Application Note:
Testing DMR devices in operational mode using the Freedom Communications System Analyzer

Application Note

The purpose of this application note is to demonstrate the use of the R8000 or R8100 for testing a DMR portable, mobile or DMR repeater in "Live" mode. The word "Live" is intended to indicate that the device is in operational mode during the test process, and not necessary over the air testing. In general, to test and align a DMR device it is necessary to utilize the "radio adjustment" software supplied by the manufacture of the device under test. With that software the technician will "back door" into the radio, place the radio in test mode and then following the manufactures test and alignment procedures. Another approach is to utilize "AUTOTUNE" test application(s) that are available for the R8000/R8100 for a variety of DMR devices. Check with your Freedom representative to see if AUTOTUNE is available for your device.

The descriptions and screen shots utilized in this application note are based on an R8100 running software version 3.6 or later and the following options enabled:

> 1) DMR test Package (R8_DMR)
> 2) DMR Live Repeater (R8_DMR-RPTR)
> 3) Extended Gen Out range (R8-GEN_EXT)

In some cases, the text will reference the R8100 O&M manual which can be found online at www. freedomcte.com.

Reference 1)
FCT-1366C – R8100 Series Communications System Analyzer Operation's Manual. Freedom Communication Technologies

DMR (ETSI Digital; Mobile Radio)

The DMR Test Package option / DMR Test Mode allows testing of repeater/subscriber radios compliant with the ETSI Digital Mobile Radio (DMR) Tier 2 conventional (non-trunked) radio transmission protocol. DMR radios use a digital transmission format employing Four-Level Frequency Shift Keying (4FSK) modulation with a channel access method of Time Division Multiple Access (TDMA) technology with two slots per frame. Pressing <Test>, <Test Mode> and then the DMR soft key initiates the DMR Test Mode. On the R8100 main display, the Standard Mode's Audio Zone and Audio Zone soft key are replaced by a DMR soft key and DMR specific content (see Figure 1). In addition, a variety of displays are available in Display Zone, and a Constellation display is automatically selected in Meter Zone as a convenience.
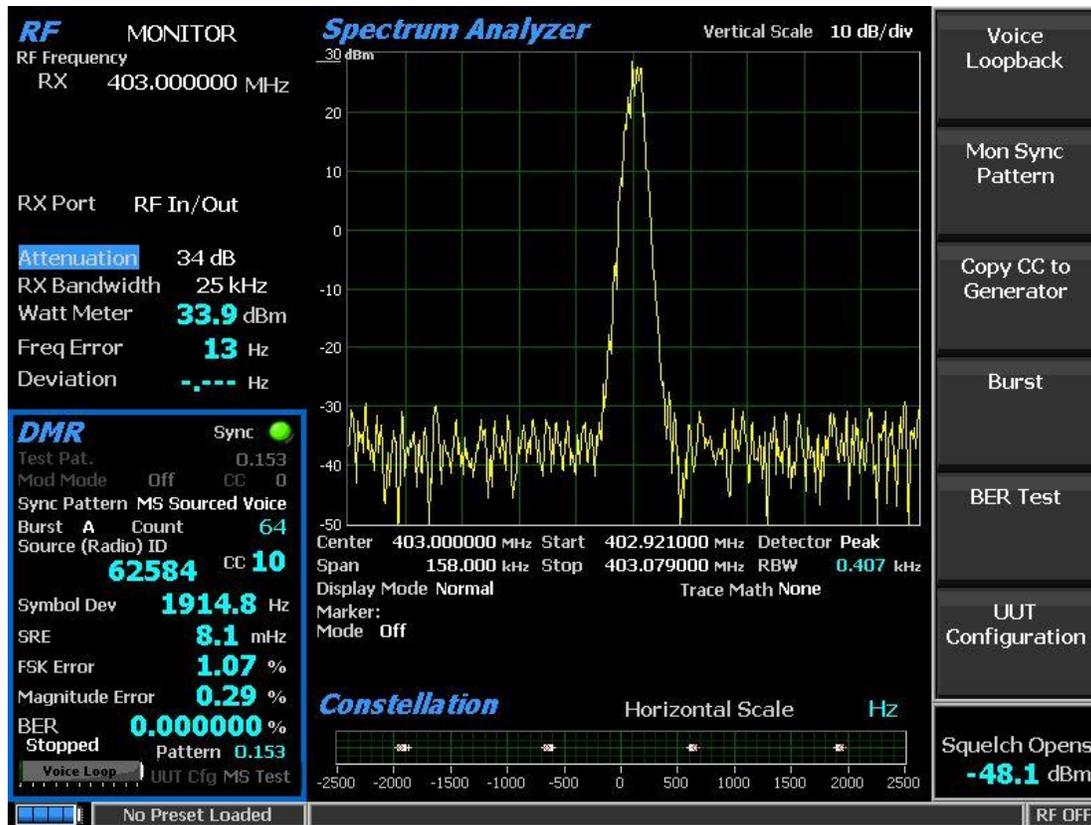
Figure 1 - DMR transmitter tests

DMR transmitter tests

These tests are performed with the R8100 in Monitor Mode (see Figure 1). During repeater/subscriber radio transmission, the R8100 continuously measures the quality of the radio's transmitted 4FSK signal over the 132 symbols (264 bits) that comprise an entire DMR TDMA burst. Although the service monitor synchronizes to the first burst, it can measure the quality of any of the six bursts transmitted by the radio.
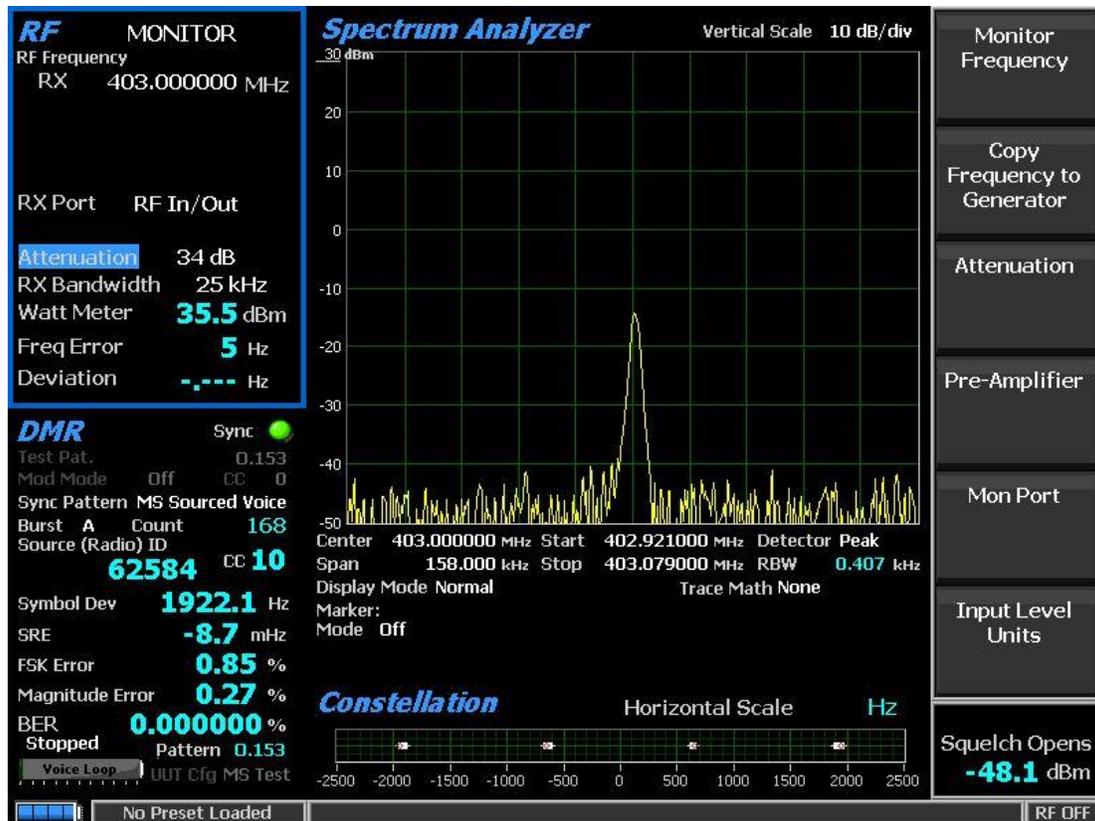
Figure 2   Zone's in Monitor Mode

RF Zone

Input Level

Input Lvl displays the average power in the specified Burst of the synchronized TDMA slot of the received signal.

Note: *Although Input Level is used for Squelch, Squelch has no effect on measurement updates.*

Note: *When the RF input power on the RF In/Out port is above +20 dBm (100 mW), the R8100 utilizes a broadband power detector for the measurement. The "Input Lvl" field in the RF Zone changes to "Watt Meter" to indicate this measurement mode.*

Note: *The TDMA transmission alternates between a used and unused time slot, so the RF Zone field will switch between the two. An unused slot has no power, so the display will flash between "Input Lvl" and "Watt Meter." In this condition the Input Level reading should be used since null slots can cause the Watt Meter indication to read approximately 3 dB less than the power in the used slots.*

Freq Error

Freq Error displays the frequency difference of the received DMR transmission carrier minus the R8100 Monitor Frequency.

Attenuation

Attenuation in this screenshot is highlighted *blue*. This indicates that automatic attenuation is in effect and changing the attenuation value will do nothing. Auto attenuation is very good for continuous signals but can sometimes cause issues for TDMA signals. If measurement issues arise, consider disabling Auto Attenuation in the <Settings>, <System Settings> menus. Once auto attenuation is disabled, the user should set attenuation to a proper level for the input power.

Note: *For other standard RF Zone settings, see the appropriate sections in the O&M manual. (reference 1)*

DMR Zone

Sync

The "Sync" indicator will turn green when the selected monitor sync pattern is located in the received transmission. If the incoming DMR transmission is visible on Spectrum Analyzer with good signal to noise and SYNC is NOT green, try selecting another sync pattern choice. Note that different sync patterns are available based on the Unit Under Test Configuration setting.

Note: *Test measurements are only displayed and updated when SYNC indicator is ON (Green).*

Sync Pattern

This display item shows what monitor sync pattern is currently being searched for.

Count

This field increments each time the specified SYNC Pattern is detected.

Source (Radio) ID

Source (Radio) ID displays the Source Identifier (ID), which identifies the individual address of the transmitter. The Source ID is displayed in base 10 (Digital) format.

CC

This field displays the four-bit Color Code (0 to 15) of the synchronized TDMA slot of the received signal transmission. CC is digital ID information equivalent to CTCSS/PL and CDCSS/DPL of analog FM radio systems. Correct Color Code is required for user access to the DMR system.

Symbol Deviation

This field displays the symbol deviation estimated by averaging the normalized frequency deviations at symbol times in the specified burst of the synchronized TDMA slot of the received signal and then scaling by the maximum symbol value. The normalized frequency deviation is computed as the ratio of the actual frequency measurement at a given symbol or deviation state to the corresponding symbol value. For verification the technician should obtain

proper Symbol Deviation from the manufacturer specifications for the radio under test. Nominal value based on ETSI Digital Mobile Radio standard is 1944 Hz.

SRE (Symbol Rate Error :New in version 3.6)

This field displays variations of symbol rate with respect to the expected nominal rate. Units are mHz. This measurement is sometimes called "Symbol Clock Error".

The measurement is determined in the following fashion:

Measured baud = symbols per slot / measured time between slot centers

SRE (mHz) = (measured baud – nominal baud)/ 1000

FSK Error

This field displays the root mean squared (rms) spread in percentage error as computed from the measured symbols to the calculated Symbol Deviation measurement in the specified Burst of the synchronized TDMA slot of the received signal.

Magnitude Error

This field displays the average envelope magnitude over the burst interval subtracted from the envelope magnitude of the sample at the decision point in percentage.

BER

This field displays the bit error rate percentage of bit differences between the O.153 pattern (or 1031 Hz pattern) and the bits of the synchronized TDMA slot of the received signal. For example, if 13 of the 1296 super frame payload bits do not match the predefined pattern, the rate will be 1.0030864% (13/1296*100%). Assurance of the computation may be gained by transmitting a different calibration test pattern (e.g. BER of 1031 Hz vs. O.153 is 47.299381%).

When the R8100 or R8000 is in Generate or Duplex mode the user can select the test pattern to transmit. If the selected TX pattern is 1031 Hz, then the RX BER will also use 1031 Hz for reference. If the selected TX pattern is any other available pattern the RX BER will use the O.153 pattern for reference.
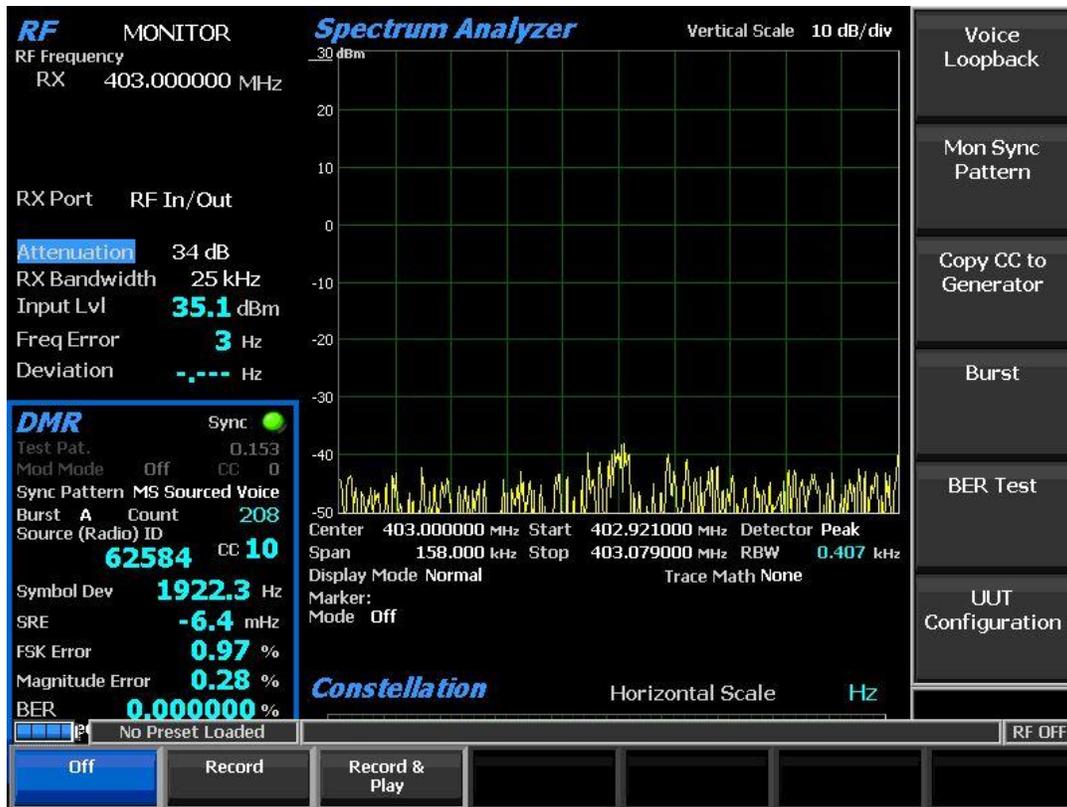
Figure 3   Voice Loopback Recording

Voice Loopback (DMR submenu)

This soft key enables the Voice Loop feature in DMR Mode (U.S. patent 5703479). Once enabled, the R8100 automatically records an input message when the radio under test transmits a signal above the squelch level setting (see Figure 4). A Voice Loop progress bar in the Test Mode zone is bold when Voice Loopback is enabled. The maximum length of the recording is 10 seconds, and a light green progress bar shows the recording's progress. The recording continues if the transmission is longer, but only the most recent is retained. When the radio is un-keyed, the R8100 automatically switches to Generate Mode (make sure the Generate Frequency is set correctly) and transmits the captured input message back to the radio (see Figure 4). The position of the played back recording is displayed with a dark green progress bar. When the recorded message has been played and a three-second settling delay has passed, the Operation Mode automatically switches back to Monitor Mode so another message can be recorded. This provides a quick end–to-end test of the radio transmitter and receiver. Voice Loopback can also be used to quickly verify basic functionality of an encrypted message.

Note: *The power Input Level of the received message is readjusted to maintain the power Output Level of the transmitted message.*
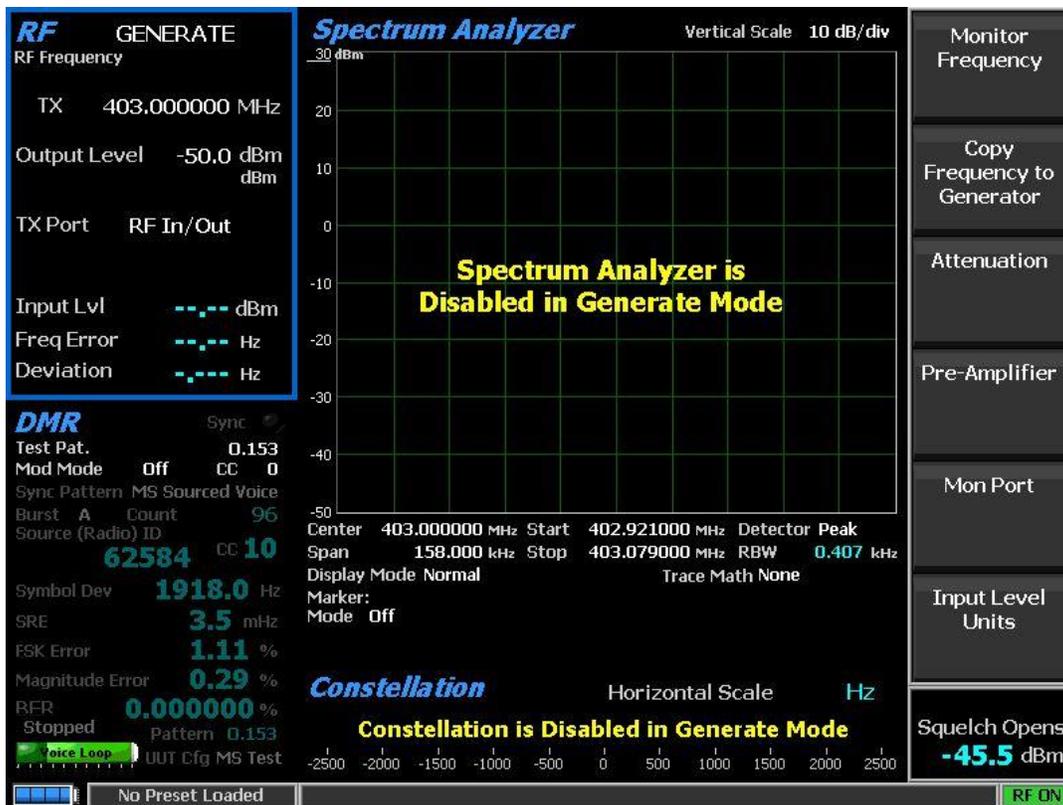
Figure 4   Generating Voice Loopback

Off selection stops a recording or playback and disables the feature; the progress bar is grayed out. The last recording is preserved for the remainder of the session; it is lost if the R8100 is power cycled.

Record selection (Monitor Mode only) disables the automatic switch to Generate Mode and subsequent playback. The last recording is automatically erased when a new input message is detected.

Play selection (Generate Mode only) repeatedly plays and rewinds the last recorded message; speech recorded from a transmitting radio under test should be heard from its receiver if the radio is operating properly. This setting disables the automatic switch to Monitor Mode and subsequent recording.

Record & Play selection automatically switches from Monitor Mode to Generate Mode to play a recording. It also switches from Generate Mode to Monitor Mode to make a new recording.

Note: Voice Loopback overrides the Color Code (CC), Modulation Mode, and Test Pattern settings during playback. *The R8100 captures and resends the Color Code, destination ID (address), and call type sent by the radio. For the radio to audibly reproduce the message, the radio must be set to a Group Call or an All Call channel.*

Note: *The "Squelch" knob setting is utilized by* Voice Loopback *for proper operation. Adjust squelch high so R8100 will transmit when radio powers down.*

Monitor SYNC Pattern (DMR submenu)

This soft key chooses the data synchronization pattern for testing with the R8100. The user MUST select a proper sync pattern for the incoming signal for the R8100 to sync with. In most cases BS Sourced Voice for a base station / repeater, or MS Sourced Voice for a portable / mobile station.

Copy CC to Generator (DMR submenu)

This key sets the R8100 Generator to use the last color code that was received in Monitor Mode.

Burst (DMR submenu)

This key allows the choice of six super frame bursts for the R8100 to display radio transmitter quality measurements. Use the horizontal submenu to select the desired burst (A through F). The following measurements are made from the selected burst: Input Level, Constellation, Symbol Deviation, FSK Error, and Magnitude Error.

BER Test (DMR submenu)

This selection allows starting or stopping Bit Error Rate (BER) testing in the DMR Mode of the R8100. This bit error rate test checks the modulation, encoding, and timing of the transmit signal during the data transmission period. When the BER Test is running, the radio transmitter under test must be transmitting the proper test pattern. To accomplish this, portables and mobiles are normally the placed into a "Diagnostic Test Mode" with testing software supplied by the radio manufacture.

UUT Configuration (DMR submenu NEW for Version 3.6 and later)

This key identifies to the R8100 what type of test is expected to be performed. Submenu selections are:

a) MS Test

Use this selection when testing a user device (portable or mobile)

b) BS Test

Use this selection when testing a base station or repeater while the BS is under control of test and diagnostic software.

c) Repeater Live (*option must be enabled*)

Use this selection when testing a DMR repeater configured for normal operating mode. See section below on "Live repeater" testing for more details.

Display Zone

Select Display (Display Zone submenu)

While in Monitor or Duplex operation the following Display zones are available and active:

   a) Spectrum Analyzer

   b) Eye Diagram (NEW in version 3.6)

   c) Power Profile

   d) Distribution Plot (NEW in version 3.6)

   e) Analysis Details (NEW in version 3.6)

   f) Protocol Details (NEW in version 3.6)

Each of these displays show information about the RF signal being received by the R8100. Examples of each screen are shown below.
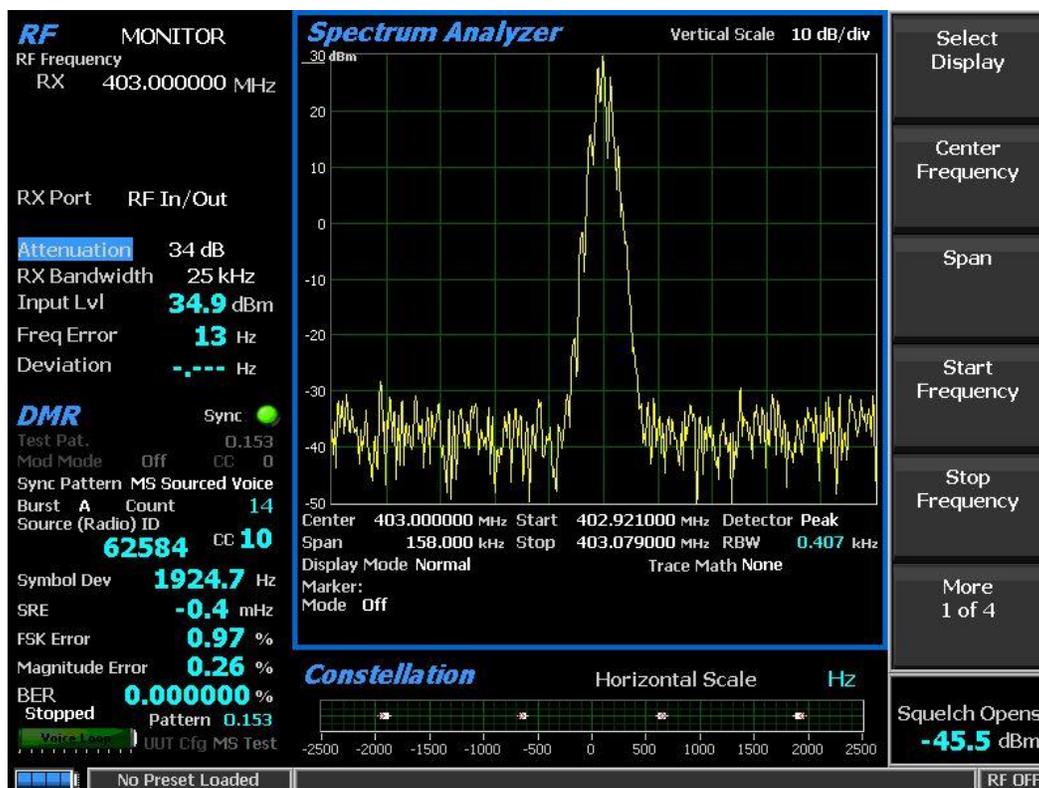
Figure 5   Spectrum Analyzer

Spectrum Analyzer (Display Zone selection)
See the full O&M for details on standard controls of spectrum analyzer. (reference 1)
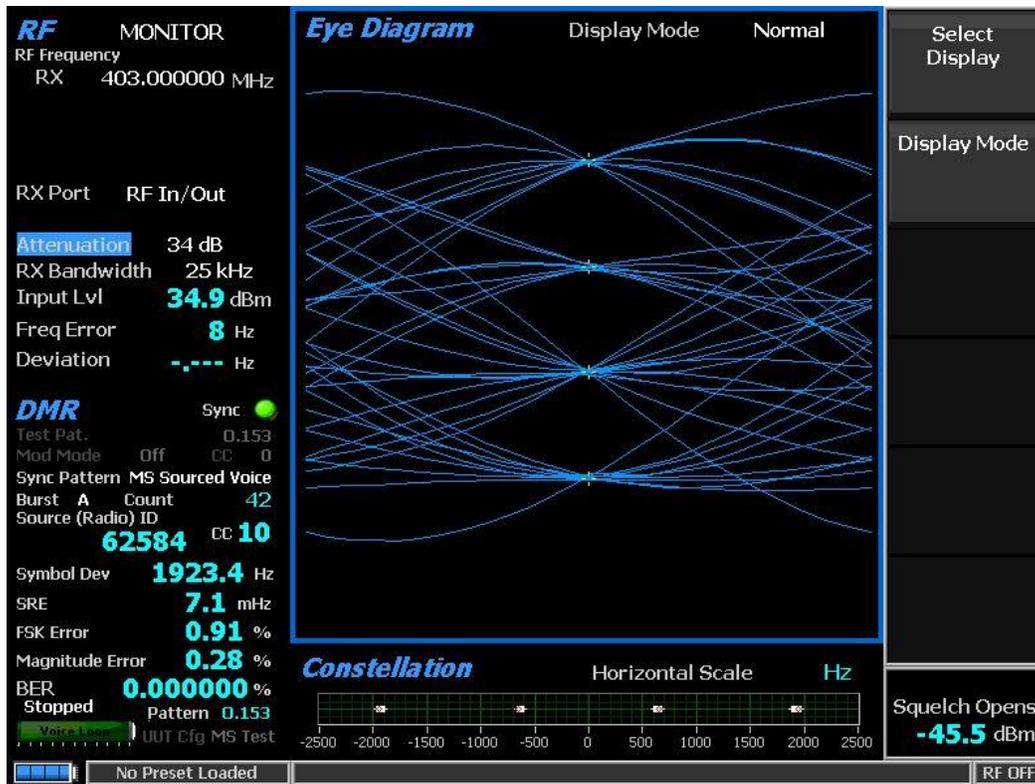
Figure 6   Eye Diagram

Eye Diagram (Display Zone selection)

The Eye Diagram gives a visual representation of the frequency shifts from one symbol to the next where time is displayed on X-axis and deviations on the Y-axis.

The "Display Mode" softkey switches the display between "normal" and "fade away" mode.

There is a significant delay when switching to "fade away" to fill in buffer.
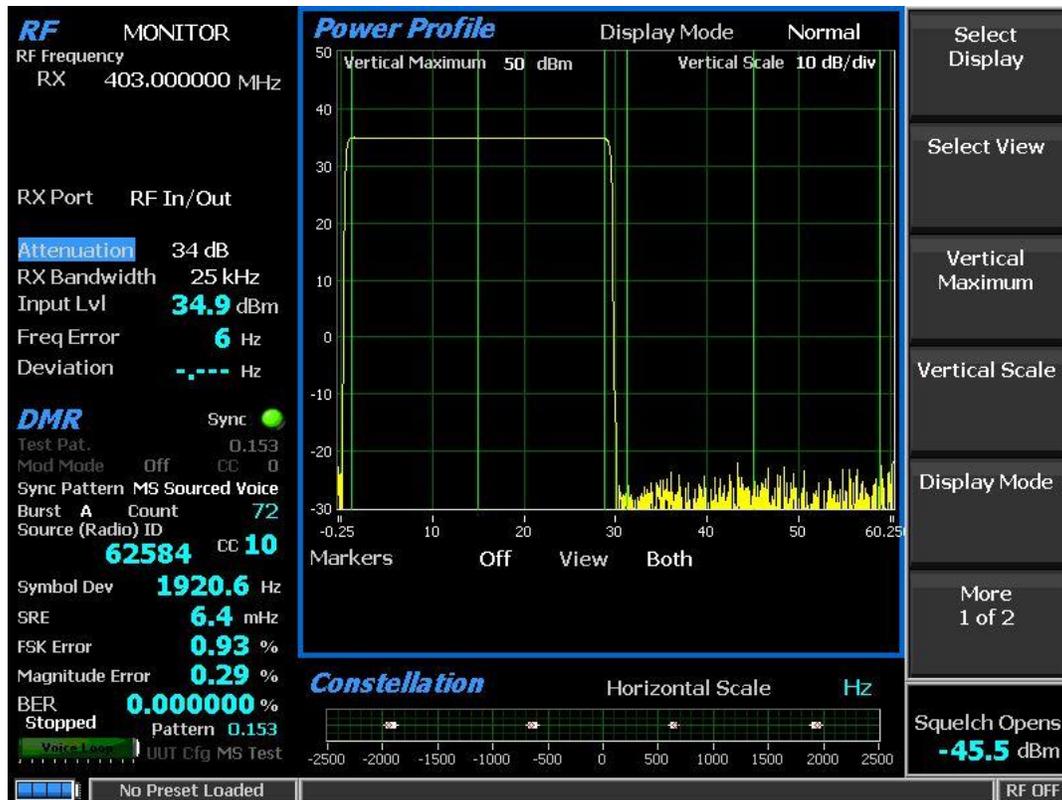
Figure 7　　　　Power Profile

Power Profile (Display Zone selection)

The power profile display provides a power versus time plot of the transmitter. The display is useful in assuring that near-far situations will not result in co-channel inter-slot interference on the alternate or non-transmission slot and that the power level will be adequate for acceptable BER performance. The scaling and position of the vertical power axis can be adjusted to inspect greater range or detail. The horizontal axis can be changed to view one or both slots including the additional ramp up/down time. Display functions and markers are available for advanced analysis. Overlays of slot centers and burst time regions are shown (see Figure 7).

Note: See the Technical Specification: ETSI TS 102 361-1 Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 1: "DMR Air Interface (AI) protocol," Burst timing.

Select View (Power Profile submenu)

Select the slot(s) to view.

Although slots are alternating 30 milliseconds, the profile for a slot is 30.5 ms, divided into three regions for ramp-up (1.5 ms), burst (27.5 ms), and ramp-down (1.5 ms).

"*Current*" selection provides the horizontal axis -0.25 ms to 30.25 ms with slot from 0 to 30 ms.

"*Alternate*" selection provides the horizontal axis 29.75 ms to 60.25 ms with slot from 30 to 60 ms.

"*Both*" selection provide the horizontal axis -0.25 ms to 60.25 ms with slots from 0 to 30 and 30 to 60 ms. (see Figure 7).

Note: Ramp up/down times for a slot overlap the adjacent slots by 0.25 milliseconds.

Vertical Maximum (Power Profile submenu)

This key adjusts the maximum level for the vertical scale of the display (top line) from -120 dBm to +60 dBm in 1 dB increments.

Vertical Scale (Power Profile submenu)

This key selects the vertical scale resolution for the display's major grid lines from 1 dB/div to 10 dB/div via a horizontal soft key list.

Display Mode (Power Profile submenu)

This soft key selects the display presentation with the following horizontal menu choices:

Normal selection allows the display to update continuously.

Freeze selection provides a snapshot of the current display indication and stops additional updates.

Max Hold selection allows the display to retain the highest peak signal amplitudes measured during successive sweeps.

Average selection displays signal amplitudes as a rolling average of the peak amplitudes measured on each successive sweep. The average consists of one to five sweeps, shown beside the Mode indication.

Marker Mode (Power Profile submenu)

This key provides display marker control via a horizontal soft key menu. Markers can be turned off or on with a choice of numeric readout for the signal measurements. "Absolute" provides actual peak readings while "Delta" measures the relative difference of both power and time between the markers.

Toggle Marker (Power Profile submenu)

This key cycles through the available markers to select the active one (yellow) for positional adjustment on the display. The active marker is moved using the Left/Right (◄►) cursor control buttons.
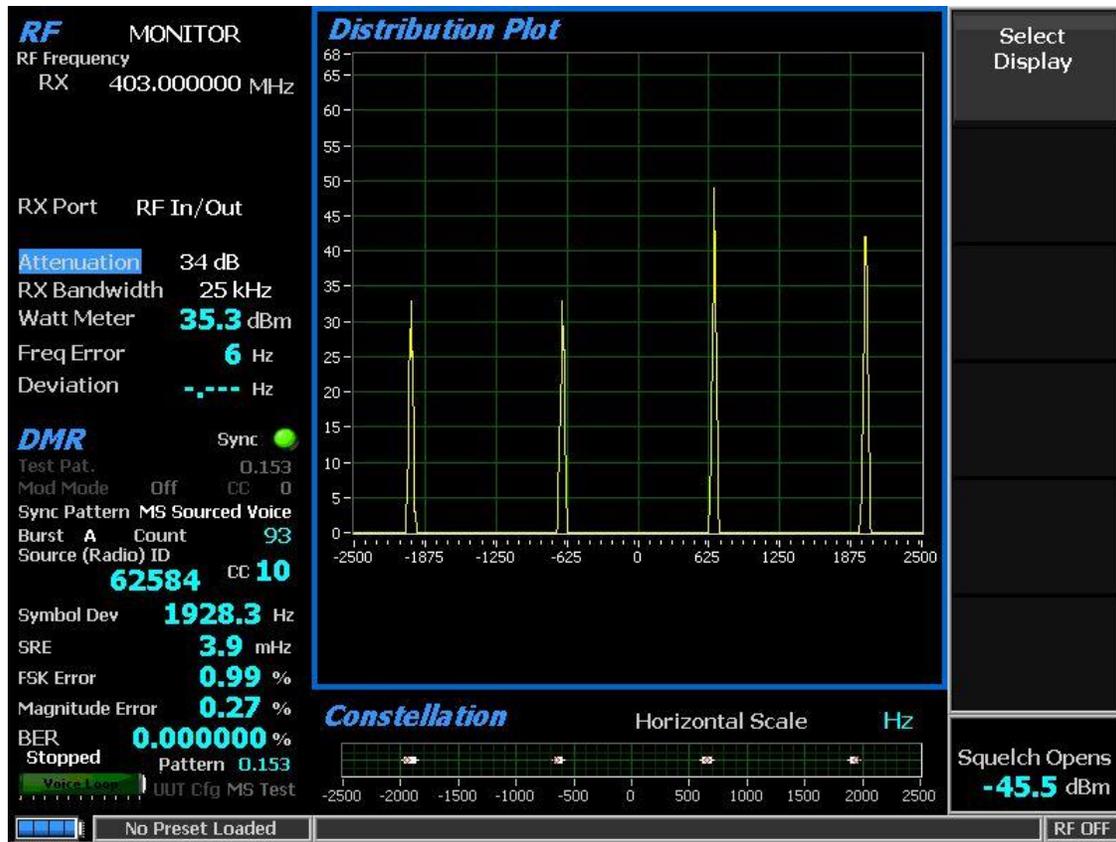
Figure 8   Distribution Plot

Distribution Plot (Display Zone selection)

The Distribution Plot depicts the spread of symbols over time about each center. There are no controls for the distribution plot.
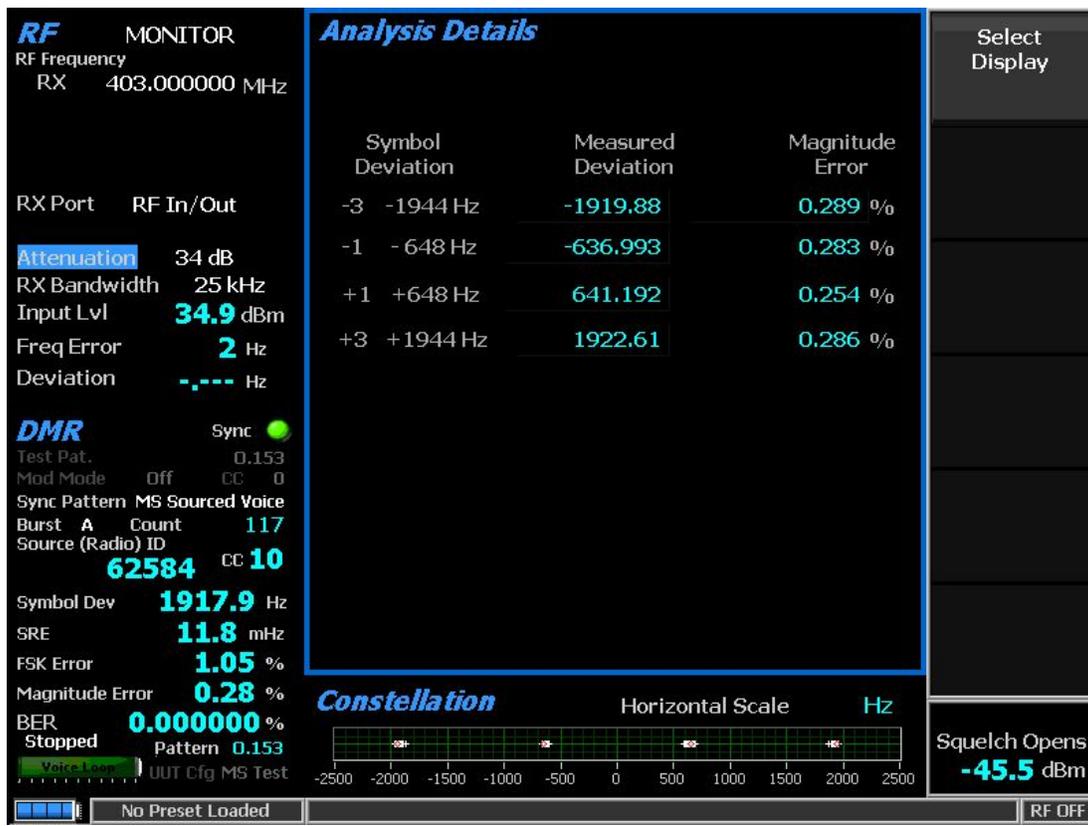
Figure 9   Analysis Details

Analysis Details (Display Zone selection)

Analysis Details displays the measured deviation points for each data symbol and the Magnitude error for each data symbol.

The nominal deviation points for each data symbol are provided on the screen as reference.

Figure 10   Protocol Details

Protocol Details (Display Zone selection)

Protocol Details displays overhead information and when working with a repeater, which slot is in use.

Call/Target Address: This field displays the Call or Group ID the transmission is intended for. Reported in decimal format

Slot Analyzed: Displays the slot number in use to calculate the reported measurements. Normally this will be the same as the slot the R8100 is in sync with. Slot information is only reported when testing a repeater. While testing a user device this field will report NA

Sync Slot: Displays the slot number the R8100 is synced to. This will be where the Monitor Sync pattern is found. Slot information is only reported when testing a repeater. While testing a user device this field will report NA.

Service Options: The R8100 reports the contents of the 8-bit DMR overhead field called "Service Options". This data is shown as decimal and hex format.

Note: Details of this field can be found in Table 7.11 of ETSI TS 102 361-2 v2.4.1 (2017-10).

Priority: Priority level is an element in the service options field. This is reported separately here. Range is 0 – 3. Where 0 = No priority and 3 = highest priority.

Note: "Service Options" is available in the standard but is not mandatory for use and manufactures may utilized propriety signaling methods for "Priority" notifications. *Check with the manufacture of the radio unit test for the validity of the use of this feature.*

Emergency: The "Emergency" indicate will light green when the emergency flag in the "Service Options" is set.

Note: "Service Options" is available in the standard but it is not mandatory for use and manufactures may utilized propriety signaling methods for "Emergency" notifications. *Check with the manufacture of the radio unit test for the validity of the use of this feature.*

Meter Zone

Select Meter

Under Select Meter user will find "Power Meter", "Voltmeter" and "Constellation". By default, the "Constellation" meter will be shown in DMR mode. See "Meter Zone" in O&M manual for standard selections (reference 1), and see below for custom selections.

Constellation (Meter Zone selection)

The Constellation display provides a visual representation of overall transmitter operation (see Figure 11). DMR radios broadcast voice and data using four frequency shift deviations of the carrier to represent symbols containing two data bits. Four red tick marks on the display represent the expected locations for the deviation states when the radio is transmitting data bit symbols using the modulation. White tick marks show the actual deviation measurement at symbol decision times. A tighter grouping around the red tick marks indicates more accurate transmitter performance.
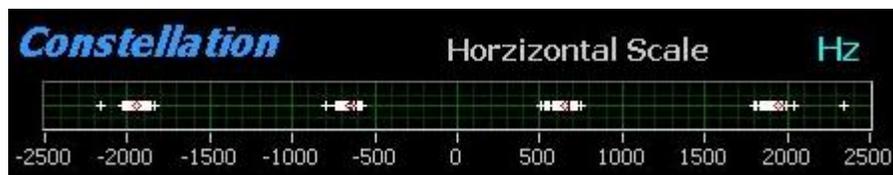
Figure 11 Submenu after pressing DMR soft key in Monitor Mode

The nominal deviation points for each data symbol are as follows:

Bits	Symbol	Deviation
01	+3	+1944 Hz
00	+1	+648 Hz
10	-1	-648 Hz
11	-3	-1944 Hz

Table 1 DMR Symbols

Generate Mode

DMR receiver tests are performed with the R8100 in Generate Mode, and protocol-specific tests are accessed with the DMR soft key (see Figure 12). The R8100 generates DMR-compliant test patterns and can be adjusted over a wide range of RF levels to determine the sensitivity and data transmission integrity of the DMR radio. DMR submenu selections are as follows:
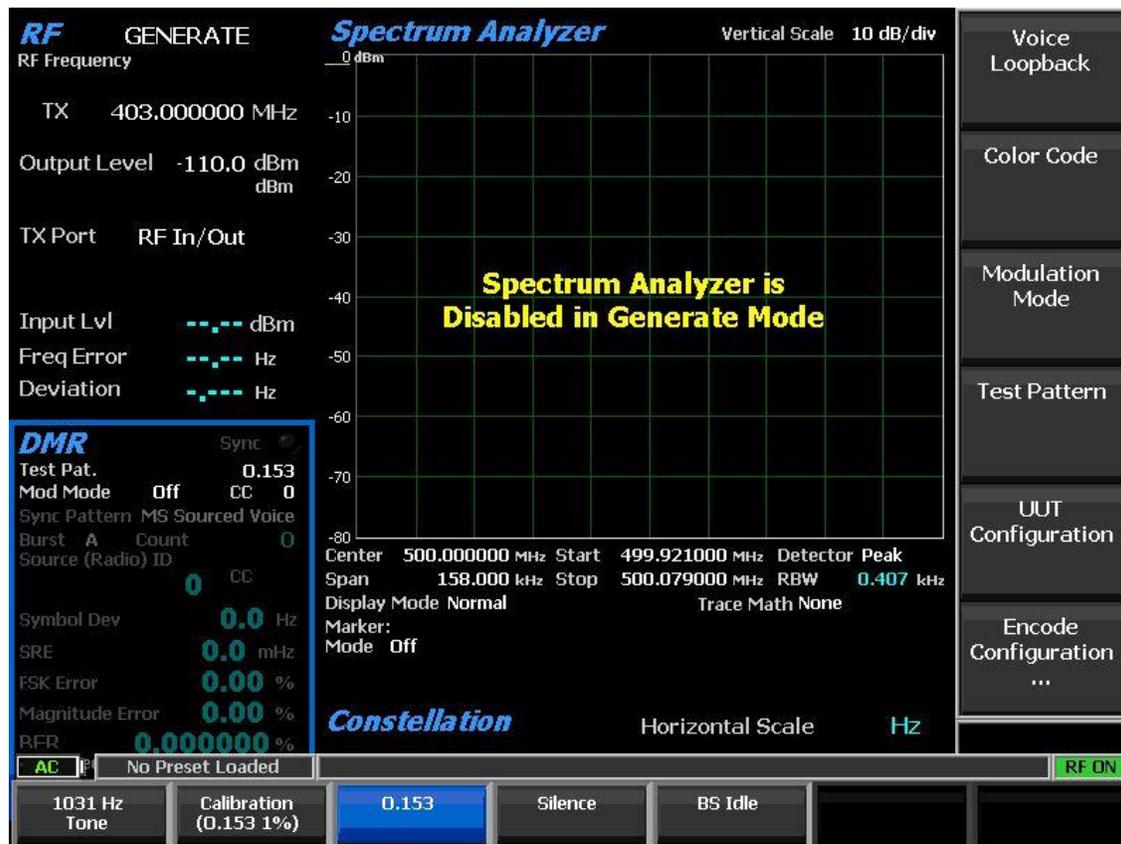
Figure 12   Submenu after pressing DMR soft key in Generate Mode

Voice Loopback

Off selection stops playback.

Play selection allows the last recorded message to be repeatedly played and rewound. **Note***: Voice Loopback overrides the Modulation Mode.*

Color Code

Select one of 16 color codes (0 to 15) to match that of the radio or base station for the specific channel frequency being tested. Although the R8100 can analyze a transmission with any color code, radios will only accept a transmission whose color code matches its own (unless the radio is in a test diagnostic mode that ignores the color code).

Modulation Mode

A horizontal submenu provides choice of Off or Continuous for the selected Test Pattern modulation.

Test Pattern

This field specifies the DMR-compliant test pattern generated by the R8100 to assess voice performance or test data transmission accuracy using BER measurements. When performing the BER test, the radio receiver under test must be placed in a Test Diagnostic Mode with the correct RX test pattern selected using the manufacturer's test software. The calculated BER is then displayed by the radio or on the computer. For sensitivity tests, the R8100 can transmit a super frame test pattern, O.153 (V.52) for example, over its entire output power level range. This provides a measurement of the reference sensitivity (1% or 5% BER) for the radio. A horizontal submenu provides the following DMR compliant patterns: (see figure 12)

1031 Hz Tone is a predefined super frame test pattern compatible with digital vocoder type AMBE+2™ that produces a 1031 Hz tone at the speaker of the receiver vocoder. It can be used to quickly check audio performance in the field. It can also be utilized for BER measurement in a repeater loopback situation.

Calibration (O.153 1%) is a test pattern with a built in 1% error. Normally this is transmitted at a good S/N level to verify BER calculations are operating correctly. The 1% BER super frame test pattern changes the value of every 100th O.153 information bit and the very last bit to yield 13 bit errors out of 1296 O.153 information bits (precisely 1.0030864%).

O.153 is a super frame test pattern based on ITU-T O.153 (formerly CCITT V.52) used to perform BER calculations.

Silence is a predefined super frame test pattern compatible with digital vocoder type AMBE+2™ that results in a silent output at the receiver vocoder.

Note: *All patterns have the all-call destination with broadcast service option as a convenience to eliminate the need to reprogram the radio's ID.*

Note: *Enabling the "DMR Live Repeater" option provides the ability to set call IDs in the transmitted test patterns. (NEW for version 3.6)*

UUT Configuration (NEW for version 3.6)

This key identifies to the R8100 what type of test is expected to be performed. Submenu selections are:

      a) MS Test

          Use this selection when testing a user device (portable or mobile)

      b) BS Test

          Use this selection when testing a base station or repeater while the BS is in test mode.

      c) Repeater Live (*option must be enabled*)

          Use this selection when testing a DMR repeater configured for normal operating mode. See section below on "Live repeater" testing for more details.

Encoder Configuration … (*option must be enabled*) *(NEW for version 3.6)*

The "Encoder Configuration" selection opens an edit menu (See Figure 13).
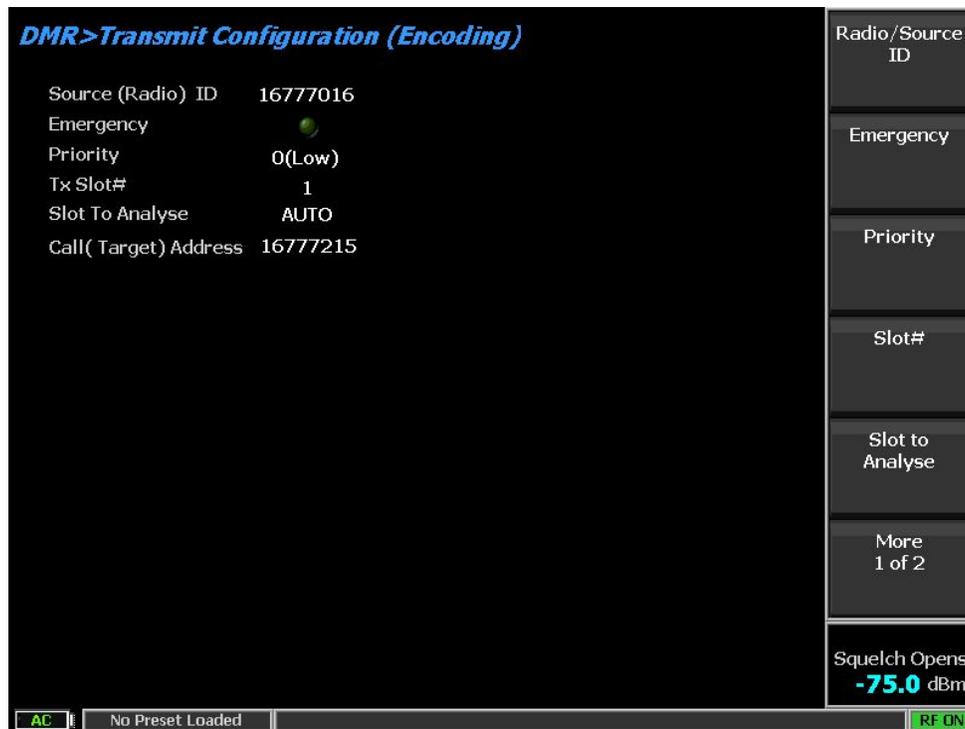
Figure 13   Encode Configuration Menu

In this menu the user can change the following on the transmitted signals:

Source (Radio) ID: Sets the source ID transmitted in test patterns.
Settable Range is 1 to 16777216. Default is 16777016

Emergency: Sets the "Emergency" flag in the DMR standard Service Options field.

Note: Details of this field can be found in Table 7.11 of ETSI TS 102 361-2 v2.4.1 (2017-10).

Note: "Service Options" is available in the standard but it is not mandatory for use and manufactures may utilized propriety signaling methods for "Emergency" notifications. Check with the manufacture of the radio unit test for the validity of the use of this feature.

Priority: Sets the Priority level in the service options field.

Range is 0 – 3. Default is 0

Where 0 = No priority and 3 = highest priority.

Note: Details of this field can be found in Table 7.11 of ETSI TS 102 361-2 v2.4.1 (2017-10).

Note: "Service Options" is available in the standard but is not mandatory for use and manufactures may utilized propriety signaling methods for "Priority" notifications. Check with the manufacture of the radio unit test for the validity of the use of this feature.

Slot#: Sets the Slot to transmit into when testing with a repeater under "Live Repeater" test mode.

Selection is 1 or 2. Default is 1.

Slot To Analyze: Sets the slot that the analyzer will attempt to make measurements on.

Range is 0, 1, 2. Default is 0 (Auto)

0 = Automatic selection in which the analyzer will make measurements on same slot as in sync with based on "monitor sync pattern".

When not set to 0 (Auto) the analyzer will sync to a slot with the expected monitor sync pattern.

Then look to see if that slot matches the desired slot to analyze. If so, it will do nothing.

If not, the analyzer will drop sync and attempt to sync to the opposite slot.

So only use this parameter if both slots have same "monitor sync pattern" and you want to see a specific slot. If the "monitor sync pattern" is only in ONE slot, and it does not match the requested slot to analyze, then the unit will repeatedly drop in and out of sync.

It is recommended that this parameter setting stay at default of 0 (Auto).

Call (Target) Address: This field sets the Call or Group ID in the transmission of the test pattern.

Range is 0 to 16777215. Default is 16777215 (All Call)

Reset to Defaults: This single key selection resets all selections on the "Encode Configuration" screen to default values.

Utilizing the Live Repeater Test Mode (Optional - R8-DMR_RPTR)

The DMR Live Repeater (R8-DMR_RPTR) option expands the standard DMR test mode to support direct interaction with a DMR repeater in conventional (digital) DMR Tier 2 mode. This option does not support any Trunking mode (such as Tier 3) or analog mode.

When testing a DMR repeater, the standard approach is to utilize the manufacture test software to place the repeater into a "test mode" and then follow the manufacture procedures for testing the transmit and receive sections of the repeater.

The Freedom DMR Live Repeater test mode configures the test analyzer to transmit a "wake" up burst at the repeater, synchronize to the repeater transmission and then transmit a selected test pattern into a selected slot. The analyzer will then perform all standard measurements on the repeated transmission.

Measurements made by the analyzer on repeated transmit include:
> Power level
> Frequency Error
> Symbol Deviation
> Symbol Rate error
> FSK error
> Magnitude Error
> Bit Error Rate

After the analyzer is synced to the repeater the technician can switch slots and adjust power output of analyzer to determine RX sensitivity of repeater.

Setting up DMR Live Repeater Test Mode

Many Freedom customers have requested a method to test the DMR repeater while it is in active operation. This test approach is often referred to as "Live" testing. To be clear the "live" testing is NOT intended to be over the air. For proper power measurements R8xxx unit should be directly connected to the TX and RX of the repeater with RF cables.

IMPROTANT: It is possible to utilize this test mode Over The Air (OTA) however, be aware that the R8xxx "Live repeater test" is not designed to play friendly with other transmitters. It does not "listen" for busy channels before transmitting and will not respond to over the air requests like a radio.

The "Live Repeater test" requires duplex operation on both the repeater and the analyzer.

If access is available to both the TX and RX ports of the repeater then for best test results it is recommended that two ports (Gen port and RF I/O) on the analyzer be utilized.

When in this configuration it is also recommended that the analyzer be outfitted with the "Extended Gen Out Range" R8-GEN_EXT option. This option allows the Gen port output to go down to -125 dBm, whereas the minimum output power of the standard Gen port is -95. Without this

option an external attenuator can be used on the Gen out port, and set the RF level offset accordantly.

If access to repeater is at a duplexed TX/RX port then only utilize the analyzer RF I/O port for testing.

For best power measurements it is also recommended that the RF level offsets be set to compensate for cable losses at each port.

Configuring the "Live Repeater Test"

When the DMR Live Repeater (R8-DMR_RPTR) option is enabled it is part of the standard DMR test mode. To utilize Live repeater select the DMR test mode by:
Press the blue <TEST> button
Selected <Test Mode> soft key
Select <DMR> soft key on bottom

Analyzer will switch to DMR test mode as seen in Figure 14.
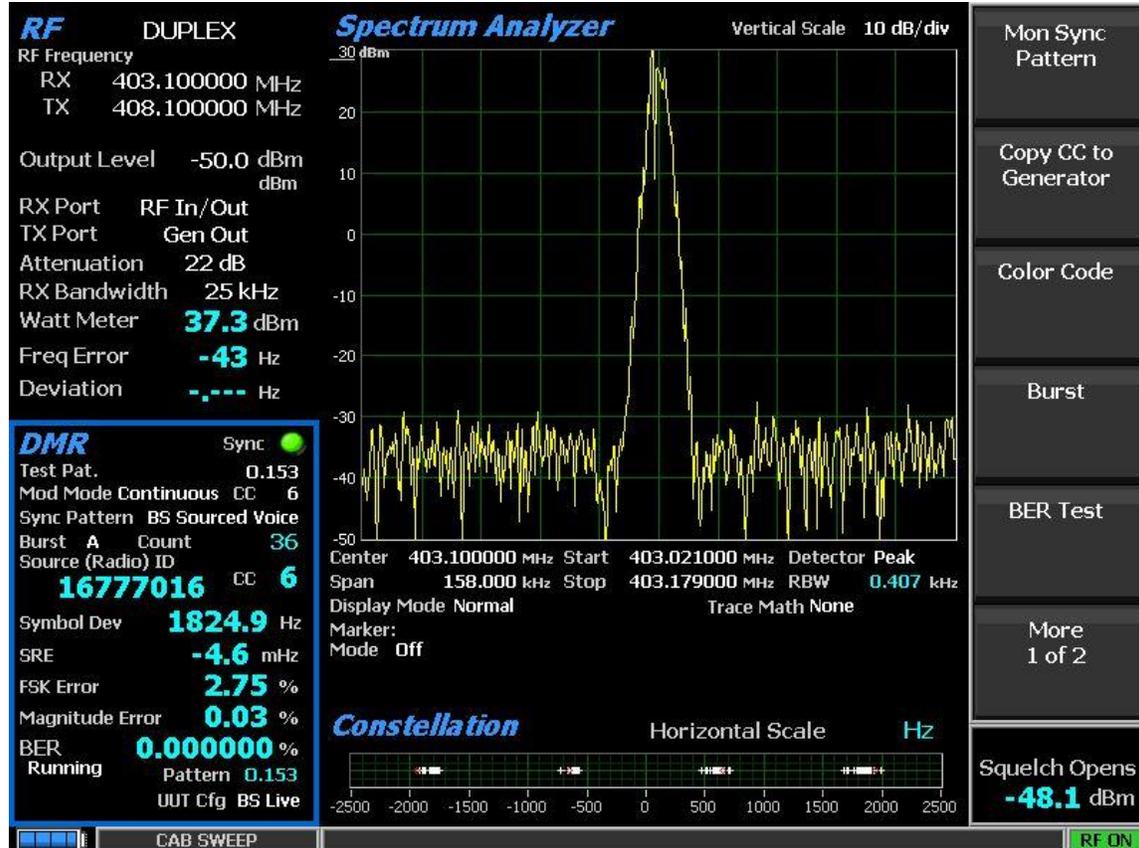
Figure 14   DMR Live mode in operation

There are several setup approaches to get the analyzer into the DMR live test mode and have the test running so no specific order is required.

The following list of parameters the MUST be set correctly for "live repeater testing" to work. If the analyzer will not go into the live repeater test mode, or will not sync, then check this list of items to verify all are properly set:

1) Analyzer is in Duplex operation
2) RX port is set to RF I/O
3) TX port is set to "Gen port" for two cable connection or "RF I/O" for one cable connection.
4) UUT Configuration is set to "Repeater Live"
5) Monitor Sync pattern is set to "BS Source Data"
6) Analyzer TX Color Code is set to the proper value for the repeater channel being tested
7) Analyzer TX frequency is set to repeater RX frequency
8) Analyzer RX frequency is set to repeater TX frequency
9) Modulation Mode is set to Continuous

Step by step configuration:

Select the blue <Duplex> button
Go to "RF zone"
Set the "Monitor Frequency" to the repeater transmit frequency
Set the "Generate Frequency" to the repeater receive frequency
Set Gen port to proper choice, "Gen Out" for two cable connection and "RF I/O" for single cable connection.
For this test mode Auto attenuation works well, so use that.

Go to "DMR zone"

To make setup easier I recommend the following order of steps:
First
Select "UUT Configuration" and press "BS Test" soft key.
Select "Color Code" and set the require color code for the repeater channel under test
Select "Mon Sync Pattern" and press "BS Sourced Data"
Select "Modulation mode" and press "Continuous"

Now go back to "UUT Configuration" and press "Repeater Live"

At this point the analyzer will send a "wake up" burst to the repeater and then look for the repeater broadcast to sync with.

If the spectrum analyzer is selected in display zone the broadcast from the repeater will be seen.

In the message bar at bottom of screen a message "Synchronizing to radio…Please wait"

Very shortly the analyzer will sink to the repeater and start broadcasting data into one of the slots.

If, however after a moment the following message is seen:

"Warning – Synchronization from Radio not found" then something may be incorrect about configuration or cabling.
The analyzer unit will attempt to sync with repeater a couple of times a second.

An easy way to restart the process from the beginning is to hit the blue <MONITOR> key and then the blue <DUPLEX> key.

If after that the system is still not in sync, then review all 9 listed settings above.

Once sync with the repeater is established then multiple measurements can be verified.

The analyzer will already be reporting all basic measurements of the slot that is currently in sync with, which will be the empty slot from the repeater.

To switch to the slot being repeated:

Selected "Mon Sync Pattern" and press "BS Sourced Voice"

Now the analyzer is looking at the returned broadcast data.

To get the BER calculation select "BER Test" and press "Start".

Depending on the repeater under test you may or may not be able to utilize the O.153 test pattern for BER.
The O.153 test pattern is being transmitted in the "voice" frame location, but it does not have the structure of a voice frame. Some repeaters will recognize the improper structure and attempt to fix it, resulting in a large BER measurement.

In that case it is recommended that 1031 Hz Tone be utilized for the BER measurement.
Select "Test Pattern" and press "1031 Hz Tone".
The reference pattern for the BER will also switch to 1031 Hz Tone.

Note: When not using the 1031 Hz Tone, the reference pattern for BER is always O.153.

If the reported BER is >45%, verify the monitor sync pattern is "BS Sourced Voice"
If the reported BER is about 35%, and using O.153, then switch to 1031 Hz tone for test pattern.

Figure 15 is an example of O.153 BER and eye diagram.
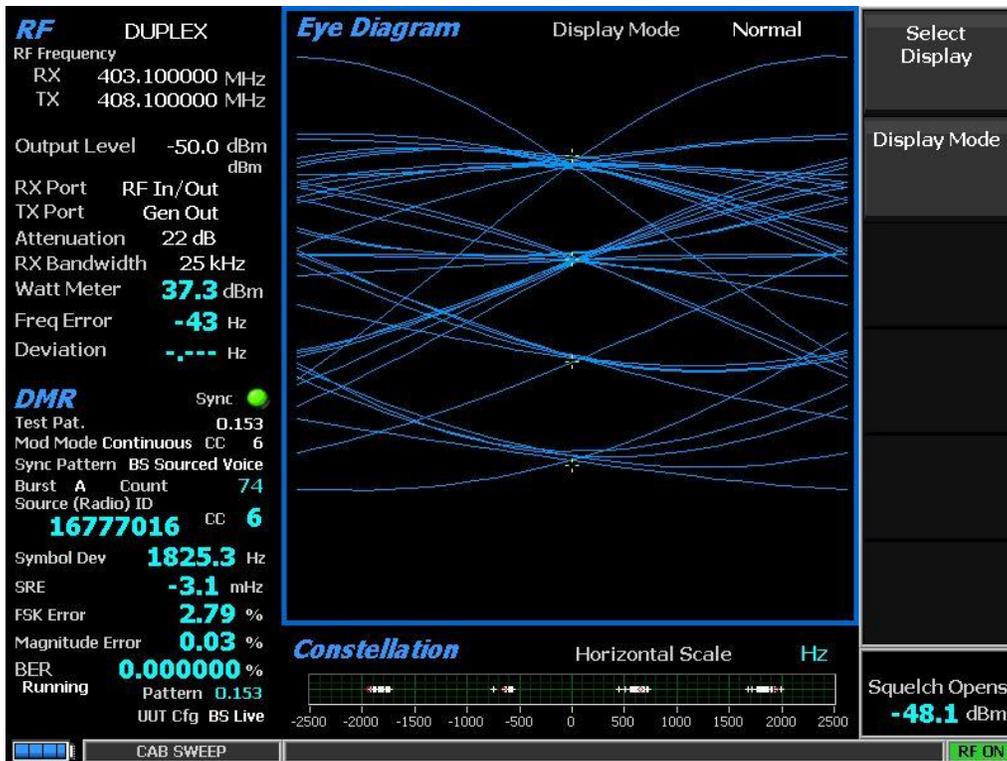
Figure 15 Live Repeater Mode with O.153 BER

Figure 16 is an example of 1031 Hz Tone BER and Protocol Details
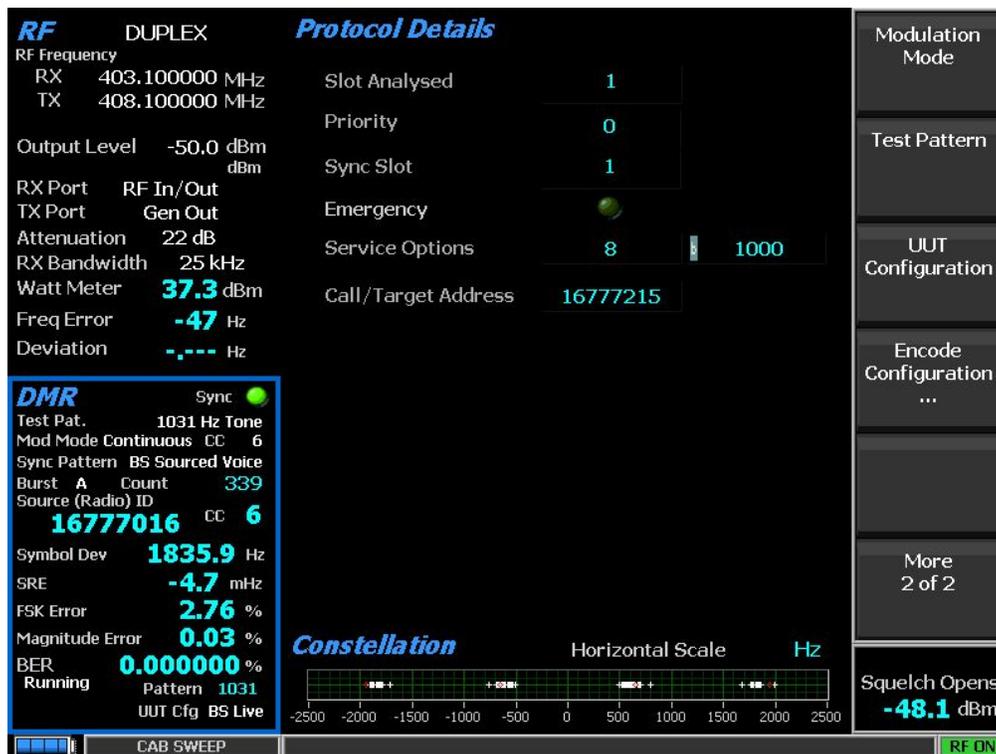
Figure 16 – 1031 Hz Tone BER and Protocol Details

In figure 16 the Protocol Details list the call ID (All call) as well as the slot the analyzer is synced with. In this case slot 1, which is the slot the analyzer is broadcasting into.

To switch slots, select "Encode Configuration"
Then select "Slot#" and select 2.

At same time it is possible to change the transmitted source ID and call ID.
Figure 17 shows a screen shot of changing Source ID to 2441, call ID to 555, emergency on and priority set to 1.

Figure 18 shows the resulting protocol details screen after the changes.
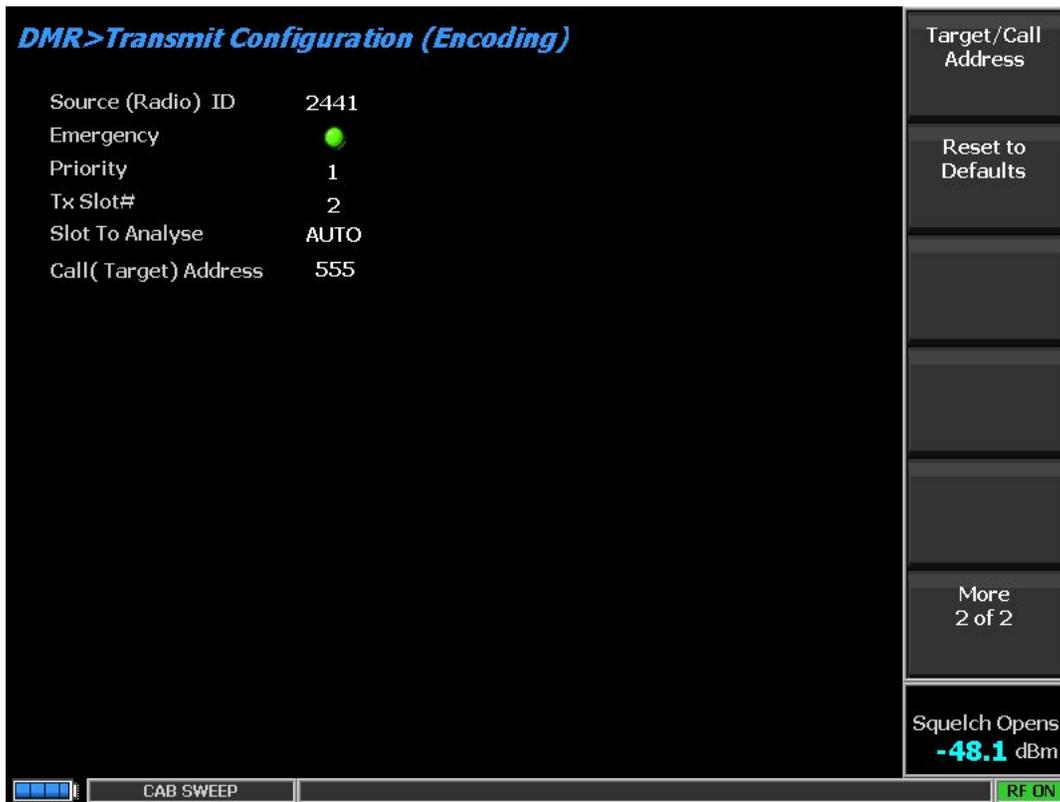
Figure 17 – Encode Configuration screen

Figure 18 – Protocol Details after changes

Utilize the "Reset to Defaults" selection under "Encode Configuration" to return to default transmit call ids.

To check the receiver sensitivity of the repeater it is only necessary to adjust the output level of the analyzer while the BER calculation is active.

For example, the 1031Hz Tone is already in use.
Go to the RF zone and select "Output Level"
Then adjust the level down while monitoring the BER calculation
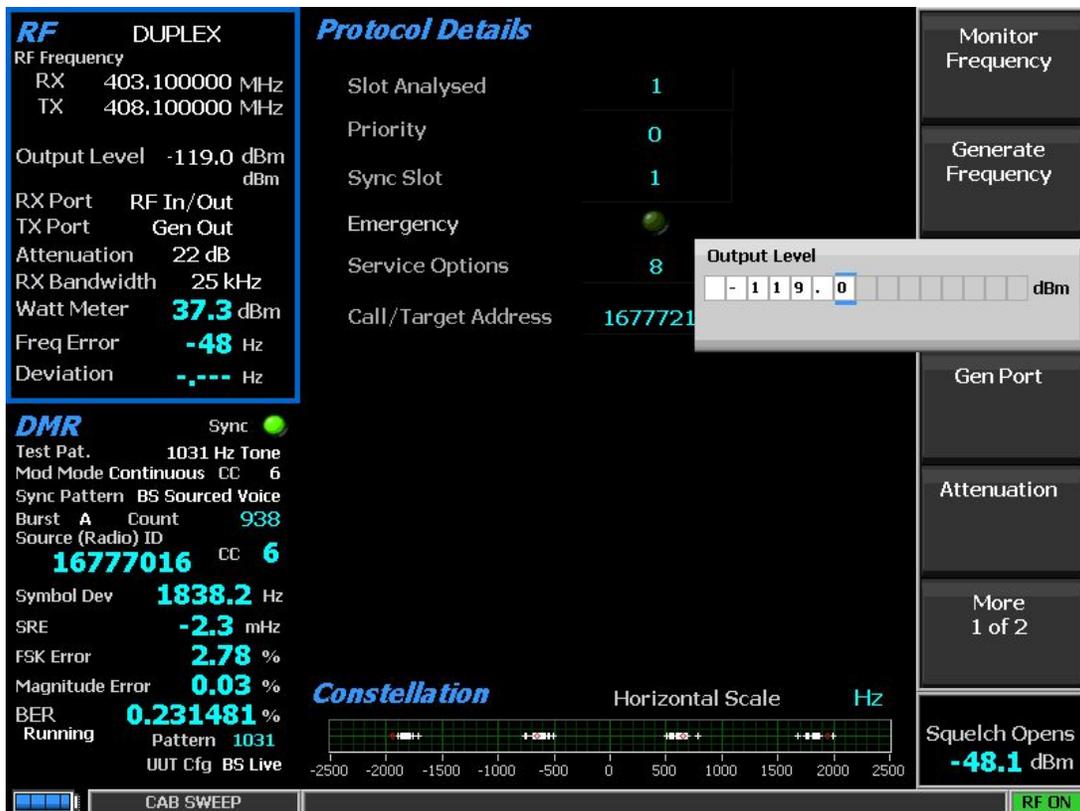
Figure 19 – BER of 1031 Hz tone at low TX into the repeater

Figure 19 shows the BER value increasing as the output level is adjusted.

NOTE: Results of BER will differ with using O.153 vs. 1031 Hz tone due to differences in test patterns. In addition, BER testing in live repeater mode will not give the same results as testing with repeater in test mode due to action of build in correction in live operation.

Conclusion

This application note has described the available capabilities of the Freedom R8xxx DMR test made and detailed the use case of testing a DMR repeater while in operational mode.