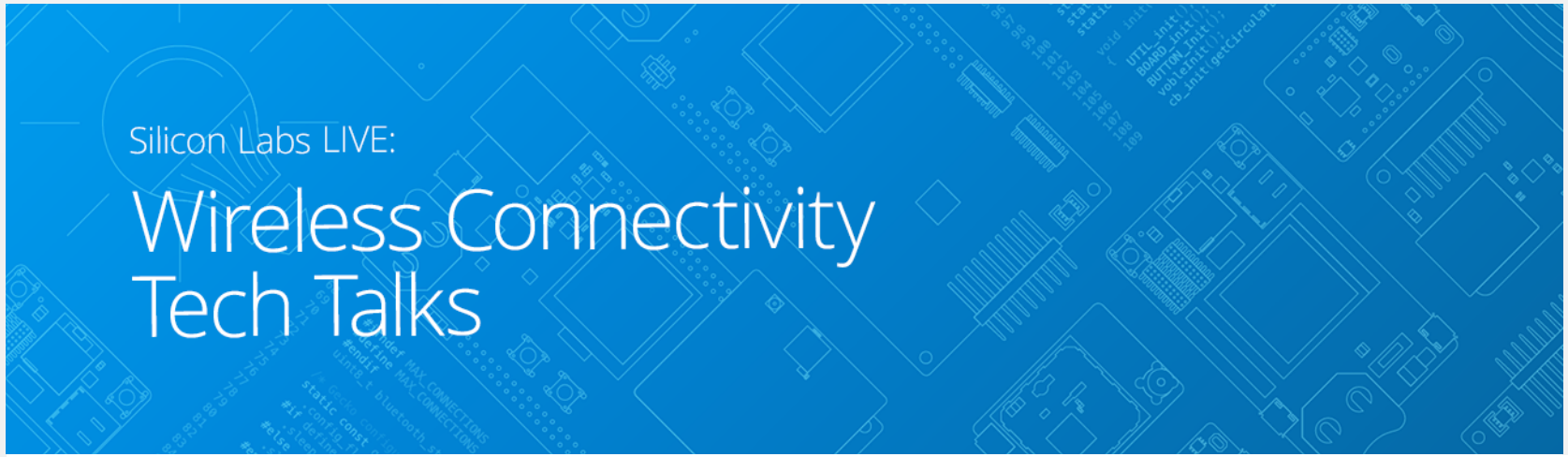
# WELCOME

Silicon Labs LIVE:

## Wireless Connectivity Tech Talks

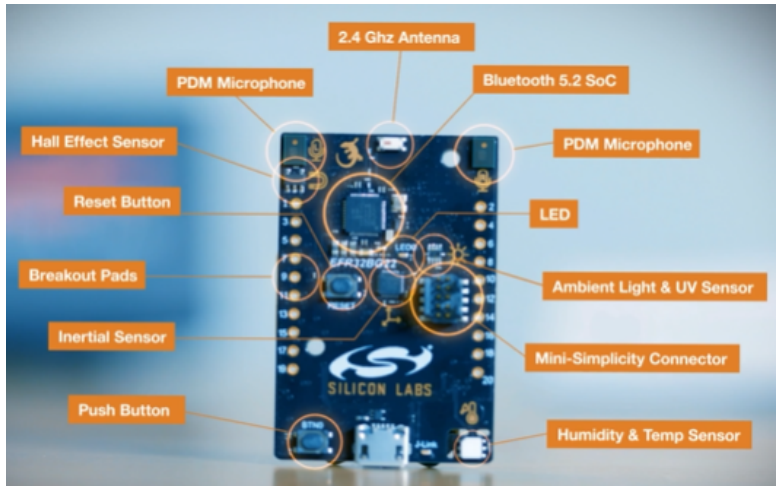
# Tech Talks LIVE Schedule – Presentation will begin shortly




| Topic | Date |
|---|---|
| Connected Home Over IP for Beginners | Tuesday, April 21 |
| Z-Wave Smart Home Solutions | Thursday, April 23 |
| **Battery Optimization with BG22** | **Tuesday, April 28** |
| Max Performance on BLE – Simultaneous Connections, Beacons and Scanning | Thursday, April 30 |
| SubGHz proprietary and Connect software stack | Tuesday, May 5 |
| How to measure and debug network performance - Using Silicon Labs network analyzer | Thursday, May 7 |

https://www.silabs.com/support/training

Please take the 3 question poll while waiting and be entered to receive a Thunder BG22 Kit.



# Training Update: Training targeted for www.silabs.com/training

| Topic | MP4 | BRAINSHARK | Mandarin |
|---|---|---|---|
| BG22 Out-of-box Experience | IntroxG22-mp4 | IntroxG22-BSHK | IntroxG22-cn-mp4 |
| BG22 Low Power Features and Demo | BG22LowEnergy-mp4 | BG22LowEnergy-BSHK | BG22LowEnergy-cn-mp4 |
| BG22 HW Design Guidance | HWConsiderationsBG22-mp4 | HWConsiderationsBG22-BSHK | HWConsiderationsBG22-cn-mp4 |
| Security Introduction | SecurityIntro-mp4 | SecurityIntro-BSHK | In Progress |
| Secure Boot with Root of Trust Secure Loader (RTSL) | SecureBootRTSL-mp4 | SecureBootRTSL-BSHK | SecureBootRTSL-cn-mp4 |
| Debug BLE with Network Analyzer | BLENetworkAnalyzer-mp4 | BLENetworkAnalyzer-BSHK | BLENetworkAnalyzer-cn-mp4 |
| Debug with EFR Connect Mobile App | IntroEFRConnect-mp4 | IntroEFRConnect-BSHK | IntroEFRConnect-cn-mp4 |
| Debug with a Secure Debug Port | SecureDebug-mp4 | SecureDebug-BSHK | SecureDebug-cn-mp4 |
| Debug with BGTool | BGTool-mp4 | BGTool-BSHK | BGTool-cn-mp4 |
| Bluetooth Advertisement Extensions | BLEAdvertExtensions-mp4 | BLEAdvertExtension-BSHK | BLEAdvertExtensions-cn-mp4 |
| Bluetooth Dynamic TX Power | BluetoothTXPower-mp4 | BluetoothTXPower-BSHK | In Progress |
| Bluetooth Secure OTA | SecureOTA-mp4 | SecureOTA-BSHK | In Progress |
| Bluetooth Direction Finding | BLEDirectionFinding-mp4 | BLEDirectionFinding-BSHK | In Progress |
| Customer Bluetooth Qualification Process | BLECertification-mp4 | BLECertification-BSHK | In Progress |
| Customer RF Regulatory Process | RFRegulatory-MP4 | RFRegulatory-BSHK | RFRegulatory-cn-mp4 |
| Z-Wave Peripheral Tutorial | ZWavePeripherals-mp4 | ZWavePeripherals-BSHK | In progress |
| Z-Wave Associations | ZWaveAssociations-mp4 | ZWaveAssociations-BSHK | In progress |
| Z-Wave Certification | ZWaveCertification-mp4 | ZWaveCertification-BSHK | In progress |
| Z-Wave CTT Introduction | ZWaveCTTIntro-mp4 | ZwaveCTTIntro-BSHK | |
| Bluetooth RF-PHY Evaluation | BluetoothRFPHYEval-mp4 | BluetoothRFPHYEval-BSHK | |

# Battery Optimization with BG22

APRIL 2020

# Agenda

- EFR32BG22 overview summary
- Available Energy modes
- BLE Stack operational overview and features for battery optimization
- SoC hardware features for battery optimization

# EFR32BG22: Optimized Battery Powered Bluetooth LE

Optimized


## 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 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

# Extending Battery Life in Bluetooth Applications


| Location Services | Data Transfer |
|---|---|
| Connected to a phone at 2000ms interval | Advertising 10 bytes every 2000ms |
| Using 2M PHY and transmitting 10 Byte / packet | TX at 0dBm and 3 using channels |
| Average current: 4.2µA | Average current: 4.7µA |
| **5+ years on CR2032<br>10+ years on a CR2354** | |

# 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!

North America: May 19th–21st, 2020

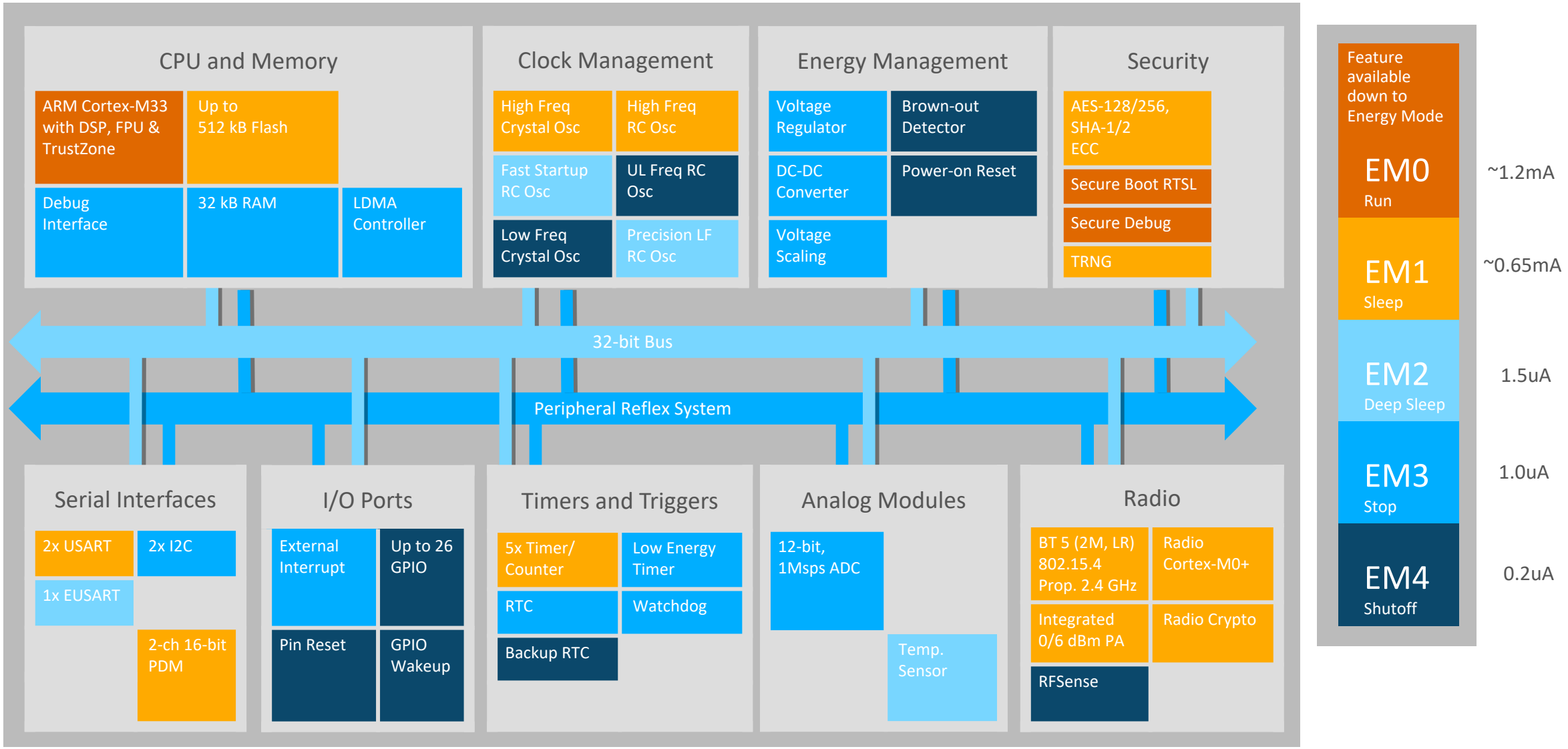
May 12th-14th, 2020

10:00AM –11:30 AM CST

(Other sessions available for Asia Pacific and Europe)

Register today! https://www.silabs.com/about-us/events/virtual-bluetooth-workshop

# SoC Hardware Features – EFR32BG22

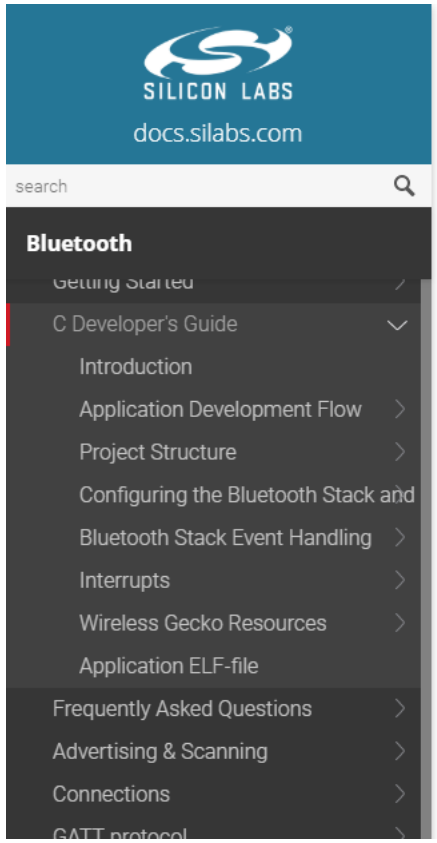


# BLE Intervals and Energy Modes

# Energy Profiler

# Battery Optimization – Software Considerations

- Resources
  - https://docs.silabs.com/bluetooth/latest/




You are viewing documentation for version: **2.13** (latest) | 2.12 | Version History

## C Developer's Guide

### Introduction

This document is a C developer's guide for the Silicon Labs Bluetooth stack.

The document covers various angles of development, and is an important reference to everyone developing in C for Wireless Gecko products that are running the Bluetooth stack.

The document covers the following topics:

- Section Application Development Flow discusses the application development flow and project structure.
- Section Configuring the Bluetooth Stack and a Wireless Gecko Device explains the project include libraries and the actual Wireless Gecko configuration in the application code.
- Section Bluetooth Stack Event Handling is an important piece for everyone developing with the Silicon Labs Bluetooth stack, as it explains how the application runs in sync with the stack in an event-based architecture.
- Section Interrupts and Wireless Gecko Resources touch on the topics of peripherals and the chipset resources, covering what is reserved for the stack usage, how interrupts should be handled, and the stack's memory footprint and available memory for the application.

# Software – Gecko Event Handler

- The SiLabs BLE stack utilizes an event handler to notify the application of BLE related events.
- If configured the BLE stack will automatically enter the lowest available power state when there are no events available from the stack.

```
/* Wait (blocking) for a Bluetooth stack event. */
evt = gecko_wait_event();
```

- The end user can prevent the stack from entering low power mode by calling a non-blocking function: gecko_peek_event.
- Low power states can still be used by requesting the available time the stack can sleep via gecko_can_sleep_ms
- Then the stack can be put into an EM low power state by issuing a gecko_sleep_for_ms command.

```
struct gecko_cmd_packet* gecko_peek_event(void)
```

```
uint32 gecko_can_sleep_ms(void)
```

```
uint32 gecko_sleep_for_ms(uint32 max)
```

https://docs.silabs.com/bluetooth/latest/general/c-developer39s-guide

# Software Timers, Ticks

- Applications typically have various actions that occur on set time intervals: Check a battery, Communication time outs, slow LED control
  - Application timers such as this consume a significant amount of power as the core needs to wake up to handle every tick event.
- Alternatively the user can actively manage application level timers, and set a timer to wake up to handle the next event

```
void SysTick_Handler(void)  { /* SysTick interrupt Handler. Interrupt every mil
  msTicks++;
}
uint32_t getTimeStamp(void){  //Return Current Tick value
    return msTicks;
}
bool timerExpired(uint32_t timestamp, delta){
    if((timestamp + delta) > msTicks)           //Determine if a Timer expired
        return true;
    else
        return false;
}
```

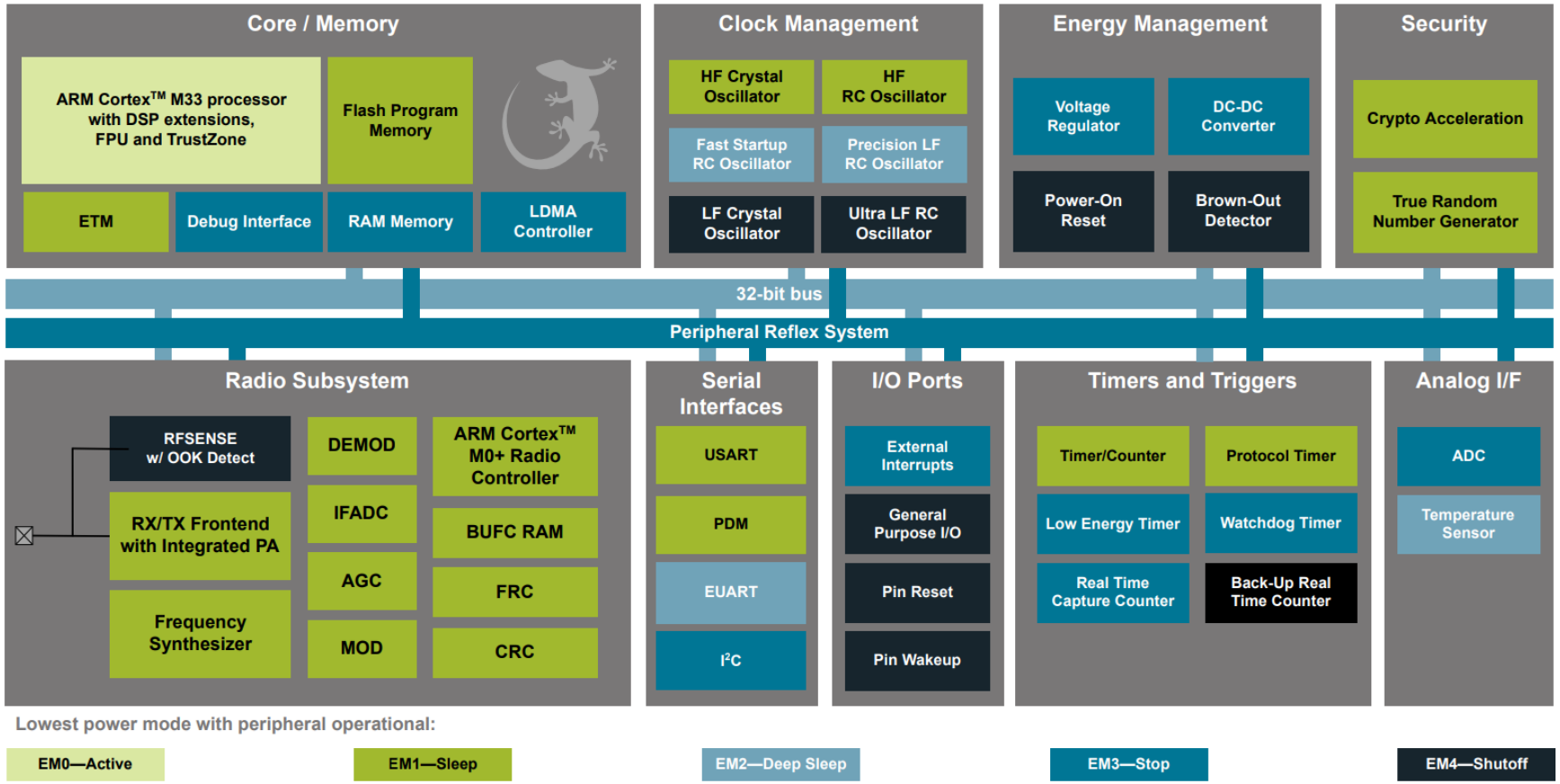
- Utilize the BLE stack software timers
  - Soft Timer
  - Lazy Soft Timer
    - Timer with ‘slack’, allows device to trigger timer event while it’s already in a high power state for other functions
  - Stack can support up to 16 simultaneous timers
  - Supports Single Shot or Repeating Timer modes
  - Valid Timer range is 10ms up to 18.2 hours

```
  gecko_cmd_hardware_set_soft_timer(SOFT_TIMER_1_SECOND, TIMER_HANDLE_POLL_UART, TIMER_ONE_SHOT);
  break;

case gecko_evt_hardware_soft_timer_id:
  switch(evt->data.evt_hardware_soft_timer.handle){
  case TIMER_HANDLE_POLL_UART:
    UARTDRV_Receive(UART_Handle, uart_data, 5, NULL);
    SLEEP_SleepBlockBegin(sleepEM2);
    gecko_cmd_hardware_set_soft_timer(SOFT_TIMER_30_SECOND, TIMER_HANDLE_STOP_UART, TIMER_ONE_SHOT);
    break;                          //Timeout UART operation if no data is received in 30 seconds

  case TIMER_HANDLE_STOP_UART:
    UARTDRV_Abort(UART_Handle, uartdrvAbortAll);
    break;
  default:
    break;
  }
  break;
```

https://docs.silabs.com/bluetooth/latest/hardware#cmd_hardware_set_soft_timer

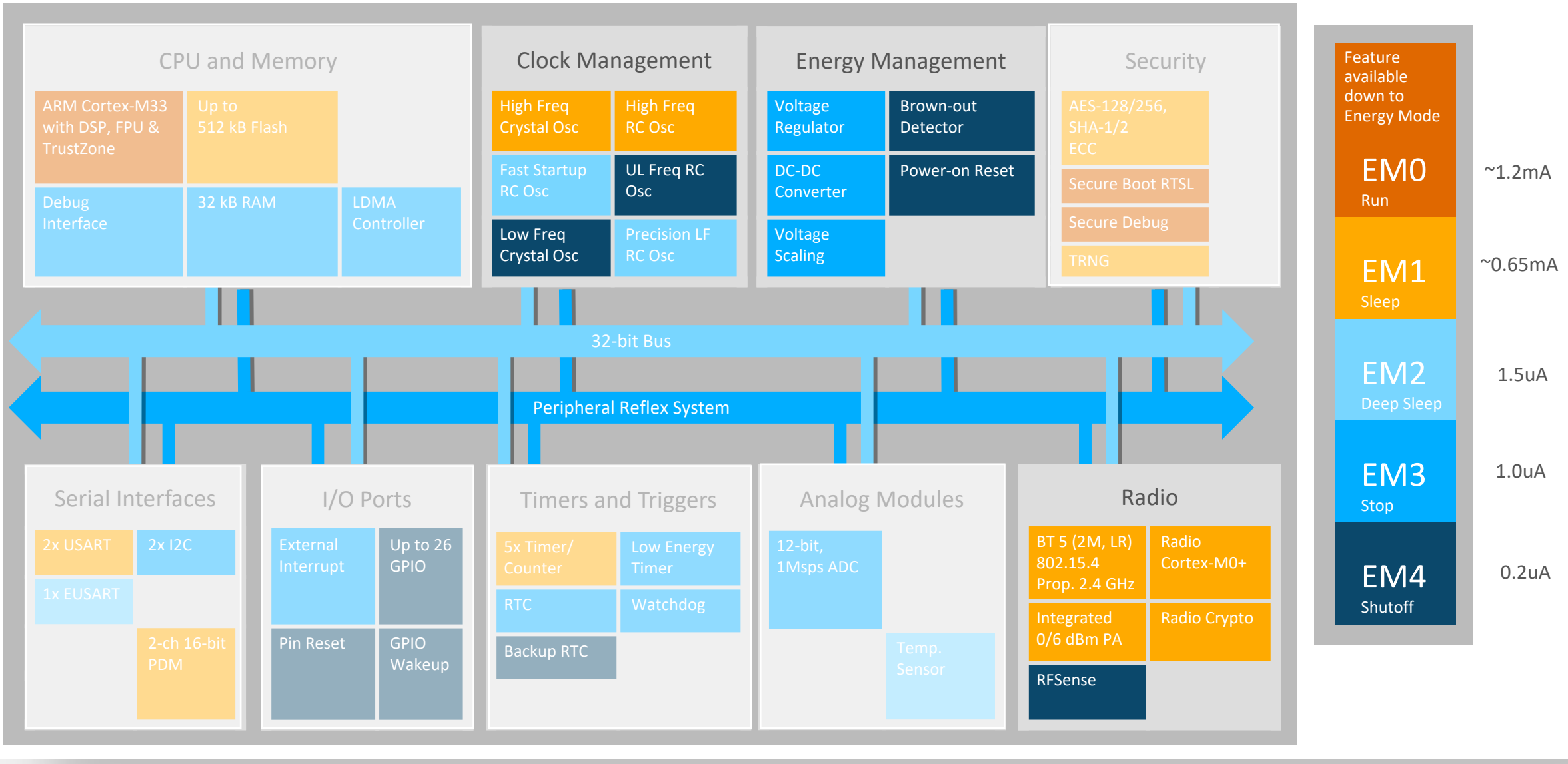
# Software – Managing Power States

- Understand the various power states and use the sleep driver to help manage the device.
  - SLEEP_SleepBlockBegin(sleepEM2);  will prevent the device from entering EM2 or lower power states
  - Use this while trying to utilize peripherals that require the high speed clocks, like ADC or UART/SPI




https://docs.silabs.com/bluetooth/latest/general/system-and-performance/using-energy-modes-with-bluetooth-stack

# SoC Hardware Features – EFR32BG22



# Save Power by using the DC/DC – Energy Management Unit

- The EFR32BG22 can consume
  - 2mA while in EM0
  - 2uA while in EM2
- Utilize the internal DC/DC for better power efficiency.
- Using the DC/DC can reduce the EM0 current consumption to
  - 1.32mA while in EM0 (30% energy savings)
  - 1.5uA in EM2 (25% energy savings).
- DC/DC converter operates down to 2.2V
- Utilize the VDD Comparator
  - The EMU contains a VDD Comparator to help monitor the main supply voltage level.
  - The comparator will trigger an interrupt if the voltage drops below a configured value to allow the user to bypass the DC/DC converter.
- DC/DC requires an extra inductor and capacitor for operation.

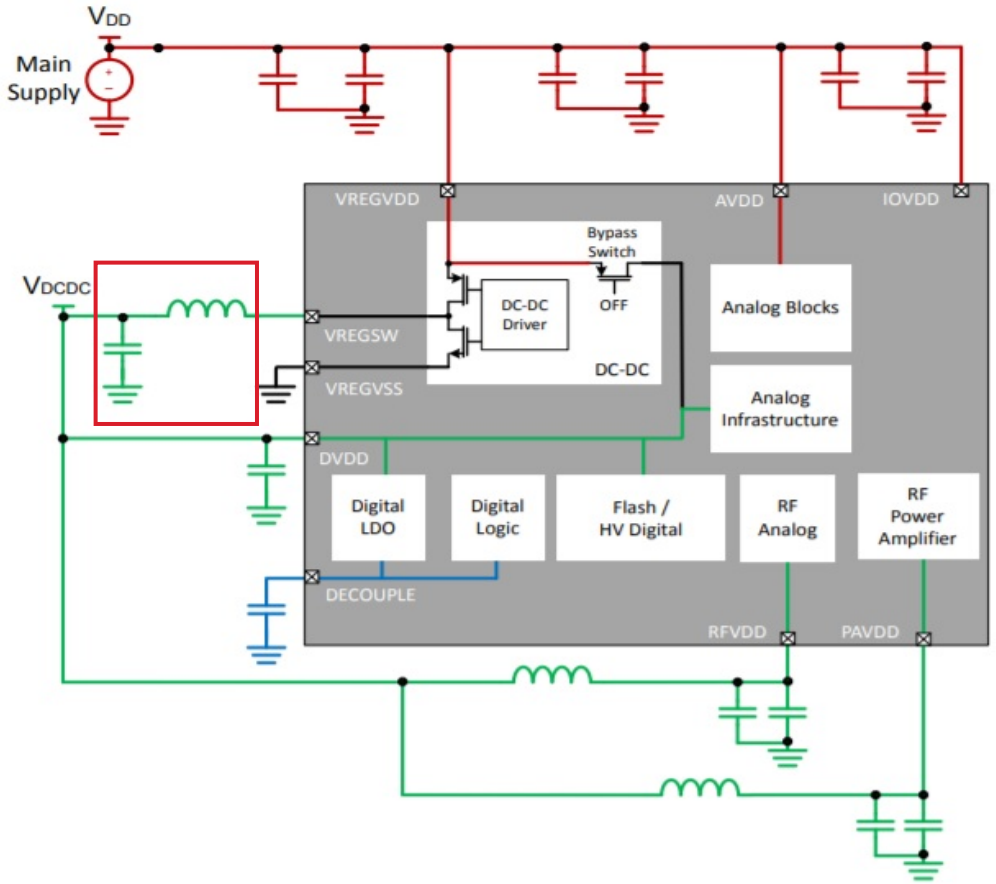
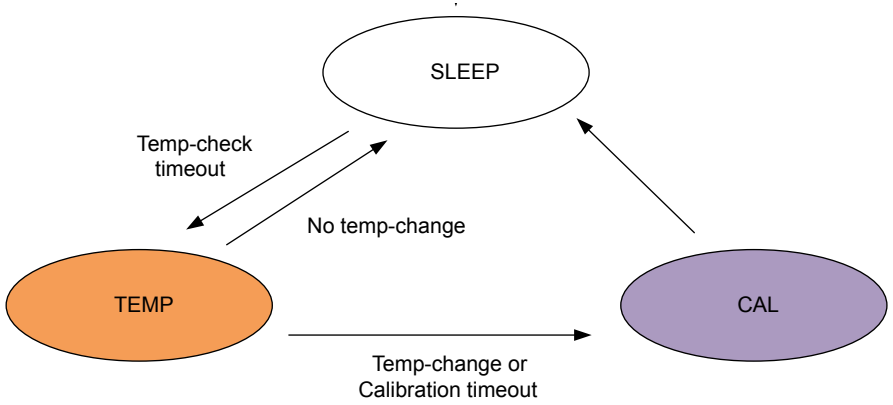


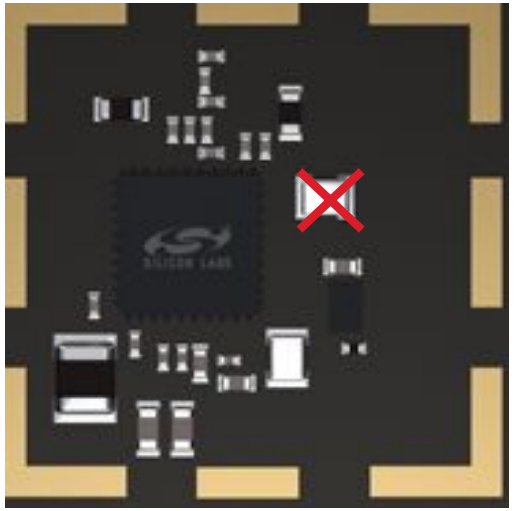

**Figure 12.4. DC-DC Power Configuration**

# Low Power considerations vs BoM reduction

- Using a precision 32k crystal can reduce overall current consumption.
  - EM2 state with an external crystal consumes 1.4uA
  - Active connection with 48ms intervals consumes 49uA average
- EFR32BG22 offers an internal Precision RC Oscillator that can be used in place of an external 32k crystal
  - Ideally used for tag application that infrequently connect.
  - Available in normal energy mode and down to EM2 in precision mode
  - Precision mode provides 500 ppm accuracy
    - Achieved with temperature sensing and autonomous calibration
    - Temperature check rate is configurable
- EM2 current consumption in precision mode
  - EM2 state with LFRCO consumes 1.7uA in stable temperature
    - > +10 uA  at dynamic temperature due calibrations
  - Active connection with 48ms intervals consumes 52uA average




```
CMU_OscillatorEnable(cmuOsc_LFRCO, true, true);
CMU_LFRCOSetPrecision(cmuPrecisionHigh);
```



# Power savings through clocking

- The EFR32BG22 requires a 38.4MHz external crystal oscillator for radio operation.
- The application core can be configured to operate at 38.4MHz or 76.8MHz.
  - If the higher operating speed is not needed current consumption can be reduced by ~50%+ by running the core at 38.4MHz.

| | | | | |
|---|---|---|---|---|
| 76.8 MHz HFRCO w/ DPLL referenced to 38.4 MHz crystal, CPU running Prime from flash, VSCALE2 | — | 28 | — | µA/MHz |
| 38.4 MHz crystal, CPU running Prime from flash | — | 28 | — | µA/MHz |

- Understanding your use case to determine the optimal clock settings
- A thermometer or asset tag would benefit from a low clock speed and the lower current consumption
- Computationally intense applications would save power by being able to process the complex data much faster.

# Maintain integrity of your battery with internal temperature sensor

- Many industrial applications operate in conditions that are not suitable for standard battery chemistries or form factors.
  - Overall battery life can be greatly impacted while used in extremely cold conditions
- The EFR32BG22 provides an integrated die level temperature sensor that can achieve accuracy of ±1.5 °C.
  - Provides resolution steps of 0.25 °C.
  - Samples taken every 250ms
  - Configurable interrupts available: new measurement, updated average, configured low threshold crossed, configured high level threshold crossed.

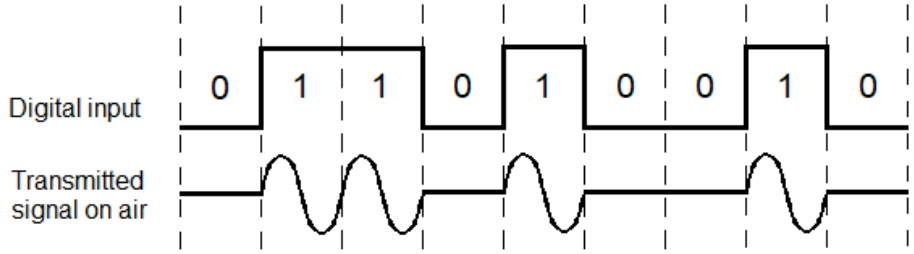

# Battery Optimization – Power Amplifier

- The BG22 has a 0dBm PA optimized for extended battery life in personal area network devices.
  - Such as Wearables, heart rate monitors, and blood glucose monitors.
- The PA of the BG22 has different operating modes: High Power and Low Power.
  - With High power mode a TX of 0dBm will require more power than if it is configured for Low Power mode.
  - High Power Mode TX at 0dBm consumes 5.2mA
  - Low Power Mode TX at 0dBm consumes 4.2mA

```
/* Bluetooth stack configuration parameters (see "UG136: Silicon Labs Bluetooth C Applica
static gecko_configuration_t config = {
  .config_flags = 0,                                  /* Check flag options from UG136 *
  .sleep.flags = SLEEP_FLAGS_DEEP_SLEEP_ENABLE,       /* Sleep is enabled */
//  .......
  .pa.config_enable = 1,                              /* Set this to be a valid PA confi
  .pa.input = GECKO_RADIO_PA_INPUT_DCDC,              /* Configure PA input to DCDC */
  .pa.pa_mode = RAIL_TX_POWER_MODE_2P4GIG_LP,         /* RAIL_TX_POWER_MODE_2P4GIG_LP  ,
//  .......
};
```

# Battery Optimization – Pre commissioned Storage

- Sealed one-time-use Badges, Wristbands and Tags
  - Devices are sealed with batteries at manufacturing
  - Devices travel to use site
  - Devices will normally then be stored before use.
- BG22 offers a deep sleep (< 200 nA) storage mode with the ability to begin normal operation with a RF wake signal
- RF Sense
  - Wake up from EM2, EM3 and EM4 modes
  - Continuous wave and OOK (On-Off keying) preamble and syncword detection
  - 4 / 8 bit preamble and 8 / 16 / 32 bit syncword
  - RF detection threshold programmed between -35dBm and -14dBm
  - Low power consumption < 200 nA



# Selecting a BG22 Device

| | BG22C112 | BG22C222 | BG22C224 |
|---|---|---|---|
| **Use cases** | High-volume, consumer | Better RF, more GPIO | Advanced features, higher temp rating |
| **Bluetooth features** | 1M and 2M PHYs<br>AoA TX | 1M and 2M PHYs<br>AoA TX | 1M and 2M PHYs<br>125k and 500k LE Coded PHYs<br>Bluetooth mesh LPN<br>IQ sampling for AoA |
| **Max TX power** | 0 dBm | 6 dBm | 6 dBm |
| **RAM** | 32 kB | 32 kB | 32 kB |
| **Flash** | 352 kB | 352 kB | 512 kB |
| **Max Temperature** | -40 to +85°C | -40 to +85°C | -40 to +85°C (GN/GM OPNs)<br>-40 to +105°C (IM OPNs) |
| **Max GPIO** | 18 | 26 | 26 |
| **Package options** | 4x4 QFN32 | 4x4 QFN32<br>4x4 TQFN32<br>5x5 QFN40 | 4x4 QFN32<br>4x4 TQFN32<br>5x5 QFN40 |

See BG22 Data Sheet for complete list of Orderable Part Numbers (OPNs)

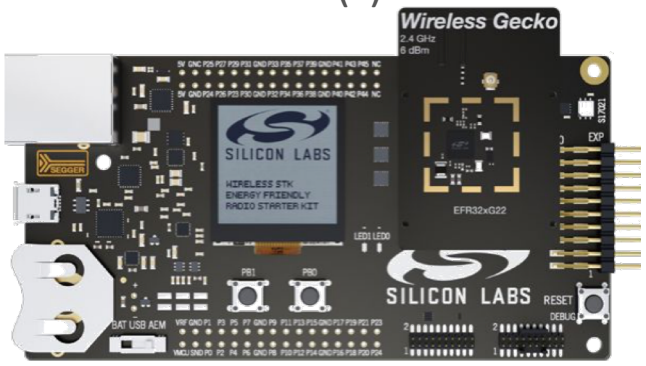
# Silicon Labs' Bluetooth Module Families

| |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| | **BGM13P** | **BGM13S** | **BGM210P** | **BGM210L** | **BGM220P (Q3'20)** | **BGM220S (Q3'20)** |
| **Protocols** | 5.1 and mesh (1M, 2M, Coded PHY and AE) | 5.1 and mesh (1M, 2M, Coded PHY and AE) | 5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE) | 5.1 and mesh 1.0 (1M, 2M, Coded PHY and AE) | 5.2 and mesh 1.0 LPN (1M, 2M, Coded PHY, AE and AoA/D) | 5.2 and mesh 1.0 LPN (1M, 2M, Coded PHY, AE and AoA/D) |
| **EFR32 SoC** | BG13 | BG13 | BG21 | BG21 | BG22 | BG22 |
| **Antenna** | Built-in or U.FL | Built-in or RF pin | Built-in or RF pin | Built-in | Built-in | Built-in or RF pin |
| **Max TX power** | +8 / +19 dBm | +8 / +18 dBm | +10 / +20 dBm | +12.5 dBm | +8 dBm | +6 dBm |
| **Sensitivity (1M)** | -94.8 dBm | -94.1 dBm | -97 dBm | -97 dBm | -98 dBm | -98 dbm |
| **Flash (kB)** | 512 | 512 | 1024 | 1024 | 512 | 512 |
| **RAM (kB)** | 64 | 64 | 96 | 96 | 32 | 32 |
| **GPIO** | 25 | 30 | 20 | 12 | 24,25 | 25 |
| **Operating Voltage** | 1.8V – 3.6V | 1.8V – 3.6V | 1.8 – 3.8V | 1.8 – 3.8V | 1.71V – 3.8V | 1.71V – 3.8V |
| **Operating Temp.** | -40 to +85C | -40 to +85C | -40 to +125C | -40 to +125C | -40 to +105C | -40 to +105C |
| **Dimensions W x L x H (mm)** | 13.0 x 15.0 x 2.2 | 6.5 x 6.5 x 1.4 | 13.0 x 15.0 x 2.2 | 13.0 x 15.0 x 2.2 | 13.0 x 15.0 x 2.2 | 6 x 6 x 1.3 |
| **Certifications** | BT, CE, FCC, ISED, Japan, S-Korea and Taiwan | BT, CE, FCC, ISED, Japan & S-Korea | BT, CE, FCC, ISED, Japan & S-Korea | BT, CE, FCC, ISED, Japan & S-Korea | BT, CE, FCC, ISED, Japan & S-Korea | BT, CE, FCC, ISED, Japan & S-Korea |

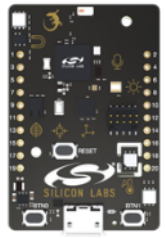
# Getting Started

https://www.silabs.com/support/getting-started/bluetooth/bluetooth-low-energy

## 1. Order Gecko kit(s)



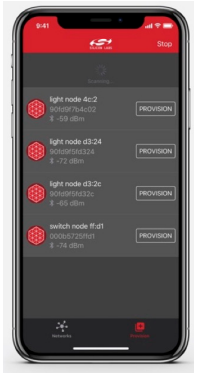

SLWSTK6021A



**Thunderboard BG22**
SLTB010A

## 2. Install Simplicity Studio


## 3. Download the SiLabs EFR Connect mobile app for iOS or Android



## 4. Explore our online resources

USER'S GUIDE
Bluetooth Profile Toolkit Developer's Guide
Read Now ›

USER'S GUIDE
C Application Developer's Guide
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Thank You!

Q & A