



**LS RESEARCH**

WIRELESS PRODUCT DEVELOPMENT

# Are you Bluetooth Smart?

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## Presentation Overview –

- Technology overview
  - Comparing Bluetooth Low Energy with Classic Bluetooth
- Interoperability and smart phone support
- EMC Certification
- Q & A

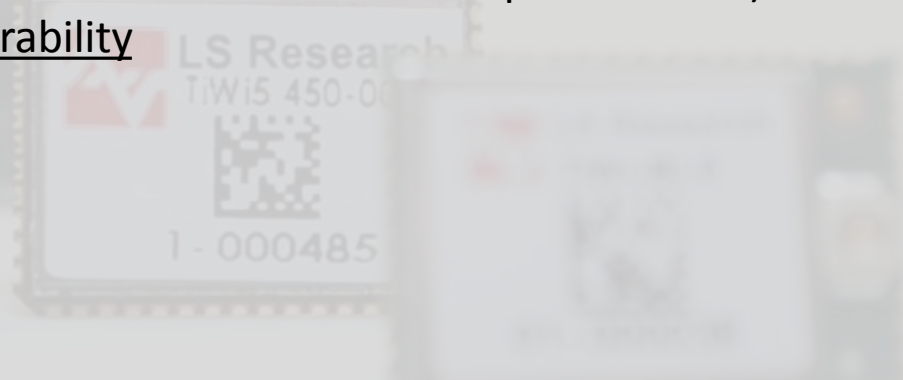


## Bluetooth Low Energy (BLE)

- **BLE is Not Really a Low Power Version of Bluetooth**
  - Active power consumption is similar to BT (for equal TX power)
  - Power saving is due to changes in the protocol
- BLE is Designed for Small Amounts of Data Transferred at a Low Duty Cycle.
  - Max data rate is 200Kbps
- Bluetooth Smart = BLE
- Bluetooth Smart Ready = Dual mode device that has BT & BLE
- BLE application profiles are based on GATT
  - General specification for sending attributes or short pieces of data
- Bluetooth shares the 2.4GHz ISM band with:
  - 802.11b/g/n Wi-Fi Systems
  - Cordless phones
  - ZigBee
  - Microwave ovens

## Why BLE?

- Adopted by health care, sports & fitness, security, home automation, and industrial markets.
- Optimized Wireless Protocol for power consumption
- Low peak, average and idle mode power consumption
- Low cost – no MFI required
- Multi-vendor interoperability
- Enhanced Range (better than classic BT at similar power levels)
- Phone / Tablet Interoperability



# Bluetooth Use Cases

## Stand-alone (sensor) devices



### Sports & fitness

- Heart rate belt
- Foot pod

### Healthcare

- Blood pressure meter
- Glucose meter

### Home & entertainment

- Remote control
- Home sensor

### Mobile & office accessories

- Mobile keyboard
- Identification systems

### Automotive

- Tyre pressure monitor
- Parking assistant

### Watch/wrist wearable device

- Call remote mgmt
- Out of range alert

## Dual-mode host devices



## Web & tele services

Weigh loss and fitness coaching

Adventure sports team room

Telehealth services

Elderly monitoring service

Gaming community

Car repair service

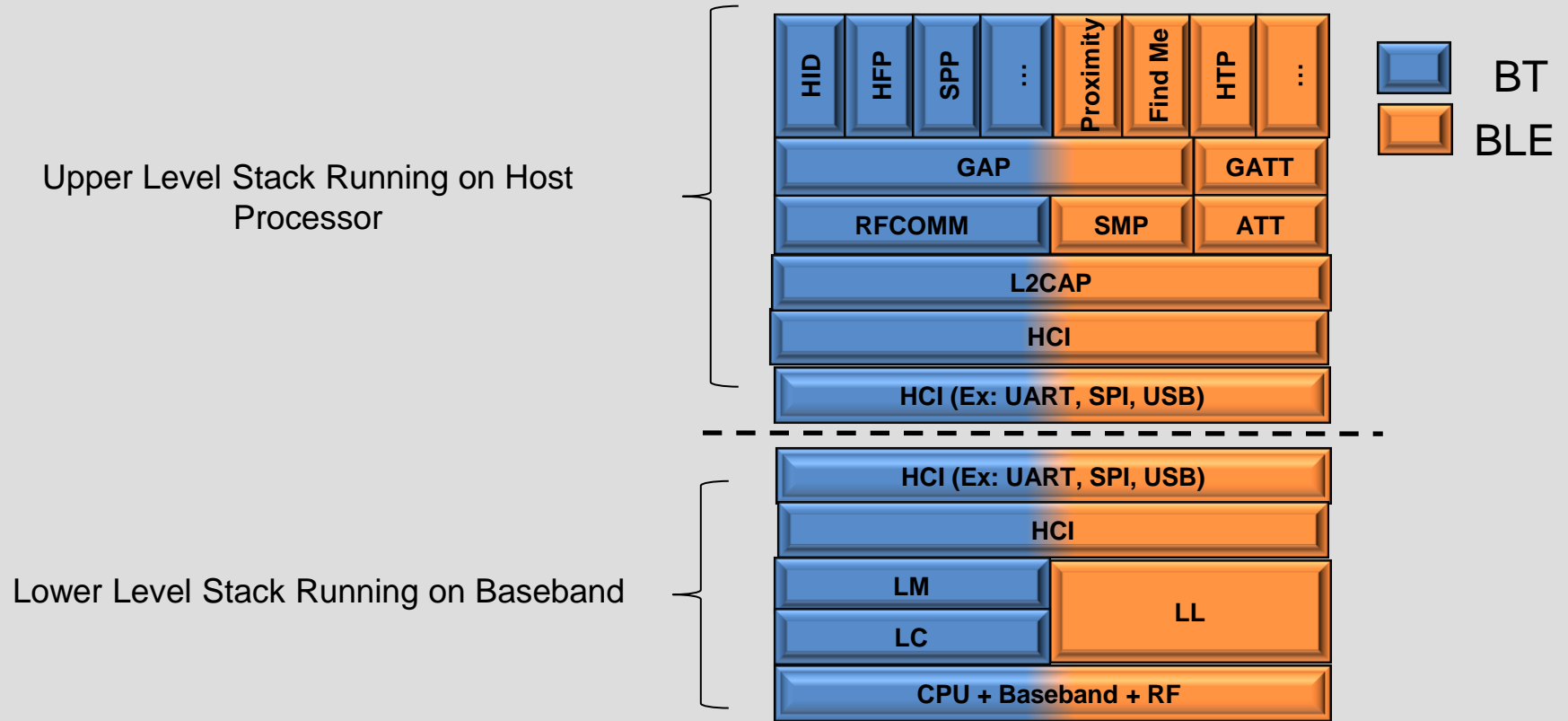
Tracking service

# Bluetooth Classic & BLE Compared



Technical Specification	Classic <i>Bluetooth</i> technology	<i>Bluetooth</i> low energy technology
Radio frequency	2.4 GHz	2.4 GHz
Distance/Range	10 meters	50 meters
Over the air data rate	1 - 3 Mbps	1 Mbps
Application throughput	0.7 - 2.1 Mbps	0.2 Mbps
Nodes/Active slaves	7	Unlimited
Security	64b/128b and application layer user defined	128b AES and application layer user defined
Robustness	Adaptive fast frequency hopping, FEC, fast ACK	Adaptive fast frequency hopping
Latency (from a non connected state)		
Total time to send data (det. battery life)	100 ms	<3 ms
Government regulation	Worldwide	Worldwide
Certification body	Bluetooth SIG	Bluetooth SIG
Voice capable	Yes	No
Network topology	Scatternet	Star-bus
Power consumption	1 as the reference	0.01 to 0.5 (depending on use case)
Peak current consumption	<30 mA	<15 mA (max 15 mA to run on coin cell battery)
Service discovery	Yes	Yes
Profile concept	Yes	Yes
Primary use cases	Mobile phones, gaming, headsets, stereo audio streaming, automotive, PCs, etc.	Mobile phones, gaming, PCs, watches, sports & fitness, healthcare, automotive, Home electronics, automation, industrial, etc.

# Bluetooth 4.0 Software Architecture



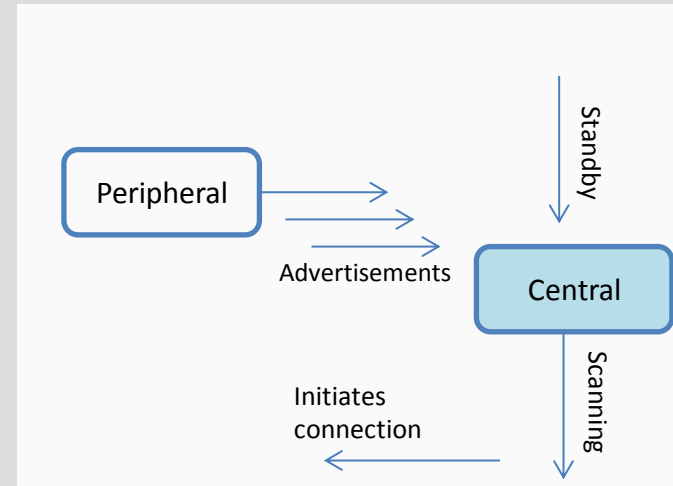
# Bluetooth Secure Simple Pairing

## History of BT and Pairing

- BT 2.0 and Prior, security depended on a PIN Code (often 0000)
- BT 2.1 Added Secure Simple Pairing
- Near field communication is being used for OOB Pairing
- Android has support for the NFC data exchange format (NDEF)
- BLE does not require pairing. If you need encrypted link then you need to pair.

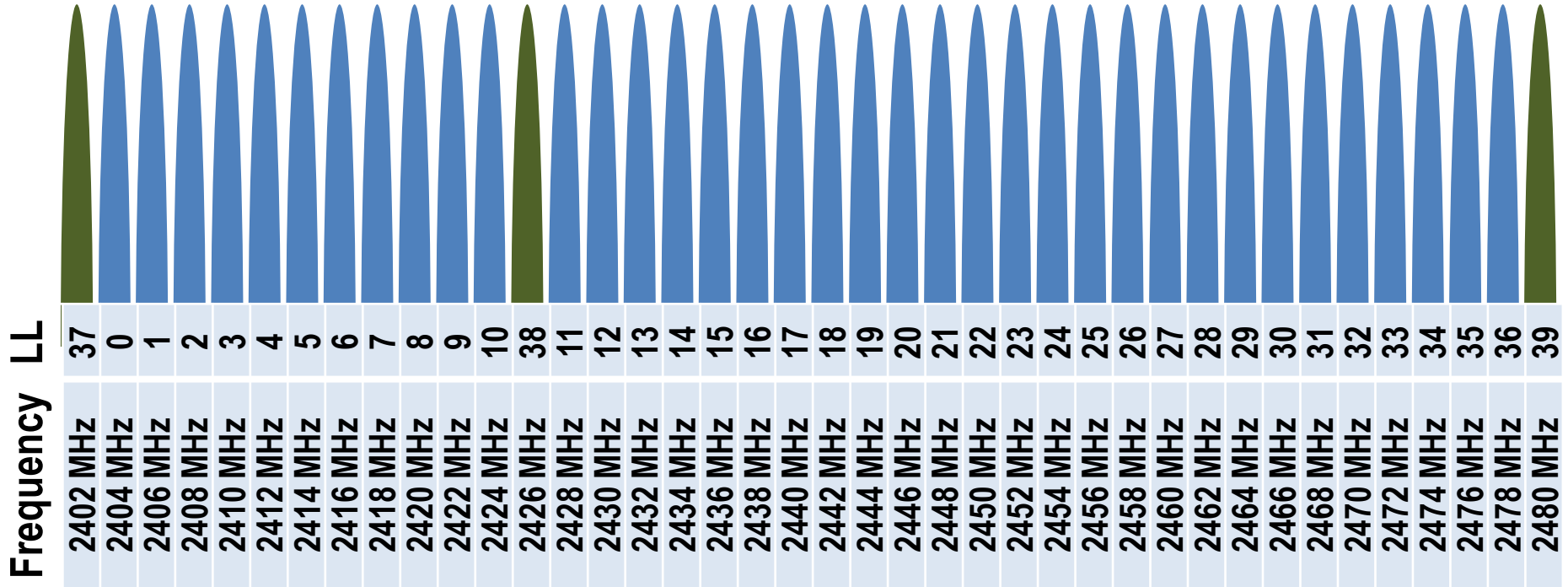
## Bluetooth Low Energy (BLE)

- Advertising is Typically at a Very Low Duty Cycle
- Can send information without being “paired”
- If pairing is required the peripheral will prompt for authentication (white listing is available)
- Connection interval is variable



State		State Description
Standby		Does not transmit or receive packets
Advertising		Broadcasts advertisements in advertising channels
Scanning		Looks for advertisers
Initiating		Initiates connection to advertiser
Connection	Master Role	Communicates with device in the Slave role, defines timings of transmissions
	Slave Role	Communicates with single device in Master Role

3 Advertising Channels and 37 Data Channels = much faster connection time



## Integration – Key Data Points

### Integrating BLE (TI CC254x)

- **Hardware Requirements**
  - Integrated stack / no external MCU
  - Network processor mode / external MCU
- **Software Integration**
  - Stack runs inside chip (Module)
  - Can run as stand alone module w/ most applications
  - Can be used in network processor mode, minimal host MCU required

### Integrating Classic Bluetooth (TI CC256x):

- **Hardware Requirements**
  - Host Processor with 75 kB Available Flash and 8 kB RAM
  - UART with RTS / CTS
  - 1.8 V I/O Interface (1.62 to 1.92 V)
  - 32.768 kHz Clock
- **Software Integration**
  - OS or Scheduler
  - Processor and Toolset
  - Which Profiles
  - Packet / Message Based Application Interface

## BLE Commands—

- GetLocalAddress Command - Returns Bluetooth address of module
  - Help - Returns list of all menu commands (main menu)
  - SetDiscoverabilityMode - 0-not discoverable, 1-limited discovery, 2-discoverable
  - SetConnectabilityMode - 0-connectable, 1-not connectable
  - SetPairabilityMode - Sets module to no I/O pairing with MITM=true
  - ChangePairingParameters - 0-display only, 1-display toggle, 2-keyboard only, 3-no I/O, 4- display&keyboard ; MITM requ 0-no, 1-yes
  - AdvertiseLE - Allow GAP LE Advertising
  - StartScanning - Returns all advertised GAP LE BT info
  - StopScanning - Stops scanning process
  - ConnectLE - Makes a connection to BT LE device of address in the command
  - DisconnectLE - Disconnects connection with connected device
  - PairLE - Pairs devices and returns pairing information
  - LEPasskeyResponse - Returns test string/shows read verification
  - QueryEncryptionMode - Returns current encryption mode: Enabled/Disabled
  - SetPasskey - Sets/Clears passkey information Returns test string/shows read verification
  - Send - Send data to connected device Send[bytes] verify bytes
  - Read - Read bytes sent by connected device Read returns correct number of bytes
  - Loopback - Returns/sets current Loopback mode
  - DisplayRawModeData - Returns/sets current RawModeData mode
  - AutomaticReadMode - Returns/sets current AutomaticReadMode mode
- 
- With BLE data transfer is based on GATT profiles
    - Custom profiles are easy to define

## Bluetooth Traditional Profiles -

- Generic Access (GAP)
  - Serial Port (SPP)
  - Dial-up Network (DUN)
  - FAX
  - Generic Object Exchange (GOEP)
  - File Transfer (FTP)
  - Object Push (OPP)
  - Basic Imaging (BIP)
  - Basic Printing (BPP)
  - Hard-copy Cable Replacement (HCRP)
  - Device ID (DID)
  - Health Device (HDP)
  - Personal Area Networking (PAN)
  - Human Interface Device (HID)
  - SIM Access (SAP)
  - Phonebook Access (PBAP)
  - Message Access (MAP)
  - Headset (HDS)
  - Handsfree (HFR)
  - Generic A/V Distribution (GAVD)
  - Advanced Audio Distribution (A2DP)
  - A/V Remote Control (AVRCP)
  - Video Distribution (VDP)
- 
- For classic Bluetooth communication data is transferred using a standard profile

## Smart Phone Support

- iOS Support Bluetooth Smart and Bluetooth Classic
- Android Supports Bluetooth Smart NOW!
- LS Research App Development

## iOS BT Support

- iOS natively supports only these BT profiles
  - Hands-Free Profile (HFP 1.5)
  - Phone Book Access Profile (PBAP)
  - Advanced Audio Distribution Profile (A2DP)
  - Audio/Video Remote Control Profile (AVCRP)
  - Personal Area Network Profile (PAN)
  - Human Interface Profile (HID)
  - Message Access Profile (MAP)
- Other BT profiles require MFi authentication
  - Company must be an MFi licensee
  - MFi authentication chip is added to the product
  - Even Serial Port Profile (SPP) requires MFi
  - Devices that don't authenticate are disconnected



## iOS BLE Support

- BLE does not require Mfi authentication
- BLE software support in iOS 5.0 and above
- BLE hardware support
  - iPhone 4S and above
  - iPod Touch (5<sup>th</sup> Generation) and above
  - iPad (3<sup>rd</sup> Generation) and above & mini
- iOS supports central and peripheral modes



# Android BT Support

- **BT Classic is supported on Android**
  - Additional Authentication is Not Required
  - Consistent API Across Platforms
- **Supported Profiles**
  - Headset Profile (HSP)
  - Hands Free Profile (HFP 1.5)
  - Advanced Audio Distribution Profile (A2DP)
  - Health Device Profile (HDP)
  - SPP is Supported in Most Devices



## Android BLE Support

- Software support in Android v4.3 (API Level 18)
- Android supports the central role
- Vendor specific BLE implementations
  - Samsung (Galaxy devices with Android 4.2)
  - HTC (HTC One X+, Droid DNA and HTC One)



# Mobile App Design & Development

- Add a powerful device to the system
  - Screen
  - Inputs (Text, Sound, Image, Touch)
  - Location and other sensors
  - Connectivity
- Cost and complexity flexibility
- Additional channel for user support and feedback
- Analytics and intelligence
- BLE is a low data transfer technology



**NEW**

## APP DEVELOPMENT

- iOS and Android Application Development
- Development platforms and experience in getting Apps on App Store
- App Designers Experienced with BLE
- On-Site Graphical User Interface and Industrial Design Team



UNITED  
STATES  
FREQUENCY  
ALLOCATIONS

THE RADIO SPECTRUM



Frequency Range	Allocation
1.6 - 1.7 MHz	FEDERAL GOVERNMENT
1.7 - 1.8 MHz	COMMERCIAL
1.8 - 1.9 MHz	INDIVIDUAL
1.9 - 2.0 MHz	OTHER
2.0 - 2.1 MHz	FEDERAL GOVERNMENT
2.1 - 2.2 MHz	COMMERCIAL
2.2 - 2.3 MHz	INDIVIDUAL
2.3 - 2.4 MHz	OTHER
2.4 - 2.5 MHz	FEDERAL GOVERNMENT
2.5 - 2.6 MHz	COMMERCIAL
2.6 - 2.7 MHz	INDIVIDUAL
2.7 - 2.8 MHz	OTHER
2.8 - 2.9 MHz	FEDERAL GOVERNMENT
2.9 - 3.0 MHz	COMMERCIAL
3.0 - 3.1 MHz	INDIVIDUAL
3.1 - 3.2 MHz	OTHER
3.2 - 3.3 MHz	FEDERAL GOVERNMENT
3.3 - 3.4 MHz	COMMERCIAL
3.4 - 3.5 MHz	INDIVIDUAL
3.5 - 3.6 MHz	OTHER
3.6 - 3.7 MHz	FEDERAL GOVERNMENT
3.7 - 3.8 MHz	COMMERCIAL
3.8 - 3.9 MHz	INDIVIDUAL
3.9 - 4.0 MHz	OTHER
4.0 - 4.1 MHz	FEDERAL GOVERNMENT
4.1 - 4.2 MHz	COMMERCIAL
4.2 - 4.3 MHz	INDIVIDUAL
4.3 - 4.4 MHz	OTHER
4.4 - 4.5 MHz	FEDERAL GOVERNMENT
4.5 - 4.6 MHz	COMMERCIAL
4.6 - 4.7 MHz	INDIVIDUAL
4.7 - 4.8 MHz	OTHER
4.8 - 4.9 MHz	FEDERAL GOVERNMENT
4.9 - 5.0 MHz	COMMERCIAL
5.0 - 5.1 MHz	INDIVIDUAL
5.1 - 5.2 MHz	OTHER
5.2 - 5.3 MHz	FEDERAL GOVERNMENT
5.3 - 5.4 MHz	COMMERCIAL
5.4 - 5.5 MHz	INDIVIDUAL
5.5 - 5.6 MHz	OTHER
5.6 - 5.7 MHz	FEDERAL GOVERNMENT
5.7 - 5.8 MHz	COMMERCIAL
5.8 - 5.9 MHz	INDIVIDUAL
5.9 - 6.0 MHz	OTHER
6.0 - 6.1 MHz	FEDERAL GOVERNMENT
6.1 - 6.2 MHz	COMMERCIAL
6.2 - 6.3 MHz	INDIVIDUAL
6.3 - 6.4 MHz	OTHER
6.4 - 6.5 MHz	FEDERAL GOVERNMENT
6.5 - 6.6 MHz	COMMERCIAL
6.6 - 6.7 MHz	INDIVIDUAL
6.7 - 6.8 MHz	OTHER
6.8 - 6.9 MHz	FEDERAL GOVERNMENT
6.9 - 7.0 MHz	COMMERCIAL
7.0 - 7.1 MHz	INDIVIDUAL
7.1 - 7.2 MHz	OTHER
7.2 - 7.3 MHz	FEDERAL GOVERNMENT
7.3 - 7.4 MHz	COMMERCIAL
7.4 - 7.5 MHz	INDIVIDUAL
7.5 - 7.6 MHz	OTHER
7.6 - 7.7 MHz	FEDERAL GOVERNMENT
7.7 - 7.8 MHz	COMMERCIAL
7.8 - 7.9 MHz	INDIVIDUAL
7.9 - 8.0 MHz	OTHER
8.0 - 8.1 MHz	FEDERAL GOVERNMENT
8.1 - 8.2 MHz	COMMERCIAL
8.2 - 8.3 MHz	INDIVIDUAL
8.3 - 8.4 MHz	OTHER
8.4 - 8.5 MHz	FEDERAL GOVERNMENT
8.5 - 8.6 MHz	COMMERCIAL
8.6 - 8.7 MHz	INDIVIDUAL
8.7 - 8.8 MHz	OTHER
8.8 - 8.9 MHz	FEDERAL GOVERNMENT
8.9 - 9.0 MHz	COMMERCIAL
9.0 - 9.1 MHz	INDIVIDUAL
9.1 - 9.2 MHz	OTHER
9.2 - 9.3 MHz	FEDERAL GOVERNMENT
9.3 - 9.4 MHz	COMMERCIAL
9.4 - 9.5 MHz	INDIVIDUAL
9.5 - 9.6 MHz	OTHER
9.6 - 9.7 MHz	FEDERAL GOVERNMENT
9.7 - 9.8 MHz	COMMERCIAL
9.8 - 9.9 MHz	INDIVIDUAL
9.9 - 10.0 MHz	OTHER

# Compliance Considerations

- What is Required
- Benefits of Modular Filing

# Certifications

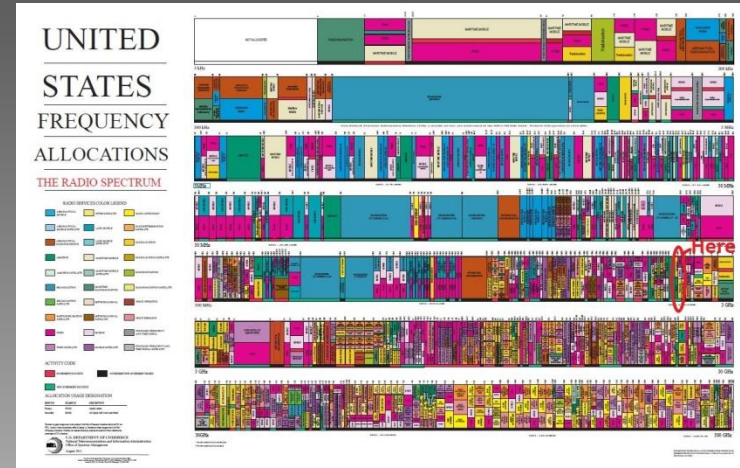
## Key Points:

1. Two Types of Testing: Intentional Radiation (\$10K+) & General Emissions (\$1K-\$3K).
2. If using a certified module with an antenna it was certified with then you do not need to go back through intentional radiation testing.
3. General emissions is required on any product with an oscillator
4. 8 point modular certification (ex Shield, power regulation, antenna)
5. FCC allows off board antenna design – LSR design guide
6. You may use a different antenna BUT must be same type and equal or lesser gain
7. Must be a member of BT SIG to use BT Logo
8. To get BT SIG qualification, need SIG testing. Using a qualified module (i.e. UB2), save up to \$35K in testing fees. LSR has a QDL (qualified design listing). Customer leverages QDL to get EPL (End product listing)

# Compliance of BLE

## BLE Spectrum Characteristics

- Operates in the unlicensed 2400-2483.5 MHz ISM Band
  - Frequency Hopping Spread Spectrum (FHSS)  
or (?)
  - Digital Transmission System / Direct Sequence Spread Spectrum (DTS / DSSS)
- Regulatory
  - FCC Part 15.247 or 15.249
  - Industry Canada RSS-210
  - ETSI EN 300 328 v1.7.1



# Compliance of BLE

## BLE Spectrum Characteristics

- Uses Gaussian Frequency-Shift Keying (GFSK) modulation similar to Classic Bluetooth
  - Minor difference in modulation index
- Uses similar channels as Classic Bluetooth
  - Low Channel 2402 MHz
  - High Channel 2480 MHz

# Compliance of BLE

Question: If the Spectrum Characteristics of BLE are Similar to Classic Bluetooth is it tested and certified the same?

Answer: NO!

Why: The protocol of BLE (advertising channels) creates conditions where it does not meet the Frequency Hopping Requirements of the regulations.

So What can be done?

Treat BLE as DTS

# Compliance of BLE

Question: BLE as DTS?

Answer: Yes, as long as the DTS bandwidth (6 dB) is greater than 500 kHz

Other Considerations for BLE as DTS:

- FCC/IC Power Spectral Density Limit of 8 dBm (as measured in 3 kHz bandwidth)
  - Usually not a problem with even 10 dBm output power
- ETSI Power Spectral Density Limit of 10 dBm EIRP (as measured in 1 MHz bandwidth)
  - Since this is EIRP (add antenna gain) and 1 MHz bandwidth it may necessary to limit output power

# Compliance of BLE

## Product Options for Compliance Testing

1. Product Certification
  - a. BLE Radio design integrated into your product with your choice of antenna
  - b. All tests (of product) required for intentional radiator FCC/ IC / ETSI and unintentional emissions and/or CE
2. FCC/IC Modular Approach
  - a. Single-modular approval of BLE radio tested in stand-alone configuration
  - b. Must meet modular requirements (RF shielding, voltage regulation, buffered I/O, etc.)  
or Limited-modular (host dependent)
  - c. Can use your certified module in multiple products (still must test end product for unintentional emissions)
3. Purchase a certified radio module, use with certified antenna, and integrate into product
  - a. Must test product for unintentional emissions

# Compliance of BLE

## Tips for Successful EMC Compliance Testing

- Consider EMC and Radio (don't forget the antenna!) aspects early in the design phase!!!
- Perform a Compliance Pre-scan before final design is “set”
- Complete the filing paperwork before final testing begins
- Tell us everything about your product
  - Human Exposure to RF (Assessment or Testing)
    - Based on output power and device usage characteristics (e.g. wrist worn , body worn, head, or far (20 cm) away)

# Compliance of BLE

## Tips for Successful EMC Compliance Testing

- Plan for an antenna port for measurements (50 ohm U.FL or similar)
- Control of Radio / End Product
  - Ability to set radio in continuous transmit modulation on selectable channels
    - Ease of programming
    - Stays in mode for long period of time
  - Receive mode with channel selection
  - Normal product operation
- Define Performance Criteria of Radio and/or product (Susceptibility)
  - Does the radio need to retain all transmitted data?
  - Would it be unfavorable if a false signal caused an event to occur?

## Benefits of using a LSR Module

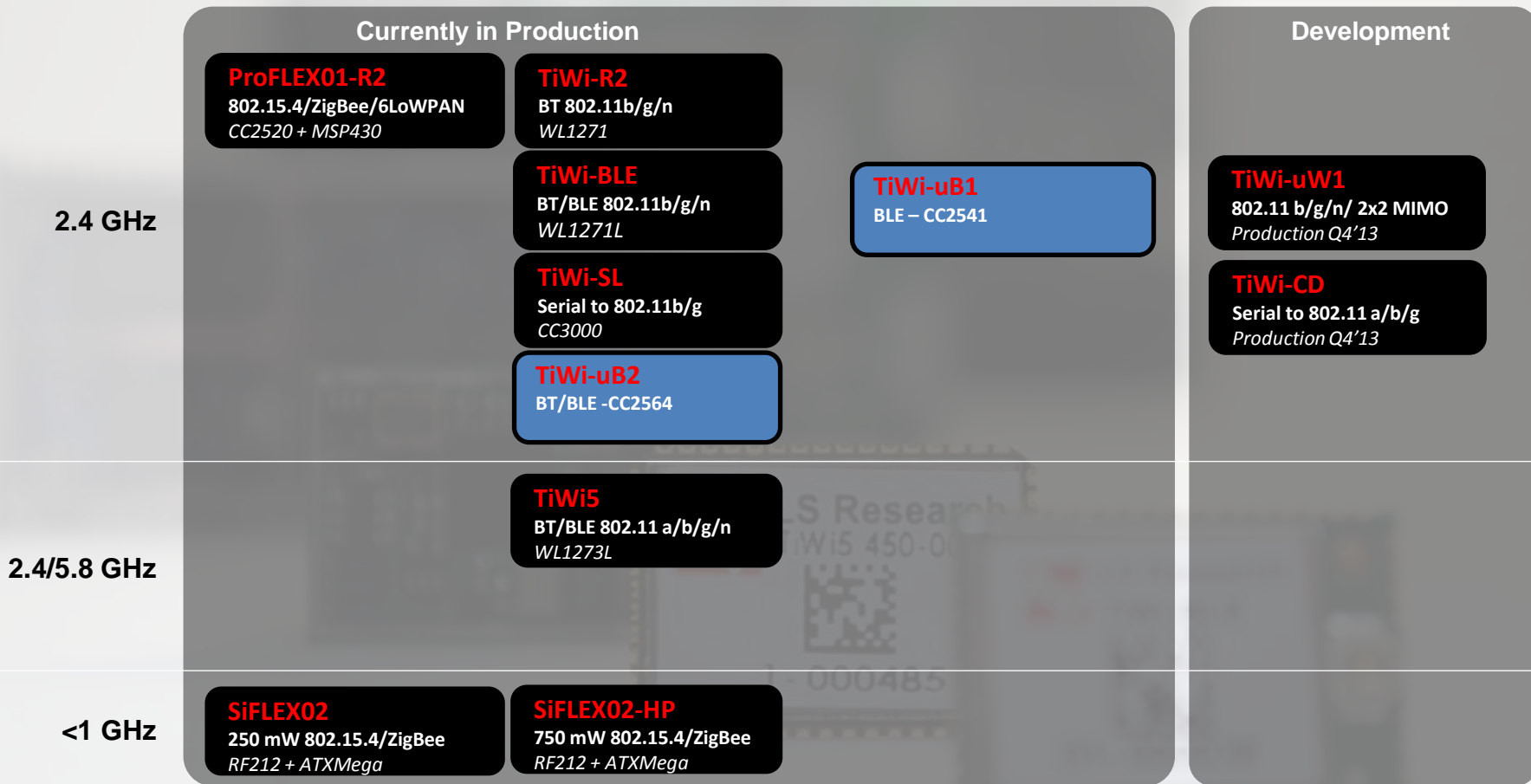
1. Fastest Time to market
2. Development Fee Savings – \$50K+
3. Certification Savings – FCC/IC = \$13K, CE Mark = \$15K, SIG = \$35K (\*single radio)
4. Capital Equipment Savings - \$50K+
5. LSR handles all support – free design reviews

UB2 1K Resale: \$6.65

UB1 1K Resale: \$5.99



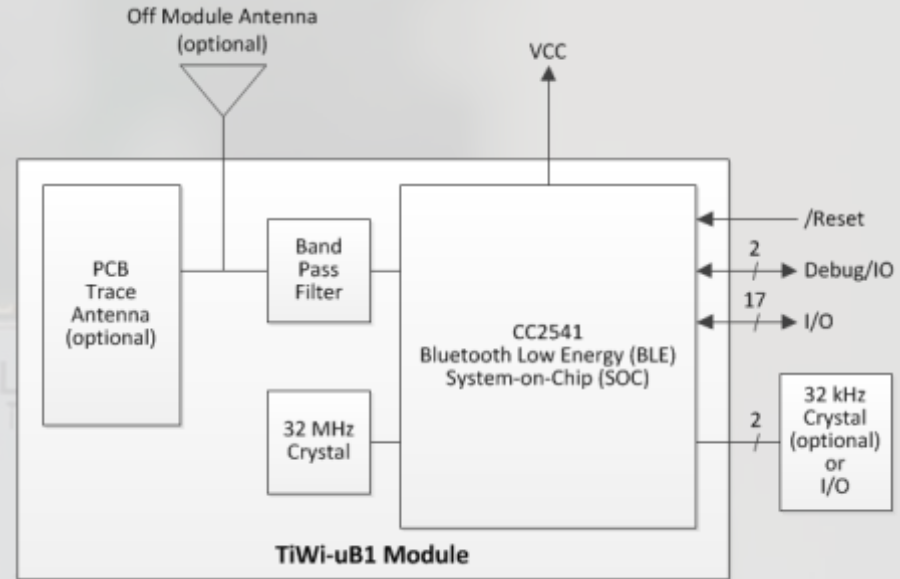
# Module Portfolio & Road Map



# uB1™ | Bluetooth® Low Energy 4.0 Module

## TiWi-uB1 SPECIFICATIONS

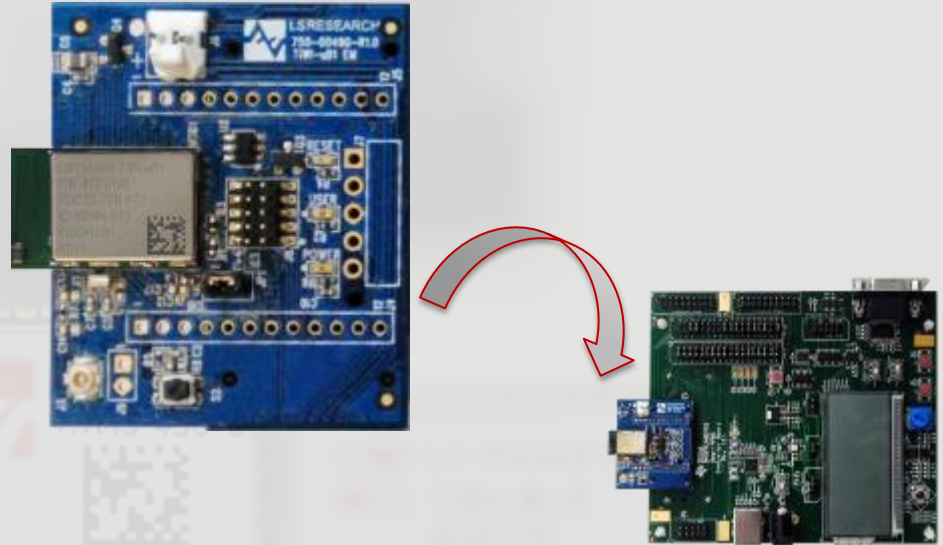
- Dimensions: 11.6 mm x 17.3 mm x 2.3 mm
- Operating temperature: -40 to +85°C
- FCC/IC/CE & Bluetooth certified (pending)
- Power consumption with DC/DC:
  - 12.6 mA in transmit
  - 15.7 mA in receive
- Output power 0 dBm
- RF sensitivity up to -94 dBm
- Integrated Hybrid™ Trace Antenna
- External antenna option
- Multiple Configuration Options
  - Single-Chip configuration, allowing applications running on an external microcontroller
  - Network processor interface for applications running on an external microcontroller



# uB1™ | Bluetooth® Low Energy 4.0 Module

## TiWi-uB1 EVALUATION KIT / DEMO SYSTEM

- Simple Out of the Box Demo
  - iPhone to/from Sensor I/O
- EM Board directly connects to SmartRF05EB platform or TI MSP/Stellaris boards for code development
- \$49.00 USD



# uB2™ | Bluetooth® 2.1+EDR & Bluetooth Low Energy 4.0 Module

## TiWi-uB2 FEATURES

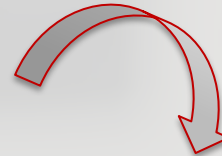
- CC2564 fully supports BT 2.1+EDR, BLE 4.0
- Power Consumption
  - 47.1 mA in transit
  - 13.0 mA in receive
- 2.2 V to 4.8 V operation
- Output power +10 dBm
- RF sensitivity up to -94 dBm
- Very Small: 7mm X 7mm X 1.5mm
- Operating temperature -30 to +85°C
- Support for Class 1.5 (high output power) applications
- Off board chip antenna
- Supports maximum Bluetooth data rate over HCI UART interface
- Supports multiple Bluetooth profiles with enhanced QoS, mono and stereo
- HCI UART and Audio PCM interfaces for Bluetooth



# uB2™ | Bluetooth® 2.1+EDR Bluetooth Low Energy 4.0 Module

## TiWi-uB2 EVALUATION KIT / DEMO SYSTEM

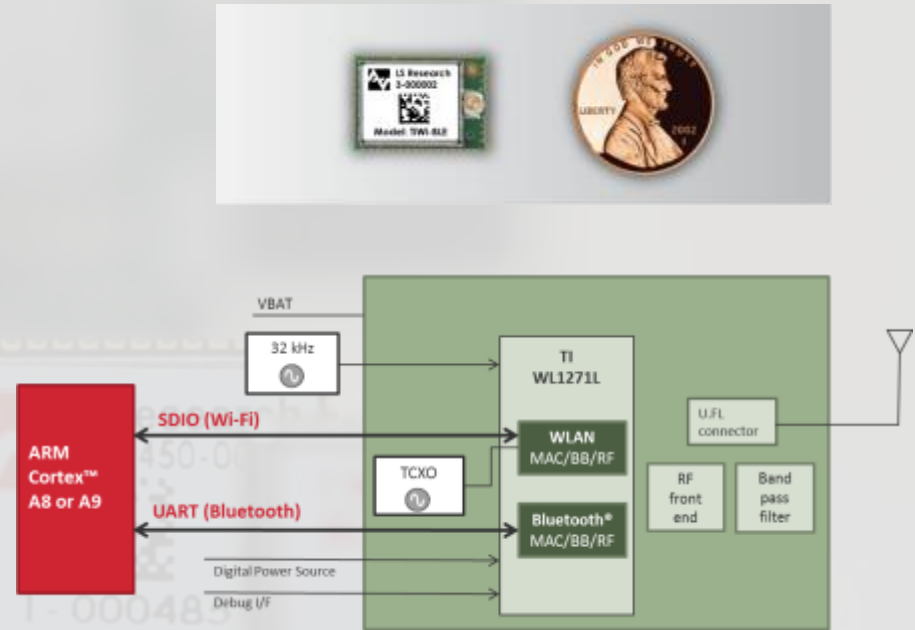
- Simple Out of the Box Demo
  - iPhone to/from Sensor I/O
- EM Board directly connects to SmartRF05EB platform or TI MSP/Stellaris boards for code development
- Antenna Design Guide
- \$49.00 USD



# TiWi-BLE™ | Bluetooth®, BLE, and 802.11 b/g/n WiFi Module

## TiWi-BLE SPECIFICATIONS

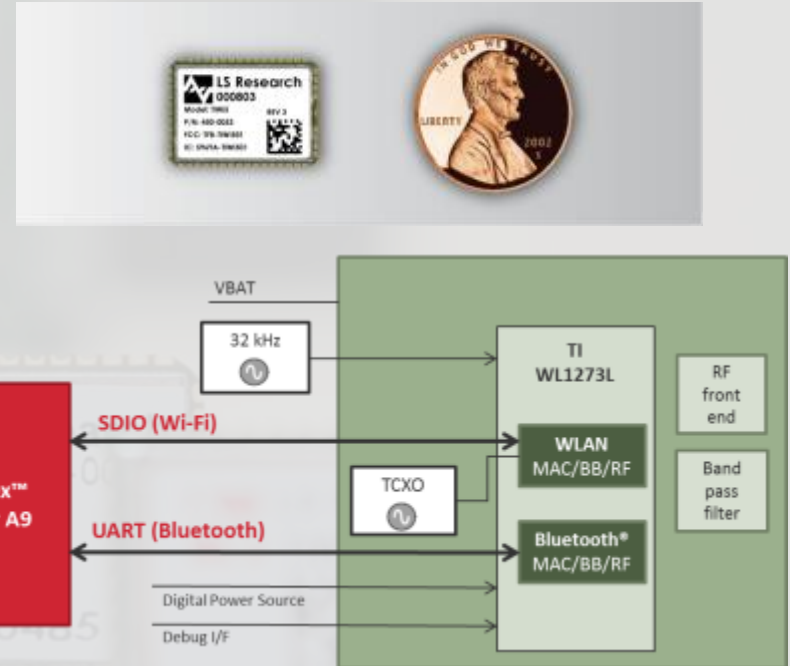
- FCC / IC / CE Certified with multiple antenna options
- Smaller than a penny: 13mm X 18mm X 1.9mm
- Industrial operating temperature: -40 to +85°C
- On-module TCXO and power regulation
- Bluetooth and BLE



# TiWi5™ | Bluetooth®, BLE, and 802.11 a/b/g/n WiFi Module

## TiWi5 SPECIFICATIONS

- 5.8GHz and 2.4GHz operation
- FCC / IC / CE certified with multiple antenna options
  - Over \$100K savings in certification costs!
- Smaller than a penny:  
13mm X 18mm X 1.9mm
- Industrial operating temperature: -40 to +85°C
- On-module TCXO and power regulation
- Bluetooth 2.1+EDR, 3.0, 4.0, Bluetooth Low Energy and ANT+ ready



# LSR Advantage with BLE – beyond the module...

- Complete customization
- Lowest bill of materials cost
- Low risk for part obsolescence
- Development of Specialized Antennas: ie. Body Worn Antennas
- One stop shop
  - Product FCC / IC / CE Certifications Guaranteed!
  - BLE Stack Customization and Development
  - Industrial / Mechanical Design for the Coolest & Smallest Products!
  - Cloud Platform Services
  - Production Services and State-of-the-Art RF Test Fixtures
- The ONLY firm that can do EVERYTHING you NEED

# Questions?

