ATBTLC1000-MR110CA

ATBTLC1000-MR110CA Ultra-Low Power BLE Module

Introduction

The ATBTLC1000-MR110CA is an ultra-low power Bluetooth® Low Energy (BLE) module with Integrated Transceiver, Modem, MAC, PA, TR Switch, and Power Management Unit (PMU). It can be used as a Bluetooth Low Energy link controller or data pump with external host MCU.

The qualified Bluetooth SIG protocol stack is stored in dedicated ROM. The firmware includes L2CAP service layer protocols, Security Manager, Attribute protocol (ATT), Generic Attribute Profile (GATT), and the Generic Access Profile (GAP). Additionally, application profiles such as Proximity, Thermometer, Heart Rate, Blood pressure and many other SIG-defined profiles.

The ATBTLC1000-MR110CA is a fully-certified module that contains the ATBTLC1000A-MU (QFN), ceramic high-gain chip antenna, 26 MHz crystal, and PMU circuit. The module needs an external 32 kHz clock or crystal to power-up.

Microchip BluSDK offers a comprehensive set of tools including reference applications for several Bluetooth SIG defined profiles and a custom profile. The BluSDK helps the user to quickly evaluate, design and develop BLE products with ATBTLC1000-MR110CA.

The ATBTLC1000-MR110CA module has passed the Bluetooth SIG certification for interoperability with the Bluetooth Low Energy 5.0 specification.

Features

- Complies with Bluetooth v5.0, FCC CFR47 Part 15, ARIB STD-T66, and TELEC
- Bluetooth Certification:
  - Bluetooth SIG QDID: 117593 https://launchstudio.bluetooth.com/listings/search
- 2.4 GHz Transceiver and Modem:
  - -95 dBm/-93 dBm programmable receiver sensitivity
  - -55 dBm to +3.5 dBm programmable Tx output power
  - Integrated T/R switch
  - Single wire antenna connection
- Processor Features:
  - ARM® Cortex®M0 32-bit processor
  - Single Wire Debug (SWD) interface
  - Four-channel Direct Memory Access (DMA) controller
  - Brown-out Detector and Power-on Reset (POR)
  - Watchdog timer
- Memory:
  - 128 KB embedded RAM(1)

  - 128 KB embedded ROM
- Hardware Security Accelerators:
  - Advanced Encryption Standard (AES) - 128
  - Secure Hash Algorithm (SHA) - 256
- Peripherals:
  - 12 digital and 1 wake-up GPIO(1)
  - Two Mixed signal GPIOs(1)
  - Programmable 96 kOhm pull up or pull-down resistor for each GPIO(1)
  - Retention capable GPIO pads(1)
  - One Serial Peripheral Interface (SPI) Master/Slave(1)
  - Two Inter-Integrated Circuit (I^2C) Master/Slave(1)
  - Two UART(1)
  - One SPI Flash(1)
  - Three-axis quadrature decoder(1)
  - Four Pulse Width Modulation (PWM) channels, three General Purpose Timers, and one Wake-up Timer(1)
  - 2-channel 11-bit Analog-to-Digital Converter (ADC)(1)
- Clock:
  - Integrated 26 MHz oscillator
  - 26 MHz crystal oscillator (XO)
  - Fully integrated sleep oscillator
  - 32 kHz Real Time Clock crystal oscillator (RTC XO)
- Ultra-Low Power
  - 2.01 µA sleep current
  - 3.91 mA peak TX current(2)
  - 5.24 mA peak RX current
  - 15.1 µA average advertisement current(3)
- Integrated Power Management:
  - 1.8V to 4.3V input range for PMU
  - 1.62V to 4.3V input range for I/O
  - Fully integrated Buck DC/DC converter
- Temperature Range: -40°C to 85°C
- Package:
  - 25-pin module package 12.700 mm x 20.152 mm

Note:

1. Usage of this feature is not supported by the BluSDK. The datasheet will be updated once the support for this feature is added in BluSDK.
2. TX output power - 0 dBm
3. Advertisement channels - 3; Advertising interval - 1 second; Advertising event type - Connectable undirected; Advertisement data payload size - 31 octets.

Table of Contents

1. Ordering Information

The following table provides the ATBTLC1000-MR110CA ordering information.

Table 1-1. Ordering Details

Model No.	Ordering Code	Package	Description
ATBTLC1000-MR110CA	ATBTLC1000-MR110CA	12.7 mm x 20.15 mm	Chip antenna

2. Package Information

The following table provides the ATBTLC1000-MR110CA package information.

Table 2-1. ATBTLC1000-MR110CA Package Information

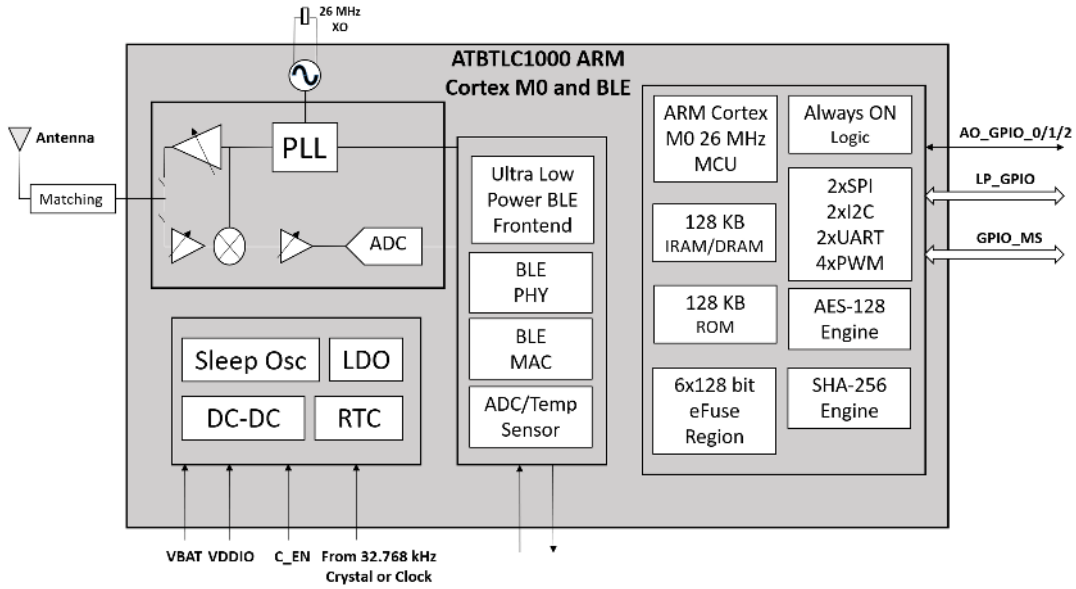
Parameter	Value	Units	Tolerance
Package size	12.700 x 20.152	mm	-
Pad count	25	-	-
Total thickness	2.0874	mm	±0.078
Tolerance (maximum pad pitch)	0.9002		-
Pad width	0.600		-
Exposed paddle pad size	2.7 x 2.7		-

Note: For details on Package drawing, refer to 9. ATBTLC1000-MR110CA Module Outline Drawing.

3. Block Diagram

The following figure illustrates the block diagram of the ATBTLC1000-MR110CA module.

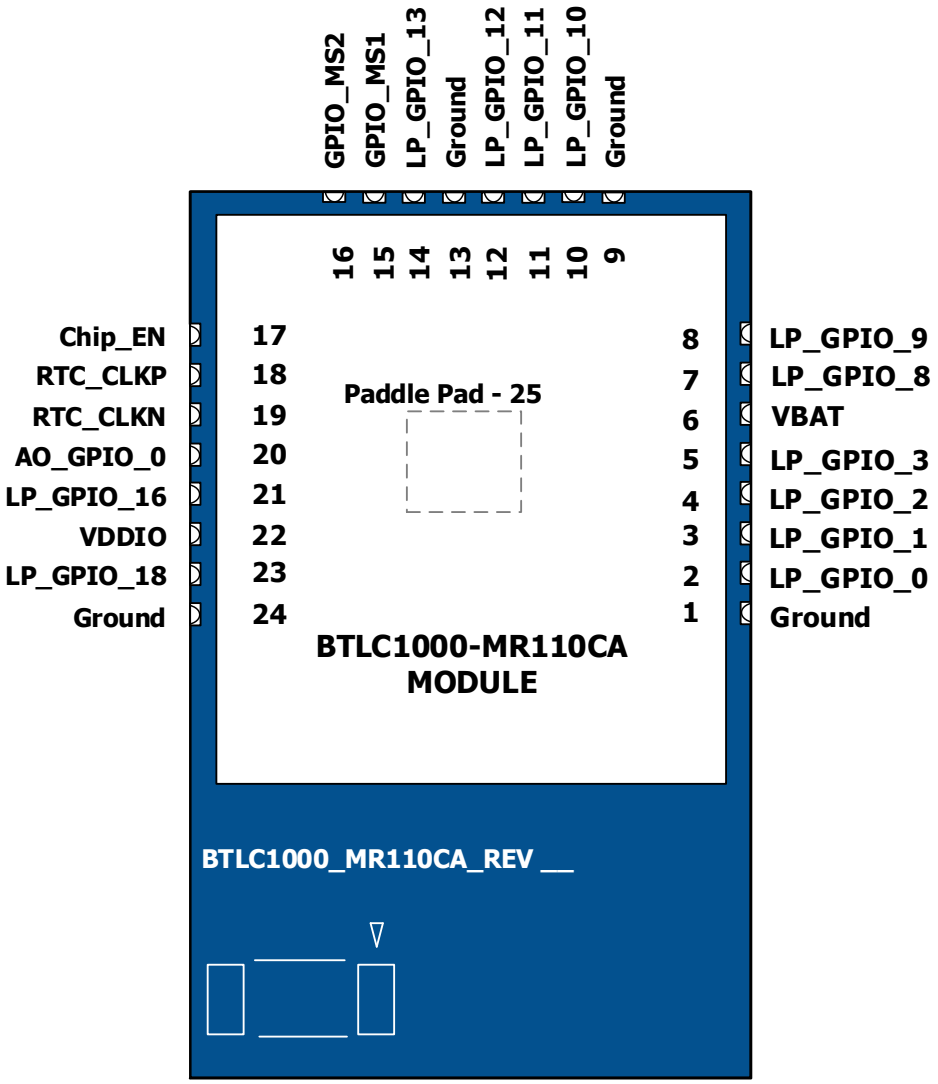
Figure 3-1. Block Diagram



4. Pinout Information

The following figure illustrates the top view and pin numbering of the module.

Figure 4-1. ATBTLC1000 Pin Description



4.1 Pin Description

The following table lists the pin assignments for the ATBTLC1000-MR110CA module.

Table 4-1. ATBTLC1000-MR110CA Pin Description

ATBTLC1000-MR110CA Pin No.	Pin Name	Pin Type	Description/Default Function
1	Ground	Power	Ground Pin. Connect to PCB ground
2	LP_GPIO_0	Digital I/O	SWD clock

.....continued

ATBTLC1000-MR110CA Pin No.	Pin Name	Pin Type	Description/Default Function
3	LP_GPIO_1	Digital I/O	SWDIO
4	LP_GPIO_2	Digital I/O	UART RXD Default function (6-wire mode): UART1_RXD Alternate (4-wire mode): UART1_RXD
5	LP_GPIO_3	Digital I/O	UART_TXD Default function (6-wire mode): UART1_TXD Alternate (4-wire mode): UART1_TXD
6	VBAT	Power	Power supply pin for the DC/DC convertor
7	LP_GPIO_8(1)	Digital I/O	UART_CTS Default function (6-wire mode): GPIO with Programmable Pull Up/Down Alternate (4-wire mode): UART1_CTS
8	LP_GPIO_9(1)	Digital I/O	UART_RTS Default function (6-wire mode): GPIO with Programmable Pull Up/Down Alternate (4-wire mode): UART1_RTS
9	GND	Ground	-
10	LP_GPIO_10	Digital I/O	SPI SCK/SPI Flash SCK Default function (6-wire mode): UART2_RTS Alternate (4-wire mode): GPIO with Programmable Pull Up/Down
11	LP_GPIO_11	Digital I/O	SPI MOSI/SPI Flash TXD Default function (6-wire mode): UART2_CTS Alternate (4-wire mode): GPIO with Programmable Pull Up/Down
12	LP_GPIO_12	Digital I/O	SPI SSN/SPI Flash SSN Default function (6-wire mode): UART2_TXD Alternate (4-wire mode): GPIO with Programmable Pull Up/Down
13	GND	Ground	-

.....continued

ATBTLC1000-MR110CA Pin No.	Pin Name	Pin Type	Description/Default Function
14	LP_GPIO_13	Digital I/O	SPI MISO/SPI Flash RXD Default function (6-wire mode): UART2_RXD Alternate (4-wire mode): GPIO with Programmable Pull Up/Down
15	GPIO_MS1	Mixed Signal I/O	GPIO with Programmable Pull Up/ Down. Default function in BluSDK: Host wake up[2]
16	GPIO_MS2	Mixed Signal I/O	GPIO with Programmable Pull Up/Down
17	Chip_EN	Digital Input	Can be used to control the state of PMU. High-level enables the module; low-level places module in Power-Down mode. Connect to a host output that defaults low at power-up. If the host output is tri-stated, add a 1 MOhm pull-down resistor to ensure a low level at power-up
18	RTC_CLKP	Analog	Crystal pin or External clock supply, see 7.2 32.768 kHz RTC Crystal Oscillator (RTC XO)
19	RTC_CLKN	Analog	Crystal pin, see 7.2 32.768 kHz RTC Crystal Oscillator (RTC XO)
20	AO_GPIO_0	Always On Digital I/O, Programmable Pull Up/Down	Can be used to wake up the device from Ultra_Low_Power mode by the host MCU
21	LP_GPIO_16	Digital I/O	GPIO with Programmable Pull Up/Down
22	VDDIO	Power supply	Power supply pin for the I/O pins. Can be less than or equal to voltage supplied at VBAT
23	LP_GPIO_18	Digital I/O	GPIO with Programmable Pull Up/Down
24	GND	Ground	-
25	Paddle	Ground	Exposed paddle must be soldered to system ground

Note:

1. These GPIO pads are high-drive pads.
2. For more details, see section 6. Host Microcontroller Interface.

5. Device States

This section provides a description of and information about controlling the device states.

5.1 Description of Device States

The ATBTLC1000-MR110CA has multiple device states, depending on the state of the ARM processor and BLE subsystem.

If the BLE subsystem is active, the ARM must be powered on.

- BLE_ON_Transmit – Device actively transmits a BLE signal (irrespective of whether ARM processor is active or not)
- BLE_ON_Receive – Device actively receives a BLE signal (irrespective of whether ARM processor is active or not)
- Ultra_Low_Power – BLE subsystem and ARM processor are powered down (with or without RAM retention)
- Power_Down – Device core supply is powered off

5.2 Controlling the Device States

The following pins are used to switch between the main device states:

- CHIP_EN – used to enable PMU
- VDDIO – I/O supply voltage from external supply
- AO_GPIO_0 - used to control the device to enter/exit Ultra_Low_Power mode

In Power_Down state, VDDIO must be ON and CHIP_EN must be set low (at GND level). To exit from the Power_Down state, CHIP_EN must change between logic low and logic high (VDDIO voltage level). Once the device is out of the Power_Down state, all other state transitions are controlled by software. When VDDIO is OFF and CHIP_EN is low, the chip is powered OFF with no leakage.

When power is not supplied to the device (DC/DC converter output and VDDIO are OFF, at ground potential), a voltage cannot be applied to the ATBTLC1000-MR110CA pins because each pin contains an ESD diode from the pin to supply. This diode turns ON when a voltage higher than one diode-drop is supplied to the pin.

If a voltage must be applied to the signal pads while the chip is in a low-power state, the VDDIO supply must be ON, so the Power_Down state is used. Similarly, to prevent the pin-to-ground diode from turning on, do not apply a voltage that is more than one diode-drop below the ground to any pin.

The AO_GPIO_0 pin is used to control the device to enter and exit the Ultra_Low_Power mode. When AO_GPIO_0 is maintained in Logic High state, the device does not enter the Ultra_Low_Power mode. When AO_GPIO_0 is maintained in Logic Low state, the device enters the Ultra_Low_Power mode when there are no BLE events to handle.

6. Host Microcontroller Interface

This section describes the interface of the ATBTLC1000-MR110CA with the host MCU.

The host interface pins depend on the mode of the device. The ATBTLC1000-MR110CA can be interfaced with host MCU in either of the two modes:

- 6-wire mode (default)
- 4-wire mode

To configure the device to function in the 4-wire mode, program the bit 28 of NVM eFuse Bank 5 Block 3. The following figures describe the required hardware interface between host MCU and the ATBTLC1000-MR110CA in both the 6-wire mode and 4-wire mode. The interface requires two additional GPIOs and one interrupt pin from the host MCU.

Figure 6-1. Host Microcontroller to ATBTLC1000-MR110CA Interface - 4-wire Mode

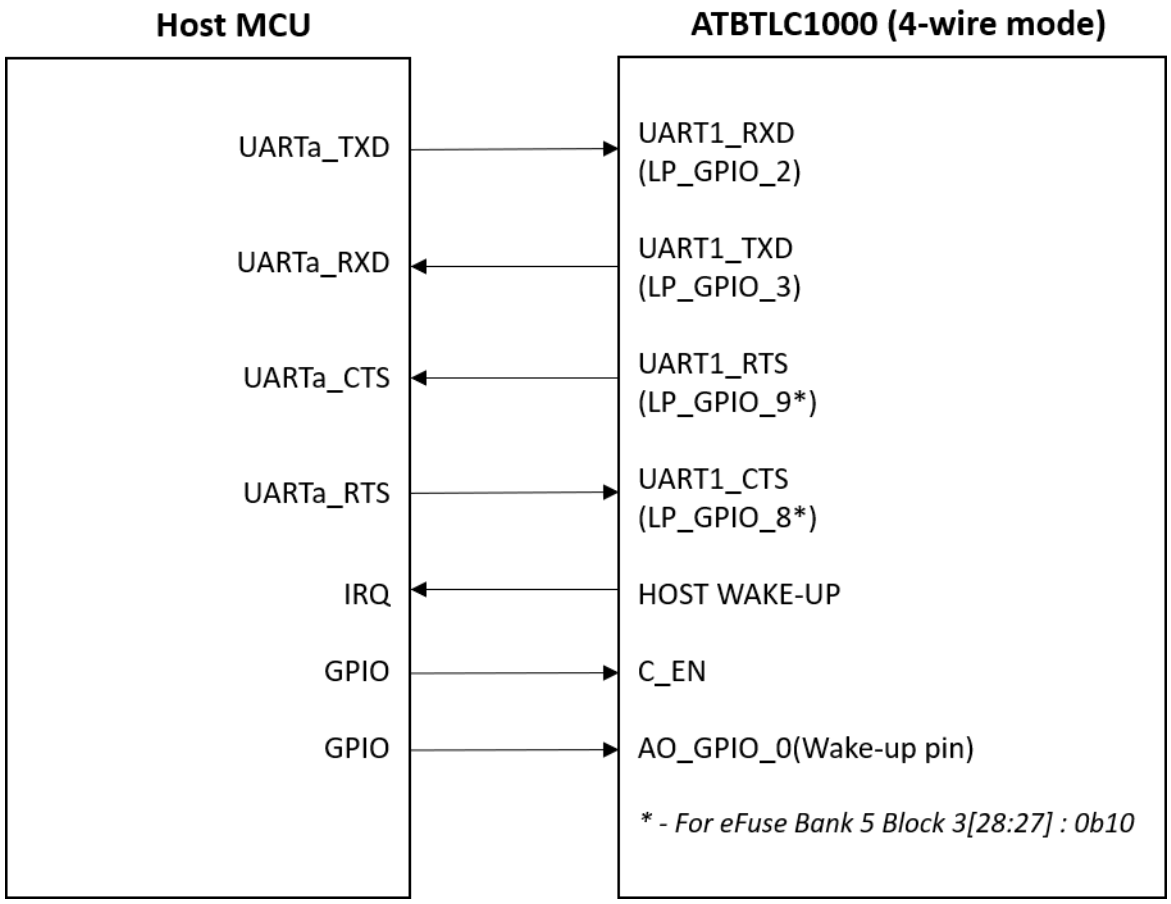
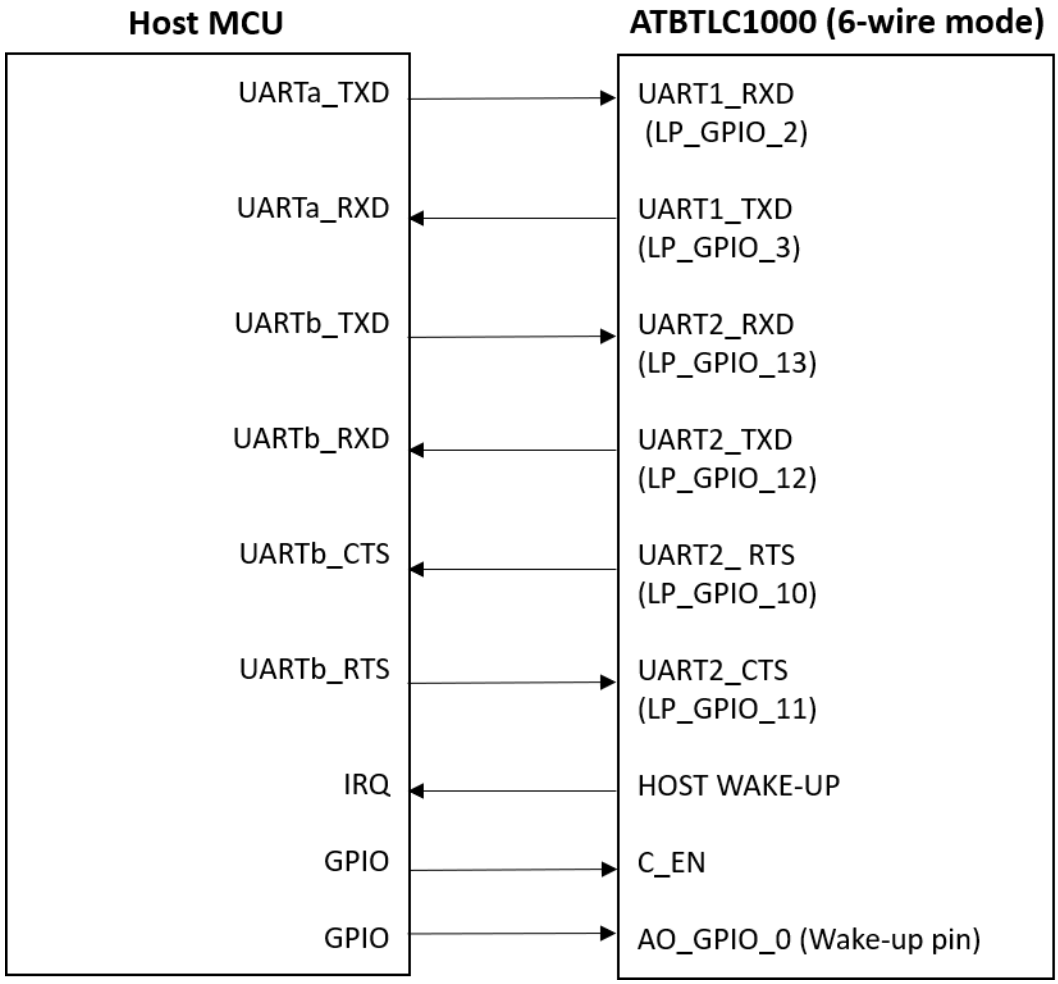


Figure 6-2. Host Microcontroller to ATBTLC1000-MR110CA Interface - 6-wire Mode



The host wake-up pin from ATBTLC1000-MR110CA can be connected to any interrupt pin of the host MCU. The host MCU can monitor this pin level and decide to wake up based on events from the ATBTLC1000-MR110CA.

The host wake-up pin will be held in logic high ('1') by default and at conditions where there is no pending event data in the ATBTLC1000-MR110CA. The host wake-up pin will be held in logic low ('0') when there is event data available from the ATBTLC1000-MR110CA and the pin will be held in this state until all event data is sent out from the ATBTLC1000-MR110CA. By default in BluSDK, GPIO_MS1 is used as the host wake-up pin. Refer to release notes and API user manual documents available in the BluSDK release package for more details on available options to reconfigure the host wake-up pin from the ATBTLC1000-MR110CA.

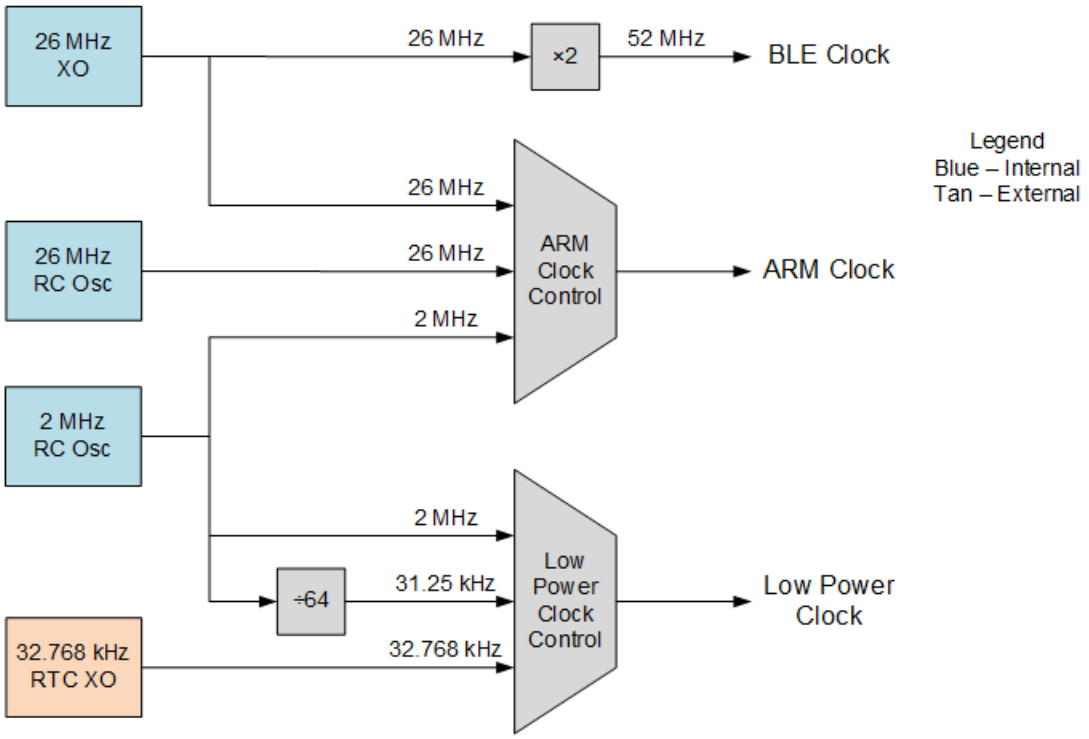
The UART configuration to be used are as follows:

- Baud rate: configurable in the BluSDK during initialization. Refer to release notes and API user manual documents available in the ATBTLC1000-MR110CA BluSDK Release Package, for more details
- Parity: None
- Stop bits: 1
- Data size: 8 bits

7. Clocking

The following figure provides an overview of the clock tree and clock management blocks.

Figure 7-1. Clock Architecture



The BLE Clock is used to drive the BLE subsystem. The ARM clock is used to drive the Cortex-M0 MCU and its interfaces (UART, SPI, and I^2C). The recommended MCU clock speed is 26 MHz. The Low Power Clock is used to drive all the low-power applications like the BLE sleep timer, always-on power sequencer, always-on timer, and others.

The 26 MHz Crystal Oscillator (XO) is used for the BLE operations or in an event. A very accurate clock is required for the ARM subsystem operations.

The 26 MHz integrated RC oscillator is used for most of the general purpose operations on the MCU and its peripherals. In the cases, when the BLE subsystem is not used, the RC oscillator can be used for lower power consumption. The frequency variation of this RC oscillator is up to ±40% over process, voltage, and temperature.

The frequency variation of 2 MHz RC oscillator is up to ±50% over process, voltage, and temperature.

The 32.768 kHz RTC Crystal Oscillator (RTC XO) is used for BLE operations as it reduces power consumption by providing the best timing for wake-up precision, allowing circuits to be in low-power Sleep mode for as long as possible until they need to wake up and connect during the BLE connection event.

7.1 26 MHz Crystal Oscillator (XO)

A 26 MHz crystal oscillator is integrated into the ATBTLC1000-MR110CA to provide the precision clock for the BLE operations.

7.2 32.768 kHz RTC Crystal Oscillator (RTC XO)

7.2.1 General Information

The ATBTLC1000-MR110CA contains a 32.768 kHz RTC oscillator that is used for Bluetooth Low Energy activities involving connection events. To be compliant with the Bluetooth Low Energy specifications for connection events, the frequency accuracy of this clock has to be within ±500 ppm. Because of the high accuracy of the 32.768 kHz crystal oscillator clock, the power consumption can be minimized by leaving radio circuits in Low-Power Sleep mode for as long as possible, until they need to wake up for the next connection timed event.

The block diagram in Figure(a) illustrates how the internal low frequency Crystal Oscillator (XO) is connected to the external crystal.

The RTC XO contains:

- Programmable internal capacitance with a maximum of 15 pF on each terminal
- RTC_CLK_P
- RTC_CLK_N

When bypassing the crystal oscillator with an external signal, the user can program down the internal capacitance to its minimum value (~1 pF) for easier driving capability. The driving signal is applied to the RTC_CLK_P terminal, as illustrated in Figure (b).

The need for external bypass capacitors depends on the chosen crystal characteristics. Typically, the crystal must be chosen with a load capacitance of 7 pF to minimize the oscillator current. Refer to the data sheet of the preferred crystal and take into account the on-chip capacitance.

Alternatively, if an external 32.768 kHz clock is available, it can be used to drive the RTC_CLK_P pin, instead of using a crystal. The XO contains 6 pF internal capacitance on the RTC_CLK_P pin. To bypass the crystal oscillator, an external signal capable of driving 6 pF can be applied to the RTC_CLK_P terminal, as illustrated in Figure (b). RTC_CLK_N must be left unconnected when driving an external source into RTC_CLK_P. Refer to the Table 7-2 for the specification of the external clock to be supplied at RTC_CLK_P.

Figure 7-2. Connections to RTC XO

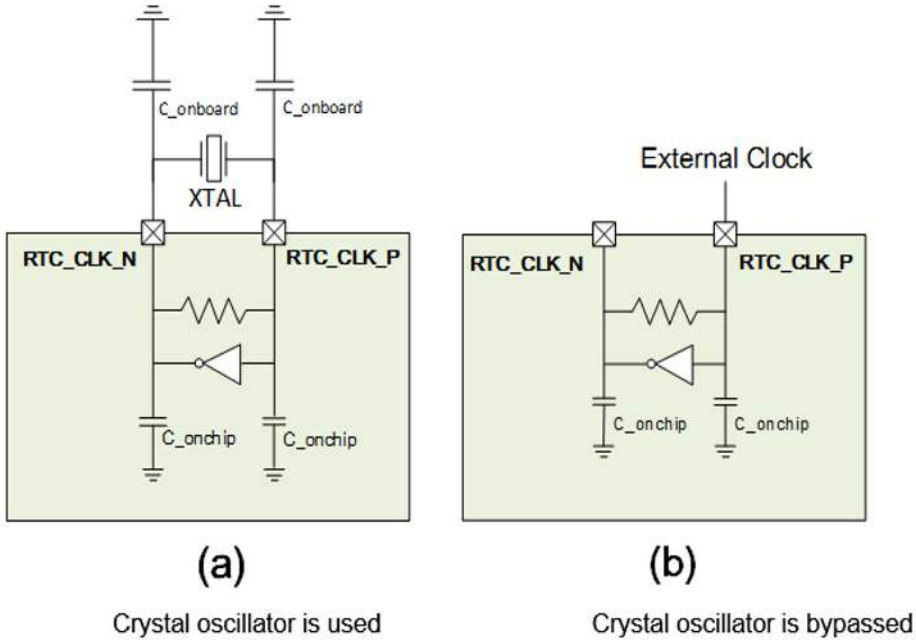


Table 7-1. 32.768 kHz External Clock Specification

Parameter	Min.	Typ.	Max	Unit	Comments
Oscillation frequency		32.768		kHz	Must be able to drive 6 pF load at desired frequency
VinH	0.7		1.2	V	High-level input voltage
VinL	0		0.2		Low-level input voltage
Stability – Temperature	-250		+250	ppm	

Additional internal trimming capacitors (C_onchip) are available. They provide the possibility to tune the frequency output of RTC XO without changing the external load capacitors.

Note:
Refer the BluSDK BLE API Software Development Guide for details on how to enable the 32.768 kHz clock output and tune the internal trimming capacitors.

Table 7-2. 32.768 kHz XTAL C_onchip Programming

Register: pierce_cap_ctrl[3:0]	C_onchip [pF]
0000	0.0
0001	1.0
0010	2.0
0011	3.0
0100	4.0
0101	5.0
0110	6.0

.....continued	
Register: pierce_cap_ctrl[3:0]	**C_onchip [pF]**
0111	7.0
1000	8.0
1001	9.0
1010	10.0
1011	11.0
1100	12.0
1101	13.0
1110	14.0
1111	15.0

7.2.2 RTC XO Design and Interface Specification

The RTC consists of two main blocks:

1. Programmable Gm stage
2. Tuning capacitors

The programmable Gm stage is used to guarantee oscillation start-up and to sustain oscillation. Tuning capacitors are used to adjust the XO center frequency and control the XO precision for different crystal models. The output of the XO is driven to the digital domain via a digital buffer stage with a supply voltage of 1.2V.

Table 7-3. RTC XO Interface

Pin Name	Function	Register Default
Digital control pins	-	-
Pierce_res_ctrl	Control feedback resistance value: • 0 is 20 MOhm feedback resistance • 1 is 30 MOhm feedback resistance	0X4000F404<15>=’1’
Pierce_cap_ctrl<3:0>	Control the internal tuning capacitors with step of 700 fF: • 0000 is 700 fF • 1111 is 11.2 pF Refer to crystal data sheet to check for optimum tuning capacitance value.	0X4000F404<23:20>=”1000”
Pierce_gm_ctrl<3:0>	Controls the Gm stage gain for different crystal mode: • 0011 for crystal with shunt cap of 1.2 pF • 1000 for crystal with shunt cap > 3 pF	0X4000F404<19:16>=”1000”
VDD_XO	1.2V	-

7.2.3 RTC Characterization with Gm Code Variation

The following graphs show the RTC total drawn current and the XO accuracy versus different tuning capacitors and different Gm codes, at a supply voltage of 1.2V and temperature at 25°C.

Figure 7-3. RTC Drawn Current vs. Tuning Caps at 25°C

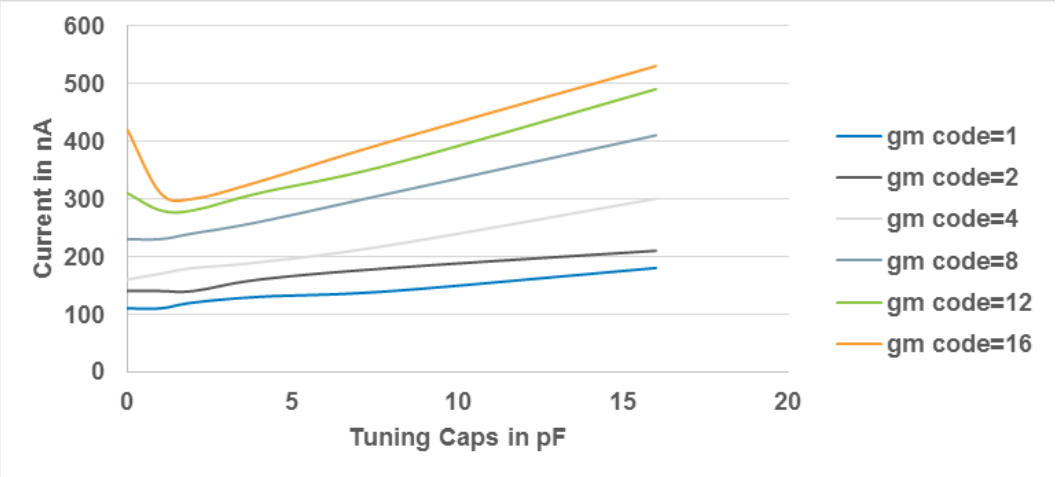
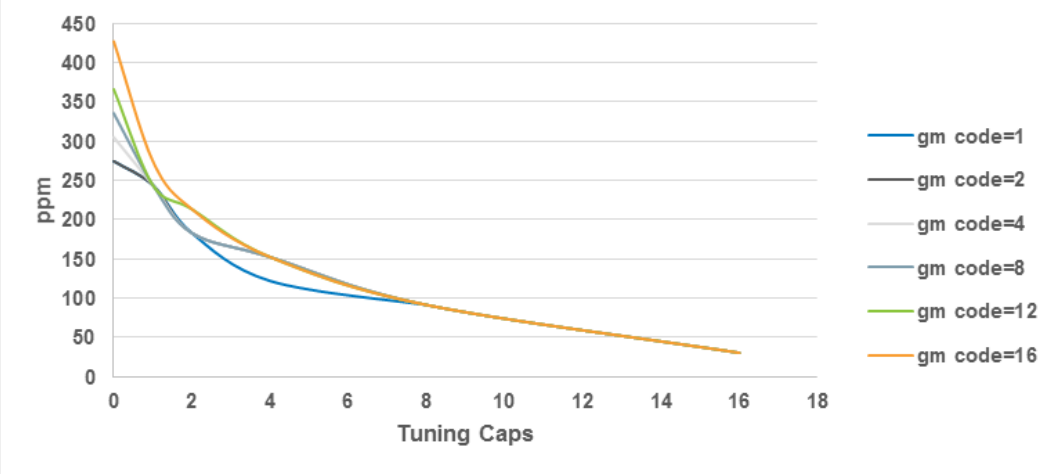


Figure 7-4. RTC Oscillation Frequency Deviation vs. Tuning Caps at 25°C



7.2.4 RTC Characterization with Supply Variation and Temperature

The following graphs show the RTC total drawn current versus different supply voltage and different gm codes, at a temperature of 25°C.

Figure 7-5. RTC Drawn Current vs. Supply Variation

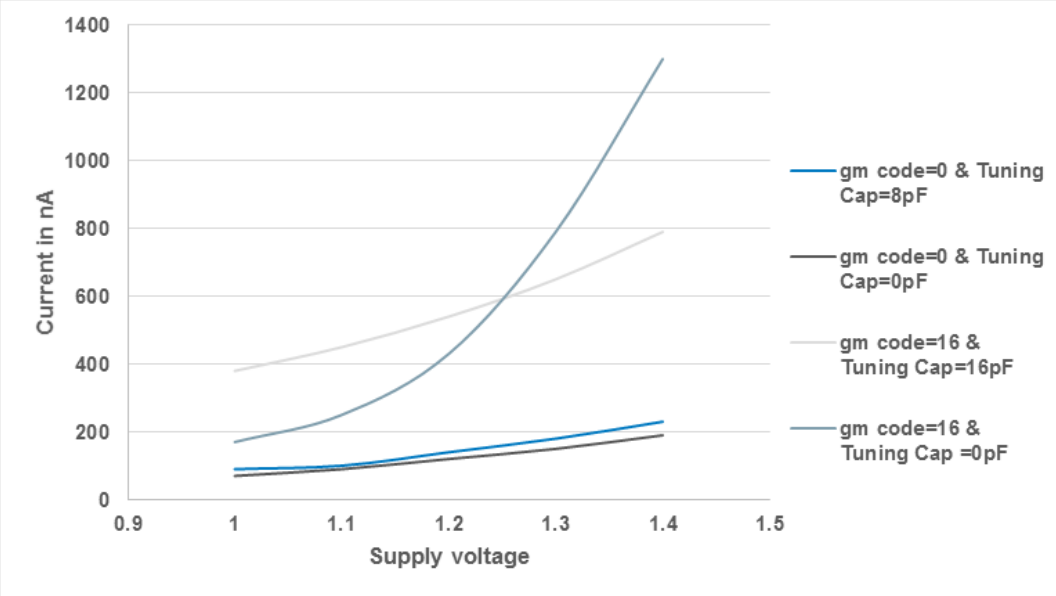
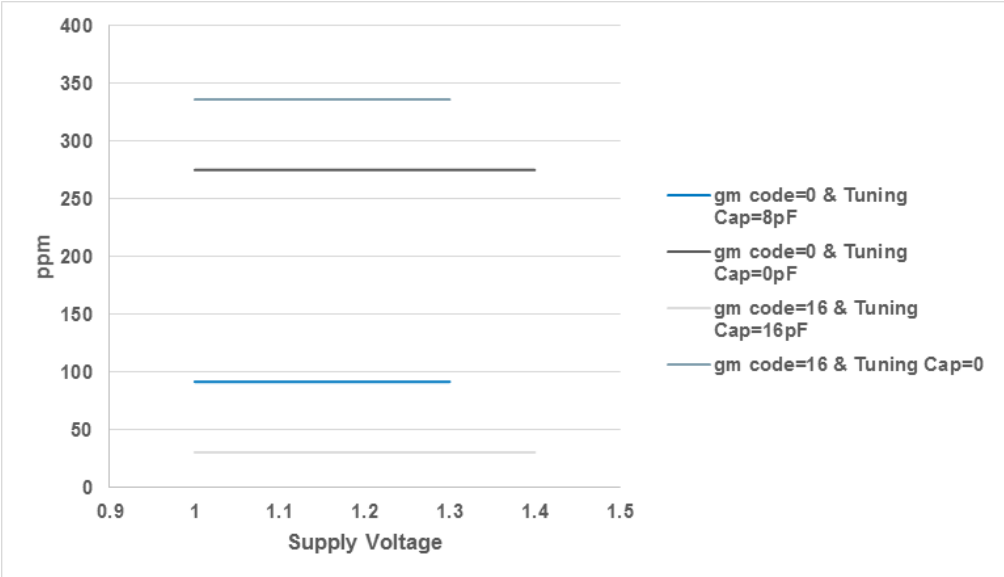


Figure 7-6. RTC Frequency Deviation vs. Supply Voltage



7.3 2 MHz and 26 MHz Integrated RC Oscillators

The 2 MHz integrated RC oscillator circuit without calibration has a frequency variation of 50% over process, temperature, and voltage variation. The calibration over process, temperature, and voltage is required to maintain the accuracy of this clock.

Figure 7-7. 32 kHz RC Oscillator PPM Variation vs. Calibration Time at Room Temperature

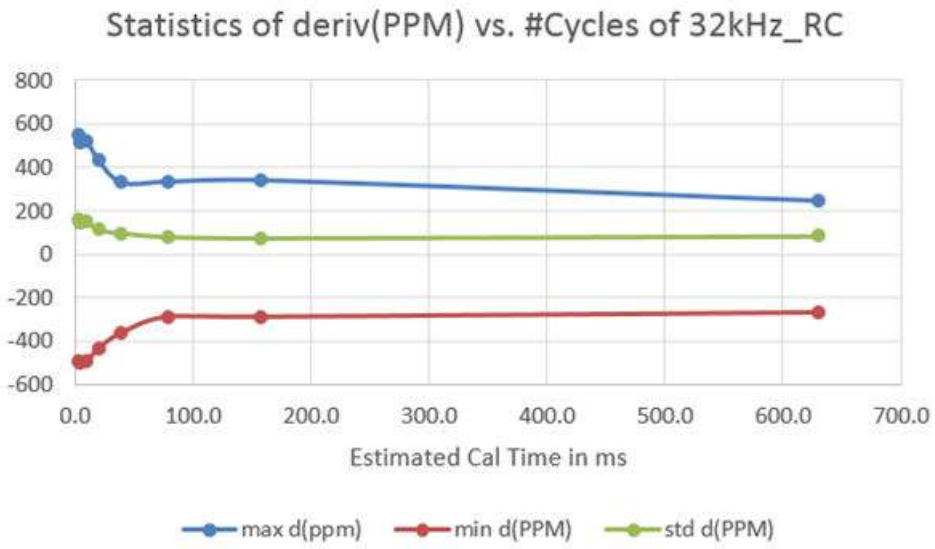
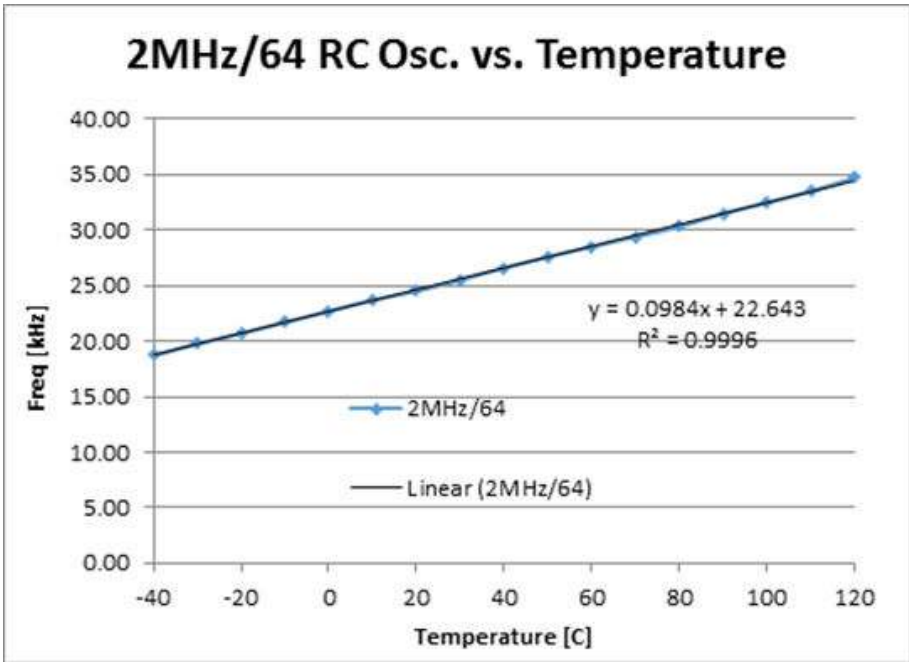


Figure 7-8. 32 kHz RC Oscillator Frequency Variation over Temperature



The 26 MHz integrated RC oscillator circuit has a frequency variation of 50% over process, temperature, and voltage variation.

8. Electrical Characteristics

There are voltage ranges, where different VDDIO levels apply. The reason for this separation is for the IO drivers, whose drive strength is directly proportional to the IO supply voltage. In the ATBTLC1000 products, there is a large gap in the IO supply voltage range (1.8V to 4.3V). A guarantee on drive strength across this voltage range will be intolerable to most vendors, who only use a subsection of the IO supply range. As such, these voltages are segmented into three manageable sections referenced as VDDIOL, VDDIOM, and VDDIOH in tables listed in this document.

8.1 Absolute Maximum Ratings

This section describes the minimum and maximum ratings the module can tolerate.

Table 8-1. ATBTLC1000-MR110CA Absolute Maximum Ratings

Symbol	Characteristics	Min.	Max.	Unit
VDDIO	I/O Supply Voltage	-0.3	5.0	V
VBAT	Battery Supply Voltage	-0.3	5.0	
V_{IN} (1)	Digital Input Voltage	-0.3	VDDIO	
V_{AIN} (2)	Analog Input Voltage	-0.3	1.5	
V_{ESDHBM} (3)	ESD Human Body Model	-1000, -2000 (see notes below)	+1000, +2000 (see notes below)	
TA	Storage Temperature	-65	150	°C
-	Junction Temperature	-	125	

Note:

1. V_{IN} corresponds to all the digital pins.
2. V_{AIN} corresponds to the following analog pins: VDDRF_RX, VDDAMS, RFIO, RTC_CLKN, RTC_CLKP, VDD_SXDIG and VDD_VCO.
3. For V_{ESDHBM}, each pin is classified as Class 1, or Class 2, or both:
   - The Class 1 pins include all the pins (both analog and digital)
   - The Class 2 pins include all digital pins only
   - V_{ESDHBM} is ±1 kV for Class 1 pins. V_{ESDHBM} is ±2 kV for Class 2 pins.

8.2 Recommended Operating Conditions

The following table provides the recommended operating conditions for the ATBTLC1000-MR110CA.

Table 8-2. ATBTLC1000-MR110CA Recommended Operating Conditions

Symbol	Characteristics	Min.	Typ.	Max.	Unit
VDDIO	I/O Supply Voltage Low Range	1.62	1.80	4.3	V
VBAT	Battery Supply Voltage(1)	1.8 (1)	3.6	4.3	

.....continued					
Symbol	**Characteristics**	**Min.**	**Typ.**	**Max.**	**Unit**
	Operating Temperature	-40		85	°C

Note:

1. VBAT supply must be greater than or equal to VDDIO.

8.3 Current Consumption in Device States

The following table provides the current consumption details in different device states.

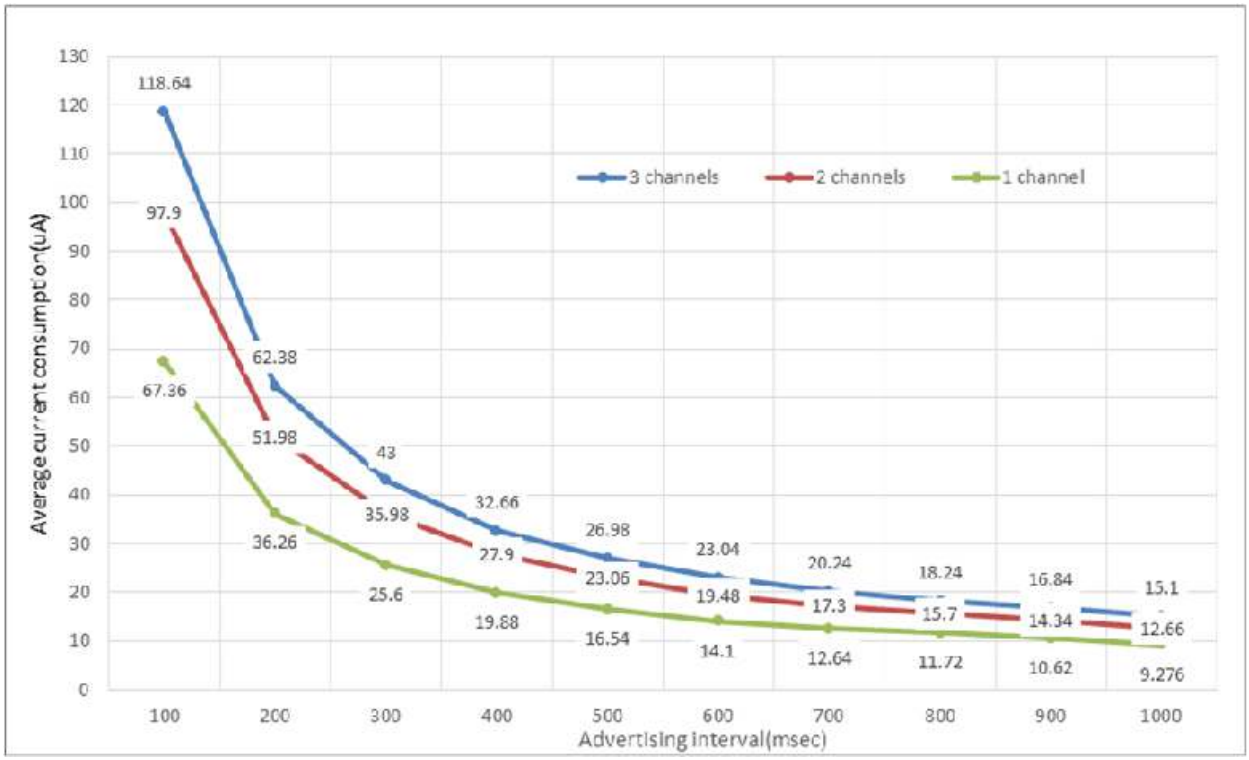
Table 8-3. ATBTLC1000-MR110CA Device State Current Consumption

Device State	C_EN	VDDIO	$I_{VBAT}+I_{VDDIO}$ (typical) (2)
Power_Down	Off	On	0.05 µA
Ultra_Low_Power with BLE timer, with RTC (1)	On	On	2.01 µA
BLE_On_Receive at channel 37 (2402 MHz)	On	On	5.24 mA
BLE_On_Transmit, 0 dBm output power at channel 37 (2402 MHz)	On	On	3.91 mA
BLE_On_Transmit, 0 dBm output power at channel 39 (2480 MHz)	On	On	3.78 mA
BLE_On_Transmit, 3 dBm output power at Channel 37 (2402 MHz)	On	On	4.74 mA
BLE_On_Transmit, 3 dBm output power at Channel 39 (2480 MHz)	On	On	4.60 mA

Note:

1. Sleep clock derived from external 32.768 kHz crystal specified for CL=7 pF, using the default on-chip capacitance only, without using external capacitance.
2. Measurement conditions
   - VBAT=3.3V
   - VDDIO=3.3V
   - Temperature=25°C
   - Measured with FW version : BluSDK V6.1.7072

Figure 8-1. ATBTLC1000-MR110CA Average Advertising Current



Note:

1. The average advertising current is measured at VBAT = 3.3 V, VDDIO = 3.3 V, TX output power=0 dBm. Temperature=25°C
2. Advertisement data payload size - 31 octets
3. Advertising event type - Connectable Undirected
4. Advertising channels used in 2 channel - 37 and 38
5. Advertising channels used in 1 channel - 37

8.4 Receiver Performance

The following table explains the ATBTLC1000-MR110CA BLE receiver performance.

Table 8-4. ATBTLC1000-MR110CA Receiver Performance

Parameter	Min.	Typ.	Max.	Unit
Frequency	2,402	-	2,480	MHz
Sensitivity with on-chip DC/DC	-94.5	-93	-	dBm
Maximum receive signal level	-	+5	-	

.....continued				
Parameter	**Min.**	**Typ.**	**Max.**	**Unit**
CCI	-	13	-	dB
ACI (N±1)	-	0	-	
N+2 Blocker (image)	-	-20	-	
N-2 Blocker	-	-38	-	
N+3 Blocker (Adj. image)	-	-35	-	
N-3 Blocker	-	-43	-	
N±4 or greater	-	-45	-	
Intermod (N+3, N+6)	-	-33	-	dBm
OOB (2 GHz < f < 2.399 GHz)	-15	-	-	
OOB (f < 2 GHz)	-10	-	-	

Note: All measurements are performed at 3.6V VBAT and 25°C with tests following Bluetooth standard tests.

8.5 Transmitter Performance

The following table explains the ATBTLC1000-MR110CA BLE Transmitter performance.

Table 8-5. ATBTLC1000-MR110CA Transmitter Performance

Parameter	Min.	Typ.	Max.	Unit
Frequency	2,402	-	2,480	MHz
Maximum output power	-	3.5(1)	-	dBm
Minimum Output Power	-55	-	-	
In-band Spurious (N±2)	-	-40	-	
In-band Spurious (N±3)	-	-50	-	
2nd Harmonic P_{out}	-	-45	-	
Frequency Deviation	-	±250	-	kHz

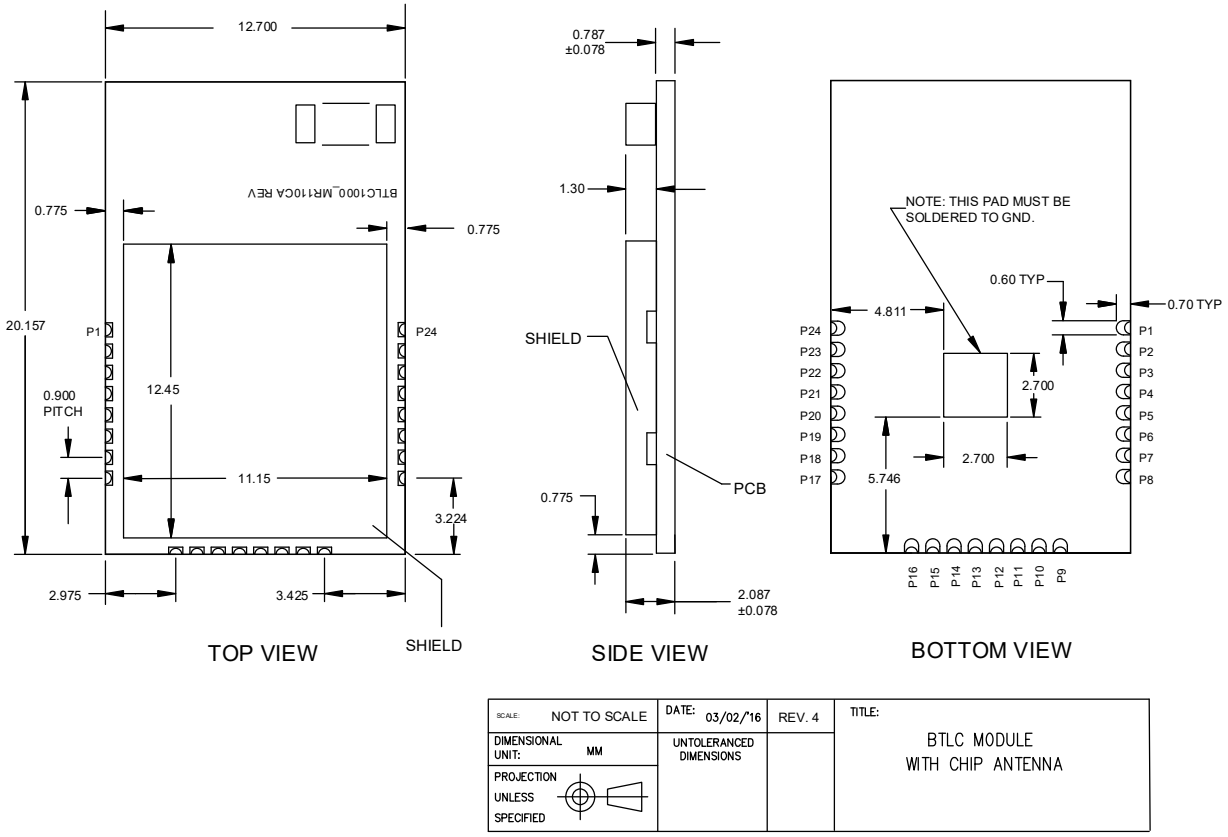
Note:

1. Country-specific transmit power settings (as per the ATBTLC1000-MR110CA Certifications) should be programmed at the host product factory to match the intended destination. Regulatory bodies prohibit exposing the transmit power settings that would configure the transmit power beyond certified limits, to the end user. This requirement needs to be taken care of via host implementation.
2. All measurements are performed at 3.6V VBAT and 25°C, with tests following the Bluetooth standard tests.

9. ATBTLC1000-MR110CA Module Outline Drawing

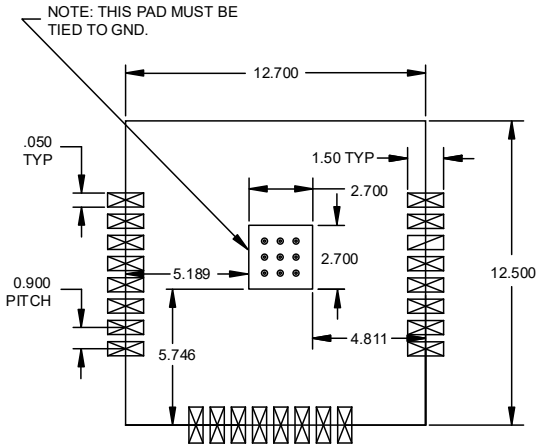
The following figure illustrates the module views and dimensions.

Figure 9-1. Module Dimensions (millimeters)



The following figure illustrates the footprint information of the module.

Figure 9-2. Customer PCB Footprint



TOP VIEW

SCALE: NOT TO SCALE	DATE: 09/08/16	REV. 4	TITLE: ATMEL BTLC1000 MR110 MODULE SOLDER PAD FOOTPRINT
DIMENSIONAL UNIT: MM	UNTOLERANCED DIMENSIONS		
PROJECTION UNLESS SPECIFIED			

10. ATBTLC1000-MR110CA Reference Schematic

This chapter provides the reference schematic for the ATBTLC1000-MR110CA module. The module design information, such as module schematics, can be obtained under an NDA from Microchip.

10.1 Reference Schematics

The ATBTLC1000-MR110CA module is fully self-contained. To use the module, power is supplied to VBAT and VDDIO. The following figures illustrate the reference schematic design for the 4-wire and 6-wire modes.

Figure 10-1. ATBTLC1000-MR110CA Reference Schematic for 4-wire Mode

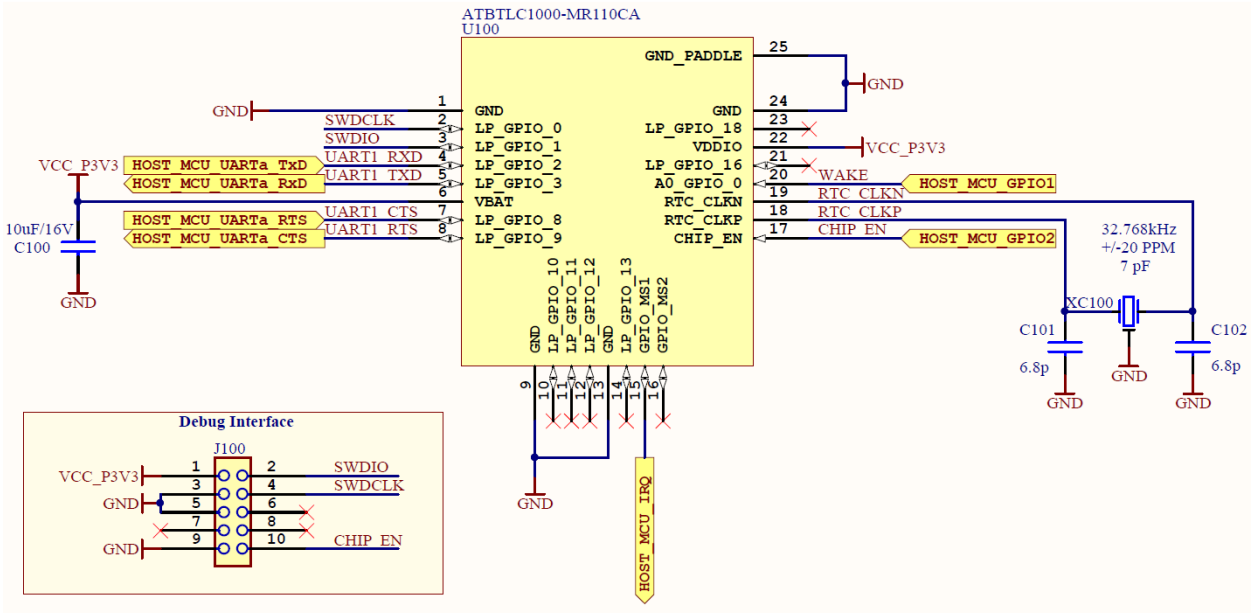
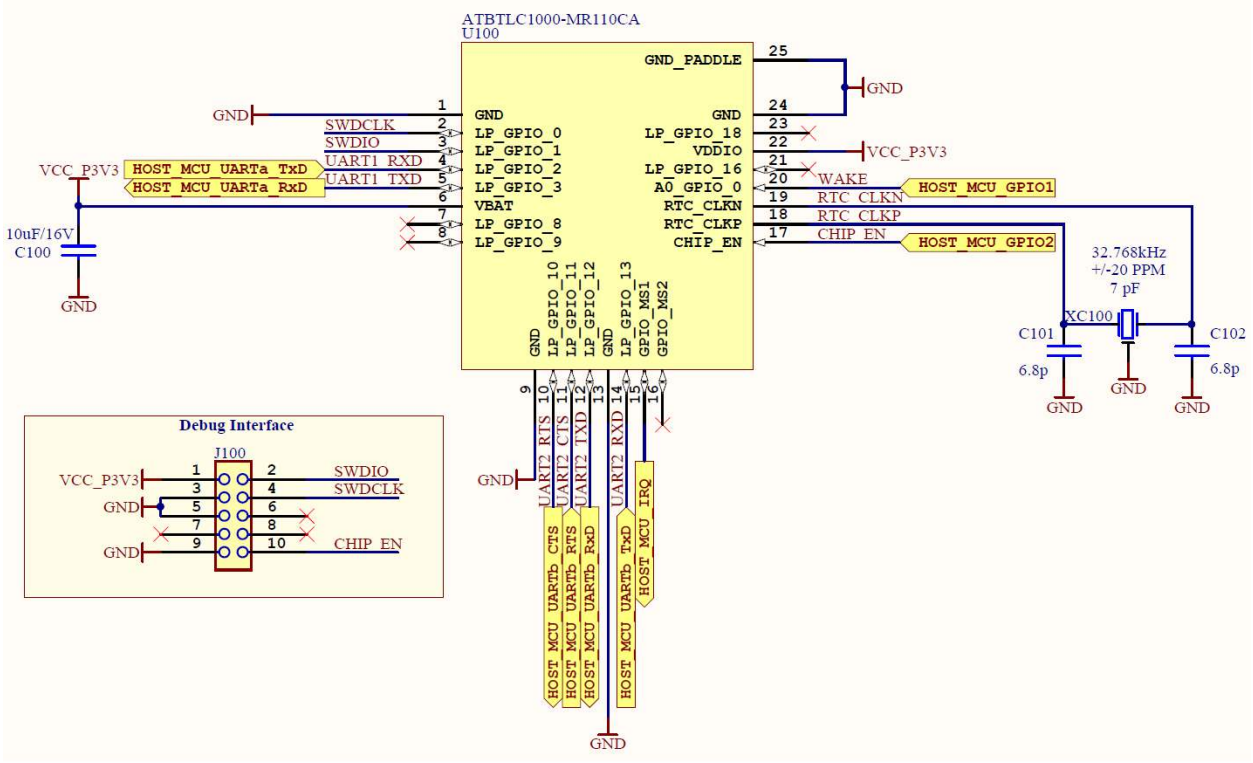


Figure 10-2. ATBTLC1000-MR110CA Reference Schematic for 6-wire Mode



11. Placement and Routing Guidelines

It is critical to follow the recommendations listed below to achieve the best RF performance for the ATBTLC1000-MR110CA module.

The board must have a solid ground plane. The center ground pad of the device must be soldered to the ground plane by using a 3 x 3 grid of vias (refer to 9. ATBTLC1000-MR110CA Module Outline Drawing). Each ground pin of the ATBTLC1000-MR110CA must have a ground via placed either in the pad or right next to the pad going down to the ground plane.

1. When the module is placed on the customer PCB design, a provision for the antenna must be made. There must be nothing under the portion of the module, which contains the antenna. This means the antenna must not be placed directly on top of the customer PCB as illustrated in the following figure (a). This can be accomplished by, for example, placing the module at the edge of the board, such that the module edge with the antenna extends beyond the customer PCB edge by 6.5 mm as illustrated in figure (b). Alternatively, a cutout in the customer PCB can be provided under the antenna. The cutout must be at least 22 mm x 6.5 mm (see Figure 11-1 and Figure 11-2. If the cutout method is used, ATBTLC1000-MR110CA must be centered in the cutout. The ATBTLC1000-MR110CA must have ground vias spaced 2.5 mm apart that must be placed all around the perimeter of the cutout. No large components must be placed near the antenna.
2. Keep large metal objects as far away as possible from the antenna, to avoid electromagnetic field blocking.
3. Do not enclose the antenna within a metal shield.
4. Keep any components that may radiate noise or signals within the 2.4 GHz to 2.5 GHz frequency band far away from the antenna or better yet, shield the components that are generating the noise. Any noise radiated from the customer PCB in this frequency band degrades the sensitivity of the ATBTLC1000-MR110CA module.

Figure 11-1. ATBTLC1000-MR110CA Placement Examples

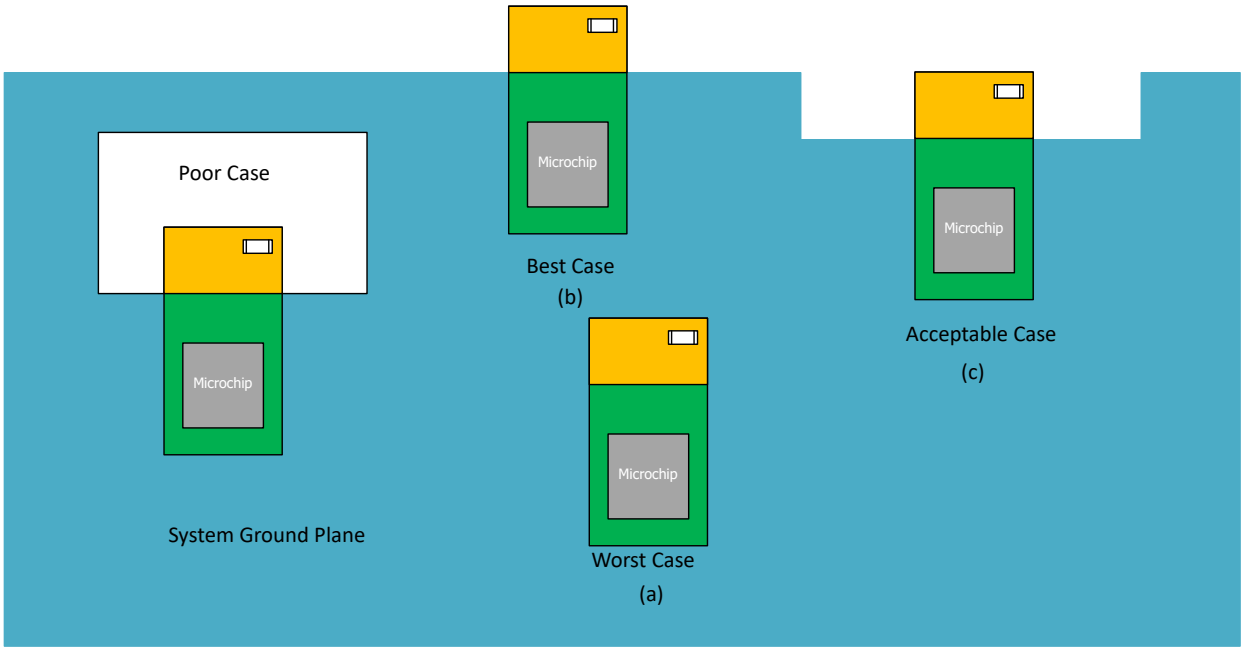
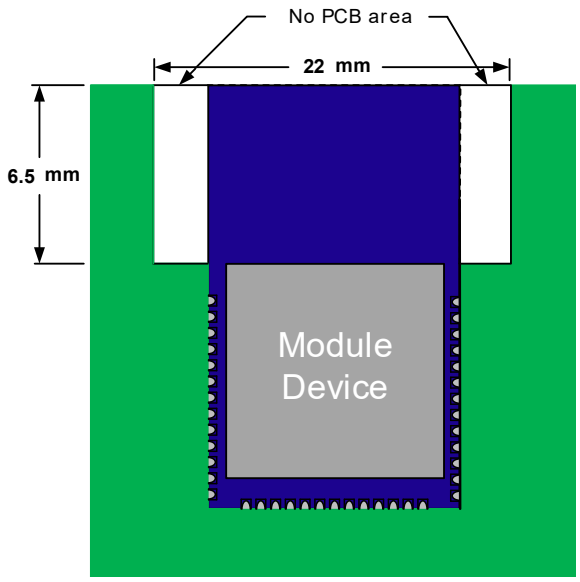


Figure 11-2. No PCB/GND Cut Out Area



11.1 Power and Ground

Dedicate one layer as a ground plane. Make sure that this ground plane does not get broken up by routes. Power can route on all layers except the ground layer. Power supply routes should be heavy copper fill planes to ensure the lowest possible inductance. The power pins of the module should have a via directly to the power plane as close to the pin as possible. Decoupling capacitors should have a via right next to the capacitor pin and this via should go directly down to the power plane – that is to say, the capacitor should not route to the power plane through a long trace. The ground side of the decoupling capacitor should have a via right next to the pad which goes directly down to the ground plane. Each decoupling capacitor should have its own via directly to the ground plane and directly to the power plane right next to the pad. The decoupling capacitors should be placed as close to the pin that it is filtering as possible.

11.2 Interferers

One of the biggest problems with RF receivers is poor performance due to interferers on the board radiating noise into the antenna or coupling into the RF traces going to input LNA. Care must be taken to make sure that no noisy circuit is placed anywhere near the antenna or the RF traces. All noise generating circuits must also be shielded, so they do not radiate noise that is picked up by the antenna. Also, make sure that no traces route underneath any of the RF traces from the antenna to the ATBTLC1000-MR110CA input. This applies to all layers. Even if there is a ground plane on a layer between the RF route and another signal, the ground return current will flow on the ground plane and couple into the RF traces.

12. Reflow Profile Information

This chapter provides guidelines for the reflow processes in soldering the ATBTLC1000-MR110CA to the customer's design.

12.1 Storage Condition

12.1.1 Moisture Barrier Bag Before Opening

A moisture barrier bag must be stored in a temperature of less than 30°C with humidity under 85% RH.

The calculated shelf life for the dry-packed product shall be 12 months from the date the bag is sealed.

12.1.2 Moisture Barrier Bag Open

Humidity indicator cards must be blue, <30%.

12.2 Stencil Design

The recommended stencil is laser-cut, stainless-steel type with a thickness of 100 µm to 130 µm, and approximately a 1:1 ratio of stencil opening to pad dimension. To improve paste release, a positive taper with bottom opening 25 µm larger than the top can be utilized. Local manufacturing experience may find other combinations of stencil thickness and aperture size to get good results.

12.3 Soldering and Reflow Condition

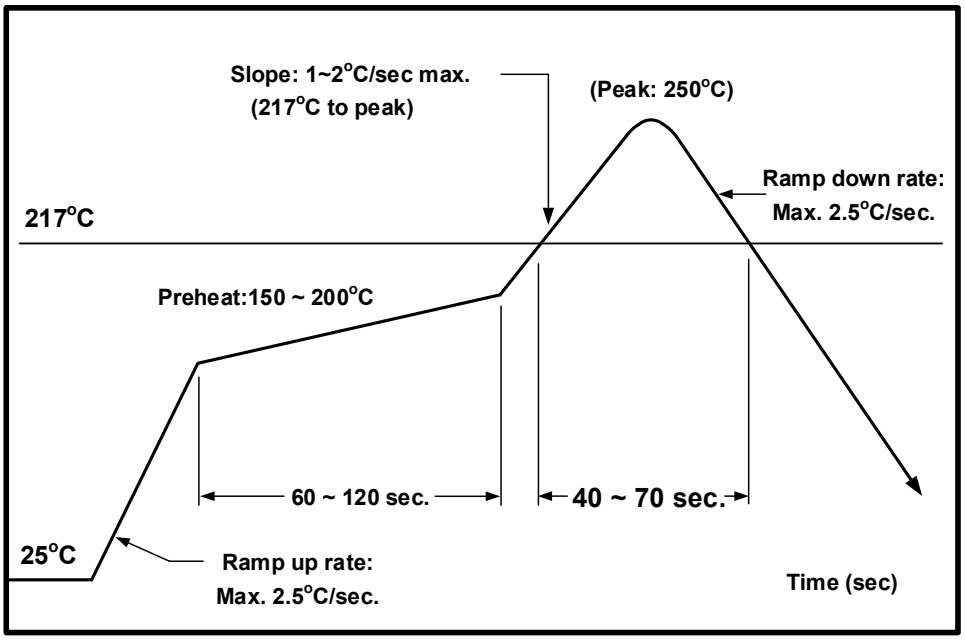
12.3.1 Reflow Oven

It is strongly recommended that a reflow oven equipped with more heating zones and Nitrogen atmosphere be used for lead-free assembly. Nitrogen atmosphere has shown to improve the wet-ability and reduce temperature gradient across the board. It can also enhance the appearance of the solder joints by reducing the effects of oxidation.

The following items must also be observed in the reflow process:

- Some recommended pastes include NC-SMQ® 230 flux and Indalloy® 241 solder paste made of 95.5 Sn/3.8 Ag/0.7 Cu or SENJU N705-GRN3360-K2-V Type 3, no clean paste.
- Allowable reflow soldering times: Three times based on the following reflow soldering profile, as illustrated in the following figure.
- Temperature profile: Reflow soldering shall be done, according to the following temperature profile as illustrated in the following figure.
- Peak temperature: 250°C.

Figure 12-1. Solder Reflow Profile



12.4 Baking Conditions

This module is rated at MSL level 3. After the sealed bag is opened, no baking is required within 168 hours so long as the devices are held at ≤30°C/60% RH or stored at <10% RH.

The module will require baking before mounting if:

- The sealed bag has been open for >168 hours
- Humidity Indicator Card reads >10%
- SIPs need to be baked for 8 hours at 125°C

12.5 Module Assembly Considerations

The ATBTLC1000-MR110CA modules are assembled with an EMI shield to ensure compliance with EMI emission and immunity rules. The EMI shield is made of a tin-plated steel (SPTE) and is not hermetically sealed. Solutions like IPA and similar solvents can be used to clean the ATBTLC1000-MR110CA module. However, cleaning solutions containing acid must never be used on the module.

The Microchip ATBTLC1000-MR110CA modules are manufactured without any conformal coating applied. It is the customer's responsibility if a conformal coating is specified and applied to the ATBTLC1000-MR110CA module.

13. Regulatory Approval

The ATBTLC1000-MR110CA has received the regulatory approval for the following countries:

- United States/FCC ID: 2ADHKBTLC1000
- Canada/ISED
  - IC: 20266-BTLC1000MR
  - HVIN: ATBTLC1000-MR110CA
  - PMN: ATBTLC1000-MR110CA
- Japan/MIC: 007-AD0208

13.1 United States (FCC)

The ATBTLC1000-MR110CA module has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C “Intentional Radiators” modular approval in accordance with Part 15.212 Modular Transmitter approval. Modular approval allows the end user to integrate the ATBTLC1000-MR110CA module into a finished product without obtaining subsequent and separate FCC approvals for intentional radiation, provided no changes or modifications are made to the module circuitry. Changes or modifications could void the user’s authority to operate the equipment.

The user must comply with all of the instructions provided by the Grantee, which indicate the installation and/or operating conditions necessary for compliance.

The finished product is required to comply with all applicable FCC equipment authorization regulations, requirements and equipment functions that are not associated with the transmitter module portion. For example, compliance must be demonstrated: to regulations for other transmitter components within a host product; to requirements for unintentional radiators (Part 15 Subpart B), such as digital devices, computer peripherals, radio receivers, etc.; and to additional authorization requirements for the non-transmitter functions on the transmitter module (i.e., Verification or Declaration of Conformity) as appropriate (e.g., Bluetooth and Wi-Fi® transmitter modules may also contain digital logic functions).

13.1.1 Labeling And User Information Requirements

The ATBTLC1000-MR110CA module has been labeled with its own FCC identifier number, and if the FCC ID is not visible when the module is installed inside another device, then the outside of the finished product into which the module is installed must display a label referring to the enclosed module. This exterior label should use the following wording:

For the ATBTLC1000-MR110CA:

> Contains Transmitter Module FCC ID: 2ADHKBTLC1000
>
> or
>
> Contains FCC ID: 2ADHKBTLC1000
>
> **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 undesired operation**

The user’s manual for the product should include the following statement:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
- Consult the dealer or an experienced radio/TV technician for help

Additional information on labeling and user information requirements for Part 15 devices can be found in KDB Publication 784748, which is available at the FCC Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB) https://apps.fcc.gov/oetcf/kdb/index.cfm

13.1.2 RF Exposure

All transmitters regulated by FCC must comply with RF exposure requirements. KDB 447498 General RF Exposure Guidance provides guidance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to Radio Frequency (RF) fields adopted by the Federal Communications Commission (FCC).

From the FCC Grant: Output power listed is conducted.

The antenna(s) used with this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

13.1.3 Helpful Websites

Federal Communications Commission (FCC): http://www.fcc.gov

FCC Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB): https://apps.fcc.gov/oetcf/kdb/index.cfm

13.2 Canada (ISED)

The ATBTLC1000-MR110CA module has been certified for use in Canada under Innovation, Science, and Economic Development (ISED, formerly Industry Canada) Radio Standards Procedure (RSP) RSP-100, Radio Standards Specification (RSS) RSS-Gen and RSS-247. Modular approval permits the installation of a module in a host device without the need to recertify the device.

13.2.1 Labeling and User Information Requirements

Labeling Requirements (from RSP-100 - Issue 10, Section 3): The host device shall be properly labeled to identify the module within the host device.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host device. Therefore, the host product must be labeled to display the Innovation, Science and Economic Development Canada certification number of the module, preceded by the word “Contains” or similar wording expressing the same meaning, as follows:

For the ATBTLC1000-MR110CA:

Contains IC: 20266-BTLC1000MR

User Manual Notice for License-Exempt Radio Apparatus (from Section 8.4 RSS-Gen, Issue 5, April 2018): User manuals for license-exempt radio apparatus shall contain the following or equivalent notice in a conspicuous location in the user manual or alternatively on the device or both:

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

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

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique 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
2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

See RSS-GEN Section 8.4(http://www.ic.gc.ca/eic/site/smt-gst.nsf/fra/sf08449.html#s8).

Transmitter Antenna (From Section 6.8 RSS-GEN, Issue 5, April 2018): User manuals, for transmitters shall display the following notice in a conspicuous location:

This radio transmitter [IC: 20266-BTLC1000MR] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Le présent émetteur radio [IC: 20266-BTLC1000MR] a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont strictement interdits pour l'exploitation de l'émetteur.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

13.2.2 RF Exposure

All transmitters regulated by Innovation, Science and Economic Development Canada (ISED) must comply with RF exposure requirements listed in RSS-102 - Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands).

This transmitter is restricted for use with a specific antenna tested in this application for certification, and must not be co-located or operating in conjunction with any other antenna or transmitters within a host device, except in accordance with Canada multi-transmitter product procedures.

The device operates at an output power level which is within ISED SAR test exemption limits at any user distance.

13.2.3 Helpful Websites

Innovation, Science and Economic Development Canada (ISED): http://www.ic.gc.ca/

13.3 Japan

The ATBTLC1000-MR110CA module has received type certification and is labeled with its own technical conformity mark and certification number as required to conform to the technical standards regulated by the Ministry of Internal Affairs and Communications (MIC) of Japan pursuant to the Radio Act of Japan.

Integration of this module into a final product does not require additional radio certification provided installation instructions are followed and no modifications of the module are allowed. Additional testing may be required:

- If the host product is subject to electrical appliance safety (for example, powered from an AC mains), the host product may require Product Safety Electrical Appliance and Material (PSE) testing. The integrator must contact their conformance laboratory to determine if this testing is required.
- There is a voluntary Electromagnetic Compatibility (EMC) test for the host product administered by VCCI: http://www.vcci.jp/vcci_e/index.html.

13.3.1 Labeling and User Information Requirements

The label on the final product which contains the ATBTLC1000-MR110CA module must follow Japan marking requirements. The integrator of the module must refer to the labeling requirements for Japan available at the Ministry of Internal Affairs and Communications (MIC) website.

On the ATBTLC1000-MR110CA module, due to a limited module size, the technical conformity logo and ID is displayed in the data sheet and/or packaging label and cannot be displayed on the module label. The final product in which this module is being used must have a label referring to the type certified module inside:

13.3.2 Helpful Websites

- Ministry of Internal Affairs and Communications (MIC): http://www.tele.soumu.go.jp/e/index.html.
- Association of Radio Industries and Businesses (ARIB): http://www.arib.or.jp/english/.

13.4 Other Regulatory Information

- For information about other countries' jurisdictions not covered here, refer to http://www.microchip.com/design-centers/wireless-connectivity

- Should other regulatory jurisdiction certifications be required by the customer, or the customer needs to recertify the module for other reasons, contact Microchip for the required utilities and documentation.

14. Reference Documentation

Microchip offers a set of collateral documentation to ease integration and device ramp. The following list of documents available on the Microchip website or integrated into development tools.

Table 14-1. Reference Documents

Title	Content
ATBTLC1000 SOC Datasheet	Data sheet for the ATBTLC1000 SOC contained on this module.
ATBTLC1000 BluSDK: Hardware Design Guidelines	ATBLTC1000 hardware design guide with references for placement and routing, external RTC, restrictions on power states and type of information.
ATBTLC1000 BluSDK Release Package	This package contains the software development kit and all the necessary documentation including getting started guides for interacting with different hardware devices, device drivers, and API call references.
ATBTLC1000 Platform Porting Guide	This document guides the user to port the Application Peripheral Interface (API) into a new platform.
ATBTLC1000 BluSDK BLE API SW Development Guide	This user guide details the functional description of Bluetooth Low Energy (BLE) Application Peripheral Interface (API) programming model. This also provides the example code to configure an API for Generic Access Profile (GAP), Generic Attribute (GATT) Profile, and other services using the ATBTLC1000.

For a complete list of development support tools and documentation, visit http://www.microchip.com, or contact the nearest Microchip field representative.

15. Document Revision History

Revision	Date	Section	Description
A	04/2019	Document	• Change of document style. • Change the name to incorporate all the ATBTLC1000 devices. • New Microchip document number, DS70005393. • Various editorial changes to match the new document style.

Rev E - 08/2016

Section	Changes
Document	• Replaced KHz with kHz • Details in Errata section incorporated into the Electrical Characteristics section.
Description	• Revised product Description content.
Pinout Information	• Correct module pad width.
Electrical Specification	• Revised Note 2 Vain in Absolute Max Power Ratings table. • Revised VDDIO Maximum Voltage value in Max Power Ratings table. • Updated RTC Example drawings. – Revised Current values in Recommended Operating Conditions table.
Characteristics	• Revised Receive Current rate in Devices States table. • Revised Receive performance number in Receiver Performance table. • Added tolerance to Frequency Dev in Transmitter Performance table.
Reflow Profile Information	• Added Module Assembly Considerations section.

Rev D – 03/2016

Section	Changes
Package Information	• Corrected package table ground pad size in Module Information table.
Pinout Information	• Updated Module POD figure.
Reflow Profile Information	• Corrected Reflow recurrence iterations.
Errata	• Corrected errata to point to correct table (Module Device States).

Rev C – 12/2015

Section	Changes
Document	• Added clearer diagrams.
Ordering Information	• Corrected Package size value in Ordering Information table.
Pinout Information	• Updated Module POD figure.
Characteristics	• Updated performance numbers.
Schematic Information	• Revised Schematic content. • Added UART Flow control.
Certification	• Added Agency Certification section.
Reflow Profile	• Added Reflow Profile section.
Errata	• Added Errata

Rev B – 07/2015

Section	Changes
Document	• Updated For Rev B Silicon

Rev A – 04/2015

Section	Changes
Document	Initial Release

The Microchip Web Site

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- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

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ISBN: 978-1-5224-4429-9

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