IS1678

Bluetooth® Dual-Mode SoC

Features

- Bluetooth Classic (BR/EDR) and Low Energy (LE)
- Fully Certified, Embedded 2.4 GHz Bluetooth version 4.2 SoC, ROM-variant (IS1678S) and Flash-variant (IS1678SM) are available
- Transparent UART mode for seamless serial data over UART interface
- Configurable I/O pins for control and status
- Integrated crystal oscillator operates with 16 MHz external crystal
- Internal voltage regulator and matching circuitry
- Easy to configure with User Interface (UI) Tool, a Windows® configuration utility, or directly by MCU
- Upgradeable Firmware via UART
- 4 Mbit Flash (Only IS1678SM)
- Supports Apple® iPod Accessory Protocol (iAP2), (only IS1678SM)
- Bluetooth 4.2 LE secure connections
- Bluetooth 4.2 LE data packet length extension
- Ideal for portable battery operated devices
- Internal battery regulator circuitry
- One LED Driver with 16 steps brightness control
- IC Size: 6 mm x 6 mm

RF/Analog

- Frequency: 2.402 GHz to 2.480 GHz
- Receive Sensitivity: -90 dBm (BR/EDR), -92 dBm (LE)
- Class 2 Output Power (+2 dBm typical)

Data Throughput

Data throughput at 1 Mbps UART baud rate:

- BR/EDR: up to 32 Kbps
- LE: up to 7 Kbps

Data throughput at 115200 bps UART baud rate:

- BR/EDR: up to 10 Kbps
- LE: up to 6 Kbps

MAC/Baseband/Higher Layer

- Secure AES128 encryption
- Bluetooth v3.0: GAP, SPP, SDP, RFCOMM, and L2CAP
- Bluetooth v4.2: GAP, GATT, ATT, SMP, and L2CAP

Operating Conditions

- Operating voltage range: 3.3V to 4.2V
- Operating temperature: -20ºC to +70ºC

Applications

- Internet of Things (IoT)
- Secure Payment
- Home and Security
- Health and Fitness
- Industrial and Data Logger
- LED Lighting (16 steps)

Packages

Type	QFN
Pin Count	40
Contact/Lead Pitch	0.5
Dimensions	6 x 6 x 0.9

Note: All dimensions are in millimeters (mm) unless specified.

General Description

The IS1678S/SM is a certified, Bluetooth version 4.2 (BR/EDR/LE) SoC that enables the user to easily add dual-mode Bluetooth wireless capability to their products. The IS1678 SoC is available in ROM-based (IS1678S) and Flash-based (IS1678SM) variants. Refer to **Section 10.0 "Ordering Information"** for additional information on the IS1678 variants.

The IS1678 bridges the customer product to smart phones or tablets for convenient data transfer, control, access to cloud applications, and delivering local connectivity for IoT. It also supports GAP, SDP, SPP, and GATT profiles. Data transfer is achieved over the Bluetooth link by sending and receiving data through transparent UART mode, making it easy to integrate any microprocessor or microcontroller with UART interface. The configuration is done by using a UI Tool, a Windows-based utility or directly by an MCU through UART.

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NOTES:

1.0 SYSTEM OVERVIEW

The IS1678S/SM is a fully certified, embedded 2.4 GHz Bluetooth version 4.2 (BR/EDR/LE) wireless IC. It includes an on board Bluetooth stack, power management subsystem, 2.4 GHz transceiver, and RF power amplifier. Users can embed Bluetooth functionality to any applications using the IS1678S/SM.

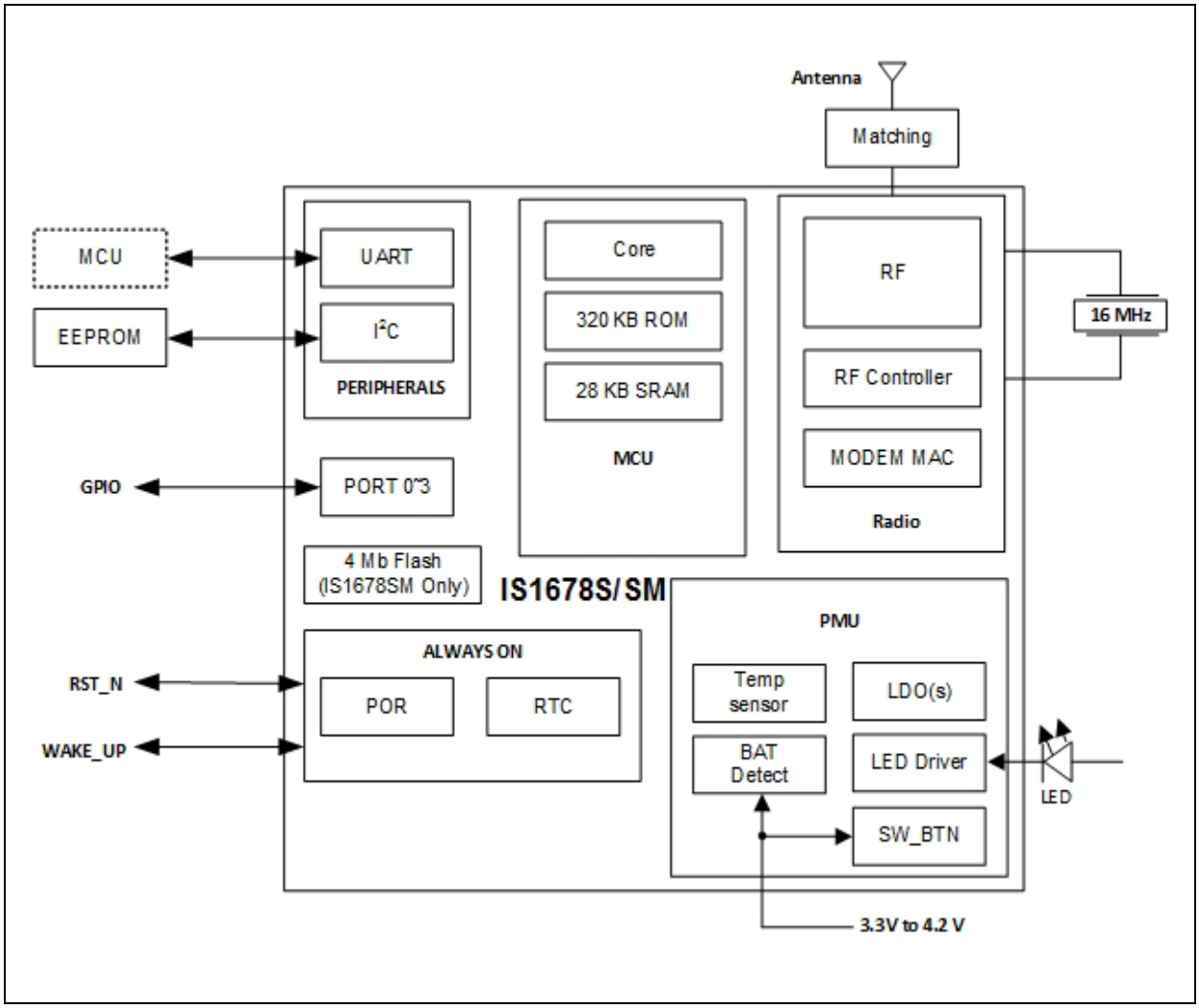
The IS1678S/SM enables rapid product development and faster time to market and it is designed to provide integrators with the following features:

- Ease of integration and programming
- Reduced development time
- Low system cost
- Interoperability with Bluetooth hosts
- Wide range of applications

The IS1678S/SM can independently maintain a low-power wireless connection. The low power usage and flexible power management maximize the lifetime of the end-product in battery-operated applications. A wide operating temperature range enables its use in indoor and outdoor environments.

Figure 1-1 illustrates a typical block diagram of the IS1678S/SM.

FIGURE 1-1: IS1678S/SM BLOCK DIAGRAM



1.1 Pin Assignment

Figure 1-2 illustrates the pin configuration of the IS1678S/SM.

FIGURE 1-2: IS1678S/SM PIN CONFIGURATION

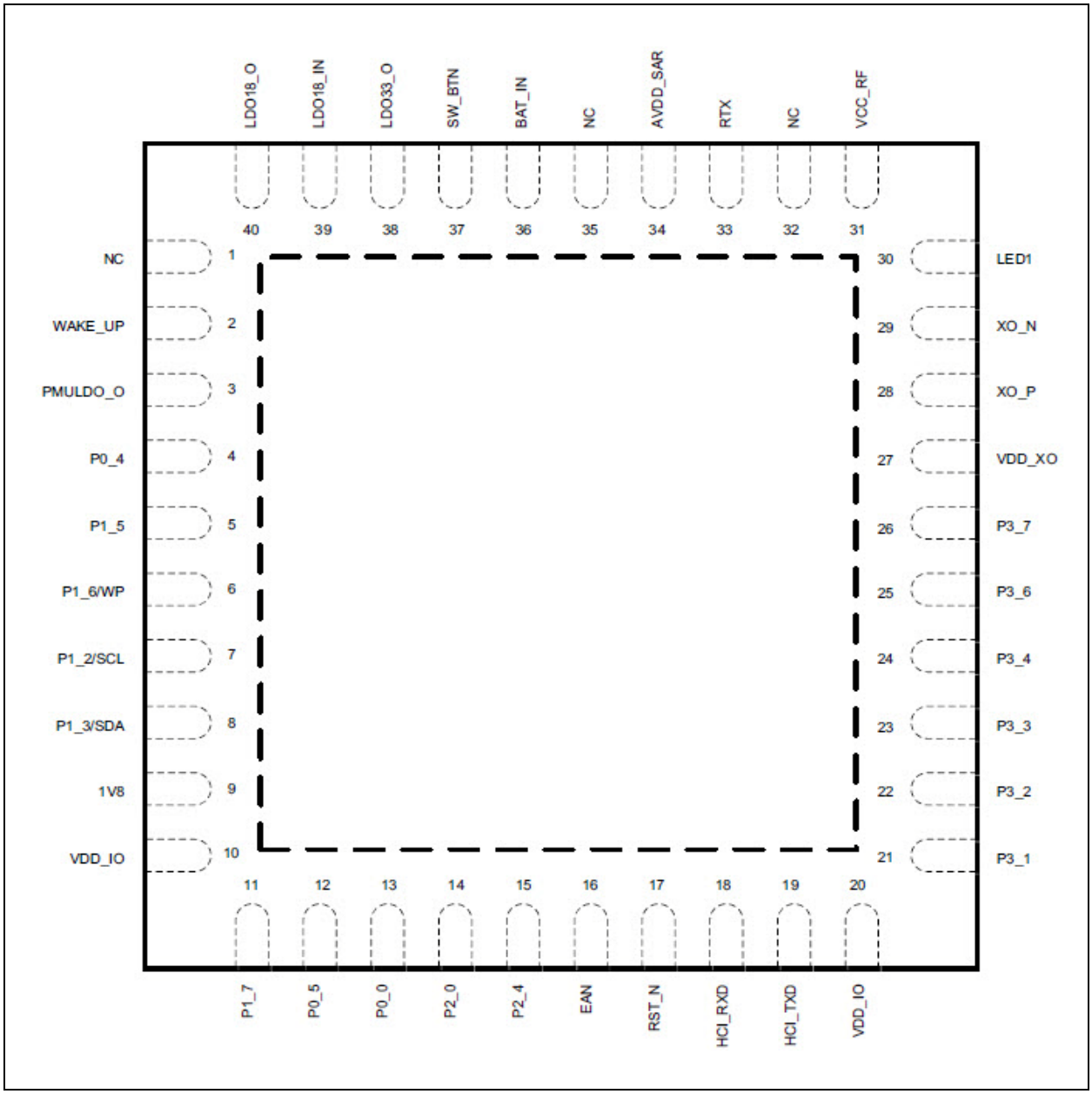


Table 1-1 provides various pins of the IS1678S/SM.

TABLE 1-1: PIN DESCRIPTION

Pin Number	Pin Name	Pin Type	Pin Description
1	NC	NC	No Connection
2	WAKE_UP	DI	Wake up from Sleep mode (active-low) (internal pull up)
3	PMULDO_O	Power	Power management unit output (1.8V), for measurement purpose only. Do not connect to external devices Connect to GND through a 1uF (X5R/X7R) capacitor
4	P0_4	DO	IS1678S/SM State Indicator Pin along with P1_5. Refer Table 2-3
5	P1_5	DO	IS1678S/SM State indicator Pin along with P0_4. Refer Table 2-3
6	P1_6/WP	DO	EEPROM WP (Connected to external EEPROM)
7	P1_2/SCL	DO	I^2C SCL to EEPROM
8	P1_3/SDA	DIO	I^2C SDA to EEPROM
9	1V8	Power	1.8V input for digital core power Connect to GND through a 1 uF (X5R/X7R) capacitor
10	VDD_IO	Power	I/O positive supply input (3.3V) Connect to GND through a 1 uF (X5R/X7R) capacitor
11	P1_7/UART_CTS	DIO	Configurable Control or Indication pin assigned to UART CTS (input)
12	P0_5	DIO	Configurable Control or Indication pin
13	P0_0/UART_RTS	DIO	Configurable Control or Indication pin assigned to UART RTS (output)
14	P2_0	DI	System configuration pin along with P2_4 and EAN pins. It is used to set the system in one of the three modes: • Application mode (for normal operation) • Test mode (to change EEPROM values) • Write Flash mode (to enter new firmware into the module). For detailed information, refer Table 2-1.
15	P2_4	DI	System configuration pin along with P2_0 and EAN pins. It is used to set the system in one of the three modes: • Application mode (for normal operation) • Test mode (to change EEPROM values) • Write Flash mode (to enter new firmware into the module). For detailed information, refer Table 2-1.
16	EAN	DI	External address-bus negative. System configuration pin along with P2_0 and P2_4 pins. It is used to set the system in one of the 3 modes: • Application mode (for normal operation) • Test mode (to change EEPROM values) • Write Flash mode (to enter new firmware into the module). ROM: Must be pulled high to VDD_IO FLASH: Must be pulled down with 4.7 Kohm to GND For detailed information, refer Table 2-1.
17	RST_N	DI	Module Reset (active-low) (internal pull up) Apply a pulse of at least 63 ns Connect to GND through a 1 uF (X5R/X7R) capacitor
18	HCI_RXD	DI	UART data input
19	HCI_TXD	DO	UART data output

Legend: A = Analog D = Digital I = Input O = Output

TABLE 1-1: PIN DESCRIPTION (CONTINUED)

Pin Number	Pin Name	Pin Type	Pin Description
20	VDD_IO	Power	I/O positive supply input (3.3V) Connect to 1 uF (X5R/X7R) capacitor
21	P3_1	DIO	Configurable control or Indication pin (Internally pulled up, if configured as an input)
22	P3_2	DIO	Configurable control or Indication pin (Internally pulled up, if configured as an input)
23	P3_3	DIO	Configurable control or Indication pin (Internally pulled up, if configured as an input)
24	P3_4	DIO	Configurable control or Indication pin (Internally pulled up, if configured as an input)
25	P3_6	DIO	Configurable control or Indication pin (Internally pulled up, if configured as an input)
26	P3_7	DIO	Configurable control or Indication pin (Internally pulled up, if configured as an input)
27	VDD_XO	Power	1.8V input for the external 16 MHz crystal Connect to GND through a 1uF (X5R/X7R) capacitor
28	XO_P	AI	Positive node for RF 16 MHz crystal input
29	XO_N	AI	Negative node for RF 16 MHz crystal input
30	LED1	DO	LED Driver
31	VCC_RF	Power	Power input for VCO and RF (1.8V) Connect to GND through a 1 uF (X5R/X7R) capacitor
32	NC	NC	NC
33	RTX	AIO	External antenna connection (50 ohm)
34	AVDD_SAR	Power	1.8V input for AVDD_SAR power Connect to GND through a 1 uF (X5R/X7R) capacitor
35	NC	NC	NC
36	BAT_IN	Power	Battery input. Main positive supply input Connect to GND through a 10 uF (X5R/X7R) capacitor
37	SW_BTN	DI	Power Button: H: Power on L: Power off
38	LDO33_O	Power	Internal 3.3V LDO regulator output Connect to GND through a 10 uF (X5R/X7R) capacitor
39	LDO18_IN	Power	Internal 1.8V LDO regulator input Connect with LDO33_O
40	LDO18_O	Power	Internal 1.8V LDO regulator output Connect to GND through a 1 uF (X5R/X7R) capacitor
41	EP	Power	Exposed pad as ground

Legend: A = Analog D = Digital I = Input O = Output

2.0 APPLICATION INFORMATION

2.1 System Configuration Pins

The I/O pins, P2_0, P2_4, and EAN, place the IS1678S/SM in operation modes. These pins have internal pull-ups and enables configuration settings and firmware updation. Table 2-1 provides system configuration setting details.

TABLE 2-1: SYSTEM CONFIGURATION SETTINGS

IC	P2_0	P2_4	EAN	Operational Mode
IS1678S	Low	High	High	Write EEPROM and Test mode
	High	High	High	Normal Operation mode or Application mode
IS1678SM	Low	Low	High	Write Flash
	Low	High	Low	Write EEPROM and Test mode
	High	High	Low	Normal Operation/Application mode

2.2 Control and Indication Pins

The I/O pins, P0_0, P0_5, P1_7, P3_1, P3_2, P3_3, P3_4, and P3_7, are configuration control and indication signal pins. The control signals are input to the IS1678S/SM and the Indication signals are output from the IS1678S/SM. Table 2-2 provides the default I/O pin configuration details.

TABLE 2-2: CONFIGURATION AND INDICATION I/O ASSIGNMENTS

PINS	N/C	UART_RTS(1,2)	UART_CTS(1,2)	LOW_BATTERY_IND	RSSI_IND	GET WIFI INFO KEY	LINK_DROP_CONTROL (DISCONNECT)	UART_RX_IND	PAIRING_KEY	INQUIRY CONTROL	PROFILE_IND
P0_0		■									
P0_5	■										
P1_7			■								
P3_1										■	
P3_2							■				
P3_3								■			
P3_4									■		
P3_7				■							

Note 1: The RTS and CTS pins are fixed and cannot be configured while using the flow control, or else these pins can be configured as GPIOs.

2: The RTS pin can only be assigned to P0_0 pin and the CTS pin can only be assigned to P1_7.

2.3 Status Indication Pins

The status indication I/O pins are P1_5 is Status Indicator 1 and P0_4 is Status Indicator 2 signal. Together, they provide status indication to the MCU as shown in Table 2-3.

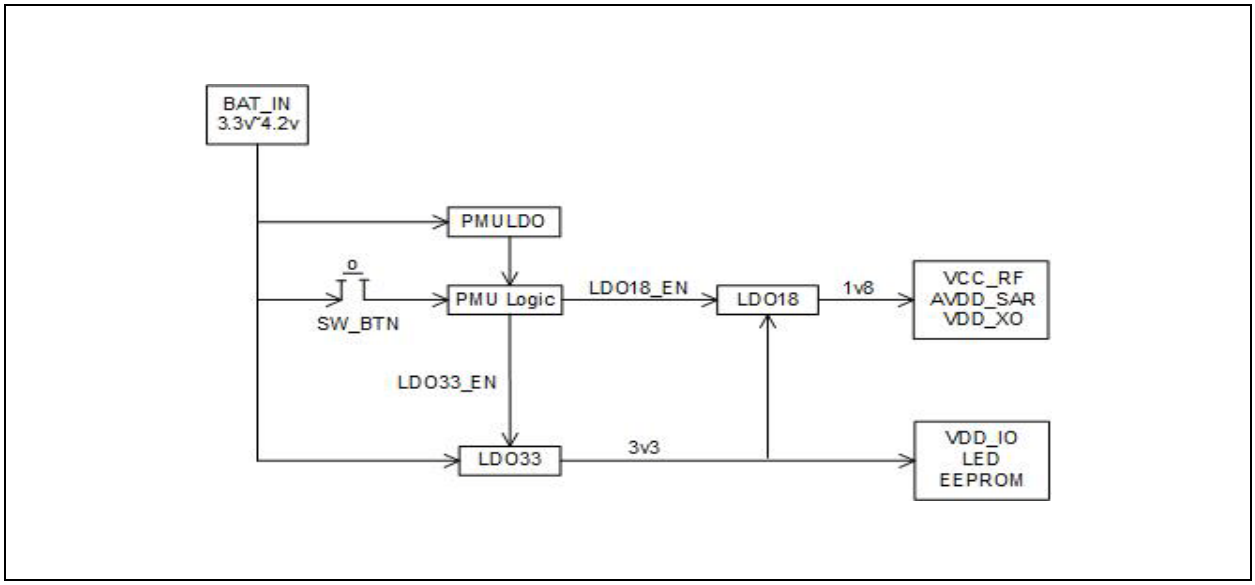
TABLE 2-3: STATUS INDICATION

P1_5 /STATUS_IND_1	P0_4/STATUS_IND_2	Indication
High	High	Power-on (default setting) and deep-sleep state. HH status should be stable for at least 500 ms.
High	Low	Access state
Low	High	Link state (UART data transmitting)
Low	Low	Link state (no UART data being transmitted)

2.4 Power Tree

Figure 2-1 illustrates the power tree diagram of the IS1678S/SM.

FIGURE 2-1: IS1678S/SM POWER TREE DIAGRAM

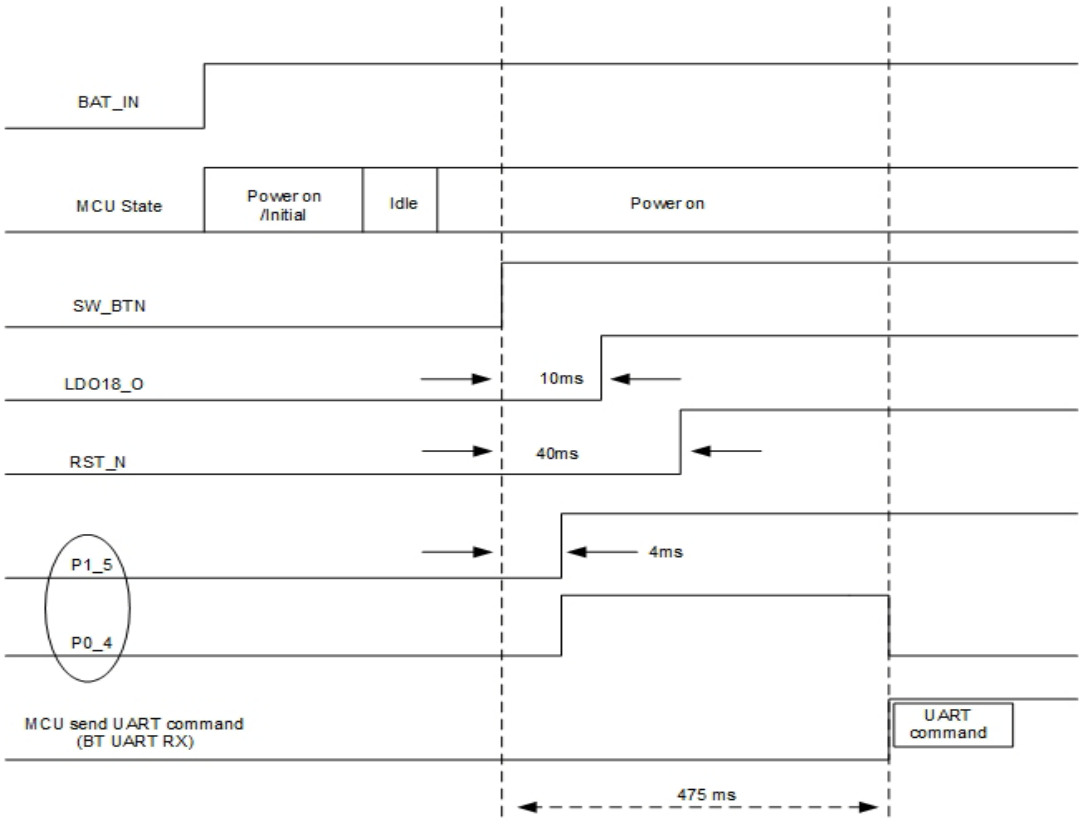


2.5 Software Button pin

The Software Button (SW_BTN) input pin powers the IS1678S/SM ON (high) or OFF (low) in to the S4 mode. The S4 mode is Deep-sleep mode and the S2 mode is Sleep mode. The S4 mode can only be triggered by the SW_BTN pin and the power consumption is lower in the S4 mode.

Figure 2-2 through Figure 2-4 illustrate the waveforms for the IS1678S/SM in the high and low (access and link) status.

FIGURE 2-2: SW_BTN TIME (HIGH) AT APPLICATION MODE(1,2,3)

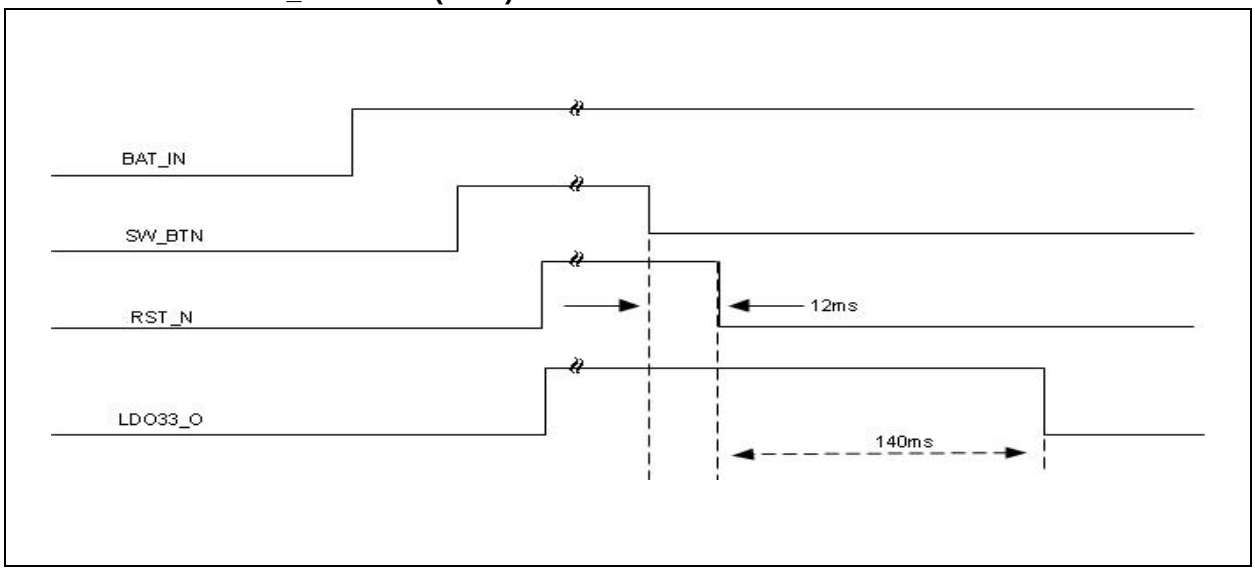


Note 1: MCU can send UART command, refer to P0_4/P1_5 status in Table 2-3.

2: Reset is 'no connect'.

3: Time is configured as default setting.

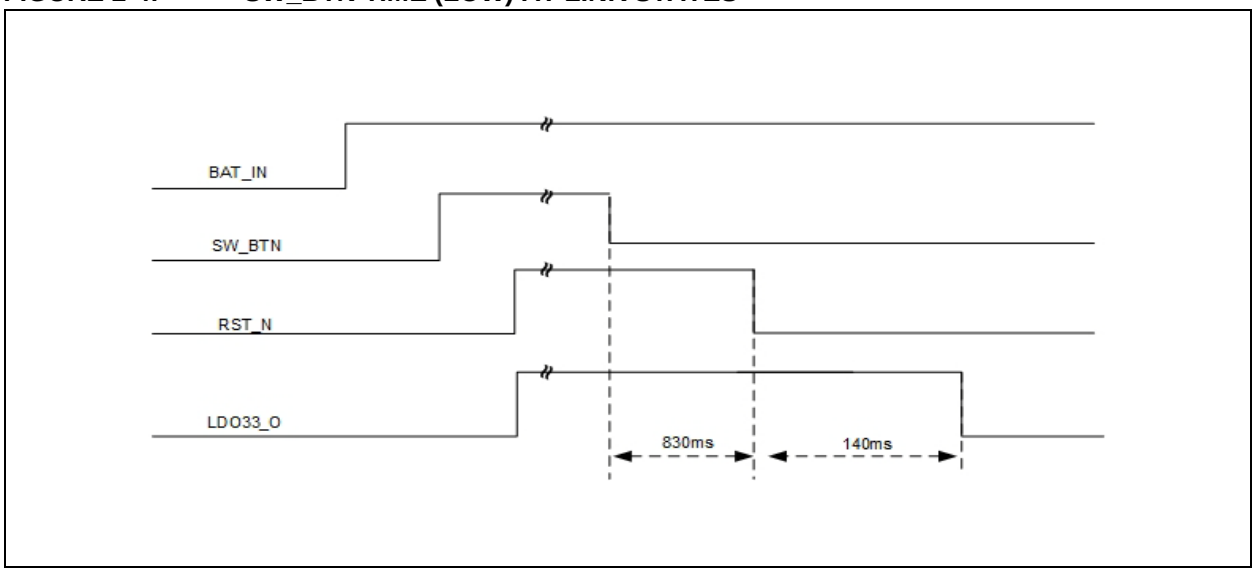
FIGURE 2-3: SW_BTN TIME (LOW) AT ACCESS STATES(1,2)



Note 1: Reset is ‘no connect’.

2: Time is configured as default setting.

FIGURE 2-4: SW_BTN TIME (LOW) AT LINK STATES(1,2,3)



Note 1: The 830 ms is a typical value measured on iPhone® 6 and it can vary from one smart phone to another.

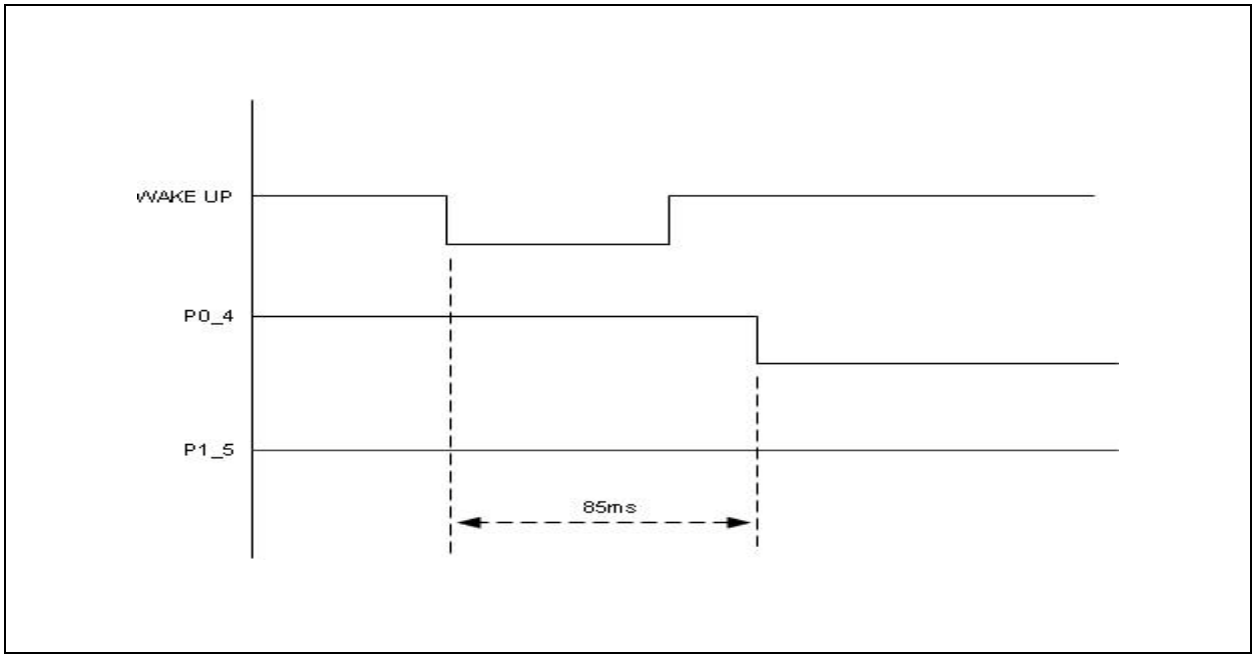
2: Reset is ‘no connect’.

3: Time is configured as default setting.

2.6 Wake Up pin

The WAKE_UP input pin (active-low) wakes up the IS1678S/SM from the S2 mode and wake up is always from Sleep mode to Standby mode. Figure 2-5 illustrates the timing diagram of the WAKE_UP pin.

FIGURE 2-5: WAKE UP TIME(1,2)



Note 1: The 85 ms is for reference purpose only and users must check the status pin.

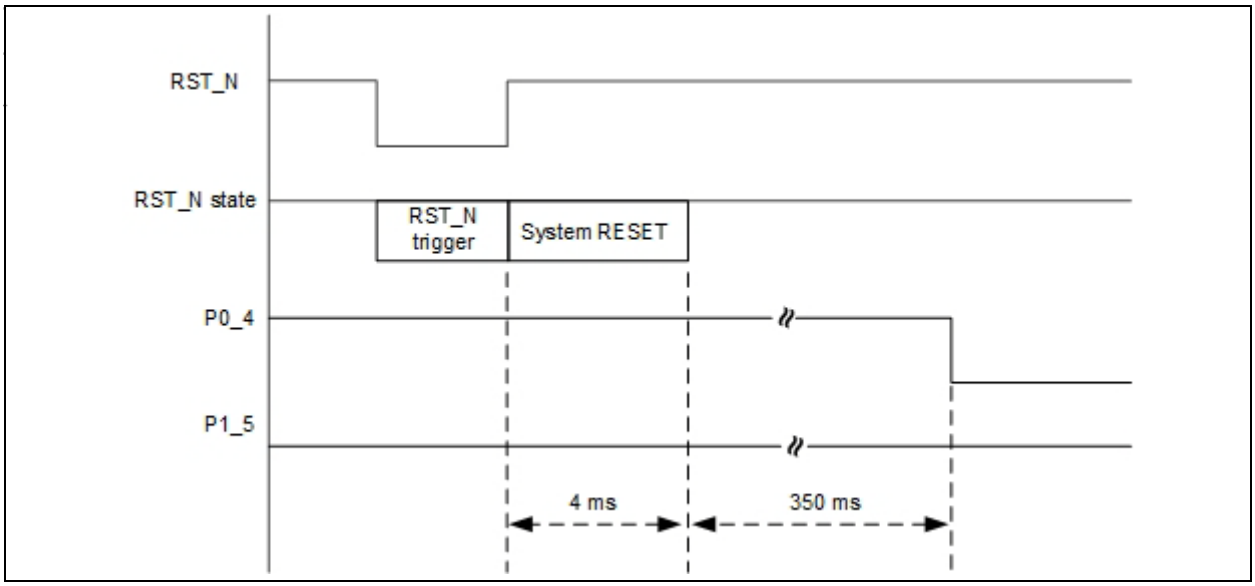
2: See Table 2-3 for the states of the P0_4 and P1_5 pins.

2.7 External Reset

The watchdog timer (WDT) can reset the IS1678S/SM. It has an integrated Power-on Reset (POR) circuit that Resets all circuits to a known Power-on state. This action can also be driven by an external Reset signal which can be used to control the device externally, that is forcing the device into a Power-on state. The RST signal input is active-low and connection is not required in most of the applications.

Figure 2-6 illustrates the timing diagram of the IS1678S/SM when it is in Reset (RST_N is set to active low).

FIGURE 2-6: RESET TIMING WAVEFORM(1,2,3,4)



Note 1: The timing is only for reference purpose, refer to the P0_4 and P1_5 status.

2: The RST_N trigger must be greater than 63 ns.

3: Auto pattern can use external Reset, refer to **Section 3.0 "Operating Modes"**.

4: Manual pattern can use external Reset and Reset command, refer to **Section 3.0 "Operating Modes"**.

2.8 Reference Clock

The IS1678S/SM is composed of an integrated crystal oscillation function. It requires a 16 MHz external crystal and two specified load capacitors to obtain a high quality system reference timer source. This function is typically used to remove the initial tolerance frequency errors associated with the crystal and its equivalent load capacitance in mass production. The Frequency trim is achieved by adjusting the crystal load capacitance through on-chip trim capacitors (Ctrim) integrated in the chip.

The value of the trimming capacitance is around 200 fF ($200x10^{-15}$ F) per LSB at 5-bit word. Therefore, the overall adjustable clock frequency is around 40 KHz.

C_{trim} = 200fF*(1~31), capacitor inside chip and could be trimmed in the MP process.

C_{int} » 3pF, C_{int} is a sub-total capacitor value on the path, which is derived from the layout trace and chip pad.

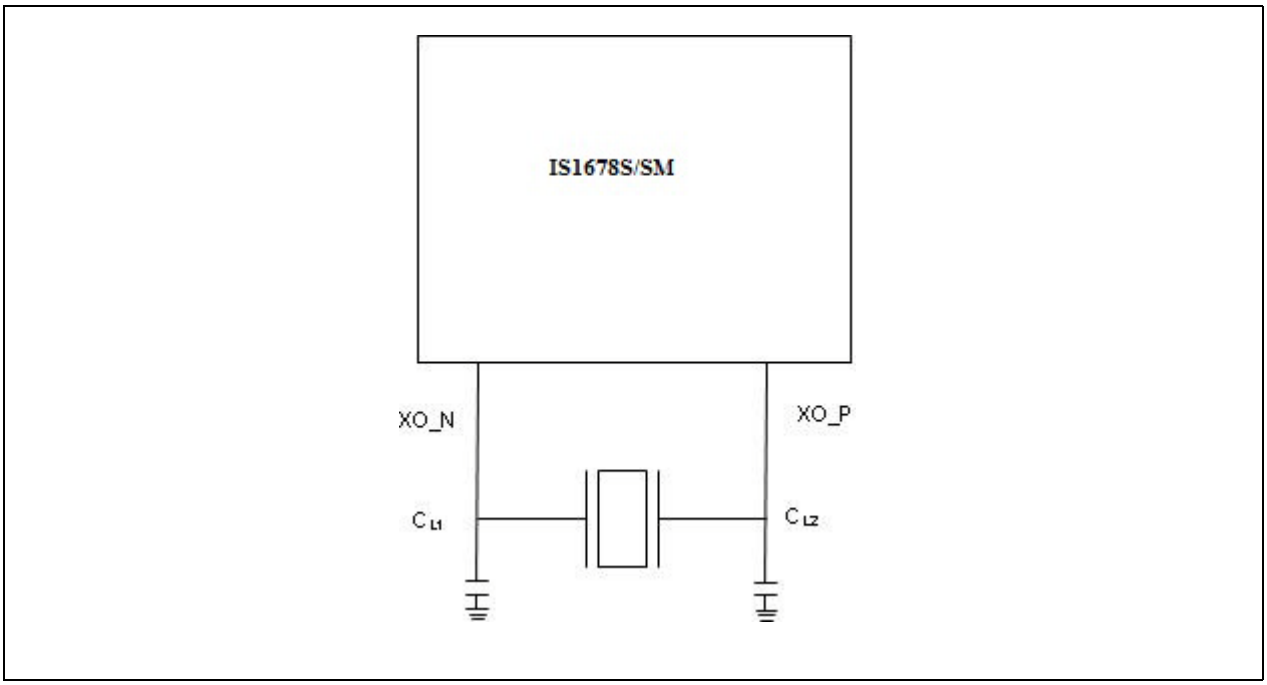
$$C_L = [(C_{L1}*C_{L2})/(C_{L1}+C_{L2})]+(C_{trim}/2)+C_{int}$$

For example, if trim value is set as 16, then C_{trim} = 3.2 pF.

For a 16 MHz crystal, where C_L = 9 pF, then $C_{L1} = C_{L2}$ = 9.1 pF

For additional information on C_L selection, refer to the data sheet of the crystal vendor.

FIGURE 2-7: EXTERNAL CRYSTAL WITH LOAD CAPACITORS

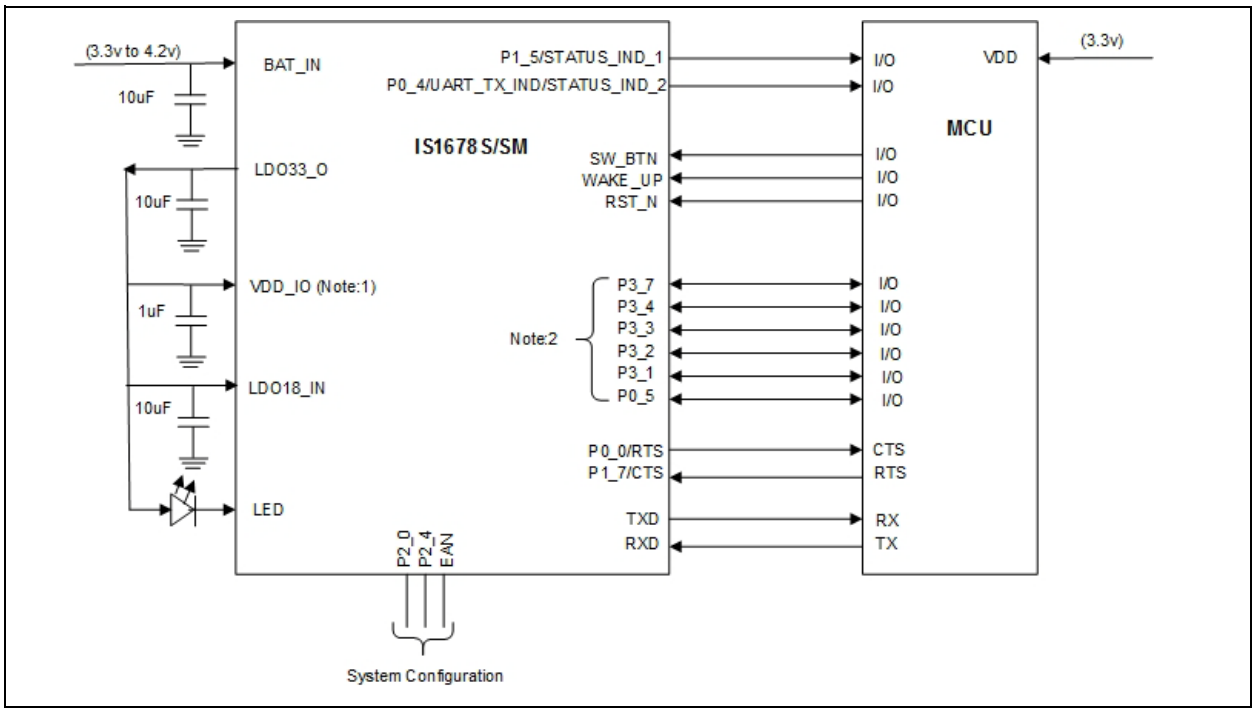


2.9 Host MCU Interface Over UART

Figure 2-8 illustrates a typical UART interface with host MCU and power scheme using 3.3V to MCU VDD. Battery power is applied to the BAT_IN pin. The voltage can be routed from the LDO33_O pin to the VDD_IO pin and external circuitry including the MCU. This power scheme ensures that the IS1678S/SM and MCU I/O voltages are compatible.

Note:	The internal 3.3V LDO current source should not exceed 50 mA (i.e maximum).

FIGURE 2-8: UART INTERFACE WITH HOST MCU

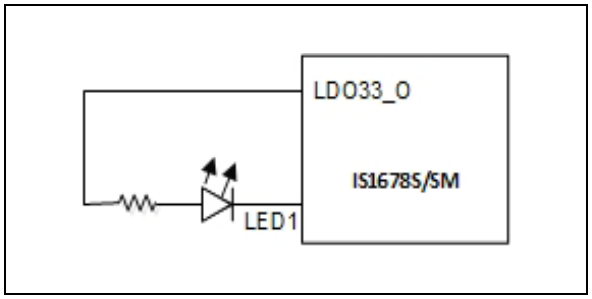


Note 1: Ensure that VDD_IO and MCU VDD voltages are compatible.

2: Control and indication ports are configurable.

The LED can be connected directly to the IS1678S/SM and one dedicated LED driver controls the LED.The maximum sourcing current for the LED is 5mA and it provides 16 options (steps) to trim the brightness of the LED. The LED brightness can be configured using the UI tool, a Windows® configuration utility. Figure 2-9 illustrates the block diagram of the LED.

FIGURE 2-9: LED DRIVER



The status indication of the LED (LED1) are as follows, and each status indication is a configurable flashing sequence:

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

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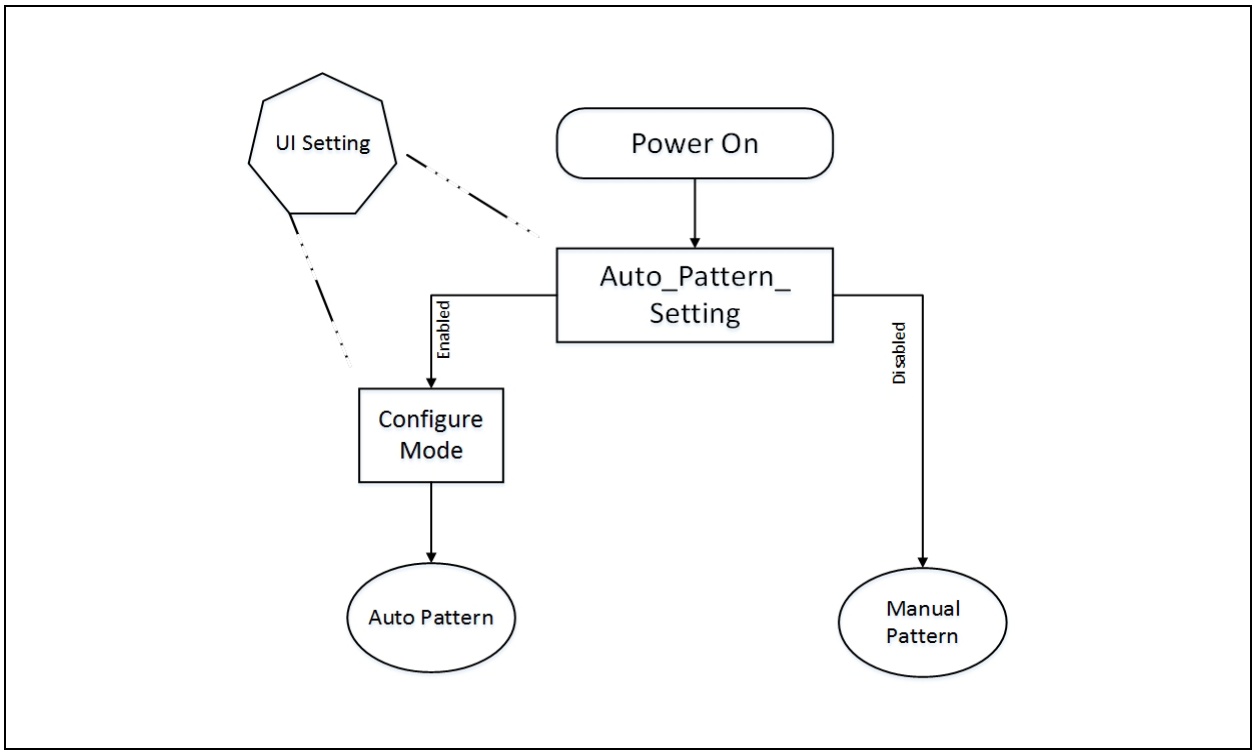
3.0 OPERATING MODES

The IS1678 provides two operating patterns, Auto pattern and Manual pattern. The operating pattern depends on the Auto_Pattern_Setting parameter that is configured by UI setting. If the Auto_Pattern_Setting parameter is enabled, the IS1678 triggers the Auto pattern state machine, otherwise Manual pattern is used. The Configure mode is available only in Auto pattern and it can be enabled or disabled by UI setting.

Figure 3-1 illustrates the differences between Auto pattern and Manual pattern.

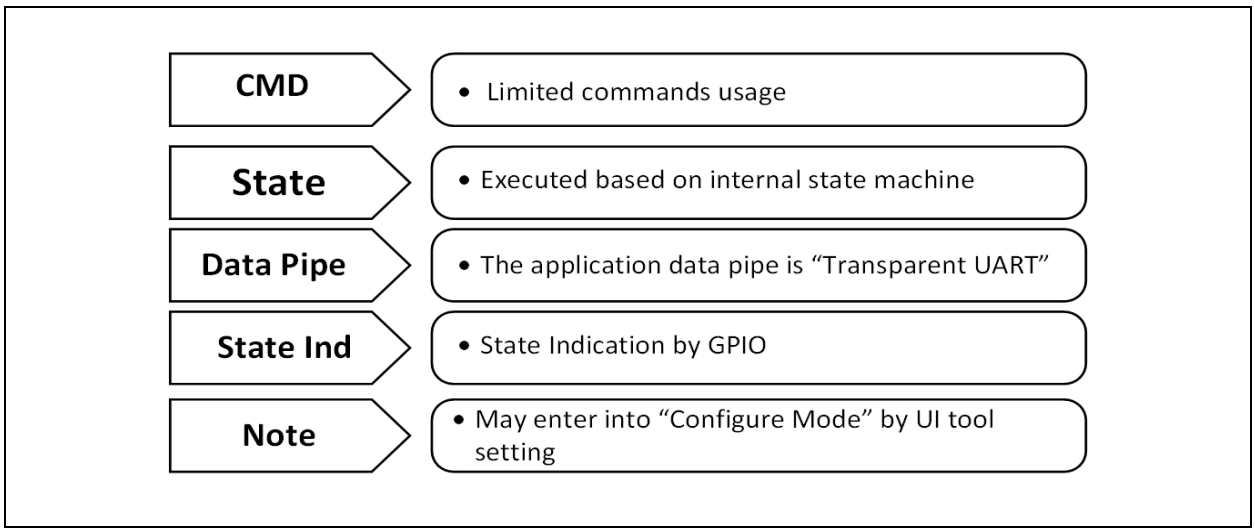
FIGURE 3-1: PATTERN CONFIGURATION



3.1 Auto Pattern

In Auto pattern, the IS1678 operates itself after Power on without any interference from the MCU. Auto pattern is the basic application of the IS1678. Figure 3-2 illustrates the characteristics of Auto pattern.

FIGURE 3-2: AUTO PATTERN CHARACTERISTICS



The IS1678 provides the flexibility for the MCU to perform specific settings in Configure mode by command set even if it is set to operate in Auto Pattern mode. If the IS1678 has enabled authenticated pairing, the command set is required to accomplish the Bluetooth link. MCU doesn’t have to deal with the IS1678 state, and it changes its state after Power on. However, still MCU can terminate the connection by GPIOs. The Transparent pipe is always used for application data transmission, and all the data is transmitted between the remote host and MCU.

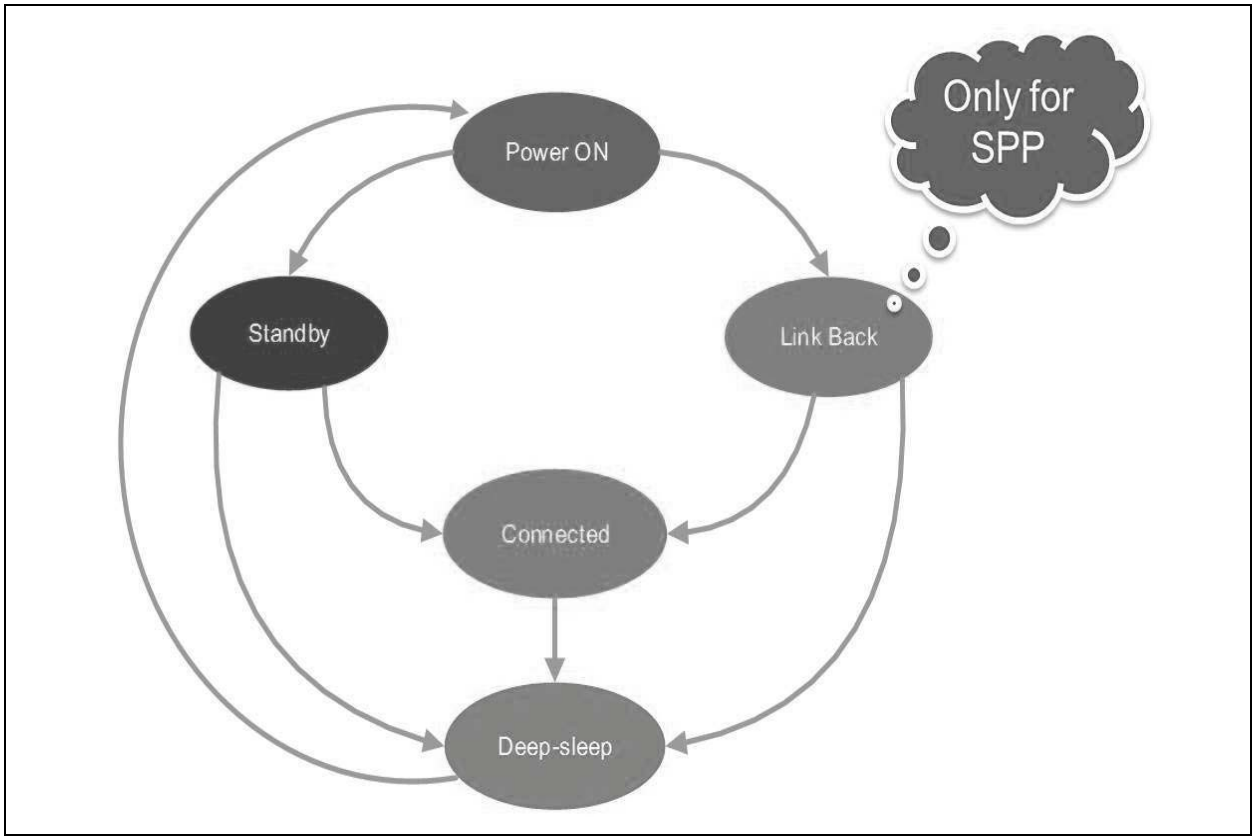
The MCU can know the state of the IS1678 by GPIOs. Configure mode is available only in Auto pattern, and it can be enabled or disable by UI tool setting. Mostly the MCU is communicating with the IS1678 by GPIOs, except for data transmission.

Figure 3-3 illustrates how the IS1678 changes its own state. After Power on, there are two options, one is to enter Standby mode, and the other is to enter Link-back mode. This depends on if any device is recorded in the IS1678. Irrespective of the mode, the IS1678 waits for the remote side to establish a connection or tries to establish a connection with the remote side.

Once the connection is established, the IS1678 status changes to Connected mode. If connection is terminated, the IS1678 enters Deep-sleep mode automatically.

Note:	Link-back mode is available only for SPP profile or mode.

FIGURE 3-3: INTERNAL STATE MACHINE



If the IS1678 stays in access state, it is ready for remote host to access. It either waits for remote side to create a connection or it tries to create a connection on its own. The Configure mode and pairing procedure are defined as access state. If the IS1678 enters link state, it means the Bluetooth link has been established successfully, and the data session is triggered. The MCU can transmit data to remote host or receive data from remote host in this state. Table 3-1 provides various states and modes.

TABLE 3-1: STATE INDICATION

State	Mode
Access State	Configure Mode Stand-by Mode Link-back mode Pairing Procedure
Link State	Connected Mode
Deep-sleep State	Deep-sleep Mode

Figure 3-4 illustrates the transparent pipe. If MCU wants to send data “12345” to the remote side, MCU needs to send the data in .hex format to IS1678. Then IS1678 transmits the received data to the remote side. Similarly, if IS1678 receives data from the remote host, then IS1678 sends the data in .hex format to the MCU directly.

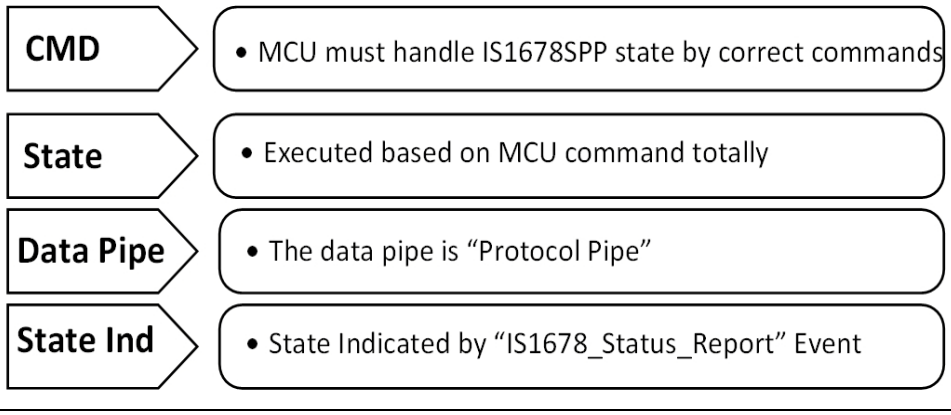
FIGURE 3-4: AUTO PATTERN TRANSPARENT PIPE

3.2 Manual Pattern

In Manual pattern, the MCU communicates with the IS1678 by command sets. The MCU must send correct commands to handle the state of the IS1678.

The change in the IS1678 state is based on the MCU commands. The data pipe for Manual pattern is also different from Auto pattern. Since MCU is communicating with MCU by command sets, the data transmission will follow the command set rule. This is defined as protocol pipe. In manual pattern, the MCU can get the detail status by the IS1678_Status_Report event. Figure 3-5 illustrates the Manual Pattern characteristics.

FIGURE 3-5: MANUAL PATTERN CHARACTERISTICS



For manual pattern, Figure 3-6 illustrates the state changes require the corresponding command. For example, MCU sends the 'Invisible_Setting' command with the parameter 'Enter_Standby_Mode', then the IS1678 enters into Standby mode. The MCU sends the 'SPP_Create_Link' command, then the IS1678 enters into Link-back mode. In Auto pattern, the IS1678 goes into Deep-sleep mode after the connection is terminated. However, in manual pattern, the IS1678 stays in Idle mode after connection is terminated. The MCU decides the mode of IS1678 once the connection has been terminated, based on the overall system behavior.

Figure 3-7 illustrates the protocol pipe. If MCU wants to send data "12345" to remote side, the data format follows the UART command protocol.

FIGURE 3-6: STATE CHANGES BY MCU IN MANUAL PATTERN

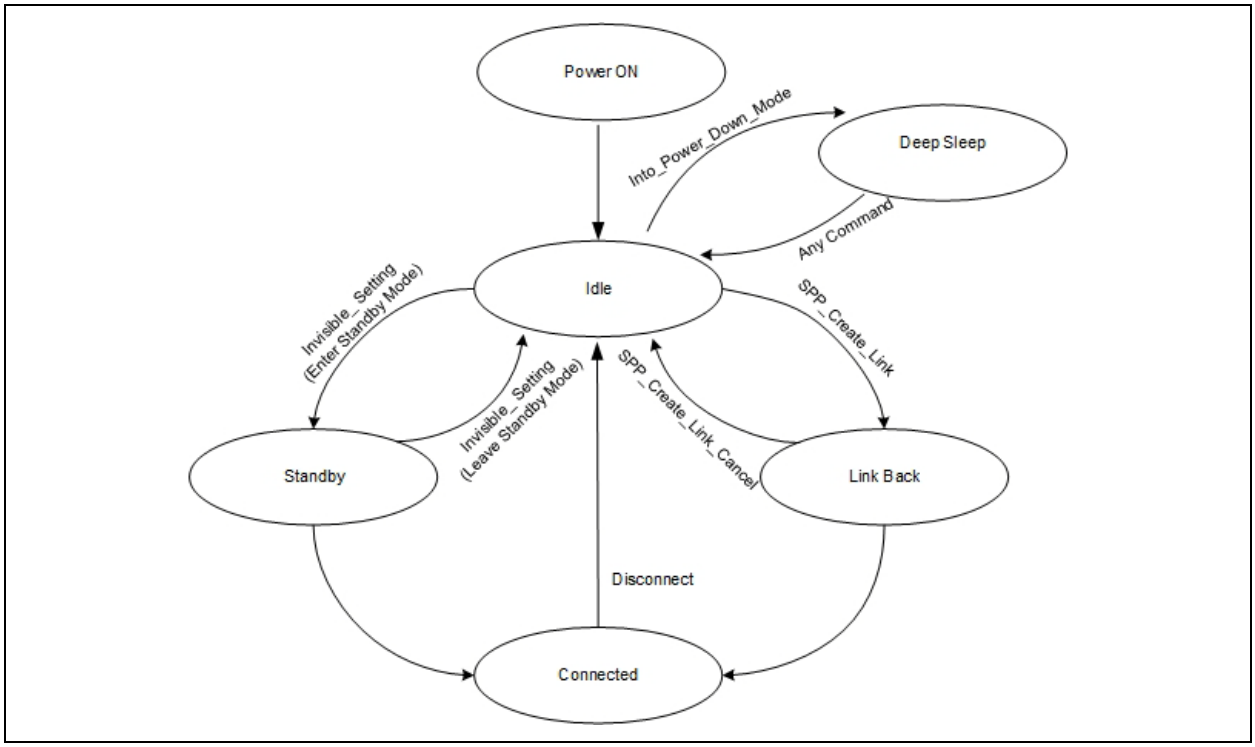
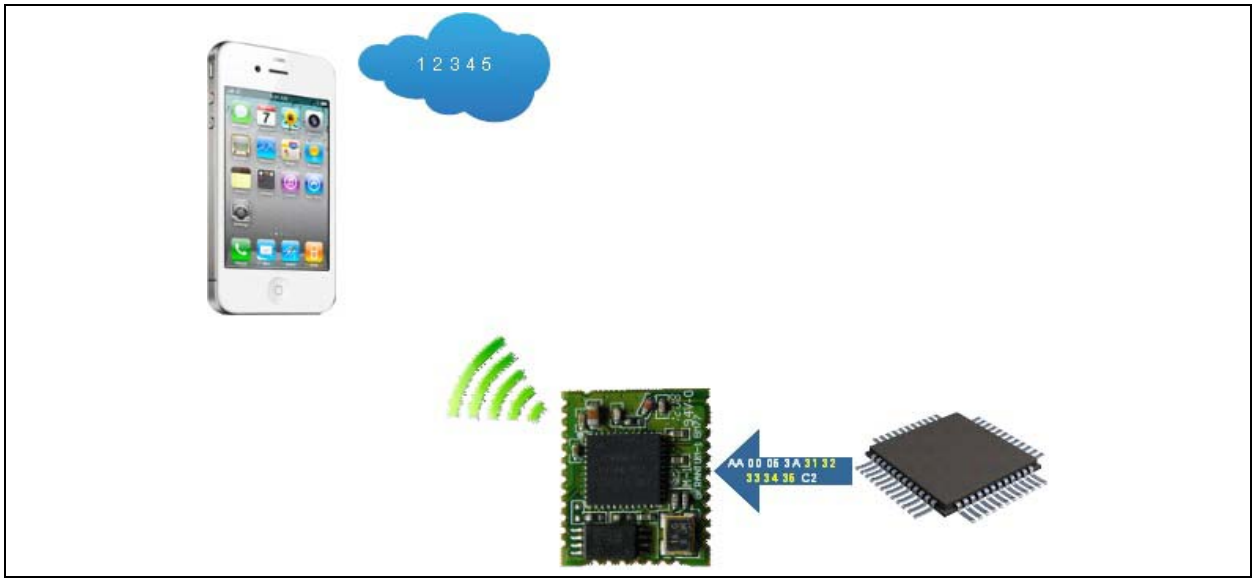


FIGURE 3-7: MANUAL PATTERN PROTOCOL PIPE

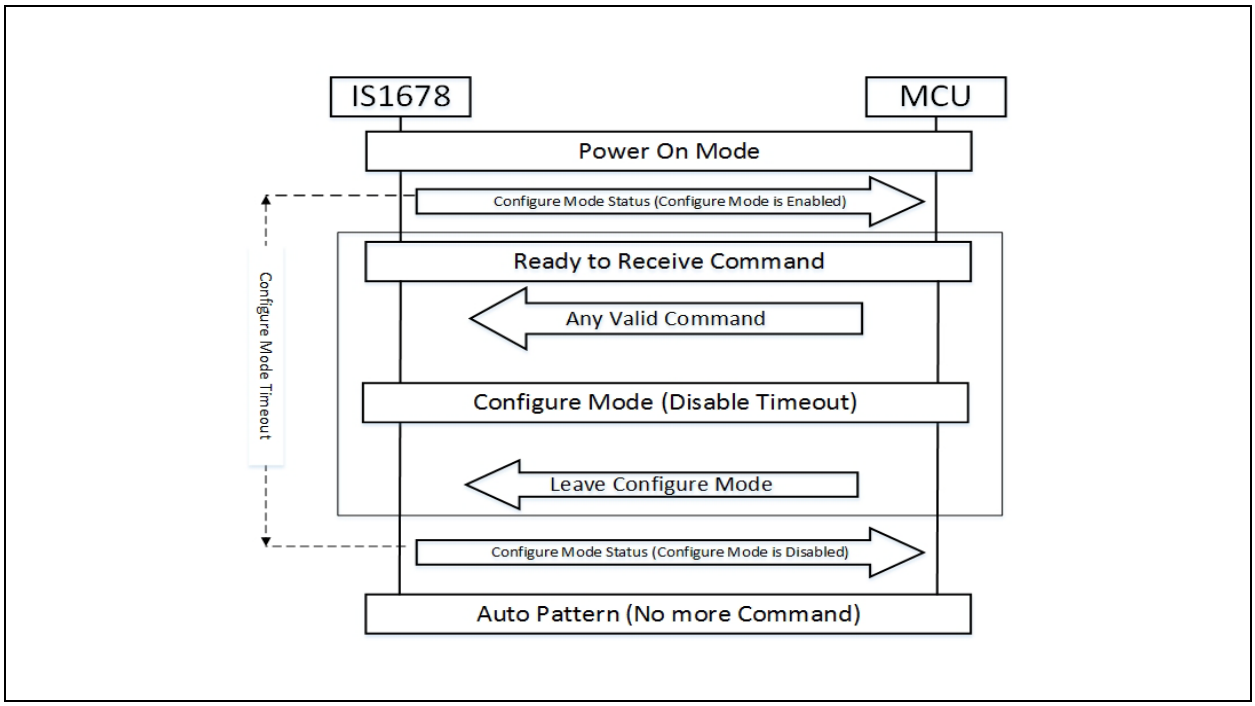


3.3 Mode Definition

3.3.1 CONFIGURE MODE

The purpose of Configure mode is to configure relative setting before the IS1678 enters into Auto pattern state. If Configure mode is enabled, the IS1678 will send Configure mode status event to notify MCU that the IS1678 is ready to receive commands. If the IS1678 doesn't receive any valid command within the specified Configure mode time, then it will exit from Configure mode automatically. Once MCU sends any valid command within the Configure mode time, the IS1678 does not exit Configure mode until MCU issues leave Configure mode command. Once the IS1678 exits from Configure mode, it goes to process Auto pattern state machine.

FIGURE 3-8: CONFIGURE MODE



3.3.2 STAND-BY MODE

- SPP (BR/EDR)
  - Enable the Inquiry Scan and Page Scan in this mode
  - Configurable to be discoverable
  - Ready to be paired
- Bluetooth Low Energy (BLE)
  - Enable the Undirected Advertising in this mode
  - Ready to be paired

3.3.3 LINK-BACK MODE

- SPP (BR/EDR)
  - Enable page procedure to establish dedicated or last connected Bluetooth SPP link
  - Configurable to be invisible situation
- BLE
  - No BLE link-back behavior because of iOS limitation
  - Configurable to be invisible situation
  - Ready to be paired

3.3.4 CONNECTED MODE

- SPP (BR/EDR)
  - Use SPP or iAP protocol to exchange the application data
  - Connection Establish status: SPP Connected mode
- BLE
  - Use GATT protocol to exchange the application data
  - Connection establish status: BLE Connected mode

3.3.5 DEEP-SLEEP MODE

- Auto Pattern
  - Enter into Deep-sleep mode automatically
  - Wake-up trigger: WAKE_UP pin
- Manual Pattern
  - Enter into Deep-sleep mode by MCU command assign
  - Wake-up trigger: WAKE_UP pin or UART_RX_Ind pin

NOTES:

4.0 ANTENNA PLACEMENT GUIDELINES

For a Bluetooth wireless product, antenna placement affects whole system performance.

The antenna needs free space to radiate the RF signal, and it cannot be surrounded by the GND plane. Figure 4-1 illustrates examples of good and poor antenna placement on a main application board with the GND plane.

FIGURE 4-1: ANTENNA PLACEMENT EXAMPLES

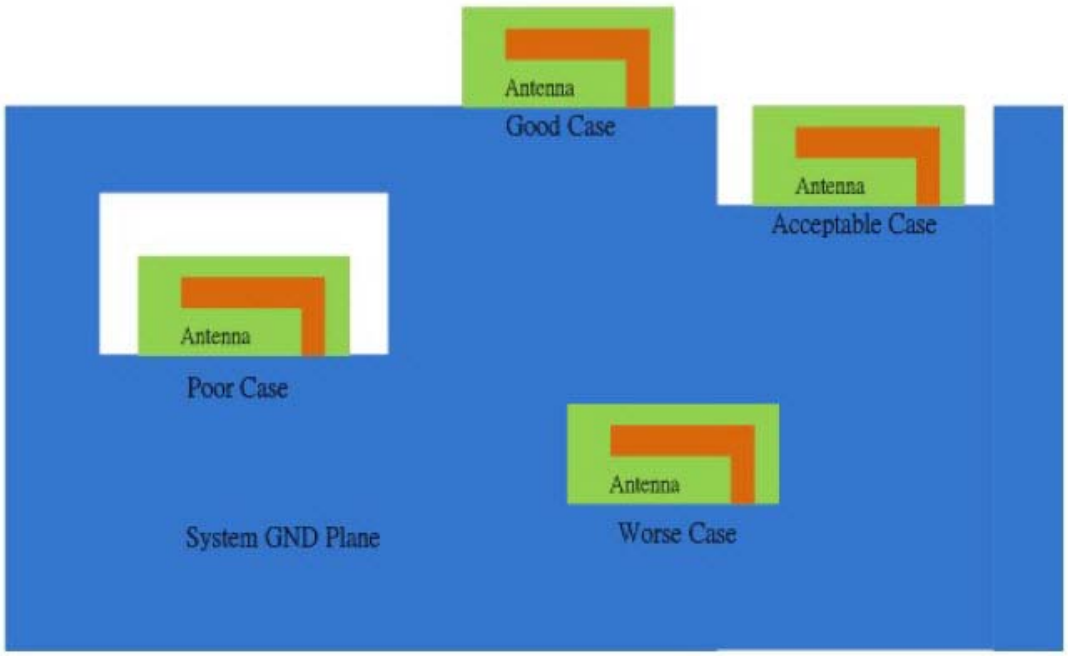
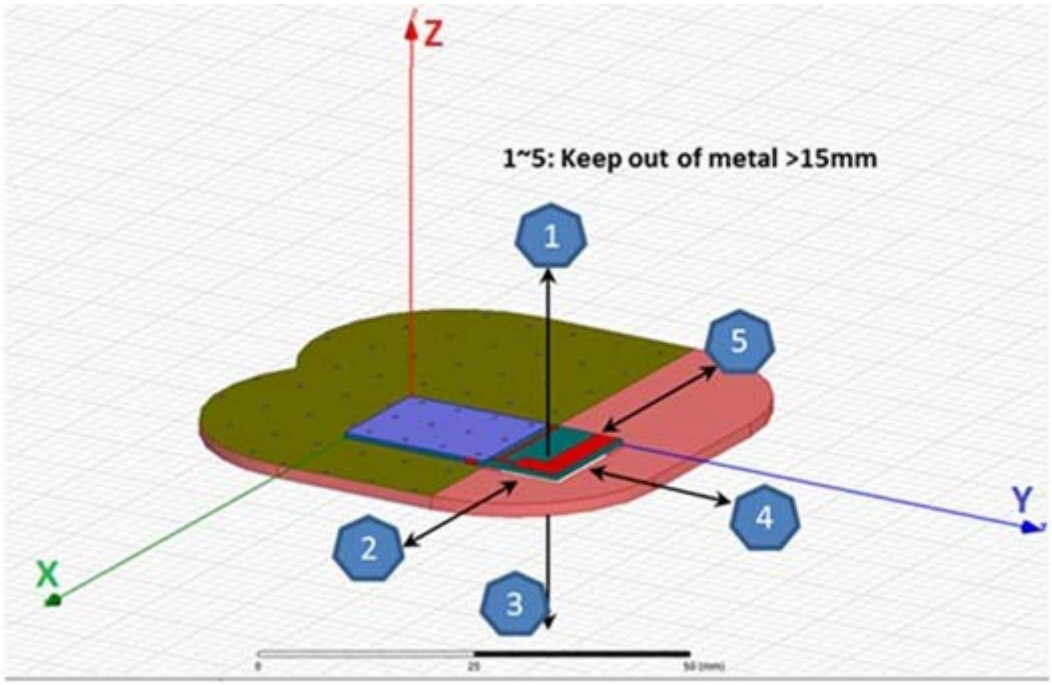


Figure 4-2 illustrates the keep out area recommended for the antenna.

FIGURE 4-2: KEEP OUT AREA RECOMMENDED FOR ANTENNA



For additional information on free space for antenna placement design, refer to the design rule of the antenna vendor.

5.0 TRANSCEIVER

The IS1678S/SM is designed and optimized for Bluetooth 2.4 GHz system. It contains a complete radio frequency transmitter/receiver section. An internal synthesizer generates a stable clock for synchronization with another device.

5.1 Transmitter

The internal Power Amplifier (PA) has a maximum output power of +4 dBm (+2 dBm typical). This is applied as input to Class 2/3 radios without external RF PA.

The transmitter directly performs IQ conversion to minimize the frequency drift, and it can exceed 12 dB power range with temperature compensation mechanism.

5.2 Receiver

The LNA operates with transmit/receive combined mode for single port application. It can save a pin on package and without an external Tx/Rx switch.

The ADC is utilized to sample the input analog wave and convert it into digital signal for de-modulator analysis. A channel filter has been integrated into the receiver channel before the ADC, to reduce the external component count and increase the anti-interference capability.

The image rejection filter is used to reject image frequency for low-IF architecture. This filter for low-IF architecture is intended to reduce external BPF component for super heterodyne architecture.

The RSSI signal is fed back to the processor to control the RF output power to make a good trade-off for effective distance and current consumption.

5.3 Synthesizer

A synthesizer generates a clock for radio transceiver operation. A VCO exists inside with a tunable internal LC tank. It can reduce the variation for components. A crystal oscillator with an internal digital trimming circuit provides a stable clock for the synthesizer.

5.4 Modem

For Bluetooth 1.2 specification and below, 1 Mbps was the standard data rate based on Gaussian Frequency Shift Keying (GFSK) modulation scheme. This basic rate modem meets BDR requirements of Bluetooth 2.0 with EDR specification.

For Bluetooth 2.0 with EDR specification, Enhanced Data Rate (EDR) has been introduced to provide 2 Mbps and 3 Mbps data rates as well as 1 Mbps. The BDR/EDR modes have fast transmission rates or high throughput.

The LE mode saves current. This enhanced data rate modem meets EDR requirements of Bluetooth 2.0 with EDR specification. From the viewpoint of baseband, both BDR and EDR utilize the same 1 MHz symbol rate and 1.6 KHz slot rate. For BDR, 1 symbol represents 1 bit. However, each symbol in the payload part of EDR packets represents 2 or 3 bits. This is achieved by using two different modulations, π/4 DQPSK and 8DPSK.

5.5 Adaptive Frequency Hopping (AFH)

The IS1678S/SM has an AFH function to avoid RF interference. It has an algorithm to monitor the interference in the environment and choose a clear channel for the Bluetooth transceiver to operate on.

NOTES:

6.0 ELECTRICAL CHARACTERISTICS

This section provides an overview of the IS1678 electrical characteristics. Additional information will be provided in future revisions of this document as it becomes available.

Absolute maximum ratings for the IS1678 devices are listed below. Exposure to the maximum rating conditions for extended periods may affect device reliability. Functional operation of the device at these or any other conditions, above the parameters indicated in the operation listings of this specification, is not implied.

Absolute Maximum Ratings

Ambient temperature under bias ..... -20°C to +70°C
Storage temperature ..... -40°C to +125°C
Voltage on V_{DD} with respect to V_{SS} ..... -0.3V to +3.6V
Voltage on any pin with respect to V_{SS} ..... -0.3V to (V_{DD} + 0.3V)
Maximum output current sunk by any I/O pin ..... 12 mA
Maximum output current sourced by any I/O pin ..... 12 mA

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

Table 6-1 through Table 6-8 provide the recommended operating conditions and the electrical specifications of the IS1678S/SM.

TABLE 6-1: RECOMMENDED OPERATING CONDITIONS

Rating		Min.	Typical	Max.
Ambient Operating temperature range		-20ºC	+25ºC	+70ºC
Relative Humidity (Operating)		10%	—	90%
Relative Humidity (Storage)		10%	—	90%
ESD	HBM	—	±2KV	—
	MM	—	±200V	—
HTOL (see **note 1**)		—	1000 hrs	—
Supply voltage: BAT_IN		3.3V	—	4.2V
Supply voltage: VDD_IO		3.0V	3.3V	3.63V
Supply voltage: LDO18_IN		3.0V	3.3V	3.63V
Supply voltage: 1V8, VCC_RF, VDD_XO, AVDD_SAR		1.8V	1.9V	2.1V
SW_BTN		3.3V	—	4.2V
LED1		—	—	3.6V
Reset $V_{TH,res}$ threshold voltage		—	1.6V	—
V_{IL} input logic levels low		-0.3V	—	0.8V
V_{IH} input logic levels high		2.0V	—	3.6V
V_{OL} output logic levels low (I_{ol} = 12 mA)		—	—	0.4V
V_{OH} output logic levels high (I_{oh} = 12 mA)		2.4V	—	—
RF continous Tx mode		—	—	43 mA
RF continous Rx mode		—	—	37 mA

Note 1: HTOL life test condition: +125ºC, BAT_IN = 4.2V, LDO33_O = 3.3V, LDO18_O = 1.9V

TABLE 6-2: 1.8V LDO ELECTRICAL PARAMETERS(1,2)

Parameter	Min.	Typical	Max.	Unit
Operating Temperature	-20	—	+70	ºC
Output Current (V_{IN} = 3.0V/load regulation with 80mV drop)	—	100	—	mA
Quiescent Current (V_{in} < 3.0V)	—	13	—	µA

Note 1: With 1 uF capacitors at LDO18_O as the condition for IP verification.

2: Output voltage can be calibrated by using the MP tool.

TABLE 6-3: 3.3V LDO ELECTRICAL PARAMETERS(1,2)

Parameter	Min.	Typical	Max.	Unit
Operating Temperature	-20	—	+70	ºC
Output Current (V_{IN} = 3.6V /load regulation with 100 mV drop)	—	100	—	mA
Quiescent Current (V_{IN} = 3.6V)	—	150	—	µA

Note 1: With 10 uF capacitor at LDO33_O as the condition for IP verification.

2: Output voltage can be calibrated by using the MP tool.

TABLE 6-4: PMU LDO ELECTRICAL PARAMETERS(1,2)

Parameter	Min.	Typical	Max.	Unit
Operating Temperature	-20	—	+70	ºC
Output Current (V_{IN} = 3.6V/load regulation with 0.3 mV drop)	—	100	—	µA
Quiescent Current (V_{IN} = 3.6V)	—	120	—	µA

Note 1: With 1 uF capacitor at PMULDO_O as the condition for IP verification.

2: Output voltage can be calibrated by using the MP tool.

TABLE 6-5: SAR-ADC AND BATTERY VOLTAGE DETECTOR(1)

Parameter	Min.	Typical	Max.	Unit
Operating Temperature	-20	—	+70	ºC
AVDD_SAR power supply	—	1.8	—	V
SAR_BAT detection(1)	3.3	—	4.2	V
Resolution	—	10	—	bit
Operating Current (including bandgap)	—	—	1	mA
Deep-sleep Current	—	—	1	µA

Note 1: SAR_BAT is connected with BAT_IN internally for battery voltage detection.

TABLE 6-6: INTENSITY CONTROLLABLE DRIVER

	Min.	Typical	Max.	Unit
Operating Temperature	-20	—	+70	ºC
Open-drain Voltage	—	—	3.6	V
Current Step	—	0.3	—	mA
Programmable Current Range	0	—	5	mA
Intensity control	—	16	—	step
Power-down open-drain current	—	—	1	µA
Deep-sleep Current	—	—	1	µA

TABLE 6-7: POWER CONSUMPTION CLASSIC(1)

Test Condition	Current (avg.) (mA)	Remarks
Standby mode	2.543	—
Deep-sleep mode	0.187	—
Connected + Sniff, Master (no data)	0.541	No data was transmitted Sniff interval = 500 ms
Connected + Sniff, Slave (no data)	0.551	No data was transmitted Sniff interval = 500 ms
Data, Master	10.67	(Data transmitted at 115200 bps; block size = 500)
Data, Slave	14.87	(Data transmitted at 115200 bps; block size = 500)

Note 1: The classic BR/EDR and UART_RX_IND functions are enabled

TABLE 6-8: POWER CONSUMPTION ENERGY(1)

Test Condition	Current (avg.) (mA)	Remarks
Deep-sleep mode	0.13	—
LE fast advertising	1.21	LE fast advertising interval = 100 ms
	0.88	LE fast advertising interval = 160 ms
	0.48	LE fast advertising interval = 500 ms
	1.72	LE fast advertising interval = 100 ms + Beacon 100ms
	0.62	LE fast advertising interval = 500 ms + Beacon 500ms
Reduced Power advertising	0.39	LE Reduced Power advertising interval = 961 ms
	1.00	LE Reduced Power advertising interval = 961 ms + Beacon 100 ms
	0.51	LE Reduced Power advertising interval = 961 ms + Beacon 500 ms
Connected (No data)	0.39	Connection interval = 1500 ms
	0.43	Connection interval = 600 ms
Connected (iPhone 6 to IC)	0.45	Connection interval = 500 ms
	0.60	Connection interval = 200 ms
Connected (IC to iPhone 6)	6.6	Connection interval = 500 ms
	7.0	Connection interval = 200 ms

Note 1: Low Energy, RX_IND Function is Enabled

7.0 RADIO CHARACTERISTICS

Table 7-1 provides the transmitter performance characteristics and Table 7-2 provides the receiver performance characteristics of the IS1678S/SM.

TABLE 7-1: TRANSMITTER PERFORMANCE(1,2)

	Min.	Typical	Max.	Bluetooth Specification	Unit
BDR power	—	2	4	-6 ~ +4	dBm
EDR (2M/3M) power	—	0	4	-6 ~ +4	
LE power	—	2	4	-20 ~ +10	

Note 1: The RF Transmit power can be calibrated during production by using the MP Tool software and the MT8852 Bluetooth Test equipment.

2: Test condition: V_{CC_RF} = 1.80V, temperature = 25ºC.

TABLE 7-2: RECEIVER PERFORMANCE(1)

Basic Data Rate	Min.	Typical	Max.	Bluetooth Specification	Unit
BDR Sensitivity	—	-90	—	≤ -70	dBm
EDR 2M Sensitivity	—	-90	—		
EDR 3M Sensitivity	—	-82	—		
LE Sensitivity	—	-92	—		

Note 1: Test condition: V_{CC_RF} = 1.80V, temperature = 25ºC.

NOTES:

8.0 PACKAGE INFORMATION

8.1 Package Marking Information

Figure 8-1 illustrates the package marking information of the IS1678S/SM.

FIGURE 8-1: IS1678S/SM PACKAGE MARKING INFORMATION

40 -Lead QFN (6x6x0.9 mm)

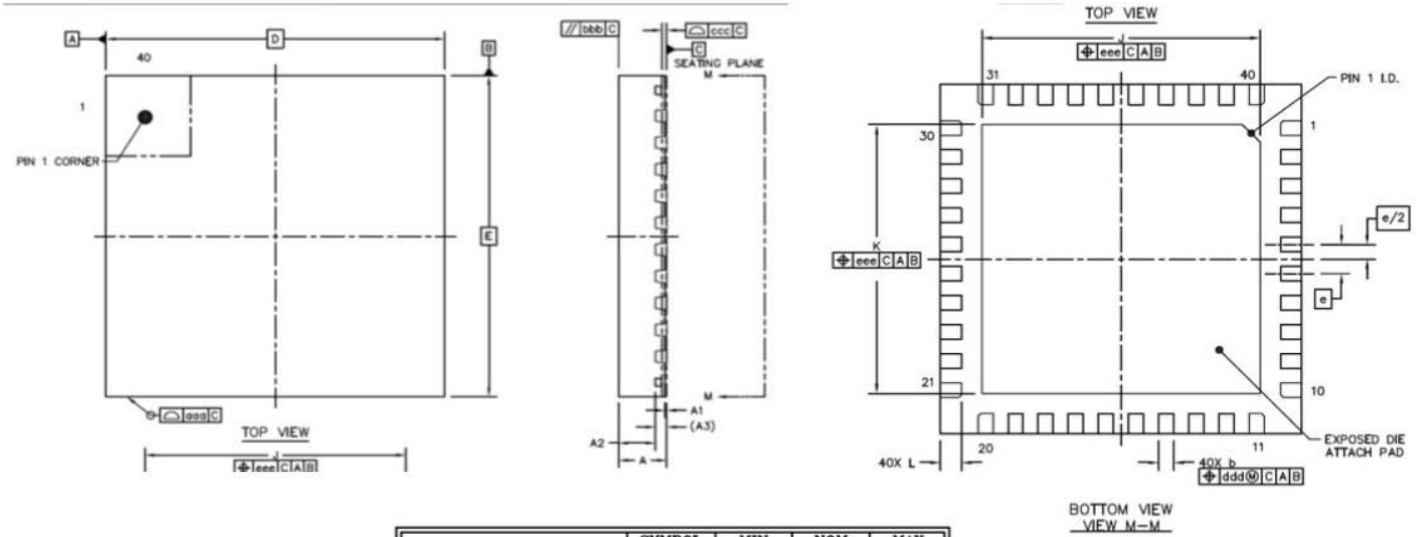
Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
		Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

8.2 Package Details

Figure 8-2 illustrates the package details of the IS1678S/SM.

FIGURE 8-2: IS1678S/SM PACKAGE DETAILS

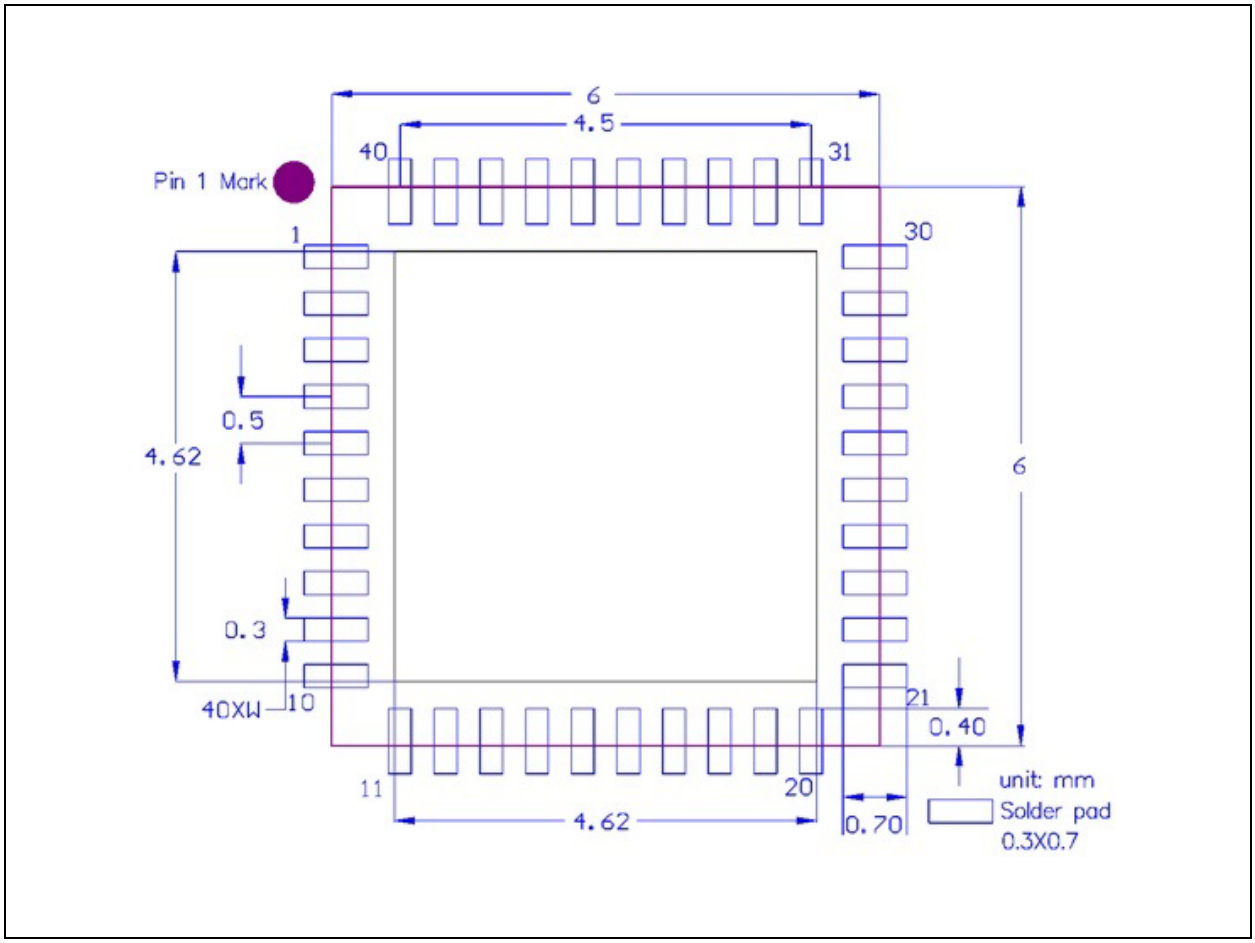


		SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS		A	0.8	0.85	0.9
STAND OFF		A1	0	0.035	0.05
MOLD THICKNESS		A2	---	0.65	---
L/F THICKNESS		A3		0.203 REF	
LEAD WIDTH		b	0.2	0.25	0.3
BODY SIZE	X	D		6 BSC	
	Y	E		6 BSC	
LEAD PITCH		e		0.5 BSC	
EP SIZE	X	J	4.52	4.62	4.72
	Y	K	4.52	4.62	4.72
LEAD LENGTH		L	0.3	0.35	0.4
PACKAGE EDGE TOLERANCE		aaa		0.1	
MOLD FLATNESS		bbb		0.1	
COPLANARITY		ccc		0.08	
LEAD OFFSET		ddd		0.1	
EXPOSED PAD OFFSET		eee		0.1	

8.3 Footprint Dimensions

Figure 8-3 illustrates the footprint dimensions of the IS1678S/SM.

FIGURE 8-3: IS1678S/SM FOOTPRINT DIMENSIONS



8.4 Package Information

FIGURE 8-4: TAPE ORIENTATION

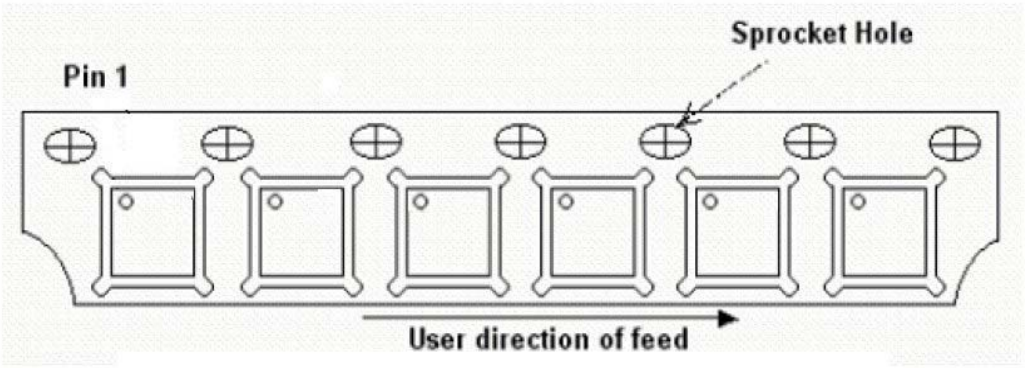


FIGURE 8-5: DIMENSIONS (ONLY REFERENCE)

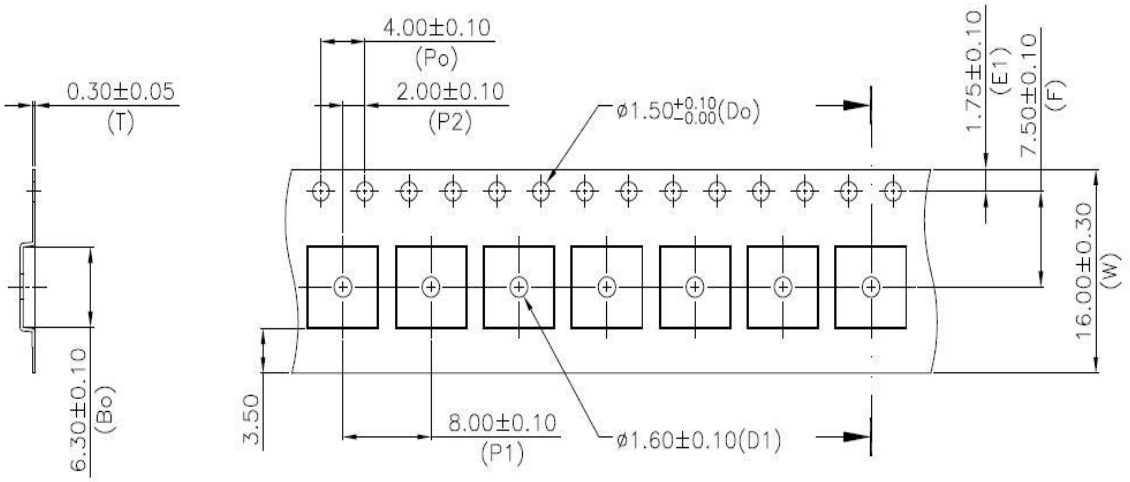


TABLE 8-1: PACKAGING DIMENSIONS

A_0	B_0	K_0	Unit	Notes
6.30	6.30	1.10	mm	1. 10 sprocket hole pitch with cumulative tolerance ±0.2 2. Material: PS + C 3. Camber not to exceed 1 mm in 100 mm 4. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

NOTES:

9.0 REFLOW PROFILE AND STORAGE CONDITION

This chapter describes reflow profiles and stencil information of the IS1678 SoC, see Figure 9-1 and Figure 9-2.

9.1 Stencil of SMT Assembly Suggestion

9.1.1 STENCIL TYPE & THICKNESS

- Laser cutting
- Stainless steel
- Thickness: 0.5 mm Pitch, thickness more than 0.15 mm

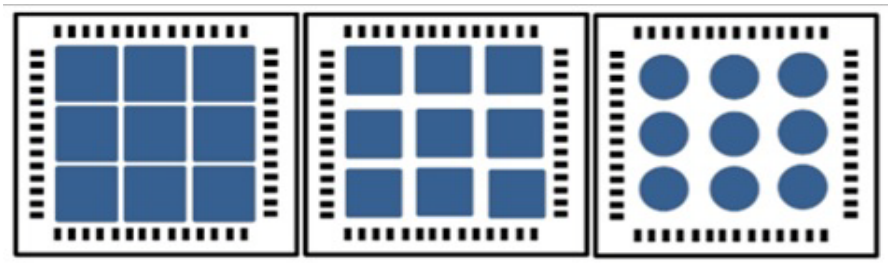
9.1.2 APERTURE SIZE AND SHAPE FOR TERMINAL PAD

- Aspect ratio (width/thickness) more than 1.5
- Aperture shape
  - The stencil aperture is designed to match the pad size on the PCB.
  - Oval-shape opening should be used to get the optimum paste release.
  - Rounded corners to minimize clogging.
  - Positive taper walls (5° tapering) with bottom opening larger than the top.

9.1.3 APERTURE DESIGN FOR THERMAL PAD

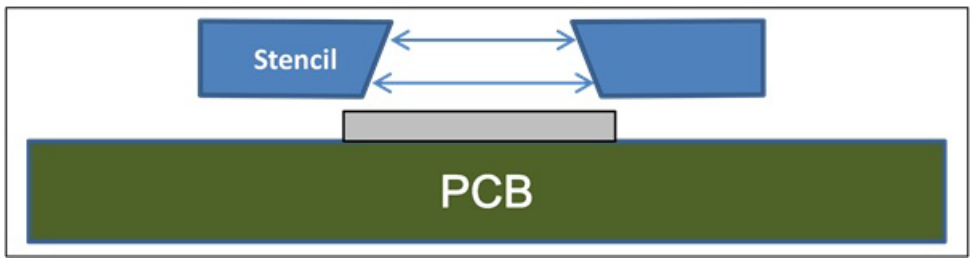
- Small multiple openings should be used instead of one big opening.
- 60~80% solder paste coverage
- Rounded corners to minimize clogging
- Positive taper walls (5° tapering) with bottom opening larger than the top

FIGURE 9-1: REFLOW PROFILE



Do not recommend Coverage 91% | Recommend Coverage 77% | Recommend Coverage 65%

FIGURE 9-2: STENCIL TYPE

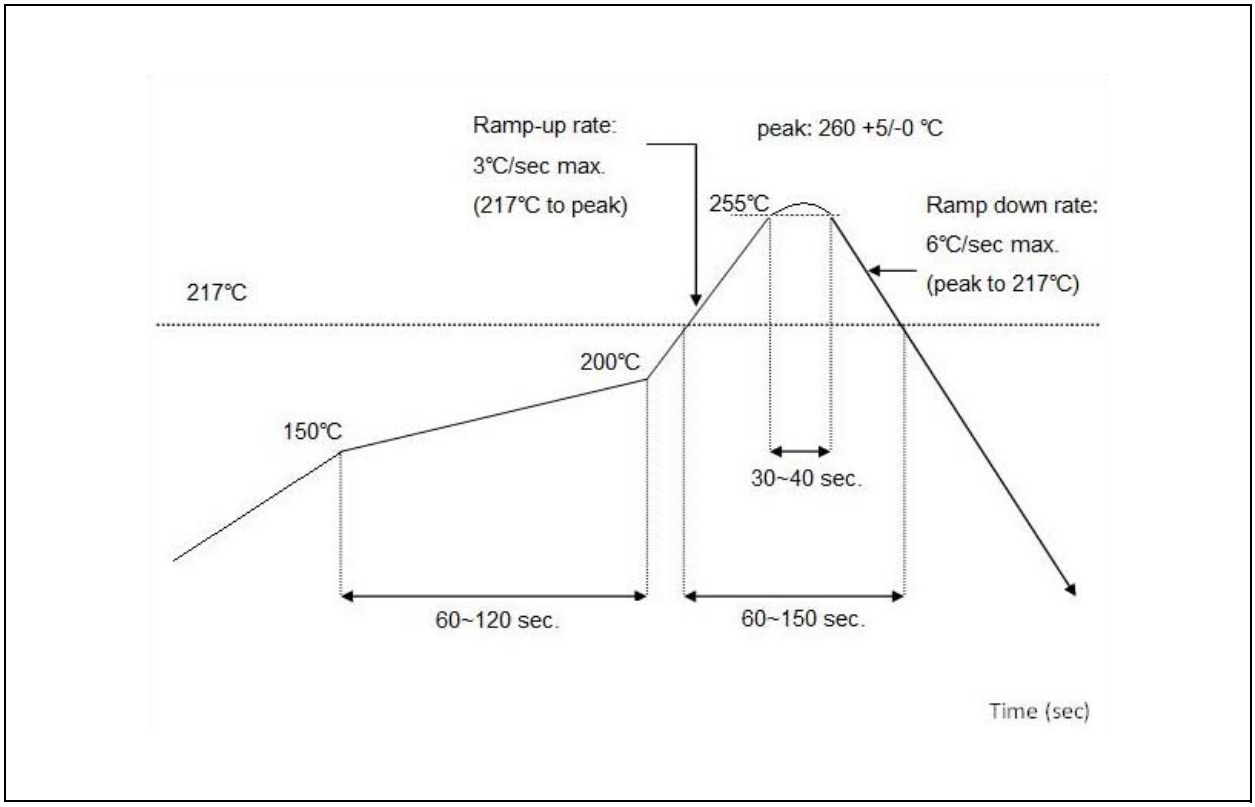


9.2 260 ℃ Reflow Profile

Figure 9-3 illustrates the reflow profile and the following are its specific features:

- Standard Condition: IPC/JEDEC J-STD-020
- Preheat: 150~200 ℃ ~60~120 seconds
- Average ramp-up rate (217 ℃ to peak): 3 ℃ /sec max.
- Temperature maintained above 217: 60~150 seconds
- Time within 5 ℃ of peak temperature: 30 ~ 40 seconds.
- Peak temperature:260 +5/-0 ℃
- Ramp-down rate (peak to 217 ℃): 6 ℃ /sec. max.
- Time 25 ℃ to peak temperature: 8 minutes max.
- Cycle interval: 5 minutes

FIGURE 9-3: REFLOW PROFILE



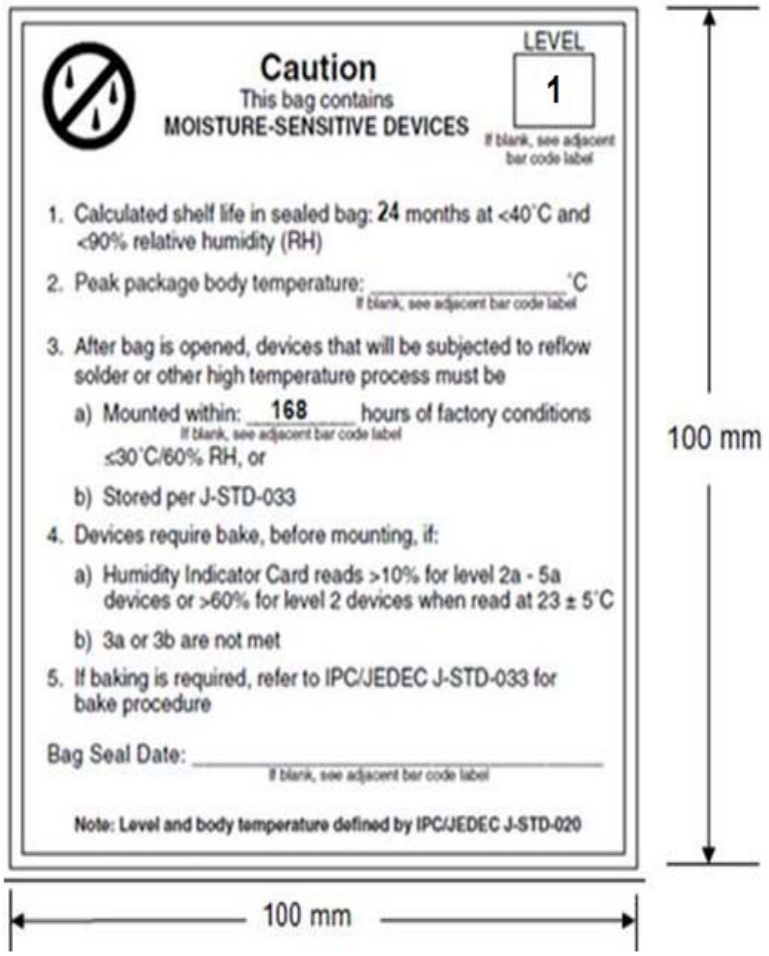
9.3 Storage Condition

Users need to follow these specific storage conditions for the IS1678 SoC.

- Calculated shelf life in the sealed bag: 24 months at <40 ℃ and <90% Relative Humidity (RH).
- After the bag is opened, devices that are subjected to reflow solder or other high temperature process must be mounted within 168 hours of factory conditions, i.e <30 ℃ /60% RH.

Figure 9-4 shows chip bag labeling details. Please note only point no. 1, 3, and 4 are applicable for the 1870x.

FIGURE 9-4: CHIP BAG LABEL



NOTES:

10.0 ORDERING INFORMATION

Table 10-1 provides the ordering information for the IS1678S/SM.

TABLE 10-1: ORDERING INFORMATION

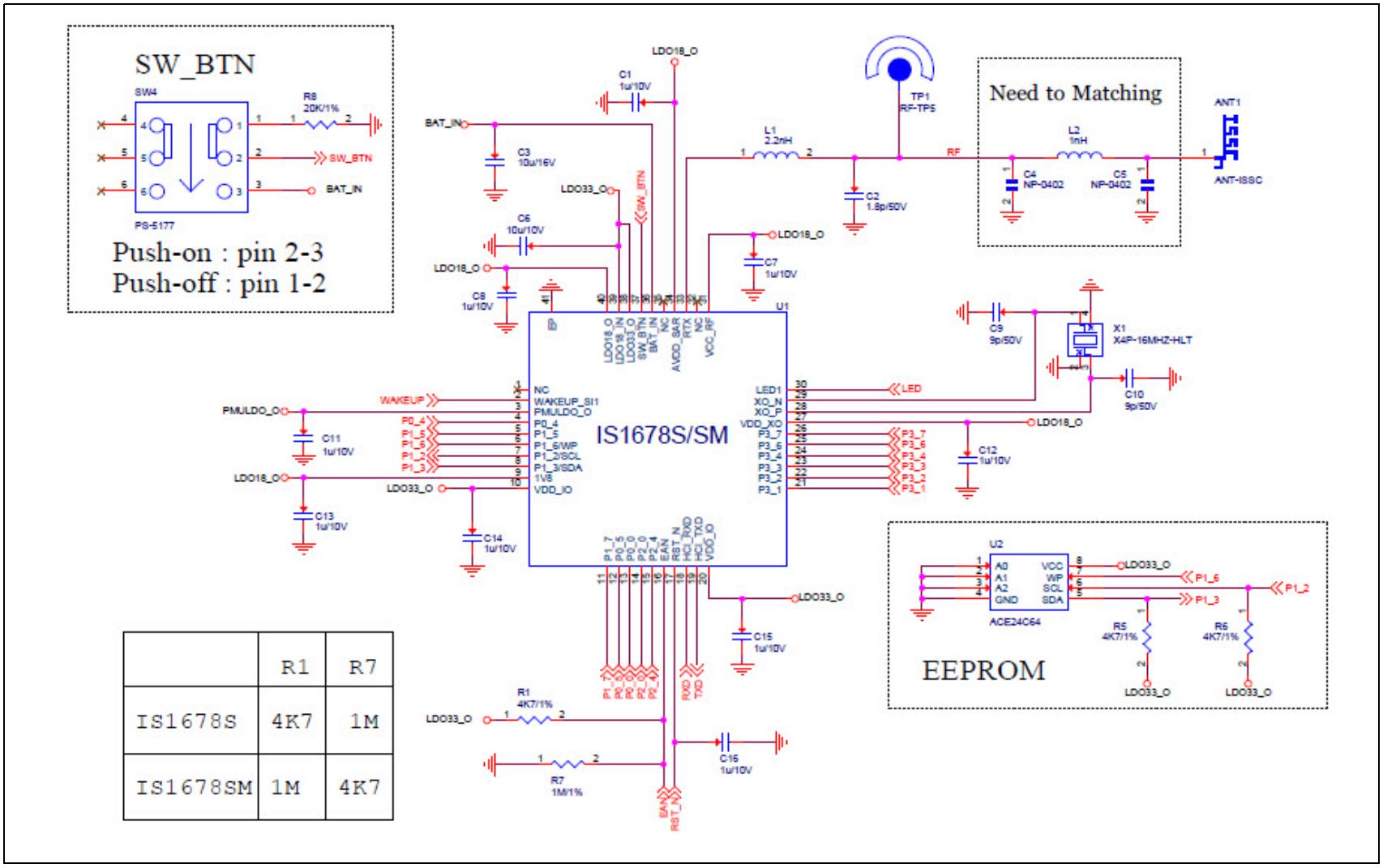
Device	Bluetooth Version	Package	Order Number
IS1678SM	Bluetooth 4.2, Flash version	QFN 40 Lead,6x6x0.9 mm^3, 0.5 mm pitch	IS1678SM-151
IS1678S	Bluetooth 4.2, ROM version	QFN 40 Lead,6x6x0.9 mm^3, 0.5 mm pitch	IS1678S-152

NOTES:

APPENDIX A: REFERENCE CIRCUIT

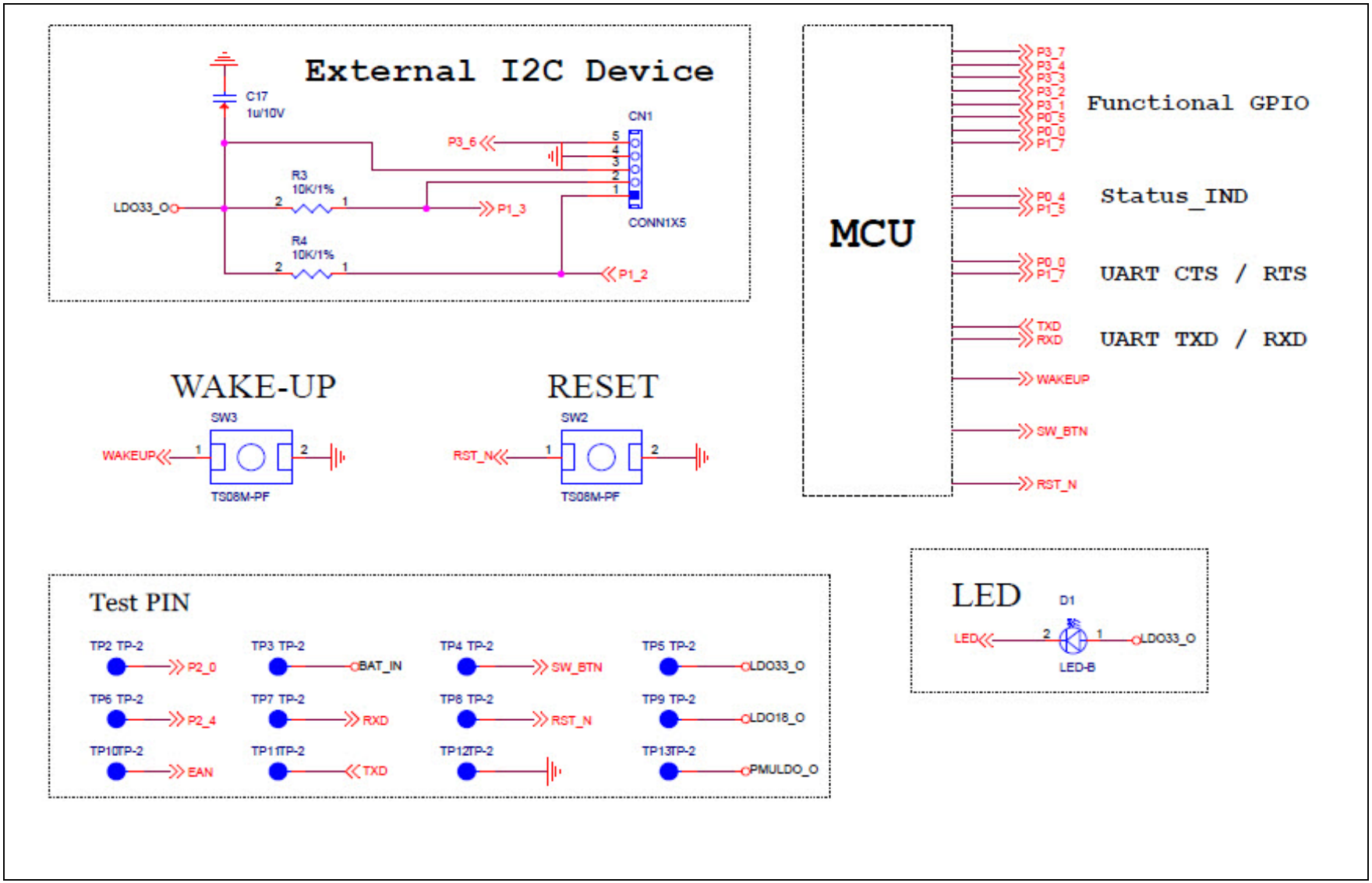
Figure 1 through Figure 2 illustrate the reference schematic for the IS1678S/SM.

FIGURE A-1: IS1678S/SM REFERENCE CIRCUIT



	R1	R7
IS1678S	4K7	1M
IS1678SM	1M	4K7

FIGURE A-2: IS1678S/SM REFERENCE CIRCUIT



APPENDIX B: REVISION HISTORY

Revision A (January 2016)

This is the initial released version of this document.

NOTES:

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NOTES:

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.
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