Measurement Guide

Land Mobile Radio Analyzer and Coverage Measurements

for Anritsu RF and Microwave Handheld Instruments

LMR Master™

	Analyzer	Coverage
Narrowband FM	Included	Included
P25/P25p2 Signal Analysis	Option 521	Option 522
NXDN Signal Analysis	Option 531	Option 532
dPMR Signal Analysis	Option 573	Option 572
TETRA Signal Analysis	Option 581	Option 582
DMR Signal Analysis	Option 591	Option 592
PTC Signal Analysis	Option 721	Option 722

Note	Not all instrument models offer every option or every measurement within a given option. Please refer to the Technical Data Sheet of your instrument for available options and measurements within the options.

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UPDATES

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http://www.anritsu.com

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Chapter 1 — General Information

1-1 Introduction

This Measurement Guide documents Land Mobile Radio signal analysis functions of the Anritsu LMR Master handheld instrument. Anritsu currently supports measurement of Narrowband FM Analog (Chapter 2) and digital transmitter Land Mobile Radio technologies including:

P25 – Project 25 or APCO-25 (Chapter 3)
P25 Phase 2 (Chapter 4)
NXDN™ – Very Narrowband Common Air Interface (Chapter 5)
dPMR – Digital Private Mobile Radio (Chapter 6)
TETRA – Terrestrial Trunked Radio (Chapter 7)
DMR – ETSI Digital Mobile Radio (Chapter 8)
PTC – ITC-R Positive Train Control (Chapter 9)

Note	Not all instrument models offer every option or measurement mode. Please refer to your instrument technical data sheet for available options and features. The screen images and menus on your instrument may vary from what is shown in this measurement guide, and may be affected by instrument configuration, setup, and received measurement data.

Read the Handheld Instruments Product Information, Compliance, and Safety Guide (PN: 10100-00065) for important safety, legal, and regulatory notices *before* operating the equipment. For additional information and literature covering your product, visit the product page of your instrument and select the Download Library tab.

1-2 Contacting Anritsu

To contact Anritsu, please visit:

http://www.anritsu.com/contact-us

From here, you can select the latest sales, select service and support contact information in your country or region, provide online feedback, complete a “Talk to Anritsu” form to have your questions answered, or obtain other services offered by Anritsu.

Updated product information can be found on the Anritsu web site:

http://www.anritsu.com/

Search for the product model number. The latest documentation is on the product page under the Library tab.

1-3 Measurement Guide Overview

This Measurement Guide details the following functions and options:

- Chapter 2, “NBFM Analyzer”
- Chapter 3, “P25 Analyzer (Option 521)”
- Chapter 4, “P25 Phase 2 Analyzer (Option 521)”
- Chapter 5, “NXDN Analyzer (Option 531)”
- Chapter 6, “dPMR Analyzer (Option 573)”
- Chapter 7, “TETRA Analyzer (Option 581)”
- Chapter 8, “DMR Analyzer (Option 591)”
- Chapter 9, “PTC Analyzer (Option 721)”
- Chapter 10, “LMR Coverage Mapping”
- Chapter 11, “High Power Input Protection”

1-4 Selecting a Measurement Mode

Press the **Menu** button and select the measurement mode by tapping its icon on the touch screen.

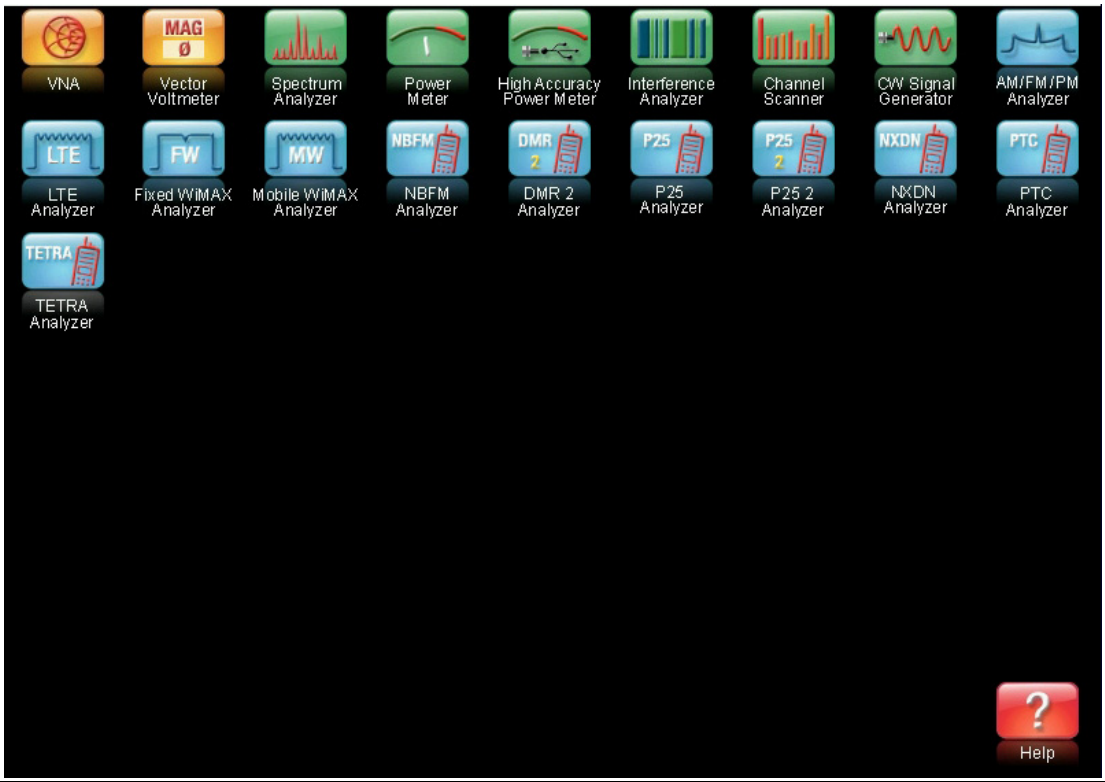


Figure 1-1. Menu Button Screen

You can also press the **Shift** key then the **Mode** (**9**) key, select the measurement from the list using the rotary knob or the **Arrow** keys, and then press **Enter**.

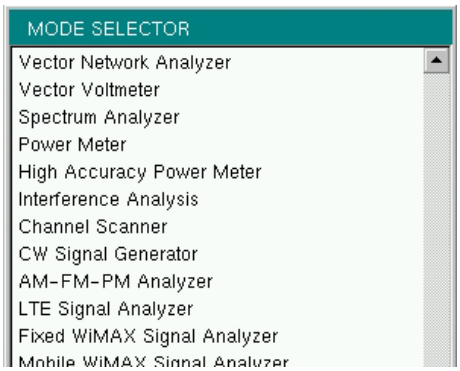


Figure 1-2. Measurement Mode Selector List

Note that the shortcut icons and modes include a selection for each application option installed in the instrument, as shipped from the factory. The Land Mobile Radio modes are: NBFM, DMR, P25, P25p2, NXDN, dPMR, PTC, and TETRA.

1-5 Multi-Screen View

The preset view in NBFM Analyzer, P25/P25p2 Analyzer, NXDN Analyzer, dPMR Analyzer, DMR Analyzer, PTC Analyzer, and TETRA Analyzer measurements is the 4 measurement view (Figure 1-3). Tap once on an individual graph to make it active (red perimeter line).

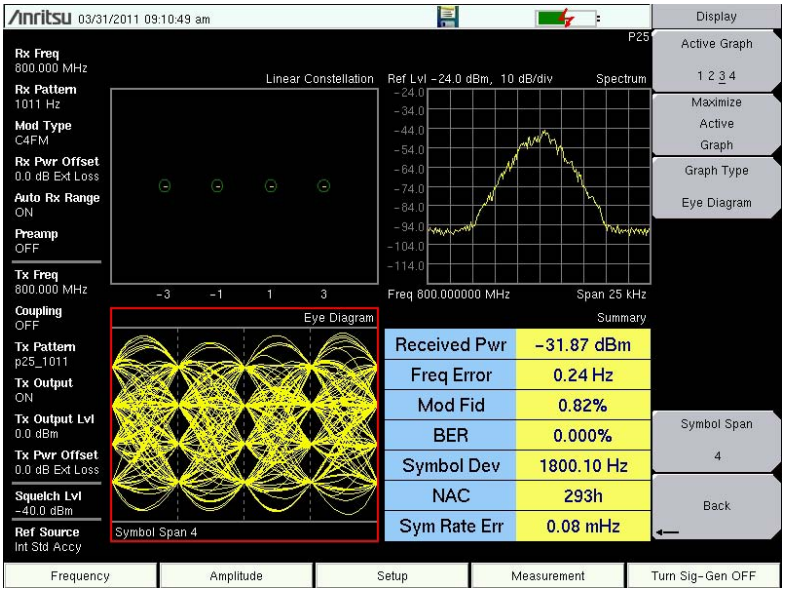


Figure 1-3. 4 Measurement View with the Eye Diagram as the Active Measurement

Tap twice on the active graph to display it in full screen view (Figure 1-4). Tap twice on the active graph again to return to 4 measurement view.

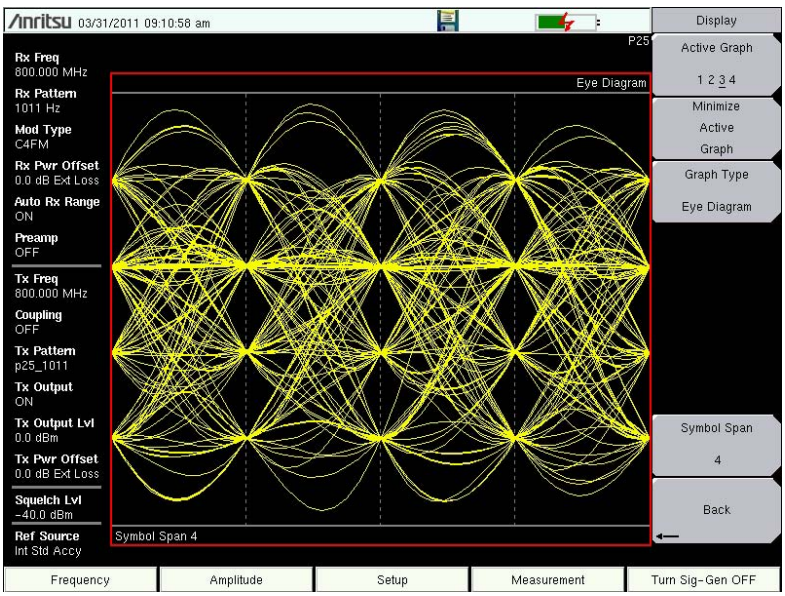


Figure 1-4. Eye Diagram as the Active Measurement in Full Screen View

The default view in Coverage Mapping (Chapter 10) is the map view.

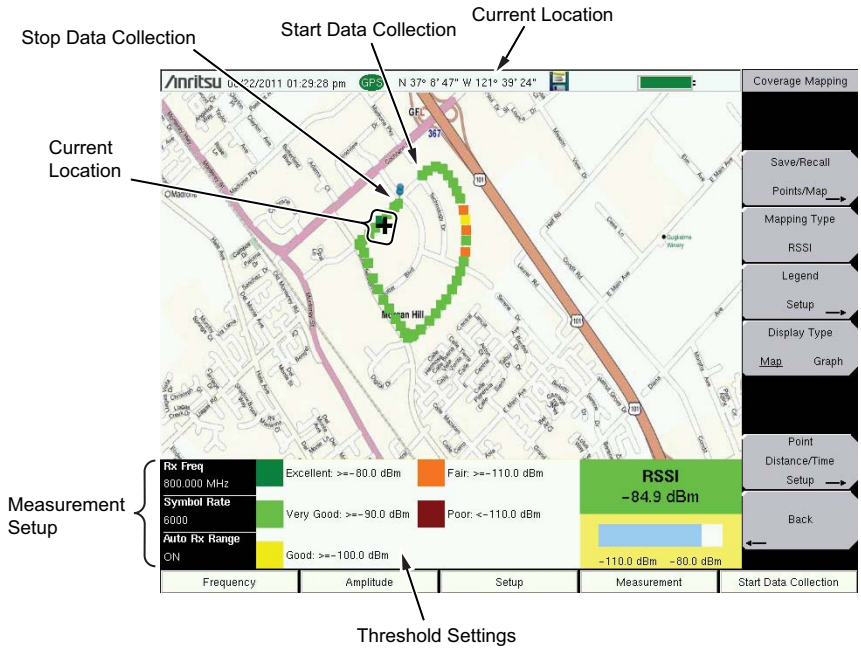


Figure 1-5. Coverage Mapping

The two measurement graph view (Figure 1-6) is also available when mapping. Tap once on a graph to make it the active graph (red perimeter line).

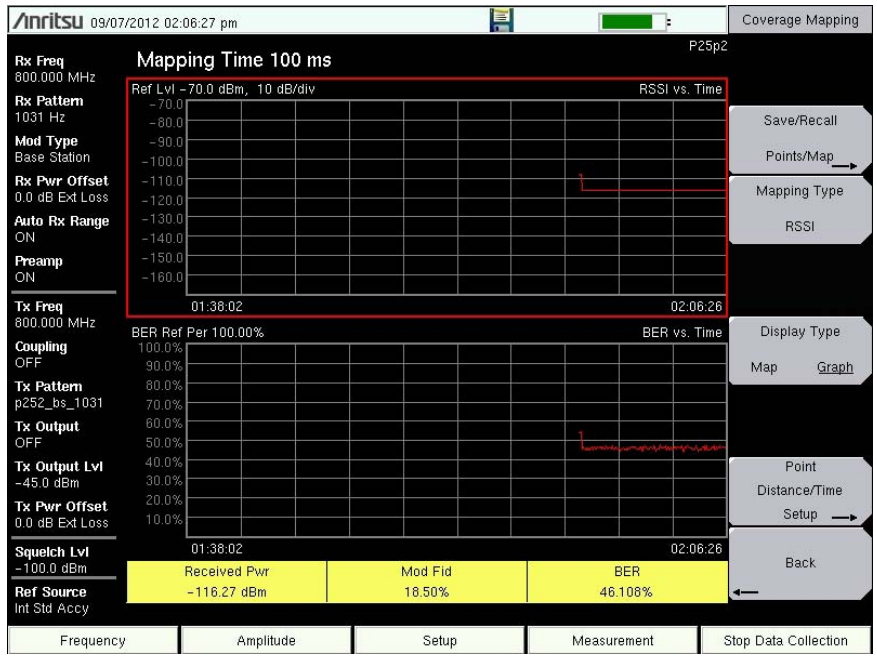


Figure 1-6. Two Measurement Mapping View with RSSI as the Active Measurement

Tap the active graph twice to display it in full screen view (Figure 1-7). Tap the active graph twice again to return to the two measurement graph view.

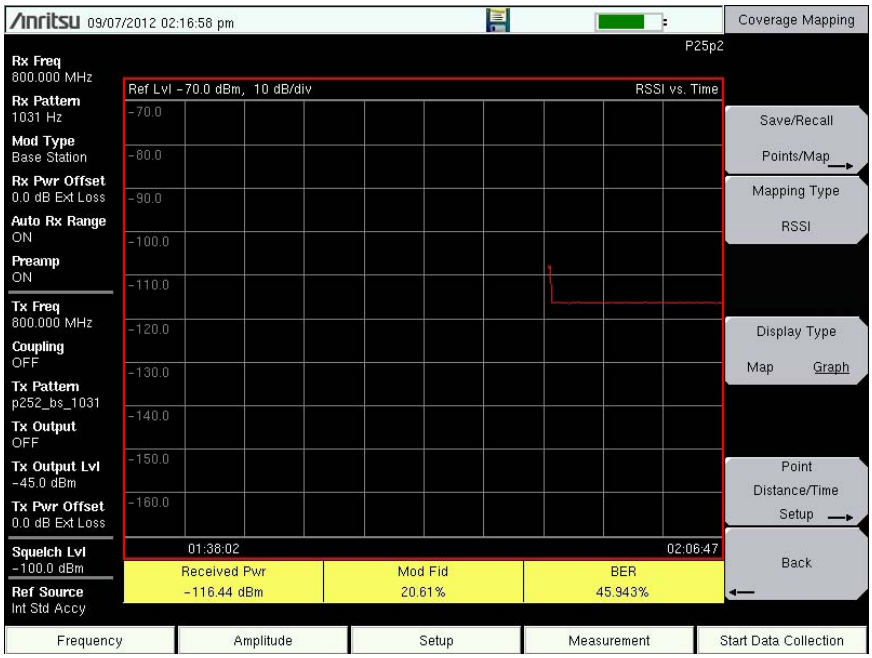


Figure 1-7. RSSI Mapping as the Active Measurement in Full Screen View

Note	Double tapping on the screen must be performed within a time limit. Experimentation will provide you with the acceptable rhythm.

1-6 Coverage Mapping

The LMR Master has several coverage mapping options:

- For NBFM, P25, P25p2, NXDN, dPMR, DMR, PTC, and TETRA coverage mapping information, refer to Chapter 10, "LMR Coverage Mapping" in this document.
- For Spectrum Analyzer and AM/FM/PM coverage mapping information, refer to the *Spectrum Analyzer Measurement Guide*. The PDF document is available on the Anritsu web site: http://www.anritsu.com.

Chapter 2 — NBFM Analyzer

2-1 Introduction

The NBFM Analyzer option provides a method to verify the operation of analog FM land mobile radios and to confirm that such radios are compliant to regulatory standards for spectrum power.

The LMR Master NBFM measurements include the ability to display frequency spectrum, audio spectrum, and the audio waveforms. In addition, a summary graph displays numeric values of Carrier Power, Carrier Frequency, Frequency Error, Frequency Deviation (peak, RMS, or Average), Modulation Rate, Signal to Noise and Distortion ratio (SINAD), Total Harmonic Distortion (THD), Occupied Bandwidth, and squelch/tone type (CTCSS, DCS, DTMF) of the input signal.

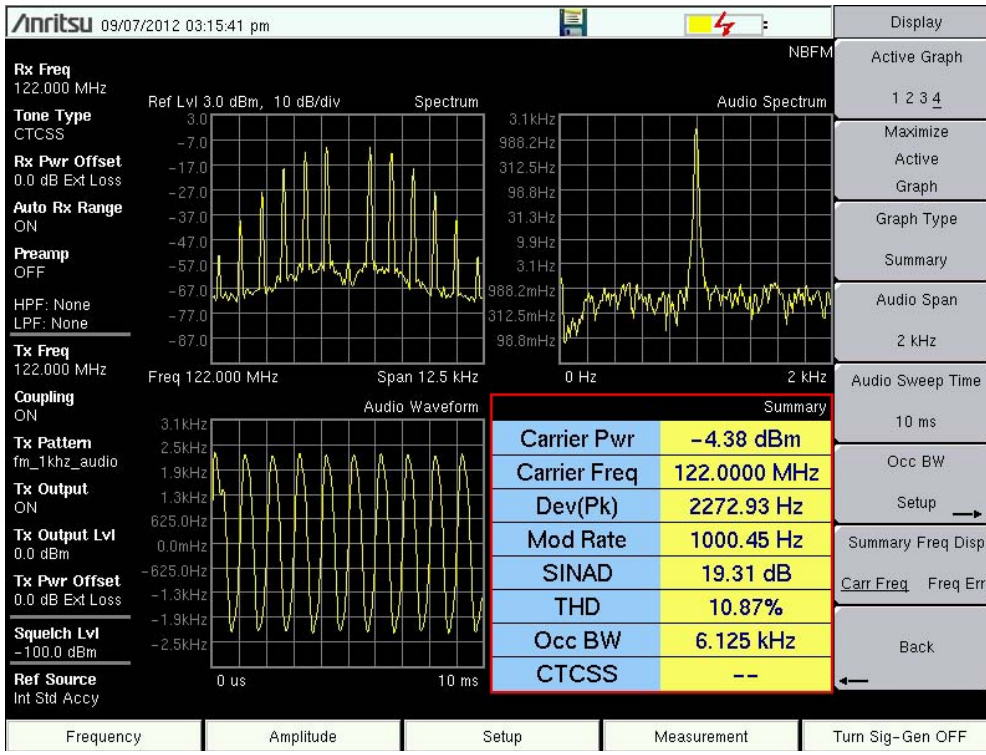


Figure 2-1. NBFM Analyzer Display

Other NBFM measurements include coverage mapping, metering of 20 dB Quieting, and metering of 12 dB SINAD.

NBFM Coverage measurements are described in Chapter 10, “LMR Coverage Mapping”. NBFM coverage allows drive-testing of analog FM LMR systems while measuring and mapping RSSI, SINAD, External SINAD, and THD parameters.

Anritsu also supports Narrowband FM Analog (Chapter 2) and digital transmitter Land Mobile Radio technologies including P25 – Project 25 or APCO-25 (Chapter 3), P25 Phase 2 (Chapter 4), NXDN™ – Very Narrowband Common Air Interface (Chapter 5), dPMR – Digital Private Mobile Radio (Chapter 6), TETRA – Terrestrial Trunked Radio (Chapter 7), DMR – ETSI Digital Mobile Radio (Chapter 8), PTC – ITC-R Positive Train Control (Chapter 9).

The LMR Master will analyze input signal strengths from +33 dBm (2.0 watts) down to levels approaching the sensitivity of LMR radios, with the ability to automatically adjust the analyzer input sensitivity based on input levels.

2-2 Transmitter Analysis Setup

1. On the LMR Master, press the **Menu** key then select the NBFM Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight NBFM Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use the Anritsu MA25200A High Power Tx/Rx Input Protector (Chapter 11), a coupler, or an attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect the transmitter to the RF In 50 Ohm connector on the LMR Master using a high power protection device, or connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Amplitude** main menu key, then the Rx Power Offset submenu key to set the attenuation (or gain) of any devices between the radio under test and the LMR Master. Use the arrow keys, rotary knob, or the numeric keypad to enter the adjustment value, up to 100 dB, and then press either the Loss or Gain submenu key. The offset will be applied to the Carrier Power value in the Summary graph. For instance, if the transmitter under test is emitting 50 watts (+47 dBm) of power, and the External Attenuation value is 40 dB (such as from a 40 dB directional coupler), then the Carrier Power displayed will be +7 dBm.
4. Press the **Frequency** main menu key to set the LMR Master receiver center frequency (Rx Freq) of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency. A second option is to use Auto Scan under the **Setup** main menu. Turn Auto Scan on and key the radio or transmitter. Auto Scan will find and display the highest power signal above +10 dBm (10 mW) between 10 MHz and 1.6 GHz in the center of the Spectrum graph. After the signal is found and displayed, set Auto Scan to Off to stop the LMR Master from scanning for a new signal.

Note	Typically, the Auto Scan feature will only work if the radio is cabled to the S412E. There is a lower-limit to the amount of power needed to make Auto Scan respond; the requirement is just above +10 dBm (10 milliwatts). This is the raw port level, the requirement increases by the amount of attenuation caused by the RF In protection device.

5. Press the **Setup** main menu key to select the tone type. Select CTCSS, DCS, or DTMF using the Tone Type key. Press the Filters submenu key and set the intermediate frequency bandwidth (IFBW) and bandwidth percentage (% IFBW). Filter the audio signal using the Low Pass Filter or High Pass Filter.
6. Press the **Measurement** key, then the NBFM Analyzer submenu key. Refer to "NBFM Analyzer Graphs" on page 2-4 for information on the available graph types.

Note	Many of the displayed settings on the left side of the screen are used as menu shortcuts. Select a setting using the touch screen to display the menu and set the parameter for editing.

2-3 Receiver Analysis Setup

1. On the LMR Master, press the **Menu** key, then select the NBFM Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight NBFM Analyzer and press **Enter**.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW (0 dBm) and the frequency range is 500 kHz to 1.6 GHz (6 GHz with Option 6).

2. Connect with required attenuation the LMR Master Signal Generator Out 50 Ohm connector to the repeater/receiver or connect an antenna with the appropriate frequency range to the LMR Master Signal Generator Out connector.
3. Press the **Amplitude** main menu key, then the Tx Output Lvl submenu key to set the output power. Enter any output attenuation or gain using the Tx Power Offset key.
4. Press the **Frequency** main menu key to set the transmit frequency using the Tx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.

   If testing a repeater, you can bind the transmit frequency to the receive frequency by setting Rx/Tx Coupling to On and entering the Coupling Offset.

Note	When Rx/Tx Coupling is On, the Tx Freq submenu key is disabled.

5. Set the transmit pattern. Press the **Setup** main menu, then the Tx Pattern submenu key.
6. As needed, adjust the pattern with the pattern specific option buttons and modulation button in the **Setup** menu (CTSS Freq, DCS Type, CTSS Freq, DTMF Tone, and FM Deviation). Additional pattern adjustments (Tone Deviation and Mod Rate) are in the More submenu. Refer to "Setup (1/2) Menu" on page 2-18 for additional information.
7. Press the **Turn Sig-Gen ON** main menu key to start the signal generator. Press the key again to turn off the signal generator.

2-4 NBFM Analyzer Graphs

The following NBFM Analyzer measurements are available on the LMR Master. From the **Measurements** main menu, press NBFM Analyzer twice. Press the Graph Type submenu key to select the measurement type.

Spectrum Graph

The spectrum view displays signal power (dBm) versus frequency. The frequency span is adjustable under the **Frequency** menu using the Span submenu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 2-16 for details. Figure 2-2 displays the same signal using a 25 kHz span and a 50 kHz span.

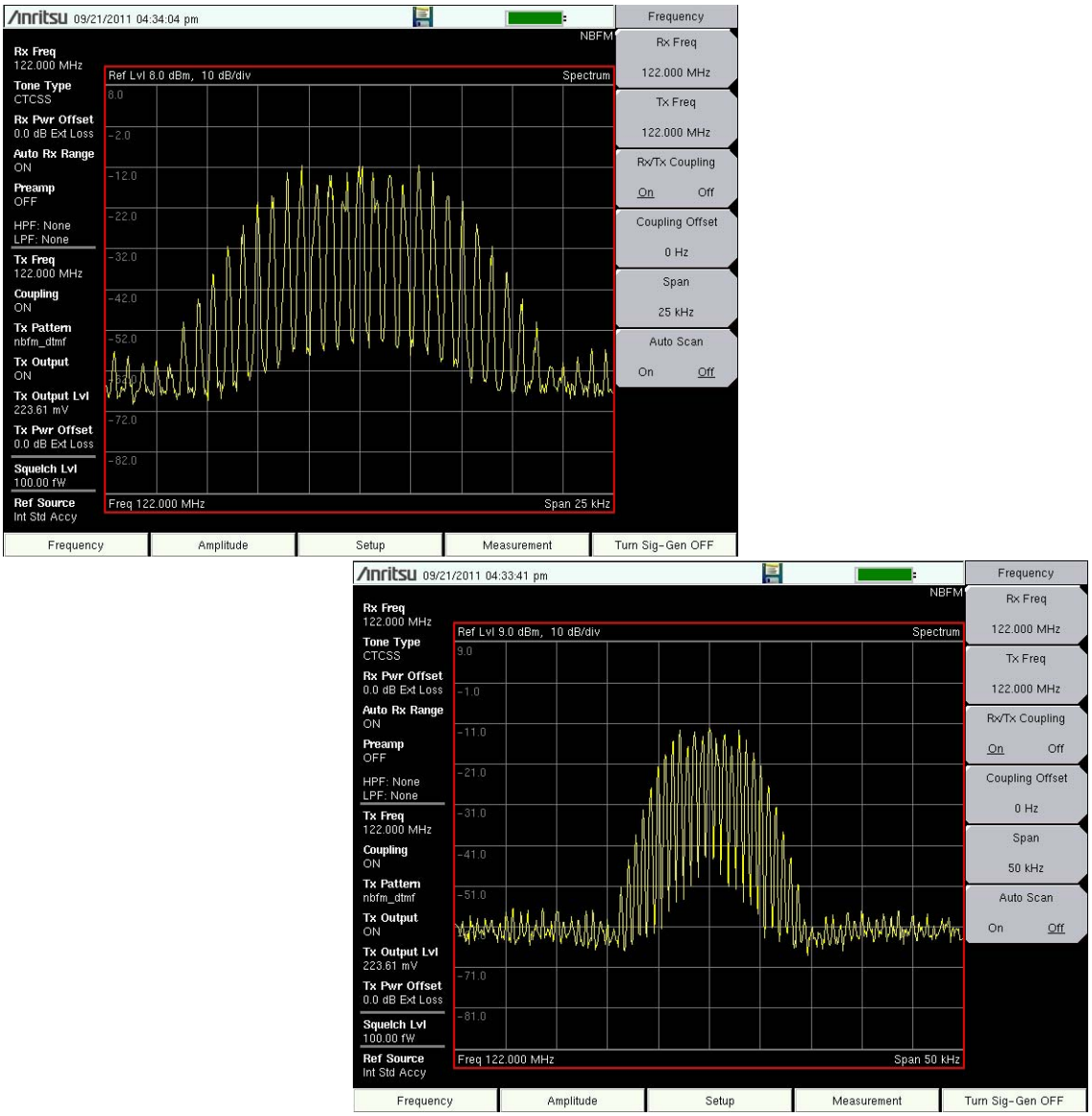


Figure 2-2. NBFM Spectrum Graph (25 kHz Span and 50 kHz Span)

Audio Spectrum Graph

The Audio Spectrum graph displays the frequency deviation in the audio. The Audio Spectrum span is adjustable in fixed increments using the Audio Span button (**Measurement** > NBFM Analyzer). The reference level setting is the product of the intermediate frequency bandwidth and percentage (**Setup** > Filters). Figure 2-3 displays the same signal using a 2 kHz span and a 10 kHz span. High Pass and Low Pass Filters are available for masking either the tone (low pass) or audio (high pass) in both the Audio Spectrum graph and Audio Waveform graph.

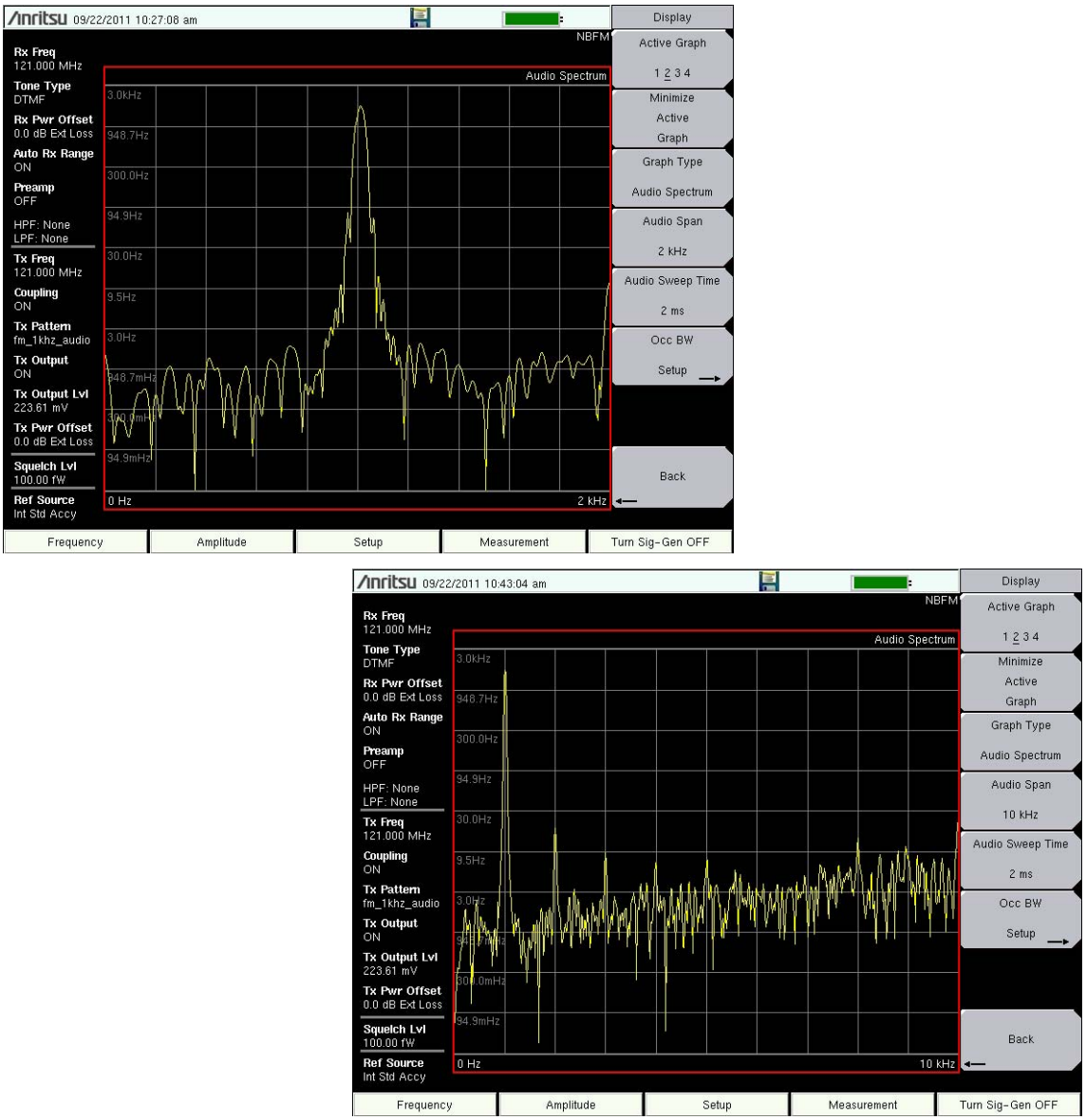


Figure 2-3. NBFM Audio Span (2 kHz and 10 kHz)

Audio Waveform Graph

The Audio Waveform graph displays a zero-span view of frequency deviation vs. time. The time span is adjustable from 50 µs to 150 ms using the Audio Sweep Time button (**Measurement** > NBFM Analyzer). The reference level setting is the product of the intermediate frequency bandwidth and percentage (**Setup** > Filters). Figure 2-4 shows a DCS tone after applying a 300 Hz low pass filter. High Pass and Low Pass Filters are available for masking either the tone (low pass) or audio (high pass) in both the Audio Spectrum graph and Audio Waveform graph.

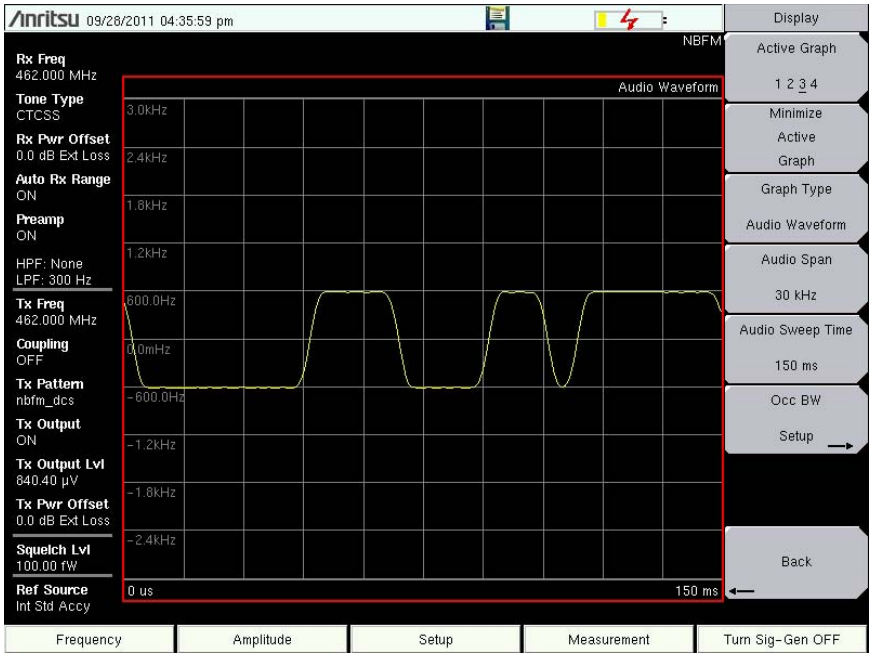


Figure 2-4. NBFM Audio Waveform Example

Summary Graph

The summary graph provides an overview of an NBFM radio transmitter. The graph displays numeric values of carrier power, carrier frequency, freq error, frequency deviation, modulation rate, Signal to Noise and Distortion ratio (SINAD), Total Harmonic Distortion (THD), occupied bandwidth, and squelch/tone type of the input signal. Select the Tone Type (CTCSS, DCS, or DTMF) under the Setup menu.

Toggle between viewing carrier frequency or frequency error using the **Measurements** > NBFM Analyzer > Summary Freq Disp submenu key.

The Carrier Power value in the summary graph can be changed between dBm, watts, and volts using the **Amplitude** > Units > Rx Units submenu key. This setting also applies to the squelch level setting.

The **Setup** > Squelch Lvl submenu key sets the squelch power level. When the carrier power is lower than the set squelch level, all summary graph measurements except for Carrier Pwr are blanked out (--). When the carrier power is above the squelch level, the measurements are displayed as shown in Figure 2-5.

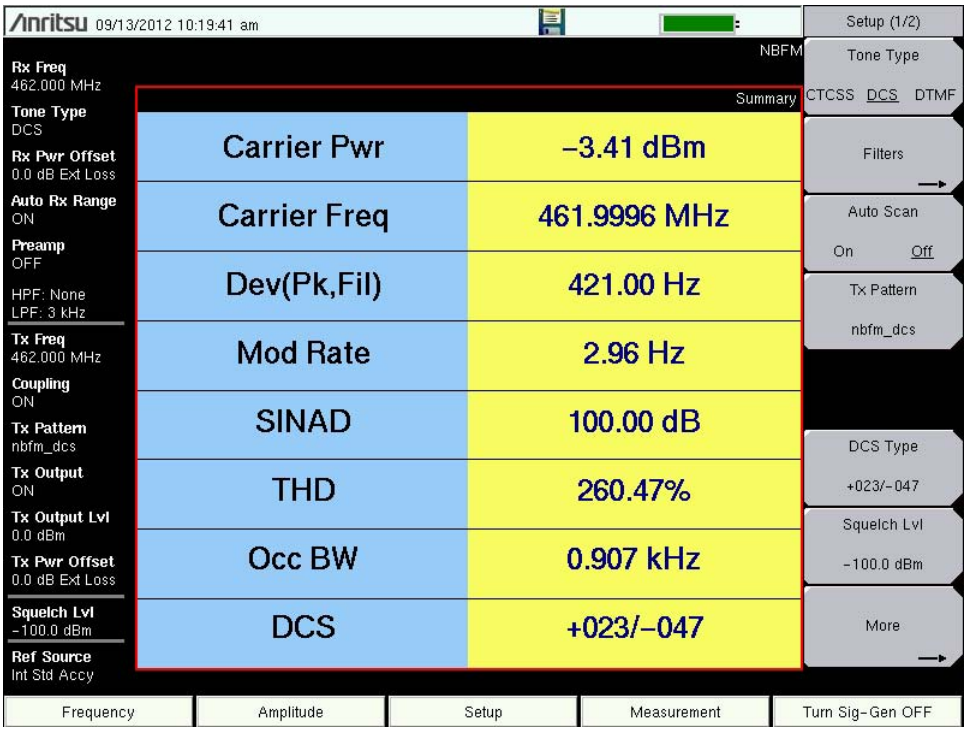


Figure 2-5. NBFM Summary Graph with Carrier Pwr Above the Squelch Level

Carrier Pwr in the Summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Carrier Pwr is a function of the instrument's RBW setting. The reduction is specified as: 10*Log(Signal Bandwidth / Resolution Bandwidth).

2-5 NBFM Coverage

Refer to Chapter 10, “LMR Coverage Mapping”.

2-6 20 dB Quieting

The LMR Master can measure FM receiver or radio sensitivity using the 20 dB quieting procedure.

1. Connect the LMR Master Signal Generator Out port to the radio antenna port. Use attenuation as required and lock out the radio transmit button during this procedure.
2. Adjust the TX Power Offset to account for the attenuation loss in the Signal Generator path.
3. Connect the LMR Master Audio In port to the radio loudspeaker or audio out connector (Figure 2-6).

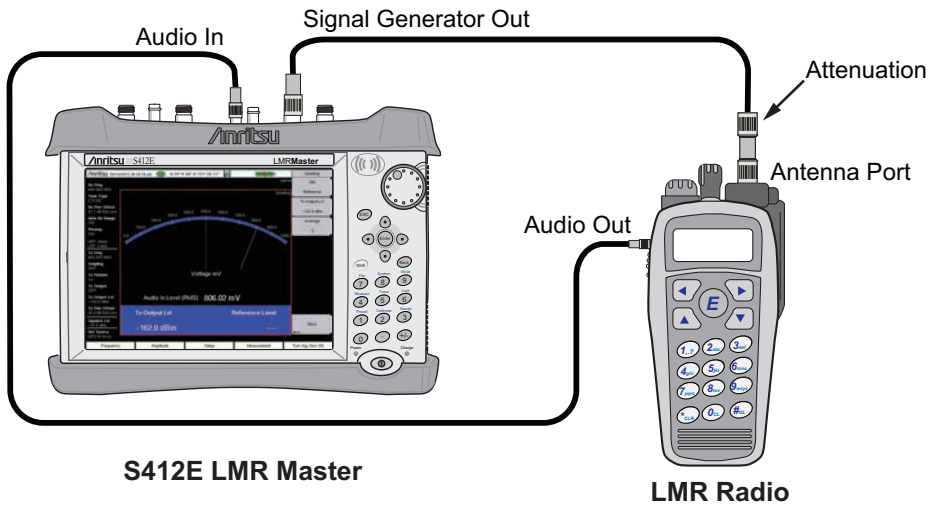


Figure 2-6. Setup for 20 dB Quieting and 12 dB SINAD

4. Set the LMR Master Tx Output Lvl to the minimum level (which will be –130 dBm + the value entered for Tx Power Offset) and the Tx Pattern to cw. Set the LMR Master Tx Freq to the radio receive frequency. Confirm that the LMR Master signal generator is Off (menu key displays **Turn Sig-Gen ON**).
5. On the LMR Master, press **Measurement** > NBFM Quieting (twice). The LMR Master displays the currently voltage at the Audio In port and the current Tx Output level setting for the LMR Master signal generator.
6. Turn on the radio and set the radio audio level to the manufacturer’s rated audio output level. The RMS voltage level present at the Audio In port is displayed below the meter for convenience. Refer to the radio maintenance manual to determine this level. This is the audio level used for measuring 20 dB quieting (Figure 2-7 on page 2-9).

7. Press the Set Reference key and note the Reference Level voltage displayed on the right side of the blue bar as shown in Figure 2-8 on page 2-10. Setting the reference will automatically adjust the voltage scale such that the voltage displayed in the middle of the meter is 10 % (–20 dB) of the reference audio voltage.
8. Press the **Turn Sig-Gen ON** main menu key to start the LMR Master transmitter.
9. Increase the LMR Master Tx Output Lvl until the needle on the voltage meter is in the center of the display (Figure 2-8). The Audio In voltage level has decreased to 10 % of the reference level. The power level displayed on the left side of the blue bar is the 20 dB quieting antenna input power level.

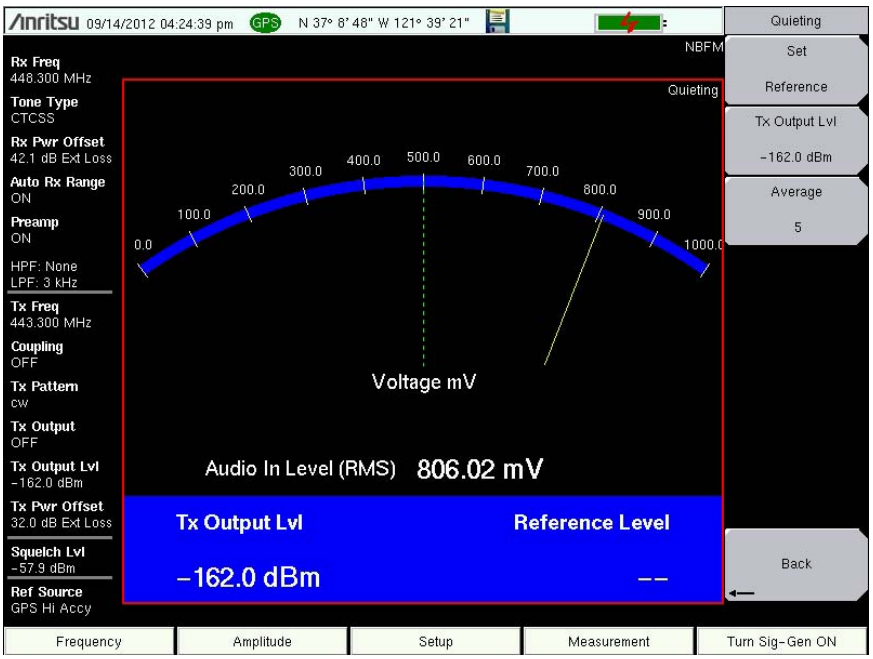


Figure 2-7. 20 dB Quieting, Ready to Set Reference Level

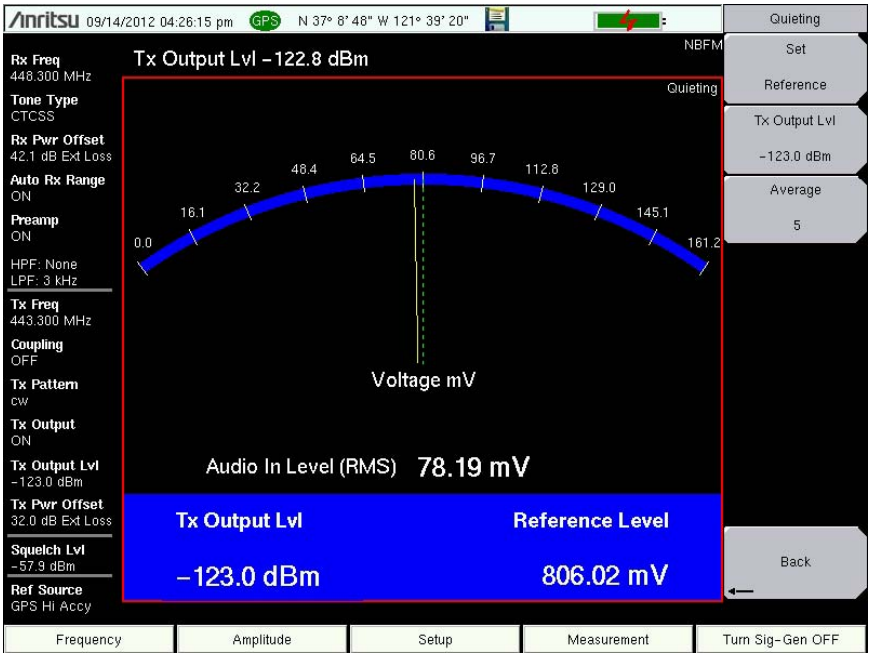


Figure 2-8. 20 dB Quieting After Increasing the LMR Master Sig-Gen Tx Output

2-7 12 dB SINAD

The LMR Master can measure FM receiver or radio sensitivity using the 12 dB SINAD procedure.

1. Connect the LMR Master Signal Generator Out port to the radio antenna port. Use attenuation as required and lock out the radio transmit button during this procedure.
2. Adjust the TX Power Offset to account for the attenuation loss in the Signal Generator path.
3. Connect the LMR Master Audio In port to the radio loudspeaker or audio out connector (Figure 2-6).
4. Set the LMR Master Tx Output Lvl to the minimum level (which will be –130 dBm + the value entered for Tx Power Offset) and the Tx Pattern to fm_1khz_audio[1] with a deviation specified by the radio manufacturer. Set the LMR Master Tx Freq to the radio receive frequency. Confirm that the LMR Master signal generator is Off (menu key displays **Turn Sig-Gen ON**).
5. On the LMR Master, press **Measurement** > NBFM Quieting (twice). The LMR Master displays the current voltage at the Audio In port, the current Tx Output level setting for the LMR Master signal generator, and current SINAD, which should be close to 0 dB.
6. Turn on the radio and set the radio audio level to the manufacturer's rated audio output level. The RMS voltage level present at the Audio In port is displayed below the meter for convenience. Refer to the radio maintenance manual to determine this level. This is the audio level used for measuring 12 dB SINAD.
7. Press the **Turn Sig-Gen ON** main menu key to start the LMR Master transmitter (Figure 2-9).
8. Increase the LMR Master Tx Output Lvl until the needle on the SINAD meter is near the center of the display and equals 12 dB (Figure 2-10). The power level displayed on the left side of the blue bar is the 12 dB SINAD level.

1. For systems that require an unmute tone in addition to the audio for 12 dB SINAD testing, use one of the following Tx Patterns:

fm_1khz_ctscc (1 kHz audio plus a CTCSS unmute tone)
or
fm_1khz_DCS (1 kHz audio plus a DCS unmute tone)

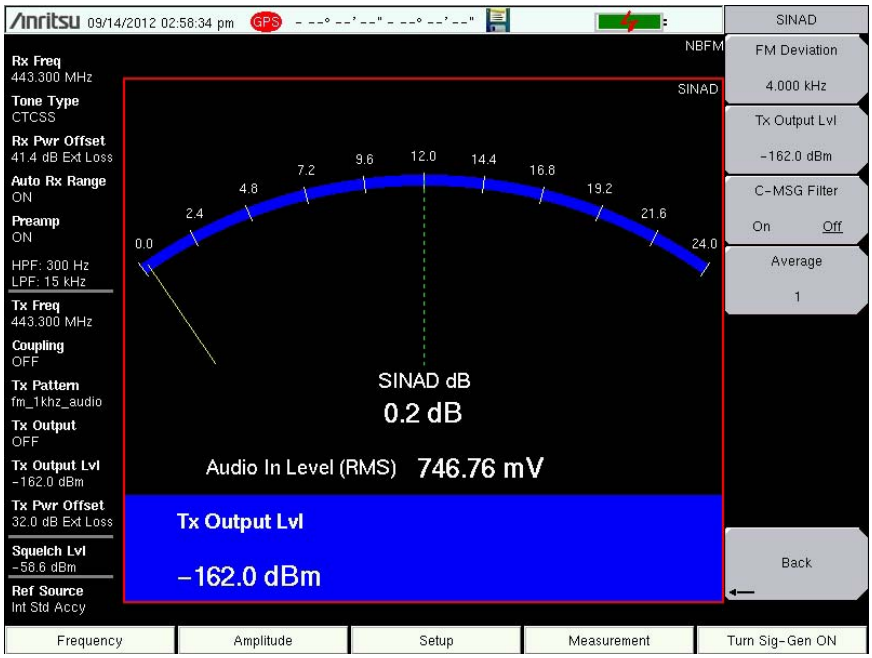


Figure 2-9. 12 dB SINAD with Signal Generator Off

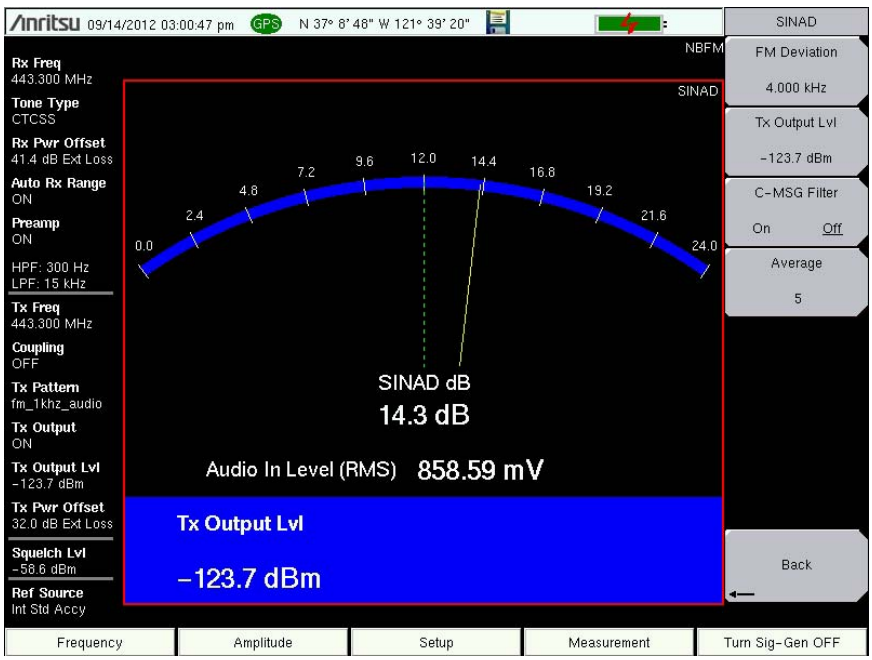


Figure 2-10. 12 dB SINAD with Signal Generator On and Meter Showing the SINAD Level

2-8 NBFM Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

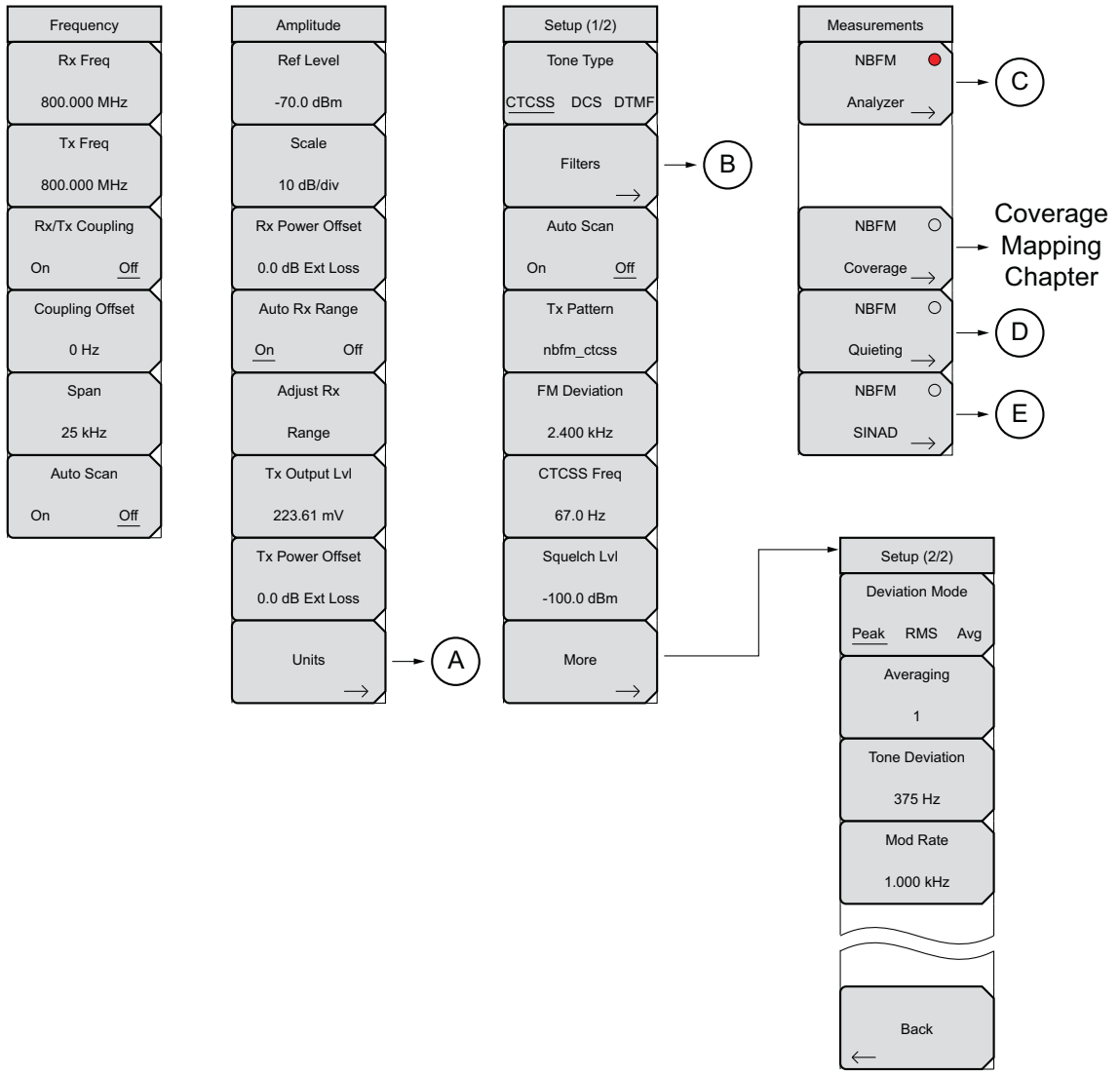


Figure 2-11. NBFM Analyzer Menu Layout (1 of 2)

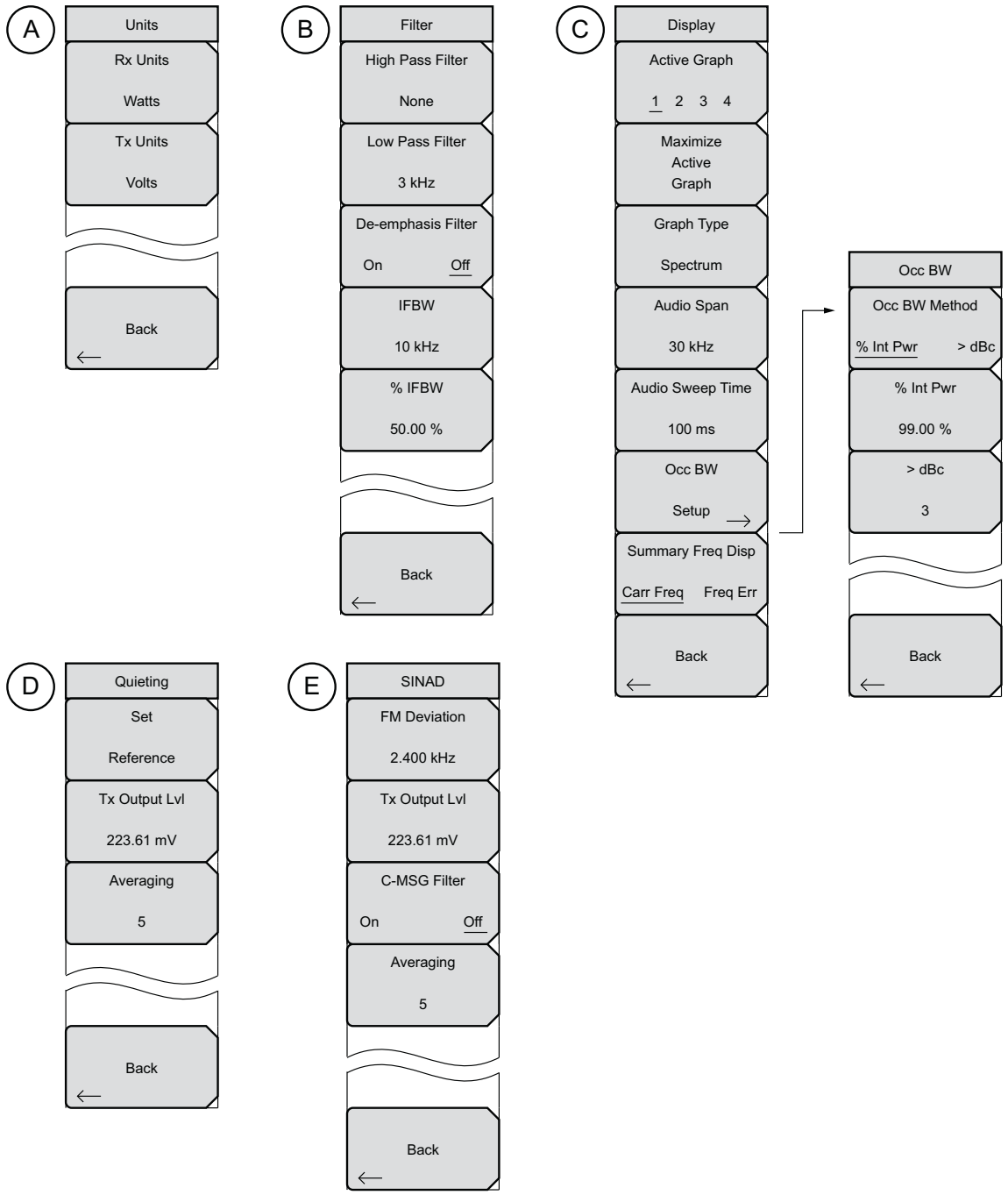
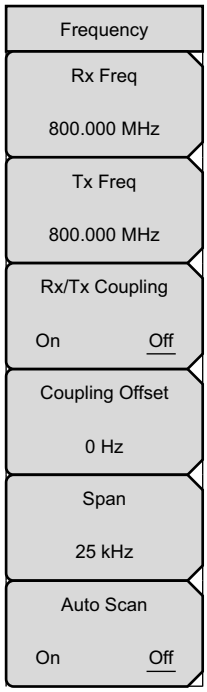


Figure 2-11. NBFM Analyzer Menu Layout (2 of 2)

Note	Many of the displayed settings on the left side of the screen are used as menu shortcuts. Select a setting using the touch screen to display the menu and set the parameter for editing.

2-9 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key (or the menu shortcut on the left side of the screen) and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, then the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press the Tx Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, then the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On, the Tx Freq key is disabled.

Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. This is functional only when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 12.5 kHz, 25 kHz, and 50 kHz.

Auto Scan: Turning Auto Scan On will cause the Rx Frequency to self-adjust to match the highest power signal detected between 10 MHz and 1.6 GHz that is above +10 dBm (10 mW) in the center of the Spectrum graph. To lock the new Rx Frequency in place, toggle Auto Scan to Off.

Figure 2-12. NBFM Analyzer Frequency Menu

2-10 Amplitude Menu

Key Sequence: **Amplitude**

Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis power scale of the Spectrum Graph. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

Note: The "Vertical Scale Menu" on page 2-17 is displayed when NBFM Coverage (**Measurement** > NBFM Coverage) is selected. This menu is not used when the NBFM Quieting or NBFM SINAD measurements are enabled.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain. The Rx Power Offset setting is displayed on the left side of the screen. The Summary graph Carrier Power and Spectrum Graph Reference Level is adjusted based on this setting.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Tx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain. The Tx Power Offset setting is displayed on the left side of the screen. The displayed Tx Output Level is adjusted based on this setting.

Units: Opens to Units Submenu.

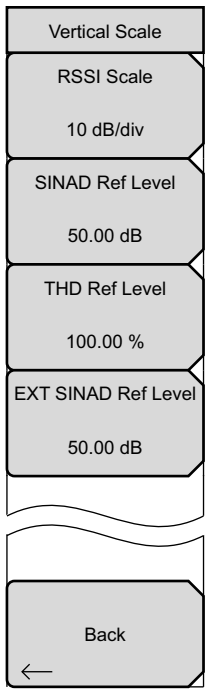
Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Summary Graph and the Squelch Level.

Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 2-13. NBFM Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale



RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. This setting is not used when the NBFM Quieting or NBFM SINAD measurements are enabled.

SINAD Ref Level: Sets the reference power level at the top of the y-axis power scale of the SINAD vs. Time graph in Coverage measurement. Enter a value from 0 dB to 100 dB using the keypad, the arrow keys, or the rotary knob.

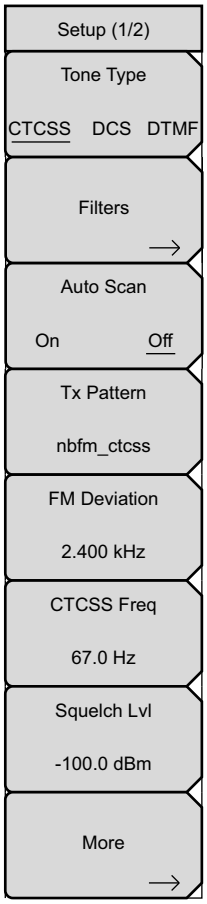
THD Ref Level: Sets the Total Harmonic Distortion reference percentage value in Coverage measurement. Enter a value from 0.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

EXT SINAD Ref Level: Sets the External SINAD reference power level in Coverage measurement. Enter a value from 0 dB to 100 dB using the keypad, the arrow keys, or the rotary knob.

Figure 2-14. Vertical Scale Menu

2-11 Setup (1/2) Menu

Key Sequence: **Setup**



Tone Type: Sets the information displayed in the last row of the Summary table. Select Continuous Tone-Coded Squelch System (CTCSS) for transmitters or radios using an analog squelch system. Select Digital Coded Squelch (DCS) for systems using digital squelch settings.

Select DTMF and the LMR Master will decode the Dual-tone multi-frequency signalling sent by the radio or transmitter.

Note: The frequency range for all 3 tone types is below the minimum spectrum display of the LMR Master in NBFM mode and also has no effect on the Tx Pattern selection.

Filters: Opens the "Filters Menu" on page 2-20.

Auto Scan: Turning Auto Scan On causes the Rx Frequency to self-adjust to match the highest power signal detected between 10 MHz and 1.6 GHz that is above +10 dBm (10 mW) in the center of the Spectrum graph. To lock the new Rx Frequency in place, toggle Auto Scan to Off. This is available only in NBFM Analyzer measurements.

Tx Pattern: Selects the transmitter pattern to send when the **Turn Sig-Gen ON** main menu key is selected. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**.

Patterns include CW, CTCSS, DCS, DTMF, AM, and FM.

CTCSS adds a low-pitch audio tone (selectable between 67 Hz to 254 Hz) on the transmitted signal. When CTCSS is selected as the Tx pattern, a submenu is displayed to set the CTCSS frequency, and the Tone Deviation is set using the More submenu.

DCS superimposes a continuous stream of frequency shift keying (FSK) digital data on the transmitted signal at 134.4 bits per second. This data is referred to as a DCS word and is 23 bits. When DCS is selected as the Tx pattern, a submenu is displayed to set the DCS Type, and the Tone Deviation is set using the More submenu.

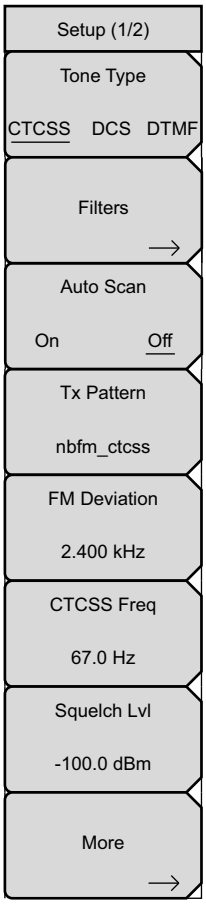
When DTMF is selected as the Tx pattern, a DTMF digit (0 to 9, A to D, *, or #) is added to the transmitted signal. The digital consist of paired tones: a row tone (697 Hz to 941 Hz) and a column tone (1209 Hz to 1633 Hz). The DTMF Tone submenu is displayed to set the DTMF Tone. Set the FM Deviation and the Tone Deviation using the More submenu.

When AM is selected as the Tx pattern, a submenu is displayed to set the percentage of Amplitude modulation. The range is 0 % to 100 %.

When FM is selected as the TX pattern, a submenu is displayed to set the cycle count of the frequency deviation. The range is 0 Hz to 100 kHz.

Figure 2-15. NBFM Analyzer Setup Menu

Setup (1/2) Menu (continued)



FM Deviation/AM Percentage: Display of this menu is based on the selected Tx Pattern.

When AM is selected as the Tx pattern, a submenu is displayed to set the percentage of Amplitude modulation. The range is 0 % to 100 %.

When FM or DTMF is selected as the Tx pattern, a submenu is displayed to set the cycle count of the frequency deviation. The range is 0 Hz to 100 kHz.

CTCSS Freq/DCS Type/DTMF Done: Display of this menu is based on the selected Tx Pattern.

When CTCSS is selected as the Tx pattern, press the CTCSS submenu key to set the CTCSS frequency.

When DCS is selected as the Tx pattern, press the DCS Type submenu key to set the DCS Type.

When DTMF is selected as the Tx pattern, press the DTMF Tone submenu to set the DTMF character to transmit.

Note: The Tone Type submenu (top of Setup 1/2) is for the LMR Master receiver and has no effect on the Tx patterns.

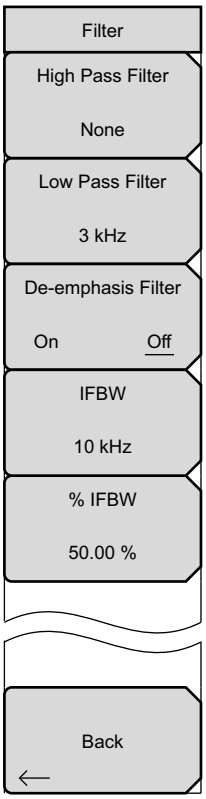
Squelch Lvl: Sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--).

More: Opens the “Setup (2/2) Menu” on page 2-21.

Figure 2-16. NBFM Analyzer Setup Menu

Filters Menu

Key Sequence: **Setup** > Filters



High Pass Filter: Displays a dialog box to select the cutoff frequency for the high pass filter (attenuates frequencies below the cutoff setting). Cutoff frequency options are: None (default), 300 Hz, or 3 kHz.

Low Pass Filter: Displays a dialog box to select the cutoff frequency for the low pass filter (attenuates frequencies above the cutoff setting). Cutoff frequency options are: None, 300 Hz, 3 kHz (default), or 15 kHz.

Filtering adjusts the display in both the Audio Spectrum and Audio Waveform graphs. In addition, filtering will effect the Deviation and possibly the Mod Rate values in the Summary table.

De-emphasis Filter: This filter produces a 6 dB/octave frequency response, with a cutoff frequency of 212 Hz. FCC rules state that Part 90 analog FM systems must support the use of a 750 µs pre/de-emphasis filter to allow older PM radios to communicate with narrowband FM radios.

IFBW: . Displays a dialog box to select the intermediate frequency bandwidth. Bandwidth options are: 5 kHz, 6.25 kHz, 10 kHz, 12.5 kHz, 30 kHz (default), or 50 kHz.

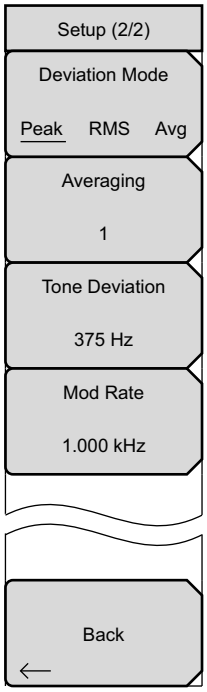
% IFBW: Scales the IFBW between 1 % to 100 %.

Back: Returns to the “Setup (1/2) Menu” on page 2-18.

Figure 2-17. NBFM Filters Menu

Setup (2/2) Menu

Key Sequence: **Setup** > More



Deviation: Sets the deviation mode displayed in the NBFM Analyzer measurement Summary table (third row down). Rotates between Peak Deviation, RMS deviation, and Average deviation.

Averaging: Sets the refresh rate of the numerical values in the NBFM Summary window. Setting a higher number (25 maximum) will reduce measurement jitter.

Tone Deviation: Sets the cycle count of the tone deviation. The range is 0 Hz to 100 kHz.

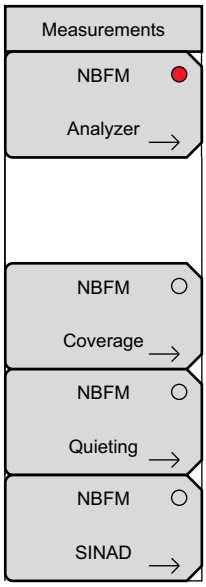
Mod Rate: Use this menu to change the default 1 kHz modulation rate.

Back: Returns to the “Setup (1/2) Menu” on page 2-18.

Figure 2-18. NBFM Filter Menu

2-12 Measurement Menu

Key Sequence: **Measurement**



NBFM Analyzer: Opens the “Display Menu” on page 2-23.

NBFM Coverage (Option 722 required): Opens the NBFM Coverage menu. Refer to Chapter 10, “LMR Coverage Mapping”.

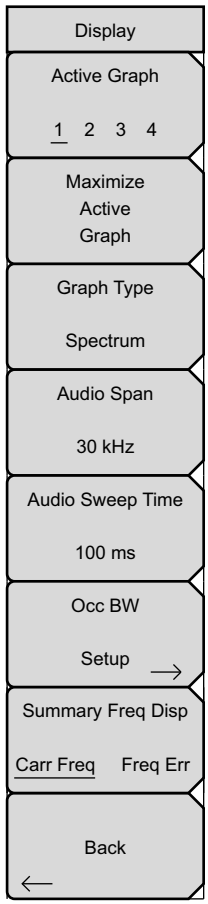
NBFM Quieting: Opens the “Quieting Menu” on page 2-24.

NBFM SINAD: Opens the “SINAD Menu” on page 2-25.

Figure 2-19. NBFM Analyzer Measurement Menu

Display Menu

Key Sequence: **Measurement** > NBFM Analyzer



Active Graph 1 2 3 4: In Four Screen view, use this menu key to make the next graph (1 2 3 4) active. The current active graph is underlined and has a red perimeter line. Any of the four graphs can also be made active by tapping once on the touch screen.

In Standard view (one graph displayed on the screen), the Active Graph key will change the display to the next graph type.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four Screen view (4 graphs) and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this button displays the current active graph type. Pressing the button displays the list of graph types available for NBFM Analyzer measurements. Select the desired graph type with the arrow keys or rotatory knob and press **Enter**. The current active graph will be replaced with the new selection.

The four available graphs are displayed in the preset view: Spectrum, Audio Spectrum, Audio Waveform, and Summary.

Refer to "NBFM Analyzer Graphs" on page 2-4 for additional information.

Audio Span: Use this menu to set the frequency span of the Audio Spectrum graph. Adjust using the predefined increments from 0.3 kHz to 30 kHz using the arrow keys, rotary knob, or the touchscreen.

Audio Sweep Time: Use this menu to set the time length of the Audio Waveform graph. Adjust from 50 µs to 150 ms using the arrow keys, rotary knob, or the keypad.

Summary Freq Disp: Use this menu to select which of the parameters (Carrier Frequency or Frequency Error) is displayed in the second row of the Summary graph.

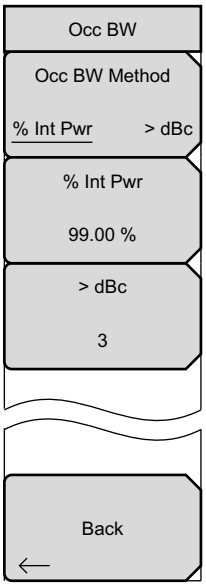
Occ BW: Displays the "Occ BW Method Menu" on page 2-24.

Back: Returns to the "Measurement Menu" on page 2-22.

Figure 2-20. NBFM Analyzer Display Menu

Occ BW Method Menu

Key Sequence: **Measurement** > NBFM Analyzer > Occ BW Setup



Occ BW Method: Toggle between % Int Pwr or > dBc.

When using % integrated power method, the occupied frequency bandwidth is calculated as the bandwidth containing the specified percentage of the transmitted power.

When using > dBc method, the occupied bandwidth is defined as the bandwidth between the upper frequency and lower frequency at which the signal level is a desired number of dB below the peak carrier level.

% Int Pwr: Use the keypad, the directional arrow keys, or the rotary knob to enter the percent of power, from 0 % to 100 %. Only active when the Occ BW Method is set to % Int Pwr.

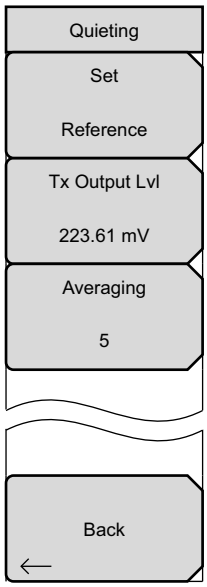
> dBc: Use the keypad, the directional arrow keys, or the rotary knob to enter the dBc value (0 dBc to 100 dBc). Only active when the Occ BW Method is set to > dBc.

Back: Returns to the "Display Menu" on page 2-23.

Figure 2-21. NBFM Analyzer Display Menu

Quieting Menu

Key Sequence: **Measurement** > NBFM Quieting



Set Reference: Sets the reference level for FM sensitivity testing.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

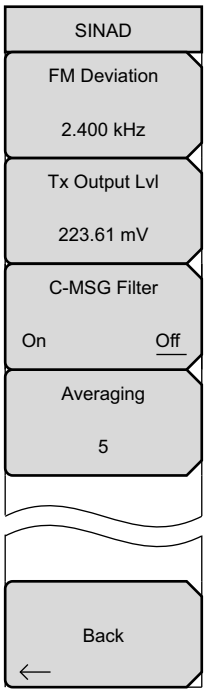
Average: Sets the refresh rate of the measurement. Setting a higher number (10 maximum) will dampen the needle movement and reduce measurement jitter.

Back: Returns to the "Measurement Menu" on page 2-22.

Figure 2-22. NBFM Analyzer Display Menu

SINAD Menu

Key Sequence: **Measurement** > NBFM SINAD



FM Deviation: Set the cycle count of the frequency deviation. The range is 0 Hz to 100 kHz.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

C-MSG Filter: Toggle the C-MSG Filter On or Off. The audio passband frequency response curve of the filter simulates the human ear response to radio noise.

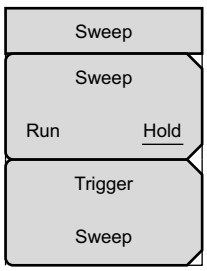
Average: Sets the refresh rate of the measurement. Setting a higher number (10 maximum) will dampen the needle movement and reduce measurement jitter.

Back: Returns to the "Measurement Menu" on page 2-22.

Figure 2-23. NBFM Analyzer Display Menu

2-13 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Figure 2-24. NBFM Analyzer Sweep Menu

2-14 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Display the "Measurement Menu" on page 2-22.

2-15 Trace Menu

This menu is not available in NBFM Analyzer measurement mode.

2-16 Limit Menu

This menu is not available in NBFM Analyzer measurement mode.

2-17 Other Menus

Preset, **Calibrate**, **File**, **System**, and **Mode** are described in the User Guide.

Chapter 3 — P25 Analyzer (Option 521)

Note	Option 521 include P25 demodulation (this Chapter) and P25 Phase 2 demodulation (Chapter 4).

3-1 Introduction

The P25 Analyzer option provides a method to verify the operation of APCO Project 25 (P25) and Linear Simulcast Modulation (LSM) tower, mobile, and portable radio transmitters. Option 521 includes the ability to display constellations, spectrum, histogram, and eye diagram graphs. In addition, a summary graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), bit error rate (BER), symbol deviation, Network Access Code (NAC), and symbol rate error of the input signal. BER comparisons can be made to the Standard Tone or the Standard Transmitter Test (O.153) pattern, regular voice traffic using a proprietary algorithm, or a Message Error Rate (MER) can be computed using the control channel messages CRC checking. In addition, estimated BER on the control channel uses a proprietary algorithm.

The LMR Master will analyze input signal strengths from +33 dBm (2.0 watts) down to levels approaching the sensitivity of P25 radios, with the ability to automatically adjust the input sensitivity based on input levels.

3-2 Setup Procedure

Direct Connect to the Transmitter

1. Press the **Menu** key, then select the P25 Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight P25 Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use the Anritsu MA25200A High Power Tx/Rx Input Protector (Chapter 11), a coupler, or an attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect the transmitter to the RF In 50 Ohm connector on the LMR Master using a coupler or attenuator.
3. Press the **Frequency** main menu key to set the receiver center frequency (Rx Freq) of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.

4. Press the **Setup** main menu key to select the modulation type and Rx pattern. Select C4FM modulation for Phase I systems or CQPSK for Phase II and LSM systems. Press the Rx pattern key to choose the pattern against which to measure error rates. 1011/1031 Hz and O.153 (V.52) will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Ctrl Channel will produce a Message Err Rate (MER) based on the CRC checksums contained in Control Channel messages and estimated BER using a proprietary algorithm.
5. Press the **Amplitude** main menu key, then the Rx Power Offset submenu key to set the receiver attenuation (or gain). Use the arrow keys, rotary knob or the numeric keypad to enter the adjustment value, up to 100 dB and select either the Loss or Gain submenu key. The offset will be applied to the Received Power value in the Summary graph. For instance, if the transmitter under test is emitting 50 watts (+47 dBm) of power, and the External Attenuation value is 40 dB (such as from a 40 dB directional coupler), the Received Power displayed will be +7 dBm.
6. Press the **Measurement** key, then the P25 Analyzer submenu key. Select the Graph types to view with the Graph Type submenu key. The Symbol Span submenu is used to adjust the number of "eyes" displayed across the screen in the Eye Diagram graph. Refer to "P25 Analyzer Graphs" on page 3-4 on the available graph types.

Over the Air (OTA) Analysis Setup

1. Press the **Menu** key, then select the P25 Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight P25 Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Frequency** main menu key to set the center frequency of the measurement using the Rx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the modulation type and Rx Pattern (BER pattern). Select C4FM modulation for Phase I systems or CQPSK for Phase II and LSM systems. Press the Rx Pattern key to choose the pattern against which to measure error rates. 1011 Hz and O.153 (V.52) will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Ctrl Channel will produce a Message Err Rate (MER) based on the CRC checksums contained in Control Channel messages and estimated BER using a proprietary algorithm. Refer to "P25 Analyzer Graphs" on page 3-4 on the available graph types.

Using the Signal Generator for Receiver or OTA Analysis

1. Press the **Menu** key then select the P25 Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight P25 Analyzer and press **Enter**.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW (0 dBm) and the frequency range is 500 kHz to 1.6 GHz.

2. Direct connect the LMR Master Signal Generator Out 50 Ohm connector to the repeater/receiver or connect an antenna with the appropriate frequency range to the connector.
3. Press the **Frequency** main menu key to set the transmit frequency using the Tx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.

   If testing a P25 repeater, you can bind the transmit frequency to the receive frequency by setting Rx/Tx Coupling to On and entering the Coupling Offset.

Note	When Rx/Tx Coupling is on, the Tx Freq submenu key is disabled.

4. Press the **Amplitude** main menu key, then the Tx Output Lvl submenu key to set the output power. Enter any output attenuation or gain using the Tx Power Offset key.
5. Set the transmit pattern by pressing the **Setup** main menu key then the Tx Pattern submenu key. Available patterns are listed on the display and additional patterns can be downloaded via the **System** > Application Options menu.

Note	Set the Network Access Control (NAC) value that is sent on the standard P25 1011 Hz Tx patterns when testing receivers. 293 is the P25 system default value.

6. Press the **Turn Sig-Gen ON** main menu key to start the signal generator. Press the key again to turn off the signal generator.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW.

3-3 P25 Analyzer Graphs

The following P25 Analyzer measurements are available on the LMR Master. From the **Measurements** main menu, press P25 Analyzer twice. Press the Graph Type submenu key to select the measurement type.

Constellation and Linear Constellation

Constellation view displays the demodulation information in an IQ format (Figure 3-1). The chart shows the relationship between the location of a constellation data point, its deviation frequency, and the information it carries.

Symbol: +3 Bit Information: 01 Dev.: +1.8 kHz	Symbol: +1 Bit Information: 00 Dev.: +600 Hz
Symbol: -3 Bit Information: 11 Dev.: -1.8 kHz	Symbol: -1 Bit Information: 10 Dev.: -600 Hz

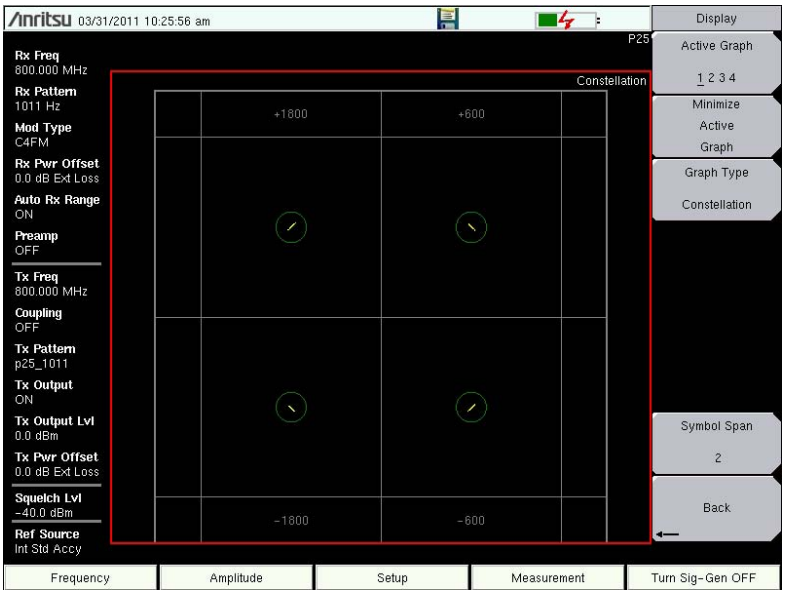


Figure 3-1. Constellation Diagram

Figure 3-2 shows the same information in the Linear Constellation View.

Symbol: -3 Bit Information: 11 Dev.: -1.8 kHz	Symbol: -1 Bit Information: 10 Dev.: -600 Hz	Symbol: +1 Bit Information: 00 Dev.: +600 Hz	Symbol: +3 Bit Information: 01 Dev.: +1.8 kHz

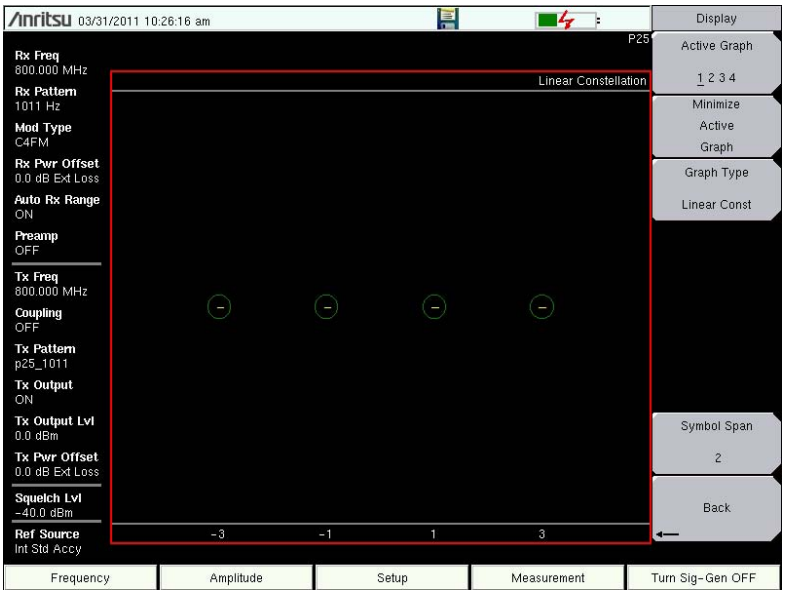


Figure 3-2. Linear Constellation Diagram

For input signals that are not P25 encoded, the LMR Master will still try to decode it and fit it to a symbol. This may cause some measurement results that are unexpected.

Histogram Graph

The Histogram graph displays a graphical representation of the symbols that are being received. The graph for each symbol represents the relative percentage that symbol was identified out of all the received symbols.

Each update of the screen is a separate representation of the latest data, rather than a cumulative total. The vertical scale is fixed at 0 % to 100 %, with each horizontal grid line representing 10 % of the total symbols received.

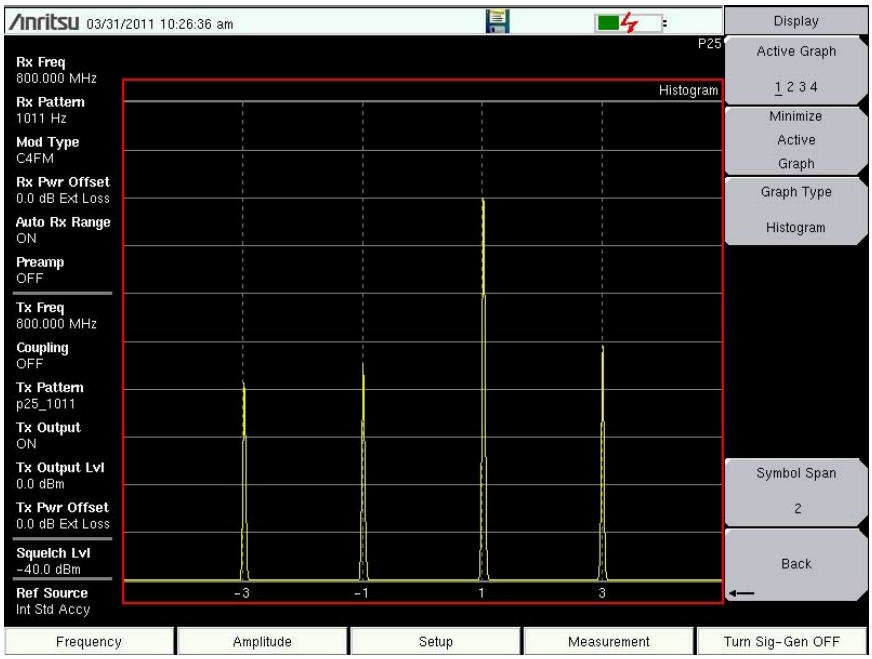


Figure 3-3. P25 Histogram

Spectrum Graph

The spectrum view displays a graphical representation of power (dBm) versus frequency. The spectrum display gives an indication if there are interferers present that may degrade the bit error rate of the P25 signal. The frequency span is adjustable under the **Frequency** menu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 3-17 for details. Figure 3-4 displays the same signal using a 25 kHz span and a 500 kHz span.

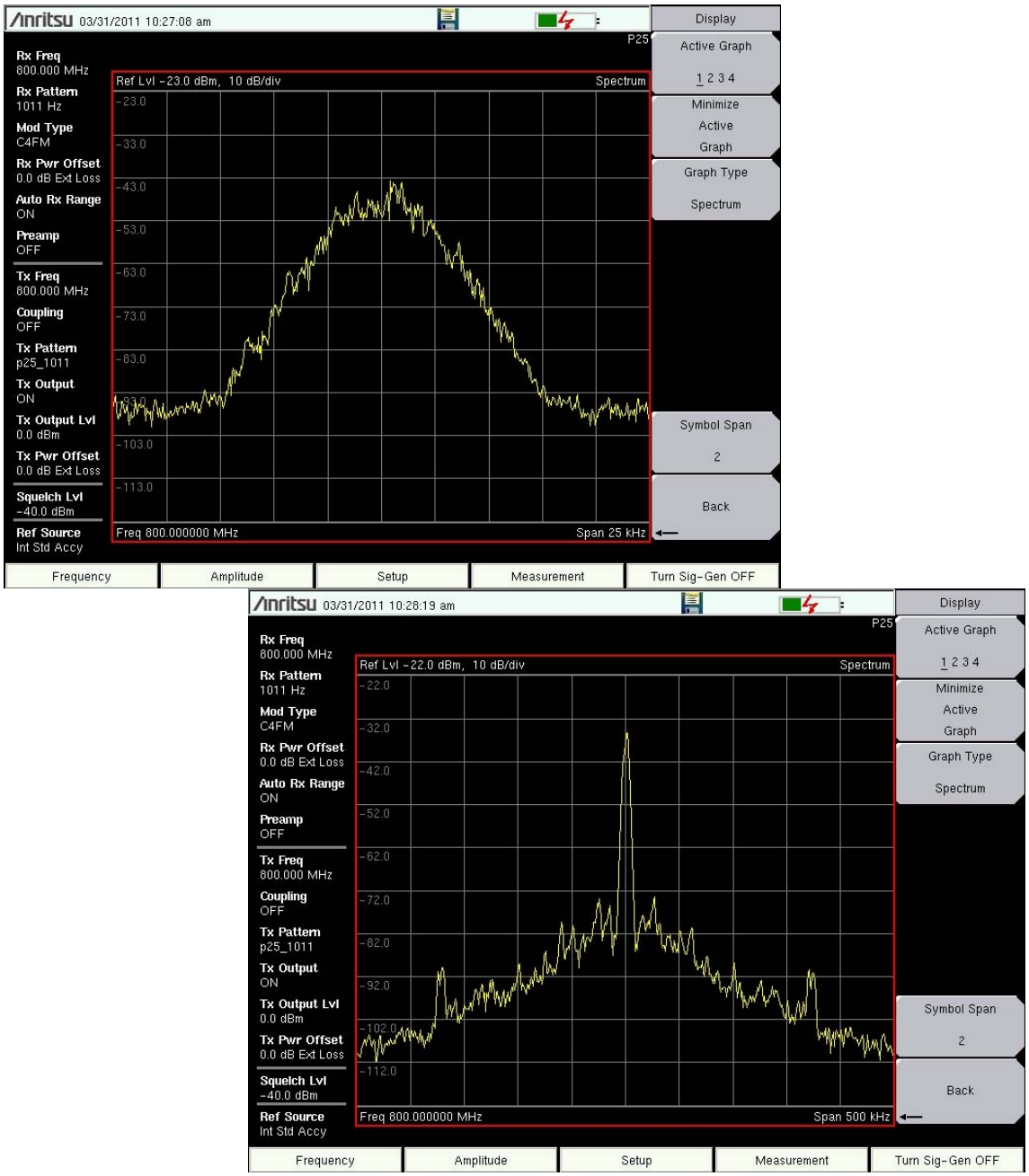


Figure 3-4. P25 Spectrum Graph (25 kHz Span and 500 kHz Span)

Eye Diagram

The eye diagram is an oscilloscope view of the P25 signal displaying the voltage of the signal vs. time. The diagram provides an indication of baseband fidelity of a P25 transmitter. With Over-the-air measurements, the Eye Diagram can indicate phase distortion from multipath. The number of “eyes” displayed is set with the Symbol Span key under the “Display Menu” on page 3-21.

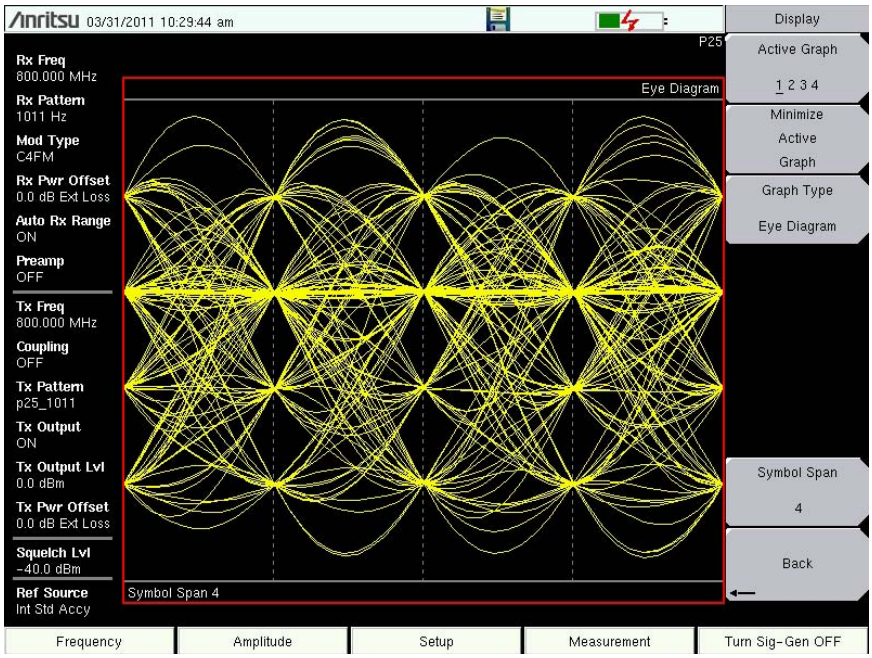


Figure 3-5. P25 Eye Diagram

Summary Graph

The summary graph provides an overview of a P25 transmitter. The graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), bit error rate (BER), symbol deviation, Network Access Code (NAC), and symbol rate error of the input signal.

The Received Power value in the summary graph can be toggled to dBm, watts, or volts by using the **Amplitude** > Units > Rx Units submenu key. This setting also applies to the squelch level setting.

The **Setup** > Squelch Lvl submenu key sets the squelch power level. When the Received Power is lower than the set squelch level all summary graph measurements except for Received Pwr will be blanked out (--). When the Received Power is above the squelch level the measurements are displayed as shown in Figure 3-6.

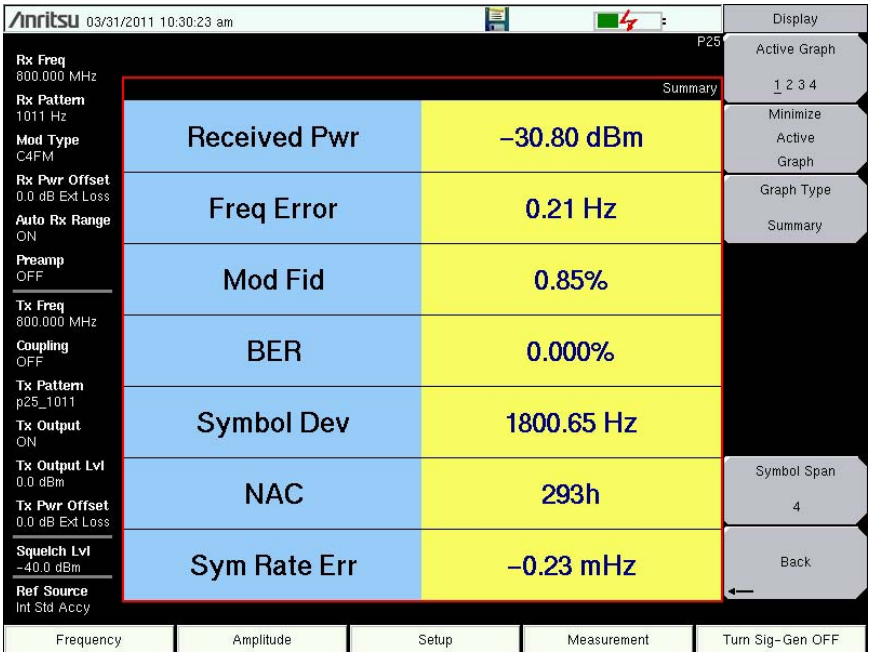


Figure 3-6. P25 Summary Graph with Received Pwr Above the Squelch Level

Received Pwr in the Summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Received Pwr is a function of the instrument's RBW setting. The reduction is specified as: 10*Log(Signal Bandwidth / Resolution Bandwidth).

3-4 P25 Control Channel Measurements

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can log the decoded bits for control messages for either the voice channel or the control channel.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose either Voice (downlink) or Ctrl Channel (uplink) as the Rx Pattern.
3. From the **Measurement** main menu press the P25 Control submenu key twice.
4. To log data, insert a formatted flash drive in the LMR Master and set Log Data to On.
5. The Hex Trigger menu and Hex Trigger Value menu are used to find a specific opcode in the Control Channel data.

   To set the hex trigger value, press the Set Trigger Value menu. An on screen keyboard is displayed and with the numbers 0 to 9 and the letters A to F. Enter the two character hex value to search for. After entering the value, press **Enter** to set the trigger value. Press **Esc** to cancel entry or changing the current hex value.

   Setting Hex Trigger to On will set the Sweep function to Hold when the hex trigger value is found in the first octet of a packet. The octet row with the found trigger value will be displayed in the middle of the table (Figure 3-7). If Log Data is set to On, all of the data on the screen is saved and Log Data is set to Off. When Sweep is set back to Run, the unit will continue to collect data and stop on the next instance of the hex trigger value. To continue to capture data to the USB flash drive, set Log Data back to On before setting Sweep to Run mode.

Figure 3-7 and Figure 3-8 are examples of the display screen measurement in Voice and Control. Valid Octet data is displayed in blue. Data displayed in red indicates a Cyclic Redundancy Check (CRC) error. P25 Control measurements include the following information:

NAC = Network Access Code
DUID = Data Unit Identifier

Control information in the voice channel also includes:

LC = link control data
LS = low speed data
KEY = key ID (part of encrypt sync word which identifies the encryption parameters)
MI = message ID (part of encrypt sync word)
ALG = algorithm ID (part of encrypt sync word)

When Log Data is set to On, the control channel information will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`CTRL_LOG`*`yearmonthdaytime`*`.p25` (for Control data)

or

`VOICE_LOG`*`yearmonthdaytime`*`.p25` (for Voice data)

Decoding Control Channel Measurements

Anritsu offers a Python script that will decode the logged hexadecimal Control Channel measurements. The script is available for download from the Anritsu web site and requires that the Python programming language is installed on your computer.

To decode control channel measurements with the Python script:

1. Install the Python programming language on a PC. Download the installer (http://www.python.org/download/) from the Python Programming Language web site.
2. Download the decoder script from the Anritsu web site:
   a. Open the Anritsu home page (http://www.anritsu.com) with a web browser.
   b. Type S412E in the search box to find the LMR Master S412E product page on the Anritsu web site. Click the product page link to display the LMR Master product page.
   c. Click the Library tab. Under the Drivers/Software Downloads section, select P25 Control Channel Decoder. Next, click the Download button then Save to copy the file "p25_ctrl_decoder.zip" to your computer.
3. Unzip and launch the python script. The script file name is `p25_ctrl_decoder.py`.

4. Press the Select File button and select the control channel file that was saved on the USB flash drive. The Python script displays the CRC errors and writes a text file in the same location with the decoded control channel commands.

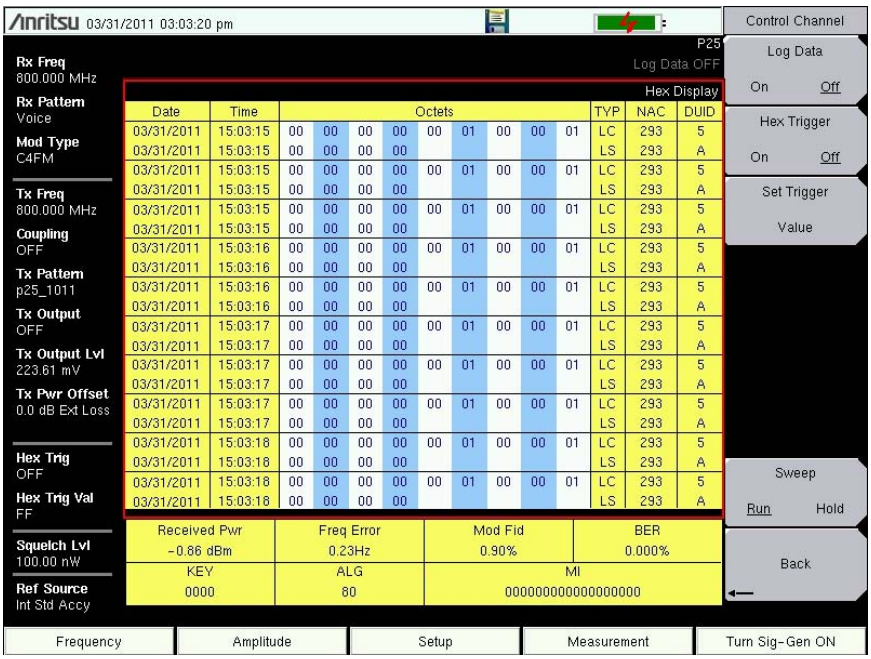


Figure 3-7. P25 Control Channel (Voice)

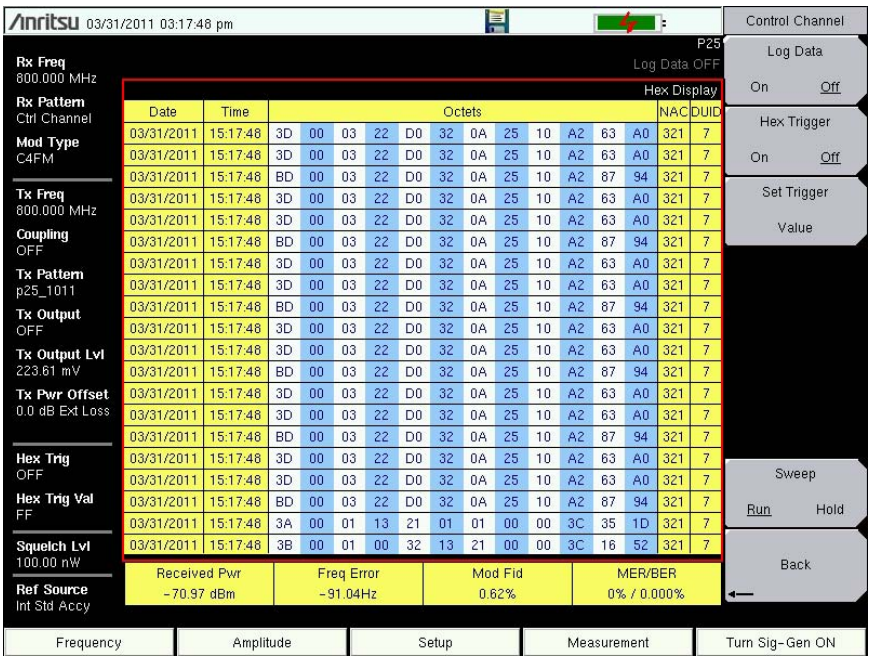


Figure 3-8. P25 Control Channel (Control)

3-5 P25 Coverage

Refer to Chapter 10, “LMR Coverage Mapping”.

3-6 P25 Bit Capture

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can provide and log raw bits (pre Forward Error Correction) when the Rx Pattern is set to Voice.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose Voice as the Rx Pattern.
3. From the **Measurement** main menu press the P25 Bit Capture submenu key twice.
4. To log data, insert a formatted USB flash drive in the LMR Master and set Log Data to On. The bit capture information will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The tab delimited text file contains the header and table information shown in Figure 3-9. The files are named:

   `BIT_CAP_LOG`*`yearmonthdaytime`*`.p25`

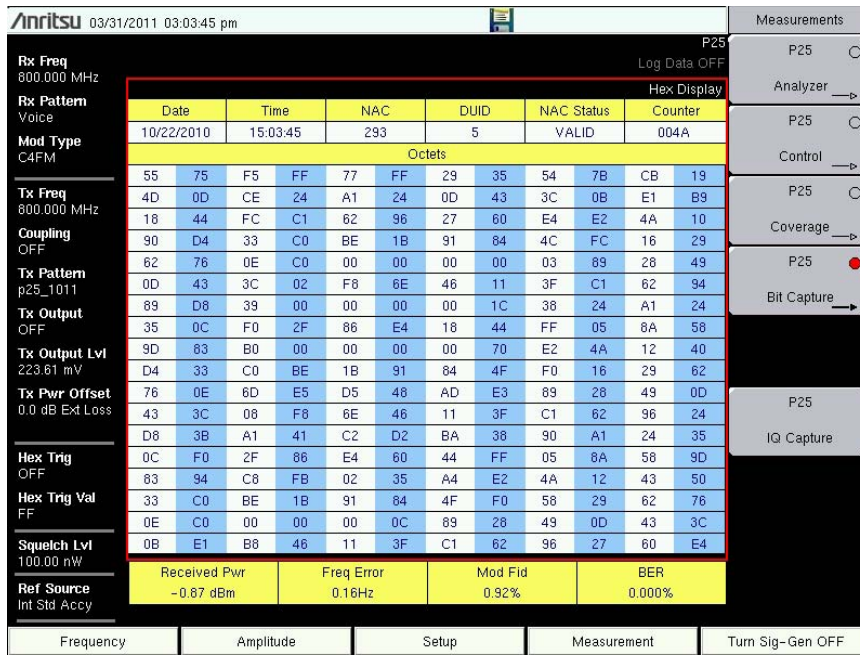


Figure 3-9. P25 Bit Capture Display

3-7 P25 IQ Data

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can capture and log P25 IQ data to a USB flash drive.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose a Mod Type.

   For C4FM modulation, interleaved Delta Phase data then Magnitude data is captured. For CQPSK modulation, interleaved I data then Q data is captured.
3. Insert a formatted USB flash drive into the LMR Master and from the **Measurement** main menu, press the P25 IQ Capture submenu key. After approximately 10 seconds, the instrument displays a message that the capture is complete.

The IQ data is sampled at 4,800 x 11 symbols per second. The saved file has an ASCII header and binary data (Figure 3-10). The data is written in 24-bit two's complement integers format. The header includes "SampleType" (I/Q for CQPSK or DeltaPhase/Mag for C4FM). The file is intended for post-processing in MATLAB or other data analysis software.

The file will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`IQ_CAPTURE`*`yearmonthday`*`time.p25`

Note	There is no display menu for P25 IQ Capture. The LMR Master will continue to display the previous measurement screen during IQ Capture.

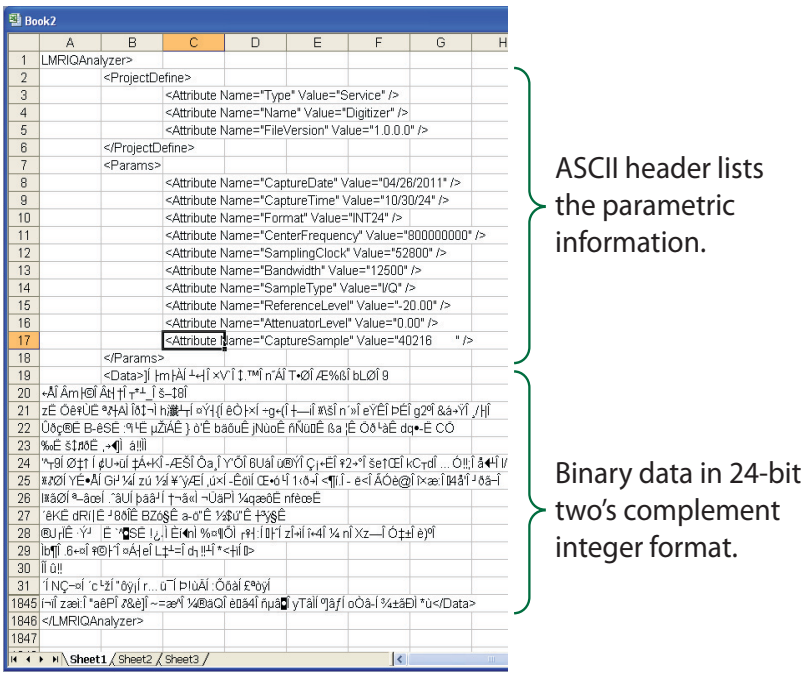


Figure 3-10. IQ Capture (CQPSK Modulation)

3-8 P25 Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

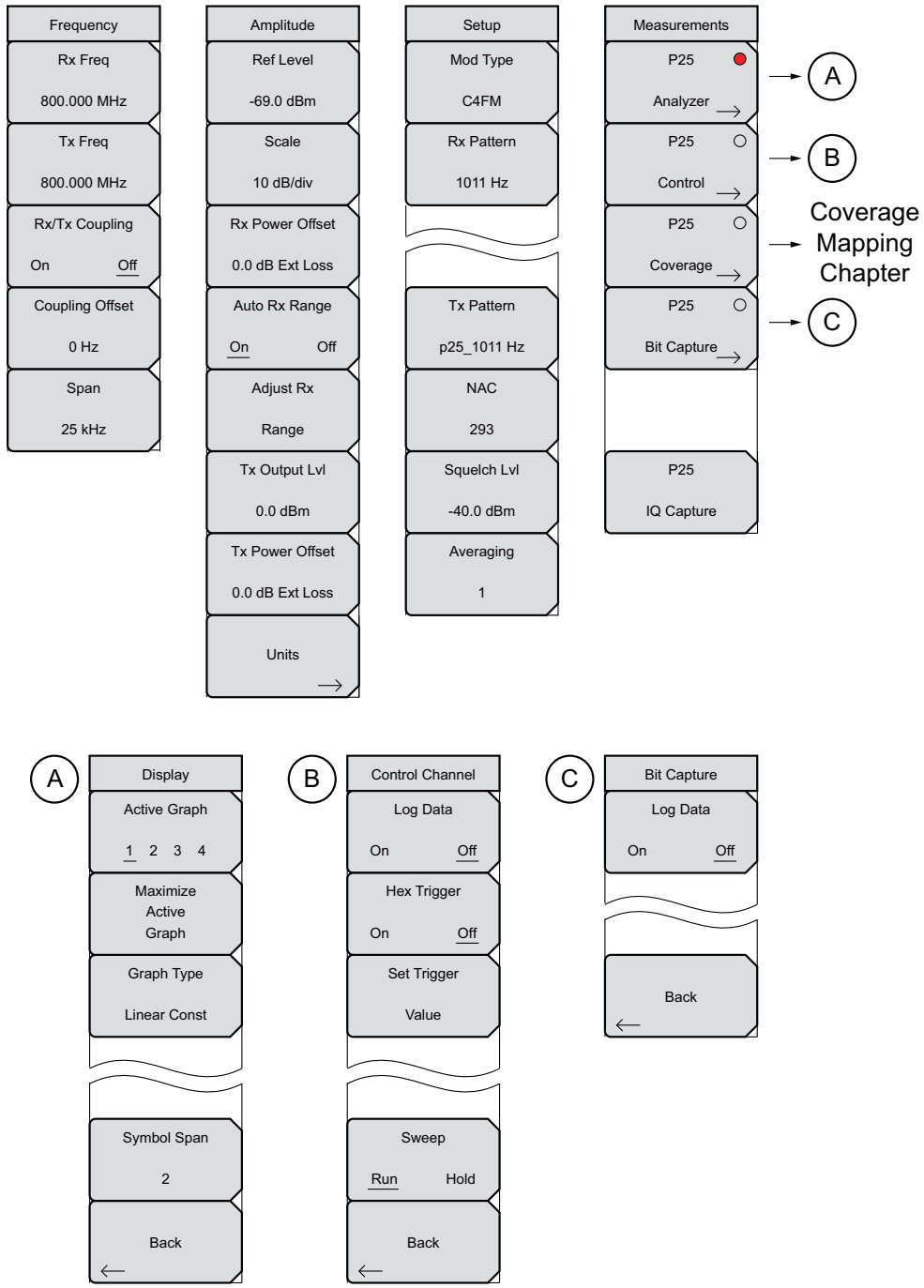
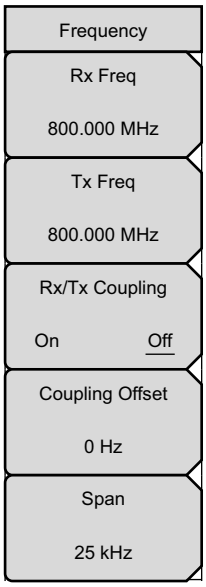


Figure 3-11. P25 Analyzer Menu Layout

3-9 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press Tx Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On the Tx Freq key is disabled.

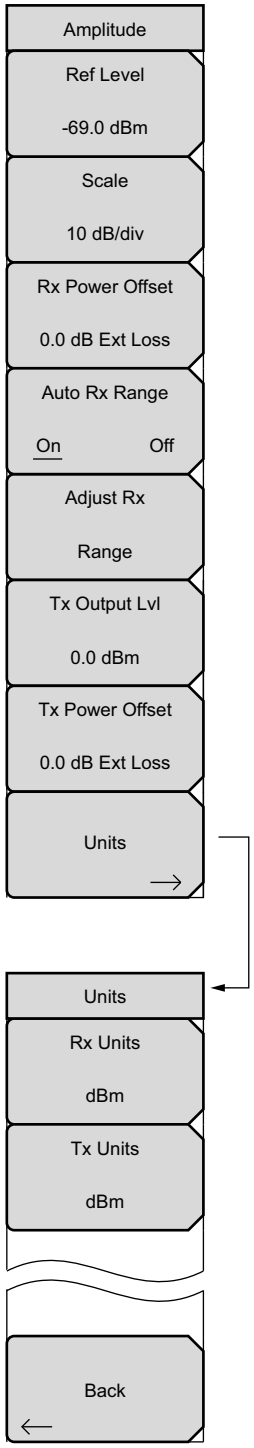
Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. Only functional when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 25 kHz, 50 kHz, 100 kHz, 500 kHz, 1 MHz, and 5 MHz.

Figure 3-12. P25 Analyzer Frequency Menu

3-10 Amplitude Menu

Key Sequence: **Amplitude**



Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis of the graticule. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. The y-axis power scale is shown on the left side of the display when viewing the Spectrum Graph.

Note: The "Vertical Scale Menu" on page 3-18 is displayed when P25 Coverage (**Measurement** > P25 Coverage) is selected.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Units: Opens to Units Submenu.

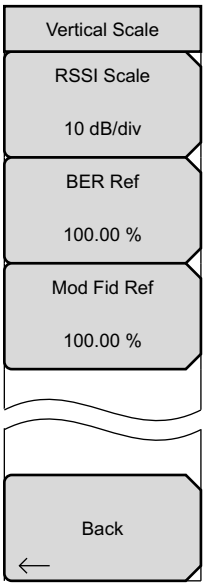
Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Summary Graph and the Squelch Level.

Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 3-13. P25 Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale



RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

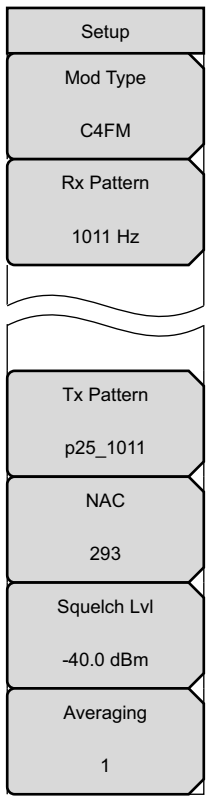
BER Ref: Sets the BER reference percentage value at the top of the y-axis in the BER vs. Time graph in Coverage measurement. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Mod Fid Ref: Sets the Modulation Fidelity reference percentage value. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Figure 3-14. Vertical Scale Menu

3-11 Setup Menu

Key Sequence: **Setup**



Mod Type: Sets the type of modulation. The options are C4FM (Phase I, 12.5 kHz BW) or CQPSK (Phase I or Phase II, 6.25 kHz equivalent BW).

Rx Pattern: Selects the receiver Bit Error Rate pattern. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**. There are four available patterns:

Automatic Frequency Control (1011 Hz)
Standard Transmitter Test (O.153 or V.52)
Voice
Ctrl (Control) Channel

Tx Pattern: Selects the transmitter pattern to send when the **Turn Sig-Gen ON** main menu key is selected. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**. Refer to "Using the Signal Generator for Receiver or OTA Analysis" on page 3-3 for the list of available transmitter patterns.

NAC: Sets the Network Access Control (NAC) that is sent on the standard P25 1011 Hz Tx Pattern when testing receivers. 293 is the P25 system default value.

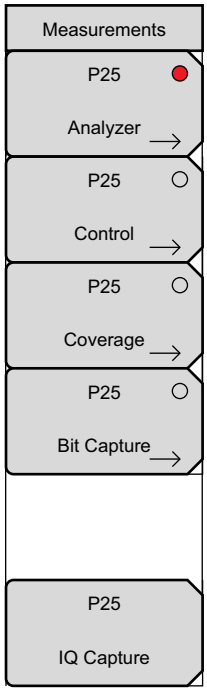
Squelch Lvl: Sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--).

Averaging: Sets the refresh rate of the numerical values in the P25 Summary window. Setting a higher number (25 maximum) will reduce measurement jitter.

Figure 3-15. P25 Analyzer Setup Menu

3-12 Measurement Menu

Key Sequence: **Measurement**



P25 Analyzer: Opens the “Display Menu” on page 3-21.

P25 Control: Opens the “Control Channel Menu” on page 3-22. This submenu key is valid only when Rx Pattern is set to Control Channel or Voice.

P25 Coverage (Option 522 required): Opens the P25 Coverage menu. Refer to Chapter 10, “LMR Coverage Mapping”.

P25 Bit Capture: This submenu key is valid only when Rx Pattern is set to Voice. Pressing this key opens a submenu for data logging. Make sure that a formatted USB flash drive is attached to the instrument before starting bit capture. Set Log Data to On to start the bit capture. Bit capture will continue until Log Data is set to Off or the USB flash drive is filled.

The files are saved in a time-stamped folder under the **usr** folder on the USB flash drive.

If Log Data is On, any of the following functions will stop the logging:

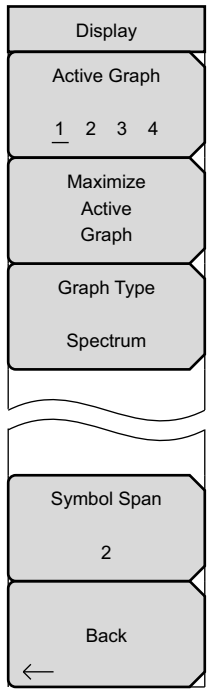
Rx Frequency change
Setup change
Starting another measurement

P25 IQ Capture: Pressing this key starts the IQ data capture. Make sure that a formatted USB flash drive is attached to the instrument before starting IQ Capture. When the capture is complete, a message is displayed. This may take a few seconds.

Figure 3-16. P25 Analyzer Measurement Menu

Display Menu

Key Sequence: **Measurement** > P25 Analyzer



Active Graph 1 2 3 4: In Four Screen view use this menu to select which of the four graphs is active. The current active graph is underlined (1 2 3 4) and has a red perimeter line. Any of the four graphs can also be made active by tapping once on the touch screen. Repeatedly pressing the Active Graph submenu key will cycle the active graph, 1 through 4.

In Standard view (one graph displayed on the screen) the Active Graphic key will rotate between the four graphs displayed in the Four Screen view.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four Screen (4 graphs) view and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this button displays the current active graph type. Pressing the button will open a list box of the graphs types available for P25 Analyzer measurements. Select the desired graph type with the arrow keys or rotatory knob and press **Enter**. The current active graph will be replaced with the new selection.

Available graphs include:

- Constellation
- Spectrum
- Histogram
- Eye Diagram
- Linear Constellation
- Summary

Refer to “P25 Analyzer Graphs” on page 3-4 for additional information.

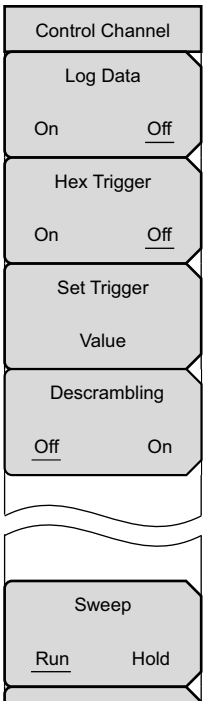
Symbol Span: Use this menu to adjust the number of symbols viewed across the screen in the Eye Diagram graph. Adjust from 2 and 5 using the keypad, the arrow keys, or the rotary knob. Keypad values entered outside of this range are ignored.

Back: Returns to the “Measurement Menu” on page 3-20.

Figure 3-17. P25 Analyzer Display Menu

Control Channel Menu

Key Sequence: **Measurement** > P25 Control



Log Data: Saves the measurements to an external USB flash drive. The external USB flash drive must be attached to one of the USB Type A connectors to Log data files.

The files are saved in a time-stamped folder under the **usr** folder on the USB flash drive.

If Log Data is On, any of the following functions will stop the logging:

Rx Frequency change
Setup change
Starting another measurement

Hex Trigger: Turns On or Off the Hex Trigger set with the following command. Sweep will continue until the trigger value is detected. At that time Sweep will change from Run to Hold.

Set Trigger Value: Opens a touchscreen hexadecimal keyboard for setting the Trigger value.

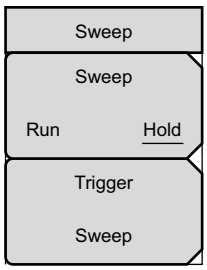
Sweep: Toggles the frequency sweep of the LMR Master between Run and Hold. Save function as **Shift** + **Sweep** (**3**).

Back: Returns to the “Measurement Menu” on page 3-20.

Figure 3-18. P25 Control Channel Menu

3-13 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Trigger Sweep is not available in P25 Control and P25 Bit Capture measurements.

Figure 3-19. P25 Analyzer Sweep Menu

3-14 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Displays the "Measurement Menu" on page 3-20.

3-15 Trace Menu

This menu is not available in P25 Analyzer measurement mode.

3-16 Limit Menu

This menu is not available in P25 Analyzer measurement mode.

3-17 Other Menus

Preset, **Calibrate**, **File**, **System** and **Mode** are described in the User Guide.

Chapter 4 — P25 Phase 2 Analyzer (Option 521)

Note	Option 521 include P25 demodulation (Chapter 3) and P25 Phase 2 demodulation (this Chapter).

4-1 Introduction

The P25 Phase 2 Analyzer option provides a method to verify the operation of APCO Project 25 Phase 2 (P25p2) and Linear Simulcast Modulation (LSM) tower, mobile, and portable radio transmitters. Option 521 includes the ability to display linear constellation, spectrum, histogram, power profile, and eye diagram graphs. In addition, summary graphs display demodulation, active and backup control channel, band plan, and adjacent site information.

The LMR Master will analyze input signal strengths from +33 dBm (2.0 watts) down to levels approaching the sensitivity of P25p2 radios, automatically adjusting the input sensitivity based on input levels.

4-2 Setup Procedure

Direct Connect to the Transmitter

1. Press the **Menu** key then select the P25 2 Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight P25p2 Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect the transmitter to the RF In 50 Ohm connector on the LMR Master using a coupler or attenuator.
3. Press the **Frequency** main menu key to set the receiver center frequency (Rx Freq) of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the modulation type. Select Base Station or Mobile Station using the Mod Type key. Press the Rx pattern key to choose the pattern against which to measure error rates. 1031 Hz will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Ctrl Channel will produce a Message Err Rate (MER) based on the CRC

checksums contained in Control Channel messages and estimated BER using a proprietary algorithm.

5. Select the TDMA slot (0 or 1) using the Rx Slot submenu key.
6. Press the **Amplitude** main menu key, then the Rx Power Offset submenu key to set the receiver attenuation (or gain). Use the arrow keys, rotary knob or the numeric keypad to enter the adjustment value, up to 100 dB and select either the Loss or Gain submenu key. The offset will be applied to the Carrier Power value in the Demodulation Summary graph. For instance, if the transmitter under test is emitting 50 watts (+47 dBm) of power, and the External Attenuation value is 40 dB (such as from a 40 dB directional coupler) the Carrier Power displayed will be +7 dBm.
7. Press the **Measurement** key, then the P25p2 Analyzer submenu key. Select the Graph types to view with the Graph Type submenu key. The Symbol Span submenu is used to adjust the number of "eyes" displayed across the screen in the Eye Diagram graph. Refer to "P25p2 Analyzer Graphs" on page 4-4 on the available graph types.

Over the Air (OTA) Analysis Setup

1. Press the **Menu** key then select the P25 2 Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight P25p2 Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Frequency** main menu key to set the center frequency of the measurement using the Rx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the modulation type. Select Base Station or Mobile Station using the Mod Type key. Press the Rx pattern key to choose the pattern against which to measure error rates. 1031 Hz will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Ctrl Channel will produce a Message Err Rate (MER) based on the CRC checksums contained in Control Channel messages and estimated BER using a proprietary algorithm. Refer to "P25p2 Analyzer Graphs" on page 4-4 on the available graph types.
5. Select the TDMA slot (0 or 1) using the Rx Slot submenu key.

Using the Signal Generator for Receiver or OTA Analysis

1. Press the **Menu** key then select the P25 2 Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight P25p2 Analyzer and press **Enter**.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW (0 dBm) and the frequency range is 500 kHz to 1.6 GHz.

2. Direct connect the LMR Master Signal Generator Out 50 Ohm connector to the repeater/receiver or connect an antenna with the appropriate frequency range to the connector.
3. Press the **Frequency** main menu key to set the transmit frequency using the Tx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.

   If testing a P25p2 repeater, you can bind the transmit frequency to the receive frequency by setting Rx/Tx Coupling to On and entering the Coupling Offset.

Note	When Rx/Tx Coupling is on, the Tx Freq submenu key is disabled.

4. Press the **Amplitude** main menu key, then the Tx Output Lvl submenu key to set the output power. Enter any output attenuation or gain using the Tx Power Offset key.
5. Set the transmit pattern by pressing the **Setup** main menu key then the Tx Pattern submenu key. Available patterns are listed on the display and additional patterns can be downloaded via the **System** > Application Options menu.
6. Select the TDMA slot (0 or 1) using the Tx Slot submenu key.
7. Press the **Turn Sig-Gen ON** main menu key to start the signal generator. Press the key again to turn off the signal generator.

4-3 P25p2 Analyzer Graphs

The following P25p2 Analyzer measurements are available on the LMR Master. From the **Measurements** main menu press P25p2 Analyzer twice. Press the Graph Type submenu key to select the measurement type.

Linear Constellation

Linear constellation view displays the demodulation information in an IQ format for Base Station (Figure 4-1) and Mobile Station (Figure 4-2). The chart shows the relationship between the location of a constellation data point, its deviation frequency, and the information it carries.

Symbol:	-3	Symbol:	-1	Symbol:	+1	Symbol:	+3
Bit Information:	11	Bit Information:	10	Bit Information:	00	Bit Information:	01

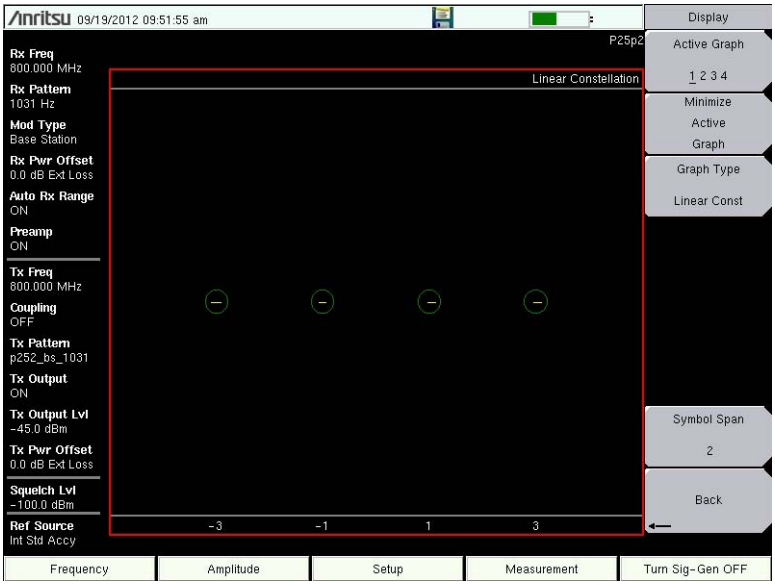


Figure 4-1. Linear Constellation Diagram (Base Station)

Symbol: -3	Symbol: -2	Symbol: -1	Symbol: 0	Symbol: +1	Symbol: +2	Symbol: +3

Figure 4-2. Linear Constellation Diagram (Mobile Station)

For input signals that are not P25p2 encoded, the LMR Master will still try to decode it and fit it to a symbol. This may cause some measurement results that are unexpected.

Histogram Graph

The Histogram graph displays a graphical representation of the symbols that are being received. The graph for each symbol represents the relative percentage that symbol was identified out of all the received symbols.

Each update of the screen is a separate representation of the latest data, rather than a cumulative total. The vertical scale is fixed at 0 to 100 %, with each horizontal grid line representing 10 % of the total symbols received.

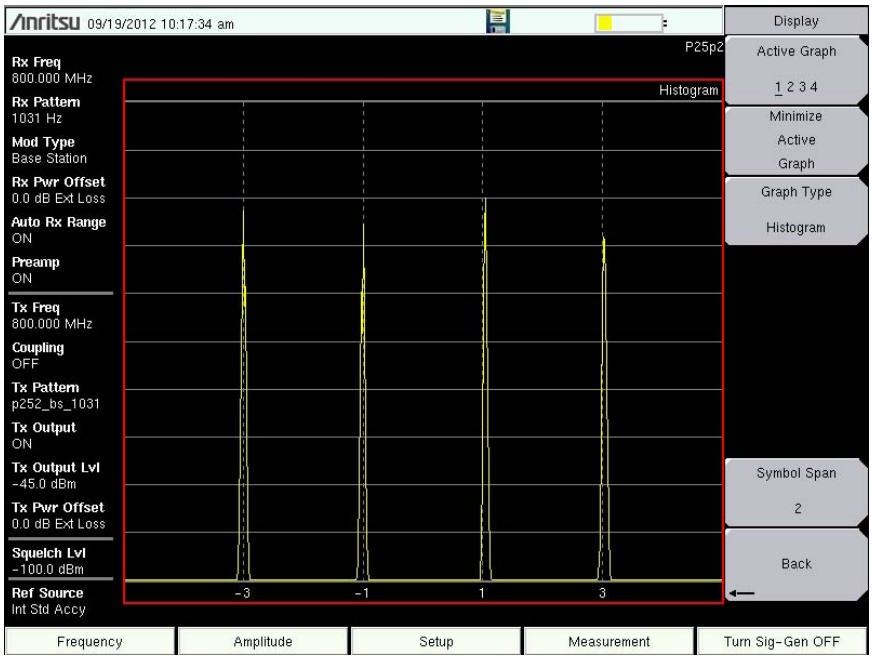


Figure 4-3. P25p2 Base Station Histogram

Spectrum Graph

The spectrum view displays a graphical representation of power (dBm) vs. frequency. The spectrum display gives an indication if there are interferers present that may degrade the bit error rate of the P25p2 signal. The frequency span is adjustable under the **Frequency** menu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 4-21 for details. Figure 4-4 displays the same signal using a 25 kHz span and a 500 kHz span.

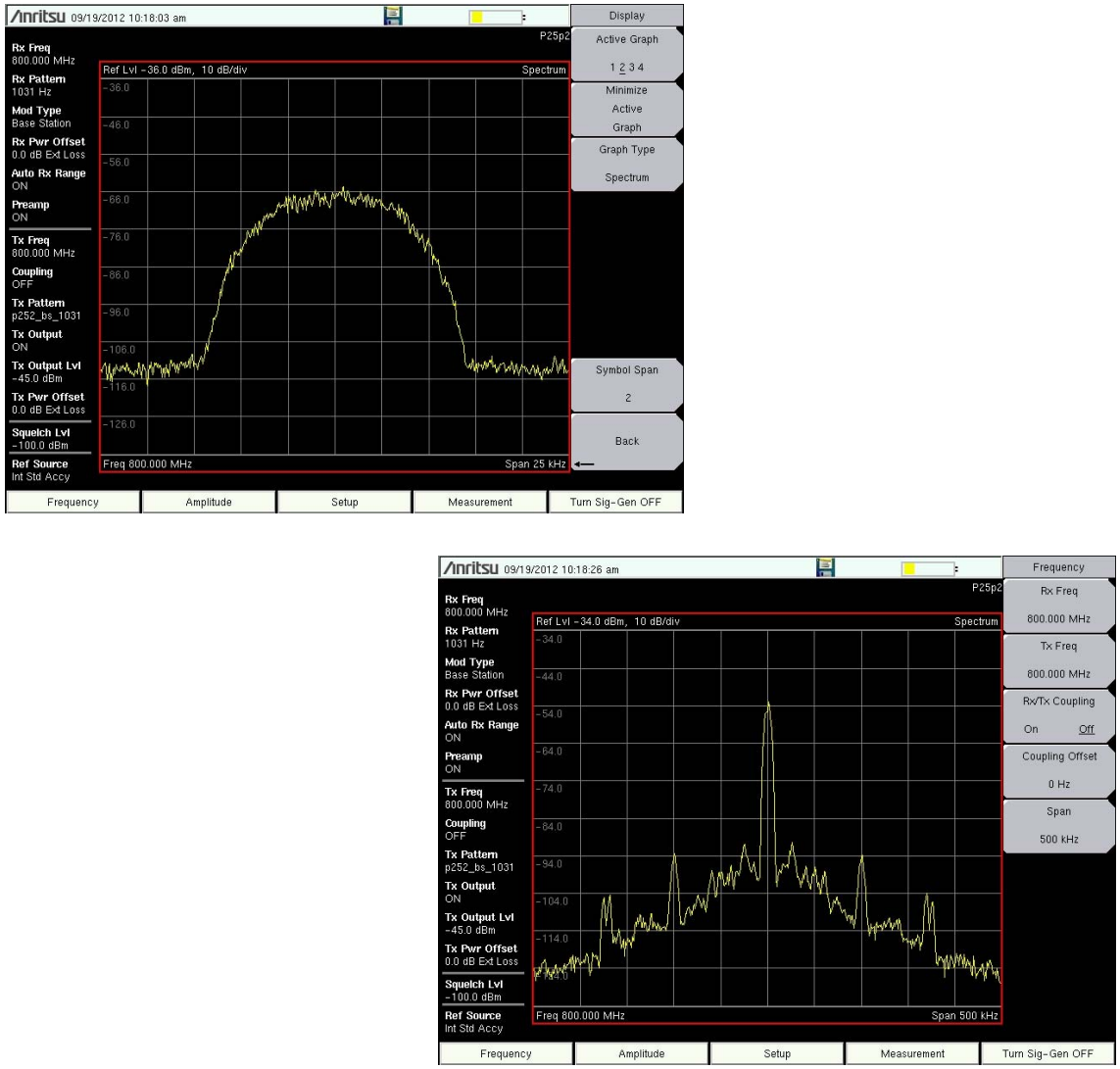


Figure 4-4. P25p2 Spectrum Graph (25 kHz Span and 500 kHz Span)

Eye Diagram

The eye diagram is an oscilloscope view of the P25p2 signal displaying the voltage of the signal vs. time. The diagram provides an indication of baseband fidelity of a P25p2 transmitter. With Over-the-air measurements the Eye Diagram can indicate phase distortion from multipath. The number of "eyes" displayed is set with the Symbol Span key under the "Display Menu" on page 4-26.

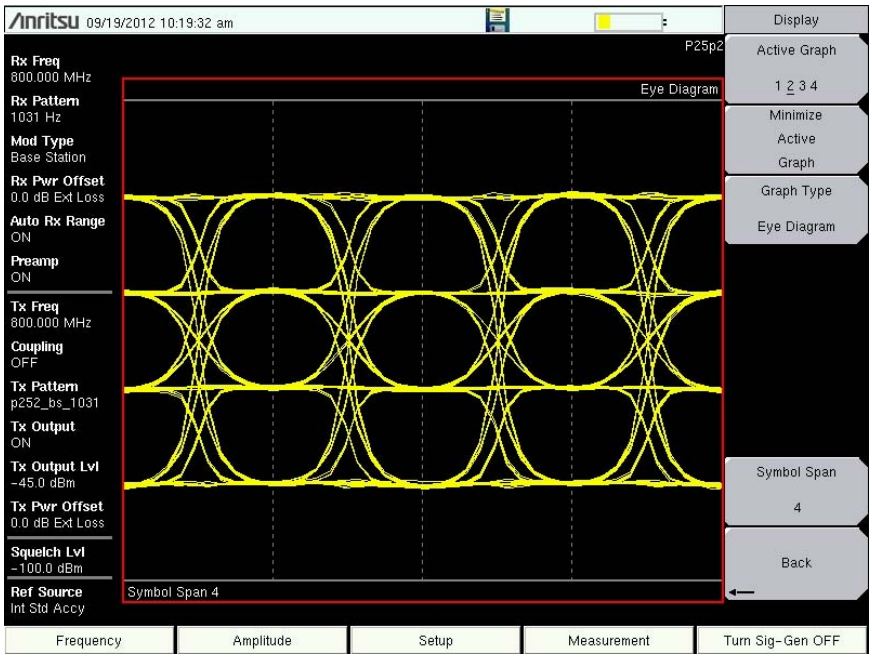


Figure 4-5. P25p2 Eye Diagram

Summary Graphs

The LMR Master offers several summary graphs to give a broad overview of many P25p2 transmitter details.

Demodulation Summary

The Demodulation Summary graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), bit error rate (BER), symbol deviation, and symbol rate error of the input signal. When the RX Pattern is set to Control Channel, the summary graph displays message error ratio (MER/BER) in place of BER.

The Received Power value in the summary graph can be displayed in dBm, watts, or volts using the **Amplitude** > Units > Rx Units submenu key. This setting also applies to the squelch level setting.

The **Setup** > Squelch Lvl submenu key sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--). When the Received Power is above the squelch level, the measurements are displayed as shown in Figure 4-6.

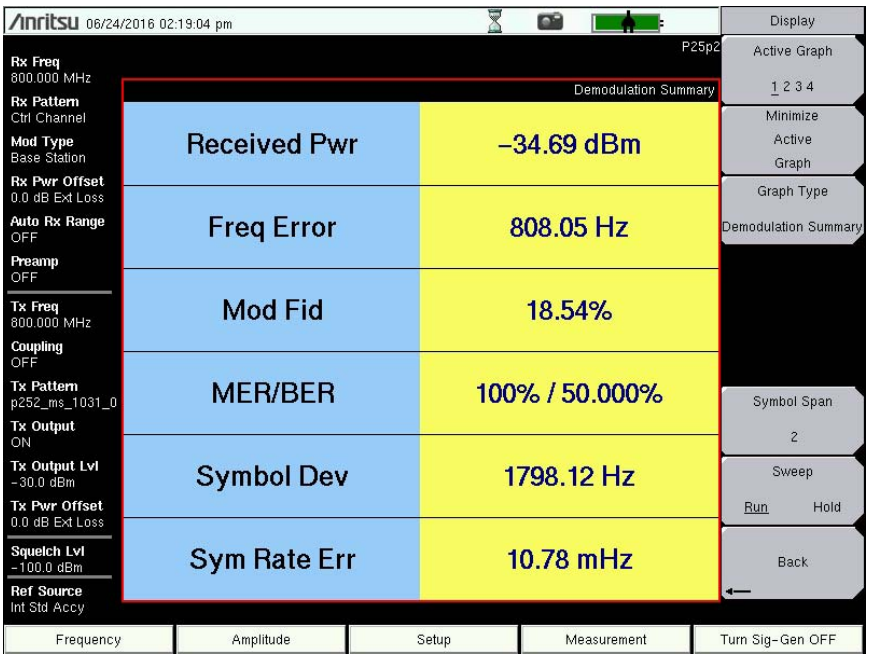


Figure 4-6. P25p2 Demodulation Summary Graph with Received Pwr Above the Squelch Level

Received Pwr in the summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Received Pwr is a function of the instruments RBW setting. The reduction is specified as: 10*Log(Signal Bandwidth / Resolution Bandwidth).

Active Control Channel Summary

The Active Control Channel Summary graph can be selected only when the Mod Type is set to Base Station and the RX Pattern is set to Ctrl Channel. This summary displays the hex value of the active system ID, wide area communications network (WACN) ID, network access control (NAC), site ID, and the current site status and manufacturer ID.

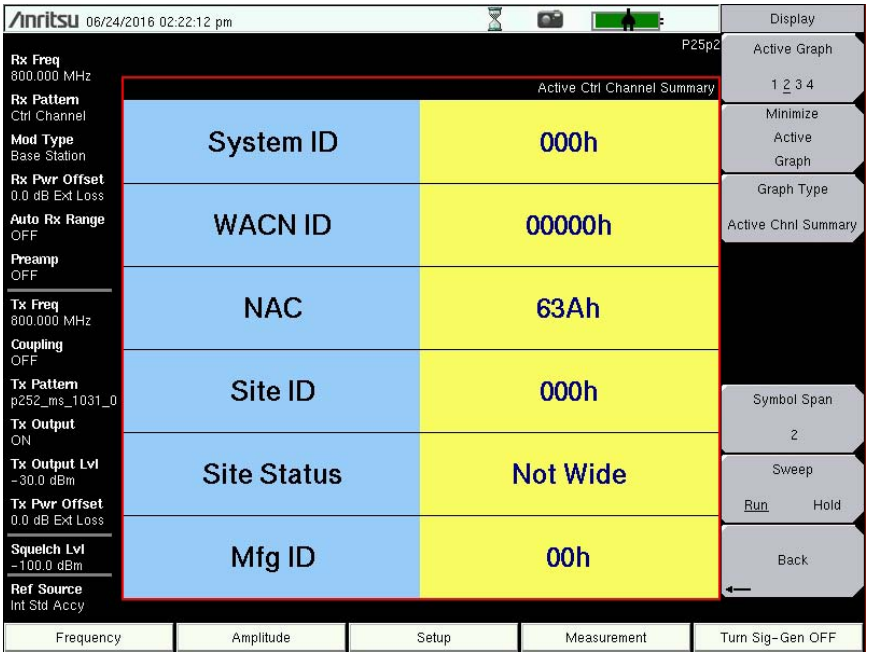


Figure 4-7. P25p2 Active Base Station Control Channel Summary

Band Plan Summary

The Band Plan Summary graph can be selected only when the Mod Type is set to Base Station and the RX Pattern is set to Ctrl Channel. This summary displays the band plan identifier, bandwidth, transmit offset, channel spacing, and base frequency.

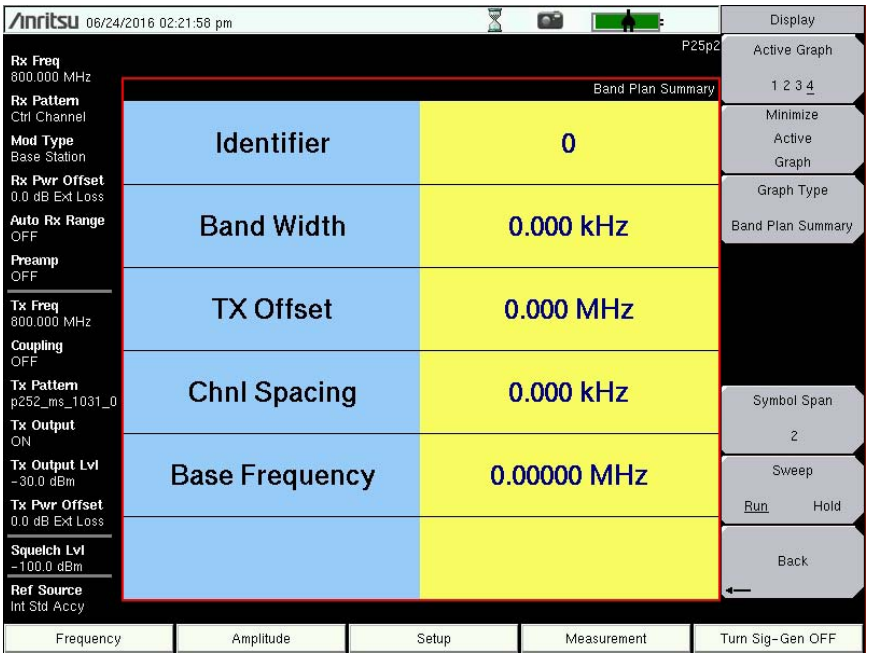


Figure 4-8. P25p2 Base Station Control Channel Band Plan Summary

Backup Control Channel Summary

The Backup Ctrl Channel Summary graph can be selected only when the Mod Type is set to Base Station and the RX Pattern is set to Ctrl Channel. This summary displays the hex values of the RF sub-system ID, site ID, channels A and B, and the manufacturer ID.

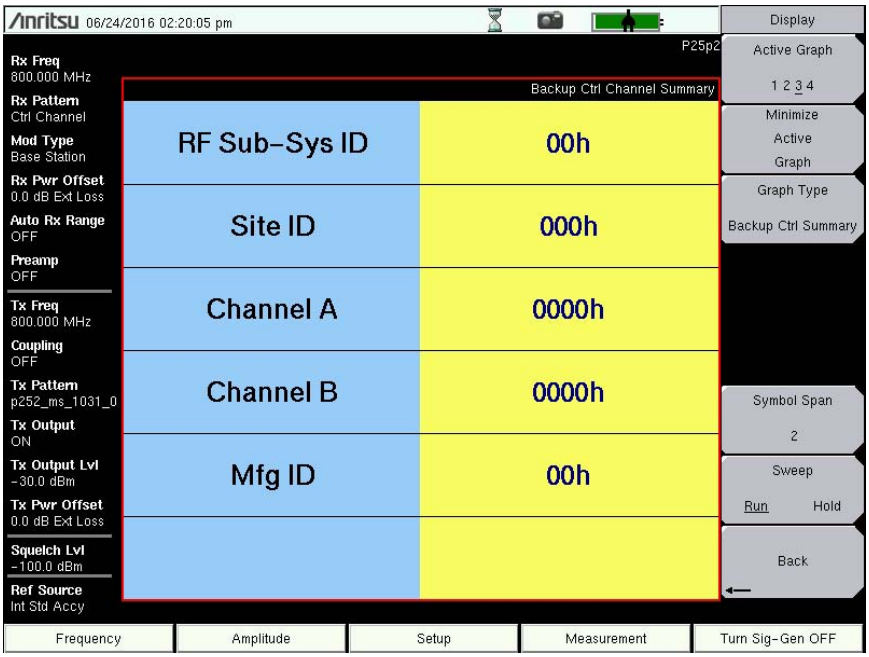


Figure 4-9. P25p2 Base Station Backup Control Channel Summary

Adjacent Site Summary

The Adjacent Site Summary graph can be selected only when the Mod Type is set to Base Station and the RX Pattern is set to Ctrl Channel. This summary displays the hex value of the adjacent site ID, sub system ID, channel, and the relative condition (F), common state (V), and RFSS state (A).

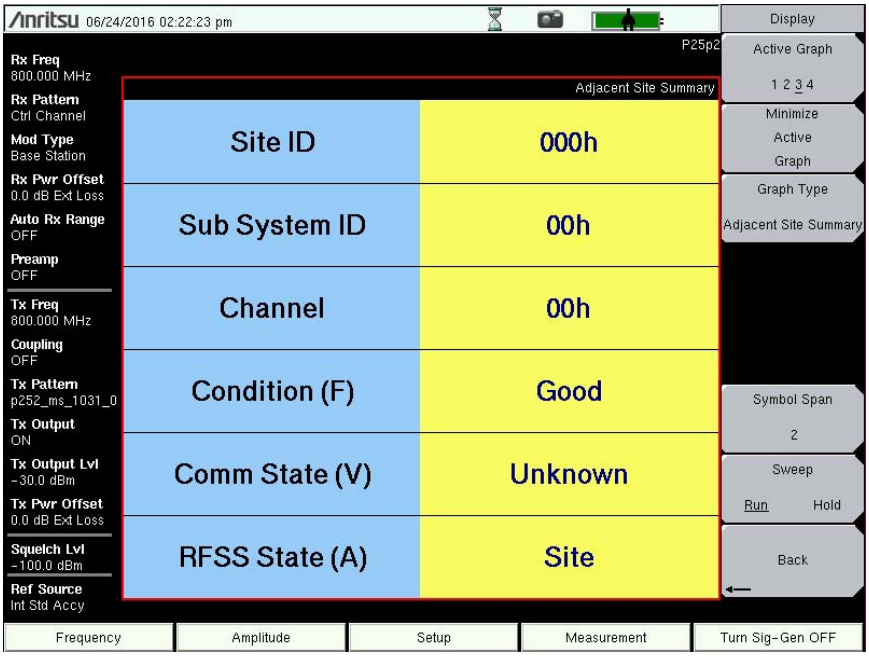


Figure 4-10. P25p2 Adjacent Base Station Control Channel Site Summary

Power Profile

The power profile graph is used with Mobile Station Mod Type to display a zero-span view of power vs. time of the selected Rx Slot.

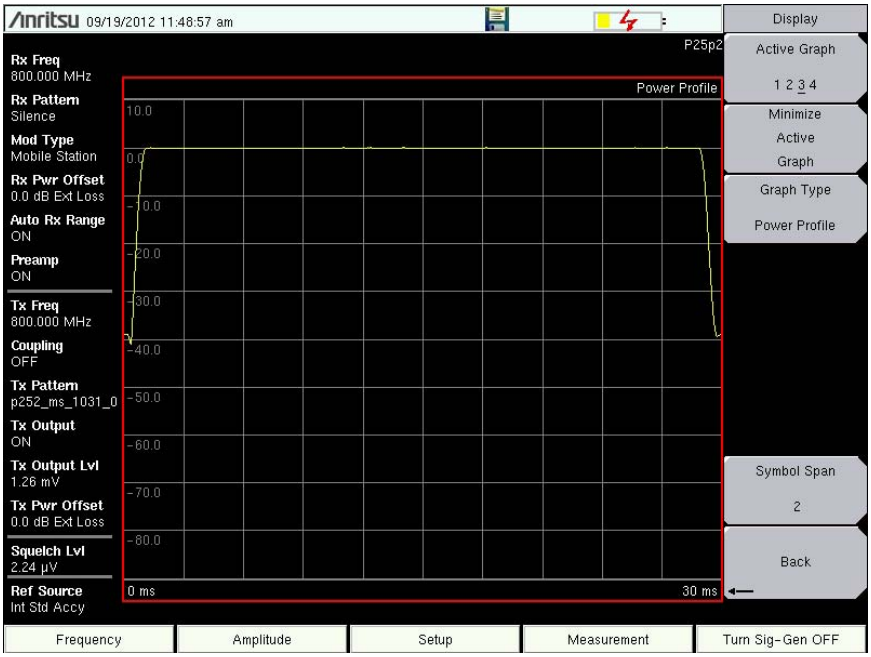


Figure 4-11. P25p2 Power Profile

4-4 P25p2 Control Measurement

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can log the decoded bits for control messages for either the voice channel or the control channel.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose either Voice (downlink) or Ctrl Channel (uplink) as the Rx Pattern.
3. From the **Measurement** main menu press the P25p2 Control submenu key twice.
4. To log data, insert a formatted flash drive in the LMR Master and set Log Data to On.
5. The Hex Trigger menu and Hex Trigger Value menu are used to find a specific opcode in the Control Channel data.

   To set the hex trigger value, press the Set Trigger Value menu. An on screen keyboard is displayed with the numbers 0 to 9 and the letters A to F. Enter the two-character hex value to search for. After entering the value, press **Enter** to set the trigger value. Press **Esc** to cancel entry or change the current hex value.

   Setting Hex Trigger to On sets the Sweep function to Hold when the hex trigger value is found in the first octet of a packet. The octet row with the found trigger value is displayed in the middle of the table (Figure 4-12). If Log Data is set to On, then all of the data on the screen are saved, and Log Data is set to Off. When Sweep is set back to Run, the unit continues to collect data and stops on the next instance of the hex trigger value. To continue to capture data on the USB flash drive, set Log Data back to On before setting Sweep to Run mode.

Figure 4-12 and Figure 4-13 are examples of the display screen measurement in Voice and Control Channel. Valid Octet data is displayed in blue. Data displayed in red indicates a Cyclic Redundancy Check (CRC) error. P25p2 Control measurements include the following information:

CC = Color Code
DT = Data Type
KEY = key ID (part of encrypt sync word which identifies the encryption parameters)
ALG = algorithm ID (part of encrypt sync word)
MI = message ID (part of encrypt sync word)

Set Descrambling to On to decrypt the data stream based on the WACN ID, System ID, and Color Code settings.

When Log Data is set to On, the control channel information is written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`CTRL_LOG`*`yearmonthdaytime`*`.p252` (for Control data)

or

`VOICE_LOG`*`yearmonthdaytime`*`.p252` (for Voice data)

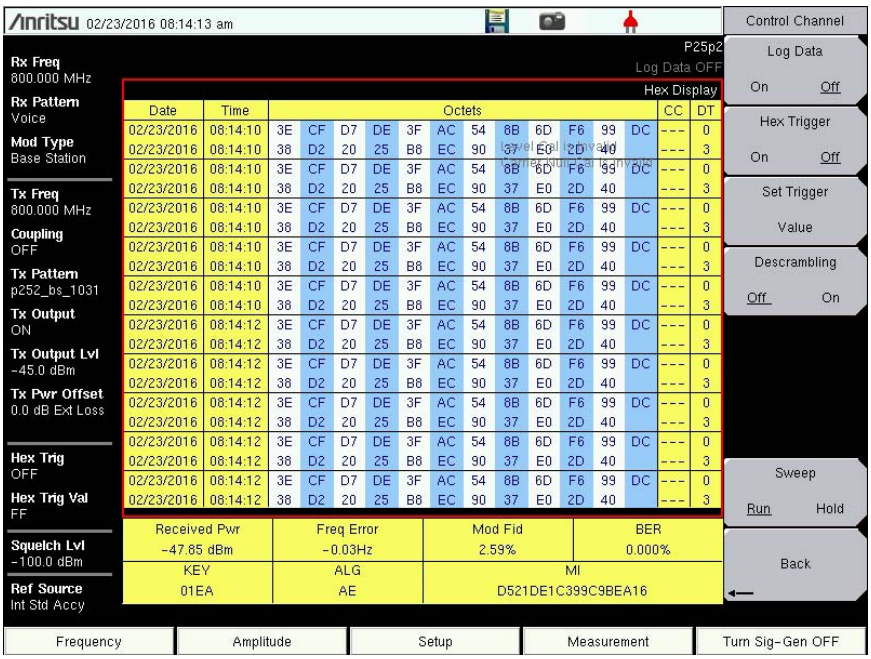


Figure 4-12. P25p2 Control Channel (Voice)

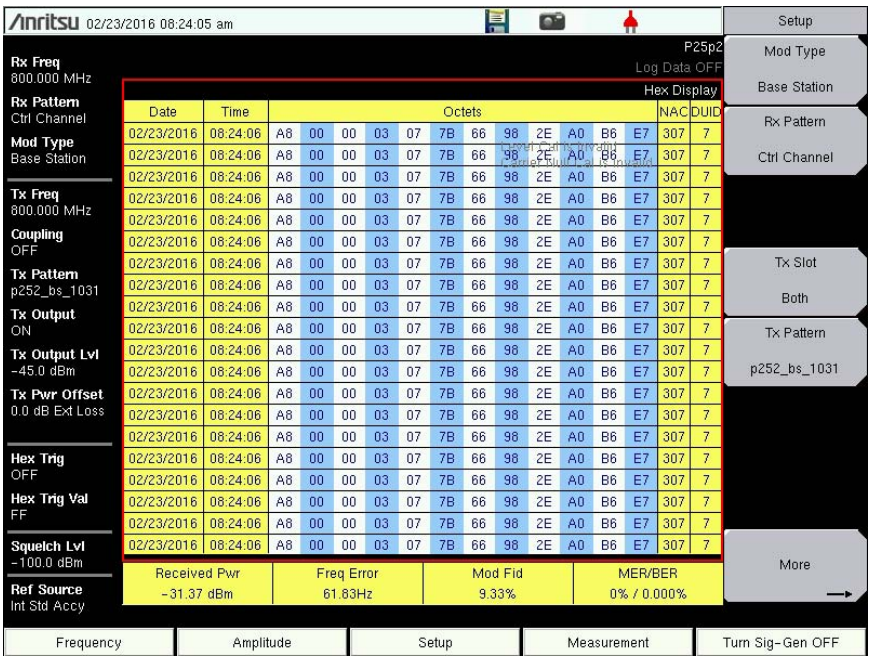


Figure 4-13. P25p2 Control Channel (Control)

4-5 P25p2 Coverage

Refer to Chapter 10, “LMR Coverage Mapping”.

4-6 P25p2 Bit Capture

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can provide and log raw bits (pre Forward Error Correction) when the Rx Pattern is set to Voice.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose Voice as the Rx Pattern.
3. From the **Measurement** main menu press the P25p2 Bit Capture submenu key twice.
4. To log data, insert a formatted USB flash drive in the LMR Master and set Descrambling to On to decrypt the data stream based on the WACN ID, System ID, and Color Code settings.
5. Set Log Data to On to start the bit capture. The information will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The tab delimited text file contains the header and table information shown in Figure 4-14. The files are named:

   `BIT_CAP_LOG`*`yearmonthdaytime`*`.p252`

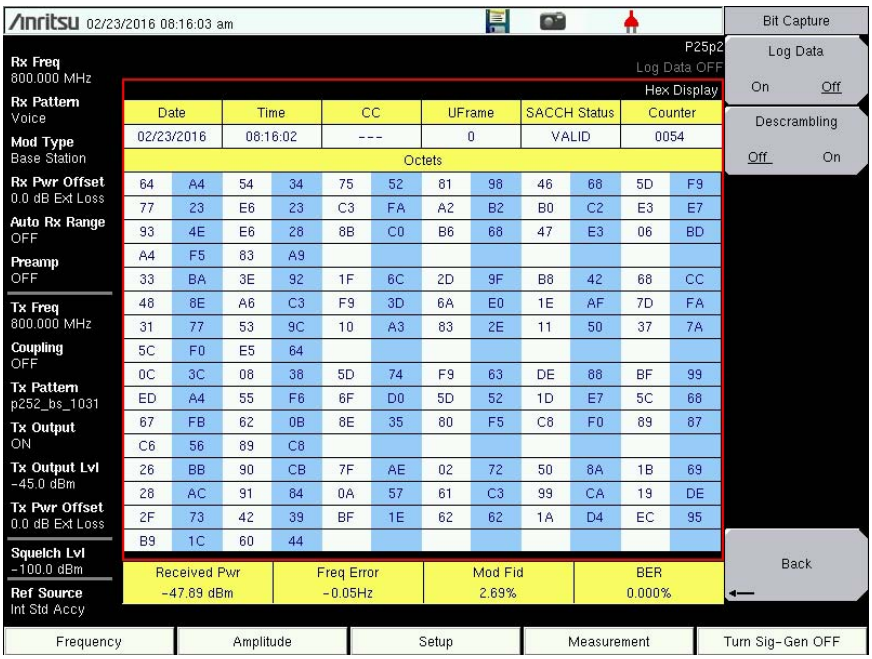


Figure 4-14. P25p2 Bit Capture Display

4-7 P25p2 IQ Data

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can capture and log P25p2 IQ data to a USB flash drive.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. Insert a formatted USB flash drive into the LMR Master and from the **Measurement** main menu, press the P25p2 IQ Capture submenu key. After approximately 10 seconds, the instrument displays a message that the capture is complete.

The IQ data is sampled at 4,800 x 11 symbols per second. The saved file has an ASCII header and binary data (Figure 4-15). The data is written in 24-bit two's complement integer format. The file is intended for post-processing in MATLAB or other data analysis software.

The file will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`IQ_CAPTURE`*`yearmonthdaytime`*`.p252`

Note	There is no display menu for P25p2 IQ Capture. The LMR Master will continue to display the previous measurement screen during IQ Capture.

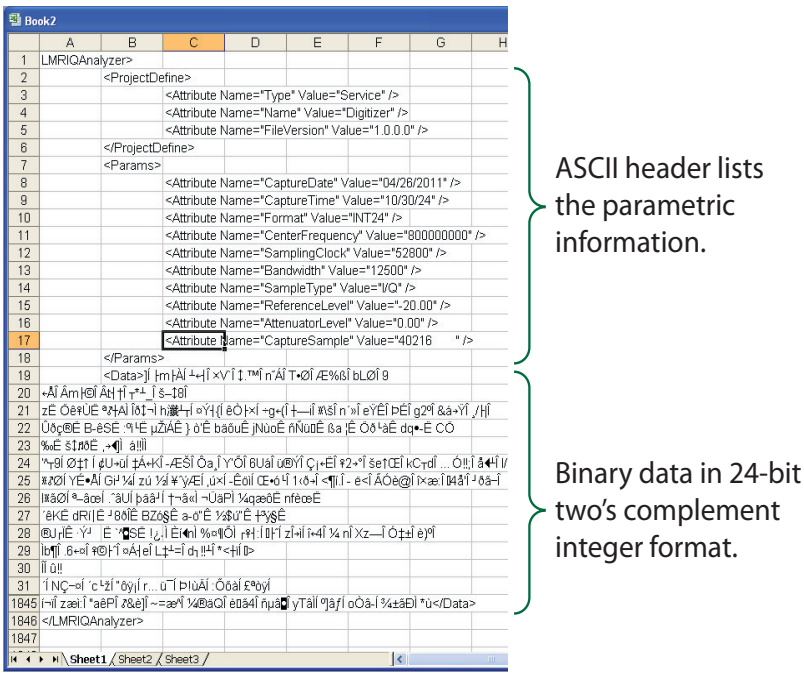


Figure 4-15. IQ Capture

4-8 P25p2 Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

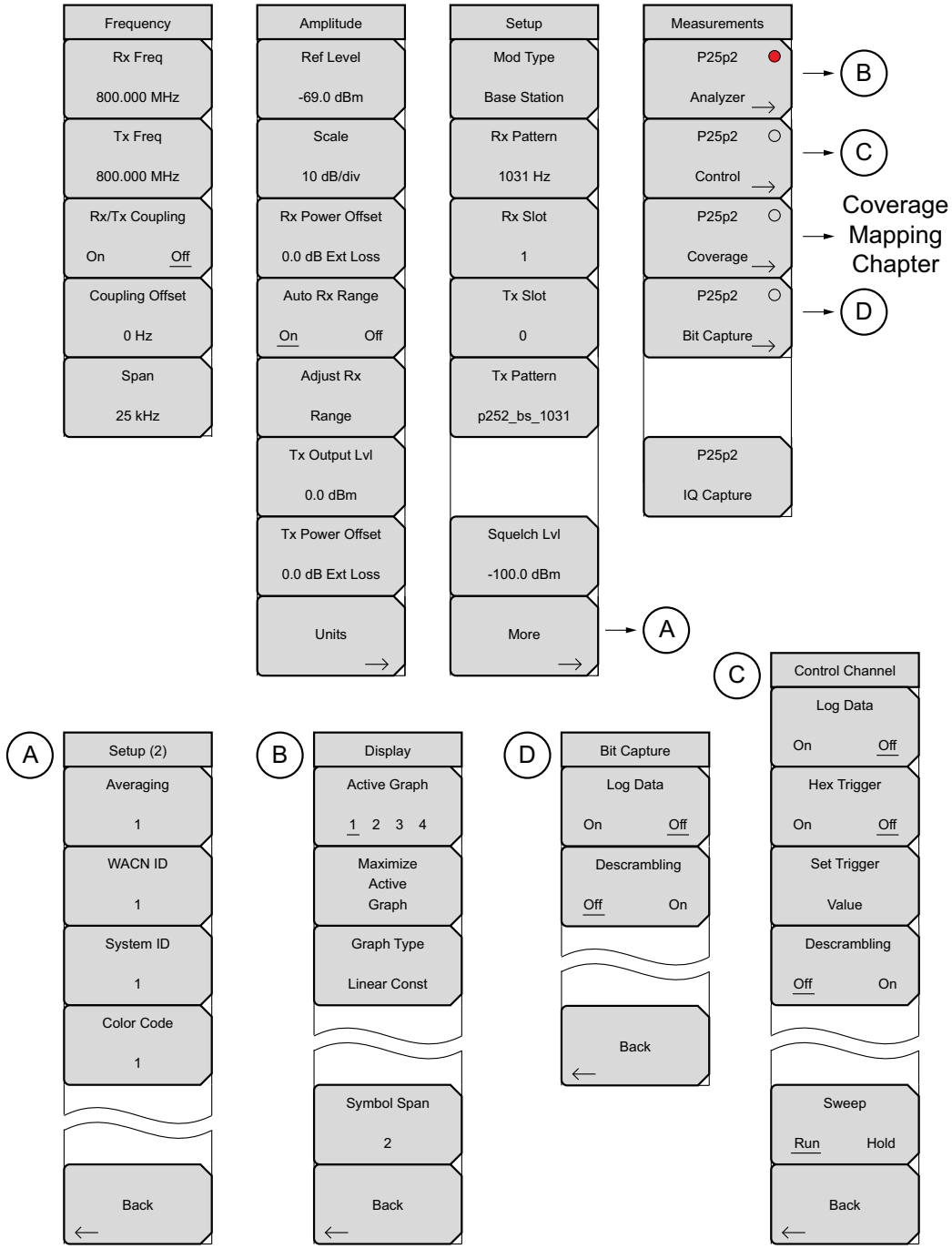
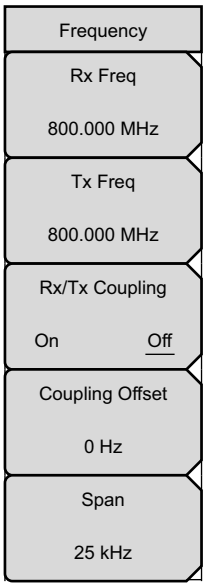


Figure 4-16. P25p2 Analyzer Menu Layout

4-9 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, then the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press the Tx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On the Tx Freq key is disabled.

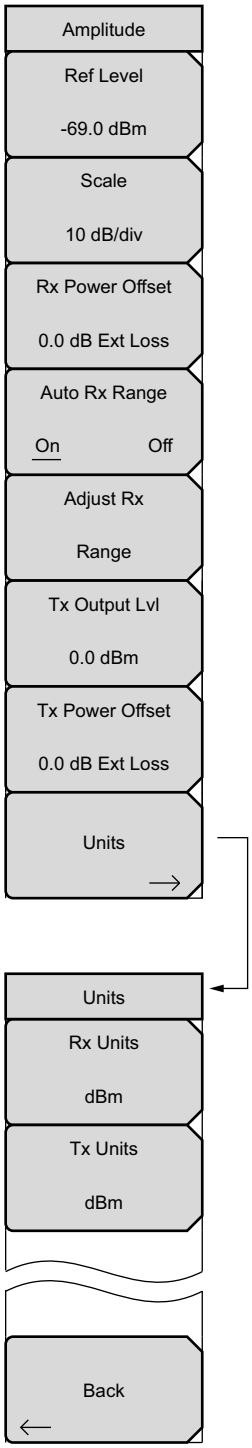
Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. Only functional when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 25 kHz, 50 kHz, 100 kHz, 500 kHz, 1 MHz, and 5 MHz.

Figure 4-17. P25p2 Analyzer Frequency Menu

4-10 Amplitude Menu

Key Sequence: **Amplitude**



Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis of the graticule. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. The y-axis power scale is shown on the left side of the display when viewing the Spectrum Graph.

Note: The "Vertical Scale Menu" on page 4-22 is displayed when P25p2 Coverage (**Measurement** > P25p2 Coverage) is selected.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Units: Opens to Units Submenu.

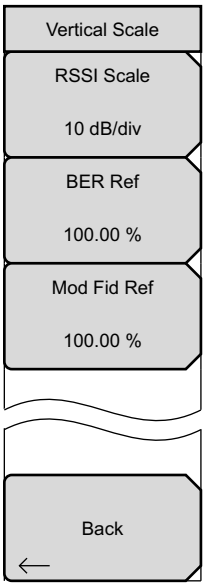
Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Demodulation Summary Graph and the Squelch Level.

Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 4-18. P25p2 Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale



RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

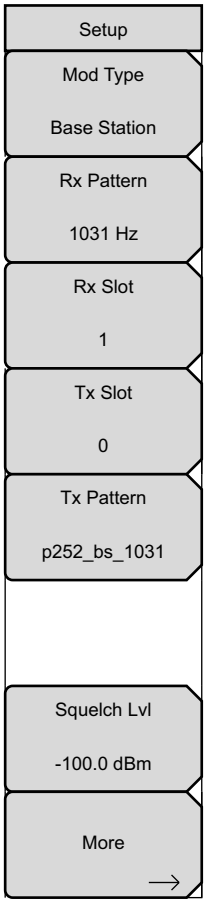
BER Ref: Sets the BER reference percentage value at the top of the y-axis in the BER vs. Time graph in Coverage measurement. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Mod Fid Ref: Sets the Modulation Fidelity reference percentage value. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Figure 4-19. Vertical Scale Menu

4-11 Setup Menu

Key Sequence: **Setup**



Mod Type: Sets the type of modulation. The options are Mobile Station or Base Station.

Rx Pattern: Selects the receiver Bit Error Rate pattern. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**. There are four available patterns:

Automatic Frequency Control (1031 Hz)
Silence
Voice
Ctrl (Control) Channel

Rx Slot: Selects the receiver time slot 0 or 1
(not available when Rx pattern is set to Ctrl Channel).

Tx Slot: Selects the LMR Master generator time slot (0 or 1) for the receiver.

Tx Pattern: Selects the transmitter pattern to send when the **Turn Sig-Gen ON** main menu key is selected. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**. Refer to "Using the Signal Generator for Receiver or OTA Analysis" on page 4-3 for the list of available transmitter patterns.

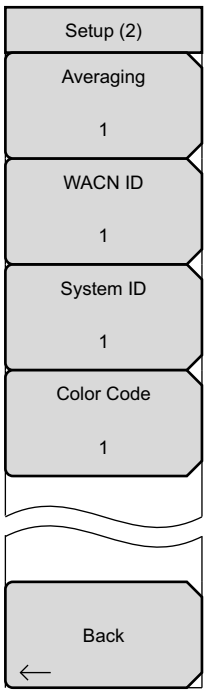
Squelch Lvl: Sets the squelch power level. When the received power is lower than the set squelch level, all demodulation summary graph measurements except for Received Pwr will be blanked out (--).

More: Opens the "Setup (2/2) Menu" on page 4-24.

Figure 4-20. P25p2 Analyzer Setup Menu

Setup (2/2) Menu

Key Sequence: **Setup** > More



Averaging: Sets the refresh rate of the numerical values in the P25p2 demodulation summary graph. Setting a higher number (25 maximum) will reduce measurement jitter.

WACN ID: Sets the Wide Area Communication Network Identifier (WACN) value the LMR Master receiver looks for in the received P25 Phase 2 transmission.

System ID: Sets the System Identifier value the LMR Master receiver looks for in the received P25 Phase 2 transmission.

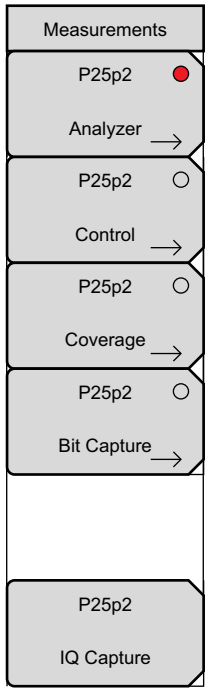
Color Code: Sets the System Identifier value the LMR Master receiver looks for in the received P25 Phase 2 transmission.

Back: Returns to the “Setup Menu” on page 4-23.

Figure 4-21. P25p2 Analyzer Setup (2/2) Menu

4-12 Measurement Menu

Key Sequence: **Measurement**



P25p2 Analyzer: Opens the "Display Menu" on page 4-26.

P25p2 Control: Opens the "Control Channel Menu" on page 4-27. This submenu key is valid only when Rx Pattern is set to Control Channel or Voice.

P25p2 Coverage (Option 522 required): Opens the P25p2 Coverage menu. Refer to Chapter 10, "LMR Coverage Mapping".

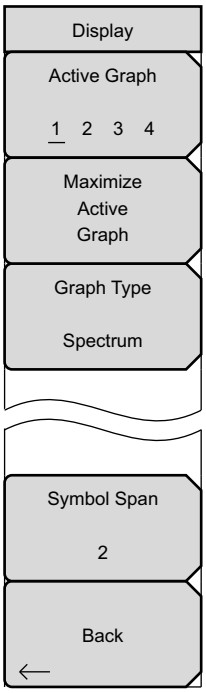
P25p2 Bit Capture: This submenu key is valid only when Rx Pattern is set to Voice. Pressing this key opens the "Bit Capture Menu" on page 4-28 for data logging.

P25p2 IQ Capture: Pressing this key starts the IQ data capture. Make sure that a formatted USB flash drive is attached to the instrument before starting IQ Capture. When the capture is complete, a message is displayed. This may take a few seconds.

Figure 4-22. P25p2 Analyzer Measurement Menu

Display Menu

Key Sequence: **Measurement** > P25p2 Analyzer



Active Graph 1 2 3 4: In Four Screen view use this menu to select which of the four graphs is active. The current active graph is underlined (1 2 3 4) and has a red perimeter line. Any of the four graphs can also be made active by tapping once on the touch screen. Repeatedly pressing the Active Graph submenu key will cycle the active graph, 1 through 4.

In Standard view (one graph displayed on the screen) the Active Graphic key will rotate between the four graphs displayed in the Four Screen view.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four Screen (4 graphs) view and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this button displays the current active graph type. Pressing the button will open a list box of the graphs types available for P25p2 Analyzer measurements. Select the desired graph type with the arrow keys or rotatory knob and press **Enter**. The current active graph will be replaced with the new selection.

Available graphs include:

- Linear Constellation
- Spectrum
- Histogram
- Eye Diagram
- Summary Graphs (demodulation, active and backup control channel, band plan, and adjacent site)
- Power Profile

Refer to “P25p2 Analyzer Graphs” on page 4-4 for additional information.

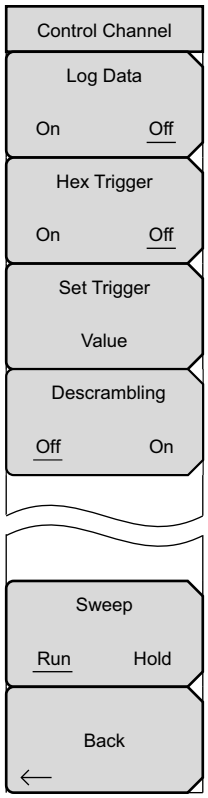
Symbol Span: Use this menu to adjust the number of symbols viewed across the screen in the Eye Diagram graph. Adjust from 2 and 5 using the keypad, the arrow keys, or the rotary knob. Keypad values entered outside of this range are ignored.

Back: Returns to the “Measurement Menu” on page 4-25.

Figure 4-23. P25p2 Analyzer Display Menu

Control Channel Menu

Key Sequence: **Measurement** > P25p2 Control



Log Data: Saves the measurements to an external USB flash drive. The external USB flash drive must be attached to one of the USB Type A connectors to Log data files.

The files are saved in a time-stamped folder under the **usr** folder on the USB flash drive.

If Log Data is On, any of the following functions will stop the logging:

Rx Frequency change
Setup change
Starting another measurement

Hex Trigger: Turns On or Off the Hex Trigger set with the following command. Sweep will continue until the trigger value is detected. At that time Sweep will change from Run to Hold.

Set Trigger Value: Opens a touchscreen hexadecimal keyboard for setting the Trigger value.

Descrambling: Decrypts the bit capture stream based on the following parameters from the "Setup (2/2) Menu" on page 4-24:

> **WACN ID:** Sets the Wide Area Communication Network Identifier (WACN) value the LMR Master receiver looks for in the received P25 Phase 2 transmission.
>
> **System ID:** Sets the System Identifier value the LMR Master receiver looks for in the received P25 Phase 2 transmission.
>
> **Color Code:** Sets the System Identifier value the LMR Master receiver looks for in the received P25 Phase 2 transmission.

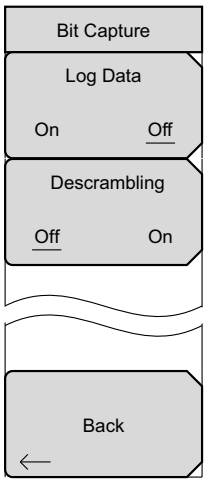
Sweep: Toggles the frequency sweep of the LMR Master between Run and Hold. Save function as **Shift** + **Sweep** (**3**).

Back: Returns to the "Measurement Menu" on page 4-25.

Figure 4-24. P25p2 Control Channel Menu

Bit Capture Menu

Key Sequence: **Measurement** > P25p2 Bit Capture



Log Data: Enables data logging. Make sure that a formatted USB flash drive is attached to the instrument before starting bit capture. Set Log Data to On to start the bit capture. Bit capture will continue until Log Data is set to Off or the USB flash drive is filled.

The files are saved in a time-stamped folder under the **usr** folder on the USB flash drive.

If Log Data is On, any of the following functions will stop the logging:

Rx Frequency change
Setup change
Starting another measurement
Selecting Log Data Off

Descrambling: Decrypts the bit capture stream based on the following parameters from the "Setup (2/2) Menu" on page 4-24:

WACN ID: Sets the Wide Area Communication Network Identifier (WACN) value the LMR Master receiver looks for in the received P25 Phase 2 transmission.

System ID: Sets the System Identifier value the LMR Master receiver looks for in the received P25 Phase 2 transmission.

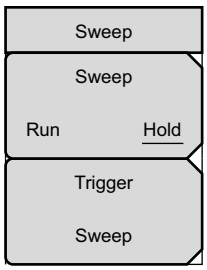
Color Code: Sets the System Identifier value the LMR Master receiver looks for in the received P25 Phase 2 transmission.

Back: Returns to the "Measurement Menu" on page 4-25.

Figure 4-25. P25p2 Analyzer Display Menu

4-13 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Trigger Sweep is not available in P25p2 Control and P25p2 Bit Capture measurements.

Figure 4-26. P25p2 Analyzer Sweep Menu

4-14 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Displays the "Measurement Menu" on page 4-25.

4-15 Trace Menu

This menu is not available in P25p2 Analyzer measurement mode.

4-16 Limit Menu

This menu is not available in P25p2 Analyzer measurement mode.

4-17 Other Menus

Preset, **Calibrate**, **File**, **System** and **Mode** are described in the User Guide.

Chapter 5 — NXDN Analyzer (Option 531)

5-1 Introduction

The NXDN Analyzer option provides a method to verify the operation of NXDN tower, mobile, and portable radio transmitters. Option 531 includes the ability to display constellation, spectrum, histogram, and eye diagram graphs. In addition, a summary graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), bit error rate (BER), symbol deviation, Radio Access Number (RAN), and symbol rate error of the input signal. BER comparisons can be made to the 1031 Hz Standard Tone or the Standard Transmitter Test (O.153) pattern, regular voice traffic using a proprietary algorithm, or a Message Error Rate (MER) can be computed using the control channel messages CRC checking. In addition, estimated BER on the control channel uses a proprietary algorithm.

The LMR Master will analyze input signal strengths from +33 dBm (2.0 watts) down to levels approaching the sensitivity of NXDN radios, automatically adjusting the input sensitivity based on input levels.

5-2 Setup Procedure

Direct Connect to the Transmitter

1. Press the **Menu** key then select the NXDN Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight NXDN Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect the transmitter to the RF In 50 Ohm connector on the LMR Master using a coupler or attenuator.
3. Press the **Frequency** main menu key to set the center frequency of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the modulation bandwidth and Rx pattern. Select 12.5 kHz or 6.25 kHz modulation bandwidth. Press the Rx pattern key to choose the pattern against which to measure error rates. 1031 and O.153 (V.52) will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Ctrl Channel will produce a Message Err Rate (MER) based on the CRC checksums contained in Control Channel messages and estimated BER using a proprietary algorithm.

5. Press the **Amplitude** main menu key, then the Rx Power Offset submenu key to set the receiver attenuation (or gain). Use the arrow keys, rotary knob or the numeric keypad to enter the adjustment value, up to 100 dB. The offset will be applied to the Received Power value in the Summary graph. For instance, if the transmitter under test is emitting 50 watts (+47 dBm) of power, and the External Attenuation value is 40 dB (such as from a 40 dB directional coupler) the Received Power displayed will be +7 dBm.
6. Press the **Measurement** key, then the NXDN Analyzer submenu key. Select the Graph types to view with the Graph Type submenu key. The Symbol Span submenu is used to adjust the number of "eyes" displayed across the screen in the Eye Diagram graph. Refer to "NXDN Analyzer Graphs" on page 5-4 on the available graph types.

Over the Air (OTA) Analysis Setup

1. Press the **Menu** key then select the NXDN Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight NXDN Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Frequency** main menu key to set the center frequency of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the modulation bandwidth and Rx pattern (BER pattern). Select 12.5 kHz or 6.25 kHz modulation bandwidth. Press the Rx Pattern key to choose the pattern against which to measure error rates. 1031 and O.153 (V.52) will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Ctrl Channel will produce a Message Err Rate (MER) based on the CRC checksums contained in Control Channel messages and estimated BER using a proprietary algorithm. Refer to "NXDN Analyzer Graphs" on page 5-4 on the available graph types.

Using the Signal Generator for Receiver or OTA Analysis

1. Press the **Menu** key then select the NXDN Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight NXDN Analyzer and press **Enter**.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW (0 dBm) and the frequency range is 500 kHz to 1.6 GHz.

2. Direct connect the LMR Master Signal Generator Out 50 Ohm connector to the repeater/receiver or connect an antenna with the appropriate frequency range to the connector.
3. Press the **Frequency** main menu key to set the transmit frequency using the Tx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.

   If testing an NXDN repeater, you can bind the transmit frequency to the receive frequency by setting Rx/Tx Coupling to On and entering the Coupling Offset.

Note	When Rx/Tx Coupling is on, the Tx Freq submenu key is disabled.

4. Press the **Amplitude** main menu key, then the Tx Output Lvl submenu key to set the output power. Enter any output attenuation or gain using the Tx Power Offset key.
5. Set the bandwidth by pressing the **Setup** main menu key and then the Mod Bandwidth submenu key. Set the signal generator pattern with the Tx Pattern submenu key. Available patterns are listed on the display and additional patterns can be downloaded via the **System** > Application Options menu.

Note	Set the Radio Access Number (RAN) value (**Setup** > RAN) that is sent on the standard NXDN 1013 Hz Tx pattern when testing receivers. Default value is 01.

   The 9600 bps patterns are shown when the bandwidth is set to 12.5 kHz. The 6.25 kHz bandwidth setting displays the 4800 bps patterns.
6. Press the **Turn Sig-Gen ON** main menu key to start the signal generator. Press the key again to turn off the signal generator.

5-3 NXDN Analyzer Graphs

The following NXDN Analyzer measurements are available on the LMR Master. From the **Measurements** main menu press NXDN Analyzer twice. Press the Graph Type submenu key to select the measurement type.

Constellation and Linear Constellation

Constellation view displays the demodulation information in an IQ format (Figure 5-1). The charts show the relationship between the location of a constellation data point, its deviation frequency, and the information it carries.

NXDN definition for 6.25 kHz bandwidth (4800 bps)

Symbol: +3 Bit Information: 01 Deviation: +1050 Hz	Symbol: +1 Bit Information: 00 Deviation: +350 Hz
Symbol: -3 Bit Information: 11 Deviation: -1050 Hz	Symbol: -1 Bit Information: 10 Deviation: -350 Hz

NXDN definition for 12.5 kHz bandwidth (9600 bps)

Symbol: +3 Bit Information: 01 Deviation: +2400 Hz	Symbol: +1 Bit Information: 00 Deviation: +800 Hz
Symbol: -3 Bit Information: 11 Deviation: -2400 Hz	Symbol: -1 Bit Information: 10 Deviation: -800 Hz

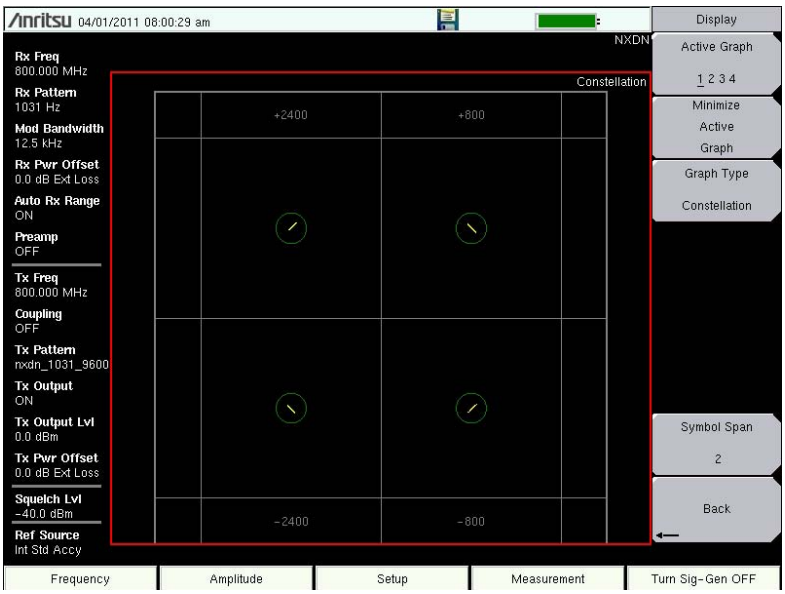


Figure 5-1. Constellation Diagram (12.5 kHz BW)

Figure 5-2 shows the same information is the Linear Constellation View.

NXDN definition for 6.25 kHz bandwidth (4800 bps)

Symbol: -3 Bit Information: 11 Deviation: -1050 Hz	Symbol: -1 Bit Information: 10 Deviation: -350 Hz	Symbol: +1 Bit Information: 00 Deviation: +350 Hz	Symbol: +3 Bit Information: 01 Deviation: +1050 Hz

NXDN definition for 12.5 kHz bandwidth (9600 bps)

Symbol: -3 Bit Information: 11 Deviation: -2400 Hz	Symbol: -1 Bit Information: 10 Deviation: -800 Hz	Symbol: +1 Bit Information: 00 Deviation: +800 Hz	Symbol: +3 Bit Information: 01 Deviation: +2400 Hz

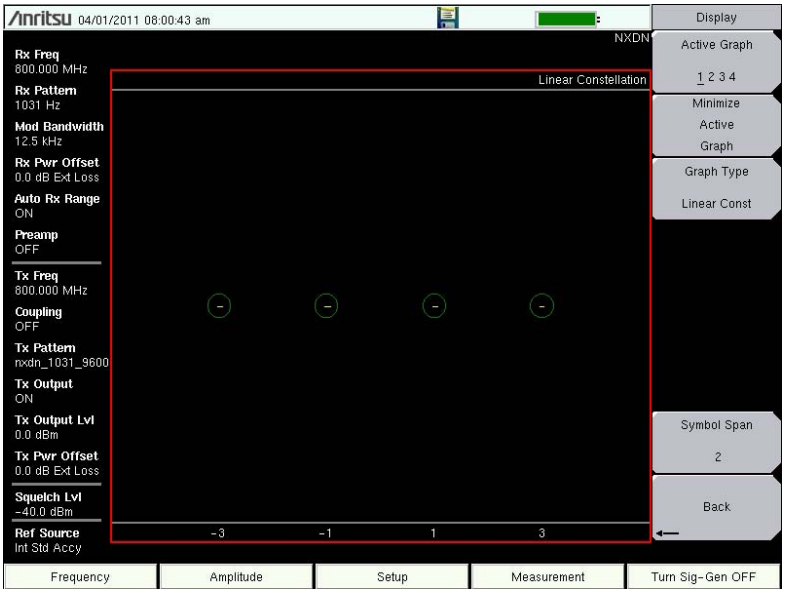


Figure 5-2. Linear Constellation Diagram

For input signals that are not NXDN encoded, the LMR Master will still try to decode it and fit it to a symbol. This may cause some measurement results that are unexpected.

Histogram Graph

The Histogram graph displays a graphical representation of the symbols that are being received. The graph for each symbol represents the relative percentage that symbol was identified out of all the received symbols.

Each update of the screen is a separate representation of the latest data, rather than a cumulative total. The vertical scale is fixed at 0 to 100 %, with each horizontal grid line representing 10 % of the total symbols received.

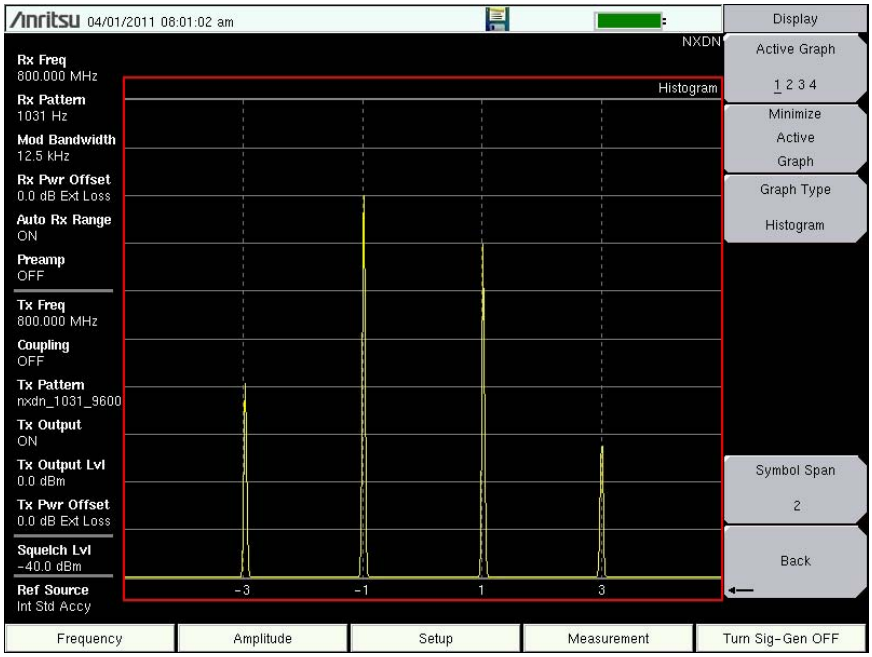


Figure 5-3. NXDN Histogram

Spectrum Graph

The spectrum view displays a graphical representation of power (dBm) vs. frequency. The spectrum display gives an indication if there are interferers present that may degrade the bit error rate of the NXDN signal. The frequency span is adjustable under the **Frequency** menu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 5-17 for details.Figure 5-4 displays the same signal using a 25 kHz span and a 500 kHz span.

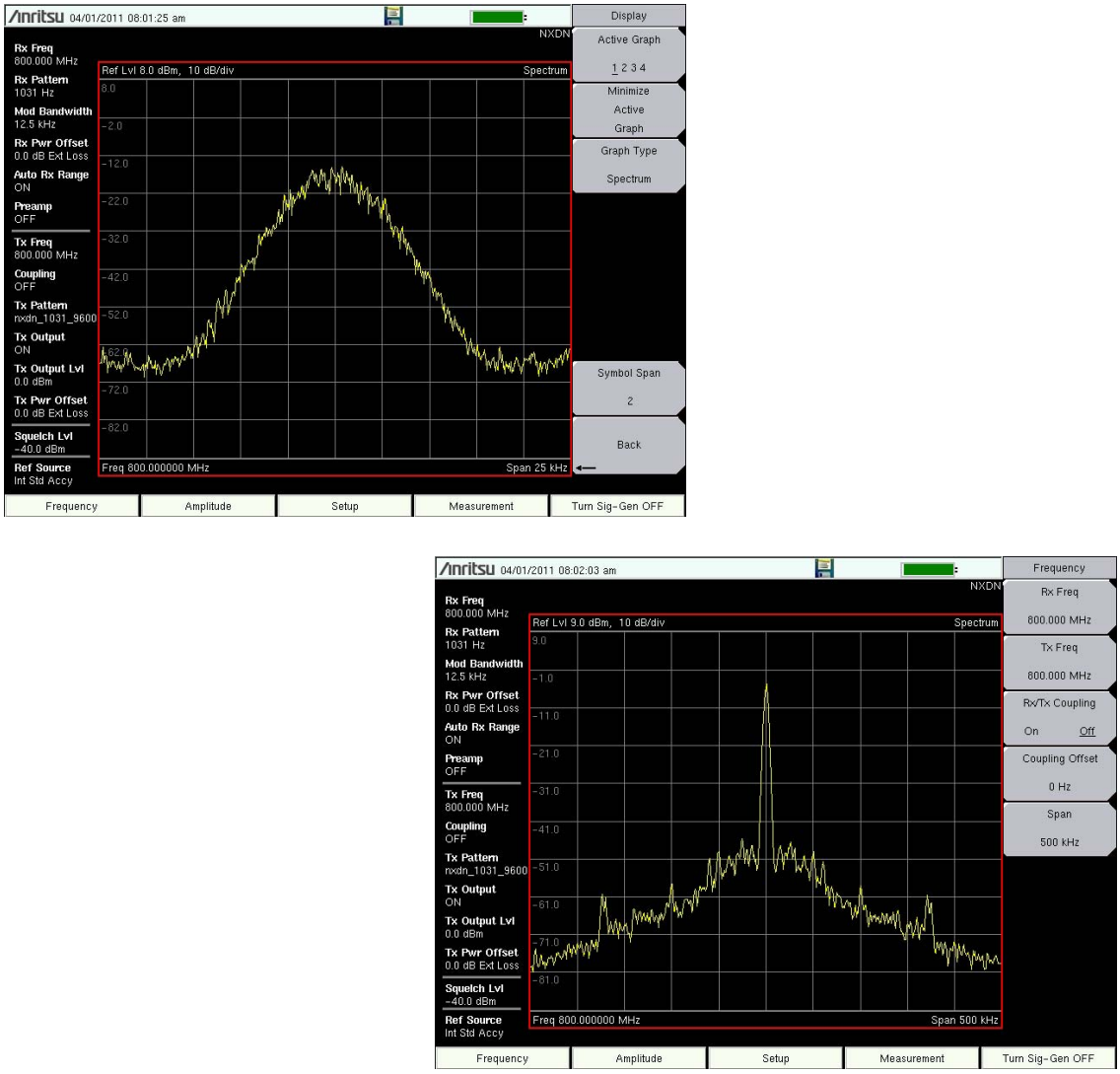


Figure 5-4. NXDN Spectrum Graph (25 kHz Span and 500 kHz Span)

Eye Diagram

The eye diagram is an oscilloscope view of the NXDN signal displaying the voltage of the signal vs. time. The diagram provides an indication of baseband fidelity of an NXDN transmitter. With Over-the-air measurements the Eye Diagram can indicate phase distortion from multipath. The number of "eyes" displayed is set with the Symbol Span key under the "Display Menu" on page 5-21.

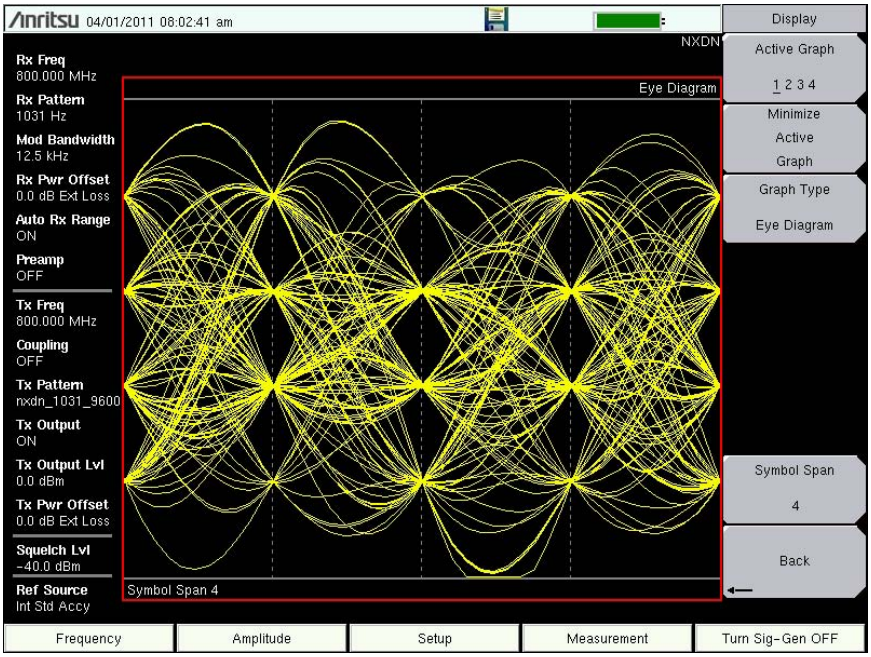


Figure 5-5. NXDN Eye Diagram

Summary Graph

The summary graph provides an overview of an NXDN transmitter. The graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), bit error rate (BER), symbol deviation, Radio Access Number (RAN), and symbol rate error of the input signal.

The Received Power value in the summary graph can be toggled to dBm, watts, or volts by using the **Amplitude** > Units > Rx Units submenu key. This setting also applies to the squelch level setting.

The **Setup** > Squelch Lvl submenu key sets the squelch power level. When the Received Power is lower than the set squelch level all summary graph measurements except for Received Pwr will be blanked out (--). When the Received Power is above the squelch level, the measurements are displayed as shown in Figure 5-6.

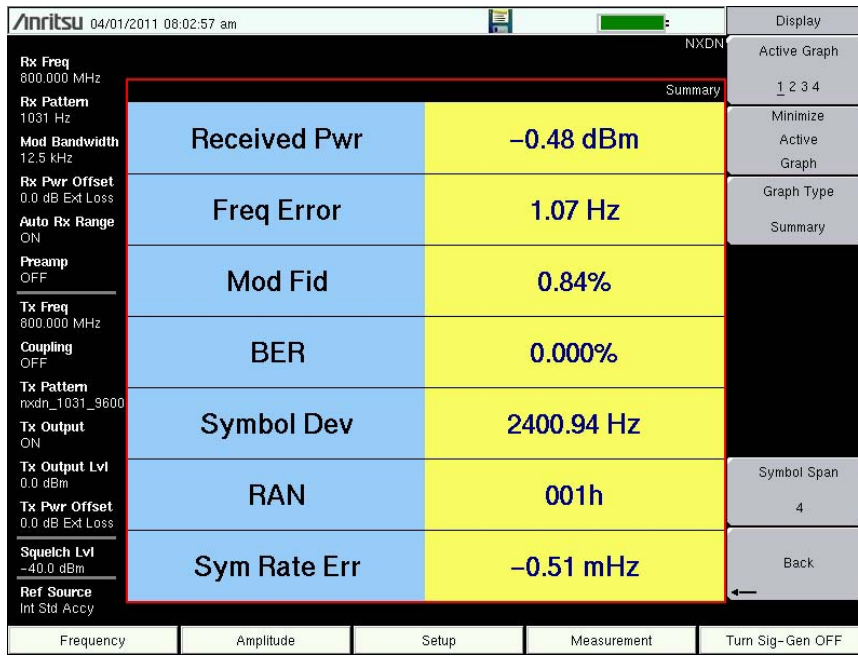


Figure 5-6. NXDN Summary Graph with Received Pwr Above the Squelch Level

Received Pwr in the Summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Received Pwr is a function of the instruments RBW setting. The reduction is specified as: 10*Log(Signal Bandwidth / Resolution Bandwidth).

5-4 NXDN Control Measurement

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can log the decoded bits for control messages for either the voice channel or the control channel.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose either Voice (downlink) or Ctrl Channel (uplink) as the Rx Pattern.
3. From the **Measurement** main menu press the NXDN Control submenu key twice.
4. To log data, insert a formatted USB flash drive in the LMR Master and set Log Data to On.
5. The Hex Trigger menu and Hex Trigger Value menu are used to find a specific opcode in the Control Channel data.

   To set the hex trigger value, press the Set Trigger Value menu. An on screen keyboard is displayed with the numbers 0 to 9 and the letters A to F. Enter the two-character hex value to search for. After entering the value, press **Enter** to set the trigger value. Press **Esc** to cancel entry or changing the current hex value.

   Setting Hex Trigger to On sets the Sweep function to Hold when the hex trigger value is found in the first octet of a packet. The octet row with the found trigger value is displayed in the middle of the table (Figure 5-7 on page 5-12). If Log Data is set to On, then all of the data on the screen are saved and Log Data is set to Off. When Sweep is set back to Run, the unit continues to collect data and stops on the next instance of the hex trigger value. To continue to capture data to the USB flash drive, set Log Data back to On before setting Sweep to Run mode.

Figure 5-7 and Figure 5-8 are examples of the display screen measurement in Voice and Control. Valid Octet data is displayed in blue. Data displayed in red indicates a Cyclic Redundancy Check (CRC) error. NXDN Control measurements include the following information:

RAN: Radio Access Number

STR: a 4-bit field which identifies the channel type

bits 0, 1 = structure field

bits 2, 3 = channel type (0 = CAC, 1 = SACCH, 2 = FACCH1, 3 = FACCH2)

When Log Data is set to On, the control channel information will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`CTRL_LOG`*`yearmonthdaytime`*`.nxdn` (for Control data)

or

`VOICE_LOG`*`yearmonthdaytime`*`.nxdn` (for Voice data)

Decoding Control Channel Measurements

Anritsu offers a Python script that will decode the logged hexadecimal Control Channel measurements. The script is available for download from the Anritsu web site and requires that the Python programming language is installed on your computer.

To decode control channel measurements with the Python script:

1. Install the Python programming language on a PC. Download the installer (http://www.python.org/download/) from the Python Programming Language web site.
2. Download the decoder script from the Anritsu web site:
   a. Open the Anritsu home page (http://www.anritsu.com) with a web browser.
   b. Type S412E in the search box to find the LMR Master S412E product page on the Anritsu web site. Click the product page link to display the LMR Master product page.
   c. Click the Library tab. Under the Drivers/Software Downloads section, select NXDN Control Channel Decoder. Next, click the Download button then Save to copy the file "dmr_ctrl_decoder.zip" to your computer.
3. Unzip and launch the python script. The script file name is `nxdn_ctrl_decoder.py`.

4. Press the Select File button and select the control channel file that was saved on the USB flash drive. The Python script will display the CRC errors and write a text file in the same location with the decoded control channel commands.

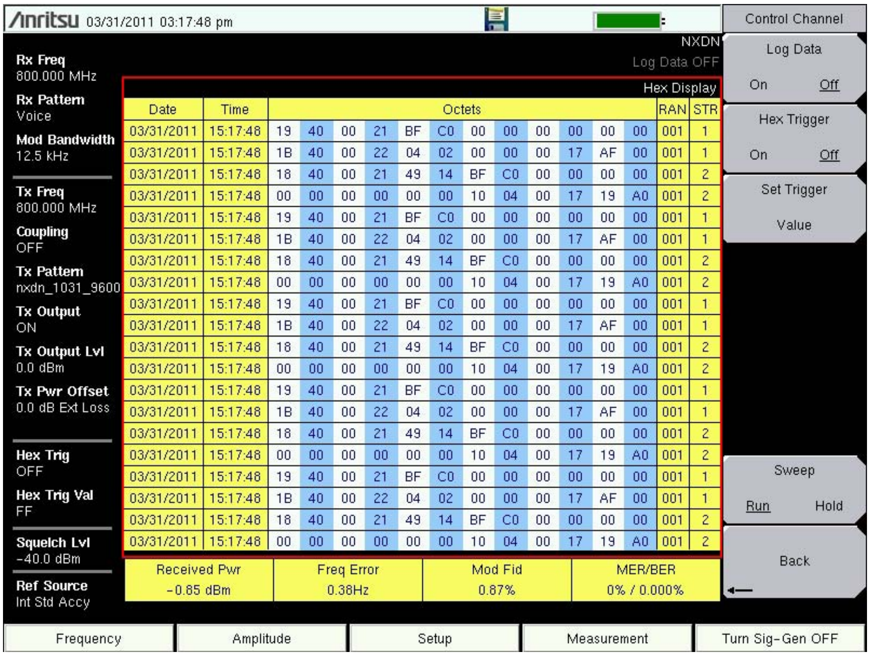


Figure 5-7. NXDN Control Channel (Voice)

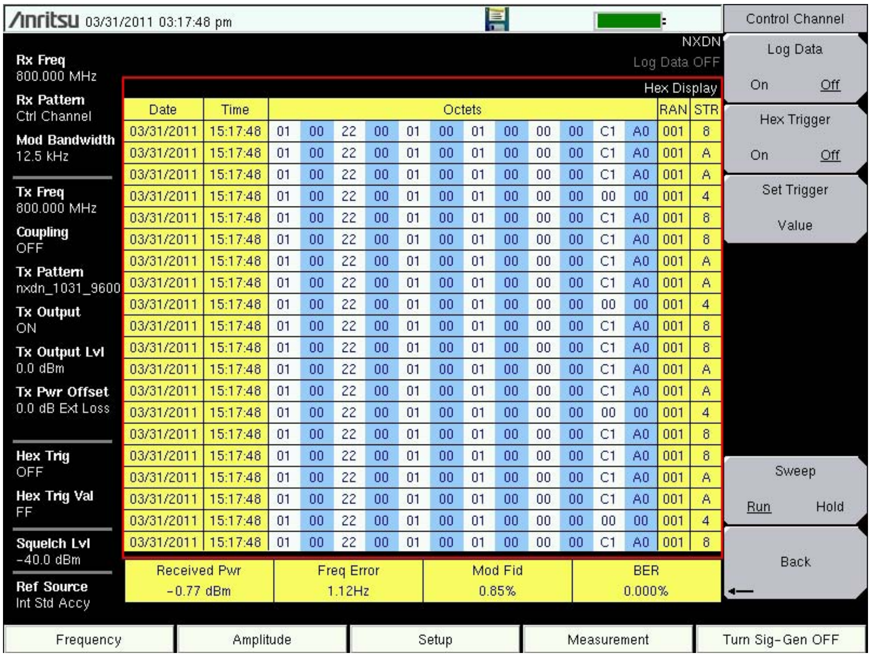


Figure 5-8. NXDN Control Channel (Control)

5-5 NXDN Bit Capture

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can provide and log raw bits (pre Forward Error Correction) when the Rx Pattern is set to Voice.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose Voice as the Rx Pattern.
3. From the **Measurement** main menu press the NXDN Bit Capture submenu key twice.
4. To log data, insert a formatted USB flash drive in the LMR Master and set Log Data to On. The bit capture information will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The tab delimited text file contains the header and table information shown in Figure 5-9. The files are named:

   `BIT_CAP_LOG`*`yearmonthdaytime`*`.nxdn`

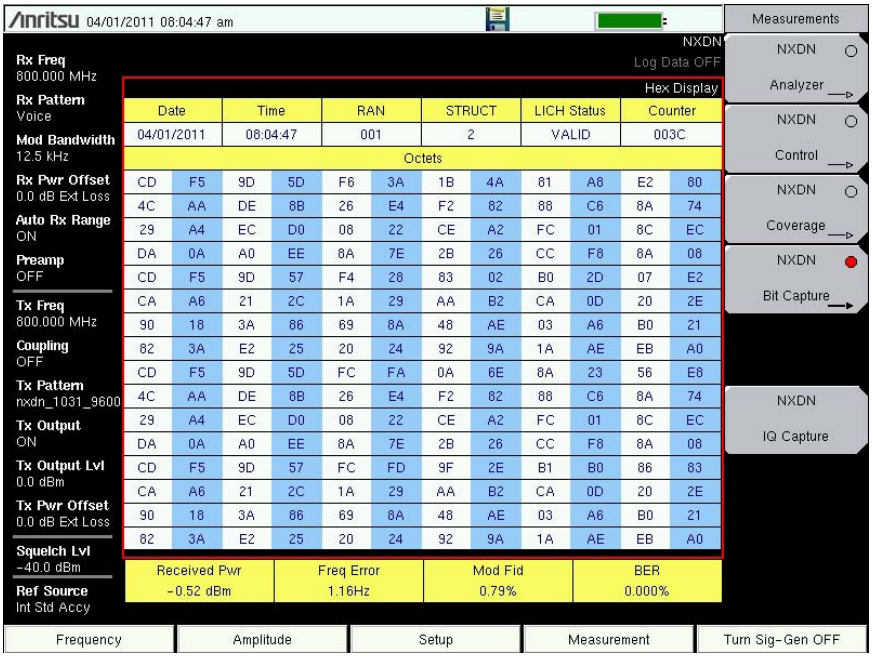


Figure 5-9. NXDN Bit Capture Display

5-6 NXDN IQ Data

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can capture and log NXDN IQ data to a USB flash drive.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose a Mod Bandwidth.
3. Insert a formatted USB flash drive into the LMR Master and from the **Measurement** main menu, press the NXDN IQ Capture submenu key. After approximately 10 seconds the instrument will display a message that the capture is complete.

The IQ data is sampled at 2,400 x 11 (6.25 kHz BW) or 4,800 x 11 (12.5 kHz BW) symbols per second. The saved file has an ASCII header and binary data (Figure 5-10). The data is written in 24-bit two's complement integers format. Interleaved Delta Phase (I) data then Magnitude (Q) data is captured. The file is intended for post-processing in MATLAB or similar software.

The file will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`IQ_CAPTURE`*`yearmonthdaytime`*`.nxdn`

Note	There is no display menu for NXDN IQ Capture. The LMR Master will continue to display the previous measurement screen during IQ Capture.

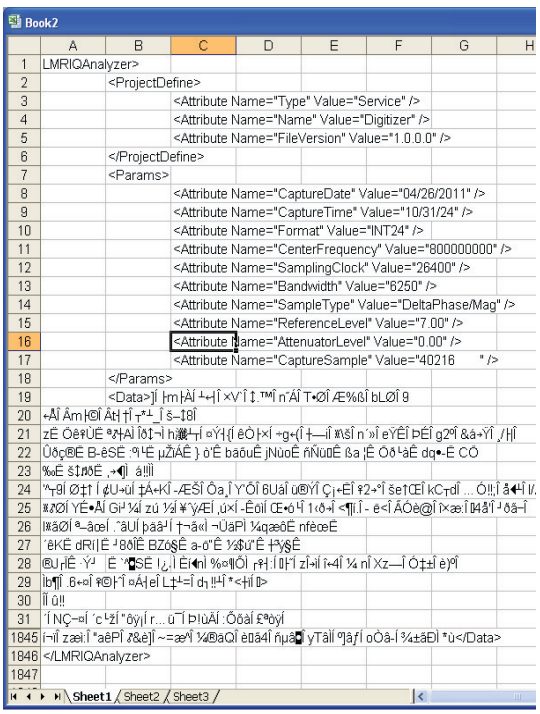


Figure 5-10. IQ Capture (6.25 kHz Bandwidth)

5-7 NXDN Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

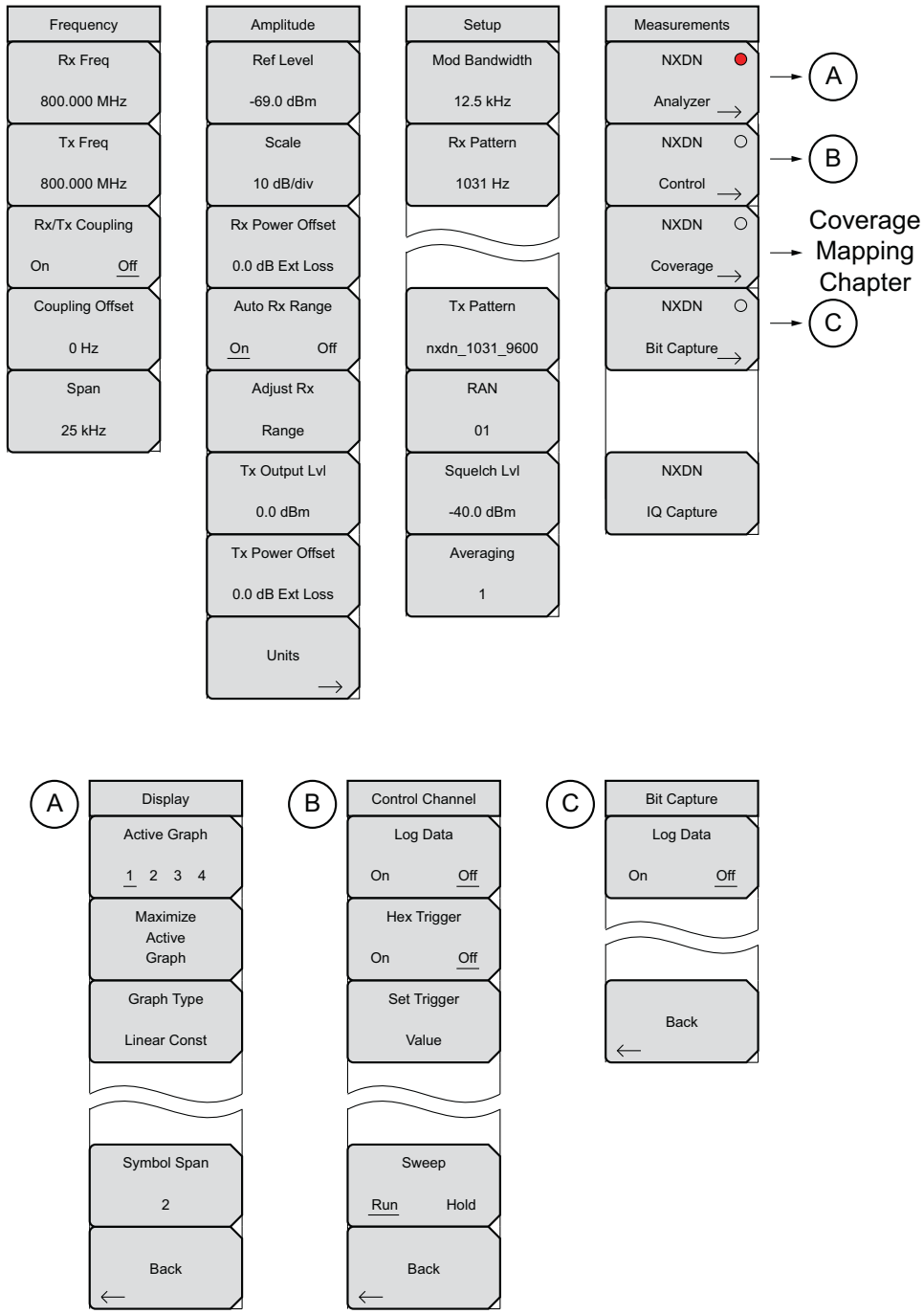
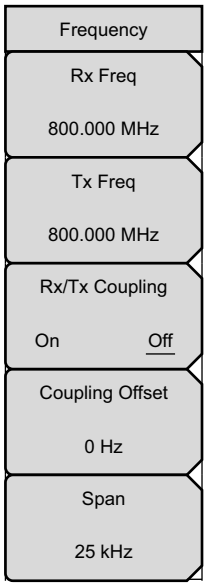


Figure 5-11. NXDN Analyzer Menu Layout

5-8 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press Tx Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On the Tx Freq key is disabled.

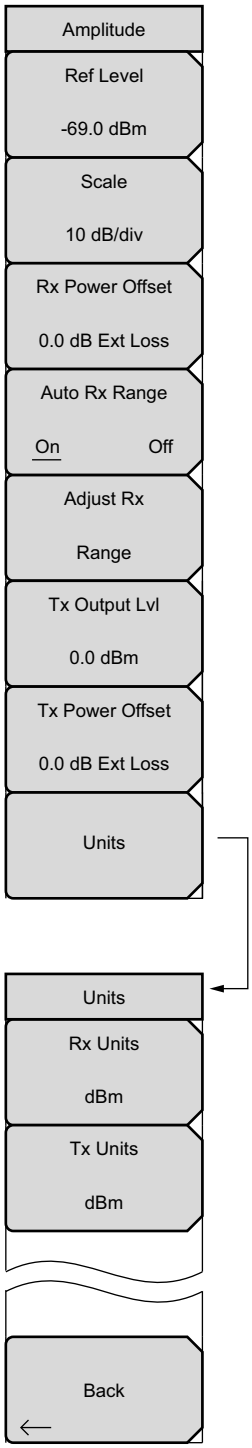
Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. Only functional when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 25 kHz, 50 kHz, 100 kHz, 500 kHz, 1 MHz, and 5 MHz.

Figure 5-12. NXDN Analyzer Frequency Menu

5-9 Amplitude Menu

Key Sequence: **Amplitude**



Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis of the graticule. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. The y-axis power scale is shown on the left side of the display when viewing the Spectrum Graph.

Note: The "Vertical Scale Menu" on page 5-18 is displayed when NXDN Coverage (**Measurement** > NXDN Coverage) is selected.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Units: Opens to Units Submenu.

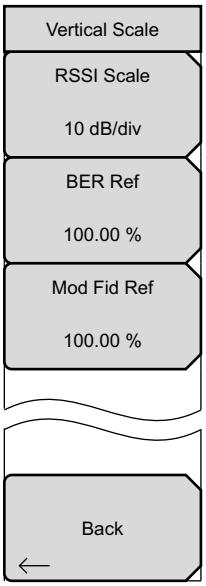
Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Summary Graph and the Squelch Level.

Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 5-13. NXDN Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale



RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

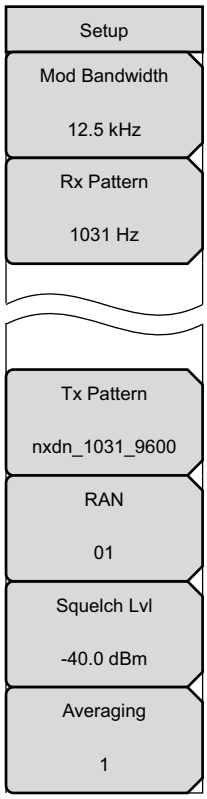
BER Ref: Sets the BER reference percentage value at the top of the y-axis in the BER vs. Time graph in Coverage measurement. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Mod Fid Ref: Sets the Modulation Fidelity reference percentage value. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Figure 5-14. Vertical Scale Menu

5-10 Setup Menu

Key Sequence: **Setup**



Mod Bandwidth: Sets the type of modulation bandwidth. This key toggles between 12.5 kHz and 6.25 kHz.

Rx Pattern: Selects the receiver Bit Error Rate pattern. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**. There are four available patterns:

1031 Hz
Standard Transmitter Test (O.153 or V.52)
Voice
Ctrl (Control) Channel

Tx Pattern: Selects the transmitter pattern to send when the **Turn Sig-Gen ON** main menu key is selected. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**.

RAN: Sets the Radio Access Number (RAN) that is sent on the standard NXDN 1031 Hz Tx Pattern when testing receivers.

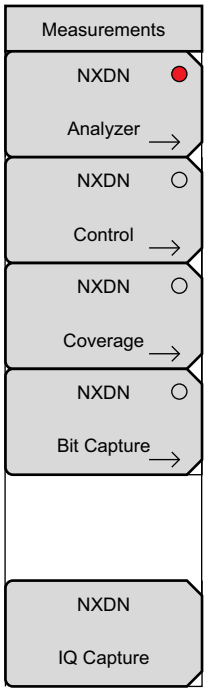
Squelch Lvl: Sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--).

Averaging: Sets the refresh rate of the numerical values in the NXDN Summary window. Setting a higher number (25 maximum) will reduce measurement jitter.

Figure 5-15. NXDN Analyzer Setup Menu

5-11 Measurement Menu

Key Sequence: **Measurement**



NXDN Analyzer: Opens the “Display Menu” on page 5-21.

NXDN Control: Opens the “Control Channel Menu” on page 5-22. This submenu key is valid only when Rx Pattern is set to Control Channel or Voice.

NXDN Coverage (Option 532 required): Opens the NXDN Coverage menu. Refer to Chapter 10, “LMR Coverage Mapping”.

NXDN Bit Capture: This submenu key is valid only when Rx Pattern is set to Voice. Pressing this key opens a submenu for data logging. Make sure that a formatted USB flash drive is attached to the instrument before starting bit capture. Set Log Data to On to start the bit capture. Bit capture will continue until Log Data is set to Off or the USB flash drive is filled.

The files are saved in a time-stamped folder under the **usr** folder on the USB flash drive.

If Log Data is On, any of the following functions will stop the logging:

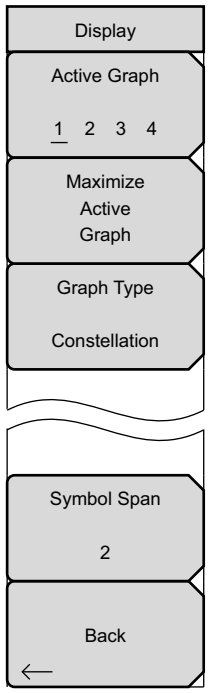
Rx Frequency change
Setup change
Starting another measurement

NXDN IQ Capture: Pressing this key starts the IQ data capture. Make sure that a formatted USB flash drive is attached to the instrument before starting IQ Capture. When the capture is complete, a message is displayed. This may take a few seconds.

Figure 5-16. NXDN Analyzer Measurement Menu

Display Menu

Key Sequence: **Measurement** > NXDN Analyzer



Active Graph 1 2 3 4: In Four Screen view use this menu to select which of the four graphs is active. The current active graph is underlined (1 2 3 4) and has a red perimeter line. Any of the four graphs can also be made active by tapping once on the touch screen. Repeatedly pressing the Active Graph submenu key will cycle the active graph, 1 through 4.

In Standard view (one graph displayed on the screen) the Active Graphic key will rotate between the four graphs displayed in the Four Screen view.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four Screen (4 graphs) view and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this button displays the current active graph type. Pressing the button will open a list box of the graphs types available for NXDN Analyzer measurements. Select the desired graph type with the arrow keys or rotatory knob and press **Enter**. The current active graph will be replaced with the new selection.

Available graphs include:

- Constellation
- Spectrum
- Histogram
- Eye Diagram
- Linear Constellation
- Summary

Refer to “NXDN Analyzer Menus” on page 5-15 for additional information.

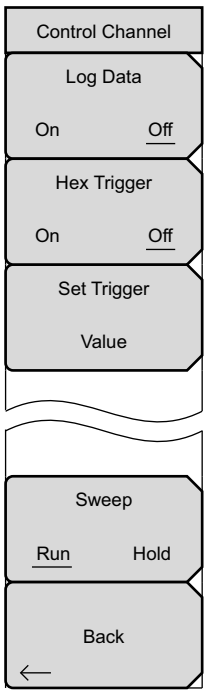
Symbol Span: Use this menu to adjust the number of symbols viewed across the screen in the Eye Diagram graph. Adjust from 2 and 5 using the keypad, the arrow keys, or the rotary knob. Keypad values entered outside of this range are ignored.

Back: Returns to the “Measurement Menu” on page 5-20.

Figure 5-17. NXDN Analyzer Display Menu

Control Channel Menu

Key Sequence: **Measurement** > NXDN Control



Log Data: Saves the measurements to an external USB flash drive. The external USB flash drive must be attached to one of the USB Type A connectors to Log data files.

The files are saved in a time-stamped folder under the **usr** folder on the USB flash drive.

If Log Data is On, any of the following functions will stop the logging:

Rx Frequency change
Setup change
Starting another measurement

Hex Trigger: Turns On or Off the Hex Trigger set with the following command. Sweep will continue until the trigger value is detected. At that time Sweep will change from Run to Hold.

Set Trigger Value: Opens a touchscreen hexadecimal keyboard for setting the Trigger value.

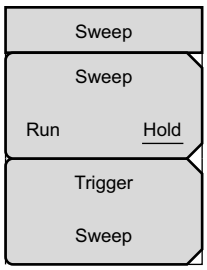
Sweep: Toggles the frequency sweep of the LMR Master between Run and Hold. Save function as **Shift** + **Sweep** (**3**).

Back: Returns to the “Measurement Menu” on page 5-20.

Figure 5-18. NXDN Control Channel Menu

5-12 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Trigger Sweep is not available in NXDN Control and NXDN Bit Capture measurements.

Figure 5-19. NXDN Analyzer Sweep Menu

5-13 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Display the "Measurement Menu" on page 5-20.

5-14 Trace Menu

This menu is not available in NXDN Analyzer measurement mode.

5-15 Limit Menu

This menu is not available in NXDN Analyzer measurement mode.

5-16 Other Menus

Preset, **Calibrate**, **File**, **System** and **Mode** are described in the User Guide.

Chapter 6 — dPMR Analyzer (Option 573)

6-1 Introduction

The dPMR Analyzer option provides a method to verify the operation of dPMR tower, mobile, and portable radio transmitters. Option 573 includes the ability to display constellation, spectrum, histogram, and eye diagram graphs. In addition, a summary graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), symbol deviation, and symbol rate error of the input signal.

The LMR Master dPMR Analyzer and dPMR Coverage Mapping options are intended for use on over-the-air (OTA) signals. The LMR Master signal generator outputs CW, AM and FM signals while in the dPMR Analyzer mode.

The LMR Master will analyze input signal strengths from +33 dBm (2.0 watts) down to levels approaching the sensitivity of dPMR radios, automatically adjusting the input sensitivity based on input levels.

6-2 Setup Procedure

Direct Connect to the Transmitter

1. Press the **Menu** key then select the dPMR Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight dPMR Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect the transmitter to the RF In 50 Ohm connector on the LMR Master using a coupler or attenuator.
3. Press the **Frequency** main menu key to set the center frequency of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. The **Setup** main menu key shows the modulation bandwidth and allows setup of the squelch level and averaging.
5. Press the **Amplitude** main menu key, then the Rx Power Offset submenu key to set the receiver attenuation (or gain). Use the arrow keys, rotary knob or the numeric keypad to enter the adjustment value, up to 100 dB. The offset will be applied to the Received Power value in the Summary graph. For instance, if the transmitter under test is emitting 50 watts (+47 dBm) of power, and the External Attenuation value is 40 dB (such as from a 40 dB directional coupler) the Received Power displayed will be +7 dBm.

6. Press the **Measurement** key, then the dPMR Analyzer submenu key. Select the Graph types to view with the Graph Type submenu key. The Symbol Span submenu is used to adjust the number of "eyes" displayed across the screen in the Eye Diagram graph. Refer to "dPMR Analyzer Graphs" on page 6-3 for the available graph types.

Over the Air (OTA) Analysis Setup

1. Press the **Menu** key and then select the dPMR Analyzer icon, or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight dPMR Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Frequency** main menu key to set the center frequency of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Amplitude** main menu key and insure the Rx Power Offset is set 0.0 dB, then set the Auto Rx Range to On.
5. Press the **Measurement** key, then the dPMR Analyzer submenu key. Select the Graph types to view with the Graph Type submenu key. The Symbol Span submenu is used to adjust the number of "eyes" displayed across the screen in the Eye Diagram graph. Refer to "dPMR Analyzer Graphs" on page 6-3 for the available graph types.

6-3 dPMR Analyzer Graphs

The following dPMR Analyzer measurements are available on the LMR Master. From the **Measurements** main menu press dPMR Analyzer twice. Press the Graph Type submenu key to select the measurement type.

Constellation and Linear Constellation

Constellation view displays the demodulation information in an IQ format (Figure 6-1). The charts show the relationship between the location of a constellation data point, its deviation frequency, and the information it carries.

Symbol: +3 Bit Information: 01 Dev.: +1050 Hz	Symbol: +1 Bit Information: 00 Dev.: +350 Hz
Symbol: -3 Bit Information: 11 Dev.: -1050 Hz	Symbol: -1 Bit Information: 10 Dev.: -350 Hz

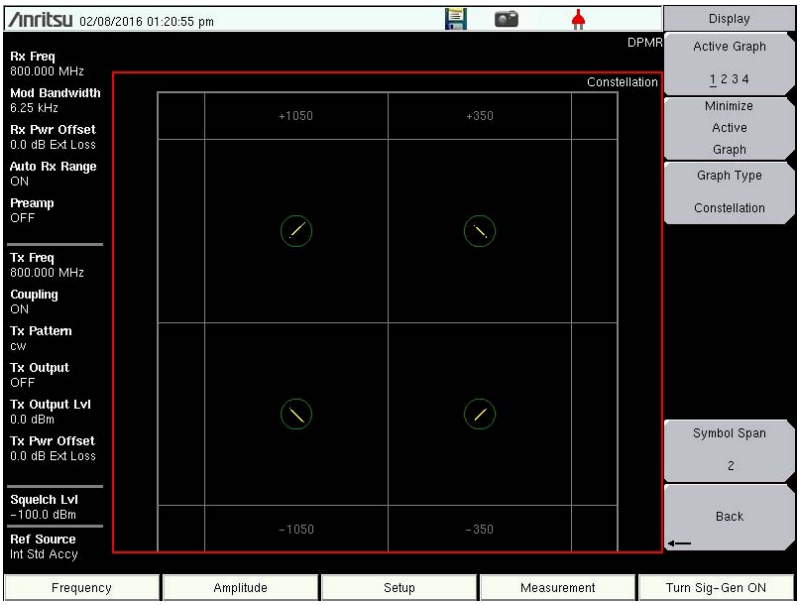


Figure 6-1. Constellation Diagram

Figure 6-2 shows the same information is the Linear Constellation View.

Symbol: -3 Bit Information: 11 Dev.: -1050 Hz	Symbol: -1 Bit Information: 10 Dev.: -350 Hz	Symbol: +1 Bit Information: 00 Dev.: +350 Hz	Symbol: +3 Bit Information: 01 Dev.: +1050 Hz

Figure 6-2. Linear Constellation Diagram

For input signals that are not dPMR encoded, the LMR Master will still try to decode it and fit it to a symbol. This may cause some measurement results that are unexpected.

Histogram Graph

The Histogram graph displays a graphical representation of the symbols that are being received. The graph for each symbol represents the relative percentage that symbol was identified out of all the received symbols.

Each update of the screen is a separate representation of the latest data, rather than a cumulative total. The vertical scale is fixed at 0 to 100 %, with each horizontal grid line representing 10 % of the total symbols received.

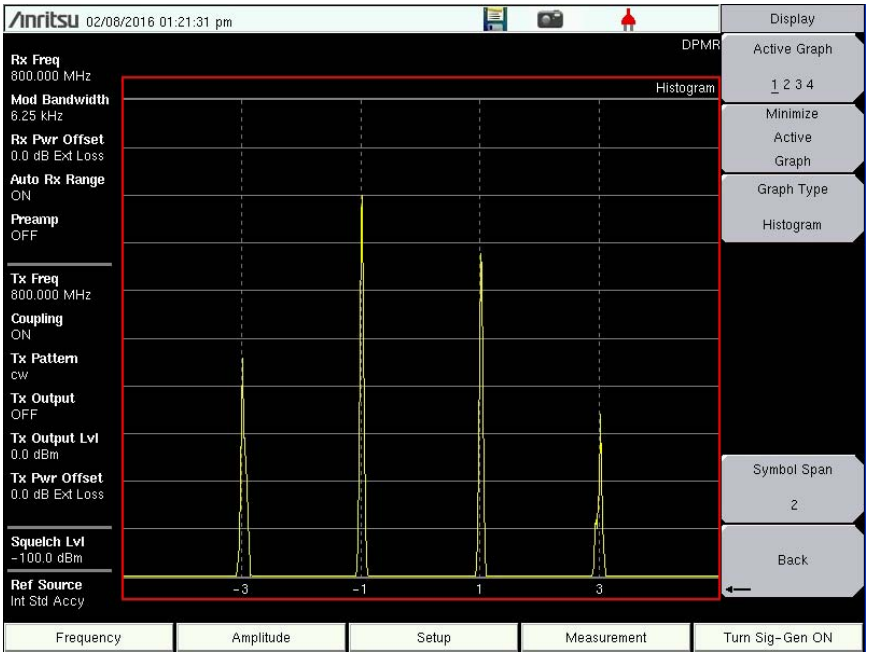


Figure 6-3. dPMR Histogram

Spectrum Graph

The spectrum view displays a graphical representation of power (dBm) vs. frequency. The spectrum display gives an indication if there are interferers present that may degrade the bit error rate of the dPMR signal. The frequency span is adjustable under the **Frequency** menu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 6-13 for details. Figure 6-4 displays a dPMR signal using a 25 kHz span.

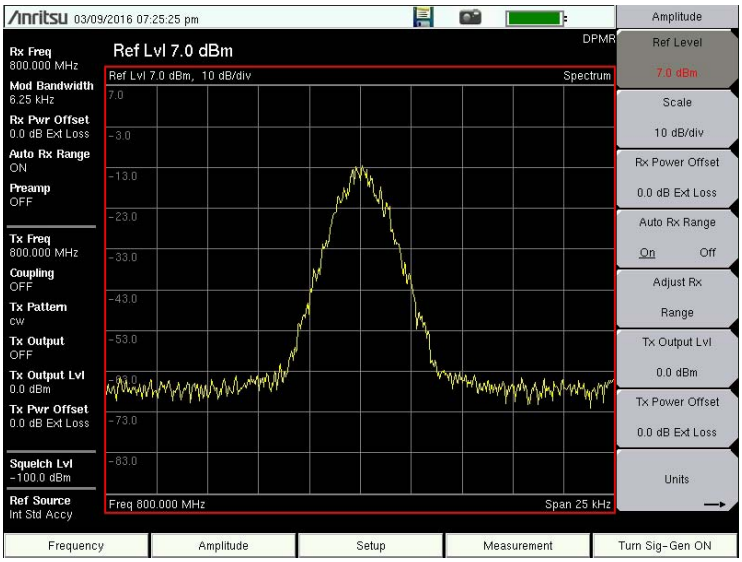


Figure 6-4. dPMR Spectrum Graph (25 kHz Span)

Eye Diagram

The eye diagram is an oscilloscope view of the dPMR signal displaying the voltage of the signal vs. time. The diagram provides an indication of baseband fidelity of an dPMR transmitter. With Over-the-air measurements the Eye Diagram can indicate phase distortion from multipath. The number of "eyes" displayed is set with the Symbol Span key under the "Display Menu" on page 6-17.

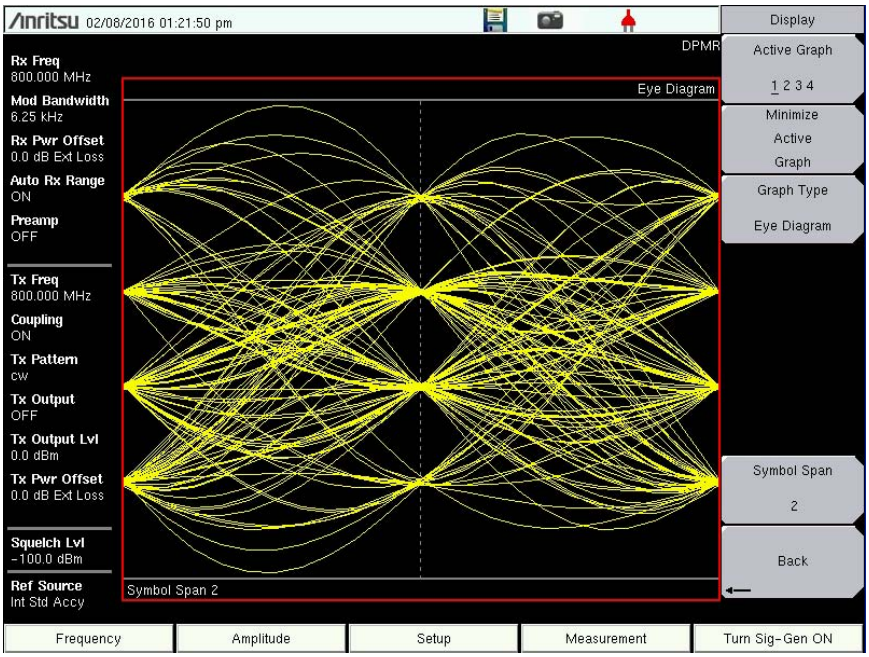


Figure 6-5. dPMR Eye Diagram

Summary Graph

The summary graph provides an overview of a DPMR transmitter. The graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), symbol deviation, and symbol rate error of the input signal.

The Received Power value in the summary graph can be toggled to dBm, watts, or volts by using the **Amplitude** > Units > Rx Units keys. This setting also applies to the squelch level setting.

The **Setup** > Squelch Lvl submenu key sets the squelch power level. When the Received Power is lower than the set squelch level all summary graph measurements except for Received Pwr will be blanked out (--). When the Received Power is above the squelch level, the measurements are displayed as shown in Figure 6-6.

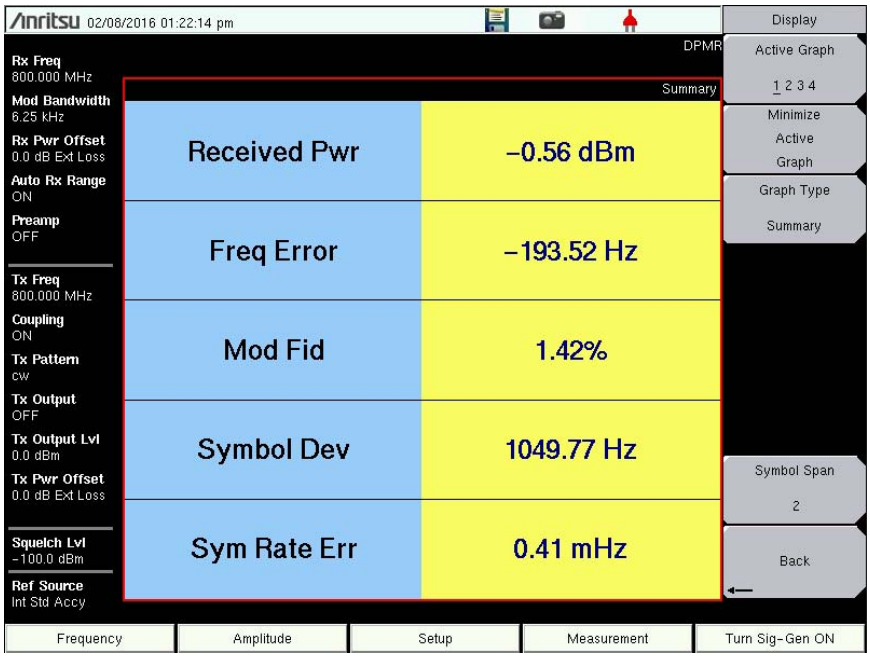


Figure 6-6. dPMR Summary Graph with Received Pwr Above the Squelch Level

Received Pwr in the Summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Received Pwr is a function of the instruments RBW setting. The reduction is specified as: 10*Log(Signal Bandwidth / Resolution Bandwidth).

6-4 dPMR IQ Data

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can capture and log dPMR IQ data to a USB flash drive.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. Press the **Amplitude** main menu key and insure the Rx Power Offset is set 0.0 dB, then set the Auto Rx Range to On.
3. Insert a formatted USB flash drive into the LMR Master and from the **Measurement** main menu, press the dPMR IQ Capture submenu key. After approximately 10 seconds the instrument will display a message that the capture is complete.

The IQ data is sampled at 2,400 x 11 (6.25 kHz BW) symbols per second. The saved file has an ASCII header and binary data (Figure 6-7). The data is written in 24-bit two's complement integers format. Interleaved Delta Phase (I) data then Magnitude (Q) data is captured. The file is intended for post-processing in MATLAB or similar software.

The file will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`IQ_CAPTURE`*`yearmonthdaytime`*`.dpmr`

Note	There is no display menu for dPMR IQ Capture. The LMR Master will continue to display the previous measurement screen during IQ Capture.

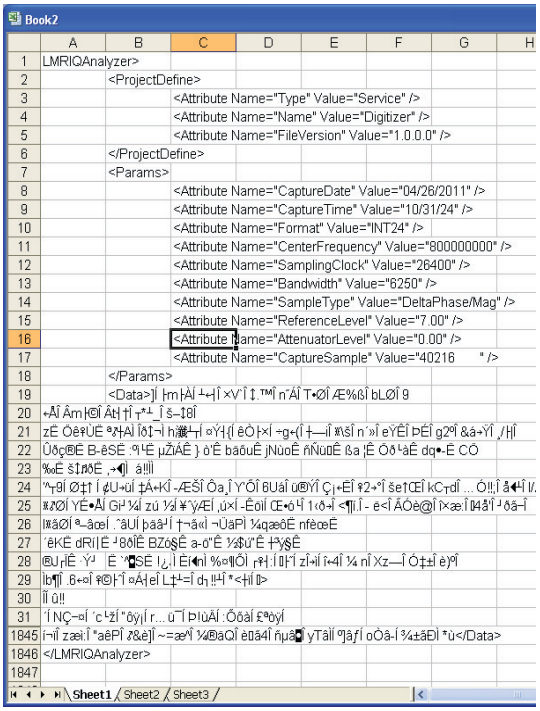


Figure 6-7. IQ Capture (6.25 kHz Bandwidth)

6-5 dPMR Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

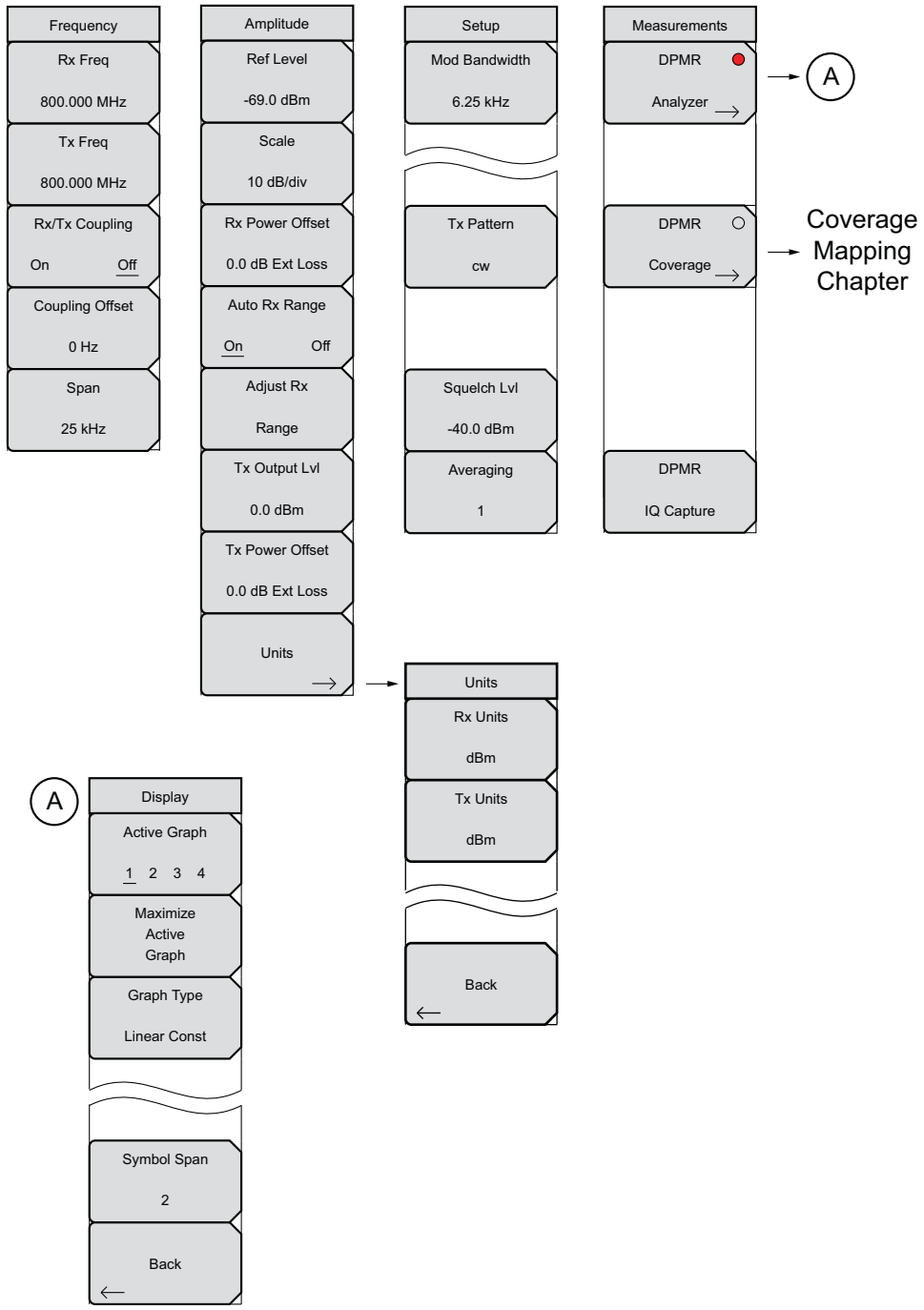
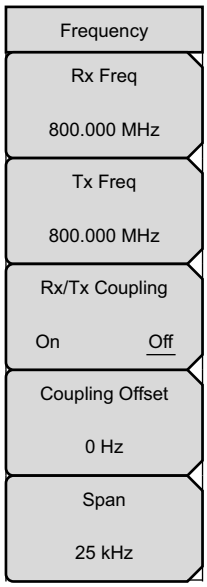


Figure 6-8. dPMR Analyzer Menu Layout

6-6 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press Tx Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On the Tx Freq key is disabled.

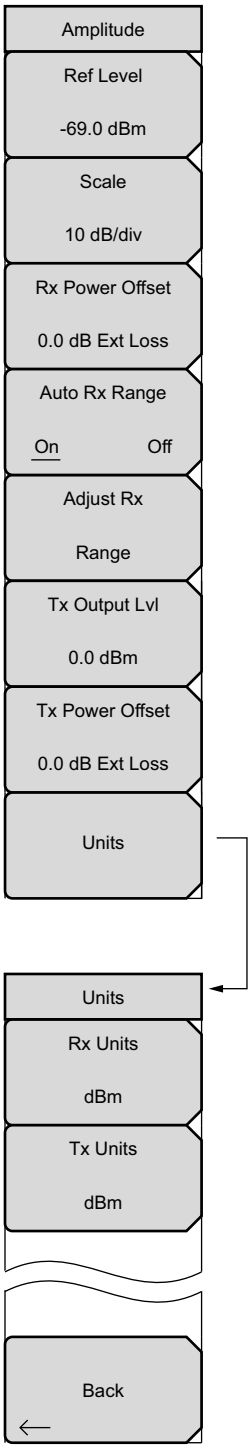
Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. Only functional when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 25 kHz, 50 kHz, 100 kHz, 500 kHz, 1 MHz, and 5 MHz.

Figure 6-9. dPMR Analyzer Frequency Menu

6-7 Amplitude Menu

Key Sequence: **Amplitude**



Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis of the graticule. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. The y-axis power scale is shown on the left side of the display when viewing the Spectrum Graph.

Note: The "Vertical Scale Menu" on page 6-14 is displayed when dPMR Coverage (**Measurement** > dPMR Coverage) is selected.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Units: Opens to Units Submenu.

Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Summary Graph and the Squelch Level.

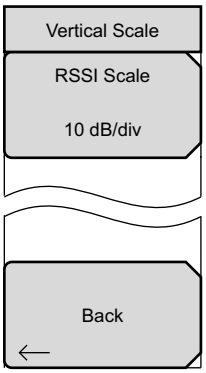
Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 6-10. dPMR Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale

Note	Note: The "Vertical Scale Menu" is displayed when dPMR Coverage (**Measurement** > dPMR Coverage) is selected.

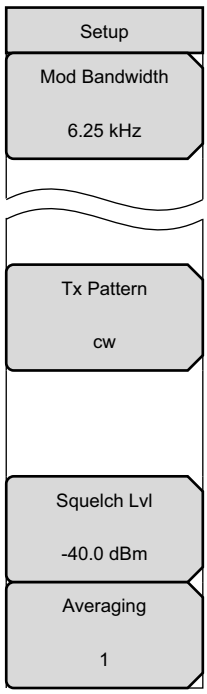


RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

Figure 6-11. Vertical Scale Menu

6-8 Setup Menu

Key Sequence: **Setup**



Mod Bandwidth: Displays the modulation bandwidth.

Tx Pattern: Selects the transmitter signal modulation to send when the **Turn Sig-Gen ON** main menu key is selected. Select a modulation type from the list box with the arrow keys or rotary knob and press **Enter**.

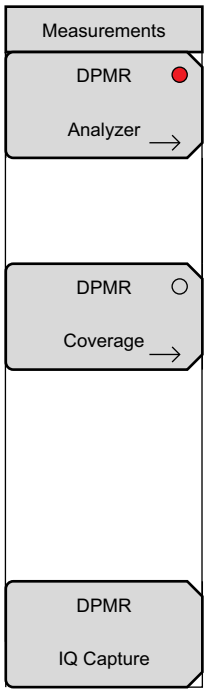
Squelch Lvl: Sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--).

Averaging: Sets the refresh rate of the numerical values in the dPMR Summary window. Setting a higher number (25 maximum) will reduce measurement jitter.

Figure 6-12. dPMR Analyzer Setup Menu

6-9 Measurement Menu

Key Sequence: **Measurement**



dPMR Analyzer: Opens the "Display Menu" on page 6-17.

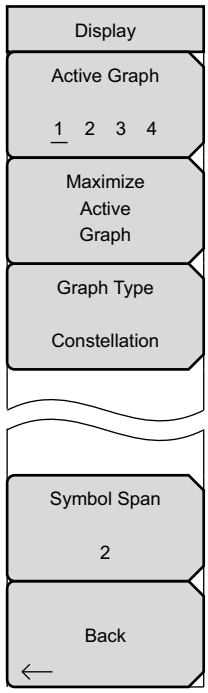
dPMR Coverage (Option 572 required): Opens the dPMR Coverage menu. Refer to Chapter 10, "LMR Coverage Mapping".

dPMR IQ Capture: Pressing this key starts the IQ data capture. Make sure that a formatted USB flash drive is attached to the instrument before starting IQ Capture. When the capture is complete, a message is displayed. This may take a few seconds.

Figure 6-13. dPMR Analyzer Measurement Menu

Display Menu

Key Sequence: **Measurement** > dPMR Analyzer



Active Graph 1 2 3 4: In Four Screen view use this menu to select which of the four graphs is active. The current active graph is underlined (1 2 3 4) and has a red perimeter line. Any of the four graphs can also be made active by tapping once on the touch screen. Repeatedly pressing the Active Graph submenu key will cycle the active graph, 1 through 4.

In Standard view (one graph displayed on the screen) the Active Graphic key will rotate between the four graphs displayed in the Four Screen view.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four Screen (4 graphs) view and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this button displays the current active graph type. Pressing the button will open a list box of the graphs types available for dPMR Analyzer measurements. Select the desired graph type with the arrow keys or rotatory knob and press **Enter**. The current active graph will be replaced with the new selection.

Available graphs include:

- Constellation
- Spectrum
- Histogram
- Eye Diagram
- Linear Constellation
- Summary

Refer to “dPMR Analyzer Menus” on page 6-11 for additional information.

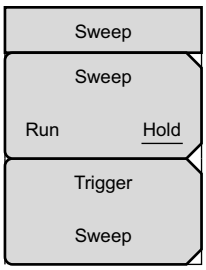
Symbol Span: Use this menu to adjust the number of symbols viewed across the screen in the Eye Diagram graph. Adjust from 2 and 5 using the keypad, the arrow keys, or the rotary knob. Keypad values entered outside of this range are ignored.

Back: Returns to the “Measurement Menu” on page 6-16.

Figure 6-14. dPMR Analyzer Display Menu

6-10 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Trigger Sweep is not available in dPMR Control and dPMR Bit Capture measurements.

Figure 6-15. dPMR Analyzer Sweep Menu

6-11 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Display the "Measurement Menu" on page 6-16.

6-12 Trace Menu

This menu is not available in dPMR Analyzer measurement mode.

6-13 Limit Menu

This menu is not available in dPMR Analyzer measurement mode.

6-14 Other Menus

Preset, **Calibrate**, **File**, **System** and **Mode** are described in the User Guide.

Chapter 7 — TETRA Analyzer (Option 581)

7-1 Introduction

The TETRA Analyzer option provides a method to verify the operation of TETRA repeater transmitters. Option 581 includes the ability to display constellation, spectrum, histogram, and eye diagram graphs. In addition, a summary graph displays numeric values of received power, frequency error, error vector magnitude (EVM), IQ imbalance, phase and magnitude errors, and symbol rate error of the input signal. The analyzer also reports the base station extended color code (BS ECC), mobile color code (Mobile CC), mobile network code (Mobile NC), base color code (Base CC), location area code (LAC), and mobile station maximum transmit power (MS Max TX Pwr) permitted on a channel from the TETRA transmitter.

The LMR Master TETRA Analyzer and TETRA Coverage Mapping options are intended for use on over-the-air (OTA) signals. The LMR Master signal generator outputs CW, AM and FM signals while in the TETRA Analyzer mode.

The LMR Master will analyze input signal strengths from +33 dBm (2.0 watts) down to levels approaching the sensitivity of TETRA radios, automatically adjusting the input sensitivity based on input levels.

7-2 Over the Air (OTA) Analysis Setup

1. Press the **Menu** key then select the TETRA Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight TETRA Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring nearby high output power devices.

2. Connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Frequency** main menu key to set the center frequency of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the appropriate numeric squelch level for OTA measurements. TETRA analysis uses a proprietary method to estimate BER and EVM from the TETRA base station data stream. Refer to "TETRA Analyzer Graphs" on page 7-3 for the available graph types.

Using the Signal Generator for Receiver or OTA Analysis

1. Press the **Menu** key then select the TETRA Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight TETRA Analyzer and press **Enter**.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW (0 dBm) and the frequency range is 500 kHz to 1.6 GHz.

2. Direct connect the LMR Master Signal Generator Out 50 Ohm connector to the repeater/receiver or connect an antenna with the appropriate frequency range to the connector.
3. Press the **Frequency** main menu key to set the transmit frequency using the Tx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.

   If testing an TETRA repeater, you can bind the transmit frequency to the receive frequency by setting Rx/Tx Coupling to On and entering the Coupling Offset.

Note	When Rx/Tx Coupling is on, the Tx Freq submenu key is disabled.

4. Press the **Amplitude** main menu key, then the Tx Output Lvl submenu key to set the output power. Enter any output attenuation or gain using the Tx Power Offset key.
5. Set the bandwidth by pressing the **Setup** main menu key and then the Mod Bandwidth submenu key. Set the signal generator pattern with the Tx Pattern submenu key. Available patterns are listed on the display and additional patterns can be downloaded via the **System** > Application Options menu.
6. Press the **Turn Sig-Gen ON** main menu key to start the signal generator. Press the key again to turn off the signal generator.

7-3 TETRA Analyzer Graphs

This section briefly describes TETRA Analyzer measurements that are available on the LMR Master. From the **Measurements** main menu press the TETRA Analyzer submenu key. If necessary, press the key a second time to show the Display menu. Press the Graph Type submenu key to select the graph type.

Constellation

Selecting Constellation as the Graph Type displays the demodulation information in an IQ format (Figure 7-1). Note that for input signals that are not TETRA encoded, the LMR Master will still try to decode them and fit them to a symbol. This may result in measurement values that are unexpected.

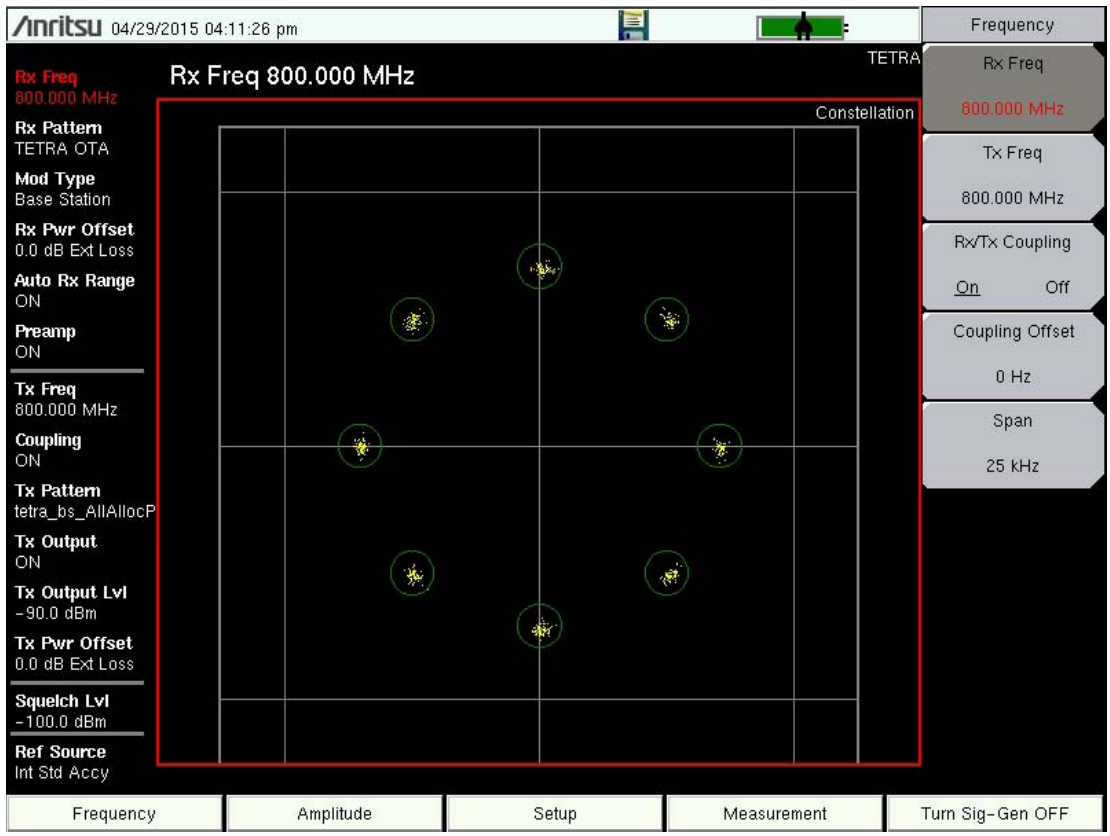


Figure 7-1. Constellation Diagram

Spectrum Graph

The spectrum view displays a graphical representation of power (dBm) vs. frequency. The spectrum display gives an indication if there are interferers present that may degrade the bit error rate of the TETRA signal. The frequency span is adjustable under the **Frequency** menu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 7-11 for details. Figure 7-2 displays the same signal using a 25 kHz span and a 500 kHz span.

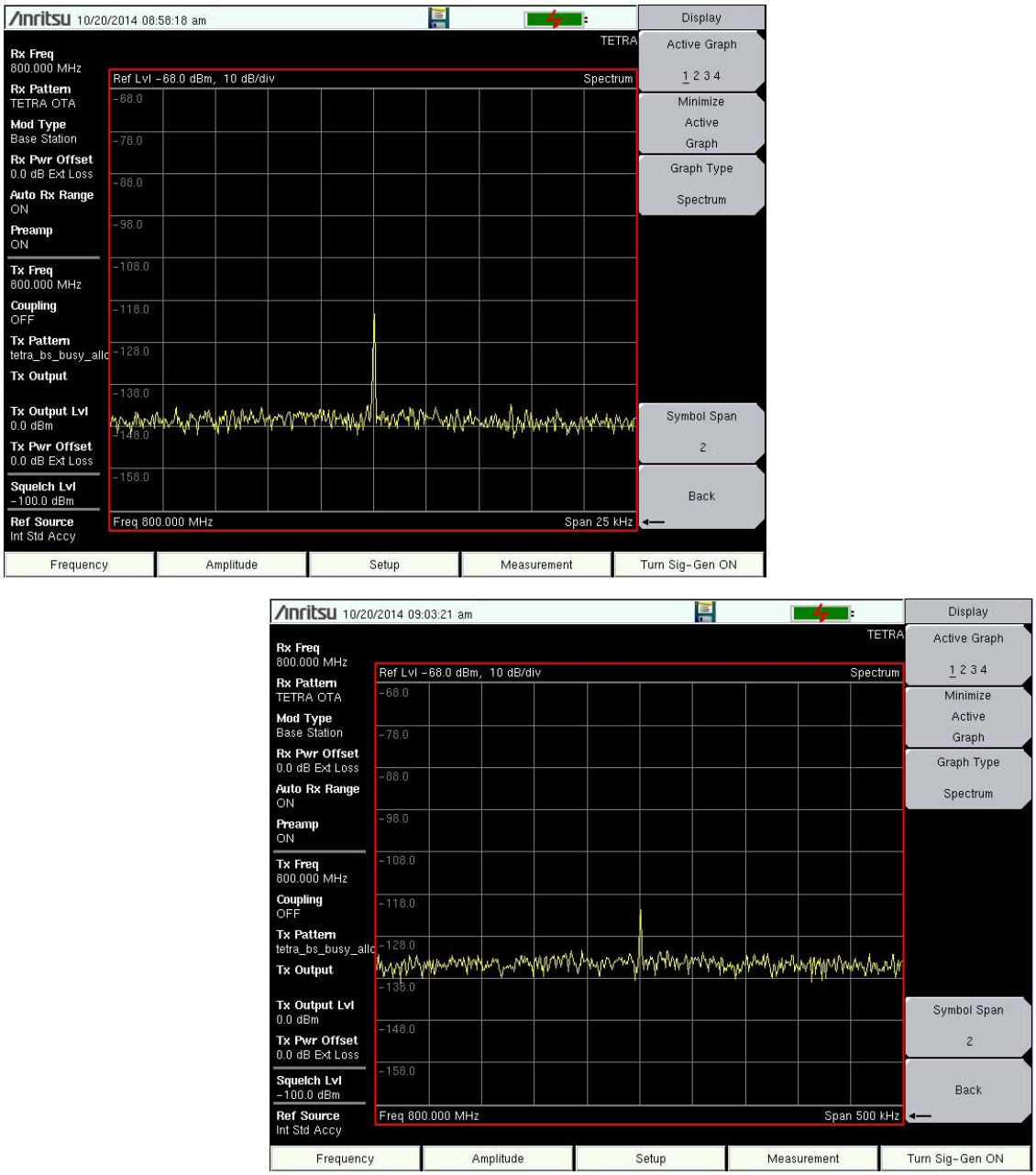


Figure 7-2. TETRA Spectrum Graph (25 kHz Span and 500 kHz Span)

Eye Diagram

The eye diagram is an oscilloscope view of the TETRA signal displaying the voltage of the signal vs. time. The diagram provides an indication of baseband fidelity of a TETRA transmitter. With over-the-air measurements, the Eye Diagram can indicate phase distortion from multipath. The number of “eyes” displayed is set with the Symbol Span key under the “Display Menu” on page 7-15.

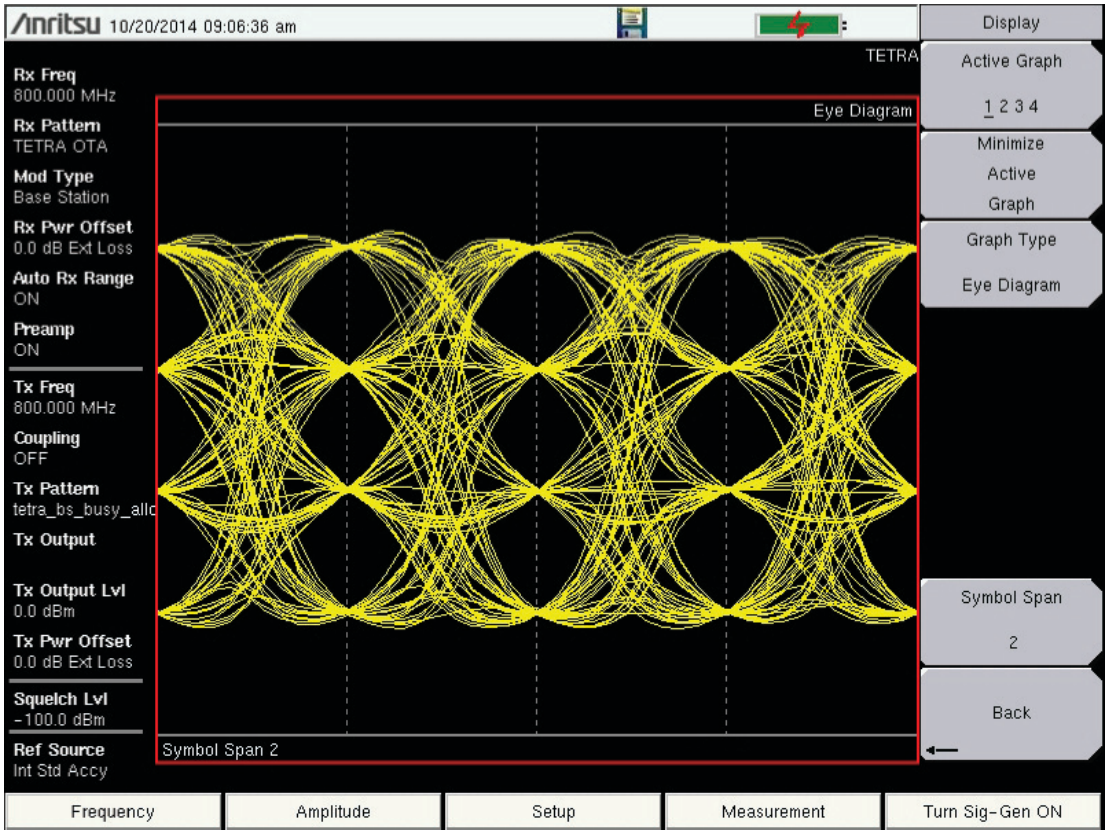


Figure 7-3. TETRA Eye Diagram

Summary and TETRA Summary Graphs

These two summary displays provide measured and decoded values in a table format.

Summary Graph

The Summary graph provides an overview of the measurements made on the signal received from a downlink TETRA transmitter. This graph displays numeric values of received power, frequency error, RMS vector error, peak vector error, residual carrier magnitude, IQ imbalance, phase and magnitude errors, and symbol rate error of the input signal.

The Received Power value in the Summary graph can be toggled to dBm, watts, or volts by using the key sequence: **Amplitude** > Units > Rx Units. The selected unit also applies to the squelch level setting.

The key sequence: **Setup** > Squelch Lvl sets the squelch power level. When the Received Power is lower than the set squelch level, all values in both summary displays except for Received Pwr are blanked out (– –). When the Received Power is above the squelch level, the measurements for this graph are displayed as shown in Figure 7-4.

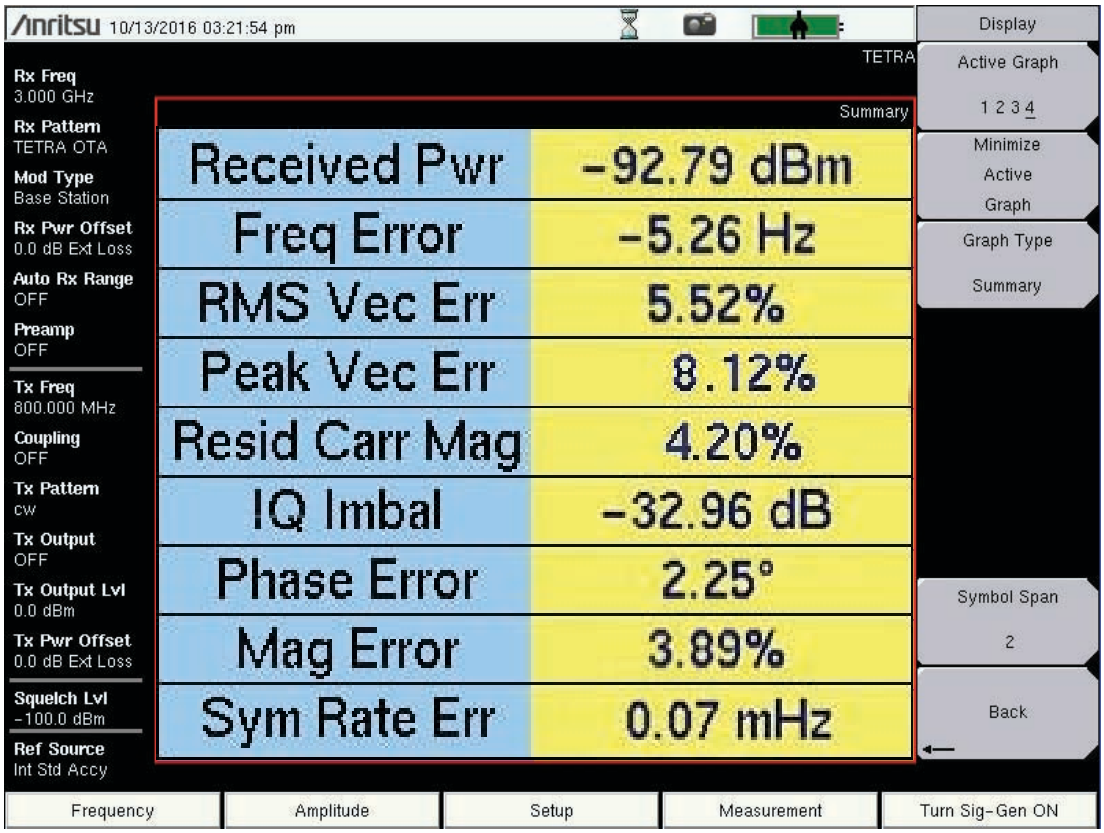


Figure 7-4. Summary Graph (with Received Power Above the Squelch Level)

Received Pwr in the Summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Received Pwr is a function of the instrument RBW setting. The reduction is specified as: 10*Log (Signal Bandwidth / Resolution Bandwidth).

TETRA Summary Graph

The TETRA Summary graph is only available with Base Station modulation type. It reports the base station extended color code (BS ECC), mobile color code (Mobile CC), mobile network code (Mobile NC), base color code (Base CC), location area code (LAC), and mobile station maximum transmit power (MS Max TX Pwr) permitted on a channel from the TETRA transmitter.

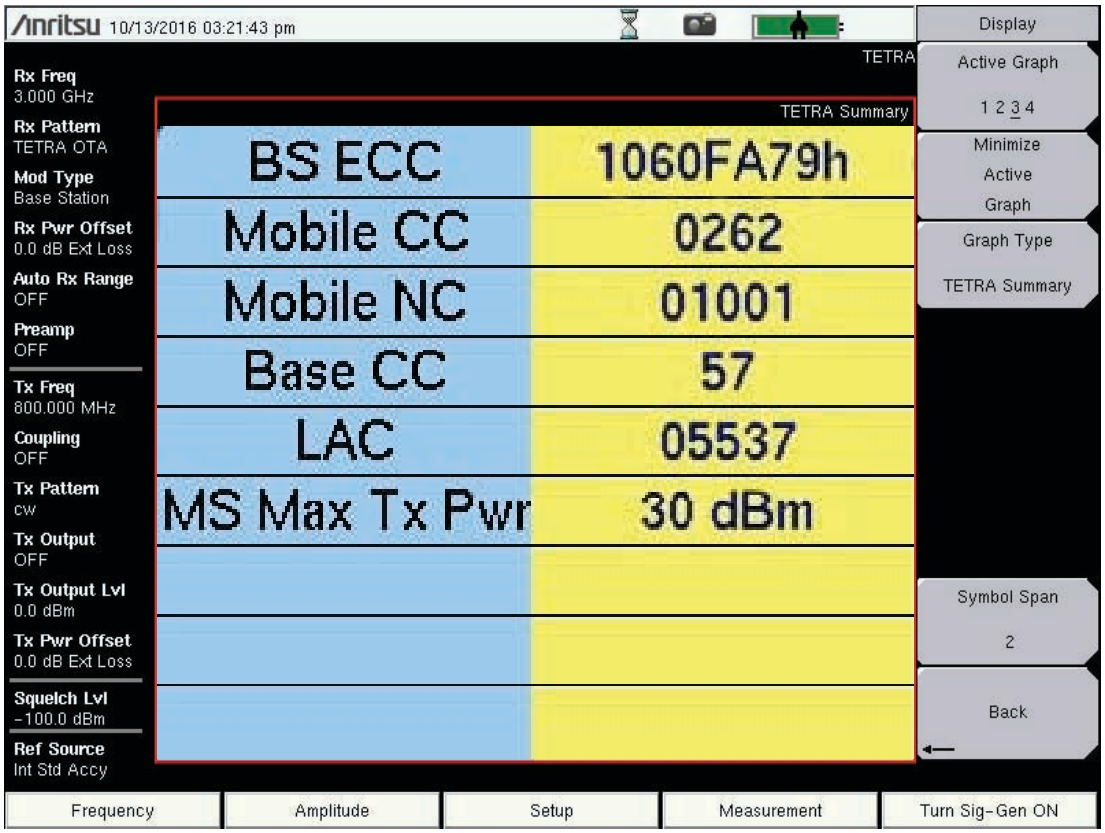


Figure 7-5. TETRA Summary Graph (with Received Power Above the Squelch Level)

Note that BS ECC in the Summary graph is provided in 8 hexadecimal digits so that the least significant 30 bits of this value may be used for verification of corresponding bits of initial state of scramblers and descramblers of encoders and decoders, respectively, of any TETRA channel other than the Broadcast Synchronization Channel.

Note	In the Summary graph, the “h” in BS ECC 1060FA79h indicates that 1060FA79 is a hexadecimal number.

7-4 TETRA IQ Data

Note	This measurement is captured on an external USB flash drive. The captured data file cannot be recalled and displayed on the instrument screen.

The LMR Master can capture and log TETRA IQ data to a USB flash drive.

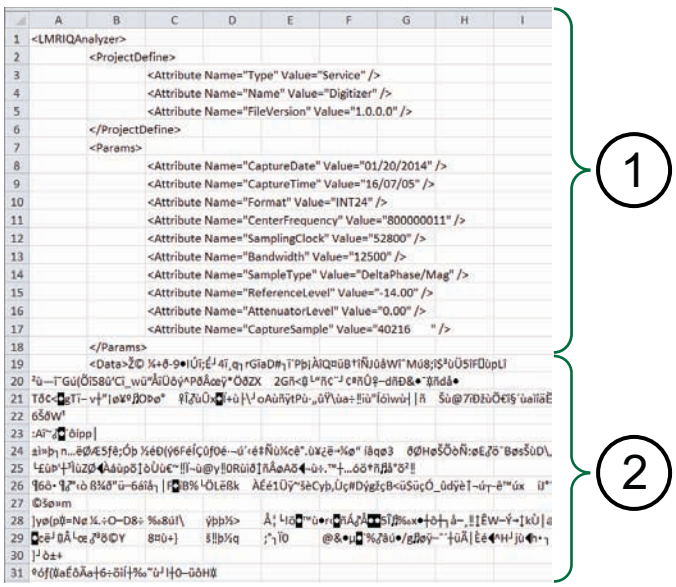
1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. Insert a formatted USB flash drive into the LMR Master, and from the **Measurement** main menu, press the TETRA IQ Capture submenu key. After approximately 10 seconds, the instrument displays a message that the capture is complete.

The IQ data is sampled at 4,800 x 11 samples per second. The saved file has an ASCII header and binary data (see Figure 7-6 on page 7-8 for an example). The data is written in 24-bit two's complement integer format. Interleaved Delta Phase (I) data then Magnitude (Q) data is captured. The file is intended for post-processing in MATLAB or other data analysis software.

The file will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`IQ_CAPTURE`*`yearmonthdaytime`*`.TETRA`

Note	There is no display menu for TETRA IQ Capture. The LMR Master will continue to display the previous measurement screen during IQ Capture.



1.	ASCII header listing parametric information
2.	Binary data in 24-bit two's complement integer format

Figure 7-6. IQ Capture

7-5 TETRA Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

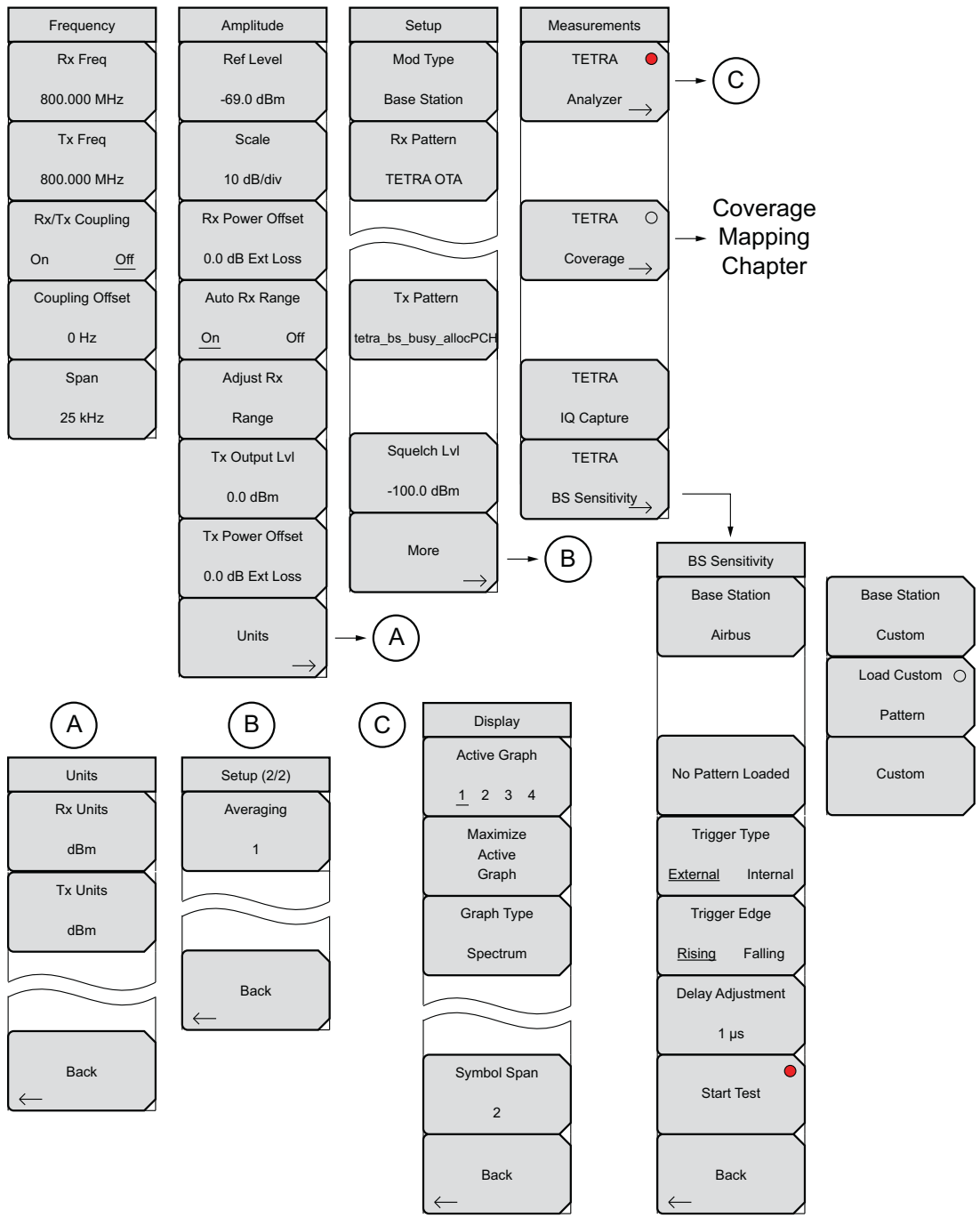
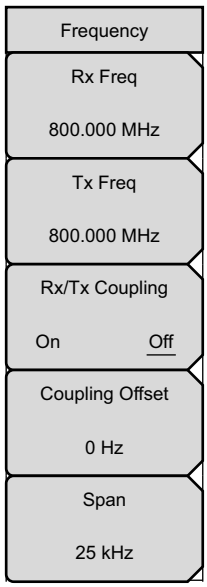


Figure 7-7. TETRA Analyzer Menu Layout

7-6 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press Tx Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On the Tx Freq key is disabled.

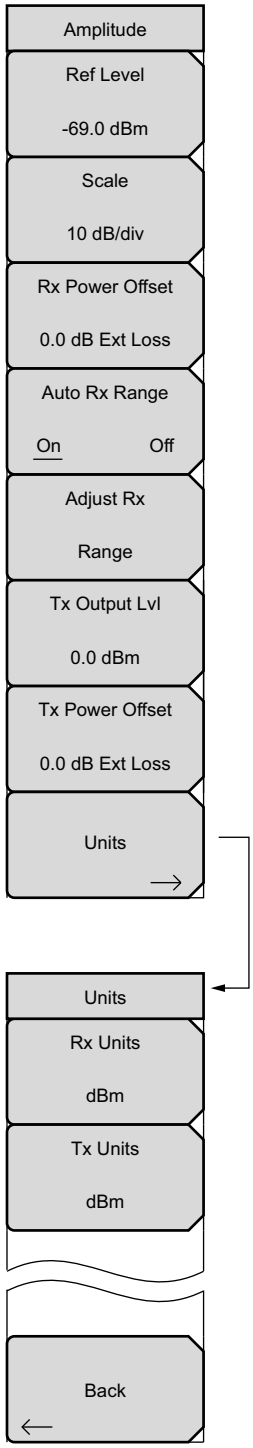
Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. Only functional when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 25 kHz, 50 kHz, 100 kHz, 500 kHz, 1 MHz, and 5 MHz.

Figure 7-8. TETRA Analyzer Frequency Menu

7-7 Amplitude Menu

Key Sequence: **Amplitude**



Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis of the graticule. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. The y-axis power scale is shown on the left side of the display when viewing the Spectrum Graph.

Note: The "Vertical Scale Menu" on page 7-12 is displayed when TETRA Coverage (**Measurement** > TETRA Coverage) is selected.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Units: Opens to Units Submenu.

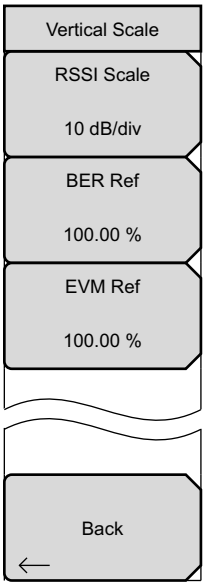
Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Summary Graph and the Squelch Level.

Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 7-9. TETRA Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale



RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

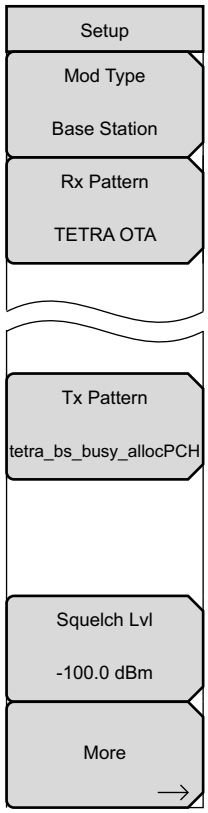
BER Ref: Sets the BER reference percentage value at the top of the y-axis in the BER vs. Time graph in Coverage measurement. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

EVM Ref: Sets the EVM reference percentage value in Coverage measurement. Enter a value from 1.00 % to 100.00 % by using the keypad, the arrow keys, or the rotary knob. If EVM is low, this scale may be set as low as 10 % to allow a more detailed examination of EVM. In general, a reference setting that is approximately 10 % higher than the current observed maximum value will provide useful information.

Figure 7-10. Vertical Scale Menu

7-8 Setup Menu

Key Sequence: **Setup**



Mod Type: Sets the type of modulation. The options are Mobile Station or Base Station.

Rx Pattern

The setting of this key is locked to “TETRA OTA”.

Tx Pattern: Selects the transmitter pattern to send when the **Turn Sig-Gen ON** main menu key is selected. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**.

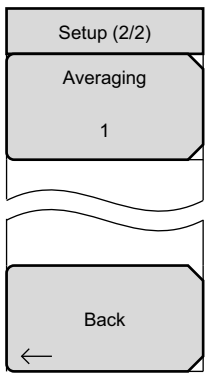
Squelch Lvl: Sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--).

More: Opens the “Setup (2/2) Menu” on page 7-13.

Figure 7-11. TETRA Analyzer Setup Menu

Setup (2/2) Menu

Key Sequence: **Setup** > More



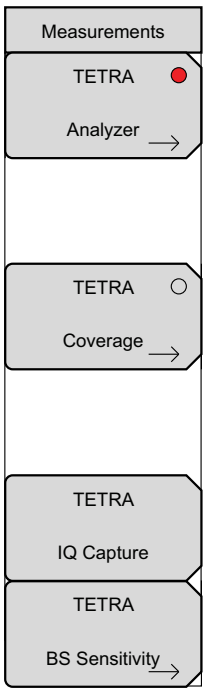
Averaging: Sets the refresh rate of the numerical values in the TETRA Summary window. Setting a higher number (25 maximum) reduces measurement jitter.

Back: Press this submenu key to return to the “Setup Menu” on page 7-13.

Figure 7-12. TETRA Analyzer Setup Menu

7-9 Measurement Menu

Key Sequence: **Measurement**



TETRA Analyzer: Opens the "Display Menu" on page 7-15.

TETRA Coverage (Option 582 required): Opens the TETRA Coverage menu. Refer to Chapter 10, "LMR Coverage Mapping".

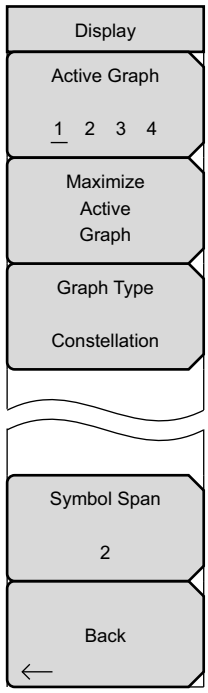
TETRA IQ Capture: Pressing this key starts the IQ data capture. Make sure that a formatted USB flash drive is attached to the instrument before starting IQ Capture. When the capture is complete, a message is displayed. This may take a few seconds.

TETRA BS Sensitivity: Opens the "BS Sensitivity Menu" on page 7-16.

Figure 7-13. TETRA Analyzer Measurement Menu

Display Menu

Key Sequence: **Measurement** > TETRA Analyzer



Active Graph 1 2 3 4: In Four Screen view use this menu to select which of the four graphs is active. The current active graph is underlined (1 2 3 4) and has a red perimeter line. Any of the four graphs can also be made active by tapping once on the touch screen. Repeatedly pressing the Active Graph submenu key will cycle the active graph, 1 through 4.

In Standard view (one graph displayed on the screen) the Active Graphic key will rotate between the four graphs displayed in the Four Screen view.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four Screen (4 graphs) view and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this button displays the current active graph type. Pressing the button will open a list box of the graphs types available for TETRA Analyzer measurements. Select the desired graph type with the arrow keys or rotatory knob and press **Enter**. The current active graph will be replaced with the new selection.

Available graphs include:

- Constellation
- Spectrum
- Eye Diagram
- Summary
- TETRA Summary

Refer to “TETRA Analyzer Graphs” on page 7-3 for additional information.

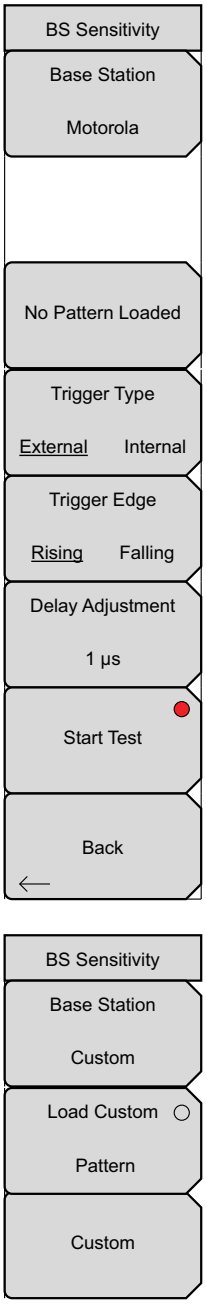
Symbol Span: Use this menu to adjust the number of symbols viewed across the screen in the Eye Diagram graph. Adjust from 2 through 5 using the keypad, the arrow keys, or the rotary knob. Keypad values entered outside of this range are ignored.

Back: Returns to the “Measurement Menu” on page 7-14.

Figure 7-14. TETRA Analyzer Display Menu

BS Sensitivity Menu

Key Sequence: **Measurement** > TETRA BS Sensitivity



Base Station: Pressing this button opens a dialog to select a preloaded base station manufacturer (Airbus, Sepura, Motorola Etlem NETIS, etc.) or to load a custom pattern. When Custom is selected, the **Load Custom Pattern** button becomes available (shown below) to load a custom pattern from memory or a USB device. Once a pattern is loaded, the button indicator turns red.

No Pattern Loaded: This button indicates Base Color Code (BCC), Mobile Country Code (MCC), Mobile Network Code (MNC), and Number of MultiFrames (#MF) of the currently loaded signal pattern. **No Pattern Loaded** is displayed when a valid pattern is not loaded.

Trigger Type: Toggles between External and Internal trigger.

Trigger Edge: Toggles between External Rising and Falling trigger edge.

Delay Adjustment: Sets the playback delay. Press the Delay Adjustment key and enter the desired playback delay using the keypad, the arrow keys, or the rotary knob. If entering a delay time using the keypad, the submenu key labels change to ms or µs. Press the appropriate units key. Note that changing the delay will change the selected Base Station to Custom or to another manufacturer.

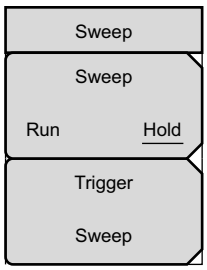
Start/Stop Test: This button is active (red indicator) once a valid TCH/7.2 test pattern has been loaded into signal memory and is ready to start a test. When this button is pressed, the test signal starts playing back continuously (clear indicator) and button text changes to **Stop Test**. Pressing the button again, changing a setting or leaving the BS Sensitivity menu will stop the test. The button may also display **Waiting for Trigger**.

Back: Returns to the “Measurement Menu” on page 7-14.

Figure 7-15. TETRA Analyzer Display Menu

7-10 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Figure 7-16. TETRA Analyzer Sweep Menu

7-11 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Display the "Measurement Menu" on page 7-14.

7-12 Trace Menu

This menu is not available in TETRA Analyzer measurement mode.

7-13 Limit Menu

This menu is not available in TETRA Analyzer measurement mode.

7-14 Other Menus

Preset, **Calibrate**, **File**, **System** and **Mode** are described in the User Guide.

Chapter 8 — DMR Analyzer (Option 591)

8-1 Introduction

The DMR Analyzer option provides a method to verify the operation of Digital Mobile Radio (DMR) compliant equipment. DMR is an open digital radio standard specified in the European Telecommunications Standards Institute (ETSI) Standards TS 102 361. Option 591 includes the ability to display constellation, spectrum, histogram, and eye diagram graphs. In addition, a summary graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), bit error rate (BER), symbol deviation, Color Code (CC), and symbol rate error of the input signal. BER comparisons can be made to the 1031 Hz Standard Tone or the Standard Transmitter Test (O.153) pattern, regular voice traffic using a proprietary algorithm.

8-2 Setup Procedure

Direct Connect to the Transmitter

1. Press the **Menu** key then select the DMR Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight DMR Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices. Refer to Chapter 11, “High Power Input Protection”

2. Connect the transmitter to the RF In 50 Ohm connector on the LMR Master using a coupler or attenuator.
3. Press the **Frequency** main menu key to set the receiver center frequency (Rx Freq) of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the receiver modulation type. Select Base Station or Mobile Station using the RX Mod Type key. Press the Rx Pattern key to choose the pattern against which to measure error rates. 1031 Hz and O.153 (V.52) will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Silence and Idle are two additional patterns in DMR that can be used to measure BER.
5. For Base Station modulation type, select the TDMA slot (1 or 2) using the Rx Slot submenu key.

6. Press the **Amplitude** main menu key, then the Rx Power Offset submenu key to set the receiver attenuation (or gain). Use the arrow keys, rotary knob or the numeric keypad to enter the adjustment value, up to 100 dB, and then press either the Loss or Gain submenu key. For instance, if the transmitter under test is emitting 50 watts (+47 dBm) of power, and the External Attenuation value is 40 dB (such as from a 40 dB directional coupler), then the Received Power displayed will be +7 dBm.
7. Press the **Measurement** key, then the DMR Analyzer submenu key. Select the Graph types to view with the Graph Type submenu key. The Symbol Span submenu is used to adjust the number of "eyes" displayed across the screen in the Eye Diagram graph. Refer to "DMR Analyzer Graphs" on page 8-4 on the available graph types.

Over the Air (OTA) Analysis Setup

1. Press the **Menu** key then select the DMR Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight DMR Analyzer and press **Enter**.

Caution	The damage input power level is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Frequency** main menu key to set the center frequency of the measurement using the Rx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to select the modulation type. Select Base Station or Mobile Station using the Mod Type key. Press the Rx Pattern key to choose the pattern against which to measure error rates. 1031 Hz and O.153 (V.52) will measure BER directly against the selected pattern. Voice uses a proprietary method to estimate BER from regular voice traffic. Silence and Idle are two additional patterns in DMR that can be used to measure BER. Refer to "DMR Analyzer Graphs" on page 8-4 on the available graph types.
5. Select the TDMA slot (1 or 2) using the Rx Slot submenu key.

Using the Signal Generator for Receiver or OTA Analysis

1. Press the **Menu** key then select the DMR Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight DMR Analyzer and press **Enter**.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW (0 dBm) and the frequency range is 500 kHz to 1.6 GHz.

2. Direct connect the LMR Master Signal Generator Out 50 Ohm connector to the repeater/receiver or connect an antenna with the appropriate frequency range to the connector.
3. Press the **Frequency** main menu key to set the transmit frequency using the Tx Freq key. Use the arrow key, rotary knob, or the numeric keypad. When using the keypad, press the appropriate terminator submenu key to set the center frequency.

   If testing a DMR repeater, then you can bind the transmit frequency to the receive frequency by setting Rx/Tx Coupling to On and entering the Coupling Offset.

Note	When Rx/Tx Coupling is on, the Tx Freq submenu key is disabled.

4. Press the **Amplitude** main menu key, then the Tx Output Lvl submenu key to set the output power. Enter any output attenuation or gain using the Tx Power Offset key.
5. Set the transmit pattern by pressing the **Setup** main menu key then the Tx Pattern submenu key. Available patterns are listed on the display and additional patterns can be downloaded via the **System** > Application Options menu.
6. For Base Station testing, select the TDMA slot (1 or 2) using the Rx Slot submenu key.
7. Press the **Turn Sig-Gen ON** main menu key to start the signal generator. Press the key again to turn Off the signal generator.

8-3 DMR Analyzer Graphs

The following DMR Analyzer measurements are available on the LMR Master. From the **Measurements** main menu press DMR Analyzer twice. Press the Graph Type submenu key to select the measurement type.

Constellation and Linear Constellation

Constellation view displays the demodulation information in an IQ format (Figure 8-1). The chart shows the relationship between the location of a constellation data point, its deviation frequency, and the information it carries.

Symbol: +3 Bit Information: 01 Dev.: +1944 Hz	Symbol: +1 Bit Information: 00 Dev.: +648 Hz
Symbol: -3 Bit Information: 11 Dev.: -1944 Hz	Symbol: -1 Bit Information: 10 Dev.: -648 Hz

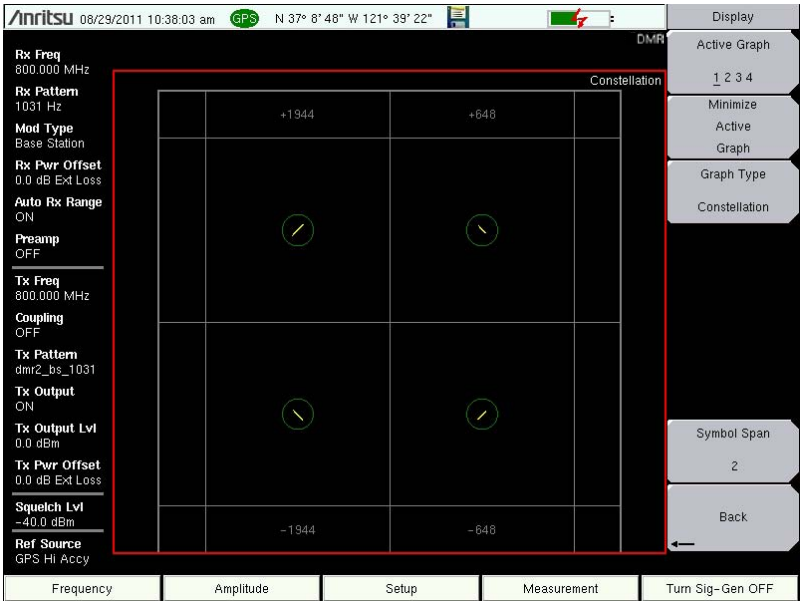


Figure 8-1. Constellation Diagram

Figure 8-2 shows the same information in the Linear Constellation View.

Symbol: -3 Bit Information: 11 Dev.: -1944 Hz	Symbol: -1 Bit Information: 10 Dev.: -648 Hz	Symbol: +1 Bit Information: 00 Dev.: +648 Hz	Symbol: +3 Bit Information: 01 Dev.: +1944 Hz

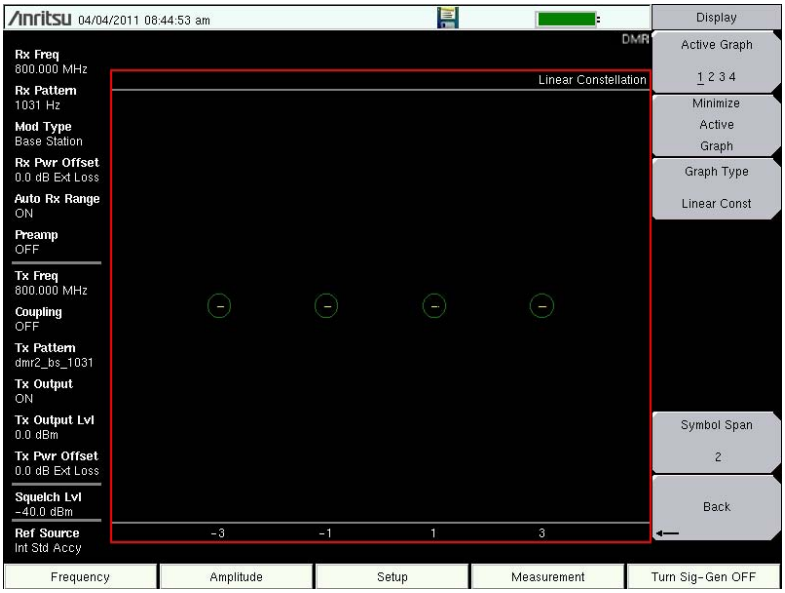


Figure 8-2. Linear Constellation Diagram

For input signals that are not DMR encoded, the LMR Master will still try to decode it and fit it to a symbol. This may cause some measurement results that are unexpected.

Histogram Graph

The Histogram graph displays a graphical representation of the symbols that are being received. The graph for each symbol represents the relative percentage that symbol was identified out of all the received symbols.

Each update of the screen is a separate representation of the latest data, rather than a cumulative total. The vertical scale is fixed at 0 % to 100 %, with each horizontal grid line representing 10 % of the total symbols received.

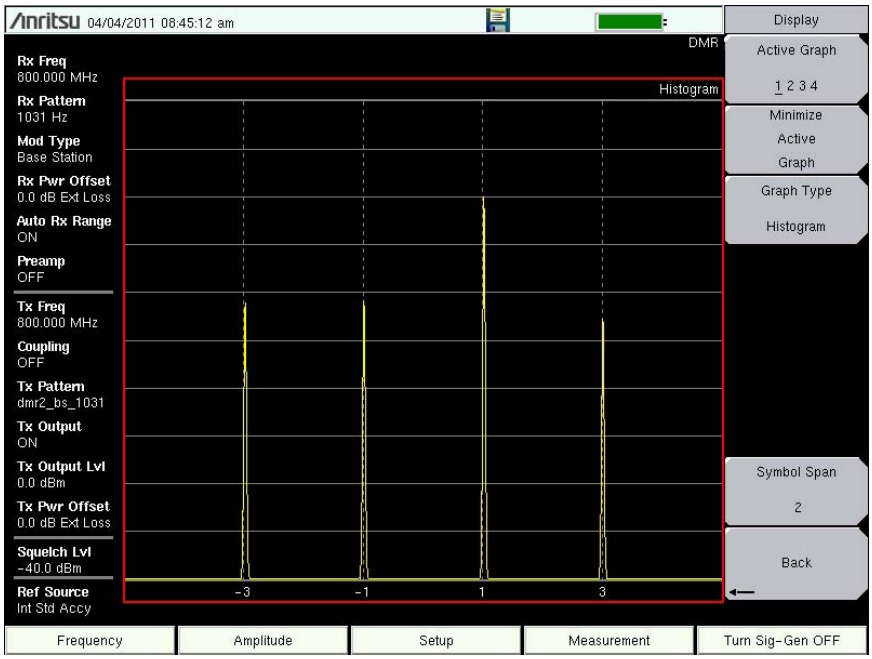


Figure 8-3. DMR Histogram

Spectrum Graph

The spectrum view displays a graphical representation of power (dBm) vs. frequency. The spectrum display gives an indication if there are interferers present that may degrade the bit error rate of the DMR signal. The frequency span is adjustable under the **Frequency** menu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 8-18 for details. Figure 8-4 displays the same signal using a 25 kHz span and a 500 kHz span.

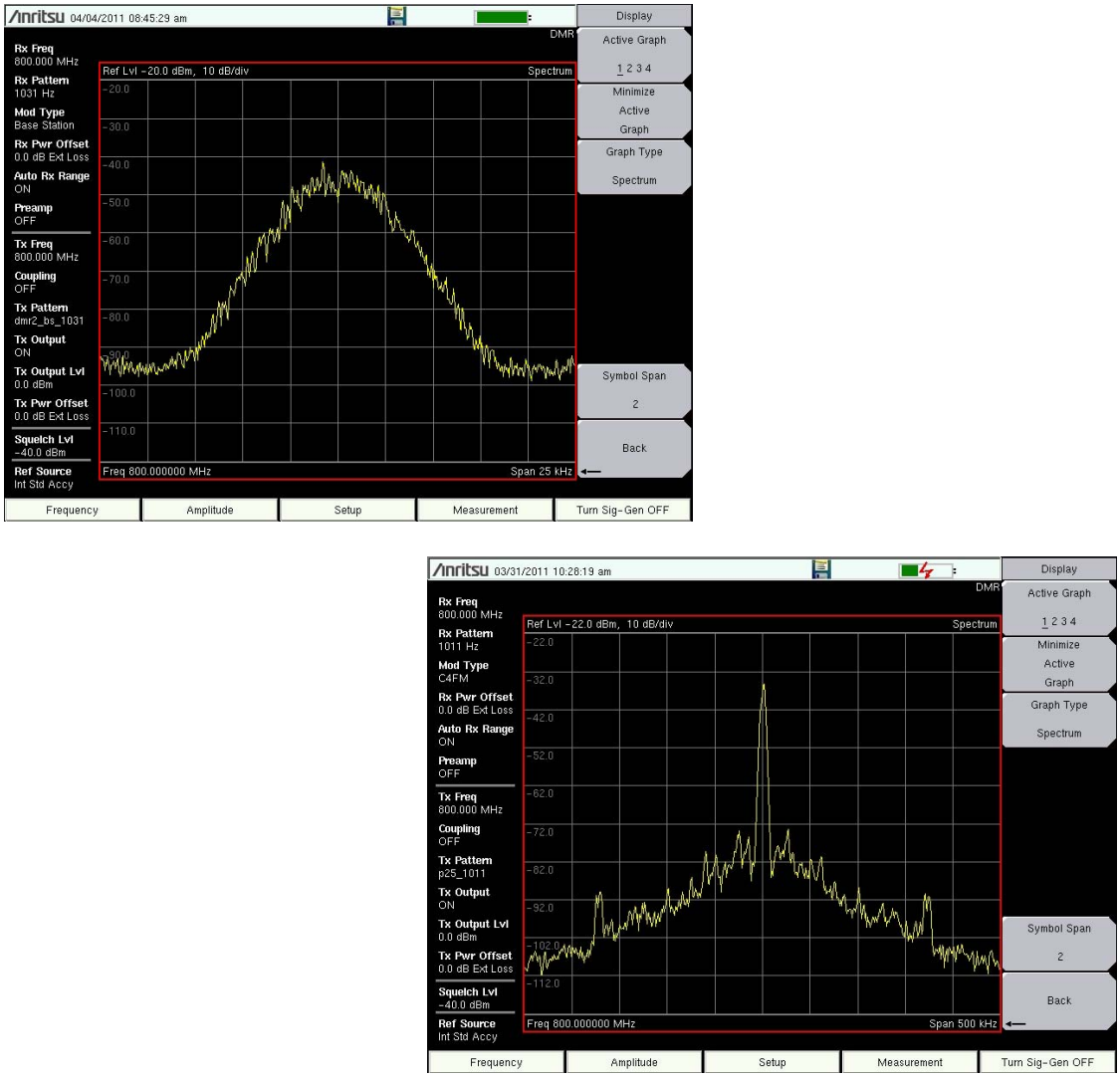


Figure 8-4. DMR Spectrum Graph (25 kHz Span and 500 kHz Span)

Eye Diagram

The eye diagram is an oscilloscope view of the DMR signal displaying the voltage of the signal vs. time. The diagram provides an indication of baseband fidelity of a DMR transmitter. With Over-the-air measurements the Eye Diagram can indicate phase distortion from multipath. The number of “eyes” displayed is set with the Symbol Span key under the “Display Menu” on page 8-22.

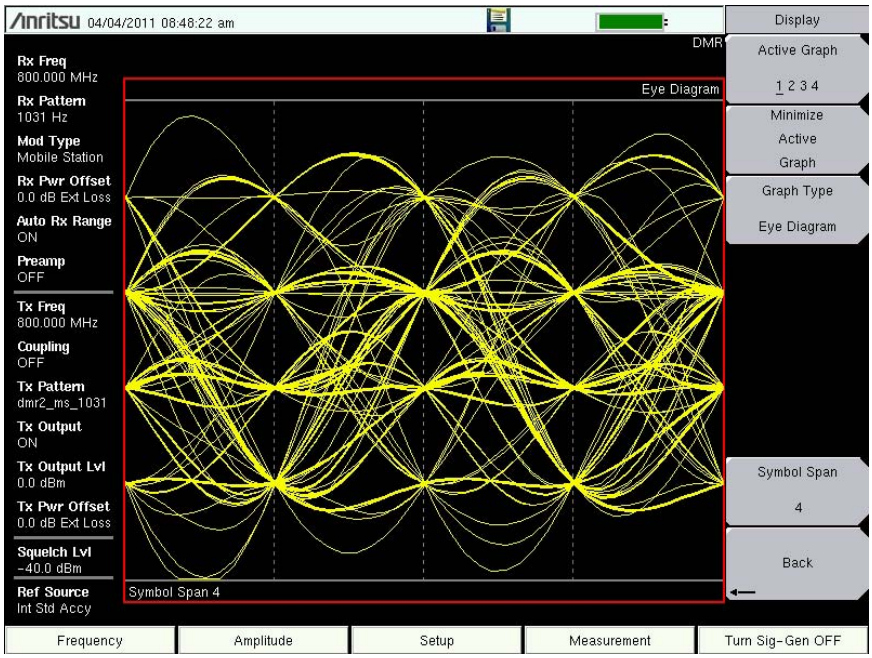


Figure 8-5. DMR Eye Diagram

Summary Graph and DMR Summary Graph

These two summary displays provide measured and decoded values in a table format.

Summary Graph

The summary graph provides an overview of a DMR transmitter. The graph displays numeric values of received power, frequency error, modulation fidelity (Mod Fid), bit error rate (BER), symbol deviation, Color Code (CC), and symbol rate error of the input signal.

The Received Power value in the summary graph can be toggled to dBm, watts, or volts by using the **Amplitude** > Units > Rx Units keys. This setting also applies to the squelch level setting.

The **Setup** > Squelch Lvl submenu key sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--). When the Received Power is above the squelch level, the measurements will display as shown in Figure 8-6.

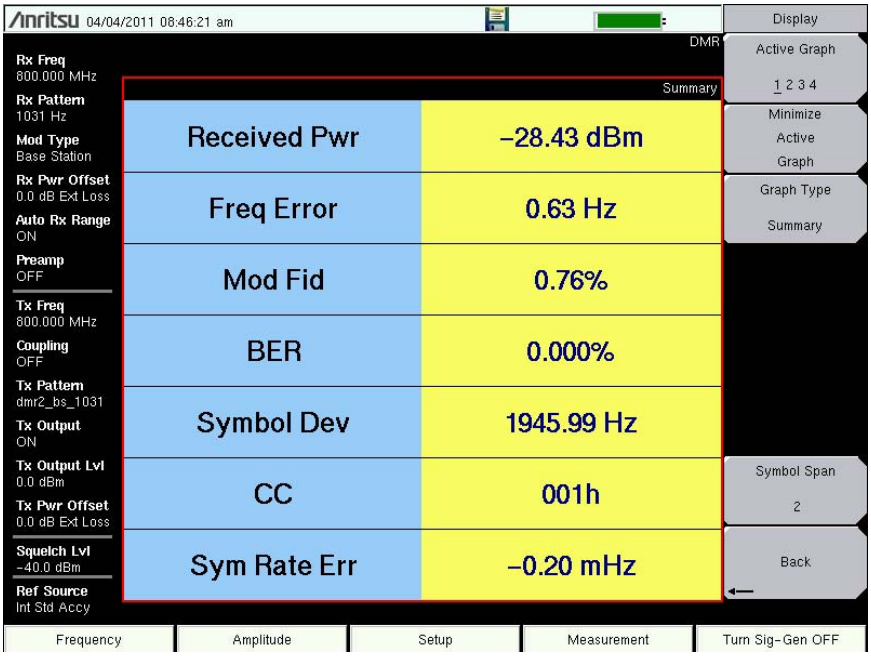


Figure 8-6. Summary Table with Received Pwr Above the Squelch Level

Received Pwr in the Summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Received Pwr is a function of the instruments RBW setting. The reduction is specified as: 10*Log (Signal Bandwidth / Resolution Bandwidth).

DMR Summary Graph

The DMR Summary graph reports the MS ID, Target ID, Talk Group ID, FID, Call Type, Base Station ID permitted on a channel from the DMR transmitter.

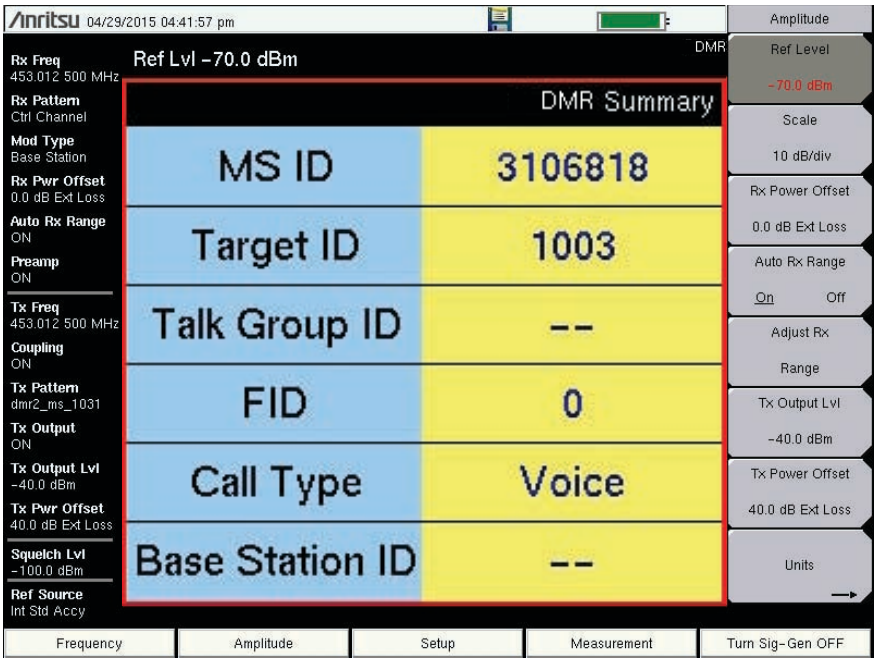


Figure 8-7. DMR Summary

Power Profile

The power profile graph is used with Mobile Station Rx Mod Type to display a zero-span view of power vs. time of the selected Rx Slot.

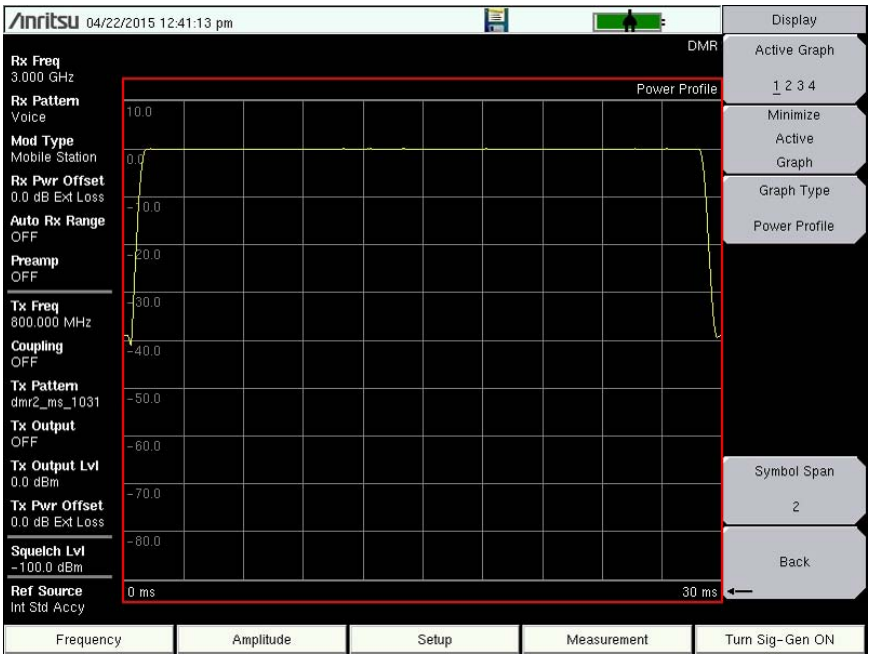


Figure 8-8. DMR Power Profile

8-4 DMR Bit Capture

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can provide and log raw bits (pre Forward Error Correction) when the Rx Pattern is set to Voice.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. From the **Setup** main menu, choose Voice as the Rx Pattern.
3. From the **Measurement** main menu press the DMR Bit Capture submenu key twice.
4. To log data, insert a formatted USB flash drive in the LMR Master and set Log Data to On. The bit capture information will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The tab delimited text file contains the header and table information shown in Figure 8-9. The files are named:

   `BIT_CAP_LOG`*yearmonthdaytime*`.dmr2`

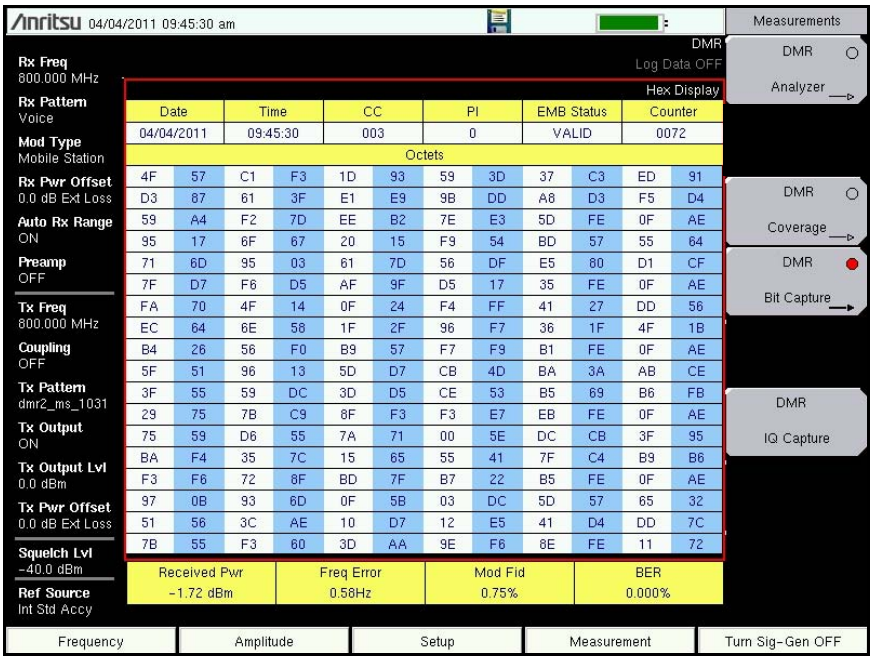


Figure 8-9. DMR Bit Capture Display

CC = Color Code
PI = Privacy Indicator
EMB Status = The EMB field contains CC, PI, and parity bits
Counter = Frame Count

8-5 DMR IQ Data

Note	This measurement is captured on an external USB flash drive. The captured data file can not be recalled and displayed on the instrument screen.

The LMR Master can capture and log DMR IQ data to a USB flash drive.

1. From the **Frequency** main menu, set the receiver frequency (Rx Freq).
2. Insert a formatted USB flash drive into the LMR Master and from the **Measurement** main menu, press the DRM IQ Capture submenu key. After approximately 10 seconds the instrument will display a message that the capture is complete.

The IQ data is sampled at 4,800 x 11 symbols per second. The saved file has an ASCII header and binary data (Figure 8-10). The data is written in 24-bit two's complement integers format. Interleaved Delta Phase (I) data then Magnitude (Q) data are captured. The file is intended for post-processing in MATLAB or other data analysis software.

The file will be written to a data stamped folder inside the `/usr` folder on the root level of the USB flash drive. The file is named:

`IQ_CAPTURE`*`yearmonthdaytime`*`.dmr2`

Note	There is no display menu for DMR IQ Capture. The LMR Master will continue to display the previous measurement screen during IQ Capture.

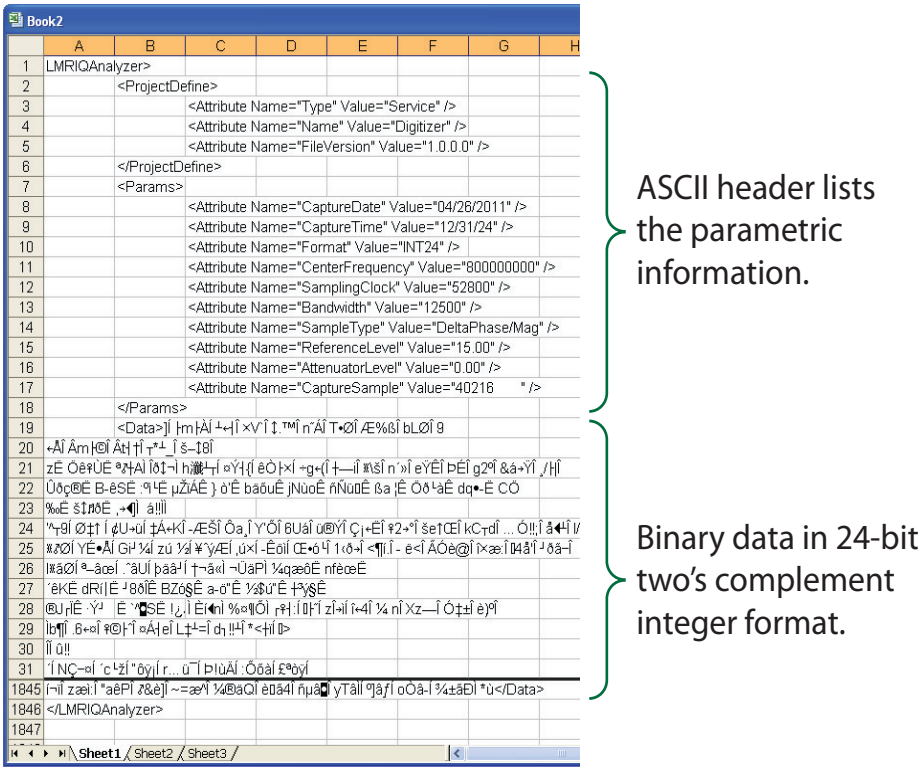


Figure 8-10. IQ Capture

8-6 DMR Repeater Receiver Sensitivity

The LMR Master can analyze the modulation quality and receiver sensitivity of a DMR repeater without needing to remove the repeater from service or to enable a special test mode.

Note	This example procedure illustrates one approach to making a repeater receiver sensitivity measurement. Different configurations may be used depending on accepted test procedures. Refer to Chapter 11, “High Power Input Protection” for an alternate connection method, especially if a direct connection to the repeater RF output is necessary.

Measuring Receiver Sensitivity Example

1. Connect the equipment as shown in Figure 8-11:
   - Connect the S412E **RF In** port to an antenna.
   - Connect the DMR repeater **Rx** port to the S412E **Signal Generator Out** port and to an antenna via a splitter or directional coupler.

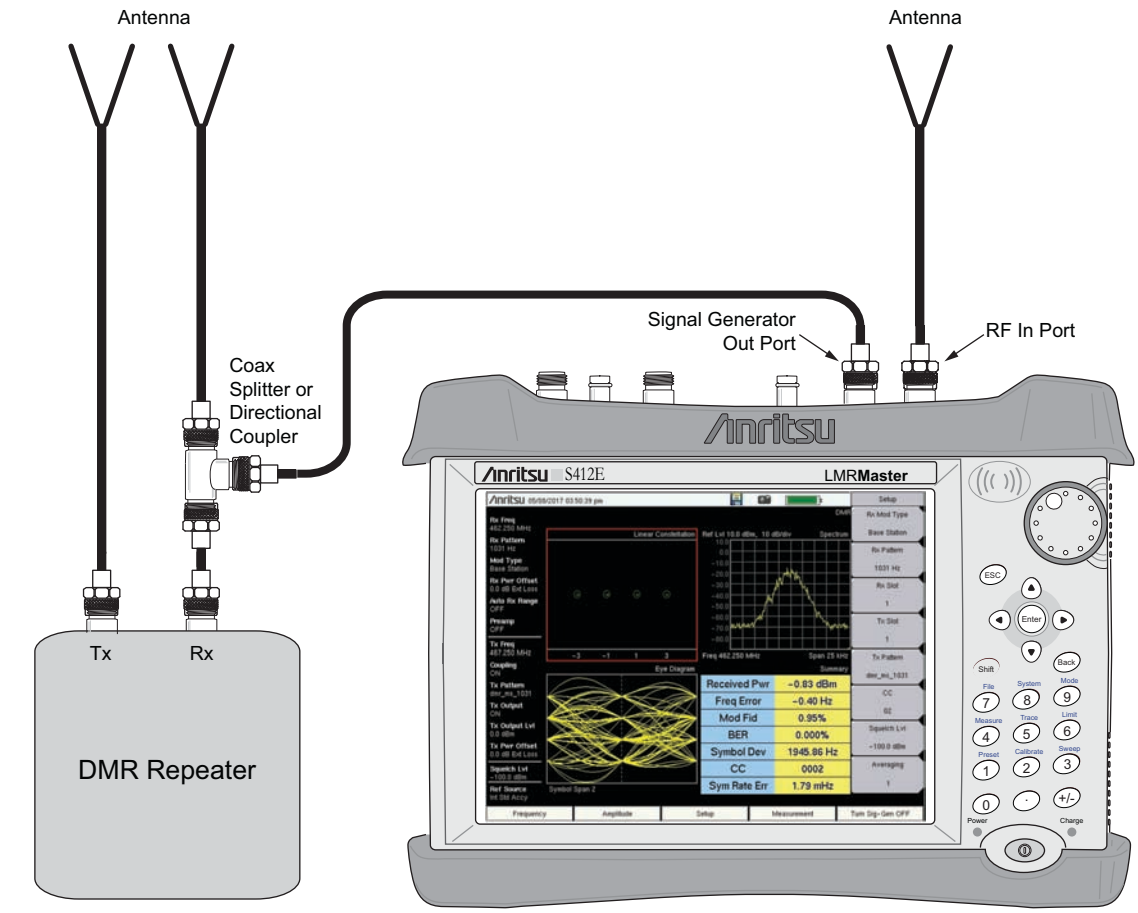


Figure 8-11. DMR Repeater Sensitivity Measurement Setup Example

2. From the S412E **Frequency** menu, set the following:
   - Rx Freq: DMR repeater transmit frequency
   - Tx Freq: DMR repeater receive frequency
   - Rx/Tx Coupling: Off
   - Coupling Offset: 0 Hz
   - Span: 25 kHz
3. From the S412E **Amplitude** menu, set the following:
   - Ref Level: Greater than expected receive signal level
   - Scale: 10 dB/div
   - Rx Power Offset: 0 dB External Loss
   - Auto Rx Range: On
   - Tx Power Offset: 3 dB External Loss for splitter (add any additional cable loss)
   - Tx Output Level: –60 dBm (initial setting)
4. From the S412E **Setup** menu, set the following:
   - Rx Mod Type: Base Station
   - Rx Pattern: 1031 Hz
   - RX and Tx Slot: Desired time slot to be measured
   - Tx Pattern: dmr_ms_1031
5. Turn the S412E Signal Generator On.
6. Toggle CC to the desired CC for testing. Toggling the CC field is used to send out a “wake-up” signal to the repeater.
7. On a DMR mobile station, listen for a tone. This indicates that the repeater is receiving and retransmitting the test signal from the LMR Master.
8. To determine if the repeater meets the sensitivity level, adjust the LMR Master signal generator output level (**Amplitude** -> Tx Output Lvl) to the specified sensitivity level.
9. Listen for a steady tone from the mobile station and note the BER measurement on the LMR Master DMR Summary screen (see Figure 8-11). The BER % should be within specification.
10. To determine the “absolute” sensitivity level, adjust the signal generator output level down until either one or both of:
    - the audible tone from the mobile station just starts to degrade
    - the BER % measurement shown on the LMR Master Summary screen is above specification.
11. Note the Tx Output Level is the absolute receiver sensitivity value.

8-7 DMR Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

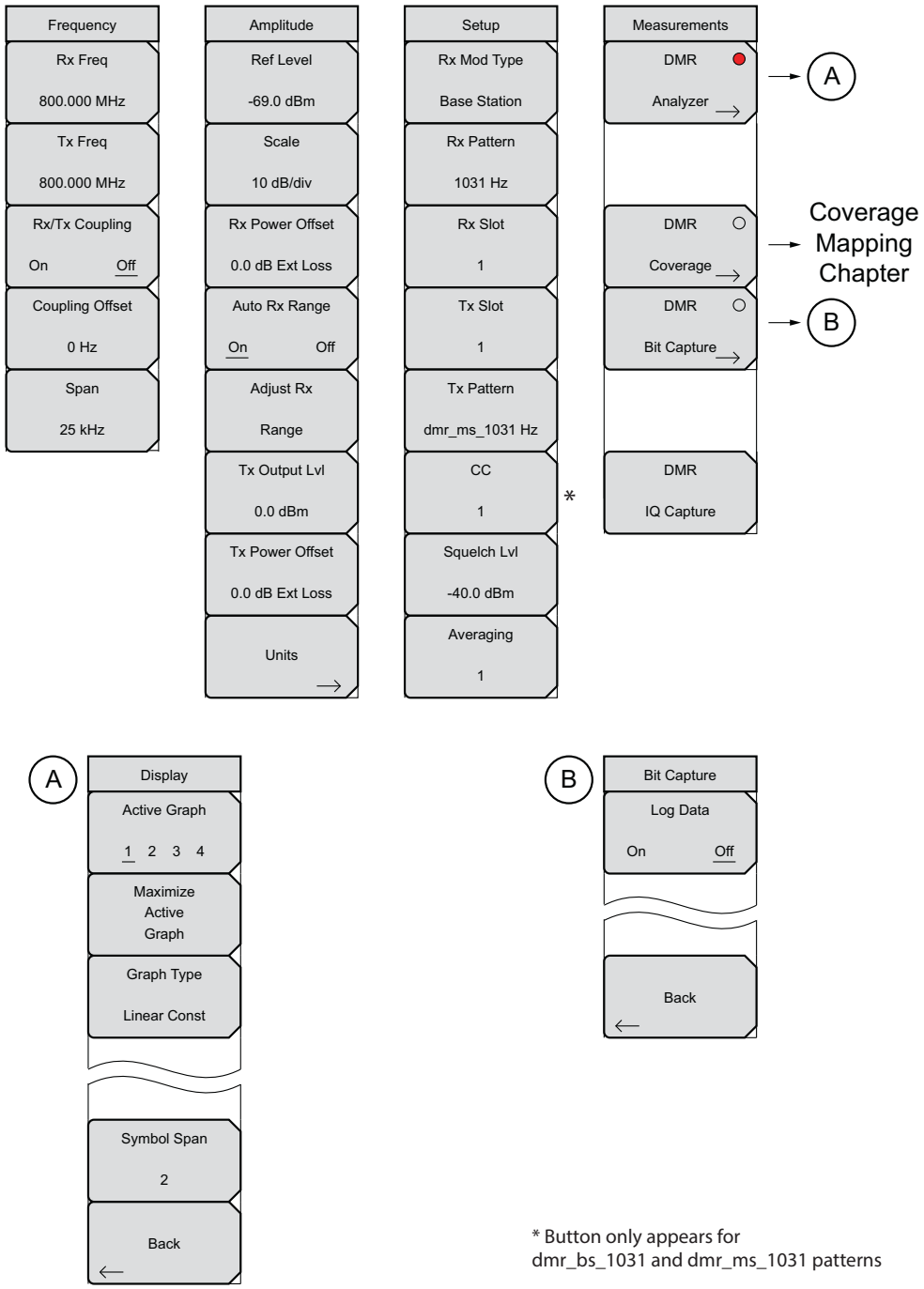
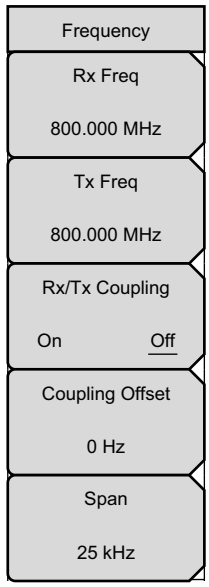


Figure 8-12. DMR Analyzer Menu Layout

8-8 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press Tx Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On the Tx Freq key is disabled.

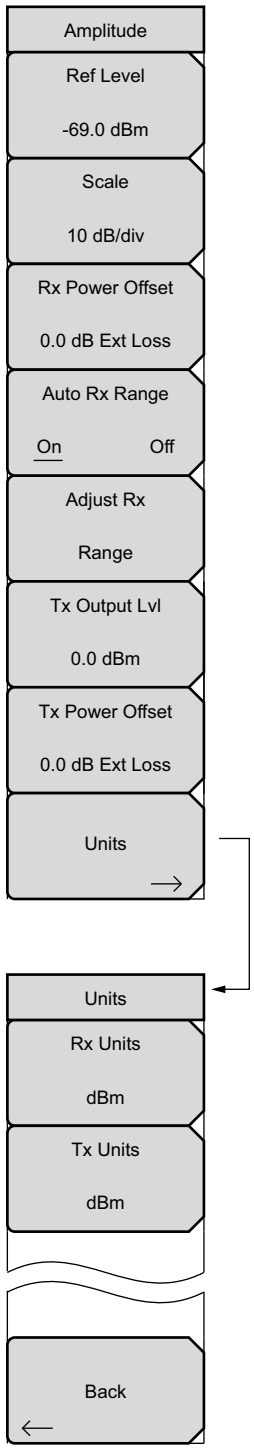
Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. Only functional when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 25 kHz, 50 kHz, 100 kHz, 500 kHz, 1 MHz, and 5 MHz.

Figure 8-13. DMR Analyzer Frequency Menu

8-9 Amplitude Menu

Key Sequence: **Amplitude**



Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis of the graticule. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. The y-axis power scale is shown on the left side of the display when viewing the Spectrum Graph.

Note: The "Vertical Scale Menu" on page 8-19 is displayed when DMR Coverage (**Measurement** > DMR Coverage) is selected.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Units: Opens to Units Submenu.

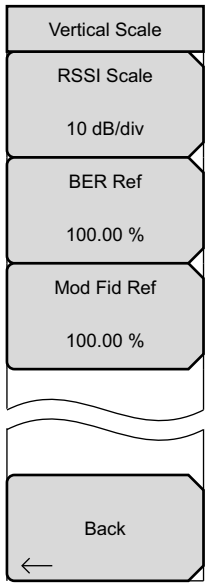
Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Summary Graph and the Squelch Level.

Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 8-14. DMR Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale



RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

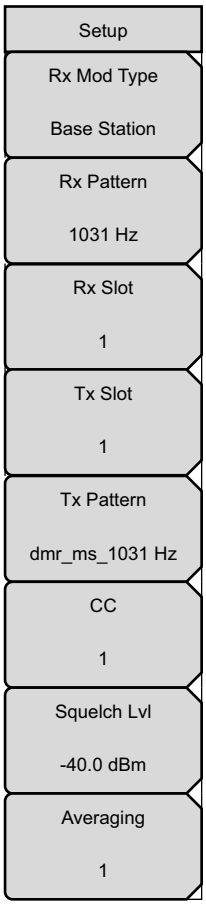
BER Ref: Sets the BER reference percentage value at the top of the y-axis in the BER vs. Time graph in Coverage measurement. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Mod Fid Ref: Sets the Modulation Fidelity reference percentage value. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Figure 8-15. Vertical Scale Menu

8-10 Setup Menu

Key Sequence: **Setup**



Rx Mod Type: Sets the type of modulation. The options are Mobile Station or Base Station.

Rx Pattern: Selects the receiver Bit Error Rate pattern. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**. There are four available patterns:

Automatic Frequency Control (1031 Hz)
Standard Transmitter Test (O.153 or V.52)
Voice
Silence (mobile station only)

Rx Slot: Selects the receiver time slot: 1 or 2 (Base Station Mod Type only).

Tx Slot: Selects the signal generator time slot: Both, 1, or, 2. (Note that selecting a time slot other than “Both” will automatically change the Tx pattern to “ms_1031” in anticipation of a receiver sensitivity test.

Tx Pattern: Selects the transmitter pattern to send when the **Turn Sig-Gen ON** main menu key is selected. Select a pattern from the list box with the arrow keys or rotary knob and press **Enter**.

CC: Sets the Color Code (CC) that is sent on the standard DMR 1031 Hz Tx Patterns. This setting is used when testing receivers and the button only appears when *dmr_bs_1031* or *dmr_ms_1031* patterns are selected.

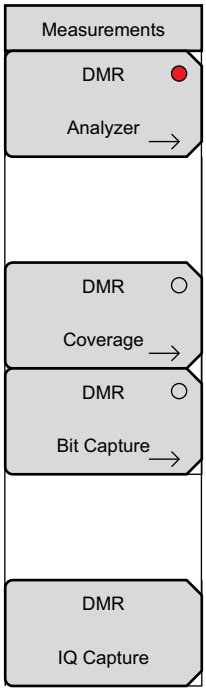
Squelch Lvl: Sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--).

Averaging: Sets the refresh rate of the numerical values in the DMR Summary window. Setting a higher number (25 maximum) reduces measurement jitter.

Figure 8-16. DMR Analyzer Setup Menu

8-11 Measurement Menu

Key Sequence: **Measurement**



DMR Analyzer: Opens the “Display Menu” on page 8-22.

DMR Coverage (Option 592 required): Opens the DMR Coverage menu. Refer to Chapter 10, “LMR Coverage Mapping”.

DMR Bit Capture: This submenu key is valid only when Rx Pattern is set to Voice. Pressing this key opens a submenu for data logging. Make sure that a formatted USB flash drive is attached to the instrument before starting bit capture. Set Log Data to On to start the bit capture. Bit capture will continue until Log Data is set to Off or the USB flash drive is filled.

The files are saved in a time-stamped folder under the **usr** folder on the USB flash drive.

If Log Data is On, any of the following functions will stop the logging:

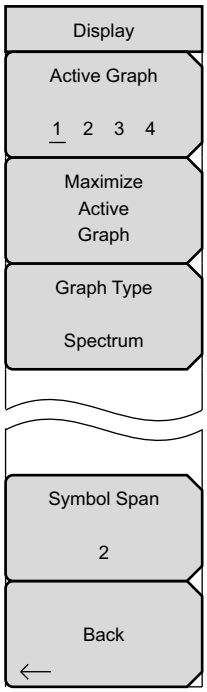
Rx Frequency change
Setup change
Starting another measurement

DMR IQ Capture: Pressing this key starts the IQ data capture. Make sure that a formatted USB flash drive is attached to the instrument before starting IQ Capture. When the capture is complete, a message is displayed. This may take a few seconds.

Figure 8-17. DMR Analyzer Measurement Menu

Display Menu

Key Sequence: **Measurement** > DMR Analyzer



Active Graph

1 2 3 4: In Four Screen view, use this menu to select which of the four graphs is active. The current active graph is underlined (1 2 3 4) and has a red perimeter line. Any of the four graphs can also be made active by tapping once on the touch screen. Repeatedly pressing the Active Graph submenu key cycles the active graph, 1 through 4.

In Standard view (one graph displayed on the screen) the Active Graphic key rotates between the four graphs displayed in the Four Screen view.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four Screen (4 graphs) view and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this button displays the current active graph type. Pressing the button will open a list box of the graphs types available for DMR Analyzer measurements. Select the desired graph type with the arrow keys or rotatory knob and press **Enter**. The current active graph will be replaced with the new selection.

Available graphs include:

- Constellation
- Spectrum
- Histogram
- Eye Diagram
- Linear Constellation
- Summary and DMR Summary
- Power Profile

Refer to “DMR Analyzer Graphs” on page 8-4 for additional information.

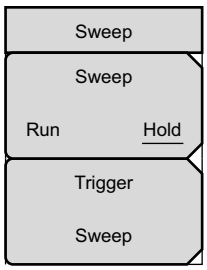
Symbol Span: Use this menu to adjust the number of symbols viewed across the screen in the Eye Diagram graph. Adjust from 2 to 5 by using the keypad, the arrow keys, or the rotary knob. Keypad values entered outside of this range are ignored.

Back: Returns to the “Measurement Menu” on page 8-21.

Figure 8-18. DMR Analyzer Display Menu

8-12 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Trigger Sweep is not available in DMR Bit Capture measurements.

Figure 8-19. DMR Analyzer Sweep Menu

8-13 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Display the "Measurement Menu" on page 8-21.

8-14 Trace Menu

This menu is not available in DMR Analyzer measurement mode.

8-15 Limit Menu

This menu is not available in DMR Analyzer measurement mode.

8-16 Other Menus

Preset, **Calibrate**, **File**, **System** and **Mode** are described in the User Guide.

Chapter 9 — PTC Analyzer (Option 721)

9-1 Introduction

The PTC Analyzer option provides a method to verify the operation of ITC-R Positive Train Control (PTC) systems. ITC-R PTC is an integrated communication and information system for controlling train movements. Option 721 includes the ability to display constellation, spectrum, histogram, and eye diagram graphs. In addition, a summary graph displays numeric values of received power, frequency error, Error Vector Magnitude (EVM), Bit Error Rate (BER), IQ (In phase and Quadrature) Offset, and symbol rate error of the input signal.

EVM is a measure of how far the constellation points are from the ideal locations. BER is a comparison against standard PTC test patterns – either O.153 or PN9. The available Symbol Rates are Half Rate (8 ksps) and Full Rate (16 ksps). IQ Offset is a combination of phase imbalance (the measured phase between I and Q arms versus an ideal 90° phase difference) and amplitude variation between the two arms.

The LMR Master will analyze input signal strengths from +33 dBm (2.0 watts) down to levels approaching the sensitivity of PTC radios, automatically adjusting the input sensitivity based on input levels.

9-2 Setup Procedure

Direct Connect to the Transmitter

1. Press the **Menu** key then select the PTC Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight PTC Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect the transmitter to the RF In 50 Ohm connector on the LMR Master using a coupler or attenuator.
3. Press the **Frequency** main menu key to set the receiver center frequency (Rx Freq) of the measurement. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key to choose the Rx and Tx patterns and set the Symbol Rate, Squelch lvl, and Averaging.

5. Press the **Amplitude** main menu key, then the Rx Power Offset submenu key to set the receiver attenuation (or gain). Use the arrow keys, rotary knob or the numeric keypad to enter the adjustment value, up to 100 dB and select either the Loss or Gain submenu key. The offset will be applied to the Receiver Power value in the Summary graph. For instance, if the transmitter under test is emitting 50 watts (+47 dBm) of power, and the External Attenuation value is 40 dB (such as from a 40 dB directional coupler) the Received Power displayed will be +7 dBm.
6. Press the **Measurement** key, then the PTC Analyzer submenu key. Select the Graph types to view with the Graph Type submenu key. The Symbol Span submenu is used to adjust the number of "eyes" displayed across the screen in the Eye Diagram graph. Refer to "PTC Analyzer Graphs" on page 9-4 for information on the available graph types.

Over the Air (OTA) Analysis Setup

1. Press the **Menu** key then select the PTC Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight PTC Analyzer and press **Enter**.

Caution	The maximum input power without damage is 2 watts (+33 dBm) to the RF In 50 Ohm connector. To prevent damage, use a coupler or attenuator to reduce the input power to below this level when measuring high output power devices.

2. Connect an antenna with the appropriate frequency range to the RF In 50 Ohm connector on the LMR Master.
3. Press the **Frequency** main menu key to set the center frequency of the measurement using the Rx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.
4. Press the **Setup** main menu key, then select the symbol rate of either Half Rate (8 ksps) or Full Rate (16 ksps) by using the Symbol Rate key.
5. Refer to "PTC Analyzer Graphs" on page 9-4 for information on the available graph types.

Using the Signal Generator for Receiver or OTA Analysis

1. Press the **Menu** key then select the PTC Signal Analyzer icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight PTC Analyzer and press **Enter**.

Caution	The maximum output power from the Signal Generator Out connector is 1 mW (0 dBm) and the frequency range is 500 kHz to 1.6 GHz.

2. Direct connect the LMR Master Signal Generator Out 50 Ohm connector to the repeater/receiver or connect an antenna with the appropriate frequency range to the connector.
3. Press the **Frequency** main menu key to set the transmit frequency using the Tx Freq key. Use the arrow key, rotary knob or the numeric keypad. When using the keypad, select the appropriate terminator submenu key to set the center frequency.

   If testing a PTC repeater, you can bind the transmit frequency to the receive frequency by setting Rx/Tx Coupling to On and entering the Coupling Offset.

Note	When Rx/Tx Coupling is On, the Tx Freq submenu key is disabled.

4. Press the **Amplitude** main menu key, then the Tx Output Lvl submenu key to set the output power. Enter any output attenuation or gain using the Tx Power Offset key.
5. Set the transmit pattern. Press the **Setup** main menu and select the Tx Pattern submenu key. The Symbol Rate settings apply to the standard PTC patterns (8 ksps or 16 ksps patterns will be shown, depending on the Symbol Rate setting).
   Available patterns are listed on the display and additional patterns can be downloaded via the **System** > Application Options menu.
6. Press the **Turn Sig-Gen ON** main menu key to start the signal generator. Press the key again to turn off the signal generator.

9-3 PTC Analyzer Graphs

The following PTC Analyzer measurements are available on the LMR Master. From the **Measurements** main menu press PTC Analyzer twice. Press the Graph Type submenu key to select the measurement type.

Constellation and Linear Constellation

Constellation view displays the demodulation information in an IQ format (Figure 9-1). The chart shows the relationship between the location of a constellation data point, its deviation frequency, and the information it carries.

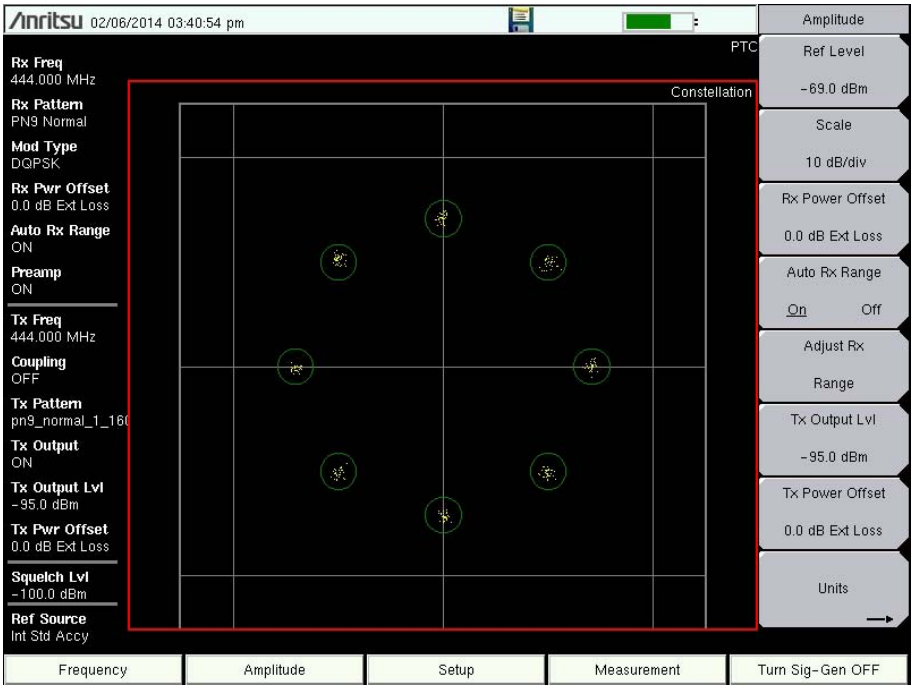


Figure 9-1. Constellation Diagram

Figure 9-2 shows the same information is the Linear Constellation View.

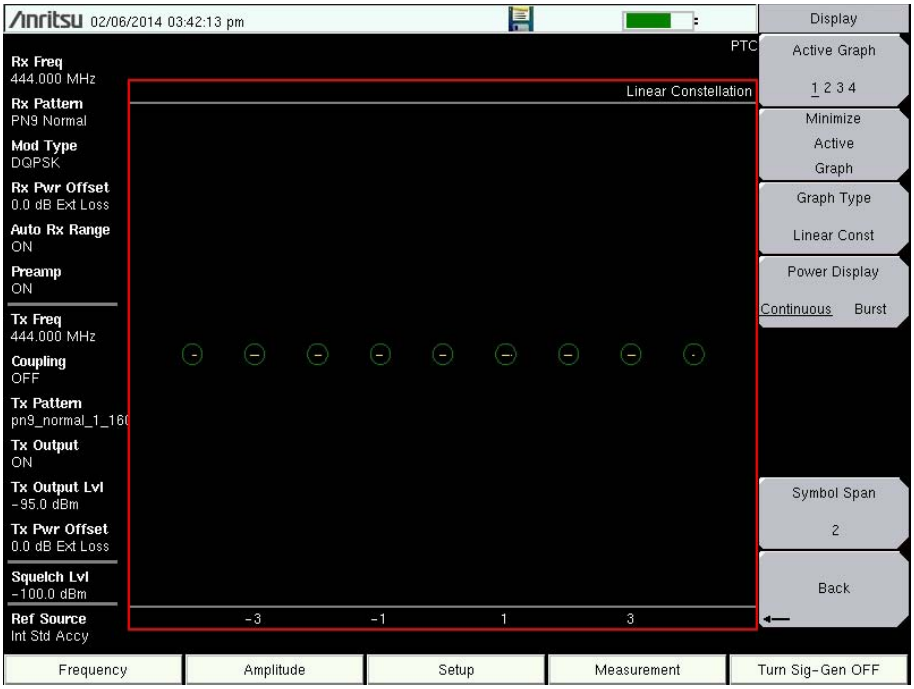


Figure 9-2. Linear Constellation Diagram

For input signals that are not PTC encoded, the LMR Master will still try to decode it and fit it to a symbol. This may cause some measurement results that are unexpected.

Histogram Graph

The Histogram graph displays a graphical representation of the symbols that are being received. The graph for each symbol represents the relative percentage that symbol was identified out of all the received symbols.

Each update of the screen is a separate representation of the latest data, rather than a cumulative total. The vertical scale is fixed at 0 to 100 %, with each horizontal grid line representing 10 % of the total symbols received.

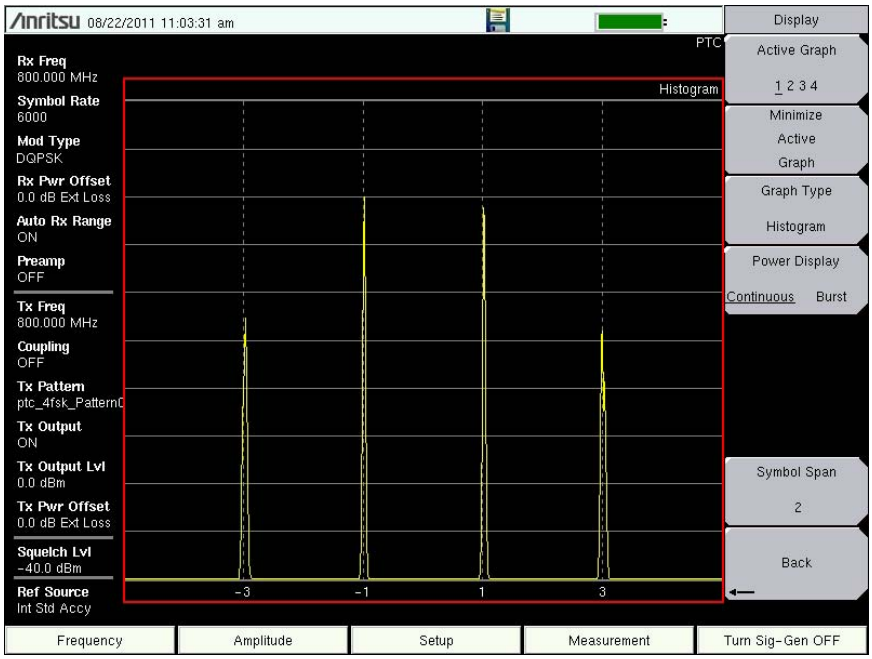


Figure 9-3. PTC Histogram

Spectrum Graph

The spectrum view displays a graphical representation of power (dBm) vs. frequency. The spectrum display gives an indication if there are interferers present that may degrade the bit error rate of the PTC signal. The frequency span is adjustable under the **Frequency** menu. The reference level is adjusted with the **Amplitude** menu. Refer to "Amplitude Menu" on page 9-12 for details. Figure 9-4 displays the same signal using a 25 kHz span and a 500 kHz span.

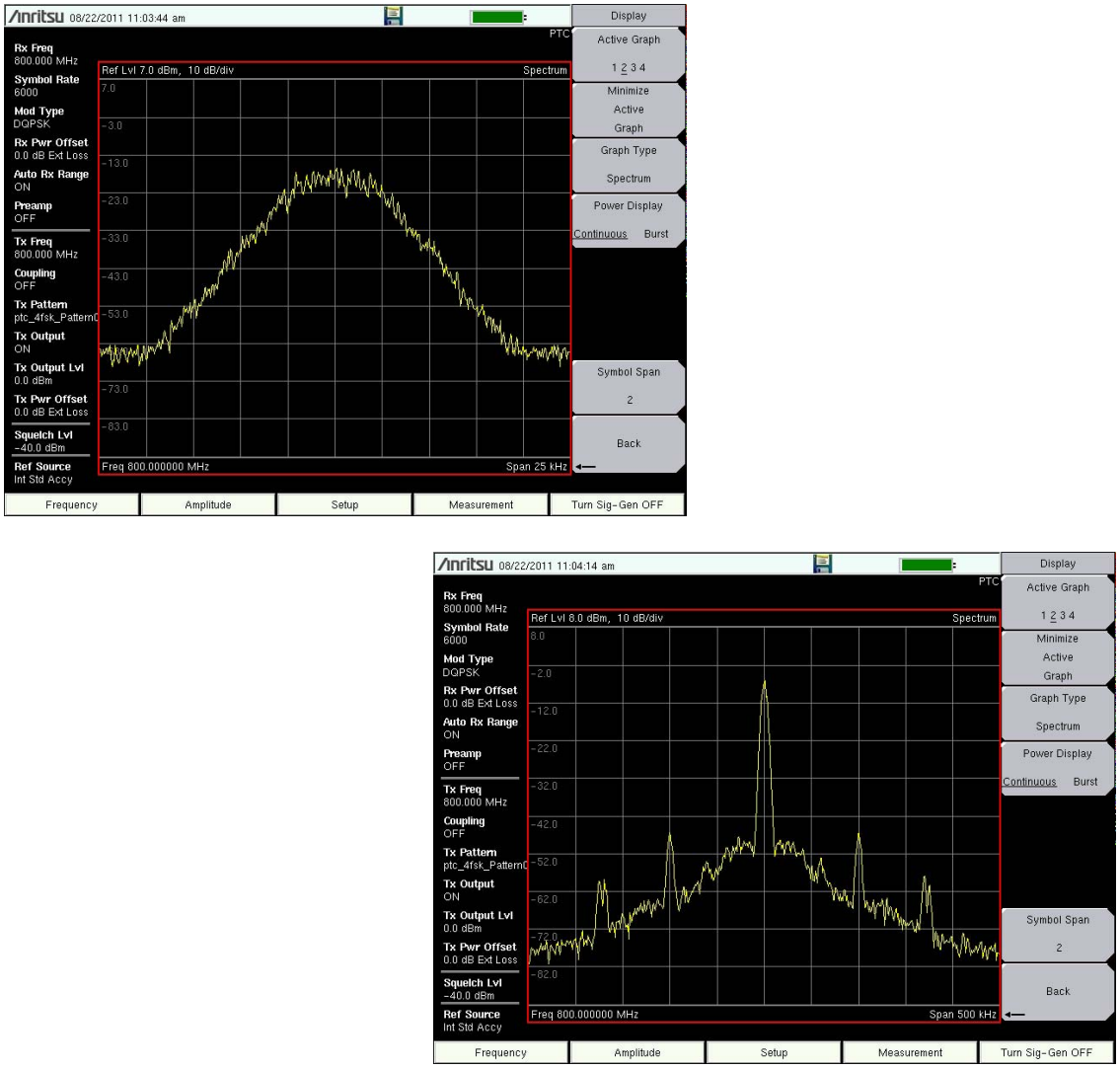


Figure 9-4. PTC Spectrum Graph (25 kHz Span and 500 kHz Span)

Eye Diagram

The eye diagram is an oscilloscope view of the PTC signal displaying the voltage of the signal vs. time. The diagram provides an indication of baseband fidelity of a PTC transmitter. With Over-the-air measurements the Eye Diagram can indicate phase distortion from multipath. The number of “eyes” displayed is set with the Symbol Span key under the “Display Menu (1 of 2)” on page 9-17.

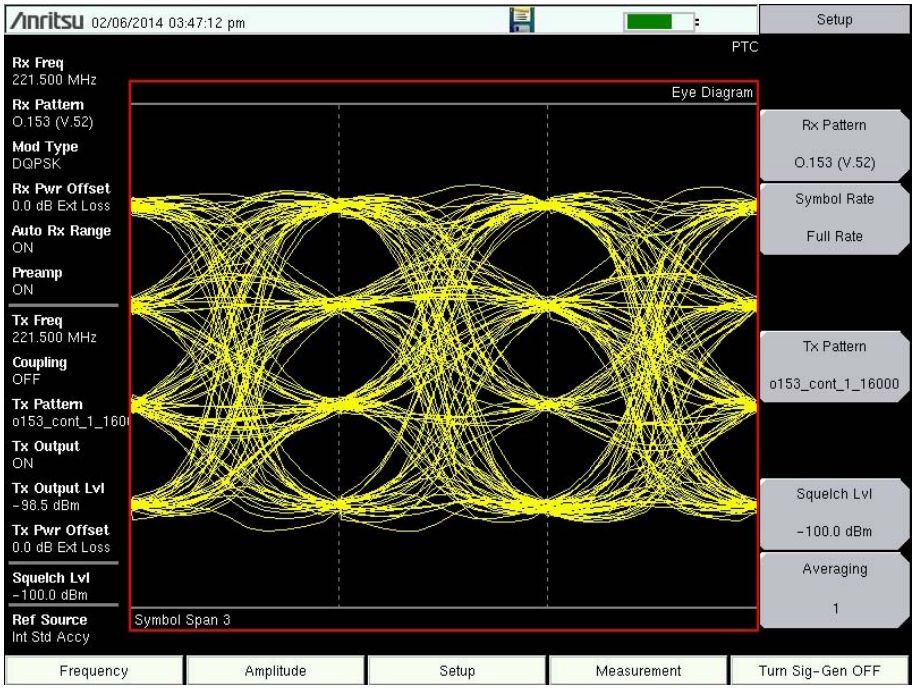


Figure 9-5. PTC Eye Diagram

Summary Graph

The summary graph provides an overview of a PTC transmitter. The graph displays received power or burst power, frequency error, error vector magnitude (EVM), bit error rate (BER), IQ offset, phase error, magnitude error, and symbol rate error of the input signal.

The Received Power value in the summary graph can be changed between dBm, watts, and volts using the **Amplitude** > Units > Rx Units submenu key. This setting also applies to the burst power and squelch level setting.

The **Setup** > Squelch Lvl submenu key sets the received power level below which summary graph results are not displayed. When the received power is lower than the set squelch level, all summary graph measurements except for Received/Burst Pwr will be blanked out (--). When the Received Power is above the squelch level the measurements will display as shown in Figure 9-6 on page 9-9.

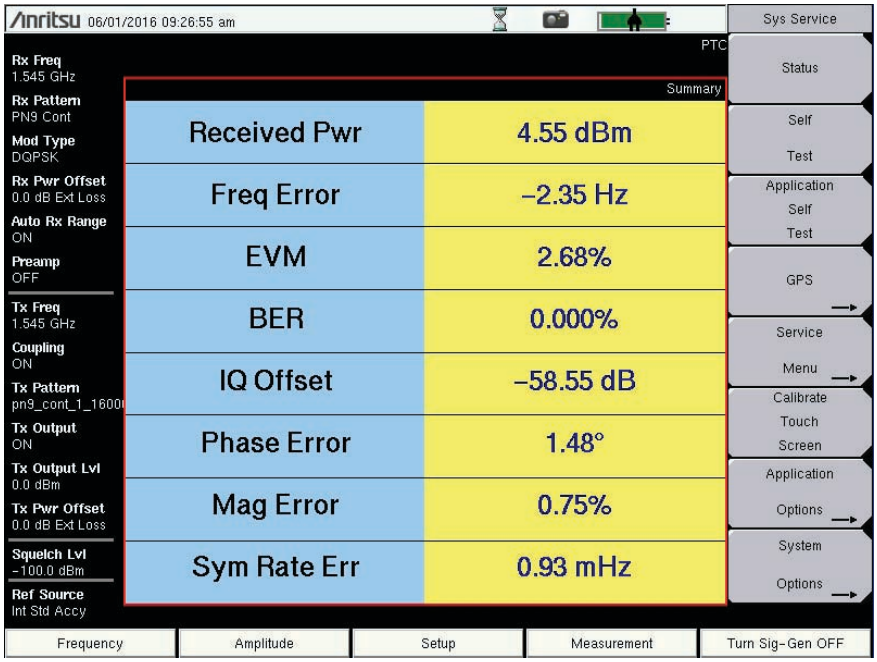


Figure 9-6. PTC Summary Graph

Received power in the Summary table is the integrated power of all the energy in the receiver bandwidth. Any peak amplitude reduction seen in the Spectrum display when compared to Received Pwr is a function of the RBW setting of the instrument. The reduction is specified as: 10*Log(Signal Bandwidth / Resolution Bandwidth). Burst power in the summary table is calculated only when the data stream contains packets.

9-4 PTC Analyzer Menus

Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

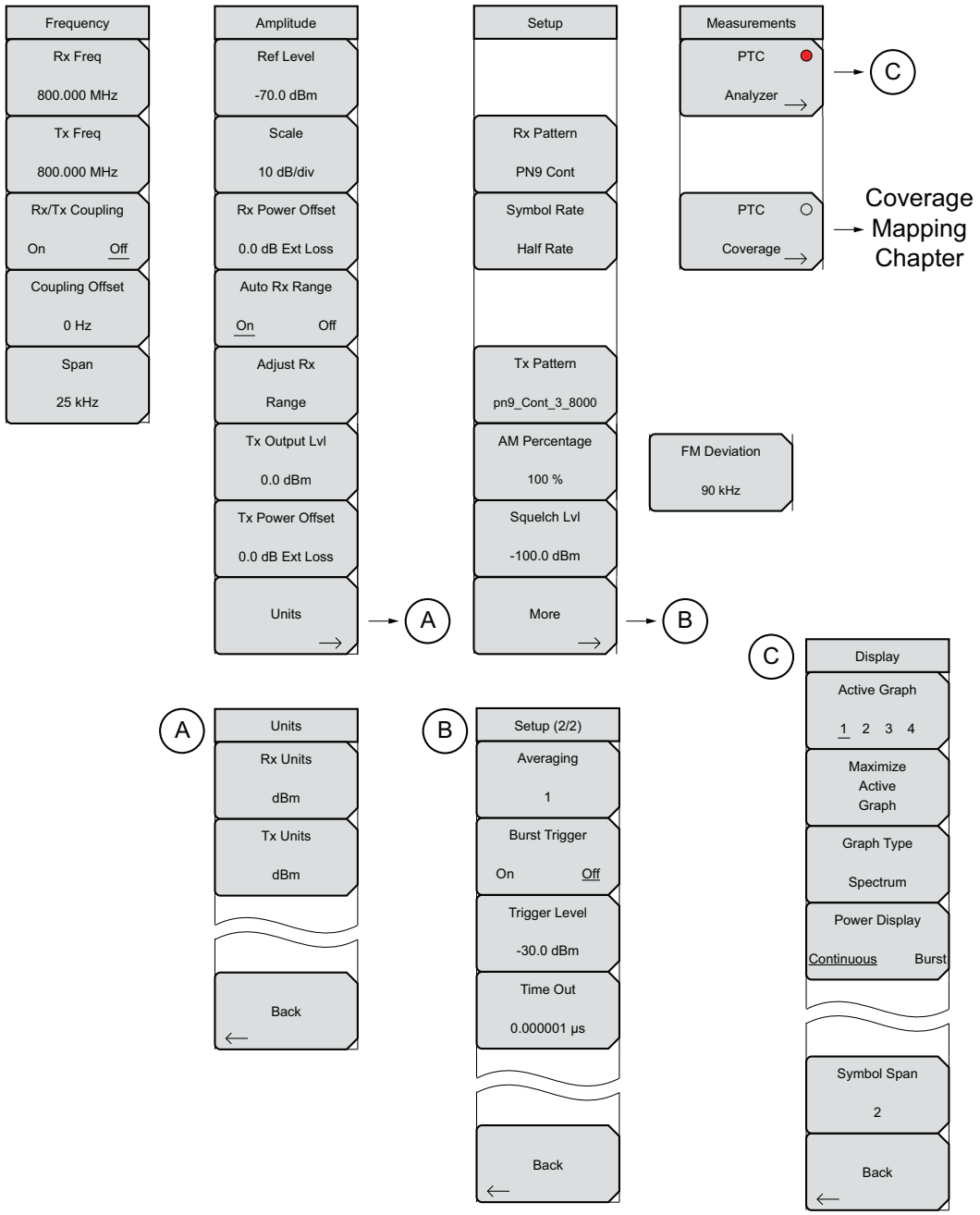
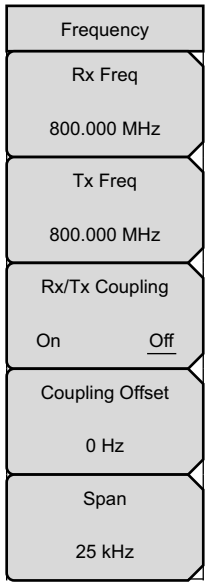


Figure 9-7. PTC Analyzer Menu Layout

9-5 Frequency Menu

Key Sequence: **Frequency**



Rx Freq: Sets the receiver frequency. Press the Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Tx Freq: Sets the signal generator frequency. Press Tx Rx Freq key and enter the desired frequency using the keypad, the arrow keys, or the rotary knob. If entering a frequency using the keypad, the submenu key labels change to GHz, MHz, kHz, and Hz. Press the appropriate units key. Pressing the **Enter** key has the same effect as pressing the MHz submenu key.

Rx/Tx Coupling: Couples the signal generator to the receiver frequency. When set to On the Tx Freq key is disabled.

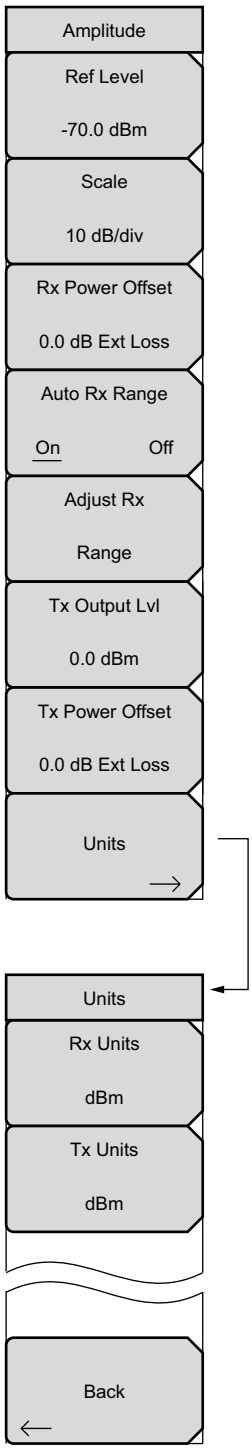
Coupling Offset: Sets the Offset of the signal generator frequency and the receiver frequency. Only functional when Rx/Tx Coupling is set to On.

Span: Sets the span of the Spectrum Graph. Span selections are 25 kHz, 50 kHz, 100 kHz, 500 kHz, 1 MHz, and 5 MHz.

Figure 9-8. PTC Analyzer Frequency Menu

9-6 Amplitude Menu

Key Sequence: **Amplitude**



Ref Level: Sets the reference power level at the top of the display when Auto Range is Off.

Scale: Scale sets the number of dB per division in the y-axis of the graticule. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob. The y-axis power scale is shown on the left side of the display when viewing the Spectrum Graph.

Note: The "Vertical Scale Menu" on page 9-13 is displayed when PTC Coverage (**Measurement** > PTC Coverage) is selected.

Rx Power Offset: Sets the receiver (RF IN connection) external attenuation or gain. Press the Rx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Auto Rx Range: Pressing this submenu key toggles between On and Off. When On, this function automatically adjusts the reference level based on the input signal.

Adjust Rx Range: When Auto Rx Range is Off, pressing Adjust Rx Range sets the Reference Level automatically for the current measurement.

Tx Output Lvl: Sets the output power of the Signal Generator (0 dBm or 1 mW or 223 mV max).

Tx Power Offset: Sets the transmitter (Signal Generator Out connection) external attenuation or gain. Press the Tx Power Offset submenu key and select a value from 0 dB to 100 dB then select either dB External Loss or dB External Gain.

Units: Opens to Units Submenu.

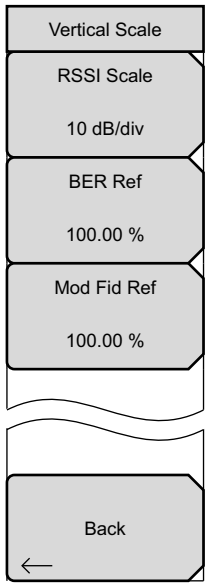
Rx Units: Sets the unit of measure (dBm, watts, or volts) for Received Power in the Summary Graph and the Squelch Level.

Tx Units: Sets the unit of measure (dBm, watts, or volts) for the Signal Generator (Tx Output Lvl submenu).

Figure 9-9. PTC Analyzer Amplitude Menu

Vertical Scale Menu

Key Sequence: **Amplitude** > Vertical Scale



RSSI Scale: Sets the number of dB per division in the y-axis power scale of the RSSI vs. Time graph in Coverage measurement. Enter a value from 1 dB per division to 15 dB per division using the keypad, the arrow keys, or the rotary knob.

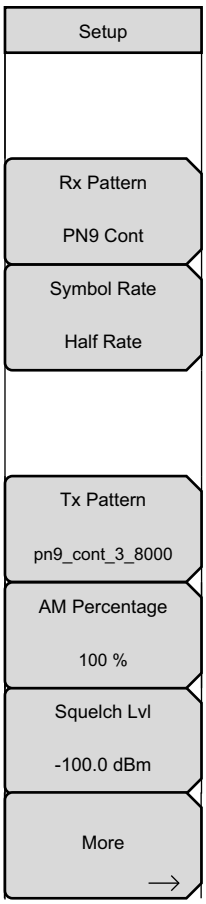
BER Ref: Sets the BER reference percentage value at the top of the y-axis in the BER vs. Time graph in Coverage measurement. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Mod Fid Ref: Sets the Modulation Fidelity reference percentage value. Enter a value from 1.00 % to 100.00 % using the keypad, the arrow keys, or the rotary knob.

Figure 9-10. Vertical Scale Menu

9-7 Setup Menu

Key Sequence: **Setup**



Rx Pattern: Selects the receiver Bit Error Rate pattern. Select a pattern from the list box with the arrow keys or rotary knob and press Enter. There are two available patterns:

PN9 Cont
PN9 Burst

Symbol Rate: Selects the symbol rate for the signal generator when using the standard PTC patterns. Options are Half Rate (8 ksps) or Full Rate (16 ksps).

Also sets the receiver IQ pattern deviation.

Tx Pattern: Selects the transmitter pattern to send when the **Turn Sig-Gen ON** main menu key is pressed. Select a pattern from the list box with the **Arrow** keys or rotary knob, and then press **Enter**.

Patterns include PN9 continuous and burst (with repeating or sequential payloads) at Half Rate or Full Rate, CW, AM 1 kHz audio, and FM 1 kHz audio.

Two submenu keys appear only with specific Tx Pattern settings:

When AM is selected as the TX pattern, a submenu key is displayed to allow setting the percentage of Amplitude modulation. The range is 0 % to 100 %

When FM is selected as the TX pattern, a submenu key is display to allow setting the cycle count of the frequency deviation. The range is 0 Hz to 100 kHz.

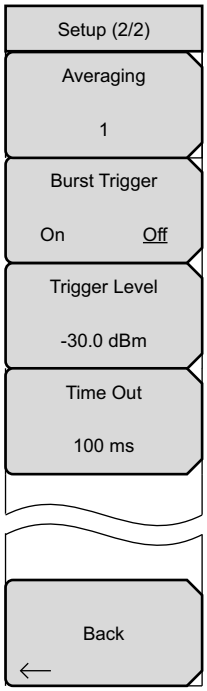
Squelch Lvl: Sets the squelch power level. When the Received Power is lower than the set squelch level, all summary graph measurements except for Received Pwr will be blanked out (--).

More: Opens the “Setup (2/2) Menu” on page 9-15.

Figure 9-11. PTC Analyzer Setup Menu

Setup (2/2) Menu

Key Sequence: **Setup** > More



Averaging: Sets the refresh rate of the numerical values in the PTC Summary window. Setting a higher number (25 maximum) will reduce measurement jitter.

Burst Trigger: Turns the Burst Trigger On or Off. When turned ON, the PTC analyzer will wait for the input signal to cross the Trigger Level signal threshold (set below) before capturing and analyzing the data. When turned Off, the PTC analyzer will capture and analyze signals continuously.

Trigger Level: Sets the minimum power level of the signal required to activate the burst trigger when Burst Trigger is On.

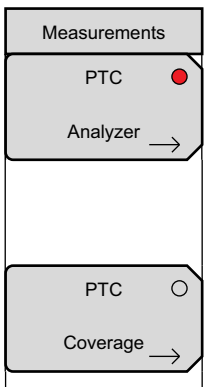
Time Out: Sets the trigger time out value. The display will not update while waiting for a trigger. When the “time out” duration elapses, the display is updated even if there is no trigger detected. The instrument provides an audible sound and displays a message to adjust the trigger level.

Back: Returns to the “Setup Menu” on page 9-14.

Figure 9-12. PTC Analyzer Setup (2/2) Menu

9-8 Measurement Menu

Key Sequence: **Measurement**



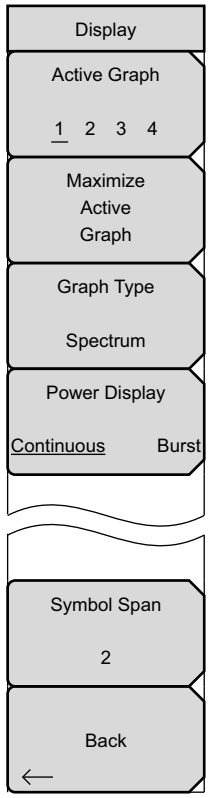
PTC Analyzer: Opens the “Display Menu (1 of 2)” on page 9-17.

PTC Coverage (Option 722 required): Opens the PTC Coverage menu. Refer to Chapter 10, “LMR Coverage Mapping”.

Figure 9-13. PTC Analyzer Measurement Menu

Display Menu (1 of 2)

Key Sequence: **Measurement** > PTC Analyzer



Active Graph
1 2 3 4: In Four-Screen view (maximized), use this submenu key to select which of the four graphs is active. The current active graph is underlined (1 2 3 4), and the graph has a red perimeter line in the sweep window. Any of the four graphs can also be made active by tapping once on the graph in the touch screen. Repeatedly pressing the Active Graph submenu key will cycle the active graph, 1 through 4.

In Standard view (one graph displayed on the screen – refer to Maximize Active Graph key) the Active Graphic key rotates active focus among the four graphs that are displayed in the Four-Screen view.

Maximize/Minimize Active Graph: The submenu key toggles between displaying the Four-Screen view (4 graphs) and the Standard view (1 graph). Tapping twice on a selected graph also toggles between the two display options.

Graph Type: The label on the bottom of this key displays the current active graph type. Pressing the key opens a list box of the graphs types available for PTC Analyzer measurements. Select the desired graph type with the **Arrow** keys or rotatory knob, and then press **Enter**. The current, active graph will be replaced with the new selection.

Available graphs include:

Constellation
Spectrum
Histogram
Eye Diagram
Linear Constellation
Summary

Refer to “PTC Analyzer Graphs” on page 9-4 for additional information.

Power Display
Continuous Burst: Depending on their configuration, ITC-R PTC radios emit signals as either a continuous data stream or a burst/packet stream. Pressing this submenu key toggles between Continuous or Burst power measurement mode. In the Continuous mode, Received Power is calculated as the integrated power over time. In the Burst mode, Received Power is calculated only when the data stream contains packets.

Note: Selection of Continuous mode when analyzing burst/packet signals produces artificially low values for Received Power. The magnitude of this error is a function of the burst/packet duty cycle.

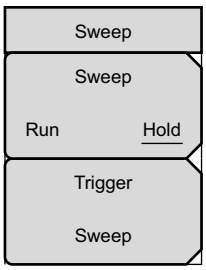
Symbol Span: Use this menu to adjust the number of symbols viewed across the screen in the Eye Diagram graph. Adjust from 2 and 5 using the keypad, the arrow keys, or the rotary knob. Keypad values entered outside of this range are ignored.

Back: Returns to the “Measurement Menu” on page 9-16.

Figure 9-14. PTC Analyzer Display Menu

9-9 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous and one starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Figure 9-15. PTC Analyzer Sweep Menu

9-10 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Display the "Measurement Menu" on page 9-16.

9-11 Trace Menu

This menu is not available in PTC Analyzer measurement mode.

9-12 Limit Menu

This menu is not available in PTC Analyzer measurement mode.

9-13 Other Menus

Preset, **Calibrate**, **File**, **System**, and **Mode** are described in the User Guide.

Chapter 10 — LMR Coverage Mapping

Note

Land Mobile Radio Coverage Mapping using the S412E LMR Master requires Option 31, GPS Receiver, and a compatible GPS Antenna for outdoor coverage mapping. Coverage mapping also requires one or more of the following options installed on the LMR Master:

- NBFM Coverage (Standard)
- P25/P25p2 Coverage (Option 522)
- NXDN Coverage (Option 532)
- dPMR Coverage (Option 572)
- TETRA Coverage (Option 582)
- DMR Coverage (Option 592)
- PTC Coverage (Option 722)

10-1 Introduction

The LMR Analyzer Coverage Mapping options provide the ability to measure and map signal strength, modulation fidelity, error vector magnitude, or bit error rate of a single channel as a function of time and location. These options are not to be confused with Option 431 Coverage Mapping, which is a legacy option that applies only to the Spectrum Analyzer mode.

The LMR Master combines the received signal information with time and location information from the internal GPS module (Option 31 required) to store data that can then be turned into coverage maps using third party software.

The easyMap Tools™ program creates single panel maps (`.map`) that are compatible with Anritsu handheld instruments. The software also creates pan and zoom maps (`.azm`) that are compatible with supported Anritsu instruments. The software imports maps from OpenStreetMap and Google Maps and creates files with or without GPS information. Anritsu easyMap Tools is available from the Anritsu Web site: www.anritsu.com.

- `.azm` map files allow Pan and Zoom on the instrument.
- `.map` map files are in a legacy format that is compatible with older firmware.

When **Start Data Collection** is turned On, OTA measurements are attached to the GPS location and time data, and the measurements are saved to a file. Captured data can be saved as a tab delimited text file (`.mtd`) for viewing coverage data in a spreadsheet, text editor, or third-party coverage prediction software. The measurements can also be saved in `.kml` format for direct viewing with mapping software, such as Google Earth.

For P25/P25p2, NXDN, dPMR, TETRA, DMR, and PTC Coverage, the measurement information that is collected includes Received Signal Strength Indication (RSSI), Bit/Message Error Rate (BER/MER), and Modulation Fidelity (in TETRA, EVM replaces Modulation Fidelity). NBFM Coverage includes RSSI, Total Harmonic Distortion (THD), Signal-to-Noise and Distortion ratio (SINAD), and External SINAD.

10-2 General Measurement Setups

Refer to the setup procedures in this Measurement Guide for the specific measurement mode used in Coverage Mapping:

- NBFM, “Transmitter Analysis Setup” on page 2-2
- P25, “Over the Air (OTA) Analysis Setup” on page 3-2
- P25p2, “Over the Air (OTA) Analysis Setup” on page 4-2
- NXDN, “Over the Air (OTA) Analysis Setup” on page 5-2
- dPMR, “Over the Air (OTA) Analysis Setup” on page 6-2
- TETRA, “Over the Air (OTA) Analysis Setup” on page 7-1
- DMR, “Over the Air (OTA) Analysis Setup” on page 8-2
- PTC, “Over the Air (OTA) Analysis Setup” on page 9-2

10-3 Coverage Mapping Introduction

Note	Outdoor coverage mapping requires Option 31 (GPS) and a GPS antenna. Indoor coverage mapping utilizes the instrument touch screen to log points, and thus does not require Option 31.

Two screen display options are available for Indoor and Outdoor mapping:

- **Map Display Type:** Displays an imported map or the default grid. After starting data collection, values for the mapping parameters are recorded for each data point.

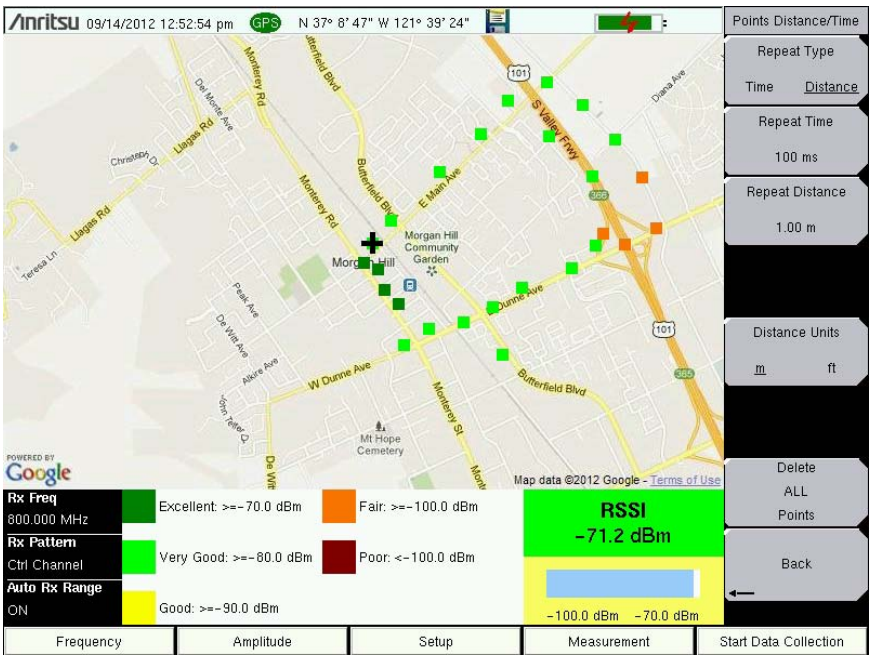


Figure 10-1. Coverage Mapping Using the Map Display

- **Graph Display Type:** Displays line graphs for 2 of the 3 measurement values for the selected frequency over time. Change the displayed graph type by using the Mapping Type button. Graph points are displayed in yellow when GPS is On and in red when GPS is Off.

The graph display can show the most recent 551 measured points, covering approximately 30 minutes of measurement. The most recent data appears at the right edge of the display. These two measurements with the third measurement type (not displayed in a graph) are shown in three fields with a yellow background at the bottom of the screen.

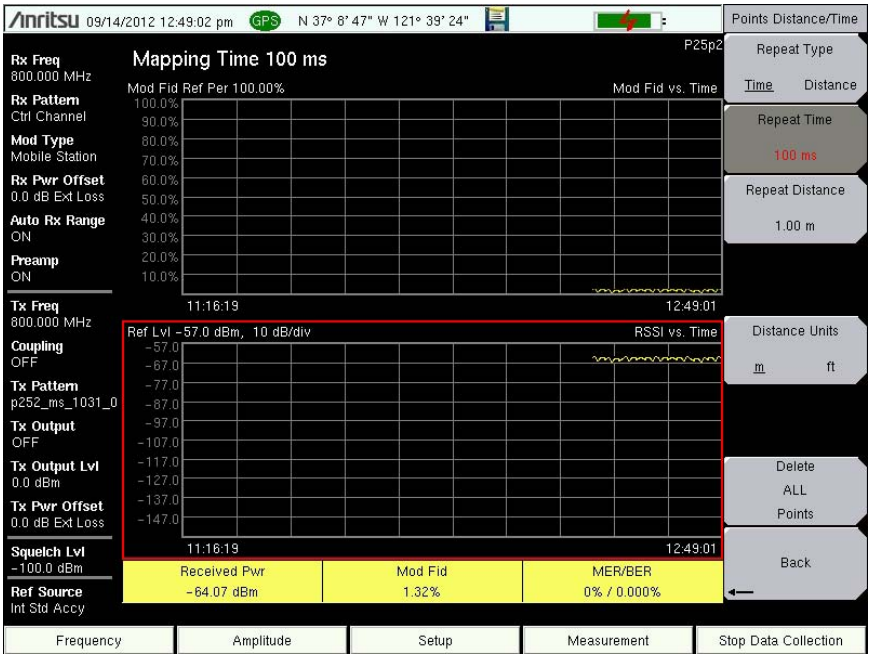


Figure 10-2. Coverage Mapping Using the Graph Display

The Coverage Mapping option allows for both indoor (no GPS signal) and outdoor (GPS signal required) mapping.

- **Indoor Mapping:** Using a start-walk-stop approach, the instrument provides in-building coverage mapping by overlaying data directly onto the downloaded map. Data is captured at user-defined time intervals or user-defined map locations by tapping the touchscreen.
- **Outdoor Mapping:** The instrument logs data automatically based on either time or distance interval. If no map is available when making the measurements, then you can still save all the data to a KML file and later combine the data file with a map. Refer to "Recall the Default Grid" on page 10-14.

Outdoor Coverage

With a valid GPS signal, the instrument identifies the current location on the displayed GeoEmbedded map with a cross. Previously saved locations are displayed as squares.

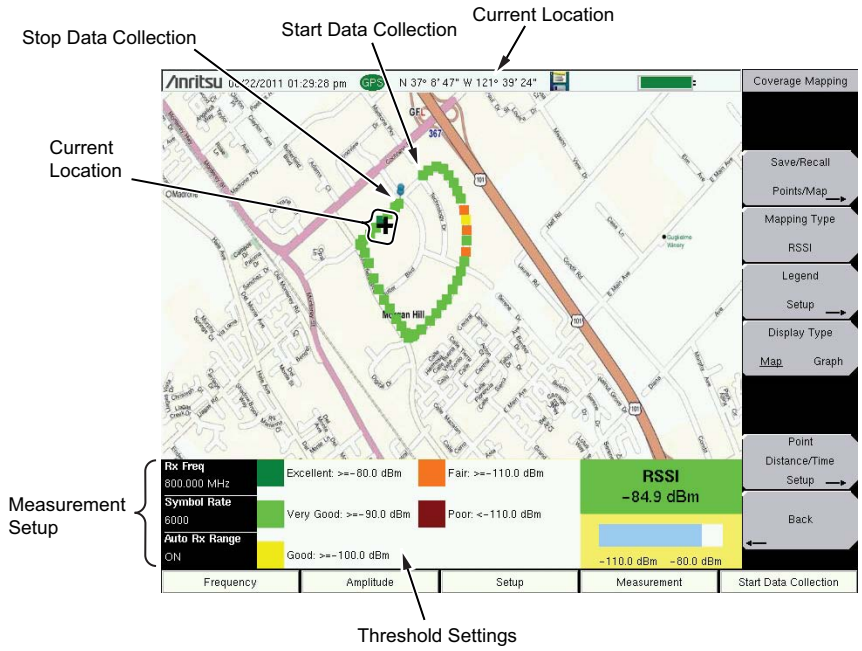


Figure 10-3. Outdoor Coverage Mapping (GPS On)

Note	The Measurement Setup and Threshold Setting boxes can be used as menu shortcuts on touch screen instruments. Use the touch screen to select the parameter to edit.

Indoor Coverage

With GPS turned Off, and with a non-GeoEmbedded map file, you indicate the current position (+) on the displayed map by using the instrument touch screen. Previously saved locations are displayed as squares.

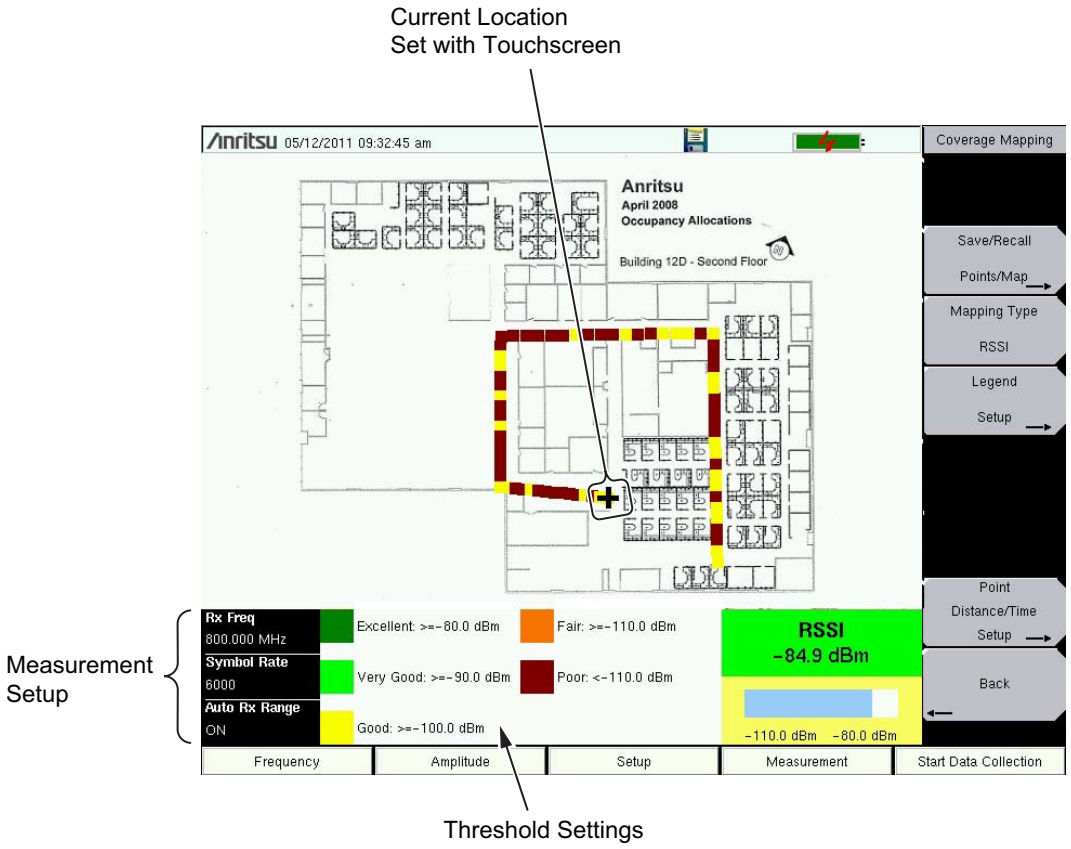


Figure 10-4. Indoor Coverage Mapping (GPS Off)

Coverage Mapping is a four-step process (refer to Section "Anritsu easyMap Tools" on page 10-7):

- Create an indoor map or an outdoor map by using "Anritsu easyMap Tools".
- Load the map and configure the "Instrument Settings" as described on page 10-12.
- Connect an antenna to the instrument and continue at Section "Measurement Setup for Map Display Type" on page 10-15.
- After measurement setup, continue at Section "Save the Coverage Mapping Information" on page 10-17.

10-4 Anritsu easyMap Tools

Anritsu easyMap Tools allows you to capture maps of any location and to create Anritsu Map Files. These Anritsu Map Files are used for Coverage Mapping. The Help button in easyMap Tools provides details for the use of the application.

Download and install Anritsu easyMap Tools from the Anritsu Web site (www.anritsu.com).

Terminology:

AZM – Anritsu Zoomable Map, the format of a map file with pan and zoom capabilities for on-instrument maps.

Coverage Map – This defines the bounds of the AZM file. Everything contained within this map shows up in the AZM file.

Detail Map – This defines the maximum image detail that is recorded in the AZM file. Ensure that desirable street names are visible here.

Red Highlight Area – This highlighted segment of the Coverage Map represents the area that is currently covered by the Detail Map.

Example Procedure:

1. Start easyMap Tools.
2. Select your Map Type, if the current one does not meet your needs.
3. The Coverage Map is displayed on the left side, and the Detail Map is displayed on the right side.
4. Enter an address (that you want the coverage map to center upon) into the Address bar, then click "Go" or press the **Enter** key.
    a. This can be a partial address, such as "Morgan Hill, CA" or "95037".
    b. This can be a full street address, such as "490 Jarvis Drive, Morgan Hill, CA.
5. Adjust the Coverage Map by panning and zooming until the Coverage Map covers everything that needs to be in the AZM file.
6. Pan around the Detail Map to confirm that the lowest level of detail is sufficient. For example, ensure that the necessary street names are shown.
    a. If the map is not detailed enough, zoom into the Detail Map until the desired level of detail is reached (maximum zoom level is 3 without API keys).
    b. Maps with more detail take longer to download and also take up more disc space.
    c. The estimates size of the map file is displayed above the Detail Map, adjacent to the Save Map button.
    d. If the Coverage Map is covering too much, it can be zoomed in to reduce total map size.
    e. Consider making multiple maps (if necessary), especially if the intended region has a significantly different shape than the Coverage Map (such as a long highway drive test).

7. Confirm that your easyMap settings meet your needs:

   Set Map Format – This determines which type of map file is created. Only AZM files can contain multiple map tiles.

   Set Color Filter – This allows the resulting AZM file to match various alternative instrument user interface color schemes.

   This does not affect the appearance of the Coverage Map or the Detail Map, but the changes show up when viewing the resulting AZM file.

   Register API keys – API keys (Google or MapQuest) must be registered for maps larger than approximately 5 MB estimated size (this allows for 3 zoom levels in your AZM file).

Note	MapQuest keys are generally easier to set up than Google Keys. The easyMap Help file has links to help pages for registering your own API Key.

   Configure Web Proxy – This is necessary only for users who must connect to their work network via Web Proxy.

8. Save your map (**File** > Save Map, with current settings).
9. When the map has finished downloading, open it (**File** > Open Map).

   When the map has finished downloading, it can be copied to your instrument via USB flash drive.

Creating an Outdoor Map File with easyMap Tools

The easyMap Tools program allows you to create a map from map providers Google and MapQuest. Google Maps offer Road, Terrain, Satellite, and Hybrid maps. MapQuest offers OpenStreetMaps.

Two methods can be used to create outdoor maps by using easyMap Tools:

Method 1: Opening a JPEG, GIF, TIFF, or PNG file and adding GPS data.

1. Capture a bitmapped image of a map from a map provider and save it in one of the available file formats.

   The image size should be close to 640 pixels by 420 pixels (approximately a 1.6:1 ratio).

2. Launch the Anritsu easyMap Tools application.
3. In the File pull-down menu, select Open Image File... and choose the image file to be converted to a map.
4. Set up the map as desired, including adding Latitude and Longitude parameters, and then save the map.
5. If you have GPS information only in the Degree-Minute-Second (DMS) format, then use the following relationship to convert to Decimal Degrees (DD):

$$\text{Degrees} + \frac{\text{Minutes}}{60} + \frac{\text{Seconds}}{3600} = \text{DD}$$

Note	Remember to enter location information for the borders of the map, not your current location.

Figure 10-5 is an example of two overlapping maps from a mapping service with GPS data for the border of each map.

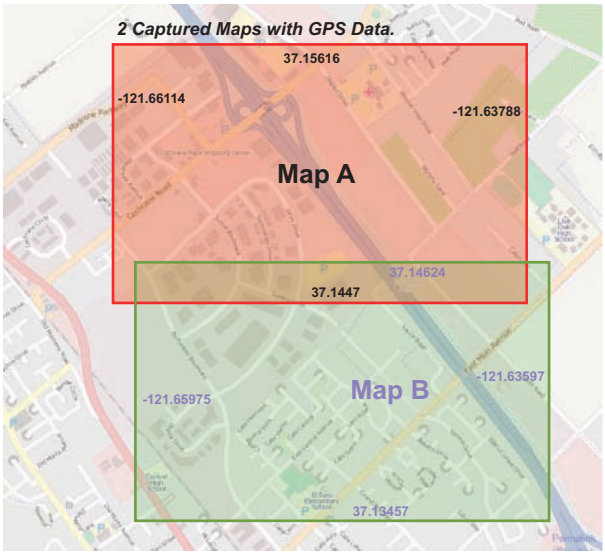


Figure 10-5. Overlapping Captured Maps with Border GPS Data

Note	easyMap Tools can open and modify GPS data in existing **.map** files.

Method 2: Typing in an address in easyMap Tools and capturing a Google map with GPS data.

1. Launch the Anritsu easyMap Tools application.
2. Enter a street address in the address field.
3. Set up the map as desired, and then save the map..

Note	A USB flash drive is required to transfer maps to the instrument.

Creating and saving `.map` files of the same address at several zoom levels can be helpful in the field when your location is off the current view, or when the vectors cross outside of the current map that is displayed on the instrument. Table 10-1 lists the map area at several zoom levels. Notice from the examples that zooming in a level with Anritsu easyMap Tools reduces the map dimensions by half, and zooming out a level doubles the map dimensions.

Table 10-1. Map Coverage at Different Zoom Levels (1 of 2)

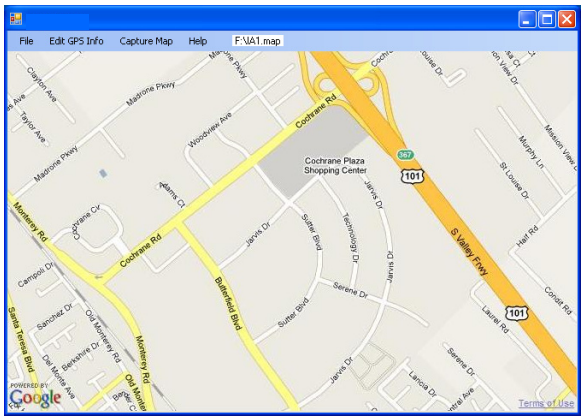
Zoom Level	Map Dimensions	Sample Map
15	1 mile x 1.5 miles (1.5 square miles)	
14	2 miles x 3 miles (6 square miles)	

Table 10-1. Map Coverage at Different Zoom Levels (2 of 2)

Zoom Level	Map Dimensions	Sample Map
13	4 miles x 6 miles (24 square miles)	

Creating an Indoor Map File with easyMap Tools

1. Capture a bitmapped image of the floor plan that is desired for indoor mapping. Save the image in one of the compatible file formats (JPEG, GIF, TIFF, or PNG). The image size must be close to 640 pixels x 420 pixels (approximately a 1.6:1 ratio) in order to display well on your handheld instrument.
2. Launch the Anritsu easyMap Tools application.
3. In the File pull-down menu, select Open Image File... and then select your indoor mapping image file.

Note	A USB flash drive is required to transfer maps to the instrument.

4. Set up the map as desired, and then save the map.

10-5 Instrument Settings

Setup

1. Create the appropriate map with Anritsu easyMap Tools. Refer to "Anritsu easyMap Tools" on page 10-7. Outdoor mapping requires a GeoEmbedded map or the default grid.
2. Press the **Menu** key, then select the coverage Analyzer mode (P25, NXDN, dPMR, TETRA, DMR, or PTC) icon or press **Shift** and then the **Mode** (**9**) button to open the Mode Selector dialog box. Highlight the desired mode and press **Enter**.
3. Open Coverage Mapping by pressing the **Measurement** main menu button followed by pressing the Coverage submenu key. The default grid or previous map is displayed.

   Continue to Step 4 for outdoor mapping only. GPS must be Off for indoor mapping.
4. Turn on GPS.
   a. Press **Shift** then **System** (**8**). Press the GPS submenu key.
   b. Connect a GPS antenna to the SMA connector.
   c. Turn on GPS. On should be underlined in the GPS submenu key.
   d. Press the GPS Voltage submenu key to select the appropriate voltage for the antenna being used. Refer to the instrument Technical Data Sheet for voltage specifications of supported GPS antennas.
   e. Press GPS info and verify that the information from three or more satellites is captured. Press **Esc** to close the info box.

   Several minutes may be required for the GPS receiver to track at least three satellites for obtaining longitude and latitude coordinates. Tracking 4 satellites will obtain altitude information. When at least three satellites are being tracked, the GPS icon at the top of the screen turns green. Refer to the User Guide for your instrument for additional information about GPS.

Recall a Map (Indoor or Outdoor Coverage)

The instrument allows you to recall a `.map` file (created with Anritsu easyMap Tools). With a valid GPS signal, the current location is displayed on an outdoor map, or an arrow shows the direction of the current location if it is outside the map coverage area. With an indoor map, you position the cross at the current location by using the touch screen, or by using the **Arrow** keys, and then pressing **Enter**.

Connect the USB flash drive to the instrument. It must have the map file (or files) that you created in "Anritsu easyMap Tools" on page 10-7.

1. Press the **Measurement** main menu key, then press the Coverage submenu key.
2. Press the Save/Recall Points/Map submenu key.
3. Press Recall a Map and select the appropriate map from the USB flash drive.
4. Use the arrow keys to scroll down to the desired map and press **Enter** to select.

   Step 5 and Step 6 apply to outdoor coverage mapping only.
5. The new map file will be displayed and the current location (if within the GPS boundaries of the displayed map) is shown as a plus sign with outdoor mapping.
6. If the current location is outside the map boundaries, an arrow indicates the direction of the current location in relation to the displayed map.

If you do not see the USB drive in the Recall menu:

1. Press the Refresh Directories submenu key.
2. If the drive is still not visible, exit the menu, then remove and reconnect the USB drive.
3. Press Recall a Map again.
4. If the drive is still not visible, reformat the USB flash drive in FAT32 format, then copy the map files to the reformatted drive.

Recall the Default Grid

The instrument is able to make coverage mapping measurements even when an Anritsu easyMap Tools file of the current indoor or outdoor location is not available. In such cases, use the default grid map, save the KML points, and recall them at a later time with a map. Figure 10-6 on page 10-14 shows a default grid in the measurement display. Refer to "Mapping Save/Recall Menu" on page 10-25 for additional information on recalling saved maps and `.kml` data.

Note	When using the default grid, the coverage area for outdoor coverage mapping is fixed at 10 miles by 10 miles. For indoor coverage mapping, the grid size is the default grid image size, 640 pixels by 420 pixels.

1. Press the **Measurement** main menu key, then press the Coverage submenu key.
2. In the Coverage Mapping menu, press the Save/Recall Points/Map submenu key.
3. Press the Recall Default Grid submenu key.

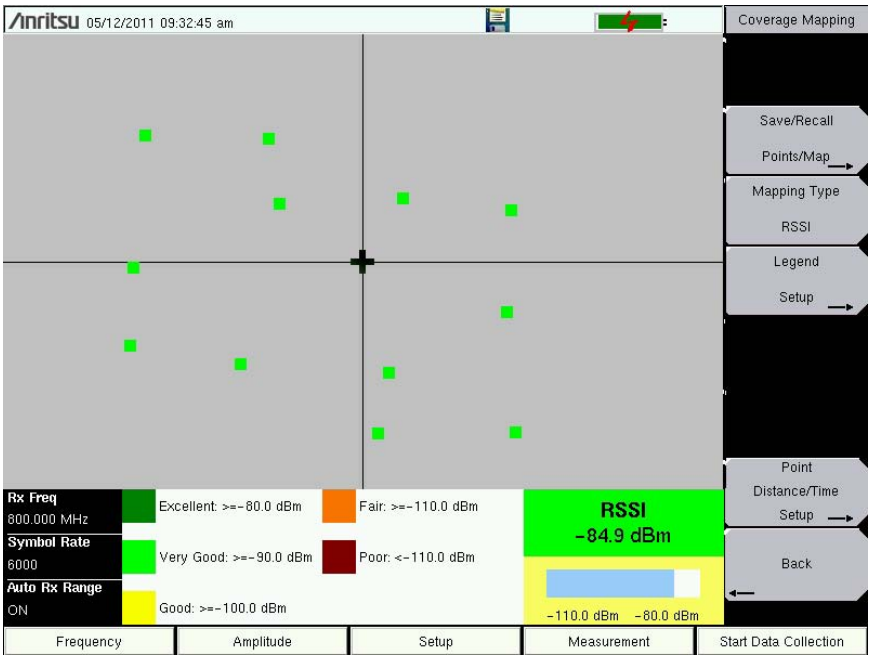


Figure 10-6. Coverage Mapping with the Default Grid.

10-6 Measurement Setup for Map Display Type

1. Refer to the appropriate chapter for frequency, amplitude, and setup parameters.
   - NBFM, "Transmitter Analysis Setup" on page 2-2
   - P25, "Over the Air (OTA) Analysis Setup" on page 3-2
   - P25p2, "Over the Air (OTA) Analysis Setup" on page 4-2
   - NXDN, "Over the Air (OTA) Analysis Setup" on page 5-2
   - dPMR, "Over the Air (OTA) Analysis Setup" on page 6-2
   - TETRA, "Over the Air (OTA) Analysis Setup" on page 7-1
   - DMR, "Over the Air (OTA) Analysis Setup" on page 8-2
   - PTC, "Over the Air (OTA) Analysis Setup" on page 9-2
2. Press the **Measurement** main menu key, then the Coverage submenu key (press the Coverage submenu key a second time if necessary to display the Coverage Mapping menu). The Display Type may be Map or Graph. Press the Display Type submenu key to toggle this setting.
3. Select the signal parameter to be mapped and displayed in bar graph form by pressing Mapping Type.

   For P25, NXDN, DMR, and PTC coverage, select: RSSI, BER, or Mod Fid.

   RSSI displays the Received Signal Strength Indicator of the received signal.

   BER displays the Bit Error Rate of the received signal. The BER is measured against the Rx Pattern and the Mod Type that are selected under the **Setup** main menu.

   Mod Fid displays the modulation fidelity of the received signal.

   For dPMR coverage, select RSSI.

   RSSI displays the Received Signal Strength Indicator of the received signal.

   For TETRA coverage, select: RSSI, BER, or EVM.

   RSSI displays the Received Signal Strength Indicator of the received signal.

   BER displays the Bit Error Rate of the received signal. The BER is measured against the Rx Pattern and the Mod Type that are selected under the **Setup** main menu.

   EVM is a measure of how far the constellation points are located from the ideal positions. EVM is measured against the Rx Pattern and the Mod Type that are selected from the Setup main menu.

   For NBFM coverage select: RSSI, THD, SINAD, or External SINAD.

   RSSI displays the Received Signal Strength Indicator of the received signal.

   THD displays the total harmonic distortion.

   SINAD and External SINAD display signal-to-noise and distortion ratio.

Note	RSSI values are offset by any Rx Power Offset setting (**Amplitude** menu).

4. All measurement values are saved for each data point, independent of which signal parameter is chosen for mapping on the instrument screen. For example, if RSSI is selected for mapping, then the resulting `.kml` file also includes BER and Mod Fid values.
5. Press the Legend Setup submenu key to set the threshold values for the selected measurement. Set the threshold levels for Excellent, Very Good, Good, Fair, or Poor. Then press the Back button.
6. Set up the interval type and the interval parameters. Press the Point Distance/Time Setup submenu key to open the Points Distance/Time menu. If Time is selected for Repeat Type, then set the time period by pressing the Repeat Time submenu key. If Distance is selected for Repeat Type, then set the Repeat Distance and Distance Units. If necessary, delete any previously stored points by pressing the Delete ALL Points button.

Note All files will be stored in the default save location. To change the default location, Press **Shift** then **File** (**7**) to enter File menu. Press Save, then press Change Save Location. Create a new folder or change the current location on the USB flash drive or in the instrument storage memory. Press Set Location to make this the new default location for saving files.

7. Press Back to return to the Coverage Mapping menu.

10-7 Measurement Mapping

After completing the setups for Coverage Mapping and measurements, you are ready to make measurements.

1. Press the **Start Data Collection** main menu key. Data will be collected at the time or distance interval based on the setting in "Point Distance/Time Setup Menu" on page 10-29. The color of the squares indicates the power level based on the chosen measurement and its threshold level setup.
2. Press the **Stop Data Collection** main menu key to end the measurement process. Save the collected data as a `.kml` file, a tab-delimited text file (`.mtd`), or a JPEG file. Refer to "Save the Coverage Mapping Information" on page 10-17.

Note

Two options are available for interior coverage mapping because the instrument does not have location or distance information available without GPS.

Option 1: Set the Repeat Type to Time and walk the perimeter of the coverage area. Press the touchscreen at each turn, and the instrument interpolates collected data points based on the Repeat Time setting.

Option 2: Set the Repeat Type to Distance and walk the coverage area. Press the touchscreen at any time that signal power data points are required.

The saved `.kml` file in either option will not have GPS data, but it will plot on a 640 x 420 grid with measurement data for each captured point.

Save the Coverage Mapping Information

Coverage Mapping has three save options: "Save KML Points", "Save Tab Delimited Points" on page 10-19, or "Save JPG" on page 10-19.

Save KML Points

Press Save/Recall Points/Map then Save KML Points. In the Save dialog, change the file name and file type (KML 2D or KML 3D) as appropriate, then press **Enter**. The following information is saved for the points that are currently displayed on the screen:

- Location and time based on GPS information
- Measurements: BER, RSSI, Mod Fid (or EVM in TETRA)
- Mapping type, Frequency, and Rx Pattern

The `.kml` file can be opened and viewed with Google Earth (Figure 10-7 on page 10-18) and can also be recalled and viewed on the instrument. Refer to "Mapping Save/Recall Menu" on page 10-25 for additional information.

Note

Installing Google Earth

1. Go to the Web site: http://earth.google.com/.
2. Click **Download Google Earth** and follow the on-screen instructions.
3. After download, install Google Earth on your computer.
4. Double-click the saved `.kml` file to view the measurements with Google Earth.

After Google Earth is opened, user instructions and several types of help are available from the Help pull-down menu.

Saved `.kml` files cannot be viewed directly from the instrument using Google Earth. The files need first to be copied to a USB memory stick.

Figure 10-7. Coverage Mapping KML File in Google Earth

Save Tab Delimited Points

Press Save/Recall Points/Map then Save Tab Delimited Points. At the Save menu, press **Enter**. A tab delimited text file (`.mtd`) is saved in the default save location for the coverage mapping data that are currently displayed on the screen.

Note	All files are stored in the default save location. To change the default location, Press **Shift** then **File** (**7**) to enter File menu. Press Save, then press Change Save Location. Create a new folder or change the current location on the USB flash drive (or in the instrument storage memory). Press Set Location to make this the new default location for saving files.

Save JPG

Press Save/Recall Points/Map then Save JPG. At the Save menu, press **Enter**. A `.jpg` file of the current screen is saved.

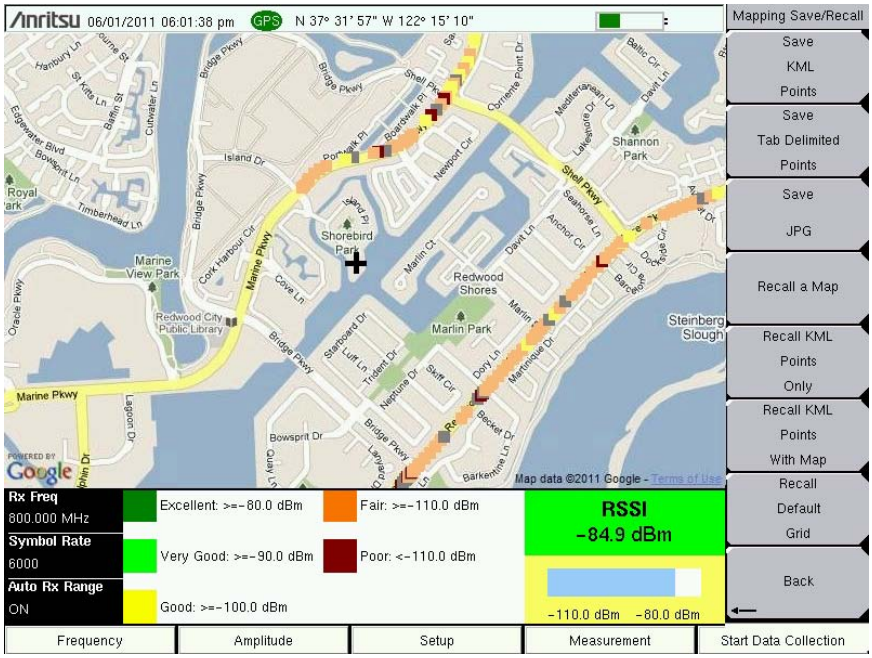


Figure 10-8. Time Interval Coverage Mapping Saved as a `.jpg` File

10-8 Measurements with Graph Display Type

In the Coverage Mapping menu, set the Display Type to Graph. Two graphs are displayed. Tap a graph to make it active (surrounded by a red bounding line).

Procedure to Monitor Base Station Synchronous Channel Decoding

1. Refer to the appropriate chapter for frequency, amplitude, and setup parameters.
   - NBFM, "Transmitter Analysis Setup" on page 2-2
   - P25, "Over the Air (OTA) Analysis Setup" on page 3-2
   - P25p2, "Over the Air (OTA) Analysis Setup" on page 4-2
   - NXDN, "Over the Air (OTA) Analysis Setup" on page 5-2
   - dPMR, "Over the Air (OTA) Analysis Setup" on page 6-2
   - TETRA, "Over the Air (OTA) Analysis Setup" on page 7-1
   - DMR, "Over the Air (OTA) Analysis Setup" on page 8-2
   - PTC, "Over the Air (OTA) Analysis Setup" on page 9-2
2. Press the **Measurement** and then Coverage menu keys. You may need to press the Coverage menu key another time to display the Coverage Mapping menu.

Figure 10-9. Display Type = Graph

3. If the Display Type is Map, then press the Display Type key again to toggle the setting to Graph. The display then shows two graphs. Figure 10-9 shows the Graph Display Type for TETRA analyzer. The two graphs may be any two types from the Mapping Type selection list. The figure shows EVM and BER plotted versus time.

   To change the plot in one of the graphs to a different mapping type:

   a. Select the graph by tapping anywhere on the graph to activate it. The activated graph is shown within a red rectangle.

   b. Press the Mapping Type submenu key and make a selection from the items displayed in the Mapping Type Selector list box: RSSI, BER, and EVM.

4. To set up the sampling time for plotting the two selected graphs, set up the parameter called Repeat Time as follows:

   a. In the Coverage Mapping menu, press the Point Distance/Time Setup submenu key.

   b. In the Point Distance/Time menu, press the Repeat Time submenu key, and then enter a value by using the numeric keypad. A Time menu provides submenu keys for the units, from hour to µs. Anritsu recommends that this value be set to equal or exceed 3 seconds.

5. To start plotting the two graphs with respect to time, press the **Start Data Collection** main menu key. Note that if the previous plots need to be deleted, then press the Delete ALL Points submenu key, followed by the **Enter** key.

6. To stop the plotting of the two graphs, press the **Stop Data Collection** main menu key.

Note	Menu settings cannot be changed while data collection is in progress. You must stop the data collection before changing instrument settings. You can, however, change the active graph, and if needed, the selected graph can be made full screen by tapping the selected graph twice.

Explanation of Graph

The graphs shown in Figure 10-9 on page 10-20 display EVM versus Time and BER versus Time for a weak signal from a TETRA base station. With this weak signal, the EVM is quite high, approximately 50 %. The EVM should be under 5 % for a strong signal.

The BER is under 10 % most of the time, but occasionally rises to more than 100 %. For a strong signal, the BER would be well under 5 %. Note that BER greater than 100 % is provided to indicate that even though the signal was above the squelch level, it was so poor that the Base Station Synchronous Channel could not be decoded. This decoding is essential for any receiver analyzing a TETRA downlink signal.

In order to determine the boundary of good reception (from the base station), the test technician needs to know if signal decoding fails, even briefly. To answer that question, the Graph Display Type provides a more convenient mode of monitoring the signal than the TETRA analyzer because the latter would have to be tediously monitored by the user uninterrupted. By monitoring the signal over a long time period, perhaps 30 minutes or 24 hours, the graph data can show any BER graph points that are greater than 100 %, which indicates a failure to decode the Base Station Synchronous Channel. Refer to "Saving Graph Data" for saving this data.

Note	The feature of BER exceeding 100 % is provided for the TETRA application and does not apply to other applications, unless stated explicitly.

Saving Graph Data

Graph data is maintained during measurement as long as instrument memory has sufficient space to hold the data. Save data points from the graph after you press **Stop Data Collection**. The following key sequence displays the Save dialog box:

Measurement > TETRA Coverage > Save/Recall Points/Map > Save Tab Delimited Points

In the Save dialog box, enter the filename and press **Enter**.

10-9 Coverage Mapping Menus

Refer to the appropriate LMR Master Analyzer chapters for the other menus, including **Frequency**, **Amplitude**, and **Setup**. Menu maps typically display all possible submenu keys, although some keys are displayed on the instruments only under special circumstances (refer to menu descriptions on the following pages).

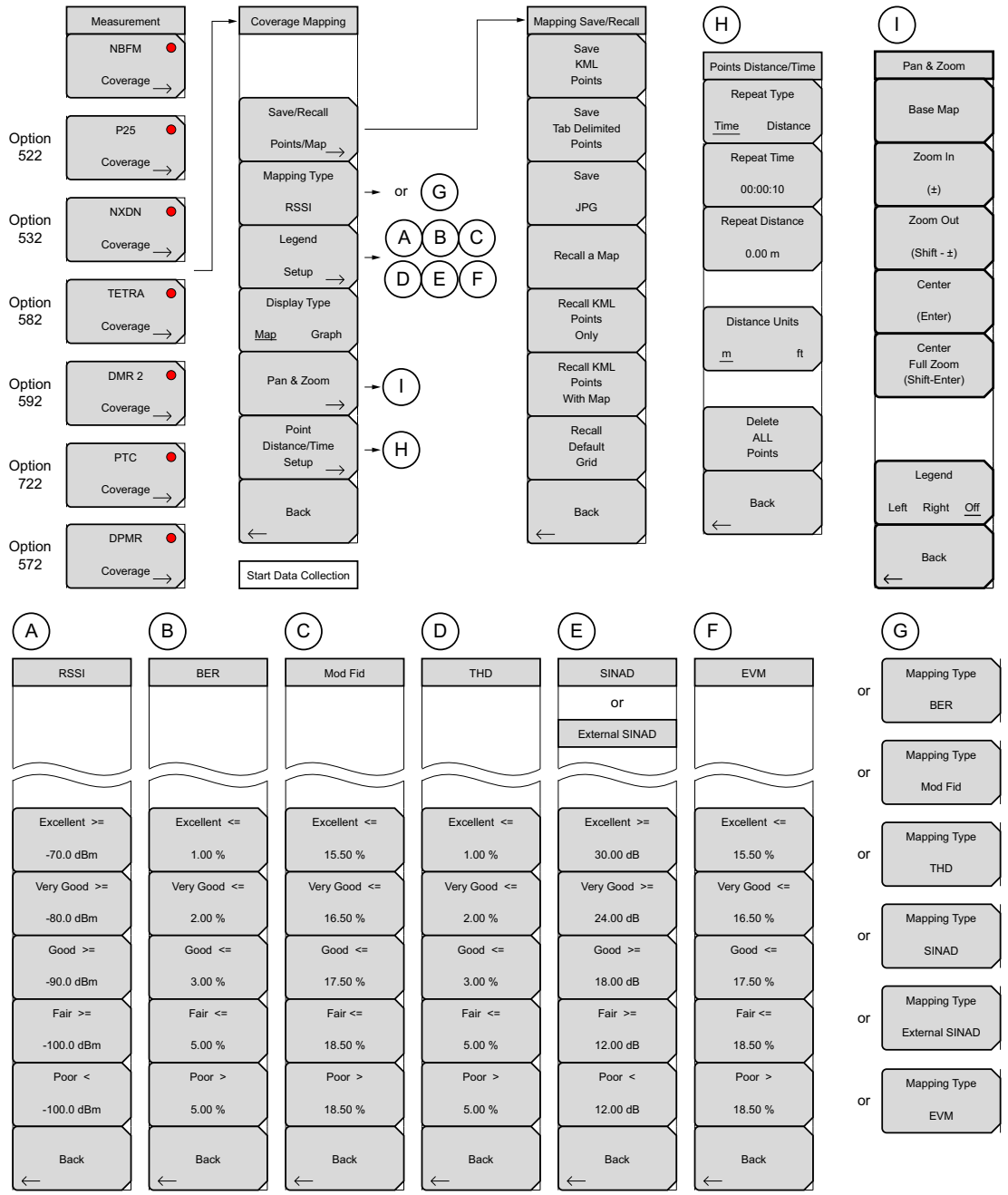
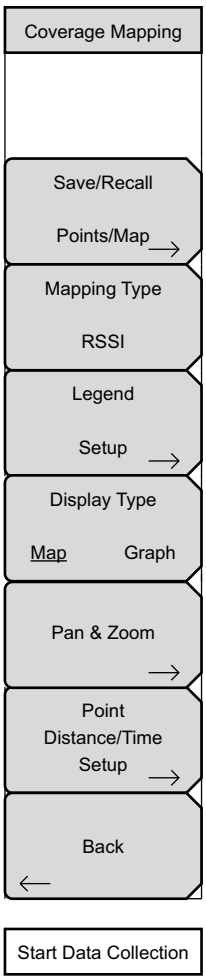


Figure 10-10. LMR Master Coverage Mapping Menu

10-10 Coverage Mapping Menu

Key Sequence: **Measurement** > ... Coverage



Save/Recall Map Points: Opens the "Mapping Save/Recall Menu" on page 10-25.

Mapping Type: Select the measurement parameter to be mapped and displayed in the bar graph. All three parameter values are saved for each data point in the saved `.kml` or `.mtd` file.

For **P25**, **NXDN**, **dPMR**, **DMR**, and **PTC** measurements, the mapping options are **RSSI**, **BER**, or **Mod Fid**.

For **TETRA** measurements, the mapping options are **RSSI**, **BER**, or **EVM**.

For **NBFM** measurements, the mapping options are **RSSI**, **THD**, **SINAD**, or **External SINAD**.

Legend Setup: This submenu key is present only when the Map Display Type is selected. It opens a submenu to set the legend color threshold values. This menu is based on the Mapping Type submenu selection. See Figure 10-13 on page 10-26.

Display Type
Map Graph: Press to toggle the display to Map or Graph.

Pan & Zoom: Opens the "Pan & Zoom Menu" on page 10-27.

Point Distance/Time Setup: Opens the "Point Distance/Time Setup Menu" on page 10-29.

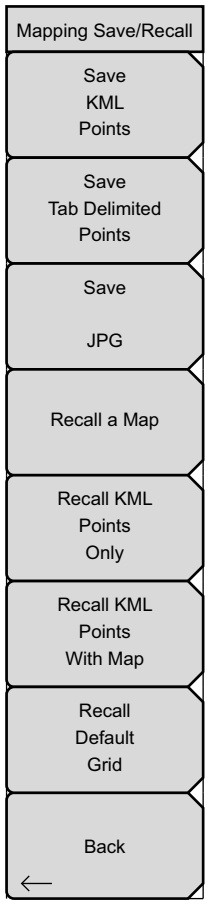
Back: Returns to the previous **Measurement** menu.

Start/Stop Data Collection: Press this main menu key to start coverage mapping data collection based on Measurement Setup settings and Point Distance/Time Setup settings. A running count of collected data points is displayed at the bottom of the screen. Press again to stop data collection.

Figure 10-11. Coverage Mapping Menu

Mapping Save/Recall Menu

Key Sequence: **Measurement** > ....Coverage > Save/Recall Points/Maps



Save KML Points: Press this button to save the KML points. FileName.kml is stored in the selected location. From the File menu, press Save, then press Change Save Location to change default location. The Filetype setting includes: KML 2D, KML 3D, Mapping Tab Delimited, and JPEG.

Save Tab Delimited Points: Press this button to save the points in a tab delimited text file. FileName.mtd is stored in the selected location.

Save JPG: Press the Save JPG key to save a `.jpg` file of the current screen.

Recall a Map: Opens the Recall menu for selecting a map created with the Anritsu easyMap Tools program to display on the screen.

Recall KML Point: Opens the Recall menu for selecting a `.kml` file. Displays the saved locations overlaid on the default grid.

Recall KML Points With Map: Opens the Recall menu for selecting a `.kml` file. If you already have a geo-referenced map or a default grid map, then press this key to recall previously stored KML points. This feature is useful if you made measurements earlier without the appropriate maps and would like to now view the saved point locations overlaid on top of a map.

Recall Default Grid: If you do not have a GPS embedded map, but you are out in the field making measurements, and you would like to save the KML points, then the Recall Default Grid submenu allows you to save points and the corresponding GPS coordinates to view at a later time.

Back: Returns to the “Coverage Mapping Menu” on page 10-24.

Figure 10-12. Mapping Save/Recall Menu

Legend Setup Menus

Key Sequence: **Measurement >** ... Coverage > Legend Setup

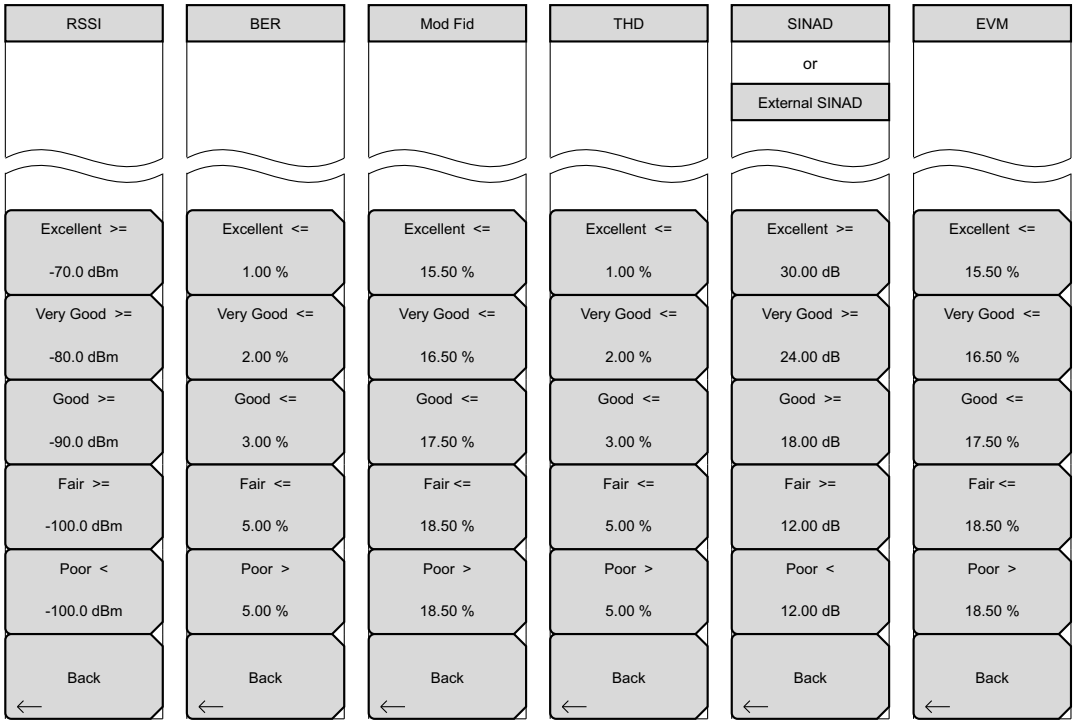


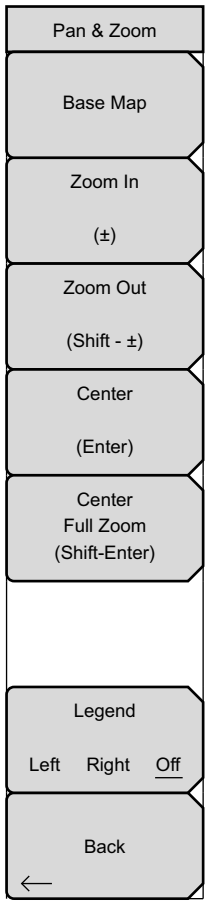
Figure 10-13. Legend Setup Menu

The titles of these menus are the selections made in the Coverage Mapping menu with the Mapping Type submenu key. The choices vary depending upon the Land Mobile Radio signal type. Refer also to the "Coverage Mapping Menu" on page 10-24.

Note	The Legend Setup submenu key is present only when the selected Display Type is Map.

Pan & Zoom Menu

Key Sequence: **Measurements** > (current LMR mode) Coverage > Pan & Zoom



Base Map: Press this button to view the full map.

Zoom In (±): Press this button to zoom in one map panel at a time. Pressing the (+/-) keypad button does the same as long as a parameter is not being adjusted.

Zoom Out (Shift - ±): Press this button to zoom out one map panel at a time. Pressing the Shift and (+/-) keypad button once does the same as long as a parameter is not being adjusted.

Center (Enter): Press this button to center the panel in which the instrument is located. Pressing the **Enter** keypad button does the same as long as a parameter is not being adjusted.

Center Full Zoom (Shift - Enter): Brings the map panel where the instrument is currently located into the display. Pressing the **Shift** and **Enter** keypad buttons does the same as long as a parameter is not being adjusted. Note that the current location may not be exactly centered on the display.

Legend Left Right Off: Press this submenu key to turn off or to display a legend at the top left or top right corner of the AZM map. The legend consists of a vertical zoom level bar, a square representing the current GPS location and base map, and three status icons (Figure 10-15). The zoom level indicator shows the number of levels of zoom in the AZM map, with the current level displayed as a dark segment on the vertical bar. Higher levels of zoom are toward the top of the indicator bar.

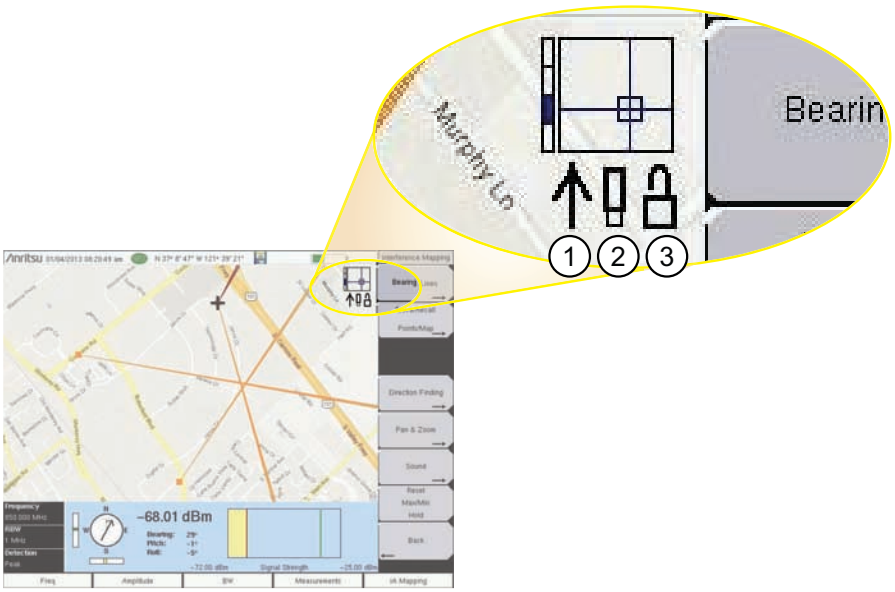
The default square with crosshairs represents a map panel with the lowest zoom. The crosshairs are at the center of that panel. As the zoom level increases, a boundary of a panel is displayed around the crosshairs. The higher the zoom level, the smaller the square around the crosshairs. When panning the map (using the instrument's arrow keys), the crosshairs and map panel boundary display your relative location in the total mapped area.

When the lock is 'locked' (by pressing **Enter**), the map is in auto-centering mode and will update continually to keep your current position centered while you move with the instrument. If you pan (using the arrow keys), the map is taken out of auto-centering mode, or unlocked, because you have intentionally shifted the map area away from your current location. When unlocked, the map will not follow if you walk or drive around with the instrument.

After panning, press the **Enter** key to re-center your GPS location on the map and lock auto-centering mode.

Back: Returns to the "Coverage Mapping Menu" on page 10-24.

Figure 10-14. Pan & Zoom Menu

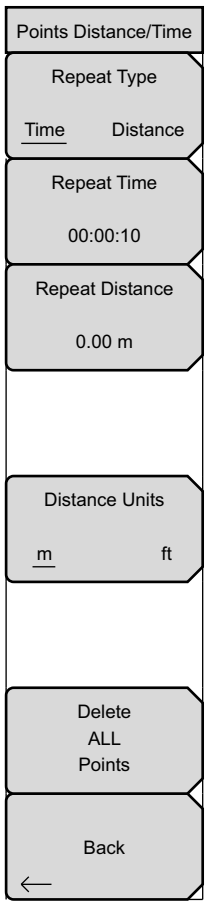


1	MA2700A USB cable is connected and recognized by the Anritsu instrument.
2	USB memory stick is available for data read/write.
3	.azm map auto-centering mode (locked/unlocked). When “locked” the instrument automatically displays the map tile at current zoom level which best centers the current GPS location. The instrument will attempt to swap map tiles as the GPS location changes to continue displaying the current location near the center of the screen.

Figure 10-15. Map Legend Status Indicators

Point Distance/Time Setup Menu

Key Sequence: **Measurement** > ....Coverage > Point Distance/Time Setup



Repeat Type: Toggles between using a Time or Distance interval for capturing data.

Repeat Time: Sets the time interval when the Time is selected in the Repeat Type button.

Repeat Distance: Sets the distance interval when the Distance is selected in the Repeat Type button.

Distance Units: Toggles the unit of measure between meters and feet.

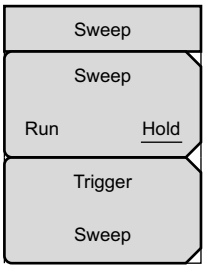
Delete ALL Points: Clears all displayed measurements.

Back: Returns to the "Coverage Mapping Menu" on page 10-24.

Figure 10-16. Point Distance/Time Setup Menu

10-11 Sweep Menu

Key Sequence: **Shift** > **Sweep** (**3**) key



Sweep Run/Hold: This submenu key toggles between continuous (run) sweep and hold sweep. In Run sweep mode, sweeps are continuous, and a sweep starts immediately after the previous sweep is completed. In Hold sweep mode, the results of the last sweep are displayed on the screen while the instrument waits for a trigger event to start a new sweep. HOLD is displayed on the right side of the screen in this mode.

Trigger Sweep: Pressing this submenu key causes the instrument to make a single sweep when the instrument is in Hold sweep mode. This key has no function when the instrument is in Run sweep mode.

Figure 10-17. DMR Coverage Sweep Menu

10-12 Measure Menu

Key Sequence: **Shift** > **Measure** (**4**) key

Displays the **Measurement** menu in the current Land Mobile Radio mode.

10-13 Trace Menu

This menu is not available in Coverage Mapping.

10-14 Limit Menu

This menu is not available in Coverage Mapping.

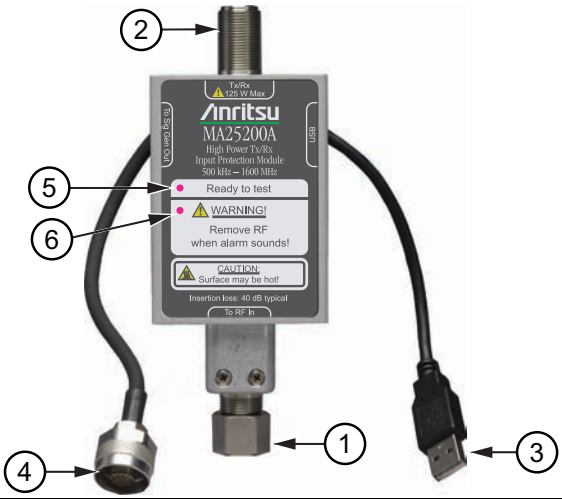
10-15 Other Menus

Preset, **Calibrate**, **File**, **System** and **Mode** are described in the User Guide.

Chapter 11 — High Power Input Protection

11-1 Overview

Use the MA25200A High Power Tx/Rx Input Protection Module to safeguard the S412E input ports from high power transmitters. The MA25200A attenuates RF power levels up to +51 dBm (125 W) to safe levels for measurements. The MA25200A connects directly to the RF input connector. It has an N(m) coaxial input cable that connects to the Signal Generator output. The top N(f) connector can be connected directly to portable or mobile antenna ports or base station transmit or receive ports. The nominal 40 dB insertion loss of the main input and signal generator ports can be compensated for in the S412E amplitude offset menus, enabling the displayed levels to match the RF levels at the input of the MA25200A. The insertion loss of the MA25200A is very flat over its frequency range of operation, supporting accurate amplitude measurements. Please see the *MA25200A High Power Rx/Tx Input Protection Module Technical Data Sheet* for specifications.



1. RF Output N(m) - connect to analyzer RF input connector.
2. RF Tx/Rx N(f) - connect to test device.
3. USB Type A - connect to the instrument to supply power for the cooling fan, LED indicators, and warning alarm.
4. Signal Generator Input N(m) - connect to instrument signal generator.
5. Green LED - indicates proper operation.
6. Red LED - indicates a fault or over temperature condition.

Figure 11-1. MA25200A Overview

Caution	When the internal temperature exceeds 100 °C, the red LED illuminates and an internal piezo alarm sounds continuously until the temperature returns to the proper operating range. Stop testing immediately to prevent damage to the LMR analyzer or MA25200A module.

11-2 Measuring a Handheld Transceiver

The following example uses an S412E LMR Master to analyze the modulation quality and receiver sensitivity of a P25 handheld transceiver (HT) in simplex mode.

Measuring Receiver Sensitivity

1. Connect the equipment as shown in Figure 11-2:
   - Connect the MA25200A to the S412E **RF In** port, **Signal Generator Out** port, and USB port.
   - Connect the HT RF output (antenna port) to the MA25200A **Tx/Rx** port.

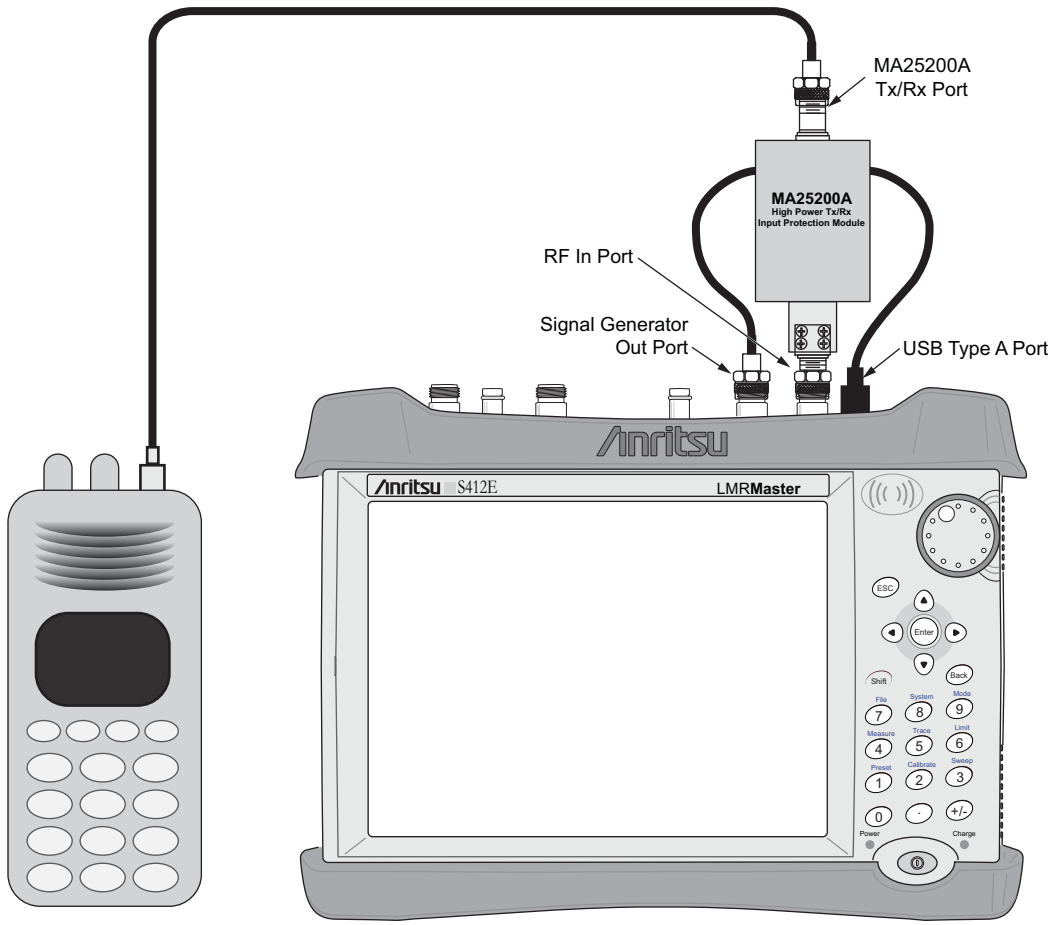


Figure 11-2. Handheld Transceiver connected to LMR Master with a MA25200A High Power Tx/Rx Input Protection Module

Note	The MA25200A combines the S412E Signal Generator Out and RF In ports to the High Power Tx/Rx port of the module.

2. Set the HT to the desired simplex mode frequency (transmit and receive frequencies set to the same values) to receive a P25 1011 Hz test pattern.
3. From the S412E Frequency menu, set the following:
   - Rx Freq: test frequency
   - Tx Freq: test frequency
   - Rx/Tx Coupling: On
   - Coupling Offset: 0 Hz
   - Span: 25 kHz
4. From the S412E Amplitude menu, set the following:
   - Ref Level: –20 dBm
   - Scale: 10 dB/div
   - Rx Power Offset: 40 dB External Loss
   - Auto Rx Range: On
   - Tx Power Offset to 40 dB External Loss
   - Tx Output Level: –120 dBm (initial setting)

   From this point, the S412E signal generator and analyzer measurements are both referenced from the MA25200A Tx/Rx port.
5. Turn the S412E Signal Generator On and use the Setup menu to set the default 1011 Hz Rx Pattern and p25_1011 Tx Pattern.
6. Return to the Amplitude menu and adjust the Tx Output Level until the signal can no longer be distinguished from the measurement noise by the receiver.
7. Note the Tx Output Level is the receiver sensitivity value.

Measuring Transmitter Modulation

8. Turn off the S412E signal generator.

Note	The MA25200A has a small amount of signal leakage from the signal generator input to the analyzer output port (S412E RF In port). This leakage is mitigated by turning off the S412E signal generator.

9. Transmit the HT RF output test signal into the MA25200A Tx/Rx input and note the receiver summary data table on the S412E display.

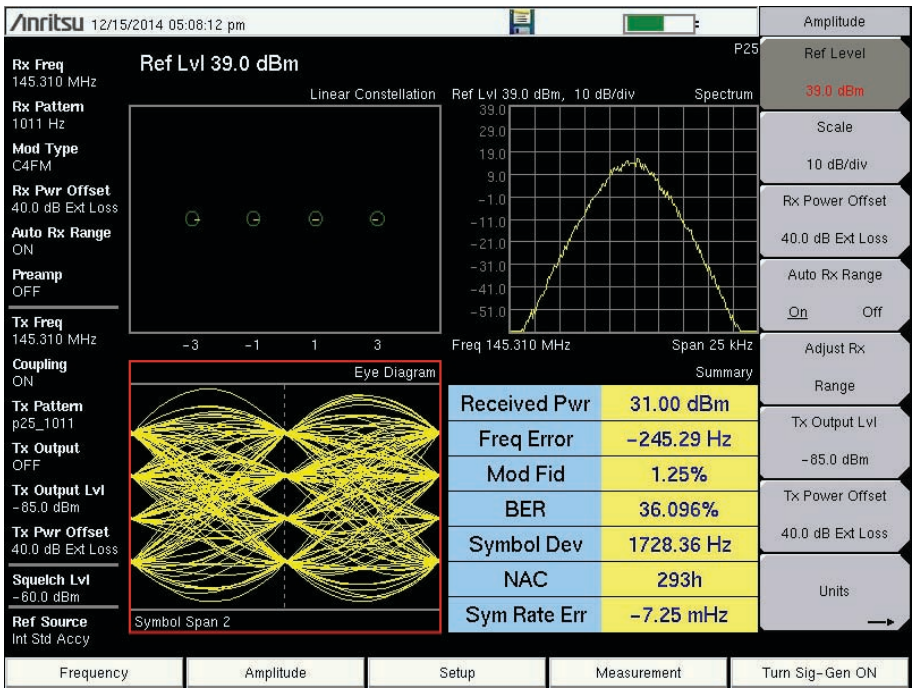


Figure 11-3. LMR Master P25 1011 Hz Analyzer Sample Display

11-3 Measuring a Base Station

The following example is using an S412E LMR Master to analyze the modulation quality and receiver sensitivity of a P25 base station transceiver.

Measuring Receiver Sensitivity

1. Connect the equipment as shown in Figure 11-4:
   - Connect the MA25200A to the S412E **RF In** port and USB port.
   - Connect the base station RF output to the MA25200A **Tx/Rx** port.
   - Connect the base station signal input port to the S412E **Signal Generator Out** port.
   - Terminate the MA25200A **Sig Gen** input with a 50 Ω termination or calibration component.

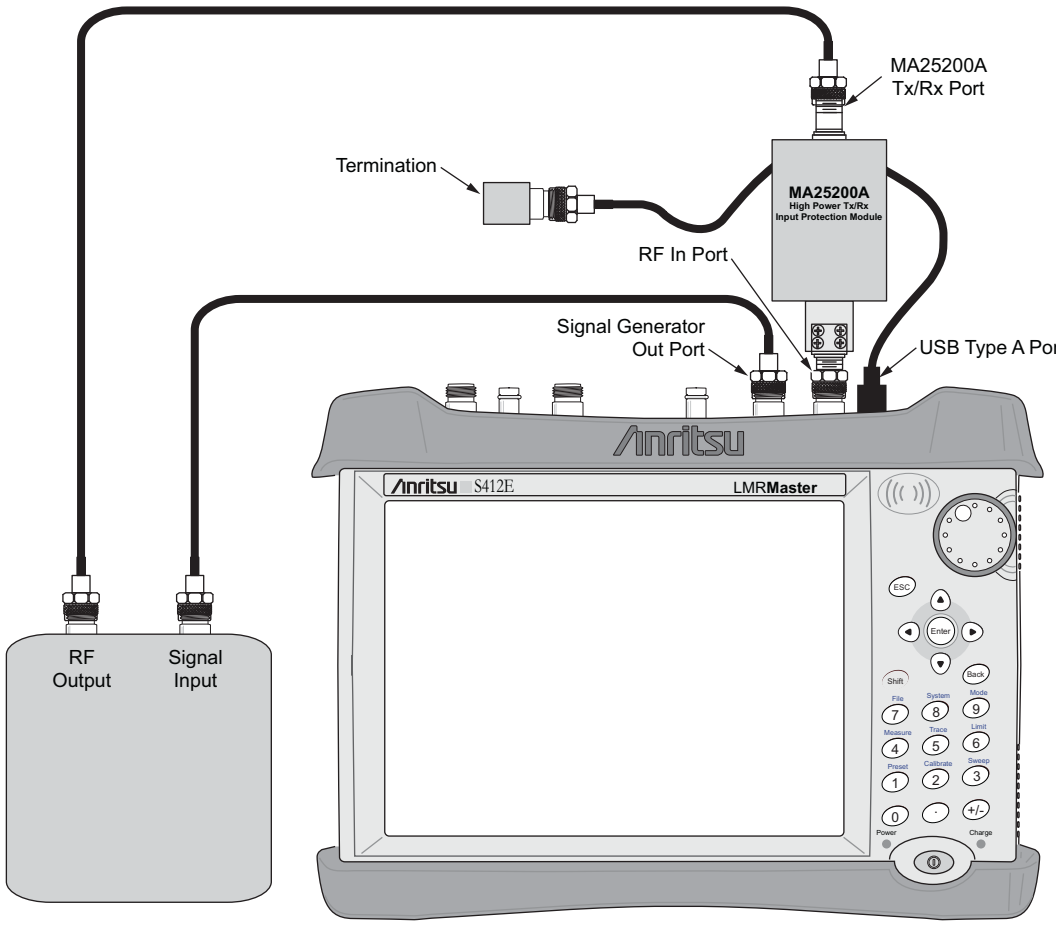


Figure 11-4. Base Station Transceiver connected to LMR Master with a MA25200A High Power Tx/Rx Input Protection Module

2. Set the base station to the desired simplex mode frequency (transmit and receive frequencies set to the same values) to receive a P25 1011 Hz test pattern.
3. From the S412E Frequency menu, set the following:
   - Rx Freq: test frequency
   - Tx Freq: test frequency
   - Rx/Tx Coupling: On
   - Coupling Offset: 0 Hz
   - Span: 25 kHz
4. From the S412E Amplitude menu, set the following:
   - Ref Level: –20 dBm
   - Scale: 10 dB/div
   - Rx Power Offset: 40 dB External Loss
   - Auto Rx Range: On
   - Tx Power Offset to 40 dB External Loss
   - Tx Output Level: –120 dBm (initial setting)

   From this point, the S412E signal generator and analyzer measurements are both referenced from the MA25200A Tx/Rx port.
5. Turn the S412E Signal Generator On and use the Setup menu to set the default 1011 Hz Rx Pattern and p25_1011 Tx Pattern.
6. Return to the Amplitude menu and adjust the Tx Output Level until the signal can no longer be distinguished from the measurement noise by the receiver.
7. Note the Tx Output Level is the receiver sensitivity value.

Measuring Transmitter Modulation

8. Turn off the S412E signal generator.

9. Transmit the base station RF output test signal into the MA25200A Tx/Rx input and note the receiver summary data table on the S412E display.

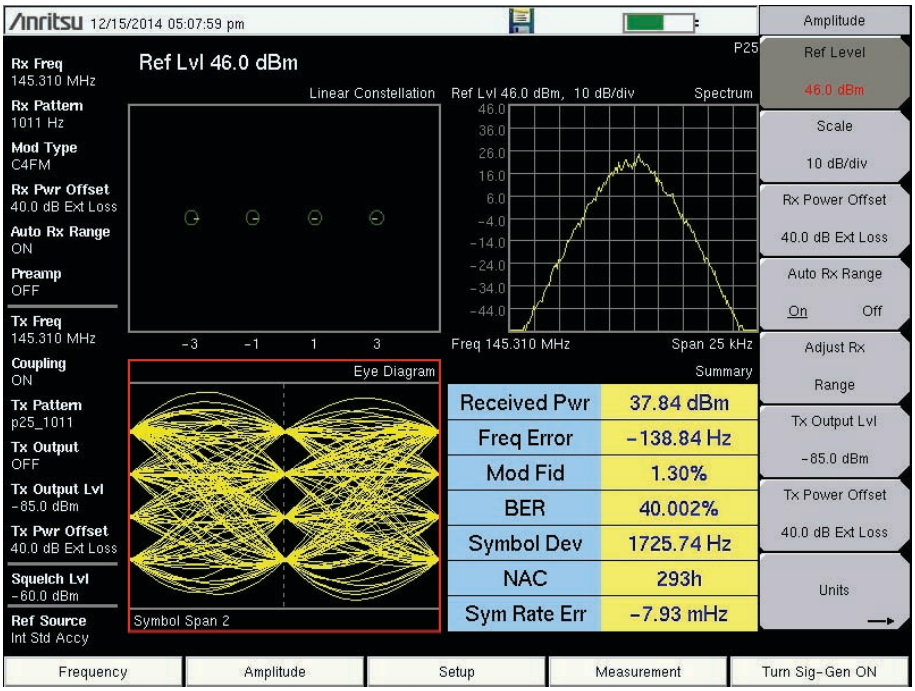


Figure 11-5. LMR Master P25 1011 Hz Analyzer Sample Display

Appendix A — Error Messages

A-1 P25/P25p2, NXDN, dPMR, TETRA, DMR, and PTC Messages

This Appendix provides a list of P25, NXDN, dPMR, TETRA, DMR, and PTC error messages. Self Test and General Operation error messages are in the User Guide.

Notifications

1. External Reference not found. Internal reference Locked successfully

   This message is displayed when the instrument has detected an external reference but couldn't lock to the reference. It automatically switches to the Internal Reference.

2. External Reference Locked Successfully

Warning Messages

1. RF Over Power: Decrease input power.
2. ADC over range: Adjust the ADC range.
   a. If Auto Range is ON: Decrease input power.
   b. If Auto Range is Off and if Atten = 65 then ADC over range: Decrease input power.
   c. If Auto Range is Off and Atten is < 65 then ADC over range: Adjust range.
3. No signal detected: Increase input power or Weak signal detected: Increase input power
   a. Increase input power or decrease any external attenuation
4. Out of band saturation

   When the software detects that there is too much power outside the current frequency range, this message is displayed. This usually means that the instrument is currently tuned to a frequency with a very low amplitude signal or no signal and there is a strong signal at another frequency outside the current IF bandwidth.

5. Lock failure %x where %x is a mix of the following in hex:

   When there is a lock failure detected from any of the internal LOs, this message is displayed. The xx is usually an error code in hex that can be interpreted by a service center to obtain more information on which LO had the failure.

   #define DSP_SAMPLER_PLL_ULOCKED 0x000100
   #define DSP_LO1_PLL_UNLOCKED 0x000200
   #define DSP_LO2_PLL_UNLOCKED 0x000400
   #define DSP_LO3_PLL_UNLOCKED 0x000800

6. Not available in REVIEW Mode
   a. Turn off Review mode

Data Logging Errors

1. Error Making Directory On USB, Verify Media is Installed.

A USB flash drive is not connected to the USB port or the device is not recognized. Try to connect again, use a different USB flash drive, or reformat the USB flash drive on a PC.

Warning	All data on a USB flash drive will be erased if it is reformatted.

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