- Integrated 3V and 1.8V Configurable Switching Regulator and LDO
- Built-in Lithium-ion Battery Charger (up to 350 mA)
- Built-in ADC for Battery Monitor and Voltage Sense
- Audio-In/Out
    - BM23 supports digital audio I^{2}S format
    - BM20 supports analog audio output
- Transparent Universal Asynchronous Receiver/Transmitter (UART) Mode for Seamless Serial Data Over UART Interface
- Integrated Crystal Oscillator and Matching Circuitry
- Secure AES128 Encryption

RF/Analog

- Frequency Spectrum: 2.402 GHz to 2.480 GHz
- Receive Sensitivity: -91 dB (π/4 DQPSK)
- Transmitter Output Power: +4 dBm (maximum) for Class 2

Audio processor

- Support 64 Kbps A-Law, μ-Law PCM format/Continuous Variable Slope Delta Modulation (CVSD) for SCO Channel Operation
- Noise Reduction (NR) and Acoustic Echo Cancellation (ACE)
- Sub-Band Coding (SBC) and Optional Advanced Audio Coding (AAC) Decoding
- Packet Loss Concealment (PLC)
- Four Languages (Chinese/ English/ Spanish/ French) Voice Prompts Support (20 events for each language) using the IS20XXS_UI tool
- Serial Copy Management System (SCMS-T) Content Protection

Audio Codec

- 20-Bit Digital-to-Analog Converter (DAC) and 16-bit Analog-to-Digital Converter (ADC) Codec
- 98 dB Signal-to-Noise ratio (SNR) DAC Playback

Peripherals

- One Line-in Port for External Audio Input
- Two LED Drivers
- One UART Interface
- Multiple I/O Pins for Control and Status
- High-Speed HCI-UART Interface (supports up to 921,600 bps)

Antenna

- PCB Antenna

Compliance

- Bluetooth Special Interest Group (SIG) Certified:
    - BM20 QDID: 121137
    - BM23 QDID: 121137

- BM20/23 modules have been granted modular approval from various countries. For additional details, refer to 9. Certification Notices.
- RoHS Compliant

Operating Conditions

- Operating Voltage: 3.0V to 4.2V
- Temperature Range: -20°C to 70°C

Applications

- Bluetooth Sound Bar
- Bluetooth Stereo Speaker Phone

Table of Contents

1. Device Overview

The BM20 and BM23 stereo module is built around the IS2020S and IS2023S SoCs, respectively, which integrates the Bluetooth radio transceiver, a Power Management Unit (PMU), and a Digital Signal Processor (DSP).

The following figure illustrates a typical example of the BM20 module that operates as an independent system or when connected to an MCU.

Figure 1-1. BM20 Typical Application
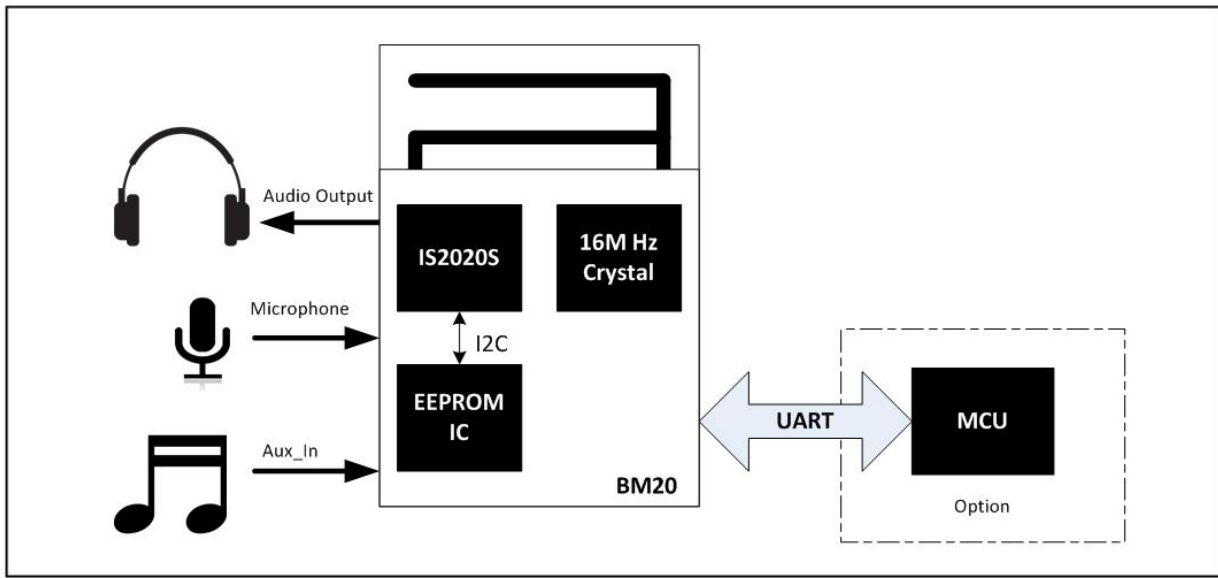
The following figure illustrates a typical example of the BM23 module connected to an external MCU and a DSP/Codec.

Figure 1-2. BM23 Typical Application
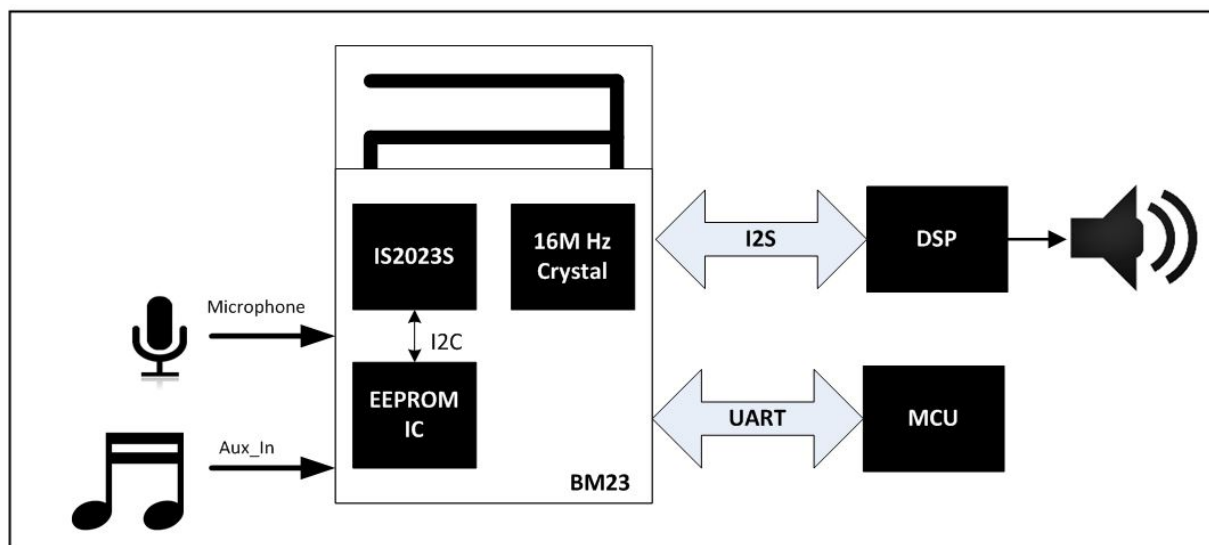
1.1 Interface Description

The following figure illustrates the pin diagram of the BM20 module.

Figure 1-3. BM20 Module Pin Diagram
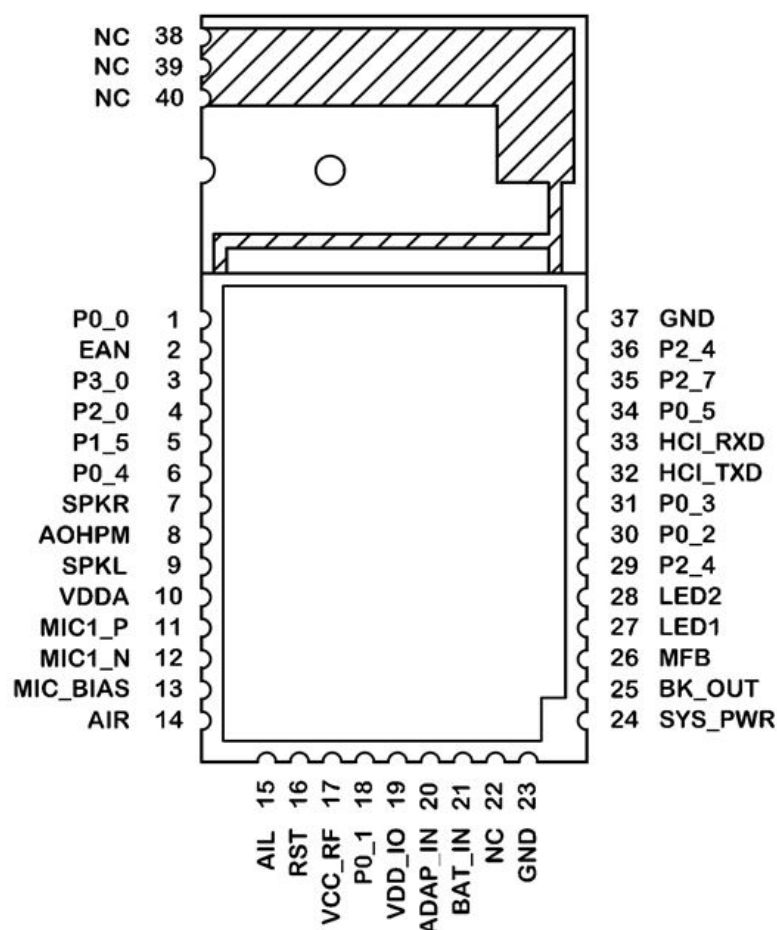
The following table provides the pin description of the BM20 module.

Table 1-1. BM20 Module Pin Description

Pin No.	Name	Pin type	Description
1	P0_0	I/O	I/O pin, default pull-high input (Note 1) • Slide switch detector, active-low • UART TX_IND, active-low
2	EAN	I	Embedded ROM/External Flash enable H: Embedded; L: External Flash
3	P3_0	I	I/O pin, default pull-high input (Note 1) Line-in Detector (default), active-low
4	P2_0	I	I/O pin, default pull-high input System Configuration, H: Application L: Base band (Test Mode)

...........continued			
Pin No.	Name	Pin type	Description
5	P1_5	I/O	I/O pin, default pull-high input (Note 1) • NFC detection pin, active low • Out_Ind_0 • Slide Switch Detector, active low • Buzzer Signal Output
6	P0_4	I/O	I/O pin, default pull-high input (Note 1) • NFC detection pin, active low • Out_Ind_0
7	SPKR	O	Right-channel, analog headphone output
8	AOHPM	O	Headphone common mode output/sense input
9	SPKL	O	Left-channel, analog headphone output
10	VDDA	P	Positive power supply/reference voltage for Codec, no need to add power to this pin
11	MIC1_P	I	MIC 1 mono differential analog positive input
12	MIC1_N	I	MIC 1 mono differential analog negative input
13	MIC_BIAS	P	Electric microphone biasing voltage
14	AIR	I	Right-channel, single-ended analog input
15	AIL	I	Left-channel, single-ended analog input
16	RST	I	System Reset pin, Low: reset
17	VCC_RF	P	1.28V RF LDO output, no need to add power to this pin
18	P0_1	I/O	I/O pin, default pull-high input (Note 1) • FWD key, when Class 2 RF (default), active-low • Class 1 Tx Control signal of external RF T/R switch, active-high
19	VDD_IO	P	Power output, no need to add power to this pin
20	ADAP_IN	P	5V Power adapter input
21	BAT_IN	P	3.0V to 4.2V Li-Ion battery input
22	NC	-	No connection
23	GND	P	Ground pin
24	SYS_PWR	P	System power output BAT mode: 3.0 to 4.2V Adapter mode: 4.0V
25	BK_OUT	P	1.8V Buck output, no need to add power to this pin
26	MFB	I	• Power key in off mode • UART_RX_IND: MCU used to wake-up Bluetooth (Note 1)
27	LED1	I	LED driver 1
28	LED2	I	LED driver 2

Pin No.	Name	Pin type	Description
	..........continued		
29	P2_4	I	I/O pin, default pull-high input System Configuration L: Boot Mode with P2_0 low combination
30	P0_2	I	I/O pin, default pull-high input (Note 1) Play/Pause key (default), active-low
31	P0_3	I/O	I/O pin, default pull-high input (Note 1) • REV key (default), active low • Buzzer Signal Output • Out_Ind_1 • Class1 Rx control signal of external RF T/R switch, active-high
32	HCI_TXD	O	HCI-UART data output
33	HCI_RXD	I	HCI-UART data input
34	P0_5	I	I/O pin, default pull-high input (Note 1) Volume down (default), active-low
35	P2_7	I	I/O pin, default pull-high input (Note 1) Volume up key (default), active-low
36	P2_4	I	I/O pin, default pull-high input System Configuration, L: Boot Mode with P2_0 low combination
37	GND	P	Ground pin
38	NC	-	No Connection
39	NC	-	No Connection
40	NC	-	No Connection

- I: Input pin
- O: Output pin
- I/O: Input/Output pin
- P: Power pin

Note: All I/O pins can be configured using the IS20XXS_UI tool.

The following figure illustrates the pin diagram of the BM23 module.

Figure 1-4. BM23 Module Pin Diagram
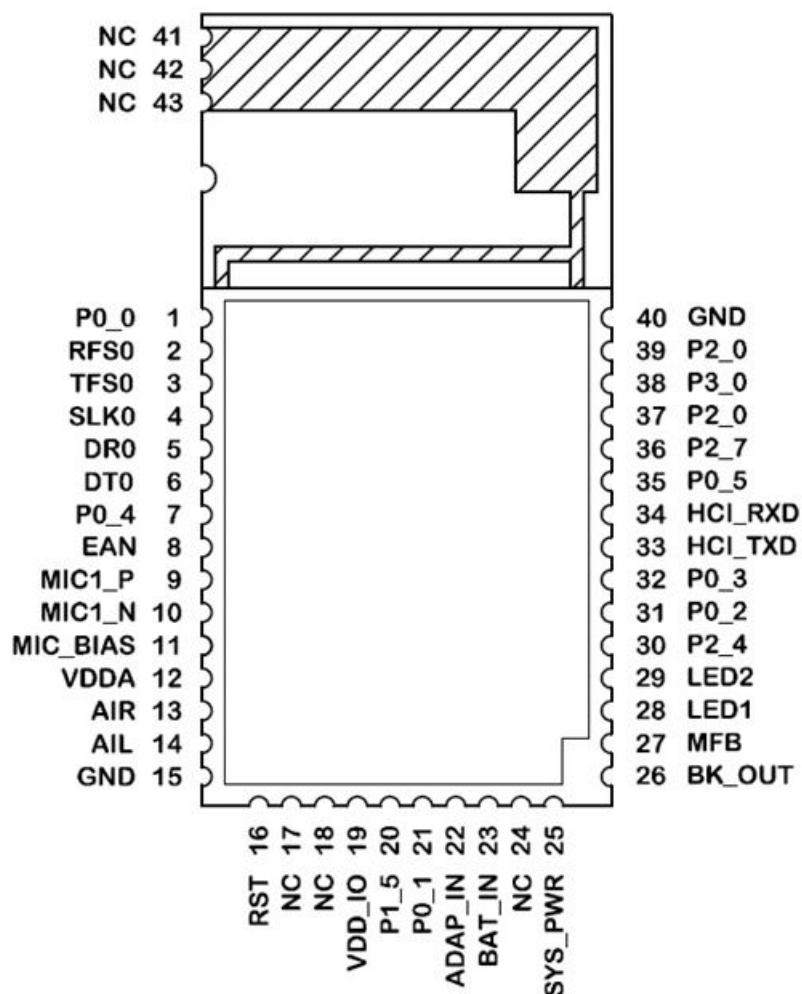
Table 1-2. BM23 Pin Description

Pin No.	Name	Pin Type	Description
1	P0_0	I/O	• I/O pin, default pull-high input (Note 1) • UART TX_IND
2	RFS0	I/O	I²S interface: DAC Left/Right clock
3	TFS0	I/O	I²S interface: ADC Left/Right clock
4	SLK0	I/O	I²S interface: Bit clock
5	DR0	I	I²S interface: DAC Digital Left/Right data
6	DT0	O	I²S interface: ADC Digital Left/Right data
7	P0_4	I/O	I/O pin, default pull-high input

Pin No.	Name	Pin Type	Description
8	EAN	I	Embedded ROM/External Flash enable High: ROM mode; Low: External Flash mode
9	MIC1_P	I	MIC 1 mono differential analog positive input
10	MIC1_N	I	MIC 1 mono differential analog negative input
11	MIC_BIAS	P	Power output, microphone biasing voltage
12	VDDA	P	Power output, reserve for external capacitance to fine tune audio frequency
13	AIR	I	Right-channel, stereo analog line-in
14	AIL	I	Left-channel, stereo analog line-in
15	GND	P	Ground
16	RST	I	System Reset pin, active when rising edge
17	NC	-	-
18	NC	-	-
19	VDDIO	P	Power output, VDDIO pin, no need to add power to this pin
20	P1_5	I/O	I/O pin, default pull-high input
21	P0_1	I/O	I/O pin, default pull-high input
22	ADAP_IN	P	5V power adapter input
23	BAT_IN	P	3.3V to 4.2V Li-Ion battery input
24	NC	-	-
25	SYS_PWR	P	System Power Output BAT mode: 3.3 to 4.2V Adapter mode: 4.0V
26	BK_OUT	P	1.8V power output, no need to add power to this pin
27	MFB	P	• Power key, when in Off mode • UART_RX_IND: MCU used to wake up Bluetooth
28	LED1	P	LED driver 1 and maximum 4 mA
29	LED2	P	LED driver 2 and maximum 4 mA
30	P2_4	I	I/O pin, default pull-high input System Configuration, L– Boot Mode with P2_0 low combination
31	P0_2	I/O	I/O pin, default pull-high input
32	P0_3	I/O	I/O pin, default pull-high input
33	HCI_TXD	O	HCI-UART data output
34	HCI_RXD	I	HCI-UART data input

...........continued

Pin No.	Name	Pin Type	Description
			..........continued
35	P0_5	I/O	I/O pin, default pull-high input
36	P2_7	I/O	I/O pin, default pull-high input
37	P2_0	I/O	I/O pin, default pull-high input
38	P3_0	I/O	I/O pin, default pull-high input
39	P2_0	I	I/O pin, default pull-high input System Configuration, H: Application L: Base band (Test Mode)
40	GND	P	Ground
41	NC	-	-
42	NC	-	-
43	NC	-	-

- I: Input pin
- O: Output pin
- I/O: Input/Output pin
- P: Power pin

Note: All I/O pins can be configured using the IS20XXS_UI tool.

2. Application Information

2.1 Operation with External MCU

The BM20/23 stereo module supports a UART command set to make an external MCU control the module. The following figure illustrates the interface between the BM20/23 module and an external MCU.

Figure 2-1. Interface between MCU and BM20/23 Module
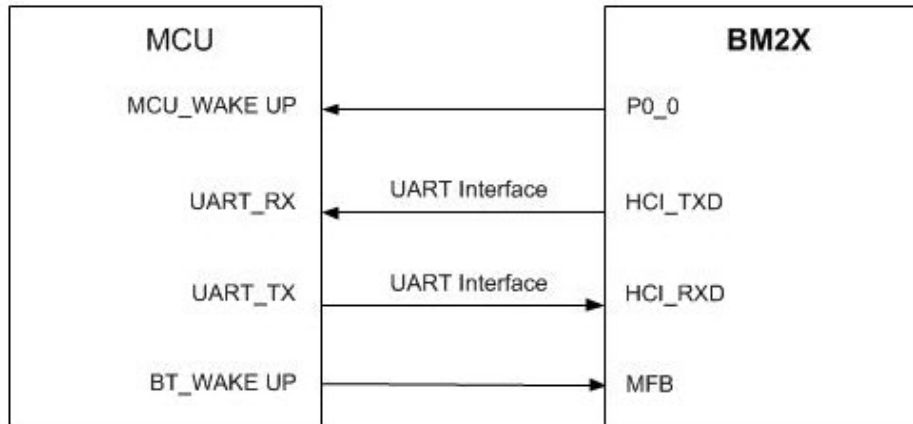
The MCU controls the module by the UART interface and wakes up the module by the PWR pin. The stereo module provides a wake-up MCU function that connects to P0_0 pin of the module.

Refer to the *UART Command Set* document for a list of functions the BM20/23 module supports and how to use the UI tool to configure the UART and UART Command Set tool.

For a more detailed description, refer to the *UART_CommandSet_v154* document and the IS20XXS_UI tool. A UART control signal timing sequence is illustrated in the following figure.

Figure 2-2. Power ON/OFF Sequence
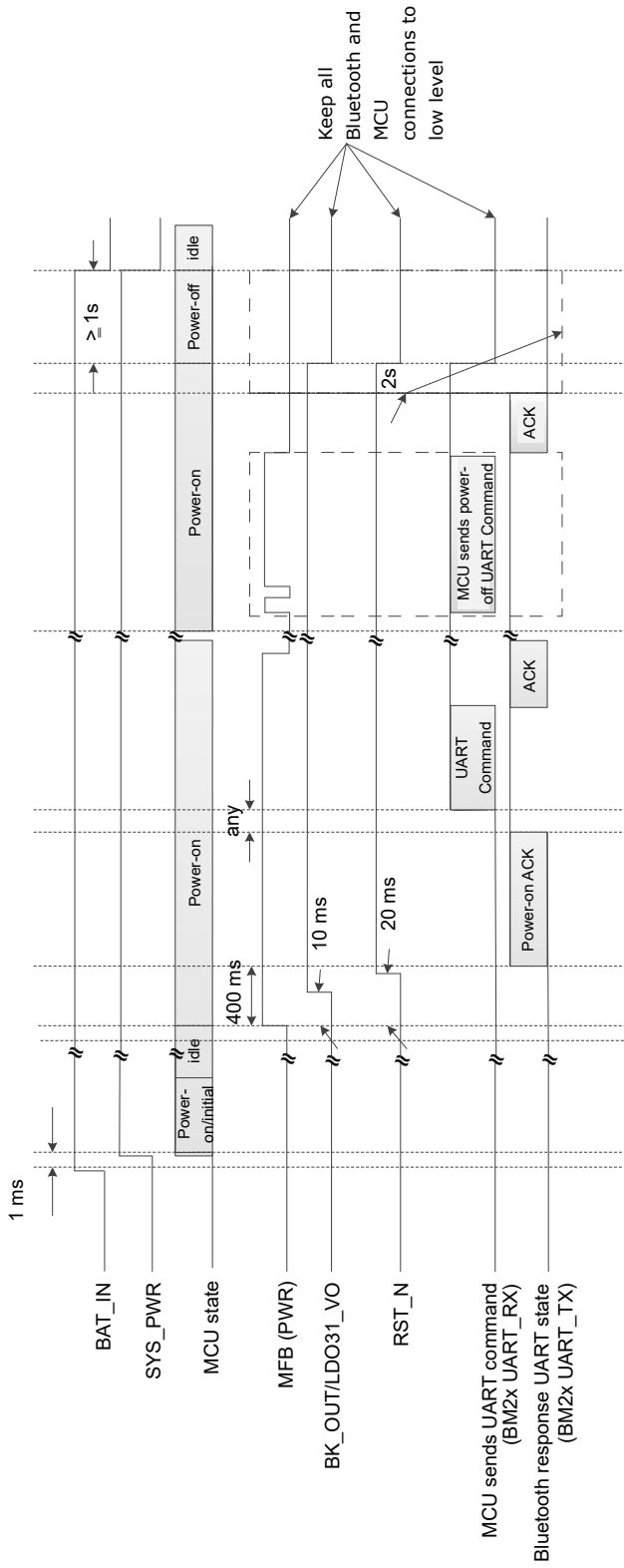
A timing sequence of Rx indication after power-on is illustrated in the following figure.

Figure 2-3. Timing Sequence of Rx Indication After Power-On
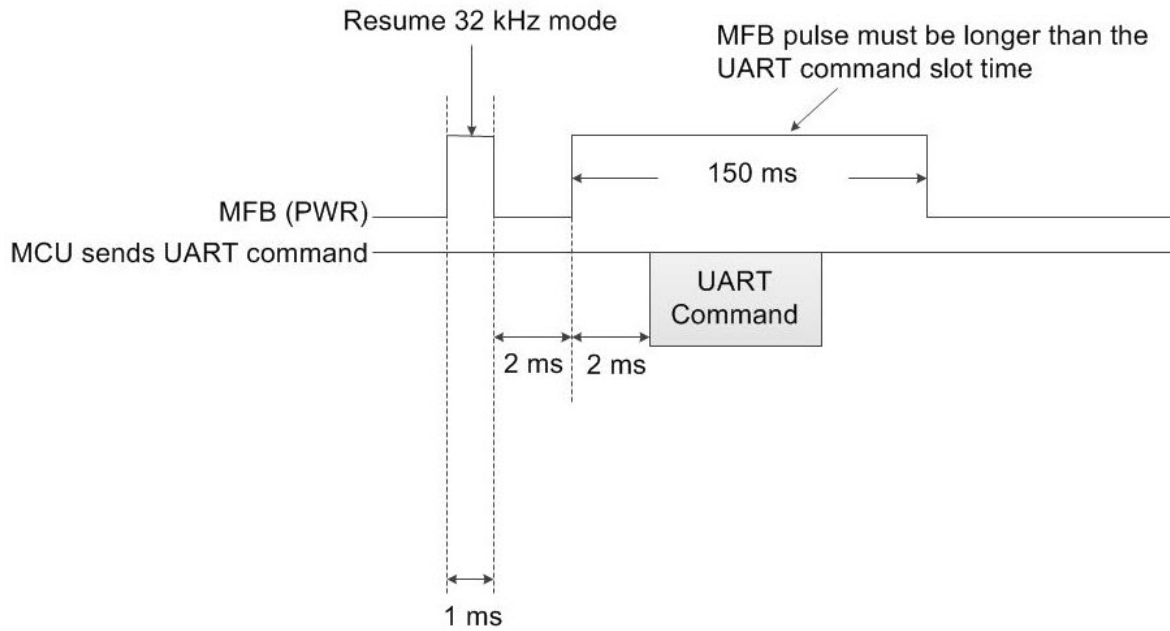
A timing sequence of Rx indication after power-off is illustrated in the following figure.

Figure 2-4. Timing Sequence of Rx Indication After Power-Off
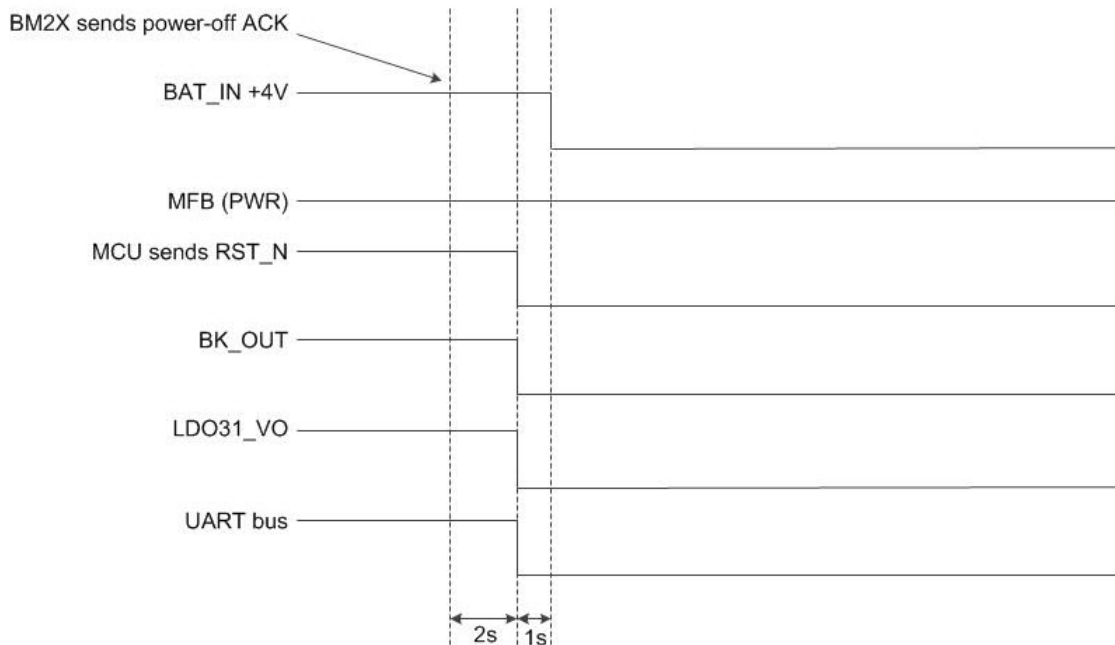
A timing sequence of power-on (Nack) is illustrated in the following figure.

Figure 2-5. Timing Sequence of Power-On (Nack)
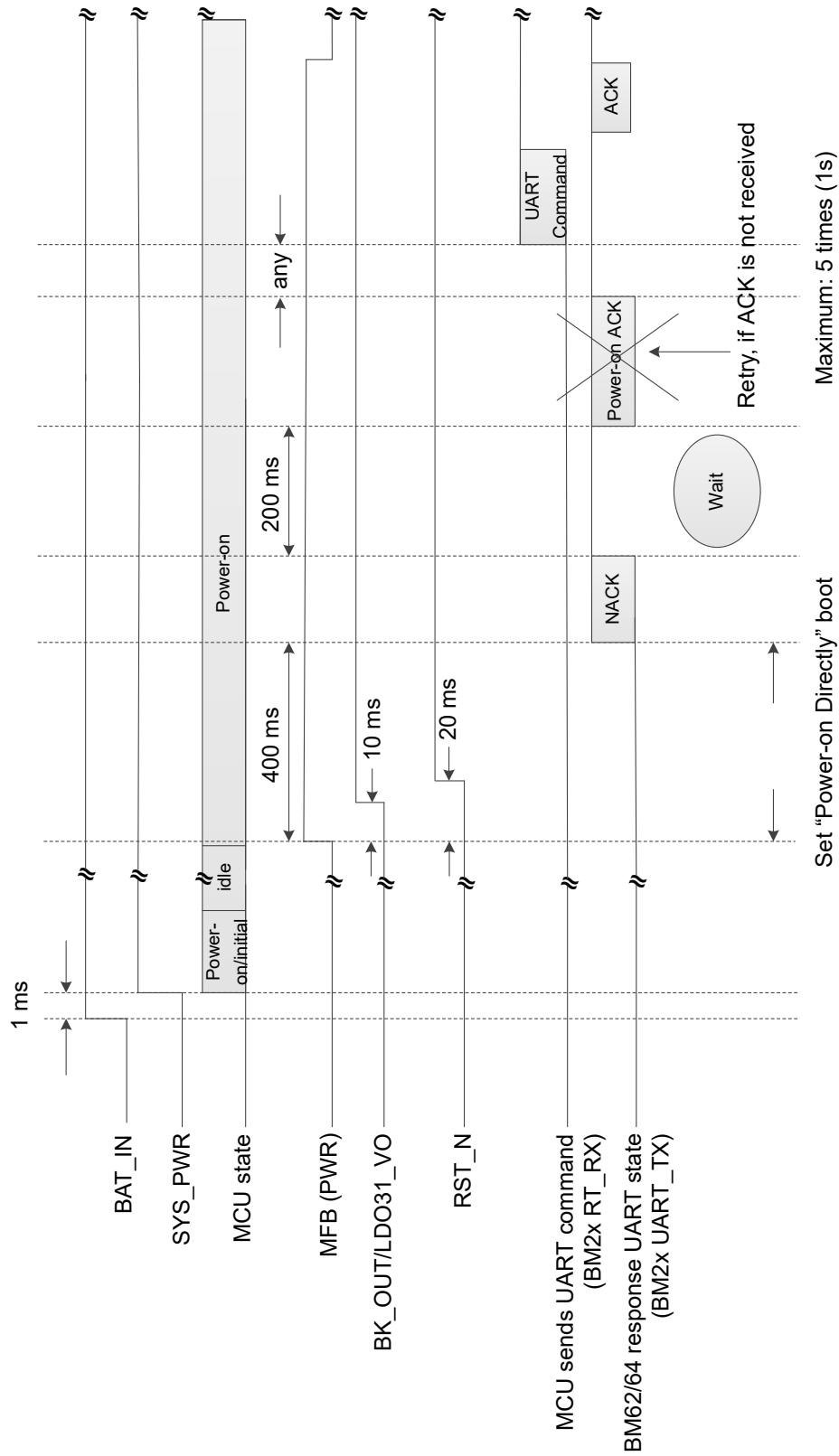
If the module is hanged, the reset timing sequence must be as illustrated in the following figure.

Figure 2-6. Reset Timing Sequence if Module is Hanged
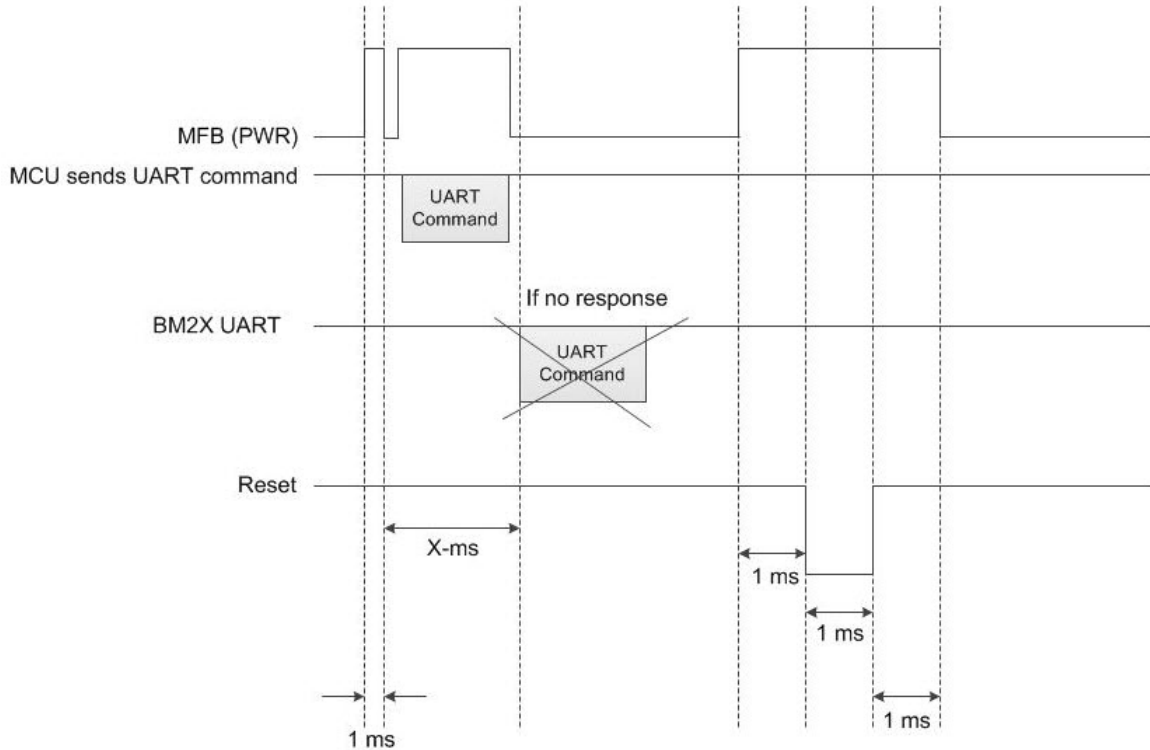
If the MCU sends a UART Command and Bluetooth does not respond within X-ms, then the MCU sends a reset signal to BT to perform the hardware reset.

A timing sequence of power drop protection is illustrated in the following figure.

Figure 2-7. Timing Sequence of Power Drop Protection
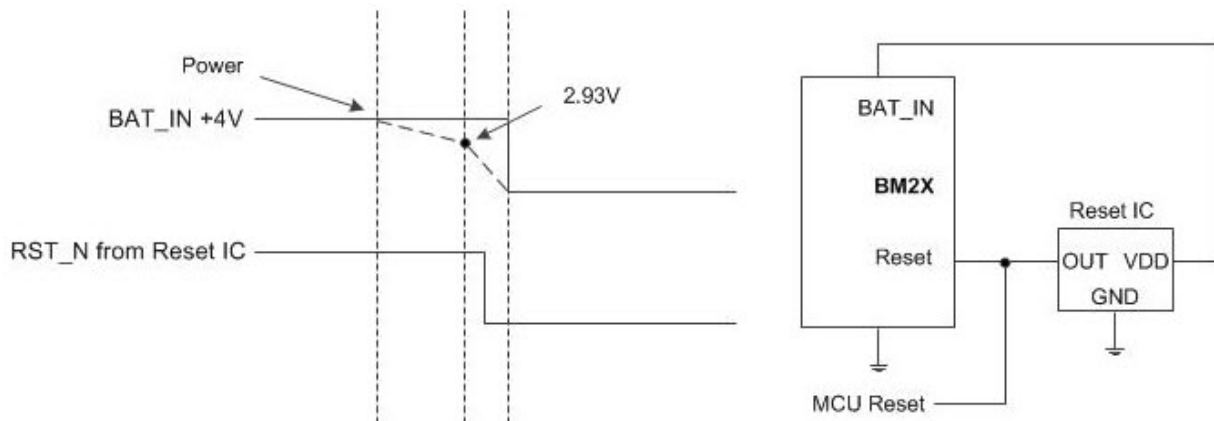
If the Bluetooth BAT uses an adapter that translates voltage by LDO, it is recommended to use "Reset IC" to avoid power-off suddenly. The Rest IC output pin must be "Open Drain" with a delay time $\leq$ 10 ms and the recommended part is TCM809SVNB713 or G691L263T73.

2.2 I²S Mode Application

The BM23 module provides an I²S digital audio signal interface to connect with an external Codec/DSP. It provides 8, 44.1 and 48 kHz sampling rates for 16-bit and 24-bit data formats. The I²S setting can be configured by using the UI and DSP tools.

The external Codec/DSP is connected to SLK0, RFS0, TFS0, DR0, and DT0 (pins 4, 2, 3, 5, and 6 respectively). The I²S signal connection between the BM23 and external DSP is illustrated in the following figure.

Figure 2-8. Master Mode Reference Connection
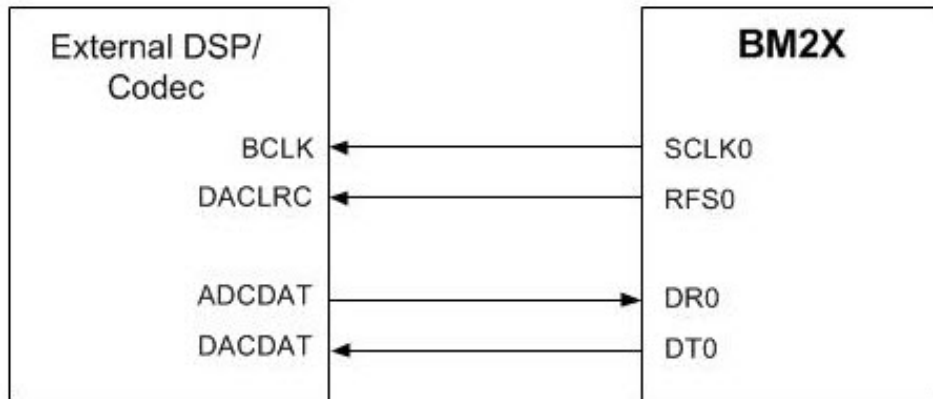
The Slave mode reference connection is shown in the following figure.

Figure 2-9. Slave Mode Reference Connection
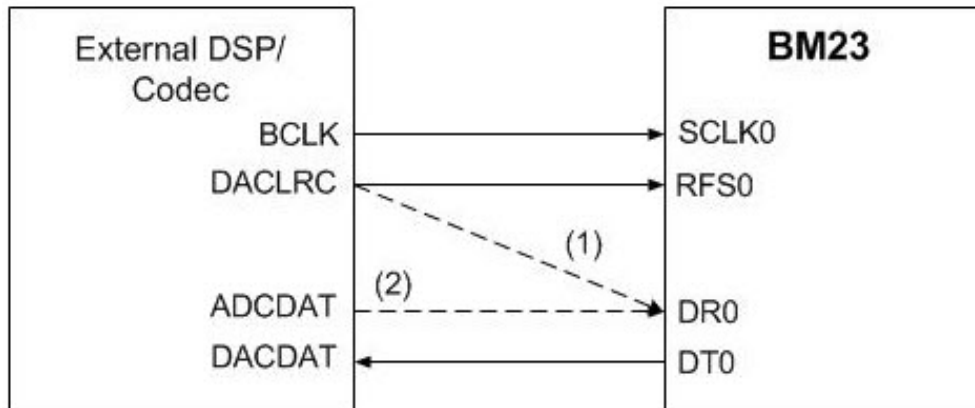
Note:
1. For 002 version chip or module, the system must connect line 1 in the above figure.
2. For other version chip or module, the system must connect line 2 in the above figure.

For Master or Slave mode setting, use the DSP Configuration Tool to set up the system. The following figures illustrate the clock and data timing diagram.

Figure 2-10. Timing for I²S Modes (both Master and Slave)
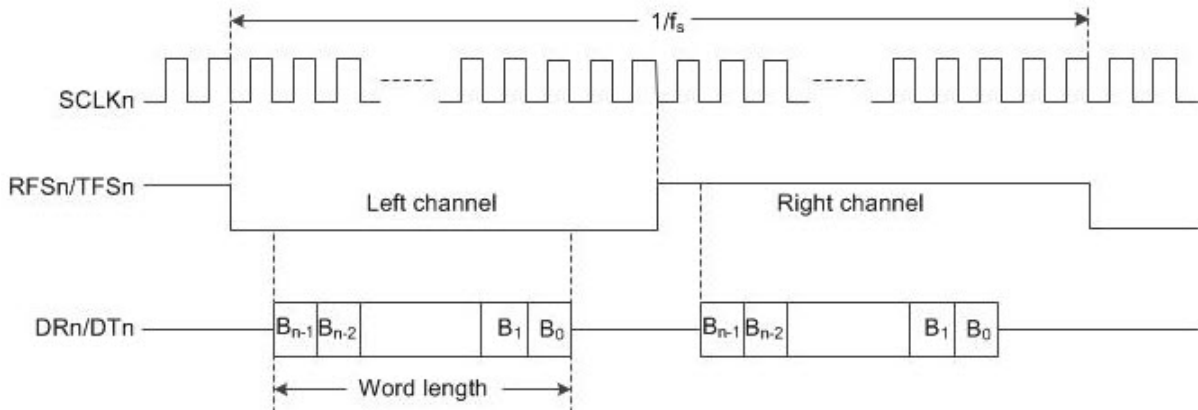
The following figures illustrate the timing diagram in the PCM modes.

Figure 2-11. Timing Diagram for PCM Modes (Master/Slave)
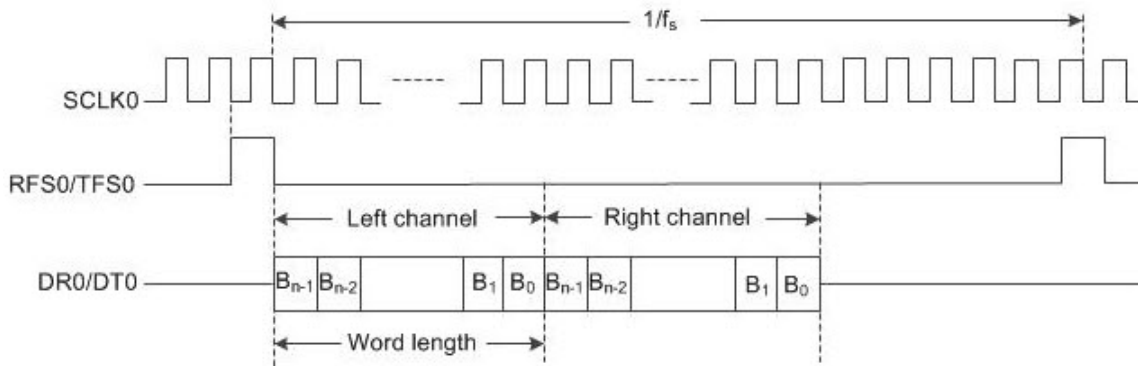
2.3   RESET (RST_N)

RST is the module reset pin, which is in Active-Low state. To reset the module, the RST_N pin must hold LOW for at least 63 ns.

2.4   Status LED (LED1, LED2)

The status LED provides the following status indications:

- Standby
- Inquiry
- Link
- Link Back
- Low Battery
- Page
- Battery Charging

Note: Each LED flashing sequence and brightness status indications are configurable by the UI tool.

2.5   External Configuration

The BM20/23 stereo module can be configured and the firmware programmed using an external configuration and programming tool available from Microchip. The following figure illustrates the configuration and firmware programming interface on BM23. It is recommended to include a pin header on the main PCB for development.

Figure 2-12. External Programming Header Connections
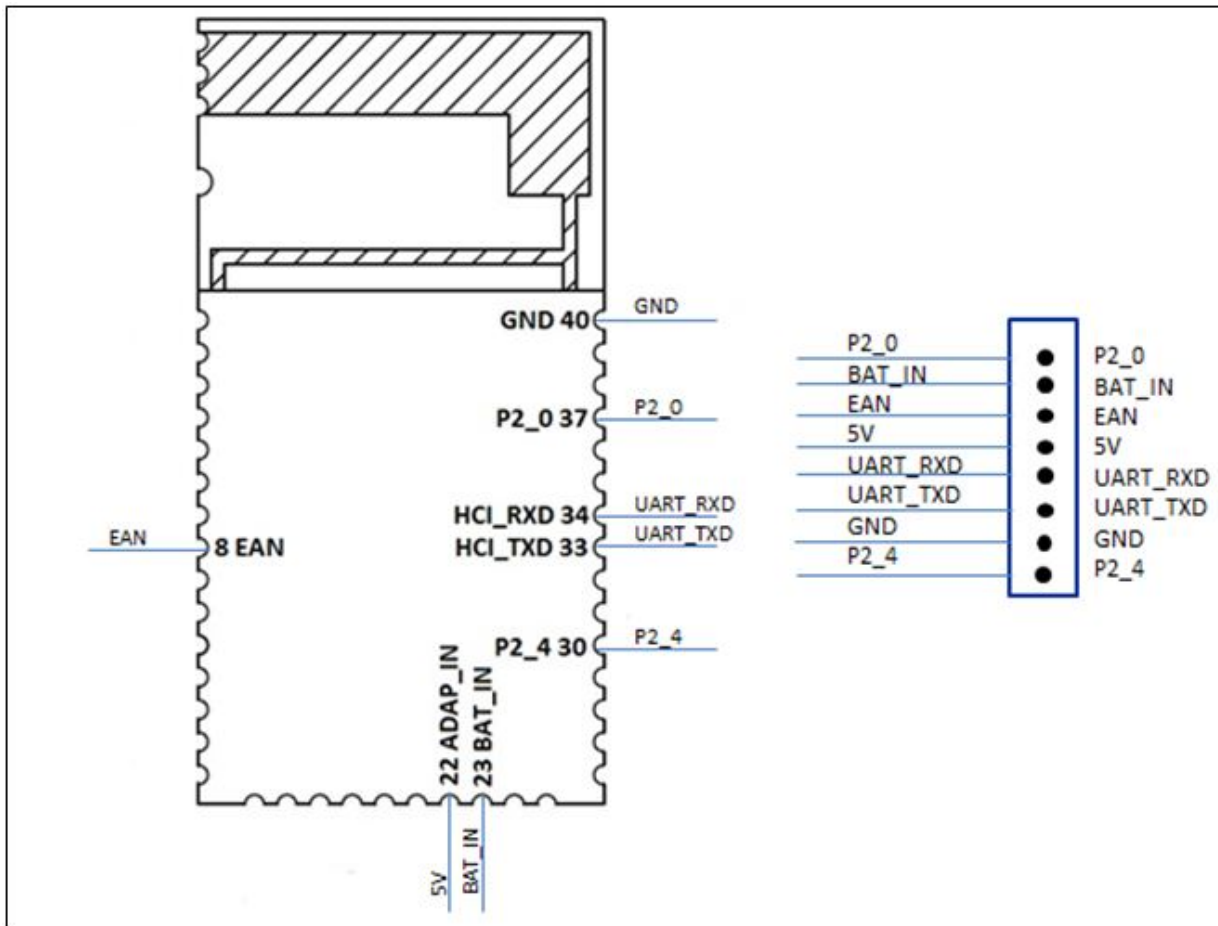
Configuration and firmware programming modes are entered according to the system configuration I/O pins as shown in the following table. Pins P20, P24 and EAN contain internal pull-up.

Table 2-1. System Configuration Settings

P20	P24	EAN	Operational Mode
High	High	High	APP mode (Normal operation)
Low	High	High	APP mode (Normal operation)
Low	Low	High	Write Flash (Firmware programming, if flash build-in in chip)

3. Electrical Characteristics

The following table provides the absolute maximum specification conditions of the BM20/23 module.

Table 3-1. Absolute Maximum Specification

Symbol	Parameter	Min.	Max.	Unit
BAT_IN	Input voltage for battery	0	4.3	V
ADAP_IN	Input voltage for adapter	0	7.0	V
T_{STORE}	Storage temperature	-65	+150	ºC
$T_{OPERATION}$	Operation temperature	-20	+70	ºC

The following table provides the recommended operating condition of the BM20/23 module.

Table 3-2. Recommended Operating Condition

Symbol	Parameter	Min.	Typical	Max.	Unit
BAT_IN	Input voltage for battery	3	3.7	4.2	V
ADAP_IN	Input voltage for adapter	4.5	5	5.5	V
$T_{OPERATION}$	Operation temperature	-20	+25	+70	ºC

Note: The absolute and recommended operating condition tables reflect typical usage for device.

⚠ **CAUTION** Stresses listed under Absolute Maximum Ratings cause permanent damage to the device. This is a stress rating only. The functional operation of the device at those or any other conditions and those indicated in the operation listings of this specification, is not implied. Exposure to maximum rating conditions for extended periods affects the device reliability.

The parameters of the I/O and reset level are shown in the following table.

Table 3-3. I/O and Reset Level

Parameter	Min.	Typ.	Max.	Units
I/O supply voltage (VDD_IO)	2.7	-	3.3	V
I/O Voltage Levels				
V_{IL} input logic levels low	-0.3	-	0.8	V
V_{IH} input logic levels high	2.0	-	3.6	V
V_{OL} output logic levels low	-	-	0.4	V
V_{OH} output logic levels high	2.4	-	-	V
RESET				
$V_{TH,RES}$ threshold voltage	-	1.6	-	V

Note:
1. VDD_IO voltage is programmable by EEPROM parameters.
2. These parameters are characterized but not tested in manufacturing.

The parameters of the battery charger are shown in the following table.

Table 3-4. Battery Charger

Parameter		Min	Typical	Max	Unit
ADAP_IN input voltage		4.5	5.0	5.5	V
Supply current to charger only		-	3	4.5	mA
Maximum battery Fast charge current Note: ENX2=0	Headroom > 0.7V (ADAP_IN=5V)	170	200	240	mA
	Headroom = 0.3V (ADAP_IN=4.5V)	160	180	240	mA
Maximum battery Fast charge current Note: ENX2=1	Headroom > 0.7V (ADAP_IN=5V)	330	350	420	mA
	Headroom = 0.3V (ADAP_IN=4.5V)	180	220	270	mA
Trickle charge voltage threshold		-	3	-	V
Battery charge termination current, (% of fast charge current)		-	10	-	%

Note:
1. Headroom = VADAP_IN – VBAT
2. ENX2 is not allowed to be enabled, when VADAP_IN – VBAT > 2V
3. These parameters are characterized but not tested in manufacturing

The parameters of the LED driver are shown in the following table.

Table 3-5. LED driver

Parameter	Min	Typical	Max	Unit
Open-drain voltage	-	-	3.6	V
Programmable current range	0	-	5.25	mA
Intensity control	-	16	-	Step
Current step	-	0.35	-	mA
Power down open-drain current	-	-	1	µA
Shutdown current	-	-	1	µA

Note:
1. Test condition: SAR_VDD = 1.8V, temperature = 25 ºC.
2. These parameters are characterized but not tested in manufacturing.

The parameters of the audio Codec ADC are provided in the following table.

T= 25ºC, V_{dd} = 3.0V, 1 kHz sine wave input, Bandwidth = 20 Hz to 20 kHz.

Table 3-6. Audio Codec ADC

Parameter (Condition)	Min.	Typ.	Max.	Unit
Resolution	-	-	16	Bits
Output sample rate	8	-	48	kHz

..........continued

Parameter (Condition)	Min.	Typ.	Max.	Unit
Signal-to-Noise Ratio **Note: 1** (SNR at MIC or Line-in mode)		88	-	dB
Digital gain	-54		4.85	dB
Digital gain resolution	-	2 to 6	-	dB
MIC boost gain	-	20	-	dB
Analog gain	-	-	60	dB
Analog gain resolution	-	2.0	-	dB
Input full-scale at maximum gain (differential)	-	4	-	mV rms
Input full-scale at minimum gain (differential)	-	800	-	mV rms
3 dB bandwidth	-	20	-	kHz
Microphone mode (input impedance)	-	24	-	kOhm
THD+N (microphone input) at 30 mV/rms input	-	0.02	-	%

Note:
1. f_{in} = 1 kHz, B/W = 20 Hz to 20 kHz, A-weighted, THD+N < 1%, 150 mV$_{pp}$ input.
2. These parameters are characterized but not tested in manufacturing.

The parameters of the audio Codec DAC are provided in the following table.

T = 25℃, V$_{dd}$ = 3.0V, 1 kHz sine wave input, Bandwidth = 20 Hz to 20 kHz

Table 3-7. Audio Codec DAC

Parameter	Min.	Typ.	Max.	Unit
Over-sampling rate	-	128	-	f_s
Resolution	16	-	20	Bits
Output sample rate	8	-	48	kHz
Signal-to-Noise Ratio (**Note: 1**) (SNR at Capless mode) for 48 kHz	-	96	-	dB
Signal-to-Noise Ratio (**Note: 1**) (SNR at Single-Ended mode) for 48 kHz	-	98	-	dB
Digital gain	-54	-	4.85	dB
Digital gain resolution	-	2 to 6	-	dB
Analog gain	-28	-	3	dB
Analog gain resolution	-	1	-	dB
Output voltage full-scale swing (AVDD=2.8V) (**Note: 3**)	-	742.5	-	mV/rms
Maximum output power (16 Ohm load)	-	34.5	-	mW

Parameter	Min.	Typ.	Max.	Unit
..........continued				
Maximum output power (32 Ohm load)	-	17.2	-	mW
Allowed load (Resistive)	8	16	O.C.	Ω
Allowed load (Capacitive)	-	-	500	pF
THD+N (16 Ohm load)	-	-	0.05	%
Signal-to-Noise Ratio (SNR at 16 Ohm load)	-	-	96	dB

Note:
1. fin = 1 kHz, B/W = 20 Hz to 20 kHz, A-weighted, THD+N < 0.01%, 0 dBFS signal, Load = 100 kOhm.
2. These parameters are characterized but not tested in manufacturing.
3. V_{dd} and AVDD are generated by internal LDO.

The parameters of the transmitter section for BDR and EDR are shown in the following table.

Test condition: VCC_RF= 1.28V, temperature=25ºC.

Table 3-8. Transmitter section for BDR and EDR

Parameter	Min.	Typ.	Max.	Bluetooth specifications	Unit
Maximum RF transmit power (BM20	-	-	-	-6 to 4	dB
Maximum RF transmit power (BM23)	-	2	-	-6 to 4	-
EDR/BDR Relative transmit power	-4	-1.2	1	-4 to 1	dB

Note: The RF Transmit power is calibrated during production using MP Tool software and MT8852 Bluetooth Test equipment.

The parameters of the receiver section for BDR and EDR are shown in the following table.

Test condition: VCC_RF = 1.28V, temperature = 25ºC.

Table 3-9. Receiver Section for BDR and EDR

Parameters	Modulation	Min.	Typ.	Max.	Bluetooth Specification	Unit
Sensitivity at 0.1% BER	GFSK	-	-90	-	≤-70	dBm
Sensitivity at 0.01% BER	π/4 DQPSK	-	-91	-	≤-70	dBm
	8DPSK	-	-82	-	≤-70	dBm

Note: These parameters are characterized but not tested in manufacturing.

The parameters of system current consumption of analog audio output are shown in the following table.

Test condition: BAT_IN = 3.8V, link with HTC EYE cell phone; distance between cell phone and EVB is 30 cm.

Table 3-10. System Current Consumption of Analog Audio Output

System Status	Typ.	Max.	Unit
System off mode	2	5	µA
Standby mode	0.8	-	mA
Linked mode	0.4	-	mA
SCO link	7.8	-	mA
A2DP link (V_{p-p} = 200 mV; 1k tone signal)	10.7	-	mA

Note: Use BM20 EVB as a test platform.

The parameters of system current consumption of digital audio output are shown in the following table.

Test condition: BAT_IN = 3.8V, link with HTC M8 cell phone; distance between cell phone and EVB is 30 cm; I^{2}S signal link with YAMAHA YDA174 EVB.

Table 3-11. System Current Consumption of Digital Audio Output

System status	Typ	Max	Unit
System Off mode	2	5	µA
Standby mode	0.4	-	mA
Linked mode	0.4	-	mA
SCO link	9.3	-	mA
A2DP link (1k tone signal)	11.7	-	mA

Note: Use BM23 EVB as a test platform.

4.   Printed Antenna Information

4.1   Module Radiation Pattern

The stereo module contains a PCB printed antenna. The PCB printed antenna radiation pattern is illustrated in the following figure.

Figure 4-1. Antenna Keep Out Area Examples
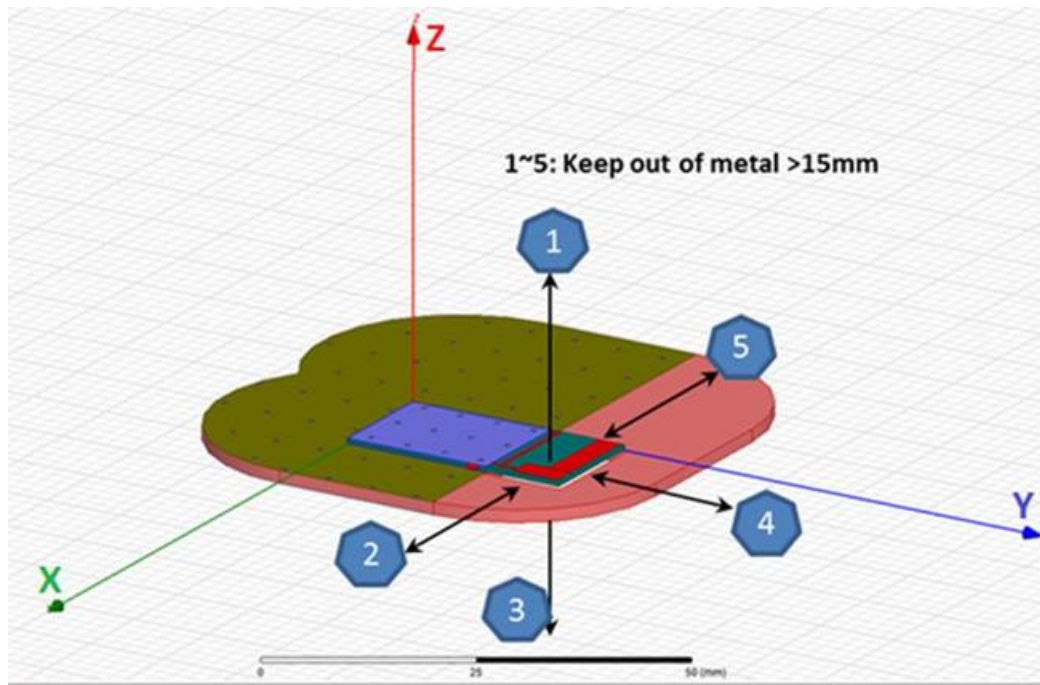
Figure 4-2. PCB Antenna 3D Radiation Pattern at 2441 MHZ
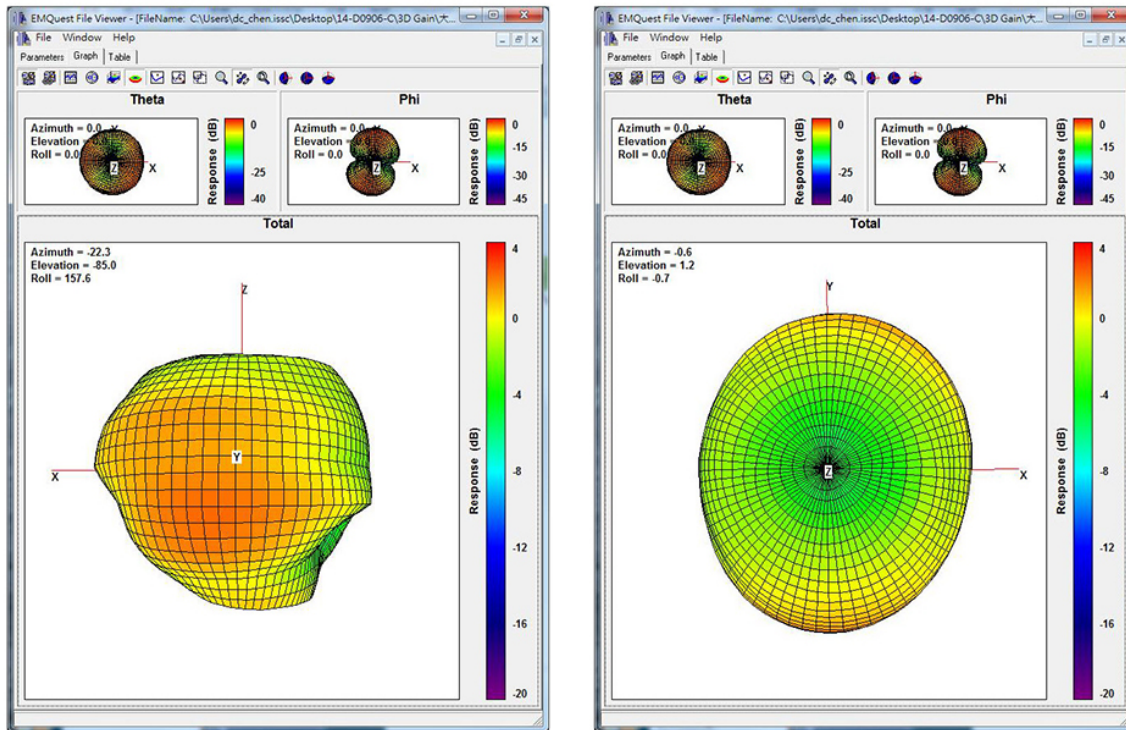
The following table provides the details of BM2X PCB Antenna characteristics.

Table 4-1. BM2x PCB Antenna Characteristics

Parameter	Values
Frequency	2400 MHz to 2480 MHz
Peak Gain	1.927 dBi
Efficiency	73.41%

4.2   Module Placement Rules

On the main PCB, the areas under the antenna should not contain any top, inner layer, or bottom copper as shown in the below figure. A low-impedance ground plane will ensure the best radio performance (best range, lowest noise). The ground plane can be extended beyond the minimum recommended as needed for the main PCB EMC noise reduction. For the best range performance, keep all external metal at least 15 mm away from the ceramic chip antenna.

Figure 4-3. Module Placement Examples
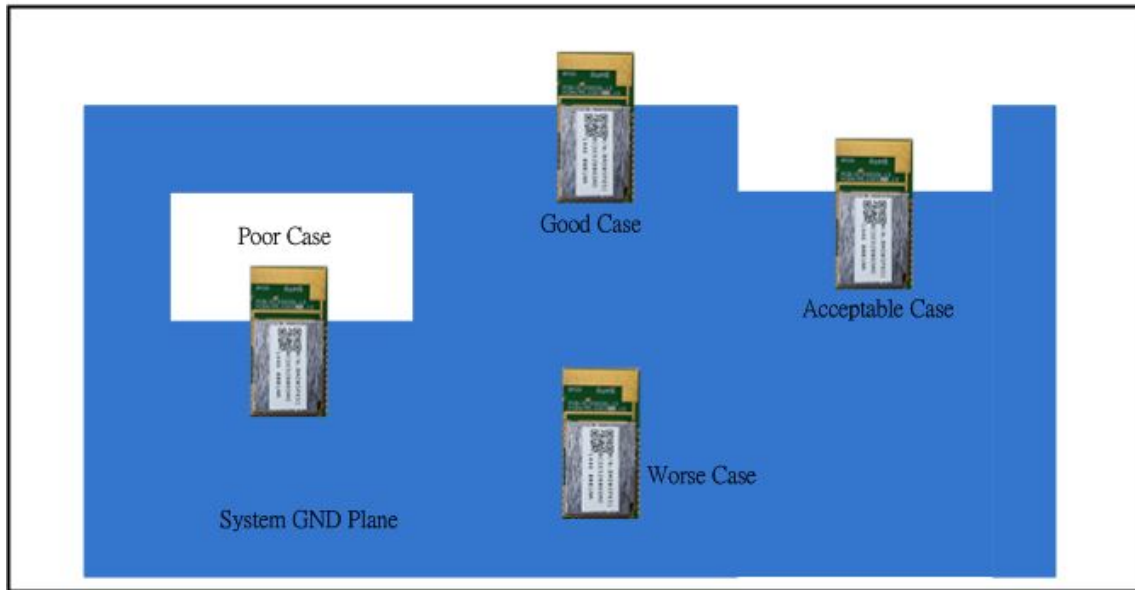
Figure 4-4. GND Plane on Main Application Board
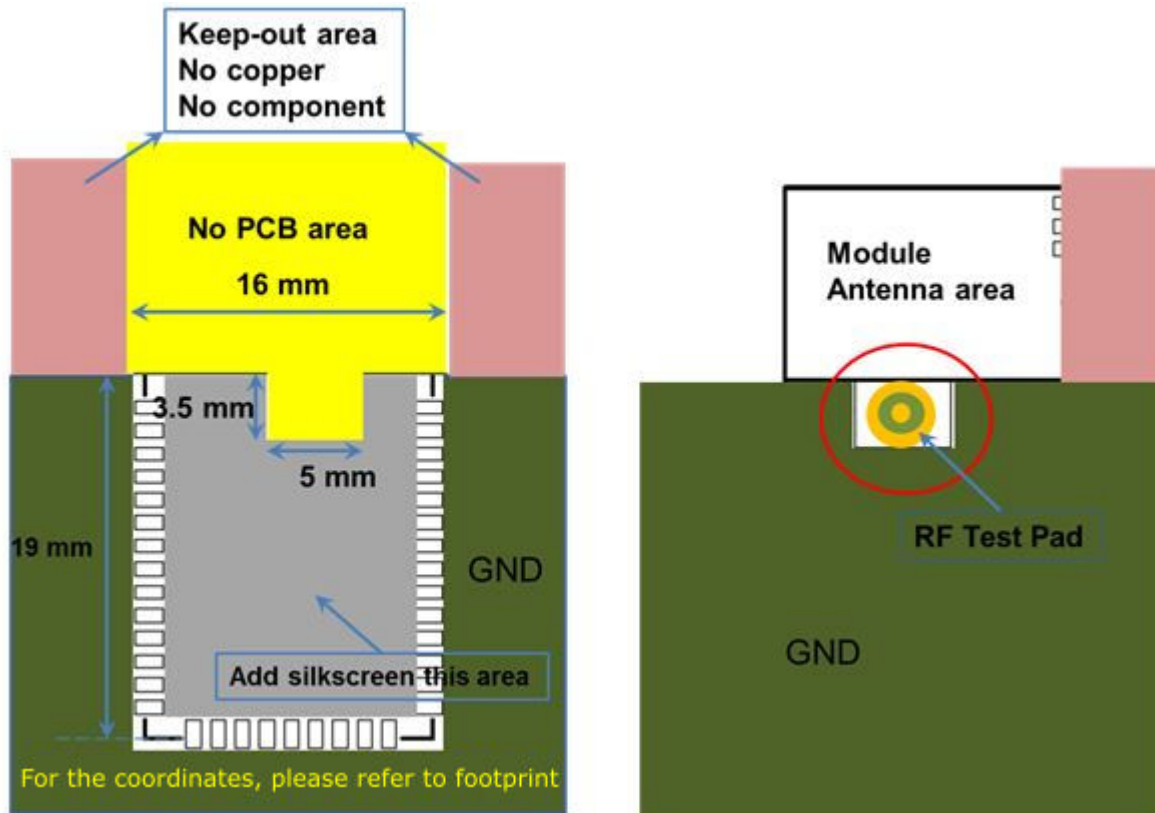
5.   Reference Circuit

This section provides the reference schematics of BM20 and BM23 modules.

5.1   BM20 Reference Circuit

The following figures illustrate the reference schematics of the BM20 module.

BM20/23
Reference Circuit

Figure 5-1. BM20 Reference Circuit
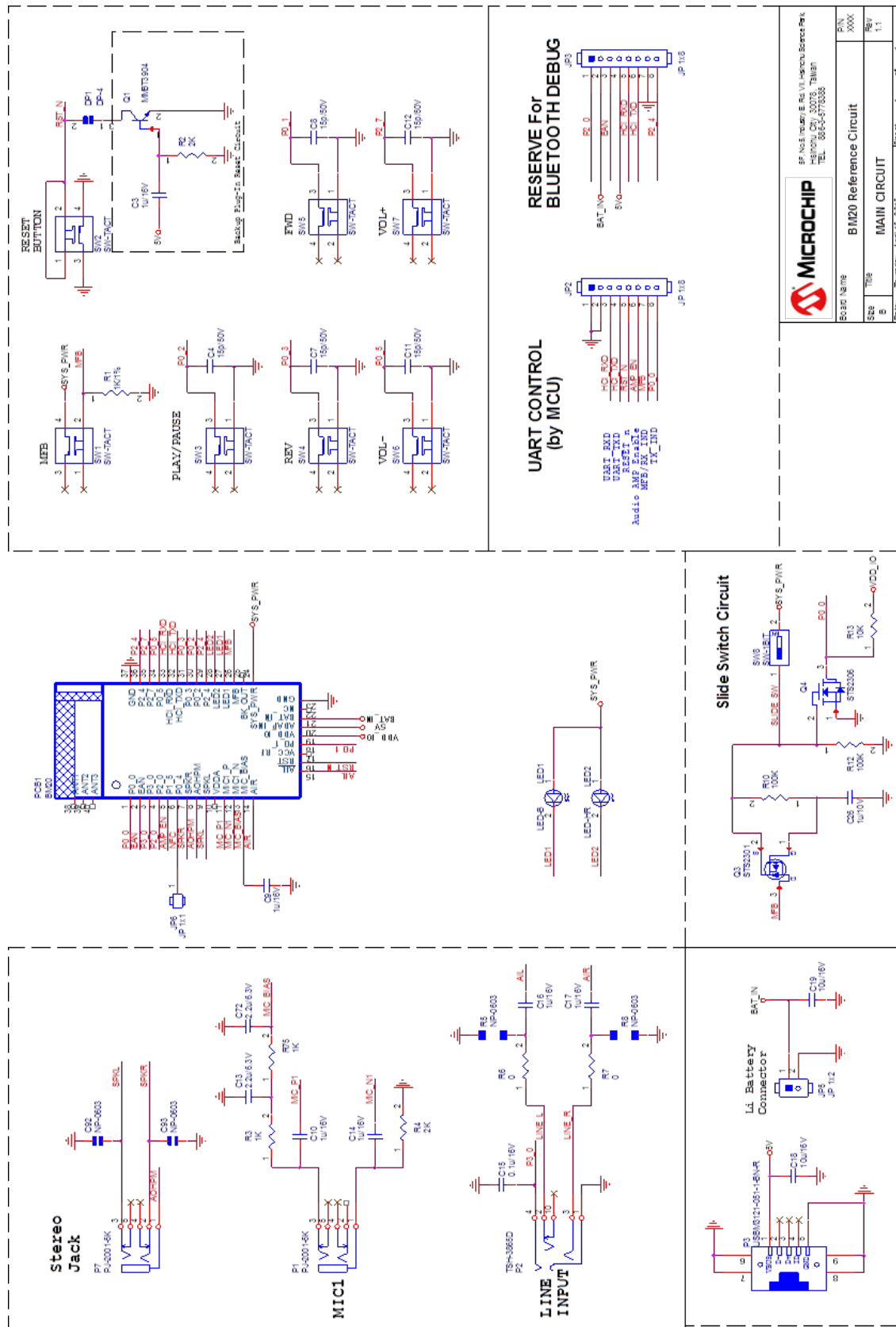
Figure 5-2. BM20 Reference Circuit
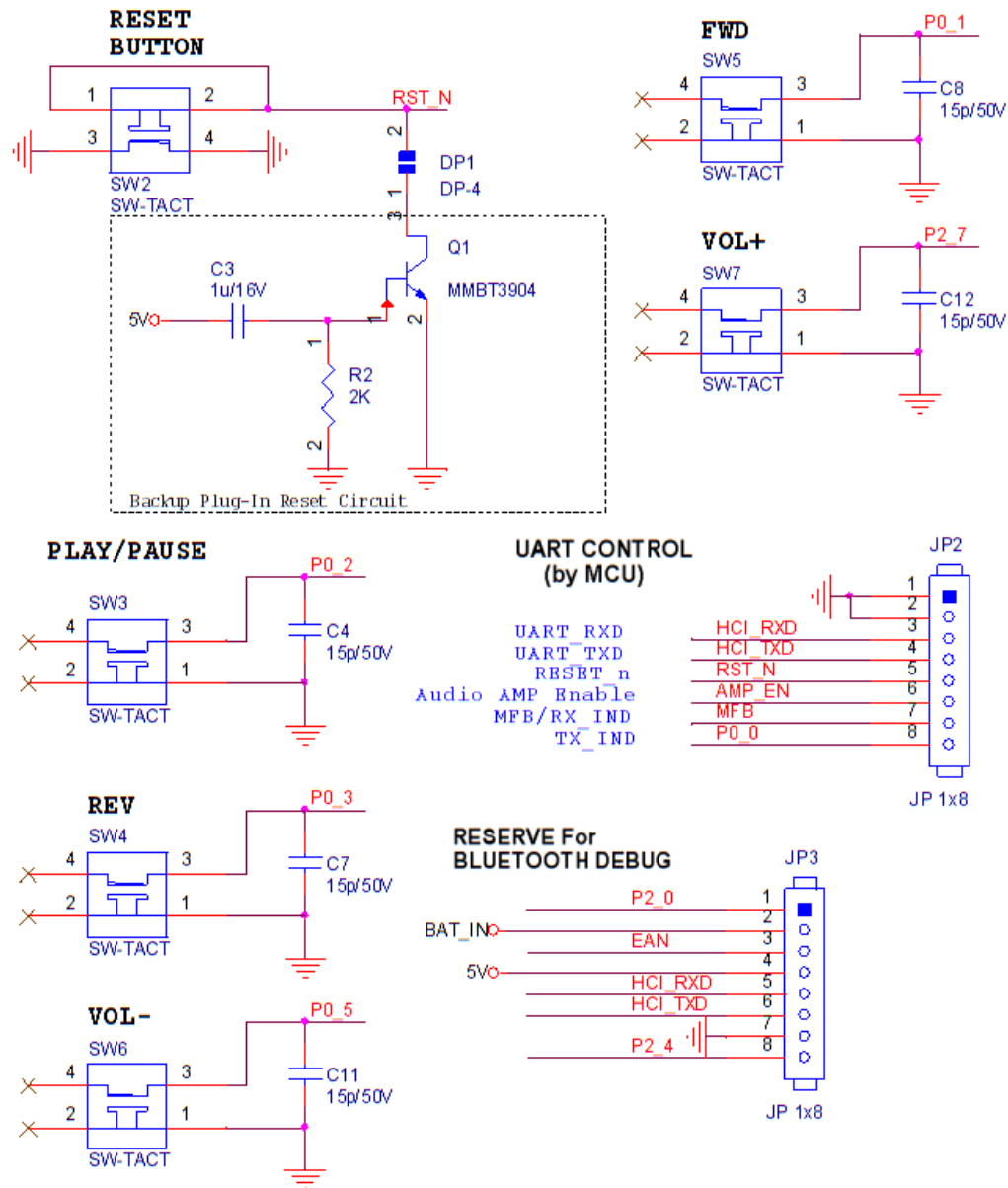
5.2 BM23 Reference circuit

The following figures illustrate the reference circuit of the BM23 module.

Figure 5-3. BM23 Reference circuit

GPIO Description

P0_0	UART_TX_IND(Flash)
P0_4	Audio AMP Enable(ROM)
P2_0	System Configuration
P2_4	System Configuration
P3_0	LINE IN Detection
MFB	PWR/MFB/UART_RX_IND
EAN	System Configuration

STEREO AUX LINE INPUT

AIR

AIL

C9 10u/16V

C10 10u/16V

C8 470p/50V

C12 470p/50V

R9 10K

R12 10K

R10 1K

R11 1K

D1 SPE0572

D3 SPE0572

D2 SPE0572

C11 0.1u/16V

P3_0

P1 PJ-3894D-S125

*P30 Low Active Line In Detect

RESERVE For BLUETOOTH DEBUG

JP3

JP 1x8

P2_0

EAN

HCI_RXD

HCI_TXD

P2_4

BAT_IN

ADAP_IN

UART CONTROL (by MCU)

JP2

JP 1x8

HCI_RXD

HCI_TXD

RST_N

AMP_EN

MFB

P0_0

UART_RXD

UART_TXD

RESET_n

Audio AMP Enable

MFB/RX_IND

TX_IND

P0_4

DP1 DP-4

I2S INTERFACE

JP1

JP 1x8

R2 33

R3 33

R1 33

R5 33

R4 33

RFS0

TFS0

SLK0

DR0

DT0

Receive frame synchronization
Transmit frame synchronization
Serial clock
Serial data receive
Serial data transmit

MIC INPUT

C2 2.2u/6.3V

MIC_BIAS

C3 0.047u/25V

MIC_P1

C6 0.047u/25V

MIC_N1

C4 220p/50V

R7 1K

C1 2.2u/6.3V

R6 1K

R8 2K

TP1 TP-4

TP3 TP-4

© 2019 Microchip Technology Inc.

Figure 5-4. BM23 Reference circuit
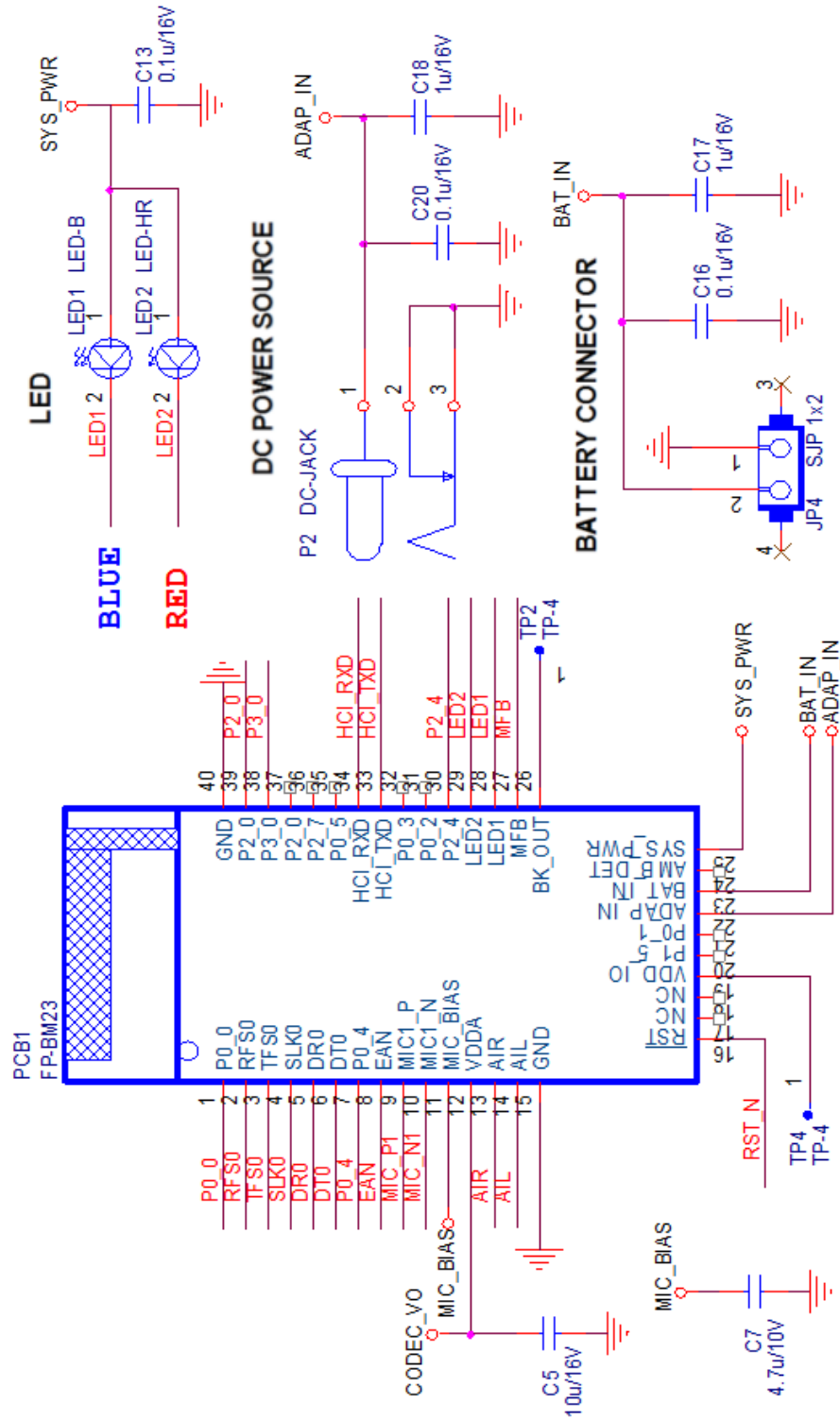
6. Physical Dimensions

The following figure shows the PCB dimension of BM20 module.

Figure 6-1. BM20 Module PCB dimension
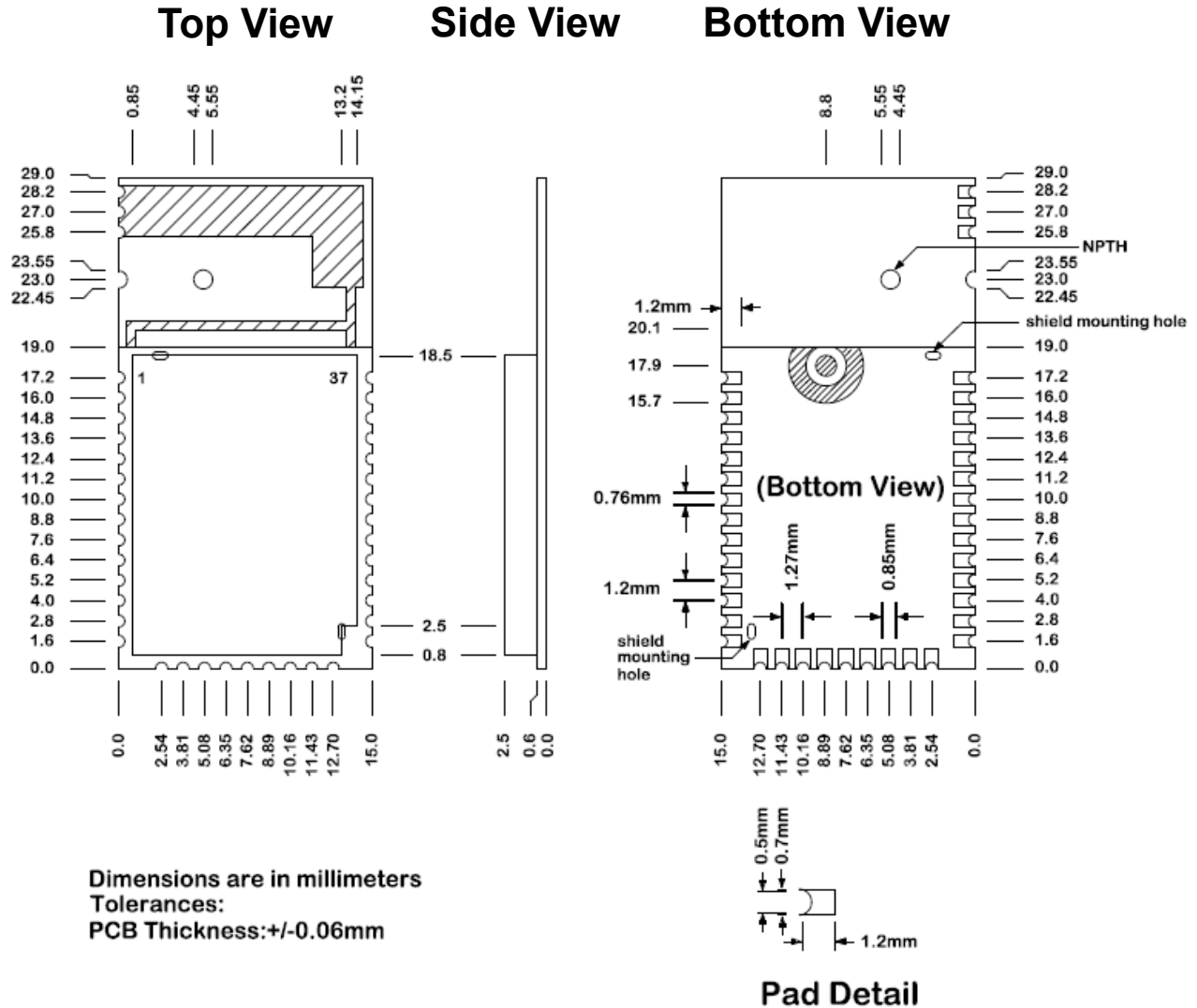
PCB dimension:

- X: 15.0 mm
- Y: 29.0 mm
- Tolerances: 0.25 mm

The following figure shows the PCB dimension of BM23 module.

Figure 6-2. BM23 Module PCB dimension
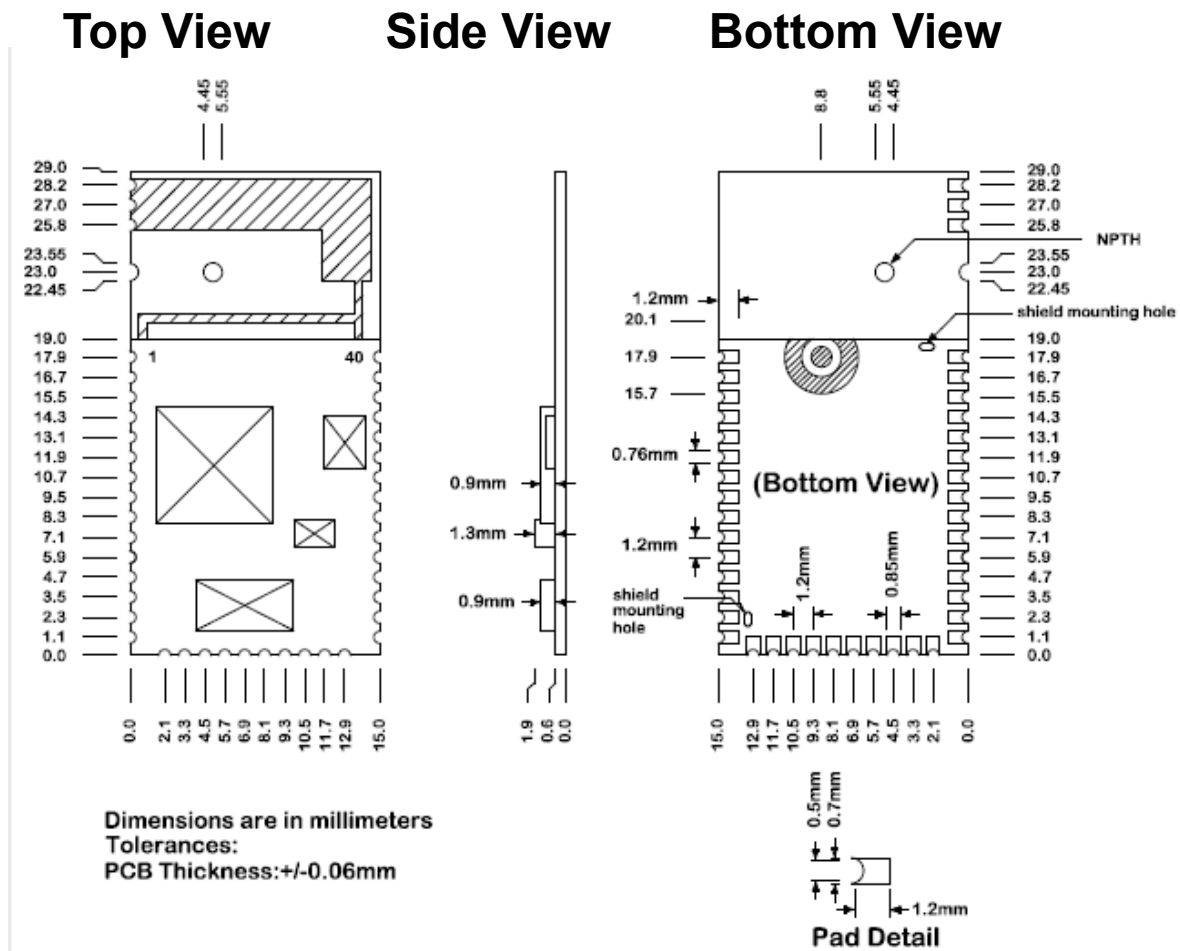
Dimensions are in millimeters
Tolerances:
PCB Thickness:+/-0.06mm

PCB dimension:

- X: 15.0 mm
- Y: 29.0 mm
- Tolerances: 0.25 mm

The following figure provides the recommended PCB footprint of the BM20 module.

Figure 6-3. BM20 module PCB Footprint
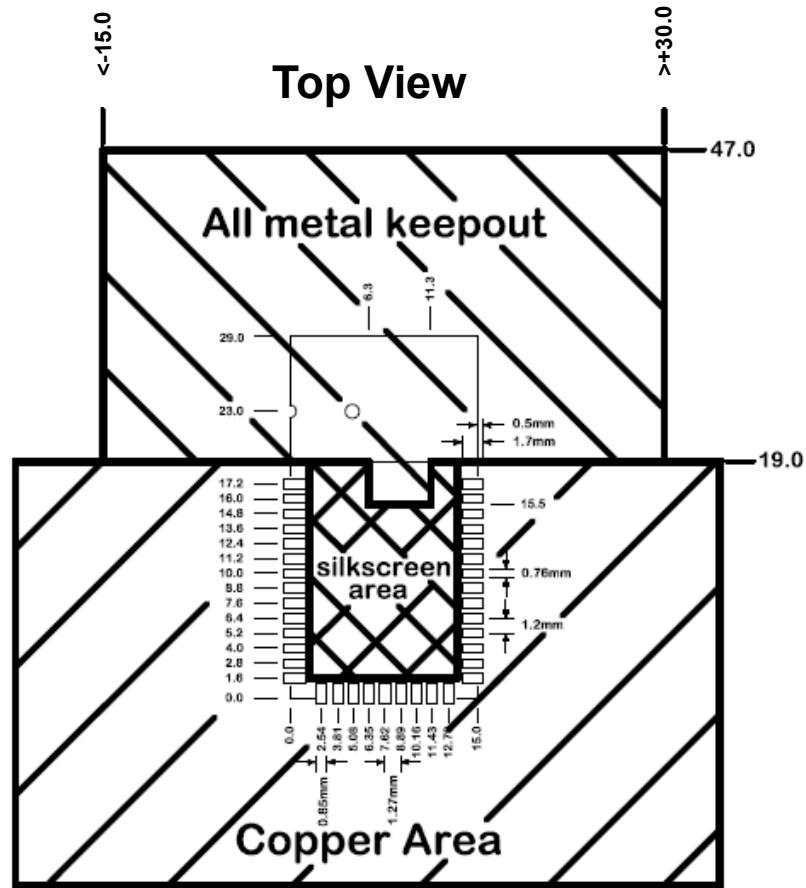
Note 1:The keep-out area is reserved to keep the RF test point away from GND plane.
2: All metal keep-out is used to isolate the PCB antenna.

The following figure provides the recommended PCB footprint of the BM23 module.

Figure 6-4. BM23 module PCB Footprint

Note 1:The keep-out area is reserved to keep the RF test point away from GND plane.
    2: All metal keep-out is used to isolate the PCB antenna.

7. Reflow Profile

The following figure illustrates the reflow profile of the BM20/23 module.

Figure 7-1. Reflow Profile

7.1 Soldering Recommendations

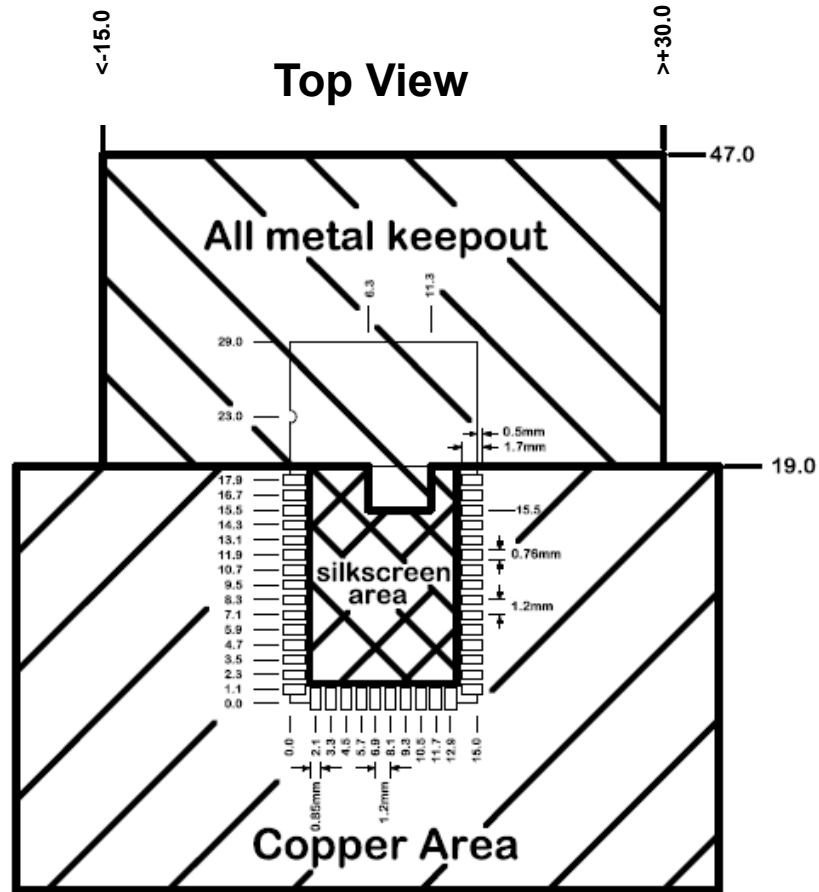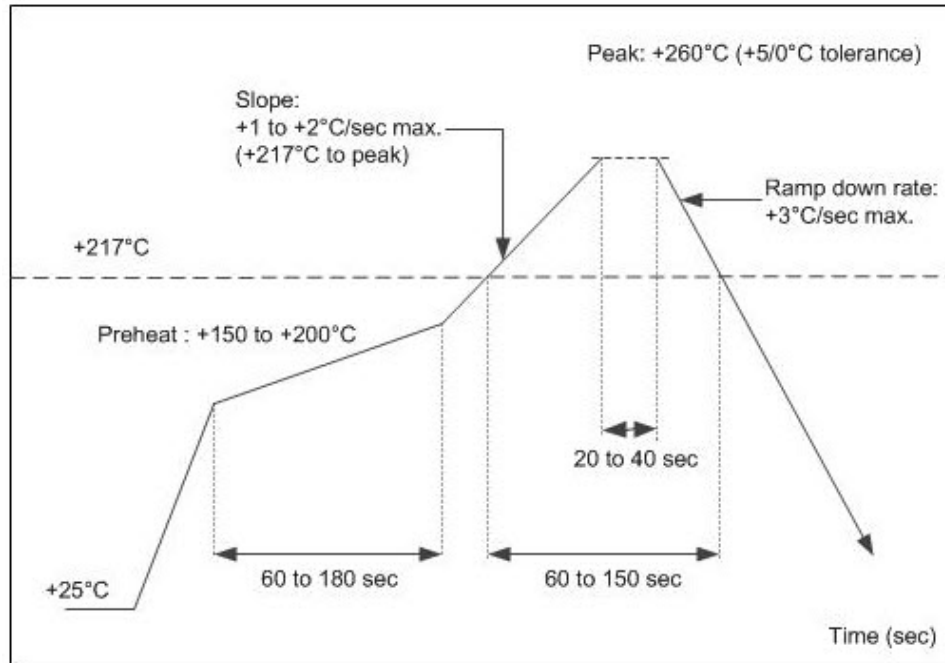The BM20/23 module is assembled using a standard lead-free reflow profile IPC/JEDEC J-STD-020. The BM20/23 module can be soldered to the main PCB using standard leaded and lead-free solder reflow profiles.

To avoid the damage to the module, follow these recommendations:

- Refer to Microchip Technology Application Note *AN233 Solder Reflow Recommendation* (DS00233) for the soldering reflow recommendations
- Do not exceed peak temperature (T_P) of +250℃
- Refer to the Solder Paste data sheet for specific reflow profile recommendations
- Use no-clean flux solder paste
- Do not wash the module, as moisture can be trapped under the shield
- Use only one flow. If the PCB requires multiple flows, apply the module on the final flow

7.2 Packing and Storage Information

The module is packaged into trays of sixty-three (63) modules in a 7 x 9 format (see the following figure). These trays are then sealed into bags. 10 sealed bags are then placed in a box of 630 pieces with a dimension of 36 x 16 x 9.5 cm^3.

The shelf life of each module in a sealed bag is 12 months at <40°C and <90% relative humidity. After a bag is opened, devices that will be subjected to reflow solder or other high temperature processes must be mounted within 168 hours (7 days) at factory conditions of <30°C and <60% relative humidity.

Figure 7-2. Packing and Storage Information
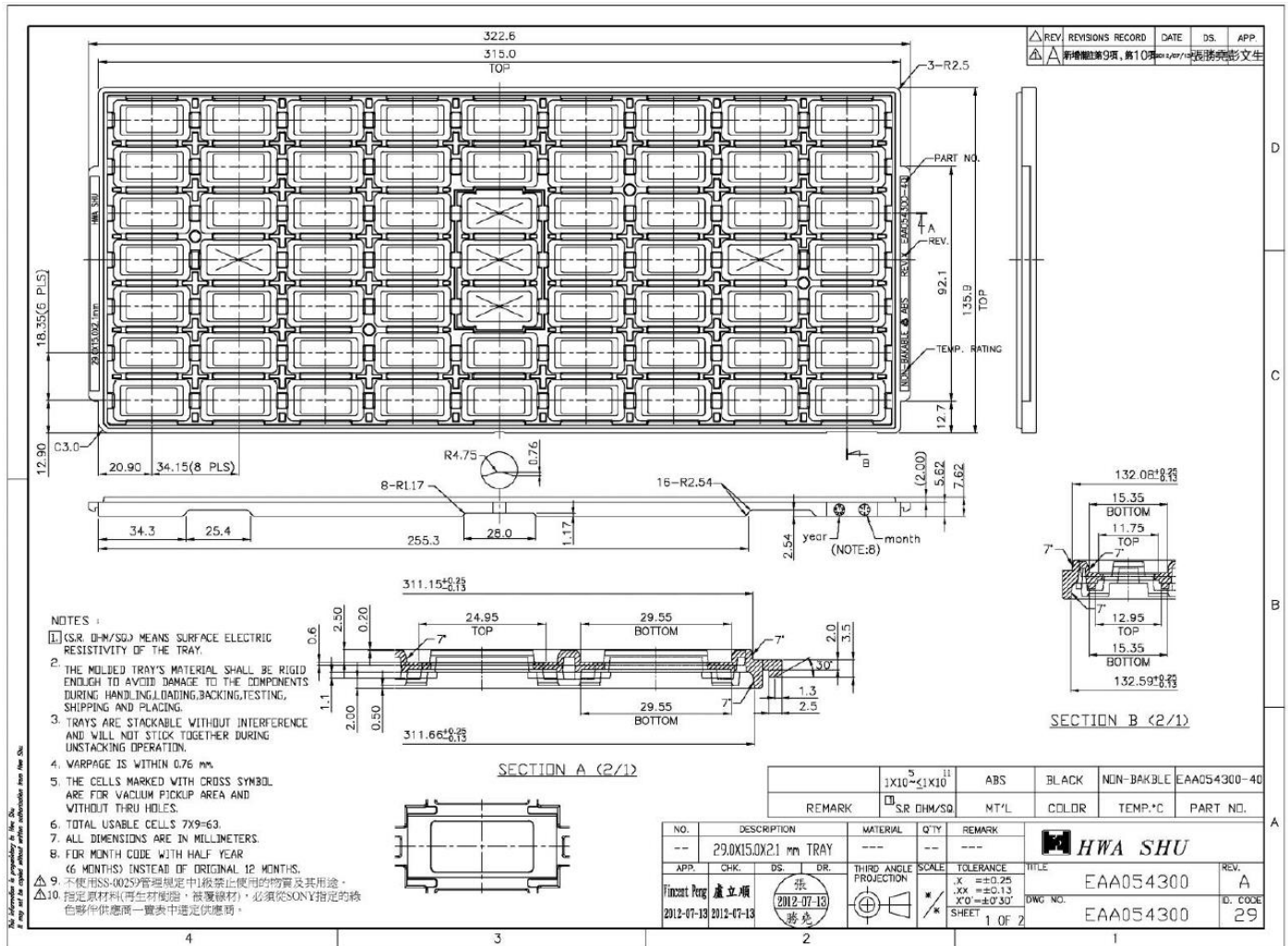
8. Ordering Information

The following table provides the ordering information of the BM20/23 module.

Table 8-1. Module Ordering Information

Part Number	Description
BM20SPKS1NBC	Bluetooth 5.0 BDR/EDR, Class 2 Surface Mount module with integrated antenna and shield.
BM23SPKS1NB9	Bluetooth 5.0 BDR/EDR, Class 2 Surface Mount module with integrated antenna and shield.

Note:
1. The module can only be purchased through a Microchip representative.
2. Go to http://www.microchip.com/ for current pricing and a list of distributors carrying Microchip products.

9. Certification Notices

BM20 module (BM20SPKS1NBC) has received the regulatory approval for the following:
- BT SIG/QDID: 121137
- United States: FCC ID: A8TBM20SPKXYNBZ
- Canada
    - IC: 12246A-BM20SPKS1
    - HVIN: BM20SPKS1
- Europe/CE
- Japan/MIC: 202-SMD048
- Korea/KCC: MSIP-CRM-mcp-BM20SPKS1NBC
- Taiwan/NCC: CCAN15LP0460T2
- China/SRRC: CMIIT ID: 2015DJ7134
- Brazil/ANATEL: 01888-19-08759
- Mexico/IFT: RCPMIBM19-0454
- Argentina/CNC ID: C-22800

BM23 module (BM23SPKS1NB9) has received the regulatory approval for the following:
- BT SIG/QDID: 121137
- United States/ FCC ID: A8TBM23SPKXYC2A
- Canada
    - IC: 12246A-BM23SPKXYC2
    - HVIN: BM23SPKXY
- Europe/CE
- Japan/MIC: 202-SMC067
- Korea/KCC: MSIP-CRM-S9S-BM23SPKXY
- Taiwan
    - NCC: CCAL15LP0270T3
    - M/N: BM23SPK
- China/SRRC: CMIIT ID: 2016DJ3553

9.1 United States

The BM20/23 stereo audio module has received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C "Intentional Radiators" single-modular approval in accordance with Part 15.212 Modular Transmitter approval. Single-modular transmitter approval is defined as a complete RF transmission sub-assembly, designed to be incorporated into another device, that must demonstrate compliance with FCC rules and policies independent of any host. A transmitter with a modular grant can be installed in different end-use products (referred to as a host, host product, or host device) by the grantee or other equipment manufacturer, then the host product may not require additional testing or equipment authorization for the transmitter function provided by that specific module or limited module device.

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

The host product itself is required to comply with all other applicable FCC equipment authorizations 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).

9.1.1 Labeling and User Information Requirements

The BM20/23 module has been labeled with its own FCC ID number. 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 also display a label referring to the enclosed module. These exterior labels use the following wording:

For BM20 Module:

> Contains Transmitter Module FCC ID: A8TBM20SPKXYNBZ
>
> or
>
> Contains FCC ID: A8TBM20SPKXYNBZ
>
> **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**

For BM23 Module:

> Contains Transmitter Module FCC ID: A8TBM23SPKXYC2A
>
> or
>
> Contains FCC ID: A8TBM23SPKXYC2A
>
> **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**

A user's manual for the product must 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 available at the FCC Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB) https://apps.fcc.gov/oetcf/kdb/index.cfm.

9.1.2 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).

For the BM20 Module:
• Output power listed is conducted. This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter, except in accordance with the FCC multi-transmitter product procedures. End-users must be provided with specific operating instructions for satisfying RF exposure compliance.
• This module is approved for installation into mobile or/and portable host platforms.

For the BM23 Module:

- Output power listed is conducted. This grant is valid only when the module is sold to OEM integrators and must be installed by the OEM or OEM integrators. This transmitter is restricted for use with the specific antenna(s) 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 FCC multi-transmitter product procedures.
- This module is approved for installation into mobile or/and portable host platforms.

9.1.3 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

9.2 Canada

The BM20/23 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.

9.2.1 Labeling and User Information Requirements

Labeling Requirements (from RSP-100, Issue 11, Section 3): The host product 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 product. Otherwise, the host device must be labeled to display the Innovation, Science and Economic Development Canada certification number of the module, preceded by the word "Contains", or similar word expressing the same meaning, as follows:

For BM20 Module:

Contains IC: 12246A-BM20SPKS1

For BM23 Module:

Contains IC: 12246A-BM23SPKXYC2

User Manual Notice for License-Exempt Radio Apparatus (from Section 8.4 RSS-Gen, Issue 4, November 2014): User manuals for license-exempt radio apparatus shall contain the following or equivalent notice in a conspicuous location in the user manual, on the device or both:

> **This device complies with Industry Canada's license-exempt RSS standard(s). 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.**
>
> **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'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.**

Guidelines on Transmitter Antenna for License Exempt Radio Apparatus:

> **Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain must be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.**
>
> **Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.**

9.2.2 RF Exposure

All transmitters regulated by the Innovation, Science and Economic Development Canada (ISED) must comply with RF exposure requirements listed in RSS-102 - Radio Frequency (RF) Exposure Compliance of Radio Communication 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, except in accordance with Innovation, Science and Economic Development Canada multi-transmitter guidelines.

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

9.2.3 Helpful Websites

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

9.3 Europe

The BM20/23 module is a Radio Equipment Directive (RED) assessed radio module that is CE marked and has been manufactured and tested with the intention of being integrated into a final product.

The BM20/23 module has been tested to RED 2014/53/EU Essential Requirements for Health and Safety (Article (3.1(a)), Electromagnetic Compatibility (EMC) (Article 3.1(b)), and Radio (Article 3.2), which is summarized in the Table 9-1 and Table 9-2 European Compliance Testing tables.

The ETSI provides guidance on modular devices in the *"Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the RED 2014/53/EU (RED) to multi-radio and combined radio and nonradio equipment"* document available at http://www.etsi.org/deliver/etsi_eg/203300_203399/203367/01.01.01_60/eg_203367v010101p.pdf.

> **Note:** To maintain conformance to the testing listed in Table 9-1 and Table 9-2, the modules shall be installed in accordance with the installation instructions in this data sheet and shall not be modified. When integrating a radio module into a completed product the integrator becomes the manufacturer of the final product and is therefore responsible for demonstrating compliance of the final product with the essential requirements against the RED.

9.3.1 Labeling and User Information Requirements

The label on the final product which contains the BM20/23 module must follow CE marking requirements.

The European Compliance Testing listed in the following tables was performed using the integral PCB antenna.

Table 9-1. European Compliance Testing (BM20)

Certification	Standards	Article	Laboratory	Report Number	Date
Safety	EN 60950-1:2006 / A11:2009 / A1:2010 / A12:2011 / A2:2013	(3.1(a))	TUV Rheinland, Taiwan	10050720 002	15 Sep 2015
Health	EN 300 328 V1.9.1 / EN 62479:2010			10050932 002	09 Sep 2015
EMC	EN 301 489-1 V1.9.2	(3.1(b))		10050691 002	16 Sep 2015
	EN 301 489-17 V2.2.1				
	EN 301 489-1 V2.1.1			10050691 003	26 May 2017
	EN 301 489-1 V2.2.0				
	EN 301 489-17 V3.1.1				
	EN 301 489-17 V3.2.0				
Radio	EN 300 328 V1.9.1	(3.2)		10050932 002	09 Sep 2015
	EN 300 328 V2.1.1			10050932 003	26 May 2017

Table 9-2. European Compliance Testing (BM23)

Certification	Standards	Article	Laboratory	Report Number	Date
Safety	EN 60950-1:2006 / A11:2009 / A1:2010 / A12:2011 / A2:2013	(3.1(a))	TUV Rheinland, Taiwan	10047732 002	26 May 2017
Health	EN 300 328 V1.9.1 / EN 62479:2010			10048076 001 & 10048076 002	15 Sep 2014 & 26 Oct 2015
EMC	EN 301 489-1 V1.9.2	(3.1(b))		10047659 001	23 Sep 2014
	EN 301 489-17 V2.2.1				
	EN 301 489-1 V2.1.1			10047659 002	26 May 2017
	EN 301 489-1 V2.2.0				
	EN 301 489-17 V3.1.1				
	EN 301 489-17 V3.2.0				
Radio	EN 300 328 V1.9.1	(3.2)		10048076 001 & 10048076 002	15 Sep 2014 & 26 Oct 2015
	EN 300 328 V2.1.1			10048076 003	26 May 2017

9.3.2 Conformity Assessment

From ETSI Guidance Note EG 203367, section 6.1 Non-radio products are combined with a radio product:

If the manufacturer of the combined equipment installs the radio product in a host non-radio product in equivalent assessment conditions (i.e. host equivalent to the one used for the assessment of the radio product) and according to the installation instructions for the radio product, then no additional assessment of the combined equipment against article 3.2 of the RED is required.

The European Compliance Testing listed in Table 9-1 and Table 9-2 was performed using the integral PCB antenna.

9.3.3 Simplified EU Declaration of Conformity

Hereby, Microchip Technology Inc. declares that the radio equipment type BM20/23 module is in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity, for this product, is available at http://www.microchip.com/design-centers/wireless-connectivity.

9.3.4 Helpful Websites

A document that can be used as a starting point in understanding the use of Short Range Devices (SRD) in Europe is the European Radio Communications Committee (ERC) Recommendation 70-03 E, which can be downloaded from the European Communications Committee (ECC): http://www.ecodocdb.dk/.

Additional helpful websites are:
- Radio Equipment Directive (2014/53/EU): https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/red_en.
- European Conference of Postal and Telecommunications Administrations (CEPT): http://www.cept.org.
- European Telecommunications Standards Institute (ETSI): http://www.etsi.org.
- The Radio Equipment Directive Compliance Association (REDCA): http://www.redca.eu/.

9.4 Japan

The BM20/23 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 should 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.

9.4.1 Labeling and User Information Requirements

The label on the final product which contains the BM20/23 module must follow Japan marking requirements. The integrator of the module should refer to the labeling requirements for Japan available at the Ministry of Internal Affairs and Communications (MIC) website.

The BM20/23 module is labeled with its own technical conformity mark and certification number. The final product in which this module is being used must have a label referring to the type of certified module inside:
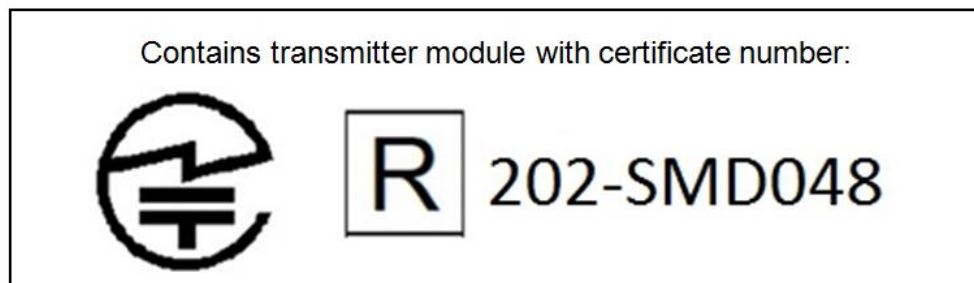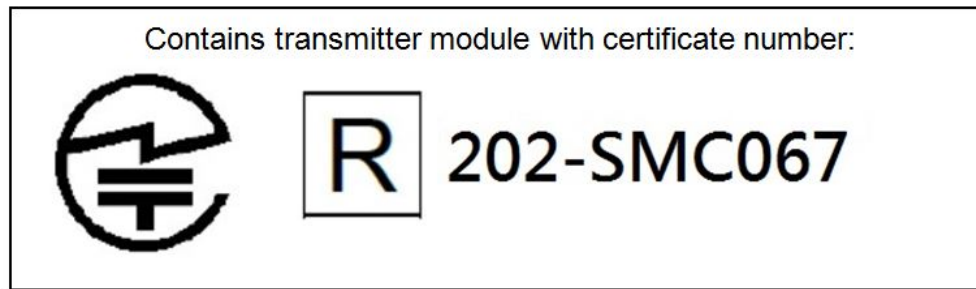
Figure 9-1. BM20 Module

Figure 9-2. BM23 Module

9.4.2 Helpful Websites

Ministry of Internal Affairs and Communications (MIC): http://www.tele.soumu.go.jp/e/index.htm.

Association of Radio Industries and Businesses (ARIB): http://www.arib.or.jp/english/.

9.5 Korea

The BM20/23 module has received certification of conformity in accordance with the Radio Waves Act. 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.

9.5.1 Labeling and User Information Requirements

The label on the final product that contains the BM20/23 module must follow KC marking requirements. The integrator of the module should refer to the labeling requirements for Korea available on the Korea Communications Commission (KCC) website.

The BM20/23 module is labeled with its own KC mark. The final product requires the KC mark and certificate number of the module:

Figure 9-3. BM20 Module
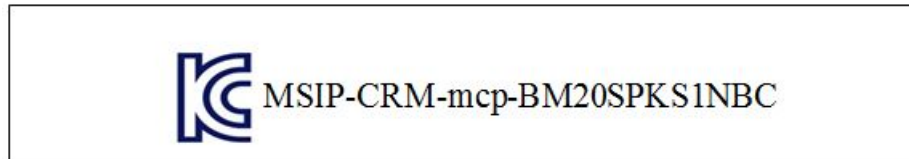
Figure 9-4. BM23 Module
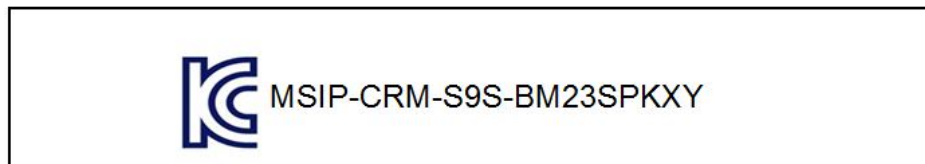
9.5.2 Helpful Websites

Korea Communications Commission (KCC): http://www.kcc.go.kr.

National Radio Research Agency (RRA): http://rra.go.kr.

9.6 Taiwan

The BM20/23 module has received compliance approval in accordance with the Telecommunications Act. Customers seeking to use the compliance approval in their product should contact the Microchip Technology Inc. sales office or distribution partners to obtain a Letter of Authority.

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.

9.6.1 Labeling and User information Requirements

The BM20/23 module is labeled with its own NCC mark and certificate number as below:

Figure 9-5. BM20 Module
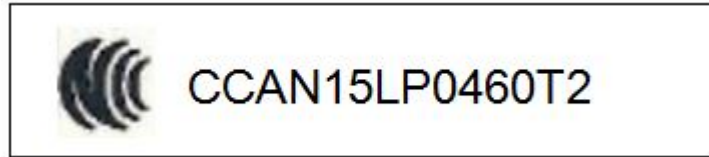
Figure 9-6. BM23 Module
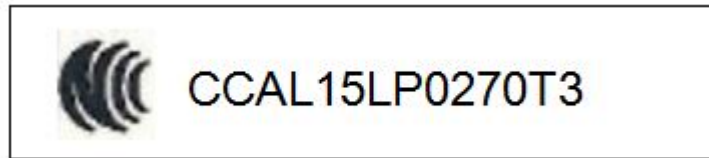
The user's manual should contain below warning (for RF device) in traditional Chinese:

注意！

依據 低功率電波輻射性電機管理辦法

第十二條 經型式認證合格之低功率射頻電機，非經許可， 公司 、商號或使用者均不得擅自變更頻率、加大功率或變更原設計 之 特性及功能。

第十四條 低功率射頻電機之使用不得影響飛航安全及干擾合法通信； 經發現有干擾現象時，應立 即停用，並改善至無干擾時方得繼續使用。 前項合法通信，指依電信規定作業之無線電信。 低 功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性 電機設備之干擾。

9.6.2 Helpful Websites

National Communications Commission (NCC): http://www.ncc.gov.tw.

9.7 China

The BM20/23 module has received certification of conformity in accordance with the China MIIT Notice 2014-01 of State Radio Regulation Committee (SRRC) certification scheme. 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.

9.7.1 Labeling and User Information Requirements

The BM20 module is labeled with its own CMIIT ID as follows:

Figure 9-7. BM20 CMIIT ID
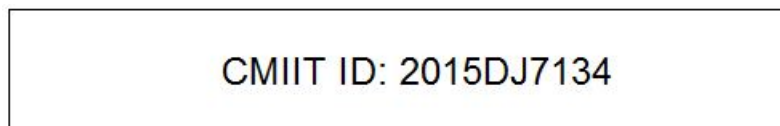
CMIIT ID: 2015DJ7134

When Host system is using an approved Full Modular Approval (FMA) radio: The host should bear a label containing the statement "This device contains SRRC approved Radio module CMIIT ID 2015DJ7134".

The BM23 module is labeled with its own CMIIT ID as follows:

Figure 9-8. BM23 CMIIT ID
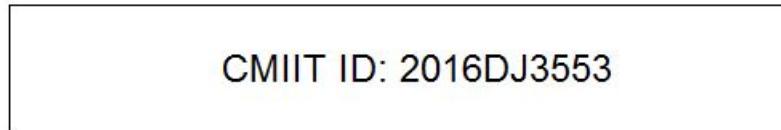
CMIIT ID: 2016DJ3553

When Host system is using an approved Full Modular Approval (FMA) radio: The host should bear a label containing the statement "This device contains SRRC approved Radio module CMIIT ID 2016DJ3553".

9.8   Brazil

The BM20 received compliance approval in accordance with the Telecommunications Act of the Federal Republic of Brazil National Telecommunications Agency (ANATEL). Customers seeking to use the compliance approval in their product must contact Microchip Technology Inc. sales or distribution partners to obtain a Letter of Authority.

Modelo: BM20SPKS1NBC

ANATEL
Agência Nacional de Telecomunicações

01888-19-08759

Este equipamento opera em caráter secundário, isto é,
não tem direito a proteção contra interferência prejudicial,
mesmo de estações do mesmo tipo, e não pode causar
interferência a sistemas operando em caráter primário

The End product (Host) manual must include the following statement:

Este product contém a placa Modelo BM20SPKS1NBC código de homologação ANATEL 01888-19-08759.

9.9   Mexico

The BM20 module has received compliance approval in accordance with the IFT (IFETEL) of Mexico.

Customers seeking to use the compliance approval in their product must contact Microchip Technology Inc. sales or distribution partners to obtain a Letter of Authority.

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.

Operation of this equipment is subject to the following two conditions: (1) this device or device may not cause harmful interference, and (2) this device or device must accept any interference, including interference that may cause undesired operation.

La operación de este equipo está sujeta a las siguientes dos condiciones: (1) es posible que este equipo o dispositivo no cause interferencia perjudicial y (2) este equipo o dispositivo debe aceptar cualquier interferencia, incluyendo la que pueda causar su operación no deseada.

9.9.1   Labeling and User Information Requirements

The BM20 module, due to limited module size, the IFT mark and ID are displayed in the data sheet and/or packaging label and cannot be displayed on the module label.

IFT: RCPMIBM19-0454

9.10   Argentina

The BM20 module has received compliance approval in accordance with the Argentine NATIONAL ENTITY OF COMMUNICATIONS (ENACOM).

Customers seeking to use the compliance approval in their product must contact Microchip Technology Inc. sales or distribution partners to obtain a Letter of Authority.

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.

9.10.1   Labeling and User Information Requirements

BM20 module, due to limited module size, the CNC mark and Certificate number are displayed in the data sheet and/or packaging label and cannot be displayed on the module label

When Host (End Product) system is using an approved radio:

The external label must be composed of the module CNC Registration Number, preceded by the legend: "Contiene Módulo CNC ID" or "Contiene CNC ID" sentence, as shown below:

Contiene Módulo CNC ID: C-22800

9.11   Other Regulatory Jurisdictions

- For information on the other countries' jurisdictions covered, refer to https://www.microchip.com/design-centers/wireless-connectivity/certifications.
- 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.

10.   Document Revision History

Table 10-1. Document Revision History

Revision	Date	Section	Description
B	08/2019	Document	Removed "Preliminary" from document footer.
A	08/2019	Document	Initial release.

The Microchip Website

Microchip provides online support via our website at http://www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to http://www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: http://www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with

your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PackeTime, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TempTrackr, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, Vite, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, INICnet, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2019, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 978-1-5224-4985-0

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit http://www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office	**Australia - Sydney**	**India - Bangalore**	**Austria - Wels**
2355 West Chandler Blvd.	Tel: 61-2-9868-6733	Tel: 91-80-3090-4444	Tel: 43-7242-2244-39
Chandler, AZ 85224-6199	**China - Beijing**	**India - New Delhi**	Fax: 43-7242-2244-393
Tel: 480-792-7200	Tel: 86-10-8569-7000	Tel: 91-11-4160-8631	**Denmark - Copenhagen**
Fax: 480-792-7277	**China - Chengdu**	**India - Pune**	Tel: 45-4450-2828
Technical Support:	Tel: 86-28-8665-5511	Tel: 91-20-4121-0141	Fax: 45-4485-2829
http://www.microchip.com/support	**China - Chongqing**	**Japan - Osaka**	**Finland - Espoo**
Web Address:	Tel: 86-23-8980-9588	Tel: 81-6-6152-7160	Tel: 358-9-4520-820
http://www.microchip.com	**China - Dongguan**	**Japan - Tokyo**	**France - Paris**
Atlanta	Tel: 86-769-8702-9880	Tel: 81-3-6880- 3770	Tel: 33-1-69-53-63-20
Duluth, GA	**China - Guangzhou**	**Korea - Daegu**	Fax: 33-1-69-30-90-79
Tel: 678-957-9614	Tel: 86-20-8755-8029	Tel: 82-53-744-4301	**Germany - Garching**
Fax: 678-957-1455	**China - Hangzhou**	**Korea - Seoul**	Tel: 49-8931-9700
Austin, TX	Tel: 86-571-8792-8115	Tel: 82-2-554-7200	**Germany - Haan**
Tel: 512-257-3370	**China - Hong Kong SAR**	**Malaysia - Kuala Lumpur**	Tel: 49-2129-3766400
Boston	Tel: 852-2943-5100	Tel: 60-3-7651-7906	**Germany - Heilbronn**
Westborough, MA	**China - Nanjing**	**Malaysia - Penang**	Tel: 49-7131-72400
Tel: 774-760-0087	Tel: 86-25-8473-2460	Tel: 60-4-227-8870	**Germany - Karlsruhe**
Fax: 774-760-0088	**China - Qingdao**	**Philippines - Manila**	Tel: 49-721-625370
Chicago	Tel: 86-532-8502-7355	Tel: 63-2-634-9065	**Germany - Munich**
Itasca, IL	**China - Shanghai**	**Singapore**	Tel: 49-89-627-144-0
Tel: 630-285-0071	Tel: 86-21-3326-8000	Tel: 65-6334-8870	Fax: 49-89-627-144-44
Fax: 630-285-0075	**China - Shenyang**	**Taiwan - Hsin Chu**	**Germany - Rosenheim**
Dallas	Tel: 86-24-2334-2829	Tel: 886-3-577-8366	Tel: 49-8031-354-560
Addison, TX	**China - Shenzhen**	**Taiwan - Kaohsiung**	**Israel - Ra'anana**
Tel: 972-818-7423	Tel: 86-755-8864-2200	Tel: 886-7-213-7830	Tel: 972-9-744-7705
Fax: 972-818-2924	**China - Suzhou**	**Taiwan - Taipei**	**Italy - Milan**
Detroit	Tel: 86-186-6233-1526	Tel: 886-2-2508-8600	Tel: 39-0331-742611
Novi, MI	**China - Wuhan**	**Thailand - Bangkok**	Fax: 39-0331-466781
Tel: 248-848-4000	Tel: 86-27-5980-5300	Tel: 66-2-694-1351	**Italy - Padova**
Houston, TX	**China - Xian**	**Vietnam - Ho Chi Minh**	Tel: 39-049-7625286
Tel: 281-894-5983	Tel: 86-29-8833-7252	Tel: 84-28-5448-2100	**Netherlands - Drunen**
Indianapolis	**China - Xiamen**		Tel: 31-416-690399
Noblesville, IN	Tel: 86-592-2388138		Fax: 31-416-690340
Tel: 317-773-8323	**China - Zhuhai**		**Norway - Trondheim**
Fax: 317-773-5453	Tel: 86-756-3210040		Tel: 47-72884388
Tel: 317-536-2380			**Poland - Warsaw**
Los Angeles			Tel: 48-22-3325737
Mission Viejo, CA			**Romania - Bucharest**
Tel: 949-462-9523			Tel: 40-21-407-87-50
Fax: 949-462-9608			**Spain - Madrid**
Tel: 951-273-7800			Tel: 34-91-708-08-90
Raleigh, NC			Fax: 34-91-708-08-91
Tel: 919-844-7510			**Sweden - Gothenberg**
New York, NY			Tel: 46-31-704-60-40
Tel: 631-435-6000			**Sweden - Stockholm**
San Jose, CA			Tel: 46-8-5090-4654
Tel: 408-735-9110			**UK - Wokingham**
Tel: 408-436-4270			Tel: 44-118-921-5800
Canada - Toronto			Fax: 44-118-921-5820
Tel: 905-695-1980			
Fax: 905-695-2078			