Ref Position	 10.00 dB Top
I/Q Waveform	
Amplitude Y Scale: Scale/Div Ref Position	 60.0 mV Ctr
Advanced	
Pre-ADC BPF	Off
RBW Filter	Gaussian
ADC Range	Auto
Data Packing	Auto
ADC Dither	Off
Decimation	1, Off

Make sure the **Waveform (Time Domain)** measurement is selected under the **Measure** menu. Press the **Meas Setup** key to access the menu which allows you to modify the averaging and trigger source for this measurement as described in “Measurement Setup” on page 43. In addition, the following waveform parameters can be modified:

- **Sweep Time -** Allows you to set the measurement acquisition time. The range is 1.000 µs to 100.0 s, depending upon the resolution bandwidth setting. It is used to specify the length of the time capture record.
- **Res BW** - Allows you to set the measurement resolution bandwidth. The range is 10.0 Hz to 7.50000 MHz with 1 or 10 Hz resolution. A higher resolution bandwidth results in a larger number of acquisition points, and reduces the maximum sweep time allowed.
- **Advanced** - Allows you to access the following selection menu. The FFT advanced features should be used if you are familiar with their operation. Changes from the default settings may result in invalid data.

NOTE Parameters under the **Advanced** key seldom need to be changed. Any changes from the default values may result in invalid measurement data.

Pre-ADC BPF - Allows you to toggle the pre-ADC bandpass filter between **On** and **Off**. The pre-ADC bandpass filter is useful for rejecting nearby signals, so that sensitivity within the span range can be improved by increasing the ADC range gain.

RBW Filter - Allows you to toggle the resolution bandwidth filter type between **Flat** (flat top) and **Gaussian**. The Gaussian filter provides more even time domain response, particularly for bursts. The flat top filter provides a flatter bandwidth but is less accurate for pulse responses. The flat top filter also requires less memory and allows longer data acquisition times. For most waveform applications, the Gaussian filter is recommended.

ADC Range - Allows you to access the following selection menu to set one of the ADC ranging functions:

Auto - The ADC range is automatically adjusted for optimum results. As this is the time domain measurement of the bursted signal, auto can maximize the time domain dynamic range.

Auto Peak - The ADC range is automatically adjusted to the highest peak signal level identified. Auto peak is a compromise that works well for both CW and bursted signals.

Auto Peak Lock - The ADC range is automatically adjusted to and held at the highest peak signal level, even when that peak signal is no longer present. Auto peak lock is more stable than auto peak for CW signals, but should not be used for “bursty” signals.

Manual - Allows you to access the selection menu: –**6 dB**, **0 dB**, **+6 dB**, **+12 dB**, **+18 dB**, **+24 dB**, to set the ADC range level. Also note that manual ranging is best for CW signals.

Data Packing - Allows you to access the following selection menu to set one of the data packing methods.

Auto - Data is automatically packed. This is the default setting and most recommended.

Short (16 bit) - Data is packed by every 16 bits.

Medium (24 bit) - Data is packed by every 24 bits.

Long (32 bit) - Data is packed by every 32 bits.

ADC Dither - Allows you to toggle the ADC dither function between **On** or **Off**. When set to on, the ADC dither function is activated to result in better amplitude linearity and resolution in low level signals, however, it reduces the dynamic range by approximately 3 dB.

Decimation - Allows you to toggle the decimation function between **On** and **Off**, and to enter a decimation value ranging from 1 to 4, by which the number of data points is reduced. The decimation function allows longer acquisition time into the same bandwidth by eliminating data points.

Changing the View

The **View/Trace** key is used to activate a measurement view with preset X and Y scale parameters, called a “window”. Using the **Span X Scale** and **Amplitude Y Scale** keys you can then modify these settings. You can also activate one specific trace using the **Trace Display** key.

Windows Available for Waveform Measurements

- **RF Envelope** - Select this window to view power (in dBm) vs. time. Remember that data acquisition will be affected when you change the sweep time. An illustration of an RF envelope window is found in Figure 3-15 on page 104.
- **I/Q Waveform** - Select this window to view the I and Q signal characteristics of the current measurement in parameters of voltage and time.

Using the Markers

The **Marker** front-panel key accesses the menu to configure the markers. If you want to use the marker function in the I/Q waveform window, press **View/Trace**, **I/Q Waveform**, **Marker**, **Trace**, **IQ Waveform**.

- **Select** - Allows you to activate up to four markers with the corresponding numbers, respectively. The selected number is underlined and its function is defined by pressing the **Function** key. The default setting is 1.
- **Normal -** Allows you to activate the selected marker to read the time and amplitude of the marker position on the waveform trace, for example, which is controlled by the RPG knob.
- **Delta** - Allows you to read the differences in times and amplitudes between the selected marker and the next.
- **Function** - Allows you to set the selected marker function to **Band Power**, **Noise**, or **Off**. The default setting is **Off**. Press **Band Power**, **Delta** to read the time and absolute power differences between the selected marker and the next. Press **Off**, **Delta** to read the time and relative power differences between the markers. The **Noise** function is not available for this measurement.
- **Trace** - Allows you to place the selected marker on the **RF Envelope** or the **I/Q Waveform** trace. The default setting is **RF Envelope**.
- **Off -** Allows you to turn off the selected marker.
- **Shape -** Allows you to access the menu to set the selected marker shape to **Diamond**, **Line**, **Square**, or **Cross**. The default setting is **Diamond**.
- **Marker All Off -** Allows you to turn off all of the markers.

For a full description of the marker features see the user's guide for your instrument.

Troubleshooting Hints

This waveform measurement, very often along with the adjacent carrier power measurement and/or spectrum measurement, can reveal some defective parts in the transmitter section of the UUT as follows:

- Some faults in the DC power supply control of the transmitter power amplifier, RF power controller of the pre-power amplifier stage, and/or I/Q control of the baseband stage, if the specified dynamic range is less than 80 dB.
- Some timing error from the faulty DC power on/off control circuit and other linear RF level control circuit.