Wirelessly Wonderful

Solutions for IoT test challenges

D & E Event – 2nd Nov 2016

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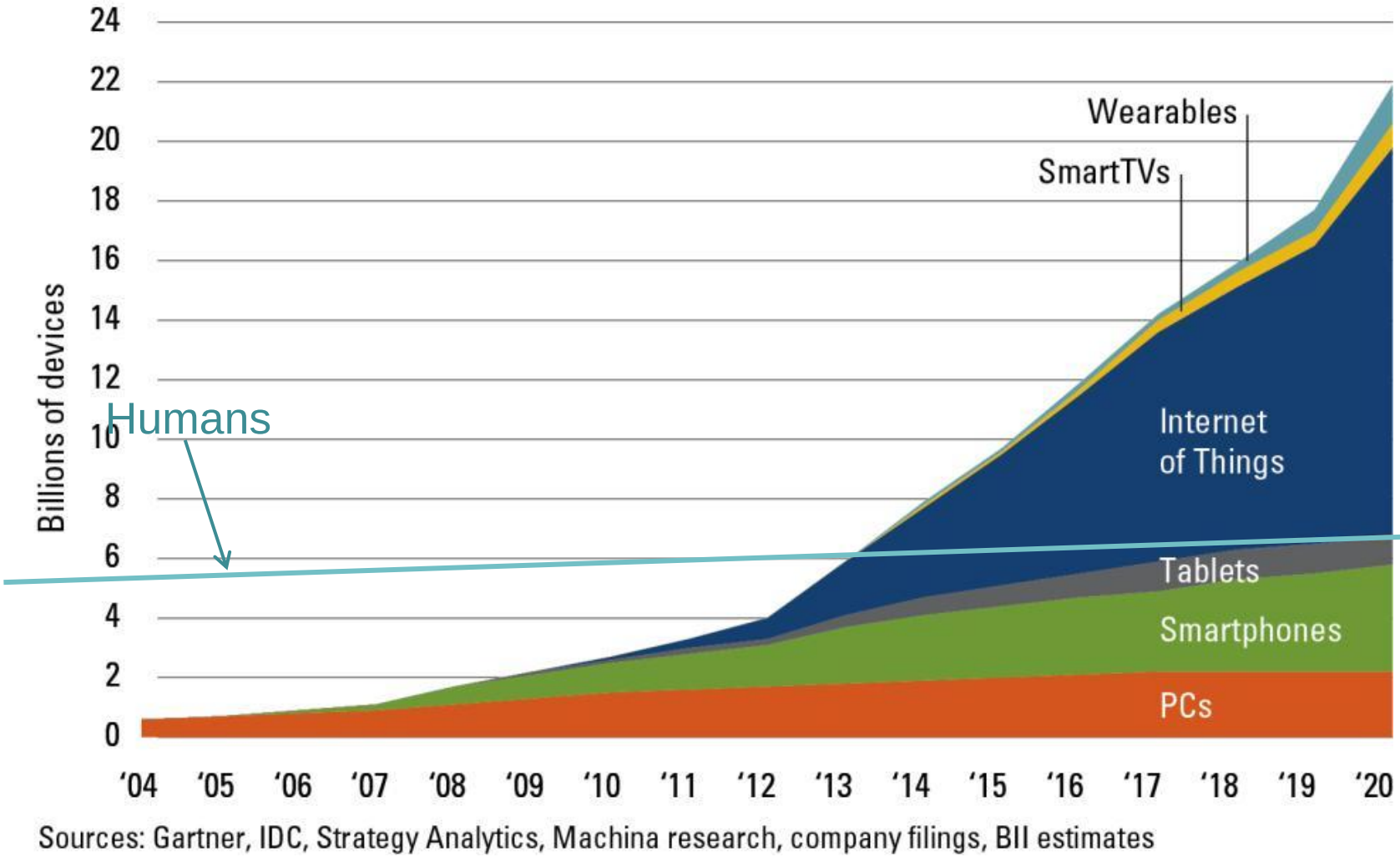
Agenda

- **The IoT (M2M*) applications, and technologies**
- **Major IoT Design and test challenges**
  1. IoT product design – leveraging the many IoT system modules
  2. Debug complex digital/analog/RF system problems
  3. Maximizing your device's battery life
  4. Speeding your device through EMC compliance
  5. Speeding your device through Wireless certification
  6. Preparing for IoT network deployment

(*) IoT : Internet of Things, M2M: Machine to Machine

Connected Devices



Sources: Gartner, IDC, Strategy Analytics, Machina research, company filings, BII estimates

IoT – Integration of Technology

- Some of the drivers

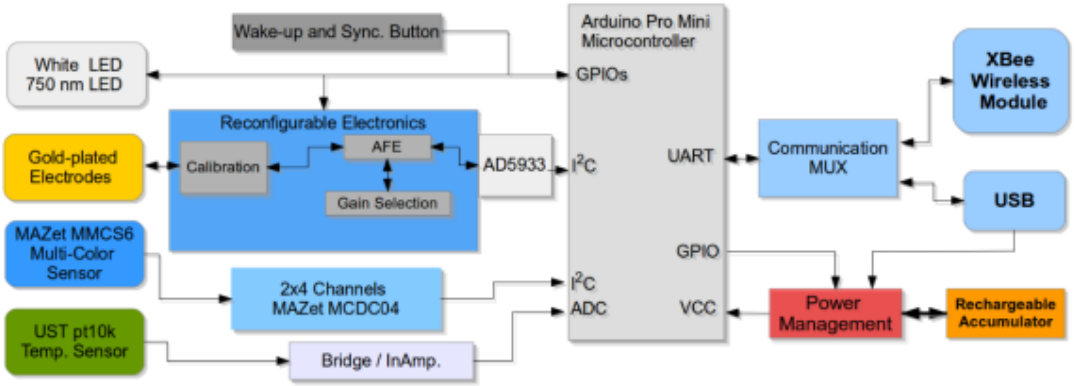
↓Cost

Key IoT Semiconductor Components: ASP Projections

Semiconductor ASPs	2012	2016	Annual Price Decline
Microcontroller	$0.49	$0.30	-12%
Wi-Fi	$1.30	$0.80	-11%
Bluetooth	$0.75	$0.35	-17%
MEMS Sensor	$1.30	$0.95	-8%
Camera (1.8 MP CMOS Sensor)	$1.70	$1.10	-10%
GPS	$1.15	$0.65	

Source: Gartner, ARM Holdings, and Raymond James

↑Modularity



Six Key IoT Design Challenges

Wireless Module Selection

Digital Design and Debug

Maximizing Battery Life

EMC and EMI Pre-Compliance

Wireless Standards Pre-Compliance

Interference of Things

IoT Design and Test Challenge #1

- IoT product design – leveraging the many IoT system modules

IoT device design value chain

Chipset → Wireless Module → Embedded Module → Boxed Product

Integrated Circuits

Several ICs (analog, RF, digital) packaged in a module

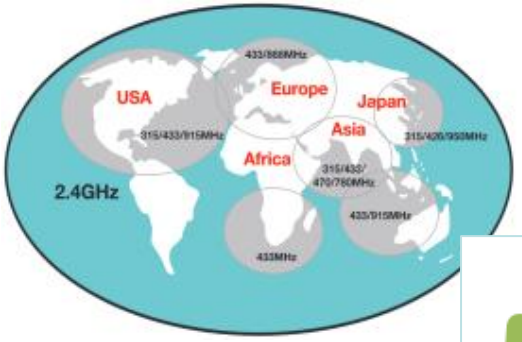
MCU, Wireless module Crystal, antenna, voltage regulators, balun, shielding, Passives, etc.

Source: Roku, Inc.

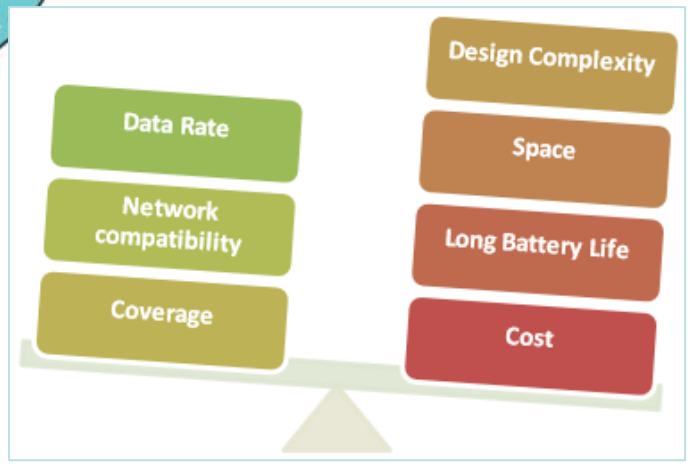
Final Product

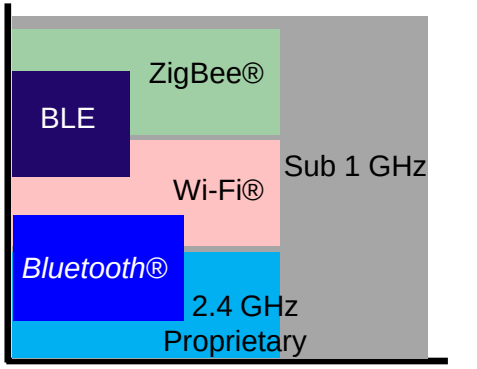
Choosing IoT connectivity technology

CONSIDERATIONS

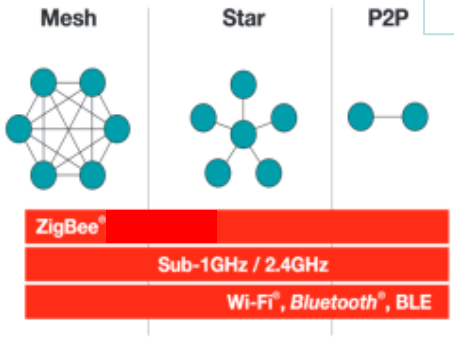


Frequency

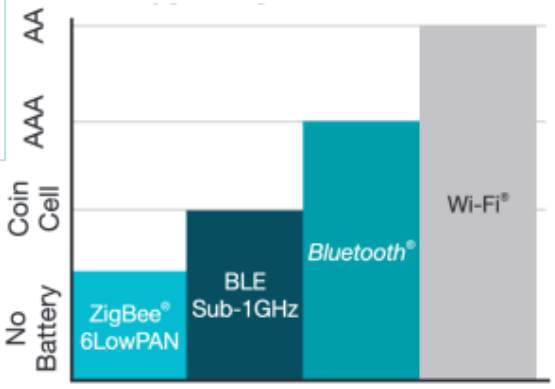




Range



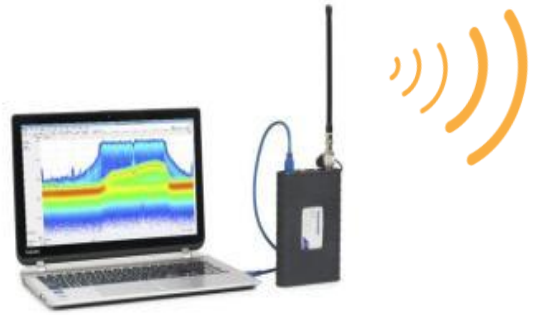
Topology



Power Source

Design your IoT device with higher confidence under true-life signal conditions

1. ***Record Signal environment with Real Time Spectrum Analyzer***



Time Spectrum Analyzer

2. ***Play back recorded signal during IoT device design***

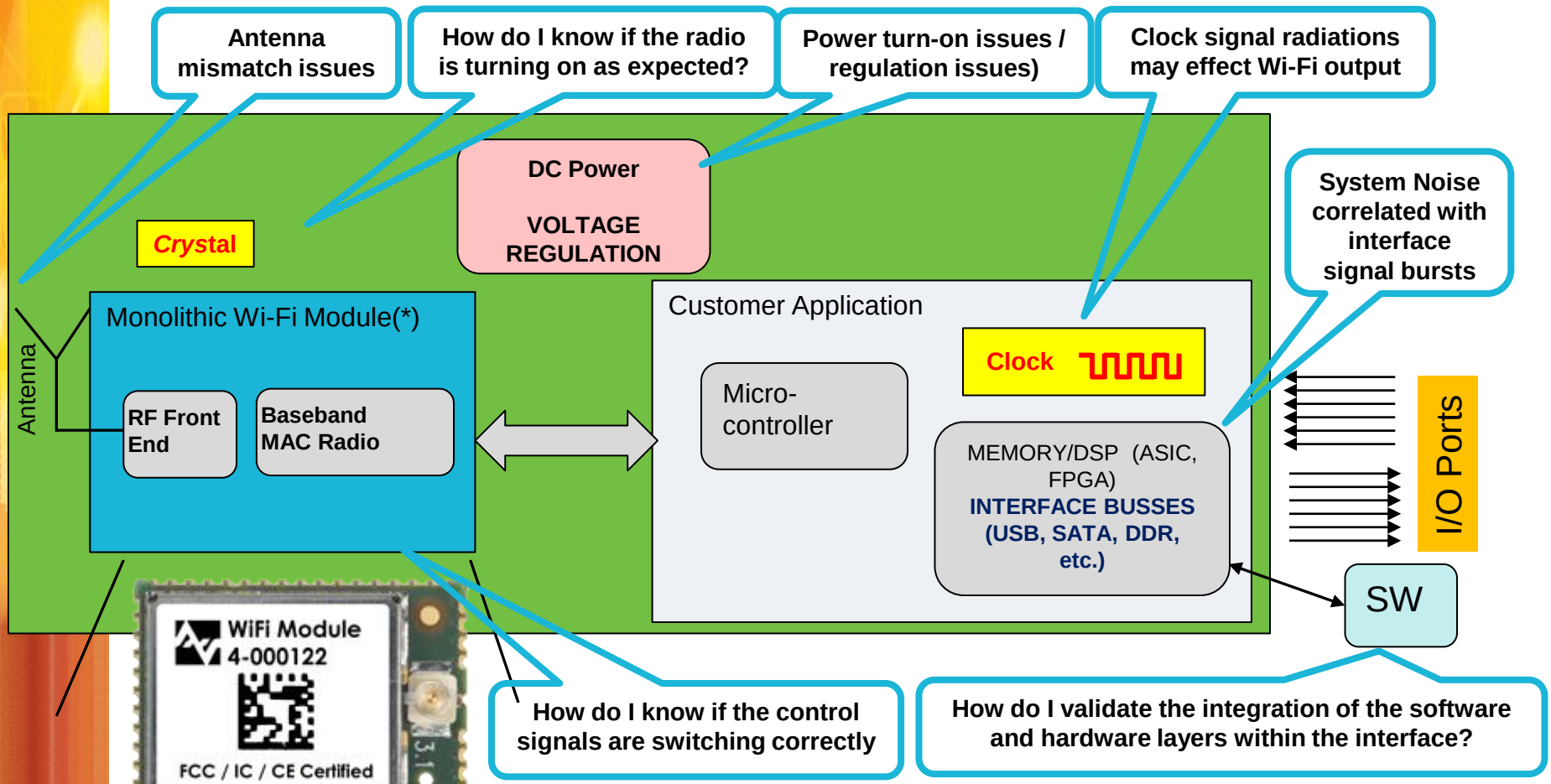
Signal Generator

Stimulus

IoT Design and Test Challenge #2

- Debug complex digital/analog/RF system problems

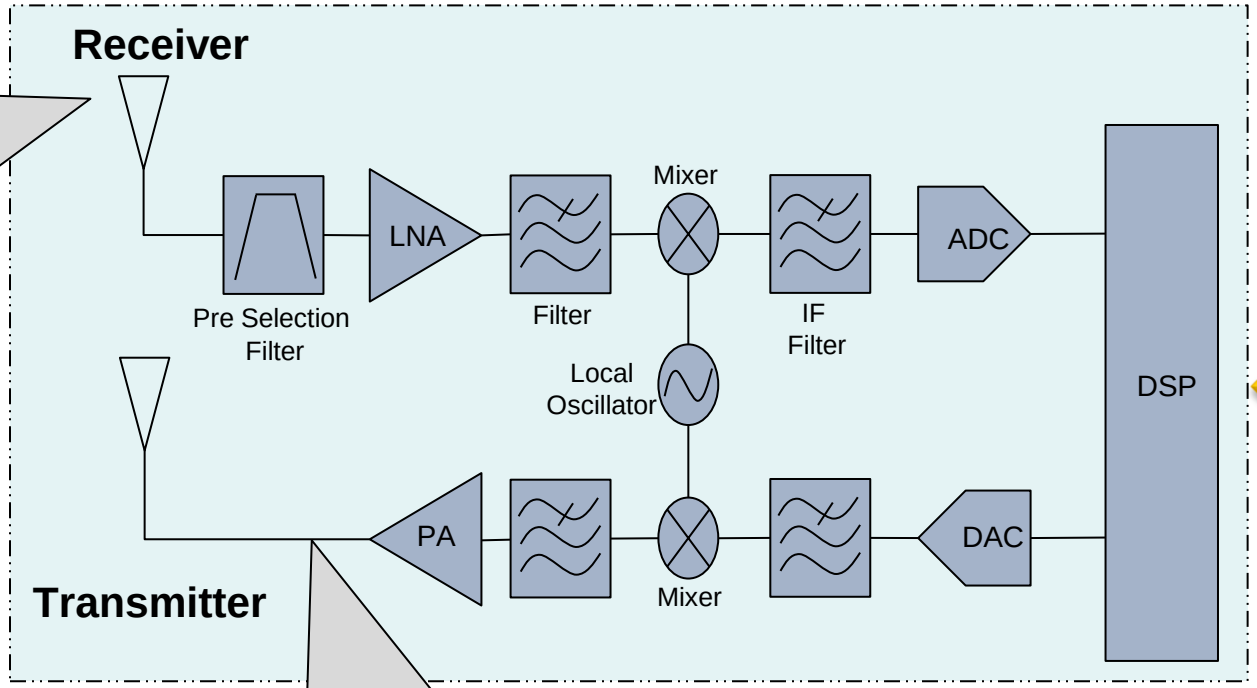
Typical IoT embedded module block diagram and common issues



(*) Certified Module doesn't mean Certified End-Product

Need RF receiver troubleshooting test solution?

I can't find an affordable Signal generator to do a simple Receiver Sensitivity or Blocking test



System Level Integration

I cannot identify the reasons why my radio is failing functional test

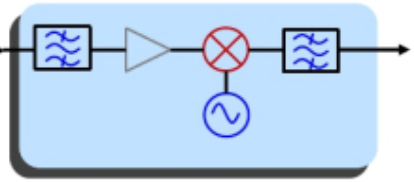
Example application – RF receiver sensitivity test

RF Spectrum Analyzer

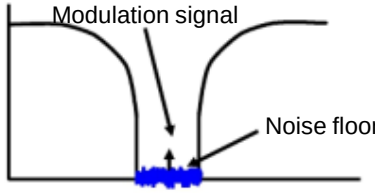
RF Signal Generator

Receiver DUT

ATT



IF signal

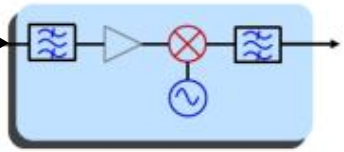


Example application – RF receiver blocking test

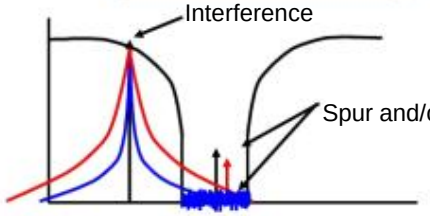
RF Signal Gen 1
(In-channel signal)

A
T
T

Receiver DUT



IF signal



RF Signal Gen 2
(out of channel signal)

RF Spectrum Analyzer

IoT Design and Test Challenge #3

- Maximizing your device's battery life

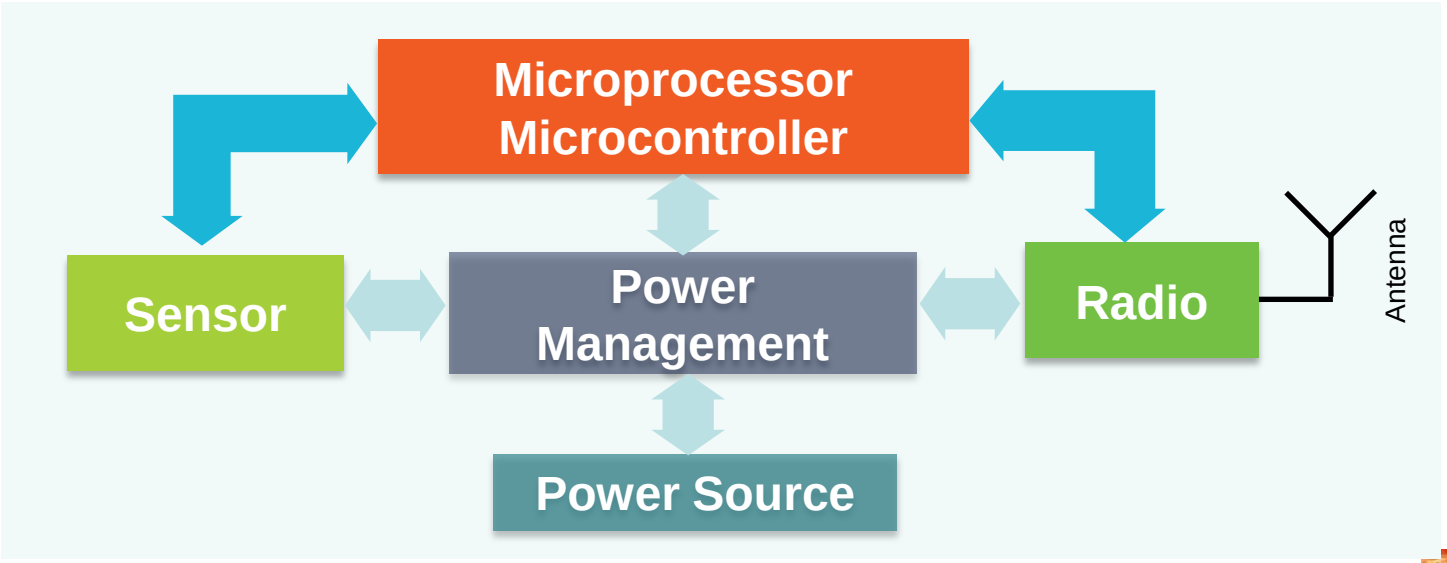
Architecture

- IoT Wireless, Portable Device







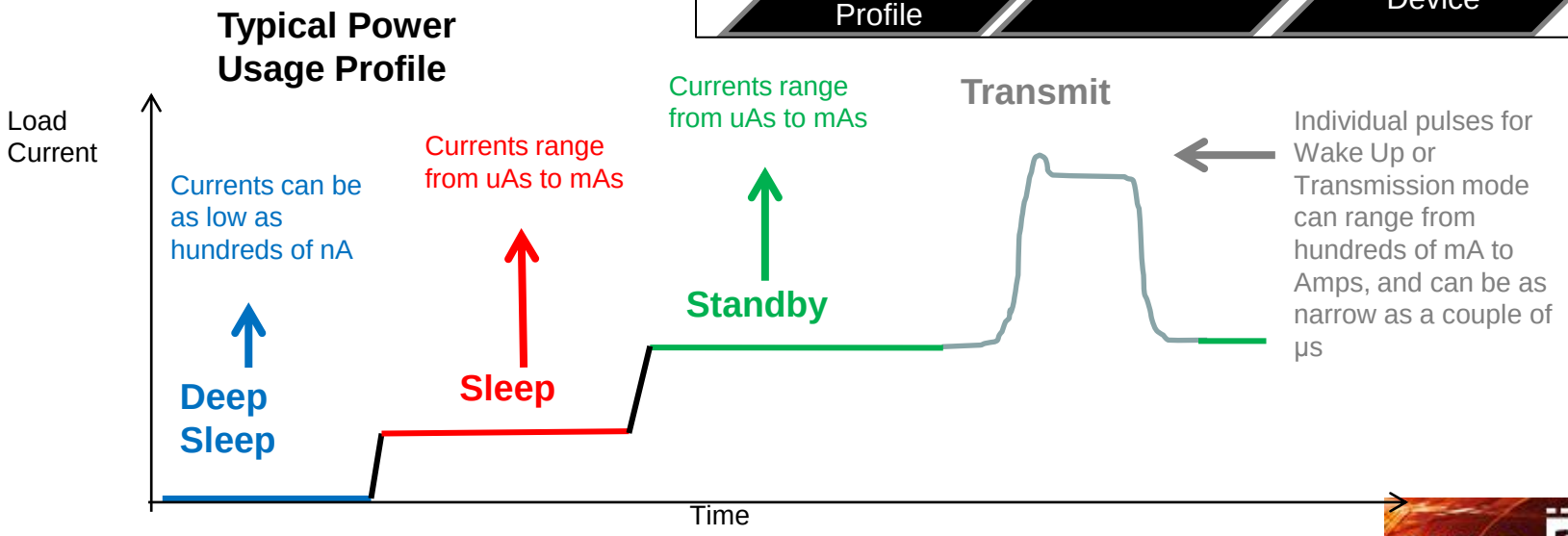
IoT device power consumption analysis

TYPICAL DEVICE POWER PROFILE

- **Power Consumption Analysis**
  - Critical for IoT Device Design
  - Directly translated into the success of any IoT product
  - Characterizing an IoT device power profile is not a trivial design activity

- **Assessing Battery Performance:**
  - How do I measure the very low battery currents when the device is in sleep or standby mode?
  - How do I measure the battery current during the transmission bursts?
  - How do I characterize total battery power consumption?
  - How does battery current change as the battery discharges?

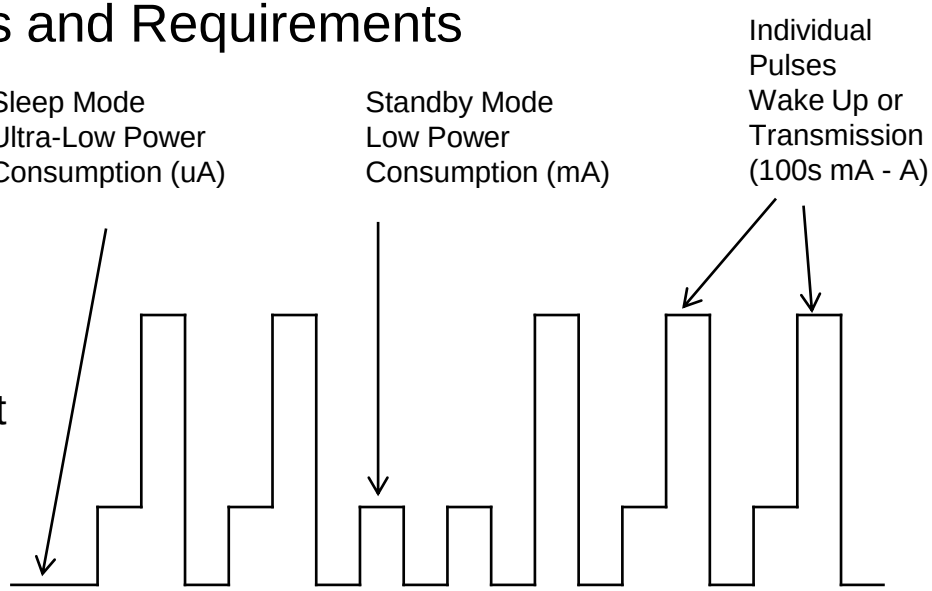
Realistic Power Usage Profile → Battery Life → Success IoT Device



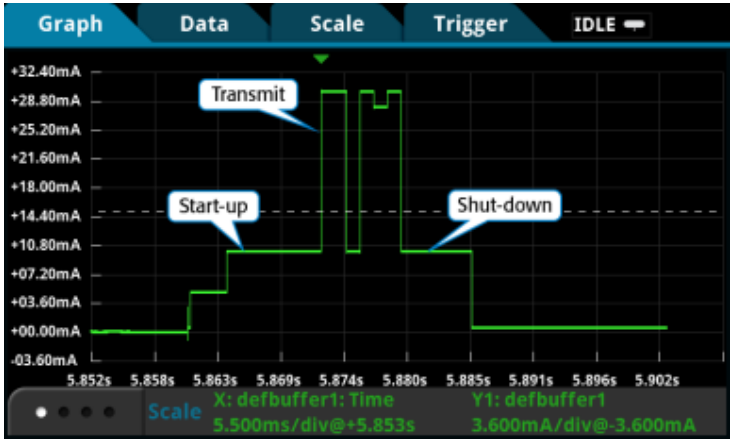
IoT power consumption analysis

Challenges and Requirements

- **Testing Challenge**
  - Accurately measuring a wide range of currents from tens of nA (deep sleep mode) to hundreds of mA (active mode)
  - Capturing transient signals that lasts only µs
  - Monitoring and saving for long period of time



- **Typical power testing requirements**:
  - **High Accuracy** for high quality characterization in wide ranges
  - **High Sample-Rate** with deep memory buffer and advance triggering capability to capture waveforms over time
  - **Ease of Use**: Pinch-and-zoom touchscreen interface to quickly analyze waveforms
  - **High Precision Supply**: Supply clean, stable, accurate DC power (supports high accuracy measurement)

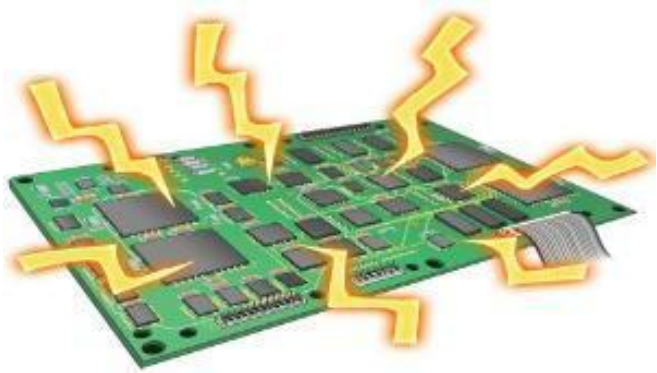


IoT Design and Test Challenge #4

- Speeding your device through EMC compliance

EMI/EMC Definitions

- EMI/EMC
- Regulations
  - Country/Region
  - Industrial/Consumer
  - Military
- Conducted Emissions
  - Unwanted signals coupled to AC mains
- Radiated Emissions
  - Unwanted signals broadcast from DUT
- Intentional Radiator
  - Spectrum Emission Mask
  - Power Limits
  - Harmonic Content
- Susceptibility/Immunity
  - Region dependent



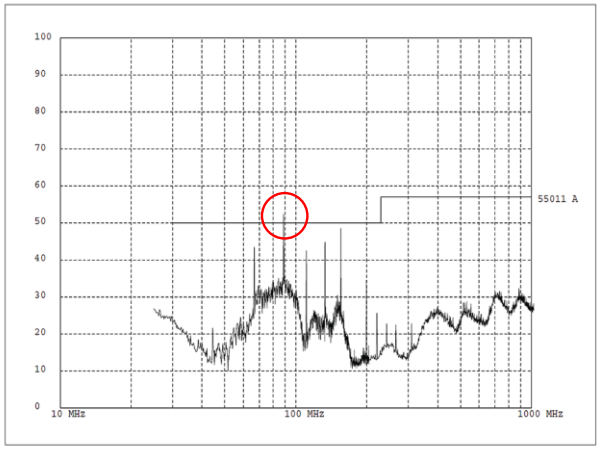
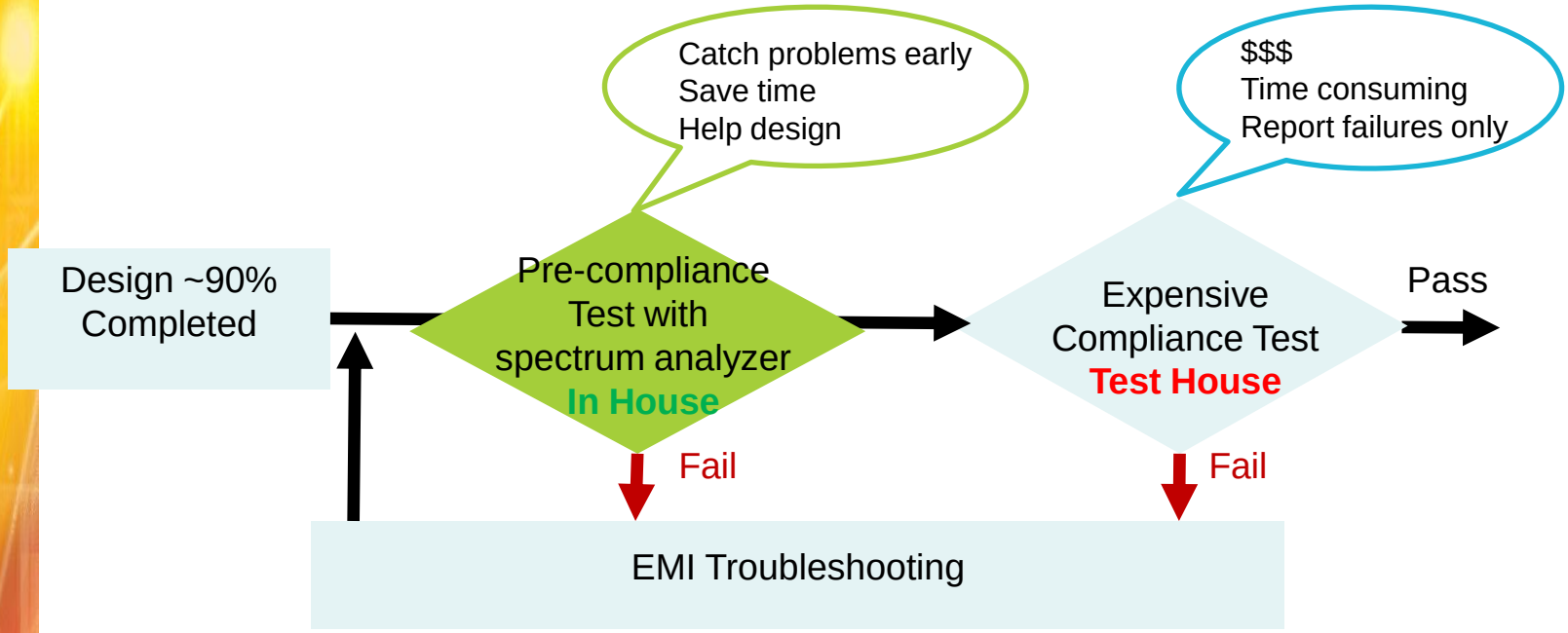


Figure 1. This EMI test report shows a failure at around 90 MHz.

EMI Testing Work Flow

SCHEDULE TIME AT TESTING LAB



EMI Pre-Compliance testing will save time/money by identifying problem areas before they become expensive re-design issues

Do I Need An EMI Receiver ?

- EMI receiver are designed specifically for spectrum sweeping
  - RBW
    - Shape
    - Bandwidth
  - Detectors
    - Peak
    - Average
    - Quasi-Peak
- Pre-selected RF tuning stages
- User defined dwell time per step
- Detailed requirements in CISPR 16-1-1
- ***For Pre-Compliance You Don't Have To Use A Special Receiver***
  - We are making an accurate approximation
  - Understand the compromises in the measurements

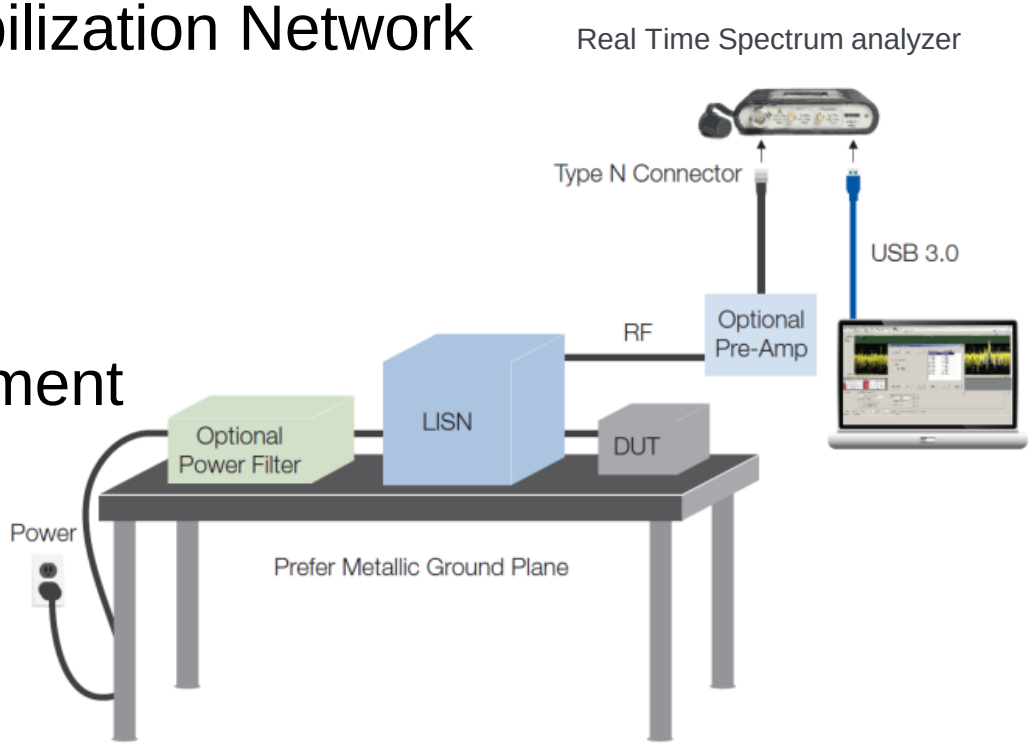
Frequency Range	Bandwidth (6 dB)	Reference BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz	200 Hz
0.15 MHz to 30 MHz (Band B)	8 kHz to 10 kHz	9 kHz
30 MHz to 1000 MHz (Bands C and D)	100 kHz to 500 kHz	120 kHz
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz	1 MHz

Table 1. Measurement Bandwidth versus Frequency specified by CISPR 16-1-1.

Setting Up A Pre-Compliance Test

CONDUCTED EMISSIONS <30 MHZ

- Utilize a metallic surface which can be grounded
- Line Impedance Stabilization Network (LISN)
- Pre-amp (Optional)
- Limiter (Optional)
- Make sure the instrument can accommodate gain/loss corrections

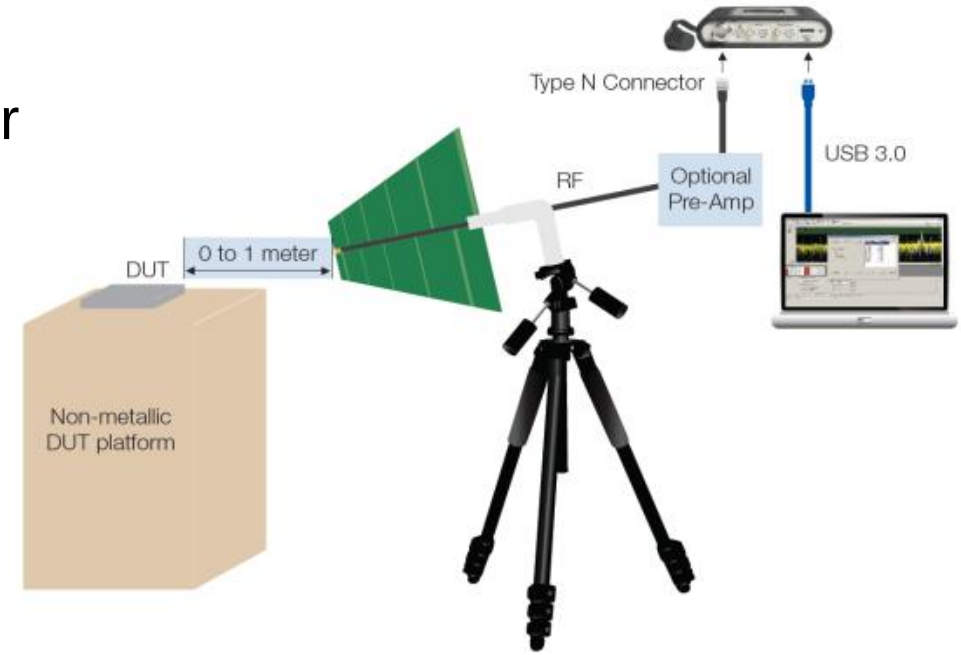


Setting Up A Pre-Compliance Test

RADIATED EMISSIONS >30 MHZ

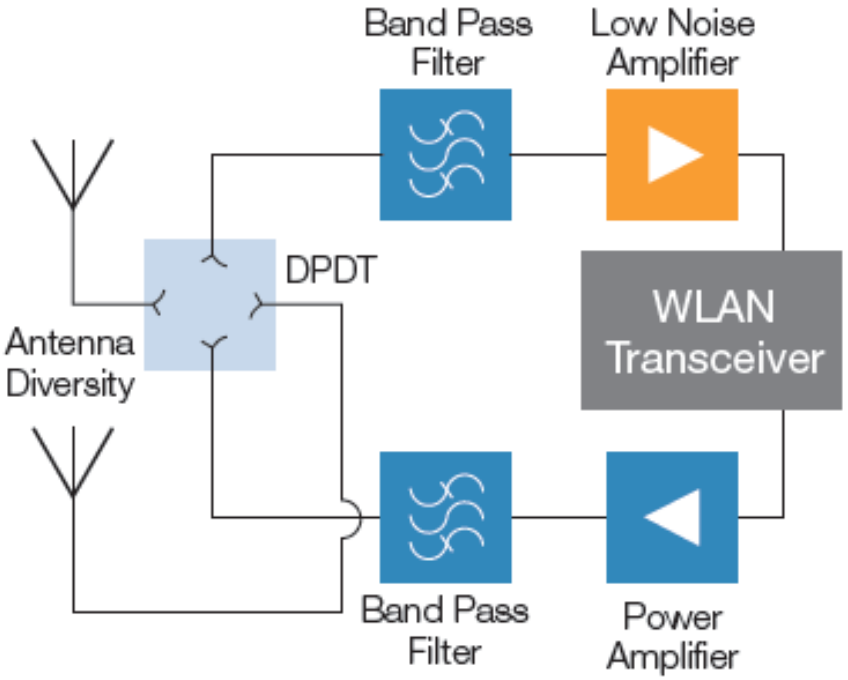
- Identify an area with natural RF shielding
  - Basements
  - Parking garages
- Watch out for DAS
  - Used to help cellular coverage

- Non metallic platform for DUT
- We need to look at 360 around DUT
- Tripod/pre-amp optional but recommended



Intentional Radiator Testing

- For devices that transmit RF energy
  - WiFi, Bluetooth, Zigbee
- In-Band Channel Power
  - Integrated channel power
  - Defined by standards body
- Out of Band Channel Power
  - Power outside channel BW
  - Commonly defined with a mask
- Specific hardware & software requirements

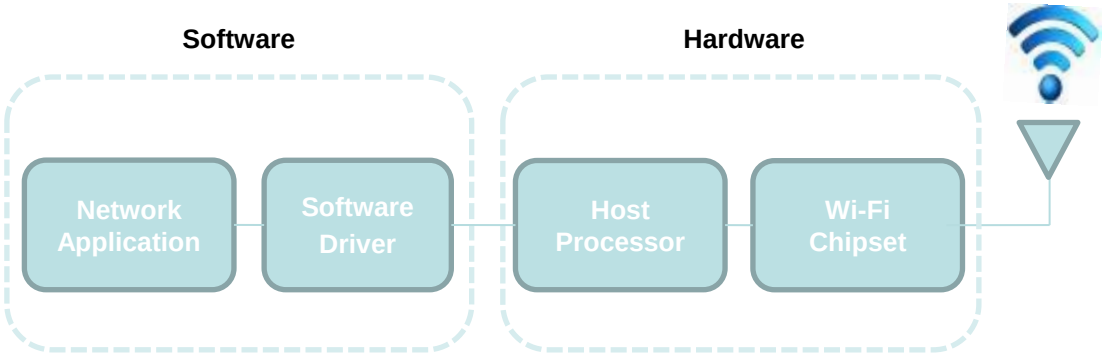


IoT Design and Test Challenge #5

- Speeding your device through wireless certification

Wireless standards certification

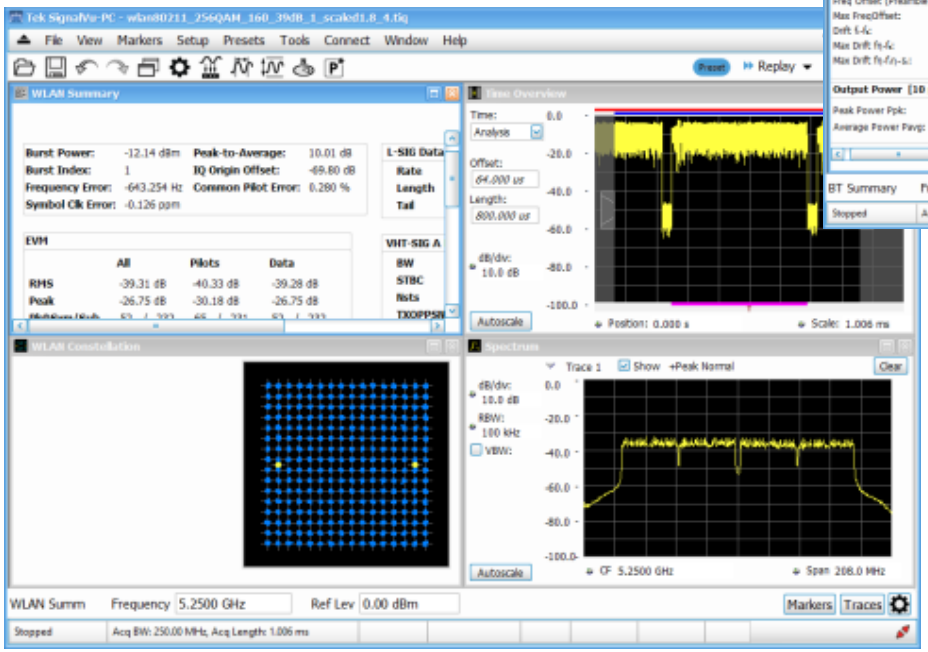
- Wireless standard certification is what allows to print a wireless standard's certified logo on a product …
- Many RF modules available that are "pre-certified". But a pre-certified RF module doesn't guarantee a certified boxed product
- Even small deviations from reference designs can cause failures
- Changes to the RF path can put you at risk
- How your software interacts with the module may affect compliance.

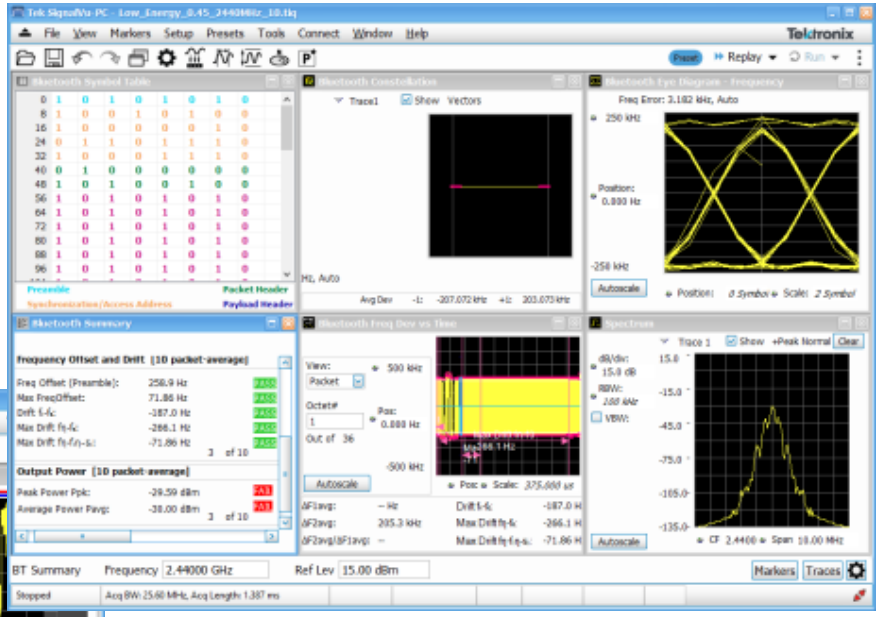


Typical Wi-Fi Enabled Device

Wireless transceiver pre-certification in SignalVu-PC

WLAN pre-certification Test (IEEE 802.11 a/b/g/n/ac)



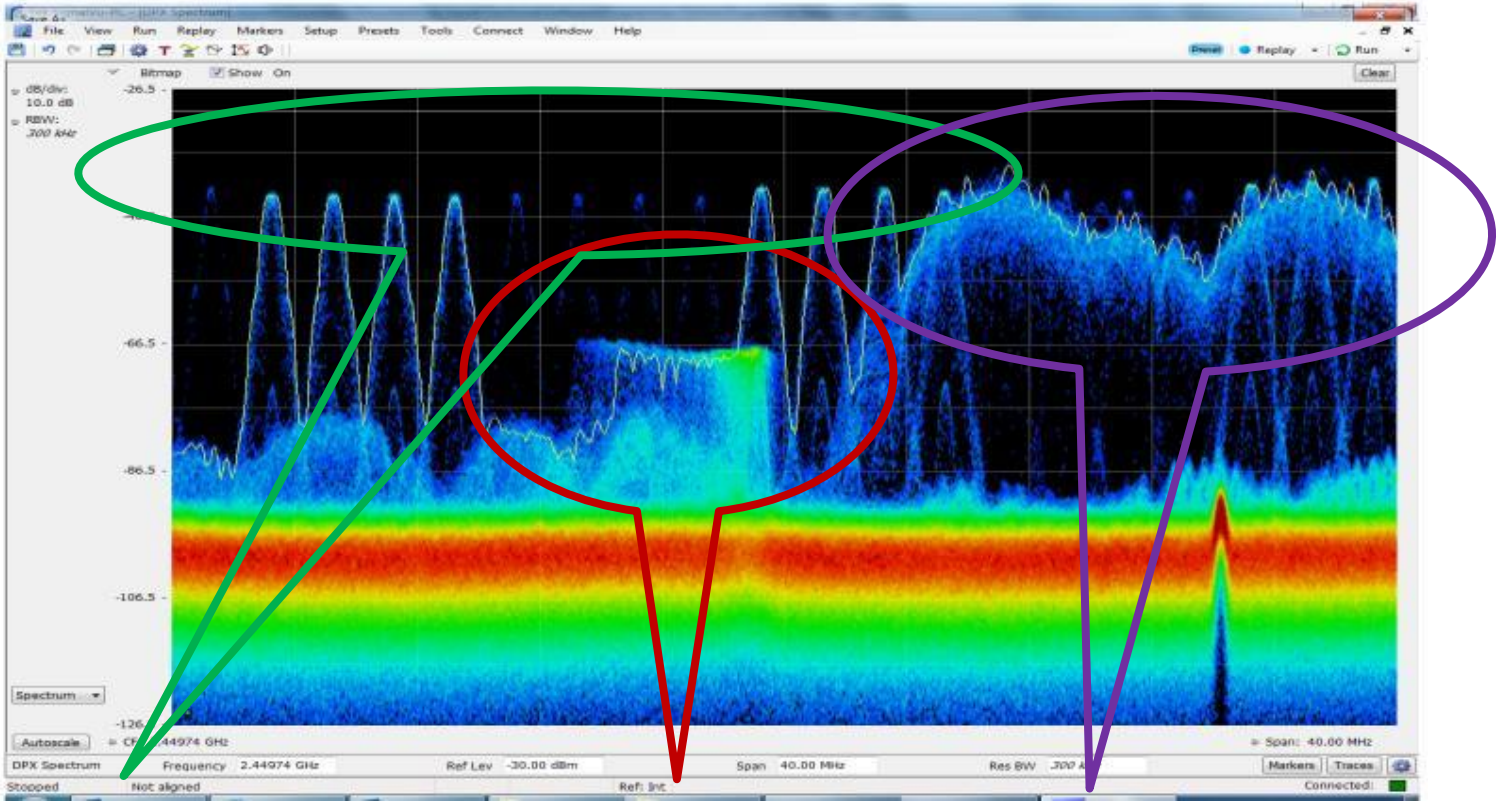


Bluetooth pre-certification Test (Low Energy, Basic Rate, and Enhanced Data Rate)

IoT Design and Test Challenge #6

- Preparing for IoT network deployment

Your IoT device is not alone out there …



Bluetooth signal

Microwave oven

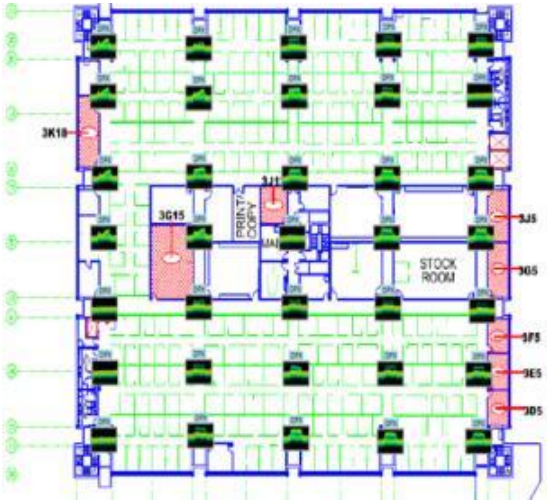
Wi-Fi signal

Deployment of long range low data rate IoT networks

Long range low data rate IoT network operators require outdoor mapping of measurements in order to validate operation frequency bands

Use SignalVu-PC mapping Option to

Hunt indoor interference



Locate transmitters

test signal quality/coverage