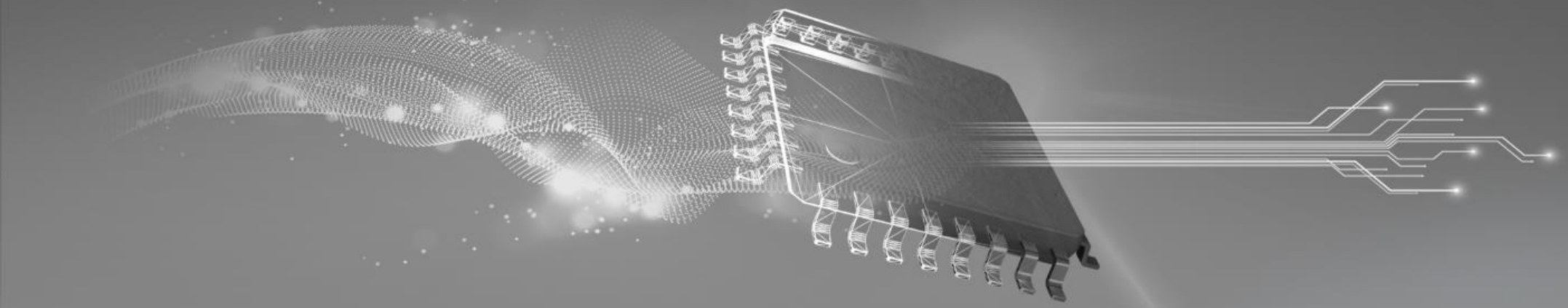
TI TECH DAYS



Overview and demonstration of the new features of Bluetooth 5.0, 5.1 and 5.2

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What is *Bluetooth*® Low Energy?

- Defined by Bluetooth SIG
  - Part of *Bluetooth* after the 4.0 Spec (2010)
  - Uses the same 2.4 GHz band as classic Bluetooth with different modulation, channels, and frequency hopping scheme
- Synchronous Protocol designed for low power
- Target Applications
  - Low Power
  - Low Latency
  - Low Throughput
- Bluetooth 5 comes to improve power consumption, data throughput, range and provides the enabling infrastructure for additional applications

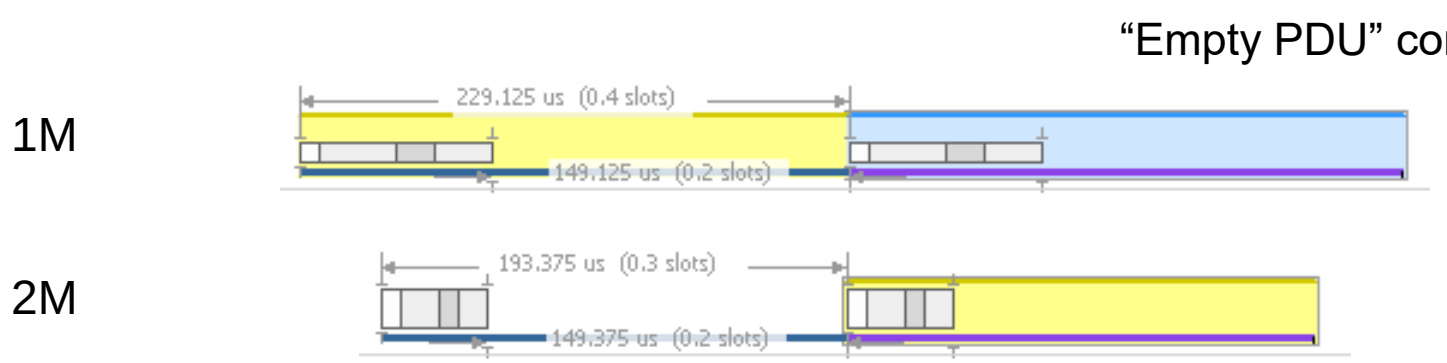
Bluetooth 5.0 Features

- Additional PHY's beyond the original 1M
  - 2M (for increased throughput) and Coded (for increased range)
- Advertising improvements through "Advertising Extension"
  - Increased possibilities for advertisement data configuration that opens various BLE beacon applications
- Improved Frequency Hopping (CSA#2)
  - Hopping sequences are now pseudo random and the distinct sequences which are possible are very large
  - Improves the interference tolerance of the Bluetooth radio
  - Is more effective at avoiding multi-path fading effects than CSA#1
    - Especially for high throughput scenarios

Bluetooth 5.0 Feature: 2M PHY

- Double symbol rate compared to 1M
- Almost half the energy consumption per frame
- Twice as fast? Not quite.
  - Still the same inter-frame spacing of 150 µs contributing to overhead, but it can use **Data Length extensions**

“Empty PDU” connection event



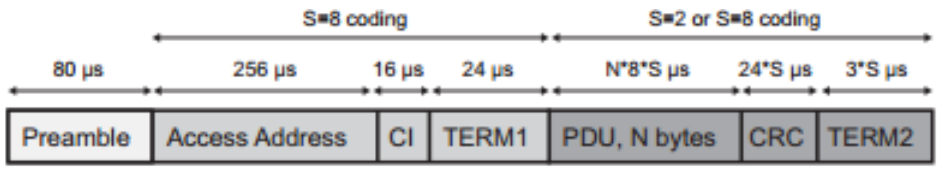
Bluetooth 5.0 Feature: Coded PHY

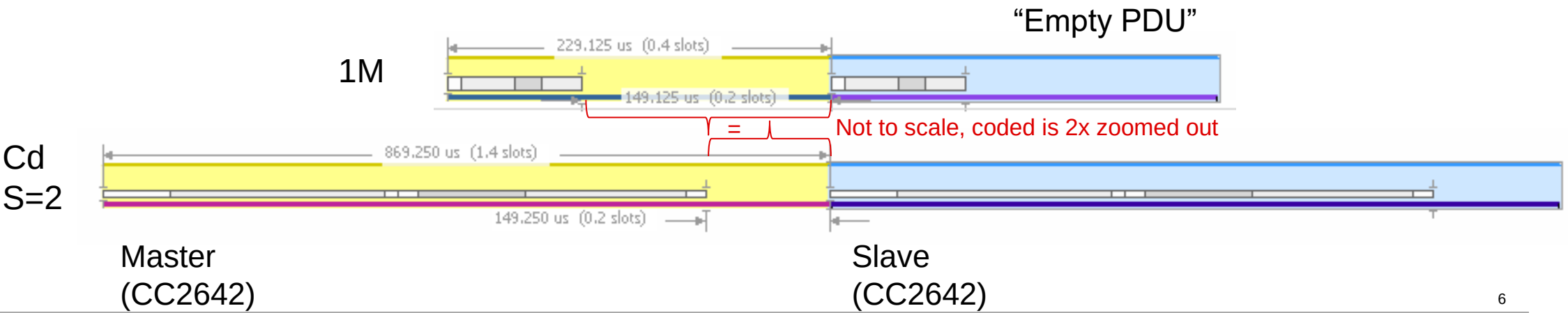
- Allows for enhanced range
- There are two ways to improve the link budget:
  - Increase the output power
  - Improve (reduce) the receiver sensitivity level
- The receiver sensitivity level is increased two ways:
  - The data rate is reduced.
  - Foreward Error Correction (FEC), correlators in the radio search for known symbol sequences in the reiceved symbols.

Bluetooth 5.0 Feature: Coded PHY

Coded PHYs:

- 500kbps (S=2) – Use two symbols per bit, with forward error correction
- 125kbps (S=8) – Use eight symbols per bit, cleverly repeats the S=2 symbols





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Bluetooth 5.0 Feature: PHY Comparison

Parameter	LE 1M	LE 2M	LE Coded S=2	LE Coded S=8
Symbol Rate	1Msps	2Msps	1Msps	1Msps
Data Rate	1Mbps	2Mbps	500kbps	125kbps
Error Correction	None	None	FEC*	FEC*
Range Multiplier	1	~0.8	~2	~4

* Forward Error Correction: the error correction mechanism used to improve the sensitivity of the receiver
https://www.bluetooth.com/blog/exploring-bluetooth-5-going-the-distance/

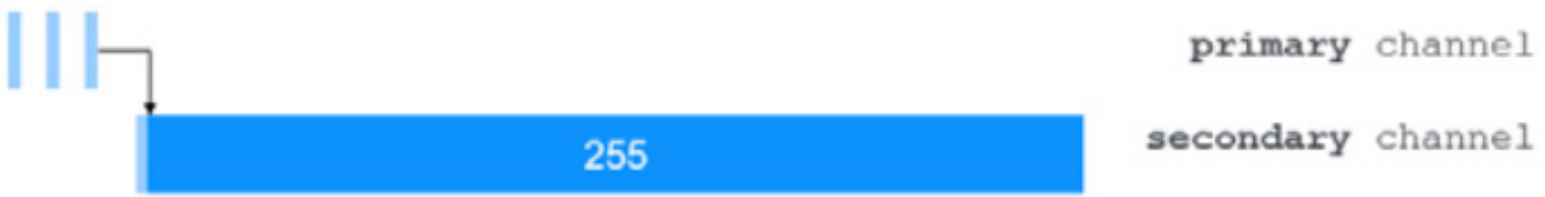
Bluetooth 5.0 Feature: Advertising Extension

Legacy advertising

- Maximum broadcast data size of 27 bytes
- Only 3 channels are used for advertising

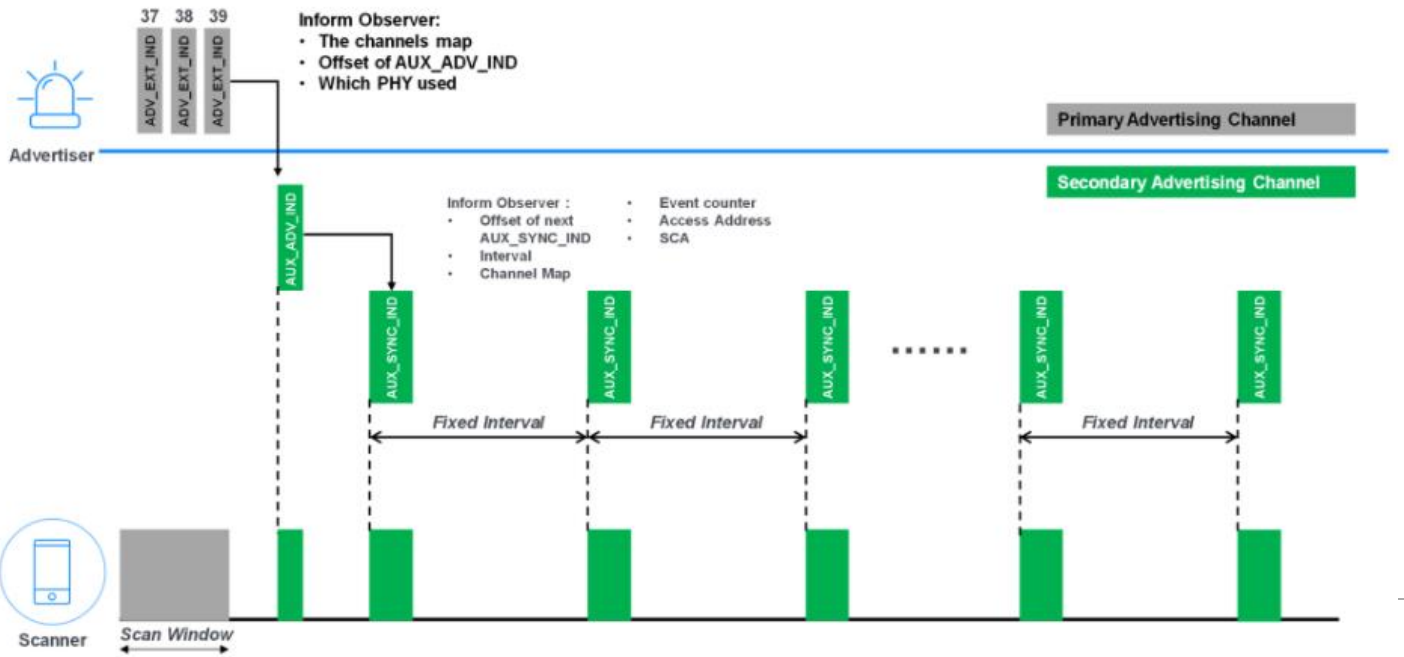
Advertising extensions

- Maximum broadcast data size of 255 bytes
- Utilizes all possible Bluetooth channels to send data
- Accomplished via a primary / secondary channel pointer mechanism



Bluetooth 5.0 Feature: Periodic Advertising

- Normal advertising includes a random jitter to prevent persistent packet collisions
- Bluetooth 5 introduces “Periodic Advertising”
  - allows scanners to synchronize their scanning for packets with the schedule of the advertising device to perform deterministic advertising

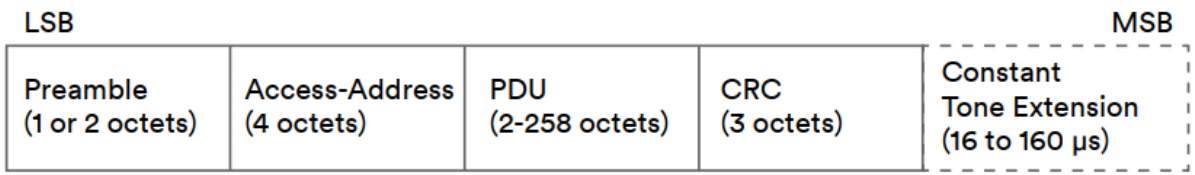


Bluetooth 5.1 Features

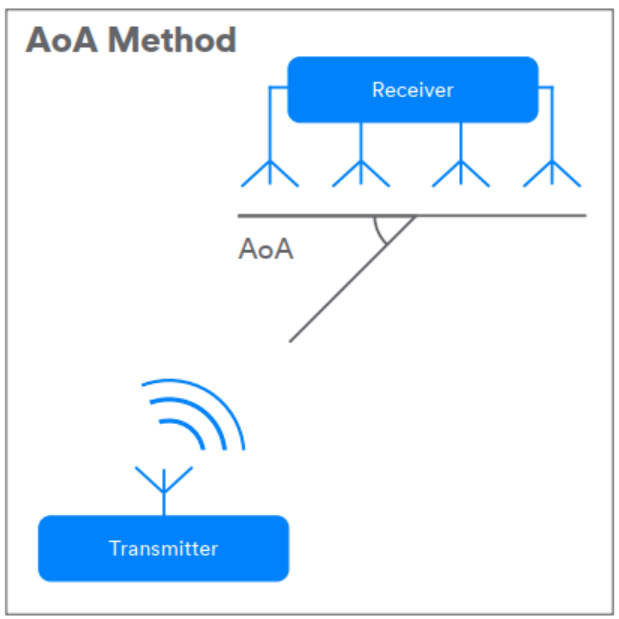
- Direction Finding
  - Previous proximity / positioning solutions relied on RSSI
  - BT 5.1 adds Angle of Arrival (AoA) and Angle of Departure (AoD)
- GATT Caching
  - Simplifies service discovery to save power
- Advertising Enhancements
  - Randomized Advertising Channel Indexing
  - Periodic Advertising Sync Transfer

Bluetooth 5.1 Feature: Angle of Arrival (AoA)

- A constant tone extension (CTE) is appended to the transmitter packet
  - provides constant frequency and wavelength signal material

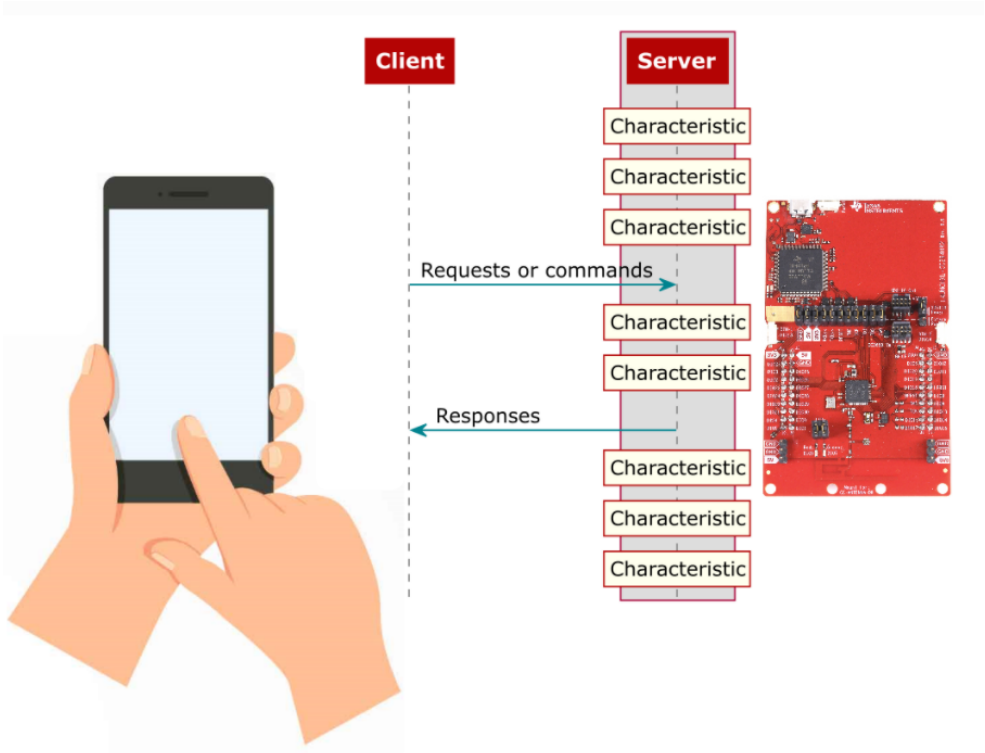


- Antenna switching used to find angle
  - The receiving device contains an antenna array
  - Switching between antennas allows In-Phase and Quadrature (IQ) sampling to measure the phase of radio waves incident upon an antenna at a specific time



Bluetooth 5.1 feature: GATT caching

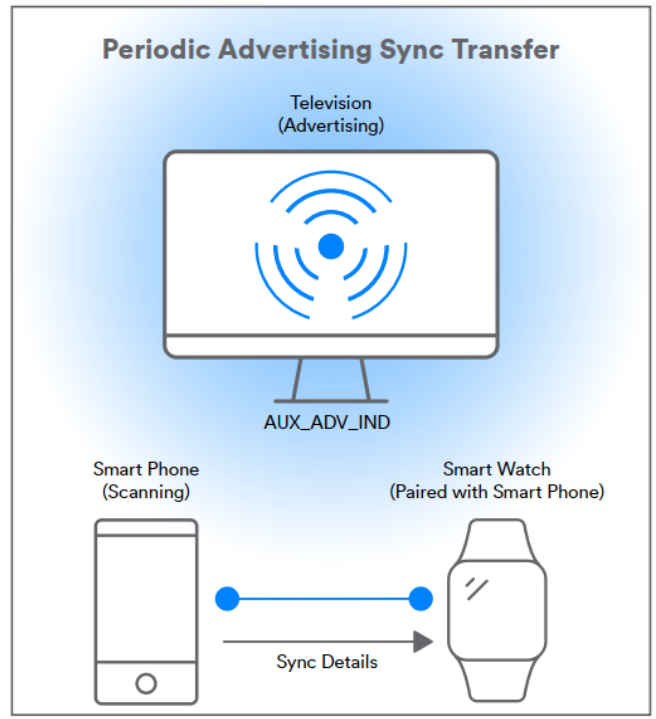
- Bluetooth Low Energy devices use the Generic Attribute Profile (GATT) to discover and send data
  - Client must discover all attributes upon connecting which consumes power
- Bluetooth 5.1 allows the client to cache this attribute table after the first discovery
  - Avoids rediscovery on subsequent connections



Bluetooth 5.1 Feature: Advertising Enhancements

- Randomized Advertising Channel Indexing
  - Previously the sequence of primary advertising channels was always 37, 38, 39
  - Bluetooth 5.1 allows for this sequence to be randomized to decrease packet collisions

- Periodic Advertising Sync Transfer
  - Periodic advertising synchronization can be a relatively processing-expensive operation
  - Bluetooth 5.1 allows simple end devices the possibility to offload some of this complexity to a second device
  - Primarily build to enable LE Audio in Bluetooth Low Energy 5.2



Bluetooth 5.2 Features

- Enhanced Attribute Protocol (EATT)
- LE Power Control
- LE Isochronous Channels

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Bluetooth 5.2 Enhanced Attribute Protocol (EATT)

- Improved version of the Attribute protocol (ATT)
- Supports concurrent transactions
- Allows interleaving of L2CAP packets relating to ATT packets from different applications
- Allows ATT MTU to be changed during a connection

Bluetooth 5.2 LE Power Control

What is it?

- Possible to dynamically optimize the transmission power used in communication between connected devices
- BLE receivers can now monitor signal strength and request transmission power level changes

Benefits

- Helps the reduction of overall power consumption by transmitters through dynamic power management on connections
- Improved reliability through active maintenance of receiver signal strength
- Improvements to coexistence with other wireless devices

Bluetooth 5.2 LE Isochronous Channels

- Primarily designed to support LE Audio
- Allows the communication of time-bound data to one or more devices for time synchronized processing
- Primarily targeted towards hearing aids and assisted hearing systems in diverse locations such as theaters, conferences, lecture halls, etc.

Bluetooth Low Energy 5 Resources

- TI Bluetooth 5 overview page:
  - https://www.ti.com/wireless-connectivity/bluetooth/overview/bluetooth-5.html
- Connect Videos at training.ti.com
  - Connect: What's new with Bluetooth® 5.0?
- TI Developer's Portal (https://dev.ti.com)
  - SimpleLink™ Academy training modules
  - Bluetooth Low Energy 5 Stack Quick Start Guide and comprehensive User's Guide
- At Bluetooth.org
  - Bluetooth 5.0 Feature Overview
  - Bluetooth 5.1 Feature Overview
  - Bluetooth 5.2 Feature Overview

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