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RN4678

Bluetooth® 4.2 Dual Mode Module

Features

- Bluetooth® Classic (BR/EDR) and Low Energy (LE)
- Certified to FCC, IC, MIC, KCC, and NCC Radio Regulations
- European R&TTE Directive Assessed Radio Module
- Bluetooth SIG 4.2 Qualified
- Transparent UART mode for seamless serial data over Bluetooth Classic using Serial Port Profile (SPP), and Bluetooth Low Energy (BLE) using Generic Attribute (GATT) Profile
- Easily Programmable through ASCII Commands and easily configurable with available PIC® MCU driver library
- Firmware can be upgraded in the field over UART (Flash version)
- Integral Chip Antenna (RN4678) or External Antenna (RN4678U)
- Integrated Crystal, Internal Voltage Regulator, and Matching Circuitry
- Available Configurable I/O Pins for Control or Status Indication
- Supports Apple® iPod Accessory Protocol (iAP2) (*only* RN4678APL)
- Supports Bluetooth 4.2 LE Secure Connections
- Bluetooth 4.2 LE Data Packet Length Extension
- Small and Compact Surface Mount Module
- Castellated SMT Pads for easy and reliable PCB mounting
- Ideal for Portable Battery-Operated Devices

RF/Analog

- Frequency: 2.402 GHz to 2.480 GHz
- RX Sensitivity: -90 dBm (BR/EDR), -92 dBm (LE)
- Class 2 Output Power (+1.5 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

Operating Conditions

- Operating Voltage Range: 3.3V to 4.2V
- Operating Temperature Range: -20°C to +70°C

MAC/Baseband/Higher Layer

- Secure AES128 Encryption
- Bluetooth 3.0: GAP, SPP, SDP, RFCOMM and L2CAP
- Bluetooth 4.2: GAP, GATT, ATT, SMP and L2CAP

Applications

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

Description

The RN4678/RN4678U module is a fully certified, Bluetooth version 4.2 module available for customers to easily add dual mode Bluetooth wireless capability to their products. The RN4678/RN4678U is built around Microchip's IS1678 Bluetooth dual mode chip. Refer to **Section 8.0 "Ordering Information"**.

The RN4678/RN4678U provides a convenient method for cable replacement for smartphones or tablets for data transfer and control based on the Bluetooth protocols. Data transfer is achieved through the Bluetooth link by sending or receiving data through SPP in Bluetooth (BT) Classic mode and through Transparent UART in the BLE mode. The ASCII interface provides an easy way to learn the operation and to integrate the module with any microprocessor or Microcontroller (MCU) with a UART interface. The RN4678/RN4678U parameters can be configured directly through UART by the host MCU.

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1.0 DEVICE OVERVIEW

1.1 Overview

The RN4678/RN4678U module is a fully certified, Bluetooth version 4.2 (BR/EDR/LE) wireless module. The module includes an on-board Bluetooth stack, power management subsystem, 2.4 GHz transceiver, and RF power amplifier. Customers can embed Bluetooth functionality into any application using the RN4678/RN4678U module.

The RN4678/RN4678U enables rapid product development and faster time to market, and it is designed to provide integrators with the following features:

- Simple integration and programming
- Reduced development time
- Superior wireless module with low-cost system
- Interoperability with Bluetooth host
- Wide range of applications

The RN4678 is a complete and fully regulatory certified module with an integral ceramic chip antenna and RF shield.

The RN4678U is a low-cost alternative with RF-out pin (for external antenna) and no RF shield. The integrator is responsible for the antenna, antenna matching, and regulatory certifications.

The RN4678/RN4678U is a small, compact and surface mounted module with castellated pads for easy and reliable host PCB mounting. The module is compatible with standard pick-and-place equipment and can independently maintain a low-power wireless connection. Low-power usage and flexible power management maximize the lifetime of the RN4678/RN4678U module in battery-operated devices. A wide operating temperature range enables its applications in indoor and outdoor environments. Figure 1-1 illustrates the internal block diagram of the RN4678/RN4678U.

FIGURE 1-1: RN4678/RN4678U INTERNAL BLOCK DIAGRAM

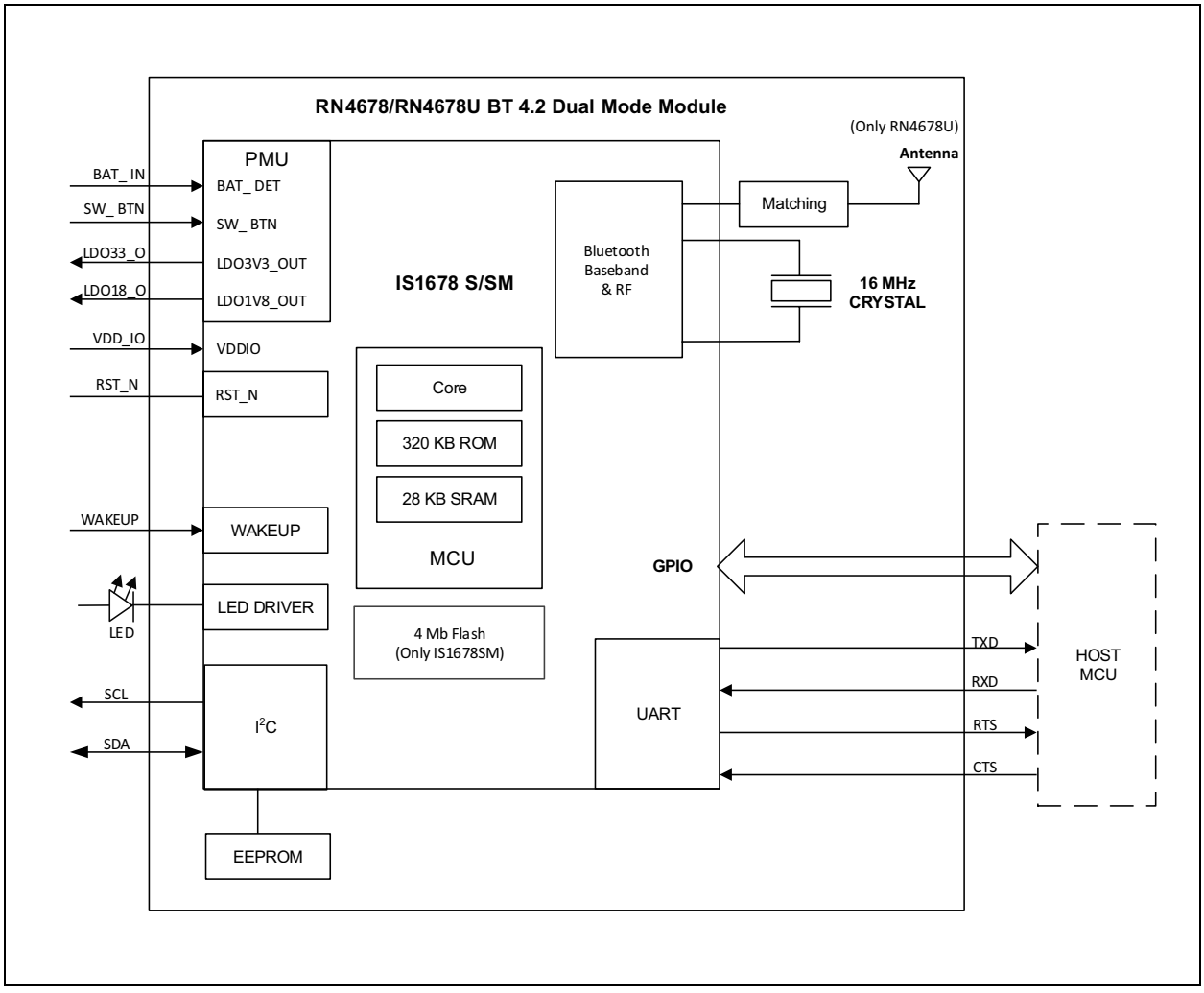


Table 1-1 provides the description of the various pins of the RN4678/RN4678U module.

TABLE 1-1: PIN DESCRIPTION

RN4678	RN4678U	Symbol	Type	Description
1	—	GND	Power	Ground reference
2	—	GND	Power	Ground reference
3	1	GND	Power	Ground reference
4	2	BAT_IN	Power	Battery Input (3.3V to 4.2V) Main positive supply input Connect to 10 µF (X5R/X7R) capacitor
5	3	SW_BTN	DI	Software Button H: Power On L: Power Off
6	4	LDO33_O	Power	Internal 3.3V LDO output; can source no more than 50 mA
7	5	VDD_IO	Power	I/O positive supply input. *For internal use only*; do *not* connect to other devices.
8	6	LDO18_O	Power	Internal 1.8V LDO output. *For internal use only*; do *not* connect to other devices.
9	7	WAKEUP	DI	Wake-up from Sleep mode (active-low) (internal pull-up)
10	8	PMULDO_O	Power	Power management unit output. *For internal use only*; do *not* connect to other devices.
11	9	P0_4	DO	Status Indication pin along with P1_5; refer to Table 2-3
12	10	P1_5	DO	Status Indication pin along with P0_4; refer to Table 2-3
13	11	P1_2/SCL	DO	I^2C SCL
14	12	P1_3/SDA	DIO	I^2C SDA
15	13	P1_7/CTS	DIO	Configurable Control or Indication pin or UART CTS (input)
16	14	P0_5	DIO	Configurable Control or Indication pin
17	15	P0_0/RTS	DIO	Configurable Control or Indication pin or UART RTS (output)
18	16	P2_0	DI	System configuration pin. Along with P2_4 and EAN pins, used to set the module in any of the following three modes: Application mode (for normal operation), Test mode (to change EEPROM values), and Write Flash mode (to enter the new firmware into the module); refer to Table 2-1.
19	17	P2_4	DI	System configuration pin. Along with P2_0 and EAN pins, used to set the module in any of the following three modes: Application mode (for normal operation), Test mode (to change EEPROM values), and Write Flash mode (to enter new firmware into the module); refer to Table 2-1.
20	18	EAN	DI	External address-bus negative pin. System configuration pin along with P2_0 and P2_4 pins, used to set the module in any of the following three modes: Application mode (for normal operation), Test mode (to change EEPROM values), and Write Flash mode (to enter new firmware into the module); refer to Table 2-1. Must be pulled down with 4.7 kΩ to GND.
21	19	$\overline{\text{RST\_N}}$	DI	Module Reset (internal pull-up). Apply a pulse of at least 63 ns.
22	20	RXD	DI	UART data input

TABLE 1-1: PIN DESCRIPTION (CONTINUED)

RN4678	RN4678U	Symbol	Type	Description
23	21	TXD	DO	UART data output
24	22	P3_1	DIO	Configurable Control or Indication pin (Internally pulled-up, if configured as an input)
25	23	P3_2	DIO	Configurable Control or Indication pin (Internally pulled-up, if configured as an input)
26	24	P3_3	DIO	Configurable Control or Indication pin (Internally pulled-up, if configured as an input)
27	25	P3_4	DIO	Configurable Control or Indication pin (Internally pulled-up, if configured as an input)
28	26	P3_6	DIO	Do *not* connect
29	27	P3_7	DIO	Configurable Control or Indication pin (Internally pulled-up, if configured as an input)
30	28	LED	DO	Status LED, connect to LDO33_0
31	29	GND	Power	Ground reference
—	30	BT_RF	AIO	External antenna connection (50 ohms)
32	—	GND	Power	Ground reference
33	—	GND	Power	Ground reference

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

Figure 1-2 and Figure 1-3 illustrate the pin diagrams of the RN4678 and the RN4678U modules, respectively.

FIGURE 1-2: RN4678 PIN DIAGRAM

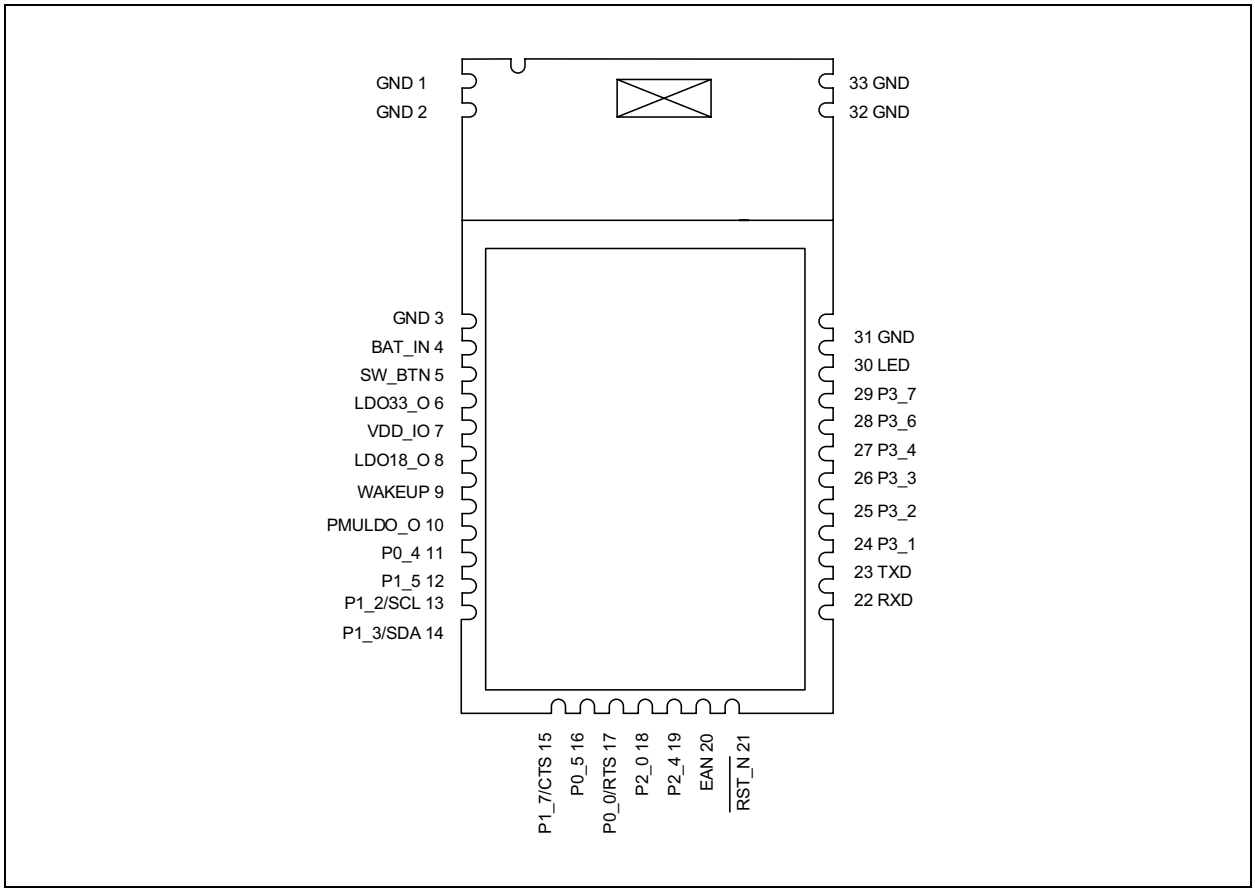
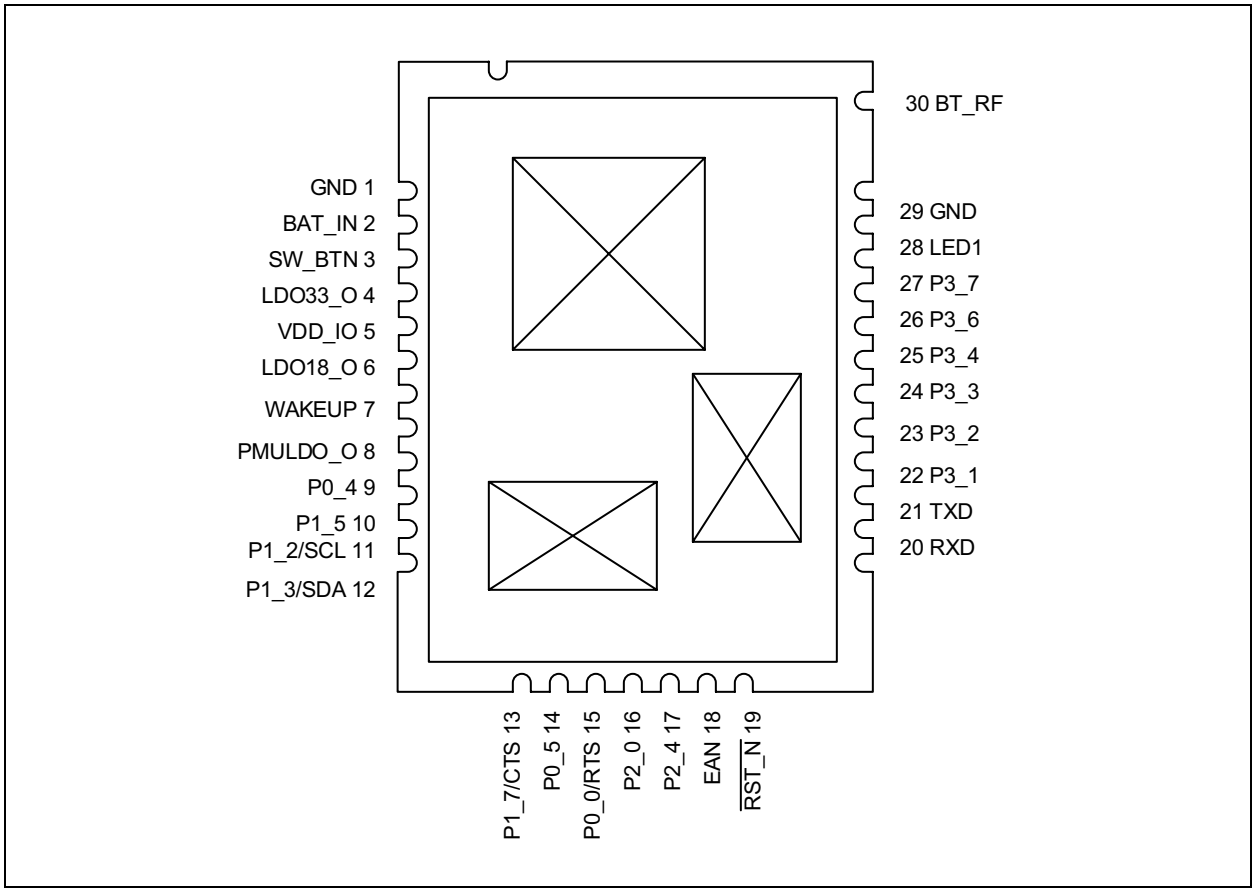


FIGURE 1-3: RN4678U PIN DIAGRAM



2.0 APPLICATION INFORMATION

2.1 Module Configuration

For the I/O pins, P2_0, P2_4 and EAN, place the RN4678/RN4678U into Operating mode. Each of these pins have internal pull-up and allow configuration settings and firmware to be updated from UART. Table 2-1 provides system configuration details.

TABLE 2-1: SYSTEM CONFIGURATION SETTINGS

P2_0	P2_4	EAN	Operational Mode
Low	Low	High	Write FLASH
Low	High	Low	Write EEPROM and test mode
High	High	Low	Normal operational/application mode

2.2 Control and Indication I/O Pins

The GPIO pins of the RN4678/RN4678U module can be configured to different functions using the ASCII command interface. Table 2-2 shows the various pins in the RN4678/RN4678U module that are available for configuration and their default configuration settings. Table 2-3 provides details on each of the functions available.

TABLE 2-2: CONTROL AND INDICATION I/O PIN ASSIGNMENTS

PIN Symbol	Default Configuration
P0_0	UART_RTS(1,2)
P0_5	N/C
P1_7	UART_CTS(1,2)
P3_1	INQUIRY CONTROL
P3_2	LINK_DROP_CONTROL (DISCONNECT)
P3_3	UART_RX_IND
P3_4	PAIRING_KEY
P3_7	LOW_BATTERY_IND

Note 1: The RTS pin can only be assigned to P0_0 and the CTS pin can only be assigned to P1_7.

2: The RTS and CTS pins can be configured as GPIOs if flow control is disabled.

TABLE 2-3: CONFIGURABLE FUNCTIONS AND DESCRIPTIONS

Function Name	Description
Low Battery Indication	Pin output goes low when the battery level is below a specified level. To set the battery level, `S:` command must be used.
RSSI Indication	Use this pin to indicate the quality of the link based on the RSSI level. If the RSSI level is lower than the specified values, then the RSSI indication pin goes low.
Link Drop Control	Use this pin to force the module to drop the current BLE link with a peer device. Pulling the Link Drop pin low forces to disconnect. The pin must be pulled low for at least 10 ms.

TABLE 2-3: CONFIGURABLE FUNCTIONS AND DESCRIPTIONS (CONTINUED)

Function Name	Description
UART RX Indication	Use this pin to enable communication with the UART when the module is in Low-Power mode. When *not* in Low-Power mode, the module runs on a 16 MHz clock. If Low-Power mode is enabled on the module by using command `SO,1`, the module runs on a 32 kHz clock thus reducing power consumption. However, in Low-Power mode, the host MCU *cannot* communicate with the module via the UART since the UART is *not* operational. If the user intends to provide data or commands via UART in the Low-Power mode, then the UART_RX_IND pin must be pulled low and the user needs to wait for at least five milliseconds before sending the data. Pulling the UART_RX_IND pin low allows the module to operate the 16 MHz clock and to enable UART.
Pairing Key	Use this pin to force the module to enter Standby mode. The pin must be pulled down for at least 160 ms.
Inquiry Control	This pin forces the module enter Inquiry mode (BT Classic). The pin must be pulled low for at least 240 ms for the device to enter Inquiry mode.
Profile_IND	This pin is used to indicate whether current connection is in BR/EDR (BT Classic), or in Bluetooth Low Energy (BLE). If the Profile_IND pin is high, then the current connection is BR/EDR connection. If low, then the current connection is a BLE connection. This pin is valid only for Link State.

2.3 Status Indication I/O Pins

The I/O pins, P1_5 and P0_4, are status indicator pins: STATUS_IND_1 and STATUS_IND_2. Together, these pins provide status indication to the MCUs. Table 2-4 provides status indication of the P1_5 and P0_4 pins.

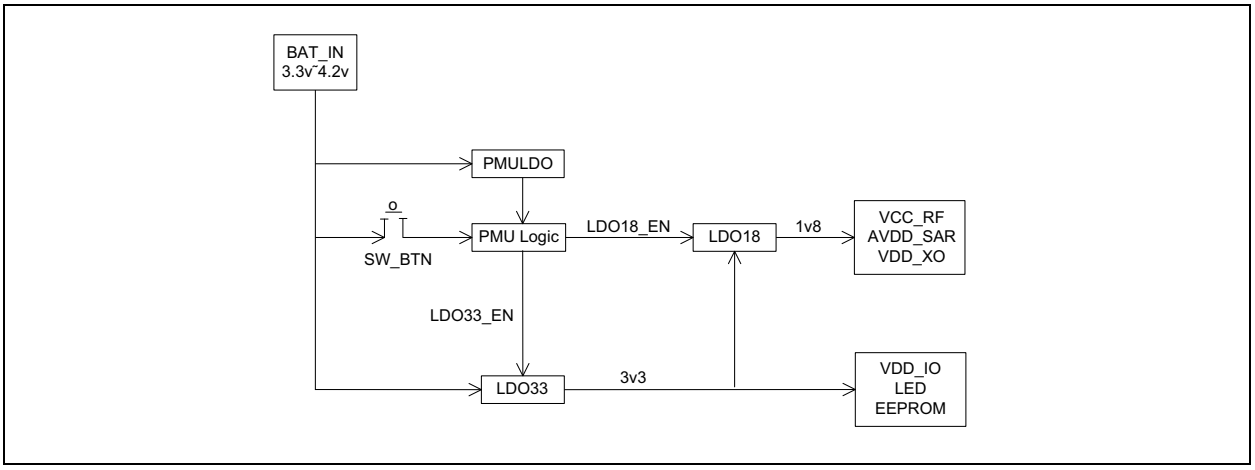
TABLE 2-4: STATUS INDICATION PINS

P1_5/STATUS_IND_1	P0_4/STATUS_IND_2	Indication
High	High	Power On (default setting) and Deep Sleep state. HH status must be stable for at least 500 ms.
High	Low	Access state
Low	High	Connected
Low	Low	*Not* connected to peer device

2.4 Power Tree

Figure 2-1 illustrates the power tree diagram of the RN4678/RN4678U.

FIGURE 2-1: POWER TREE DIAGRAM

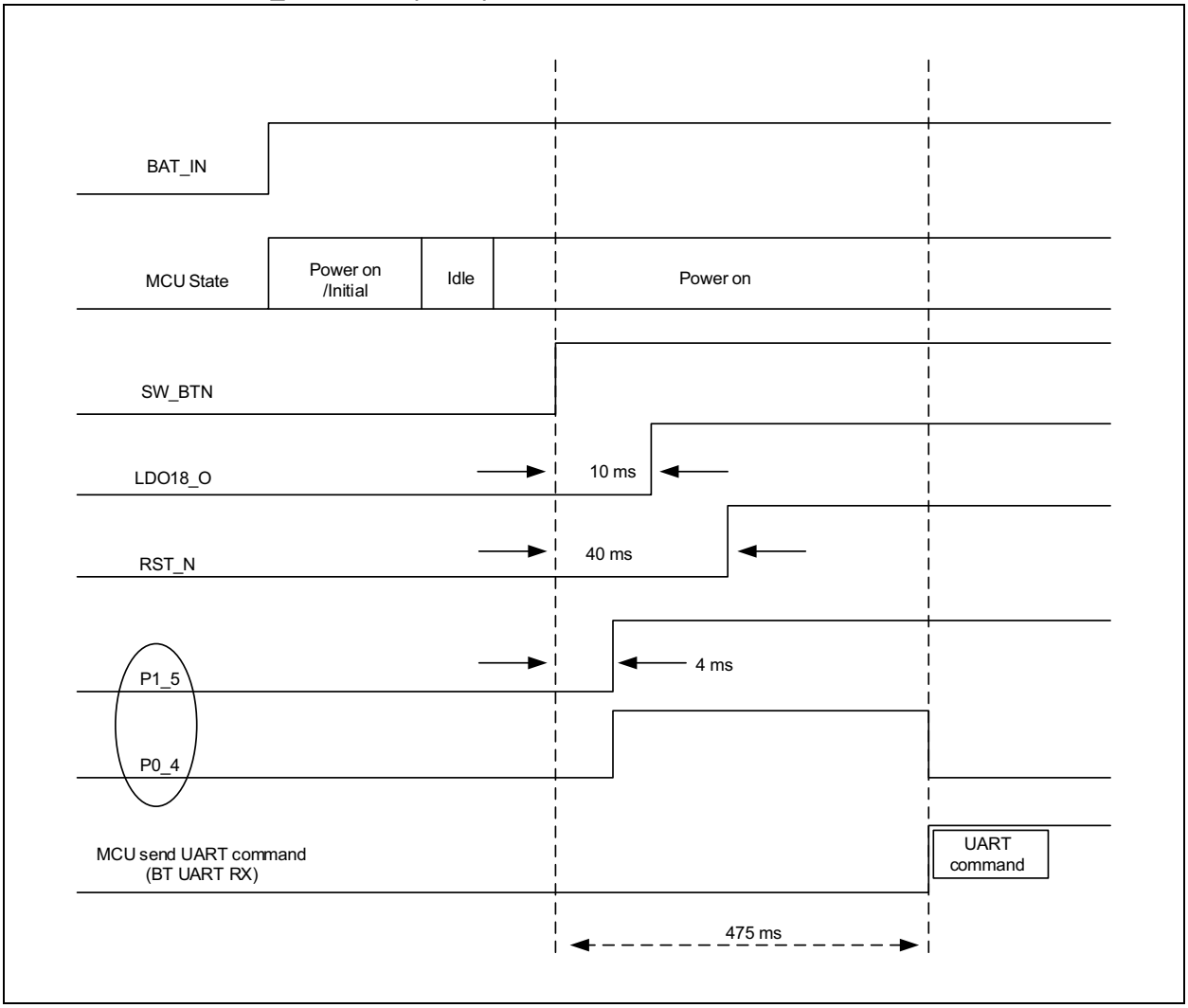


2.5 Software Button (SW_BTN)

The Software Button (SW_BT) pin powers the main sections of the module into operation. If the SW_BTN pin is low, the module is turned OFF. After turning the module ON via the SW_BTN, the host MCU must wait for specific time before sending the first command. The timing diagrams for the SW_BTN, other related pins, and the time delay are required before the host MCU sends the first command.

Figure 2-2 through Figure 2-4 show the timing diagrams for the RN4678/RN4678U with regard to the SW_BTN and the other relevant pins in different states of the module.

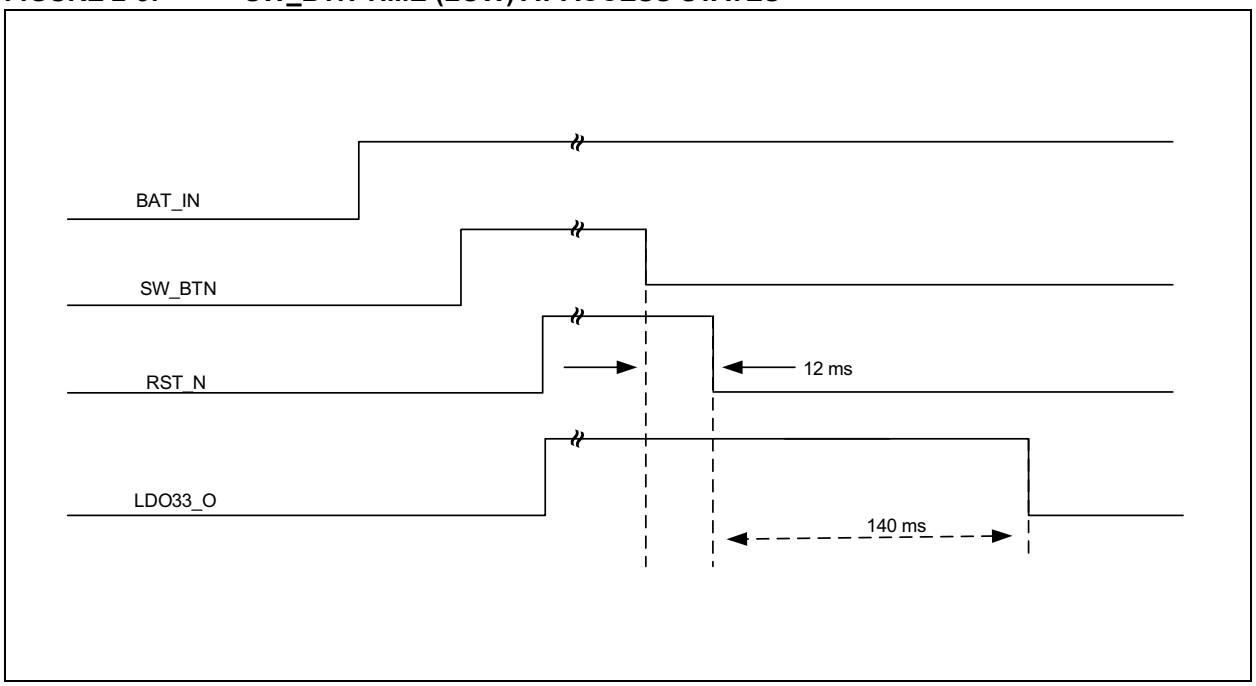
FIGURE 2-2: SW_BTN TIME (HIGH) AT APP MODE(1,2)



Note 1: Time duration (475 ms) is for reference purpose only. Use the Status Indication pins to verify the exact time when the host MCU can start sending the commands.

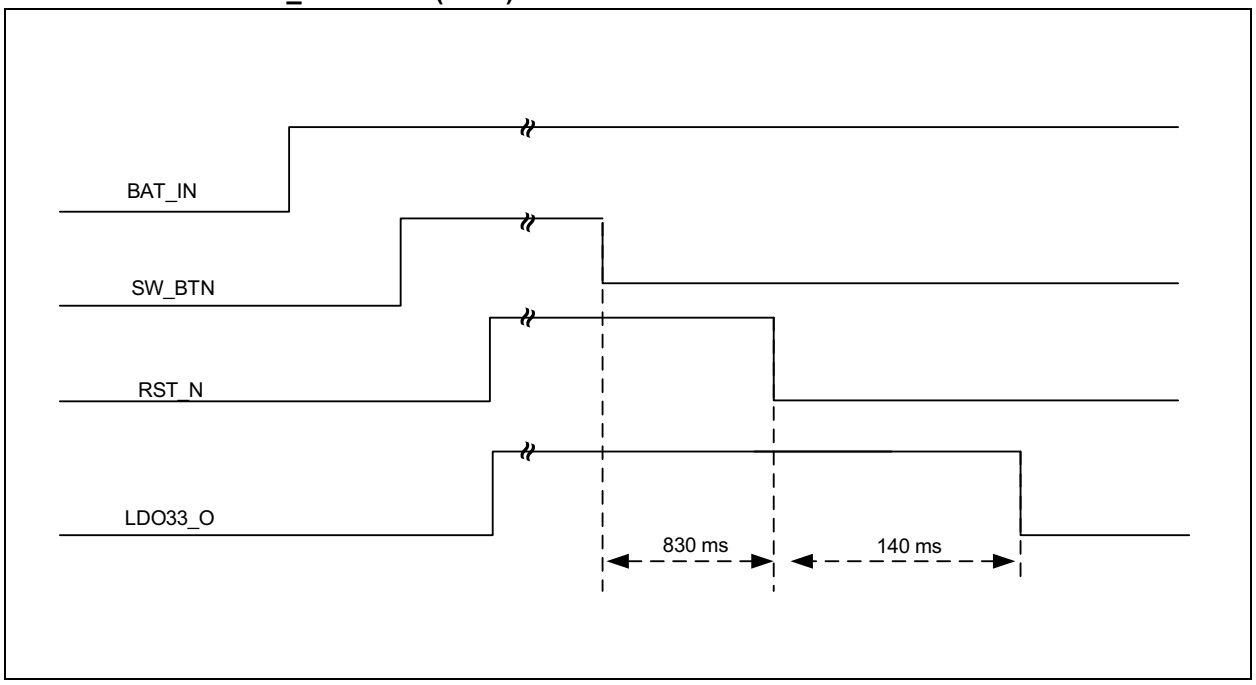
2: Reset pin is *not* connected.

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



Note 1: Reset pin is *not* connected.

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



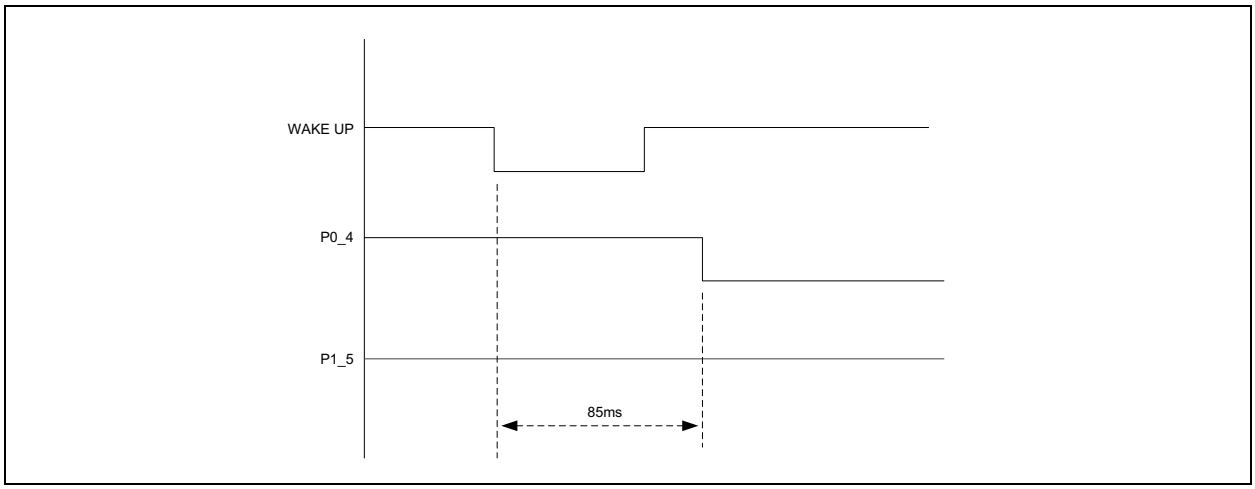
Note 1: 830 ms time duration is a typical value measured on iPhone® 6 and this time duration can vary from one smartphone to another.

2: Reset pin is *not* connected.

2.6 WAKE-UP

The WAKEUP input pin wakes the RN4678/RN4678U module from Deep-Sleep mode. The WAKEUP pin is active-low and puts module in Standby mode. Figure 2-5 illustrates the timing diagram of the RN4678/RN4678U in the Wake-Up mode.

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



Note 1: The 85 ms is for reference time. Use the Status Indication pins to verify the exact results.

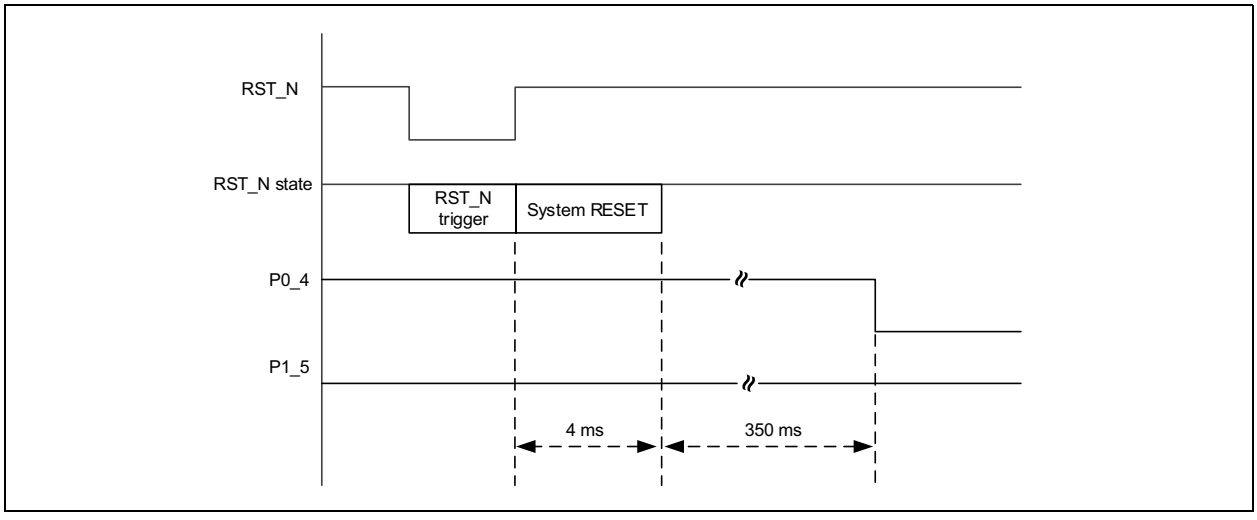
2: Refer to **Section 2.3 "Status Indication I/O Pins"** for the status of the P0_4/P1_5 pin.

2.7 External Reset

The RN4678/RN4678U provides an External Reset pin which resets the module. The Reset pin, RST_N, is active-low.

Figure 2-6 shows the timing diagram for the RST_N pin of the RN4678 module.

FIGURE 2-6: TIMING WAVEFORMS ON RESET (1,2)



Note 1: The RST_N state trigger must be greater than 63 ns.

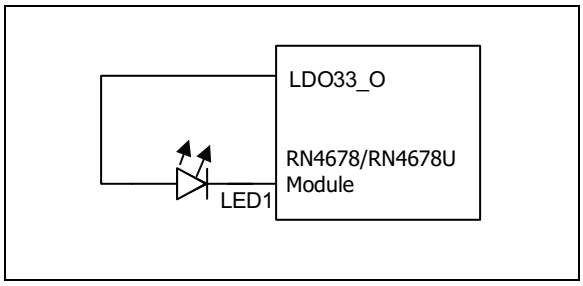
2: Time duration (350 ms) is for reference purpose only. Use the Status Indication pins to verify the exact results.

2.8 LED Driver

The RN4678/RN4678U has a dedicated LED driver and the LED can be connected directly to this pin as shown in Figure 2-7.

The maximum current sourcing for the LED is 5 mA. The brightness of this LED can be configured via an ASCII command.

FIGURE 2-7: LED DRIVER



The following are the LED status indications and each indication is a configurable flashing sequence:

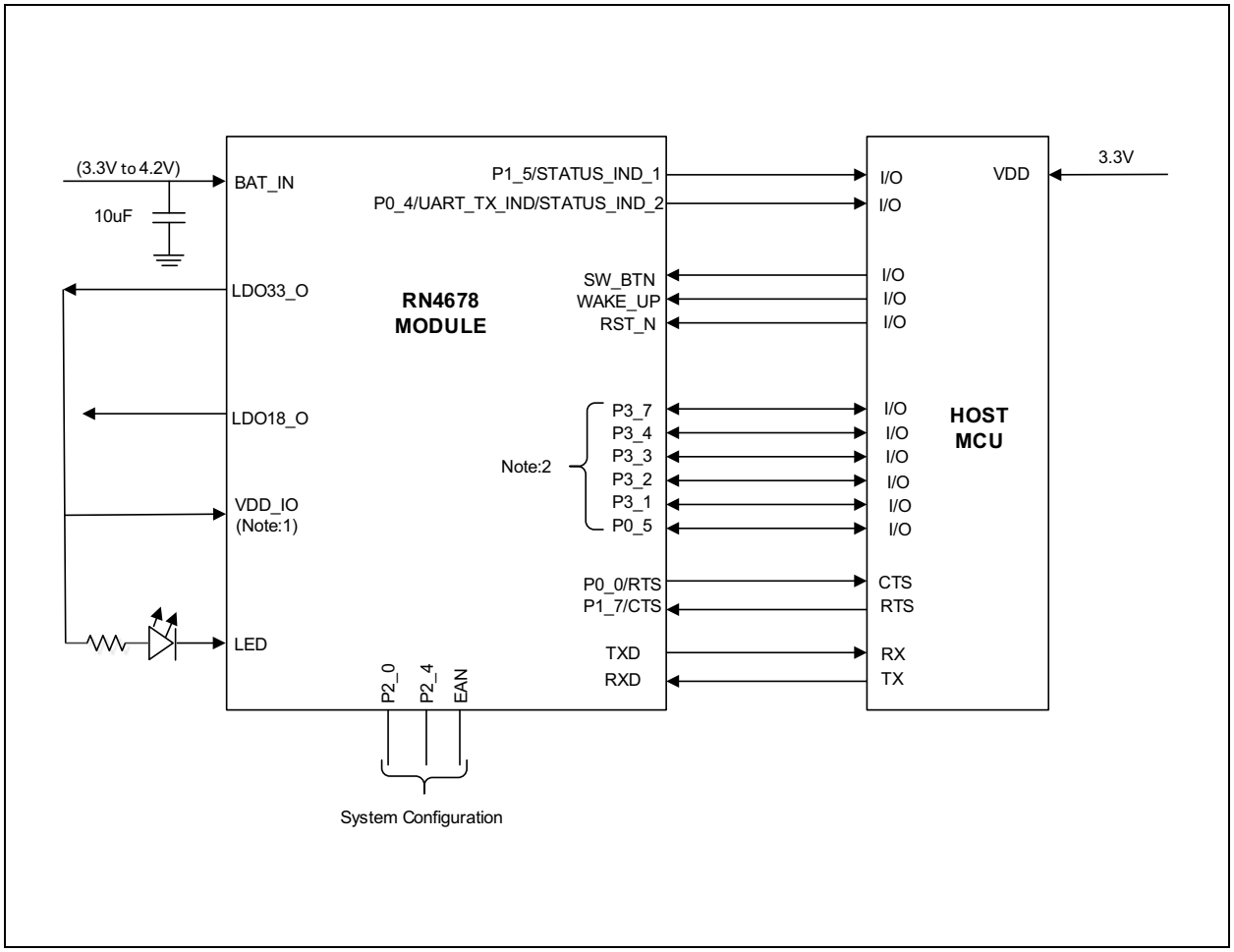
- Standby
- Link Back
- Low Battery
- Inquiry
- Link

2.9 Host MCU Interface over UART

Figure 2-8 illustrates an example of UART interface with host MCU and power scheme using 3.3V to the V_{DD}. From the LDO33_O pin, voltage can be routed to the VDD_IO pin and the external circuitry including the MCU. This power scheme ensures that the RN4678/RN4678U and the MCU I/O voltages are compatible.

Note:	The internal 3.3V LDO current source must *not* exceed 50 mA (maximum).

FIGURE 2-8: POWER AND MCU INTERFACE EXAMPLE FOR RN4678



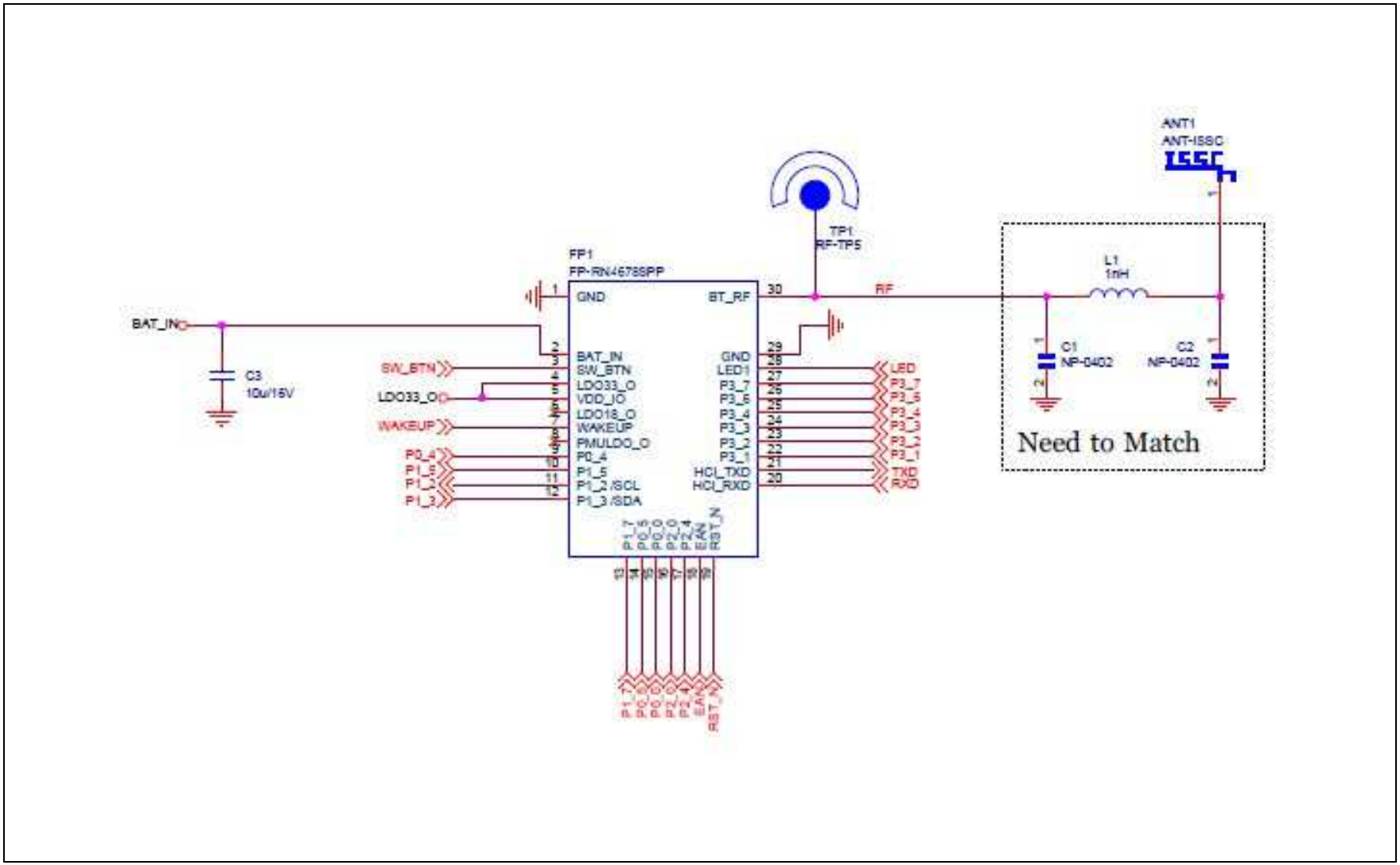
Note 1: Ensure that VDD_IO and MCU VDD voltages are compatible.

2: The control and indication ports are configurable

2.10 Reference Circuit

Figure 2-9 through Figure 2-12 illustrate the reference schematic of the power supply design implemented for the RN4678/RN4678U.

FIGURE 2-9: RN4678U REFERENCE CIRCUIT



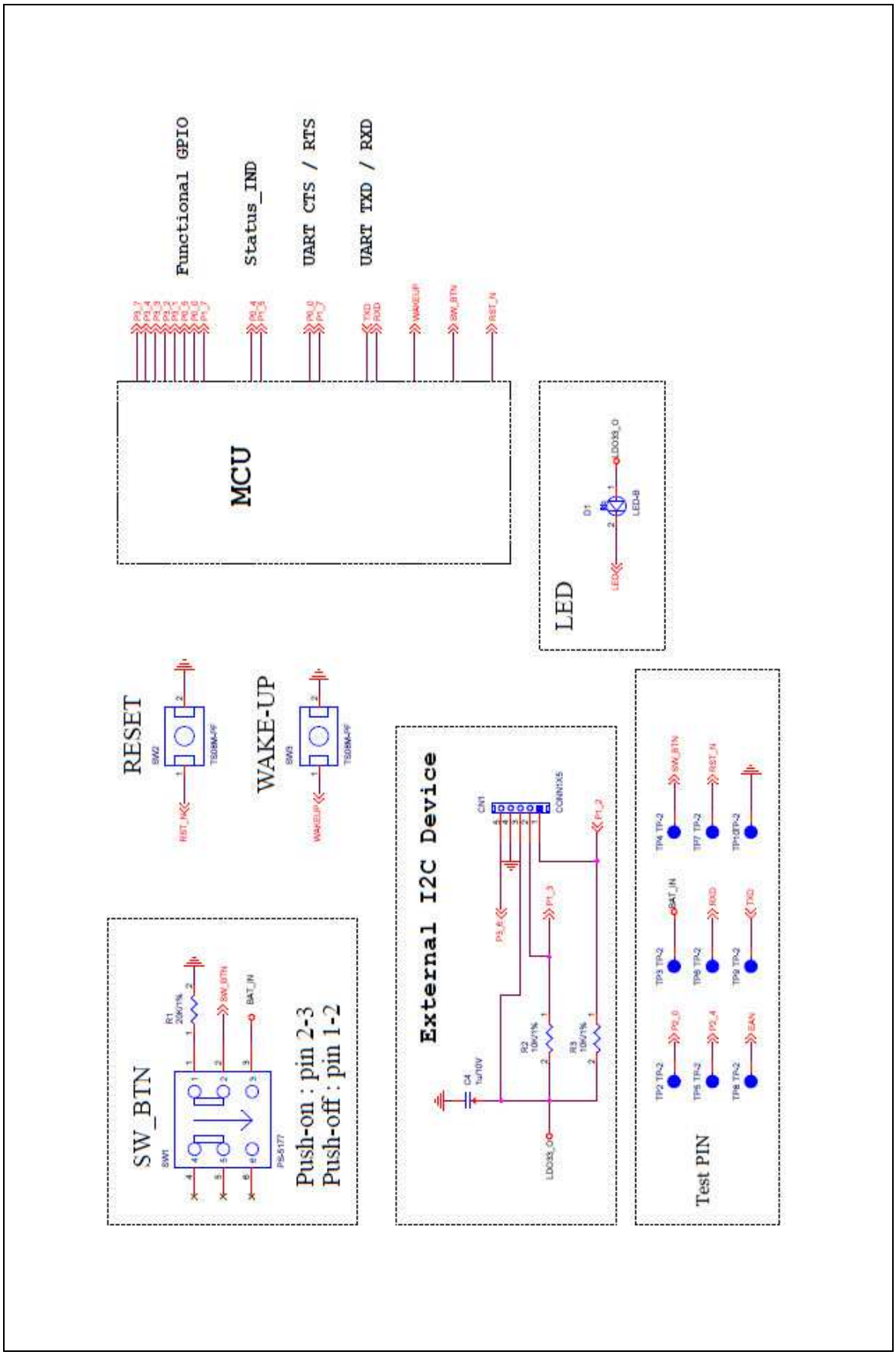


FIGURE 2-10: RN4678U REFERENCE CIRCUIT

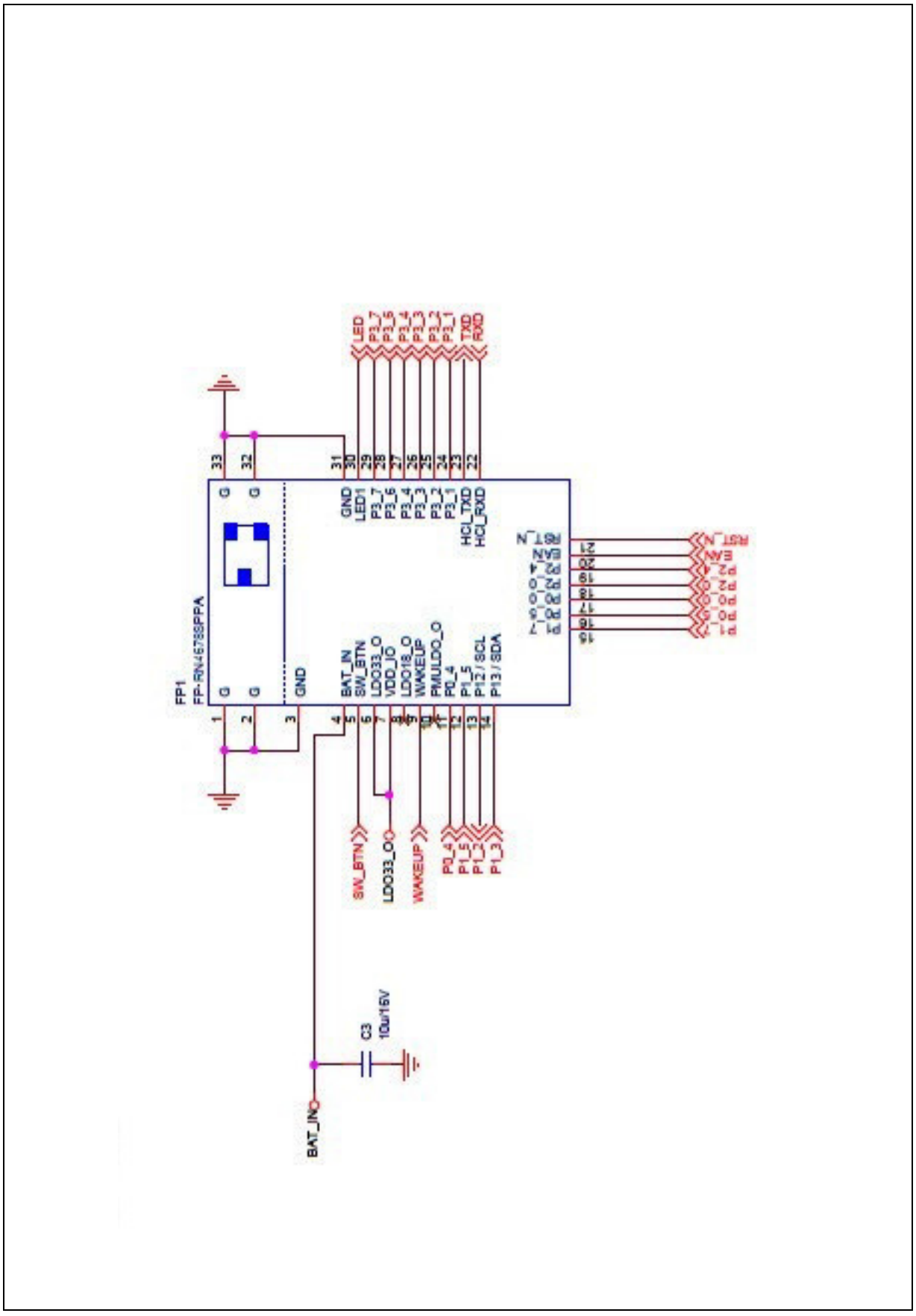


FIGURE 2-11: RN4678 REFERENCE CIRCUIT

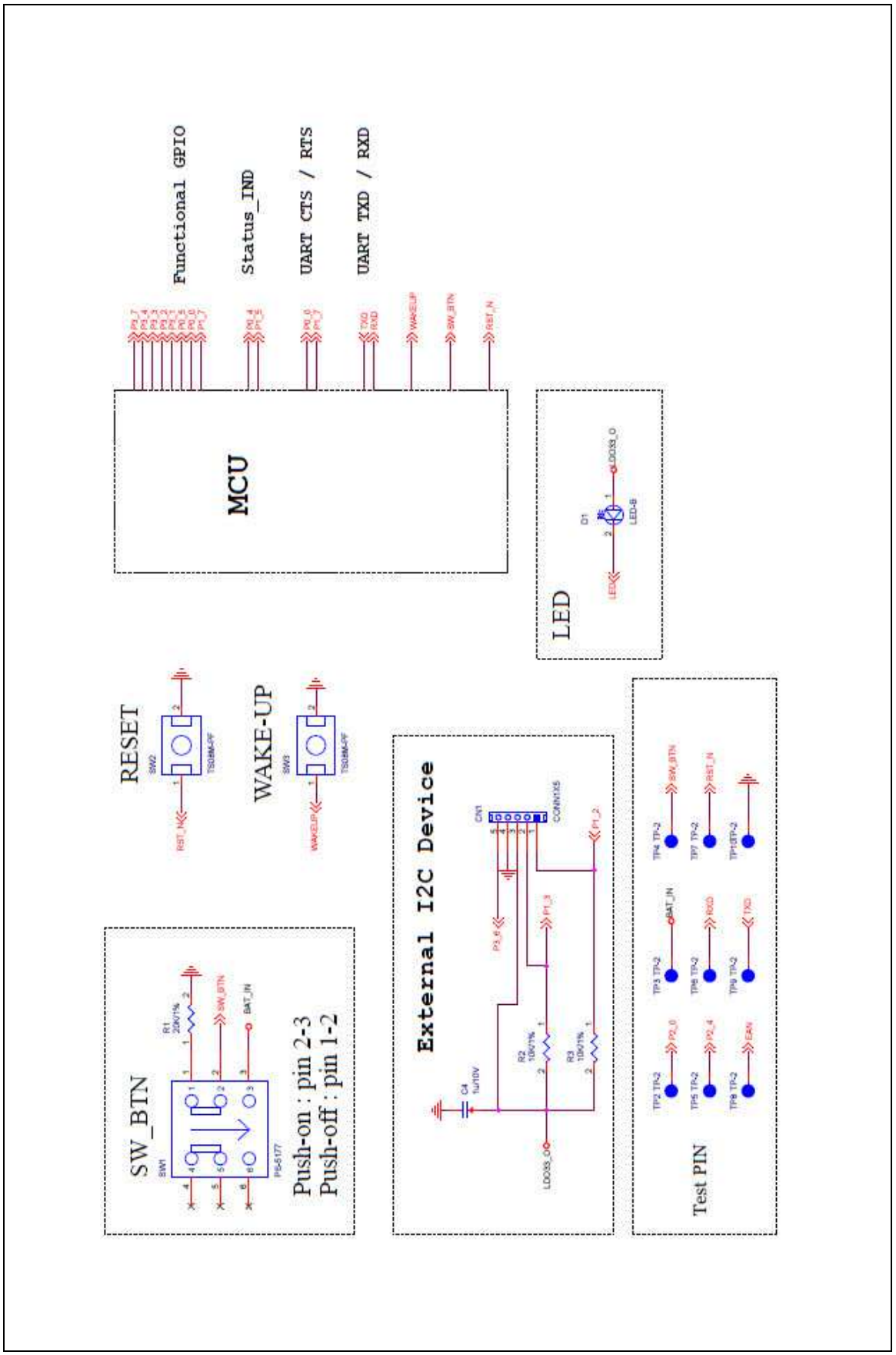


FIGURE 2-12: RN4678 REFERENCE CIRCUIT

3.0 ELECTRICAL CHARACTERISTICS

This section provides an overview of the electrical characteristics of the RN4678/RN4678U module. Additional information is provided in future revisions of this document as it becomes available.

Absolute maximum ratings for the RN4678 devices are listed below. Exposure to these 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 ..... -65°C to +150°C
Voltage on V_{DD} with respect to V_{SS} ..... -0.3V to +3.6V
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 3-1 through Table 3-7 provide the recommended operating conditions and the electrical specifications of the module.

TABLE 3-1: 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	—	±2 KV	—
	MM	—	±200V	—
HTOL(1)		—	1000 hrs	—
Supply Voltage: BAT_IN		3.3V	—	4.2V
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 Level Low		-0.3V	—	0.8V
V_{IH} Input Logic Level High		2.0V	—	3.6V
V_{OL} Output Logic Level Low (I_{Ol} = 12 mA)		—	—	0.4V
V_{OH} Output Logic Level High (I_{Oh} = 12 mA)		2.4V	—	—
RF continuous TX mode		—	—	43 mA
RF continuous RX mode		—	—	37 mA

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

TABLE 3-2: 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 using the MP tool.

TABLE 3-3: PMU LDO(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 1µF capacitor at PMULDO_O as the condition for IP verification.

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

TABLE 3-4: SAR-ADC AND BATTERY VOLTAGE DETECTOR

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 3-5: INTENSITY CONTROLLABLE LED DRIVER

Parameter	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 3-6: POWER CONSUMPTION-CLASSIC(1)

Test Condition	Current Consumption (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: Classic BR/EDR and RX_IND functions are enabled.

TABLE 3-7: POWER CONSUMPTION-LOW ENERGY(1,2)

Test Condition	Current Consumption (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 100 ms
	0.62	LE fast advertising interval = 500 ms + Beacon 500 ms
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 module)	0.45	Connection interval = 500 ms
	0.60	Connection interval = 200 ms
Connected (module to iPhone 6)	6.6	Connection interval = 500 ms
	7.0	Connection interval = 200 ms

Note 1: Low energy, RX_IND function is enabled.

2: Only low energy

4.0 RADIO CHARACTERISTICS

Table 4-1 provides the transmitter performance characteristics of the RN4678/RN4678U module.

TABLE 4-1: TRANSMITTER PERFORMANCE(1,2)

	Min.	Typical	Max.	Bluetooth Specification	Unit
BDR power	—	1.5	—	-6 ~ +4	dBm
EDR (2M/3M) power	—	-1	—	-6 ~ +4	
LE power	—	0.5	—	-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: VCC RF = 1.80V, temperature = 25ºC.

Table 4-2 provides the receiver performance characteristics of the RN4678/RN4678U module.

TABLE 4-2: RECEIVER PERFORMANCE(1)

	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: VCC RF = 1.80V, temperature = 25ºC

NOTES:

5.0 PHYSICAL DIMENSIONS

Figure 5-1 illustrates the physical dimensions of the RN4678 module.

FIGURE 5-1: RN4678 MODULE DIMENSIONS

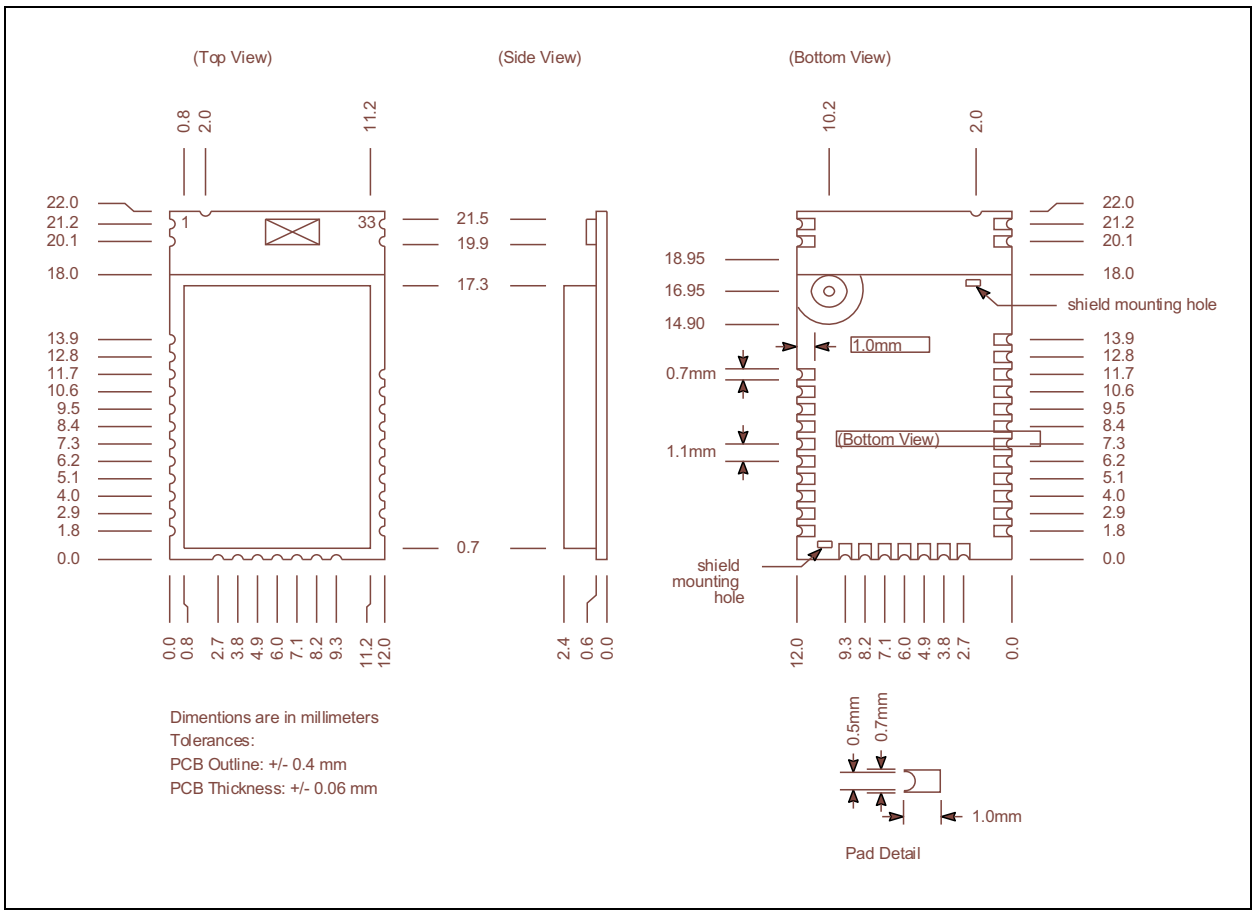


Figure 5-2 illustrates the recommended host PCB foot print.

FIGURE 5-2: RN4678 RECOMMENDED PCB FOOTPRINT

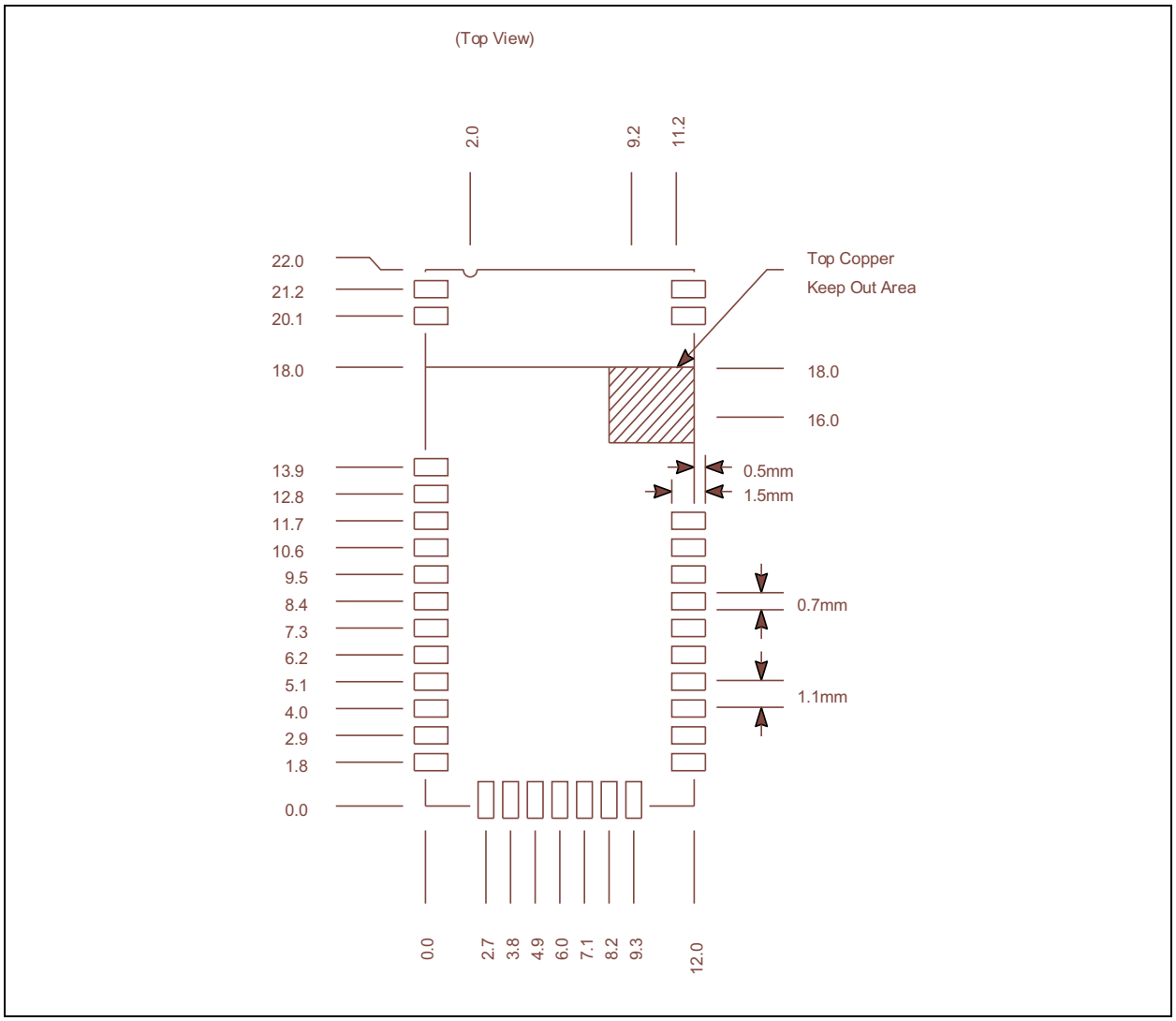


Figure 5-3 illustrates the recommendations for mounting the RN4678 on the host PCB, and also shows the minimum ground plane area to the left and right of the module for the best antenna performance.

Avoid top copper layer near the test pin area. When designing the host PCB, the areas under the antenna must *not* contain any top, inner or bottom copper layer.

A low-impedance ground plane ensures best radio performance (best range and lowest noise). The ground plane can be extended beyond the minimum recommended as required for the host PCB EMC noise reduction. For best range performance, keep all external metal at least 31 mm away from the ceramic chip antenna.

FIGURE 5-3: RN4678 HOST PCB MOUNTING SUGGESTION