BLE112 Bluetooth® Smart 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

- Integrated Bluetooth low energy stack
  GAP, GATT, L2CAP and SMP
  Bluetooth low energy profiles

- Radio performance
  Transmit power: +3 dBm to -23dBm
  Receiver sensitivity: -87dBm to -93dBm

- Ultra low current consumption
  Transmit: 27mA (0 dBm)
  Sleep mode 3: 0.4uA

- Programmable 8051 processor for embedding full applications
  No external MCU needed, when applications runs on BLE112

- Bluetooth end product, CE, FCC, IC and South-Korea qualified
Benefits
BLE112: Benefits

- **Fully integrated Bluetooth smart solution**
  - Integrated Bluetooth Radio, micro controller and software stack
  - Fast time to market
  - Low development risks

- **Applications can be run on BLE112**
  - No need for external MCU
  - Free-of-charge development tools
  - Simple development with BGscript™ scripting language

- **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
  - Software programmable TX power

- **Bluetooth, CE,FCC, IC and South Korea Qualified**
  - Proven interoperability
  - Minimal qualification costs
BLE112 overview
BLE112: Radio

*Bluetooth low energy single-mode radio*
- Frequency: 2402 – 2480 MHz (40 channels)
- TX power: +3 dBm to -20 dBm
- RX sensitivity: -87 dBm to -93 dBm (high-gain)
- Modulation: GFSK

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

*Range:*
- +3dbm/-93dbm, line-of sight: ~50-80 meters
- +0dbm/-87dbm, line-of sight: ~20-30 meters
- -20dbm/-87dbm, line-of sight: ~5 meters

*) contact sales@bluegiga.com
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

- **I2C:**
  - Software I2C
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: MCU

- Architecture: 8051
- SRAM: 8kB
- Flash: 128kB
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**

<table>
<thead>
<tr>
<th>Mode</th>
<th>TX Current (mA)</th>
<th>TX Power (dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31.6</td>
<td>+3</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>23.8</td>
<td>-6</td>
</tr>
<tr>
<td></td>
<td>21.1</td>
<td>-23</td>
</tr>
</tbody>
</table>

*) External DC/DC (TPS62730) reduces current peak consumption around 30% |

<table>
<thead>
<tr>
<th>Mode</th>
<th>RX Current (mA)</th>
<th>RX Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.1</td>
<td>high gain mode</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mode</th>
<th>Sleep Current (uA)</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>235</td>
<td>power mode 1</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
<td>power mode 2</td>
</tr>
<tr>
<td></td>
<td>0.4</td>
<td>power mode 3</td>
</tr>
</tbody>
</table>
BLE112: Sleep modes

- **Power mode 1:**
  - Current: 235uA
  - Transition time to active mode: 4µs
  - 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:**
  - Current: 0.9uA
  - Transition time to active mode: 120µs
  - 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:**
  - Current: 0.4uA
  - Transition time to active mode: 120µs
  - Digital regulator off
  - No clocks
  - POR active
  - RAM and register retention
  - External wake-up needed
Bluetooth low energy stack
**Bluetooth** low energy stack

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

<table>
<thead>
<tr>
<th>Octet</th>
<th>Octet bits</th>
<th>Length</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
</table>
| octet 0 | 7 | 1 bit | Message type (MT) | \(0: \text{Command/response} \\
| | | | \(1: \text{Event}\) |
| | 6:3 | 4 bits | Technology type (TT) | \(0000: \text{Bluetooth 4.0 single mode}\) |
| | 2:0 | 3 bits | Length high (LH) | Payload length (high bits) |
| octet 1 | 7:0 | 8 bits | Length low (LL) | Payload length (low bits) |
| octet 2 | 7:0 | 8 bits | Class ID (CID) | Command class ID |
| octet 3 | 7:0 | 8 bits | Command ID (CMD) | Command ID |
| octet 4-n | 0-2048 bytes | Payload (PL) | Up to 2048 bytes of payload |
BGAPI protocol

BGAPI

Host

BGLib (implements BGAPI)

Application

Host Controller Interface (HCI)

Link layer

Physical

L2CAP

Generic Access Profile (GAP)

Security Manager (SM)

Attribute protocol (ATT)

Generic Attribute Protocol (GATT)

Bluetooth low energy profiles

Connection Manager (CM)
BGLib™ host library

BGLib implements a parser for the BGAPI protocol

Uses a function and call back architecture

Implemented with ANSI C and therefore protable for several host, like:
- Windows
- Linux
- Mac
- Fully embedded implementations

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 language

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
Architecture with BGScript™

Application (done with BGScript)

BGAPI

- Bluetooth low energy profiles
- Generic Attribute Profile (GATT)
- Attribute protocol (ATT)
- Security Manager (SM)
- Generic Access Profile (GAP)
- Connection Manager (CM)

L2CAP

Host Controller Interface (HCI)

Link layer

Radio

Bluetooth low energy radio
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
BLE112: Software Development Kit

Bluetooth stack delivered as object code

A high-level C API
   Allows development of more complex applications into BLE112
   Into the 8051 microcontroller
   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: Q4/2012
Bluetooth low energy profile toolkit

Fast development of BLE profiles on top of GATT

- XML based profile & service description language
- Bluegiga provides adopted services & profiles as templates
- Can be used to make proprietary profiles & services in matter of few hours

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

- **Bluetooth 4.0**
  - BLE112 certified as a *Controller Subsystem*
  - Bluetooth stack certified as a *Host subsystem*
  - Simple: Same as today

- **CE**
  - Europe
  - EN300328
  - EMC330489

- **FCC**
  - United States
  - Modular approval - 15.21,15.105(b)

- **Industry Canada (IC)**
  - Canada

- **South Korea**
Evaluation & development tools
Evaluation & development tools

**BLE112 Evaluation kit**
- Includes BLE112 Bluetooth low energy radio
- Full RS232 and USB interfaces
- Battery sensor, temperature sensor, accelerometer and potentiometer
- Display
- Buttons/keyboard connected to GPIO pins
- Coin cell powered
- IO header
- Profile examples code and applications

**BLED112 USB dongle**
- Can be used to add Bluetooth low energy to a USB host device (e.g., PC)
- Bluetooth low energy control/data over the USB interface
Thank you