



KEYSIGHT
WORLD 2019

The Faster, Easier Way to Verify IoT Device RF Performance During Manufacturing

IoT Segment Manager/ Keysight Technologies

Sook Hua Wong



Agenda

- Challenges of RF manufacturing test for IoT devices
- RF test methods
- A new solution
- Success stories
- Optimization considerations and alternatives
- Summary and resources

Wireless IoT Device Functional Test

A quick golden radio connection test is not enough



“

I don't expect a new wireless medical device to work, coming into my hospital.

Wireless I.T. Manager

“

I have 950 Wi-Fi devices on my networks and rogue networks coming in the front door every minute. A visitor walks in with a smartphone, a smart watch, a wireless headset, a Fitbit, and his phone configured as a Wi-Fi hotspot.

Wireless I.T. Professional

“

My new device worked great in the lab, but then it hit the hospital and fell flat on its face.

Design Engineer

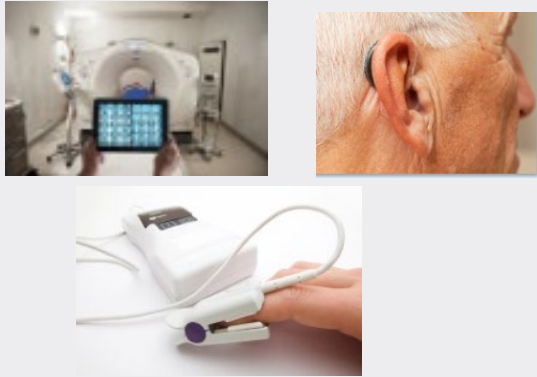
Key Metrics of Reliability

- Can my device connect repeatably?
- What is the Receiver Sensitivity?
- What is the Receiver Signal Strength Indicator (RSSI)?
- What is the Packet Error Rate?
- User-defined key performance indicators
 - Maintain connectivity for “n” hours
 - Successfully download FW update
 - Report alarm within “s” seconds
 - Other device-specific parameters

Challenges of IoT Device Manufacturers

Many companies going into the IoT are not RF specialists.

Connected medical devices



Consumer devices



Industrial / smart city



Challenges

Limited RF knowledge

Low cost

High quality

Fast time-to-market

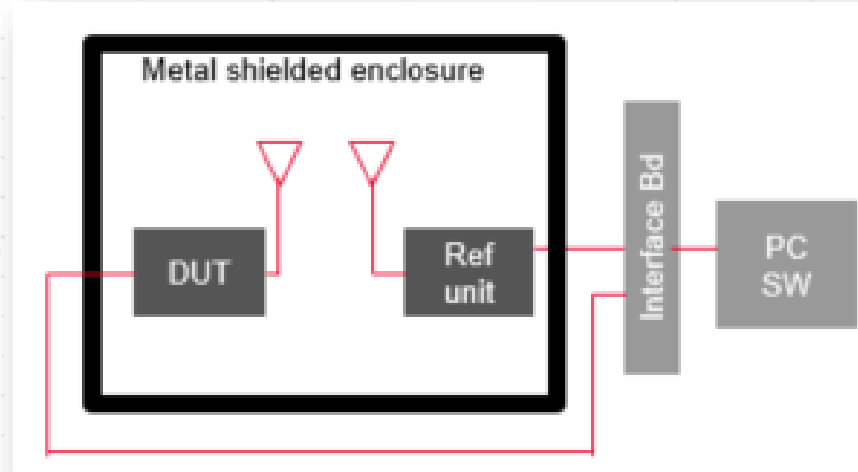
Typical Test Solutions (Current State)

GOLDEN RADIO OR SIMPLE PHONE PAIRING



Simple pairing method
(e.g. smartphone)

Or



Golden radio
(chipset / reference radio)

Simple, Low Cost!

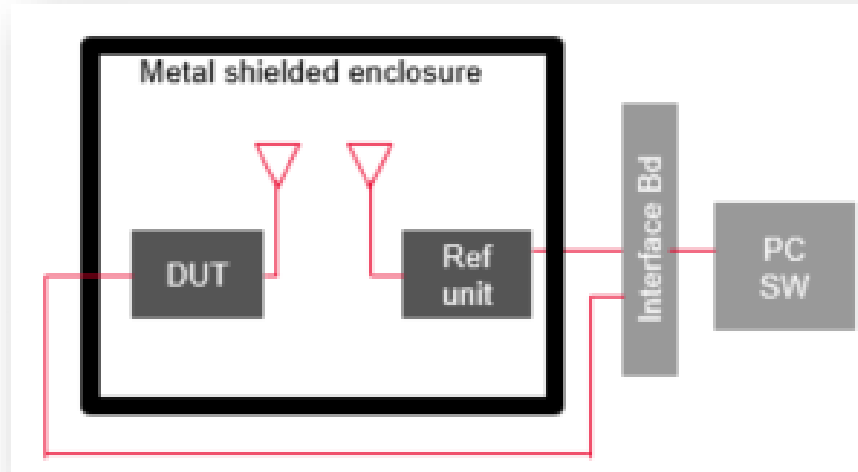
Typical Test Solutions (Current State)

GOLDEN RADIO OR SIMPLE PHONE PAIRING



Simple pairing method
(e.g. smartphone)

Or



Golden radio
(chipset / reference radio)

But...

Short range!

Slow data!

Intermittent connection!



Simple and Low Cost!

Why?

Limitation of Golden Radio Test Method

WHAT YOU MAY NOT REALIZE...

Poor accuracy

- No direct power measurements (accuracy is unknown)
- Only provide RSSI, $P = \text{RSSI} + \text{offset}$
- RSSI is an indicative value with reference to unknown initial value (vendor dependent)

Short operating range?

Lack of capability

- No power control capability
- You are not testing at the actual use

Intermittent network connectivity?

Lack of test coverage

- No signaling PER test
- PER is important receiver performance check
- You will not know the performance of your receiver

Slow data rate?

Medical?
Traceability
challenges

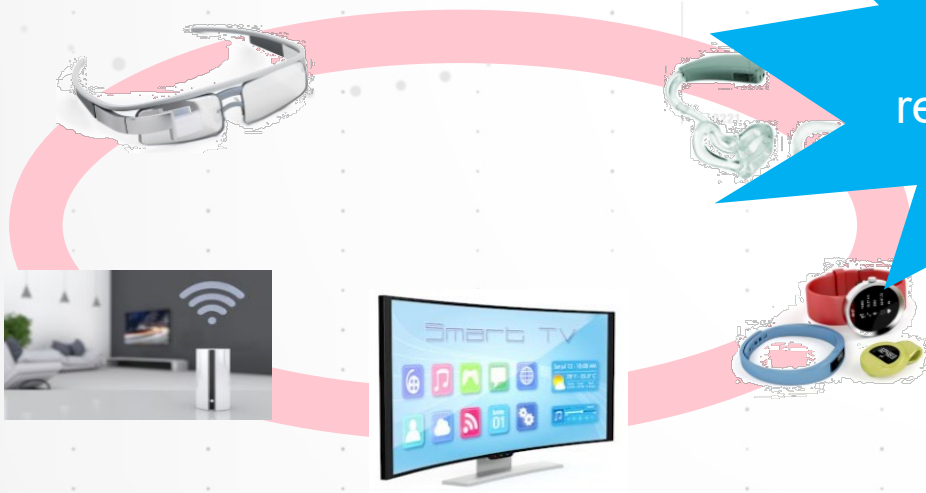
You may be shipping faulty devices!



Assessing the Impact

PRODUCT QUALITY IS IMPACTED BY THE TEST

- Assume you produce 1000 devices a day at \$100 per device
- If insufficient test shuts down your line...
- Loss of business → **\$100,000 per day** → **\$3M per month**
- If your faulty device is built into a bigger system and sold into critical applications → **major product recall**



Medical?
Government
regulators can shut
you down



Is There a Better Way?

IMPROVE YOUR TEST EFFECTIVENESS

- Cost & risk of existing approaches to verify IoT device performance is too high.
- Need a method to confidently catch manufacturing defects with low cost of test

Wrong component

Missing component

Extra component

Inter-component short

Broken trace

Solder bridge

Integrated Solution Approach

KEY BENEFITS

Keysight X8711A IoT Device Functional Test Solution



Test IoT devices in actual operation and final form

- No chipset-specific driver required
- No wired connections, test over-the-air

Ensure that your devices meet quality levels

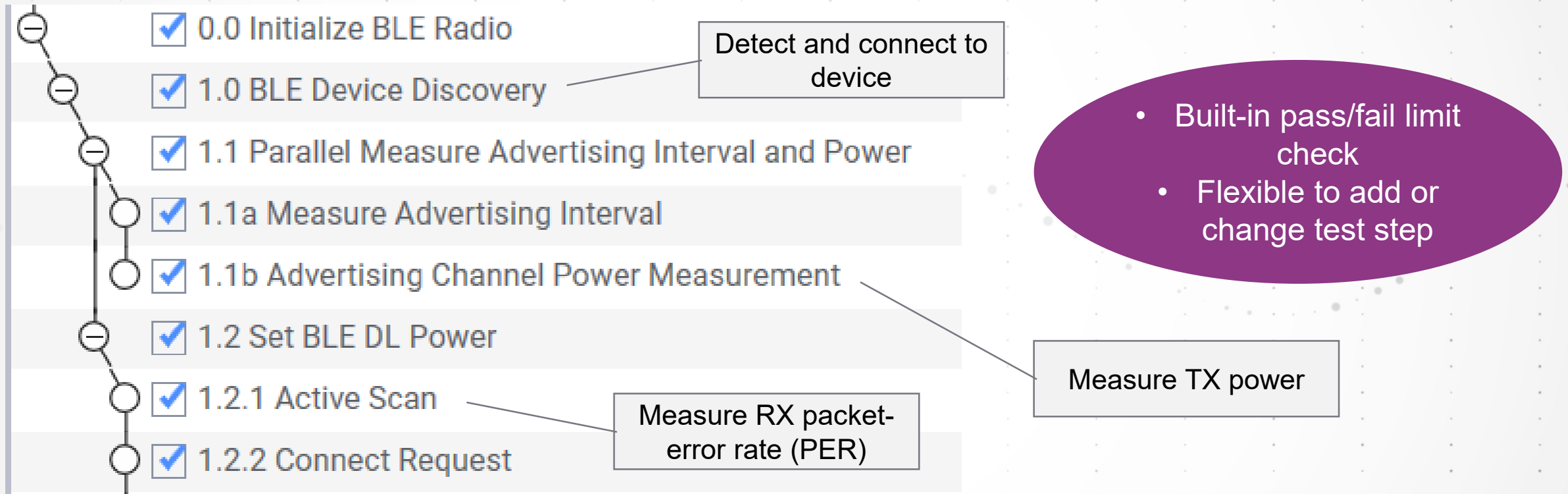
- Objectively measure key RF transmitter and receiver parameters
- DUT transmit power measurement, receiver sensitivity PER tests

Maximize mfg. throughput; accelerate time to market

- Perform transmit power and receiver PER test in seconds

Software Automation

SIMPLE STRUCTURE, BASED ON PROVEN TEST AUTOMATION PLATFORM



Sample BLE Signaling Test Plan

Success Story #1

HEARING AID MANUFACTURER

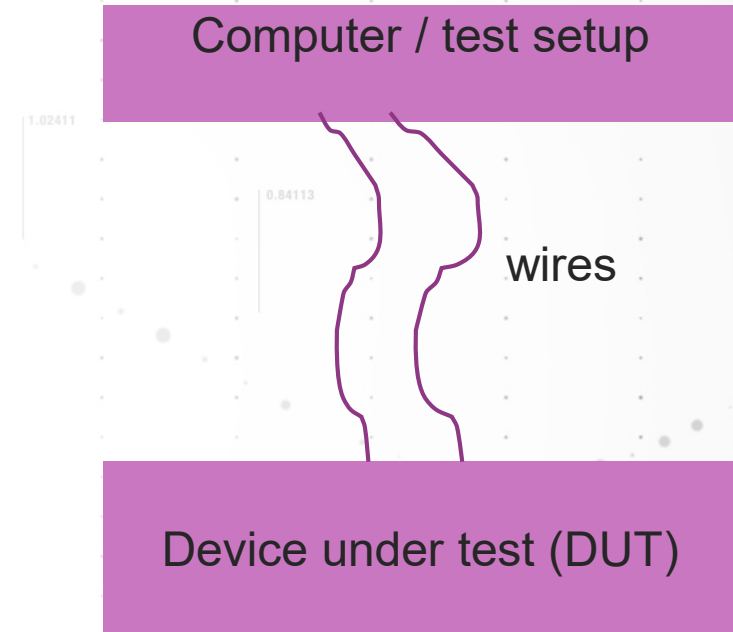
- Company integrating Bluetooth Low Energy (BLE) into their hearing aids to control hearing aid from smart phone
- Allows customer to quickly switch between input channels
- Existing non-signaling test method is costly and time-consuming
- X8711A cut test time by 25%, manufacturing test costs by 50%
- [Case study](#) available



Problems with existing non-signaling test solution

COSTLY, TIME-CONSUMING, RISKS DAMAGING DEVICE

- Wired computer interface adds:
 - Antennas (changes RF characteristics)
 - Product handling / damage risk
 - Cost
 - Complexity
 - Time
- Long test development and testing time
 - Develop test firmware to control DUT
 - Additional time to flash in test firmware into every unit during production



Success Story #2

AIR-CONDITIONING UNIT MANUFACTURER

- Manufacturer moved from NFC (near field communication) to BLE to increase the transmission range of their AC remote control unit
- Existing BLE test solution:
 - Expensive
 - Difficult to use
- Integrated solution with X8711A
 - Simple to use
 - Cost-effective – all essential tests in one solution
 - Upgradeable to new additional wireless formats
 - Useable for design verification and manufacturing test
- X8711A is being used in multiple sites for design validation test of various smart home devices



Success Story #3

CATARACT SURGICAL MACHINE

- Manufacturer faced yield issue
- High failure with the Zigbee radio module used to wirelessly control certain function of the machine
- Failure only discovered during final test
- Failed units have to go through assembly rework and retest – consume long time and pile up inventory
- Solution:
 - Implemented X8711A for incoming material check
 - Pre-test for the Zigbee module before other tests
- Results:
 - Significant yield improvement; reduced WIP inventory



The IoT Evolves Quickly

X8711A IS CONTINUOUSLY ENHANCED TO MEET THE NEEDS

- Bluetooth Low Energy 4.2
- IEEE 802.11 b/g/n

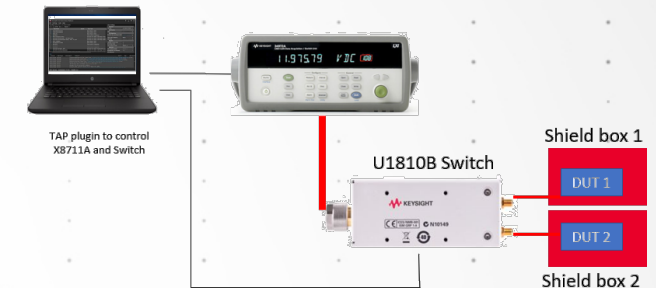
Recent enhancements:

- Bluetooth Low Energy 5
- ZigBee 3.0
- ZigBee Pro
- Different data rates
- Flexible multi-DUT configurations
- Etc.

Eliminate Handling Time for Even Faster Performance

MULTI-DUT CONFIGURATION

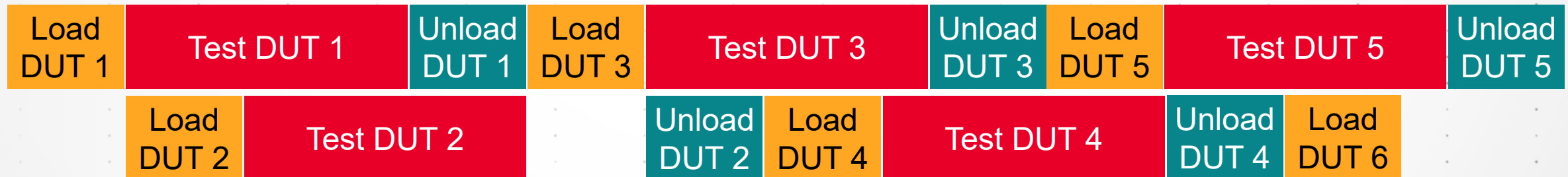
- One measurement system is shared with 2 shield boxes for sequential test.
- Do operator handling (load/unload) while other shield box is testing



Single DUT configuration



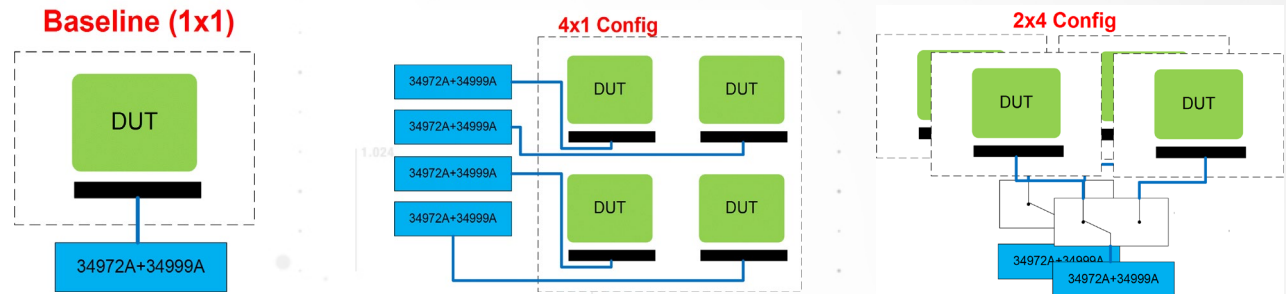
1×2 configuration



Other Possible Multi-Up Configurations

WHAT IS YOUR ULTIMATE GOAL?

- Maximum throughput?
- Maximum equipment utilization?
- Minimum capital equipment cost?
- Minimum total cost of test?



Test instruments	Shield boxes	Notes (typical)
1	1	Standard configuration
1	2	Improved throughput
4	4	Best throughput
2	4	Lowest overall cost of test
Other configurations are possible!		

Summary: Problem and Solution

- **Problems with traditional test**

- Need special test firmware
- Need to connect physically to DUT
- Lack quantitative data
- Handling time reduces throughput

- **Benefits of integrated solution**

- Test your IoT devices in actual operation mode and in its final form
- Ensure that devices meet quality levels
- Objectively measures key Tx/Rx parameters
- Complete Tx power and Rx PER test in seconds
- Multi-DUT configurations eliminate handling time

Resources

- www.keysight.com/find/x8711a
- <https://www.youtube.com/watch?v=jDKDbHBct8E>
- <https://www.youtube.com/playlist?list=PLvQ5Bzr3tM52nITxPhwBJWZzEEEnMSbGv4>



***X8711A IoT device functional
test solution***

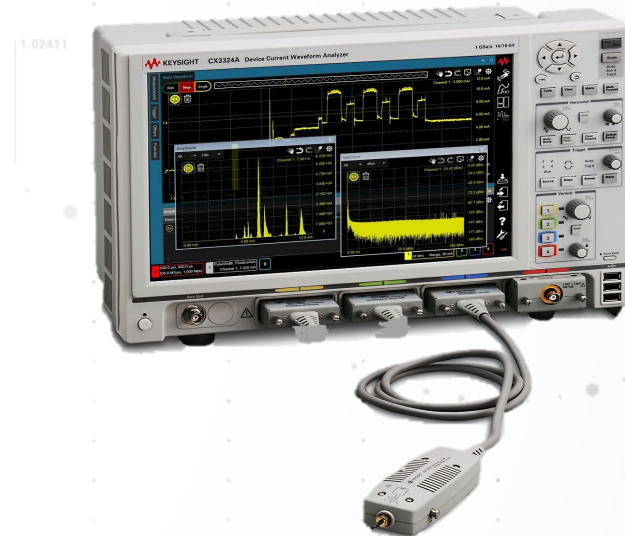
Having Issues to Prolong the Battery Life of Your Device?

KEYSIGHT BATTERY LIFE OPTIMIZATION TEST SOLUTIONS



X8712A Battery Life Optimization Test Solution

- Seamless current measurement range from nA to A
- Easily identify subsystems consuming the most current
 - Automatically calculate battery life



CX3300 Series Device Current Waveform Analyzer

- Precisely visualizes current waveforms previously unmeasurable
- Measure dynamic current down to 100pA with 16-bit resolution
 - Up to 200 MHz bandwidth and 1 GHz max sampling rate

Keysight X8712A IoT device battery life optimization solution

KEY BENEFITS

TAP-based SW
(KS833A1B)

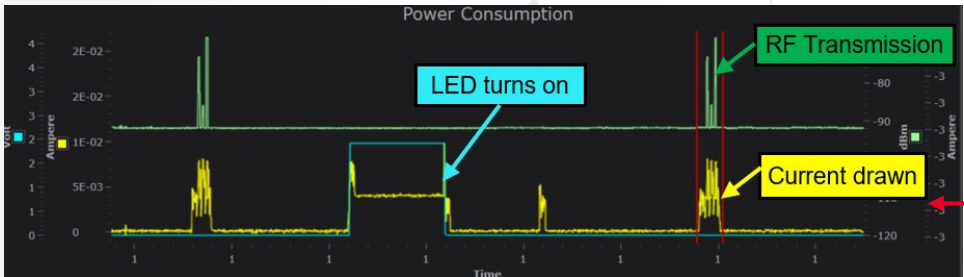


Shield box with
device under test

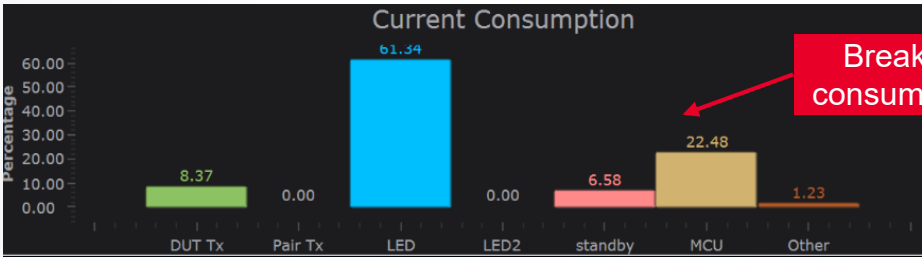
N6705C DC Power Analyzer with
N6781A SMU module

X8712AD RF Event Detector

*Detect design weakness with quick and effortless
event-based power consumption analysis*



Correlate current
waveform with other
RF/DC events



Break down current
consumption% by event

*Simplify battery life estimation of your IoT or
battery powered device*

Battery (Ah)	0.2
--------------	-----

Battery capacity

Max Current	11.04 mA
Cycle Time	6.02 ms
Charge Energy	5.24 nAh
Battery Life	63.84 h

Max current

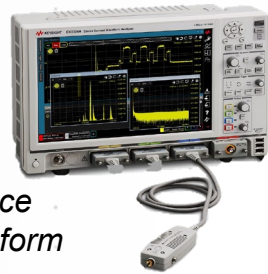
Charge consumed

Battery life

Keysight Solutions for IoT / Smart Devices

Power Consumption Analysis

CX3300 device current waveform analyser



X8712A battery life optimization test solution



SMU and DMM



R&D

Design validation

Manufacturing

Wireless Connectivity Test

X-series signal generator and analyser



EXM Wireless Test Set



X8711A IoT device functional test solution





KEYSIGHT
WORLD 2019



Summary - IoT Device Test Solutions

KEYSIGHT SOLUTIONS COVER ALL THE CHALLENGES

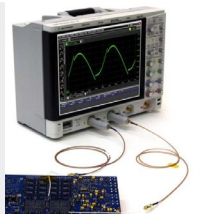
Power Consumption tests

New



Visualize current drain from nA to A in one pass and one picture unlocking insights to deliver exceptional battery life

Signal & power integrity



Best visibility of your signal and data integrity issues

Sensor test



Breath of basic instruments to meet different measurement and budget needs

Simulation & design software



Complete tools for ecosystems from component, IC, Board to System level.

Battery

Power Management

MCU

Interface

Analog front end

RF

Sensor

Actuator/Display

Digital

Regulatory & Conformance tests



New

One box for EMI and spectrum regulatory pre-compliance tests

ZA0047A Radio Regulatory compliance test solution (ETSI/ FCC)

OTA functional test for manufacturing

New



Complete TX power and RX sensitivity tests in less than 30 seconds

Wireless & interference tests



Broadest format coverage, wide range of solutions for R&D, manufacturing to field deployment