Keysight X-Series Signal Analyzers

This manual provides documentation for the following Analyzers:

PXA Signal Analyzer N9030A

MXA Signal Analyzer N9020A

EXA Signal Analyzer N9010A

CXA Signal Analyzer N9000A

Notice: This document contains references to Agilent. Please note that Agilent's Test and Measurement business has become Keysight Technologies. For more information, go to www.keysight.com.

N9081A & W9081A Bluetooth Measurement Application Measurement Guide

KEYSIGHT TECHNOLOGIES

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Table of Contents

3 Concepts

1 About Bluetooth Measurement Application

This chapter provides overall information on the Keysight N9081A & W9081A Bluetooth Measurement Application and describes the measurements made by the analyzer.

What Does the Keysight N9081A & W9081A Bluetooth Measurement Application Do?

The Keysight N9081A & W9081A Bluetooth measurement application can be used to quickly ensure a product development conforms to regulatory requirements, as well as providing RF diagnostic and troubleshooting capability for a Bluetooth device.

The Bluetooth measurement application supports the following standards:

- Basic: Basic Bluetooth
- EDR: Enhanced Data Rate, which offers enhanced data rates by using Phase Modulation (DPSK) and Frequency Modulation (GFSK).
- Low Energy: LE, which is based on Basic Bluetooth with less power.

NOTE You can select the standard by pressing **Mode Setup**, **Radio Standard** and select the geography by pressing **FREQ Channel**, **Geography**.

The Option N9081A & W9081A Bluetooth measurement application provides the following one-button measurements:

- Adjacent Channel Power (ACP) Measurement
- Enhanced Data Rate (EDR) In-band Spurious Emissions Measurement
- Low Energy (LE) In-band Emissions Measurement
- Monitor Spectrum Measurement
- Output Spectrum Bandwidth (OBW) Measurement
- Transmit Analysis Measurement

When you select the standard format for use, the instrument automatically makes measurements using the measurement methods and limits defined in the standards. Detailed measurement results are displayed allowing you to make further analysis.

NOTE To reduce the number of variables and identify individual performance characteristics, frequency hopping is turned off for the above Bluetooth measurements.

Measurement parameters may be altered for specialized analysis via the **Meas Setup** menu.

The measurements conform to the following Bluetooth RF Test Specifications. Supported tests are briefed in the Table 1-1 on page 12.

- Bluetooth Test Specification Ver. 1.2/2.0/2.0 + EDR/2.1/2.1 + EDR

- Bluetooth Low Energy RF Test Specifications: RF PHY 0.7 Draft

Table 1-1 Supported Tests

Test Purposes		Measurement
TRM/CA/01/C	Output Power	Transmit Analysis (Radio Standard is Basic or Low Energy)
TRM/CA/05/C	Tx Output Spectrum - 20 dB Bandwidth	Output Spectrum BW
TRM/CA/06/C	TX Output Spectrum - Adjacent Channel Power	Adjacent Channel Power
TRM/CA/07/C	Modulation Characteristics	Transmit Analysis (Radio Standard is Basic or Low Energy)
TRM/CA/08/C	ICFT	Transmit Analysis (Radio Standard is Basic or Low Energy)
TRM/CA/09/C	Carrier Frequency Drift	Transmit Analysis (Radio Standard is Basic or Low Energy)
TRM/CA/10/C	EDR Relative Transmit Power	Transmit Analysis (Radio Standard is EDR)
TRM/CA/11/C	EDR Carrier Freq Stability and Mod Accuracy	Transmit Analysis (Radio Standard is EDR)
TRM/CA/12/C	EDR Differential Phase Encoding	Transmit Analysis (Radio Standard is EDR)
TRM/CA/13/C	EDR In-band Spurious Emissions	EDR In-band Spur Emissions
TRM-LE/CA/02/C	In-band Emissions	LE In-band Emissions

Licenses for N9081A & W9081A Bluetooth Measurement Application

The Option N9081A supports the following license types:

- N9081A-2FP: Fixed/Perpetual license which enables the Bluetooth application on a single X-Series instrument. It cannot be transported from the instrument.
- N9081A-2TP: Transportable/Perpetual license which enables the Bluetooth application on a single X-Series instrument.
- N9081A-2F3: Fixed/Time-limited license which is 3 month duration and cannot be transported from the instrument.

The Option W9081A supports the following license types:

- W081A-2FP: Fixed/Perpetual license which enables the Bluetooth application on a single X-Series instrument. It cannot be transported from the instrument.
- W9081A-2TP: Transportable/Perpetual license which enables the Bluetooth application on a single X-Series instrument.

- W9081A-2F3: Fixed/Time-limited license which is 3 month duration and cannot be transported from the instrument.

2 Making Bluetooth Measurements

This chapter describes procedures to set up and perform measurements for analysis of Bluetooth signals. Details of the steps necessary for accurate signal analysis are provided as well.

Introduction

This chapter provides measurement procedures and also shows example results obtained using the Bluetooth measurement application.

There are six measurements available in this mode:

- **Transmit Analysis**
- **Adjacent Channel Power**
- **Output Spectrum BW**
- **EDR In-band Spurious Emissions**
- **LE In-band Emissions**
- **Monitor Spectrum**

NOTE Before you can begin making measurements, make sure you have installed the required license.

1. Press **Mode**, and check to make sure that **Bluetooth** is available.
2. Press **Meas**, and check to make sure that all the measurements are available.

The following main subjects are presented in this chapter:

- "Making Transmit Analysis Measurements" on page 18

  This section describes steps to perform a Transmit Analysis measurement.

- "Making Adjacent Channel Power Measurements" on page 29

  This section describes steps to perform an Adjacent Channel Power measurement.

- "Making Output Spectrum BW Measurements" on page 37

  This section describes steps to perform an Output Spectrum BW measurement.

- "Making EDR In-band Spurious Emissions Measurements" on page 43

  This section describes steps to perform an EDR In-band Spurious Emissions measurement.

- "Making LE In-band Emissions Measurements" on page 51

  This section describes steps to perform a LE In-band Emissions measurement.

- "Making Monitor Spectrum Measurements" on page 59

  This section describes steps to perform a Monitor Spectrum measurement.

- "Troubleshooting Bluetooth Measurements" on page 64

This section introduces error messages you may have when making a Bluetooth measurement.

NOTE

For more information on how to make an Output Spectrum BW measurement, please refer to *N9020A Signal Analyzer Measurement Guide*.

For more information on how to make a Monitor Spectrum measurement, please refer to *N9020A Signal Analyzer Measurement Guide*.

Making Transmit Analysis Measurements

Transmit Analysis Measurement Overview

Making successful measurements of Bluetooth signals is easy when you follow the main steps below. The procedure overview below provides links in blue to a detailed procedure and description for each step:

"Step 1 - Set Up the Test Equipment and DUT" on page 18

This step configures the analyzer connections for an RF measurement.

"Step 2 - Select the Mode and Preset the Analyzer" on page 19

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

"Step 3 - Select the Mode Setup Parameters" on page 20

This step specifies the radio parameters and carriers configuration.

"Step 4 - Select Measurement" on page 20

This step allows you to make a transmit analysis measurement either by preset settings or desired settings.

"Step 6 - Configure the Display" on page 21

This step enables you to select different views of display.

"Step 7 - Optimize your Results" on page 26

Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Most results are also available in tabular format.

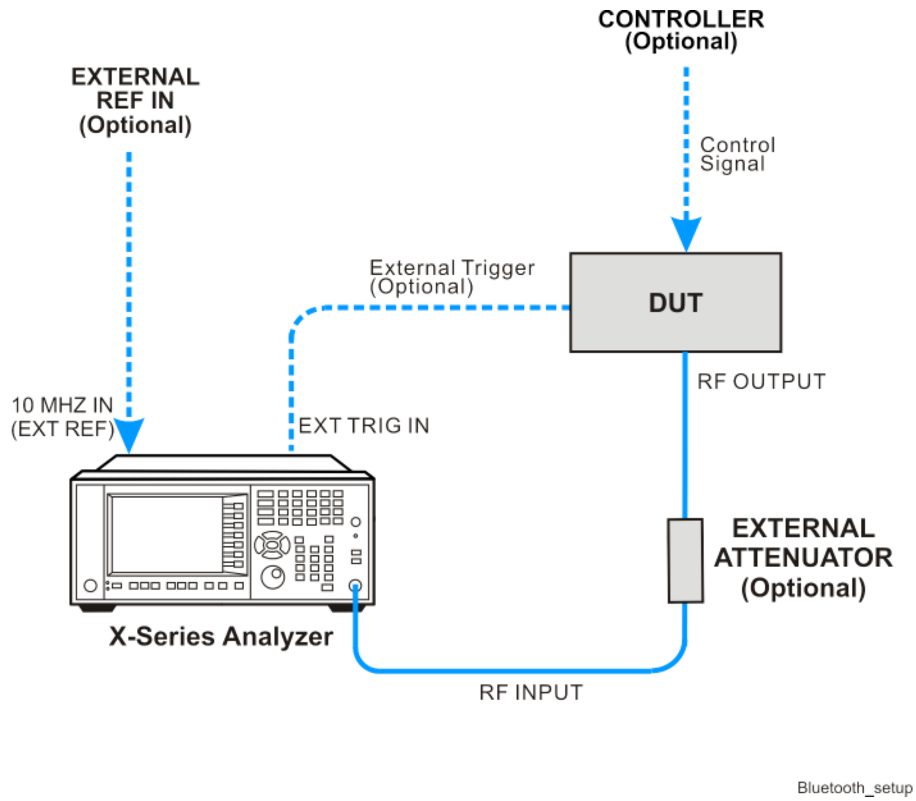
Step 1 - Set Up the Test Equipment and DUT

This step configures the analyzer connections for measuring Bluetooth signals.

Making the Initial Signal Connection

CAUTION Before connecting a signal to the instrument, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the connectors on the front panel.

Figure 2-1 Bluetooth Measurement Setup



The Bluetooth device under test (DUT) is connected to the RF input port by an appropriate RF cable as shown. The DUT may possibly be controlled externally by a computer. External attenuator, external trigger, and external reference are optional.

Click to Go Back to "Making Transmit Analysis Measurements" on page 18.

Step 2 - Select the Mode and Preset the Analyzer

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

Step	Action	Notes
2a. Select the Mode.	Press **MODE**, **Bluetooth**.	
2b. Preset the analyzer.	a. Press the green **Mode Preset** button for the factory preset. b. To recall a user-defined Preset: Press **User Preset,** User Preset to preset the current mode.	

Click to Go Back to "Making Transmit Analysis Measurements" on page 18.

Step 3 - Select the Mode Setup Parameters

This step is to select the radio standard and the frequency range for signals of your interest and select the default limit value for the Output Power measurements.

Step	Action	Notes
3a. Select Mode Setup menu.	Press **Mode Setup**, if needed.	
3b. Select radio standards menu and select the desired standard.	Press **Radio Standard**, and select the standard from the list.	
3c. Select the default output power limit.	a. Press **Device**, and select the desired power class from the list.	
3d. If necessary, select the frequency settings.	a. Press **FREQ Channel**, and input the desired center frequency or select the France bands or non-France bands by toggling **Geography**. The default setting is **Others**.	Channel number is coupled with Center Frequency.

Click to Go Back to "Making Transmit Analysis Measurements" on page 18.

Step 4 - Select Measurement

This step is to invoke the measurement you want to run.

Step	Action	Notes
4a. Select the transmit analysis measurement.	Press **Meas, Transmit Analysis**.	
4b. If desired, change the parameters for the measurement.	Press **Meas Setup,** then select the parameters you want to change and input your settings.	
4c. Select the transmit analysis measurement again or restart the measurement.	Press **Meas, Transmit Analysis**, or press **Restart**.	

Click to Go Back to "Making Transmit Analysis Measurements" on page 18.

Step 5 - Select the Meas Setup Parameters

This step is to adjust the measurement settings.

Step	Action	Notes
5a. Select the measurement setup menus.	Press **Meas Setup**.	
5b. If desired, change the synchronization method.	Press **Meas Setup, Burst Sync,** then select one from **Preamble**, **RF Amptd** or **None.**	Changing Burst Sync may only impact the Output Power measurement result.
5c. If desired, change the limit parameters.	Press **Meas Setup, Limits**. You can turn on or turn off the limit test by toggling **Limit Test**. You can also change the limit lines for your measurements.	The limit lines are preset according to the test spec.
5d. If desired, store the measurement results for Δf1 Avg or Δf2 Avg.	Press **Meas Setup, Hold Result,** then select **Δf1 Avg** or **Δf2 Avg**.	The selected result will not be updated until Hold Result is Off.
5e. If desired, change the start point or the end point when calculating the signal power.	Press **Meas Setup, More**, then select what you want to change and input your settings.	

Click to Go Back to “Making Transmit Analysis Measurements” on page 18.

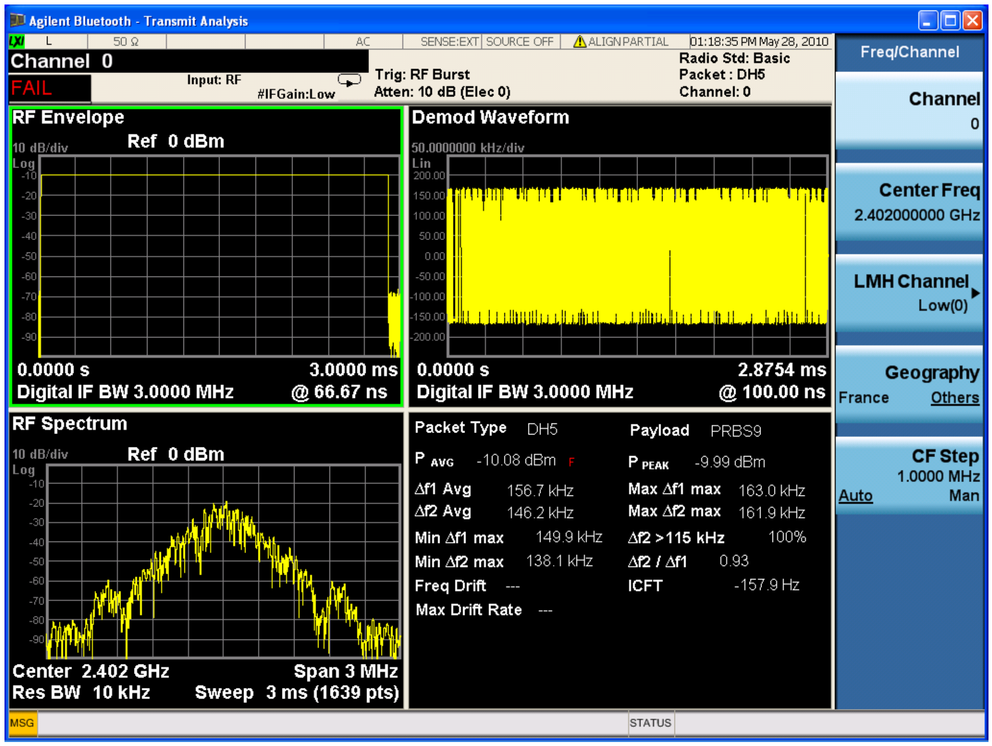
Step 6 - Configure the Display

Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Most results are also available in tabular format.

Step	Action	Notes
6a. Select a view of results display.	a. Press **View/Display**, and select a view from a selection of useful combinations of related data trace displays.	

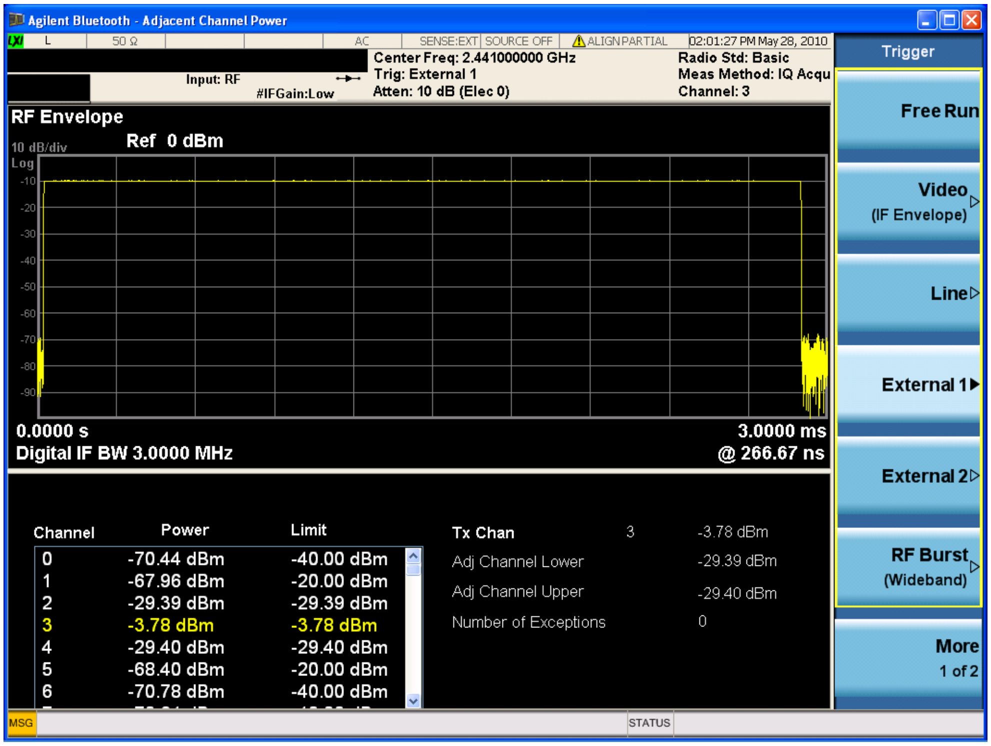
View - Quad View

The Quad View provides a combination view of RF Envelope, Demod Waveform, RF Spectrum graph and Results Metrics in four quadrants.



View - RF Envelope

The RF Envelope view provides a combination view of RF Envelope graph and Results Metrics. RF Envelop graph shows the Power vs. Time trace for a single channel.



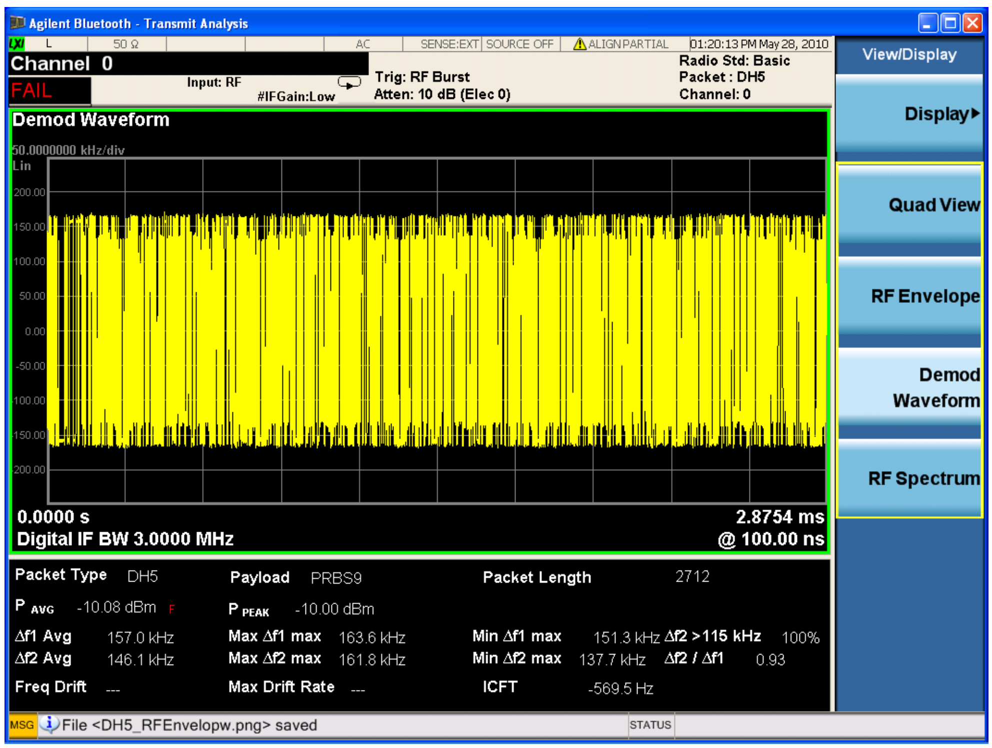
View - Demod Waveform

NOTE	If radio standard is Basic or Lower Energy, this view is Demod Waveform. If radio standard is EDR, this view is Constellation view.

The Demod Waveform or Constellation view provides a combination view of Demod Waveform graph and Results Metrics.

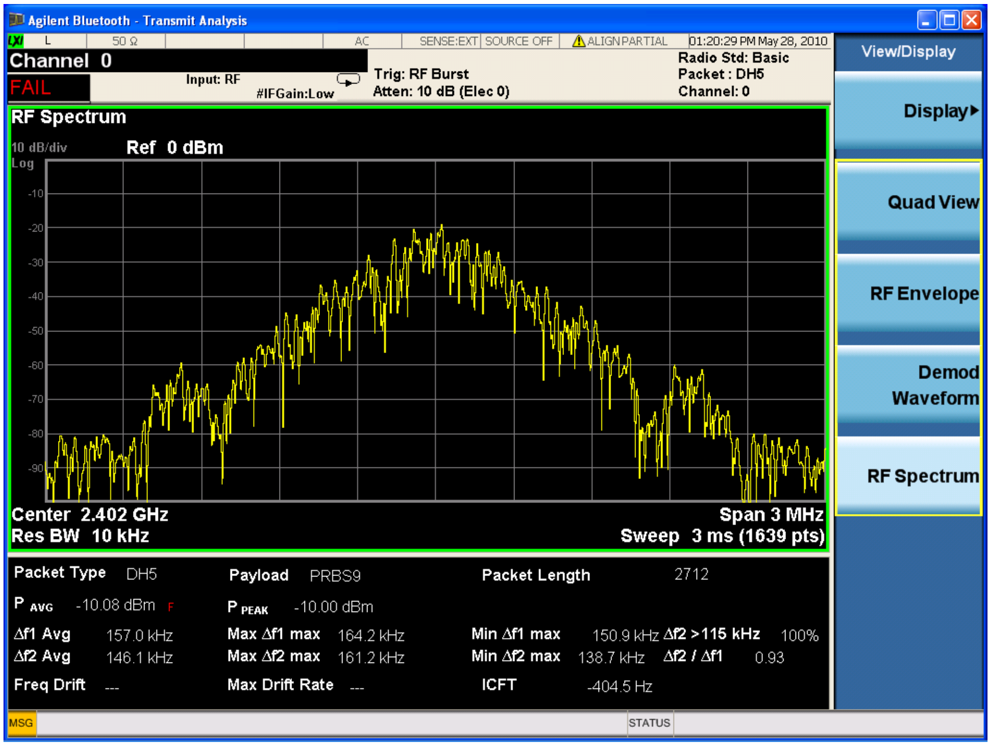
For Basic and Low Energy, the modulation is GFSK and Demod Waveform shows the demodulated signal as a Frequency vs. Time trace.

For EDR, the modulation is DQPSK/D8PSK and Constellation view shows an I/Q measured polar vector trace.



View - RF Spectrum

The RF Spectrum view shows a Spectrum trace.



Step 7 - Optimize your Results

In this step you can finalize the presentation of your data by adjusting various parameters to make your measurement data more useful.

Step	Action	Notes
7a. Select a graph for optimization.	Use the "Next Window" key (boxes with arrows) below the display to move the green outline "focus" to activate a graph for customization.	
7b. Optimize the X Scale.	a. Press **SPAN X Scale**, **Scale/Div**, then use the front-panel keypad to input the scale/div, then press a units key, like **µs**, to complete the entry. **OR** b. Press **SPAN X Scale**, **More, X Scale Auto** to allow the instrument to complete the scaling.	
7c. Optimize the Y Scale.	a. Press **AMPTD YScale**, **Scale/Div**, then use the front-panel keypad to input the scale/div, then press a units key, like **µs**, to complete the entry. **OR** b. Press AMPTD YScale**, Auto Scale** to allow the instrument to complete the scaling.	
7d. Use **a Marker** to indicate and measure signal characteristics.	a. Press **Marker**, **Select Marker**, and select the number of the maker desired for your display. b. Press **Marker Function**, **Select Marker** to assign a function to the marker. c. Select either **Band/Interval Power**, or **Band/Interval Density**, to set the marker control function type. d. Press **Marker**, **Delta** to set a Delta marker on/off and adjust its position on the graph.	For more information on Markers see the Markers section under Measurement Setup in Help.
7e. Add titles, or make other changes to the measurement graphs.	a. Press **View/Display**, **Display**, **System, Settings** to adjust other parts of the display for all measurement windows. b. Press **View/Display**, **Display**, **Annotation**, to turn on/off various parts of the display annotation. c. Press **View/Display**, **Display**, **Title, Change Title** to create a title for the graph. d. Press **View/Display**, **Display**, **Graticule** to turn graticules on/off. e. Press **View/Display**, **Display**, **Display Line** to turn a reference line on/off and adjust its position on the graph.	For more information on Display settings see the Display section under Analyzer Setup in Help.

Click to Go Back to "Making Transmit Analysis Measurements" on page 18.

Viewing Transmit Analysis Measurement Results

Measurement results available include graphical displays of various trace data as well as tabular results available remotely. These graphic results may be viewed separately, or combined into views. For more information on Views see “Step 6 - Configure the Display” on page 21.

Graphical Measurement Results

To help pin-point modulation problems, the Transmit Analysis measurement provides three different graphs and numeric results tables.

You can assign any available data to any of the traces displayed on the screen. The list below of data types may also be viewed in various formats, depending on the data, like constellation, spectrum, and so on.

Transmit Analysis Measurement Data includes three sets of test results combined into this measurement. Each set of results has limit testing to provide a Pass or Fail test result.

- Power vs. Time Results
- Frequency vs. Time Results
- Spectrum Results

For more information on what these data traces are, see the *N9081A Bluetooth Measurement Application User’s and Programmer’s Reference* section on Trace/Detector, Data.

Click to Go Back to “Making Transmit Analysis Measurements” on page 18.

Example of One-Button-Measurement - Transmit Analysis

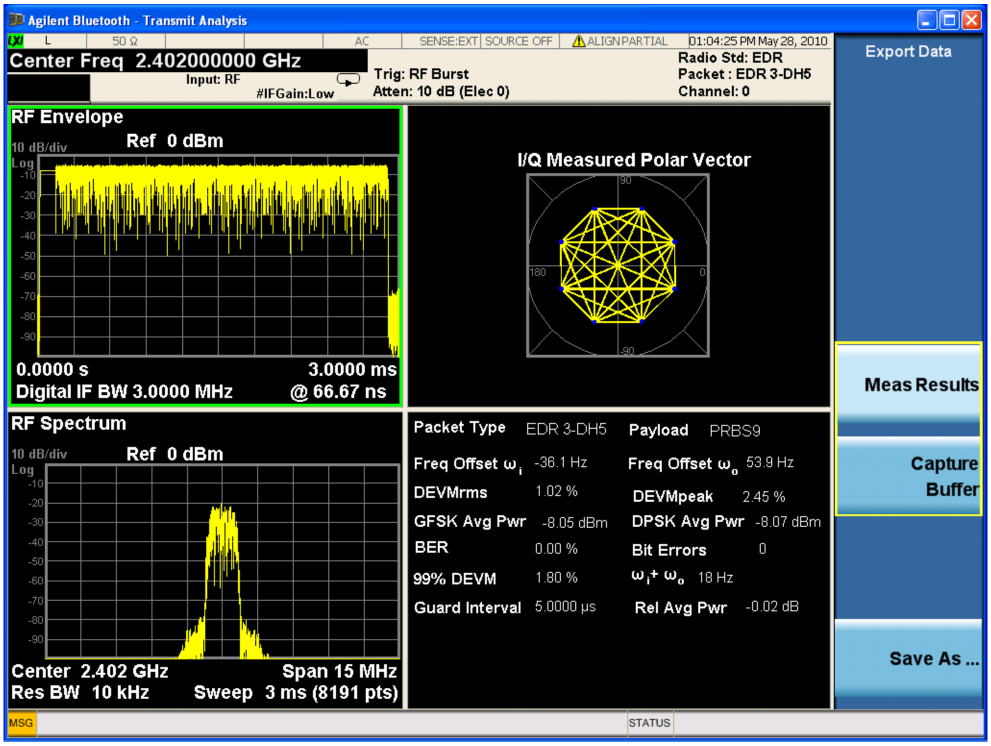
This example assumes the signal is correctly applied to the input.

Step 1. Press **Mode Preset**

Step 2. Press **Meas, Transmit Analysis**

Step 3. View the measurement default view. (See Figure 2-2).

Figure 2-2 *Transmit Analysis (QuadView)*



If you have a problem, and get an error message, see *Instrument Messages*.

Example of Using SCPI Commands

Select Bluetooth mode

:INST BT

Select the Transmit Analysis measurement

CONF:TX

Get the measurement result array of 27 comma-separated results.

READ:TX1?

Making Adjacent Channel Power Measurements

Adjacent Channel Power Measurement Overview

Making successful measurements of Bluetooth signals is easy when you follow the main steps below. The procedure overview below provides links in blue to a detailed procedure and description for each step:

"Step 1 - Set Up the Test Equipment and DUT" on page 18

This step configures the analyzer connections for an RF measurement.

"Step 2 - Select the Mode and Preset the Analyzer" on page 19

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

"Step 3 - Select the Mode Setup Parameters" on page 20

This step specifies the radio parameters and carriers configuration.

"Step 4 - Select Measurement" on page 20

This step allows you to make an adjacent channel power measurement either by preset settings or desired settings.

"Step 5 - Select the Meas Setup Parameters" on page 21

This step specifies the measurement setup parameters.

"Step 6 - Configure the Display" on page 21

This step enables you to select different views of display.

"Step 7 - Optimize your Results" on page 26

Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Most results are also available in tabular format.

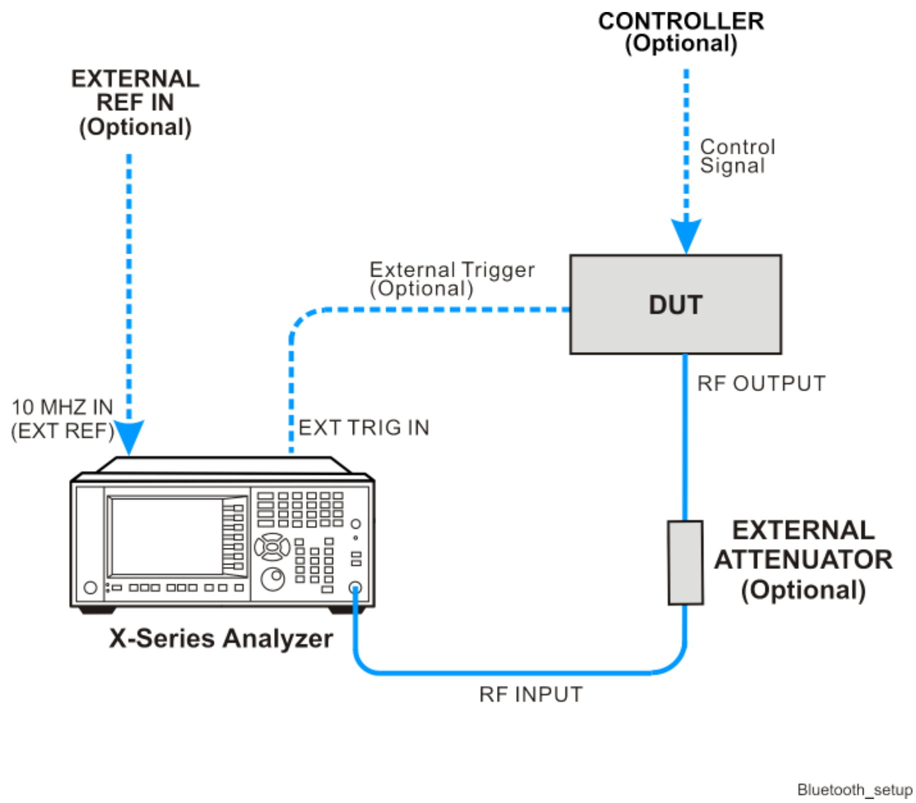
Step 1 - Set Up the Test Equipment and DUT

This step configures the analyzer connections for measuring Bluetooth signals.

Making the Initial Signal Connection

CAUTION Before connecting a signal to the instrument, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the connectors on the front panel.

Figure 2-3 *Bluetooth Measurement Setup*



The device under test (DUT) is connected to the RF input port. The DUT may possibly be controlled externally by a computer. External attenuator, external trigger, and external reference are optional. Using the appropriate cables, connect the equipment as shown.

Click to Go Back to "Making Adjacent Channel Power Measurements" on page 29.

Step 2 - Select the Mode and Preset the Analyzer

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

Step	Action	Notes
2a. Select the Mode.	Press **MODE**, **Bluetooth**.	
2b. Preset the analyzer.	a. Press the green **Mode Preset** button for the factory preset. b. To recall a user-defined Preset: Press **User Preset,** User Preset to preset the current mode.	

Click to Go Back to "Making Adjacent Channel Power Measurements" on page 29.

Step 3 - Select the Mode Setup Parameters

This step is to select the radio standard for signals of your interest and select the default limit value for the Output Power measurements.

Step	Action	Notes
3a. Select Mode Setup menu.	Press **Mode Setup**, if needed.	
3b. Select radio standards menu and select the desired standard.	Press **Radio Standard**, and select the standard from the list.	
3c. Select the default output power limit.	a. Press **Device**, and select the desired power class from the list.	
3d. If necessary, select the frequency settings.	a. Press **FREQ Channel**, and input the desired center frequency or select the France bands or non-France bands by toggling **Geography**.	

Click to Go Back to "Making Adjacent Channel Power Measurements" on page 29.

Step 4 - Select Measurement

This step is to invoke the measurement you want to run.

Step	Action	Notes
4a. Select the transmit power measurement.	Press **Meas, Adjacent Channel Power**.	
OR		
4b. If desired, change the parameters for the measurement.	Press **Meas Setup,** then select the parameters you want to change and input your settings.	
4c. Select the adjacent channel power measurement again or restart the measurement.	Press **Meas, Adjacent Channel Power**, or press **Restart.**	

Click to Go Back to "Making Adjacent Channel Power Measurements" on page 29.

Step 5 - Select the Meas Setup Parameters

This step is to adjust the measurement settings.

Step	Action	Notes
5a. Select the measurement setup menus.	Press **Meas Setup**.	
5b. If desired, change the measurement method.	Press **Meas Setup, Meas Method** to toggle between **Sweep** and **IQ Acquisition**.	The test spec defines the measurement method as Sweep, the default method.
5c. If desired, change the limit parameters.	Press **Meas Setup, Limits**. You can turn on or turn off the limit test by toggling **Limit Test**. You can also change the limit lines for your measurements.	The limit lines are preset according to the test spec.
5d. If desired, preset the parameters to comply with the standard requirement.	Press **Meas Setup, Preset Standard.**	The couplings include Average settings, RBW, VBW, sweep time, detector settings and gate settings.

Click to Go Back to "Making Adjacent Channel Power Measurements" on page 29.

Step 6 - Configure the Display

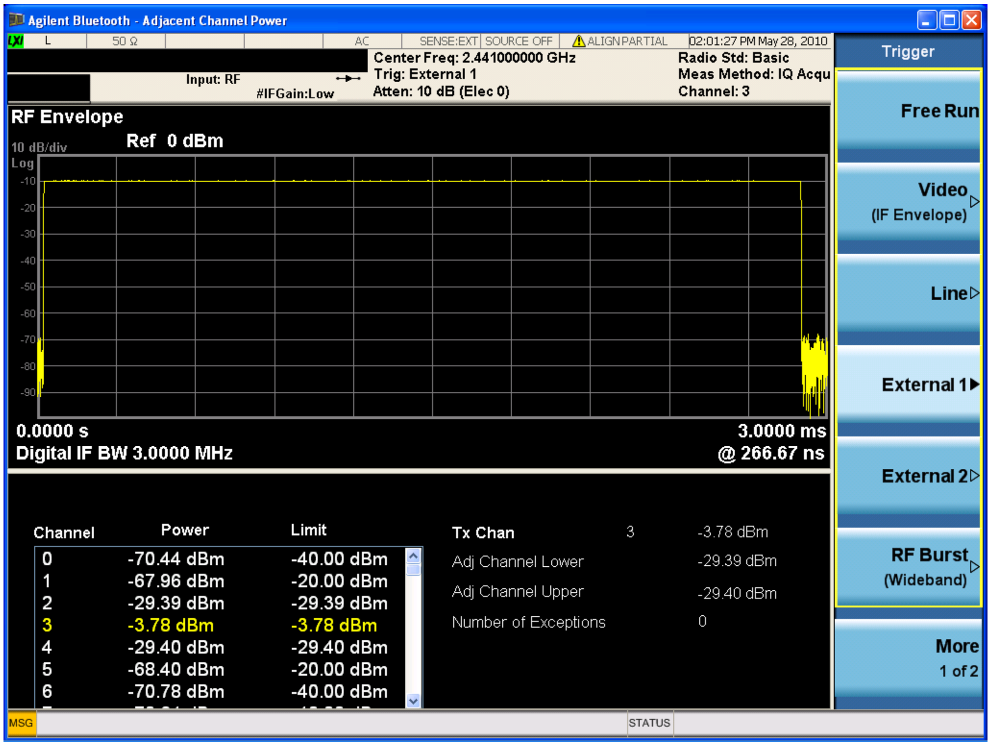
Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Required results are also available in tabular format.

Step	Action	Notes
6a. Select a view of results display.	a. Press **View/Display**, and select a view from a selection of useful combinations of related data trace displays.	

View - RF Envelope

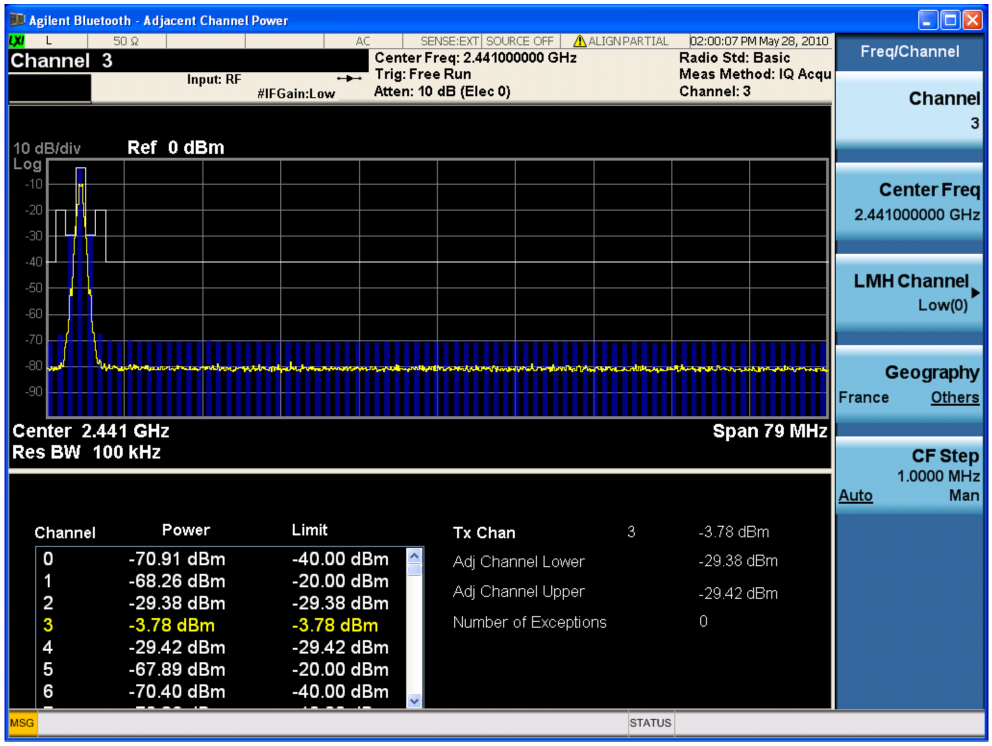
The RF Envelope view provides a combination view of RF Envelope graph and Results Metrics. RF Envelop graph shows the Power vs. Time trace for a single channel.

NOTE This view is not available when Meas Method is set to Sweep.



View - RF Spectrum

The RF Spectrum view shows a Spectrum trace.



Step 7 - Optimize your Results

In this step you can finalize the presentation of your data by adjusting various parameters to make your measurement data more useful.

See “Step 7 - Optimize your Results” on page 26.

Click to Go Back to “Making Adjacent Channel Power Measurements” on page 29.

Viewing Adjacent Channel Power Measurement Results

Measurement results available include graphical displays of various trace data as well as tabular results available remotely. These graphic results may be viewed separately, or combined into views. For more information on Views see “Step 6 - Configure the Display” on page 32.

Graphical Measurement Results

The adjacent channel power measurement provides two different graphical views with numeric results tables.

Adjacent Channel Power Measurement Data includes two sets of test results combined into this measurement. Each set of results has limit testing to provide a Pass or Fail test result.

- Power vs. Time Results
- Spectrum Results

For more information on what these data traces are, see the *N9081A Bluetooth Measurement Application User’s and Programmer’s Reference* section on Trace/Detector, Data.

Click to Go Back to “Making Adjacent Channel Power Measurements” on page 29.

Example Measurement - Adjacent Channel Power

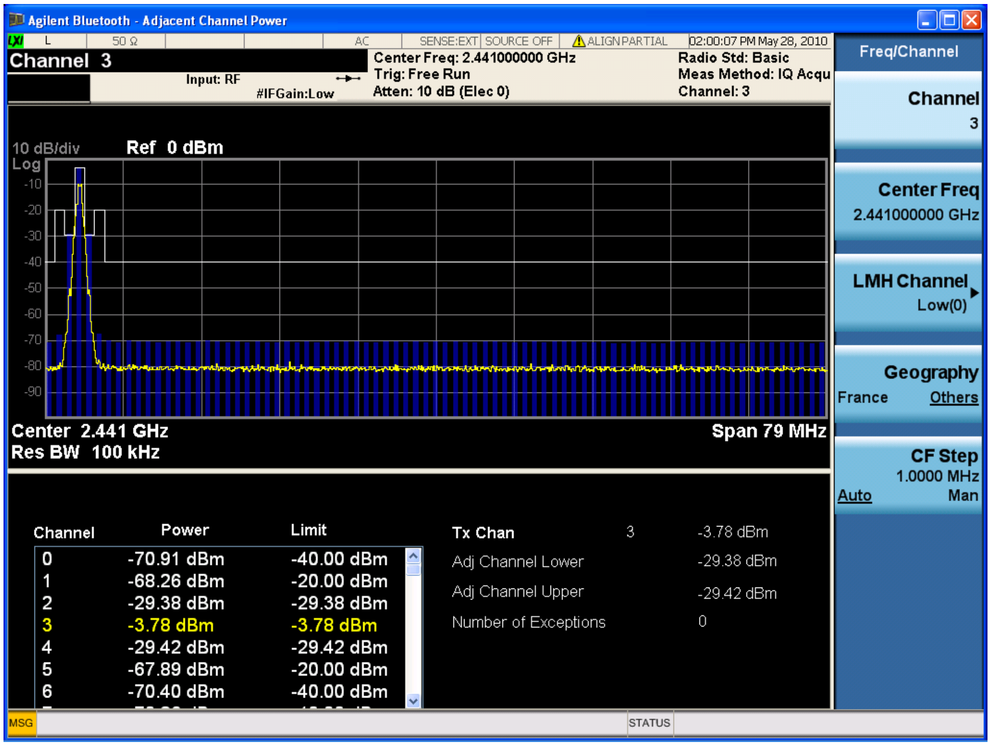
This example assumes the signal is correctly applied to the input.

Step 1. Press **Mode Preset**

Step 2. Press **Meas, Adjacent Channel Power**

Step 3. View the measurement default view. (See Figure 2-4).

Figure 2-4 *Adjacent Channel Power (RF Spectrum View)*



If you have a problem, and get an error message, see *Instrument Messages*.

Example of Using SCPI Commands

Select Bluetooth mode

:INST BT

Select the ACP measurement

CONF:ACP

Get the measurement results array

READ:ACP2?

Making Output Spectrum BW Measurements

Output Spectrum BW Measurement Overview

Making successful measurements of Bluetooth signals is easy when you follow the main steps below. The procedure overview below provides links in blue to a detailed procedure and description for each step:

"Step 1 - Set Up the Test Equipment and DUT" on page 37

This step configures the analyzer connections for an RF measurement.

"Step 2 - Select the Mode and Preset the Analyzer" on page 38

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

"Step 3- Select the Mode Setup Parameters" on page 39

This step specifies the radio parameters and carriers configuration.

"Step 4- Select Measurement" on page 39

This step allows you to make an output spectrum measurement either by preset settings or desired settings.

"Step 5 - Select the Meas Setup Parameters" on page 40

This step specifies the measurement setup parameters.

"Step 6 - Optimize your Results" on page 40

This step enables you to view the result display.

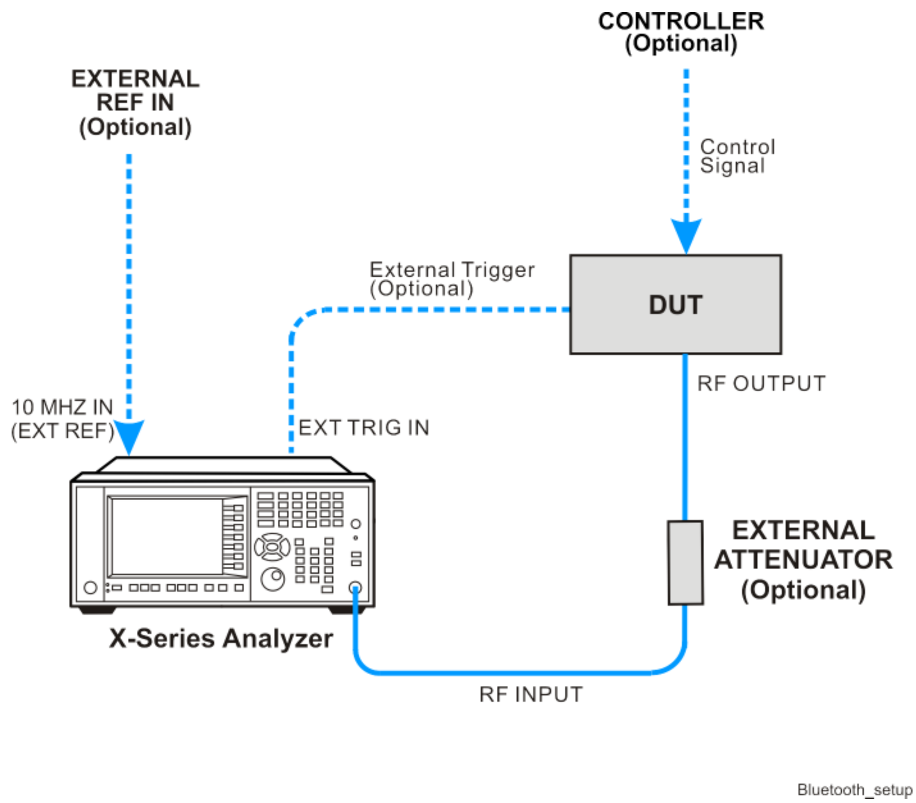
Step 1 - Set Up the Test Equipment and DUT

This step configures the analyzer connections for measuring Bluetooth signals.

Making the Initial Signal Connection

CAUTION Before connecting a signal to the instrument, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the connectors on the front panel.

Figure 2-5 *Bluetooth Measurement Setup*



The Bluetooth device under test (DUT) is connected to the RF input port by an appropriate RF cable as shown. The DUT may possibly be controlled externally by a computer. External attenuator, external trigger, and external reference are optional.

Click to Go Back to "Making Output Spectrum BW Measurements" on page 37.

Step 2 - Select the Mode and Preset the Analyzer

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

Step	Action	Notes
2a. Select the Mode.	Press **MODE**, **Bluetooth.**	
2b. Preset the analyzer.	a. Press the green **Mode Preset** button for the factory preset. b. To recall a user-defined Preset: Press **User Preset,** User Preset to preset the current mode.	

Click to Go Back to "Making Output Spectrum BW Measurements" on page 37.

Step 3- Select the Mode Setup Parameters

This step is to select the radio standard for signals of your interest and select the default limit value for the Output Power measurements.

Step	Action	Notes
3a. Select Mode Setup menu.	Press **Mode Setup**, if needed.	
3b. Select radio standards menu and select the desired standard.	Press **Radio Standard**, and select the standard from the list.	
3c. Select the default output power limit.	a. Press **Device**, and select the desired power class from the list.	
3d. If necessary, select the frequency settings.	a. Press **FREQ Channel**, and input the desired center frequency or select the France bands or non-France bands by toggling **Geography**. The default setting is **Others**.	Channel number is coupled with Center Frequency.

Click to Go Back to "Making Output Spectrum BW Measurements" on page 37.

Step 4- Select Measurement

This step is to invoke the measurement you want to run.

Step	Action	Notes
4a. Select the output spectrum BW measurement.	Press **Meas, Output Spectrum BW**.	
4b. If desired, change the parameters for the measurement.	Press **Meas Setup,** then select the parameters you want to change and input your settings.	
4c. Select the output spectrum BW measurement again or restart the measurement.	Press **Meas, Output Spectrum BW**, or press **Restart**.	

Click to Go Back to "Making Output Spectrum BW Measurements" on page 37.

Step 5 - Select the Meas Setup Parameters

This step is to adjust the measurement settings.

Step	Action	Notes
5a. Select the measurement setup menus.	Press **Meas Setup**.	
5b. If desired, change the measurement method.	Press **Meas Setup, Meas Method** to toggle between **Sweep** and **IQ Acquisition**.	The test spec defines the measurement method as Sweep, the default method.
5c. If desired, change the limit parameters.	Press **Meas Setup, Limits.** You can turn on or turn off the limit test by toggling **Limit Test.** You can also change the limit lines for your measurements.	The limit lines are preset according to the test spec.
5d. If desired, preset the parameters to comply with the standard requirement.	Press **Meas Setup, Preset Standard.**	The couplings include Average settings, RBW, VBW, sweep time, detector settings and gate settings.

Click to Go Back to "Making Output Spectrum BW Measurements" on page 37.

Step 6 - Optimize your Results

In this step you can finalize the presentation of your data by adjusting various parameters to make your measurement data more useful.

See "Step 7 – Optimize your Results" on page 26.

Click to Go Back to "Making Output Spectrum BW Measurements" on page 37.

Viewing Output Spectrum BW Measurement Results

Measurement results available include graphical displays of trace data as well as tabular results available.

Output Spectrum BW Measurement Data Includes:

- 20 dB Bandwidth
- Transmit Frequency Error
- Total Power
- Occupied Bandwidth
- OBW Power

For more information on what these data traces are, see the *N9081A Bluetooth Measurement Application User's and Programmer's Reference* section on Trace/Detector, Data.

Click to Go Back to "Making Output Spectrum BW Measurements" on page 37.

Example of One-Button-Measurement - Output Spectrum BW

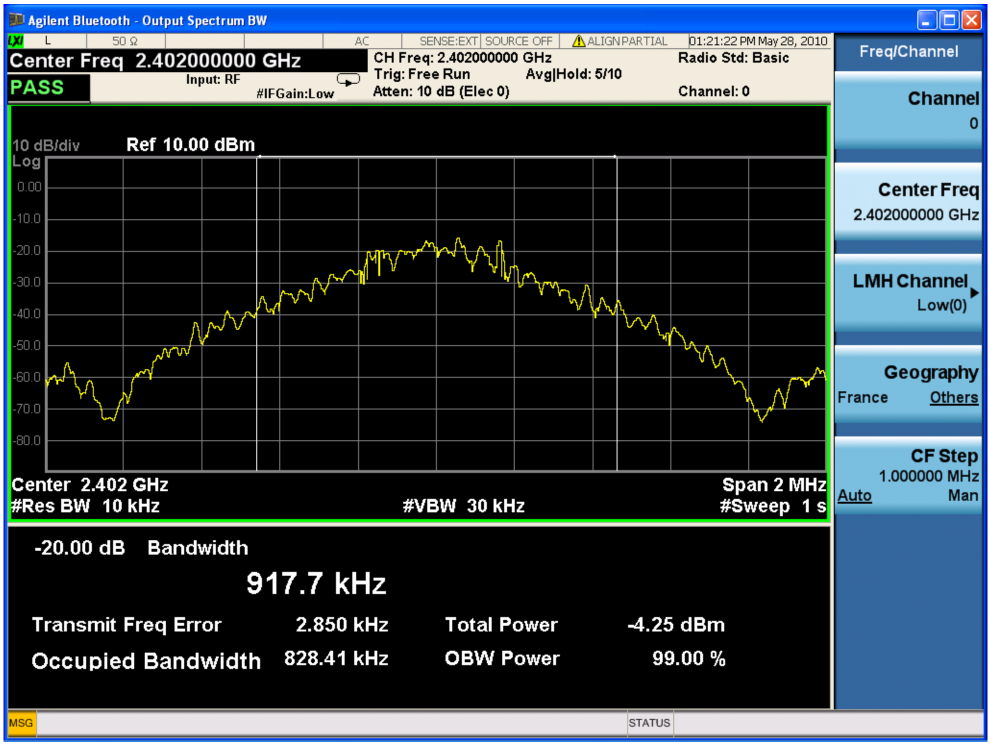
This example assumes the signal is correctly applied to the input.

Step 1. Press **Mode Preset**

Step 2. Press **Meas, Output Spectrum BW**

Step 3. View the measurement result. (See Figure 2-6).

Figure 2-6 *Output Spectrum BW*



If you have a problem, and get an error message, see *Instrument Messages*.

Example of Using SCPI Commands

Select Bluetooth mode

:INST BT

Select the Output Spectrum BW measurement

CONF:OBW

Get the measurement results array

READ:OBW?

Making EDR In-band Spurious Emissions Measurements

EDR In-band Spurious Emissions Measurement Overview

Making successful measurements of Bluetooth signals is easy when you follow the main steps below. The procedure overview below provides links in blue to a detailed procedure and description for each step:

"Step 1 - Set Up the Test Equipment and DUT" on page 43

This step configures the analyzer connections for making a RF measurement.

"Step 2 - Select the Mode and Preset the Analyzer" on page 44

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

"Step 3- Select the Mode Setup Parameters" on page 45

This step specifies the radio parameters and carriers configuration.

"Step 4- Select Measurement" on page 45

This step allows you to make an EDR in-band spurious emissions measurement either by preset settings or desired settings.

"Step 5 - Select the Meas Setup Parameters" on page 46

This step specifies the measurement setup parameters.

"Step 6 - Configure the Display" on page 46

This step enables you to select different views of display.

"Step 7 - Optimize your Results" on page 48

Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Most results are also available in tabular format.

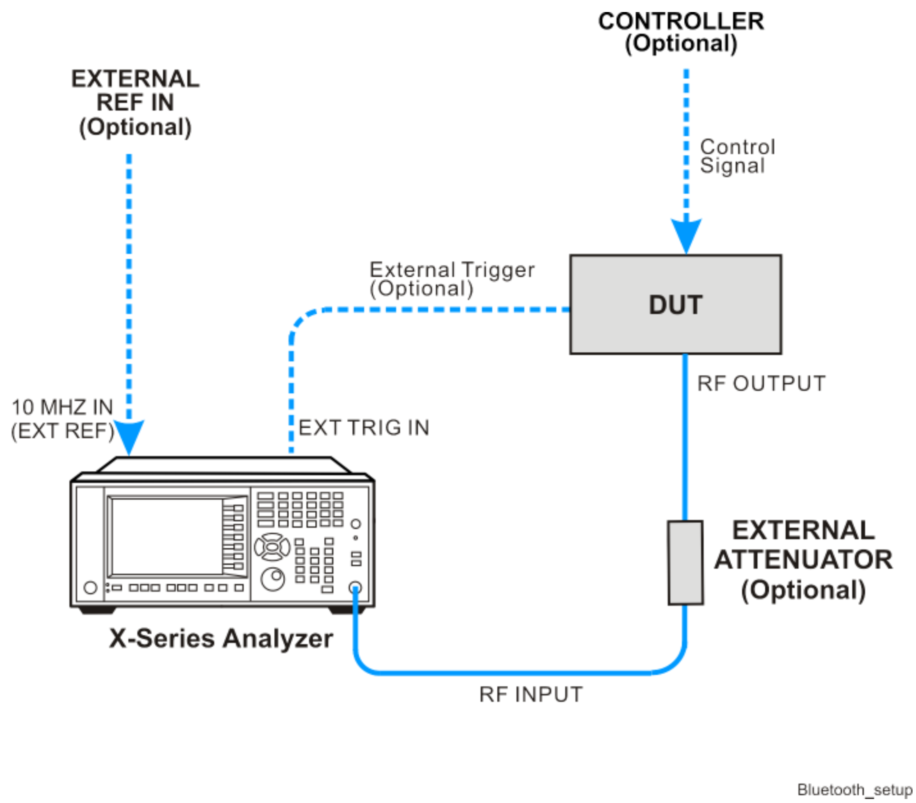
Step 1 - Set Up the Test Equipment and DUT

This step configures the analyzer connections for measuring Bluetooth signals.

Making the Initial Signal Connection

CAUTION Before connecting a signal to the instrument, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the connectors on the front panel.

Figure 2-7 *EDR In-band Spurious Emissions Measurement Setup*



The device under test (DUT) is connected to the RF input port of the analyzer. The DUT may possibly be controlled externally by a computer. External attenuator, external trigger, and external reference are optional. Using the appropriate cables, connect the equipment as shown.

Click to Go Back to "Making EDR In-band Spurious Emissions Measurements" on page 43.

Step 2 - Select the Mode and Preset the Analyzer

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

Step	Action	Notes
2a. Select the Mode.	Press **MODE**, **Bluetooth**.	
2b. Preset the analyzer.	a. Press the green **Mode Preset** button for the factory preset. b. To recall a user-defined Preset: Press **User Preset,** User Preset to preset the current mode.	

Click to Go Back to "Making EDR In-band Spurious Emissions Measurements" on page 43.

Step 3- Select the Mode Setup Parameters

This step is to turn on the Tests you want to run.

Step	Action	Notes
3a. Select Mode Setup menu.	Press **Mode Setup**, if needed.	
3b. Select radio standards menu and select the desired standard.	Press **Radio Standard**, and select the standard from the list.	
3c. Select the default output power limit.	a. Press **Device**, and select the desired power class from the list.	
3d. If necessary, select the frequency settings.	a. Press **FREQ Channel**, and input the desired center frequency or select the France bands or non-France bands by toggling **Geography**.	

Click to Go Back to "Making EDR In-band Spurious Emissions Measurements" on page 43

Step 4- Select Measurement

This step is to invoke the measurement you want to run.

Step	Action	Notes
4a. Select the EDR in-band spurious emissions measurement.	Press **Meas, EDR In-band Spur Emissions.**	
4b. If desired, change the parameters for the measurement.	Press **Meas Setup,** then select the parameters you want to change and input your settings.	
4c. Select the EDR in-band spurious emissions measurement again or restart the measurement.	Press **Meas, EDR In-band Spur Emissions**, or press **Restart**.	

Click to Go Back to "Making EDR In-band Spurious Emissions Measurements" on page 43.

Step 5 - Select the Meas Setup Parameters

This step is to adjust the measurement settings.

Step	Action	Notes
5a. Select the measurement setup menus.	Press **Meas Setup**.	
5b. If desired, change the measurement method.	Press **Meas Setup, Meas Method** to toggle between **Sweep** and **IQ Acquisition**.	The test spec defines the measurement method as Sweep, the default method.
5c. If desired, change the synchronization timing parameters.	Press **Meas Setup, Guard Delay**, and enter the guard interval for your test. Press **Meas Setup, Sync Interval**, and enter the interval for your test.	The Guard Delay defaults to a negative value because it's prior to S0.
5d. If desired, change the limit parameters.	Press **Meas Setup, Limits**. You can turn on or turn off the limit test by toggling **Limit Test**. You can also change the limit lines for your measurements.	The limit lines are preset according to the test spec.
5e. If desired, preset the parameters to comply with the standard requirement.	Press **Meas Setup, Preset Standard**.	The couplings include Average settings, RBW, VBW, sweep time, detector settings and gate settings.

Click to Go Back to "Making EDR In-band Spurious Emissions Measurements" on page 43.

Step 6 - Configure the Display

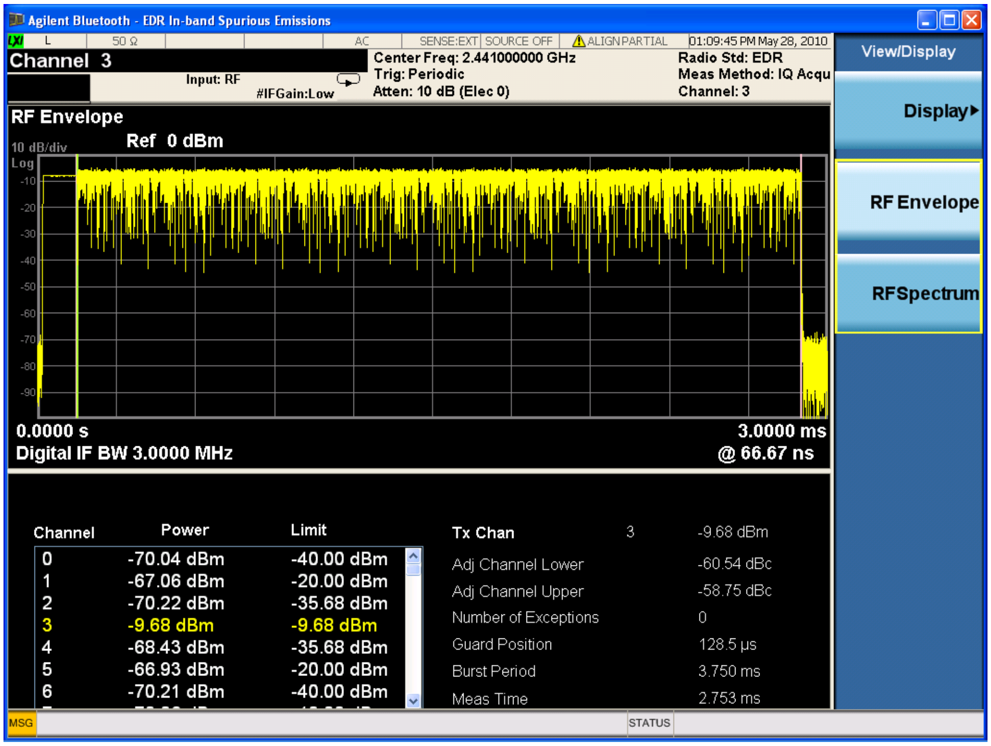
Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Required results are also available in tabular format.

Step	Action	Notes
6a. Select a view of results display.	Press **View/Display**, and select a view from a selection of useful combinations of related data trace displays.	

View - RF Envelope

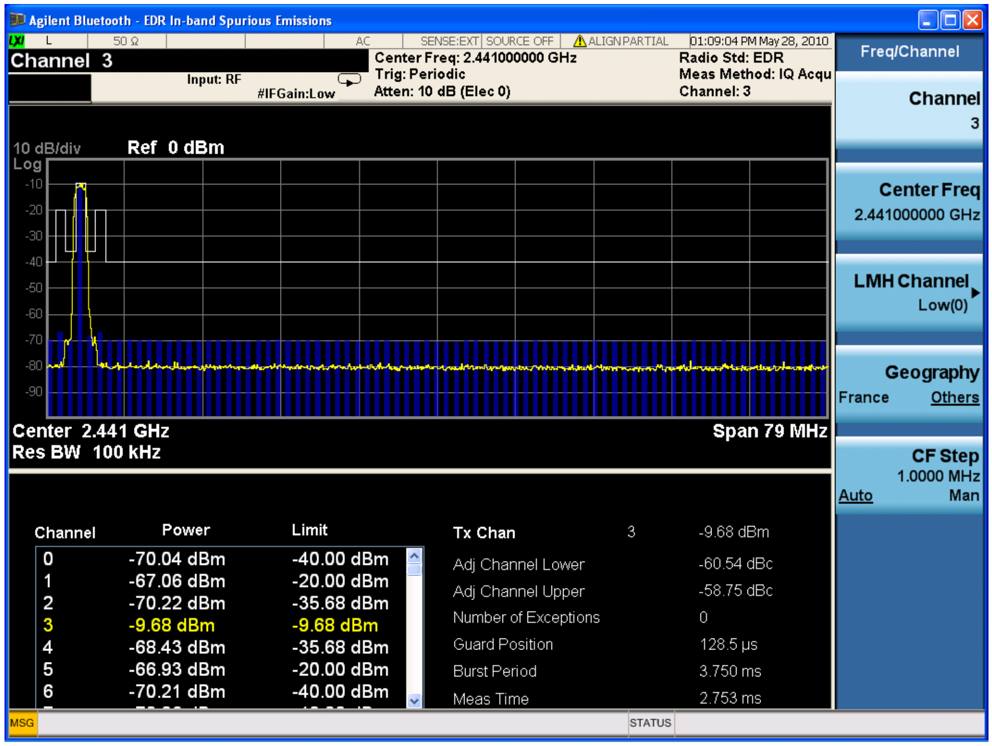
The RF Envelope view provides a combination view of RF Envelope graph and Results Metrics. RF Envelop graph shows the Power vs. Time trace for a single channel.

NOTE This view is not available when Meas Method is set to Sweep.



View - RF Spectrum

The RF Spectrum view shows a Spectrum trace.



Step 7 - Optimize your Results

In this step you can finalize the presentation of your data by adjusting various parameters to make your measurement data more useful.

See “Step 7 - Optimize your Results” on page 26.

Click to Go Back to “Making EDR In-band Spurious Emissions Measurements” on page 43.

Viewing EDR In-band Spurious Emissions Measurement Results

Measurement results available include graphical displays of various trace data as well as tabular results available remotely. These graphic results may be viewed separately, or combined into views. For more information on Views see "Step 6 - Configure the Display" on page 32.

Graphical Measurement Results

The adjacent channel power measurement provides two different graphical views with numeric results tables.

EDR In-band Spurious Emissions Measurement Data includes two sets of test results combined into this measurement. Each set of results has limit testing to provide a Pass or Fail test result.

- Power vs. Time Results
- Spectrum Results

For more information on what these data traces are, see the *N9081A Bluetooth Measurement Application User's and Programmer's Reference* section on Trace/Detector, Data.

Click to Go Back to "Making EDR In-band Spurious Emissions Measurements" on page 43.

Example Measurement - EDR In-band Spurious Emissions

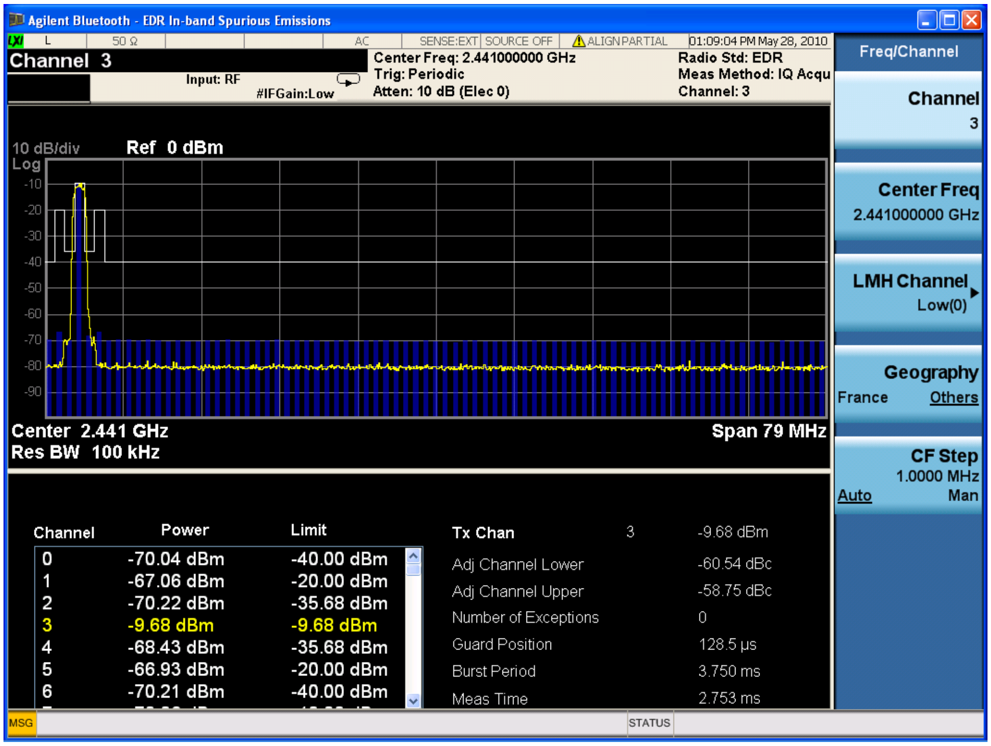
This example assumes the signal is correctly applied to the input.

Step 1. Press **Mode Preset**

Step 2. Press **Meas, EDR In-band Spurious Emissions**

Step 3. View the measurement default view. (See Figure 2-8).

Figure 2-8 EDR In-band Spurious Emissions RF Spectrum View (Default)



If you have a problem, and get an error message, see *Instrument Messages*.

Example of Using SCPI Commands

Select Bluetooth mode

:INST BT

Select the EDR In-band Spur Emissions measurement

CONF:IBSP

Get the measurement results array

READ:IBSP2?

Making LE In-band Emissions Measurements

LE In-band Emissions Measurement Overview

"Step 1 - Set Up the Test Equipment and DUT" on page 51

This step configures the analyzer connections for making a EDR In-band Spurious Emissions Measurement.

"Step 2 - Select the Mode and Preset the Analyzer" on page 52

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

"Step 3 - Select the Mode Setup Parameters" on page 53

This step specifies the radio parameters and carriers configuration.

"Step 4 - Select Measurement" on page 53

This step allows you to make a LE In-band Emissions Measurement either by preset settings or desired settings.

"Step 5 - Select the Meas Setup Parameters" on page 54

This step specifies the measurement setup parameters.

"Step 6 - Configure the Display" on page 54

This step enables you to select different views of display.

"Step 7 - Optimize your Results" on page 56

Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Most results are also available in tabular format.

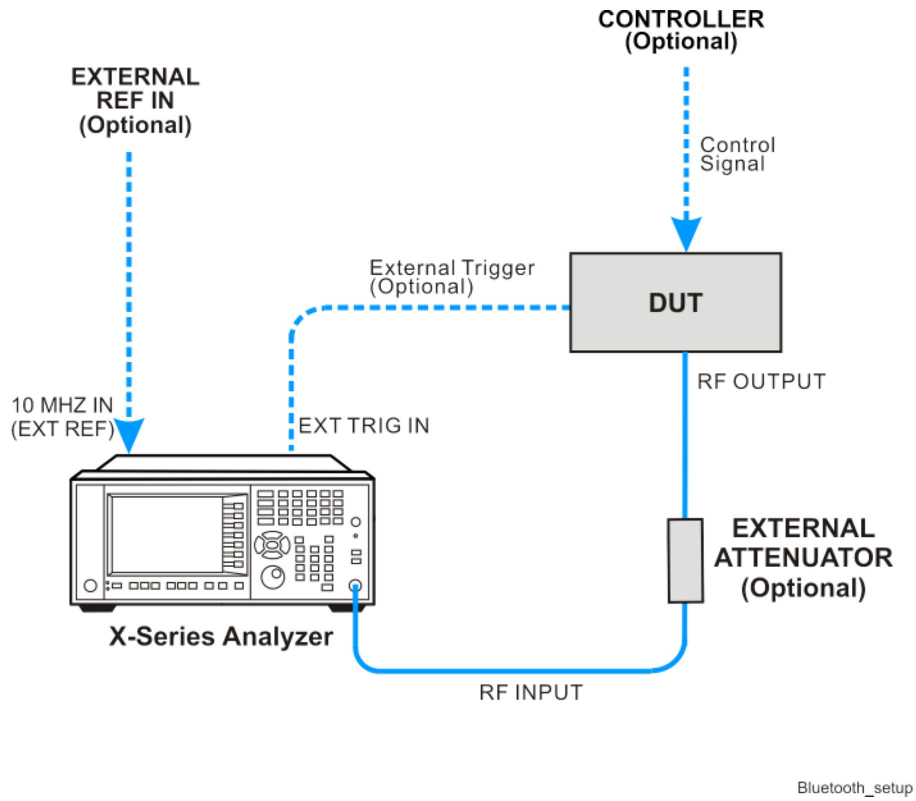
Step 1 - Set Up the Test Equipment and DUT

This step configures the analyzer connections for measuring Bluetooth signals.

Making the Initial Signal Connection

CAUTION Before connecting a signal to the instrument, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the connectors on the front panel.

Figure 2-9 LE In-band Emissions Measurement Setup



The device under test (DUT) is connected to the RF input port of the analyzer. The DUT may possibly be controlled externally by a computer. External attenuator, external trigger, and external reference are optional. Using the appropriate cables, connect the equipment as shown.

Click to Go Back to "Making LE In-band Emissions Measurements" on page 51.

Step 2 - Select the Mode and Preset the Analyzer

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

Step	Action	Notes
2a. Select the Mode.	Press **MODE**, **Bluetooth.**	
2b. Preset the analyzer.	a. Press the green **Mode Preset** button for the factory preset. b. To recall a user-defined Preset: Press **User Preset,** User Preset to preset the current mode.	

Click to Go Back to "Making LE In-band Emissions Measurements" on page 51.

Step 3 - Select the Mode Setup Parameters

This step is to turn on the Tests you want to run.

Step	Action	Notes
3a. Select Mode Setup menu.	Press **Mode Setup**, if needed.	
3b. Select radio standards menu and select the desired standard.	Press **Radio Standard**, and select the standard from the list.	
3c. Select the default output power limit.	Press **Device**, and select the desired power class from the list.	
3d. If necessary, select the frequency settings.	Press **FREQ Channel**, and input the desired center frequency or select the France bands or non-France bands by toggling **Geography**.	

Click to Go Back to "Making LE In-band Emissions Measurements" on page 51

Step 4 - Select Measurement

This step is to invoke the measurement you want to run.

Step	Action	Notes
4a. Select the LE in-band emissions measurement.	Press **Meas, LE In-band Emissions.**	
4b. If desired, change the parameters for the measurement.	Press **Meas Setup,** then select the parameters you want to change and input your settings.	
4c. Select the LE in-band emissions measurement again or restart the measurement.	Press **Meas, LE In-band Emissions**, or press **Restart.**	

Click to Go Back to "Making LE In-band Emissions Measurements" on page 51.

Step 5 - Select the Meas Setup Parameters

This step is to adjust the measurement settings.

Step	Action	Notes
5a. Select the measurement setup menus.	Press **Meas Setup**.	
5b. If desired, change the measurement method.	Press **Meas Setup, Meas Method** to toggle between **Sweep** and **IQ Acquisition.**	The test spec defines the measurement method as Sweep, the default method.
5c. If desired, change the limit parameters.	Press **Meas Setup, Limits.** You can turn on or turn off the limit test by toggling **Limit Test.** You can also change the limit lines for your measurements.	The limit lines are preset according to the test spec.
5d. If desired, preset the parameters to comply with the standard requirement.	Press **Meas Setup, Preset Standard.**	The couplings include Average settings, RBW, VBW, sweep time, detector settings and gate settings.

Click to Go Back to "Making LE In-band Emissions Measurements" on page 51.

Step 6 - Configure the Display

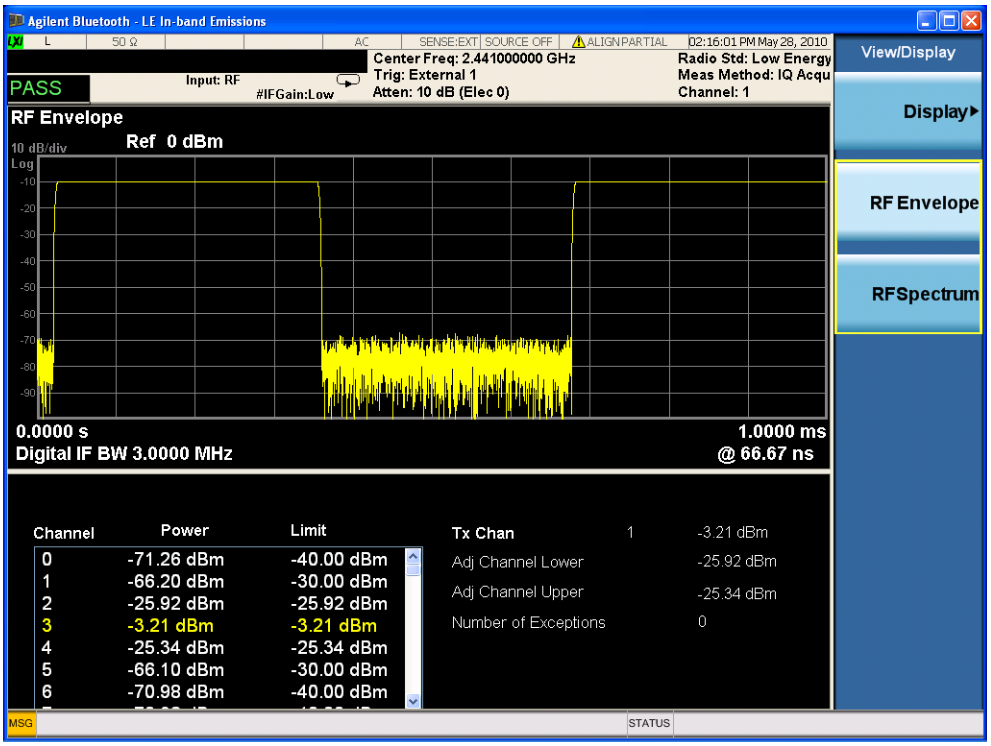
Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Required results are also available in tabular format.

Step	Action	Notes
6a. Select a view of results display.	a. Press **View/Display**, and select a view from a selection of useful combinations of related data trace displays.	

View - RF Envelope

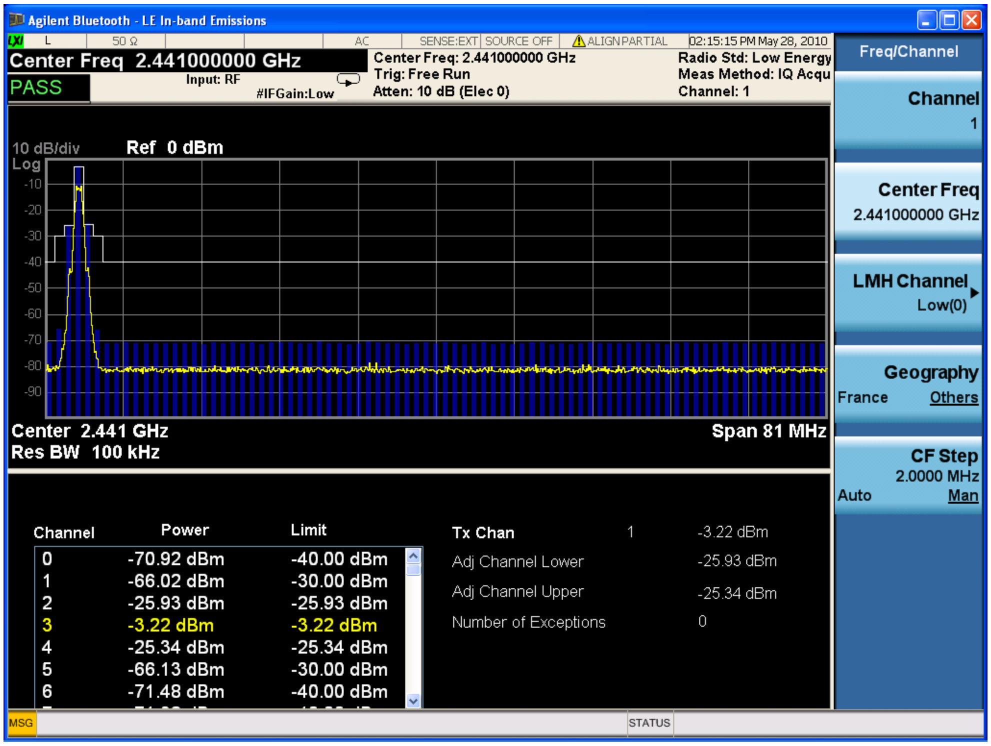
The RF Envelope view provides a combination view of RF Envelope graph and Results Metrics. RF Envelop graph shows the Power vs. Time trace for a single channel.

NOTE This view is not available when Meas Method is set to Sweep.



View - RF Spectrum

The RF Spectrum view shows a Spectrum trace.



Step 7 - Optimize your Results

In this step you can finalize the presentation of your data by adjusting various parameters to make your measurement data more useful.

See “Step 7 - Optimize your Results” on page 26.

Click to Go Back to “Making LE In-band Emissions Measurements” on page 51.

Viewing LE In-band Emissions Measurement Results

This section provides some examples of LE In-band Emissions Measurement results. Results available include graphical displays of various trace data as well as tabular results available remotely. These graphic results may be viewed separately, or combined into views. For more information on Views see “Step 6 - Configure the Display” on page 54 and “Step 7 - Optimize your Results” on page 56.

LE In-band Emissions Measurement Data includes two sets of test results combined into this measurement. Each set of results has limit testing to provide a Pass or Fail test result.

- Power vs. Time Results
- Spectrum Results

For more information on what these data traces are, see the *N9081A Bluetooth Measurement Application User’s and Programmer’s Reference* section on Trace/Detector, Data.

Click to Go Back to “Making LE In-band Emissions Measurements” on page 51.

Example Measurement - LE In-band Emissions

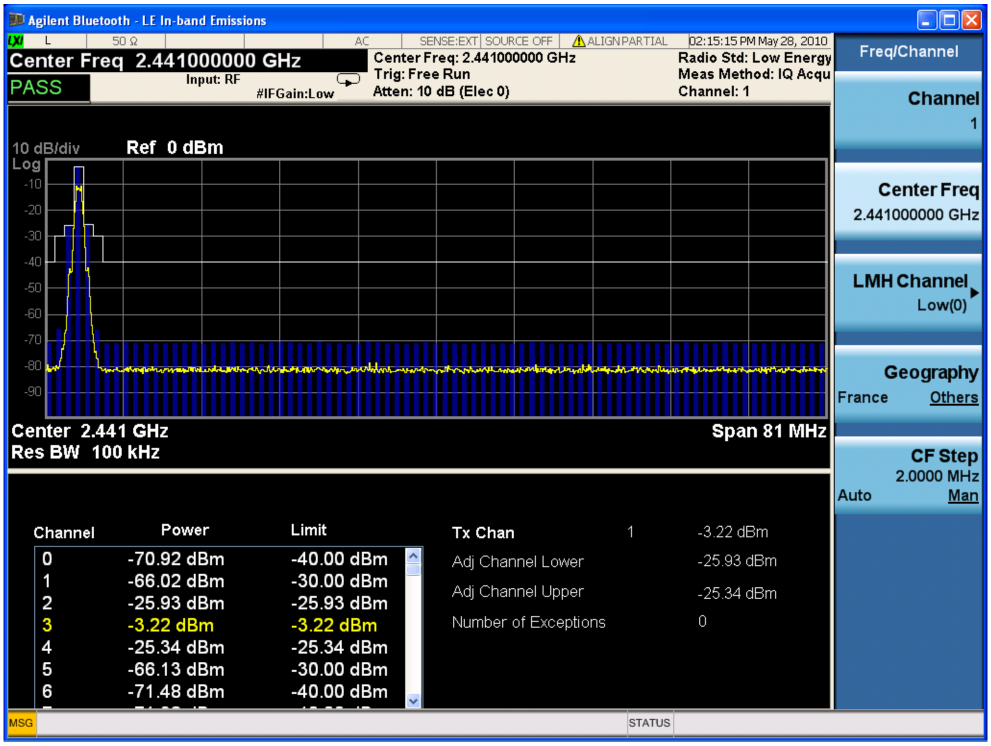
This example assumes the signal is correctly applied to the input.

Step 1. Press **Mode Preset**

Step 2. Press **Meas, LE In-band Emissions**

Step 3. View the measurement default view. (See Figure 2-10).

Figure 2-10 *LE In-band Emissions RF Spectrum View (Default)*



If you have a problem, and get an error message, see *Instrument Messages*.

Example of Using SCPI Commands

Select Bluetooth mode

:INST BT

Select the LE In-band Emissions measurement

CONF:IBEM

Get the measurement results array

READ:IBEM2?

Making Monitor Spectrum Measurements

Monitor Spectrum Measurement Overview

Making successful measurements of Bluetooth signals is easy when you follow the main steps below. The procedure overview below provides links in blue to a detailed procedure and description for each step:

"Step 1 - Set Up the Test Equipment and DUT" on page 59

This step configures the analyzer connections for an RF measurement.

"Step 2 - Select the Mode and Preset the Analyzer" on page 60

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

"Step 3- Select the Mode Setup Parameters" on page 61

This step specifies the radio parameters and carriers configuration.

"Step 4- Select Measurement" on page 61

This step allows you to make a transmit analysis measurement either by preset settings or desired settings.

"Step 5 - Optimize your Results" on page 61

Measurement results are available in graphical displays that can be presented in preset groups or adjusted to suit your specific application. Most results are also available in tabular format.

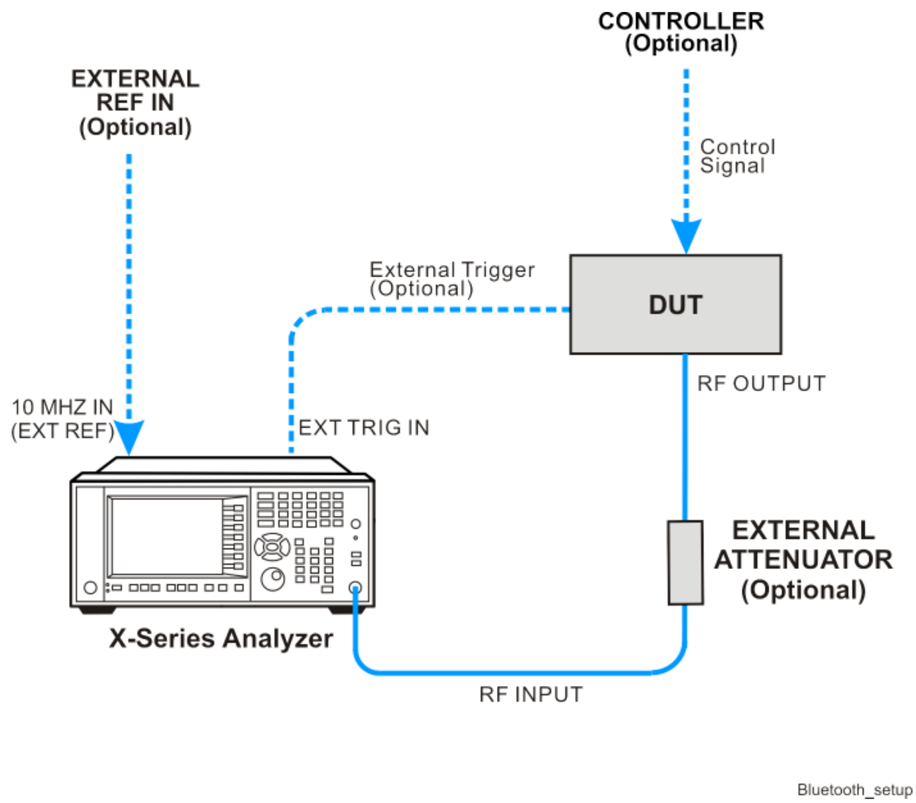
Step 1 - Set Up the Test Equipment and DUT

This step configures the analyzer connections for measuring Bluetooth signals.

Making the Initial Signal Connection

CAUTION Before connecting a signal to the instrument, make sure the instrument can safely accept the signal level provided. The signal level limits are marked next to the connectors on the front panel.

Figure 2-11 Bluetooth Measurement Setup



The Bluetooth device under test (DUT) is connected to the RF input port by an appropriate RF cable as shown. The DUT may possibly be controlled externally by a computer. External attenuator, external trigger, and external reference are optional.

Click to Go Back to "Making Monitor Spectrum Measurements" on page 59.

Step 2 - Select the Mode and Preset the Analyzer

This step assures the analyzer will be set to a known state, either the factory preset or a user-configured preset.

Step	Action	Notes
2a. Select the Mode.	Press **MODE**, **Bluetooth.**	
2b. Preset the analyzer.	a. Press the green **Mode Preset** button for the factory preset. b. To recall a user-defined Preset: Press **User Preset,** User Preset to preset the current mode.	

Click to Go Back to "Making Monitor Spectrum Measurements" on page 59.

Step 3- Select the Mode Setup Parameters

This step is to select the radio standard for signals of your interest and select the default limit value for the Output Power measurements.

Step	Action	Notes
3a. Select Mode Setup menu.	Press **Mode Setup**, if needed.	
3b. Select radio standards menu and select the desired standard.	Press **Radio Standard**, and select the standard from the list.	
3c. Select the default output power limit.	a. Press **Device**, and select the desired power class from the list.	
3d. If necessary, select the frequency settings.	a. Press **FREQ Channel**, and input the desired center frequency or select the France bands or non-France bands by toggling **Geography**. The default setting is **Others**.	Channel number is coupled with Center Frequency.

Click to Go Back to "Making Monitor Spectrum Measurements" on page 59.

Step 4- Select Measurement

This step is to invoke the measurement you want to run.

Step	Action	Notes
4a. Select the monitor spectrum measurement.	Press **Meas, Monitor Spectrum.**	
4b. If desired, change the parameters for the measurement.	Press **Meas Setup,** then select the parameters you want to change and input your settings.	
4c. Select the monitor spectrum measurement again or restart the measurement.	Press **Meas, Monitor Spectrum**, or press **Restart.**	

Click to Go Back to "Making Monitor Spectrum Measurements" on page 59.

Step 5 - Optimize your Results

In this step you can finalize the presentation of your data by adjusting various parameters to make your measurement data more useful.

See "Step 7 - Optimize your Results" on page 26.

Click to Go Back to "Making Monitor Spectrum Measurements" on page 59.

Viewing Monitor Spectrum Measurement Results

Monitor Spectrum Measurement provides a graphic display only.

For more information on what these data traces are, see the *N9081A Bluetooth Measurement Application User's and Programmer's Reference* section on Trace/Detector, Data.

Click to Go Back to "Making Monitor Spectrum Measurements" on page 59.

Example of One-Button-Measurement - Monitor Spectrum

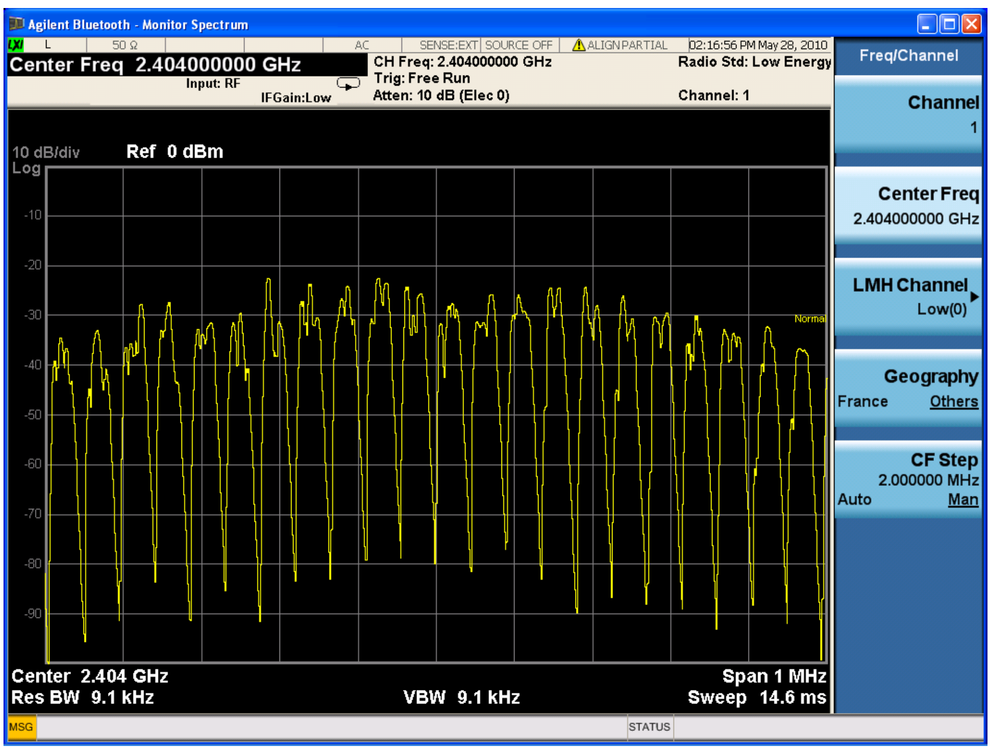
This example assumes the signal is correctly applied to the input.

Step 1. Press **Mode Preset**

Step 2. Press **Meas, Monitor Spectrum**

Step 3. View the measurement result. (See Figure 2-12).

Figure 2-12 *Monitor Spectrum*



If you have a problem, and get an error message, see *Instrument Messages*.

Example of Using SCPI Commands

Select Bluetooth mode

:INST BT

Select the Transmit Analysis measurement

CONF:MON

Get the measurement results array

READ:MON?

Troubleshooting Bluetooth Measurements

The following table provides some with descriptions you might encounter when making Bluetooth measurements.

Table 2-1

Error Numbers	Messages	Notes
207	Burst Not Found; Preamble not found	Packet preamble has not been detected.
207	Burst Not Found; Acq time too short	The data does not include the falling edge.
215	Sync error; EDR Sync not found	The capture data does not include EDR sync code.
215	Sync error; Preamble not found	The preamble code is not detected.
217	Demod error; Invalid packet type	Packet type detected is not recognized.
217	Demod error; Acq time too short	Not an entire Payload is captured, that is, the acquisition time is too short.
159	Settings Alert; Parm/data mismatch	The actual captured data length is not long enough, or, the offset from Tx Frequency to center frequency is not an integer multiple of 1 MHz.

For more information on error messages see *Instrument Messages*.

3 Concepts

This chapter describes basics of Bluetooth technology and an explanation of how measurements are performed by the instrument.

Introduction

This chapter provides a variety of digital modulation concepts to help you to better understand the features and measurements performed by the signal analyzer.

"Understanding Bluetooth" on page 67, explains the basic concepts of the Bluetooth standards.

"Measurement Concepts and Results" on page 75, explains the methods by which a digital baseband signal is modulated onto an RF carrier.

Understanding Bluetooth

NOTE	Bluetooth is a trademark of the Bluetooth SIG, Inc.

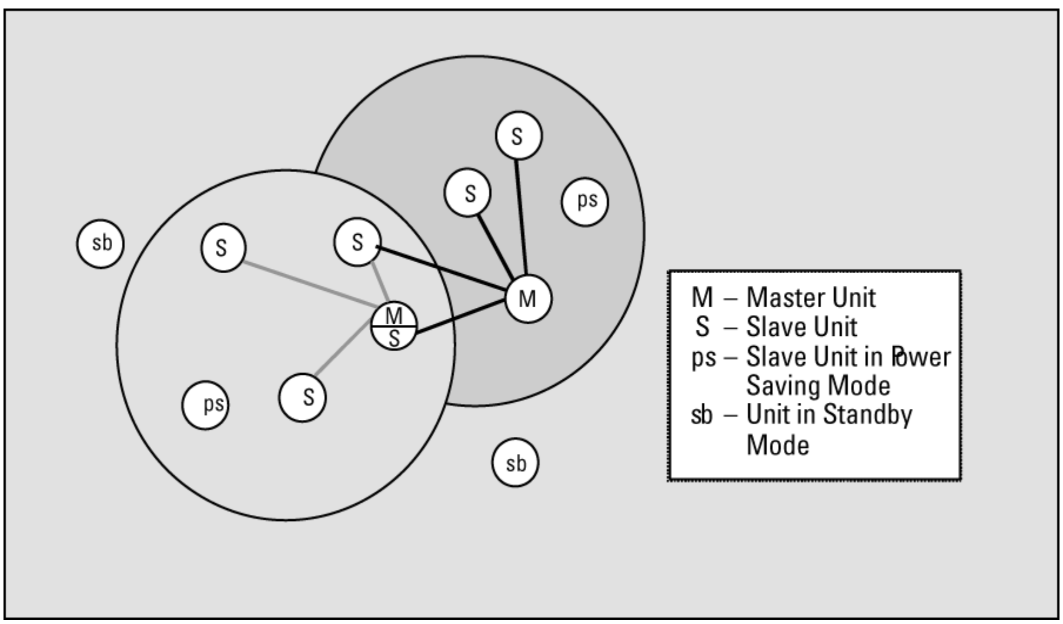
What is Bluetooth

Bluetooth is a limited range RF link technology. It targets at voice and data transmission between appliances for home or business environments. The need for interconnecting cables is eliminated. The system, typically now a single integrated component, consists of a radio, baseband link control, and link management.

The Bluetooth radio system may operate as either master or slave units. The connection topology is basically a star, with a single master and up to 7 slaves. Another 200+ slaves can be registered and in a non-communicating, power-saving mode.

This area of control is defined as a piconet. A master in one piconet may be a slave to a master from a different piconet. Similarly, multiple masters from different piconets may control a single slave. This network of piconets is referred to as a scatternet. Figure 3-1 depicts two piconets comprising a scatternet. Units that are not part of either piconet remain in standby mode.

Figure 3-1 Bluetooth Network Topology



What is Bluetooth Enhanced Data Rate (EDR)

The key characteristic of Bluetooth enhanced data rate technology is that the transmitted date rate and modulation scheme are changed within the packet. The access code and packet header are transmitted with the GFSK modulation scheme (Basic Rate 1 Mbps) and the subsequent synchronization sequence, payload, and trailer sequence are transmitted using the π/4DQPSK (2 Mbps) or 8DPSK (3 Mbps).

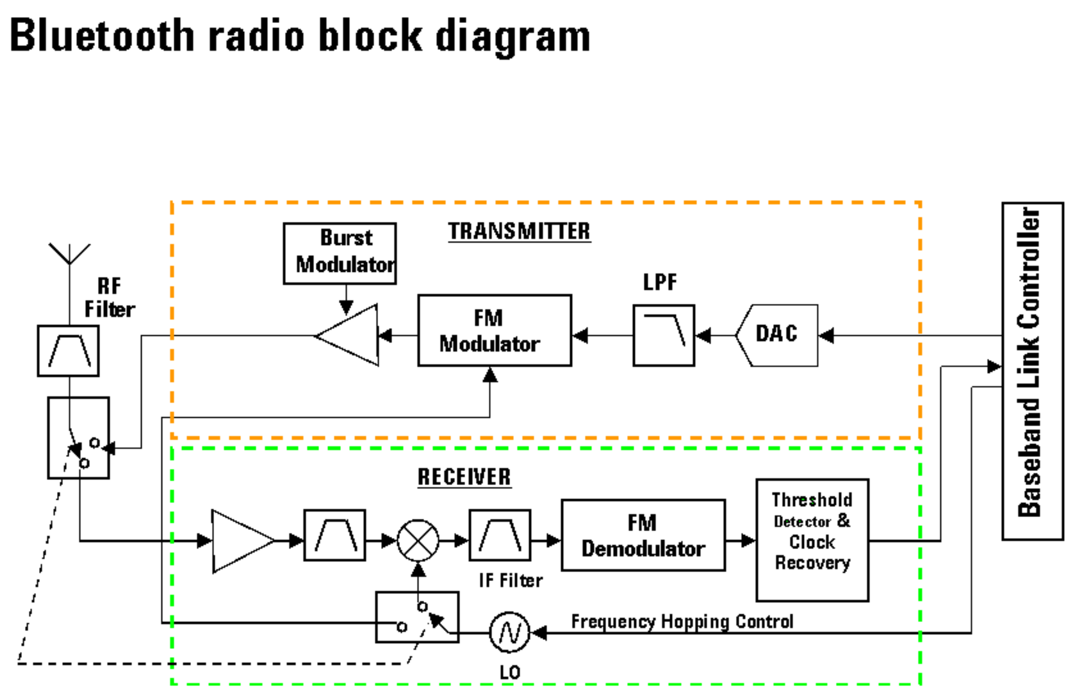
What is Bluetooth Low Energy (LE)

Bluetooth low energy technology is a new extension of Bluetooth technology. It is designed with two modes: stand-alone mode and dual mode. Small devices like watches and sports sensors are based on a stand-alone Bluetooth low energy implementation and consume minimal power. Dual mode implementations use parts of the existing Bluetooth hardware, sharing one physical radio and antenna and will basically keep the same power consumption as classic Bluetooth technology.

Bluetooth Radio Characteristics

Figure 3-2 is a block diagram for the Bluetooth radio system, showing the baseband controller and the RF transmitter and receiver sections.

Figure 3-2 *Bluetooth Radio Block Diagram*



Bluetooth devices operate in the 2.4 to 2.485 GHz Industrial, Scientific and Medical (ISM) band. This band is unlicensed and available globally.

The design emphasis for Bluetooth device is on very low power, extremely low cost, and robust operation in the uncoordinated, interference dominated RF environment of the ISM band.

The operating range depends on the device class.

- Power Class 3: has a range of up to 1 meter
- Power Class 2: has a range of 10 meters
- Power Class 1: has a range of 100 meters with an additional 20 dB power amplifier

Table 3-1

Power Class	Operating Range	Maximum Power	Minimum Power	Power Control	Notes
3	up to 1 m	100 mW (20 dBm)	1 mW (0 dBm)	Yes	

Table 3-1

Power Class	Operating Range	Maximum Power	Minimum Power	Power Control	Notes
2	up to 10 m	2.5 mW (4 dBm)	0.25 mW (-6 dBm)	NA	nominal 1 mW (0 dBm)
1	100 m	1 mW (0 dBm)		NA	

Bluetooth low energy technology has a range of up to 200 meters.

Bluetooth devices are designed to have very low power consumption. The most commonly used radio is Class 2 and uses 2.5 mW of power.

Bluetooth low energy technology consumes between 1/2 and 1/100 the power of classic Bluetooth technology.

Bluetooth has two modulation modes: Basic Rate, a mandatory mode, which uses a shaped, binary FM modulation to minimize transceiver complexity, and Enhanced Data Rate (EDR), an optional mode, which uses PSK modulation and has two variant: π/4DQPSK and 8DPSK. The symbol rate for all modulation schemes is 1 M s/sec.

For classic Bluetooth devices, the maximum data rates for a single link are 432.6/432.6 kbps symmetrical, or 721.0/57.6 kbps asymmetrical.

For Bluetooth low energy, the maximum data rates are 1 Mbps.

For EDR, the maximum data rates are 2 Mbps using π/4DQPSK and 3 Mbps using 8DPSK.

The Bluetooth radio unit employs adaptive frequency hopping (AFH), usually at 1600 hops/sec. The signal is nominally at each hop frequency for one 625 µs timeslot. Each pair of time consecutive slots constitute a time-division duplex (TDD) frame. In the TDD scheme used, the master transmits in even-numbered timeslots, and the slave transmits in odd-numbered timeslots.

A Bluetooth channel is divided into timeslots, each 625 µs in length. There are 79 Bluetooth channels, each 1 MHz wide.

Baseband Characteristics

Voice or data communication is by packet based TDD. Data packets may extend over one, three, or five time slots, whereas voice packets are limited to a single time slot. Frequency hopping occurs at the end of the last time slot associated with the packet.

A Basic Rate packet, shown in Figure 3-3, contains an access code, header and payload. The access code consists of a preamble, a sync word, and an optional trailer. The header contains piconet member address and packet information. The payload data, consisting of payload header, payload data and CRC, carries the user’s voice or data information. The payload CRC (Cyclic Redundancy Check) is a 16-bit field at the end of the payload that is used for a data integrity check. Depending on the packet type, a payload starts with a 1 (DH1) or 2 (DH3/5) byte header, and finishes with a 2 byte CRC.

Figure 3-3 *Bluetooth Basic Rate Packet Format*

A general format of Enhanced Data Rate packet is shown in Figure 3-4. The access code and header are identical in format and modulation to Basic Rate packets. It has a guard time and synchronization sequence following the header and two trailer symbols following the payload.

Figure 3-4 *Bluetooth Enhanced Data Rate Packet Format*

The Bluetooth Radio Unit

The Bluetooth radio unit is shown in Figure 3-2 as the transmitter and receiver sections of the block diagram. The transmitter upconverts the baseband information to the frequency-modulated carrier. Frequency hopping and bursting are performed at this level. Conversely, the receiver downconverts and demodulates the RF signal. Table 3-2 summarizes some of the key RF characteristics of Bluetooth.

Table 3-2 *Bluetooth RF Characteristics*

Characteristic	**Specification**	**Notes**
Carrier Frequency	2400 to 2483.5 MHz (ISM radio band)	f=2402+k MHz, k=0,...,78
Modulation	0.5 BT Gaussian-filtered 2FSK at 1 Msymbol/s Modulation index: 0.28 to 0.35 (0.32 nominal)	Digital FM scheme The peak frequency deviation allowed is 175 kHz

Table 3-2 Bluetooth RF Characteristics

Characteristic	Specification	Notes
Hopping	1600 hops/s (in normal operation)[a] 1 MHz channel spacing The system has 5 different hopping sequences: 1) Page hopping sequence 2) Page response sequence 3) Inquiry sequence 4) Inquiry response sequence 5) Channel hopping sequence The first four are restricted hopping sequences used during connection setup. The normal channel hopping sequence is pseudorandom based on the master clock value and device address.	The channel hopping sequence is designed to visit each frequency regularly and with roughly equal probability. It has a periodicity of 23 hours and 18 minutes.
Transmit Power	Power Class 1: 1 mW (0 dBm) to 100 mW (+20 dBm) Power Class 2: 0.25 mW (–6 dBm) to 2.5 mW (+4 dBm) Power Class 3: 1 mW (0 dBm)	Class 1 power control: +4 to +20 dBm (required) –30 to 0 dBm (optional) Class 2 power control: –30 to 0 dBm (optional) Class 3 power control: –30 to 0 dBm (optional)
Operating Range	10 cm to 10 m (100 m with Power Class 1)	
Maximum Data Throughput	The asynchronous channel can support an asymmetric link of maximally 721 kbps in either direction while permitting 57.6 kb/s in the return direction, or a 432.6 kbps symmetric link.	Data throughput is lower than the 1 Msymbol/s rate as a result of the overhead, which is inherent in the protocol.

a. Hop speed may vary depending on packet length.

The Bluetooth Link Control Unit and Link Management

The Bluetooth link control unit, also known as the link controller, determines the state of the device. It is responsible for establishing the network connections as well as power efficiency, error correction, and encryption.

Bluetooth radios may operate as either master or slave units. The link manager sets up the connection between master and slave units and also determines the slave's power saving mode.

The link management software works with the link control unit. Devices communicate among each other through the link manager. Table 3-3 provides a summary of the link control and management functions.

Table 3-3 Link Control and Management Functions

Characteristic	Specification	Notes
Network Connections	The master's link controller initiates the connection procedure and sets the power saving mode of the slave.	
Link Types	Two link types: ▪ Synchronous Connection Oriented (SCO) type, primarily for voice ▪ Asynchronous Connectionless (ACL) type, primarily for packet data	Bluetooth can support an asynchronous data channel, up to three simultaneous synchronous voice channels, or a channel that simultaneously supports asynchronous data and synchronous voice. Time-Division Duplexing is used for full duplex operation.
Packet Types	NULL, POLL,FHS - System packets DM1, DM3, DM5 - Medium rate, error-protected data packets DH1, DH3, DH5 - High rate, non-protected data packets HV1, HV2, HV3 - Digitized audio, 3 levels of error protection DV - Mixed data and voice AUX1 - For other uses	The 1, 3 and 5 suffixes indicate the number of time slots occupied by the data burst. Nominal burst lengths: DH1–366 ms DH3–1622 ms DH5–2870 ms
Error Correction	Three error correction schemes: ▪ 1/3 rate Forward Error Correction (FEC) code ▪ 2/3 rate Forward Error Correction (FEC) code ▪ Automatic repeat request (ARQ) scheme for data	Error correction is provided by the Link Manager
Authentication	Challenge-response algorithm. Authentication may be unused, unidirectional, or bidirectional.	Authentication is provided by the Link Manager

Table 3-3 Link Control and Management Functions

Characteristic	Specification	Notes
Encryption	Stream cipher with secret key lengths of 0, 40, or 64 bits.	
Test Modes	Provides the ability to place the device into test loop-back mode and allows control of test parameters such as frequency settings, power control, and packet type.	

Measurement Concepts and Results

The N9081A & W9081A Bluetooth measurement application provides:

- Adjacent Channel Power (ACP) Measurement
- Enhanced Data Rate (EDR) In-band Spurious Emissions Measurement
- Low Energy (LE) In-band Emissions Measurement
- Monitor Spectrum Measurement
- Output Spectrum Bandwidth (OBW) Measurement
- Transmit Analysis Measurement

Adjacent Channel Power Measurement

The Adjacent Channel Power measurement is a low cost test for Bluetooth + LE devices to conform to the following Bluetooth specifications:

- Bluetooth 2.1 TRM/CA/06/C (TX Output Spectrum - Adjacent Channel Power) RF test specifications

The measurement is performed to verify the emissions levels within the operating frequency range conform to the limits. The power measurements covered by this test are total peak power for adjacent channels.

The measurement provides 79 scalar values of the transmit power per channel. The front panel results include:

- Tx Chan: transmit channel number
- Tx Chan Power: transmit channel power
- Adj Chan kHz Lower: adjacent 500 kHz lower channel power
- Adj Chan kHz Upper: adjacent 500 kHz upper channel power
- Number of Exceptions: pass/fail indicator for every channel

EDR In-band Spurious Emissions Measurement

The EDR In-band Spurious Emissions measurement is a low cost test for Bluetooth + EDR devices to conform to the following Bluetooth specifications:

- Bluetooth 2.1 TRM/CA/13/C (EDR - In-band Spurious Emissions) RF test specifications

The measurement verifies whether the level of unwanted signal with the used frequency band lies below the required level.

The analyzer is set to zero span with a sweep time of packet length, a sweep mode of Max Hold, a detector of Average, a RBW of 100 kHz and VBW of 300 kHz. By adjusting the Gate delay and Gate length, the analyzer records the signal only in those parts of the signal in which the device transmits DPSK-modulated data. The measurement is implemented by sweep.

The measurement provides 79 scalar values of the Tx power per channel. The front panel results include:

- Tx Chan: transmit channel number
- Tx Chan Power: transmit channel power
- Adj 500 kHz Lower
- Adj 500 kHz Upper
- Number of Exceptions: pass/fail indicator for every channel

LE In-band Emissions Measurement

The LE In-band Emissions measurement is a low cost test for Bluetooth + LE devices to conform to the following Bluetooth specifications:

- Bluetooth + LE RF PHY 0.7 (TRM-LE/CA-02-C) RF test specifications

The power measurements are total peak power for adjacent channels.

The measurement provides 80 scalar values of the Tx power per channel. The front panel results include:

- Tx Chan: transmit channel number
- Tx Chan Power: transmit channel power
- Adj Chan kHz Lower
- Adj Chan kHz Upper
- Number of Exceptions: pass/fail indicator for every channel

Output Spectrum Bandwidth

The output spectrum bandwidth measurement is used to verify if the emissions inside the operating frequency are within the limits.

The Bluetooth RF Specification defines a minimal bandwidth of 3 MHz, normally for a standard gaussian filter, which may causes around 4% frequency deviation when 0101 symbol sequence is used. Therefore it is recommended to use a higher bandwidth IF that has a flat amplitude characteristics and does not affect the frequency deviation of the signal under test.

To perform this measurement the analyzer is tuned to the channel to be measured and the span is set to 2 MHz. The peak of the current trace is identified. The measurement then places markers at the points highest and lowest in frequency in the current span where the signal drops –20dB from this peak value. The frequency between these two points is measured as the output spectrum bandwidth.

Transmit Analysis Measurement

The transmit analysis measurement is a low cost test, which combines multiple measurements in a single package, for Bluetooth + EDR devices to conform to the following Bluetooth specifications:

- Bluetooth + EDR Ver2.1 RF test specifications
- Bluetooth Low Energy RF test specifications

The measurement is performed on a single IQ data acquisition. If radio standard is Basic or Low Energy, it measures Output Power, Modulation Characteristics, Initial Carrier Frequency Tolerance (ICFT) and Carrier Frequency Drift. If radio standard is EDR, it measures Relative Transmit Power, Frequency Stability and Modulation Accuracy, and Differential Phase Decoding.

The results shown on the front panel depend upon the radio standard selected from **Mode Setup**, **Radio**. The following results are common to all standards:

- Packet Type
- Payload
- Payload Length

The following results are common to basic Bluetooth standard by pressing **Mode Setup**, **Radio**, **Basic**:

- Output Power
- GFSK Average Power
- GFSK Peak Power
- Modulation Characteristics:
    — ΔF1 Avg for the 11110000 payload data pattern
    — ΔF2 Avg for the 10101010 payload data pattern
    — Min ΔF1 Max
    — Max ΔF1 Max
    — Min ΔF2 Max
    — Max ΔF Max
    — ΔF2 > 115 kHz
    — ΔF2/ΔF1 Ratio
- Initial Carrier Frequency Tolerance (ICFT)
- Carrier Frequency Drift
    — Frequency Drift
    — Max Drift Rate

The following results are common to basic Bluetooth standard by pressing **Mode Setup**, **Radio**, **EDR**:

- Carrier Frequency Stability & Modulation Accuracy
  - Frequency Offset wi
  - Frequency Offset w0
  - Frequency Offset wi+w0
  - RMS DEVM
  - Peak DEVM
  - 99% DEVM for EDR modulation
- EDR Relative Transmit Power
  - GFSK Avg Power
  - DPSK Avg Power
  - Relative Power (GFSK Avg Power - DPSK Avg Power)
- EDR Differential Phase Encoding
  - BER
  - Bit Errors
  - Guard Interval

Output Power

Output power measurements are performed to ensure power levels are high enough to maintain links, yet low enough to minimize interference within the ISM band and to maximize battery life.

The power measurements covered by this test are average power and peak power for the specified channel or center frequency. The analyzer is set to zero span mode with a sweeptime dependent on the packet type being measured. When the analyzer is triggered, it makes a sweep over the duration of the burst.

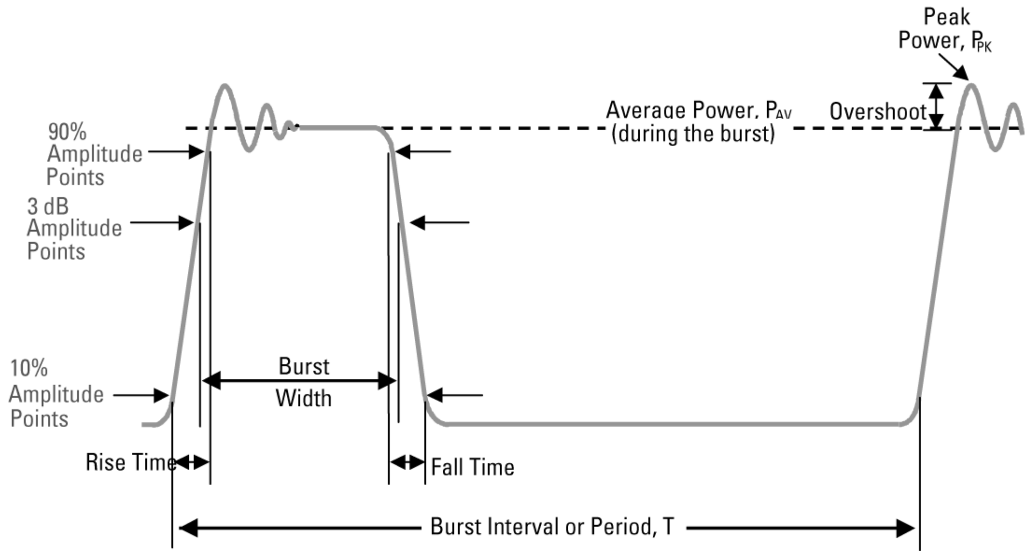
The peak power is calculated as the highest point in the burst.

The average power is calculated as the average power over 20% to 80% of the burst duration. You can choose a method to determine the burst duration:

1. Preamble - The position of p0 is used to define the start of the burst.
2. RF Amptd - The burst duration is taken as the time between the leading and trailing 3 db points compared to the average power.
3. None - There is no synchronization process.

Figure 3-5 illustrates power and timing characteristics of a signal burst in the time domain.

Figure 3-5 *Time Domain Power and Timing Analysis*



Carrier Frequency Drift

The carrier frequency drift measurement checks the performance of the modulator circuitry and the stability of the Voltage Controlled Oscillator (VCO).

To make the measurement a demodulated signal is used with the payload data consisting of a repeating 4-bit 1010 sequence. The absolute frequencies of the 4 preamble bits are measured and integrated, providing the initial carrier frequency. The absolute frequencies of each successive 10-bit pattern in the payload are then measured and integrated.

The frequency drift is the maximum difference between the average frequency of the 4 preamble bits and the average frequency of any 10 bits in the payload field. The maximum drift rate applies to the difference between any two 10-bit groups separated by 50 µs within the payload field.

Monitor Band/Channel Measurement

This measurement can be used to visually check either the Bluetooth band or individual channels. In Monitor Band, you can easily check the channel occupancy and flatness when frequency hopping is on. In Monitor Channel you can verify the correct spectral shape of the selected channel.

Any interfering signals may also be apparent when using this measurement.

This procedure scans the specified band or channels. By placing markers on the trace it is possible to check the band/channels for interference or other impairments. A Max Hold function enables monitoring over time. This is useful for dealing with hopping signals.

Initial Carrier Frequency Tolerance

The initial carrier frequency tolerance measurement is designed to verify the accuracy of the transmitter's initial carrier frequency.

This is measured by integrating over the frequency deviations of the packets first 4 bits (the preamble bits). The result is either a positive or negative number in Hz indicating the frequency difference from the specified nominal carrier 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.

Modulation Characteristics

Modulation characteristics is a frequency deviation measurement which is designed to verify both the modulator performance and the accuracy of the pre-modulation 0.5BT Gaussian Filter.

Two separate test signals are required for this measurement, each one containing an 8-bit repeating sequence in the payload. These repeating sequences are 11110000 and 10101010.

The measurement is performed in 2 stages, each stage requiring a different packet: one carrying the 11110000 payload, the other carrying the 10101010 payload.

Using the 11110000 payload

The average frequency over the first 8 bits in the payload is calculated and then the maximum deviation from this average over bits 2,3,6 & 7 is measured. The maximum for each repeating 8-bit sequence in the payload is measured in the same way, each time calculating a new average frequency over the respective 8 bits. Eventually, the average of all these maximums is calculated and shown in the results window as Δf1 Avg.

Using the 10101010 payload

The average frequency over the first 8 bits in the payload is calculated and then the maximum deviation from this average over all 8 bits is measured. The maximum for each repeating 8-bit sequence in the payload is measured in the same way, each time calculating a new average frequency over the respective 8 bits. Eventually the average of all these maximums is calculated and shown in the results window as Δf2 Avg.

Once the measurement has acquired values for Δf1 Avg and Δf2 Avg, the ratio of Δf2 Avg to Δf1 Avg is also displayed.

Since this measurement requires human interaction (to manually change test signals), it will display only either Δf1 Avg or Δf2 Avg the first time it is run, depending on the signal type. The first result must be "held" using the **Hold Result** parameter and the measurement restarted. At this point the other signal type should be supplied, and the measurement restarted.

If a remote query of all three results is requested after having obtained only one result, then 3 values will be returned, although only 1 result will be correct and the other 2 will contain NaN.