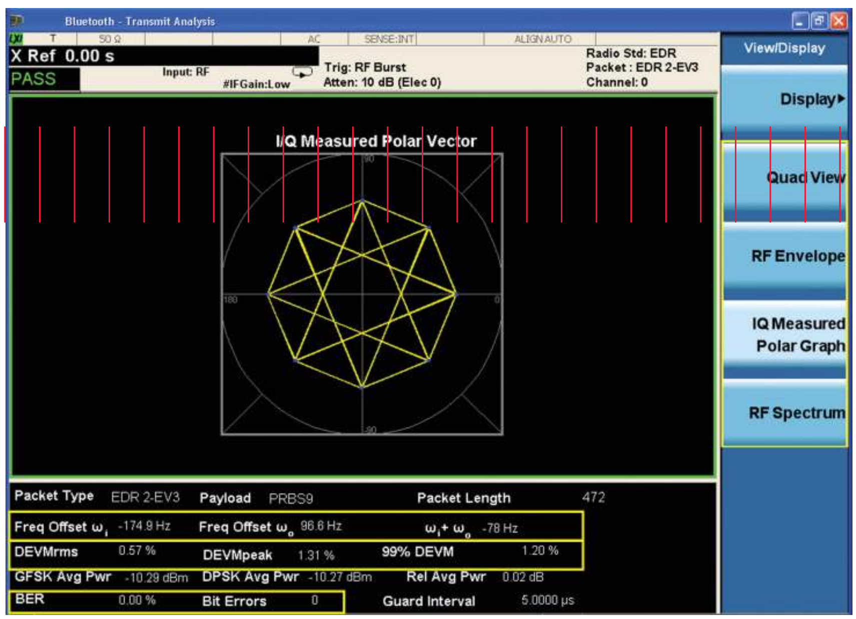
Keysight Technologies
N9081A & W9081A *Bluetooth*®

X-Series Measurement Application

Demo Guide



KEYSIGHT TECHNOLOGIES

Introduction

This demonstration guide will follow the list from Table 1 on page 2 which includes all of the test cases for transmitter tests defined by the *Bluetooth* SIG in version 2.1+EDR of the test specification and ULP (Ultra Low Energy) *Bluetooth* RF PHY Test Specification. Each demonstration is given a brief description of its function.

Bluetooth RF Transmitter Tests

Table 1. Bluetooth RF transmitter tests

Bluetooth transmitter tests	Identifier	N/W9081A X-Series measurement application
Basic rate		
Output power	TRM/CA/01/C	Transmit analysis
Power density	TRM/CA/02/C	No one-button support. Use GPSA mode. Not included in this document
Power control	TRM/CA/03/C	No one-button support, Use GPSA mode. Not included in this document
TX output spectrum frequency range	TRM/CA/04/C	No one-button support, use GPSA mode. Not included in this document
TX output spectrum –20 dB bandwidth	TRM/CA/05/C	Output spectrum bandwidth
TX output spectrum adjacent channel power	TRM/CA/06/C	Adjacent channel power
Modulation characteristics	TRM/CA/07/C	Transmit analysis
Initial carrier frequency tolerance	TRM/CA/08/C	Transmit analysis
Carrier frequency drift	TRM/CA/09/C	Transmit analysis
EDR		
EDR relative transmit power	TRM/CA/10/C	Transmit analysis
EDR carrier frequency stability and modulation accuracy	TRM/CA/11/C	Transmit analysis
EDR differential phase encoding	TRM/CA/12/C	Transmit analysis
EDR in-band spurious emissions	TRM/CA/13/C	EDR in-band spurious emissions
LE (Low Energy) or ULP (Ultra Low Power)		
Output power	TRM/CA-01-C	Transmit analysis
In-band emissions	TRM/CA-02-C	LE in-band emissions
Modulation characteristics	TRM/CA-03-C	Transmit analysis
Carrier frequency offset and drift	TRM/CA-04-C	Transmit analysis

Demonstration Preparation

All demonstrations utilize the N9030A PXA, N9020A MXA or N9010A EXA signal analyzer with the N9081A *Bluetooth* measurement application, the N9000A CXA with the W9081A *Bluetooth* measurement application, and the Keysight Technologies, Inc. N5182A MXG vector signal generator with the N7606B *Bluetooth* Signal Studio software.

Keystrokes surrounded by [ ] indicate hard keys on X-Series analyzers, while key names surrounded by { } indicate soft keys located on the right edge of the X-Series display.

Minimum equipment configuration requirements

Product type	Model number	Required options
MXG vector signal generator Note: ESG-C can also be used	N5182A (or E4438C)	– 503 or 506 – frequency range at 3 GHz or 6 GHz – 651,652 or 654 – internal baseband generator – Option 654 – 125 MSa clock rate required for MXG not for ESG-C
Signal Studio software for *Bluetooth*	N7606B – V1.2.1.0 or later	– 3FP – N5182A connectivity – QFP – Advanced *Bluetooth* V1.1 option – RFP – Advanced *Bluetooth* V2.1 + EDR option – SFP – Advanced *Bluetooth* ultra low power option
X-Series signal analyzer	N9030A PXA N9020A MXA N9010A EXA N9000A CXA Note: Firmware revision A.06.06 or later	– 503, 508 (507 for EXA), 513 or 526 – frequency range up to 26.5 GHz – B25 – 25 MHz analysis bandwidth
X-Series *Bluetooth* measurement application	N9081A-2FP W9081A-2FP	– *Bluetooth* measurement application (for PXA/MXA/EXA) – *Bluetooth* measurement application (for CXA only)
Controller PC for Signal Studio		Install N7606B to generate and download the signal waveform into the MXG via GPIB or LAN (TCP/IP) – please refer to the online documentation for installation and setup

Helpful tip:

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

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

Demonstration Setup

Connect the PC, X-Series signal analyzer, and MXG signal generator

Connect a PC (loaded with N7606B Keysight Signal Studio for *Bluetooth* software and Keysight I/O libraries) to the N5182A MXG via GPIB or LAN. Follow the Signal Studio instruction to complete the connection, then perform the following steps to interconnect the X-Series and MXG (see Figure 1 for a graphical overview):

A. Connect the MXG RF Output port to the MXA RF Input port

B. Recommend to connect the MXG 10 MHz Out to the X-Series Ext Ref In port (rear panel) for frequency accuracy

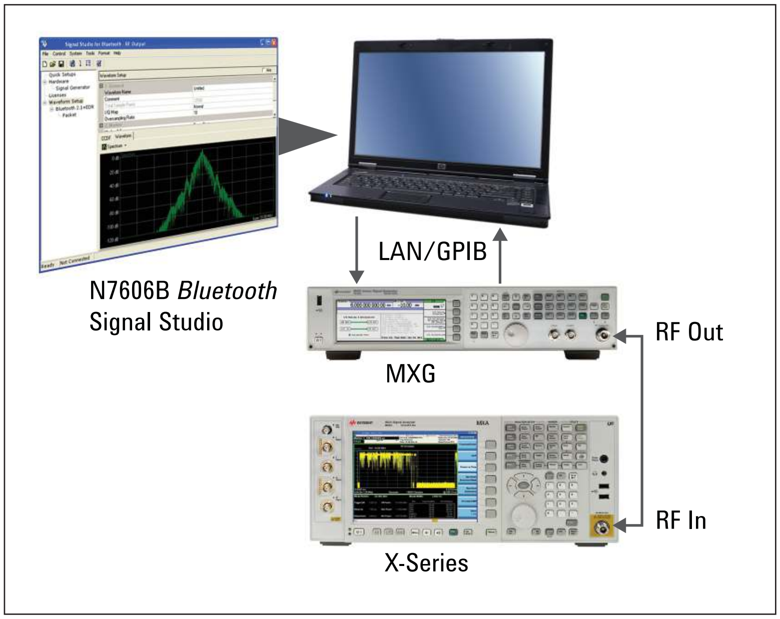
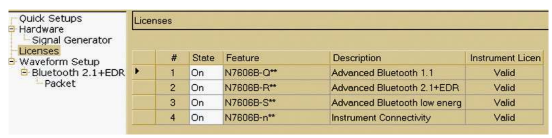


Figure 1. Demonstration setup

Generate *Bluetooth* waveform with Signal Studio on N5182A MXG

The Keysight N7606B Signal Studio for *Bluetooth* is a Windows-based utility that simplifies the creation of standards-based waveforms for *Bluetooth* v2.1+EDR and low energy wireless technology testing.

Instructions	Keystrokes
On the MXG	
Preset the MXG; check the IP address	**[Preset]** **[Utility] {I/O Config} {GPIB/LAN Setup}** e.g. **{GPIB Address 20}**
On the Signal Studio software	
Run the Keysight Signal Studio for *Bluetooth*	Double-click on the ***Bluetooth*** shortcut on the desktop or access the program via the Windows start menu
Verify the software is communicating with the instrument via the GPIB or LAN (TCP/IP) link	To establish a new connection, click on the **{System}** pull-down menu at the top of the Signal Studio program window. Next, select **{Run System Configuration Wizard}**
Use the basic parameters of the signal at center frequency 2.402 GHz, amplitude –10 dBm, and RF Output turned ON	Click **Signal Generator** at the Hardware on the explorer menu on the left. Press **[Preset]** green button on the top. Then use the default setting Frequency = 2.402 GHz, Amplitude = –10 dBm, RF Output = On, ALC = On
Set a test signal in waveform setup; the N7606B needs to install the following option(s) for: *Bluetooth* 1.1 – Option QFP, *Bluetooth* 2.1+EDR – Option RFP, *Bluetooth* low energy – Option SFP	Verify which version of standard *Bluetooth* signals supported in your *Bluetooth* signal studio. Click **Licenses** on the Explorer menu on the left, and ensure that the states for N7606B-x* is set to On * x represents Q, R, S, or n  The *Bluetooth* low energy wireless technology packet can be selected from the **Format** in the menu bar 
Download the signal to the MXG	Click **Generate and Download** button on the top tool bar. If you encounter any errors, please refer to the online help of Signal Studio software
Save the signal file for future use	**File > Save Setting File > Bluetooth_Demo1.scp** (name it as you like)

Demonstrations

Demonstration 1:

Transmit analysis for *Bluetooth* basic rate and low energy technologies

The RF transmit power and modulation characteristics measurements are combined into this single transmit analysis in the N/W9081A with one-button measurement for basic rate and low energy technologies. From the perspective of test cases for the *Bluetooth* RF layer certification testing, this one-button measurement can perform and complete the test purposes (TP) listed in Table 2 at one time.

The automation detection and predefined parameter are set up by pushing the one-button transmit analysis measurement and display a single view with four traces (Figure 2).

*Table 2. Transmit analysis for basic rate and ultra low energy (ULE)**

TP identifier	Transmit tests	Demonstrations in N/W9081A
TRM/CA/01/C	Output power	Demo 1.1
TRM/CA/07/C	Modulation characteristics	Demo 1.2
TRM/CA/08/C	Initial carrier frequency tolerance	Demo 1.3
TRM/CA/09/C	Carrier frequency drift	Demo 1.4

* *Note: The ULE Bluetooth RF PHY test cases and implementations are derived from the basic rate Bluetooth RF test cases. For the transmit analysis, both have the same test conditions. For the following demonstrations, we will use the Bluetooth basic rate signals.*

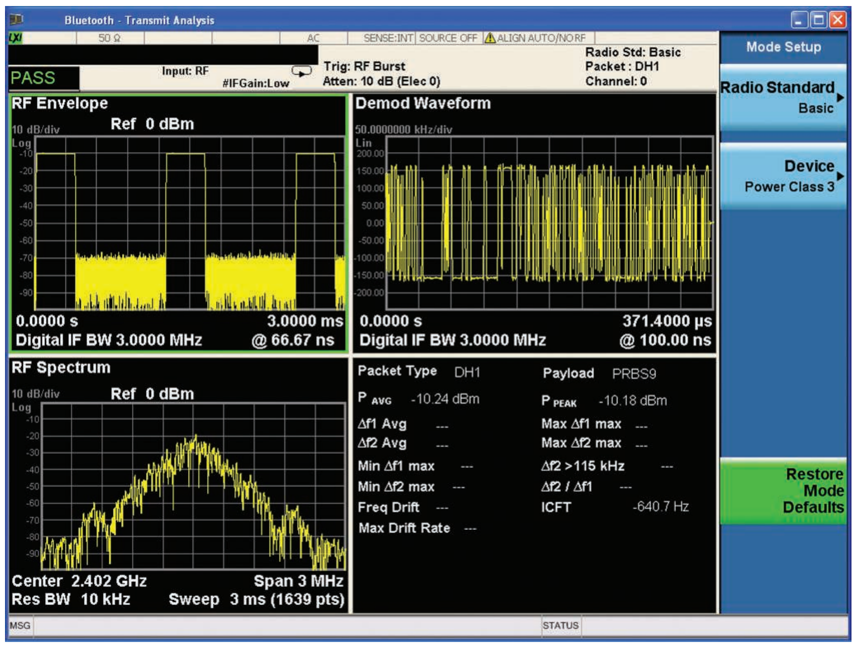


Figure 2. Transmit analysis for a Bluetooth basic rate signal
Top left: RF envelope
Top right: Demodulation waveform
Bottom left: RF spectrum
Bottom right: Numeric summary table

Demonstration 1.1:

Output power (TRM/CA/01/C)

Power level is a critical parameter in digital communication systems. The power tests help to ensure that power levels are high enough to maintain links, yet low enough to minimize interference within the ISM band and to maximize battery life. *Bluetooth* devises are classified according to three power classes shown in Table 3.

Most portable *Bluetooth* devices are in Power Class 1 or 2 (with a nominal output power of 0 dBm), due to cost and battery life issues. In Table 3, the power limit ranges are also defined in the N/W9081A *Bluetooth* measurement application.

Output power measurements are performed in the time domain. Because the *Bluetooth* signal is a sequence of TDD bursts, it is necessary to trigger properly. Triggering occurs on the rising edge of the envelope to obtain a viewable signal. Figure 3 illustrates power and timing characteristics of a standard *Bluetooth* signal burst in the time domain.

Table 3. Bluetooth transmit power classification

Power class	Output power range	Power limit range on N/W9081A
1	1 to 100 mW	0 to + 20 dBm
2	0.25 to 2.5 mW	–6 to + 4 dBm
3	1 mW max power	–100 to 0 dBm

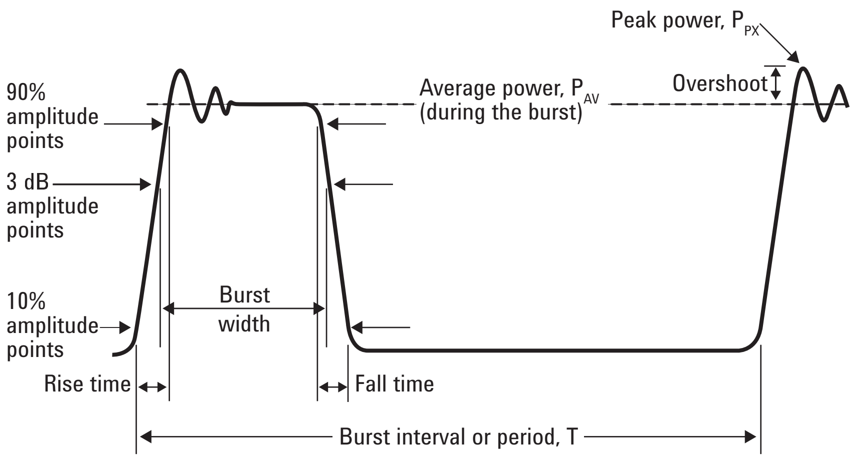


Figure 3. Time domain power and timing analysis

Helpful tip:

Signal Studio *Bluetooth* generates –10 dBm signal power in default, but the N/W9081A predefines the device power class at 1, so in order to achieve the PASS indication, you need to change the power class from 1 to 3 under the Mode Setup. Refer to Figure 2.

In the N/W9081A, the *Bluetooth* signal with packet type, payload and packet length in bits can be automatically determined. The following power measurement parameters can be controlled:

– Burst synchronization method: Preamble (p0 defines the start of the burst), RF amplitude (3 dB points of the burst) and None (no synchronization process)

– Output power start and stop markers can be modified (default to start at 20% and stop at 80% per standard required)

– Trigger source: free run, video, external-1 /2, and RF burst (default is RF burst)

– Display results as average power and peak power

X-Series instructions	Keystrokes
Select *Bluetooth* mode	**[Mode Preset] [Mode] {Bluetooth}**
Change a center frequency if it is not at the default 2.402 GHz	**{Center Freq] [Center Frequency Number] {GHz}** In this demonstration, we use the default center frequency at 2.402 GHz
Run a transmit analysis measurement	**[Meas] {Transmit Analysis}**
Choose power class for device	**[Mode Setup] {Device} {Power Class 3}**
Select RF Envelope view (Figure 4)	**[View/Display] {RF Envelope}**
Change acquisition time to see one burst *Bluetooth* signal	**[Sweep/Control] {Acquisition time}** Push the button of [⬇] down key and make the trace to a best display position (see Figure 5)

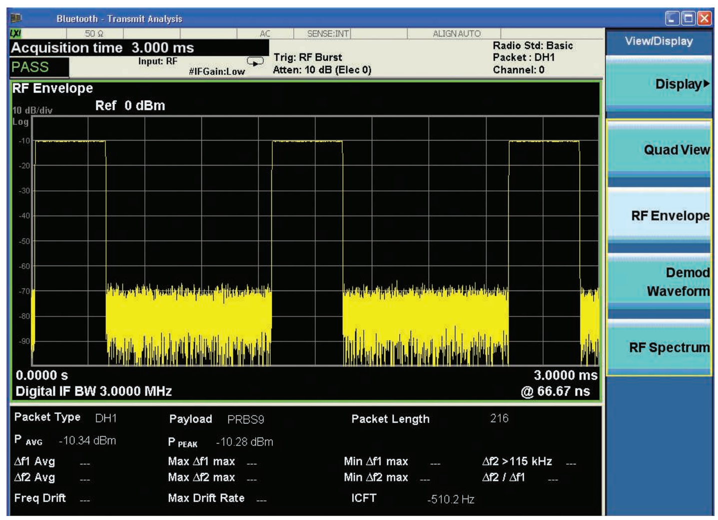


Figure 4. RF envelope view of transmit analysis measurement for the Bluetooth basic rate

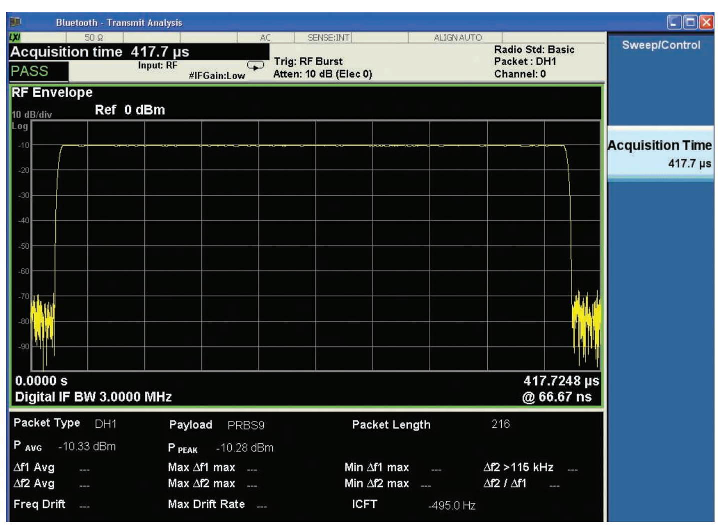


Figure 5. The Bluetooth one burst signal (DH1 packet, PRBS9 as payload and packet length 216 bits)

Demonstration 1.2:

Modulation characteristics (TRM/CA/07/C)

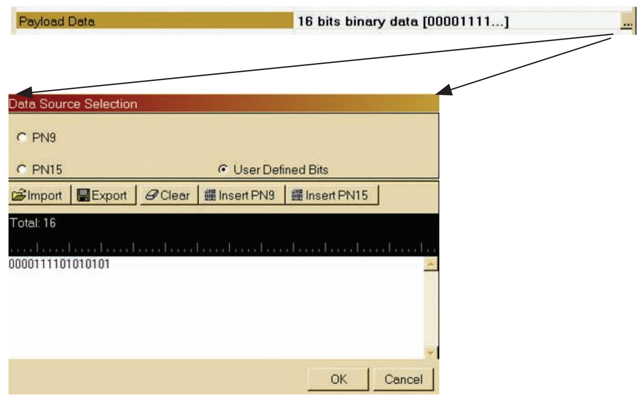
The modulation characteristics test is a frequency deviation measurement. For modulation characteristics, two sets of a repeating 8-bit sequence are used in the payload. These are 00001111 and 10101010. The combination of the two sequences checks both the modulator performance and the pre-modulation filtering. This test procedure requires using the longest supported packets and running the measurement at the lowest, middle, and highest operating frequencies. In the standard, the test procedures are quite complex to have Δf1max, Δf1avg for the pattern 00001111, and Δf2max and Δf2avg for the resulting 01010101 pattern. The following measurement conditions are verified to ensure the modulation characteristics:

1. 140 kHz ≤ Δf1avg ≤ 175 kHz
2. Δf2max ≥ 115 kHz
3. Δf2max /Δf1avg ≥ 0.8

The N/W9081A provides the ability to perform this test automatically.

– Modulation graph and numeric results showed at same time
– Provide "Pass" or "Fail" indicator per standard conditions

Generate the payload sequence 00001111 and 01010101 in the Signal Studio:

Signal Studio Instructions	Keystrokes
Modify the waveform setup	Click on **Packet** under *Bluetooth* 2.1+EDR on the Explorer menu on the left
Manually set the payload date	Click on **Payload Data** in the manual of Payload Setting under Packet Parameters Setup on the right, then find a small button ... in end that line, click it to access a dialog box to define the packet payload
Type the bits	Select **User Defined Bits**, type **0000111101010101** in the blank area, the user interface should looks like:  Click **OK** button
Download the signal to the MXG	Then Press **Generate and Download** button on the top tool bar

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Select the transmit analysis	**[Meas] {Transmit Analysis}**
View demodulation waveform only (Figure 6)	**[View/Display] {Demod Waveform}**

The numeric results are shown in the bottom view trace, the details are:

Packet type:	DH1
Payload:	User defined bits
Packet length:	216
P_{AVG}:	–10.33 dBm
P_{PEAK}:	–10.29 dBm
Δf1avg:	156.5 kHz
Max Δf1max:	157.8 kHz
Min Δf1max:	156.2 kHz
Δf2 >115 kHz:	100%
Δf2avg:	144.1 kHz
Max Δf2max:	162.8 kHz
Min Δf2max:	136.2 kHz
Δf2/Δf1:	0.92
Freq drift:	none
Max drift rate:	none
ICFT:	–1.054 kHz

Figure 6. The demodulation waveform shows the modulation characteristics measurement for the Bluetooth basic rate

Demonstration 1.3:

Initial carrier frequency tolerance (TRM/CA/08/C)

The initial carrier frequency tolerance test (also called frequency offset test) verifies the accuracy of the transmitter's carrier frequency. A standard DH1 packet with a preamble and with a pseudorandom bit sequence (PRBS) as payload is used. The initial four bits of a packet, the preamble bits, are analyzed to determine the extent of the frequency deviation from center frequency. This measurement requires the signal to be demodulated to measure the frequency deviation of each symbol. After demodulation, the frequency offset of each of the preamble bits is measured and averaged.

Generate the packet type DH1 with payload sequence PRBS9 in the Signal Studio:

Signal Studio instructions	Keystrokes
Modify the waveform setup	Click on **Packet** under *Bluetooth* 2.1+EDR on the Explorer menu on the left
Manually set the payload date	Click on **Payload Data** in the manual of Payload Setting under Packet Parameters Setup on the right, then find a small button in end that line, click it to access a dialog box to define the packet payload
Type the bits	Check **PN9** in the Data Source Selection Click **OK** button
Download the signal to the MXG	Press **Generate and Download** button on the top tool bar

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Select transmit analysis	**[Meas] {Transmit Analysis}**
View demodulation waveform only	**[View/Display] {Demod Waveform}**
Stop the trace updates	Press **[Single]** button
Zoom in for the first eight bits display (Figure 7)	Then press **[SPAN X Scale] {Scale/div}** Enter 4 us of Scale/div The ICFT result is showing –452.1 Hz offset, and the first four of these bits comprise the 1010 preamble. (The ICFT result should be different from this demonstration, it is an instantaneous value)

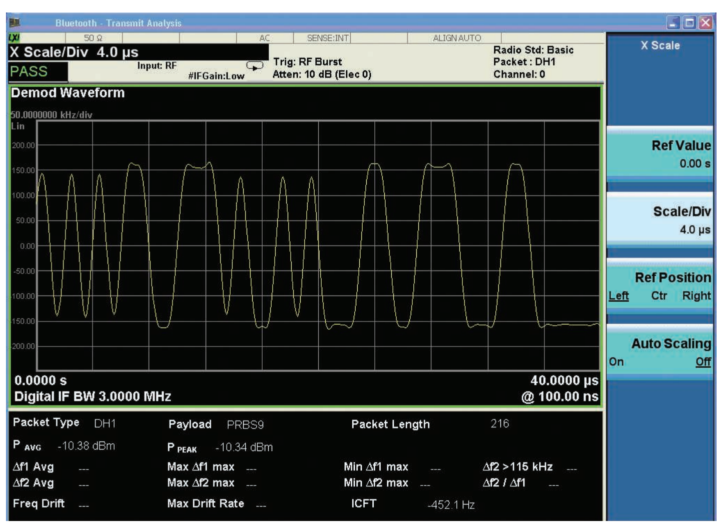


Figure 7. Zooming in ICFT result with the demodulation waveform

Demonstration 1.4:

Carrier frequency drift (TRM/CA/09/C)

Carrier frequency drift consists of verification of the transmitter center frequency drift with a packet. As with the two previous tests, modulation characteristics and initial carrier frequency tolerance, carrier frequency drift is also measured as a demodulated signal. In the standard, this carrier frequency drift test is required for three types of packets (DH1, DH3, DH5) with payload data consisting of a repeating 4-bit 1010 sequence.

In the N/W9081A, this carrier frequency drift is combined into the transmit analysis measurement with modulation characteristics and initial carrier frequency tolerance.

Generate the packet type DH3 with payload sequence 1010 in the Signal Studio:

Signal Studio instructions	Keystrokes
Modify the waveform setup	Click on **Packet** under *Bluetooth* 2.1+EDR on the explorer menu on the left
Change the packet type to DH3	Click on **Packet Type** in the manual of General Setting under Packet Parameters Setup on the right, pull-down menu of the packet type to find DH3
Manually set the payload date	Click on **Payload Data** in the manual of Payload Setting under Packet Parameters Setup on the right, then find a small button ... at the end of that line, click it to access a dialog box to define the packet payload
Select user defined bits	Select **User Defined Bits**, type **1010** in the blank area. Click **OK** button
Download the signal to the MXG	Press **Generate and Download** button on the top tool bar

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Change the test status from single to continue	Press **[Cont]**
Select transmit analysis	**[Meas] {Transmit Analysis}**
View demodulation waveform only	**[View/Display] {Demod Waveform}**
Modify the scale of X-axes (Figure 8)	**[SPAN X Scale] {Scale/div}** Enter 40 us of Scale/div

Figure 8 results show the following:
Frequency drift: 375 Hz
Max drift rate: 264 Hz/50 μs

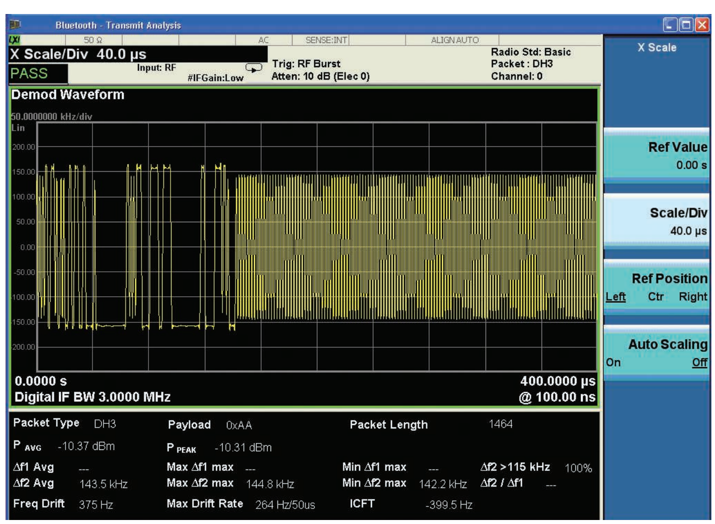


Figure 8. Frequency drift result for DH3 with 1010 payload

Demonstration 2:

Transmit output spectrum for *Bluetooth* basic rate and low energy technologies

The transmit output spectrum measurements analyze the power levels in the frequency domain to ensure that out-of-channel emissions are minimized. These help reduce overall system interference and ensure regulatory compliance. In the *Bluetooth* core specification, the transmit output spectrum consists of three parts, frequency range, –20 dB bandwidth and adjacent channel power. Since the frequency range test can be performed in the spectrum analyzer mode, we will not discuss it here and instead focus on the other two measurements in Table 4.

Table 4. Transmit output spectrum measurements for Bluetooth basic rate

TP identifier	Transmit tests	Demonstrations in N/W9081A
TRM/CA/05/C	Tx output spectrum –20 dB bandwidth	Demo 2.1
TRM/CA/06/C	Tx output spectrum – adjacent channel power	Demo 2.2

Demonstration 2.1:

Tx output spectrum –20 dB bandwidth (TRM/CA/05/C)

The –20 dB bandwidth is the difference between the frequency points below and above the operating frequency, as transmit power drops 20 dB. This test is performed at the lowest, middle and highest frequency channels. In the specification, it requires to use a 2 MHz span, peak detector and max hold mode with RBW 10 kHz and VBW at 30 kHz. In the N/W9081A, all of these parameters are already predefined in the signal analyzer.

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Preset the *Bluetooth* mode	**[Mode Preset]** green key on top right hand corner of the X-Series hardware
Measure the output spectrum bandwidth (Figure 9)	**[Meas] {Output Spectrum BW}**
Adjust parameters if necessary	**[Meas Setup Scale]**

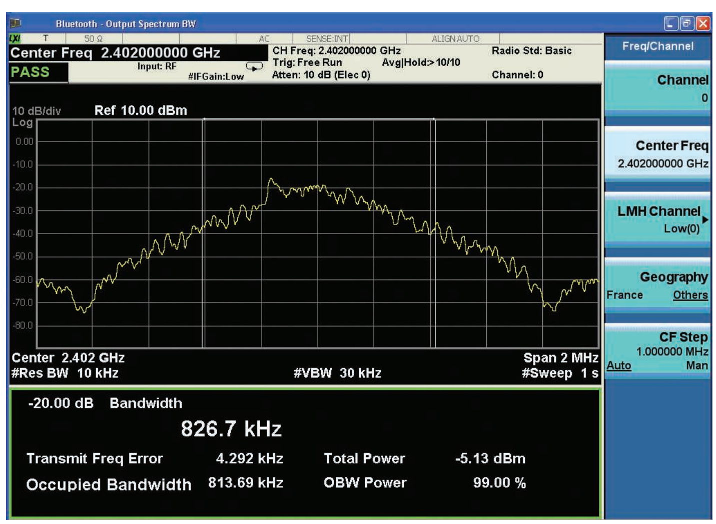


Figure 9. A –20 dB output spectrum bandwidth for a Bluetooth basic rate signal at the lowest channel (0)

Demonstration 2.2:

Tx output spectrum – adjacent channel power (TRM/CA/06/C)

The adjacent channel power, also known as ACP, is the most complex of the transmit output spectrum measurements. In the specifications, the power measurements are total peak powers for adjacent channels. It defines the equipment under test (EUT) transmitting on channel M and the adjacent power measured on channel N. The following conditions must be verified for compliance:

P_{TX} (f) ≤ –20 dBm for |M-N| = 2
P_{TX} (f) ≤ –40 dBm for |M-N| ≥ 3

The N/W9081A, with a proprietary algorithm, performs a very quick ACP measurement with the press of a single button. It makes the complex ACP measurement easy and provides an ideal tool for precompliance test.

Change the center frequency in the Signal Studio:

Signal Studio instructions	Keystrokes
Change the frequency	Select **Signal Generator** under Hardware on the left, Click on **Frequency** line of Basic under Instrument Controls on the right, type **2.441 GHz**
Download the signal to the MXG	Press **Generate and Download** button on the top tool bar

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Set the middle channel	**[Freq] {LMH Channel}{Mid(39)}**
Measure the adjacent channel power (Figure 10)	**[Meas] {Adjacent Channel Power}**
Adjust parameters if necessary	**[Meas Setup]**

Figure 10 shows an ACP measurement performed for channel 39 (M=39). The condition P_{TX} (f) ≤ –20 dBm is checked for channels 37 and 41 (N=37, 41) and the condition P_{TX} (f) ≤ –40 dBm is verified for the rest of the channels. The conditional limits can be changed under [Meas Setup].

Figure 10. ACP measurement

Demonstration 3:

Transmit analysis for *Bluetooth* EDR

The *Bluetooth* core specification has evolved to support 2 Mb/s and 3 Mb/s peak data rates with the introduction of the enhanced data rate (EDR) feature. The key characteristic of the EDR packet is the change in modulation to differential phase shift keying (DPSK) following the packet header. The 2 Mb/s EDR packets use a π/4-DQPSK modulation and the 3 Mb/s EDR packets use 8DPSK modulation. The former is a mandatory function in any v2.0+EDR compliant radio, the 8DPSK is optional. Figure 11 shows the format for an EDR packet.

There is another one button measurement of transmit analysis for EDR in the N/W9081A which performs and completes the test purposes (TP) in the Table 5 at one time.

A single view with four traces in shown in Figure 12.

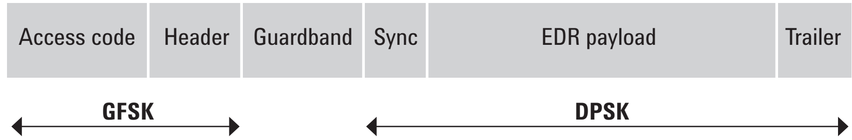


Figure 11. Bluetooth EDR packet format

Table 5. Transmit analysis for enhanced data rate (EDR)

TP identifier	Transmit tests	Demonstrations in N/W9081A
TRM/CA/10/C	EDR relative transmit power	Demo 3.1
TRM/CA/11/C	EDR carrier frequency stability and modulation accuracy	Demo 3.2
TRM/CA/12/C	EDR differential phase encoding	Demo 3.3

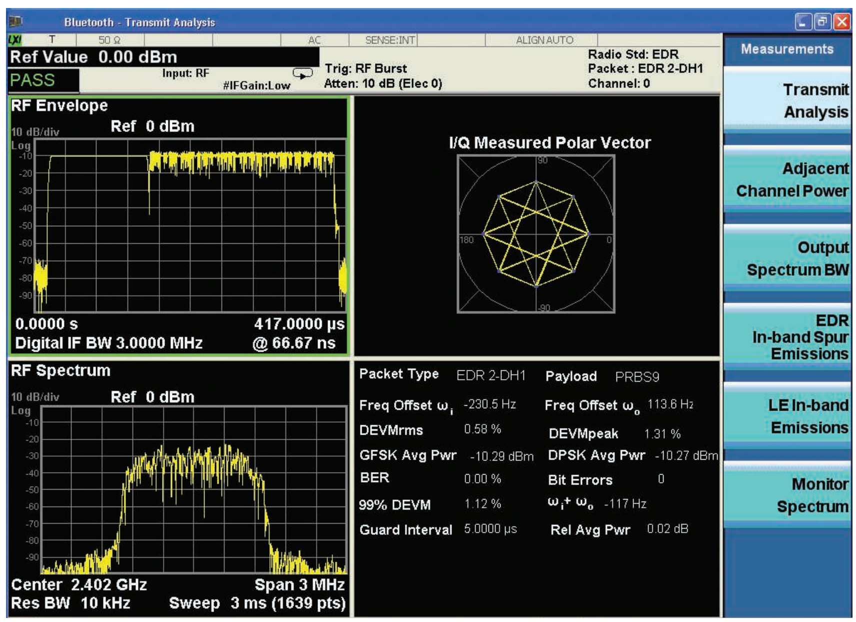


Figure 12. Transmit analysis for an EDR signal
Top left: RF envelope
Top right: I/Q measured constellation/polar graph of an EDR payload
Bottom left: RF spectrum
Bottom right: Numeric summary table

Demonstration 3.1:

EDR relative transmit power (TRM/CA/10/C)

The EDR relative transmit power verifies the difference between the average transmit power during the GFSK modulation and the average transmit power during the DPSK modulation within a specified range. The relative output is expected to comply with the following measurement condition:

$(P_{GFSK} - 4\text{ dB}) < P_{DPSK} < (P_{GFSK} + 1\text{ dB})$.

Generate the *Bluetooth* EDR signal in the Signal Studio:

Signal Studio instructions	Keystrokes
Modify the waveform setup	Click on **Packet** under *Bluetooth* 2.1+EDR on the Explorer menu on the left
Select a predefined EDR signal	Explore the menu of the **Link Type** under General Setting, click on **ACL (Enhanced Data Rate)**
Download the signal to the MXG	Click **OK** button, then press **Generate and Download** button on the top tool bar

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Select transmit analysis	**[Meas] {Transmit Analysis}**
View RF envelope only	**[View/Display] {RF Envelope}**
Make the measurement in single mode	**[Single]**
Zoom in for one burst display of preamble and payload (Figure 13)	**[SPAN X Scale] {Scale/div}** Enter 44 µs of Scale/div

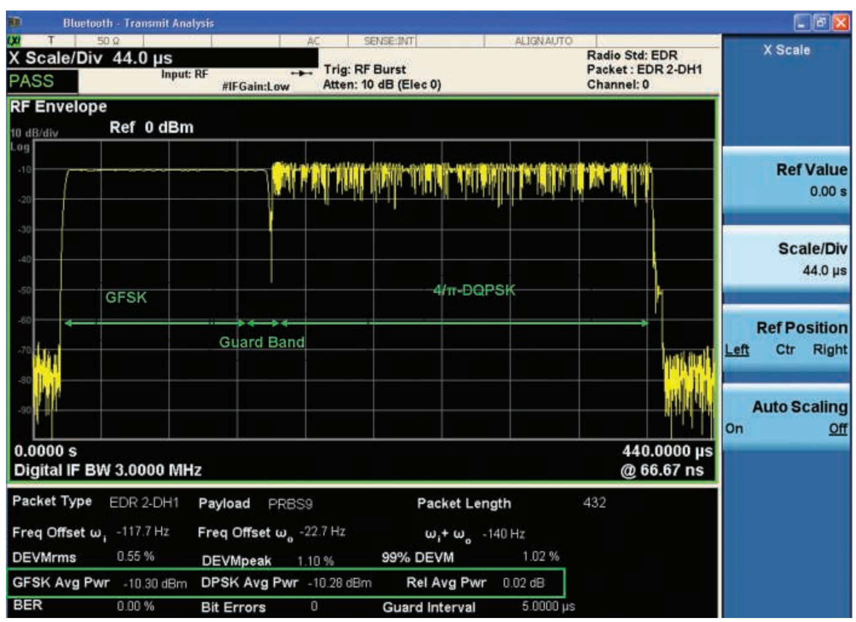


Figure 13. This RF envelope shows the N/W9081A displaying the transition between GFSK and 4/π-DQPSK modulation schemes with the guard band separating the two modulation schemes when transmitting a 2-DH1. The EDR relative transmit power results are framed in the lower numerical trace. Note: The green markers/data are for illustrative purposes and not actually displayed on the instrument's screen.

Demonstration 3.2:

EDR carrier frequency stability and modulation accuracy (TRM/CA/11/C)

This test verifies that the modulation accuracy and the frequency stability are working within the required limits. The EDR carrier frequency stability test verifies the frequency stability for the transmitter's RF center frequency carrier. According to the *Bluetooth* RF core specification, this measurement requires to records 200 non-overlapping blocks, each with a length of 50 symbols (μs) for evaluation. The Figure 14 illuminates the ωi (reported as initial frequency error) and ω0 (the worst-case block frequency error) with their limits.

The maximum value of the combined frequency errors, ωi+ω0, to ± 75 kHz.

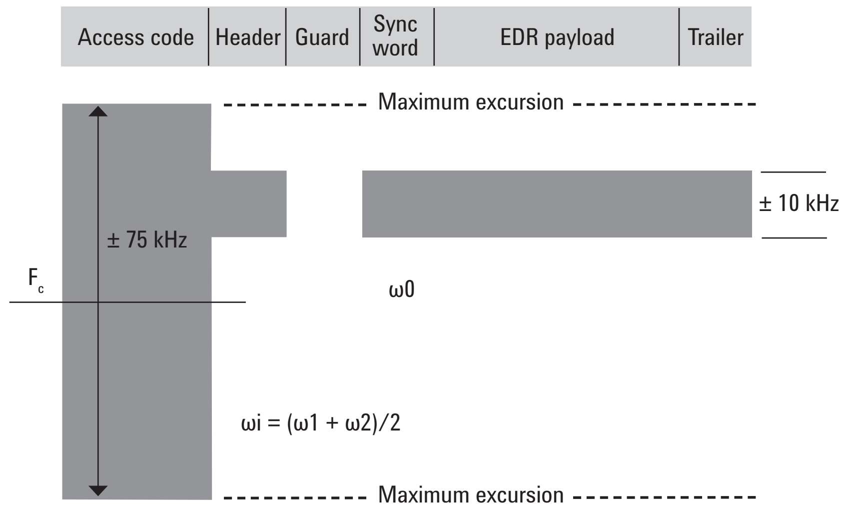


Figure 14. The carrier frequency stability limits over different portions of the Bluetooth EDR packet

Generate the *Bluetooth* EDR signal in the Signal Studio:

Signal Studio instructions	Keystrokes
Modify the waveform setup	Click on **Packet** under *Bluetooth* 2.1+EDR on the Explorer menu on the left
Select a predefined EDR signal	Explore the menu of the **Link Type** under General Setting, click on **eSCO** (**Enhanced Data Rate)**
Select a different packet type	Explore the menu of the **Packet Type** under General Setting, click on **6: 2-EV3** [1]
Download the signal to the MXG	Click **OK** button, then press **Generate and Download** button on the top tool bar

1. There are five packet types have been defined to use for the TRM/CA/11/C measurement item

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Select transmit analysis	**[Meas] {Transmit Analysis}**
View constellation only (Figure 15)	**[View/Display] {IQ Measured Polar Graph}**
Make the measurement to continue mode	**[Cont]**

Figure 15 shows that an instantaneous initial frequency stability is measured as –174.9 Hz, the block frequency error as 96.6 Hz and combined frequency error as –78 Hz.

The modulation accuracy is tested using a differential error vector magnitude (DEVM) measurement. The DEVM measurement is similar to the traditional error vector magnitude (EVM) measurement specified in other digital communication system. The DEVM defined in the *Bluetooth* core specification represents the magnitude of the error between two received signals spaced one symbol apart in time. The error is measured after all linear distortions are removed from the received signal, which includes tracking the frequency drift of the carrier. The modulation accuracy is reported as three separate values, the 99% DEVM, RMS DEVM, and peak DEVM. Figure 15 also provides these three results in the third line in the numerical summary table.

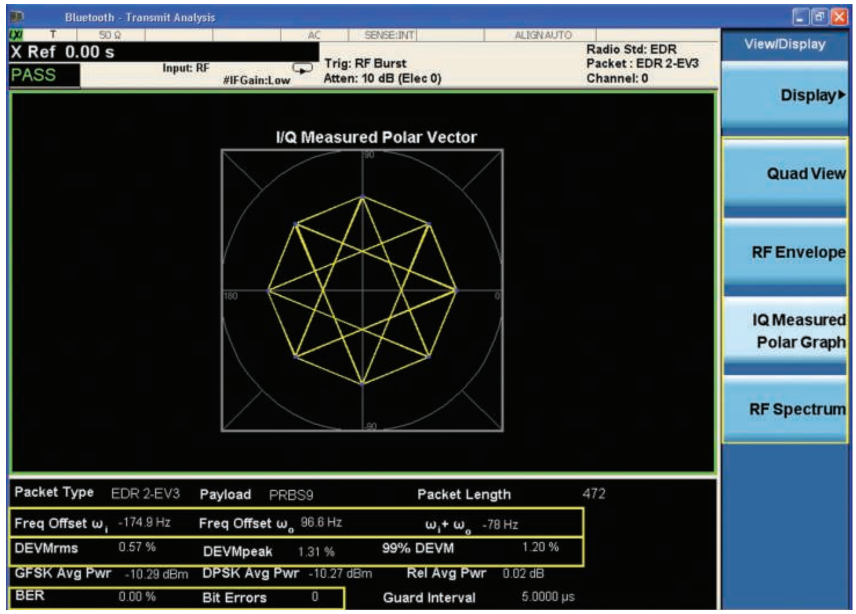


Figure 15. Constellation view of an EDR payload using a π/4-DQPSK modulation with numeric results summary table for the EDR transmit analysis

Demonstration 3.3:

EDR differential phase encoding (TRM/CA/12 /C)

This test verifies that the modulator corrects differential phase encoding. For the EDR payload, the modulator is required to correctly map the binary data stream into a set of specified phase angles in the complex plane. The test conditions require to perform over 100 packets.

In Figure 15, the latest line is showing the differential phase encoding results with no bit errors (Bit Error=0) and bit error rate (BER=0%) in the numerical summary table.

Demonstration 4:

EDR in-band spurious emissions (TMR/CA/13/C)

This test verifies that the level of unwanted signals from the DPSK-modulated data produced within the frequency range is below a limit set by the modulation scheme used. In the *Bluetooth* specification, the signal must meet the following conditions:

$P_{TX-26\ dB}$ (f) $\leq P_{TXref}$ –26 dB for |M-N| = 1
P_{TX} (f) $\leq$ –20 dBm for |M-N| = 2
P_{TX} (f) $\leq$ –40 dBm for |M-N| $\geq$ 3

In the N/W9081A, the measurement provides 79 scalar values of the P_{TX} per channel with a proprietary algorithm quickly, the same as the ACP measurement for basic rate and low energy technologies. Using a single button, the EDR in-band spurious emission measurement provides more results.

Change the center frequency in the Signal Studio:

Signal Studio instructions	Keystrokes
Change the frequency	Select **Signal Generator** under Hardware on the left, Click on **Frequency** line of Basic under Instrument Controls on the right, type **2.405 GHz**
Download the signal to the MXG	Press **Generate and Download** button on the top tool bar

Set up the X-Series analyzer to analyze the *Bluetooth* signal.

X-Series instructions	Keystrokes
Set channel 3 as the input signal	**[Freq] {Channel} Enter [3]{Enter}**
Measure the EDR in-band spurious emissions (Figure 16)	**[Meas] {EDR In-band Spur Emissions}**
Adjust parameters if necessary	**[Meas Setup]**

Figure 16 shows an in-band spurious emissions measurement for EDR signal performed for channel 3 (M=3). The condition $P_{TX-26\ dB}$ (f) $\leq P_{TXref}$ –26 dB is checked for channels 2 and 4 (N=2, 4); P_{TX} (f) $\leq$ –20 dBm is checked for channels 1 and 5 (N=1, 5) and the condition P_{TX} (f) $\leq$ –40 dBm is verified for the rest of the channels. In the right of the numeric result table, the adjacent channel power between 1 MHz and 1.5 MHz from the carrier (Adj 500 kHz lower/upper) shall be at least 26 dB below the maximum power of the carrier transmit channel.

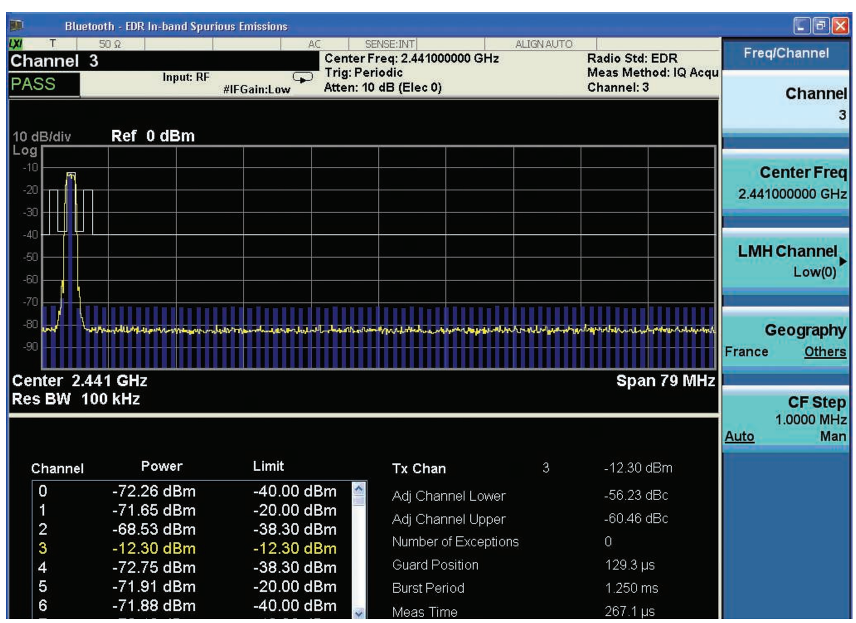


Figure 16. EDR in-band spurious emissions measurement

Demonstration 5:

Low energy in-band emissions (TMR/CA-02-C)

For the *Bluetooth* low energy technology, its specification of the in-band emissions is defined in ULP *Bluetooth* RF PHY test specifications. It has the same test procedures and conditions as the *Bluetooth* EDR in-band spurious emissions measurement.

$P_{TX}(f) \leq -20$ dBm for ($f_{TX} \pm 2$ MHz)
$P_{TX}(f) \leq -30$ dBm for ($f_{TX} \pm [3+n]$ MHz), n=0,1,2...

Generate the *Bluetooth* low energy signal in the Signal Studio:

Signal Studio instructions	Keystrokes
Select the low energy format	Dropdown menu of the **Format** in the menu bar, click on the *Bluetooth* low energy technology as selection 
Change the center frequency to 2.405 GHz	Click on **Signal Generator** on the Explorer menu on the left. Enter **2.478 GHz** in the **Frequency** line under the Basic
Download the signal to the MXG	Click **OK** button, then press **Generate and Download** button on the top tool bar

Set up the X-Series analyzer to analyze the *Bluetooth* low energy signal.

X-Series instructions	Keystrokes
Change to low energy mode	**[Mode Setup] {Radio Standard} {Low Energy}**
Change center frequency number	**[Freq] {Center Freq} {LMH Channel} {High(39)}**
Measure the LE in-band emissions (Figure 17)	**[Meas] {LE In-band Emissions}**
Adjust parameters if necessary	**[Meas Setup]**

Figure 17 shows an in-band spurious emissions measurement for a low energy signal performed for a high channel. Here the high channel is 39, the whole channel space is 78 MHz ± 2 MHz.

Figure 17. LE in-band spurious emissions measurement

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