BLE112 *Bluetooth*® low energy module

Product Presentation

Topics

- Key features
- Benefits
- BLE 112 overview
- *Bluetooth* low energy stack
- Certifications
- Evaluation & development tools
- Use cases

Key features

BLE112: Key features

- ***Bluetooth v.4.0*, single mode compliant**
  - Supports master and slave modes
  - 4+ connections is master mode
- **Integrated *Bluetooth* low energy stack**
  - GAP, GATT, L2CAP, SMP
  - *Bluetooth* low energy profiles
- **Radio performance**
  - Transmit power: +4 dBm to -23dBm
  - Receiver sensitivity: -87dBm to -93dBm
- **Ultra low current consumption**
  - Transmit: 27mA (0 dBm)
  - Receive: 19.6mA
  - Sleep mode 3: 0.5uA
- **Programmable 8051 processor for embedding full applications**
- ***Bluetooth* end product, CE, FCC and IC, South-Korea and Telec qualified***

** In progress*

Benefits

BLE112: Benefits

- **Fully integrated solution**
  - Lower cost
  - Faster time to market
- **Application hosting capabilities**
  - All application code can be executed on the BLE112
  - Simple and fast implementation
  - Lower cost
- **Flash based**
  - Firmware is field upgradable
  - Application data can be stored on the flash
  - Settings can be stored on the flash
- **Good radio performance**
  - Long range and robust connections
  - Programmable TX power
- ***Bluetooth* Qualified**
  - Proven interoperability
  - No qualification costs

BLE112 overview

BLE112: Radio

- ***Bluetooth* low energy single-mode radio**
  - TX power: +3 dBm to -23 dBm
  - RX sensitivity: -88 dBm to -93 dBm (high-gain)
  - Modulation: GFSK

- **Antenna**
  - Integrated chip
  - U.FL connector
  - 50 ohm RF pin

- **Proprietary radio modulations**
  - FSK, 250kbps
  - MSK, 500kbps
  - GFSK and MSK, 1Mbps

BLE112: Radio

- **Operating freq. (ISM):** 2402 – 2480 MHz
- **TX power:** +3 dBm to -23 dBm
- **RX sensitivity:** -87 dBm (GFSK)
  -93 dBm (GFSK high-gain mode)
- **Modulation methods:** 1 Mbps GFSK (*Bluetooth* low energy)
  250 kbps FSK (proprietary)
  500 kbps MSK (proprietary)
  1 Mbps GFSK (proprietary)
- **Range:** +4dbm/-93dbm, line-of sight: ~100 meters
  +0dbm/-88dbm, line-of sight: ~30 meters
  -23dbm/-88dbm, line-of sight: ~5 meters

BLE112: Interfaces

21 general purpose, software programmable I/O pins

- **USART0** SPI master/slave or UART
  1Mbps
  HW flow control
- **USART1** SPI master/slave or UART
  1Mbps
  HW flow control
- **USB:** Full speed 12Mbps USB 2.0 device interface
- **Analog:** 12-bit ADC with 8 channels, 7-12-bit resolution

BLE112: Interfaces

- **Timers:**
  Two 8-bit timers
  One 16-bit timer
  Timer, counter or PWM functionality

- **Other:**
  Integrated High-Performance Op-Amp and Ultralow-Power Comparator
  Built-in battery monitor and temperature sensor
  IR generation circuitry

BLE112: Microcontroller

- **Architecture:** 8051
  high performance
  low power
- **SRAM:** 8kB
- **Flash:** 128kB (default)
  256kB

BLE112: Power consumption

- **General**
  - TX/RX can be as low as 17mA
  - Low MCU current consumption (~250uA/MHz)
  - Extremely low power sleep modes – as low as 0.5uA
- **Optimized for coin cell CR2032**
  - Quick start-up – minimize duration of peak current consumption
  - Minimum operating voltage of 2.0 V provides good resistance to dips in voltage supply
  - Architecture allows 8051 core to operate independently from the radio keeping peak current as small as possible
- **Good for alkaline as well**
  - Operating voltage range of 2.0 – 3.6 V matches dual AA

BLE112: Power consumption

- **TX:** 32mA (+4 dBm)
  27mA (0 dBm)
  24mA (-6 dBm)
  21mA (-23 dBm)
  **) External DC/DC (*TPS62730*) reduces current consumption around 20%*

- **RX:** 19.6mA
  22.1mA (high gain mode)

- **Sleep modes:** 235uA (power mode 1)
  0.9uA (power mode 2)
  0.4uA (power mode 3)

BLE112: Sleep modes

- **Power mode 1**:

  235uA: **4µs** to active mode
  Digital regulator on
  16 MHz RCOSC and 32 MHz crystal oscillator off
  32.768 kHz XOSC, POR, BOD and sleep timer active
  RAM and register retention

- **Power mode 2**:

  0.9uA: **120µs** to active mode
  Digital regulator off
  16 MHz RCOSC and 32 MHz crystal oscillator off
  32.768 kHz XOSC, POR, and sleep timer active
  RAM and register retention

- **Power mode 3**:

  0.4uA: **120µs** to active mode
  Digital regulator off
  No clocks
  POR active
  RAM and register retention

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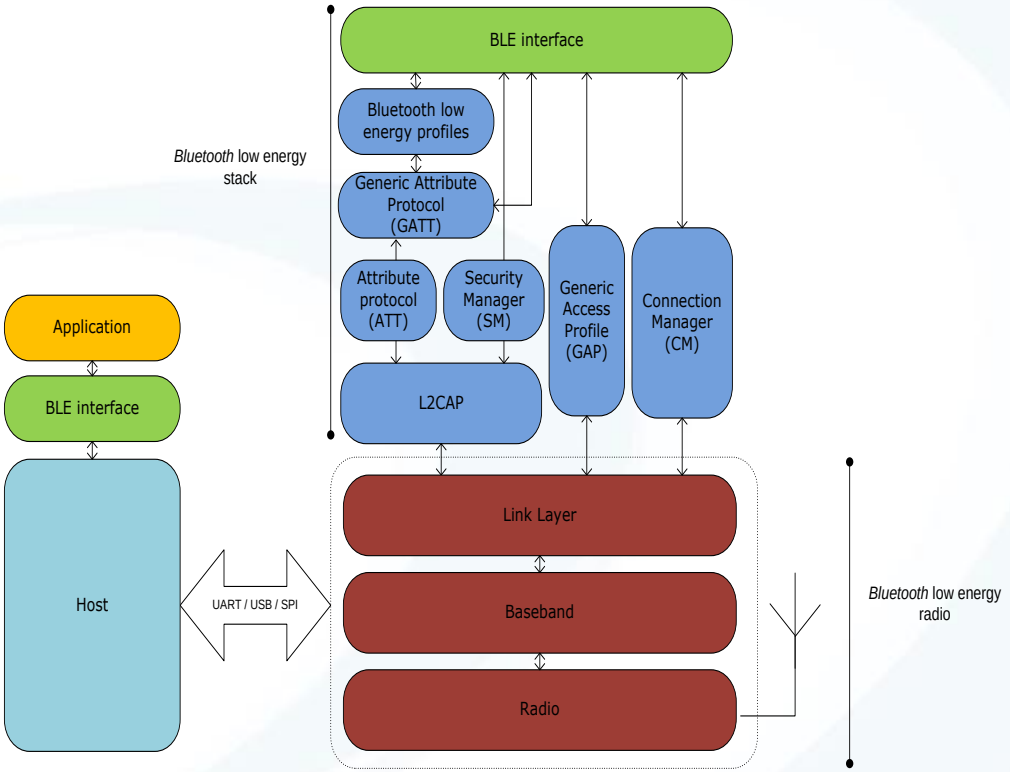
Bluetooth low energy stack

Bluetooth low energy stack

- ***Bluetooth v.4.0*, single mode compliant**
  - Supports master and slave modes
  - 4+ connections is master mode
- **Implements all Bluetooth v.4.0 functionality**
  - GAP, ATT, GATT, L2CAP
  - Security manager: bonding, encryption
  - *Bluetooth* low energy profiles
- **Flexible host interface**
  - Binary command API over UART, USB or SPI
  - ANSI C library for host processors
- **On-module applications**
  - BGScript™ : simple scripting language
  - Object code availability for ANSI C development
  - **No host needed**
- **Blutoooth low energy profile toolkit**
  - XML based development tool for BLE profiles
  - Fast and simple profile development
- **Small memory requirements**
  - ~2-3kB RAM
  - ~40-50kB flash (depending of used features/profiles)
- ***Bluetooth* qualified**



Overview

BGAPI
- A binary API between the host and the stack

Profiles
- Application specific data

GAP
- Device discovery, connections

GATT
- Organization of data

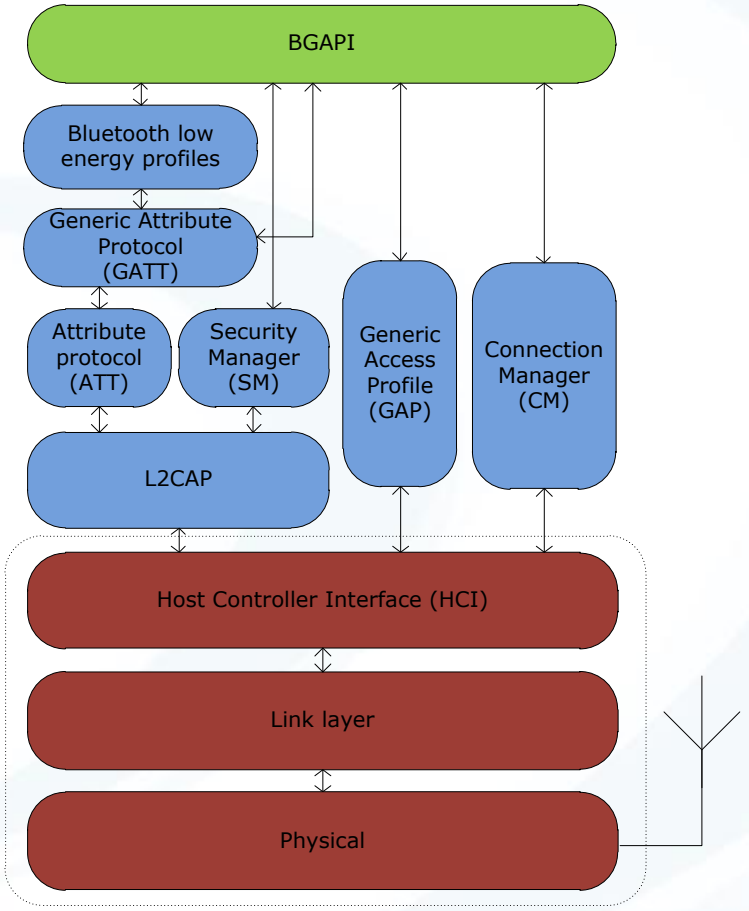
ATT
- Data access protocol

L2CAP
- Protocol multiplexer
- Fragmentation/assembly of packet

HCI
- Interface between host and controller

Link layer
- Packets and radio control

Physical layer
- Transmission/reception of bits



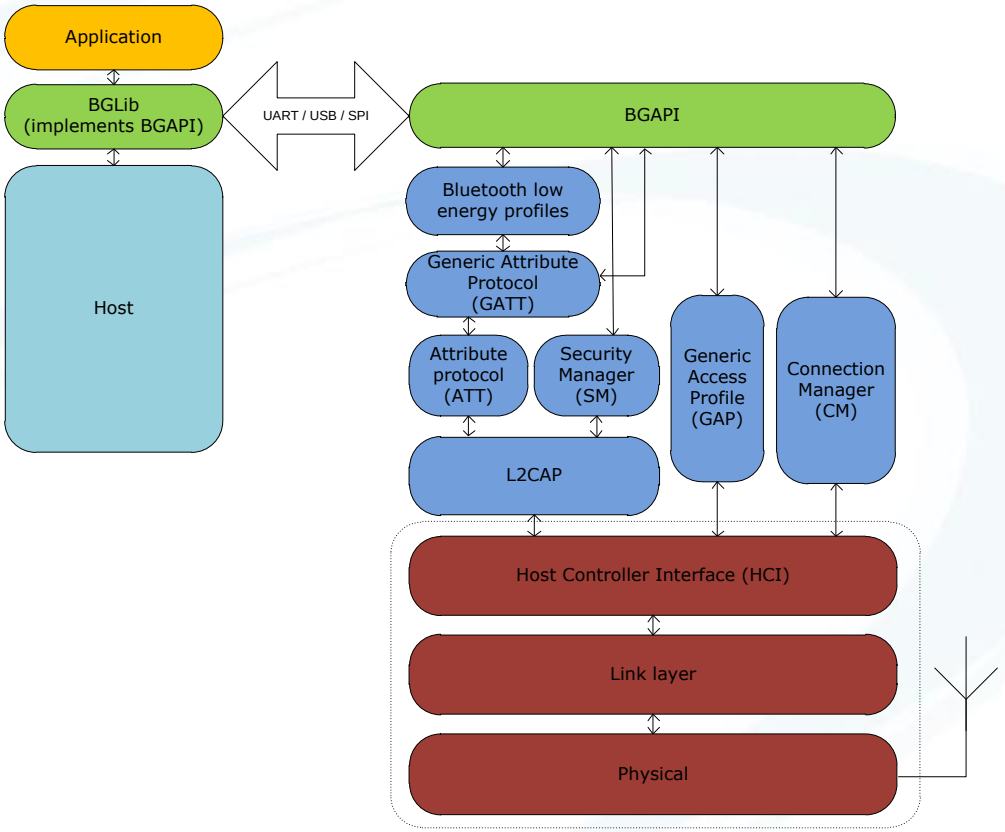
BGAPI protocol

- A binary command, response and event protocol between the host and the stack
- Small size requirement and low implementation overhead
- Good for application with a separate host
- A portable ANSI C host library (BGLib) available

Packets in either direction use the following format.

Byte	Value	Name	Description
0	See description	Message type	Identifies the message type See Message types table.
1	0 - n	Payload length	Identifies the payload length
2	See description	Class ID	Identifies the command class See Class IDs table.
3	See description	Command ID	Identifies the unique command Depends on each command.
4 – n	Depends on command	Payload	Command parameters and payload Depends on each command.

BGAPI protocol



BGAPI example

Table 1: COMMAND

Byte	Type	Name	Description
0	0x00	hilen	Message type: command
1	0x0D	lolen	Minimum payload length
2	0x06	class	Message class: Generic Access Profile
3	0x03	method	Message ID
4 - 9	**bd_addr**	**address**	
10	**uint8**	**addr_type**	see:enum gap_address_type
11 - 12	**uint16**	**conn_interval_min**	
13 - 14	**uint16**	**conn_interval_max**	
15 - 16	**uint16**	**timeout**	

Table 2: RESPONSE

Byte	Type	Name	Description
0	0x40	hilen	Message type: response
1	0x03	lolen	Minimum payload length
2	0x06	class	Message class: Generic Access Profile
3	0x03	method	Message ID
4 - 5	**uint16**	**result**	
6	**uint8**	**conn**	

BGLib host library

APIs available for several host systems:

- Windows
- Linux
- Fully embedded implementation

Function and call back arhitecture

Benefits:

- Fast application development
- Proven / tested code
- Ready made example applications

C Functions

```
/* Function */
void ble_cmd_gap_connect_direct(
    bd_addr address ,
    uint8 addr_type ,
    uint16 conn_interval_min ,
    uint16 conn_interval_max ,
    uint16 timeout
);

/* Callback */
void ble_rsp_gap_connect_direct(
    uint16 result ,
    uint8 conn
);
```

Many *Bluetooth* low energy applications are VERY VERY simple

- Temperature meter
- Door lock

Many *Bluetooth* low energy applications are VERY VERY price sensitive

- Consumer electronics
- Sports sensors

Many *Bluetooth* low energy applications require LOW power

- Key fob
- Watches

BGScript : Application scripting interface

Basic style scripting API

- Fast development of simple applications
- Examples: Pairing, simple user interfaces, simple sensors

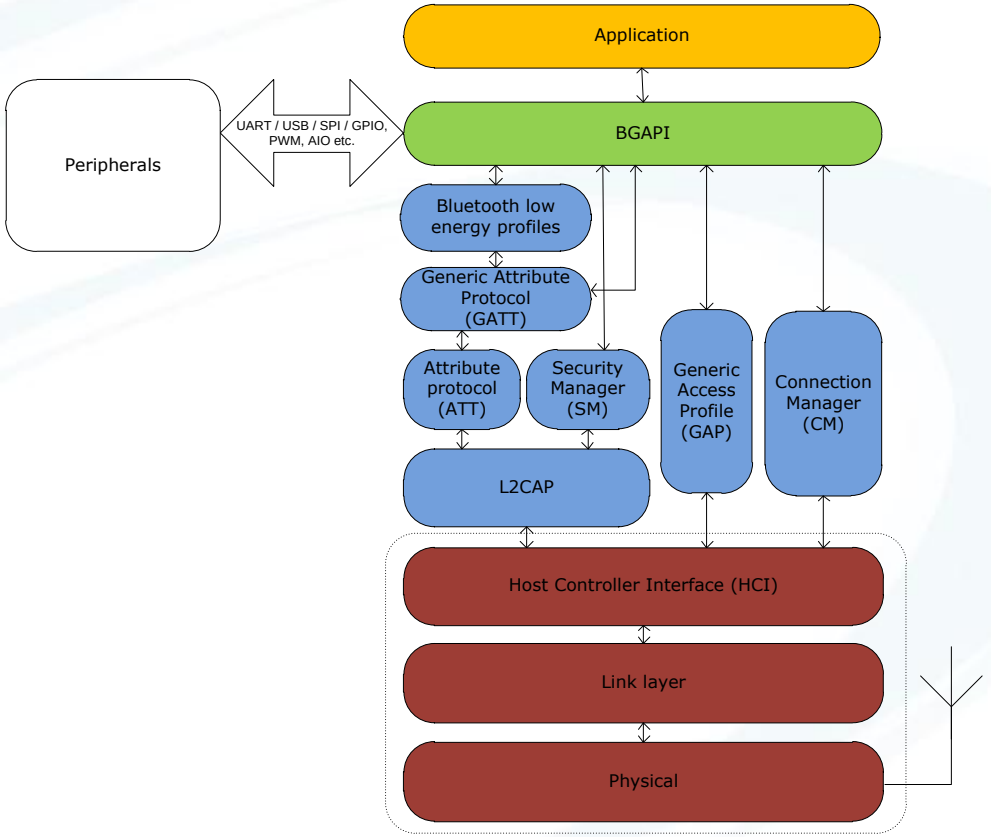
Software tools

- Code developed with any text or source code editor
- Code compiled with Bluegiga's compiler
- Binary application flashed to the hardware

Cuts out the need for external MCU:

- Reduced product cost
- Smaller footprint
- Faster time-to-market

BGScript


Application
BGAPI
Peripherals
UART / USB / SPI / GPIO, PWM, AIO etc.
Bluetooth low energy profiles
Generic Attribute Protocol (GATT)
Attribute protocol (ATT)
Security Manager (SM)
Generic Access Profile (GAP)
Connection Manager (CM)
L2CAP
Host Controller Interface (HCI)
Link layer
Physical

BGScript : HR sensor example

```
/* boot hardware, make device discoverable,connectable and enable pairing mode */
event system_boot(version,protocol,hw)
  call gap_set_mode(gap_general_discoverable,gap_undirected_connectable)
  call sm_set_bondable_mode(1)
  /* enable software timer */
  call hardware_set_soft_timer(32000)
  /* Configure IO */
  call hardware_io_port_config_irq(0,64,0)
end

/* Event listener for timer events*/
event hardware_soft_timer(handle)
  call hardware_adc_read(15,3,0) //read ADC
end

/* Event listener for ADC events*/
event hardware_adc_result(input,value)
  call attributes_write(xgatt_battery,2,value) //write battery status to GATT DB
end

/* Event listener for disconnection events*/
event connection_disconnected(handle,result)
  call gap_set_mode(gap_general_discoverable,gap_undirected_connectable)
end

/* Event listener for HR hardware */
event hardware_io_port_status(delta, port, irq, state)
  tmp(0:1)=2
  tmp(1:1)=60*32768/delta    /* Write BPM value to GATT DB */
  call attributes_write(xgatt_hr,2,tmp(0:2))
end
```

The C API

A high-level C API

Allows development of more complex applications into BLE112
Examples: Watches, devices with GUI etc.

Software tools

Bluetooth low energy stack provided as object code
IDE: IAR Embedded Workbench® or free 8051 tools

Cuts out the need for external MCU:

Reduced product cost
Smaller footprint
Faster time-to-market

Availability : Q4/2011

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Bluetooth low energy profile toolkit

Fast development of BLE profiles on top of GATT

- XML based profile description language
- XML-to-BIN compiler tool
- XML-to-API generator
- Flashing application

Standard *Bluetooth* low energy profiles

Manufacturer specific *Bluetooth* low energy profiles

```
<?xml version="1.0" encoding="UTF-8" ?>
- <configuration>
  + <service>
  - <service>
      <uuid>3a00</uuid>
      <description>Heartrate Service</description>
    - <characteristic id="heartrate">
      - <properties>
          <read />
          <notify />
        </properties>
        <uuid>3a01</uuid>
        <value type="UINT8" />
        <description>Beats per minute</description>
      </characteristic>
    - <characteristic id="rr_interval">
      + <properties>
        <uuid>3a02</uuid>
        <value type="UINT16" />
        <description>R-R Interval</description>
      </characteristic>
    - <characteristic>
        <uuid>3a03</uuid>
      + <properties>
        <value type="SFLOAT" unit="kJ" />
        <description>Energy Expended</description>
      </characteristic>
    - <characteristic>
        <uuid>3a04</uuid>
      + <properties>
        <value type="UINT8" />
        <description>Sensor Status</description>
      </characteristic>
    + <characteristic type="aggregate">
    </service>
</configuration>
```

Certifications

Certifications

- **Bluetooth 4.0**
  - Module will be certified as a *Controller Subsystem*
  - Bluetooth low energy stack will be certified as a host subsystem
    - Only *End Product Listing* is needed – free of charge
  - Simple: Same as today
- **CE**
  - Europe
  - EN300328
  - EMC330489
- **FCC**
  - United States
  - Modular approval - 15.21,15.105(b)
- **Industry Canada (IC)**
  - Canada
- **Telec**
  - Japan
- **Australia**

Evaluation & development tools

Evaluation & development tools

BLE112 Evaluation kit

- Includes BLE112 *Bluetooth* low energy radio
- Full RS232 and USB interfaces
- Example sensors in SPI/USART/AIO interfaces
- Led screen
- Buttons/keyboard connected to GPIO pins
- Coin cell powered
- IO header

BLE112 starter package

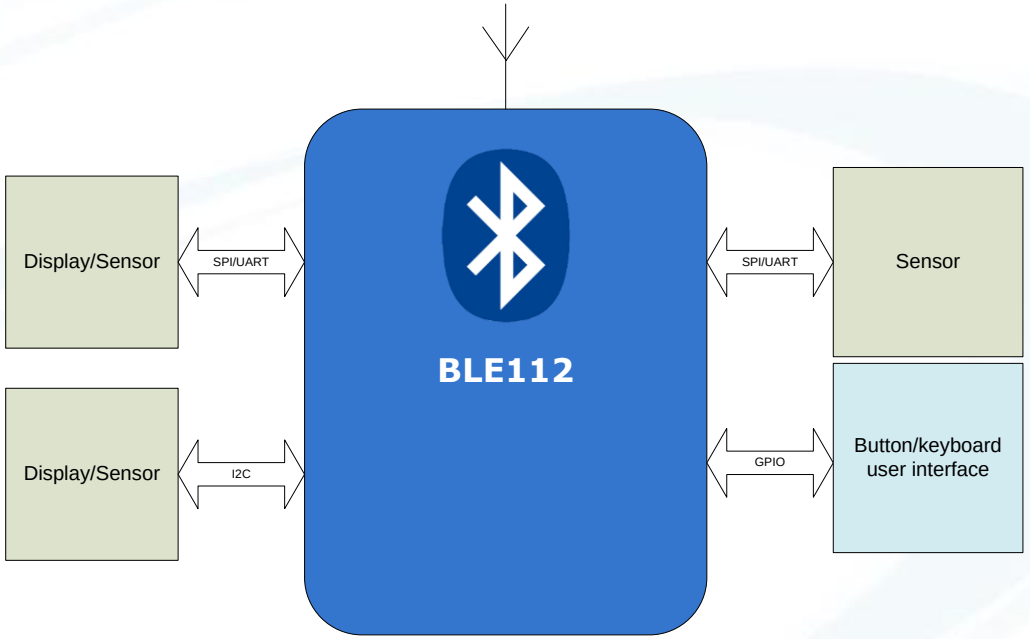
- Two BLE USB dongles
- Two BLE112 modules
- Flash programming tool
- Software and documentation

BLED112 USB dongle

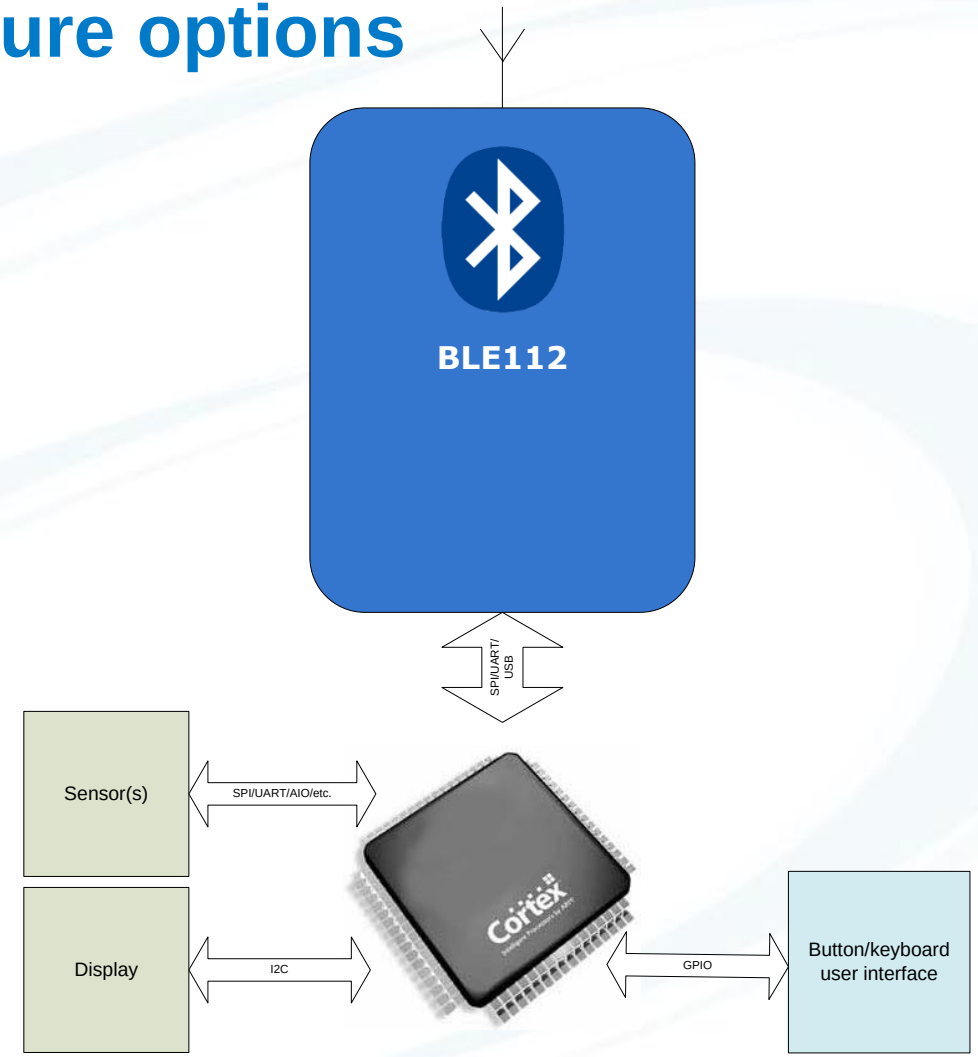
- Can be used to add Bluetooth low energy to a USB host device (f.ex PC)
- Bluetooth low energy control/data over the USB interface

Use cases

Architecture options

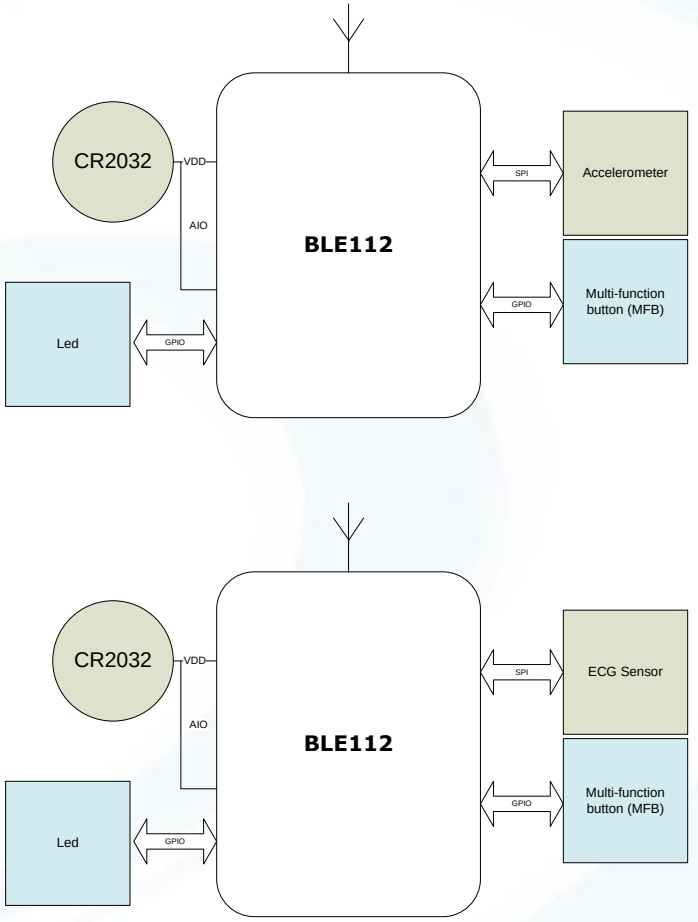


Architecture options



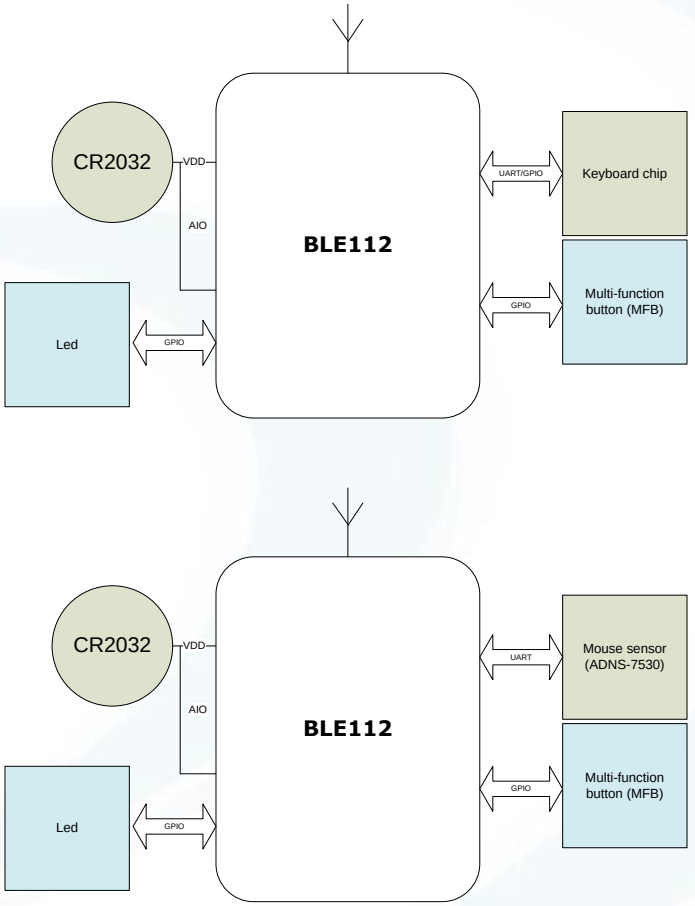
Sensor examples

- **Multi-function Button**
  - f.ex. Pairing
- **ECG sensor**
  - Interfaces via SPI
- **Accelerometer**
  - Interfaces via SPI
  - For pedometer
- **Power supply**
  - CR2032
  - AIO to read battery status
- **Led**
  - status / low-power
- **Bluetooth low energy**
  - Sensor profile for consumer
  - HDP for health & medical
  - Battery status profile



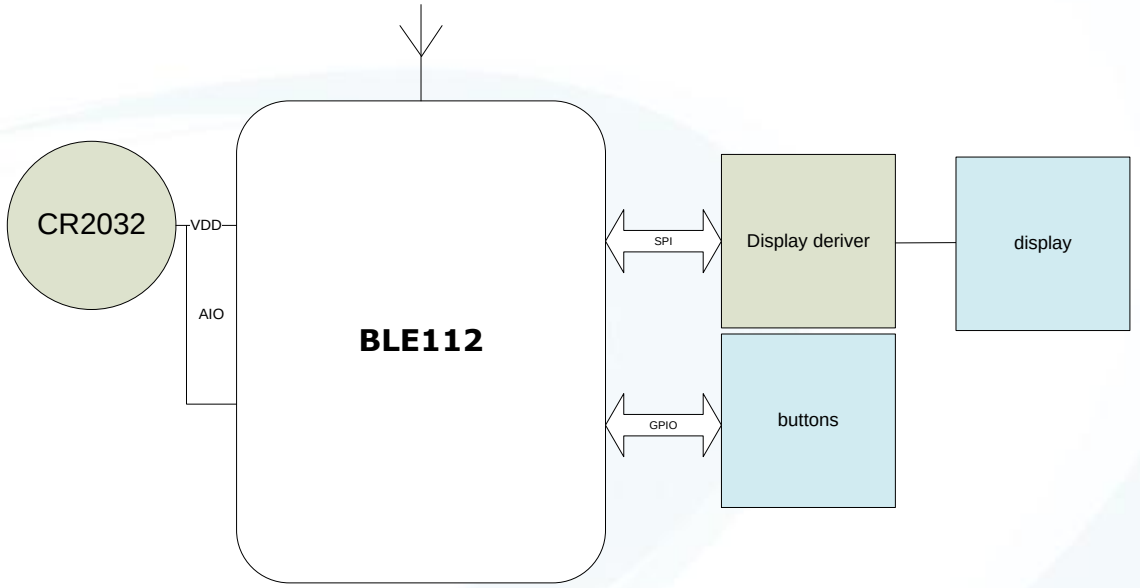
Keyboard/mouse examples

- **Multi-function Button**
  - f.ex. Pairing
- **Mouse/keyboard sensor**
  - Interfaces via UART or GPIO
  - f.ex ADNS-7530
- **Power supply**
  - CR2032 / AAA / AA
  - AIO to read battery status
- **Led**
  - status / low-power
- **Bluetooth low energy**
  - HID profile
  - Battery status profile



Watch example

- **Buttons**
  - User interfacing
- **Display**
  - Requires a display driver
  - Interfaces via SPI
- **Power supply**
  - CR2032
  - AIO to read battery status
- **Bluetooth low energy**
  - Watch profile
  - Battery status profile

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