Welcome

Silicon Labs Live:
Wireless Connectivity Tech Talks
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Agenda

BT 5
- 2x data throughput with 2Mbps PHY: Faster OTAs
- 4x range: Building automation
- 8x Enh Advertisements configuration: Multiple Beacons

BT 5.1
- Direction finding: Asset tracking
- GATT Caching: Lower power on service discovery

BT 5.2
- LE Isochronous Channel: Multi-Stream Audio and Broadcast
- LE Power Control: Dynamic TX change, lower power, more reliability
Bluetooth 5 Summary

2x Speed
- 2M PHY vs. 1M PHY (BT 4x)
- double the throughput up to 1.4Mbps
- 15-50% lower power consumption

4x Range
- 125/500kbps coded PHYs improve Rx sensitivity /range
- New channel selection algorithm enables +20dBm TX

8x Advertisement Capacity
- Advertisement payload grows from 31B (BT 4) to 255B (BT 5)
- 37 new advertisement channels help offload 3 primary advertisement channels
- New advertisement schemes for advanced beacons
- Periodic Advertisement
Bluetooth 4 uses a single 1M PHY

Bluetooth 5 adds an optional 2M PHY

- Faster data rate – up to 1.4Mbps
- ~15%-50% lower power due to shorter TX/RX
- 0.8x range (Rx senstivity lower for 2M PHY)

<table>
<thead>
<tr>
<th>PHY</th>
<th>Symbol rate</th>
<th>Range multiplier</th>
<th>PDU Length</th>
<th>Minimum packet time</th>
<th>Maximum packet time</th>
<th>Maximum throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M</td>
<td>1 M symbols/s</td>
<td>1x</td>
<td>0–257 B</td>
<td>80us</td>
<td>2.12ms</td>
<td>800 kbps</td>
</tr>
<tr>
<td>2M</td>
<td>2 M symbols/s</td>
<td>0.8x</td>
<td>0–257 B</td>
<td>44us</td>
<td>1.064ms</td>
<td>1438 kbps</td>
</tr>
</tbody>
</table>
Bluetooth 5 adds two new LE coded PHYs

- Use 1M PHY but payload is coded at 125kbps or 500kbps
- Also adds Forward Error Correction and Pattern Mapper
- Improves sensitivity from 4 to 6dB and this means roughly 2x range
- LE Coded PHY can also be used for advertisement

Up to 2x range improvement

However, reduces throughput and increases TX/RX times (current consumption)

<table>
<thead>
<tr>
<th>Coded PHY (kbps)</th>
<th>Symbol rate</th>
<th>Error correction</th>
<th>Range multiplier</th>
<th>PDU Length</th>
<th>Minimum packet time</th>
<th>Maximum packet time</th>
<th>Maximum throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>500</td>
<td>1 M symbols/s</td>
<td>FEC</td>
<td>1.5x</td>
<td>0–257 B</td>
<td>462 µs</td>
<td>4.54 ms</td>
<td>382 kbps</td>
</tr>
<tr>
<td>125</td>
<td>1 M symbols/s</td>
<td>FEC</td>
<td>2x</td>
<td>0–257 B</td>
<td>720 µs</td>
<td>17.04 ms</td>
<td>112 kbps</td>
</tr>
</tbody>
</table>
EFR32BG13 to EFR32BG13 Indoor Range: +10dBm, 1M PHY, PCB antenna

- 800kbps over 5 meters
- 690kbps over 35 meters
- 622kbps over 21 meters
- 233kbps over 21 meters
- 230kbps over 23 meters
- 690kbps over 35 meters
- 800kbps over 5 meters

EFR32BG13 WSTK
EFR32BG13 to EFR32BG13 Indoor Range: +10dBm, 125k PHY, PCB antenna

- 100kbps over 5 meters
- 83kbps over 20 meters
- 90kbps over 21 meters
- 57kbps over 35 meters
- 90kbps over 35 meters
- 94kbps over 90 meters
- 83kbps over 5 meters
Bluetooth 5.1 Summary

**Direction finding**
- Detecting Bluetooth signal direction with AoA
- Adding signal direction to outgoing packets with AoD
- Benefits asset tracking and indoor positioning applications
- <1m accuracy vs. 3-5m accuracy with RSSI

**Faster and lower power connections**
- GATT caching
- Reduces need for GATT service discovery
- Faster and lower power connections

**Reduced interference for busy RF environments**
- Randomizing the advertisement packet collisions
- Reduces the number of packet collisions and improves PER

**Periodic advertising sync transfer**
- Transfer of periodic advertising sync between devices
How Angle-of-Arrival (AoA) Works?

**An asset wants to broadcast its location**
- Continuous tone extension (CTE) is added to the end of a Bluetooth advertisement or connection packet
- Asset can support other Bluetooth functions while being tracked as CTE does not use the payload

**A locator wants to find the asset**
- A locator needs to have multiple antennas, as antenna is switched during the CTE reception
- A locator listens for CTE packets and measures IQ data from the CTE payload
- Can perform spherical azimuth and elevation calculation, or pass the IQ data forward to back-end processing
How AoA Works at a System Level?

Local Position Engine
- Collects relative raw or pre-processed IQ data from all locators
- Performs X,Y and Z calculations
- Additional applications (site planning zones, alerts, heat maps etc.)

Bluetooth AoA Locators
- While one locator can be used to estimate the assets location, a network of multiple locators improve accuracy and reliability
- Locators with enough processing power can pre-process to IQ data

Cloud Position Engine
- Collects relative raw or pre-processed IQ data from all locators
- Performs X,Y and Z calculations
- Additional applications (site planning zones, alerts, heat maps etc.)

Locators with enough processing power can pre-process to IQ data. While one locator can be used to estimate the asset's location, a network of multiple locators improves accuracy and reliability. Additional applications include site planning zones, alerts, and heat maps.
GATT Caching

**How it works?**
- A hash value is calculated over the GATT service database
- Its value is exposed via Generic Attribute Service
- Reading the value does not require bonding

**Benefits**
- Client device can easily check if GATT database has changed
- Reduces the need for service discovery and therefore saves power and enables faster connections
- If client connects to multiple same type devices, can reduce the need for service discovery significantly

**Applications that benefit**
- Any that use connections
Bluetooth 5.2 Summary

**LE Isochronous Channels**
- Time-bound data distribution to one or more devices
- LE Audio
- Low Complexity Communications Codec (LC3)
- Four Bluetooth LE PHYs (2M, 1M, 500K, 125K)
- Multi-Stream Audio
  - True Wireless Earbuds, Multi-room audio synchronization system
- Broadcast Audio → Audio Sharing
  - Personal audio sharing
  - Location-based audio sharing: public venues

**More reliable connections, lower power and better coexistence**
- LE Power Control
- Reduction of overall power consumption by dynamic power management conducted between connected devices.
- Improvements in reliability through the active maintenance of receiver signal strength
- Improvements relating to coexistence with other wireless devices that are in the environment and are using the 2.4 GHz frequency range.
LE Power Control

How it works?
- Dynamic changing of the Transmitter Power level based on Receiver RSSI
- Allows receiving device to be on the Golden Receiving Range
  - RSSI is too low – request to increase TX power
  - RSSI is in the optimal range – no need to change
  - RSSI is too high – request to decrease TX power
- Monitors and reports path loss

Benefits
- Optimization on Power from TX and RX sides
- Improvement on Reliability and requiring less retries
- Better Over the Air Coexistence with other 2.4GHz devices
- Better user experience in terms of throughput and responsiveness.

Applications that benefit
- Any that use connections
BG21: Optimized for Secure Mains Powered Devices

Radio
- Up to +20 dBm TX
- -97.5 dBm @1 Mbps RX sensitivity
- Bluetooth 5.1

Current Consumption
- 8.8 mA RX (1 Mbit/s GFSK)
- 10.5 mA TX @ 0 dBm
- 33.8 mA TX @ 10 dBm
- 4-8uA EM2 (DeepSleep Mode)

World Class Protocol Stacks
- Bluetooth 5.1 and Bluetooth mesh
- Apple HomeKit protocol

Compact Size
- 4x4 QFN32 (20 GPIO)

Operating Temp.
- -40 to 125 °C ambient

ARM Cortex-M33 with TrustZone
- 38.4/80 MHz
- FPU and DSP
- Up to 96kB RAM and 1024kB flash
- 50.9 µA/MHz

Peripherals Fit for Purpose
- 3x USART, 2x I2C
- 1x 12-bit ADC, 2x ACMP
- 7x timers
- Up to 20x GPIO

Security
- True Random Number Generator
- Hardware Accelerated Crypto Engine
- Secure Boot with root of trust
- Secure debug with lock/unlock
- DPA Countermeasures

With Secure Vault™
- Anti tamper
- Secure attestation
- Secure key management and storage
- Advanced crypto

BG21 can be paired with Energy Friendly Power Management IC to reduce active TX/RX current consumption:
https://www.silabs.com/power/efp01-power-management-ic
BG22: Optimized Battery Powered Bluetooth LE

**Secure Bluetooth 5.2 SoCs for High-Volume Products**

**Radio**
- Bluetooth 5.2
- TX: -27 to +6 dBm
- RX: -96 to -107 dBm
- 1M, 2M and LE Coded PHYs
- AoA & AoD

**Ultra-Low Power**
- 3.5 mA @ 0dBm TX (radio)
- 2.6 mA RX (radio)
- 1.4 µA EM2 with 32 kB RAM
- 0.5 µA w/ RTC in EM4

**World Class Software**
- Bluetooth 5.2
- Bluetooth mesh LPN
- Direction Finding

**Compact Size**
- 5x5 QFN40 (26 GPIO)
- 4x4 QFN32 (18 GPIO)
- 4x4 TQFN32 (18 GPIO)

**ARM Cortex-M33 with TrustZone**
- 38.4/76.8 MHz
- 352/512 kB of flash
- 32kB RAM

**Peripherals Fit for Purpose**
- 2x USART, 2x I2C, 2x PDM and GPIO
- 12-bit ADC (16 channels)
- Built-in temperature sensor with +/-1.5 °C
- Built-in 32 kHz, 500ppm sleep clock

**Security**
- AES128/256,SHA-1, SHA-2 (256-bit)
- ECC (up to 256-bit), ECDSA and ECDH
- True Random Number Generator (TRNG)
- Secure boot with RTSL
- Secure debug with lock/unlock
## Silicon Labs’ Bluetooth SoC Families

<table>
<thead>
<tr>
<th></th>
<th>Series 1 - BG13</th>
<th>Series 2 - BG21</th>
<th>Series 2 - BG22</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target applications</strong></td>
<td>General purpose Bluetooth LE and mesh</td>
<td>Mains powered Bluetooth LE and mesh</td>
<td>Lowest power Bluetooth LE, Direction Finding and Bluetooth mesh LPNs</td>
</tr>
<tr>
<td><strong>Bluetooth features</strong></td>
<td>5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)</td>
<td>5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)</td>
<td>5.2 and Bluetooth mesh LPN (1M, 2M, LE Coded PHYs, AE and AoA/D)</td>
</tr>
<tr>
<td><strong>Proprietary 2.4G</strong></td>
<td>2/4(G)FSK, OQPSK/(G)MSK, DSSS, BPSK/DBPSK TX, OOK/ASK</td>
<td>N/A</td>
<td>2/4(G)FSK, (G)MSK, OQPSK, DSSS</td>
</tr>
<tr>
<td><strong>TX / RX (1M, GFSK)</strong></td>
<td>+19 dBm / -95.8 dBm</td>
<td>+20 dBm / -97.5 dBm</td>
<td>+6 dBm / -99 dB</td>
</tr>
<tr>
<td><strong>TX Current (0 dBm)</strong></td>
<td>10.5 mA</td>
<td>10.5 mA</td>
<td>4.1 mA*</td>
</tr>
<tr>
<td><strong>RX Current (1M, GFSK)</strong></td>
<td>9.5 mA</td>
<td>8.8 mA</td>
<td>8.2 mA (6 dBm)*</td>
</tr>
<tr>
<td><strong>CPU / Clock Speed</strong></td>
<td>Cortex M4 (38.4 MHz)</td>
<td>Cortex M33 (80 MHz)</td>
<td>Cortex M33 (up to 76.8 MHz)</td>
</tr>
<tr>
<td><strong>Flash (kB)</strong></td>
<td>512</td>
<td>Up to 1024</td>
<td>Up to 512</td>
</tr>
<tr>
<td><strong>RAM (kB)</strong></td>
<td>64</td>
<td>Up to 96</td>
<td>32</td>
</tr>
<tr>
<td><strong>Sleep Current (EM2)</strong></td>
<td>1.3 µA (16 kB RAM)</td>
<td>4.5 µA (96 RAM)</td>
<td>1.21 µA (8 kB RAM) - 1.4 µA (32 kB RAM)</td>
</tr>
<tr>
<td><strong>Active Current (EM0)</strong></td>
<td>70 µA/MHz</td>
<td>51 µA/MHz</td>
<td>25 µA/MHz</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>2x AES-128/256, SHA-1/2 ECC, SHA-1/224/256, TRNG</td>
<td>AES-128/256, SHA-1/2 ECC, ECDSA and TRNG</td>
<td>AES-128/256, SHA-1/2 ECC, ECDSA and TRNG</td>
</tr>
<tr>
<td><strong>Operating Voltage</strong></td>
<td>1.8V – 3.6V</td>
<td>1.8V – 3.8V</td>
<td>1.71V – 3.8V</td>
</tr>
<tr>
<td><strong>Packages (mm)</strong></td>
<td>7x7 QFN48, 5x5 QFN32</td>
<td>4x4 QFN32 (20x GPIO)</td>
<td>5x5 QFN40 (26x GPIO) 4x4 QFN32, TQFN32 (18x GPIO)</td>
</tr>
</tbody>
</table>

* MCU + radio value
## Silicon Labs’ Bluetooth Module Families

<table>
<thead>
<tr>
<th>Protocols</th>
<th>BGM13P</th>
<th>BGM13S</th>
<th>BGM210P</th>
<th>BGM210L</th>
<th>BGM220P (Q2’20)</th>
<th>BGM220S (Q2’20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 and mesh (1M, 2M, Coded PHY and AE)</td>
<td>5.1 and mesh (1M, 2M, Coded PHY and AE)</td>
<td>5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE)</td>
<td>5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE)</td>
<td>5.2 and mesh 1.0 LPN (1M, 2M, Coded PHY, AE and AoA/D)</td>
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<td></td>
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<tr>
<th>EFR32 SoC</th>
<th>BG13</th>
<th>BG13</th>
<th>BG21</th>
<th>BG21</th>
<th>BG22</th>
<th>BG22</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Antenna</th>
<th>Built-in or U.FL</th>
<th>Built-in or RF pin</th>
<th>Built-in or RF pin</th>
<th>Built-in</th>
<th>Built-in</th>
<th>Built-in or RF pin</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Max TX power</th>
<th>+8 / +19 dBm</th>
<th>+8 / +18 dBm</th>
<th>+10 / +20 dBm</th>
<th>+12.5 dBm</th>
<th>+8 dBm</th>
<th>+6 dBm</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Sensitivity (1M)</th>
<th>-94.8 dBm</th>
<th>-94.1 dBm</th>
<th>-97 dBm</th>
<th>-97 dBm</th>
<th>-98 dBm</th>
<th>-98 dbm</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Flash (kB)</th>
<th>512</th>
<th>512</th>
<th>1024</th>
<th>1024</th>
<th>512</th>
<th>512</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>RAM (kB)</th>
<th>64</th>
<th>64</th>
<th>96</th>
<th>96</th>
<th>32</th>
<th>32</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>GPIO</th>
<th>25</th>
<th>30</th>
<th>20</th>
<th>12</th>
<th>24,25</th>
<th>25</th>
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</thead>
</table>

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<tr>
<th>Operating Voltage</th>
<th>1.8V – 3.6V</th>
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<th>1.71V – 3.8V</th>
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</thead>
</table>

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<tr>
<th>Operating Temp.</th>
<th>-40 to +85C</th>
<th>-40 to +85C</th>
<th>-40 to +125C</th>
<th>-40 to +125C</th>
<th>-40 to +105C</th>
<th>-40 to +105C</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Dimensions W x L x H (mm)</th>
<th>13.0 x 15.0 x 2.2</th>
<th>6.5 x 6.5 x 1.4</th>
<th>13.0 x 15.0 x 2.2</th>
<th>13.0 x 15.0 x 2.2</th>
<th>13.0 x 15.0 x 2.2</th>
<th>6 x 6 x 1.3</th>
</tr>
</thead>
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<table>
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<tr>
<th>Certifications</th>
<th>BT, CE, FCC, ISED, Japan, S-Korea and Taiwan</th>
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Bluetooth LE Software

A Bluetooth 5.2 compliant Bluetooth stack, with:
- Bluetooth 5.2 LE power control*
- Bluetooth 5.1 Direction Finding* and GATT caching
- Bluetooth 5.0 standard features
- Relevant Bluetooth 4.x features

Packed with advanced functionality
- Multiple connections and advertisers
- Concurrent advertising, scanning and LE connections
- Optimized throughput and power consumption

Built on top of the common EFR32 software platform
- Gecko bootloader
- emLib for MCU peripherals and drivers
- NVM3 key/value pair data storage with wear leveling
- RAIL radio driver

Thunderboard BG22

- Bluetooth 5.2 BG22 Soc
- Relative Humidity Sensor
- Ambient Light and UV Index Sensor
- Hall effect sensor
- 6 axis Gyro and Accel Sensor (Asset Tags and Beacons)
- 2 Digital mems Microphones with PDM output
- Built-in Debugger
- Free iPhone and Android App
- $19.99
BG22 Virtual Workshop

Learn how to develop and deploy more powerful, efficient, and secure IoT products with your own BG22 Thunderboard – free for all registrants!

Asia Pacific (Mandarin): June 17th - June 19th, 2020
10:00AM – 11:30 HKT
(Other sessions available for Americas and Europe)

SEPTEMBER 9-11, 2020 | AUSTIN TEXAS

https://workswith.silabs.com

PROMO CODE: WWSH
50% OFF EARLY BIRD
Thank You  | Questions

Any query, please contact us or email to Winking.He@silabs.com

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