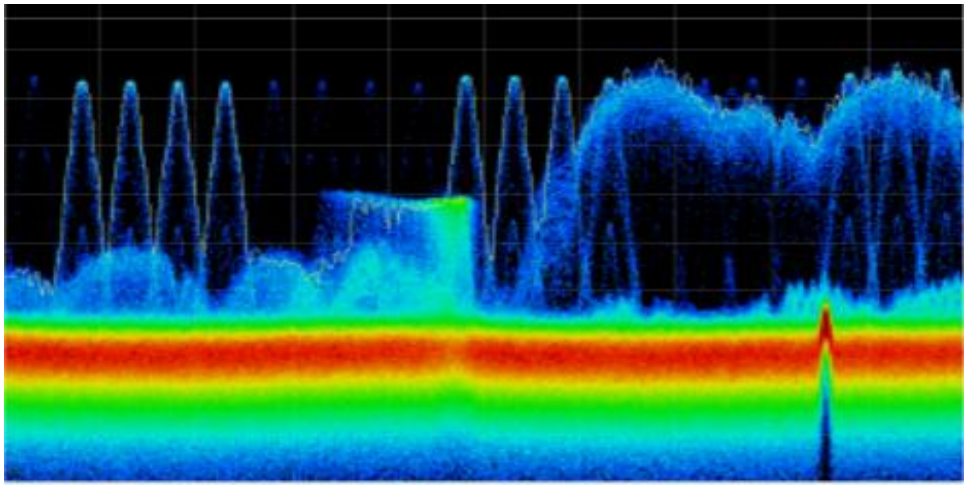
Solutions for IoT test challenges



Rick Kundi
Applications Engineer, Tektronix

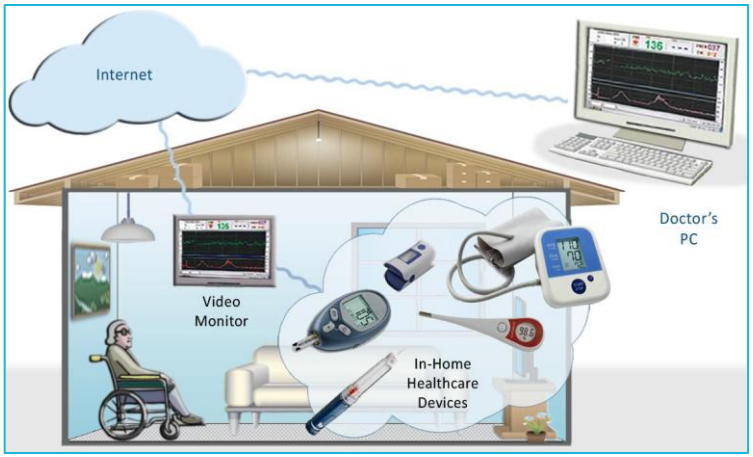
Agenda

- **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

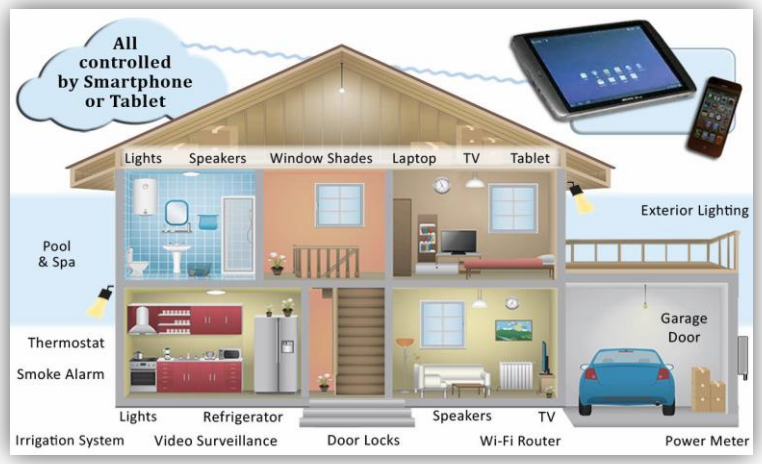
(*) IoT : Internet of Things, M2M: Machine to Machine

IoT applications

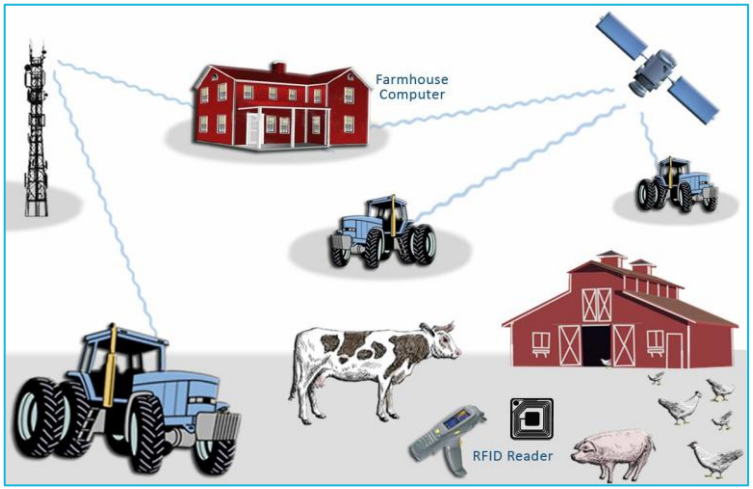
Health



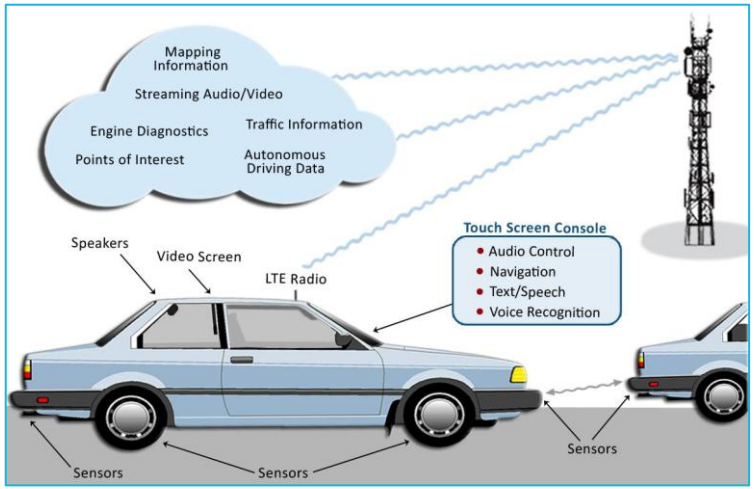
Home automation



Farming / Smart metering / …

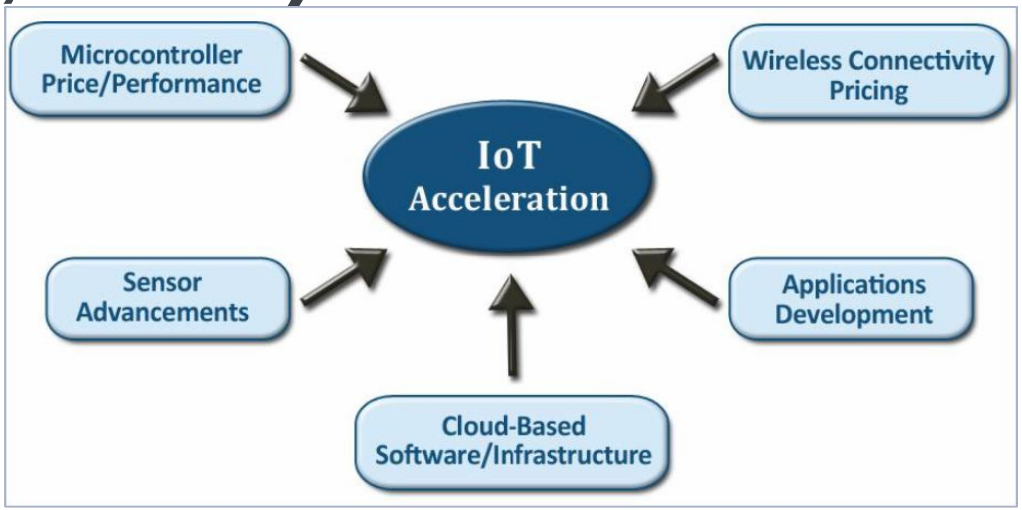


Automotive



Source: Raymond James research

Device development is accelerated by new low cost IoT modules (sensors, RF modules, MCUs)

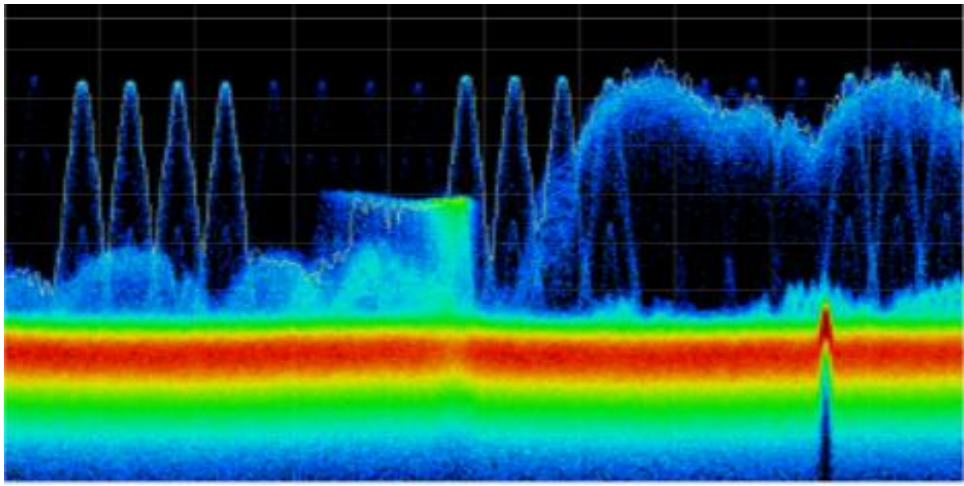


Source: Raymond James research

- Explosion of sensor systems and components. Several physical/chemical parameters can be sensed (temperature, pressure, movements, etc.)
- Wireless connectivity made simpler with wider offering of high performance RF modules
- MCUs offering higher performances (low power, computation speed, DSP, etc.)

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

IoT device development strategies

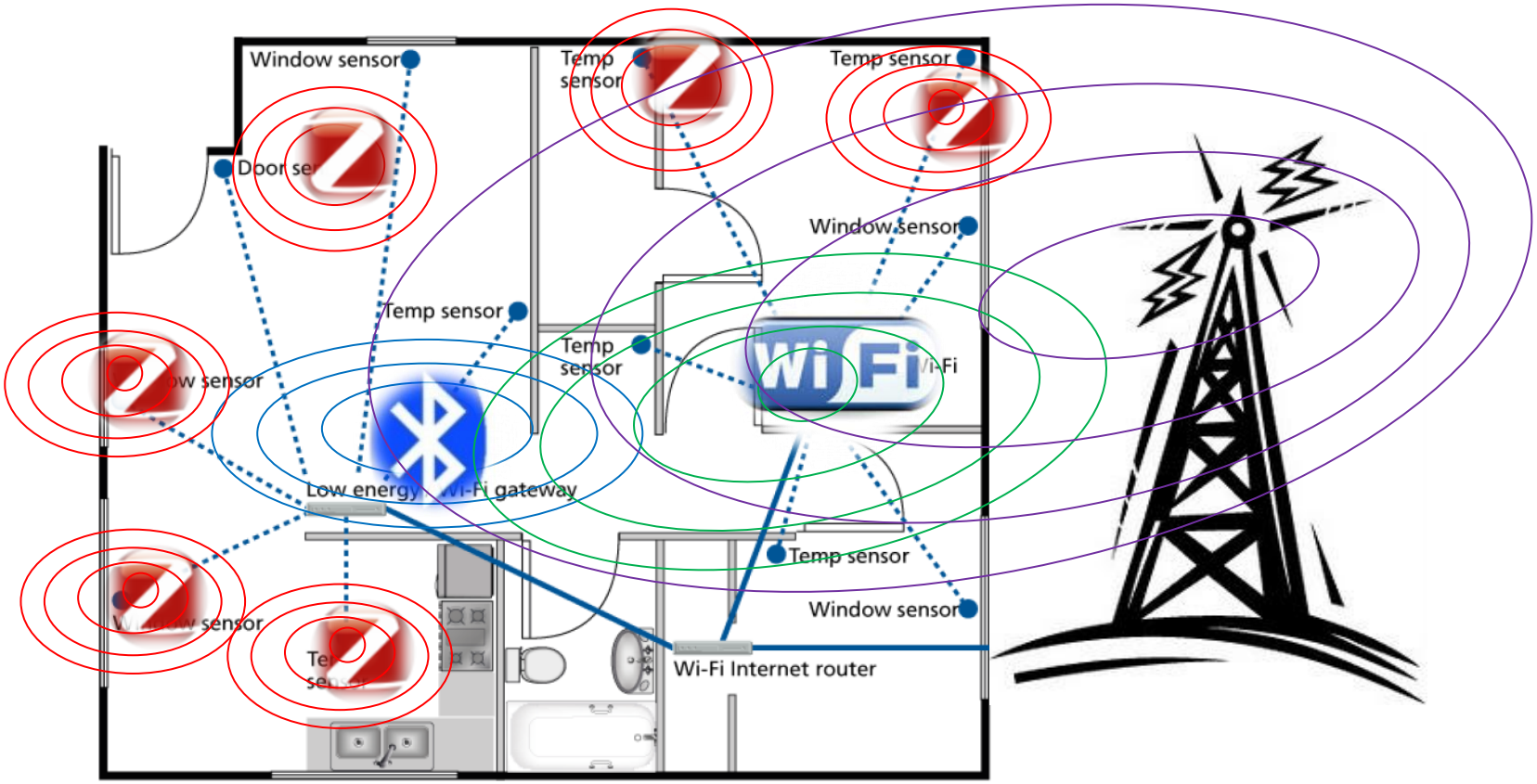
- Which wireless connectivity technology ?
- What regulatory certifications will be needed ?
- What standard qualifications (BT, WLAN, ZigBee, RFID, etc.) will be needed ?
- Hardware design choice:
  - “Chip” versus “Module” ?
  - “Embedded Module” versus “Standalone Modules” ?
- Software development : License or develop ?

Wireless module selection tips

RF Modules come in two main types:

- Pre-certified
  - If you use the reference design board and antenna, the module vendor will guarantee that it will pass the Wireless certification step. It also helps your chances on passing the EMC testing – this depends on how the other parts of your circuit performs.
  - High unit costs
  - Restricted to the manufacture’s antenna selection
- Non-Certified
  - Lower unit cost
  - More flexibility in antenna selection and location
  - Typically longer design time

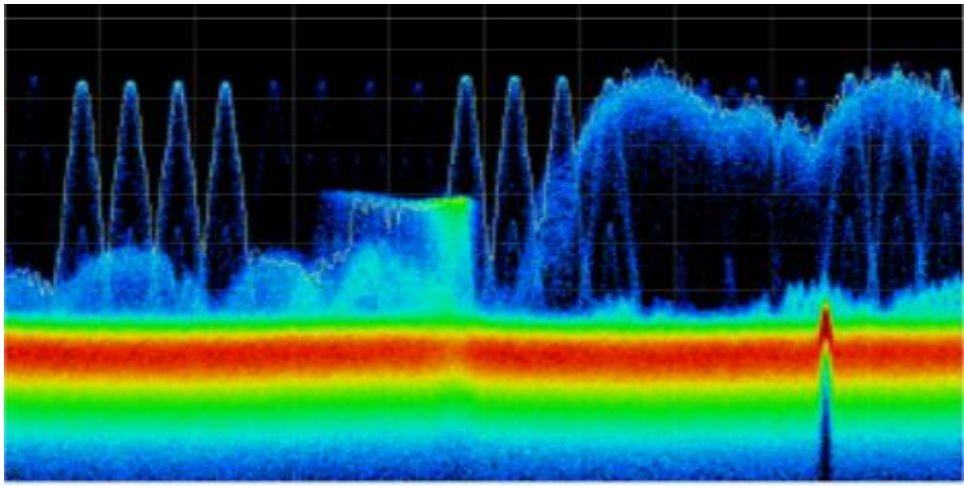
Take into account your signal environment during IoT design phase



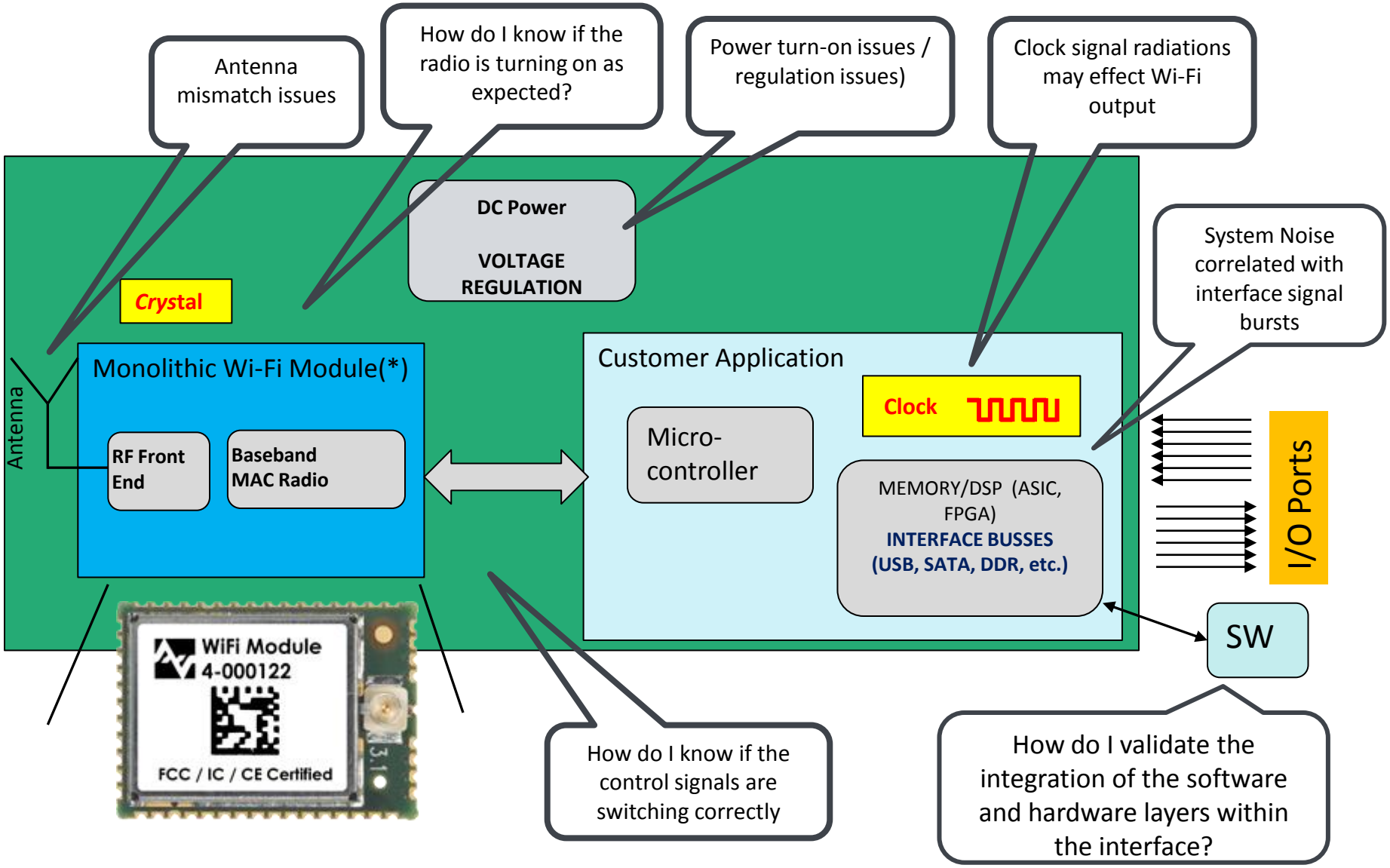
Many RF technologies coexist in the unlicensed frequency bands. If not taken care of during design phase, IoT device communication can be interfered and become inoperative

IoT Design and Test Challenge #2

Debug complex digital/analog/RF system problems



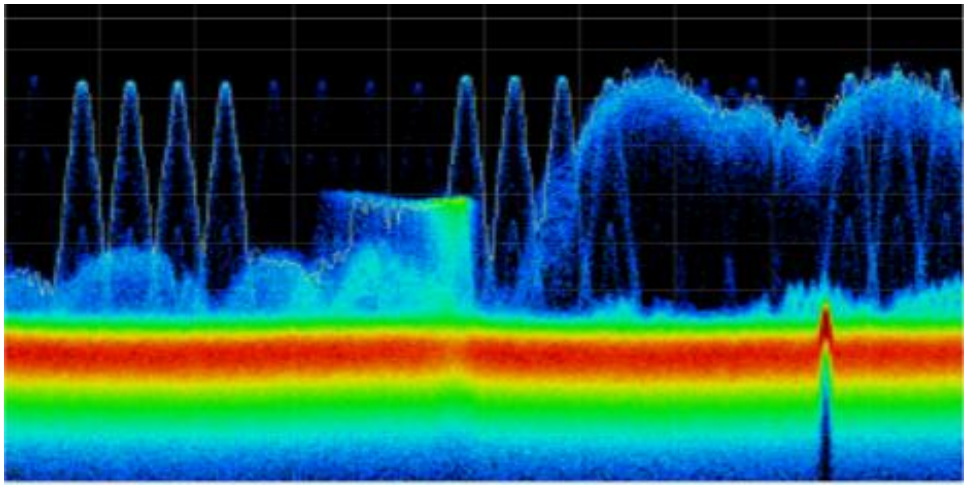
Typical IoT embedded module block diagram and common issues



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

IoT Design and Test Challenge #3

Maximizing your device's battery life



Wireless Remote Key

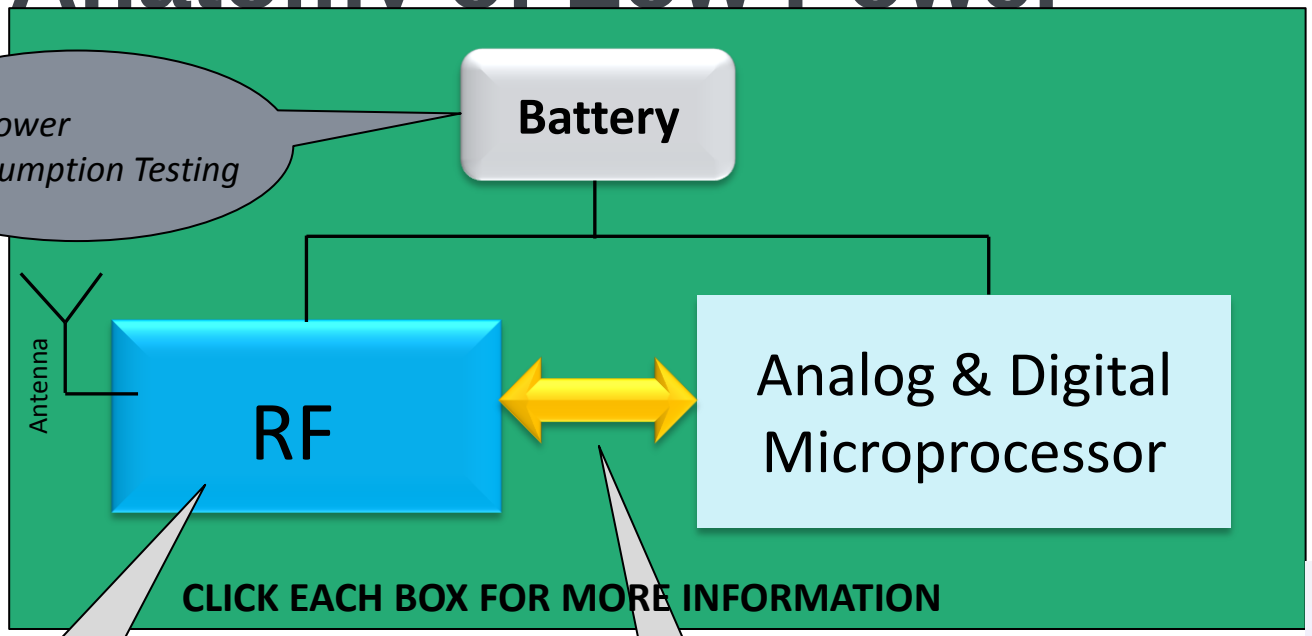
Smart Phone

Wireless Light

Wireless Tire Pressure Sensor

Wireless Activity Tracker

Anatomy of Low Power



DC Power Consumption Testing

RF testing

System Level Integration Testing

Wireless Headset

Wireless Pacemaker

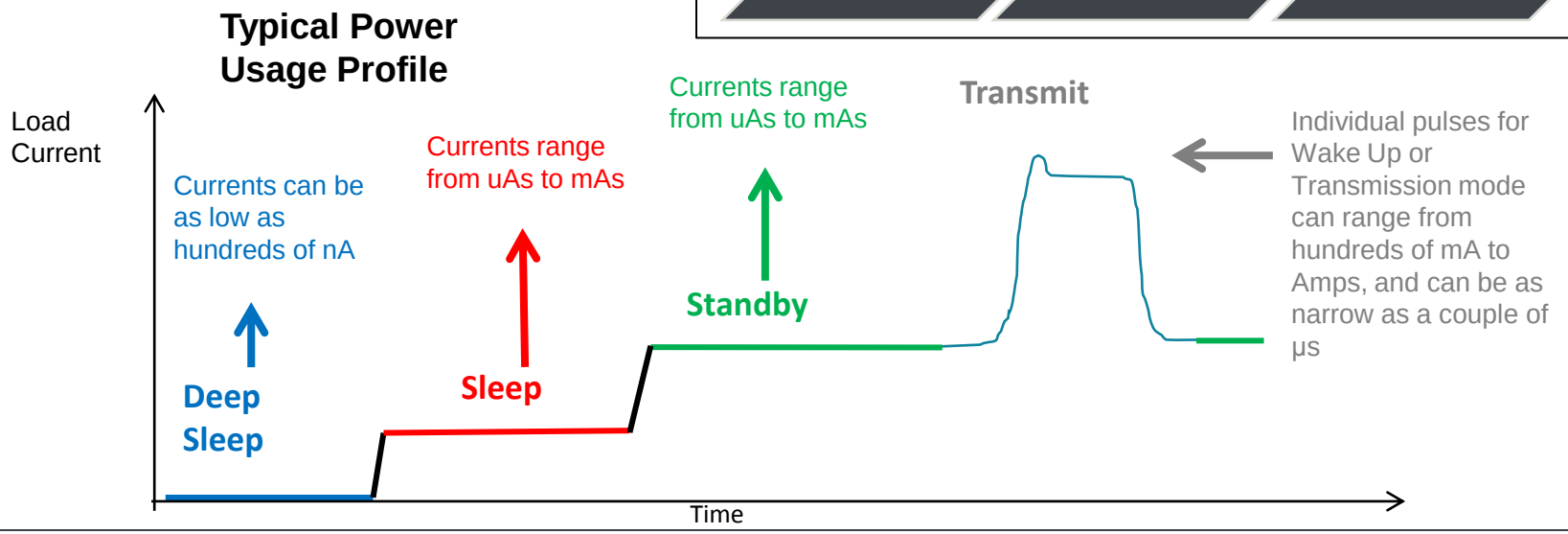
IoT device power consumption analysis

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

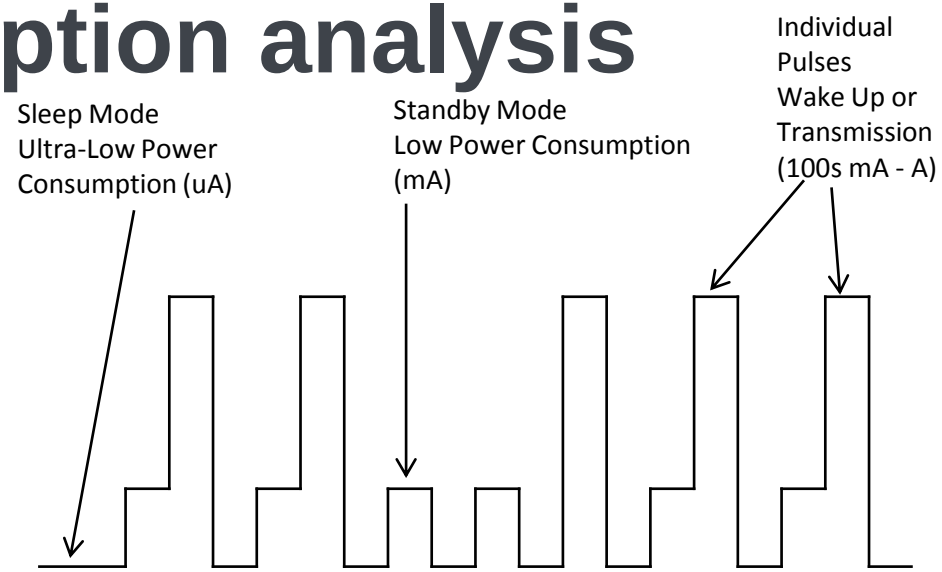
- **Assessing Battery Performance:**
  - How do I measure the very low battery currents when the device is in sleep or standby mode?
  - How do I measure the battery current during the transmission bursts?
  - How do I characterize total battery power consumption?
  - How does battery current change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

Realistic Power Usage Profile → Battery Life → Success IoT Device



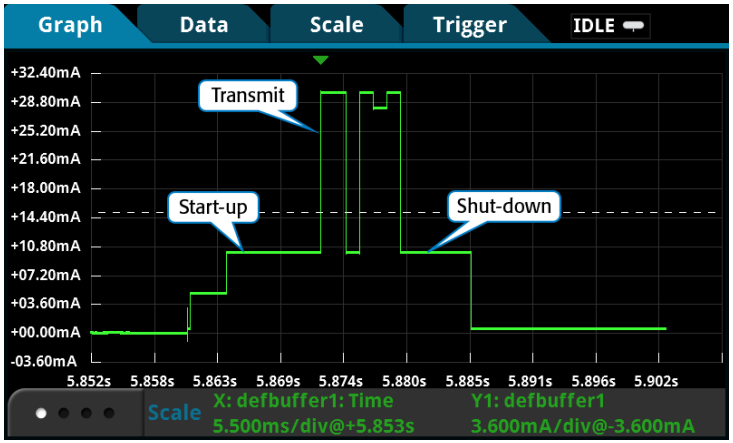
IoT power consumption analysis

Challenges and Requirements



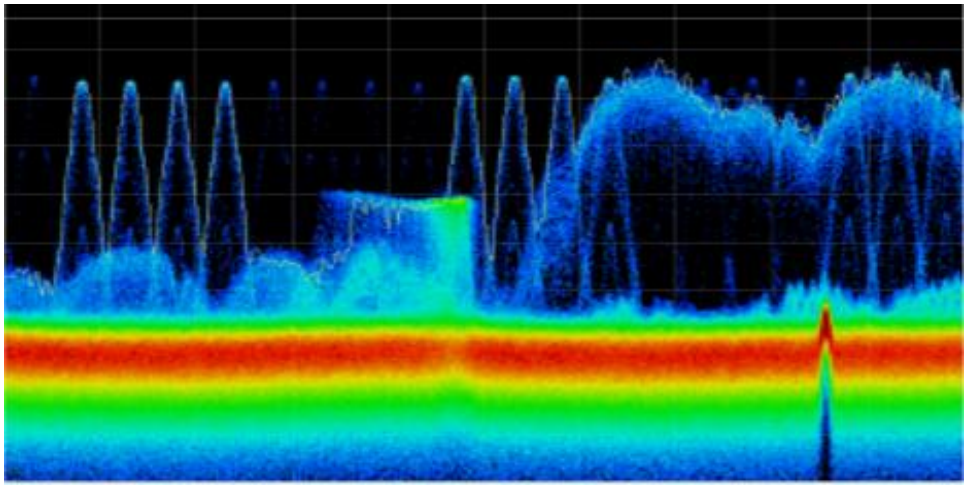
- **Testing Challenge**
  - Accurately measuring a wide range of currents from tens of nA (deep sleep mode) to hundreds of mA (active mode)
  - Capturing transient signals that lasts only µs
  - Monitoring and saving for long period of time

- **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

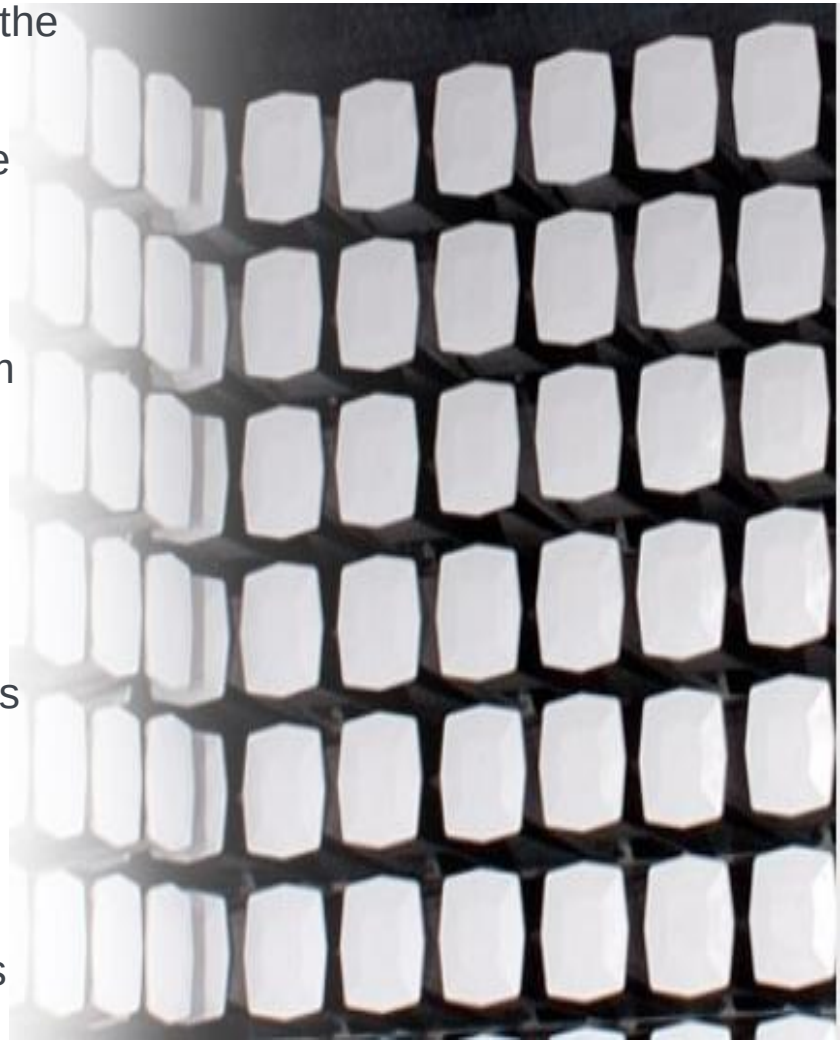
Speeding your device through EMC compliance



Speeding your device through EMC compliance & Wireless certification

- **Electromagnetic compatibility** (EMC) qualifies the ability of electronic and electrical systems or components to work correctly when they are close together. In practice this means that the electromagnetic disturbances from each item of equipment must be limited and also that each item must have an adequate level of immunity to the disturbances in its environment.

- **Wireless standards certification** is an **internationally recognized approval** for products indicating that they have met **industry agreed standards** (i.e. 802.11, Bluetooth, Bluetooth Low Energy, 3GPP WCDMA / LTE, etc.) for interoperability, security, and range of applications specific protocol



Pass your EMC compliance test the first time

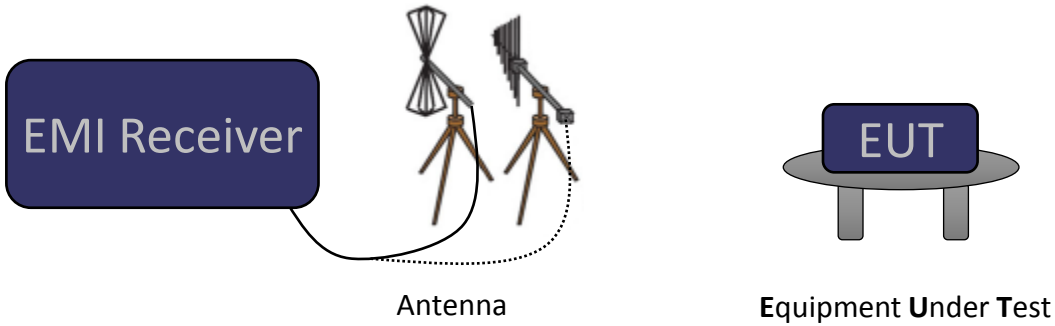
- Passing the compliance test for regional regulations (FCC, ETSI, IC, …) isn't easy. In fact, the odds are against you. Only **1 in 10** engineers report passing the first time.
- **Failing means project delays and big expenses - the average cost of compliance testing is $10,000*.**
- Your pre-compliance must be successful to avoid these issues.

Regulatory compliances

- Un-intentional radiated emissions
  - Unwanted signals
  - Class of service
  - Frequency range varies
- Conducted emissions
  - Unwanted signals coupled to AC
  - Class of service
  - Generally < 30MHz
- Intentional radiated emissions
  - Frequency band dependent
  - Class of service

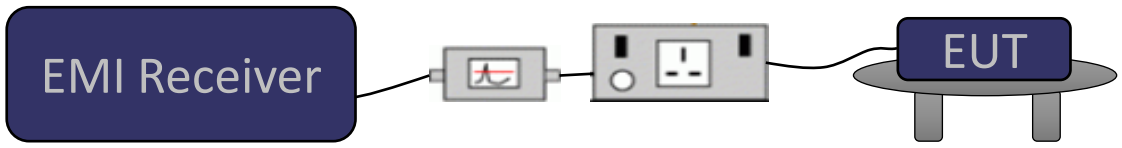
Radiated emissions

- Performed in RF isolated chamber
- Far field measurements (3m or 10m)
- EUT is placed on a turn-table, idle state
- Fully calibrated setup
  - Chamber
  - Receiver
  - Antenna’s



Conducted emissions

- For devices which connect to power grid
- Characterize energy conducted to AC grid
- Line Impedance Stabilization Network
  - Connected Rx between AC and EUT
- EUT is in operational state



Limiter and LISN

Equipment **U**nder **T**est

Do pre-compliance before going to certification house

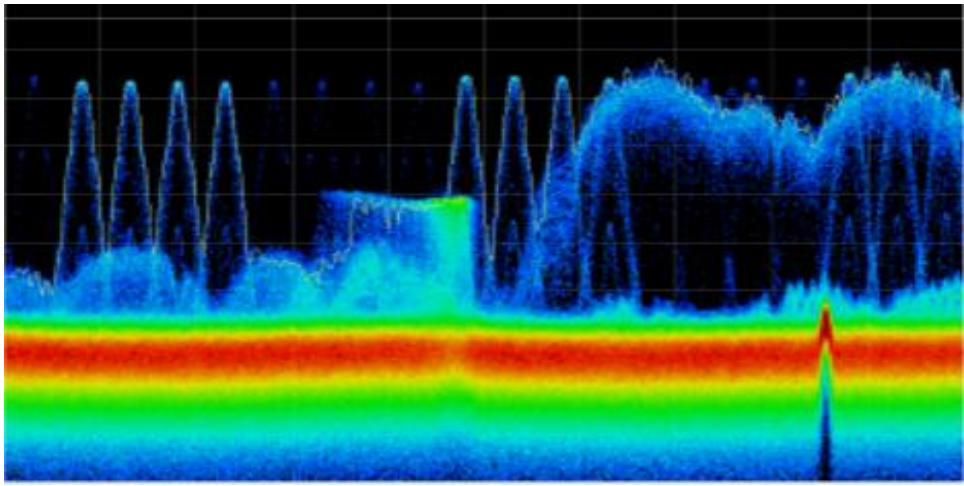
1. Pre-Compliance Measurement → **In House**
   - Test for problems throughout the design process
   - Test more often
   - General purpose instrumentation can be used for pre-compliance
   - **You still need to go to a certification house**

2. Compliance Measurements → **certification House**
   - Complex setup
   - Chamber time = cost
   - Failure of test means scheduling another visit

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

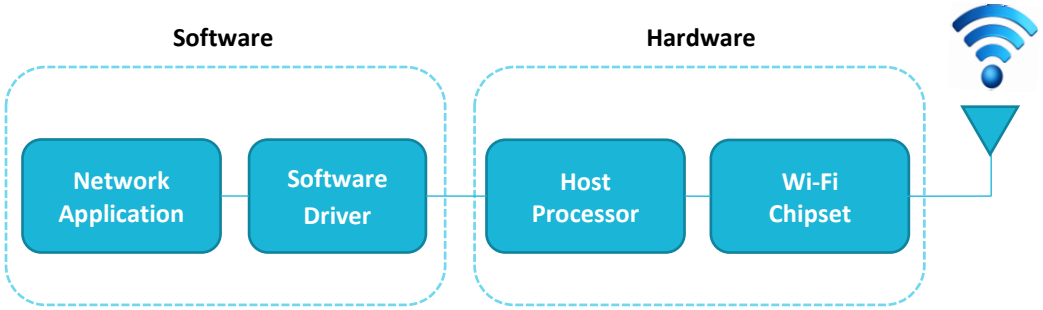
IoT Design and Test Challenge #5

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

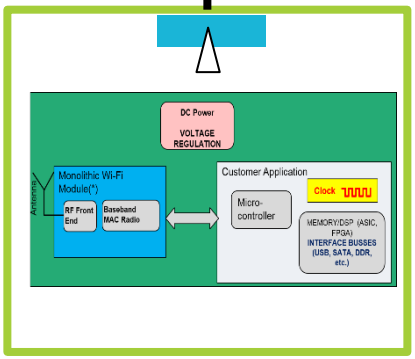
Using Tektronix's wireless standard pre-certification solution

Spectrum Analyzer

VSA Software

- **Bluetooth pre-certification**
- **WLAN 802.11 pre-certification**

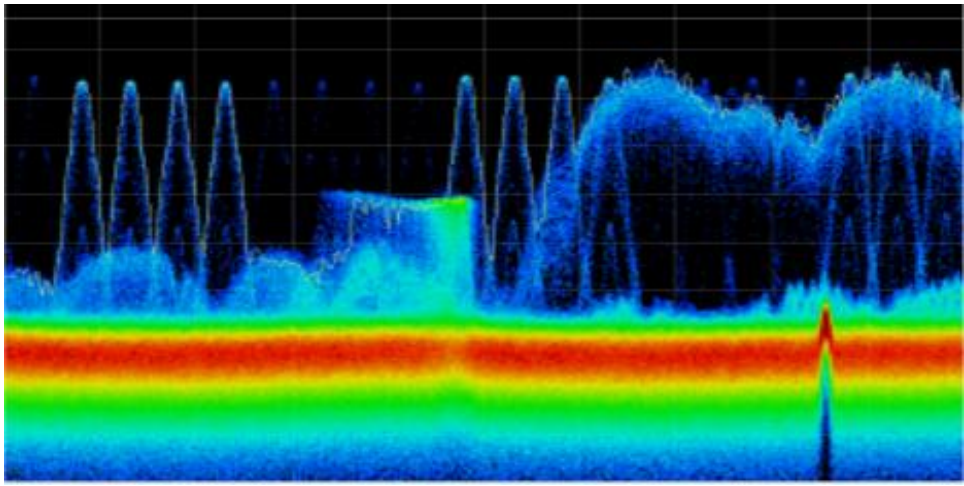
- **+ Digital modulation analysis for RFID, ZigBee, etc.**



RF Isolation Box

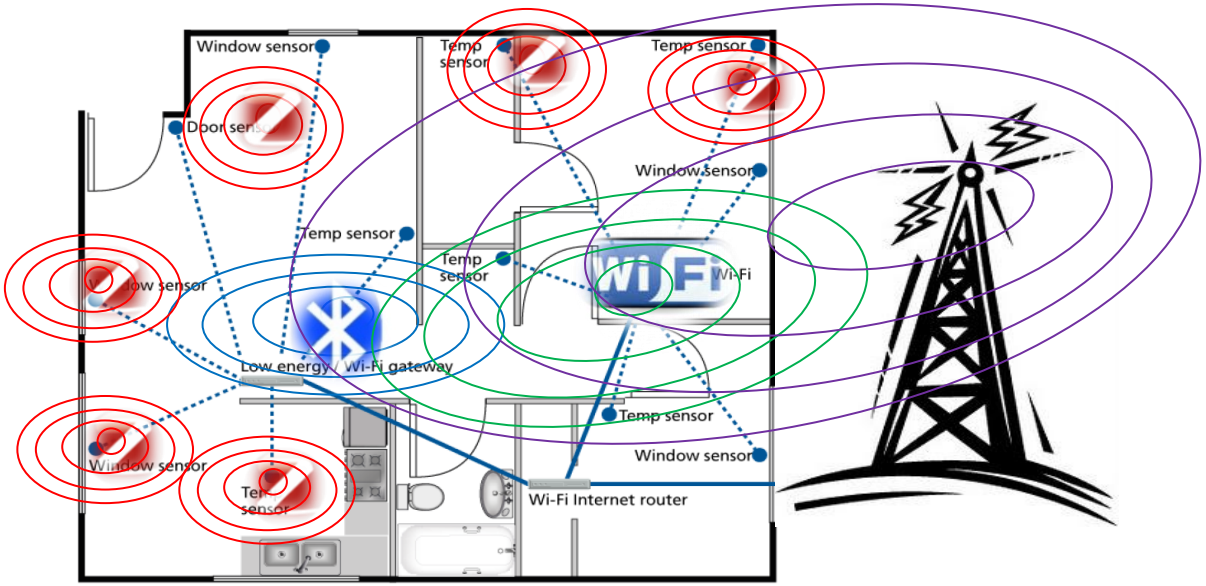
IoT Design and Test Challenge #6

Preparing for IoT network deployment



Your IoT device is not alone out there …

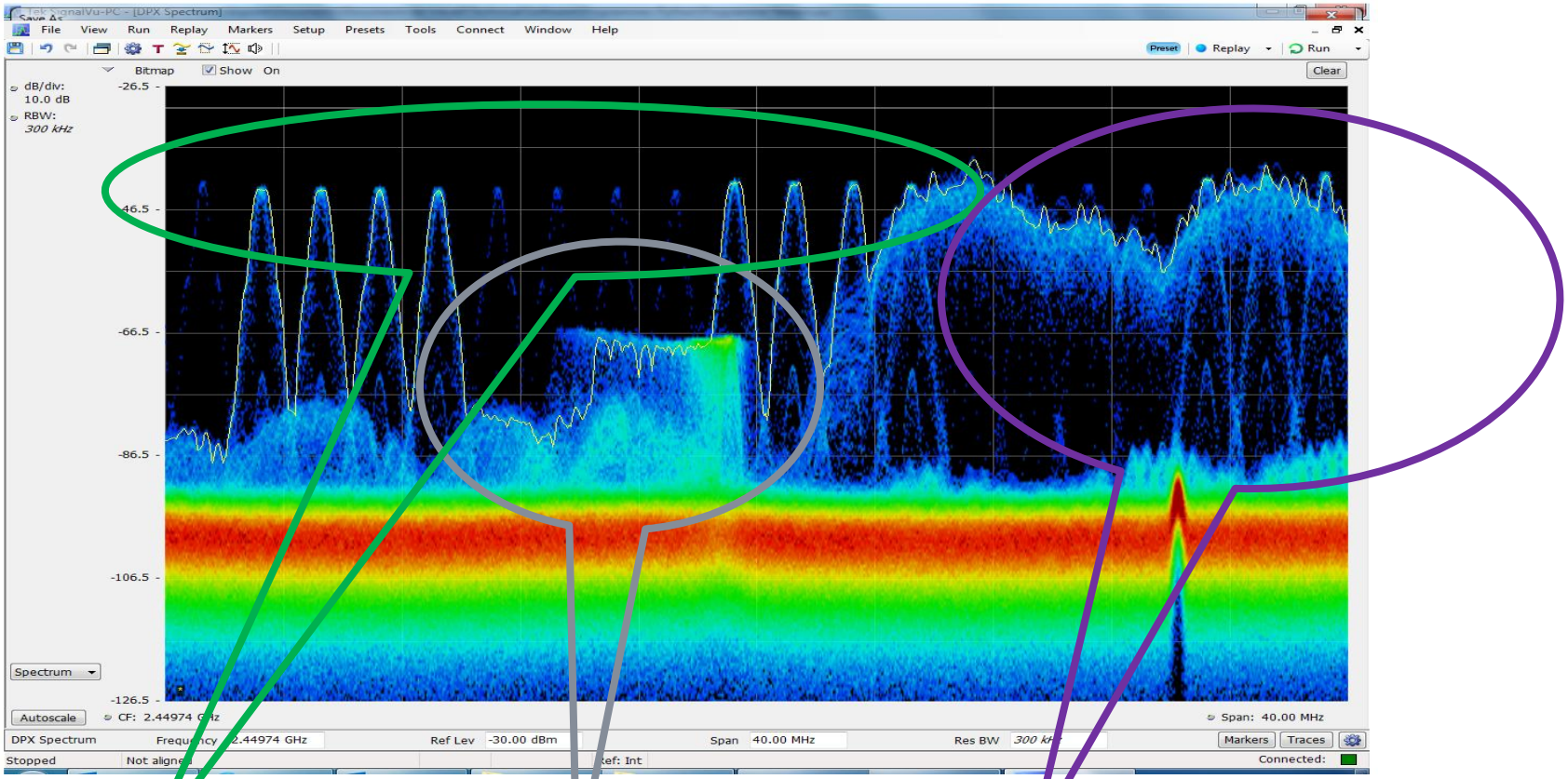
- Many IoT Devices need to operate in the ISM heavily crowded frequency bands are (WiFi, Bluetooth, ZigBee, wireless video transfer, microwave oven, etc.); Cellular communication can also interfere
- ISM band is a harsh radio environment



Use RSA306 to verify the noise level in your IoT device's frequency band

Light and high performance! Fits in your pocket

Example application – Indoor OTA (Over The Air) measurements



Thank you

- Questions?