

# BGM111 Blue Gecko *Bluetooth*® Module 数据表



Blue GeckoBGM111 是一个面向低功耗蓝牙应用的 Bluetooth® 模块，可以满足用户对于卓越 RF 性能、低功耗和轻松开发应用程序的关键需求。在 TX 功率为 +8 dBm 时，BGM111 对于需要短程和中程蓝牙连接的应用来说，是理想的选择。

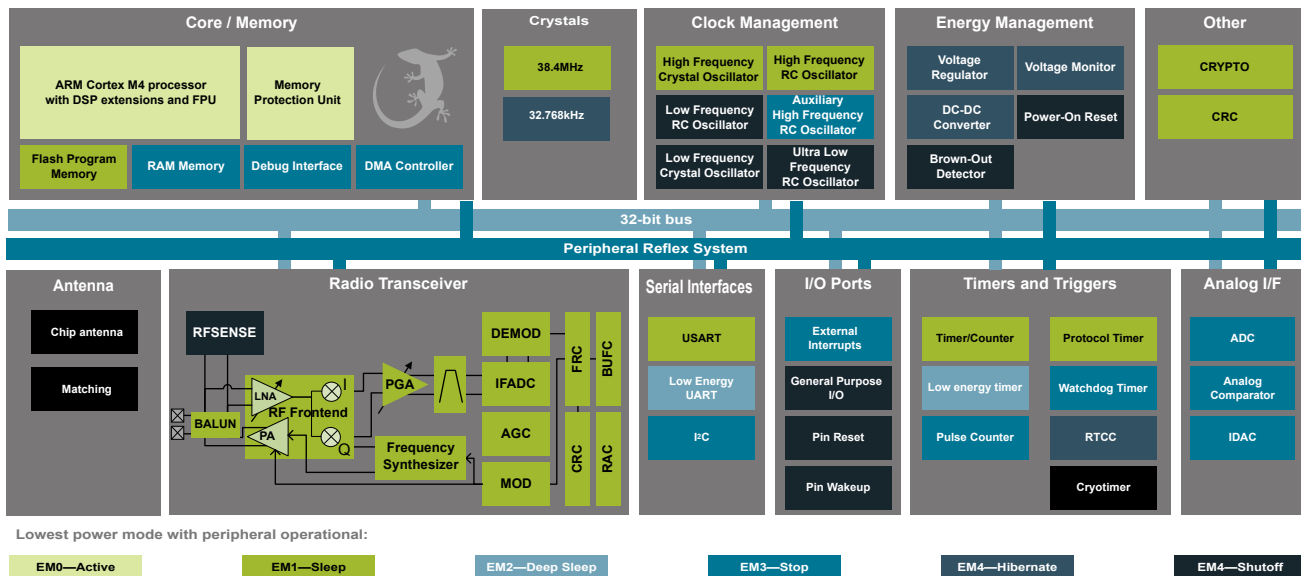
BGM111 融合了蓝牙应用所需的所有必要元素：蓝牙低功耗无线电、软件协议栈和基于 GATT 协议的配置文件，同时还可部署终端用户应用程序，这意味着大小、价格或功率受限的设备中不再需要外部微控制器。BGM111 蓝牙模块还具有高度灵活的硬件接口，可连接不同的外围设备或传感器。

BGM111 可用于广泛的应用中：

- IoT 传感器和终端设备
- 商业和零售
- 健康和保健
- 工业、家庭和楼宇自动化
- 智能手机、平板电脑和台式电脑配件

## 主要特点

- 兼容 Bluetooth 4.2
- 集成天线
- TX 功率：高达 +8 dBm
- RX 灵敏度：低至 -92 dBm
- 距离：长达 200 米
- 32 位 ARM® Cortex®-M4（内核为 40 MHz）
- 闪存：256 kB
- RAM：32 kB
- 自主硬件加密加速器和随机数生成器
- 集成直流转换器
- 板载 Bluetooth 协议栈



## 1. 功能列表

BGM111 重要功能如下所列。

- **低功耗无线片上系统。**
  - 高性能 32 位 38.4 MHz ARM Cortex®-M4，带有 DSP 指令和浮点单元，可实现高效的信号处理
  - 256 kB 闪存编程存储器
  - 32 kB RAM 数据存储
  - 2.4 GHz 无线电操作
  - TX 功率高达 +8 dBm
- **低功耗**
  - 在 2.4 GHz 时，RX 电流为 8.7 mA
  - 在 2.4 GHz 时，0 dBm 输出功率下的 TX 电流为 8.2 mA
  - 在活动模式（EM0）下，运行功耗为 63  $\mu$ A/MHz
  - 在 EM2 深度睡眠模式（完整保留 RAM，RTCC 从 LFXO 中运行）下，电流为 2.5  $\mu$ A
  - 在 EM3 停止模式（状态/RAM 保留）下，电流为 2.1  $\mu$ A
  - 无线模块唤醒，带有信号强度检测、前导模式检测、帧检测和超时
- **卓越的接收器性能**
  - -92 dBm 灵敏度（1 Mbit/s GFSK（2.4 GHz）条件下）
- **支持的协议**
  - Bluetooth®
- **支持 Internet 安全**
  - 通用 CRC
  - 随机数生成器
  - 适用于 AES 128/256、SHA-1、SHA-2（SHA-224 和 SHA-256）以及 ECC 的硬件加密加速
- **MCU 外围设备选择广泛**
  - 12 位 1 Msps SAR AD 转换器（ADC）
  - 2 个模数比较器（ACMP）
  - DA 电流转换器（IDAC）
  - 25 个引脚连接到模拟比较器、ADC 和 IDAC 共用的模拟通道（APORT）
  - 25 组通用 I/O 引脚，带输出状态保留和异步中断
  - 8 通道 DMA 控制器
  - 12 通道外围设备反射系统（PRS）
  - 2 个 16 位定时器/计数器
    - 3 + 4 比较/捕获/PWM 通道
  - 32 位实时计数器和日历
  - 16 位低功耗定时器，用于生成波形
  - 32 位超低功耗定时器/计数器，用于从任何能量模式定期唤醒
  - 带异步操作的 16 位脉冲计数器
  - 看门狗定时器，配有电流为 50 nA 的专用 RC 振荡器
  - 2 个通用同步/异步接收器/发射器（UART/SPI/SmartCard（ISO 7816）/IrDA/I<sup>2</sup>S）
  - 低功耗 UART（LEUART™）
  - I<sup>2</sup>C 接口，在 EM3 停止状态下支持 SMBus 和地址识别
- **操作范围广泛**
  - 1.85 V 至 3.8 V 单电源供电电压
  - 2.4 V 至 3.8 V（使用 DC-DC 时）
  - 集成 DC-DC
  - -40° C 至 +85° C
- **尺寸**
  - 12.9 x 15.00 x 2.2 mm

## 2. Ordering Information

| Ordering Code               | Protocol Stack  | Frequency Band | Max TX Power (dBm) | Encryption | Flash (KB) | RAM (KB) | GPIO | Package          |
|-----------------------------|-----------------|----------------|--------------------|------------|------------|----------|------|------------------|
| BGM111A256V2                | Bluetooth Smart | 2.4 GHz        | +8                 | Full       | 256        | 32       | 25   | 100 pcs cut reel |
| BGM111A256V2R               | Bluetooth Smart | 2.4 GHz        | +8                 | Full       | 256        | 32       | 25   | 1000 pcs reel    |
| BGM111A256V21 <sup>2</sup>  | Bluetooth Smart | 2.4 GHz        | +8                 | Full       | 256        | 32       | 25   | 100 pcs cut reel |
| BGM111A256V21R <sup>2</sup> | Bluetooth Smart | 2.4 GHz        | +8                 | Full       | 256        | 32       | 25   | 1000 pcs reel    |
| SLWSTK6101C <sup>1</sup>    |                 |                |                    |            |            |          |      |                  |

**Note:**

1. Blue Gecko Bluetooth Smart Module Wireless Development Kit (WSTK) with BGM111 (with antenna) and BGM121 radio boards, expansion board and accessories.
2. The "V21" OPNs have the Bluetooth software 2.0.2 pre-installed and exposing BGAPI serial protocol (NCP) mode over UART interface as shown in the Power, Ground, Debug and Host UART reference schematic.

# Table of Contents

|                                                                       |          |
|-----------------------------------------------------------------------|----------|
| <b>1. Feature List</b>                                                | <b>2</b> |
| <b>2. Ordering Information</b>                                        | <b>3</b> |
| <b>3. System Overview</b>                                             | <b>7</b> |
| 3.1 Introduction                                                      | 7        |
| 3.2 Radio                                                             | 7        |
| 3.2.1 Antenna Interface                                               | 7        |
| 3.2.2 Wake on Radio                                                   | 8        |
| 3.2.3 RFSENSE                                                         | 8        |
| 3.2.4 Packet and State Trace                                          | 8        |
| 3.2.5 Random Number Generator                                         | 8        |
| 3.3 Power                                                             | 9        |
| 3.3.1 Energy Management Unit (EMU)                                    | 9        |
| 3.3.2 DC-DC Converter                                                 | 9        |
| 3.4 General Purpose Input/Output (GPIO)                               | 9        |
| 3.5 Clocking                                                          | 10       |
| 3.5.1 Clock Management Unit (CMU)                                     | 10       |
| 3.5.2 Internal Oscillators                                            | 10       |
| 3.6 Counters/Timers and PWM                                           | 10       |
| 3.6.1 Timer/Counter (TIMER)                                           | 10       |
| 3.6.2 Real Time Counter and Calendar (RTCC)                           | 10       |
| 3.6.3 Low Energy Timer (LETIMER)                                      | 10       |
| 3.6.4 Ultra Low Power Wake-up Timer (CRYOTIMER)                       | 10       |
| 3.6.5 Pulse Counter (PCNT)                                            | 11       |
| 3.6.6 Watchdog Timer (WDOG)                                           | 11       |
| 3.7 Communications and Other Digital Peripherals                      | 11       |
| 3.7.1 Universal Synchronous/Asynchronous Receiver/Transmitter (USART) | 11       |
| 3.7.2 Low Energy Universal Asynchronous Receiver/Transmitter (LEUART) | 11       |
| 3.7.3 Inter-Integrated Circuit Interface (I <sup>2</sup> C)           | 11       |
| 3.7.4 Peripheral Reflex System (PRS)                                  | 11       |
| 3.8 Security Features                                                 | 11       |
| 3.8.1 GPCRC (General Purpose Cyclic Redundancy Check)                 | 11       |
| 3.8.2 Crypto Accelerator (CRYPTO)                                     | 12       |
| 3.9 Analog                                                            | 12       |
| 3.9.1 Analog Port (APORT)                                             | 12       |
| 3.9.2 Analog Comparator (ACMP)                                        | 12       |
| 3.9.3 Analog to Digital Converter (ADC)                               | 12       |
| 3.9.4 Digital to Analog Current Converter (IDAC)                      | 12       |
| 3.10 Reset Management Unit (RMU)                                      | 12       |
| 3.11 Core and Memory                                                  | 12       |
| 3.11.1 Processor Core                                                 | 12       |
| 3.11.2 Memory System Controller (MSC)                                 | 13       |
| 3.11.3 Linked Direct Memory Access Controller (LDMA)                  | 13       |

|           |                                                        |            |
|-----------|--------------------------------------------------------|------------|
| 3.12      | Memory Map . . . . .                                   | .14        |
| 3.13      | Configuration Summary . . . . .                        | .15        |
| <b>4.</b> | <b>Electrical Specifications . . . . .</b>             | <b>.16</b> |
| 4.1       | Electrical Characteristics . . . . .                   | .16        |
| 4.1.1     | Absolute Maximum Ratings . . . . .                     | .16        |
| 4.1.2     | Operating Conditions . . . . .                         | .17        |
| 4.1.3     | DC-DC Converter . . . . .                              | .18        |
| 4.1.4     | Current Consumption . . . . .                          | .20        |
| 4.1.5     | Wake up times . . . . .                                | .24        |
| 4.1.6     | Brown Out Detector . . . . .                           | .25        |
| 4.1.7     | Frequency Synthesizer Characteristics . . . . .        | .25        |
| 4.1.8     | 2.4 GHz RF Transceiver Characteristics . . . . .       | .26        |
| 4.1.9     | Oscillators . . . . .                                  | .28        |
| 4.1.10    | Flash Memory Characteristics . . . . .                 | .30        |
| 4.1.11    | GPIO . . . . .                                         | .31        |
| 4.1.12    | VMON . . . . .                                         | .32        |
| 4.1.13    | ADC . . . . .                                          | .33        |
| 4.1.14    | IDAC . . . . .                                         | .36        |
| 4.1.15    | Analog Comparator (ACMP) . . . . .                     | .38        |
| 4.1.16    | I2C . . . . .                                          | .40        |
| 4.1.17    | USART SPI . . . . .                                    | .43        |
| <b>5.</b> | <b>Typical Connection Diagrams . . . . .</b>           | <b>.45</b> |
| 5.1       | Power, Ground, Debug and Host UART . . . . .           | .45        |
| 5.2       | SPI Peripheral Connection . . . . .                    | .45        |
| 5.3       | I <sup>2</sup> C Peripheral Connection. . . . .        | .46        |
| <b>6.</b> | <b>Layout Guidelines . . . . .</b>                     | <b>.47</b> |
| 6.1       | Recommended Placement on the Application PCB . . . . . | .47        |
| 6.2       | Effect of Plastic and Metal Materials . . . . .        | .48        |
| 6.3       | Effect of Human Body . . . . .                         | .48        |
| 6.4       | 2D Radiation Pattern Plots . . . . .                   | .49        |
| <b>7.</b> | <b>Pin Definitions . . . . .</b>                       | <b>.51</b> |
| 7.1       | Pin Definitions . . . . .                              | .51        |
| 7.1.1     | GPIO Overview . . . . .                                | .60        |
| 7.2       | Alternate Functionality Pinout . . . . .               | .61        |
| 7.3       | Analog Port (APORT) . . . . .                          | .68        |
| <b>8.</b> | <b>Package Specifications . . . . .</b>                | <b>.76</b> |
| 8.1       | BGM111 Dimensions . . . . .                            | .76        |
| 8.2       | BGM111 Package Marking . . . . .                       | .77        |
| 8.3       | BGM111 Module Dimensions and Footprint . . . . .       | .77        |
| 8.4       | BGM111 Land Pattern . . . . .                          | .78        |

|                                        |           |
|----------------------------------------|-----------|
| <b>9. Tape and Reel Specifications</b> | <b>79</b> |
| 9.1 Tape and Reel Packaging            | .79       |
| 9.2 Reel and Tape Specifications       | .79       |
| 9.3 Orientation and Tape Feed          | .80       |
| 9.4 Tape and Reel Box Dimensions       | .81       |
| 9.5 Moisture Sensitivity Level         | .81       |
| <b>10. Soldering Recommendations</b>   | <b>82</b> |
| 10.1 Soldering Recommendations         | .82       |
| <b>11. Certifications</b>              | <b>83</b> |
| 11.1 Bluetooth                         | .83       |
| 11.2 CE                                | .83       |
| 11.3 FCC                               | .83       |
| 11.4 IC                                | .84       |
| 11.5 Japan                             | .86       |
| 11.6 KC (South-Korea)                  | .86       |
| <b>12. Revision History</b>            | <b>87</b> |
| 12.1 Revision 1.4                      | .87       |
| 12.2 Revision 1.3                      | .87       |
| 12.3 Revision 1.2                      | .87       |
| 12.4 Revision 1.1                      | .87       |
| 12.5 Revision 1.0                      | .87       |
| 12.6 Revision 0.991                    | .88       |
| 12.7 Revision 0.99                     | .88       |
| 12.8 Revision 0.98                     | .88       |
| 12.9 Revision 0.97                     | .88       |
| 12.10 Revision 0.96                    | .88       |
| 12.11 Revision 0.95                    | .88       |
| 12.12 Revision 0.94                    | .88       |
| 12.13 Revision 0.93                    | .88       |
| 12.14 Revision 0.92                    | .88       |
| 12.15 Revision 0.91                    | .89       |
| 12.16 Revision 0.90                    | .89       |



### 3.2.2 Wake on Radio

The Wake on Radio feature allows flexible, autonomous RF sensing, qualification, and demodulation without required MCU activity, using a subsystem of the BGM111 including the Radio Controller (RAC), Peripheral Reflex System (PRS), and Low Energy peripherals.

### 3.2.3 RFSENSE

The RFSENSE module generates a system wakeup interrupt upon detection of wideband RF energy at the antenna interface, providing true RF wakeup capabilities from low energy modes including EM2, EM3 and EM4.

RFSENSE triggers on a relatively strong RF signal and is available in the lowest energy modes, allowing exceptionally low energy consumption. RFSENSE does not demodulate or otherwise qualify the received signal, but software may respond to the wakeup event by enabling normal RF reception.

Various strategies for optimizing power consumption and system response time in presence of false alarms may be employed using available timer peripherals.

### 3.2.4 Packet and State Trace

The BGM111 Frame Controller has a packet and state trace unit that provides valuable information during the development phase. It features:

- Non-intrusive trace of transmit data, receive data and state information
- Data observability on a single-pin UART data output, or on a two-pin SPI data output
- Configurable data output bitrate / baudrate
- Multiplexed transmitted data, received data and state / meta information in a single serial data stream

### 3.2.5 Random Number Generator

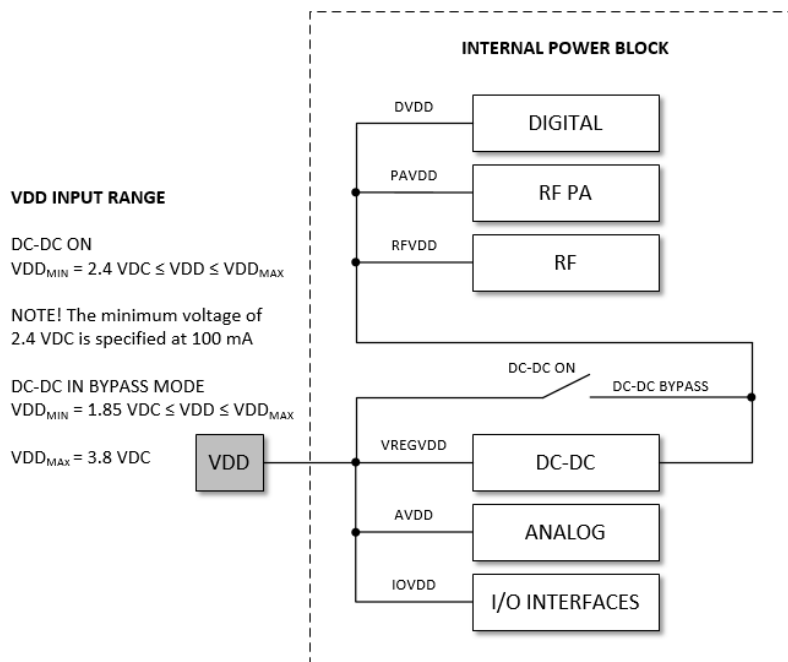
The Frame Controller (FRC) implements a random number generator that uses entropy gathered from noise in the RF receive chain. The data is suitable for use in cryptographic applications.

Output from the random number generator can be used either directly or as a seed or entropy source for software-based random number generator algorithms such as Fortuna.



### 3.3 Power

The BGM111 has an Energy Management Unit (EMU) and efficient integrated regulators to generate internal supply voltages. Only a single external supply voltage is required, from which all internal voltages are created. An integrated DC-DC buck regulator is utilized to further reduce the current consumption.



**Figure 3.2. Power Supply Configuration**

#### 3.3.1 Energy Management Unit (EMU)

The Energy Management Unit manages transitions of energy modes in the device. Each energy mode defines which peripherals and features are available and the amount of current the device consumes. The EMU can also be used to turn off the power to unused RAM blocks, and it contains control registers for the dc-dc regulator and the Voltage Monitor (VMON). The VMON is used to monitor multiple supply voltages. It has multiple channels which can be programmed individually by the user to determine if a sensed supply has fallen below a chosen threshold.

#### 3.3.2 DC-DC Converter

The DC-DC buck converter covers a wide range of load currents and provides up to 90% efficiency in energy modes EM0, EM1, EM2 and EM3. Patented RF noise mitigation allows operation of the DC-DC converter without degrading sensitivity of radio components. Protection features include programmable current limiting, short-circuit protection, and dead-time protection. The DC-DC converter may also enter bypass mode when the input voltage is too low for efficient operation. In bypass mode, the DC-DC input supply is internally connected directly to its output through a low resistance switch. Bypass mode also supports in-rush current limiting to prevent input supply voltage droops due to excessive output current transients.

### 3.4 General Purpose Input/Output (GPIO)

BGM111 has up to 25 General Purpose Input/Output pins. Each GPIO pin can be individually configured as either an output or input. More advanced configurations including open-drain, open-source, and glitch-filtering can be configured for each individual GPIO pin. The GPIO pins can be overridden by peripheral connections, like SPI communication. Each peripheral connection can be routed to several GPIO pins on the device. The input value of a GPIO pin can be routed through the Peripheral Reflex System to other peripherals. The GPIO subsystem supports asynchronous external pin interrupts.

## 3.5 Clocking

### 3.5.1 Clock Management Unit (CMU)

The Clock Management Unit controls oscillators and clocks in the BGM111. Individual enabling and disabling of clocks to all peripheral modules is performed by the CMU. The CMU also controls enabling and configuration of the oscillators. A high degree of flexibility allows software to optimize energy consumption in any specific application by minimizing power dissipation in unused peripherals and oscillators.

### 3.5.2 Internal Oscillators

The BGM111 fully integrates two crystal oscillators and four RC oscillators, listed below.

- A 38.4MHz high frequency crystal oscillator (HFXO) provides a precise timing reference for the MCU and radio.
- A 32.768 kHz crystal oscillator (LFXO) provides an accurate timing reference for low energy modes.
- An integrated high frequency RC oscillator (HFRCO) is available for the MCU system, when crystal accuracy is not required. The HFRCO employs fast startup at minimal energy consumption combined with a wide frequency range.
- An integrated auxiliary high frequency RC oscillator (AUXHFRCO) is available for timing the general-purpose ADC and the Serial Wire debug port with a wide frequency range.
- An integrated low frequency 32.768 kHz RC oscillator (LFRCO) can be used as a timing reference in low energy modes, when crystal accuracy is not required.
- An integrated ultra-low frequency 1 kHz RC oscillator (ULFRCO) is available to provide a timing reference at the lowest energy consumption in low energy modes.

## 3.6 Counters/Timers and PWM

### 3.6.1 Timer/Counter (TIMER)

TIMER peripherals keep track of timing, count events, generate PWM outputs and trigger timed actions in other peripherals through the PRS system. The core of each TIMER is a 16-bit counter with up to 4 compare/capture channels. Each channel is configurable in one of three modes. In capture mode, the counter state is stored in a buffer at a selected input event. In compare mode, the channel output reflects the comparison of the counter to a programmed threshold value. In PWM mode, the TIMER supports generation of pulse-width modulation (PWM) outputs of arbitrary waveforms defined by the sequence of values written to the compare registers, with optional dead-time insertion available in timer unit TIMER\_0 only.

### 3.6.2 Real Time Counter and Calendar (RTCC)

The Real Time Counter and Calendar (RTCC) is a 32-bit counter providing timekeeping in all energy modes. The RTCC includes a Binary Coded Decimal (BCD) calendar mode for easy time and date keeping. The RTCC can be clocked by any of the on-board oscillators with the exception of the AUXHFRCO, and it is capable of providing system wake-up at user defined instances. When receiving frames, the RTCC value can be used for timestamping. The RTCC includes 128 bytes of general purpose data retention, allowing easy and convenient data storage in all energy modes.

### 3.6.3 Low Energy Timer (LETIMER)

The unique LETIMER is a 16-bit timer that is available in energy mode EM2 Deep Sleep in addition to EM1 Sleep and EM0 Active. This allows it to be used for timing and output generation when most of the device is powered down, allowing simple tasks to be performed while the power consumption of the system is kept at an absolute minimum. The LETIMER can be used to output a variety of waveforms with minimal software intervention. The LETIMER is connected to the Real Time Counter and Calendar (RTCC), and can be configured to start counting on compare matches from the RTCC.

### 3.6.4 Ultra Low Power Wake-up Timer (CRYOTIMER)

The CRYOTIMER is a 32-bit counter that is capable of running in all energy modes. It can be clocked by either the 32.768 kHz crystal oscillator (LFXO), the 32.768 kHz RC oscillator (LFRCO), or the 1 kHz RC oscillator (ULFRCO). It can provide periodic Wakeup events and PRS signals which can be used to wake up peripherals from any energy mode. The CRYOTIMER provides a wide range of interrupt periods, facilitating flexible ultra-low energy operation.

### 3.6.5 Pulse Counter (PCNT)

The Pulse Counter (PCNT) peripheral can be used for counting pulses on a single input or to decode quadrature encoded inputs. The clock for PCNT is selectable from either an external source on pin PCTNn\_S0IN or from an internal timing reference, selectable from among any of the internal oscillators, except the AUXHFRCO. The module may operate in energy mode EM0 Active, EM1 Sleep, EM2 Deep Sleep, and EM3 Stop.

### 3.6.6 Watchdog Timer (WDOG)

The watchdog timer can act both as an independent watchdog or as a watchdog synchronous with the CPU clock. It has windowed monitoring capabilities, and can generate a reset or different interrupts depending on the failure mode of the system. The watchdog can also monitor autonomous systems driven by PRS.

## 3.7 Communications and Other Digital Peripherals

### 3.7.1 Universal Synchronous/Asynchronous Receiver/Transmitter (USART)

The Universal Synchronous/Asynchronous Receiver/Transmitter is a flexible serial I/O module. It supports full duplex asynchronous UART communication with hardware flow control as well as RS-485, SPI, MicroWire and 3-wire. It can also interface with devices supporting:

- ISO7816 SmartCards
- IrDA
- I<sup>2</sup>S

### 3.7.2 Low Energy Universal Asynchronous Receiver/Transmitter (LEUART)

The unique LEUART™ provides two-way UART communication on a strict power budget. Only a 32.768 kHz clock is needed to allow UART communication up to 9600 baud. The LEUART includes all necessary hardware to make asynchronous serial communication possible with a minimum of software intervention and energy consumption.

### 3.7.3 Inter-Integrated Circuit Interface (I<sup>2</sup>C)

The I<sup>2</sup>C module provides an interface between the MCU and a serial I<sup>2</sup>C bus. It is capable of acting as both a master and a slave and supports multi-master buses. Standard-mode, fast-mode and fast-mode plus speeds are supported, allowing transmission rates from 10 kbit/s up to 1 Mbit/s. Slave arbitration and timeouts are also available, allowing implementation of an SMBus-compliant system. The interface provided to software by the I<sup>2</sup>C module allows precise timing control of the transmission process and highly automated transfers. Automatic recognition of slave addresses is provided in active and low energy modes.

### 3.7.4 Peripheral Reflex System (PRS)

The Peripheral Reflex System provides a communication network between different peripheral modules without software involvement. Peripheral modules producing Reflex signals are called producers. The PRS routes Reflex signals from producers to consumer peripherals which in turn perform actions in response. Edge triggers and other functionality can be applied by the PRS. The PRS allows peripheral to act autonomously without waking the MCU core, saving power.

## 3.8 Security Features

### 3.8.1 GPCRC (General Purpose Cyclic Redundancy Check)

The GPCRC module implements a Cyclic Redundancy Check (CRC) function. It supports both 32-bit and 16-bit polynomials. The supported 32-bit polynomial is 0x04C11DB7 (IEEE 802.3), while the 16-bit polynomial can be programmed to any value, depending on the needs of the application.

### 3.8.2 Crypto Accelerator (CRYPTO)

The Crypto Accelerator is a fast and energy-efficient autonomous hardware encryption and decryption accelerator. It supports AES encryption and decryption with 128- or 256-bit keys and ECC over both GF(P) and GF(2<sup>m</sup>), SHA-1 and SHA-2 (SHA-224 and SHA-256).

Supported modes of operation for AES include: ECB, CTR, CBC, PCBC, CFB, OFB, CBC-MAC, GMAC and CCM.

Supported ECC NIST recommended curves include P-192, P-224, P-256, K-163, K-233, B-163 and B-233.

The CRYPTO is tightly linked to the Radio Buffer Controller (BUFC) enabling fast and efficient autonomous cipher operations on data buffer content. It allows fast processing of GCM (AES), ECC and SHA with little CPU intervention. CRYPTO also provides trigger signals for DMA read and write operations.

## 3.9 Analog

### 3.9.1 Analog Port (APORT)

The Analog Port (APORT) is an analog interconnect matrix allowing access to analog modules ADC, ACMP, and IDAC on a flexible selection of pins. Each APORT bus consists of analog switches connected to a common wire. Since many clients can operate differentially, buses are grouped by X/Y pairs.

### 3.9.2 Analog Comparator (ACMP)

The Analog Comparator is used to compare the voltage of two analog inputs, with a digital output indicating which input voltage is higher. Inputs are selected from among internal references and external pins. The tradeoff between response time and current consumption is configurable by software. Two 6-bit reference dividers allow for a wide range of internally-programmable reference sources. The ACMP can also be used to monitor the supply voltage. An interrupt can be generated when the supply falls below or rises above the programmable threshold.

### 3.9.3 Analog to Digital Converter (ADC)

The ADC is a Successive Approximation Register (SAR) architecture, with a resolution of up to 12 bits at up to 1 MSamples/s. The output sample resolution is configurable and additional resolution is possible using integrated hardware for averaging over multiple samples. The ADC includes integrated voltage references and an integrated temperature sensor. Inputs are selectable from a wide range of sources, including pins configurable as either single-ended or differential.

### 3.9.4 Digital to Analog Current Converter (IDAC)

The Digital to Analog Current Converter can source or sink a configurable constant current. This current can be driven on an output pin or routed to the selected ADC input pin for capacitive sensing. The current is programmable between 0.05 µA and 64 µA with several ranges with various step sizes.

## 3.10 Reset Management Unit (RMU)

The RMU is responsible for handling reset of the BGM111. A wide range of reset sources are available, including several power supply monitors, pin reset, software controlled reset, core lockup reset and watchdog reset.

## 3.11 Core and Memory

### 3.11.1 Processor Core

The ARM Cortex-M4F processor includes a 32-bit RISC processor integrating the following features and tasks in the system:

- ARM Cortex-M4F RISC processor achieving 1.25 Dhrystone MIPS/MHz
- Memory Protection Unit (MPU) supporting up to 8 memory segments
- 256 KB flash program memory
- 32 KB RAM data memory
- Configuration and event handling of all modules
- 2-pin Serial-Wire debug interface

### 3.11.2 Memory System Controller (MSC)

The Memory System Controller (MSC) is the program memory unit of the microcontroller. The flash memory is readable and writable from both the Cortex-M and DMA. The flash memory is divided into two blocks; the main block and the information block. Program code is normally written to the main block, whereas the information block is available for special user data and flash lock bits. There is also a read-only page in the information block containing system and device calibration data. Read and write operations are supported in energy modes EM0 Active and EM1 Sleep.

### 3.11.3 Linked Direct Memory Access Controller (LDMA)

The Linked Direct Memory Access (LDMA) controller features 8 channels capable of performing memory operations independently of software. This reduces both energy consumption and software workload. The LDMA allows operations to be linked together and staged, enabling sophisticated operations to be implemented.

### 3.12 Memory Map

The BGM111 memory map is shown in the figures below.

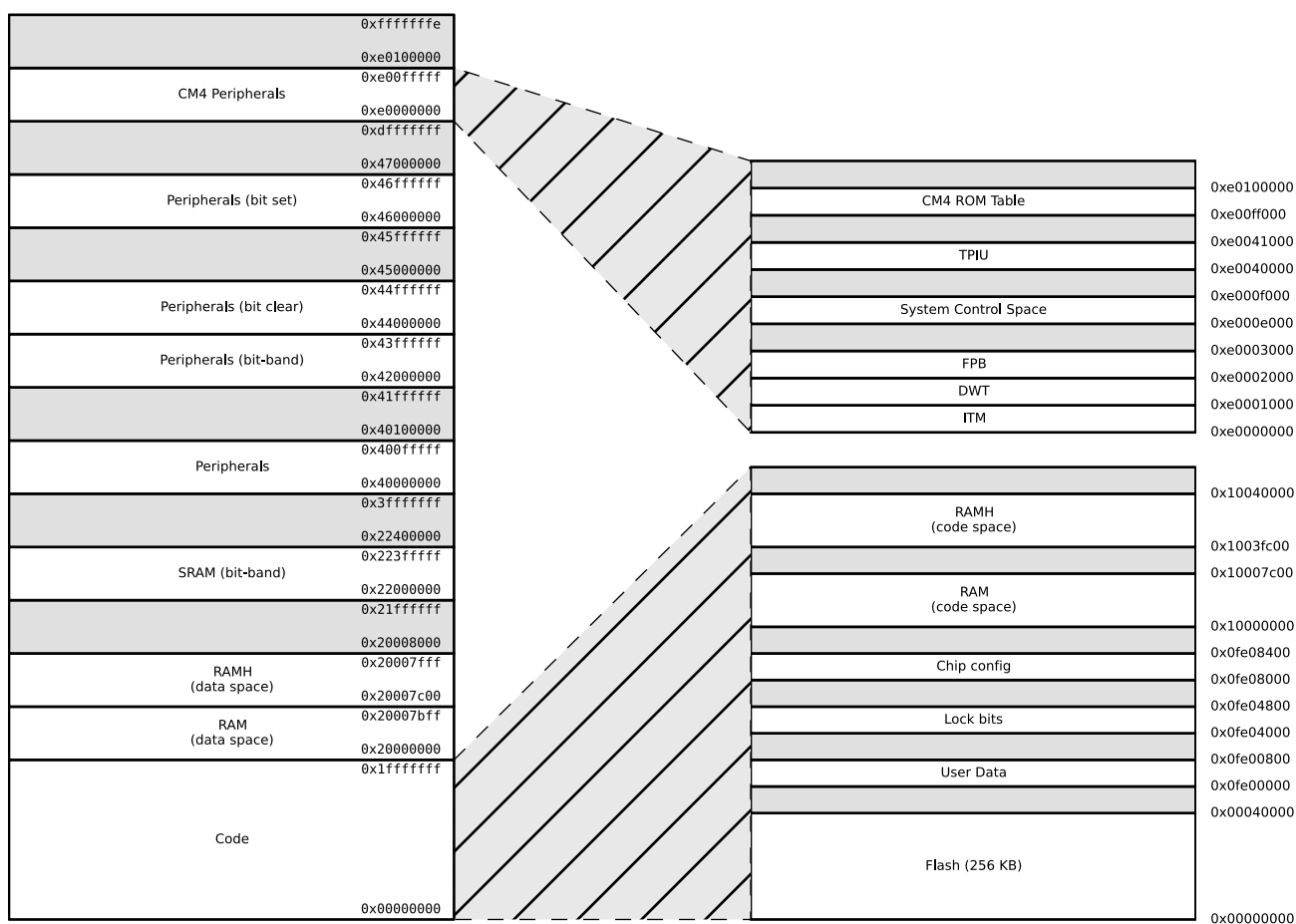


Figure 3.3. BGM111 Memory Map — Core Peripherals and Code Space

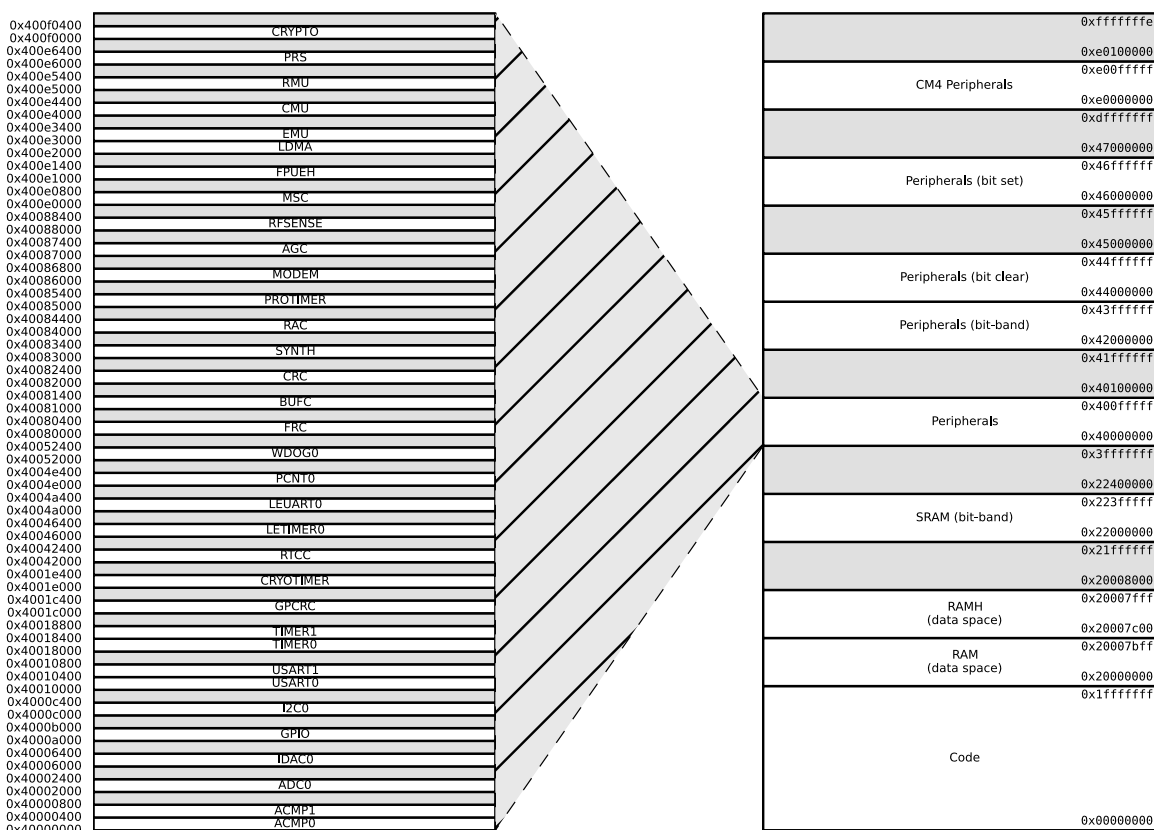


Figure 3.4. BGM111 Memory Map — Peripherals

### 3.13 Configuration Summary

The features of the BGM111 are a subset of the feature set described in the device reference manual. The table below describes device specific implementation of the features. Remaining modules support full configuration.

Table 3.2. Configuration Summary

| Module | Configuration                   | Pin Connections                 |
|--------|---------------------------------|---------------------------------|
| USART0 | IrDA SmartCard                  | US0_TX, US0_RX, US0_CLK, US0_CS |
| USART1 | IrDA I <sup>2</sup> S SmartCard | US1_TX, US1_RX, US1_CLK, US1_CS |
| TIMER0 | with DTI                        | TIM0_CC[2:0], TIM0_CDTI[2:0]    |
| TIMER1 |                                 | TIM1_CC[3:0]                    |

## 4. Electrical Specifications

### 4.1 Electrical Characteristics

All electrical parameters in all tables are specified under the following conditions, unless stated otherwise:

- Typical values are based on  $T_{AMB}=25^{\circ}\text{C}$  and  $V_{DD}=3.3\text{ V}$ , by production test and/or technology characterization.
- Radio performance numbers are measured in conducted mode, based on Silicon Laboratories reference designs using output power-specific external RF impedance-matching networks for interfacing to a  $50\ \Omega$  antenna.
- Minimum and maximum values represent the worst conditions across supply voltage, process variation, and operating temperature, unless stated otherwise.

Refer to [Table 4.2 General Operating Conditions on page 17](#) for more details about operational supply and temperature limits.

#### 4.1.1 Absolute Maximum Ratings

Stresses above those listed below may cause permanent damage to the device. This is a stress rating only and functional operation of the devices at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability. For more information on the available quality and reliability data, see the Quality and Reliability Monitor Report at <http://www.silabs.com/support/quality/pages/default.aspx>.

**Table 4.1. Absolute Maximum Ratings**

| Parameter                                              | Symbol           | Test Condition | Min  | Typ | Max                      | Unit               |
|--------------------------------------------------------|------------------|----------------|------|-----|--------------------------|--------------------|
| Storage temperature range                              | $T_{STG}$        |                | -40  | —   | +85                      | $^{\circ}\text{C}$ |
| External main supply voltage                           | $V_{DDMAX}$      |                | 0    | —   | 3.8                      | V                  |
| External main supply voltage ramp rate                 | $V_{DDRAMP MAX}$ |                | —    | —   | 1                        | V / $\mu\text{s}$  |
| External main supply voltage with DC-DC in bypass mode |                  |                | 1.85 |     | 3.8                      | V                  |
| Voltage on any 5V tolerant GPIO pin <sup>1</sup>       | $V_{DIGPIN}$     |                | -0.3 | —   | Min of 5.25 and IOVDD +2 | V                  |
| Voltage on non-5V tolerant GPIO pins                   |                  |                | -0.3 | —   | IOVDD+0.3                | V                  |
| Max RF level at input                                  | $P_{RFMAX2G4}$   |                | —    | —   | 10                       | dBm                |
| Total current into VDD power lines (source)            | $I_{VDDMAX}$     |                | —    | —   | 200                      | mA                 |
| Total current into VSS ground lines (sink)             | $I_{VSSMAX}$     |                | —    | —   | 200                      | mA                 |
| Current per I/O pin (sink)                             | $I_{IOMAX}$      |                | —    | —   | 50                       | mA                 |
| Current per I/O pin (source)                           |                  |                | —    | —   | 50                       | mA                 |
| Current for all I/O pins (sink)                        | $I_{IOALLMAX}$   |                | —    | —   | 200                      | mA                 |
| Current for all I/O pins (source)                      |                  |                | —    | —   | 200                      | mA                 |
| Voltage difference between AVDD and VREGVDD            | $\Delta V_{DD}$  |                | —    | —   | 0.3                      | V                  |

**Note:**

1. When a GPIO pin is routed to the analog module through the APORT, the maximum voltage = IOVDD.



## 4.1.2 Operating Conditions

The following subsections define the operating conditions for the module.

### 4.1.2.1 General Operating Conditions

**Table 4.2. General Operating Conditions**

| Parameter                                 | Symbol            | Test Condition                          | Min              | Typ  | Max | Unit |
|-------------------------------------------|-------------------|-----------------------------------------|------------------|------|-----|------|
| Operating temperature range               | T <sub>OP</sub>   | Ambient temperature range               | -40              | 25   | 85  | °C   |
| VDD Operating supply voltage <sup>1</sup> | V <sub>VDD</sub>  | DCDC in regulation                      | 2.4 <sup>3</sup> | 3.3  | 3.8 | V    |
|                                           |                   | DCDC in bypass, 50mA load               | 1.85             | 3.3  | 3.8 | V    |
| VDD Current                               | I <sub>VDD</sub>  | DCDC in bypass                          | —                | —    | 200 | mA   |
| HFCLK frequency                           | f <sub>CORE</sub> | 0 wait-states (MODE = WS0) <sup>2</sup> | —                | —    | 26  | MHz  |
|                                           |                   | 1 wait-states (MODE = WS1) <sup>2</sup> | —                | 38.4 | 40  | MHz  |

**Note:**

1. The minimum voltage required in bypass mode is calculated using R<sub>BYP</sub> from the DC-DC specification table. Requirements for other loads can be calculated as  $V_{VDD\_min} + I_{LOAD} * R_{BYP\_max}$
2. In MSC\_READCTRL register
3. The minimum voltage of 2.4 V for DCDC is specified at 100 mA.

### 4.1.3 DC-DC Converter

Test conditions:  $V_{\text{DCDC\_I}}=3.3\text{ V}$ ,  $V_{\text{DCDC\_O}}=1.8\text{ V}$ ,  $I_{\text{DCDC\_LOAD}}=50\text{ mA}$ , Heavy Drive configuration,  $F_{\text{DCDC\_LN}}=7\text{ MHz}$ , unless otherwise indicated.

**Table 4.3. DC-DC Converter**

| Parameter                                      | Symbol                    | Test Condition                                                                                                                                            | Min  | Typ | Max                       | Unit |
|------------------------------------------------|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----|---------------------------|------|
| Input voltage range                            | $V_{\text{DCDC\_I}}$      | Bypass mode, $I_{\text{DCDC\_LOAD}} = 50\text{ mA}$                                                                                                       | 1.85 | —   | $V_{\text{VREGVDD\_MAX}}$ | V    |
|                                                |                           | Low noise (LN) mode, 1.8 V output, $I_{\text{DCDC\_LOAD}} = 100\text{ mA}$ , or Low power (LP) mode, 1.8 V output, $I_{\text{DCDC\_LOAD}} = 10\text{ mA}$ | 2.4  | —   | $V_{\text{VREGVDD\_MAX}}$ | V    |
|                                                |                           | Low noise (LN) mode, 1.8 V output, $I_{\text{DCDC\_LOAD}} = 200\text{ mA}$                                                                                | 2.6  | —   | $V_{\text{VREGVDD\_MAX}}$ | V    |
| Output voltage programmable range <sup>1</sup> | $V_{\text{DCDC\_O}}$      |                                                                                                                                                           | 1.8  | —   | $V_{\text{VREGVDD}}$      | V    |
| Regulation DC Accuracy                         | $\text{ACC}_{\text{DC}}$  | Low noise (LN) mode, 1.8 V target output                                                                                                                  | 1.7  | —   | 1.9                       | V    |
| Regulation Window <sup>2</sup>                 | $\text{WIN}_{\text{REG}}$ | Low power (LP) mode, $\text{LPCMPBIAS}^3 = 0$ , 1.8 V target output, $I_{\text{DCDC\_LOAD}} \leq 75\text{ }\mu\text{A}$                                   | 1.63 | —   | 2.2                       | V    |
|                                                |                           | Low power (LP) mode, $\text{LPCMPBIAS}^3 = 3$ , 1.8 V target output, $I_{\text{DCDC\_LOAD}} \leq 10\text{ mA}$                                            | 1.63 | —   | 2.1                       | V    |
| Steady-state output ripple                     | $V_{\text{R}}$            | Radio disabled.                                                                                                                                           | —    | 3   | —                         | mVpp |
| Output voltage under/overshoot                 | $V_{\text{OV}}$           | CCM Mode ( $\text{LNFORCECCM}^3 = 1$ ), Load changes between 0 mA and 100 mA                                                                              | —    | —   | 150                       | mV   |
|                                                |                           | DCM Mode ( $\text{LNFORCECCM}^3 = 0$ ), Load changes between 0 mA and 10 mA                                                                               | —    | —   | 150                       | mV   |
|                                                |                           | Overshoot during LP to LN CCM/DCM mode transitions compared to DC level in LN mode                                                                        | —    | 200 | —                         | mV   |
|                                                |                           | Undershoot during BYP/LP to LN CCM ( $\text{LNFORCECCM}^3 = 1$ ) mode transitions compared to DC level in LN mode                                         | —    | 50  | —                         | mV   |
|                                                |                           | Undershoot during BYP/LP to LN DCM ( $\text{LNFORCECCM}^3 = 0$ ) mode transitions compared to DC level in LN mode                                         | —    | 125 | —                         | mV   |
| DC line regulation                             | $V_{\text{REG}}$          | Input changes between $V_{\text{VREGVDD\_MAX}}$ and 2.4 V                                                                                                 | —    | 0.1 | —                         | %    |
| DC load regulation                             | $I_{\text{REG}}$          | Load changes between 0 mA and 100 mA in CCM mode                                                                                                          | —    | 0.1 | —                         | %    |

| Parameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Symbol | Test Condition | Min | Typ | Max | Unit |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------|-----|-----|-----|------|
| <b>Note:</b> <ol style="list-style-type: none"><li>1. Due to internal dropout, the DC-DC output will never be able to reach its input voltage, <math>V_{VREGVDD}</math></li><li>2. LP mode controller is a hysteretic controller that maintains the output voltage within the specified limits</li><li>3. In EMU_DCDCMISCCTRL register</li><li>4. Drive levels are defined by configuration of the PFETCNT and NFETCNT registers. Light Drive: PFETCNT=NFETCNT=3; Medium Drive: PFETCNT=NFETCNT=7; Heavy Drive: PFETCNT=NFETCNT=15.</li></ol> |        |                |     |     |     |      |

## 4.1.4 Current Consumption

### 4.1.4.1 Current Consumption 3.3 V (DC-DC in Bypass Mode)

Unless otherwise indicated, typical conditions are: VDD = 3.3 V. T<sub>OP</sub> = 25 °C. EMU\_PWRCFG\_PWRCG=NODCDC. EMU\_DCDCCTRL\_DCDCMODE=BYPASS. Minimum and maximum values in this table represent the worst conditions across supply voltage and process variation at T<sub>OP</sub> = 25 °C.

**Table 4.4. Current Consumption 3.3V without DC/DC**

| Parameter                                                            | Symbol              | Test Condition                                                   | Min | Typ  | Max  | Unit   |
|----------------------------------------------------------------------|---------------------|------------------------------------------------------------------|-----|------|------|--------|
| Current consumption in EM0 Active mode with all peripherals disabled | I <sub>ACTIVE</sub> | 38.4 MHz crystal, CPU running while loop from flash <sup>1</sup> | —   | 130  | —    | µA/MHz |
|                                                                      |                     | 38 MHz HFRCO, CPU running Prime from flash                       | —   | 88   | —    | µA/MHz |
|                                                                      |                     | 38 MHz HFRCO, CPU running while loop from flash                  | —   | 100  | 105  | µA/MHz |
|                                                                      |                     | 38 MHz HFRCO, CPU running CoreMark from flash                    | —   | 112  | —    | µA/MHz |
|                                                                      |                     | 26 MHz HFRCO, CPU running while loop from flash                  | —   | 102  | 106  | µA/MHz |
|                                                                      |                     | 1 MHz HFRCO, CPU running while loop from flash                   | —   | 222  | 350  | µA/MHz |
| Current consumption in EM1 Sleep mode with all peripherals disabled  | I <sub>EM1</sub>    | 38.4 MHz crystal <sup>1</sup>                                    | —   | 65   | —    | µA/MHz |
|                                                                      |                     | 38 MHz HFRCO                                                     | —   | 35   | 38   | µA/MHz |
|                                                                      |                     | 26 MHz HFRCO                                                     | —   | 37   | 41   | µA/MHz |
|                                                                      |                     | 1 MHz HFRCO                                                      | —   | 157  | 275  | µA/MHz |
| Current consumption in EM2 Deep Sleep mode.                          | I <sub>EM2</sub>    | Full RAM retention and RTCC running from LFXO                    | —   | 3.3  | —    | µA     |
|                                                                      |                     | 4 kB RAM retention and RTCC running from LFRCO                   | —   | 3    | 6.3  | µA     |
| Current consumption in EM3 Stop mode                                 | I <sub>EM3</sub>    | Full RAM retention and CRYO-TIMER running from ULFRCO            | —   | 2.8  | 6    | µA     |
| Current consumption in EM4H Hibernate mode                           | I <sub>EM4</sub>    | 128 byte RAM retention, RTCC running from LFXO                   | —   | 1.1  | —    | µA     |
|                                                                      |                     | 128 byte RAM retention, CRYO-TIMER running from ULFRCO           | —   | 0.65 | —    | µA     |
|                                                                      |                     | 128 byte RAM retention, no RTCC                                  | —   | 0.65 | 1.3  | µA     |
| Current consumption in EM4S Shutoff mode                             | I <sub>EM4S</sub>   | no RAM retention, no RTCC                                        | —   | 0.04 | 0.11 | µA     |
| <b>Note:</b><br>1. CMU_HFXOCTRL_LOWPOWER=0                           |                     |                                                                  |     |      |      |        |

**4.1.4.2 Current Consumption 3.3 V using DC-DC Converter**

Unless otherwise indicated, typical conditions are: VDD = 3.3V. T<sub>OP</sub> = 25 °C. Minimum and maximum values in this table represent the worst conditions across supply voltage and process variation at T<sub>OP</sub> = 25 °C.

**Table 4.5. Current Consumption 3.3V with DC-DC**

| Parameter                                                                                                       | Symbol              | Test Condition                                                   | Min | Typ  | Max | Unit   |
|-----------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------------------------------------|-----|------|-----|--------|
| Current consumption in EM0 Active mode with all peripherals disabled, DCDC in Low Noise DCM mode <sup>1</sup> . | I <sub>ACTIVE</sub> | 38.4 MHz crystal, CPU running while loop from flash <sup>2</sup> | —   | 88   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO, CPU running Prime from flash                       | —   | 63   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO, CPU running while loop from flash                  | —   | 71   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO, CPU running CoreMark from flash                    | —   | 78   | —   | μA/MHz |
|                                                                                                                 |                     | 26 MHz HFRCO, CPU running while loop from flash                  | —   | 76   | —   | μA/MHz |
| Current consumption in EM0 Active mode with all peripherals disabled, DCDC in Low Noise CCM mode <sup>3</sup> . |                     | 38.4 MHz crystal, CPU running while loop from flash <sup>2</sup> | —   | 98   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO, CPU running Prime from flash                       | —   | 75   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO, CPU running while loop from flash                  | —   | 81   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO, CPU running CoreMark from flash                    | —   | 88   | —   | μA/MHz |
|                                                                                                                 |                     | 26 MHz HFRCO, CPU running while loop from flash                  | —   | 94   | —   | μA/MHz |
| Current consumption in EM1 Sleep mode with all peripherals disabled, DCDC in Low Noise DCM mode <sup>1</sup> .  | I <sub>EM1</sub>    | 38.4 MHz crystal <sup>2</sup>                                    | —   | 49   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO                                                     | —   | 32   | —   | μA/MHz |
|                                                                                                                 |                     | 26 MHz HFRCO                                                     | —   | 38   | —   | μA/MHz |
| Current consumption in EM1 Sleep mode with all peripherals disabled, DCDC in Low Noise CCM mode <sup>3</sup> .  |                     | 38.4 MHz crystal <sup>2</sup>                                    | —   | 61   | —   | μA/MHz |
|                                                                                                                 |                     | 38 MHz HFRCO                                                     | —   | 45   | —   | μA/MHz |
|                                                                                                                 |                     | 26 MHz HFRCO                                                     | —   | 58   | —   | μA/MHz |
| Current consumption in EM2 Deep Sleep mode. DCDC in Low Power mode <sup>4</sup> .                               | I <sub>EM2</sub>    | Full RAM retention and RTCC running from LFXO                    | —   | 2.5  | —   | μA     |
|                                                                                                                 |                     | 4 kB RAM retention and RTCC running from LFRCO                   | —   | 2.2  | —   | μA     |
| Current consumption in EM3 Stop mode                                                                            | I <sub>EM3</sub>    | Full RAM retention and CRYO-TIMER running from ULFRCO            | —   | 2.1  | —   | μA     |
| Current consumption in EM4H Hibernate mode                                                                      | I <sub>EM4</sub>    | 128 byte RAM retention, RTCC running from LFXO                   | —   | 0.86 | —   | μA     |
|                                                                                                                 |                     | 128 byte RAM retention, CRYO-TIMER running from ULFRCO           | —   | 0.58 | —   | μA     |
|                                                                                                                 |                     | 128 byte RAM retention, no RTCC                                  | —   | 0.58 | —   | μA     |

| Parameter                                | Symbol     | Test Condition            | Min | Typ  | Max | Unit    |
|------------------------------------------|------------|---------------------------|-----|------|-----|---------|
| Current consumption in EM4S Shutoff mode | $I_{EM4S}$ | no RAM retention, no RTCC | —   | 0.04 | —   | $\mu A$ |

**Note:**

1. DCDC Low Noise DCM Mode = Light Drive (PFETCNT=NFETCNT=3), F=3.0 MHz (RCOBAND=0), ANASW=DVDD
2. CMU\_HFXOCTRL\_LOWPOWER=0
3. DCDC Low Noise CCM Mode = Light Drive (PFETCNT=NFETCNT=3), F=6.4 MHz (RCOBAND=4), ANASW=DVDD
4. DCDC Low Power Mode = Medium Drive (PFETCNT=NFETCNT=7), LPOSCDIV=1, LPBIAS=3, LPCILIMSEL=1, ANASW=DVDD

**4.1.4.3 Current Consumption 1.85 V (DC-DC in Bypass Mode)**

Unless otherwise indicated, typical conditions are: VDD = 1.85 V. T<sub>OP</sub> = 25 °C. DC-DC in bypass mode. Minimum and maximum values in this table represent the worst conditions across supply voltage and process variation at T<sub>OP</sub> = 25 °C.

**Table 4.6. Current Consumption 1.85V without DC/DC**

| Parameter                                                               | Symbol              | Test Condition                                                   | Min | Typ  | Max | Unit   |
|-------------------------------------------------------------------------|---------------------|------------------------------------------------------------------|-----|------|-----|--------|
| Current consumption in EM0<br>Active mode with all peripherals disabled | I <sub>ACTIVE</sub> | 38.4 MHz crystal, CPU running while loop from flash <sup>1</sup> | —   | 131  | —   | µA/MHz |
|                                                                         |                     | 38 MHz HFRCO, CPU running Prime from flash                       | —   | 88   | —   | µA/MHz |
|                                                                         |                     | 38 MHz HFRCO, CPU running while loop from flash                  | —   | 100  | —   | µA/MHz |
|                                                                         |                     | 38 MHz HFRCO, CPU running CoreMark from flash                    | —   | 112  | —   | µA/MHz |
|                                                                         |                     | 26 MHz HFRCO, CPU running while loop from flash                  | —   | 102  | —   | µA/MHz |
|                                                                         |                     | 1 MHz HFRCO, CPU running while loop from flash                   | —   | 220  | —   | µA/MHz |
| Current consumption in EM1<br>Sleep mode with all peripherals disabled  | I <sub>EM1</sub>    | 38.4 MHz crystal <sup>1</sup>                                    | —   | 65   | —   | µA/MHz |
|                                                                         |                     | 38 MHz HFRCO                                                     | —   | 35   | —   | µA/MHz |
|                                                                         |                     | 26 MHz HFRCO                                                     | —   | 37   | —   | µA/MHz |
|                                                                         |                     | 1 MHz HFRCO                                                      | —   | 154  | —   | µA/MHz |
| Current consumption in EM2<br>Deep Sleep mode                           | I <sub>EM2</sub>    | Full RAM retention and RTCC running from LFXO                    | —   | 3.2  | —   | µA     |
|                                                                         |                     | 4 kB RAM retention and RTCC running from LFRCO                   | —   | 2.8  | —   | µA     |
| Current consumption in EM3<br>Stop mode                                 | I <sub>EM3</sub>    | Full RAM retention and CRYO-TIMER running from ULFRCO            | —   | 2.7  | —   | µA     |
| Current consumption in EM4H<br>Hibernate mode                           | I <sub>EM4</sub>    | 128 byte RAM retention, RTCC running from LFXO                   | —   | 1    | —   | µA     |
|                                                                         |                     | 128 byte RAM retention, CRYO-TIMER running from ULFRCO           | —   | 0.62 | —   | µA     |
|                                                                         |                     | 128 byte RAM retention, no RTCC                                  | —   | 0.62 | —   | µA     |
| Current consumption in EM4S<br>Shutoff mode                             | I <sub>EM4S</sub>   | No RAM retention, no RTCC                                        | —   | 0.02 | —   | µA     |

**Note:**

1. CMU\_HFXOCTRL\_LOWPOWER=0

#### 4.1.4.4 Current Consumption Using Radio

Unless otherwise indicated, typical conditions are: VDD = 3.3 V. T<sub>OP</sub> = 25 °C. DC-DC on. Minimum and maximum values in this table represent the worst conditions across supply voltage and process variation at T<sub>OP</sub> = 25 °C.

**Table 4.7. Current Consumption Using Radio 3.3 V with DC-DC**

| Parameter                                                                                                        | Symbol               | Test Condition                                                  | Min | Typ  | Max | Unit |
|------------------------------------------------------------------------------------------------------------------|----------------------|-----------------------------------------------------------------|-----|------|-----|------|
| Current consumption in receive mode, active packet reception (MCU in EM1 @ 38.4 MHz, peripheral clocks disabled) | I <sub>RX</sub>      | 1 Mbit/s, 2GFSK, F = 2.4 GHz, Radio clock prescaled by 4        | —   | 8.7  | —   | mA   |
| Current consumption in transmit mode (MCU in EM1 @ 38.4 MHz, peripheral clocks disabled)                         | I <sub>TX</sub>      | F = 2.4 GHz, CW, 0 dBm output power, Radio clock prescaled by 3 | —   | 8.2  | —   | mA   |
|                                                                                                                  |                      | F = 2.4 GHz, CW, 3 dBm output power                             | —   | 16.5 | —   | mA   |
|                                                                                                                  |                      | F = 2.4 GHz, CW, 8 dBm output power                             | —   | 23.3 | —   | mA   |
| RFSENSE current consumption                                                                                      | I <sub>RFSENSE</sub> |                                                                 | —   | 51   | —   | nA   |

#### 4.1.5 Wake up times

**Table 4.8. Wake up times**

| Parameter                                  | Symbol               | Test Condition            | Min | Typ  | Max | Unit       |
|--------------------------------------------|----------------------|---------------------------|-----|------|-----|------------|
| Wake up from EM2 Deep Sleep                | t <sub>EM2_WU</sub>  | Code execution from flash | —   | 10.7 | —   | µs         |
|                                            |                      | Code execution from RAM   | —   | 3    | —   | µs         |
| Wakeup time from EM1 Sleep                 | t <sub>EM1_WU</sub>  | Executing from flash      | —   | 3    | —   | AHB Clocks |
|                                            |                      | Executing from RAM        | —   | 3    | —   | AHB Clocks |
| Wake up from EM3 Stop                      | t <sub>EM3_WU</sub>  | Executing from flash      | —   | 10.7 | —   | µs         |
|                                            |                      | Executing from RAM        | —   | 3    | —   | µs         |
| Wake up from EM4H Hibernation <sup>1</sup> | t <sub>EM4H_WU</sub> | Executing from flash      | —   | 60   | —   | µs         |
| Wake up from EM4S Shut-off <sup>1</sup>    | t <sub>EM4S_WU</sub> |                           | —   | 290  | —   | µs         |

**Note:**

1. Time from wakeup request until first instruction is executed. Wakeup results in device reset.



#### 4.1.6 Brown Out Detector

For the table below, see [Figure 3.2 Power Supply Configuration on page 9](#) on page 5 to see the relation between the modules external VDD pin and internal voltage supplies. The module itself has only one external power supply input (VDD).

**Table 4.9. Brown Out Detector**

| Parameter           | Symbol               | Test Condition               | Min  | Typ | Max  | Unit |
|---------------------|----------------------|------------------------------|------|-----|------|------|
| AVDD BOD threshold  | $V_{AVDDBOD}$        | AVDD rising                  | —    | —   | 1.85 | V    |
|                     |                      | AVDD falling                 | 1.62 | —   | —    | V    |
| AVDD BOD hysteresis | $V_{AVDDBOD\_HYST}$  |                              | —    | 21  | —    | mV   |
| AVDD response time  | $t_{AVDDBOD\_DELAY}$ | Supply drops at 0.1V/μs rate | —    | 2.4 | —    | μs   |
| EM4 BOD threshold   | $V_{EM4BOD}$         | AVDD rising                  | —    | —   | 1.7  | V    |
|                     |                      | AVDD falling                 | 1.45 | —   | —    | V    |
| EM4 BOD hysteresis  | $V_{EM4BOD\_HYST}$   |                              | —    | 46  | —    | mV   |
| EM4 response time   | $t_{EM4BOD\_DELAY}$  | Supply drops at 0.1V/μs rate | —    | 300 | —    | μs   |

#### 4.1.7 Frequency Synthesizer Characteristics

**Table 4.10. Frequency Synthesizer Characteristics**

| Parameter                                            | Symbol                 | Test Condition          | Min  | Typ | Max    | Unit |
|------------------------------------------------------|------------------------|-------------------------|------|-----|--------|------|
| RF Synthesizer Frequency range                       | $F_{RANGE\_2400}$      | 2.4 GHz frequency range | 2400 | —   | 2483.5 | MHz  |
| LO tuning frequency resolution with 38.4 MHz crystal | $F_{RES\_2400}$        | 2400 - 2483.5 MHz       | —    | —   | 73     | Hz   |
| Maximum frequency deviation with 38.4 MHz crystal    | $\Delta F_{MAX\_2400}$ |                         | —    | —   | 1677   | kHz  |

## 4.1.8 2.4 GHz RF Transceiver Characteristics

### 4.1.8.1 RF Transmitter General Characteristics for the 2.4 GHz Band

Unless otherwise indicated, typical conditions are:  $T_{OP} = 25\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ , DC-DC on. Crystal frequency = 38.4 MHz. RF center frequency 2.45 GHz. Conducted measurement from the antenna feedpoint.

**Table 4.11. RF Transmitter General Characteristics for 2.4 GHz Band**

| Parameter                                              | Symbol          | Test Condition                                                                                                        | Min  | Typ | Max    | Unit |
|--------------------------------------------------------|-----------------|-----------------------------------------------------------------------------------------------------------------------|------|-----|--------|------|
| Maximum TX power                                       | $POUT_{MAX}$    |                                                                                                                       | —    | +8  | —      | dBm  |
| Minimum active TX Power                                | $POUT_{MIN}$    | CW                                                                                                                    |      | -26 | —      | dBm  |
| Output power step size                                 | $POUT_{STEP}$   | -5 dBm < Output power < 0 dBm                                                                                         | —    | 1   | —      | dB   |
|                                                        |                 | 0 dBm < output power < $POUT_{MAX}$                                                                                   | —    | 0.5 | —      | dB   |
| Output power variation vs supply at $POUT_{MAX}$       | $POUT_{VAR\_V}$ | $1.85\text{ V} < V_{VREGVDD} < 3.3\text{ V}$ , PAVDD connected directly to external supply, for output power = 8 dBm. | —    | 2.3 | —      | dB   |
| Output power variation vs temperature at $POUT_{MAX}$  | $POUT_{VAR\_T}$ | From $-40$ to $+85\text{ }^{\circ}\text{C}$ , PAVDD connected to DC-DC output                                         | —    | 1.5 | —      | dB   |
| Output power variation vs RF frequency at $POUT_{MAX}$ | $POUT_{VAR\_F}$ | Over RF tuning frequency range                                                                                        | —    | 0.4 | —      | dB   |
| RF tuning frequency range                              | $F_{RANGE}$     |                                                                                                                       | 2400 | —   | 2483.5 | MHz  |

### 4.1.8.2 RF Receiver General Characteristics for the 2.4 GHz Band

Unless otherwise indicated, typical conditions are:  $T_{OP} = 25\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ , DC-DC on. Crystal frequency = 38.4 MHz. RF center frequency 2.440 GHz. Conducted measurement from the antenna feedpoint.

**Table 4.12. RF Receiver General Characteristics for 2.4 GHz Band**

| Parameter                                                                 | Symbol            | Test Condition                            | Min  | Typ   | Max    | Unit |
|---------------------------------------------------------------------------|-------------------|-------------------------------------------|------|-------|--------|------|
| RF tuning frequency range                                                 | $F_{RANGE}$       |                                           | 2400 | —     | 2483.5 | MHz  |
| Receive mode maximum spurious emission                                    | $SPUR_{RX}$       | 30 MHz to 1 GHz                           | —    | -57   | —      | dBm  |
|                                                                           |                   | 1 GHz to 12 GHz                           | —    | -47   | —      | dBm  |
| Max spurious emissions during active receive mode, per FCC Part 15.109(a) | $SPUR_{RX\_FCC}$  | 216 MHz to 960 MHz, Conducted Measurement | —    | -55.2 | —      | dBm  |
|                                                                           |                   | Above 960 MHz, Conducted Measurement      | —    | -47.2 | —      | dBm  |
| Level above which RFSENSE will trigger <sup>1</sup>                       | $RFSENSE_{TRIG}$  | CW at 2.45 GHz                            | —    | -24   | —      | dBm  |
| Level below which RFSENSE will not trigger <sup>1</sup>                   | $RFSENSE_{THRES}$ |                                           | —    | -50   | —      | dBm  |

**Note:**

1. RFSENSE performance is only valid from 0 to 85 °C. RFSENSE should be disabled outside this temperature range.

**4.1.8.3 RF Receiver Characteristics for Bluetooth Smart in the 2.4 GHz Band**

Unless otherwise indicated, typical conditions are:  $T_{OP} = 25\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 3.3\text{ V}$ . Crystal frequency = 38.4 MHz. RF center frequency 2.440 GHz. DC-DC on. Conducted measurement from the antenna feedpoint.

**Table 4.13. RF Receiver Characteristics for Bluetooth Smart in the 2.4GHz Band**

| Parameter                                                                                  | Symbol               | Test Condition                                                        | Min | Typ   | Max  | Unit |
|--------------------------------------------------------------------------------------------|----------------------|-----------------------------------------------------------------------|-----|-------|------|------|
| Max usable receiver input level, 0.1% BER                                                  | SAT                  | Signal is reference signal <sup>1</sup> . Packet length is 20 bytes.  | —   | 10    | —    | dBm  |
| 30.8% Packet Error Rate <sup>2</sup>                                                       | SENS                 | With non-ideal signals as specified in RF-PHY.TS.4.2.2, section 4.6.1 | —   | -92   | —    | dBm  |
| Signal to co-channel interferer, 0.1% BER                                                  | $C/I_{CC}$           | Desired signal 3 dB above reference sensitivity                       | —   | 8.3   | —    | dB   |
| Blocking, 0.1% BER, Desired is reference signal at -67 dBm. Interferer is CW in OOB range. | BLOCK <sub>OOB</sub> | Interferer frequency $30\text{ MHz} \leq f \leq 2000\text{ MHz}$      | —   | -27   | —    | dBm  |
|                                                                                            |                      | Interferer frequency $2003\text{ MHz} \leq f \leq 2399\text{ MHz}$    | —   | -32   | —    | dBm  |
|                                                                                            |                      | Interferer frequency $2484\text{ MHz} \leq f \leq 2997\text{ MHz}$    | —   | -32   | —    | dBm  |
|                                                                                            |                      | Interferer frequency $3\text{ GHz} \leq f \leq 12.75\text{ GHz}$      | —   | -27   | —    | dBm  |
| Intermodulation performance                                                                | IM                   | Per Core_4.1, Vol 6, Part A, Section 4.4 with $n = 3$                 | —   | -25.8 | —    | dBm  |
| Upper limit of input power range over which RSSI resolution is maintained                  | RSSI <sub>MAX</sub>  |                                                                       | 4   | —     | —    | dBm  |
| Lower limit of input power range over which RSSI resolution is maintained                  | RSSI <sub>MIN</sub>  |                                                                       | —   | —     | -101 | dBm  |
| RSSI resolution                                                                            | RSSI <sub>RES</sub>  | Over RSSI <sub>MIN</sub> to RSSI <sub>MAX</sub>                       | —   | —     | 0.5  | dB   |

**Note:**

- Reference signal is defined 2GFSK at -67 dBm, Modulation index = 0.5, BT = 0.5, Bit rate = 1 Mbps, desired data = PRBS9; interferer data = PRBS15; frequency accuracy better than 1 ppm
- Receive sensitivity on Bluetooth Smart channel 26 is -86 dBm

## 4.1.9 Oscillators

### 4.1.9.1 LFXO

**Table 4.14. LFXO**

| Parameter                                                          | Symbol            | Test Condition | Min  | Typ    | Max | Unit |
|--------------------------------------------------------------------|-------------------|----------------|------|--------|-----|------|
| Crystal frequency                                                  | $f_{\text{LFXO}}$ |                | —    | 32.768 | —   | kHz  |
| Overall frequency tolerance in all conditions <sup>1</sup>         |                   |                | -100 |        | 100 | ppm  |
| <b>Note:</b><br>1. XTAL nominal frequency tolerance = $\pm 20$ ppm |                   |                |      |        |     |      |

### 4.1.9.2 HFXO

**Table 4.15. HFXO**

| Parameter                   | Symbol            | Test Condition | Min | Typ  | Max | Unit |
|-----------------------------|-------------------|----------------|-----|------|-----|------|
| Crystal frequency           | $f_{\text{HFXO}}$ |                | -   | 38.4 | -   | MHz  |
| Crystal frequency tolerance |                   |                | -40 |      | 40  | ppm  |

### 4.1.9.3 LFRCO

**Table 4.16. LFRCO**

| Parameter                                                                                             | Symbol             | Test Condition              | Min    | Typ    | Max    | Unit |
|-------------------------------------------------------------------------------------------------------|--------------------|-----------------------------|--------|--------|--------|------|
| Oscillation frequency                                                                                 | f <sub>LFRCO</sub> | ENVREF = 1 in CMU_LFRCOCTRL | 30.474 | 32.768 | 34.243 | kHz  |
|                                                                                                       |                    | ENVREF = 0 in CMU_LFRCOCTRL | 30.474 | 32.768 | 33.915 | kHz  |
| Startup time                                                                                          | t <sub>LFRCO</sub> |                             | —      | 500    | —      | μs   |
| Current consumption <sup>1</sup>                                                                      | I <sub>LFRCO</sub> | ENVREF = 1 in CMU_LFRCOCTRL | —      | 342    | —      | nA   |
|                                                                                                       |                    | ENVREF = 0 in CMU_LFRCOCTRL | —      | 494    | —      | nA   |
| <b>Note:</b><br>1. Block is supplied by AVDD if ANASW = 0, or DVDD if ANASW=1 in EMU_PWRCTRL register |                    |                             |        |        |        |      |

## 4.1.9.4 HFRCO and AUXHFRCO

Table 4.17. HFRCO and AUXHFRCO

| Parameter                           | Symbol              | Test Condition                                            | Min  | Typ | Max | Unit          |
|-------------------------------------|---------------------|-----------------------------------------------------------|------|-----|-----|---------------|
| Frequency Accuracy                  | $f_{\text{HFRCO}}$  | Any frequency band, across supply voltage and temperature | -2.5 | —   | 2.5 | %             |
| Start-up time                       | $t_{\text{HFRCO}}$  | $f_{\text{HFRCO}} \geq 19 \text{ MHz}$                    | —    | 300 | —   | ns            |
|                                     |                     | $4 < f_{\text{HFRCO}} < 19 \text{ MHz}$                   | —    | 1   | —   | $\mu\text{s}$ |
|                                     |                     | $f_{\text{HFRCO}} \leq 4 \text{ MHz}$                     | —    | 2.5 | —   | $\mu\text{s}$ |
| Current consumption on all supplies | $I_{\text{HFRCO}}$  | $f_{\text{HFRCO}} = 38 \text{ MHz}$                       | —    | 204 | 228 | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 32 \text{ MHz}$                       | —    | 171 | 190 | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 26 \text{ MHz}$                       | —    | 147 | 164 | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 19 \text{ MHz}$                       | —    | 126 | 138 | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 16 \text{ MHz}$                       | —    | 110 | 120 | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 13 \text{ MHz}$                       | —    | 100 | 110 | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 7 \text{ MHz}$                        | —    | 81  | 91  | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 4 \text{ MHz}$                        | —    | 33  | 35  | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 2 \text{ MHz}$                        | —    | 31  | 35  | $\mu\text{A}$ |
|                                     |                     | $f_{\text{HFRCO}} = 1 \text{ MHz}$                        | —    | 30  | 35  | $\mu\text{A}$ |
| Step size                           | $SS_{\text{HFRCO}}$ | Coarse (% of period)                                      | —    | 0.8 | —   | %             |
|                                     |                     | Fine (% of period)                                        | —    | 0.1 | —   | %             |
| Period Jitter                       | $PJ_{\text{HFRCO}}$ |                                                           | —    | 0.2 | —   | % RMS         |

## 4.1.9.5 ULFRCO

Table 4.18. ULFRCO

| Parameter             | Symbol              | Test Condition | Min  | Typ | Max  | Unit |
|-----------------------|---------------------|----------------|------|-----|------|------|
| Oscillation frequency | $f_{\text{ULFRCO}}$ |                | 0.95 | 1   | 1.07 | kHz  |

## 4.1.10 Flash Memory Characteristics

Table 4.19. Flash Memory Characteristics<sup>1</sup>

| Parameter                                 | Symbol               | Test Condition | Min   | Typ | Max | Unit   |
|-------------------------------------------|----------------------|----------------|-------|-----|-----|--------|
| Flash erase cycles before failure         | EC <sub>FLASH</sub>  |                | 10000 | —   | —   | cycles |
| Flash data retention                      | RET <sub>FLASH</sub> |                | 10    | —   | —   | years  |
| Word (32-bit) programming time            | t <sub>W_PROG</sub>  |                | 20    | 26  | 40  | μs     |
| Page erase time                           | t <sub>PERASE</sub>  |                | 20    | 27  | 40  | ms     |
| Mass erase time                           | t <sub>MERASE</sub>  |                | 20    | 27  | 40  | ms     |
| Device erase time <sup>2</sup>            | t <sub>DERASE</sub>  |                | —     | 60  | 74  | ms     |
| Page erase current <sup>3</sup>           | I <sub>ERASE</sub>   |                | —     | —   | 3   | mA     |
| Mass or Device erase current <sup>3</sup> |                      |                | —     | —   | 5   | mA     |
| Write current <sup>3</sup>                | I <sub>WRITE</sub>   |                | —     | —   | 3   | mA     |

**Note:**

- Flash data retention information is published in the Quarterly Quality and Reliability Report.
- Device erase is issued over the AAP interface and erases all flash, SRAM, the Lock Bit (LB) page, and the User data page Lock Word (ULW)
- Measured at 25°C

#### 4.1.11 GPIO

For the table below, see [Figure 3.2 Power Supply Configuration on page 9](#) on page 5 to see the relation between the modules external VDD pin and internal voltage supplies. The module itself has only one external power supply input (VDD).

**Table 4.20. GPIO**

| Parameter                                                      | Symbol          | Test Condition                                                             | Min               | Typ | Max               | Unit       |
|----------------------------------------------------------------|-----------------|----------------------------------------------------------------------------|-------------------|-----|-------------------|------------|
| Input low voltage                                              | $V_{IOIL}$      |                                                                            | —                 | —   | $IOVDD \cdot 0.3$ | V          |
| Input high voltage                                             | $V_{IOIH}$      |                                                                            | $IOVDD \cdot 0.7$ | —   | —                 | V          |
| Output high voltage relative to IOVDD                          | $V_{IOOH}$      | Sourcing 3 mA, $IOVDD \geq 3$ V,<br>DRIVESTRENGTH <sup>1</sup> = WEAK      | $IOVDD \cdot 0.8$ | —   | —                 | V          |
|                                                                |                 | Sourcing 1.2 mA, $IOVDD \geq 1.62$ V,<br>DRIVESTRENGTH <sup>1</sup> = WEAK | $IOVDD \cdot 0.6$ | —   | —                 | V          |
|                                                                |                 | Sourcing 20 mA, $IOVDD \geq 3$ V,<br>DRIVESTRENGTH <sup>1</sup> = STRONG   | $IOVDD \cdot 0.8$ | —   | —                 | V          |
|                                                                |                 | Sourcing 8 mA, $IOVDD \geq 1.62$ V,<br>DRIVESTRENGTH <sup>1</sup> = STRONG | $IOVDD \cdot 0.6$ | —   | —                 | V          |
| Output low voltage relative to IOVDD                           | $V_{IOOL}$      | Sinking 3 mA, $IOVDD \geq 3$ V,<br>DRIVESTRENGTH <sup>1</sup> = WEAK       | —                 | —   | $IOVDD \cdot 0.2$ | V          |
|                                                                |                 | Sinking 1.2 mA, $IOVDD \geq 1.62$ V,<br>DRIVESTRENGTH <sup>1</sup> = WEAK  | —                 | —   | $IOVDD \cdot 0.4$ | V          |
|                                                                |                 | Sinking 20 mA, $IOVDD \geq 3$ V,<br>DRIVESTRENGTH <sup>1</sup> = STRONG    | —                 | —   | $IOVDD \cdot 0.2$ | V          |
|                                                                |                 | Sinking 8 mA, $IOVDD \geq 1.62$ V,<br>DRIVESTRENGTH <sup>1</sup> = STRONG  | —                 | —   | $IOVDD \cdot 0.4$ | V          |
| Input leakage current                                          | $I_{IOLEAK}$    | All GPIO except LFXO pins, $GPIO \leq IOVDD$                               | —                 | 0.1 | 30                | nA         |
|                                                                |                 | LFXO Pins, $GPIO \leq IOVDD$                                               | —                 | 0.1 | 50                | nA         |
| Input leakage current on 5VTOL pads above IOVDD                | $I_{5VTOLLEAK}$ | $IOVDD < GPIO \leq IOVDD + 2$ V                                            | —                 | 3.3 | 15                | $\mu$ A    |
| I/O pin pull-up resistor                                       | $R_{PU}$        |                                                                            | 30                | 43  | 65                | k $\Omega$ |
| I/O pin pull-down resistor                                     | $R_{PD}$        |                                                                            | 30                | 43  | 65                | k $\Omega$ |
| Pulse width of pulses removed by the glitch suppression filter | $t_{IOGLITCH}$  |                                                                            | 20                | 25  | 35                | ns         |

| Parameter                                     | Symbol    | Test Condition                                                                                | Min | Typ | Max | Unit |
|-----------------------------------------------|-----------|-----------------------------------------------------------------------------------------------|-----|-----|-----|------|
| Output fall time, From 70% to 30% of $V_{IO}$ | $t_{IOF}$ | $C_L = 50\text{ pF}$ ,<br>DRIVESTRENGTH <sup>1</sup> = STRONG,<br>SLEWRATE <sup>1</sup> = 0x6 | —   | 1.8 | —   | ns   |
|                                               |           | $C_L = 50\text{ pF}$ ,<br>DRIVESTRENGTH <sup>1</sup> = WEAK,<br>SLEWRATE <sup>1</sup> = 0x6   | —   | 4.5 | —   | ns   |
| Output rise time, From 30% to 70% of $V_{IO}$ | $t_{IOR}$ | $C_L = 50\text{ pF}$ ,<br>DRIVESTRENGTH <sup>1</sup> = STRONG,<br>SLEWRATE = 0x6 <sup>1</sup> | —   | 2.2 | —   | ns   |
|                                               |           | $C_L = 50\text{ pF}$ ,<br>DRIVESTRENGTH <sup>1</sup> = WEAK,<br>SLEWRATE <sup>1</sup> = 0x6   | —   | 7.4 | —   | ns   |

**Note:**  
1. In GPIO\_Pn\_CTRL register

#### 4.1.12 VMON

**Table 4.21. VMON**

| Parameter                        | Symbol            | Test Condition                               | Min  | Typ  | Max  | Unit          |
|----------------------------------|-------------------|----------------------------------------------|------|------|------|---------------|
| VMON Supply Current              | $I_{VMON}$        | In EM0 or EM1, 1 supply monitored            | —    | 5.8  | 8.26 | $\mu\text{A}$ |
|                                  |                   | In EM0 or EM1, 4 supplies monitored          | —    | 11.8 | 16.8 | $\mu\text{A}$ |
|                                  |                   | In EM2, EM3 or EM4, 1 supply monitored       | —    | 62   | —    | nA            |
|                                  |                   | In EM2, EM3 or EM4, 4 supplies monitored     | —    | 99   | —    | nA            |
| VMON Loading of Monitored Supply | $I_{SENSE}$       | In EM0 or EM1                                | —    | 2    | —    | $\mu\text{A}$ |
|                                  |                   | In EM2, EM3 or EM4                           | —    | 2    | —    | nA            |
| Threshold range                  | $V_{VMON\_RANGE}$ |                                              | 1.62 | —    | 3.4  | V             |
| Threshold step size              | $N_{VMON\_STESP}$ | Coarse                                       | —    | 200  | —    | mV            |
|                                  |                   | Fine                                         | —    | 20   | —    | mV            |
| Response time                    | $t_{VMON\_RES}$   | Supply drops at $1\text{V}/\mu\text{s}$ rate | —    | 460  | —    | ns            |
| Hysteresis                       | $V_{VMON\_HYST}$  |                                              | —    | 26   | —    | mV            |



#### 4.1.13 ADC

For the table below, see [Figure 3.2 Power Supply Configuration on page 9](#) on page 5 to see the relation between the modules external VDD pin and internal voltage supplies. The module itself has only one external power supply input (VDD).

**Table 4.22. ADC**

| Parameter                                                                                                                                                  | Symbol                           | Test Condition                                                         | Min               | Typ | Max                      | Unit |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------------------------------------------------------------------|-------------------|-----|--------------------------|------|
| Resolution                                                                                                                                                 | $V_{\text{RESOLUTION}}$          |                                                                        | 6                 | —   | 12                       | Bits |
| Input voltage range                                                                                                                                        | $V_{\text{ADCIN}}$               | Single ended                                                           | 0                 | —   | $2 \cdot V_{\text{REF}}$ | V    |
|                                                                                                                                                            |                                  | Differential                                                           | $-V_{\text{REF}}$ | —   | $V_{\text{REF}}$         | V    |
| Input range of external reference voltage, single ended and differential                                                                                   | $V_{\text{ADCREFIN\_P}}$         |                                                                        | 1                 | —   | $V_{\text{AVDD}}$        | V    |
| Power supply rejection <sup>1</sup>                                                                                                                        | $\text{PSRR}_{\text{ADC}}$       | At DC                                                                  | —                 | 80  | —                        | dB   |
| Analog input common mode rejection ratio                                                                                                                   | $\text{CMRR}_{\text{ADC}}$       | At DC                                                                  | —                 | 80  | —                        | dB   |
| Current from all supplies, using internal reference buffer. Continuous operation. $\text{WARMUPMODE}^2 = \text{KEEPADC-WARM}$                              | $I_{\text{ADC\_CONTINUOUS\_LP}}$ | 1 Msps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 1 <sub>3</sub>    | —                 | 301 | 350                      | μA   |
|                                                                                                                                                            |                                  | 250 ksps / 4 MHz ADCCLK, BIASPROG = 6, GPBIASACC = 1 <sub>3</sub>      | —                 | 149 | —                        | μA   |
|                                                                                                                                                            |                                  | 62.5 ksps / 1 MHz ADCCLK,<br>BIASPROG = 15, GPBIASACC = 1 <sub>3</sub> | —                 | 91  | —                        | μA   |
| Current from all supplies, using internal reference buffer. Duty-cycled operation. $\text{WARMUPMODE}^2 = \text{NORMAL}$                                   | $I_{\text{ADC\_NORMAL\_LP}}$     | 35 ksps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 1 <sub>3</sub>   | —                 | 51  | —                        | μA   |
|                                                                                                                                                            |                                  | 5 ksps / 16 MHz ADCCLK<br>BIASPROG = 0, GPBIASACC = 1 <sub>3</sub>     | —                 | 9   | —                        | μA   |
| Current from all supplies, using internal reference buffer. Duty-cycled operation. $\text{AWARMUPMODE}^2 = \text{KEEPINSTANDBY}$ or $\text{KEEPINSLOWACC}$ | $I_{\text{ADC\_STANDBY\_LP}}$    | 125 ksps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 1 <sub>3</sub>  | —                 | 117 | —                        | μA   |
|                                                                                                                                                            |                                  | 35 ksps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 1 <sub>3</sub>   | —                 | 79  | —                        | μA   |

| Parameter                                                                                                                                    | Symbol                         | Test Condition                                                         | Min | Typ  | Max | Unit   |
|----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------------------------------------------------------------------------|-----|------|-----|--------|
| Current from all supplies, using internal reference buffer. Continuous operation. WARMUPMODE <sup>2</sup> = KEEPADC-WARM                     | I <sub>ADC_CONTINUOUS_HP</sub> | 1 Msps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 0 <sup>3</sup>    | —   | 345  | —   | μA     |
|                                                                                                                                              |                                | 250 ksps / 4 MHz ADCCLK, BIASPROG = 6, GPBIASACC = 0 <sup>3</sup>      | —   | 191  | —   | μA     |
|                                                                                                                                              |                                | 62.5 ksps / 1 MHz ADCCLK,<br>BIASPROG = 15, GPBIASACC = 0 <sup>3</sup> | —   | 132  | —   | μA     |
| Current from all supplies, using internal reference buffer. Duty-cycled operation. WARMUPMODE <sup>2</sup> = NORMAL                          | I <sub>ADC_NORMAL_HP</sub>     | 35 ksps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 0 <sup>3</sup>   | —   | 102  | —   | μA     |
|                                                                                                                                              |                                | 5 ksps / 16 MHz ADCCLK<br>BIASPROG = 0, GPBIASACC = 0 <sup>3</sup>     | —   | 17   | —   | μA     |
| Current from all supplies, using internal reference buffer. Duty-cycled operation. AWARMUPMODE <sup>2</sup> = KEEPINSTANDBY or KEEPINSLOWACC | I <sub>ADC_STANDBY_HP</sub>    | 125 ksps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 0 <sup>3</sup>  | —   | 162  | —   | μA     |
|                                                                                                                                              |                                | 35 ksps / 16 MHz ADCCLK,<br>BIASPROG = 0, GPBIASACC = 0 <sup>3</sup>   | —   | 123  | —   | μA     |
| Current from HUPERCLK                                                                                                                        | I <sub>ADC_CLK</sub>           | HUPERCLK = 16 MHz                                                      | —   | 140  | —   | μA     |
| ADC Clock Frequency                                                                                                                          | f <sub>ADCCLK</sub>            |                                                                        | —   | —    | 16  | MHz    |
| Throughput rate                                                                                                                              | f <sub>ADCRATE</sub>           |                                                                        | —   | —    | 1   | Msps   |
| Conversion time <sup>4</sup>                                                                                                                 | t <sub>ADCCONV</sub>           | 6 bit                                                                  | —   | 7    | —   | cycles |
|                                                                                                                                              |                                | 8 bit                                                                  | —   | 9    | —   | cycles |
|                                                                                                                                              |                                | 12 bit                                                                 | —   | 13   | —   | cycles |
| Startup time of reference generator and ADC core                                                                                             | t <sub>ADCSTART</sub>          | WARMUPMODE <sup>2</sup> = NORMAL                                       | —   | —    | 5   | μs     |
|                                                                                                                                              |                                | WARMUPMODE <sup>2</sup> = KEEPINSTANDBY                                | —   | —    | 2   | μs     |
|                                                                                                                                              |                                | WARMUPMODE <sup>2</sup> = KEEPINSLOWACC                                | —   | —    | 1   | μs     |
| SNDR at 1Msps and f <sub>in</sub> = 10kHz                                                                                                    | SNDR <sub>ADC</sub>            | Internal reference, 2.5 V full-scale, differential (-1.25, 1.25)       | 58  | 67   | —   | dB     |
|                                                                                                                                              |                                | vrefp_in = 1.25 V direct mode with 2.5 V full-scale, differential      | —   | 68   | —   | dB     |
| Spurious-Free Dynamic Range (SFDR)                                                                                                           | SFDR <sub>ADC</sub>            | 1 MSamples/s, 10 kHz full-scale sine wave                              | —   | 75   | —   | dB     |
| Input referred ADC noise, rms                                                                                                                | V <sub>REF_NOISE</sub>         | Including quantization noise and distortion                            | —   | 380  | —   | μV     |
| Offset Error                                                                                                                                 | V <sub>ADCOFFSETERR</sub>      |                                                                        | -3  | 0.25 | 3   | LSB    |

| Parameter                                      | Symbol                    | Test Condition           | Min | Typ   | Max | Unit  |
|------------------------------------------------|---------------------------|--------------------------|-----|-------|-----|-------|
| Gain error in ADC                              | $V_{\text{ADC\_GAIN}}$    | Using internal reference | —   | -0.2  | 5   | %     |
|                                                |                           | Using external reference | —   | -1    | —   | %     |
| Differential non-linearity (DNL)               | $\text{DNL}_{\text{ADC}}$ | 12 bit resolution        | -1  | —     | 2   | LSB   |
| Integral non-linearity (INL), End point method | $\text{INL}_{\text{ADC}}$ | 12 bit resolution        | -6  | —     | 6   | LSB   |
| Temperature Sensor Slope                       | $V_{\text{TS\_SLOPE}}$    |                          | —   | -1.84 | —   | mV/°C |

**Note:**

1. PSRR is referenced to AVDD when ANASW=0 and to DVDD when ANASW=1 in EMU\_PWRCTRL
2. In ADCn\_CNTL register
3. In ADCn\_BIASPROG register
4. Derived from ADCCLK

**4.1.14 IDAC**

For the table below, see [Figure 3.2 Power Supply Configuration on page 9](#) on page 5 to see the relation between the modules external VDD pin and internal voltage supplies. The module itself has only one external power supply input (VDD).

**Table 4.23. IDAC**

| Parameter                                   | Symbol                   | Test Condition                                                                | Min  | Typ  | Max | Unit |
|---------------------------------------------|--------------------------|-------------------------------------------------------------------------------|------|------|-----|------|
| Number of Ranges                            | N <sub>IDAC_RANGES</sub> |                                                                               | —    | 4    | —   | -    |
| Output Current                              | I <sub>IDAC_OUT</sub>    | RANGSEL <sup>1</sup> = RANGE0                                                 | 0.05 | —    | 1.6 | μA   |
|                                             |                          | RANGSEL <sup>1</sup> = RANGE1                                                 | 1.6  | —    | 4.7 | μA   |
|                                             |                          | RANGSEL <sup>1</sup> = RANGE2                                                 | 0.5  | —    | 16  | μA   |
|                                             |                          | RANGSEL <sup>1</sup> = RANGE3                                                 | 2    | —    | 64  | μA   |
| Linear steps within each range              | N <sub>IDAC_STEPS</sub>  |                                                                               | —    | 32   | —   |      |
| Step size                                   | SS <sub>IDAC</sub>       | RANGSEL <sup>1</sup> = RANGE0                                                 | —    | 50   | —   | nA   |
|                                             |                          | RANGSEL <sup>1</sup> = RANGE1                                                 | —    | 100  | —   | nA   |
|                                             |                          | RANGSEL <sup>1</sup> = RANGE2                                                 | —    | 500  | —   | nA   |
|                                             |                          | RANGSEL <sup>1</sup> = RANGE3                                                 | —    | 2    | —   | μA   |
| Total Accuracy, STEPSEL <sup>1</sup> = 0x10 | ACC <sub>IDAC</sub>      | EM0 or EM1, AVDD=3.3 V, T = 25 °C                                             | -2   | —    | 2   | %    |
|                                             |                          | EM0 or EM1                                                                    | -18  | —    | 22  | %    |
|                                             |                          | EM2 or EM3, Source mode, RANGSEL <sup>1</sup> = RANGE0, AVDD=3.3 V, T = 25 °C | —    | -2   | —   | %    |
|                                             |                          | EM2 or EM3, Source mode, RANGSEL <sup>1</sup> = RANGE1, AVDD=3.3 V, T = 25 °C | —    | -1.7 | —   | %    |
|                                             |                          | EM2 or EM3, Source mode, RANGSEL <sup>1</sup> = RANGE2, AVDD=3.3 V, T = 25 °C | —    | -0.8 | —   | %    |
|                                             |                          | EM2 or EM3, Source mode, RANGSEL <sup>1</sup> = RANGE3, AVDD=3.3 V, T = 25 °C | —    | -0.5 | —   | %    |
|                                             |                          | EM2 or EM3, Sink mode, RANGSEL <sup>1</sup> = RANGE0, AVDD=3.3 V, T = 25 °C   | —    | -0.7 | —   | %    |
|                                             |                          | EM2 or EM3, Sink mode, RANGSEL <sup>1</sup> = RANGE1, AVDD=3.3 V, T = 25 °C   | —    | -0.6 | —   | %    |
|                                             |                          | EM2 or EM3, Sink mode, RANGSEL <sup>1</sup> = RANGE2, AVDD=3.3 V, T = 25 °C   | —    | -0.5 | —   | %    |
|                                             |                          | EM2 or EM3, Sink mode, RANGSEL <sup>1</sup> = RANGE3, AVDD=3.3 V, T = 25 °C   | —    | -0.5 | —   | %    |

| Parameter                                                                                          | Symbol                   | Test Condition                                                                                 | Min | Typ  | Max | Unit |
|----------------------------------------------------------------------------------------------------|--------------------------|------------------------------------------------------------------------------------------------|-----|------|-----|------|
| Start up time                                                                                      | t <sub>IDAC_SU</sub>     | Output within 1% of steady state value                                                         | —   | 5    | —   | μs   |
| Settling time, (output settled within 1% of steady state value)                                    | t <sub>IDAC_SETTLE</sub> | Range setting is changed                                                                       | —   | 5    | —   | μs   |
|                                                                                                    |                          | Step value is changed                                                                          | —   | 1    | —   | μs   |
| Current consumption in EM0 or EM1 <sup>2</sup>                                                     | I <sub>IDAC</sub>        | Source mode, excluding output current                                                          | —   | 8.9  | 13  | μA   |
|                                                                                                    |                          | Sink mode, excluding output current                                                            | —   | 12   | 16  | μA   |
| Current consumption in EM2 or EM3 <sup>2</sup>                                                     |                          | Source mode, excluding output current, duty cycle mode, T = 25 °C                              | —   | 1.04 | —   | μA   |
|                                                                                                    |                          | Sink mode, excluding output current, duty cycle mode, T = 25 °C                                | —   | 1.08 | —   | μA   |
|                                                                                                    |                          | Source mode, excluding output current, duty cycle mode, T ≥ 85 °C                              | —   | 8.9  | —   | μA   |
|                                                                                                    |                          | Sink mode, excluding output current, duty cycle mode, T ≥ 85 °C                                | —   | 12   | —   | μA   |
| Output voltage compliance in source mode, source current change relative to current sourced at 0 V | I <sub>COMP_SRC</sub>    | RANGESEL1=0, output voltage = min(V <sub>IOVDD</sub> , V <sub>AVDD</sub> <sup>2</sup> -100 mV) | —   | 0.04 | —   | %    |
|                                                                                                    |                          | RANGESEL1=1, output voltage = min(V <sub>IOVDD</sub> , V <sub>AVDD</sub> <sup>2</sup> -100 mV) | —   | 0.02 | —   | %    |
|                                                                                                    |                          | RANGESEL1=2, output voltage = min(V <sub>IOVDD</sub> , V <sub>AVDD</sub> <sup>2</sup> -150 mV) | —   | 0.02 | —   | %    |
|                                                                                                    |                          | RANGESEL1=3, output voltage = min(V <sub>IOVDD</sub> , V <sub>AVDD</sub> <sup>2</sup> -250 mV) | —   | 0.02 | —   | %    |
| Output voltage compliance in sink mode, sink current change relative to current sunk at IOVDD      | I <sub>COMP_SINK</sub>   | RANGESEL1=0, output voltage = 100 mV                                                           | —   | 0.18 | —   | %    |
|                                                                                                    |                          | RANGESEL1=1, output voltage = 100 mV                                                           | —   | 0.12 | —   | %    |
|                                                                                                    |                          | RANGESEL1=2, output voltage = 150 mV                                                           | —   | 0.08 | —   | %    |
|                                                                                                    |                          | RANGESEL1=3, output voltage = 250 mV                                                           | —   | 0.02 | —   | %    |

**Note:**

1. In IDAC\_CURPROG register
2. The IDAC is supplied by either AVDD, DVDD, or IOVDD based on the setting of ANASW in the EMU\_PWRCTRL register and PWRSEL in the IDAC\_CTRL register. Setting PWRSEL to 1 selects IOVDD. With PWRSEL cleared to 0, ANASW selects between AVDD (0) and DVDD (1).

## 4.1.15 Analog Comparator (ACMP)

Table 4.24. ACMP

| Parameter                                                                                        | Symbol         | Test Condition                                                       | Min   | Typ | Max                | Unit |
|--------------------------------------------------------------------------------------------------|----------------|----------------------------------------------------------------------|-------|-----|--------------------|------|
| Input voltage range                                                                              | $V_{ACMPIN}$   | ACMPVDD =<br>ACMPn_CTRL_PWRSEL <sup>1</sup>                          | 0     | —   | $V_{ACMPVDD}$      | V    |
| Supply Voltage                                                                                   | $V_{ACMPVDD}$  | BIASPROG <sup>2</sup> ≤ 0x10 or FULL-<br>BIAS <sup>2</sup> = 0       | 1.85  | —   | $V_{VREGVDD\_MAX}$ | V    |
|                                                                                                  |                | 0x10 < BIASPROG <sup>2</sup> ≤ 0x20 and<br>FULLBIAS <sup>2</sup> = 1 | 2.1   | —   | $V_{VREGVDD\_MAX}$ | V    |
| Active current not including<br>voltage reference                                                | $I_{ACMP}$     | BIASPROG <sup>2</sup> = 1, FULLBIAS <sup>2</sup> = 0                 | —     | 50  | —                  | nA   |
|                                                                                                  |                | BIASPROG <sup>2</sup> = 0x10, FULLBIAS <sup>2</sup><br>= 0           | —     | 306 | —                  | nA   |
|                                                                                                  |                | BIASPROG <sup>2</sup> = 0x20, FULLBIAS <sup>2</sup><br>= 1           | —     | 74  | 95                 | μA   |
| Current consumption of inter-<br>nal voltage reference                                           | $I_{ACMPREF}$  | VLP selected as input using 2.5 V<br>Reference / 4 (0.625 V)         | —     | 50  | —                  | nA   |
|                                                                                                  |                | VLP selected as input using VDD                                      | —     | 20  | —                  | nA   |
|                                                                                                  |                | VBDIV selected as input using<br>1.25 V reference / 1                | —     | 4.1 | —                  | μA   |
|                                                                                                  |                | VADIV selected as input using<br>VDD/1                               | —     | 2.4 | —                  | μA   |
| Hysteresis ( $V_{CM}$ = 1.25 V,<br>BIASPROG <sup>2</sup> = 0x10, FULL-<br>BIAS <sup>2</sup> = 1) | $V_{ACMPHYST}$ | HYSTSEL <sup>3</sup> = HYST0                                         | -1.75 | 0   | 1.75               | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST1                                         | 10    | 18  | 26                 | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST2                                         | 21    | 32  | 46                 | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST3                                         | 27    | 44  | 63                 | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST4                                         | 32    | 55  | 80                 | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST5                                         | 38    | 65  | 100                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST6                                         | 43    | 77  | 121                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST7                                         | 47    | 86  | 148                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST8                                         | -4    | 0   | 4                  | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST9                                         | -27   | -18 | -10                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST10                                        | -47   | -32 | -18                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST11                                        | -64   | -43 | -27                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST12                                        | -78   | -54 | -32                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST13                                        | -93   | -64 | -37                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST14                                        | -113  | -74 | -42                | mV   |
|                                                                                                  |                | HYSTSEL <sup>3</sup> = HYST15                                        | -135  | -85 | -47                | mV   |

| Parameter                            | Symbol           | Test Condition                                          | Min | Typ  | Max  | Unit |
|--------------------------------------|------------------|---------------------------------------------------------|-----|------|------|------|
| Comparator delay <sup>4</sup>        | $t_{ACMPDELAY}$  | BIASPROG <sup>2</sup> = 1, FULLBIAS <sup>2</sup> = 0    | —   | 30   | —    | μs   |
|                                      |                  | BIASPROG <sup>2</sup> = 0x10, FULLBIAS <sup>2</sup> = 0 | —   | 3.7  | —    | μs   |
|                                      |                  | BIASPROG <sup>2</sup> = 0x20, FULLBIAS <sup>2</sup> = 1 | —   | 35   | —    | ns   |
| Offset voltage                       | $V_{ACMPOFFSET}$ | BIASPROG <sup>2</sup> = 0x10, FULLBIAS <sup>2</sup> = 1 | -35 | —    | 35   | mV   |
| Reference Voltage                    | $V_{ACMPREF}$    | Internal 1.25 V reference                               | 1   | 1.25 | 1.47 | V    |
|                                      |                  | Internal 2.5 V reference                                | 2   | 2.5  | 2.8  | V    |
| Capacitive Sense Internal Resistance | $R_{CSRES}$      | CSRESSEL <sup>5</sup> = 0                               | —   | inf  | —    | kΩ   |
|                                      |                  | CSRESSEL <sup>5</sup> = 1                               | —   | 15   | —    | kΩ   |
|                                      |                  | CSRESSEL <sup>5</sup> = 2                               | —   | 27   | —    | kΩ   |
|                                      |                  | CSRESSEL <sup>5</sup> = 3                               | —   | 39   | —    | kΩ   |
|                                      |                  | CSRESSEL <sup>5</sup> = 4                               | —   | 51   | —    | kΩ   |
|                                      |                  | CSRESSEL <sup>5</sup> = 5                               | —   | 102  | —    | kΩ   |
|                                      |                  | CSRESSEL <sup>5</sup> = 6                               | —   | 164  | —    | kΩ   |
|                                      |                  | CSRESSEL <sup>5</sup> = 7                               | —   | 239  | —    | kΩ   |

**Note:**

1. ACMPVDD is a supply chosen by the setting in ACMPn\_CTRL\_PWRSEL and may be IOVDD, AVDD or DVDD
2. In ACMPn\_CTRL register
3. In ACMPn\_HYSTERESIS register
4. ±100 mV differential drive
5. In ACMPn\_INPUTSEL register

The total ACMP current is the sum of the contributions from the ACMP and its internal voltage reference as given as:

$$I_{ACMPTOTAL} = I_{ACMP} + I_{ACMPREF}$$

$I_{ACMPREF}$  is zero if an external voltage reference is used.

## 4.1.16 I2C

## I2C Standard-mode (Sm)

Table 4.25. I2C Standard-mode (Sm)<sup>1</sup>

| Parameter                                        | Symbol              | Test Condition | Min | Typ | Max  | Unit |
|--------------------------------------------------|---------------------|----------------|-----|-----|------|------|
| SCL clock frequency <sup>2</sup>                 | f <sub>SCL</sub>    |                | 0   | —   | 100  | kHz  |
| SCL clock low time                               | t <sub>LOW</sub>    |                | 4.7 | —   | —    | μs   |
| SCL clock high time                              | t <sub>HIGH</sub>   |                | 4   | —   | —    | μs   |
| SDA set-up time                                  | t <sub>SU,DAT</sub> |                | 250 | —   | —    | ns   |
| SDA hold time <sup>3</sup>                       | t <sub>HD,DAT</sub> |                | 100 | —   | 3450 | ns   |
| Repeated START condition set-up time             | t <sub>SU,STA</sub> |                | 4.7 | —   | —    | μs   |
| (Repeated) START condition hold time             | t <sub>HD,STA</sub> |                | 4   | —   | —    | μs   |
| STOP condition set-up time                       | t <sub>SU,STO</sub> |                | 4   | —   | —    | μs   |
| Bus free time between a STOP and START condition | t <sub>BUF</sub>    |                | 4.7 | —   | —    | μs   |

**Note:**

1. For CLHR set to 0 in the I2Cn\_CTRL register
2. For the minimum HPPERCLK frequency required in Standard-mode, refer to the I2C chapter in the reference manual
3. The maximum SDA hold time (t<sub>HD,DAT</sub>) needs to be met only when the device does not stretch the low time of SCL (t<sub>LOW</sub>)



**I2C Fast-mode (Fm)****Table 4.26. I2C Fast-mode (Fm)<sup>1</sup>**

| Parameter                                        | Symbol              | Test Condition | Min | Typ | Max | Unit |
|--------------------------------------------------|---------------------|----------------|-----|-----|-----|------|
| SCL clock frequency <sup>2</sup>                 | f <sub>SCL</sub>    |                | 0   | —   | 400 | kHz  |
| SCL clock low time                               | t <sub>LOW</sub>    |                | 1.3 | —   | —   | µs   |
| SCL clock high time                              | t <sub>HIGH</sub>   |                | 0.6 | —   | —   | µs   |
| SDA set-up time                                  | t <sub>SU,DAT</sub> |                | 100 | —   | —   | ns   |
| SDA hold time <sup>3</sup>                       | t <sub>HD,DAT</sub> |                | 100 | —   | 900 | ns   |
| Repeated START condition set-up time             | t <sub>SU,STA</sub> |                | 0.6 | —   | —   | µs   |
| (Repeated) START condition hold time             | t <sub>HD,STA</sub> |                | 0.6 | —   | —   | µs   |
| STOP condition set-up time                       | t <sub>SU,STO</sub> |                | 0.6 | —   | —   | µs   |
| Bus free time between a STOP and START condition | t <sub>BUF</sub>    |                | 1.3 | —   | —   | µs   |

**Note:**

1. For CLHR set to 1 in the I2Cn\_CTRL register
2. For the minimum HPPERCLK frequency required in Fast-mode, refer to the I2C chapter in the reference manual
3. The maximum SDA hold time (t<sub>HD,DAT</sub>) needs to be met only when the device does not stretch the low time of SCL (t<sub>LOW</sub>)

**I2C Fast-mode Plus (Fm+)****Table 4.27. I2C Fast-mode Plus (Fm+)<sup>1</sup>**

| Parameter                                        | Symbol              | Test Condition | Min  | Typ | Max  | Unit |
|--------------------------------------------------|---------------------|----------------|------|-----|------|------|
| SCL clock frequency <sup>2</sup>                 | f <sub>SCL</sub>    |                | 0    | —   | 1000 | kHz  |
| SCL clock low time                               | t <sub>LOW</sub>    |                | 0.5  | —   | —    | µs   |
| SCL clock high time                              | t <sub>HIGH</sub>   |                | 0.26 | —   | —    | µs   |
| SDA set-up time                                  | t <sub>SU,DAT</sub> |                | 50   | —   | —    | ns   |
| SDA hold time                                    | t <sub>HD,DAT</sub> |                | 100  | —   | —    | ns   |
| Repeated START condition set-up time             | t <sub>SU,STA</sub> |                | 0.26 | —   | —    | µs   |
| (Repeated) START condition hold time             | t <sub>HD,STA</sub> |                | 0.26 | —   | —    | µs   |
| STOP condition set-up time                       | t <sub>SU,STO</sub> |                | 0.26 | —   | —    | µs   |
| Bus free time between a STOP and START condition | t <sub>BUF</sub>    |                | 0.5  | —   | —    | µs   |

**Note:**

1. For CLHR set to 0 or 1 in the I2Cn\_CTRL register
2. For the minimum HFPERCLK frequency required in Fast-mode Plus, refer to the I2C chapter in the reference manual

## 4.1.17 USART SPI

## SPI Master Timing

Table 4.28. SPI Master Timing

| Parameter                      | Symbol                | Test Condition | Min                          | Typ | Max | Unit |
|--------------------------------|-----------------------|----------------|------------------------------|-----|-----|------|
| SCLK period <sup>1 2</sup>     | $t_{\text{SCLK}}$     |                | 2 *<br>$t_{\text{HFPERCLK}}$ | —   | —   | ns   |
| CS to MOSI <sup>1 2</sup>      | $t_{\text{CS\_MO}}$   |                | 0                            | —   | 8   | ns   |
| SCLK to MOSI <sup>1 2</sup>    | $t_{\text{SCLK\_MO}}$ |                | 3                            | —   | 20  | ns   |
| MISO setup time <sup>1 2</sup> | $t_{\text{SU\_MI}}$   | IOVDD = 1.62 V | 56                           | —   | —   | ns   |
|                                |                       | IOVDD = 3.0 V  | 37                           | —   | —   | ns   |
| MISO hold time <sup>1 2</sup>  | $t_{\text{H\_MI}}$    |                | 6                            | —   | —   | ns   |

**Note:**

1. Applies for both CLKPHA = 0 and CLKPHA = 1 (figure only shows CLKPHA = 0)
2. Measurement done with 8 pF output loading at 10% and 90% of  $V_{\text{DD}}$  (figure shows 50% of  $V_{\text{DD}}$ )

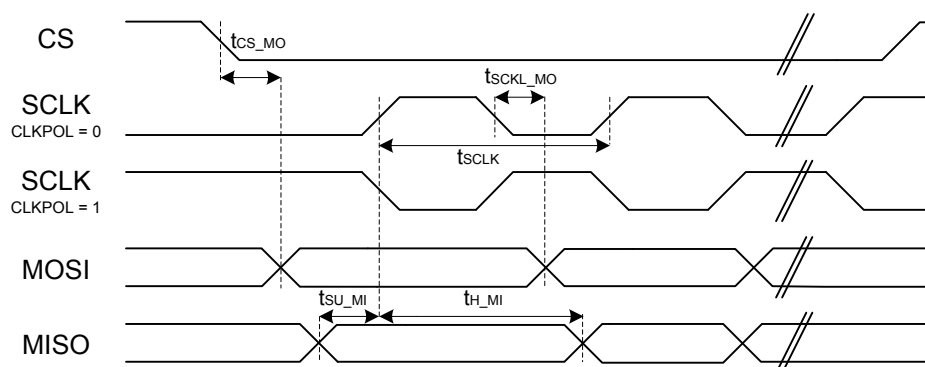


Figure 4.1. SPI Master Timing Diagram

## SPI Slave Timing

Table 4.29. SPI Slave Timing

| Parameter                         | Symbol                   | Test Condition | Min                             | Typ | Max                              | Unit |
|-----------------------------------|--------------------------|----------------|---------------------------------|-----|----------------------------------|------|
| SCKL period <sup>1 2</sup>        | $t_{\text{SCLK\_sl}}$    |                | 2 *<br>$t_{\text{HFERCLK}}$     | —   | —                                | ns   |
| SCLK high period <sup>1 2</sup>   | $t_{\text{SCLK\_hi}}$    |                | 3 *<br>$t_{\text{HFERCLK}}$     | —   | —                                | ns   |
| SCLK low period <sup>1 2</sup>    | $t_{\text{SCLK\_lo}}$    |                | 3 *<br>$t_{\text{HFERCLK}}$     | —   | —                                | ns   |
| CS active to MISO <sup>1 2</sup>  | $t_{\text{CS\_ACT\_MI}}$ |                | 4                               | —   | 50                               | ns   |
| CS disable to MISO <sup>1 2</sup> | $t_{\text{CS\_DIS\_MI}}$ |                | 4                               | —   | 50                               | ns   |
| MOSI setup time <sup>1 2</sup>    | $t_{\text{SU\_MO}}$      |                | 4                               | —   | —                                | ns   |
| MOSI hold time <sup>1 2</sup>     | $t_{\text{H\_MO}}$       |                | 3 + 2 *<br>$t_{\text{HFERCLK}}$ | —   | —                                | ns   |
| SCLK to MISO <sup>1 2</sup>       | $t_{\text{SCLK\_MI}}$    |                | 16 +<br>$t_{\text{HFERCLK}}$    | —   | 66 + 2 *<br>$t_{\text{HFERCLK}}$ | ns   |

**Note:**

1. Applies for both CLKPHA = 0 and CLKPHA = 1 (figure only shows CLKPHA = 0)
2. Measurement done with 8 pF output loading at 10% and 90% of  $V_{\text{DD}}$  (figure shows 50% of  $V_{\text{DD}}$ )

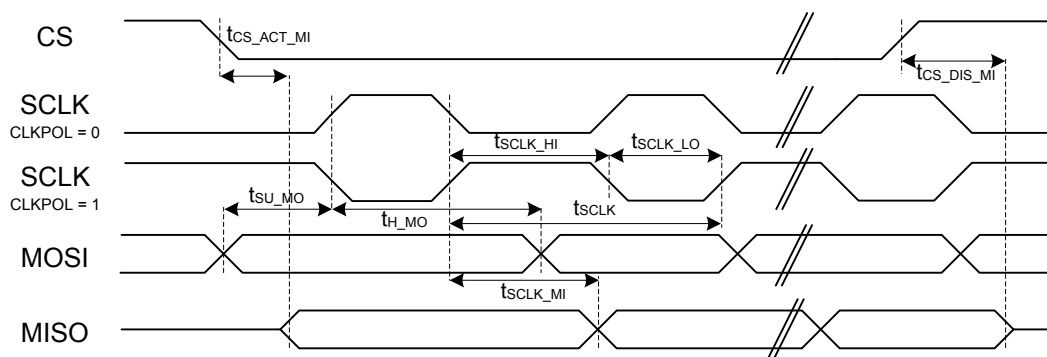


Figure 4.2. SPI Slave Timing Diagram

## 5. Typical Connection Diagrams

### 5.1 Power, Ground, Debug and Host UART

Typical power supply, ground and MCU debug and host (NCP) UART connections are shown in the figure below.

**Note:** The Module Reset signal is recommended to be connected to a GPIO line on the Host CPU.

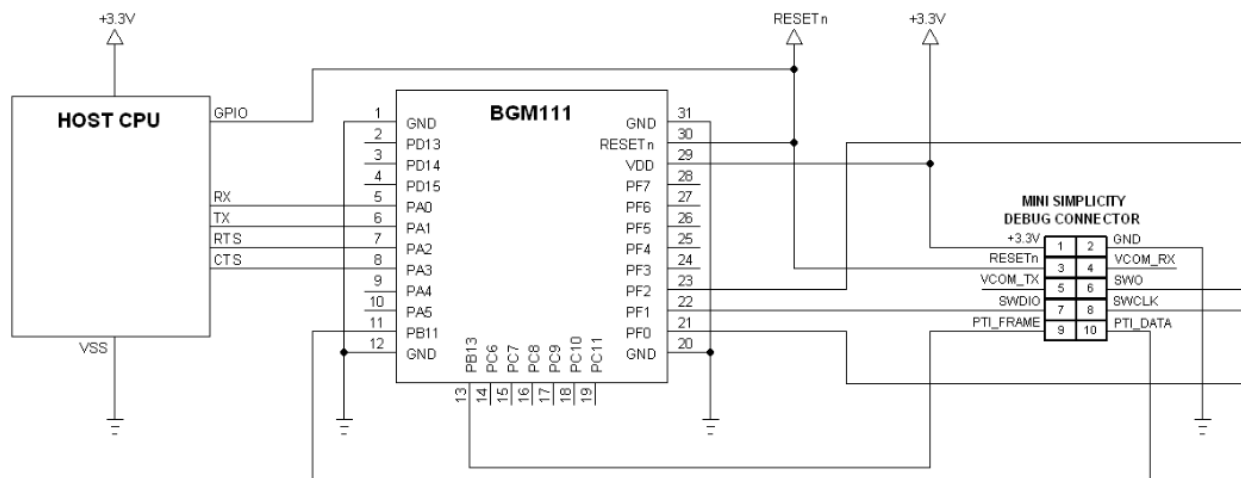


Figure 5.1. BGM111 Connected to a Host CPU with Typical Power Supply, Ground and Debug connections

### 5.2 SPI Peripheral Connection

The figure below shows how to connect a SPI peripheral device

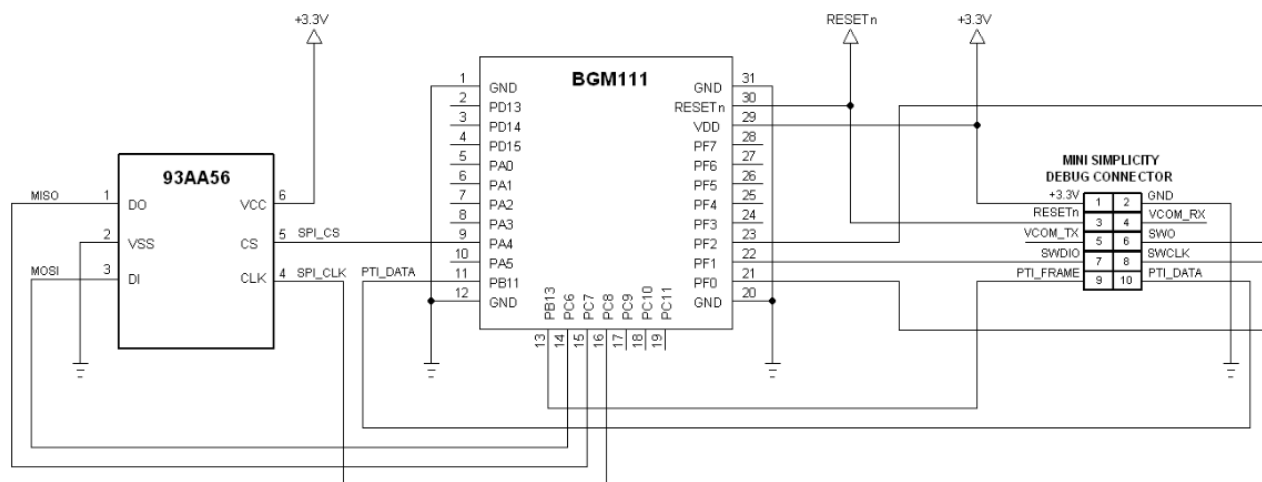


Figure 5.2. SPI Peripheral Connections

### 5.3 I<sup>2</sup>C Peripheral Connection

The figure below shows how to connect an I<sup>2</sup>C peripheral.

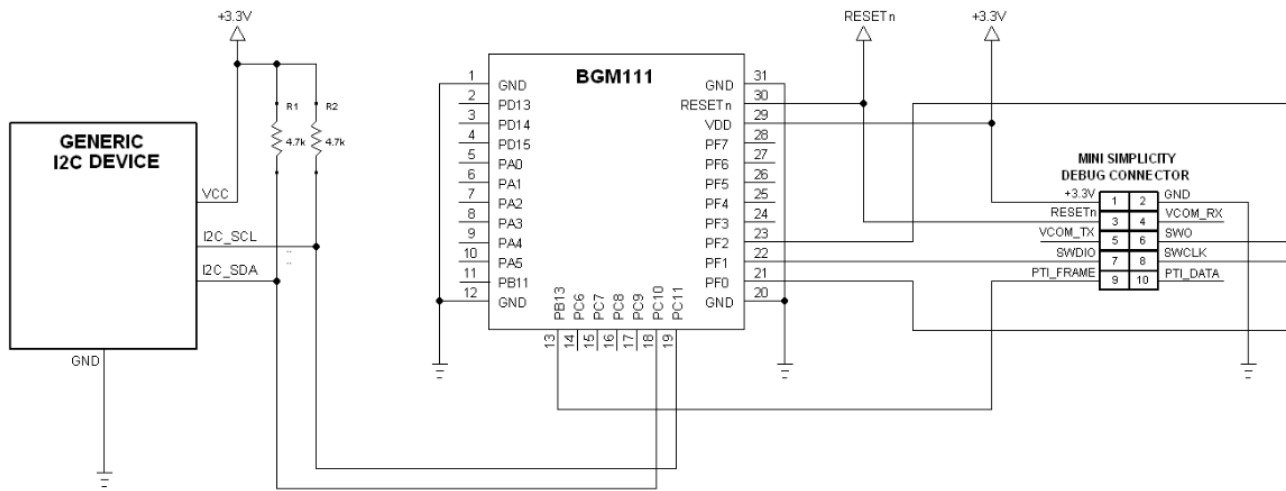


Figure 5.3. BGM111 Module Connected with I<sup>2</sup>C Device

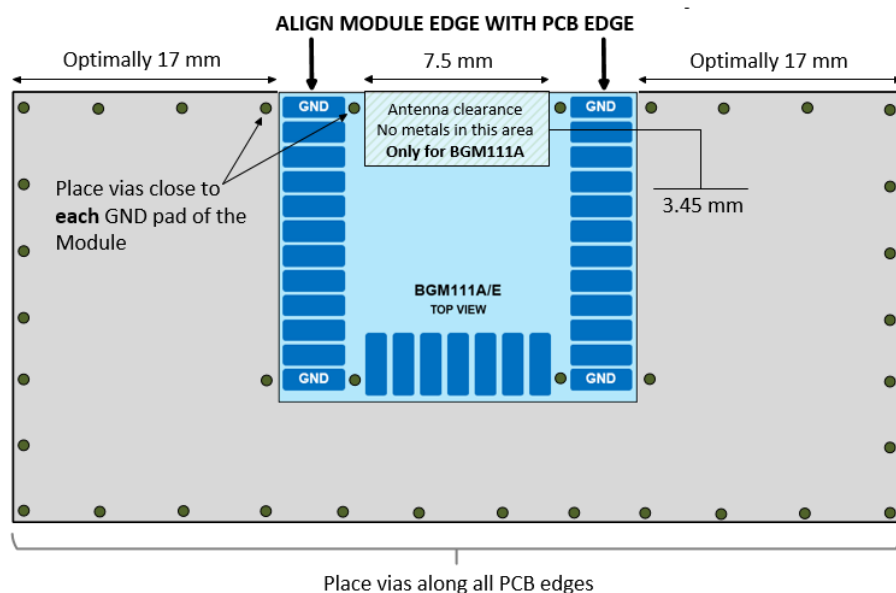
## 6. Layout Guidelines

For optimal performance of the BGM111, please follow the PCB layout guidelines and ground plane recommendations indicated in this section.

### 6.1 Recommended Placement on the Application PCB

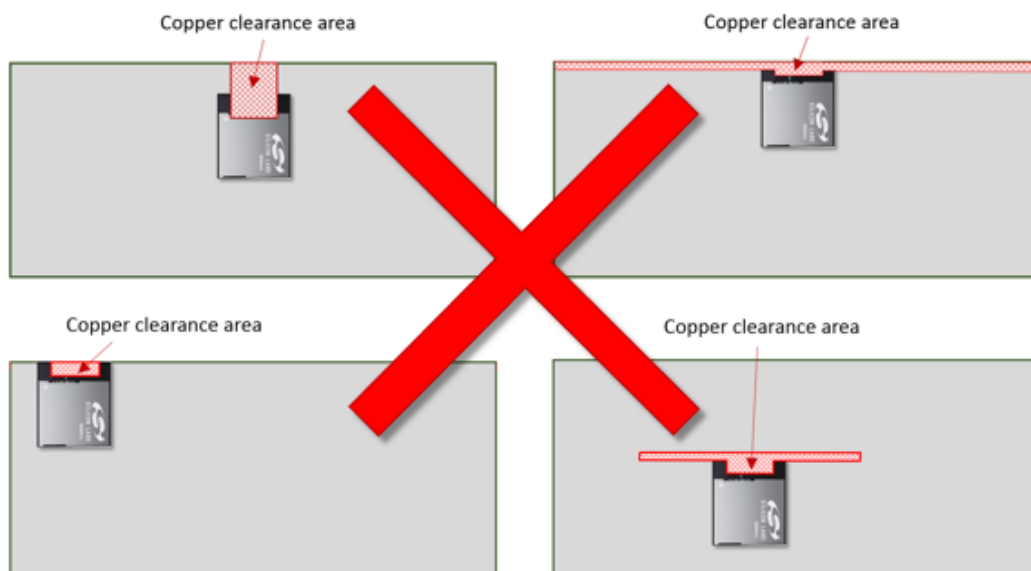
For optimal performance of the BGM111 Module, please follow these guidelines:

- Place the module at the edge of the PCB, as shown in the figure below.
- Do not place any metal (traces, components, battery, etc.) within the clearance area of the antenna (shown in the figure below).
- Connect all ground pads directly to a solid ground plane.
- Place the ground vias as close to the ground pads as possible.

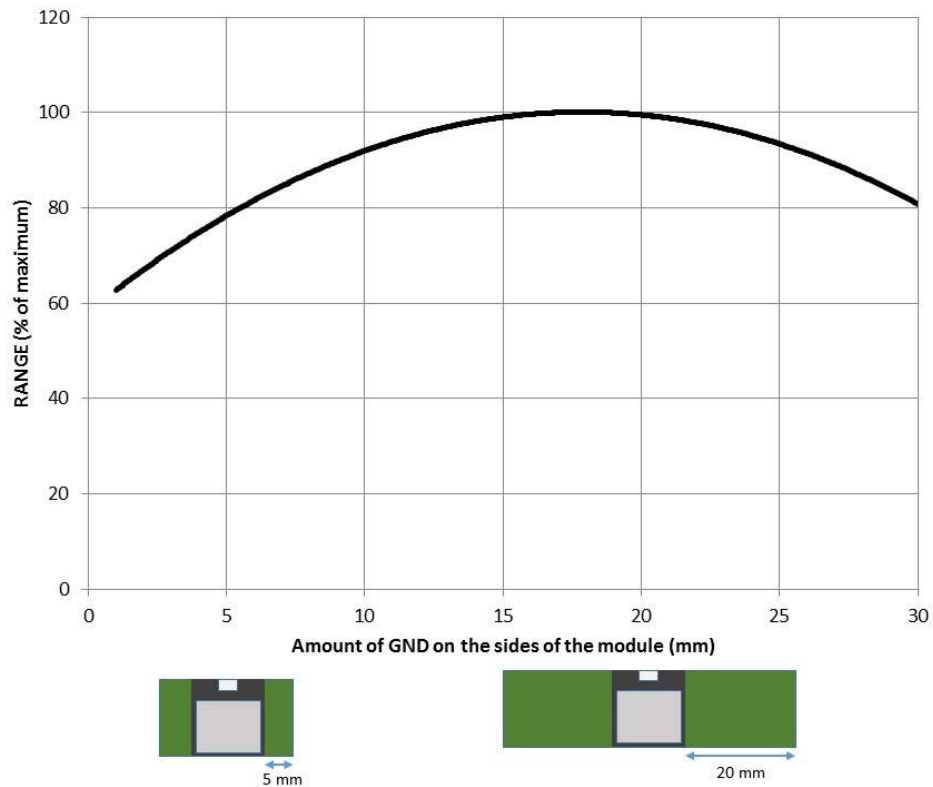


**Figure 6.1. Recommended Application PCB Layout for the BGM111 Module**

The layouts in the next figure will result in severely degraded RF-performance.



**Figure 6.2. Non-optimal Application PCB Layouts for the BGM111 Module**



**Figure 6.3. Effect of Ground Plane on Antenna Efficiency for the BGM111**

## 6.2 Effect of Plastic and Metal Materials

Plastic can be in close proximity but not physically touching the antenna.

Any metallic objects in close proximity to the antenna will prevent the antenna from radiating freely. The minimum recommended distance of metallic and/or conductive objects is 10 mm in any direction from the antenna except in the directions of the application PCB ground planes.

## 6.3 Effect of Human Body

Placing the module in touch or very close to the human body will negatively impact antenna efficiency and reduce range.



## 6.4 2D Radiation Pattern Plots

## 2D pattern, front view

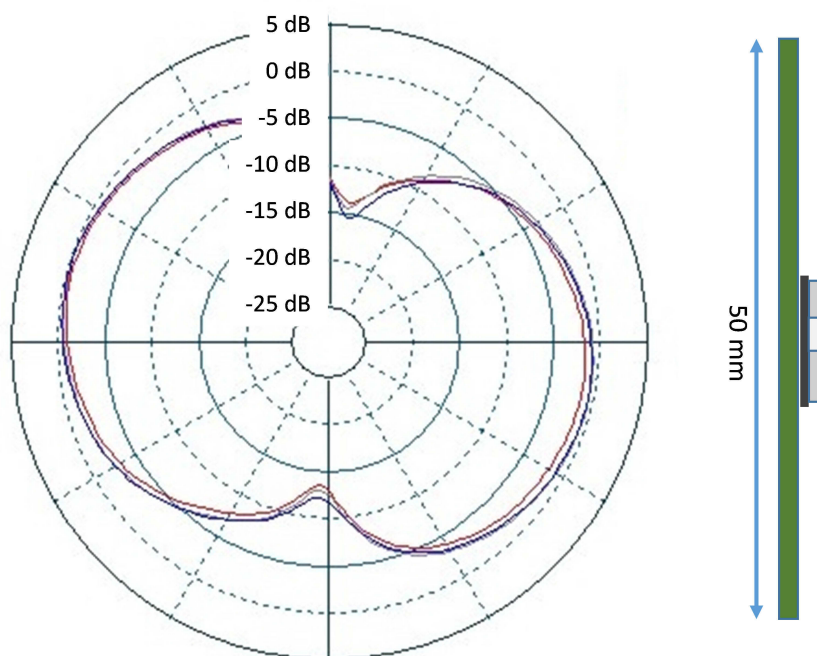


Figure 6.4. Typical 2D Radiation Pattern – Front View

## 2D pattern, side view

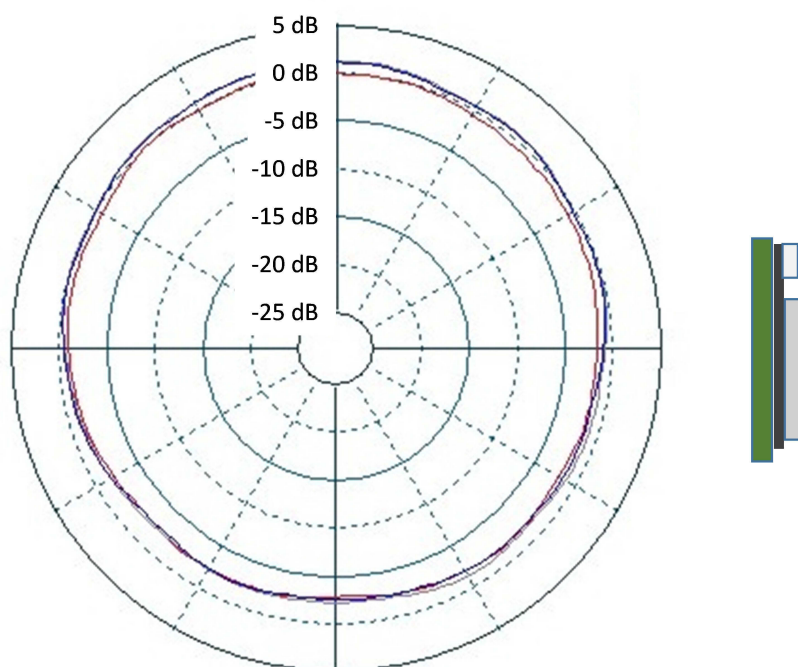
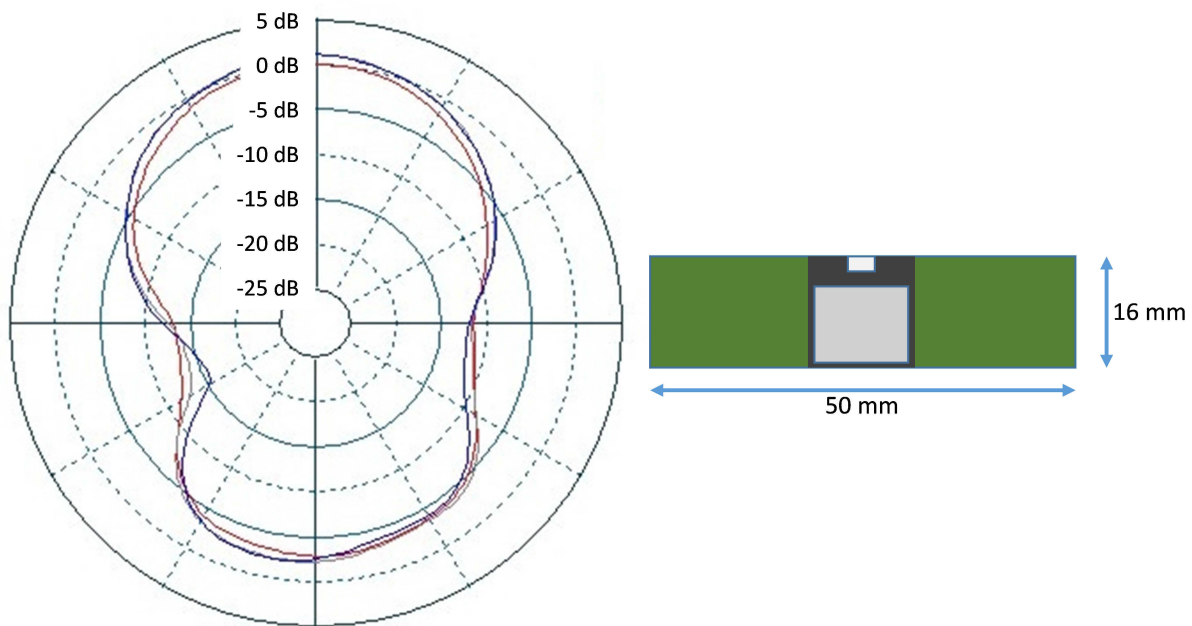


Figure 6.5. Typical 2D Radiation Pattern – Side View

## 2D pattern, top view



**Figure 6.6. Typical 2D Radiation Pattern – Top View**

## 7. Pin Definitions

### 7.1 Pin Definitions

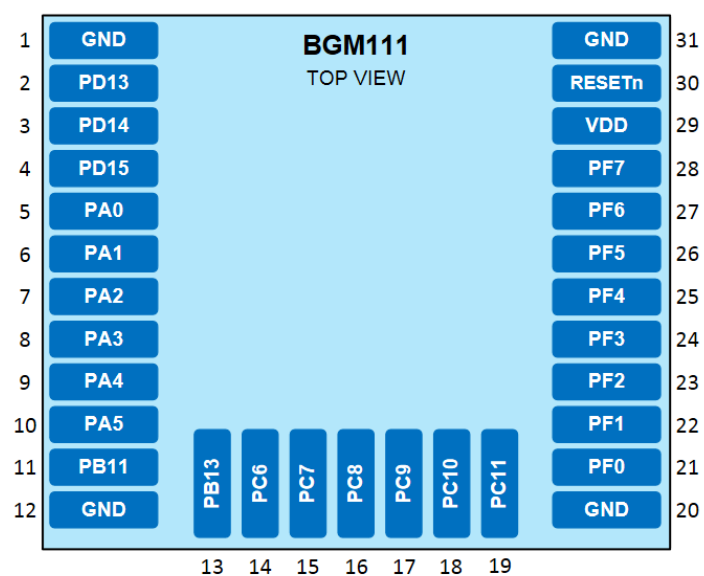


Figure 7.1. BGM111 Pinout

Table 7.1. Device Pinout

| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                                              |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                    |
|--------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Pin #  | Pin Name | Analog                                                                                                                                                                                 | Timers                                                                                                                                                                                                                                         | Communication                                                                                                                                                                                                                            | Radio                                                                                                                                             | Other                                                                                                              |
| 1      | GND      | Ground                                                                                                                                                                                 |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                    |
| 2      | PD13     | BUSCY [ADC0:<br>APORT3YCH5<br>ACMP0:<br>APORT3YCH5<br>ACMP1:<br>APORT3YCH5<br>IDAC0:<br>APORT1YCH5]<br><br>BUSDX [ADC0:<br>APORT4XCH5<br>ACMP0:<br>APORT4XCH5<br>ACMP1:<br>APORT4XCH5] | TIM0_CC0 #21<br>TIM0_CC1 #20<br>TIM0_CC2 #19<br>TIM0_CDTI0 #18<br>TIM0_CDTI1 #17<br>TIM0_CDTI2 #16<br>TIM1_CC0 #21<br>TIM1_CC1 #20<br>TIM1_CC2 #19<br>TIM1_CC3 #18 LE-<br>TIM0_OUT0 #21<br>LETIM0_OUT1 #20<br>PCNT0_S0IN #21<br>PCNT0_S1IN #20 | US0_TX #21<br>US0_RX #20<br>US0_CLK #19<br>US0_CS #18<br>US0_CTS #17<br>US0_RTS #16<br>US1_TX #21<br>US1_RX #20<br>US1_CLK #19<br>US1_CS #18<br>US1_CTS #17<br>US1_RTS #16<br>LEU0_TX #21<br>LEU0_RX #20<br>I2C0_SDA #21<br>I2C0_SCL #20 | FRC_DCLK #21<br>FRC_DOUT #20<br>FRC_DFRAME #19<br>MODEM_DCLK<br>#21 MODEM_DIN<br>#20 MO-<br>DEM_DOUT #19<br>MODEM_ANT0<br>#18 MO-<br>DEM_ANT1 #17 | PRS_CH3 #12<br>PRS_CH4 #4<br>PRS_CH5 #3<br>PRS_CH6 #15<br>ACMP0_O #21<br>ACMP1_O #21                               |
| 3      | PD14     | BUSCX [ADC0:<br>APORT3XCH6<br>ACMP0:<br>APORT3XCH6<br>ACMP1:<br>APORT3XCH6<br>IDAC0:<br>APORT1XCH6]<br><br>BUSDY [ADC0:<br>APORT4YCH6<br>ACMP0:<br>APORT4YCH6<br>ACMP1:<br>APORT4YCH6] | TIM0_CC0 #22<br>TIM0_CC1 #21<br>TIM0_CC2 #20<br>TIM0_CDTI0 #19<br>TIM0_CDTI1 #18<br>TIM0_CDTI2 #17<br>TIM1_CC0 #22<br>TIM1_CC1 #21<br>TIM1_CC2 #20<br>TIM1_CC3 #19 LE-<br>TIM0_OUT0 #22<br>LETIM0_OUT1 #21<br>PCNT0_S0IN #22<br>PCNT0_S1IN #21 | US0_TX #22<br>US0_RX #21<br>US0_CLK #20<br>US0_CS #19<br>US0_CTS #18<br>US0_RTS #17<br>US1_TX #22<br>US1_RX #21<br>US1_CLK #20<br>US1_CS #19<br>US1_CTS #18<br>US1_RTS #17<br>LEU0_TX #22<br>LEU0_RX #21<br>I2C0_SDA #22<br>I2C0_SCL #21 | FRC_DCLK #22<br>FRC_DOUT #21<br>FRC_DFRAME #20<br>MODEM_DCLK<br>#22 MODEM_DIN<br>#21 MO-<br>DEM_DOUT #20<br>MODEM_ANT0<br>#19 MO-<br>DEM_ANT1 #18 | CMU_CLK0 #5<br>PRS_CH3 #13<br>PRS_CH4 #5<br>PRS_CH5 #4<br>PRS_CH6 #16<br>ACMP0_O #22<br>ACMP1_O #22<br>GPIO_EM4WU4 |
| 4      | PD15     | BUSCY [ADC0:<br>APORT3YCH7<br>ACMP0:<br>APORT3YCH7<br>ACMP1:<br>APORT3YCH7<br>IDAC0:<br>APORT1YCH7]<br><br>BUSDX [ADC0:<br>APORT4XCH7<br>ACMP0:<br>APORT4XCH7<br>ACMP1:<br>APORT4XCH7] | TIM0_CC0 #23<br>TIM0_CC1 #22<br>TIM0_CC2 #21<br>TIM0_CDTI0 #20<br>TIM0_CDTI1 #19<br>TIM0_CDTI2 #18<br>TIM1_CC0 #23<br>TIM1_CC1 #22<br>TIM1_CC2 #21<br>TIM1_CC3 #20 LE-<br>TIM0_OUT0 #23<br>LETIM0_OUT1 #22<br>PCNT0_S0IN #23<br>PCNT0_S1IN #22 | US0_TX #23<br>US0_RX #22<br>US0_CLK #21<br>US0_CS #20<br>US0_CTS #19<br>US0_RTS #18<br>US1_TX #23<br>US1_RX #22<br>US1_CLK #21<br>US1_CS #20<br>US1_CTS #19<br>US1_RTS #18<br>LEU0_TX #23<br>LEU0_RX #22<br>I2C0_SDA #23<br>I2C0_SCL #22 | FRC_DCLK #23<br>FRC_DOUT #22<br>FRC_DFRAME #21<br>MODEM_DCLK<br>#23 MODEM_DIN<br>#22 MO-<br>DEM_DOUT #21<br>MODEM_ANT0<br>#20 MO-<br>DEM_ANT1 #19 | CMU_CLK1 #5<br>PRS_CH3 #14<br>PRS_CH4 #6<br>PRS_CH5 #5<br>PRS_CH6 #17<br>ACMP0_O #23<br>ACMP1_O #23<br>DBG_SWO #2  |

| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                                                           |                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                      |                                                                                                                                               |                                                                                                  |
|--------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Pin #  | Pin Name | Analog                                                                                                                                                                                              | Timers                                                                                                                                                                                                                                       | Communication                                                                                                                                                                                                                        | Radio                                                                                                                                         | Other                                                                                            |
| 5      | PA0      | ADC0_EXTN<br>BUSCX [ADC0:<br>APORT3XCH8<br>ACMP0:<br>APORT3XCH8<br>ACMP1:<br>APORT3XCH8<br>IDAC0:<br>APORT1XCH8]<br><br>BUSDY [ADC0:<br>APORT4YCH8<br>ACMP0:<br>APORT4YCH8<br>ACMP1:<br>APORT4YCH8] | TIM0_CC0 #0<br>TIM0_CC1 #31<br>TIM0_CC2 #30<br>TIM0_CDTI0 #29<br>TIM0_CDTI1 #28<br>TIM0_CDTI2 #27<br>TIM1_CC0 #0<br>TIM1_CC1 #31<br>TIM1_CC2 #30<br>TIM1_CC3 #29 LE-<br>TIM0_OUT0 #0 LE-<br>TIM0_OUT1 #31<br>PCNT0_S0IN #0<br>PCNT0_S1IN #31 | US0_TX #0<br>US0_RX #31<br>US0_CLK #30<br>US0_CS #29<br>US0_CTS #28<br>US0_RTS #27<br>US1_TX #0<br>US1_RX #31<br>US1_CLK #30<br>US1_CS #29<br>US1_CTS #28<br>US1_RTS #27<br>LEU0_TX #0<br>LEU0_RX #31<br>I2C0_SDA #0<br>I2C0_SCL #31 | FRC_DCLK #0<br>FRC_DOUT #31<br>FRC_DFRAME #30<br>MODEM_DCLK #0<br>MODEM_DIN #31<br>MODEM_DOUT<br>#30 MO-<br>DEM_ANT0 #29<br>MODEM_ANT1<br>#28 | CMU_CLK1 #0<br>PRS_CH6 #0<br>PRS_CH7 #10<br>PRS_CH8 #9<br>PRS_CH9 #8<br>ACMP0_O #0<br>ACMP1_O #0 |
| 6      | PA1      | ADC0_EXTP<br>BUSCY [ADC0:<br>APORT3YCH9<br>ACMP0:<br>APORT3YCH9<br>ACMP1:<br>APORT3YCH9<br>IDAC0:<br>APORT1YCH9]<br><br>BUSDX [ADC0:<br>APORT4XCH9<br>ACMP0:<br>APORT4XCH9<br>ACMP1:<br>APORT4XCH9] | TIM0_CC0 #1<br>TIM0_CC1 #0<br>TIM0_CC2 #31<br>TIM0_CDTI0 #30<br>TIM0_CDTI1 #29<br>TIM0_CDTI2 #28<br>TIM1_CC0 #1<br>TIM1_CC1 #0<br>TIM1_CC2 #31<br>TIM1_CC3 #30 LE-<br>TIM0_OUT0 #1 LE-<br>TIM0_OUT1 #0<br>PCNT0_S0IN #1<br>PCNT0_S1IN #0     | US0_TX #1<br>US0_RX #0<br>US0_CLK #31<br>US0_CS #30<br>US0_CTS #29<br>US0_RTS #28<br>US1_TX #1<br>US1_RX #0<br>US1_CLK #31<br>US1_CS #30<br>US1_CTS #29<br>US1_RTS #28<br>LEU0_TX #1<br>LEU0_RX #0<br>I2C0_SDA #1<br>I2C0_SCL #0     | FRC_DCLK #1<br>FRC_DOUT #0<br>FRC_DFRAME #31<br>MODEM_DCLK #1<br>MODEM_DIN #0<br>MODEM_DOUT<br>#31 MO-<br>DEM_ANT0 #30<br>MODEM_ANT1<br>#29   | CMU_CLK0 #0<br>PRS_CH6 #1<br>PRS_CH7 #0<br>PRS_CH8 #10<br>PRS_CH9 #9<br>ACMP0_O #1<br>ACMP1_O #1 |
| 7      | PA2      | BUSCX [ADC0:<br>APORT3XCH10<br>ACMP0:<br>APORT3XCH10<br>ACMP1:<br>APORT3XCH10<br>IDAC0:<br>APORT1XCH10]<br><br>BUSDY [ADC0:<br>APORT4YCH10<br>ACMP0:<br>APORT4YCH10<br>ACMP1:<br>APORT4YCH10]       | TIM0_CC0 #2<br>TIM0_CC1 #1<br>TIM0_CC2 #0<br>TIM0_CDTI0 #31<br>TIM0_CDTI1 #30<br>TIM0_CDTI2 #29<br>TIM1_CC0 #2<br>TIM1_CC1 #1<br>TIM1_CC2 #0<br>TIM1_CC3 #31 LE-<br>TIM0_OUT0 #2 LE-<br>TIM0_OUT1 #1<br>PCNT0_S0IN #2<br>PCNT0_S1IN #1       | US0_TX #2<br>US0_RX #1<br>US0_CLK #0<br>US0_CS #31<br>US0_CTS #30<br>US0_RTS #29<br>US1_TX #2<br>US1_RX #1<br>US1_CLK #0<br>US1_CS #31<br>US1_CTS #30<br>US1_RTS #29<br>LEU0_TX #2<br>LEU0_RX #1<br>I2C0_SDA #2<br>I2C0_SCL #1       | FRC_DCLK #2<br>FRC_DOUT #1<br>FRC_DFRAME #0<br>MODEM_DCLK #2<br>MODEM_DIN #1<br>MODEM_DOUT #0<br>MODEM_ANT0<br>#31 MO-<br>DEM_ANT1 #30        | PRS_CH6 #2<br>PRS_CH7 #1<br>PRS_CH8 #0<br>PRS_CH9 #10<br>ACMP0_O #2<br>ACMP1_O #2                |

| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                                                     |                                                                                                                                                                                                                                      |                                                                                                                                                                                                                              |                                                                                                                                     |                                                                                                 |
|--------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Pin #  | Pin Name | Analog                                                                                                                                                                                        | Timers                                                                                                                                                                                                                               | Communication                                                                                                                                                                                                                | Radio                                                                                                                               | Other                                                                                           |
| 8      | PA3      | BUSCY [ADC0:<br>APORT3YCH11<br>ACMP0:<br>APORT3YCH11<br>ACMP1:<br>APORT3YCH11<br>IDAC0:<br>APORT1YCH11]<br><br>BUSDX [ADC0:<br>APORT4XCH11<br>ACMP0:<br>APORT4XCH11<br>ACMP1:<br>APORT4XCH11] | TIM0_CC0 #3<br>TIM0_CC1 #2<br>TIM0_CC2 #1<br>TIM0_CDTI0 #0<br>TIM0_CDTI1 #31<br>TIM0_CDTI2 #30<br>TIM1_CC0 #3<br>TIM1_CC1 #2<br>TIM1_CC2 #1<br>TIM1_CC3 #0 LE-<br>TIM0_OUT0 #3 LE-<br>TIM0_OUT1 #2<br>PCNT0_S0IN #3<br>PCNT0_S1IN #2 | US0_TX #3<br>US0_RX #2<br>US0_CLK #1<br>US0_CS #0<br>US0_CTS #31<br>US0_RTS #30<br>US1_TX #3<br>US1_RX #2<br>US1_CLK #1<br>US1_CS #0<br>US1_CTS #31<br>US1_RTS #30<br>LEU0_TX #3<br>LEU0_RX #2<br>I2C0_SDA #3<br>I2C0_SCL #2 | FRC_DCLK #3<br>FRC_DOUT #2<br>FRC_DFRAME #1<br>MODEM_DCLK #3<br>MODEM_DIN #2<br>MODEM_DOUT #1<br>MODEM_ANT0 #0<br>MODEM_ANT1<br>#31 | PRS_CH6 #3<br>PRS_CH7 #2<br>PRS_CH8 #1<br>PRS_CH9 #0<br>ACMP0_O #3<br>ACMP1_O #3<br>GPIO_EM4WU8 |
| 9      | PA4      | BUSCX [ADC0:<br>APORT3XCH12<br>ACMP0:<br>APORT3XCH12<br>ACMP1:<br>APORT3XCH12<br>IDAC0:<br>APORT1XCH12]<br><br>BUSDY [ADC0:<br>APORT4YCH12<br>ACMP0:<br>APORT4YCH12<br>ACMP1:<br>APORT4YCH12] | TIM0_CC0 #4<br>TIM0_CC1 #3<br>TIM0_CC2 #2<br>TIM0_CDTI0 #1<br>TIM0_CDTI1 #0<br>TIM0_CDTI2 #31<br>TIM1_CC0 #4<br>TIM1_CC1 #3<br>TIM1_CC2 #2<br>TIM1_CC3 #1 LE-<br>TIM0_OUT0 #4 LE-<br>TIM0_OUT1 #3<br>PCNT0_S0IN #4<br>PCNT0_S1IN #3  | US0_TX #4<br>US0_RX #3<br>US0_CLK #2<br>US0_CS #1<br>US0_CTS #0<br>US0_RTS #31<br>US1_TX #4<br>US1_RX #3<br>US1_CLK #2<br>US1_CS #1<br>US1_CTS #0<br>US1_RTS #31<br>LEU0_TX #4<br>LEU0_RX #3<br>I2C0_SDA #4<br>I2C0_SCL #3   | FRC_DCLK #4<br>FRC_DOUT #3<br>FRC_DFRAME #2<br>MODEM_DCLK #4<br>MODEM_DIN #3<br>MODEM_DOUT #2<br>MODEM_ANT0 #1<br>MODEM_ANT1 #0     | PRS_CH6 #4<br>PRS_CH7 #3<br>PRS_CH8 #2<br>PRS_CH9 #1<br>ACMP0_O #4<br>ACMP1_O #4                |
| 10     | PA5      | BUSCY [ADC0:<br>APORT3YCH13<br>ACMP0:<br>APORT3YCH13<br>ACMP1:<br>APORT3YCH13<br>IDAC0:<br>APORT1YCH13]<br><br>BUSDX [ADC0:<br>APORT4XCH13<br>ACMP0:<br>APORT4XCH13<br>ACMP1:<br>APORT4XCH13] | TIM0_CC0 #5<br>TIM0_CC1 #4<br>TIM0_CC2 #3<br>TIM0_CDTI0 #2<br>TIM0_CDTI1 #1<br>TIM0_CDTI2 #0<br>TIM1_CC0 #5<br>TIM1_CC1 #4<br>TIM1_CC2 #3<br>TIM1_CC3 #2 LE-<br>TIM0_OUT0 #5 LE-<br>TIM0_OUT1 #4<br>PCNT0_S0IN #5<br>PCNT0_S1IN #4   | US0_TX #5<br>US0_RX #4<br>US0_CLK #3<br>US0_CS #2<br>US0_CTS #1<br>US0_RTS #0<br>US1_TX #5<br>US1_RX #4<br>US1_CLK #3<br>US1_CS #2<br>US1_CTS #1<br>US1_RTS #0<br>LEU0_TX #5<br>LEU0_RX #4<br>I2C0_SDA #5<br>I2C0_SCL #4     | FRC_DCLK #5<br>FRC_DOUT #4<br>FRC_DFRAME #3<br>MODEM_DCLK #5<br>MODEM_DIN #4<br>MODEM_DOUT #3<br>MODEM_ANT0 #2<br>MODEM_ANT1 #1     | PRS_CH6 #5<br>PRS_CH7 #4<br>PRS_CH8 #3<br>PRS_CH9 #2<br>ACMP0_O #5<br>ACMP1_O #5                |

| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                                                     |                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                  |                                                                                                                                          |                                                                                                               |
|--------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| Pin #  | Pin Name | Analog                                                                                                                                                                                        | Timers                                                                                                                                                                                                                                   | Communication                                                                                                                                                                                                                    | Radio                                                                                                                                    | Other                                                                                                         |
| 11     | PB11     | BUSCY [ADC0:<br>APORT3YCH27<br>ACMP0:<br>APORT3YCH27<br>ACMP1:<br>APORT3YCH27<br>IDAC0:<br>APORT1YCH27]<br><br>BUSDX [ADC0:<br>APORT4XCH27<br>ACMP0:<br>APORT4XCH27<br>ACMP1:<br>APORT4XCH27] | TIM0_CC0 #6<br>TIM0_CC1 #5<br>TIM0_CC2 #4<br>TIM0_CDTI0 #3<br>TIM0_CDTI1 #2<br>TIM0_CDTI2 #1<br>TIM1_CC0 #6<br>TIM1_CC1 #5<br>TIM1_CC2 #4<br>TIM1_CC3 #3 LE-<br>TIM0_OUT0 #6 LE-<br>TIM0_OUT1 #5<br>PCNT0_S0IN #6<br>PCNT0_S1IN #5       | US0_TX #6<br>US0_RX #5<br>US0_CLK #4<br>US0_CS #3<br>US0_CTS #2<br>US0_RTS #1<br>US1_TX #6<br>US1_RX #5<br>US1_CLK #4<br>US1_CS #3<br>US1_CTS #2<br>US1_RTS #1<br>LEU0_TX #6<br>LEU0_RX #5<br>I2C0_SDA #6<br>I2C0_SCL #5         | FRC_DCLK #6<br>FRC_DOUT #5<br>FRC_DFRAME #4<br>MODEM_DCLK #6<br>MODEM_DIN #5<br>MODEM_DOUT #4<br>MODEM_ANT0 #3<br>MODEM_ANT1 #2          | PRS_CH6 #6<br>PRS_CH7 #5<br>PRS_CH8 #4<br>PRS_CH9 #3<br>ACMP0_O #6<br>ACMP1_O #6                              |
| 12     | GND      | Ground                                                                                                                                                                                        |                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                  |                                                                                                                                          |                                                                                                               |
| 13     | PB13     | BUSCY [ADC0:<br>APORT3YCH29<br>ACMP0:<br>APORT3YCH29<br>ACMP1:<br>APORT3YCH29<br>IDAC0:<br>APORT1YCH29]<br><br>BUSDX [ADC0:<br>APORT4XCH29<br>ACMP0:<br>APORT4XCH29<br>ACMP1:<br>APORT4XCH29] | TIM0_CC0 #8<br>TIM0_CC1 #7<br>TIM0_CC2 #6<br>TIM0_CDTI0 #5<br>TIM0_CDTI1 #4<br>TIM0_CDTI2 #3<br>TIM1_CC0 #8<br>TIM1_CC1 #7<br>TIM1_CC2 #6<br>TIM1_CC3 #5 LE-<br>TIM0_OUT0 #8 LE-<br>TIM0_OUT1 #7<br>PCNT0_S0IN #8<br>PCNT0_S1IN #7       | US0_TX #8<br>US0_RX #7<br>US0_CLK #6<br>US0_CS #5<br>US0_CTS #4<br>US0_RTS #3<br>US1_TX #8<br>US1_RX #7<br>US1_CLK #6<br>US1_CS #5<br>US1_CTS #4<br>US1_RTS #3<br>LEU0_TX #8<br>LEU0_RX #7<br>I2C0_SDA #8<br>I2C0_SCL #7         | FRC_DCLK #8<br>FRC_DOUT #7<br>FRC_DFRAME #6<br>MODEM_DCLK #8<br>MODEM_DIN #7<br>MODEM_DOUT #6<br>MODEM_ANT0 #5<br>MODEM_ANT1 #4          | PRS_CH6 #8<br>PRS_CH7 #7<br>PRS_CH8 #6<br>PRS_CH9 #5<br>ACMP0_O #8<br>ACMP1_O #8<br>DBG_SWO #1<br>GPIO_EM4WU9 |
| 14     | PC6      | BUSAX [ADC0:<br>APORT1XCH6<br>ACMP0:<br>APORT1XCH6<br>ACMP1:<br>APORT1XCH6]<br><br>BUSBY [ADC0:<br>APORT2YCH6<br>ACMP0:<br>APORT2YCH6<br>ACMP1:<br>APORT2YCH6]                                | TIM0_CC0 #11<br>TIM0_CC1 #10<br>TIM0_CC2 #9<br>TIM0_CDTI0 #8<br>TIM0_CDTI1 #7<br>TIM0_CDTI2 #6<br>TIM1_CC0 #11<br>TIM1_CC1 #10<br>TIM1_CC2 #9<br>TIM1_CC3 #8 LE-<br>TIM0_OUT0 #11<br>LETIM0_OUT1 #10<br>PCNT0_S0IN #11<br>PCNT0_S1IN #10 | US0_TX #11<br>US0_RX #10<br>US0_CLK #9<br>US0_CS #8<br>US0_CTS #7<br>US0_RTS #6<br>US1_TX #11<br>US1_RX #10<br>US1_CLK #9<br>US1_CS #8<br>US1_CTS #7<br>US1_RTS #6<br>LEU0_TX #11<br>LEU0_RX #10<br>I2C0_SDA #11<br>I2C0_SCL #10 | FRC_DCLK #11<br>FRC_DOUT #10<br>FRC_DFRAME #9<br>MODEM_DCLK<br>#11 MODEM_DIN<br>#10 MO-<br>DEM_DOUT #9<br>MODEM_ANT0 #8<br>MODEM_ANT1 #7 | CMU_CLK0 #2<br>PRS_CH0 #8<br>PRS_CH9 #11<br>PRS_CH10 #0<br>PRS_CH11 #5<br>ACMP0_O #11<br>ACMP1_O #11          |



| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                      |                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                        |                                                                                                                                                   |                                                                                                      |
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| Pin #  | Pin Name | Analog                                                                                                                                                         | Timers                                                                                                                                                                                                                                        | Communication                                                                                                                                                                                                                          | Radio                                                                                                                                             | Other                                                                                                |
| 15     | PC7      | BUSAY [ADC0:<br>APORT1YCH7<br>ACMP0:<br>APORT1YCH7<br>ACMP1:<br>APORT1YCH7]<br><br>BUSBX [ADC0:<br>APORT2XCH7<br>ACMP0:<br>APORT2XCH7<br>ACMP1:<br>APORT2XCH7] | TIM0_CC0 #12<br>TIM0_CC1 #11<br>TIM0_CC2 #10<br>TIM0_CDTI0 #9<br>TIM0_CDTI1 #8<br>TIM0_CDTI2 #7<br>TIM1_CC0 #12<br>TIM1_CC1 #11<br>TIM1_CC2 #10<br>TIM1_CC3 #9 LE-<br>TIM0_OUT0 #12<br>LETIM0_OUT1 #11<br>PCNT0_S0IN #12<br>PCNT0_S1IN #11    | US0_TX #12<br>US0_RX #11<br>US0_CLK #10<br>US0_CS #9<br>US0_CTS #8<br>US0_RTS #7<br>US1_TX #12<br>US1_RX #11<br>US1_CLK #10<br>US1_CS #9<br>US1_CTS #8<br>US1_RTS #7<br>LEU0_TX #12<br>LEU0_RX #11<br>I2C0_SDA #12<br>I2C0_SCL #11     | FRC_DCLK #12<br>FRC_DOUT #11<br>FRC_DFRAME #10<br>MODEM_DCLK<br>#12 MODEM_DIN<br>#11 MO-<br>DEM_DOUT #10<br>MODEM_ANT0 #9<br>MODEM_ANT1 #8        | CMU_CLK1 #2<br>PRS_CH0 #9<br>PRS_CH9 #12<br>PRS_CH10 #1<br>PRS_CH11 #0<br>ACMP0_O #12<br>ACMP1_O #12 |
| 16     | PC8      | BUSAX [ADC0:<br>APORT1XCH8<br>ACMP0:<br>APORT1XCH8<br>ACMP1:<br>APORT1XCH8]<br><br>BUSBY [ADC0:<br>APORT2YCH8<br>ACMP0:<br>APORT2YCH8<br>ACMP1:<br>APORT2YCH8] | TIM0_CC0 #13<br>TIM0_CC1 #12<br>TIM0_CC2 #11<br>TIM0_CDTI0 #10<br>TIM0_CDTI1 #9<br>TIM0_CDTI2 #8<br>TIM1_CC0 #13<br>TIM1_CC1 #12<br>TIM1_CC2 #11<br>TIM1_CC3 #10 LE-<br>TIM0_OUT0 #13<br>LETIM0_OUT1 #12<br>PCNT0_S0IN #13<br>PCNT0_S1IN #12  | US0_TX #13<br>US0_RX #12<br>US0_CLK #11<br>US0_CS #10<br>US0_CTS #9<br>US0_RTS #8<br>US1_TX #13<br>US1_RX #12<br>US1_CLK #11<br>US1_CS #10<br>US1_CTS #9<br>US1_RTS #8<br>LEU0_TX #13<br>LEU0_RX #12<br>I2C0_SDA #13<br>I2C0_SCL #12   | FRC_DCLK #13<br>FRC_DOUT #12<br>FRC_DFRAME #11<br>MODEM_DCLK<br>#13 MODEM_DIN<br>#12 MO-<br>DEM_DOUT #11<br>MODEM_ANT0<br>#10 MO-<br>DEM_ANT1 #9  | PRS_CH0 #10<br>PRS_CH9 #13<br>PRS_CH10 #2<br>PRS_CH11 #1<br>ACMP0_O #13<br>ACMP1_O #13               |
| 17     | PC9      | BUSAY [ADC0:<br>APORT1YCH9<br>ACMP0:<br>APORT1YCH9<br>ACMP1:<br>APORT1YCH9]<br><br>BUSBX [ADC0:<br>APORT2XCH9<br>ACMP0:<br>APORT2XCH9<br>ACMP1:<br>APORT2XCH9] | TIM0_CC0 #14<br>TIM0_CC1 #13<br>TIM0_CC2 #12<br>TIM0_CDTI0 #11<br>TIM0_CDTI1 #10<br>TIM0_CDTI2 #9<br>TIM1_CC0 #14<br>TIM1_CC1 #13<br>TIM1_CC2 #12<br>TIM1_CC3 #11 LE-<br>TIM0_OUT0 #14<br>LETIM0_OUT1 #13<br>PCNT0_S0IN #14<br>PCNT0_S1IN #13 | US0_TX #14<br>US0_RX #13<br>US0_CLK #12<br>US0_CS #11<br>US0_CTS #10<br>US0_RTS #9<br>US1_TX #14<br>US1_RX #13<br>US1_CLK #12<br>US1_CS #11<br>US1_CTS #10<br>US1_RTS #9<br>LEU0_TX #14<br>LEU0_RX #13<br>I2C0_SDA #14<br>I2C0_SCL #13 | FRC_DCLK #14<br>FRC_DOUT #13<br>FRC_DFRAME #12<br>MODEM_DCLK<br>#14 MODEM_DIN<br>#13 MO-<br>DEM_DOUT #12<br>MODEM_ANT0<br>#11 MO-<br>DEM_ANT1 #10 | PRS_CH0 #11<br>PRS_CH9 #14<br>PRS_CH10 #3<br>PRS_CH11 #2<br>ACMP0_O #14<br>ACMP1_O #14               |



| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                            |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                       |
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| Pin #  | Pin Name | Analog                                                                                                                                                               | Timers                                                                                                                                                                                                                                         | Communication                                                                                                                                                                                                                            | Radio                                                                                                                                             | Other                                                                                                                 |
| 18     | PC10     | BUSAX [ADC0:<br>APORT1XCH10<br>ACMP0:<br>APORT1XCH10<br>ACMP1:<br>APORT1XCH10]<br><br>BUSBY [ADC0:<br>APORT2YCH10<br>ACMP0:<br>APORT2YCH10<br>ACMP1:<br>APORT2YCH10] | TIM0_CC0 #15<br>TIM0_CC1 #14<br>TIM0_CC2 #13<br>TIM0_CDTI0 #12<br>TIM0_CDTI1 #11<br>TIM0_CDTI2 #10<br>TIM1_CC0 #15<br>TIM1_CC1 #14<br>TIM1_CC2 #13<br>TIM1_CC3 #12 LE-<br>TIM0_OUT0 #15<br>LETIM0_OUT1 #14<br>PCNT0_S0IN #15<br>PCNT0_S1IN #14 | US0_TX #15<br>US0_RX #14<br>US0_CLK #13<br>US0_CS #12<br>US0_CTS #11<br>US0_RTS #10<br>US1_TX #15<br>US1_RX #14<br>US1_CLK #13<br>US1_CS #12<br>US1_CTS #11<br>US1_RTS #10<br>LEU0_TX #15<br>LEU0_RX #14<br>I2C0_SDA #15<br>I2C0_SCL #14 | FRC_DCLK #15<br>FRC_DOUT #14<br>FRC_DFRAME #13<br>MODEM_DCLK<br>#15 MODEM_DIN<br>#14 MO-<br>DEM_DOUT #13<br>MODEM_ANT0<br>#12 MO-<br>DEM_ANT1 #11 | CMU_CLK1 #3<br>PRS_CH0 #12<br>PRS_CH9 #15<br>PRS_CH10 #4<br>PRS_CH11 #3<br>ACMP0_O #15<br>ACMP1_O #15<br>GPIO_EM4WU12 |
| 19     | PC11     | BUSAY [ADC0:<br>APORT1YCH11<br>ACMP0:<br>APORT1YCH11<br>ACMP1:<br>APORT1YCH11]<br><br>BUSBX [ADC0:<br>APORT2XCH11<br>ACMP0:<br>APORT2XCH11<br>ACMP1:<br>APORT2XCH11] | TIM0_CC0 #16<br>TIM0_CC1 #15<br>TIM0_CC2 #14<br>TIM0_CDTI0 #13<br>TIM0_CDTI1 #12<br>TIM0_CDTI2 #11<br>TIM1_CC0 #16<br>TIM1_CC1 #15<br>TIM1_CC2 #14<br>TIM1_CC3 #13 LE-<br>TIM0_OUT0 #16<br>LETIM0_OUT1 #15<br>PCNT0_S0IN #16<br>PCNT0_S1IN #15 | US0_TX #16<br>US0_RX #15<br>US0_CLK #14<br>US0_CS #13<br>US0_CTS #12<br>US0_RTS #11<br>US1_TX #16<br>US1_RX #15<br>US1_CLK #14<br>US1_CS #13<br>US1_CTS #12<br>US1_RTS #11<br>LEU0_TX #16<br>LEU0_RX #15<br>I2C0_SDA #16<br>I2C0_SCL #15 | FRC_DCLK #16<br>FRC_DOUT #15<br>FRC_DFRAME #14<br>MODEM_DCLK<br>#16 MODEM_DIN<br>#15 MO-<br>DEM_DOUT #14<br>MODEM_ANT0<br>#13 MO-<br>DEM_ANT1 #12 | CMU_CLK0 #3<br>PRS_CH0 #13<br>PRS_CH9 #16<br>PRS_CH10 #5<br>PRS_CH11 #4<br>ACMP0_O #16<br>ACMP1_O #16<br>DBG_SWO #3   |
| 20     | GND      | Ground                                                                                                                                                               |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                       |
| 21     | PF0      | BUSAX [ADC0:<br>APORT1XCH16<br>ACMP0:<br>APORT1XCH16<br>ACMP1:<br>APORT1XCH16]<br><br>BUSBY [ADC0:<br>APORT2YCH16<br>ACMP0:<br>APORT2YCH16<br>ACMP1:<br>APORT2YCH16] | TIM0_CC0 #24<br>TIM0_CC1 #23<br>TIM0_CC2 #22<br>TIM0_CDTI0 #21<br>TIM0_CDTI1 #20<br>TIM0_CDTI2 #19<br>TIM1_CC0 #24<br>TIM1_CC1 #23<br>TIM1_CC2 #22<br>TIM1_CC3 #21 LE-<br>TIM0_OUT0 #24<br>LETIM0_OUT1 #23<br>PCNT0_S0IN #24<br>PCNT0_S1IN #23 | US0_TX #24<br>US0_RX #23<br>US0_CLK #22<br>US0_CS #21<br>US0_CTS #20<br>US0_RTS #19<br>US1_TX #24<br>US1_RX #23<br>US1_CLK #22<br>US1_CS #21<br>US1_CTS #20<br>US1_RTS #19<br>LEU0_TX #24<br>LEU0_RX #23<br>I2C0_SDA #24<br>I2C0_SCL #23 | FRC_DCLK #24<br>FRC_DOUT #23<br>FRC_DFRAME #22<br>MODEM_DCLK<br>#24 MODEM_DIN<br>#23 MO-<br>DEM_DOUT #22<br>MODEM_ANT0<br>#21 MO-<br>DEM_ANT1 #20 | PRS_CH0 #0<br>PRS_CH1 #7<br>PRS_CH2 #6<br>PRS_CH3 #5<br>ACMP0_O #24<br>ACMP1_O #24<br>DBG_SWCLKTCK<br>#0              |

| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                            |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                                              |
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| Pin #  | Pin Name | Analog                                                                                                                                                               | Timers                                                                                                                                                                                                                                         | Communication                                                                                                                                                                                                                            | Radio                                                                                                                                             | Other                                                                                                                                        |
| 22     | PF1      | BUSAY [ADC0:<br>APORT1YCH17<br>ACMP0:<br>APORT1YCH17<br>ACMP1:<br>APORT1YCH17]<br><br>BUSBX [ADC0:<br>APORT2XCH17<br>ACMP0:<br>APORT2XCH17<br>ACMP1:<br>APORT2XCH17] | TIM0_CC0 #25<br>TIM0_CC1 #24<br>TIM0_CC2 #23<br>TIM0_CDTI0 #22<br>TIM0_CDTI1 #21<br>TIM0_CDTI2 #20<br>TIM1_CC0 #25<br>TIM1_CC1 #24<br>TIM1_CC2 #23<br>TIM1_CC3 #22 LE-<br>TIM0_OUT0 #25<br>LETIM0_OUT1 #24<br>PCNT0_S0IN #25<br>PCNT0_S1IN #24 | US0_TX #25<br>US0_RX #24<br>US0_CLK #23<br>US0_CS #22<br>US0_CTS #21<br>US0_RTS #20<br>US1_TX #25<br>US1_RX #24<br>US1_CLK #23<br>US1_CS #22<br>US1_CTS #21<br>US1_RTS #20<br>LEU0_TX #25<br>LEU0_RX #24<br>I2C0_SDA #25<br>I2C0_SCL #24 | FRC_DCLK #25<br>FRC_DOUT #24<br>FRC_DFRAME #23<br>MODEM_DCLK<br>#25 MODEM_DIN<br>#24 MO-<br>DEM_DOUT #23<br>MODEM_ANT0<br>#22 MO-<br>DEM_ANT1 #21 | PRS_CH0 #1<br>PRS_CH1 #0<br>PRS_CH2 #7<br>PRS_CH3 #6<br>ACMP0_O #25<br>ACMP1_O #25<br>DBG_SWDIOTMS<br>#0                                     |
| 23     | PF2      | BUSAX [ADC0:<br>APORT1XCH18<br>ACMP0:<br>APORT1XCH18<br>ACMP1:<br>APORT1XCH18]<br><br>BUSBY [ADC0:<br>APORT2YCH18<br>ACMP0:<br>APORT2YCH18<br>ACMP1:<br>APORT2YCH18] | TIM0_CC0 #26<br>TIM0_CC1 #25<br>TIM0_CC2 #24<br>TIM0_CDTI0 #23<br>TIM0_CDTI1 #22<br>TIM0_CDTI2 #21<br>TIM1_CC0 #26<br>TIM1_CC1 #25<br>TIM1_CC2 #24<br>TIM1_CC3 #23 LE-<br>TIM0_OUT0 #26<br>LETIM0_OUT1 #25<br>PCNT0_S0IN #26<br>PCNT0_S1IN #25 | US0_TX #26<br>US0_RX #25<br>US0_CLK #24<br>US0_CS #23<br>US0_CTS #22<br>US0_RTS #21<br>US1_TX #26<br>US1_RX #25<br>US1_CLK #24<br>US1_CS #23<br>US1_CTS #22<br>US1_RTS #21<br>LEU0_TX #26<br>LEU0_RX #25<br>I2C0_SDA #26<br>I2C0_SCL #25 | FRC_DCLK #26<br>FRC_DOUT #25<br>FRC_DFRAME #24<br>MODEM_DCLK<br>#26 MODEM_DIN<br>#25 MO-<br>DEM_DOUT #24<br>MODEM_ANT0<br>#23 MO-<br>DEM_ANT1 #22 | CMU_CLK0 #6<br>PRS_CH0 #2<br>PRS_CH1 #1<br>PRS_CH2 #0<br>PRS_CH3 #7<br>ACMP0_O #26<br>ACMP1_O #26<br>DBG_TDO #0<br>DBG_SWO #0<br>GPIO_EM4WU0 |
| 24     | PF3      | BUSAY [ADC0:<br>APORT1YCH19<br>ACMP0:<br>APORT1YCH19<br>ACMP1:<br>APORT1YCH19]<br><br>BUSBX [ADC0:<br>APORT2XCH19<br>ACMP0:<br>APORT2XCH19<br>ACMP1:<br>APORT2XCH19] | TIM0_CC0 #27<br>TIM0_CC1 #26<br>TIM0_CC2 #25<br>TIM0_CDTI0 #24<br>TIM0_CDTI1 #23<br>TIM0_CDTI2 #22<br>TIM1_CC0 #27<br>TIM1_CC1 #26<br>TIM1_CC2 #25<br>TIM1_CC3 #24 LE-<br>TIM0_OUT0 #27<br>LETIM0_OUT1 #26<br>PCNT0_S0IN #27<br>PCNT0_S1IN #26 | US0_TX #27<br>US0_RX #26<br>US0_CLK #25<br>US0_CS #24<br>US0_CTS #23<br>US0_RTS #22<br>US1_TX #27<br>US1_RX #26<br>US1_CLK #25<br>US1_CS #24<br>US1_CTS #23<br>US1_RTS #22<br>LEU0_TX #27<br>LEU0_RX #26<br>I2C0_SDA #27<br>I2C0_SCL #26 | FRC_DCLK #27<br>FRC_DOUT #26<br>FRC_DFRAME #25<br>MODEM_DCLK<br>#27 MODEM_DIN<br>#26 MO-<br>DEM_DOUT #25<br>MODEM_ANT0<br>#24 MO-<br>DEM_ANT1 #23 | CMU_CLK1 #6<br>PRS_CH0 #3<br>PRS_CH1 #2<br>PRS_CH2 #1<br>PRS_CH3 #0<br>ACMP0_O #27<br>ACMP1_O #27<br>DBG_TDI #0                              |

| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                            |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                   |
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| Pin #  | Pin Name | Analog                                                                                                                                                               | Timers                                                                                                                                                                                                                                         | Communication                                                                                                                                                                                                                            | Radio                                                                                                                                             | Other                                                                                             |
| 25     | PF4      | BUSAX [ADC0:<br>APORT1XCH20<br>ACMP0:<br>APORT1XCH20<br>ACMP1:<br>APORT1XCH20]<br><br>BUSBY [ADC0:<br>APORT2YCH20<br>ACMP0:<br>APORT2YCH20<br>ACMP1:<br>APORT2YCH20] | TIM0_CC0 #28<br>TIM0_CC1 #27<br>TIM0_CC2 #26<br>TIM0_CDTI0 #25<br>TIM0_CDTI1 #24<br>TIM0_CDTI2 #23<br>TIM1_CC0 #28<br>TIM1_CC1 #27<br>TIM1_CC2 #26<br>TIM1_CC3 #25 LE-<br>TIM0_OUT0 #28<br>LETIM0_OUT1 #27<br>PCNT0_S0IN #28<br>PCNT0_S1IN #27 | US0_TX #28<br>US0_RX #27<br>US0_CLK #26<br>US0_CS #25<br>US0_CTS #24<br>US0_RTS #23<br>US1_TX #28<br>US1_RX #27<br>US1_CLK #26<br>US1_CS #25<br>US1_CTS #24<br>US1_RTS #23<br>LEU0_TX #28<br>LEU0_RX #27<br>I2C0_SDA #28<br>I2C0_SCL #27 | FRC_DCLK #28<br>FRC_DOUT #27<br>FRC_DFRAME #26<br>MODEM_DCLK<br>#28 MODEM_DIN<br>#27 MO-<br>DEM_DOUT #26<br>MODEM_ANT0<br>#25 MO-<br>DEM_ANT1 #24 | PRS_CH0 #4<br>PRS_CH1 #3<br>PRS_CH2 #2<br>PRS_CH3 #1<br>ACMP0_O #28<br>ACMP1_O #28                |
| 26     | PF5      | BUSAY [ADC0:<br>APORT1YCH21<br>ACMP0:<br>APORT1YCH21<br>ACMP1:<br>APORT1YCH21]<br><br>BUSBX [ADC0:<br>APORT2XCH21<br>ACMP0:<br>APORT2XCH21<br>ACMP1:<br>APORT2XCH21] | TIM0_CC0 #29<br>TIM0_CC1 #28<br>TIM0_CC2 #27<br>TIM0_CDTI0 #26<br>TIM0_CDTI1 #25<br>TIM0_CDTI2 #24<br>TIM1_CC0 #29<br>TIM1_CC1 #28<br>TIM1_CC2 #27<br>TIM1_CC3 #26 LE-<br>TIM0_OUT0 #29<br>LETIM0_OUT1 #28<br>PCNT0_S0IN #29<br>PCNT0_S1IN #28 | US0_TX #29<br>US0_RX #28<br>US0_CLK #27<br>US0_CS #26<br>US0_CTS #25<br>US0_RTS #24<br>US1_TX #29<br>US1_RX #28<br>US1_CLK #27<br>US1_CS #26<br>US1_CTS #25<br>US1_RTS #24<br>LEU0_TX #29<br>LEU0_RX #28<br>I2C0_SDA #29<br>I2C0_SCL #28 | FRC_DCLK #29<br>FRC_DOUT #28<br>FRC_DFRAME #27<br>MODEM_DCLK<br>#29 MODEM_DIN<br>#28 MO-<br>DEM_DOUT #27<br>MODEM_ANT0<br>#26 MO-<br>DEM_ANT1 #25 | PRS_CH0 #5<br>PRS_CH1 #4<br>PRS_CH2 #3<br>PRS_CH3 #2<br>ACMP0_O #29<br>ACMP1_O #29                |
| 27     | PF6      | BUSAX [ADC0:<br>APORT1XCH22<br>ACMP0:<br>APORT1XCH22<br>ACMP1:<br>APORT1XCH22]<br><br>BUSBY [ADC0:<br>APORT2YCH22<br>ACMP0:<br>APORT2YCH22<br>ACMP1:<br>APORT2YCH22] | TIM0_CC0 #30<br>TIM0_CC1 #29<br>TIM0_CC2 #28<br>TIM0_CDTI0 #27<br>TIM0_CDTI1 #26<br>TIM0_CDTI2 #25<br>TIM1_CC0 #30<br>TIM1_CC1 #29<br>TIM1_CC2 #28<br>TIM1_CC3 #27 LE-<br>TIM0_OUT0 #30<br>LETIM0_OUT1 #29<br>PCNT0_S0IN #30<br>PCNT0_S1IN #29 | US0_TX #30<br>US0_RX #29<br>US0_CLK #28<br>US0_CS #27<br>US0_CTS #26<br>US0_RTS #25<br>US1_TX #30<br>US1_RX #29<br>US1_CLK #28<br>US1_CS #27<br>US1_CTS #26<br>US1_RTS #25<br>LEU0_TX #30<br>LEU0_RX #29<br>I2C0_SDA #30<br>I2C0_SCL #29 | FRC_DCLK #30<br>FRC_DOUT #29<br>FRC_DFRAME #28<br>MODEM_DCLK<br>#30 MODEM_DIN<br>#29 MO-<br>DEM_DOUT #28<br>MODEM_ANT0<br>#27 MO-<br>DEM_ANT1 #26 | CMU_CLK1 #7<br>PRS_CH0 #6<br>PRS_CH1 #5<br>PRS_CH2 #4<br>PRS_CH3 #3<br>ACMP0_O #30<br>ACMP1_O #30 |

| BGM111 |          | Pin Alternate Functionality / Description                                                                                                                                                   |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                  |
|--------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Pin #  | Pin Name | Analog                                                                                                                                                                                      | Timers                                                                                                                                                                                                                                         | Communication                                                                                                                                                                                                                            | Radio                                                                                                                                             | Other                                                                                                            |
| 28     | PF7      | BUSAY [ADC0:<br>APORT1YCH23<br>ACMP0:<br>APORT1YCH23<br>ACMP1:<br>APORT1YCH23]<br><br>BUSBX [ADC0:<br>APORT2XCH23<br>ACMP0:<br>APORT2XCH23<br>ACMP1:<br>APORT2XCH23]                        | TIM0_CC0 #31<br>TIM0_CC1 #30<br>TIM0_CC2 #29<br>TIM0_CDTI0 #28<br>TIM0_CDTI1 #27<br>TIM0_CDTI2 #26<br>TIM1_CC0 #31<br>TIM1_CC1 #30<br>TIM1_CC2 #29<br>TIM1_CC3 #28 LE-<br>TIM0_OUT0 #31<br>LETIM0_OUT1 #30<br>PCNT0_S0IN #31<br>PCNT0_S1IN #30 | US0_TX #31<br>US0_RX #30<br>US0_CLK #29<br>US0_CS #28<br>US0_CTS #27<br>US0_RTS #26<br>US1_TX #31<br>US1_RX #30<br>US1_CLK #29<br>US1_CS #28<br>US1_CTS #27<br>US1_RTS #26<br>LEU0_TX #31<br>LEU0_RX #30<br>I2C0_SDA #31<br>I2C0_SCL #30 | FRC_DCLK #31<br>FRC_DOUT #30<br>FRC_DFRAME #29<br>MODEM_DCLK<br>#31 MODEM_DIN<br>#30 MO-<br>DEM_DOUT #29<br>MODEM_ANT0<br>#28 MO-<br>DEM_ANT1 #27 | CMU_CLK0 #7<br>PRS_CH0 #7<br>PRS_CH1 #6<br>PRS_CH2 #5<br>PRS_CH3 #4<br>ACMP0_O #31<br>ACMP1_O #31<br>GPIO_EM4WU1 |
| 29     | VDD      | Module power supply                                                                                                                                                                         |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                  |
| 30     | RESETn   | Reset input, active low. To apply an external reset source to this pin, it is required to only drive this pin low during reset, and let the internal pull-up ensure that reset is released. |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                  |
| 31     | GND      | Ground                                                                                                                                                                                      |                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                          |                                                                                                                                                   |                                                                                                                  |

### 7.1.1 GPIO Overview

The GPIO pins are organized as 16-bit ports indicated by letters A through F, and the individual pins on each port are indicated by a number from 15 down to 0.

**Table 7.2. GPIO Pinout**

| Port   | Pin 15    | Pin 14    | Pin 13    | Pin 12 | Pin 11    | Pin 10    | Pin 9    | Pin 8    | Pin 7    | Pin 6    | Pin 5    | Pin 4    | Pin 3    | Pin 2    | Pin 1    | Pin 0    |
|--------|-----------|-----------|-----------|--------|-----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Port A | -         | -         | -         | -      | -         | -         | -        | -        | -        | -        | PA5 (5V) | PA4 (5V) | PA3 (5V) | PA2 (5V) | PA1      | PA0      |
| Port B | -         | -         | PB13 (5V) | -      | PB11 (5V) | -         | -        | -        | -        | -        | -        | -        | -        | -        | -        | -        |
| Port C | -         | -         | -         | -      | PC11 (5V) | PC10 (5V) | PC9 (5V) | PC8 (5V) | PC7 (5V) | PC6 (5V) | -        | -        | -        | -        | -        | -        |
| Port D | PD15 (5V) | PD14 (5V) | PD13 (5V) | -      | -         | -         | -        | -        | -        | -        | -        | -        | -        | -        | -        | -        |
| Port E | -         | -         | -         | -      | -         | -         | -        | -        | -        | -        | -        | -        | -        | -        | -        | -        |
| Port F | -         | -         | -         | -      | -         | -         | -        | -        | PF7 (5V) | PF6 (5V) | PF5 (5V) | PF4 (5V) | PF3 (5V) | PF2 (5V) | PF1 (5V) | PF0 (5V) |

**Note:** GPIO with 5V tolerance are indicated by (5V).

**Note:** The pins PA4, PA3, PA2, PB13, PB11, PD15, PD14 and PD13 will not be 5V tolerant on all future devices. In order to preserve upgrade options with full hardware compatibility, do not use these pins on 5V domains.

## 7.2 Alternate Functionality Pinout

A wide selection of alternate functionality is available for multiplexing to various pins. The following table shows the name of the alternate functionality in the first column, followed by columns showing the possible LOCATION bitfield settings.

**Note:** Some functionality, such as analog interfaces, do not have alternate settings or a LOCATION bitfield. In these cases, the pinout is shown in the column corresponding to LOCATION 0.

**Table 7.3. Alternate functionality overview**

| Alternate     | LOCATION                             |                             |                        |                                           |          |                                  |                                          |                                          |                                                                                                                                                                           |
|---------------|--------------------------------------|-----------------------------|------------------------|-------------------------------------------|----------|----------------------------------|------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Functionality | 0 - 3                                | 4 - 7                       | 8 - 11                 | 12 - 15                                   | 16 - 19  | 20 - 23                          | 24 - 27                                  | 28 - 31                                  | Description                                                                                                                                                               |
| ACMP0_O       | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3 | 4: PA4<br>5: PA5<br>6: PB11 | 8: PB13<br><br>11: PC6 | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10 | 16: PC11 | 21: PD13<br>22: PD14<br>23: PD15 | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | Analog comparator ACMP0, digital output.                                                                                                                                  |
| ACMP1_O       | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3 | 4: PA4<br>5: PA5<br>6: PB11 | 8: PB13<br><br>11: PC6 | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10 | 16: PC11 | 21: PD13<br>22: PD14<br>23: PD15 | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | Analog comparator ACMP1, digital output.                                                                                                                                  |
| ADC0_EXTN     | 0: PA0                               |                             |                        |                                           |          |                                  |                                          |                                          | Analog to digital converter ADC0 external reference input negative pin                                                                                                    |
| ADC0_EXTP     | 0: PA1                               |                             |                        |                                           |          |                                  |                                          |                                          | Analog to digital converter ADC0 external reference input positive pin                                                                                                    |
| CMU_CLK0      | 0: PA1<br>2: PC6<br>3: PC11          | 5: PD14<br>6: PF2<br>7: PF7 |                        |                                           |          |                                  |                                          |                                          | Clock Management Unit, clock output number 0.                                                                                                                             |
| CMU_CLK1      | 0: PA0<br>2: PC7<br>3: PC10          | 5: PD15<br>6: PF3<br>7: PF6 |                        |                                           |          |                                  |                                          |                                          | Clock Management Unit, clock output number 1.                                                                                                                             |
| DBG_SWCLKTCK  | 0: PF0                               |                             |                        |                                           |          |                                  |                                          |                                          | Debug-interface Serial Wire clock input and JTAG Test Clock.<br><br>Note that this function is enabled to the pin out of reset, and has a built-in pull down.             |
| DBG_SWDIOTMS  | 0: PF1                               |                             |                        |                                           |          |                                  |                                          |                                          | Debug-interface Serial Wire data input / output and JTAG Test Mode Select.<br><br>Note that this function is enabled to the pin out of reset, and has a built-in pull up. |

| Alternate     | LOCATION                                |                                  |                              |                                            |          |                                             |                                          |                                          |                                                                                                                                                         |
|---------------|-----------------------------------------|----------------------------------|------------------------------|--------------------------------------------|----------|---------------------------------------------|------------------------------------------|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Functionality | 0 - 3                                   | 4 - 7                            | 8 - 11                       | 12 - 15                                    | 16 - 19  | 20 - 23                                     | 24 - 27                                  | 28 - 31                                  | Description                                                                                                                                             |
| DBG_SWO       | 0: PF2<br>1: PB13<br>2: PD15<br>3: PC11 |                                  |                              |                                            |          |                                             |                                          |                                          | Debug-interface<br>Serial Wire viewer<br>Output.<br><br>Note that this function is not enabled after reset, and must be enabled by software to be used. |
| DBG_TDI       | 0: PF3                                  |                                  |                              |                                            |          |                                             |                                          |                                          | Debug-interface<br>JTAG Test Data In.<br><br>Note that this function is enabled to pin out of reset, and has a built-in pull up.                        |
| DBG_TDO       | 0: PF2                                  |                                  |                              |                                            |          |                                             |                                          |                                          | Debug-interface<br>JTAG Test Data Out.<br><br>Note that this function is enabled to pin out of reset.                                                   |
| FRC_DCLK      | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3    | 4: PA4<br>5: PA5<br>6: PB11      | 8: PB13<br><br>11: PC6       | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11 | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | Frame Controller,<br>Data Sniffer Clock.                                                                                                                |
| FRC_DFRAME    | 0: PA2<br>1: PA3<br>2: PA4<br>3: PA5    | 4: PB11<br><br>6: PB13           | 9: PC6<br>10: PC7<br>11: PC8 | 12: PC9<br>13: PC10<br>14: PC11            | 19: PD13 | 20: PD14<br>21: PD15<br>22: PF0<br>23: PF1  | 24: PF2<br>25: PF3<br>26: PF4<br>27: PF5 | 28: PF6<br>29: PF7<br>30: PA0<br>31: PA1 | Frame Controller,<br>Data Sniffer Frame active                                                                                                          |
| FRC_DOUT      | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4    | 4: PA5<br>5: PB11<br><br>7: PB13 | 10: PC6<br>11: PC7           | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |          | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | Frame Controller,<br>Data Sniffer Output.                                                                                                               |
| GPIO_EM4WU0   | 0: PF2                                  |                                  |                              |                                            |          |                                             |                                          |                                          | Pin can be used to wake the system up from EM4                                                                                                          |
| GPIO_EM4WU1   | 0: PF7                                  |                                  |                              |                                            |          |                                             |                                          |                                          | Pin can be used to wake the system up from EM4                                                                                                          |
| GPIO_EM4WU4   | 0: PD14                                 |                                  |                              |                                            |          |                                             |                                          |                                          | Pin can be used to wake the system up from EM4                                                                                                          |
| GPIO_EM4WU8   | 0: PA3                                  |                                  |                              |                                            |          |                                             |                                          |                                          | Pin can be used to wake the system up from EM4                                                                                                          |

| Alternate     | LOCATION                              |                              |                                         |                                            |                                  |                                             |                                          |                                          |                                                                                   |
|---------------|---------------------------------------|------------------------------|-----------------------------------------|--------------------------------------------|----------------------------------|---------------------------------------------|------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------|
| Functionality | 0 - 3                                 | 4 - 7                        | 8 - 11                                  | 12 - 15                                    | 16 - 19                          | 20 - 23                                     | 24 - 27                                  | 28 - 31                                  | Description                                                                       |
| GPIO_EM4WU9   | 0: PB13                               |                              |                                         |                                            |                                  |                                             |                                          |                                          | Pin can be used to wake the system up from EM4                                    |
| GPIO_EM4WU12  | 0: PC10                               |                              |                                         |                                            |                                  |                                             |                                          |                                          | Pin can be used to wake the system up from EM4                                    |
| I2C0_SCL      | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br>7: PB13 | 10: PC6<br>11: PC7                      | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                  | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | I2C0 Serial Clock Line input / output.                                            |
| I2C0_SDA      | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11  | 8: PB13<br>11: PC6                      | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11                         | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | I2C0 Serial Data input / output.                                                  |
| LETIM0_OUT0   | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11  | 8: PB13<br>11: PC6                      | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11                         | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | Low Energy Timer LETIM0, output channel 0.                                        |
| LETIM0_OUT1   | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br>7: PB13 | 10: PC6<br>11: PC7                      | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                  | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | Low Energy Timer LETIM0, output channel 1.                                        |
| LEU0_RX       | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br>7: PB13 | 10: PC6<br>11: PC7                      | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                  | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | LEUART0 Receive input.                                                            |
| LEU0_TX       | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA4<br>5: PA5<br>6: PB11  | 8: PB13<br>11: PC6                      | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11                         | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | LEUART0 Transmit output. Also used as receive input in half-duplex communication. |
| MODEM_ANT0    | 0: PA3<br>1: PA4<br>2: PA5<br>3: PB11 | 5: PB13                      | 8: PC6<br>9: PC7<br>10: PC8<br>11: PC9  | 12: PC10<br>13: PC11                       | 18: PD13<br>19: PD14             | 20: PD15<br>21: PF0<br>22: PF1<br>23: PF2   | 24: PF3<br>25: PF4<br>26: PF5<br>27: PF6 | 28: PF7<br>29: PA0<br>30: PA1<br>31: PA2 | MODEM antenna control output 0, used for antenna diversity.                       |
| MODEM_ANT1    | 0: PA4<br>1: PA5<br>2: PB11           | 4: PB13<br>7: PC6            | 8: PC7<br>9: PC8<br>10: PC9<br>11: PC10 | 12: PC11                                   | 17: PD13<br>18: PD14<br>19: PD15 | 20: PF0<br>21: PF1<br>22: PF2<br>23: PF3    | 24: PF4<br>25: PF5<br>26: PF6<br>27: PF7 | 28: PA0<br>29: PA1<br>30: PA2<br>31: PA3 | MODEM antenna control output 1, used for antenna diversity.                       |
| MODEM_DCLK    | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11  | 8: PB13<br>11: PC6                      | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11                         | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | MODEM data clock out.                                                             |
| MODEM_DIN     | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA4<br>5: PB11<br>7: PB13 | 10: PC6<br>11: PC7                      | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                  | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | MODEM data in.                                                                    |
| MODEM_DOUT    | 0: PA2<br>1: PA3<br>2: PA4<br>3: PA5  | 4: PB11<br>6: PB13           | 9: PC6<br>10: PC7<br>11: PC8            | 12: PC9<br>13: PC10<br>14: PC11            | 19: PD13                         | 20: PD14<br>21: PD15<br>22: PF0<br>23: PF1  | 24: PF2<br>25: PF3<br>26: PF4<br>27: PF5 | 28: PF6<br>29: PF7<br>30: PA0<br>31: PA1 | MODEM data out.                                                                   |



| Alternate     | LOCATION                              |                                      |                                        |                                            |                      |                                             |                                          |                                          |                                              |
|---------------|---------------------------------------|--------------------------------------|----------------------------------------|--------------------------------------------|----------------------|---------------------------------------------|------------------------------------------|------------------------------------------|----------------------------------------------|
| Functionality | 0 - 3                                 | 4 - 7                                | 8 - 11                                 | 12 - 15                                    | 16 - 19              | 20 - 23                                     | 24 - 27                                  | 28 - 31                                  | Description                                  |
| PCNT0_S0IN    | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11          | 8: PB13<br><br>11: PC6                 | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11             | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | Pulse Counter<br>PCNT0 input number 0.       |
| PCNT0_S1IN    | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br><br>7: PB13     | 10: PC6<br>11: PC7                     | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                      | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | Pulse Counter<br>PCNT0 input number 1.       |
| PRS_CH0       | 0: PF0<br>1: PF1<br>2: PF2<br>3: PF3  | 4: PF4<br>5: PF5<br>6: PF6<br>7: PF7 | 8: PC6<br>9: PC7<br>10: PC8<br>11: PC9 | 12: PC10<br>13: PC11                       |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 0.  |
| PRS_CH1       | 0: PF1<br>1: PF2<br>2: PF3<br>3: PF4  | 4: PF5<br>5: PF6<br>6: PF7<br>7: PF0 |                                        |                                            |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 1.  |
| PRS_CH2       | 0: PF2<br>1: PF3<br>2: PF4<br>3: PF5  | 4: PF6<br>5: PF7<br>6: PF0<br>7: PF1 |                                        |                                            |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 2.  |
| PRS_CH3       | 0: PF3<br>1: PF4<br>2: PF5<br>3: PF6  | 4: PF7<br>5: PF0<br>6: PF1<br>7: PF2 |                                        | 12: PD13<br>13: PD14<br>14: PD15           |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 3.  |
| PRS_CH4       |                                       | 4: PD13<br>5: PD14<br>6: PD15        |                                        |                                            |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 4.  |
| PRS_CH5       |                                       | 4: PD14<br>5: PD15                   |                                        |                                            |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 5.  |
|               | 3: PD13                               |                                      |                                        |                                            |                      |                                             |                                          |                                          |                                              |
| PRS_CH6       | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11          | 8: PB13                                | 15: PD13                                   | 16: PD14<br>17: PD15 |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 6.  |
| PRS_CH7       | 0: PA1<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA5<br>5: PB11<br><br>7: PB13     | 10: PA0                                |                                            |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 7.  |
| PRS_CH8       | 0: PA2<br>1: PA3<br>2: PA4<br>3: PA5  | 4: PB11<br><br>6: PB13               | 9: PA0<br>10: PA1                      |                                            |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 8.  |
| PRS_CH9       | 0: PA3<br>1: PA4<br>2: PA5<br>3: PB11 | 5: PB13                              | 8: PA0<br>9: PA1<br>10: PA2<br>11: PC6 | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11             |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 9.  |
| PRS_CH10      | 0: PC6<br>1: PC7<br>2: PC8<br>3: PC9  | 4: PC10<br>5: PC11                   |                                        |                                            |                      |                                             |                                          |                                          | Peripheral Reflex<br>System PRS, channel 10. |



| Alternate     | LOCATION                              |                              |                                          |                                            |                                             |                                             |                                          |                                          |                                                      |
|---------------|---------------------------------------|------------------------------|------------------------------------------|--------------------------------------------|---------------------------------------------|---------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------------------|
| Functionality | 0 - 3                                 | 4 - 7                        | 8 - 11                                   | 12 - 15                                    | 16 - 19                                     | 20 - 23                                     | 24 - 27                                  | 28 - 31                                  | Description                                          |
| PRS_CH11      | 0: PC7<br>1: PC8<br>2: PC9<br>3: PC10 | 4: PC11<br>5: PC6            |                                          |                                            |                                             |                                             |                                          |                                          | Peripheral Reflex System PRS, channel 11.            |
| TIM0_CC0      | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11  | 8: PB13<br><br>11: PC6                   | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11                                    | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | Timer 0 Capture Compare input / output channel 0.    |
| TIM0_CC1      | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br>7: PB13 | 10: PC6<br>11: PC7                       | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                             | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | Timer 0 Capture Compare input / output channel 1.    |
| TIM0_CC2      | 0: PA2<br>1: PA3<br>2: PA4<br>3: PA5  | 4: PB11<br>6: PB13           | 9: PC6<br>10: PC7<br>11: PC8             | 12: PC9<br>13: PC10<br>14: PC11            | 19: PD13                                    | 20: PD14<br>21: PD15<br>22: PF0<br>23: PF1  | 24: PF2<br>25: PF3<br>26: PF4<br>27: PF5 | 28: PF6<br>29: PF7<br>30: PA0<br>31: PA1 | Timer 0 Capture Compare input / output channel 2.    |
| TIM0_CDT10    | 0: PA3<br>1: PA4<br>2: PA5<br>3: PB11 | 5: PB13                      | 8: PC6<br>9: PC7<br>10: PC8<br>11: PC9   | 12: PC10<br>13: PC11                       | 18: PD13<br>19: PD14                        | 20: PD15<br>21: PF0<br>22: PF1<br>23: PF2   | 24: PF3<br>25: PF4<br>26: PF5<br>27: PF6 | 28: PF7<br>29: PA0<br>30: PA1<br>31: PA2 | Timer 0 Complimentary Dead Time Insertion channel 0. |
| TIM0_CDT11    | 0: PA4<br>1: PA5<br>2: PB11           | 4: PB13<br>7: PC6            | 8: PC7<br>9: PC8<br>10: PC9<br>11: PC10  | 12: PC11                                   | 17: PD13<br>18: PD14<br>19: PD15            | 20: PF0<br>21: PF1<br>22: PF2<br>23: PF3    | 24: PF4<br>25: PF5<br>26: PF6<br>27: PF7 | 28: PA0<br>29: PA1<br>30: PA2<br>31: PA3 | Timer 0 Complimentary Dead Time Insertion channel 1. |
| TIM0_CDT12    | 0: PA5<br>1: PB11<br>3: PB13          | 6: PC6<br>7: PC7             | 8: PC8<br>9: PC9<br>10: PC10<br>11: PC11 |                                            | 16: PD13<br>17: PD14<br>18: PD15<br>19: PF0 | 20: PF1<br>21: PF2<br>22: PF3<br>24: PF4    | 24: PF4<br>25: PF6<br>26: PF7<br>27: PA0 | 28: PA1<br>29: PA2<br>30: PA3<br>31: PA4 | Timer 0 Complimentary Dead Time Insertion channel 2. |
| TIM1_CC0      | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11  | 8: PB13<br><br>11: PC6                   | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11                                    | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | Timer 1 Capture Compare input / output channel 0.    |
| TIM1_CC1      | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br>7: PB13 | 10: PC6<br>11: PC7                       | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                             | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | Timer 1 Capture Compare input / output channel 1.    |
| TIM1_CC2      | 0: PA2<br>1: PA3<br>2: PA4<br>3: PA5  | 4: PB11<br>6: PB13           | 9: PC6<br>10: PC7<br>11: PC8             | 12: PC9<br>13: PC10<br>14: PC11            | 19: PD13                                    | 20: PD14<br>21: PD15<br>22: PF0<br>23: PF1  | 24: PF2<br>25: PF3<br>26: PF4<br>27: PF5 | 28: PF6<br>29: PF7<br>30: PA0<br>31: PA1 | Timer 1 Capture Compare input / output channel 2.    |
| TIM1_CC3      | 0: PA3<br>1: PA4<br>2: PA5<br>3: PB11 | 5: PB13                      | 8: PC6<br>9: PC7<br>10: PC8<br>11: PC9   | 12: PC10<br>13: PC11                       | 18: PD13<br>19: PD14                        | 20: PD15<br>21: PF0<br>22: PF1<br>23: PF2   | 24: PF3<br>25: PF4<br>26: PF6<br>27: PF6 | 28: PF7<br>29: PA0<br>30: PA1<br>31: PA2 | Timer 1 Capture Compare input / output channel 3.    |
| US0_CLK       | 0: PA2<br>1: PA3<br>2: PA4<br>3: PA5  | 4: PB11<br>6: PB13           | 9: PC6<br>10: PC7<br>11: PC8             | 12: PC9<br>13: PC10<br>14: PC11            | 19: PD13                                    | 20: PD14<br>21: PD15<br>22: PF0<br>23: PF1  | 24: PF2<br>25: PF3<br>26: PF4<br>27: PF5 | 28: PF6<br>29: PF7<br>30: PA0<br>31: PA1 | USART0 clock input / output.                         |
| US0_CS        | 0: PA3<br>1: PA4<br>2: PA5<br>3: PB11 | 5: PB13                      | 8: PC6<br>9: PC7<br>10: PC8<br>11: PC9   | 12: PC10<br>13: PC11                       | 18: PD13<br>19: PD14                        | 20: PD15<br>21: PF0<br>22: PF1<br>23: PF2   | 24: PF3<br>25: PF4<br>26: PF5<br>27: PF6 | 28: PF7<br>29: PA0<br>30: PA1<br>31: PA2 | USART0 chip select input / output.                   |

| Alternate     | LOCATION                              |                                  |                                          |                                            |                                             |                                             |                                          |                                          |                                                                                                                                                           |
|---------------|---------------------------------------|----------------------------------|------------------------------------------|--------------------------------------------|---------------------------------------------|---------------------------------------------|------------------------------------------|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Functionality | 0 - 3                                 | 4 - 7                            | 8 - 11                                   | 12 - 15                                    | 16 - 19                                     | 20 - 23                                     | 24 - 27                                  | 28 - 31                                  | Description                                                                                                                                               |
| US0_CTS       | 0: PA4<br>1: PA5<br>2: PB11           | 4: PB13<br><br>7: PC6            | 8: PC7<br>9: PC8<br>10: PC9<br>11: PC10  | 12: PC11                                   | 17: PD13<br>18: PD14<br>19: PD15            | 20: PF0<br>21: PF1<br>22: PF2<br>23: PF3    | 24: PF4<br>25: PF5<br>26: PF6<br>27: PF7 | 28: PA0<br>29: PA1<br>30: PA2<br>31: PA3 | USART0 Clear To Send hardware flow control input.                                                                                                         |
| US0_RTS       | 0: PA5<br>1: PB11<br><br>3: PB13      | 6: PC6<br>7: PC7                 | 8: PC8<br>9: PC9<br>10: PC10<br>11: PC11 |                                            | 16: PD13<br>17: PD14<br>18: PD15<br>19: PF0 | 20: PF1<br>21: PF2<br>22: PF3<br>23: PF4    | 24: PF5<br>25: PF6<br>26: PF7<br>27: PA0 | 28: PA1<br>29: PA2<br>30: PA3<br>31: PA4 | USART0 Request To Send hardware flow control output.                                                                                                      |
| US0_RX        | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br><br>7: PB13 | 10: PC6<br>11: PC7                       | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                             | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | USART0 Asynchronous Receive.<br><br>USART0 Synchronous mode Master Input / Slave Output (MISO).                                                           |
| US0_TX        | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3  | 4: PA4<br>5: PA5<br>6: PB11      | 8: PB13<br><br>11: PC6                   | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10  | 16: PC11                                    | 21: PD13<br>22: PD14<br>23: PD15            | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | USART0 Asynchronous Transmit. Also used as receive input in half duplex communication.<br><br>USART0 Synchronous mode Master Output / Slave Input (MOSI). |
| US1_CLK       | 0: PA2<br>1: PA3<br>2: PA4<br>3: PA5  | 4: PB11<br><br>6: PB13           | 9: PC6<br>10: PC7<br>11: PC8             | 12: PC9<br>13: PC10<br>14: PC11            | 19: PD13                                    | 20: PD14<br>21: PD15<br>22: PF0<br>23: PF1  | 24: PF2<br>25: PF3<br>26: PF4<br>27: PF5 | 28: PF6<br>29: PF7<br>30: PA0<br>31: PA1 | USART1 clock input / output.                                                                                                                              |
| US1_CS        | 0: PA3<br>1: PA4<br>2: PA5<br>3: PB11 | 5: PB13                          | 8: PC6<br>9: PC7<br>10: PC8<br>11: PC9   | 12: PC10<br>13: PC11                       | 18: PD13<br>19: PD14                        | 20: PD15<br>21: PF0<br>22: PF1<br>23: PF2   | 24: PF3<br>25: PF4<br>26: PF5<br>27: PF6 | 28: PF7<br>29: PA0<br>30: PA1<br>31: PA2 | USART1 chip select input / output.                                                                                                                        |
| US1_CTS       | 0: PA4<br>1: PA5<br>2: PB11           | 4: PB13<br><br>7: PC6            | 8: PC7<br>9: PC8<br>10: PC9<br>11: PC10  | 12: PC11                                   | 17: PD13<br>18: PD14<br>19: PD15            | 20: PF0<br>21: PF1<br>22: PF2<br>23: PF3    | 24: PF4<br>25: PF5<br>26: PF6<br>27: PF7 | 28: PA0<br>29: PA1<br>30: PA2<br>31: PA3 | USART1 Clear To Send hardware flow control input.                                                                                                         |
| US1_RTS       | 0: PA5<br>1: PB11<br><br>3: PB13      | 6: PC6<br>7: PC7                 | 8: PC8<br>9: PC9<br>10: PC10<br>11: PC11 |                                            | 16: PD13<br>17: PD14<br>18: PD15<br>19: PF0 | 20: PF1<br>21: PF2<br>22: PF3<br>23: PF4    | 24: PF5<br>25: PF6<br>26: PF7<br>27: PA0 | 28: PA1<br>29: PA2<br>30: PA3<br>31: PA4 | USART1 Request To Send hardware flow control output.                                                                                                      |
| US1_RX        | 0: PA1<br>1: PA2<br>2: PA3<br>3: PA4  | 4: PA5<br>5: PB11<br><br>7: PB13 | 10: PC6<br>11: PC7                       | 12: PC8<br>13: PC9<br>14: PC10<br>15: PC11 |                                             | 20: PD13<br>21: PD14<br>22: PD15<br>23: PF0 | 24: PF1<br>25: PF2<br>26: PF3<br>27: PF4 | 28: PF5<br>29: PF6<br>30: PF7<br>31: PA0 | USART1 Asynchronous Receive.<br><br>USART1 Synchronous mode Master Input / Slave Output (MISO).                                                           |

| Alternate     | LOCATION                             |                             |                        |                                           |          |                                  |                                          |                                          |                                                                                                                                                                  |
|---------------|--------------------------------------|-----------------------------|------------------------|-------------------------------------------|----------|----------------------------------|------------------------------------------|------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Functionality | 0 - 3                                | 4 - 7                       | 8 - 11                 | 12 - 15                                   | 16 - 19  | 20 - 23                          | 24 - 27                                  | 28 - 31                                  | Description                                                                                                                                                      |
| US1_TX        | 0: PA0<br>1: PA1<br>2: PA2<br>3: PA3 | 4: PA4<br>5: PA5<br>6: PB11 | 8: PB13<br><br>11: PC6 | 12: PC7<br>13: PC8<br>14: PC9<br>15: PC10 | 16: PC11 | 21: PD13<br>22: PD14<br>23: PD15 | 24: PF0<br>25: PF1<br>26: PF2<br>27: PF3 | 28: PF4<br>29: PF5<br>30: PF6<br>31: PF7 | <p>USART1 Asynchronous Transmit. Also used as receive input in half duplex communication.</p> <p>USART1 Synchronous mode Master Output / Slave Input (MOSI).</p> |

### 7.3 Analog Port (APORT)

The Analog Port (APORT) is an infrastructure used to connect chip pins with on-chip analog clients such as analog comparators, ADCs, and DACs. The APORT consists of wires, switches, and control needed to configurably implement the routes. Please see the device Reference Manual for a complete description.

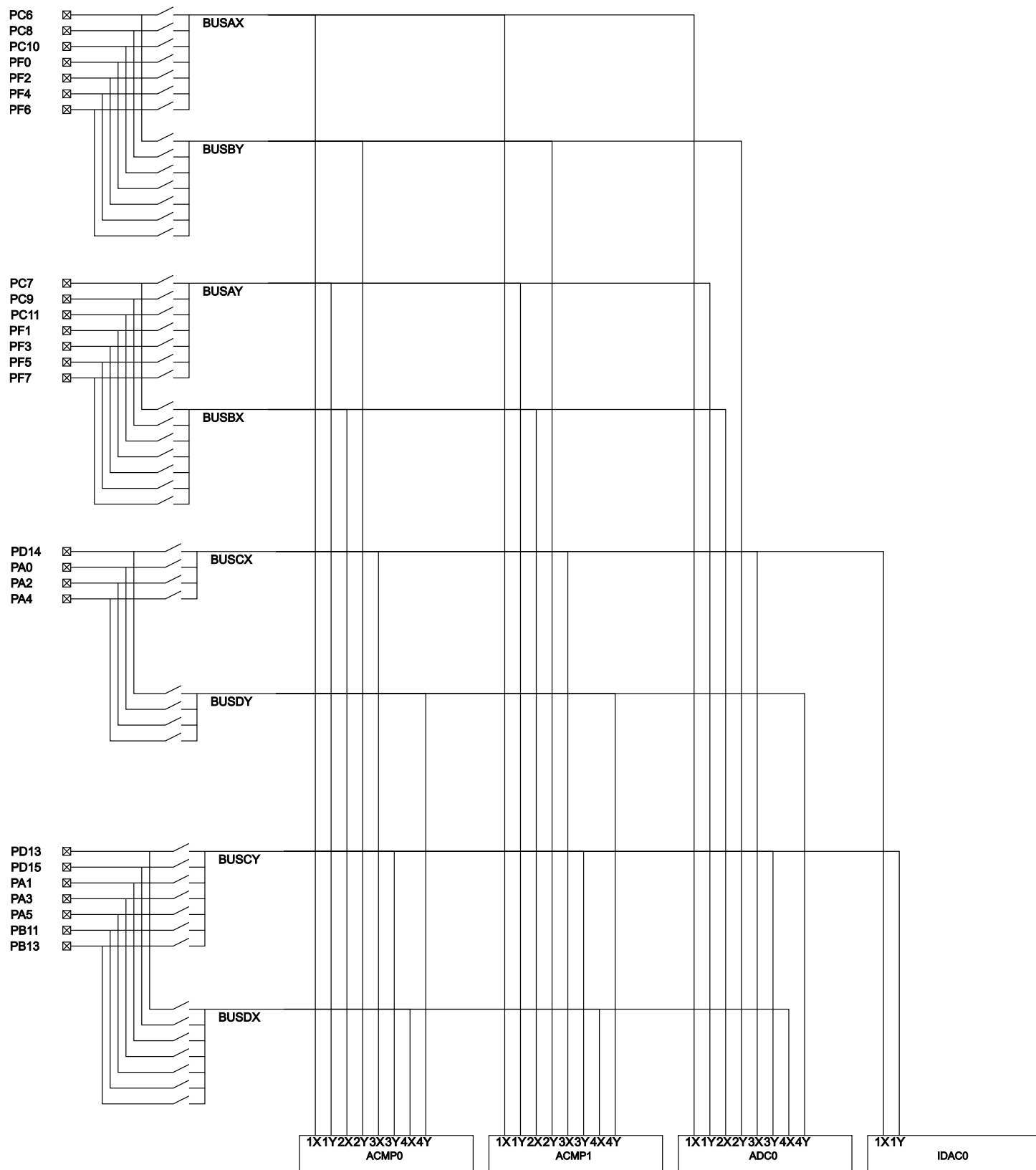


Figure 7.2. BGM111 APORT

Table 7.4. APORT Client Map

| Analog Module | Analog Module Channel | Shared Bus | Pin  |
|---------------|-----------------------|------------|------|
| ACMP0         | APORT1XCH6            | BUSAX      | PC6  |
|               | APORT1XCH8            |            | PC8  |
|               | APORT1XCH10           |            | PC10 |
|               | APORT1XCH16           |            | PF0  |
|               | APORT1XCH18           |            | PF2  |
|               | APORT1XCH20           |            | PF4  |
|               | APORT1XCH22           |            | PF6  |
| ACMP0         | APORT1YCH7            | BUSAY      | PC7  |
|               | APORT1YCH9            |            | PC9  |
|               | APORT1YCH11           |            | PC11 |
|               | APORT1YCH17           |            | PF1  |
|               | APORT1YCH19           |            | PF3  |
|               | APORT1YCH21           |            | PF5  |
|               | APORT1YCH23           |            | PF7  |
| ACMP0         | APORT2XCH7            | BUSBX      | PC7  |
|               | APORT2XCH9            |            | PC9  |
|               | APORT2XCH11           |            | PC11 |
|               | APORT2XCH17           |            | PF1  |
|               | APORT2XCH19           |            | PF3  |
|               | APORT2XCH21           |            | PF5  |
|               | APORT2XCH23           |            | PF7  |
| ACMP0         | APORT2YCH6            | BUSBY      | PC6  |
|               | APORT2YCH8            |            | PC8  |
|               | APORT2YCH10           |            | PC10 |
|               | APORT2YCH16           |            | PF0  |
|               | APORT2YCH18           |            | PF2  |
|               | APORT2YCH20           |            | PF4  |
|               | APORT2YCH22           |            | PF6  |

| Analog Module | Analog Module Channel | Shared Bus | Pin  |
|---------------|-----------------------|------------|------|
| ACMP0         | APOINT3XCH2           | BUSCX      |      |
|               | APOINT3XCH4           |            |      |
|               | APOINT3XCH6           |            | PD14 |
|               | APOINT3XCH8           |            | PA0  |
|               | APOINT3XCH10          |            | PA2  |
|               | APOINT3XCH12          |            | PA4  |
|               | APOINT3XCH28          |            |      |
|               | APOINT3XCH30          |            |      |
| ACMP0         | APOINT3YCH3           | BUSCY      |      |
|               | APOINT3YCH5           |            | PD13 |
|               | APOINT3YCH7           |            | PD15 |
|               | APOINT3YCH9           |            | PA1  |
|               | APOINT3YCH11          |            | PA3  |
|               | APOINT3YCH13          |            | PA5  |
|               | APOINT3YCH27          |            | PB11 |
|               | APOINT3YCH29          |            | PB13 |
| ACMP0         | APOINT4XCH3           | BUSDX      |      |
|               | APOINT4XCH5           |            | PD13 |
|               | APOINT4XCH7           |            | PD15 |
|               | APOINT4XCH9           |            | PA1  |
|               | APOINT4XCH11          |            | PA3  |
|               | APOINT4XCH13          |            | PA5  |
|               | APOINT4XCH27          |            | PB11 |
|               | APOINT4XCH29          |            | PB13 |
| ACMP0         | APOINT4YCH2           | BUSDY      |      |
|               | APOINT4YCH4           |            |      |
|               | APOINT4YCH6           |            | PD14 |
|               | APOINT4YCH8           |            | PA0  |
|               | APOINT4YCH10          |            | PA2  |
|               | APOINT4YCH12          |            | PA4  |
|               | APOINT4YCH28          |            |      |
|               | APOINT4YCH30          |            |      |

| Analog Module | Analog Module Channel | Shared Bus | Pin  |
|---------------|-----------------------|------------|------|
| ACMP1         | APOINT1XCH6           | BUSAX      | PC6  |
|               | APOINT1XCH8           |            | PC8  |
|               | APOINT1XCH10          |            | PC10 |
|               | APOINT1XCH16          |            | PF0  |
|               | APOINT1XCH18          |            | PF2  |
|               | APOINT1XCH20          |            | PF4  |
|               | APOINT1XCH22          |            | PF6  |
| ACMP1         | APOINT1YCH7           | BUSAY      | PC7  |
|               | APOINT1YCH9           |            | PC9  |
|               | APOINT1YCH11          |            | PC11 |
|               | APOINT1YCH17          |            | PF1  |
|               | APOINT1YCH19          |            | PF3  |
|               | APOINT1YCH21          |            | PF5  |
|               | APOINT1YCH23          |            | PF7  |
| ACMP1         | APOINT2XCH7           | BUSBX      | PC7  |
|               | APOINT2XCH9           |            | PC9  |
|               | APOINT2XCH11          |            | PC11 |
|               | APOINT2XCH17          |            | PF1  |
|               | APOINT2XCH19          |            | PF3  |
|               | APOINT2XCH21          |            | PF5  |
|               | APOINT2XCH23          |            | PF7  |
| ACMP1         | APOINT2YCH6           | BUSBY      | PC6  |
|               | APOINT2YCH8           |            | PC8  |
|               | APOINT2YCH10          |            | PC10 |
|               | APOINT2YCH16          |            | PF0  |
|               | APOINT2YCH18          |            | PF2  |
|               | APOINT2YCH20          |            | PF4  |
|               | APOINT2YCH22          |            | PF6  |
| ACMP1         | APOINT3XCH2           | BUSCX      |      |
|               | APOINT3XCH4           |            |      |
|               | APOINT3XCH6           |            | PD14 |
|               | APOINT3XCH8           |            | PA0  |
|               | APOINT3XCH10          |            | PA2  |
|               | APOINT3XCH12          |            | PA4  |
|               | APOINT3XCH28          |            |      |
|               | APOINT3XCH30          |            |      |

| Analog Module | Analog Module Channel | Shared Bus | Pin  |
|---------------|-----------------------|------------|------|
| ACMP1         | APOINT3YCH3           | BUSCY      |      |
|               | APOINT3YCH5           |            | PD13 |
|               | APOINT3YCH7           |            | PD15 |
|               | APOINT3YCH9           |            | PA1  |
|               | APOINT3YCH11          |            | PA3  |
|               | APOINT3YCH13          |            | PA5  |
|               | APOINT3YCH27          |            | PB11 |
|               | APOINT3YCH29          |            | PB13 |
|               | APOINT3YCH31          |            |      |
| ACMP1         | APOINT4XCH3           | BUSDX      |      |
|               | APOINT4XCH5           |            | PD13 |
|               | APOINT4XCH7           |            | PD15 |
|               | APOINT4XCH9           |            | PA1  |
|               | APOINT4XCH11          |            | PA3  |
|               | APOINT4XCH13          |            | PA5  |
|               | APOINT4XCH27          |            | PB11 |
|               | APOINT4XCH29          |            | PB13 |
|               | APOINT4XCH31          |            |      |
| ACMP1         | APOINT4YCH2           | BUSDY      |      |
|               | APOINT4YCH4           |            |      |
|               | APOINT4YCH6           |            | PD14 |
|               | APOINT4YCH8           |            | PA0  |
|               | APOINT4YCH10          |            | PA2  |
|               | APOINT4YCH12          |            | PA4  |
|               | APOINT4YCH28          |            |      |
|               | APOINT4YCH30          |            |      |
|               |                       |            |      |
| ADC0          | APOINT1XCH6           | BUSAX      | PC6  |
|               | APOINT1XCH8           |            | PC8  |
|               | APOINT1XCH10          |            | PC10 |
|               | APOINT1XCH16          |            | PF0  |
|               | APOINT1XCH18          |            | PF2  |
|               | APOINT1XCH20          |            | PF4  |
|               | APOINT1XCH22          |            | PF6  |



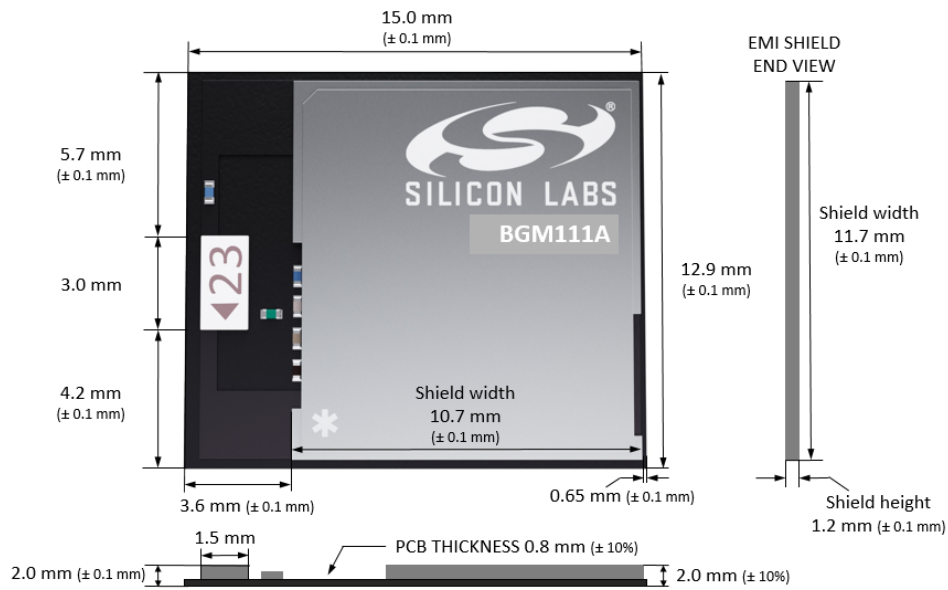
| Analog Module | Analog Module Channel | Shared Bus | Pin  |
|---------------|-----------------------|------------|------|
| ADC0          | APOINT1YCH7           | BUSAY      | PC7  |
|               | APOINT1YCH9           |            | PC9  |
|               | APOINT1YCH11          |            | PC11 |
|               | APOINT1YCH17          |            | PF1  |
|               | APOINT1YCH19          |            | PF3  |
|               | APOINT1YCH21          |            | PF5  |
|               | APOINT1YCH23          |            | PF7  |
| ADC0          | APOINT2XCH7           | BUSBX      | PC7  |
|               | APOINT2XCH9           |            | PC9  |
|               | APOINT2XCH11          |            | PC11 |
|               | APOINT2XCH17          |            | PF1  |
|               | APOINT2XCH19          |            | PF3  |
|               | APOINT2XCH21          |            | PF5  |
|               | APOINT2XCH23          |            | PF7  |
| ADC0          | APOINT2YCH6           | BUSBY      | PC6  |
|               | APOINT2YCH8           |            | PC8  |
|               | APOINT2YCH10          |            | PC10 |
|               | APOINT2YCH16          |            | PF0  |
|               | APOINT2YCH18          |            | PF2  |
|               | APOINT2YCH20          |            | PF4  |
|               | APOINT2YCH22          |            | PF6  |
| ADC0          | APOINT3XCH2           | BUSCX      |      |
|               | APOINT3XCH4           |            |      |
|               | APOINT3XCH6           |            | PD14 |
|               | APOINT3XCH8           |            | PA0  |
|               | APOINT3XCH10          |            | PA2  |
|               | APOINT3XCH12          |            | PA4  |
|               | APOINT3XCH28          |            |      |
|               | APOINT3XCH30          |            |      |

| Analog Module | Analog Module Channel | Shared Bus | Pin  |
|---------------|-----------------------|------------|------|
| ADC0          | APOINT3YCH3           | BUSCY      |      |
|               | APOINT3YCH5           |            | PD13 |
|               | APOINT3YCH7           |            | PD15 |
|               | APOINT3YCH9           |            | PA1  |
|               | APOINT3YCH11          |            | PA3  |
|               | APOINT3YCH13          |            | PA5  |
|               | APOINT3YCH27          |            | PB11 |
|               | APOINT3YCH29          |            | PB13 |
|               | APOINT3YCH31          |            |      |
| ADC0          | APOINT4XCH3           | BUSDX      |      |
|               | APOINT4XCH5           |            | PD13 |
|               | APOINT4XCH7           |            | PD15 |
|               | APOINT4XCH9           |            | PA1  |
|               | APOINT4XCH11          |            | PA3  |
|               | APOINT4XCH13          |            | PA5  |
|               | APOINT4XCH27          |            | PB11 |
|               | APOINT4XCH29          |            | PB13 |
|               | APOINT4XCH31          |            |      |
| ADC0          | APOINT4YCH2           | BUSDY      |      |
|               | APOINT4YCH4           |            |      |
|               | APOINT4YCH6           |            | PD14 |
|               | APOINT4YCH8           |            | PA0  |
|               | APOINT4YCH10          |            | PA2  |
|               | APOINT4YCH12          |            | PA4  |
|               | APOINT4YCH28          |            |      |
|               | APOINT4YCH30          |            |      |
|               |                       |            |      |
| IDAC0         | APOINT1XCH2           | BUSCX      |      |
|               | APOINT1XCH4           |            |      |
|               | APOINT1XCH6           |            | PD14 |
|               | APOINT1XCH8           |            | PA0  |
|               | APOINT1XCH10          |            | PA2  |
|               | APOINT1XCH12          |            | PA4  |
|               | APOINT1XCH28          |            |      |
|               | APOINT1XCH30          |            |      |

| Analog Module | Analog Module Channel | Shared Bus | Pin  |
|---------------|-----------------------|------------|------|
| IDAC0         | APOINT1YCH3           | BUSCY      |      |
|               | APOINT1YCH5           |            | PD13 |
|               | APOINT1YCH7           |            | PD15 |
|               | APOINT1YCH9           |            | PA1  |
|               | APOINT1YCH11          |            | PA3  |
|               | APOINT1YCH13          |            | PA5  |
|               | APOINT1YCH27          |            | PB11 |
|               | APOINT1YCH29          |            | PB13 |
|               | APOINT1YCH31          |            |      |

## 8. Package Specifications

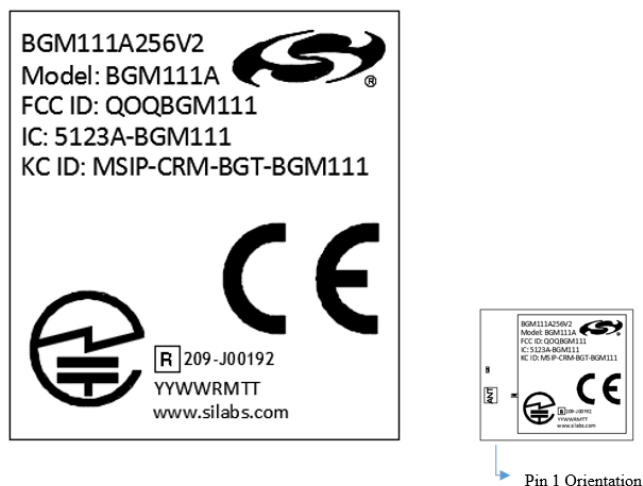
### 8.1 BGM111 Dimensions



**Figure 8.1. BGM111 Package Dimensions**

## 8.2 BGM111 Package Marking

The figure below shows the package markings printed on the module.



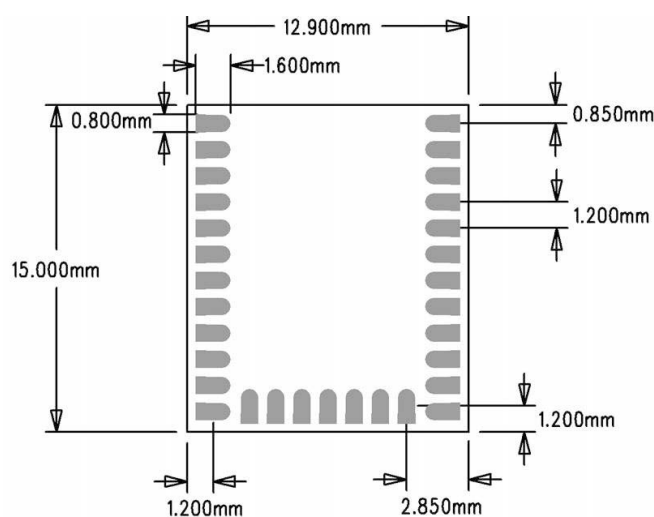
**Table 8.1. Explanations**

| Marking | Explanation                                                 |
|---------|-------------------------------------------------------------|
| YY      | Last 2 digits of manufacturing year<br>• Example: 17 = 2017 |
| WW      | Work week (01-53)                                           |
| R       | Product Revision or FW Revision                             |
| M       | Contract Manufacturer Site assigned by Silicon Labs         |
| TT      | Unique Batch ID assigned by CM (2 characters A-Z)           |

**Figure 8.2. BGM111 Package Marking**

## 8.3 BGM111 Module Dimensions and Footprint

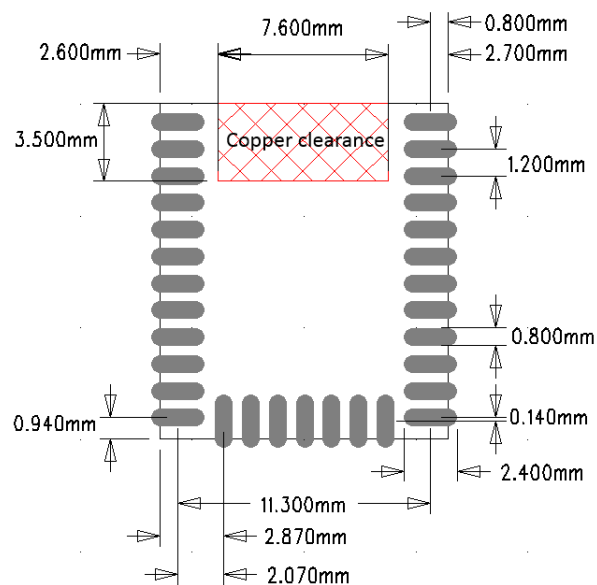
The figure below shows the Module dimensions and footprint.



**Figure 8.3. BGM111 Dimensions and Footprint**

## 8.4 BGM111 Land Pattern

The figure below shows the recommended land pattern.



**Figure 8.4. BGM111 Recommended PCB Land Pattern**

## 9. Tape and Reel Specifications

### 9.1 Tape and Reel Packaging

This section contains information regarding the tape and reel packaging for the BGM111 Blue Gecko Module.

### 9.2 Reel and Tape Specifications

- Reel material: Polystyrene (PS)
- Reel diameter: 13 inches (330 mm)
- Number of modules per reel: 1000 pcs
- Disk deformation, folding whitening and mold imperfections: Not allowed
- Disk set: consists of two 13 inch (330 mm) rotary round disks and one central axis (100 mm)
- Antistatic treatment: Required
- Surface resistivity:  $10^4 - 10^9 \Omega/\text{sq}$ .

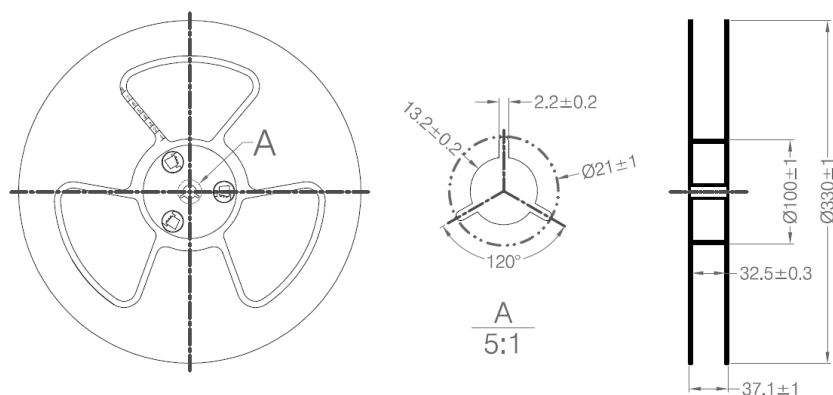


Figure 9.1. Reel Dimensions - Side View

| Symbol | Dimensions [mm] |
|--------|-----------------|
| W0     | $32.5 \pm 0.3$  |
| W1     | $37.1 \pm 1.0$  |

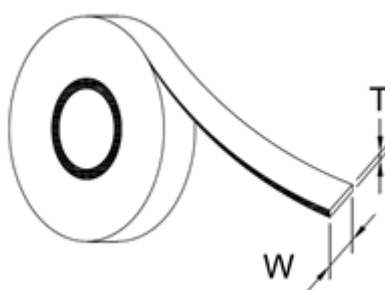


Figure 9.2. Cover Tape Information

| Symbol        | Dimensions [mm] |
|---------------|-----------------|
| Thickness (T) | 0.061           |
| Width (W)     | $25.5 \pm 0.2$  |

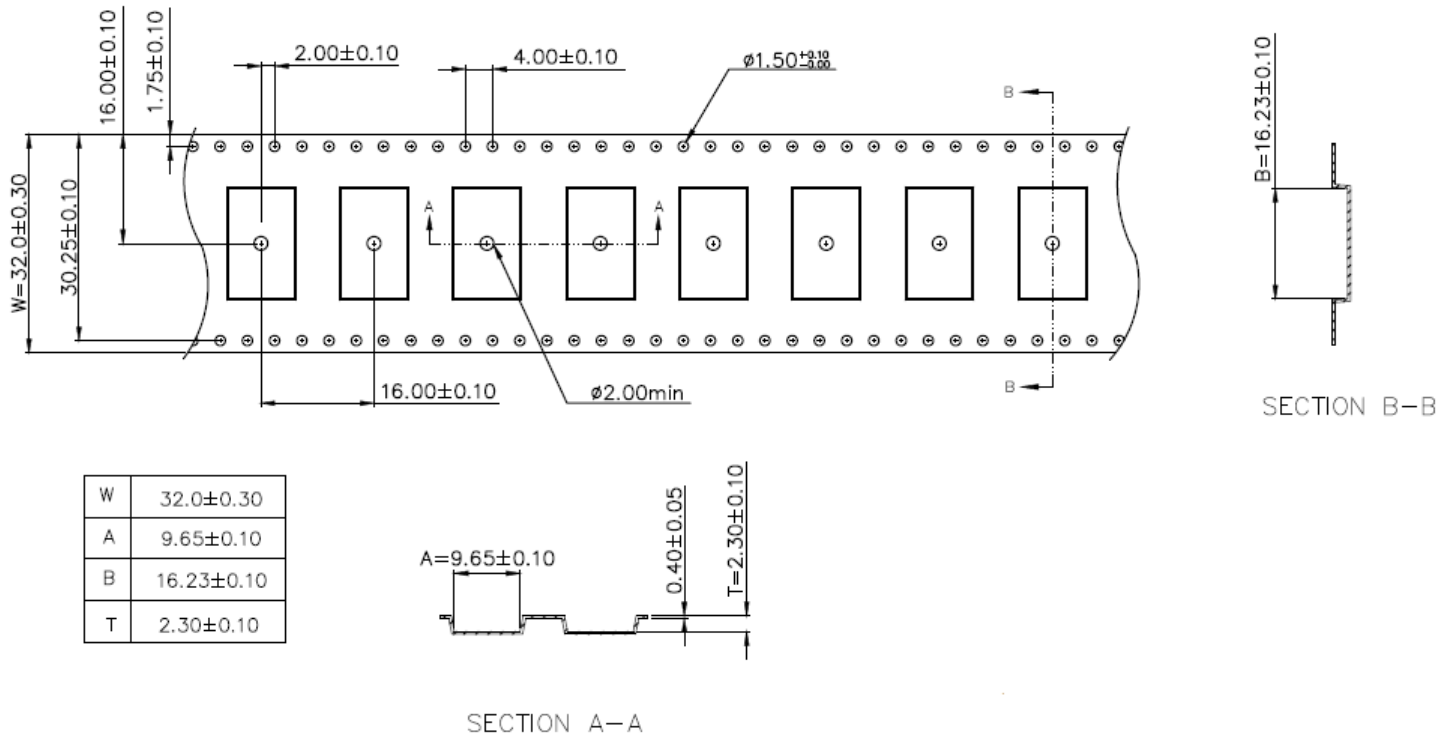


Figure 9.3. Tape information

### 9.3 Orientation and Tape Feed

The user direction of feed, start and end of tape on reel and orientation of the Modules on the tape are shown in the figures below.

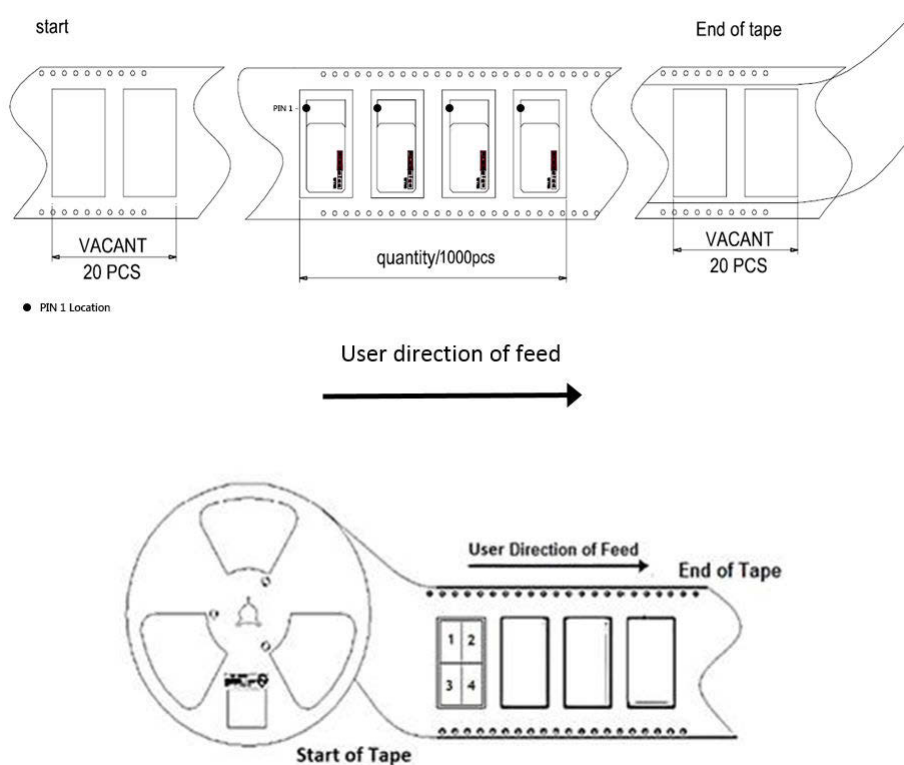


Figure 9.4. Module Orientation and Feed Direction



## 9.4 Tape and Reel Box Dimensions

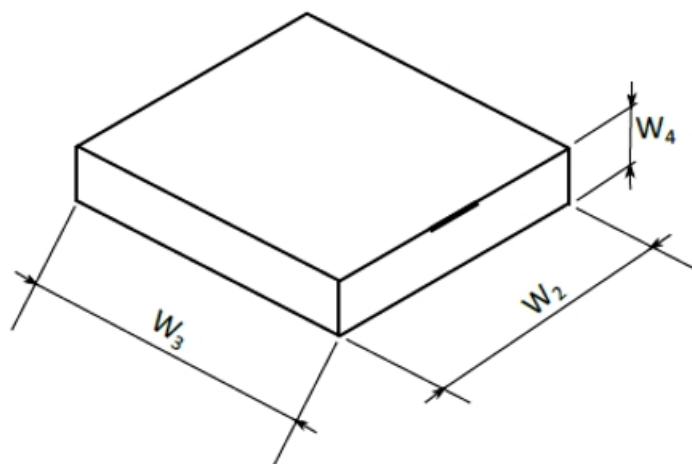


Figure 9.5. Tape and Reel Box Dimensions

| Symbol | Dimensions [mm] |
|--------|-----------------|
| $W_2$  | 368             |
| $W_3$  | 338             |
| $W_4$  | 72              |

## 9.5 Moisture Sensitivity Level

Reels are delivered in packing which conforms to MSL3 (Moisture Sensitivity Level 3) requirements.

## 10. Soldering Recommendations

### 10.1 Soldering Recommendations

This section describes the soldering recommendations regarding BGM111 Module.

BGM111 is compatible with industrial standard reflow profile for Pb-free solders. The reflow profile used is dependent on the thermal mass of the entire populated PCB, heat transfer efficiency of the oven, and particular type of solder paste used.

- Refer to technical documentations of particular solder paste for profile configurations.
- Avoid using more than two reflow cycles.
- Aperture size of the stencil should be 1:1 with the pad size.
- A no-clean, type-3 solder paste is recommended.
- For further recommendation, please refer to the JEDEC/IPC J-STD-020, IPC-SM-782 and IPC 7351 guidelines.

## 11. Certifications

### 11.1 Bluetooth

The BGM111 is Bluetooth qualified.

The Bluetooth declaration ID is D030732.

### 11.2 CE

The BGM111 module is in conformity with the essential requirements and other relevant requirements of the Radio Equipment Directive (RED). Please note that every application using the BGM111 will need to perform the radio EMC tests on the end product according to EN 301 489-17.

Separate RF testing is not required provided that the customer follows the module manufacturer's recommendations and instructions and does not make modifications e.g. to the provided antenna solutions or requirements.

A formal DoC is available via [www.silabs.com](http://www.silabs.com).

### 11.3 FCC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesirable operation.

Any changes or modifications not expressly approved by Silicon Labs could void the user's authority to operate the equipment.

#### FCC RF Radiation Exposure Statement:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End users must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter meets both portable and mobile limits as demonstrated in the RF Exposure Analysis. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product procedures. As long as the condition above is met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

#### OEM Responsibilities to comply with FCC Regulations

The BGM111 Module has been certified for integration into products only by OEM integrators under the following condition:

- The antenna(s) must be installed such that a minimum separation distance of 0 mm is maintained between the radiator (antenna) and all persons at all times.
- The transmitter module must not be co-located or operating in conjunction with any other antenna or transmitter except in accordance with FCC multi-transmitter product procedures.

As long as the conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

**Note:** In the event that this condition cannot be met (for certain configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

#### End Product Labeling

The BGM111 Module is labeled with its own FCC ID. If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labeled in a visible area with the following:

**"Contains Transmitter Module FCC ID: QOQBGM111"**

or

**"Contains FCC ID: QOQBGM111"**

The OEM integrator must not provide information to the end user regarding how to install or remove this RF module or change RF related parameters in the user manual of the end product.

## 11.4 IC

### IC (English)

This radio transmitter has been approved by Industry Canada to operate with the embedded chip antenna. Other antenna types are strictly prohibited for use with this device.

This device complies with Industry Canada's license-exempt RSS standards. Operation is subject to the following two conditions:

1. This device may not cause interference; and
2. This device must accept any interference, including interference that may cause undesired operation of the device.

### RF Exposure Statement

Exception from routine SAR evaluation limits are given in RSS-102 Issue 5. BGM111 meets the given requirements when the minimum separation distance to human body 15 mm. RF exposure or SAR evaluation is not required when the separation distance is 15 mm or more. If the separation distance is less than 15 mm the OEM integrator is responsible for evaluating the SAR.

### OEM Responsibilities to comply with IC Regulations

The BGM111 Module has been certified for integration into products only by OEM integrators under the following conditions:

- The antenna(s) must be installed such that a minimum separation distance of 15 mm is maintained between the radiator (antenna) and all persons at all times.
- The transmitter module must not be co-located or operating in conjunction with any other antenna or transmitter.

As long as the two conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

**Note:** In the event that these conditions cannot be met (for certain configurations or co-location with another transmitter), then the IC authorization is no longer considered valid and the IC ID cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate IC authorization.

### End Product Labeling

The BGM111 module is labeled with its own IC ID. If the IC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labeled in a visible area with the following:

**"Contains Transmitter Module IC: 5123A-BGM111"**

or

**"Contains IC: 5123A-BGM111"**

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module or change RF related parameters in the user manual of the end product.

### IC (Français)

Cet émetteur radio (IC : 5123A-BGM111) a reçu l'approbation d'Industrie Canada pour une exploitation avec l'antenne puce incorporée. Il est strictement interdit d'utiliser d'autres types d'antenne avec cet appareil.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

1. L'appareil ne doit pas produire de brouillage; et
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible de provoquer un fonctionnement non désiré de l'appareil.

### Déclaration relative à l'exposition aux radiofréquences (RF)

Les limites applicables à l'exemption de l'évaluation courante du DAS sont énoncées dans le CNR 102, 5e édition. Le module Bluetooth BGM111 répond aux exigences données quand la distance de séparation minimum par rapport au corps humain est de 15 mm. L'évaluation de l'exposition aux RF ou du DAS n'est pas requise quand la distance de séparation est de 15 mm ou plus. Si la distance de séparation est inférieure à 15 mm, il incombe à l'intégrateur FEO d'évaluer le DAS.

### Responsabilités du FEO ayant trait à la conformité avec les règlements IC

Le Module Bluetooth BGM111 a été certifié pour une intégration dans des produits uniquement par les intégrateurs FEO dans les conditions suivantes:

- La ou les antennes doivent être installées de telle façon qu'une distance de séparation minimum de 15 mm soit maintenue entre le radiateur (antenne) et toute personne à tout moment.
- Le module émetteur ne doit pas être installé au même endroit ou fonctionner conjointement avec toute autre antenne ou émetteur.

Dès lors que les deux conditions ci-dessus sont respectées, aucun test supplémentaire de l'émetteur n'est obligatoire. Cependant, il incombe toujours à l'intégrateur FEO de tester la conformité de son produit final vis-à-vis de toute exigence supplémentaire requise avec ce module installé (par exemple, émissions de dispositifs numériques, exigences relatives aux matériels périphériques PC, etc).

**Note:** S'il s'avère que ces conditions ne peuvent être respectées (pour certaines configurations ou la colocation avec un autre émetteur), alors l'autorisation IC n'est plus considérée comme valide et l'identifiant IC ne peut plus être employé sur le produit final. Dans ces circonstances, l'intégrateur FEO aura la responsabilité de réévaluer le produit final (y compris l'émetteur) et d'obtenir une autorisation IC distincte.

### Étiquetage du produit final

L'étiquette du Module BGM111 porte son propre identifiant IC. Si l'identifiant IC n'est pas visible quand le module est installé à l'intérieur d'un autre appareil, alors l'extérieur de l'appareil dans lequel le module est installé doit aussi porter une étiquette faisant référence au module qu'il contient. Dans ce cas, une étiquette comportant les informations suivantes doit être apposée sur une partie visible du produit final.

**"Contient le module émetteur IC: 5123A-BGM111"**

ou

**"Contient IC : 5123A-BGM111"**

L'intégrateur FEO doit être conscient de ne pas fournir d'informations à l'utilisateur final permettant d'installer ou de retirer ce module RF ou de changer les paramètres liés aux RF dans le mode d'emploi du produit final.

## 11.5 Japan

The BGM111 is certified in Japan with certification number 209-J00192

Since September 1, 2014 it is allowed (and highly recommended) that a manufacturer who integrates a radio module in their host equipment can place the certification mark and certification number (the same marking/number as depicted on the label of the radio module) on the outside of the host equipment. The certification mark and certification number must be placed close to the text in the Japanese language which is provided below. This change in the Radio Law has been made in order to enable users of the combination of host and radio module to verify if they are actually using a radio device which is approved for use in Japan.

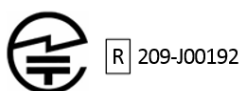
当該機器には電波法に基づく、技術基準適合証明等を受けた特定無線設備を装着している。

**Figure 11.1. Certification Text to be Placed on the Outside Surface of the Host Equipment**

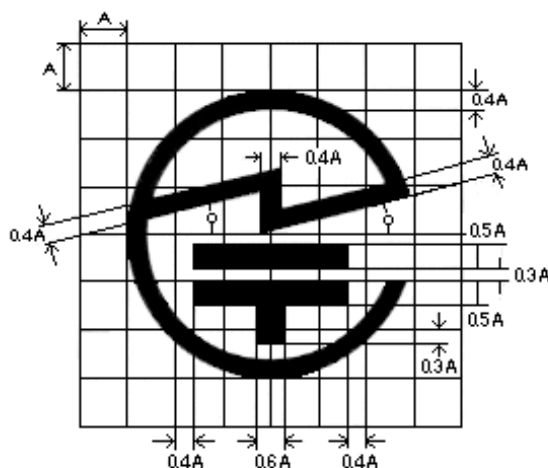
### Translation of the text in the above figure:

*"This equipment contains specified radio equipment that has been certified to the Technical Regulation Conformity Certification under the Radio Law."*

The "Giteki" marking shown in the figure below must be affixed to an easily noticeable section of the specified radio equipment. Note that additional information may be required if the device is also subject to a telecom approval.



**Figure 11.2. The Certification Mark to be Placed on the Outside Surface of the Host Equipment**



**Figure 11.3. The Certification Mark ("Giteki") Dimensions**

The diameter of the mark must be 5 mm or greater. If the volume of the certified equipment is less than 100 cc, the diameter of the mark may be 3 mm or greater.

## 11.6 KC (South-Korea)

BGM111 Blue Gecko *Bluetooth*® Module has certification in South-Korea.

Certification number: MSIP-CRM-BGT-BGM111

## 12. Revision History

### 12.1 Revision 1.4

- Figure 3.2 now included and updated.
- Table 4.2
  - VDD Operating supply voltage line in table and DCDC in regulation minimum value: footnote 3 added defining that the minimum voltage of 2.4 V for DCDC is specified at 100 mA.
- Table 4.11 output power variation vs supply at POUT<sub>MAX</sub> line and column Test Condition entry change to "With DCDC in bypass mode" and typical value changed from 3.8 to 2.3. The second sub-row removed.
- Typical Connection Diagrams
  - Fig 5.1 / Fig 5.2 / Fig 5.3: schematics redrawn and now include the mini simplicity connector.
- Layout Guidelines
  - Figure 6.1 redrawn to include both BGM111A and BGM111E information.
  - Min 17 mm changed to Optimally 17 mm
- Package Specifications
  - Figure 8.1 package dimensions: some tolerance values updated.
  - Figure 8.2 package Markings: Changed image to show BGM111A with YYWWRTT now updated to correct format.
  - Figure 8.2 explanation of the YYWWMTT code included as a table.
  - Figure 8.3 BGM111 dimensions and footpring refreshed.
  - Figure 8.4 BGM111 recommended application PCB landpattern updated.
- Certifications
  - Comment concerning RF testing added to CE section.
  - Section 11.2 edited. R&TTE changed to RED.
  - Japan certification mark info added.
  - Giteki info added.

### 12.2 Revision 1.3

- Alternate functionality overview table - the following pins missing were added into table:
  - PA2 / PA3 / PA4 / PA5
  - PC6 / PC7 / PC8 / PC9
  - PF4 / PF5 / PF6 / PF7
- Alternate functionality overview table - LEU0\_TX row added.
- Alternate functionality overview table - layout within cells in the table modified.
- Feature list updated
- Package marking updated

### 12.3 Revision 1.2

- Updated figure 5.1 where SWDIO and SWCLK where reversed.
- OPN table updated

### 12.4 Revision 1.1

- Added soldering recommendations
- Updated Tape and Reel specifications

### 12.5 Revision 1.0

- Update to 1.0 with characterization data for Full Production

## 12.6 Revision 0.991

- Power block image updated
- Connection diagrams clarified concerning reset signal
- RESET pin renamed to RESETn
- LFX TAL\_P function removed from Table 7.3
- Table 4.1 Absolute Maximum Ratings updated
- Table 4.2 General Operating Conditions updated
- Section 4.1.3 DC-DC Converter updated
- Table 4.11 updated
- Table 4.13 updated
- Sections 4.1.6, 4.1.11, 4.1.13 and 4.1.14 edited to contain a short clarification of the VDD in relation to other voltages inside the Module
- Table 4.15 updated
- Feature list updated

## 12.7 Revision 0.99

- Effect of antenna GND plane image added
- 2D radiation plot images added
- Pinout diagram edited (RESET changed to RESETn)

## 12.8 Revision 0.98

- LFXO and HFXO tolerances added
- Bluetooth Smart changed to Bluetooth
- Design guidelines updated
- Electrical characteristics updated

## 12.9 Revision 0.97

- Electrical characteristics updated
- Certification information updated
- Packaging and Tape and Reel material updated

## 12.10 Revision 0.96

- Ordering information updated
- FCC and IC IDs updated

## 12.11 Revision 0.95

- Certification status updated
- Current consumption figures added
- New block diagram added

## 12.12 Revision 0.94

- Disclaimer section added to certifications chapter
- TBD values updated

## 12.13 Revision 0.93

- Added a schematics to show connection principle with external host

## 12.14 Revision 0.92

- Corrected supply voltage range



#### **12.15 Revision 0.91**

- Style changes

#### **12.16 Revision 0.90**

- Preliminary data sheet

Silicon Labs

# Simplicity Studio™4



## Simplicity Studio

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