Keysight Technologies
Bluetooth®
X-Series Measurement App, Multi-Touch
N9081C

Technical Overview

- Measure *Bluetooth* RF transmitter performance, compliant to *Bluetooth* RF test specifications 2.1+EDR/3.0/3.0+HS and Low Energy (RF-PHY.TS/4.0/4.2/5)
- Perform one-button tests with pass/fail limits per *Bluetooth* RF test specifications
- Multi-touch user interface or SCPI remote user interface
- Built-in context sensitive help
- Move application between X-Series signal analyzers with transportable licensing

KEYSIGHT TECHNOLOGIES

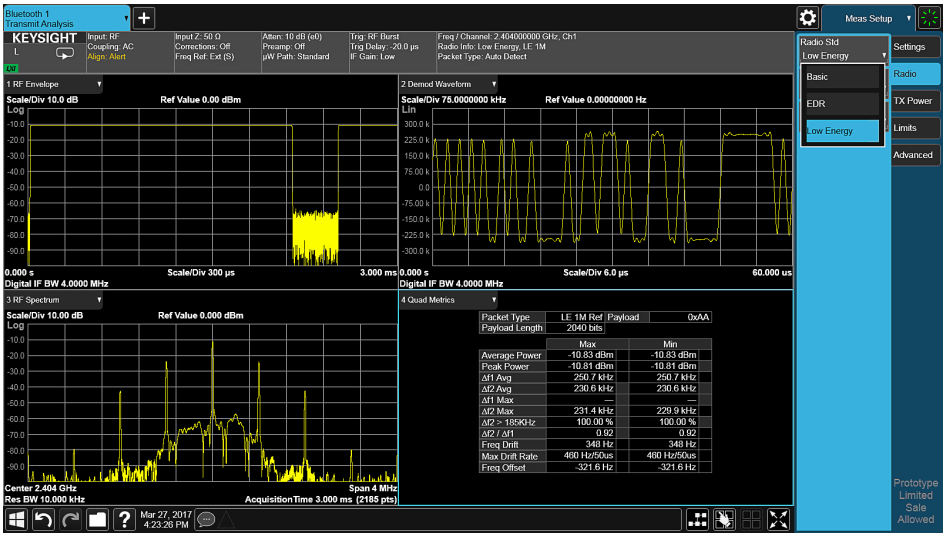
Unlocking Measurement Insights

Bluetooth Measurement Application

The *Bluetooth* measurement application transforms the X-Series signal analyzers into standard-based *Bluetooth* RF transmitter testers by adding fast, one-button RF conformance measurements to help you design, evaluate, and manufacture your *Bluetooth* devices. The measurement application is standard-compliant to the *Bluetooth* Core Specification to verify your *Bluetooth* design with confidence and support manufacturing with a single application covering basic rate, EDR and low energy technologies for production.

X-Series measurement applications

X-Series measurement applications increase the capability and functionality of Keysight Technologies, Inc. signal analyzers to speed time to insight. They provide essential measurements for specific tasks in general-purpose, cellular communications, wireless connectivity and digital video applications, covering established standards and modulation types. Applications are supported across X-Series analyzers, with the only difference being the level of performance achieved by the hardware you select.



RF Transmitter Tests

With the X-Series signal analyzers and the *Bluetooth* measurement application, you can perform the RF layer test procedure and specification (TSS/TP 4).

Standard-based RF transmitter tests

The *Bluetooth* specifications are developed and licensed by the *Bluetooth* Special Interest Group (SIG). The *Bluetooth* Test Specification document contains the Test Suite Structure (TSS) and Test Purpose (TP) to test the *Bluetooth* RF layer including Basic Rate, Enhanced Data Rate and Low Energy. This specification is a basis for conformance tests of *Bluetooth* devices, giving a high probability of air interface inter-operability between different manufacturer's *Bluetooth* devices.

The Keysight X-Series Bluetooth measurement application refers to the following *Bluetooth* RF test specifications:

- *Bluetooth* Test Specification 1.2/2.0/2.0+EDR/2.1/2.1+EDR/3.0/3.0+HS
- *Bluetooth* Low Energy RF Test Specifications: RF-PHY.TS/4.0/4.2/5

Table 1 provides a list of tests with their test purpose identifiers and corresponding measurement applications for transmitter tests only.

Table 1. *Bluetooth* RF transmitter measurements and the corresponding measurements in N9081C

***Bluetooth* transmitter tests**	**Identifier[2]**	**N9081C X-Series measurement application**
Basic rate		
Output power	TRM/CA/01/C	Transmit analysis
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
Enhanced data rate (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
Low Energy (LE) or Ultra Low Power (ULP)		
Output power at NOC	TRM-LE/CA/01/C	Transmit analysis
Output power at EOC	TRM-LE/CA/02/C	Transmit analysis
In-band emission at NOC	TRM-LE/CA/03/C	LE in-band emission
In-band emission at EOC	TRM-LE/CA/04/C	LE in-band emission
Modulation characteristics	TRM-LE/CA/05/C	Transmit analysis
Carrier frequency offset and drift at NOC	TRM-LE/CA/06/C	Transmit analysis
Carrier frequency offset and drift at EOC	TRM-LE/CA/07/C	Transmit analysis

1. Radio frequency Test Suite Structure (TSS) and Test Purposes (TP) system specifications
2. Identifier format is: (Test)/CA/NN/C, in which
   TRM = Transmitter test
   CA = Capability test (defines the type of testing)
   NN = Test purpose number
   C = Conformance test performed on dedicated Bluetooth test system

Measurement details

All of the Bluetooth RF transmitter measurements as defined for basic, EDR and low energy in the test specifications, as well as a wide range of additional measurements and analysis tools, are available with a press of a button (Table 2). These measurements are fully remote controllable via the IEC/IEEE bus or LAN, using SCPI commands.

Figure 1. Transmit analysis for EDR signal

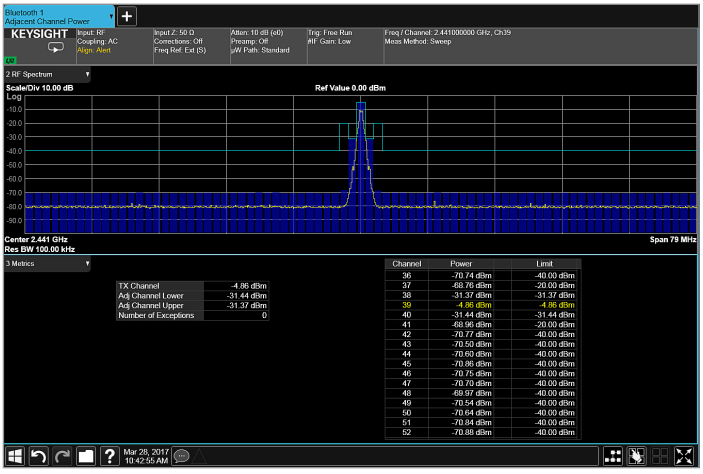


Figure 2. Adjacent channel power for basic rate *Bluetooth* signal

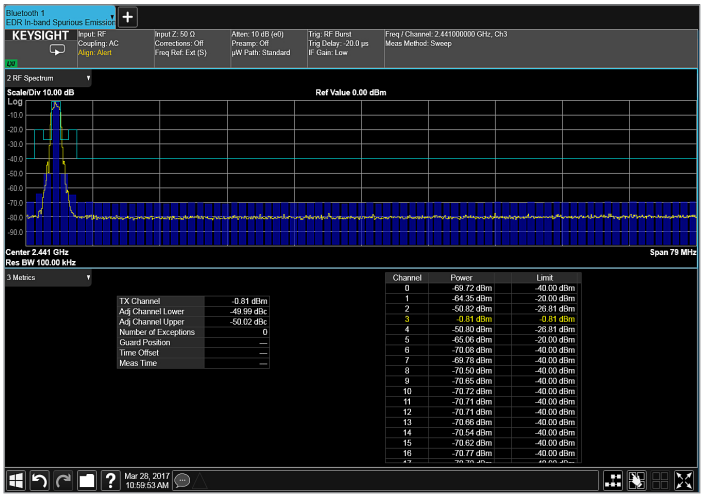


Figure 3. EDR in-band emission

Figure 4. Transmit analysis for low energy (LE) signal

Measurement details (continued)

Table 2. One-button measurements provided by the N9081C measurement application

***Bluetooth* Technology**	**Basic data rate**	**Enhanced data rate**	**Low energy**
Transmit analysis			
Output power (in time domain)			
Peak power	●		●
Average power	●		●
Modulation characteristics			
ΔF1 avg (11110000)	●		●
ΔF2 avg (10101010)	●		●
Min Δf1/ Δf2 max,	●		●
Max ΔF1/ ΔF2 max,	●		●
ΔF2 > 115 kHz	●		●
ΔF2/ΔF1 ratio			
Initial carrier frequency tolerance (ICFT)	●		
Frequency offset			●
Carrier frequency drift			
Frequency drift	●		●
Max drift rate	●		●
Adjacent channel power	●		
Output power – 20 dB bandwidth	●		
EDR transmit analysis			
Relative transmit power			
GFSK average power		●	
DPSK average power		●	
Relative power		●	
Frequency stability and modulation accuracy			
Freq offset ωi/ω0, ωi+ω0		●	
RMS DEVM (differential DVM)		●	
Peak DEVM		●	
Differential phase decoding			
BER		●	
Bit error		●	
99% DEVM		●	
EDR in-band spurious emissions		●	
LE in-band emissions			●

Key Specifications

Definitions

– 95th percentile values indicate the breadth of the population (≈2σ) of performance tolerances expected to be met in 95% of cases with a 95% confidence. Typical values are designated with the abbreviation “typ.” These are performance beyond specification that 80% of the units exhibit with a 95% confidence. Nominal values are designated with the abbreviation “nom.” These values indicate expected performance, or describe product performance that is useful in the application of the product.

Note: Data subject to change

Supported devices and standard version

Device type	***Bluetooth* devices**
Standard version	*Bluetooth* radio frequency system specification 1.2/2.0/2.0+EDR/2.1/2.1+EDR revision 2.1.E.0 – basic rate – enhanced data rate *Bluetooth* Low Energy RF PHY test specification (LE RF-PHY.TS/4.0/4.2/5)
Power classes	Class 1, class 2 and class 3
Radio band	*Bluetooth* basic rate and EDR system: 2.400 to 2.4835 GHz (f = 2402 +k MHz, k = 0, ...,78) *Bluetooth* low energy system: 2.400 to 2.4835 GHz (f = 2402 +kx2 MHz, k = 0, ...,39)

For a complete list of specifications refer to the appropriate specifications guide.

Benchtop:
UXA: **www.keysight.com/find/uxa_specifications**
PXA: **www.keysight.com/find/pxa_specifications**
MXA: **www.keysight.com/find/mxa_specifications**
EXA: **www.keysight.com/find/exa_specifications**
CXA: **www.keysight.com/find/cxa_specifications**

Key Specifications

Supported standards	
Bluetooth basic rate	Revision 2.1.E.0
Bluetooth Enhanced Data Rate	Revision 2.1.E.0/3.0/3.0+HS
Bluetooth Low Energy	LE. RF-PHY.TS/4.0/4.2/5

Description	**PXA**	**MXA**	**EXA**	**CXA**
Basic rate or Low energy measurements				
Output power				
Packet type		DH1, DH3, DH5, HV3		
Payload		PRBS9, BS00, BSFF, BS0F, BS55		
Synchronization		RF Burst or Preamble		
Trigger		External, RF Burst, Periodic Timer, Free Run, Video		
Supported measurements		Average power, peak power		
Range		+30 dBm to –70 dBm		
Absolute power accuracy	± 0.20 dB (95%)	± 0.25 dB (95%)	± 0.29 dB (95%)	± 0.61 dB (95%)
Measurement floor		–70 dBm (nom)		
Modulation characteristics				
Packet type		DH1, DH3, DH5, HV3 (for Basic), Reference packet (for LE)		
Payload		BS0F, BS55		
Synchronization		Preamble		
Trigger		External, RF Burst, Periodic Timer, Free Run, Video		
Supported measurements		Min/max Δf1avg, min Δf2max (kHz), total Δf2max > Δf2max lower limit (%), min of min Δf2avg/max Δf1avg, pseudo frequency deviation (Δf1and Δf2)		
RF input level range		+30 dBm to –70 dBm		
Deviation range		± 250 kHz (nom)		
Deviation resolution		100 Hz (nom)		
Measurement accuracy		± 100 Hz + tfa[1] (nom)		
Initial carrier frequency tolerance				
Packet type		DH1, DH3, DH5, HV3 (for Basic), Reference packet (for LE)		
Payload		PRBS9, BS00, BSFF, BS0F, BS55		
Synchronization		Preamble		
Trigger		External, RF Burst, Periodic Timer, Free Run, Video		
RF input level range		+30 dBm to –70 dBm		
Measurement range		Nominal channel freq ± 100 kHz (nom)		
Measurement accuracy		± 100 Hz + tfa[1] (nom)		
Carrier frequency drift				
Packet type		DH1, DH3, DH5, HV3 (for Basic), Reference packet (for LE)		
Payload		PRBS9, BS00, BSFF, BS0F, BS55		
Synchronization		Preamble		
Trigger		External, RF Burst, Periodic Timer, Free Run, Video		
RF input level range		+30 dBm to –70 dBm		
Measurement range		± 100 kHz (nom)		
Measurement accuracy		± 100 Hz + tfa[1] (nom)		
Adjacent channel power[2] (Basic Rate)				
Packet type		DH1, DH3, DH5, HV3		
Payload		PRBS9, BS00, BSFF, BS0F, BS55		
Synchronization		None		
Trigger		External, RF Burst, Periodic Timer, Free Run, Video		
Absolute power accuracy		Dominated by the variance of measurements[4]		
Packet type		Reference packet		
Payload		PRBS9, BS00, BSFF, BS0F, BS55		
Packet length		Up to 255 octets (*Bluetooth* 4.2)		
Trigger		External, RF Burst, Periodic Timer, Free Run, Video		
Absolute power accuracy		Dominated by the variance of measurements[4]		

Key Specifications (continued)

Description	PXA	MXA	EXA	CXA
Enhanced data rate (EDR) measurements				
EDR relative transmit power				
Packet type	2-DH1, 2-DH3, 2-DH5, 3-DH1, 3-DH3, 3-DH5			
Payload	PRBS9, BS00, BSFF, BS0F, BS55			
Synchronization	DPSK synchronization sequence			
Trigger	External, RF Burst, Periodic Timer, Free Run, Video			
Supported measurements	Power in GFSK header, power in PSK payload, relative power between GFSK header and PSK payload			
RF input level range	+30 dBm to –70 dBm			
Absolute power accuracy	± 0.20 dB (95%)	± 0.25 dB (95%)	± 0.29 dB (95%)	± 0.61 dB (95%)
Measurement floor	–70 dBm (nom)			
EDR modulation accuracy				
Packet type	2-DH1, 2-DH3, 2-DH5, 3-DH1, 3-DH3, 3-DH5			
Payload	PRBS9, BS00, BSFF, BS55			
Synchronization	DPSK synchronization sequence			
Trigger	External, RF Burst, Periodic Timer, Free Run, Video			
Supported measurements	rms DEVM, peak DEVM, 99% DEVM			
RF input level range	+30 dBm to –70 dBm			
Range (rms DEVM)	0 to 12%			0 to 12% (nom)
Floor	1.5%			1.6% (nom)
Accuracy	± 1.2%[5]			
EDR carrier frequency stability				
Packet type	2-DH1, 2-DH3, 2-DH5, 3-DH1, 3-DH3, 3-DH5			
Payload	PRBS9, BS00, BSFF, BS55			
Synchronization	DPSK synchronization sequence			
Trigger	External, RF Burst, Periodic Timer, Free Run, Video			
Supported measurements	Worst case initial frequency error(ωi) for all packets (carrier frequency stability), worst case frequency error for all blocks (ωo),(ωo + ωi) for all blocks			
RF input level range	+30 dBm to –70 dBm			
Carrier frequency stability and frequency error	± 100 Hz + tfa[1] (nom)			
EDR in-band spurious emissions				
Packet type	2-DH1, 2-DH3, 2-DH5, 3-DH1, 3-DH3, 3-DH5			
Payload	PRBS9, BS00, BSFF, BS55			
Synchronization	DPSK synchronization sequence			
Trigger	External, RF Burst, Periodic Timer, Free Run, Video			
Measurement accuracy				
offset freq = 1 MHz to 1.5 MHz	Dominated by the ambiguity of the measurement standards[6]			
offset freq = other offset (2 MHz to 78 MHz)	Dominated by the variance of measurements[4]			

1. tfa = transmitter frequency × frequency reference accuracy.
2. The accuracy is for absolute power measured at 2.0 MHz offset and other offsets (offset = K MHz, K= 3,...,78).
3. The accuracy is for absolute power measured at 2.0 MHz offset and other offsets (offset = 2 MHz * K, K = 2,...,39).
4. The measurement at these offsets is usually the measurement of noise-like signals and therefore has considerable variance. For example, with 100 ms sweeping time, the standard deviation of the measurement is about 0.5 dB. In comparison, the computed uncertainties of the measurement for the case with CW interference is only ± 0.20 dB (PXA), ± 0.25 dB (MXA), ± 0.29 dB (EXA), ± 0.61 dB (CXA) (95th percentile).
5. The accuracy specification applies when the EVM to be measured is well above the measurement floor. Please refer to Bluetooth specification guide for N9081A or W9081A for more detail explanation.
6. The measurement standards call for averaging the signal across 3.5 µs apertures and reporting the highest result. For common impulsive power at these offsets, this gives a variation of result with the time location of that interference that is 0.8 dB peak-to-peak and changes with a scallop shape with a 3.5 µs period. Uncertainties in the accuracy of measuring CW-like relative power at these offsets are nominally only ± 0.03 dB (PXA), ± 0.07 dB (MXA), ± 0.09 dB (EXA), ± 0.11 dB (CXA), but observed variations of the measurement algorithm used with impulsive interference are similar to the scalloping error.

Ordering Information

Software licensing and configuration

Choose from two license types:

- Fixed, perpetual license:
  This allows you to run the application in the X-Series analyzer in which it is initially installed.
- Transportable, perpetual license:
  This allows you to run the application in the X-Series analyzer in which it is initially installed, plus it may be transferred from one X-Series analyzer to another.

You Can Upgrade!

Options can be added after your initial purchase.
All of our X-Series application options are license-key upgradeable.

The table below contains information on our fixed, perpetual licenses. For more information, please visit the product web pages.

N9081C *Bluetooth* X-Series measurement application

Description	Model-Option	Additional Information
	UXA, PXA, MXA, EXA, CXA	
Bluetooth BR/EDR/LE4.0/4.2	N9081C-2FP	
Bluetooth 5	N9081C-3FP	Requires 2FP and firmware above A.19.05

Hardware configuration

For optimizing measurements on *Bluetooth* signals with the Bluetooth measurement application, Keysight recommends a minimum level of X-Series multi-touch instrument hardware functionality at each instrument performance point.

Supported instruments include:

- UXA N9040B
- PXA N9030B
- MXA N9020B
- EXA N9010B
- CXA N9000B

Capability	Instrument Option	Benefit
Analysis bandwidth	25 MHz minimum (-B25) or wider	**Required**: Up to full aggregated bandwidth for multiple carrier capture for LTE-Advanced TDD transmit on/off power measurement
Precision Frequency Reference	-PFR	**Recommended**: For enhanced frequency accuracy and repeatability for lower measurement uncertainty
Electronic Attenuator	-EA3	**Recommended**: Fast and reliable attenuation changes ideal for manufacturing without the wear associated with mechanical attenuators up to 3.6 GHz in 1 dB steps
Pre-amplifier	3.6 GHz (-P03) or higher	**Recommended**: For maximizing the measurement sensitivity
Fine Resolution Step attenuator	-FSA	**Recommended**: Useful for maximizing useable dynamic range to see signals
Analog baseband I/Q inputs	-BBA on PXA and MXA only	**Optional**: To extend measurements at baseband if required by device under test

Related Literature

N9081A & W9081A Bluetooth, Self-Guide Demonstration,
Literature Number 5990-6161EN

Bluetooth Measurement Fundamentals, Application Note,
Literature Number 5988-3760EN

Verifying Bluetooth Baseband Signals using Mixed Signal Oscilloscopes, Application Note AN 1333-3, Literature Number 5988-2181EN

Keysight E4438C Signal Studio for Bluetooth, Application Note 1421,
Literature Number 5988-5417EN

Keysight Innovative Solution for Testing Bluetooth Enhanced Data Rate Products, Product Overview, Literature Number 5989-3055EN

User's and Programmer's Reference Guide is available in the library section of the N9081A and W9081A product pages.

Web

Product page:
www.keysight.com/find/N9081C

X-Series measurement applications:
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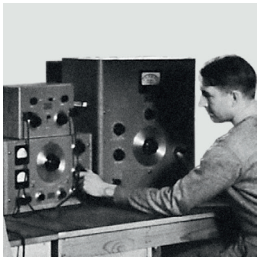

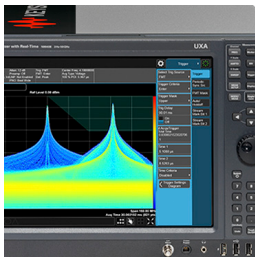

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