Bluetooth 5

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Frontline Joins Teledyne Technologies

Charlottesville, Virginia, USA – April 7, 2016 – Frontline Test Equipment, Inc. the worldwide leader in Bluetooth® protocol analyzers and testing services is excited to announce that they have been acquired by Teledyne LeCroy, Inc., the worldwide leader in protocol test solutions, expanding their family of protocol analysis solutions to include the best *Bluetooth* protocol analysis on the market, as well as a host of analysis tools for other wireless and wired "Internet of Things" (IoT) technologies…

http://teledynelecroy.com/pressreleases/document.aspx?news_id=1956&capid=107&mid=554

Teledyne LeCroy Frontline - The *Bluetooth* Experts

- 30+ years of protocol analysis experience
- Involved with *Bluetooth* wireless technology initiatives from the beginning (~13 years)
- Work closely with the *Bluetooth* SIG – specifications, working groups, technology committees
- Frontline products support every *Bluetooth* specification, profile and protocol

"…accelerate our partners' time to market, increase their product quality and ensure a superior end user experience for their customers, through our products, services, and consulting."

Teledyne LeCroy Frontline – Products and Services

Services

- Interoperability
  - Bluetooth
  - WiFi
  - NFC
- Validation
- Benchmark testing

Products

- *Bluetooth*
- NFC
- 802.11
- SDIO
- HSU
- Industrial Protocols

Bluetooth 5 meeting Agenda

- 1. Bluetooth spec history
- 2. Bluetooth 5 features.
- 3. Use cases for new Bluetooth 5 features (Benefits)
- 4. Some technical details on Bluetooth 5 features
- 5. Mesh roadmap.
- 6. Why Mesh?
- 7. basic operation of Mesh
- 8. Sniffer support for Bluetooth 5 and Mesh.

Bluetooth short History

- Bluetooth Classic

Also know as Basic Rate/Enhanced Data rate (BR/EDR)

It is possible to have a Classic Only Bluetooth chip
(V2.0/EDR, V2.1, V4.0,V4.1)

Bluetooth low energy:

Sometimes also referred to as Bluetooth V4.0

It is possible to have a low energy Only Bluetooth chip
(V4.0,V4.1)

Bluetooth Sensors

It is also possible to have a Dual mode Chip
(supports Classic + low energy)

Bluetooth 5

This includes above specifications (Classic and low energy) Plus new specification features based on low energy features.

Transmitter Characteristics: Bluetooth 5 specification.

Minimum Output Power	Maximum Output Power
0.01 mW (-20 dBm)	100 mW (+20 dBm)

Note: the Max O/P Power for LE V4.0, 4.2, 4.2 is 10mW (+20dBm)

Bluetooth Devices may be Classified into Power Classes (see below) based on the Max Power O/P the LE PHY supports.

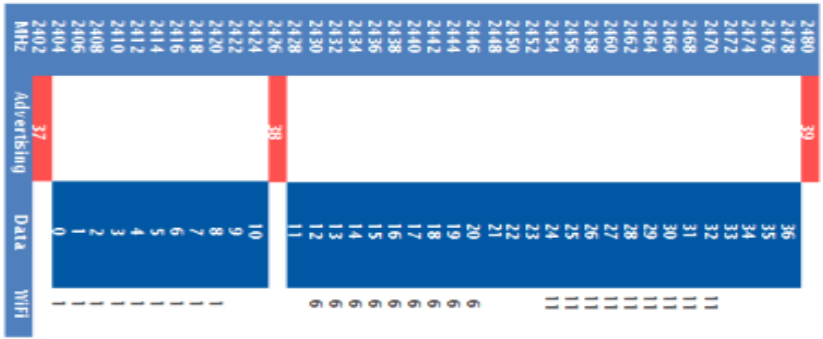
Power Class	Maximum Output Power (P_{max})	Minimum Output Power[1]
1	100 mW (+20 dBm)	10 mW (+10 dBm)
1.5	10 mW (+10 dBm)	0.01 mW (-20 dBm)
2	2.5 mW (+4 dBm)	0.01 mW (-20 dBm)
3	1 mW (0 dBm)	0.01 mW (-20 dBm)

Using High Tx power within close proximity between devices can result in Rx saturation and connection link loss. Using 2 or more Power levels can ensure low Tx Power for short range use cases and avoid Rx saturation and possibly link loss.

Scope: LE Physical layer

- Two Modulation schemes are available.
- 1 Msyms/s Modulation is mandatory and supports 2 PHYs.
- LE 1M Uncoded data @ 1 Mb/s
- LE Coded (Optional)

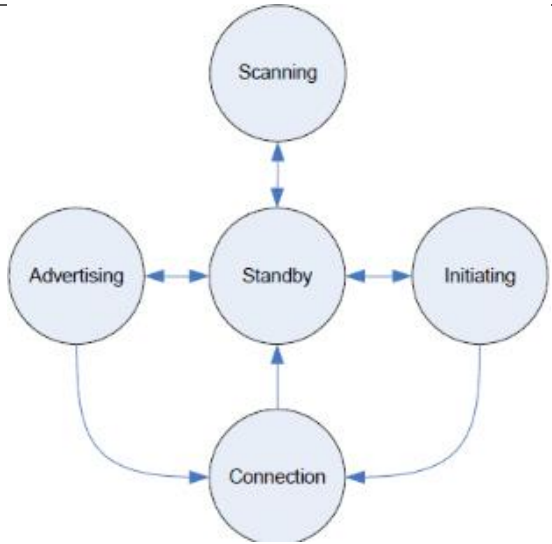
- 2 Msyms/s Modulation supports 1 PHY
- LE 2M with uncoded data @ 2 Mb/s
- LE operates in 2.4GHz band (2.400 - 2.4835GHz)
- LE system uses 40 RF Channels, 2MHz per channel, 0…..39 Channels



Lower guard band of 2MHz, upper guard band of 3.5MHz

Channels and Connection Events

- Two types of Channels.
- Advertising Channels (37,38,39)
- Data Channels (0….36).
- Devices can be in different states.



- Connection state:
- The LL shall send Data Channel PDUs in Connection Events. A Channel Index is used for each Connection Event. The sam Channel Index will be used for that event.
- The connection Event is open as long as M&S send packets.

Core System Architecture

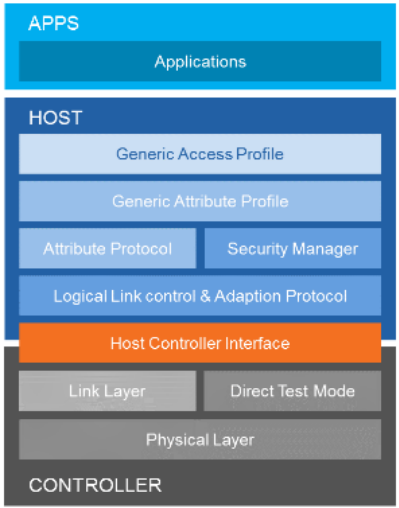
Physical (PHY) Layer
Controls transmission/receiving of the 2.4Ghz radio with Bluetooth communication channels. BR/EDR provides more channels with narrower bandwidth, while LE uses fewer channels but broader bandwidth.

Link Layer
Defines packet structure/channels, discovery/connection procedure and sends/receives data.

Direct Test Mode
Allows testers to instruct the PHY layer to transmit or receive a given sequence of packets, submitting commands to it either via the HCI or via a 2-wire UART interface.

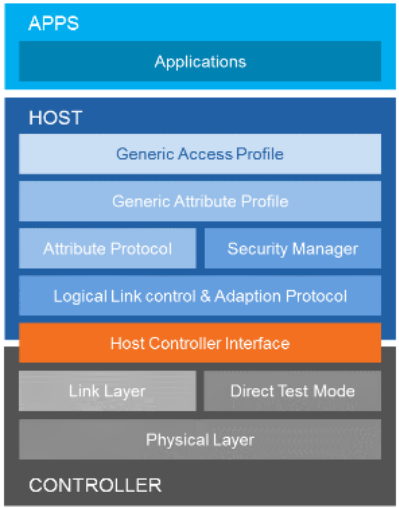
Host to Controller Interface (HCI)
Optional standard interface between the Bluetooth controller subsystem (bottom three layers) and the Bluetooth host.

Logical Link Control and Adaptation Protocol (L2CAP) Layer
A packet-based protocol that transmits packets to the HCI or directly to the Link Manager in a hostless system. Supports higher-level protocol multiplexing, packet segmentation and reassembly, and the conveying of quality of service information to higher layers.



Core System Architecture

- **Attribute Protocol (ATT)**
- Defines the client/server protocol for data exchange once a connection is established. Attributes are grouped together into meaningful services using the Generic Attribute Profile (GATT). ATT is used in LE implementations and occasionally in BR/EDR implementations.
- **Security Manager**
- Defines the protocol and behavior that manages pairing integrity, authentication and encryption between Bluetooth devices, and provides a toolbox of security functions that other components use to support almost any level of security needed by diverse applications.
- **Generic Attribute Profile (GATT)**
- Using the Attribute Protocol, GATT groups services that encapsulate the behavior of part of a device and describes a use case, roles and general behaviors based on the GATT functionality. Its service framework defines procedures and formats of services and their characteristics, including discovering, reading, writing, notifying and indicating characteristics, as well as configuring the broadcast of characteristics. GATT is used only in Bluetooth LE implementations. Get additional in-depth GATT information.
- **Generic Access Profile (GAP)**
- Works in conjunction with GATT in Bluetooth LE implementations to define the procedures and roles related to the discovery of Bluetooth devices and sharing information, and link management aspects of connecting to Bluetooth devices.



Bluetooth 5

Bluetooth® 5, Doubles Speed, Quadruples Range, Increases Data Broadcasting Capacity by 800%

IT'S ALL ABOUT…… Bluetooth 5

- Creating a new opportunity on how to utilize the IoT
- Delivering Reliable IoT connections
- Enhancing the adoption of Beacons
- Decreasing connection barriers to experience seamless IoT experience
- Next generation Audio capability with new increased Speed feature.
- Long Range feature will enhance IoT connectivity for Industrial-Home use cases.

- Bluetooth 5 is Uibiquitous.
- Bluetooth 5 has an install base of over 10 billion devces.
- Bluetooth 5 includes features to enhance Coexistence with other technologies
- Bluetooth 5 new features still ensures low-energy functionality and better more flexable performance.

- Coexistence with other technologies.
- Bluetooth 5 also includes updates that enhance Coexistence with other technologies in an increasingly complex IoT world.

Frontline Sodera Support for Bluetooth 5 Features

Feature	Supported
2 Mbps LE	Yes
LE Advertising Extensions	Yes
Slot Availability Masks	Yes
LE Long Range	Yes
Channel Selection #2	Yes
High Duty Cycle Non-Connectable Advertising	Yes

Bluetooth wideband Sniffer

2Mbps LE

Increased bandwidth for *Bluetooth*® technology with low energy

Key Feature:

Up to 2x bandwidth of Bluetooth 4.2 with low energy.

Bluetooth 5.0 introduces a new capability to increase the bandwidth to 2 Mbps. By doubling the amount of data that devices can transfer, Bluetooth 5.0 reduces the time required for transmitting and receiving data, facilitating rapid and reliable over-the-air firmware updates for mobile devices and fast upload of days' worth of collected data from a sensor when a mobile device is turned on.

2Mbps LE

- 2Mbps LE feature includes the following:
- additions to the Physical layer to allow 2 Ms/s(megasymbol per second) packets to be transmitted and received by the radio;
- a new control procedure in the Link Layer to allow transition between 1 Ms/s and 2 Ms/s;
- additional HCI commands and events to transition the LL between 1 Ms/s and 2 Ms/s;
- new Link Layer MSCs;
- an update to DTM mode for PHY testing.

Bluetooth 5 – Faster (Double) Speed

- Doubles the speed of low energy communications
- Will support faster data transfers and software updates for devices. Increase Bandwidth to 2Mbs.
- Applications benefiting from faster Bluetooth include:
  - more responsive apps
  - more responsive human interface devices
  - Faster update of Sensor information
  - better audio over Bluetooth
  - more responsive beacons
  - ALL applications benefit from faster speed

LE Long Range (Up to 1000 Meters)

Increased range for low energy enables whole-home, building, or location coverage

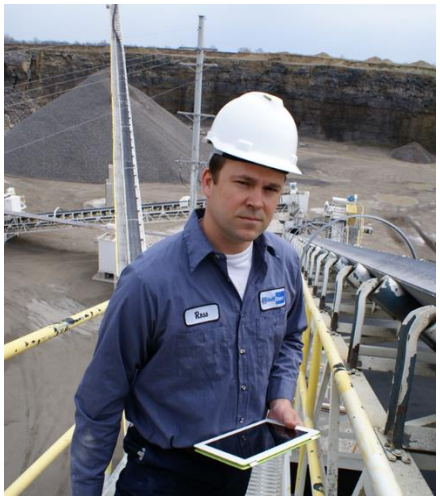
Key Feature:
Up to 4x range of Bluetooth 4.2 with low energy.

Bandwidth can be decreased to achieve up to 4x longer range while maintaining similar power requirements. With quadruple the range over which their devices can transmit and receive data, product designers creating home automation and security solutions can provide coverage of an entire home, building, or locality.

The range can be tuned for a variety of environments. Not every application requires the same range, speed or broadcasting capability. Bluetooth 5.0 provides the flexibility for a developer to make the best choice for their implementation.

Bluetooth 5 – Longer (Quadruple) Range

- Quadruples the range while maintaining Power requirements.
- Will enable connections to IoT devices that extend far beyond the walls of a typical home
- Applications benefiting from long range Bluetooth include:
  - medical devices
  - ePOS terminals
  - automotive diagnostic equipment
  - barcode scanners
  - industrial cable replacement
  - truck weighing scales
  - pipeline leak detection devices
  - anything over water (which rapidly attenuates RF signal)



Increase Broadcast Capacity by 800%

Broadcasting channel improvements power the beacon revolution

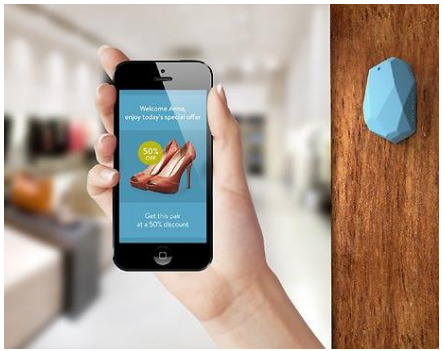
Key Features:

Up to 8x the broadcasting message capacity over Bluetooth 4.2, with support for larger data packets: 31-octet to 255-octet packages.

Ability to offload advertising date from the 3 advertising channels to up to 37 broadcasting channels.

Bluetooth 5 – Greater (800% Increase) Messaging Capacity

- Increases the capacity of connectionless data broadcasts by 800 percent. 30-octet to 255 octet packets.
- Ability to offload Adv. Data from 3 channels to 37 Channels.
- Applications benefiting from greater advertising packet capacity include:
  - Less Broadcasting time to complete the tasks.
  - More efficient utilization of 2.4Ghz Band
  - Larger Data packets
  - More channels to Broadcast on (37)
  - New Application to avail of more efficient ecosystem.
  - Creating a friendlier RF environment



Slot Availability Mask. (Negate LTE Interference)

Slot availability masks detect and prevent interference on neighboring bands

Key Feature:

Detect and prevent interference at the edges of the 2.4 GHz ISM band and the neighboring LTE band.

For mobile phone developers creating the next generation of devices, slot availability masks can be used to detect interference on neighboring bands and automatically prevent the interference. A Bluetooth 5.0 device can indicate transmission and reception availability of its slots when working with Mobile Wireless Standard (MWS) systems.

Bluetooth 5 Facts and information

- Bluetooth 5 extends the functionality of Bluetooth 4.0-4.2
- Bluetooth 5 is backward compatible in relation to LE 4.0-4.2
- Bluetooth 5 is backward compatible with BR/EDR V1.1- forward.
- Bluetooth 5 features designed for Bluetooth LE enhancements
- Bluetooth 5 adds performance and Interoperability performances.
- To update a previous qualified product to Bluetooth 5, you need to requalify.
- Previous qualified products do not require new qualification.