

Keysight X8711A IoT Device Functional Test Solution

A New Way To Perform Functional Testing

As an IoT device manufacturer, time and money are the essence of your operation. You must balance cost with quicker test development time to enable faster time to market. The solution you choose at the design and validation stage or manufacturing, to verify the proper functioning of your IoT device's radio must help you achieve these goals.

The X8711A IoT device functional test solution is a cost-effective, over-the-air* signaling test solution that allows you to test your *Bluetooth*® Low Energy 4.2 and WLAN b/g/n IoT devices* in actual operation mode and in its final form. With this solution, you can:

- Complete transmit (Tx) power and receiver (Rx) Packet Error Rate (PER) test in seconds
- Objectively measure key transmitter and receiver parameters with quantitative measurements, ensuring device quality and performance
- Simplify test development with a complete test solution that includes hardware, software, support and calibration – all from the same solution provider
- Easily perform signaling power measurements with measurement suites that include test steps



Figure 1: The X8711A IoT Device Functional Test Solution consists of the 34972A Data Acquisition Unit, 34999A RF module and the Keysight Test Automation Platform based measurement suites, the KS83301A/KS83301B BLE 4.2 signaling and the KS83302A/KS83302B WLAN b/g/n signaling. PC and RF cable are not included. X8751A RF shield enclosure and X8753A multi-up configuration are available. Source: [Keysight.com](https://www.keysight.com)

*Over-the-air (OTA) measurement is conducted in a controlled environment/shield box to verify the OTA Tx and Rx performance of the device-under-test



IoT functional test made easy

The testing of your IoT device specifically its transmitter and receiver, whether at the design or validation stage or in the manufacturing line after final assembly, helps you ensure that your IoT device functions properly in real world conditions.

* We can customize this solution to support *Bluetooth* 5 and Zigbee devices through the ZA0060A custom IoT test solution. Please contact your local Keysight representative

Challenges Faced by Traditional Solutions

Golden Radio Method

The golden radio method, where a known good radio is used to connect to the IoT device, is attractive to many engineers because it is low-cost, easy to set up and doesn't require a lot of RF experience. However, there are many shortcomings that you may not realize at first glance.

1. This method does not provide direct transmit power (Tx power) measurement capability and uses Received Signal Strength Indicator (RSSI) test instead. RSSI test has unknown test conditions, and only provides an indicative value with reference to an unknown initial value that is decided by individual vendors. This means you will not know the true performance of your device-under-test (DUT)'s transmitter.
2. The golden radio device likely has limited downlink power adjustment, meaning you will not know how much margin you have in the communication link. It is possible to communicate with the golden radio device and pass the test when the DUT is close to the golden radio during testing, but in real-world conditions, the DUT operates some distance away, and it may only work marginally or fail altogether.
3. This method does not provide signaling packet error rate (PER) test or receiver sensitivity test, which are important receiver performance checks.

Non-signaling Method

Another common method used to test the functionality of an IoT device is the non-signaling method, typically by using parametric one box testers.

1. This method requires special device firmware, that places the DUT in a special test mode. This adds complexity and additional test steps to your test process and does not test the real operation of the device.
2. This method also requires wired connection to the device for firmware flashing and mode control, which requires sending commands to the DUT. This adds an additional layer of complexity to the test setup and may impact RF test results due to additional handling of the device or the introduction of another coupling path.
3. Putting your DUT into test mode by connecting physical wires to the DUT, establishing a connection and sending commands may add time to your test.
4. This method cannot test devices in their final form and cannot screen out defects caused during final assembly that will impact RF performance.

How the X8711A Works

The X8711A takes a new approach for functional RF test which enables you to test your IoT device without having to take your device apart, or subject it to special test firmware.

It tests the DUT's transmit power and receiver sensitivity while the device is in normal operation mode with production-release software. Key capabilities include:

1. Tx power in normal operation mode
2. PER bi-directional interrogation of the DUT
3. Sensitivity test using PER as an indicator and adjusting the downlink (DL-power from the X8711A to the DUT) power while maintaining good signaling conditions to the X8711A's receiver. This ensures that any packet errors are generated by the DUT and not the X8711A.

These capabilities ensure that the DUT's transmitter and receiver are effectively and sufficiently tested.

Bluetooth Low Energy (BLE) 4.2 Signaling Tests

Device discovery

The X8711A is capable of testing BLE devices with the roles of peripheral or beacon. The supported Protocol Data Unit (PDU) types are ADV_IND, ADV_SCAN_IND, ADV_NONCONN_IND and ADV_SCAN_IND. In the initial device discovery phase, the X8711A automatically determines the PDU type of the DUT.

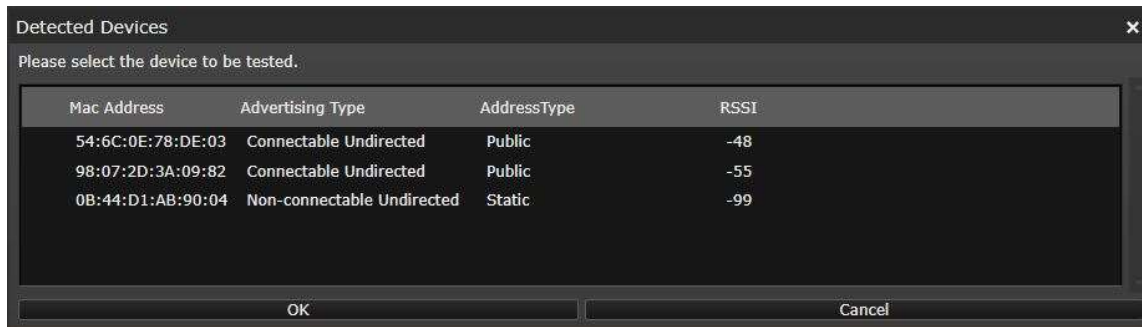


Figure 2: During device discovery, the pop-up window displays all the *Bluetooth* LE devices found by the X8711A. Select your DUT to proceed with the tests.

The Over-The-Air (OTA) Advantage

The X8711A makes an OTA connection with the DUT by making full use of the signals present in the normal operation mode of the radios. For *Bluetooth* LE, the X8711A also takes advantage of the Advertising Data or Connection Mode to make Tx/Rx measurements.

Input power measurement

In *Bluetooth* LE, the DUT advertises at a prescribed interval, which is anywhere from every 20 ms to 10.24 s.

X8711A listens for this advertisement and captures three packets (using channels 37, 38 and 39) simultaneously and reports the power at each channel. This method is highly effective to measure the performance of the DUT's transmitter, thus ensuring its quality especially after the manufacturing process.

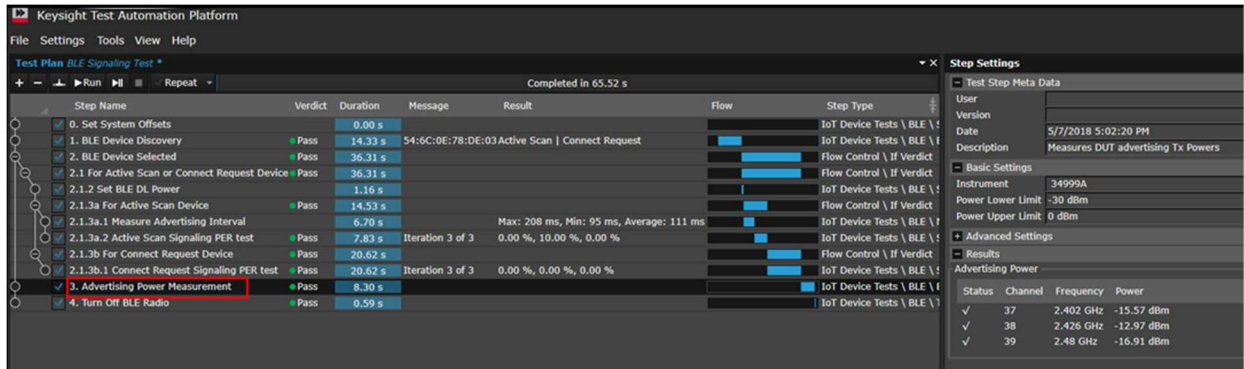


Figure 3: *Bluetooth* LE input power measurement.

Rx Packet Error Rate (PER)

PER is the ratio, in percent, of the packet error count to the number of packets tested. This test helps you ensure the quality of your DUT's receiver.

Using the information from the device discovery phase, the X8711A adaptively selects the correct PER method (Active Scan PER or Connection Mode PER) for your DUT. It also allows you to specify the PER limit, packet counts and number of iterations.

X8711A supports two PER test methods:

- Active Scan PER: This test only verifies the advertising channels through the Scan Request and Scan Response messages
- Connection Mode PER: This test is done after tester is connected to the device under test and therefore testing the PER for the data channels

The larger the number of packets tested, the better the confidence.

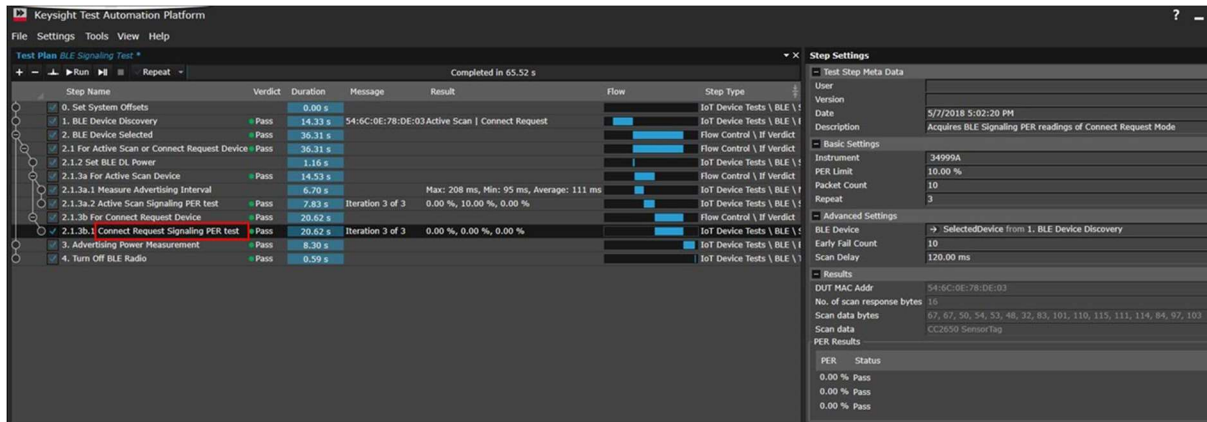


Figure 4: Bluetooth LE PER.

Rx Sensitivity Measurement

Sensitivity is defined as the lowest level signal the DUT can receive at a certain error rate. By adjusting the power level of the Down Link (DL) signal to the DUT and measuring the PER, you will be able to determine the sensitivity level of the DUT. This enables you to confidently know your device's widest possible range of operation.

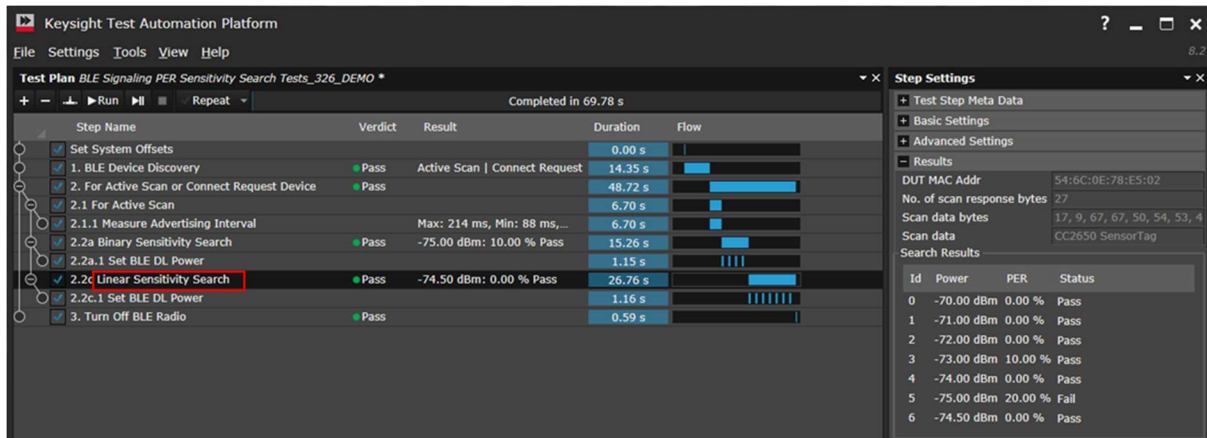


Figure 5: Bluetooth LE linear sensitivity search.

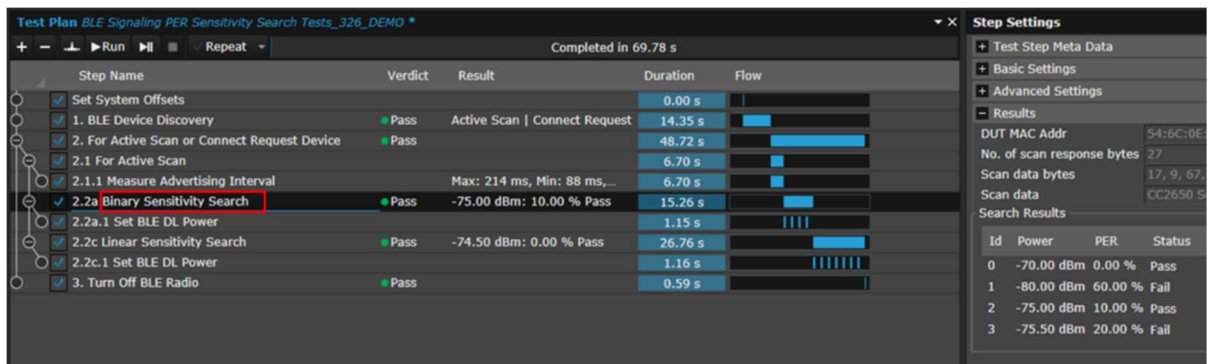


Figure 6: Bluetooth LE binary sensitivity search.

Read and Write UUIDs

To control devices using *Bluetooth*, there are dedicated *Bluetooth* profiles for specific services such as battery services, blood pressure monitoring or health monitoring. These profiles also provide the devices involved with the information like TX power, user data and more. Each of these profiles or services have unique identifiers (UUIDs). The X8711A allows the user to check if the BLE device supports a predefined list (or custom) UUIDs, and it reads out the supported UUIDs, the values and the handles. If the registers are set as write-able during stack compilation, you can use the handle definition retrieved during the read UUID step to overwrite a specific UUID and its values.

This feature is only available for *Bluetooth* LE devices supporting Connected Mode.

This capability provides the following benefits:

- As an application or firmware developer, you can easily verify that the software or firmware has been implemented correctly.
- As a manufacturer, you can program individual DUTs from the assembly line with specific manufacturing data.
- As a form of device security checking whereby you can write a script of reads and writes to try to access certain registers in the device to see if any of the registers has been unintentionally left unlocked and post security risk.

GATT Heart Rate Service				
	Handle	Type (UUID)	Value	Permissions
Service				
Declaration	0x8000	SERVICE(0x2800)	0x180D	READ
Characteristics				
Declaration	0x8001	CHAR (0x2803)	NOT[0x800ZHRM	READ
"Heart Rate Measurement" Value	0x8002	HRM (0x2A37)	bpm	NONE
Descriptor	0x8003	CCCD(0x2902)	0x0001	READ/WRITE

Figure 7: GATT Profile Example of a Heart Rate Service.

WLAN b/g/n Signaling Tests

The Over-The-Air (OTA) Advantage

The X8711A broadcasts its service set identifier (SSID) and the DUT must be configured to connect with the SSID and password combination.

If the DUT presents the correct SSID/password combination, the X8711A will then make a connection with the DUT.

Input Power Measurement

The X8711A captures the average power of the DUT Tx during its normal scanning process using its power detection circuit. This is done by measuring the Tx power measurement on the sync signal (beacon) from DUT.

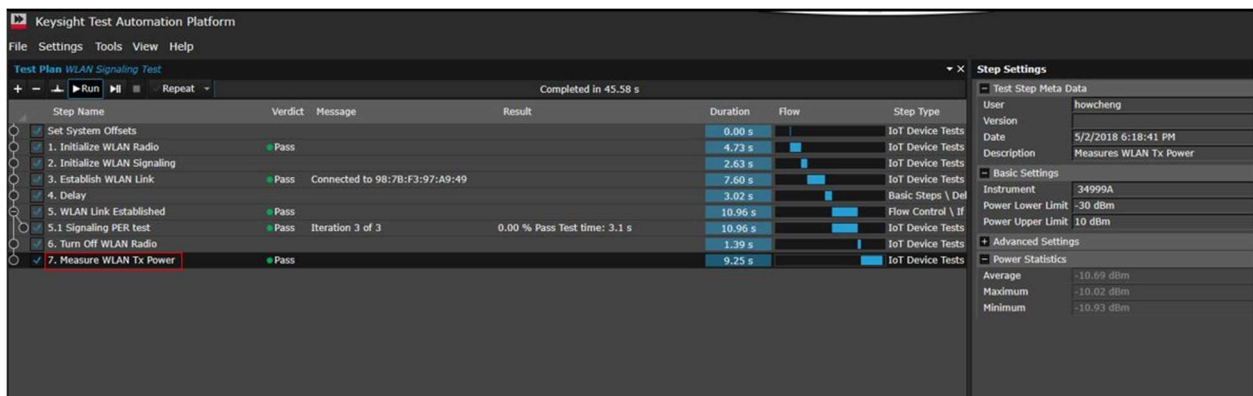


Figure 8: WLAN input power measurement.

Packet Error Rate (PER)

Similar to the *Bluetooth* LE PER test, PER is usually presented as a percentage which is derived from the number of missing or bad packets and the number of packets sent. You are able to set the PER limit and packet counts to effectively test the receiver of your DUT using this test.

The X8711A will initiate a PING. During the PING, the X8711A will send a packet to the DUT and request for it to respond. If the X8711A receives a response without errors, it will be considered a good packet. This process is repeated for PER test. PER is the number of missing or bad packets to the number of packets sent expressed in percentage.

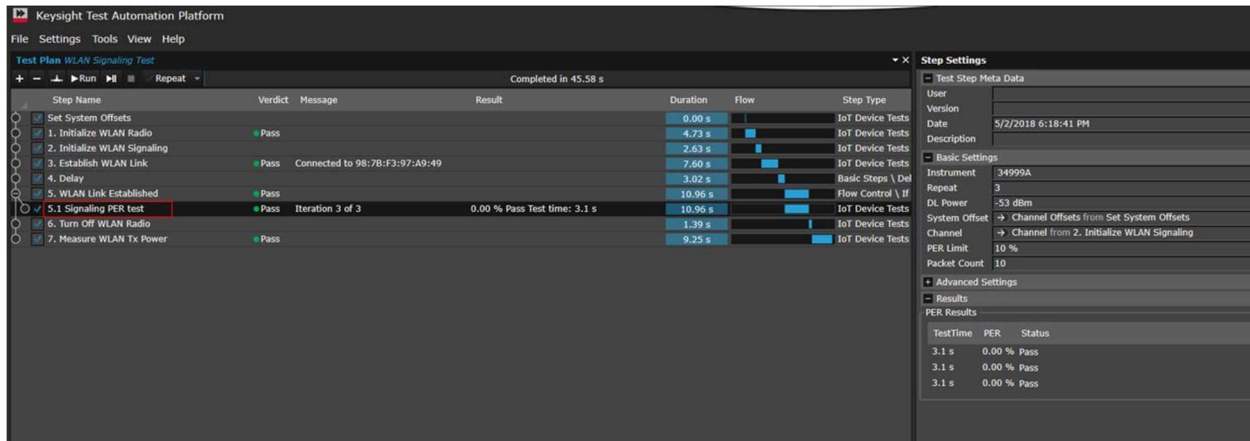


Figure 9: WLAN PER test.

Rx Sensitivity Measurements

Similar to *Bluetooth* LE, the X8711A also provides receiver sensitivity measurements to enable you to determine the sensitivity level of your WLAN DUT.

X8711A – Test Automation Platform (TAP) Systems

The KS83301A/KS83301B BLE 4.2 Signaling Measurement Suite and the KS83302A/KS83302B WLAN b/g/n Signaling Measurement Suite are built on the Keysight TAP system. Either the KS8400A TAP Developer's system or the KS8000A TAP Deployment system can be used to run the measurement suites. Here is the comparison between the two:

	KS8400A TAP Developer's System	KS8000A TAP Deployment System
Intended use	R&D, design validation – software developers	Manufacturing
Capabilities	<ol style="list-style-type: none"> 1. Test sequence/steps or measurement setting adjustments in the KS83301A/KS83301B BLE 4.2 signaling or KS83302A/KS83302B WLAN b/g/n signaling measurement suites 2. Create own custom GUI, test steps and sequence 3. Setup test parameters 4. Provides data logging and reporting 	Execute test plans created in KS8400A in a command line interface
TAP components	<ul style="list-style-type: none"> • Core Engine • Command Line Interface (CLI) • Graphical User Interface (GUI) • Package Manager CLI • Package Manager GUI • Software Development Kit (SDK) • Results Viewer • Run Explorer • Timing Analyzer 	<ul style="list-style-type: none"> • Core Engine • Command Line Interface (CLI) • Package Manager CLI
User Interface	GUI	CLI or custom GUI
Results report in .csv	Yes	Yes

Software Requirements

PC Operating System	<ul style="list-style-type: none"> • Windows 7 SP1 • Windows 10
Prerequisite drivers and software	<ul style="list-style-type: none"> • Keysight License Manager version 5.1 • Keysight IO Libraries Suite version 18.0 or above • Keysight Test Automation Platform (TAP) Software <ul style="list-style-type: none"> • KS8400A TAP Developer's System • KS8000A TAP Deployment System • Keysight 34999A Utility software version 1.1 or above

X8711A Characteristics

Radio	Bluetooth	WLAN
Format	BLE 4.2	802.11 b/g/n 2.4 GHz
Input Power Measurement (DUT Transmit Power)	Range: 10 to -30 dBm Accuracy: ± 2 dB (spec)	Range: 10 to -30 dBm Accuracy: ± 2 dB (spec)
Rx Sensitivity	Range: -40 to -75 dBm Resolution: 0.5 dB Accuracy: ± 2 dB (spec) Range: -75 to -100 dBm Accuracy: ± 2.5 dB (spec)	Range: -33 to -70 dBm Resolution: 0.5 dB Accuracy: ± 2 dB (spec)

1. All specifications are specified at operating temperature of $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, with relative humidity less than 80%.
2. All specifications are referenced to RFIO port.

X8711A Test Coverage

X8711A can test *Bluetooth* LE and WLAN devices with roles below. The supported test parameters are also listed.

Bluetooth LE test coverage

Device Role	Description	Tx Power Test	Active Scan PER	Connect request PER
Central*	Master or controlling device	No	No	No
Peripheral	Slave device that can send and receive info	Yes	Yes	Yes
Beacon	Transmit only device	Yes	No	No
Observer	Receive only device	Yes	No	No

* Can be supported via ZA0060A custom solution. Please contact Keysight representative for more information.

WLAN test coverage

Device Role	Description	Tx Power Test	Rx PER
Access Point	A networking device that allows other WLAN devices to connect to a wired network	Yes	Yes
Station	A device that has the capability to use the 802.11 protocol	Yes	Yes

* Can be supported via the ZA0060A custom solution. Please contact Keysight representative for more information.

The supported BLE PDU Types are:

PDU Type	Description	Unique Characteristics	Example device	Tx Power	Active Scan PER	Connected PER
ADV_IND	Connectable undirected advertisement	Connectable Non directed to specific central device	This is used when a slave/peripheral device is powered up for the first time (has never connected with a master and is looking to connect to any node. Typically represents a factory default state) Eg: Smart watch requests connection to any central device	Yes	Yes	DUT dependent (depend on DUT capability whether it is designed to connect to a central device)
ADV_DIRECT_IND	Connectable directed advertisement	Connectable (need specific information about the central device) Directed to specific central device	Typically used after a slave/peripheral has connected with a master/central device. It is not looking to be discovered, rather, it already has the device address of its peer and wishes to reconnect quickly to a specific master/central device. Eg: sample watch requesting connection to a specific central device	Yes	Yes	No
ADV_NONCONN_IND	Non-connectable undirected advertisement	Not connectable Not directed to specific central device Tx only	Beacon device	Yes	No	No
ADV_SCAN_IND	Discoverable undirected advertisement	Not connectable Not directed to specific central device Rx and Tx can provide additional scan information	Smart tag which broadcasts information, and responds to central device request for additional information	Yes	Yes	No

Supplemental Characteristics

Type of measurements supported	Tx power measurement, Rx packet error rate (PER), Rx sensitivity test (linear sensitivity search, binary sensitivity search, mid-point sensitivity search)
Maximum supported 34999A RF module	One unit. The remaining two 34972A slots can be used for other 34972A modules. Refer to the Keysight 34972A Technical Overview for more information (Publication Number: 5965-5290EN).
Voltage sourcing range	Refer to the <i>Keysight E36100B Series Programmable DC Power Supplies</i> Datasheet (Publication number: 5992-2437EN)
Computer interface	LAN and USB
AC power line frequency	Refer to the <i>Keysight 34970A Data Acquisition/Switch Unit Family</i> Technical Overview (Publication number: 5965-5290EN)
Weight	34972A: 3.6 kg 34999A: 0.5 kg E36102B: 3.7 kg
Physical dimensions	34972A: 254.4 mm (W) x 374.0 mm (D) x 103.6 mm (H) (with bumper) 34999A: 91.9 mm (W) x 315.6 mm (D) E36102B: 102 mm (H) x 106 mm (W) x 365 mm (D)

X8751A RF Shield Enclosure Specifications

The X8751A RF shield enclosure kit consists of:

- TC-5910D shield box
- 1x M591012B I/O module
- 1x TC-93023B antenna coupler
- 1x F59105A universal grid fixture (140(W) x 210 (D) x 11(H) mm)
- 1x RF cable, 0.9 m
- 1x SMA male to N male adapter
- 1x RF terminator N 50 Ohm

It provides:

- Reliable high RF shielding up to 6 Hz
- Shock absorber on lid

X8751A is non-RoHS compliant



Typical RF shielding

The shield effectiveness below is measured when the blank panel is mounted; the I/O interface panel results a different shielding effectiveness of the shield box

100 to 2000 MHz	> 70 dB
2000 to 3000 MHz	> 70 dB
3000 to 6000 MHz	> 50 dB

M591012B USB 2.0 I/O Interface Panel

- *Shielding Effectiveness: >60 dB from 0.1 to 6 GHz
- DB25 (p) outside and DB25 (s) inside, 1000 pF Pi filter
- USB A(p), 10 pF Pi filter
- Data line Capacity: 100 VDC, 3 Amps max

Weight	Approx. 5 kg
Physical dimensions	Inside: 130 (W) x 235 (D) x 138 (H) mm Outside: 207 (W) x 424 (D) x 170 (H) mm, lid closed. 435 (H) mm, lid open

Ordering Information for X8711A

The X8711A IoT Functional Test Solution System

Please choose from the configurations below according to your test needs.

For hardware:

- X8711A-ATO - 34972A LXI Data Acquisition Switch Unit is included as it is the chassis for the RF module

For software:

- All the options (KS83301B and KS83302B measurement suites, and KS8400A TAP) are optional. These options are also available for standalone orders.
- 12 months of support subscription is included.
- There are three license types; node-locked, floating and transportable and two license terms; perpetual and time-based (12 months).

I. Bluetooth Low Energy 4.2 Standard Configuration

Option Number	Description
Hardware	
X8711A-001	Bluetooth LE 4.2 Signaling RF module
X8711A-DPS (optional)	E36102B DC Power Supply
Software	
KS83301B	Bluetooth LE 4.2 Signaling Measurement Suite
KS8400A	Test Automation Platform, Developer's System (recommended)

II. WLAN b/g/n Standard Configuration

Option Number	Description
Hardware	
X8711A-002	WLAN b/g/n Signaling RF module
X8711A-DPS (optional)	E36102B DC Power Supply
Software	
KS83302B	WLAN b/g/n signaling measurement suite
KS8400A	Test Automation Platform, Developer's System (recommended)

III. Bluetooth Low Energy 4.2 and WLAN b/g/n Standard Configuration

Option Number	Description
Hardware	
X8711A-100	Bluetooth LE 4.2 and WLAN b/g/n Signaling RF module
X8711A-DPS (optional)	E36102B DC Power Supply
Software	
KS83301B	Bluetooth LE 4.2 Signaling Measurement Suite
KS83302B	WLAN b/g/n signaling measurement suite
KS8400A	Test Automation Platform, Developer's System (recommended)

Software – License Types and Terms

I. For the KS83301B and KS83302B measurement suites

Perpetual license type and support subscription	
R-X5Q-001-A	Node-locked (single PC), perpetual
R-X6Q-001-L	12 months, node-locked, support subscription
KS83301B-1FP	License redemption in KSM
R-X5Q-002-B	Floating (single site), perpetual
R-X6Q-002-L	12 months, floating, support subscription
KS83301B-1NP	License redemption in KSM
R-X5Q-004-D	Transportable, perpetual
R-X6Q-004-L	12 months, transportable, support subscription
KS83301B-1TP	License redemption in KSM
Time-based software license and support subscription	
R-X4Q-001-L	12 months, node-locked license, software support subscription
KS83301B-1FL	License redemption in KSM
R-X4Q-002-L	12 months, floating license (single site), software support subscription
KS83301B-1NL	License redemption in KSM
R-X4Q-004-L	12 months, transportable license, software support subscription
KS83301B-1TL	License redemption in KSM

II. For the KS8400A TAP Developer's System and KS8000A TAP Deployment System

Perpetual license type and support subscription	
R-D5A-001-A	Node-locked (single PC), perpetual
R-D6A-001-L	12 months, node-locked, support subscription
KS8x00A-1FP	License redemption in KSM
R-D5A-002-B	Floating (single site), perpetual
R-D6A-002-L	12 months, floating, support subscription
KS8x00A-1NP	License redemption in KSM
R-D5A-004-D	Transportable, perpetual
R-D6A-004-L	12 months, transportable, support subscription
KS8x00A-1TP	License redemption in KSM
Time-based software license and support subscription	
R-D4A-001-L	12 months, node-locked license, software support subscription
KS8x00A-1FL	License redemption in KSM
R-D4A-002-L	12 months, floating license (single site), software support subscription
KS8x00A-1NL	License redemption in KSM
R-D4A-004-L	12 months, transportable license, software support subscription
KS8x00A-1TL	License redemption in KSM

X8711AU - Upgrade Model of the X8711A

To upgrade your existing X8711A system to include more radio formats, purchase the X8711AU. Choose from the configurations

- This is done through firmware upgrade – the entitlement certification will provide instructions on how to upgrade your existing RF module to include the new radio format.
- All software options are optional.

Wants → Has ↓	Bluetooth LE 4.2	WLAN b/g/n
Bluetooth LE 4.2	X	X8711AU-002, KS83302B software
WLAN b/g/n	X8711AU-001, KS83301B software	X

I. Bluetooth Low Energy 4.2 Standard Configuration

Option Number	Description
Hardware (firmware upgrade)	
X8711AU-001	Bluetooth LE 4.2 Signaling
X8711AU-DPS (optional)	E36102B DC Power Supply
Software	
KS83301B	Bluetooth LE 4.2 Signaling Measurement Suite

II. WLAN b/g/n Standard Configuration


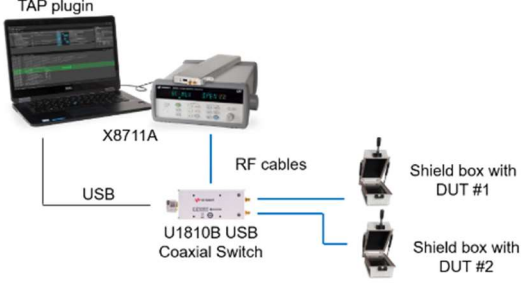
Option Number	Description
Hardware (firmware upgrade)	
X8711AU-002	WLAN b/g/n Signaling
X8711AU-DPS (optional)	E36102B DC Power Supply
Software	
KS83302B	WLAN b/g/n signaling measurement suite

Upgrade to Bluetooth 5 or Zigbee

We can customize this solution to support Bluetooth 5 and Zigbee devices through the ZA0060A custom IoT test solution. Please contact your local Keysight representative for more information.

Accessories

We offer the following custom accessories or options to suit your testing needs. Contact Keysight to discuss your needs.

X8751A RF Shield Enclosure Kit	X8753A Multi-Up Configuration
	
<ul style="list-style-type: none"> • Suitable for small device under tests. • Includes I/O module, antenna coupler, grid fixture and RF cable <p>*Not available in Europe</p>	<ul style="list-style-type: none"> • For high volume manufacturing • 1x2 multi-up option - one measurement system is shared with 2 devices under test (DUTs) for sequential testing. • Includes: 1x U1810B USB coaxial switch, 3x SMA-Male to N-Male RF cables and 1x N-Female to N-Female adapter. • More configurations are available. Contact Keysight to discuss on your needs.
<p>Model number: X8751A</p>	<p>Option number: X8753A-001</p>

Related Information

X8711A IoT device functional test solution	http://www.keysight.com/find/X8711A
ZA0060A Custom IoT Device Functional Test Solution	https://literature.cdn.keysight.com/litweb/pdf/5992-3871EN.pdf
34972A LXI data acquisition/data logger switch unit	http://www.keysight.com/find/34972A
KS8400A and KS8000A Test Automation Platform	http://www.keysight.com/find/TAP
E36102B DC power supply	http://www.keysight.com/find/E36102B

Bluetooth® and the Bluetooth® logos are registered trademarks owned by Bluetooth SIG, Inc., and any use of such marks by Keysight Technologies is under license.

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

