70th Anniversary

展望太克 榮耀70

2016太克科技

春季創新論壇

Tektronix®

Tektronix

70th Anniversary
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Wirelessly Wonderful

Solutions for IoT test challenges

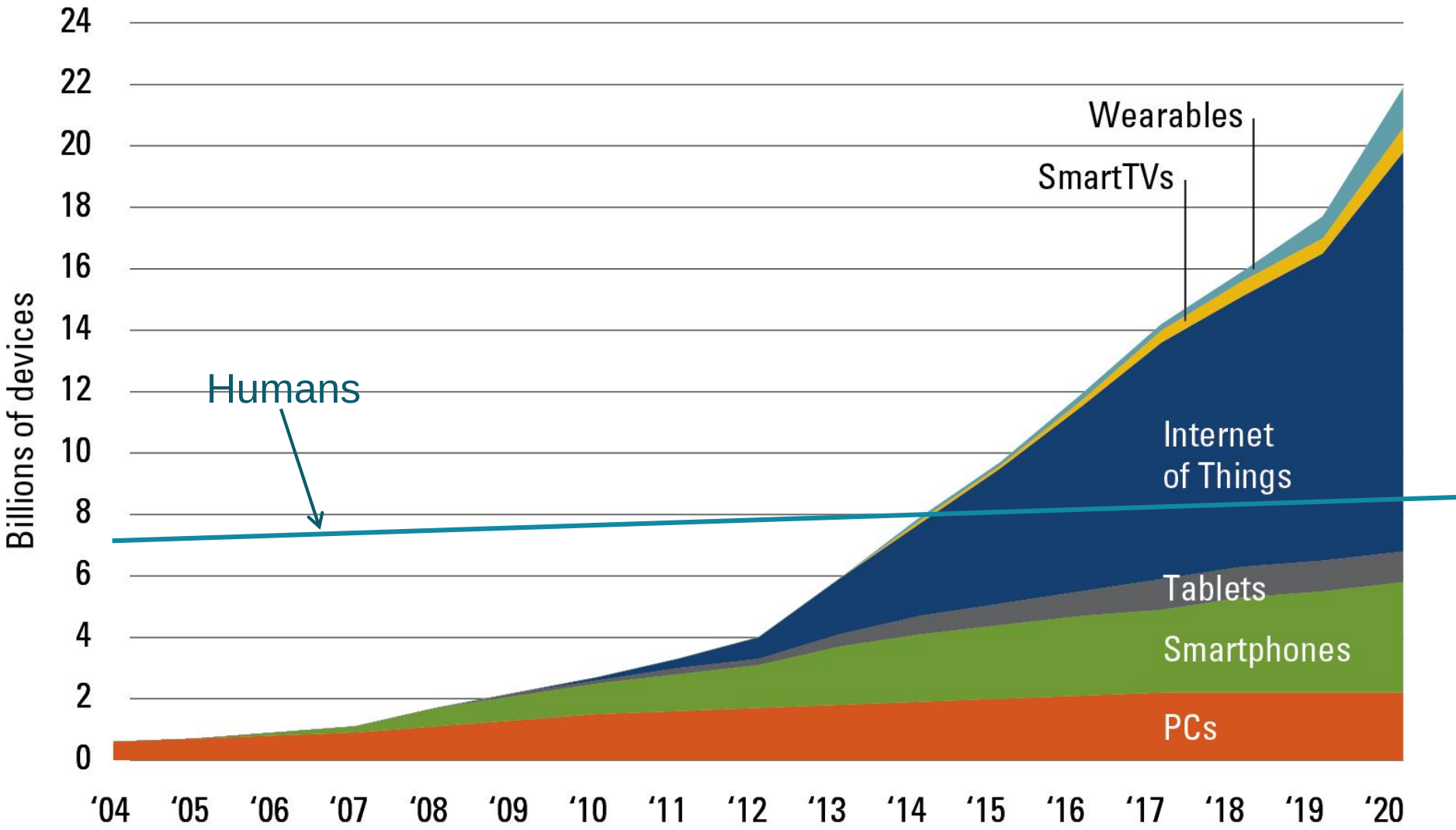
5/20/2016

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

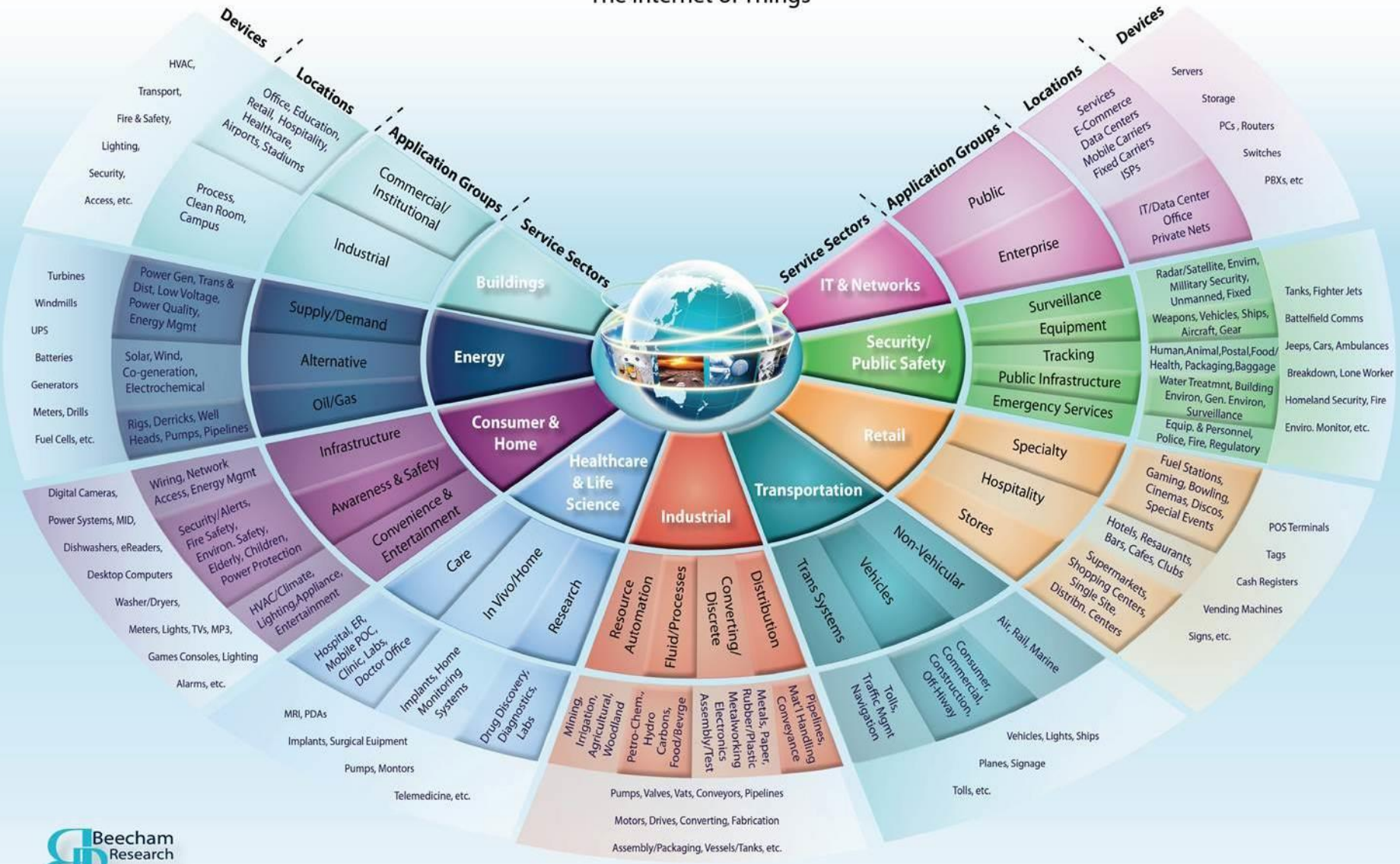
Connected Devices



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

M2M World of Connected Services

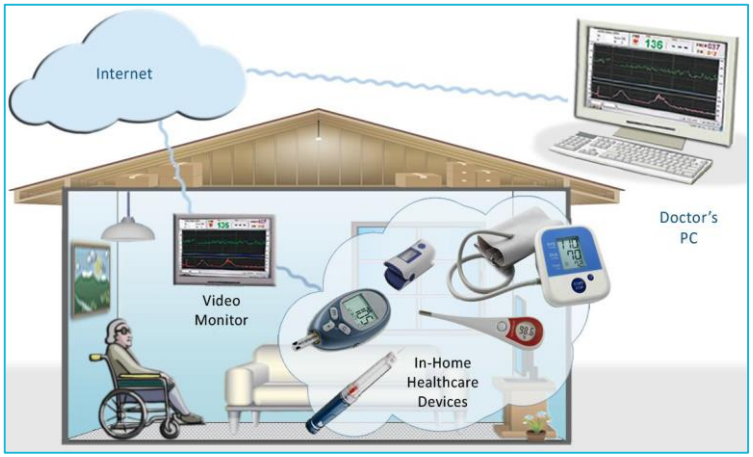
The Internet of Things



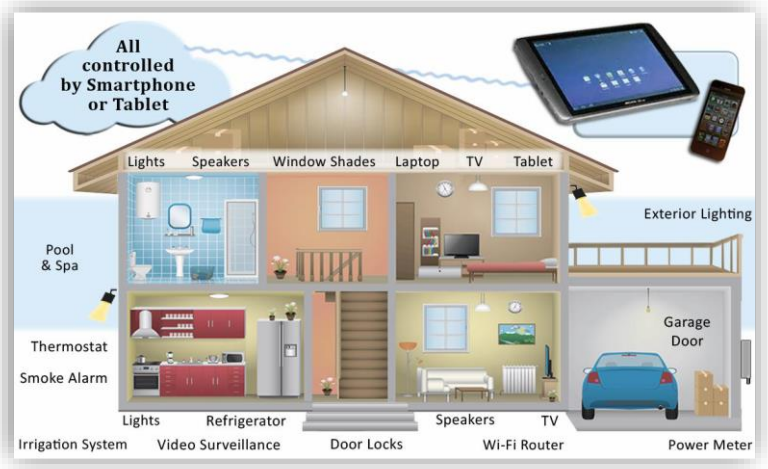
Beecham Research

IoT applications

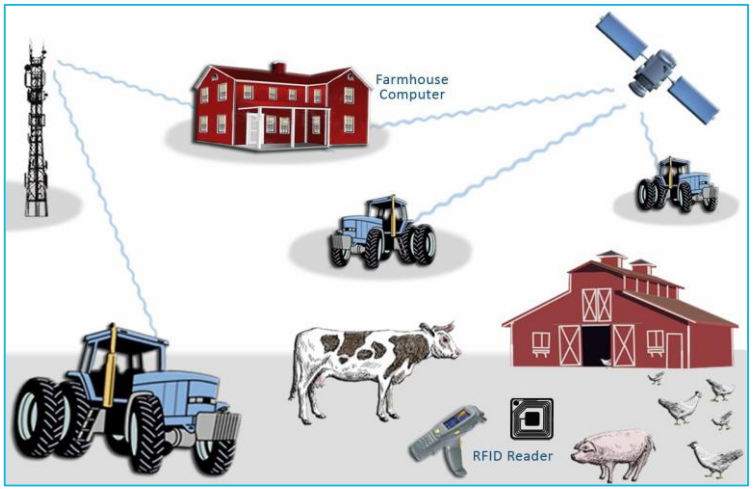
Health



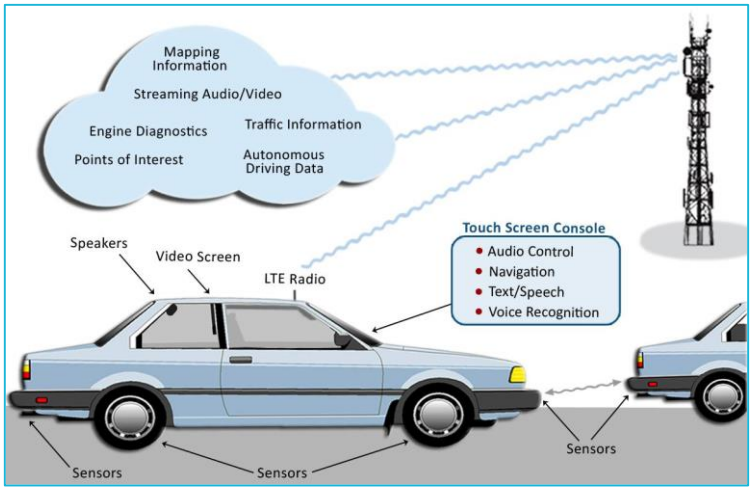
Home automation



Farming / Smart metering / …



Automotive



Source: Raymond James research

IoT – Integration of Technology

SOME OF THE DRIVERS

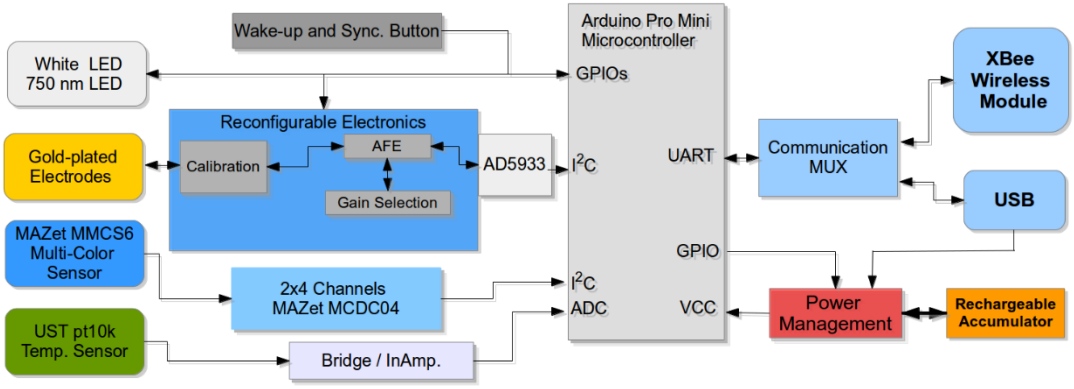
↓Cost

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	-13%

Source: Gartner, ARM Holdings, and Raymond James research.

↑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

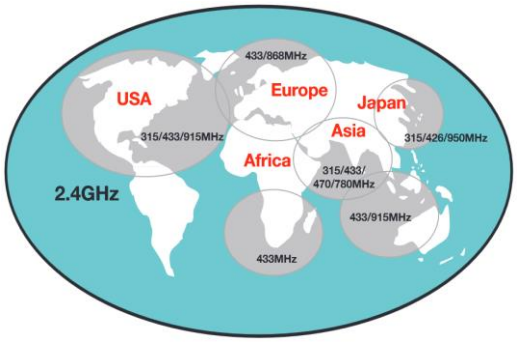
MCU, Wireless module Crystal, antenna, voltage regulators, balun, shielding, Passives, etc.

Source: Roku, Inc.

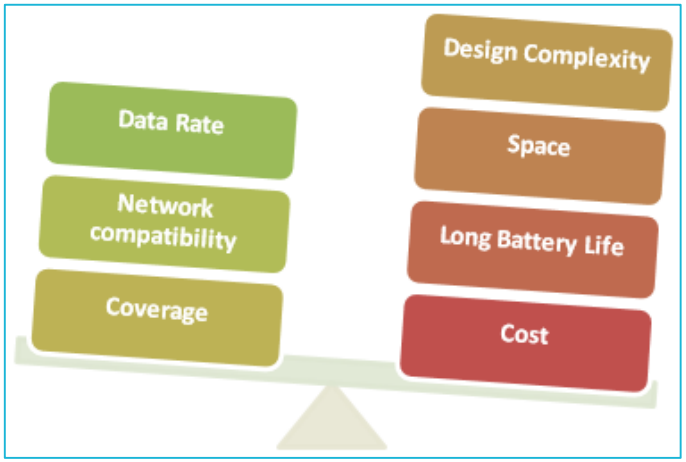
Final Product

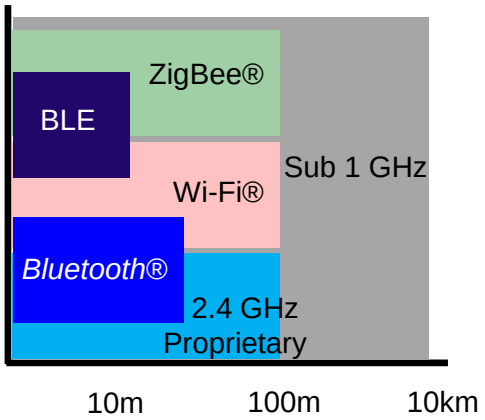
Choosing IoT connectivity technology

CONSIDERATIONS

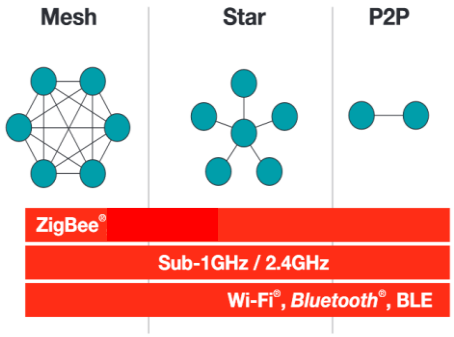


Frequency

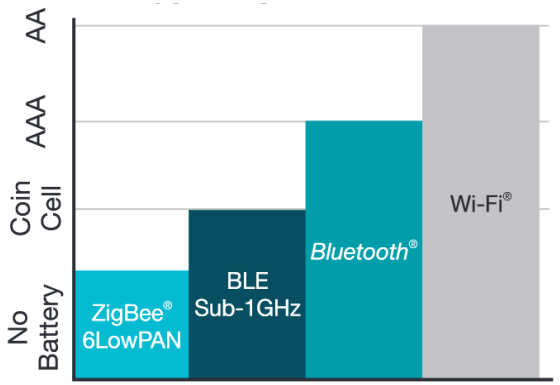




Range



Topology

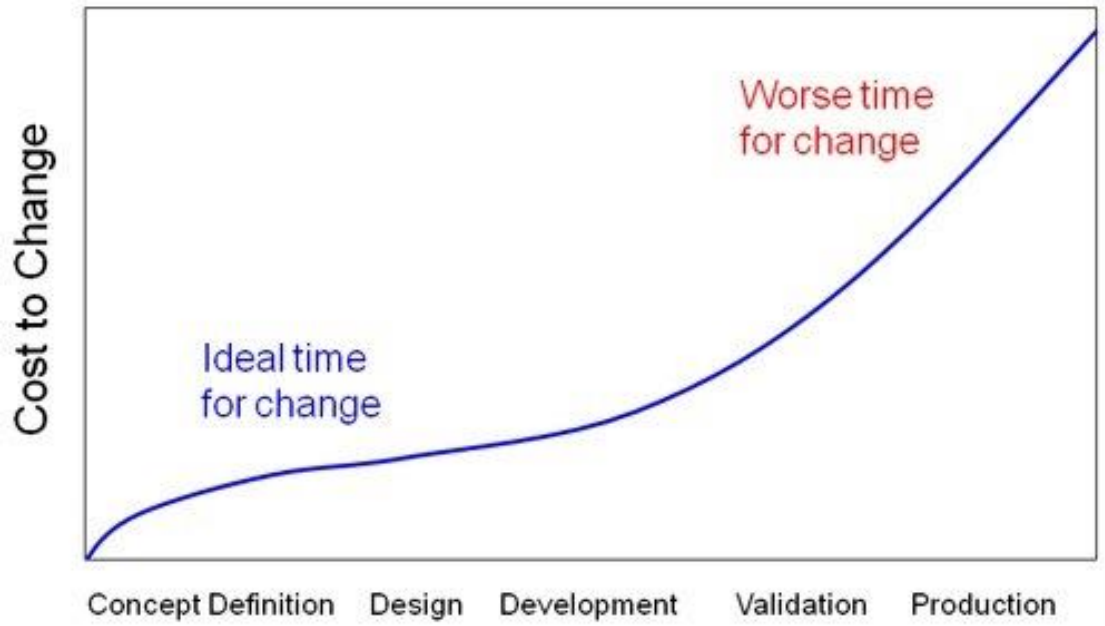


Power Source

IoT – Integrator of Things

DO WE REALLY NEED TO TEST PRE-CERTIFIED MODULES?

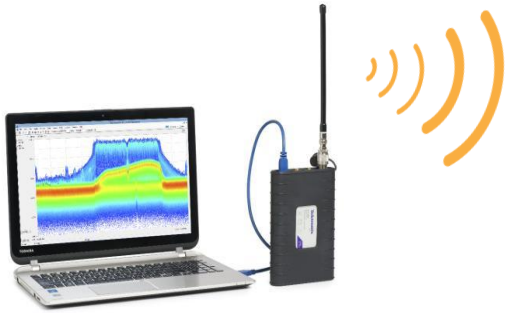
- Reference designs are ideal designs – not certified to work together!
- How good is “Pass”?: Marginal or Robust?
- EMI Compliance: only 1 in 10 engineers report passing the first time
  - Average compliance testing cost: $10k, not including delays, late redesign, etc.



EMI pre-compliance and wireless checks are easy and affordable!

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

1 *Record Signal environment with RSA306*



RSA306B USB Real – Time Spectrum Analyzer

2 *Play back recorded signal during IoT device design*

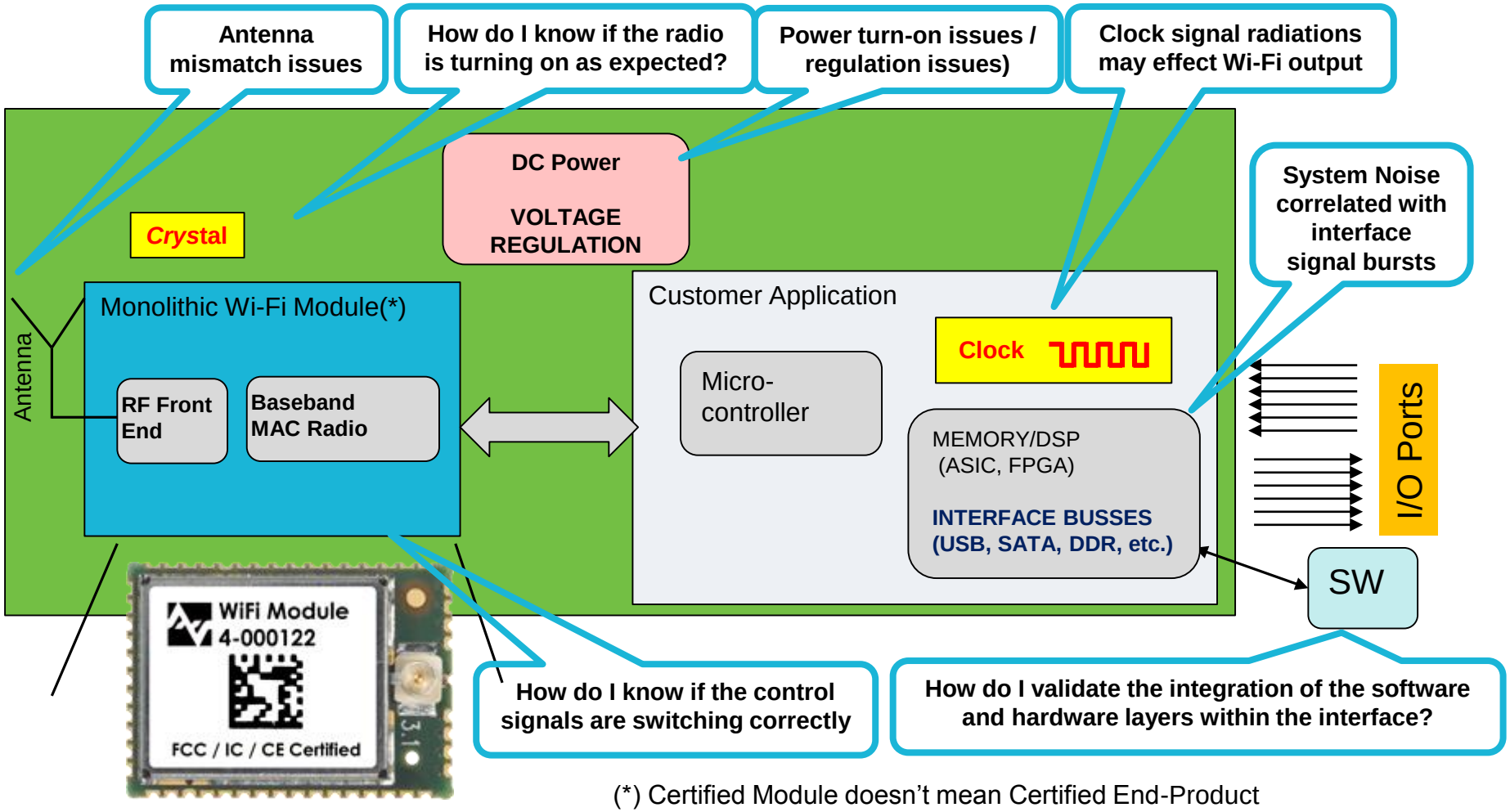
TSG 4100A
Signal Generator

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

Wondering if your IoT device is transmitting?

Use Tektronix RSA USB Spectrum Analyzer to:

- Verify your IoT device is transmitting
- Verify power level
- Verify frequency accuracy

- ❑ Cost from $3,890
- ❑ Frequency range 9kHz to 7.5 GHz
- ❑ IF bandwidth 40 MHz
- ❑ Uses real-time spectrum analysis
- ❑ Powered by USB cable
- ❑ Signal analysis software runs on PC
- ❑ Basic spectrum analysis functions
  - ✓ Numeric FFT spectrum
  - ✓ DPX real-time spectrum (*)
  - ✓ Spectrogram
  - ✓ Channel Power, ACPR, CCDF
  - ✓ Frequency mask violation detection
- ❑ Tracking Generator option
- ❑ Digital modulation options for analysis of wireless standard signals WLAN, BT, LTE, …

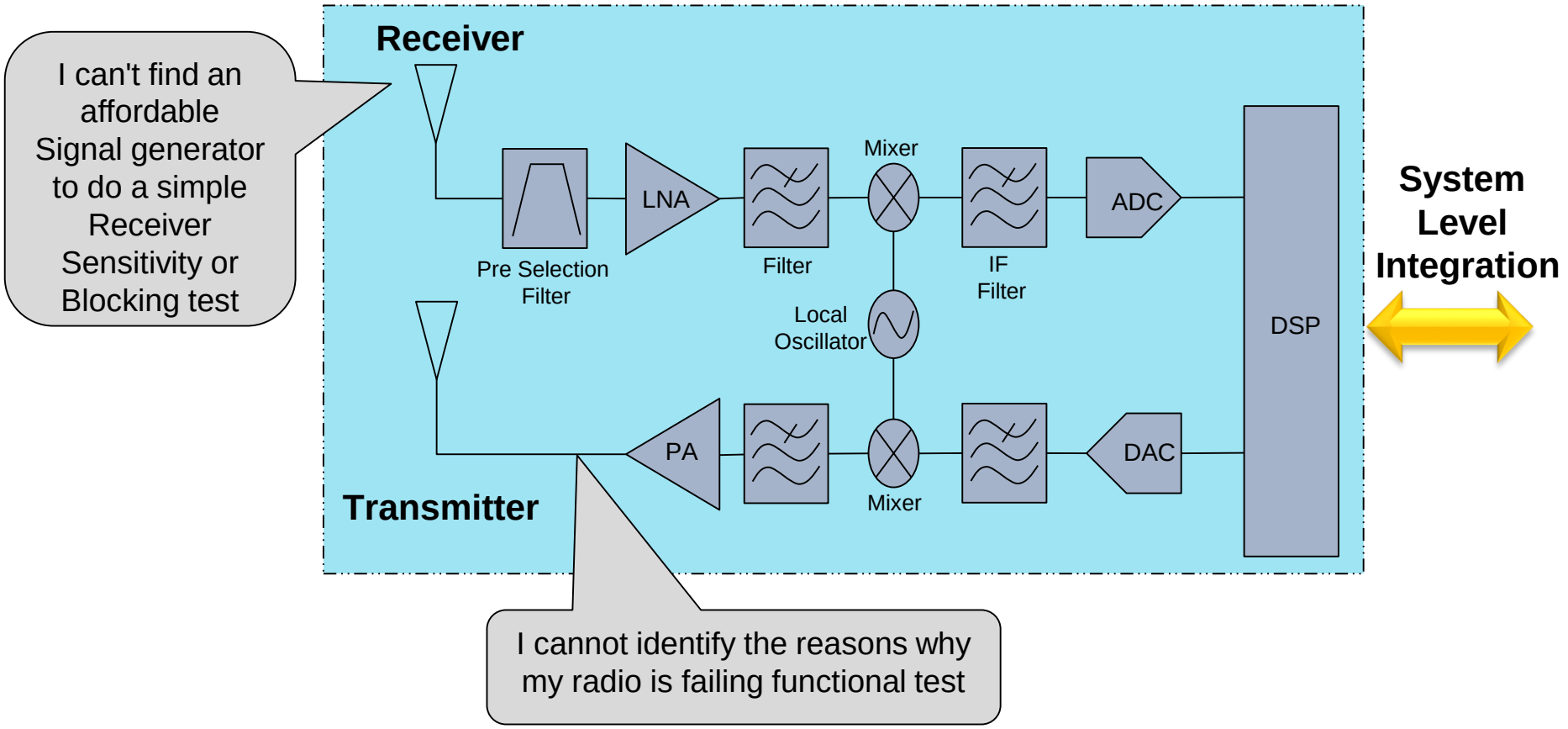
(*) Learn more about Real Time Spectrum Analysis on www.Tektronix.com/spectrum-analyzer

Want to see all digital/analog and RF signals in one instrument ?

MDO4000C Mixed Domain Oscilloscopes

- 6 *high performance* instruments in one portable package
- *Fast insights* with *reliable oscilloscope measurements*
- Completely *customizable* and fully *upgradeable*
- Simultaneous synchronized capture of time and frequency domains

Need RF receiver troubleshooting test solution?



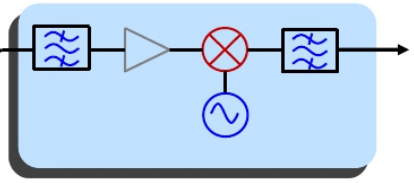
Example application – RF receiver sensitivity test

RF Signal Generator

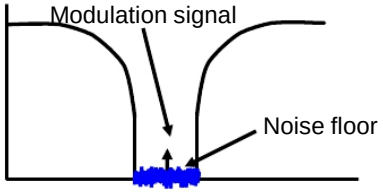
Tektronix TSG4k

ATT

Receiver DUT



IF signal



RF Spectrum Analyzer

Tektronix RSA306, RSA500, and RSA600

Tektronix MDO4k

VSA software SignalVu-PC

Tektronix TSG4k performances:

- Modulation Capability
- Amplitude range: **-110 ~ +16 dBm**
- Amplitude accuracy **< ±0.6 dB** (output level > -100dBm @ 10M Hz < Fc < 4 GHz)
- Amplitude resolution **0.01dBm**
- Very low noise floor

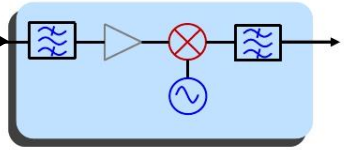
Example application – RF receiver blocking test

RF Signal Gen 1
(In-channel signal)

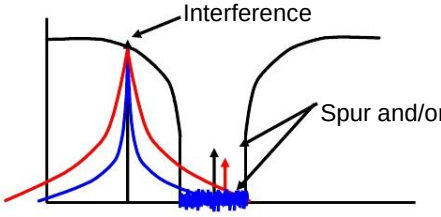
Tektronix TSG4k

ATT

Receiver DUT



IF signal



RF Signal Gen 2
(out of channel signal)

Tektronix TSG4k

RF Spectrum Analyzer

Tektronix RSA306, RSA500, and RSA600

Tektronix MDO4kC

VSA software SignalVu-PC

Tektronix TSG4k performance:

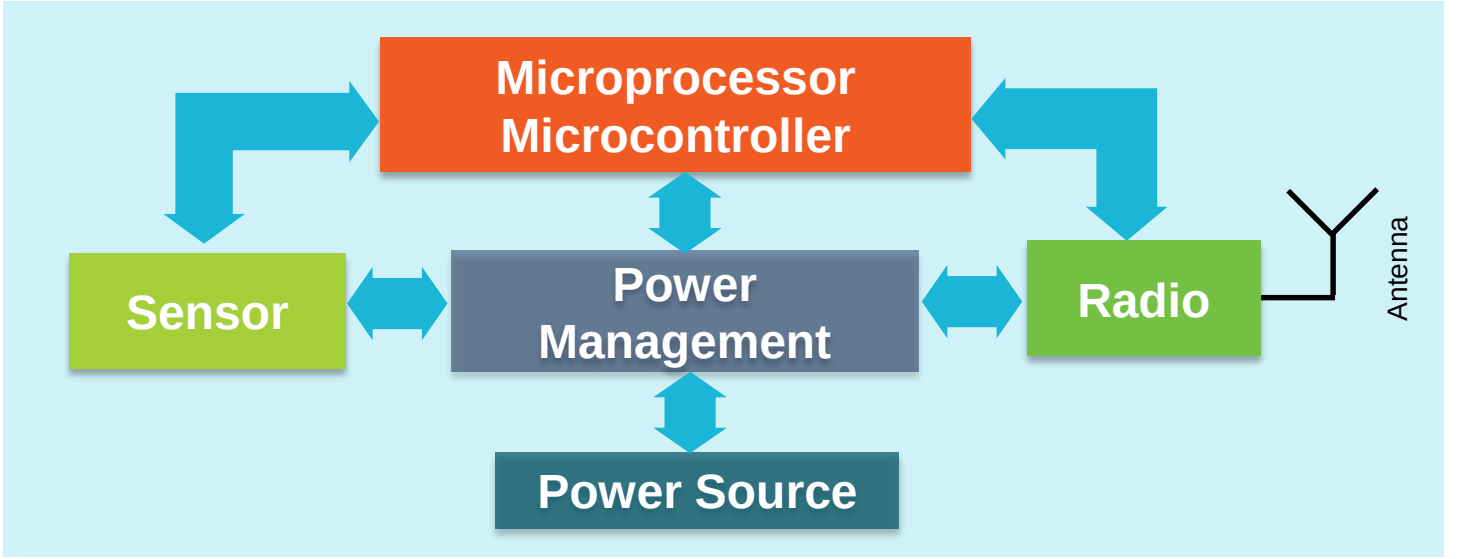
- Spur/non-harmonics performance : ***<-68dBc*** *@1GHz, >10K Hz offset*
- Outstanding phase noise : ***-113dBc/Hz*** *@ 1G Hz, 20K Hz offset*
- Very low noise floor

IoT Design and Test Challenge #3

Maximizing your device’s battery life

Architecture

IOT WIRELESS, PORTABLE DEVICE



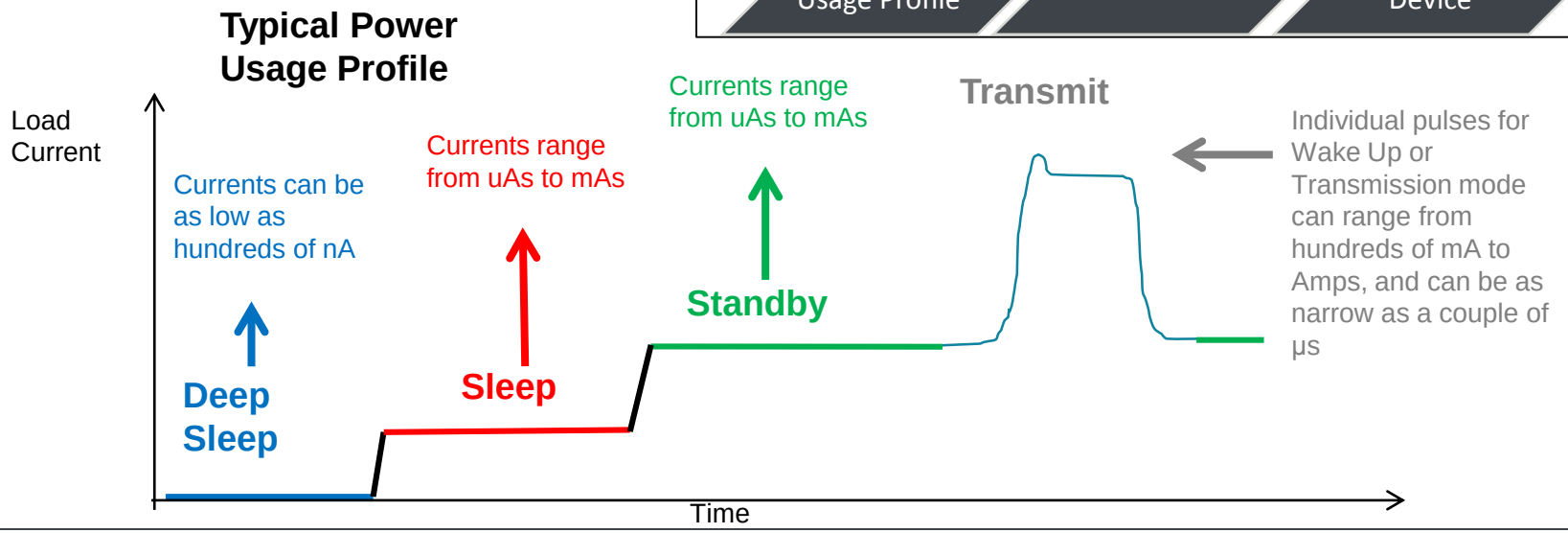
IoT device power consumption analysis

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?

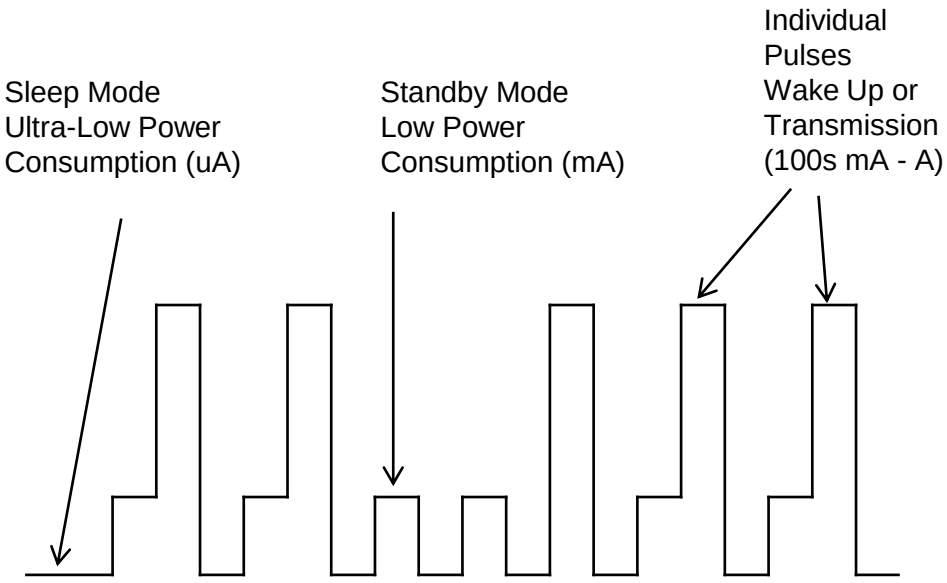
Realistic Power Usage Profile → Battery Life → Success IoT Device



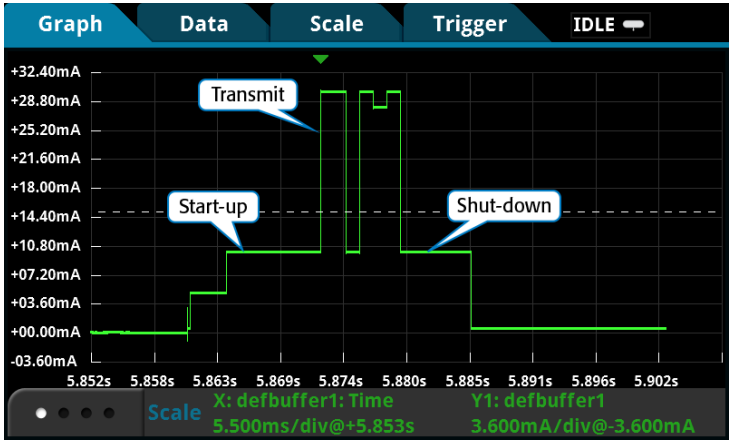
IoT power consumption analysis

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)



Keithley Low Power Solutions

Power Consumption Analysis

- Hi resolution 1MS/s current and voltage sampling with sensitivity and visualization to capture all device states
- Low Noise, quality constant voltage source

< $6k

Battery Modeling, Simulation + Power Consumption

- Create different battery model based on charging and discharging profile
- Dynamic battery simulation based on the model created to power the DUT
- Hi resolution 1MS/s current and voltage sampling with sensitivity and visualization to capture all device states

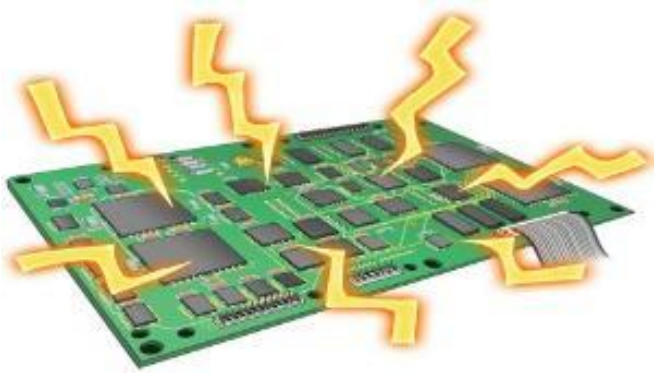
< $12k

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



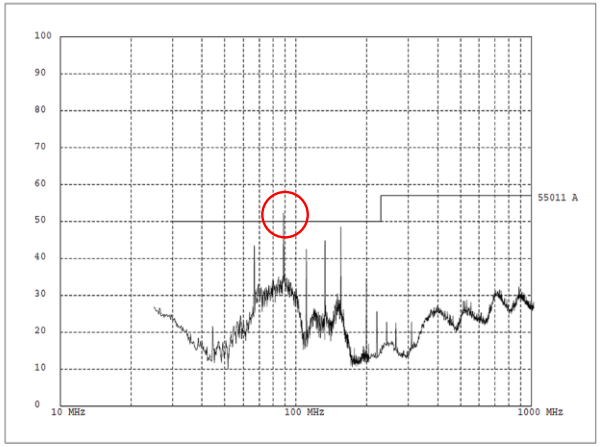
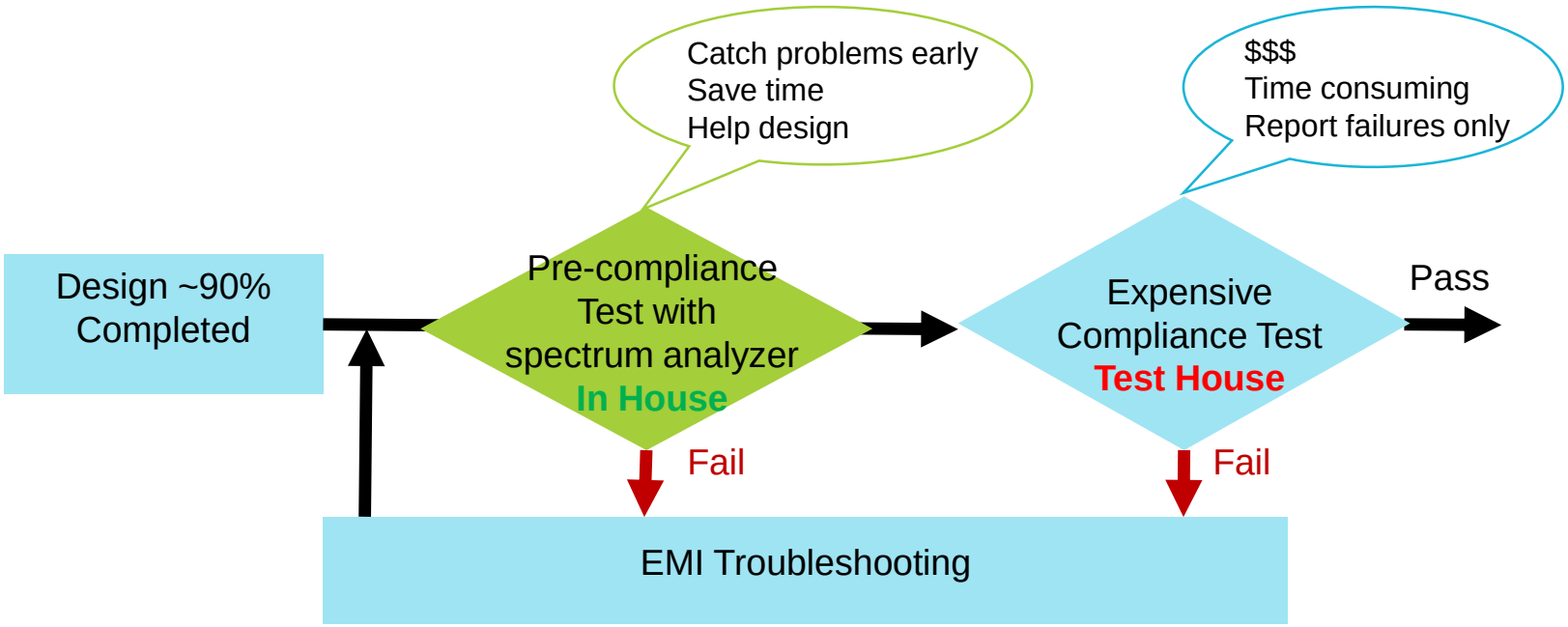


Figure 1. This EMI test report shows a failure at around 90 MHz.

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

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

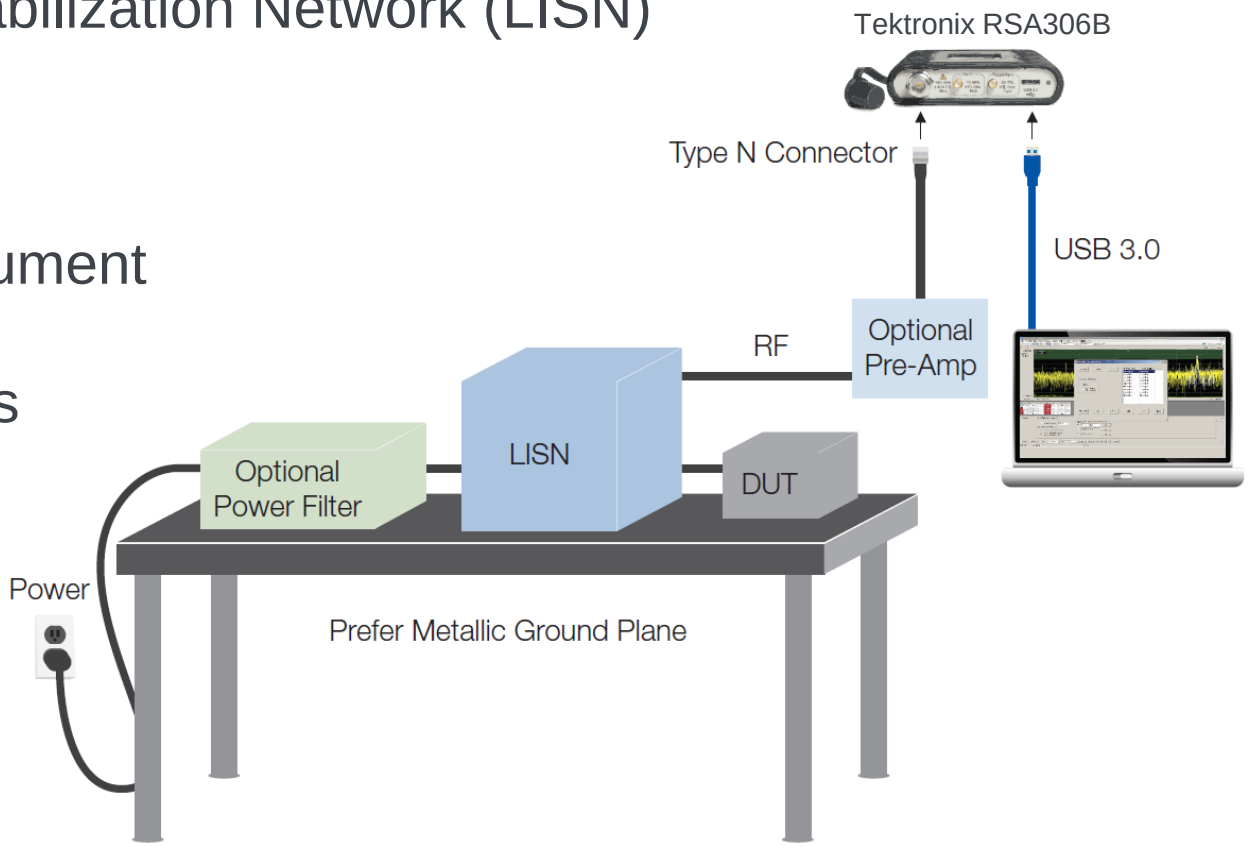
Table 1. Measurement Bandwidth versus Frequency specified by CISPR 16-1-1.

- ***For Pre-Compliance You Don't Have To Use A Special Receiver***
  - We are making an accurate approximation
  - Understand the compromises in the measurements

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

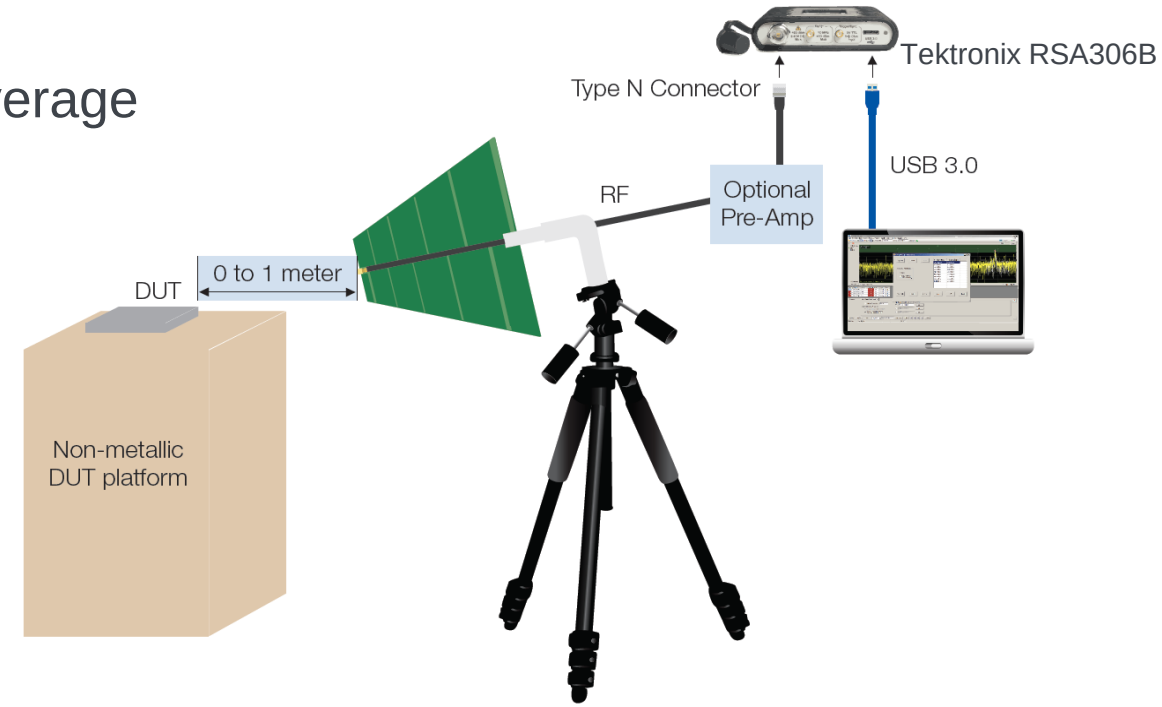


Setting Up A Pre-Compliance Test

RADIATED EMISSIONS >30 MHz

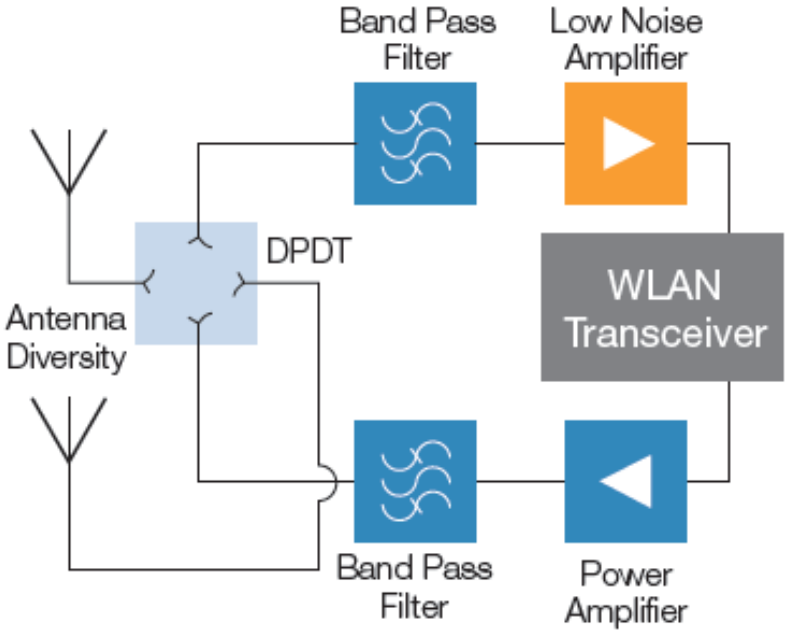
- Identify an area with natural RF shielding
  - Basements
  - Parking garages
- Watch out for DAS
  - Used to help cellular coverage

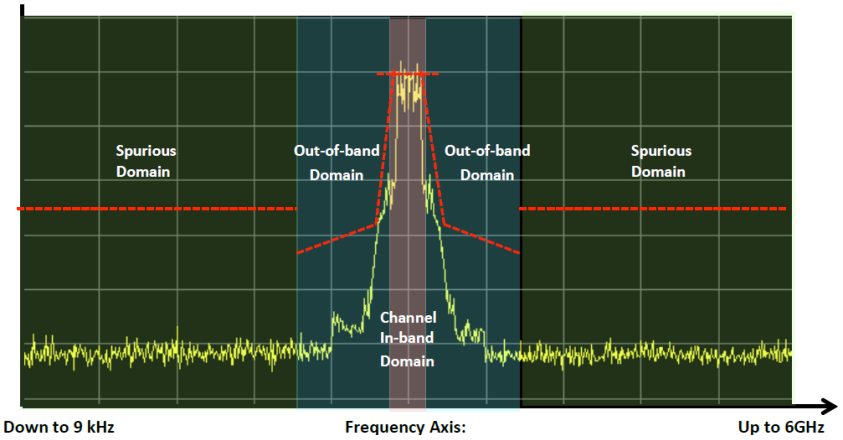
- Non metallic platform for DUT
- We need to look at 360 around DUT
- Tripod/pre-amp optional but recommended



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



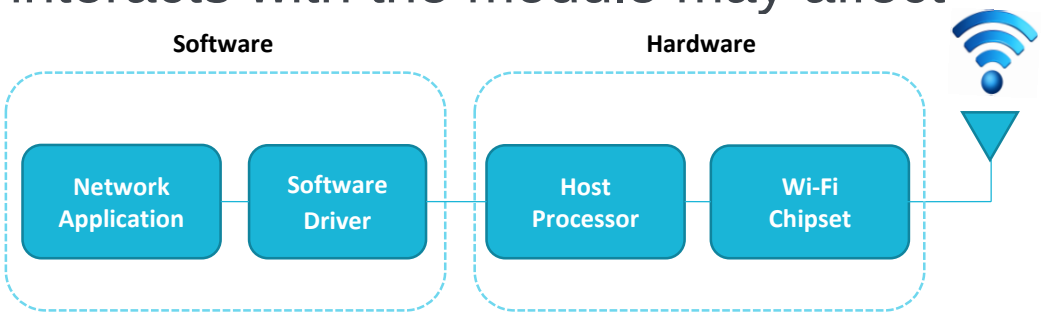


IoT Design and Test Challenge #5

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

Protocol compliance: WiFi case

- WiFi Alliance
- Industry agreed requirements
- Protocol conformance
  - Inter-operability
  - Security
  - Applications & services
- http://www.wi-fi.org/

Wi-Fi CERTIFIED™ is an internationally-recognized seal of approval for products indicating that they have met industry-agreed standards for interoperability, security, and a range of application specific protocols.

Wi-Fi CERTIFIED products have undergone rigorous testing by one of our independent Authorized Test Laboratories. When a product successfully passes testing, the manufacturer or vendor is granted the right to use the Wi-Fi CERTIFIED logo. Certification means that a product has been tested in numerous configurations with a diverse sampling of other devices to validate interoperability with other Wi-Fi CERTIFIED equipment operating in the same frequency band.

Using Tektronix's wireless standard pre-certification solution

SignalVu-PC VSA Software

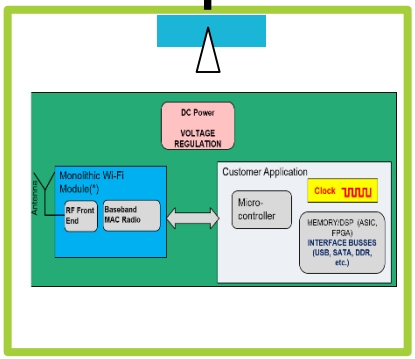
USB Spectrum Analyzer

Tektronix RSA306B

Tektronix RSA600A

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

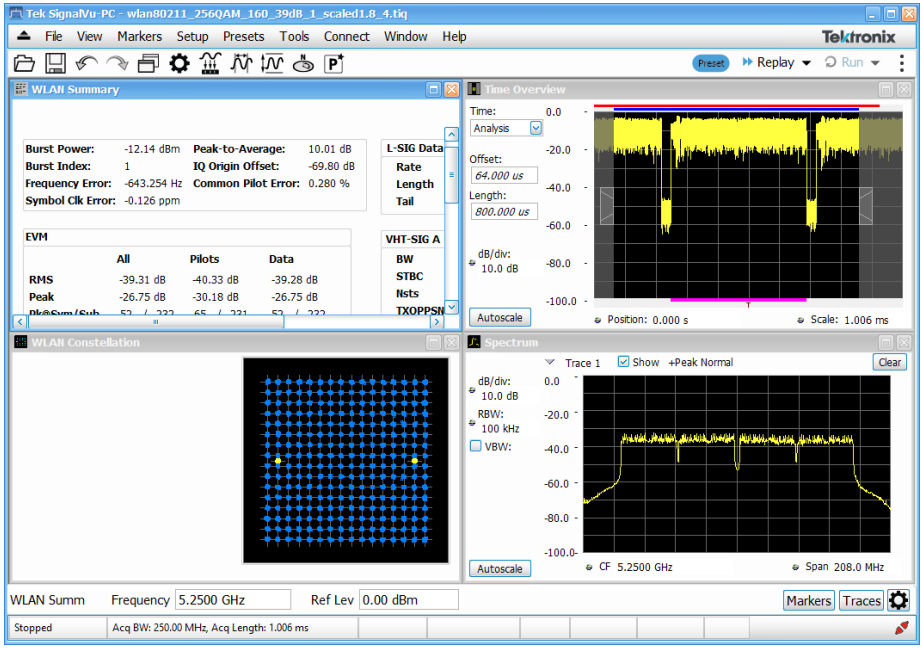
- **+ Digital modulation analysis for RFID, ZigBee, etc.**

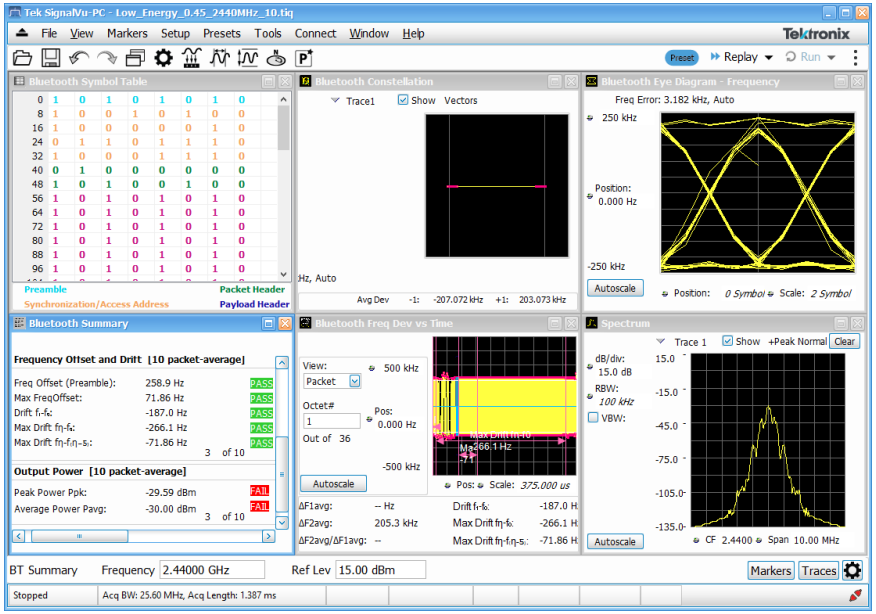


RF Isolation Box

Wireless transceiver pre-certification in SignalVu-PC

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

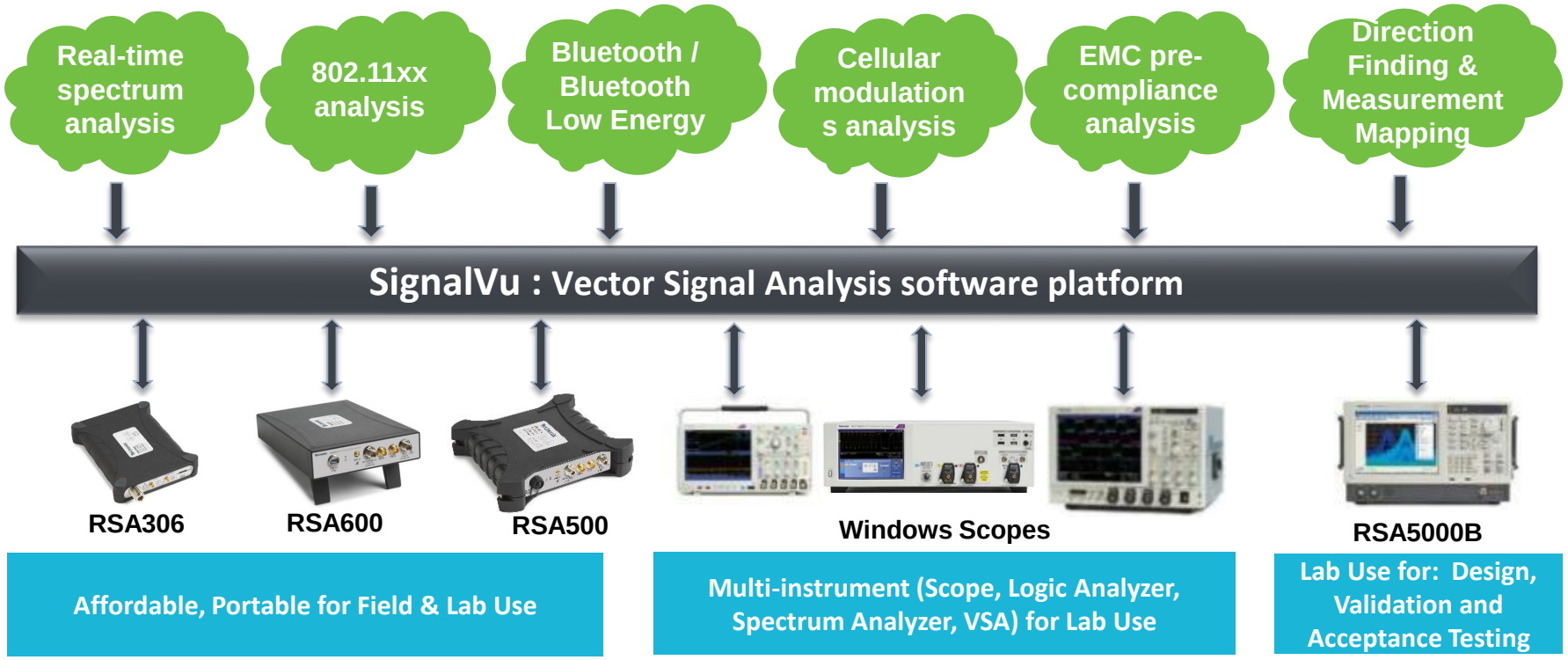




Bluetooth pre-certification Test (Low Energy, Basic Rate, and Enhanced Data Rate)

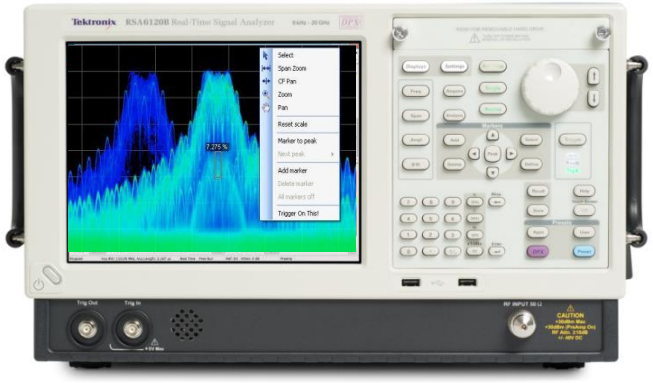
Tektronix RF Vector Signal Analysis software platform

- Single User Interface supporting all signal acquisition hardware (Benchtop or Portable)
- All setups and data remains on your PC
- ***Starting price from $3,890***



RSA5126B and RSA5115B Performance Real-Time Signal Analyzer

- High Performance Real Time Signal Analyzer with Mid-Performance Price
- Rich feature set to 26.5 GHz
- 165 MHz BW
- World's most advanced Real Time capabilities available
  - 29 to 312 X faster spectrum processing (than RSA306)
  - 10,000x better resolution in real time
- Advanced Triggering
  - Able to trigger on complex system interactions and brief transients in frequency domain
- Vector Signal Analyzer, Pulse Measurement Suite



Key Specifications for the RSA5126B:

Freq range: 1 Hz to 26.5 GHz

DANL @ 10 kHz: -129 dBm/Hz

DANL w/preamp @ 26 GHz: -155 dBm/Hz

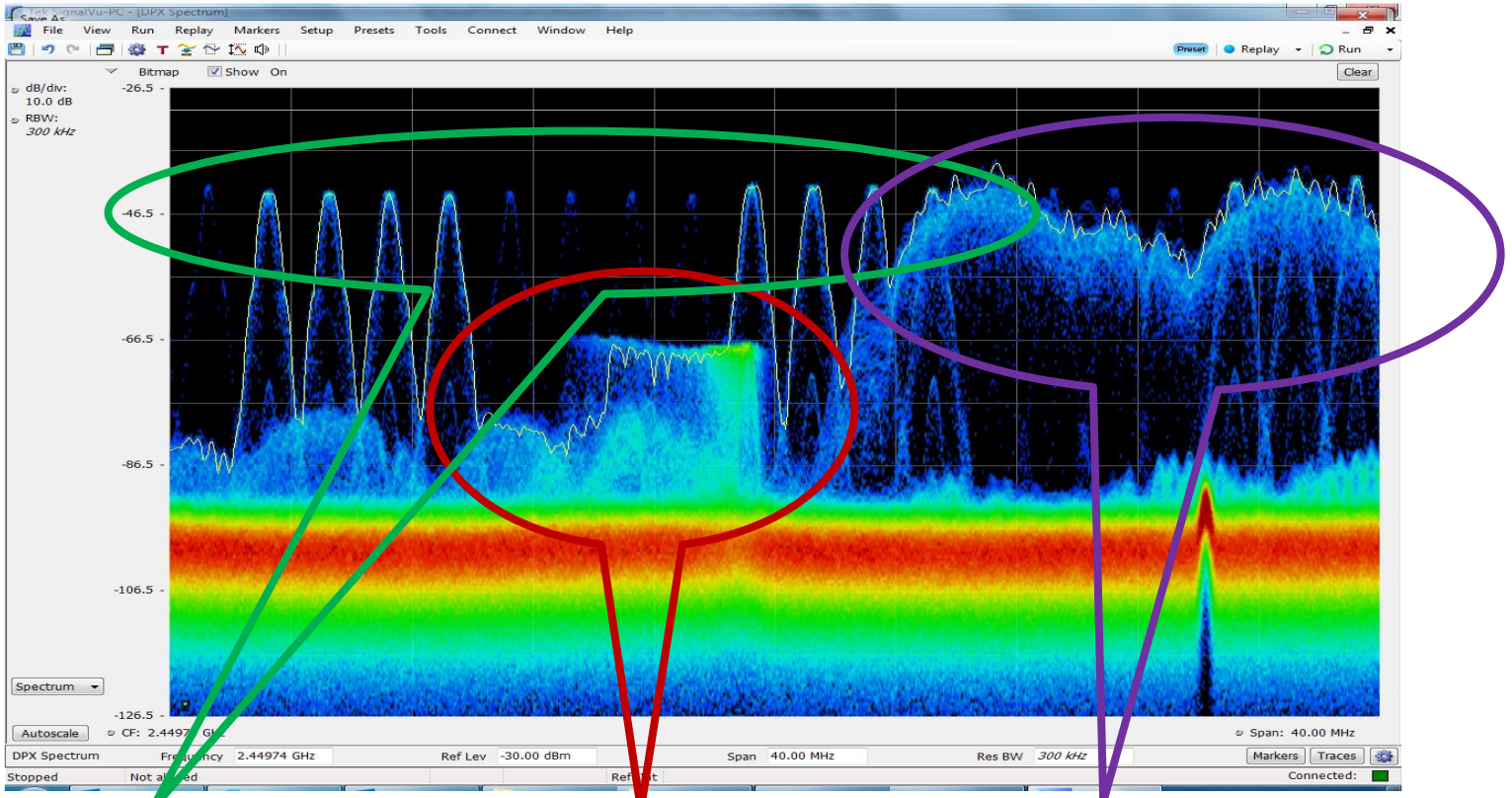
Phase noise @ 1 GHz: -113 dBc/Hz at 10 kHz

Bandwidth: up to 165 MHz

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

Tektronix RSA306B

Verify the noise level in your IoT device's frequency band
Light and high performance!
Fits in your pocket

Tektronix RSA500A

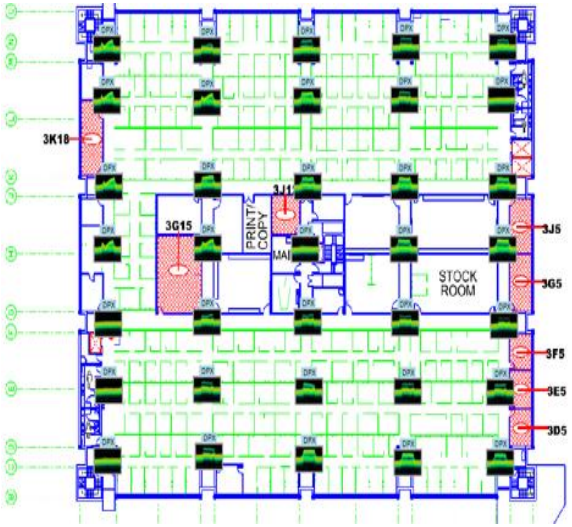
Solves your toughest interference problems and
Puts a 1 kg PC in your hands instead of a 3 kg spectrum analyzer

Deployment of long range low data rate IoT networks

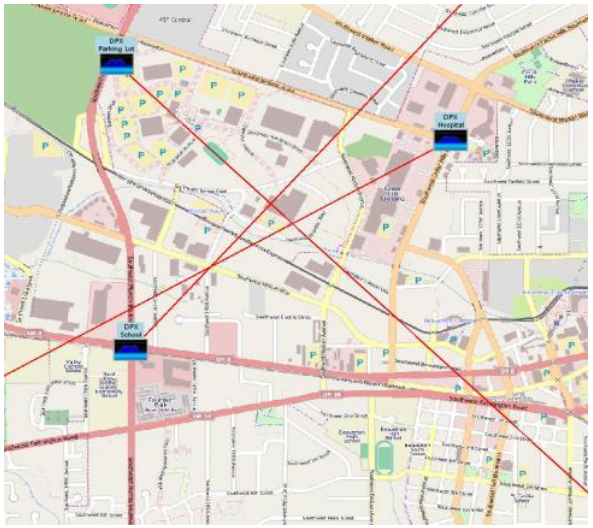
Long range low data rate IoT network operators require outdoor mapping of measurements in order to validate operation frequency bands

Use SignalVu-PC mapping Option to

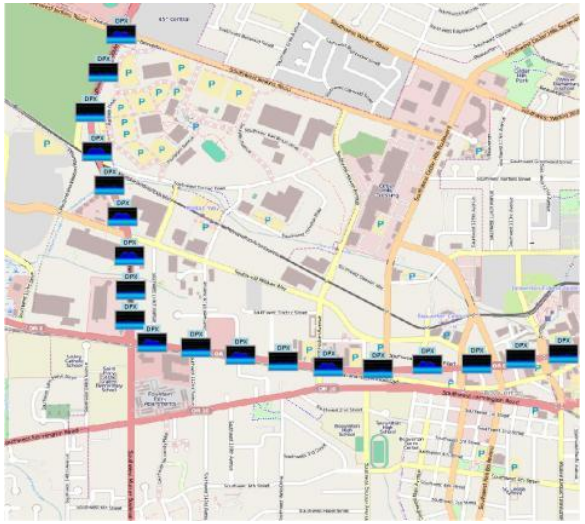
Hunt indoor interference



Locate transmitters



test signal quality/coverage



IoT – Instruments of Tektronix

PORTFOLIO SUMMARY

Signal Analyzers	
Mixed Domain Scope	MDO4000 series
Real-Time Spectrum Analyzer	RSA306, RSA500, RSA600
Vector Signal Analysis Software	SignalVu-PC
Wireless modulation analysis	Bluetooth, WiFi, Zigbee, etc.

Signal Generators	
RF Signal Generator	TSG4100 series

DC Power	
Graphical Sampling DMM	DMM7510
High Precision Power Supply	2280S

Right size your IoT device test budget without compromising performance

Tektronix solutions solve IoT test challenges

Challenges	Solutions
IoT product design – leveraging the many IoT system modules	Wide variety of wireless modules. Design your IoT device under real condition signals
Debug complex digital/analog/RF system problems	MDO4000 RSA306 / SignalVu-PC TSG4100
Maximizing your device's battery life	DMM7510 2280
Speeding your device through EMC compliance	RSA306 / SignalVu-PC Accessories
Speeding your device through Wireless certification	RSA306 / SignalVu-PC Bluetooth, Bluetooth LE, WLAN analysis
Preparing for IoT network deployment	RSA306 / SignalVu-PC

Thank you