Datasheet

Type 1ZM Wi-Fi™ + Bluetooth® Module

NXP 88W8987 Chipset for 802.11a/b/g/n/ac + Bluetooth 5.1
Datasheet - Rev. 21

- Design Name: Type 1ZM
- P/N: LBEE5QD1ZM-572

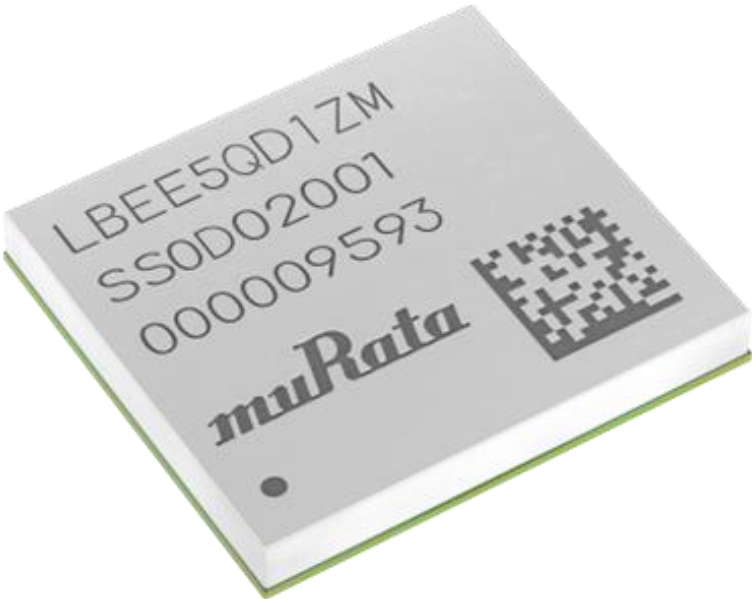


Table of Contents

Figures

Tables

About This Guide

Murata's Type 1ZM is a small and high-performance module based on NXP's 88W8987 combo chipset, supporting IEEE 802.11a/b/g/n/ac + Bluetooth 5.1 BR/EDR/LE. This datasheet describes Type 1ZM module in detail.

Please be aware that an important notice concerning availability, standard warranty and use in critical applications of Murata products and disclaimers thereto appears at the end of this specification sheet.

Audience & Purpose

Intended audience includes any customer looking to integrate this module into their product. In particular, RF, hardware, software, and systems engineers.

Document Conventions

Table 1 describes the document conventions.

Table 1: Document Conventions

Conventions	Description
	Warning Note Indicates very important note. Users are strongly recommended to review.
	Info Note Intended for informational purposes. Users should review.
	Menu Reference Indicates menu navigation instructions. **Example**: Insert➔Tables➔Quick Tables➔Save Selection to Gallery
	External Hyperlink This symbol indicates a hyperlink to an external document or website. **Example**: Murata Click on the text to open the external link.
	Internal Hyperlink This symbol indicates a hyperlink within the document. **Example**: Scope Click on the text to open the link.
`Console input/output or code snippet`	**Console I/O or Code Snippet** This text ***Style*** denotes console input/output or a code snippet.
`# Console I/O comment` `// Code snippet comment`	**Console I/O or Code Snippet Comment** This text ***Style*** denotes a console input/output or code snippet comment. • Console I/O comment (preceded by "#") is for informational purposes only and does not denote actual console input/output. • Code Snippet comment (preceded by "//") may exist in the original code.

1 Scope

This specification is applied to the IEEE 802.11a/b/g/n/ac + Bluetooth 5.1 BR/EDR/LE combo module.

2 Key Features

- NXP 88W8987 inside
- Supports IEEE 802.11a/b/g/n/ac specification: Dual band 2.4 GHz and 5 GHz
- SISO with 20 MHz, 40 MHz, and 80 MHz channels
- Up to MCS9 data rates (433 Mbps)
- Supports Bluetooth specification version 5.1
- For supported Bluetooth functions, refer to Bluetooth SIG site
- WLAN interface: SDIO 3.0
- Bluetooth interface: HCI UART, and PCM
- Temperature Range: - 30 °C to 85 °C
- Dimensions: 10.2 x 9.3 x 1.3 mm
- Weight: 318 mg
- MSL: 3
- Surface-mount type
- RoHS compliant
- Total Fit: 57

3 Ordering Information

Table 2 describes the ordering information of the module.

Table 2: Ordering Information

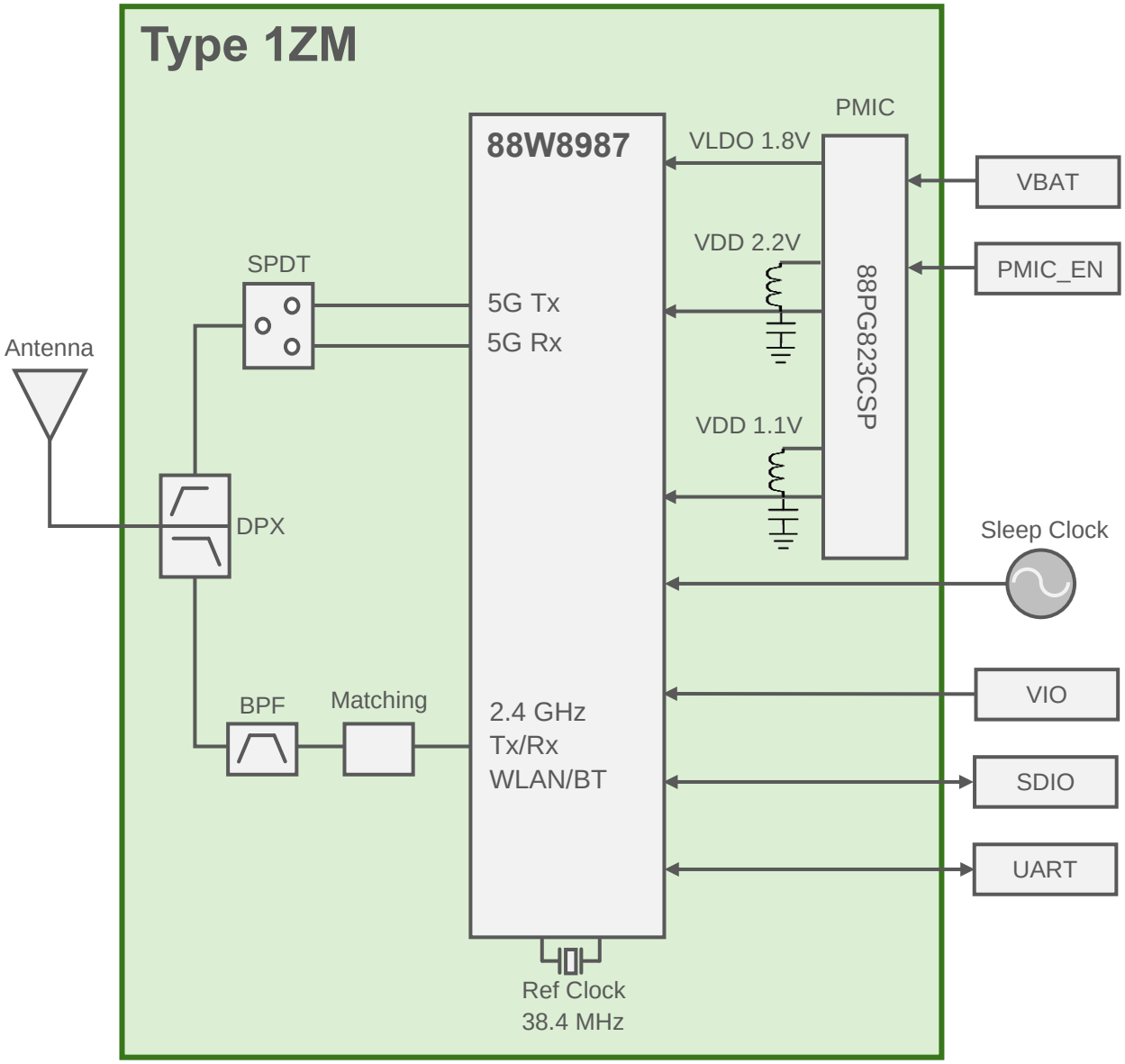
Ordering Part Number	Description
LBEE5QD1ZM-572	Module order
LBEE5QD1ZM-SMP	Sample module order (If module samples are not available through distribution, contact Murata referencing this part number)
EAR00364	Embedded Artists Type 1ZM M.2 EVB (default EVB available through distribution)
LBEE5QD1ZM-EVB	Murata Type 1ZM M.2 EVB (contact Murata as this is special order item)

"Type 1ZM" is design name of this module. Design name may be used in certification test report.

4 Block Diagram

Figure 1 shows the block diagram of Type 1ZM module.

Figure 1: Block Diagram



5 Certification Information

This section has information about radio and Bluetooth certification.

5.1 Radio Certification

Transmit output power setting is defined by “txpower_XX.bin” The transmit power files are hosted at Murata GitHub for Linux and FreeRTOS. **Table 3** shows the transmit power file required for each region.

Table 3: Transmit Power Limit Files

Country	ID	Country Code	Tx Power Limit File	
			Linux	FreeRTOS
USA (FCC)	VPYLB1ZM	US	txpower_US.bin	wlan_txpwrlimit_cfg_murata_1ZM_US.h
Canada (ISED)	772C-LB1ZM	CA	txpower_CA.bin	wlan_txpwrlimit_cfg_murata_1ZM_CA.h
Europe	EN300328/301893, EN300440 conducted test report is prepared.	DE	txpower_EU.bin	wlan_txpwrlimit_cfg_murata_1ZM_EU.h
Japan	Japanese type certification R 001-P01598	JP	txpower_JP.bin	wlan_txpwrlimit_cfg_murata_1ZM_JP.h
Taiwan	CCAM24Y10030T8	TW	txpower_TW.bin	wlan_txpwrlimit_cfg_murata_1ZM_TW.h

Each country code is defined by Murata’s db.txt file. Please ask your contact person from Murata.

5.2 Bluetooth Qualification

- QDID: 142383
- Set Bluetooth Tx Power to Class 1 by using bt_power_config_1.sh.
- For supported Bluetooth functions, refer to Bluetooth SIG site.

6 Dimensions, Markings and Terminal Configurations

This section provides information about dimensions, markings, and terminal configuration for Type 1ZM.

Figure 2: Dimensions, Markings and Terminal Configurations

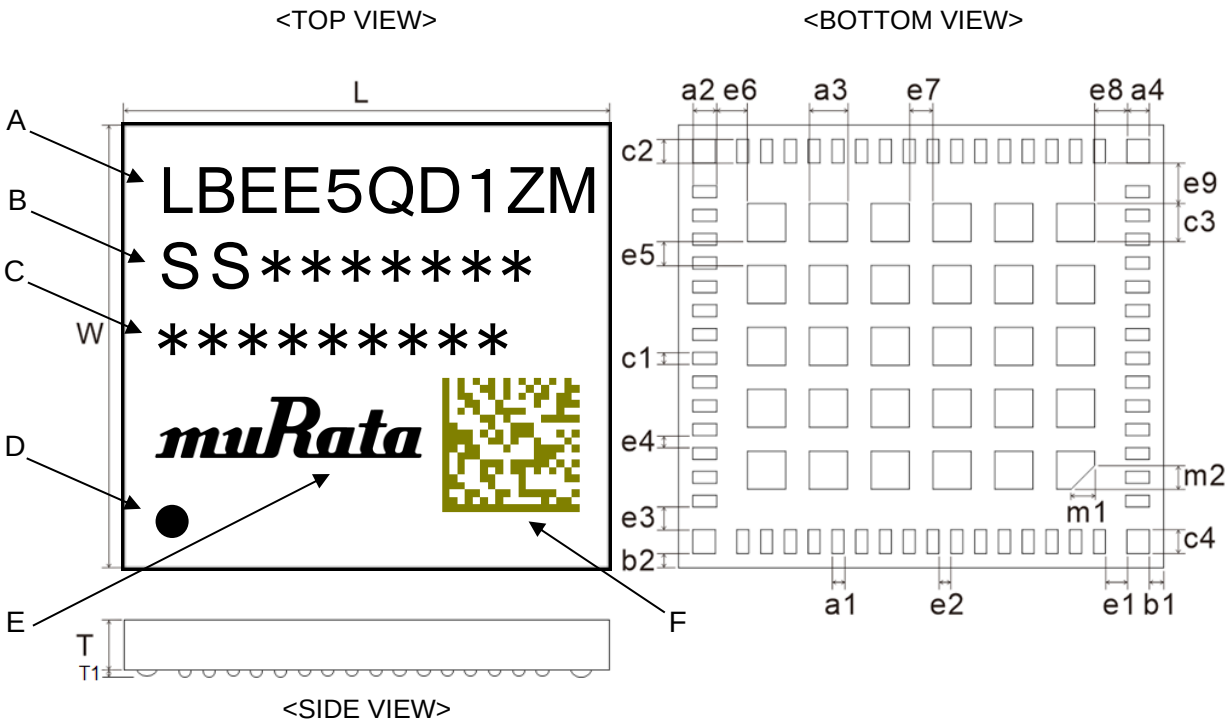


Table 4 and **Table 5 d**escribes the markings and dimensions shown in **Figure 2**.

Table 4: Markings

Marking	Meaning
A	Module Type
B	Inspection Number
C	Serial Number
D	Pin 1 Marking
E	Murata Logo
F	2D code

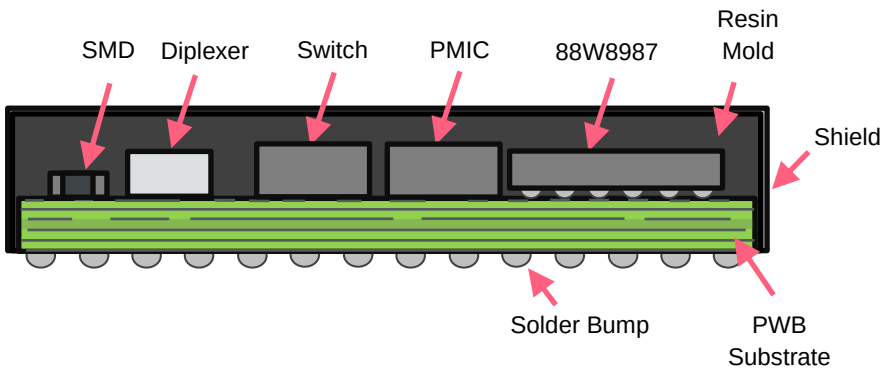
Table 5: Dimensions

Mark	Dimensions (mm)	Mark	Dimensions (mm)	Mark	Dimensions (mm)
L	10.2 +/- 0.2	W	9.3 +/- 0.2		
T	1.30 maximum	T1	0.045 typical		
a1	0.25 +/- 0.1	a2	0.5 +/- 0.1	a3	0.8 +/- 0.1
a4	0.475 +/- 0.1	b1	0.3 +/- 0.2	b2	0.3 +/- 0.2
c1	0.25 +/- 0.1	c2	0.5 +/- 0.1	c3	0.8 +/- 0.1
c4	0.5 +/- 0.1	e1	0.45 +/- 0.1	e2	0.25 +/- 0.1
e3	0.475 +/- 0.1	e4	0.25 +/- 0.1	e5	0.5 +/- 0.1
e6	0.65 +/- 0.1	e7	0.5 +/- 0.1	e8	0.65 +/- 0.1
e9	0.85 +/- 0.1	m1	0.5 +/- 0.1	m2	0.5 +/- 0.1

T dimension does not include height of solder bumps.
Unit of Dimensions are in mm.

Figure 3 shows the structure for 1ZM module.

Figure 3: Structure



The sides of the module are GND shielded. In order to avoid contact between the GND shield and the electrodes on the mother board, please carefully evaluate the standoff before use the module.

7 Module Pin Descriptions

This section has the pin descriptions of Type 1ZM and pin assignments layout descriptions.

7.1 Pin Assignments

Type 1ZM pin-assignment (top view) is presented in **Figure 4**.

Figure 4: Pin Assignments - Top View

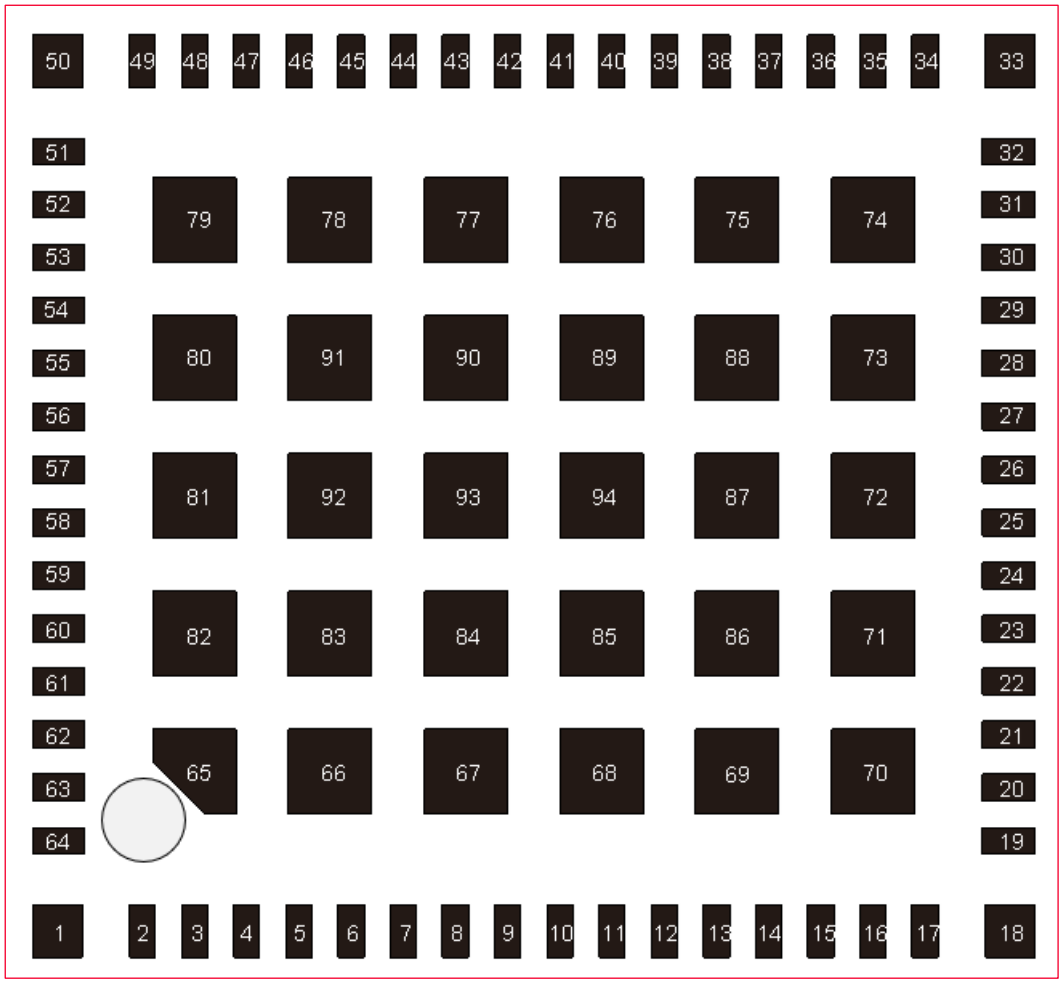


Table 6 illustrates the terminal configurations.

Table 6: Terminal Configurations

No	Pin name	No	Pin name	No	Pin name	No	Pin name
1	GND	18	GND	35	VBAT	52	GND
2	GND	19	GND	36	GND	53	SD_DAT2
3	GPIO19	20	RF	37	GND	54	SD_DAT3
4	GPIO18	21	GND	38	GPIO15	55	SD_DAT1
5	GPIO17	22	GND	39	GPIO14	56	SD_DAT0
6	GPIO16	23	CONFIG_AUTO_REF_DET	40	GPIO13	57	SD_CMD
7	GPIO7	24	GND	41	GPIO12	58	GND

No	Pin name	No	Pin name	No	Pin name	No	Pin name
8	GPIO0	25	GND	42	PMIC_EN	59	SD_CLK
9	GPIO6	26	GND	43	GND	60	GND
10	GPIO5	27	GPIO1	44	NC(PDn)	61	SLP_CLK_IN
11	GPIO4	28	GPIO2	45	GND	62	GND
12	CONFIG_HOST[0]	29	GPIO3	46	GPIO11	63	VIO
13	CONFIG_HOST[1]	30	GPIO20	47	GPIO10	64	GND
14	AVDD18	31	GND	48	GPIO9	65 ~ 94	GND
15	GND	32	GND	49	GPIO8		
16	GND	33	GND	50	GND		
17	GND	34	VBAT	51	GND		

7.2 Pin Descriptions

Table 7 lists the pin descriptions of Type 1ZM.

Table 7: Pin Descriptions

No.	Pin name	Type	Connection to IC Pin Name	Description
1	GND			Ground
2	GND			Ground
3	NC (GPIO19)	I/O	GPIO[19](88W8987) DVS1(PMIC)	NC
4	NC (GPIO18)	I/O	GPIO[18](88W8987) DVS0(PMIC)	NC
5	GPIO17	I/O	GPIO[17]	Programmable GPIO Pin
6	GPIO16	I/O	GPIO[16]	Programmable GPIO Pin
7	GPIO7 (BT_PCM_SYNC)	I/O	GPIO[7]	Programmable GPIO Pin
8	GPIO0	I/O	GPIO[0]	Programmable GPIO Pin
9	GPIO6 (BT_PCM_CLK)	I/O	GPIO[6]	Programmable GPIO Pin
10	GPIO5 (BT_PCM_DOUT)	I/O	GPIO[5]	Programmable GPIO Pin
11	GPIO4 (BT_PCM_DIN)	I/O	GPIO[4]	Programmable GPIO Pin
12	CONFIG_HOST[0]	I	CONFIG_HOST[0]	Firmware Boot Options
13	CONFIG_HOST[1]	I	CONFIG_HOST[1]	
14	AVDD18	O	AVDD18(88W8987) VLDO(PMIC)	LDO Output. Use for CONFIG_HOST pull-up.
15	GND			Ground
16	GND			Ground
17	GND			Ground
18	GND			Ground

No.	Pin name	Type	Connection to IC Pin Name	Description
19	GND			Ground
20	RF	I/O		WLAN/Bluetooth Antenna
21	GND			Ground
22	GND			Ground
23	CONFIG_AUTO_REF_DET	I	CONFIG_AUTO_REF_DET	Reference Clock Frequency Detection Select 0 = reference clock frequency detection by CONFIG_XOSC_SEL/GPIO8 1 = reference clock frequency detection using external sleep clock (Default/internal PU) (valid only when external sleep clock is used)
24	GND			Ground
25	GND			Ground
26	GND			Ground
27	GPIO1 (WLAN_WAKEUP_HOST)[1]	I/O	GPIO[1]	Programmable GPIO Pin WLAN to HOST wakeup.[2]
28	GPIO2	I/O	GPIO[2]	Programmable GPIO Pin
29	GPIO3	I/O	GPIO[3]	Programmable GPIO Pin
30	GPIO20 (BT_WAKEUP_HOST)[1]	I/O	GPIO[20]	Programmable GPIO Pin BT to HOST wakeup.[2]
31	GND			Ground
32	GND			Ground
33	GND			Ground
34	VBAT	I	PVIN(PMIC)	Power supply
35	VBAT	I	PVIN(PMIC)	Power supply
36	GND			Ground
37	GND			Ground
38	GPIO15	I/O	GPIO[15]	Programmable GPIO Pin. (JTAG_TMS)
39	GPIO14	I/O	GPIO[14]	Programmable GPIO Pin. (JTAG_TCK)
40	GPIO13 (HOST_WAKEUP_WLAN)[1]	I/O	GPIO[13]	Programmable GPIO Pin HOST to WLAN wakeup.[2]
41	GPIO12 (HOST_WAKEUP_BT)[1]	I/O	GPIO[12]	Programmable GPIO Pin HOST to BT wakeup[2]
42	PMIC_EN	I	EN(PMIC)	Enable build-in PMIC. Logic high enables internal regulators and internal hardware reset is de-asserted. Please input more than 1.2V for Logic High. Logic low disables regulators and internal hardware reset is asserted. Please input less than 0.4V for Logic low. **Do not float this pin**

[1] NXP recommended GPIO. Check whether NXP software can support this function or not.
[2] Configurable by Software.

No.	Pin name	Type	Connection to IC Pin Name	Description
43	GND			Ground
44	NC			
45	GND			Ground. (PDn)
46	GPIO11 (BT_UART_RTS)	I/O	GPIO[11]	Programmable GPIO Pin[2]
47	GPIO10 (BT_UART_CTS)	I/O	GPIO[10]	Programmable GPIO Pin[2]
48	GPIO9 (BT_UART_RXD)	I/O	GPIO[9]	Programmable GPIO Pin[2]
49	GPIO8 (BT_UART_TXD)	I/O	GPIO[8]	Reference Clock Frequency Select Low when CONFIG_AUTO_REF_DET = 0 NC when CONFIG_AUTO_REF_DET = 1[2]
50	GND			Ground
51	GND			Ground
52	GND			Ground
53	SD_DAT2	I/O	SD_DAT[2]	SDIO Data line Bit[2]
54	SD_DAT3	I/O	SD_DAT[3]	SDIO Data line Bit[3]
55	SD_DAT1	I/O	SD_DAT[1]	SDIO Data line Bit[1]
56	SD_DAT0	I/O	SD_DAT[0]	SDIO Data line Bit[0]
57	SD_CMD	I/O	SD_CMD	SDIO Command/response
58	GND			Ground
59	SD_CLK	I	SD_CLK	SDIO Clock input
60	GND			Ground
61	SLP_CLK_IN	I	SLP_CLK_IN	Sleep Clock input
62	GND			Ground
63	VIO	I	VIO VIO_RF VIO_SD	Power supply
64	GND			Ground
65~94	GND			Ground

() of “pin name” is BSP configuration of NXP iMX8.

7.3 Configuration Pins

The pin configurations of Type 1ZM module is shown in **Table 8**.

Table 8: Configuration Pins

CONFIG_HOST[0]	CONFIG_HOST[1]	WLAN	Bluetooth	Remarks
1	1	SDIO	SDIO	May not be supported in software. Contact Murata.
0	1	SDIO	UART	Murata Default

AVDD18 output can be used to pull-up CONFIG_HOST pins.

7.4 Pin States

Pin state information for the **Table 9** include:

- After firmware is downloaded, the pads (GPIO, Serial interface, RF control) are programmed in functional mode per the functionality of the pins.
- For SDIO, once the command is received from the host, the pads are configured accordingly.
- Pull-up and pull-down are only effective when the pad is in input mode.
- The power-down state shown is the default configuration. Many pads have programmable power-down values, which can be set by firmware.
- Do not need any termination to the open pins in input mode that have an Internal pull-up/pull-down resistor (PU/PD). Do not need any termination to the open pins in output mode.

Table 9: I/O State Table

Pin Name	Supply	No Pad Power State	Reset State	HW State[3]	PD State[4]	PD Prog[5]	Internal PU/PD	Int'l Pull Value [Ω][6]
GPIO0	VIO	tristate	output	output	drive low	yes	nominal PU	90K
GPIO1	VIO	tristate	input	input	tristate	yes	weak PU	800K
GPIO2	VIO	tristate	input	drive high[7]	tristate	yes	weak PU	800K
GPIO3	VIO	tristate	input	drive high[7]	tristate	yes	weak PU	800K
GPIO4	VIO	tristate	input	input	tristate	yes	nominal PU	90K
GPIO5	VIO	tristate	input	input	tristate	yes	weak PU	800K

[3] Hardware default state after reset
[4] Power-down state
[5] Power-down state programmable
[6] Calculate appropriate external pull values with internal pull value
[7] The signal may toggle while boot code is executing

Pin Name	Supply	No Pad Power State	Reset State	HW State[3]	PD State[4]	PD Prog[5]	Internal PU/PD	Int'l Pull Value [Ω][6]
GPIO6	VIO	tristate	input	input	tristate	yes	nominal PU	90K
GPIO7	VIO	tristate	input	input	tristate	yes	nominal PU	90K
GPIO8	VIO	tristate	input	Input[8] output[9]	drive low	yes	weak PU	800K
GPIO9	VIO	tristate	input	input	tristate	yes	nominal PU	90K
GPIO10	VIO	tristate	input	input	tristate	yes	nominal PU	90K
GPIO11	VIO	tristate	input	input[8] output[9]	drive high	yes	weak PU	800K
GPIO12	VIO	tristate	input	input	tristate	yes	nominal PD	90K
GPIO13	VIO	tristate	input	input[8] output[9]	drive high	yes	nominal PU	90K
GPIO14	VIO	tristate	input	input	tristate	yes	nominal PU	90K
GPIO15	VIO	tristate	input	input	drive high	yes	nominal PU	90K
GPIO16	VIO	tristate	input	input	tristate	yes	nominal PD	90K
GPIO17	VIO	tristate	input	input	tristate	yes	weak PU	800K
GPIO18	VIO	tristate	output	drive high	tristate	yes	weak PU	800K
GPIO19	VIO	tristate	output	drive high	tristate	yes	weak PU	800K
GPIO20	VIO	tristate	output	drive high[7]	tristate	yes	weak PU	800K
SD_CLK	VIO	tristate	input	input	tristate	no	nominal PU	90K
SD_CMD	VIO	tristate	input	input	tristate	no	nominal PU	90K
SD_D0	VIO	tristate	input	input	tristate	no	nominal PU	90K
SD_D1	VIO	tristate	input	input	tristate	no	nominal PU	90K
SD_D2	VIO	tristate	input	input	tristate	no	nominal PU	90K
SD_D3	VIO	tristate	input	input	tristate	no	nominal PU	90K
CONFIG_HOST[0]	AVDD18	tristate	input	input	tristate	no	weak PU	800K
CONFIG_HOST[1]	AVDD18	tristate	input	input	tristate	no	weak PU	800K
CONFIG_AUTO_REF_DET	AVDD18	tristate	input	input	tristate	no	weak PU	800K
SLP_CLK_IN	VIO	tristate	Input[10]	input	tristate	no	nominal PU	90K

- Not all GPIO pins can be used for Host-to-SoC wakeup signals.
- Maximum input voltage is 0.4V when VIO has no power (or in uncertain situations).

[8] When the device is in SDIO-SDIO mode
[9] When the device is in SDIO-UART mode
[10] Input mode after reset

7.5 SDIO Pin Descriptions

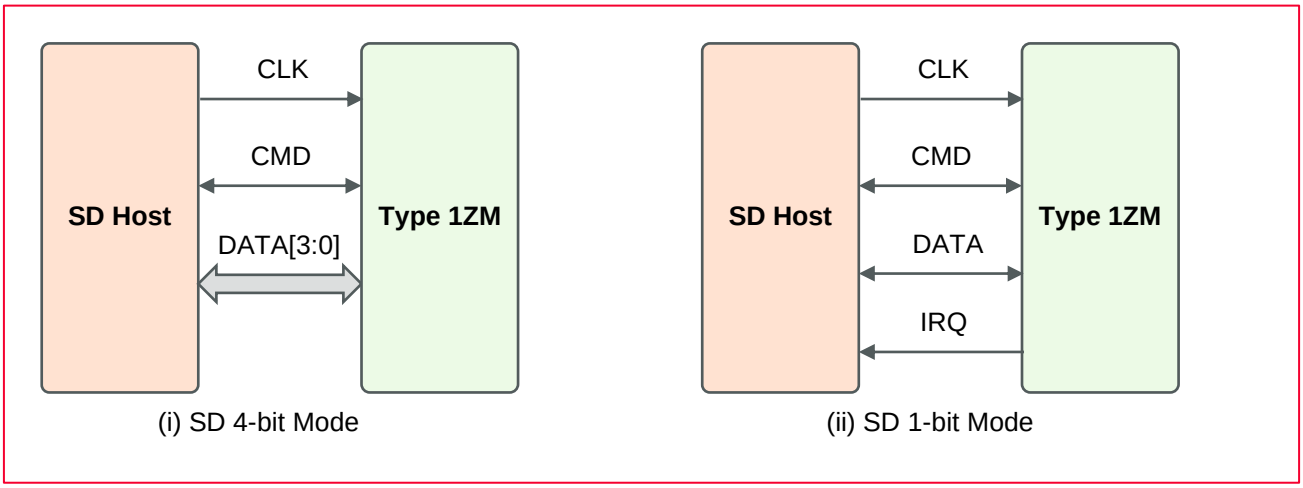
The SDIO pin descriptions of Type 1ZM module is shown in **Table 10**.

Table 10: SDIO Pin Descriptions

No.	Pin Name	(i) SD 4-bit Mode		(ii) SD 1-bit Mode	
59	SDIO_CLK	CLK	Clock	CLK	Clock
56	SDIO_D0	DATA0	Data line 0	DATA	Data line
55	SDIO_D1	DATA1	Data line 1 /Interrupt	IRQ	Interrupt
53	SDIO_D2	DATA2	Data line 2	NC	Not used
54	SDIO_D3	DATA3	Data line 3	NC	Not used
57	SDIO_CMD	CMD	Command line	CMD	Command line

Figure 5 shows the SDIO pin diagram for Type 1ZM module.

Figure 5: SDIO Pins



8 Absolute Maximum Ratings

Table 11 shows the absolute maximum ratings of Type 1ZM.

Table 11: Absolute Maximum Ratings

Parameter		Minimum	Maximum	Unit
Storage Temperature		-40	+85	°C
Supply Voltage	VBAT	-0.3	6.0	V
	VIO	-0.3	2.2	V

Stresses in excess of the absolute ratings may cause permanent damage. Functional operation is not implied under these conditions. Exposure to absolute ratings for extended periods of time may adversely affect reliability. No damage assuming only one parameter is set at limit at a time with all other parameters are set within operating condition.

9 Operating Conditions

9.1 Operating Conditions

The operating conditions are shown in **Table 12**.

Table 12: Operating Conditions

Parameter		Minimum	Typical	Maximum	Unit
Operating Temperature		-30	25	+85	°C
Supply Voltage	VBAT	2.7		5.5	V
	VIO	1.62	1.8	1.92	V
IO Current	VIO		0.1	0.5	mA
Peak Current	VBAT		770	950	mA

- Operation beyond the recommended operating conditions is neither recommended nor guaranteed.
- Peak current of VBAT (RF portion) happens during DPD calibration when the firmware is downloaded.

9.2 External Sleep Clock Requirements

Table 13 shows the external sleep clock requirements of Type 1ZM.

Table 13: External Sleep Clock Requirements

Symbol	Parameter	Minimum	Typical	Maximum	Unit
CLK	Clock frequency range/accuracy CMOS input clock signal type ±250 ppm (initial, aging, temperature)		32.768		kHz
V_{IH}	Input levels, where VIO=1.8V	0.7 * VIO		VIO + 0.4	V
V_{IL}		-0.4		0.3 * VIO	V
PN	Phase Noise Requirement (@ 100 kHz)		-125		dBc/Hz
J_C	Cycle jitter		1.5		ns (RMS)
SR	Slew rate limit (10-90%)			100	ns
DC	Duty cycle tolerance	20		80	%

Voltage input level = 1.8V

9.3 PMIC_EN I/O Requirements

Table 14 shows the PMIC_EN I/O requirements of Type1ZM.

Table 14: PMIC_EN IO Requirements

Symbol	Parameter	Minimum	Maximum	Unit
$V_{PMIC\_EN\_IH}$	Input high voltage	1.2		V
$V_{PMIC\_EN\_IL}$	Input low voltage		0.4	V

9.4 Digital I/O Requirements

Table 15 shows the digital I/O requirements of Type 1ZM.

Table 15: Digital I/O Requirements

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
V_{IH}	Input high voltage		0.7 * VIO		VIO + 0.4	V
V_{IL}	Input low voltage		-0.4		0.3 * VIO	V
V_{HYS}	Input hysteresis		100			mV
V_{OH}	Output high voltage		VIO - 0.4			V
V_{OL}	Output low voltage				0.4	V

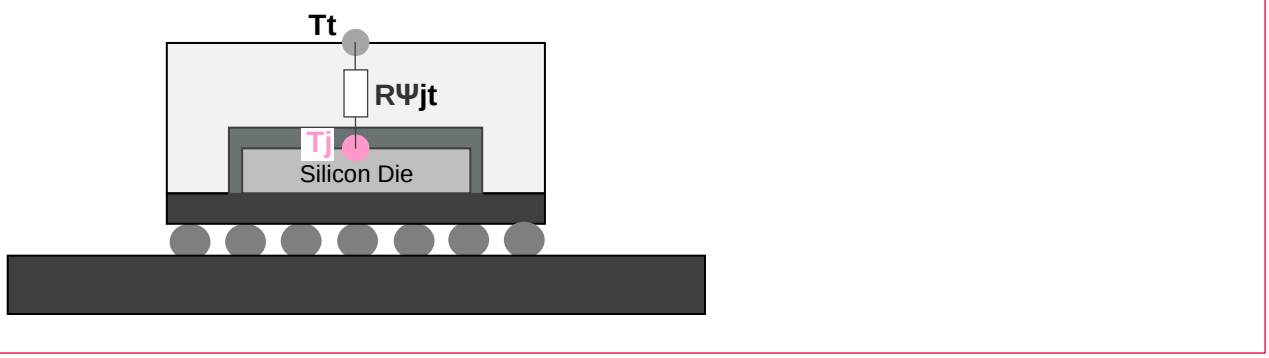
9.5 Package Thermal Conditions

The package thermal conditions as shown in **Figure 6** are as below:

- RΨjt: 2.76 °C/W
- RΨjt = (Tj - Tt)/P

Tj: Junction temperature (℃), Tt: Top temperature (℃), P: Total Power Consumption (W)

Figure 6: Package Thermal Conditions



10 Power Sequence

This section describes the power-on and power-off sequences along with their parameters.

10.1 Power-On Sequence

Figure 7 shows the power-on sequence graph.

- VBAT and VIO must be good (90%) at the same time or before assert PMIC_EN (= 0 to 1).
- Ramp-up time of VIO must be < 100 ms.

Figure 7: Power-On Sequence Graph

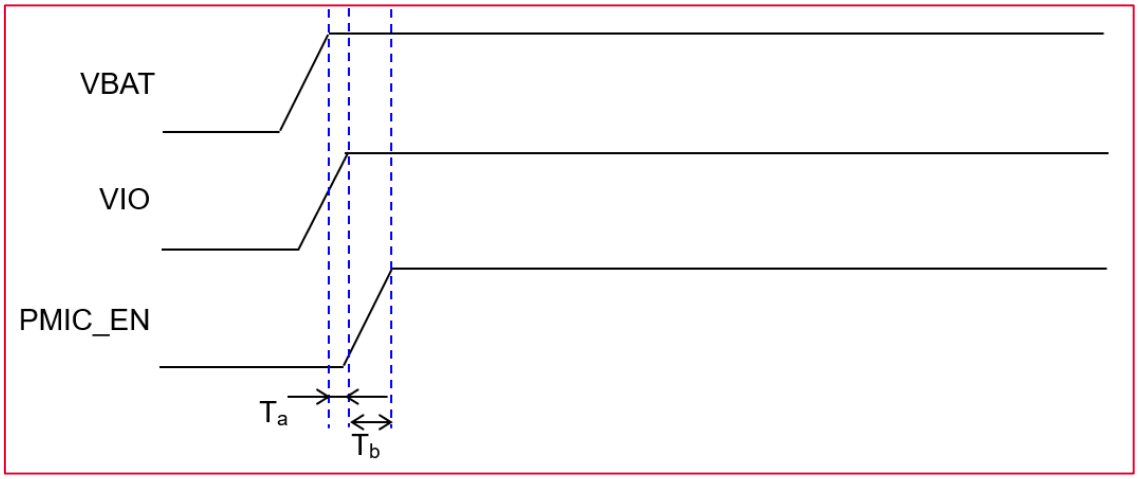


Table 16 describes the power-on sequence parameters.

Table 16: Power-On Sequence Parameters

Symbol	Parameter	Minimum	Typical	Maximum	Unit
T_a	VBAT to VIO time	0			ms
T_b	VIO to PMIC_EN time	0			ms

10.2 Power-Off Sequence

- VBAT and VIO must be down at the same time or before de-assert PMIC_EN (= 1 to 0).
- Ramp-down time of VIO must be < 100 ms.

Figure 8 shows the power-off sequence graph.

Figure 8: Power-Off Sequence Graph

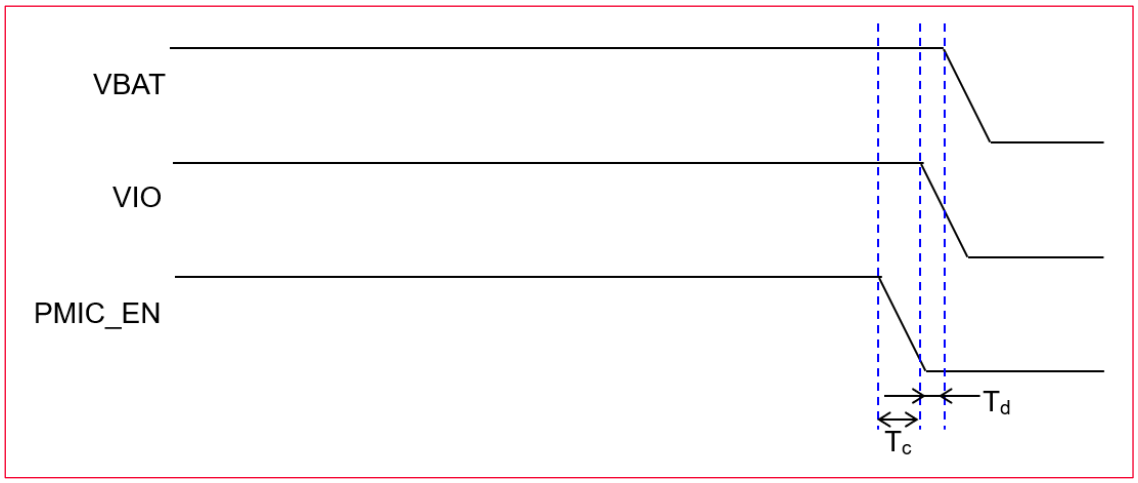


Table 17: Power-Off Sequence Parameters

Symbol	Parameter	Minimum	Typical	Maximum	Unit
Tc	PMIC_EN to VIO time	0			ms
Td	VIO to VBAT time	0			ms

describes the power-off sequence parameters.

Table 17: Power-Off Sequence Parameters

Symbol	Parameter	Minimum	Typical	Maximum	Unit
T_c	PMIC_EN to VIO time	0			ms
T_d	VIO to VBAT time	0			ms

11 Interface Timing

This section describes the interface timings; SDIO and UART timings and their speed modes, related parameters, and graphs.

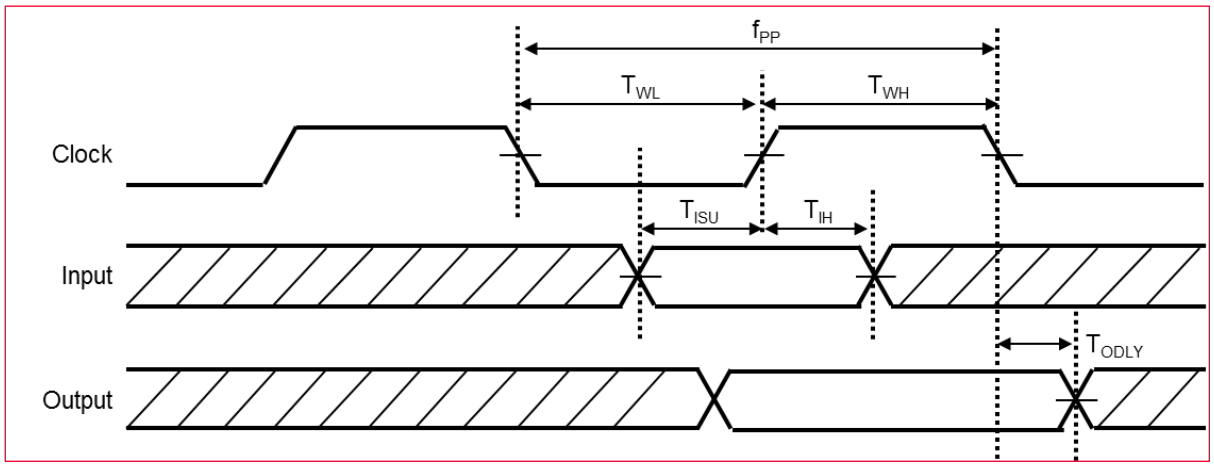
11.1 SDIO Timing

This section describes the SDIO timing for different modes.

11.1.1 Default Speed Mode

The default speed mode is shown in **Figure 9**.

Figure 9: SDIO Protocol Timing Diagram - Default Speed Mode



11.1.2 High Speed Mode

The high-speed mode is shown in **Figure 10**.

Figure 10: SDIO Protocol Timing Diagram - High Speed Mode

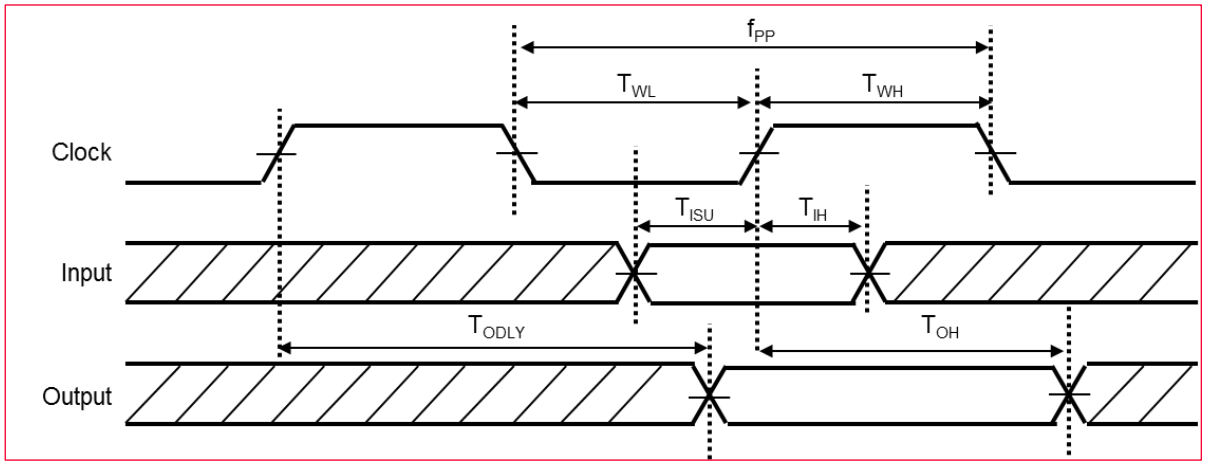


Table 18 describes the SDIO protocol timing parameters in default speed and high-speed modes.

Table 18: SDIO Protocol Timing Parameters - Default / High-Speed Modes

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
f_{PP}	Clock frequency	Normal	0		25	MHz
		High-speed	0		50	MHz
T_{WL}	Clock low time	Normal	10			ns
		High-speed	7			ns
T_{HW}	Clock high time	Normal	10			ns
		High-speed	7			ns
T_{ISU}	Input setup time	Normal	5			ns
		High-speed	6			ns

T_{IH}	Input hold time	Normal	5			ns
		High-speed	2			ns
T_{OLDY}	Output delay time	Normal			14	ns
	CL ≤ 40 pF (1 card)	High-speed			14	ns
T_{OH}	Output hold time	High-speed	2.5			ns

11.1.3 SDR12, SDR25, SDR50 Modes (up to 100 MHz)

The SDIO protocol timing diagram for SDR12, SDR25, SDR50 modes are shown in **Figure 11**.

Figure 11: SDIO Protocol Timing Diagram - SDR12, SDR25, SDR50 Mode

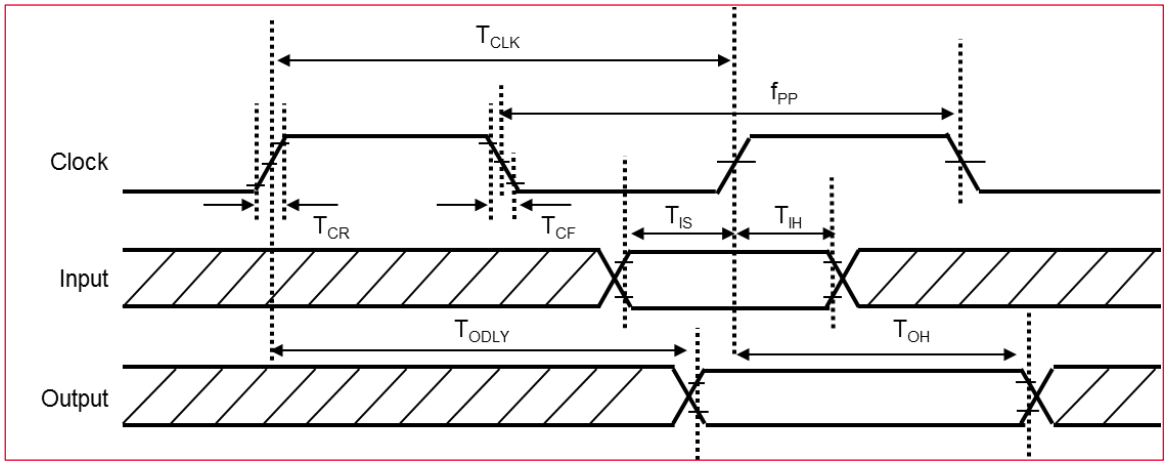


Table 19 describes the SDIO protocol timing parameters in SDR12, SDR25, SDR50 modes.

Table 19: SDIO Protocol Timing Parameters - SDR12, SDR25, SDR50 Modes

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
f_{PP}	Clock frequency	SDR12/25/50	25		100	MHz
T_{IS}	Input Setup time	SDR12/25/50	3			ns
T_{IH}	Input hold time	SDR12/25/50	0.8			ns
T_{CLK}	Clock time	SDR12/25/50	10		40	ns
T_{CR}, T_{CF}	Rise time, fall time	SDR12/25/50			0.2*T_{CLK}	ns
T_{ODLY}	Output delay time T_{CR}, T_{CF} < 2 ns (maximum) at 100 MHz C_{CARD} = 10 pF	SDR12/25/50			7.5	ns
T_{OH}	Output hold time	SDR12/25/50	1.5			ns

11.1.4 SDR104 Mode (208 MHz)

Figure 12 shows the SDIO protocol timing diagram for SDR104 Mode (208 MHz).

Figure 12: SDIO Protocol Timing Diagram - SDR104 Mode

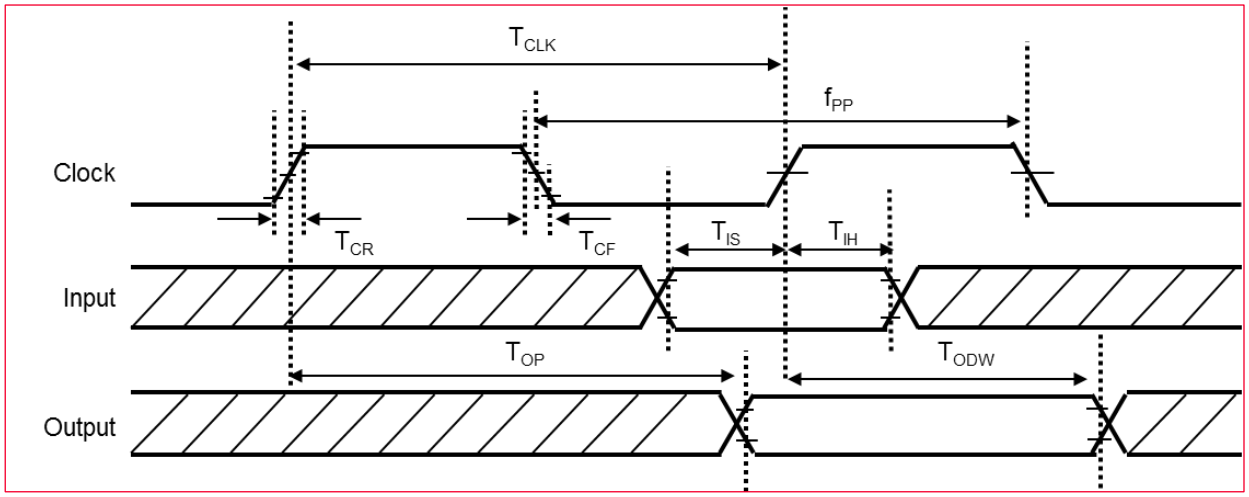


Table 20 SDIO protocol timing parameters in SDR104 mode.

Table 20: SDIO Protocol Timing Parameters - SDR104 Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
f_{PP}	Clock frequency	SDR104	0		208	MHz
T_{IS}	Input Setup time	SDR104	1.4			ns
T_{IH}	Input hold time	SDR104	0.8			ns
T_{CLK}	Clock time	SDR104	4.8			ns
T_{CR}, T_{CF}	Rise time, fall time T_{CR}, T_{CF}<0.96 ns(maximum) at 208 MHz C_{CARD} = 10 pF	SDR104			0.2*T_{CLK}	ns
T_{OP}	Card output phase	SDR104	0		10	ns
T_{ODW}	Output timing of variable data window	SDR104	2.88			ns

11.1.5 DDR50 Mode (50 MHz)

Figure 13 shows the SDIO CMD timing diagram and **Figure 14** shows the SDIO DATA timing diagram for DDR50 Mode (50 MHz).

Figure 13: SDIO CMD Timing Diagram - DDR50 Mode

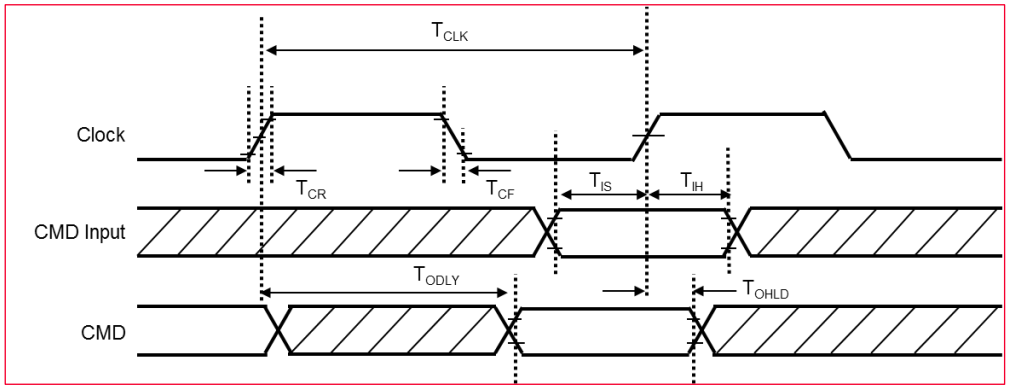


Figure 14: SDIO DATA Timing Diagram - DDR50 Mode

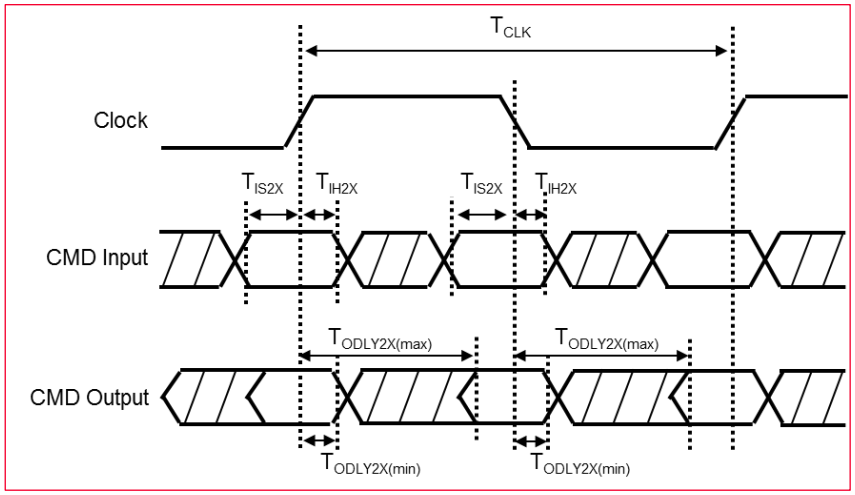


Table 21 describes the SDIO protocol timing parameters in DDR50 mode.

Table 21: SDIO Protocol Timing Parameters - DDR50 Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
Clock						
T_{CLK}	Clock time 50 MHz (maximum) between rising edge	DDR50	20			MHz
T_{CR}, T_{CF}	Rise time, fall time T_{CR}, T_{CF} < 4.00 ns (maximum) at 50 MHz C_{CARD} = 10 pF	DDR50			0.2 * T_{CLK}	ns
Clock Duty	-	DDR50	45		55	%
CMD Input (referenced to clock rising edge)						
T_{IS}	Input Setup time	DDR50	6			ns
T_{IH}	Input hold time	DDR50	0.8			ns

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
CMD Output (referenced to clock rising edge)						
T_{ODLY}	Output delay time during data transfer mode $C_L \leq 30$ F (1 card)	DDR50			13.7	ns
T_{OHLD}	Output hold time $C_L \geq 15$ F (1 card)	DDR50	1.5			ns
DAT [3:0] Input (referenced to clock rising and falling edges)						
T_{IS2x}	Input setup time $C_{CARD} \leq 10$ pF (1 card)	DDR50	3			ns
T_{IH2x}	Input hold time $C_{CARD} \leq 10$ pF (1 card)	DDR50	0.8			ns
DAT [3:0] Output (referenced to clock rising and falling edges)						
$T_{ODLY2x\ (max)}$	Output delay time during data transfer mode $C_L \leq 25$ pF (1 card)	DDR50			7.0	ns
$T_{ODLY2x\ (min)}$	Output hold time $C_L \geq 15$ pF (1 card)	DDR50	1.5			ns

11.2 High Speed UART Specifications

The default baud rate is 115200 bps. Baud rate is configurable by the host stack. **Figure 15** shows the high speed UART timing diagram.

Figure 15: High Speed UART Timing Diagram

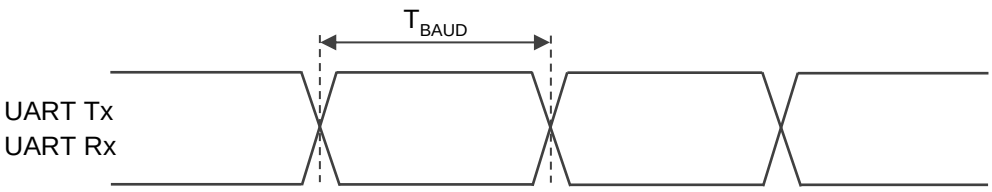


Table 22 describes the high speed UART timing parameters.

Table 22: High Speed UART Timing Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{BAUD}	Baud rate	38.4 MHz	250			ns

The acceptable deviation from the UART Rx target baud rate is ±3%.

11.3 Bluetooth PCM Timing

This section describes the PCM timings: PCM_Sync signal - Master mode, PCM_Sync signal - Slave mode along with their data signals and parameters.

11.3.1 Master Mode

Figure 16 and **Figure 17** shows the timing diagram of master mode for data and PCM_SYNC signals.

Figure 16: Bluetooth Data Signal - Master Mode

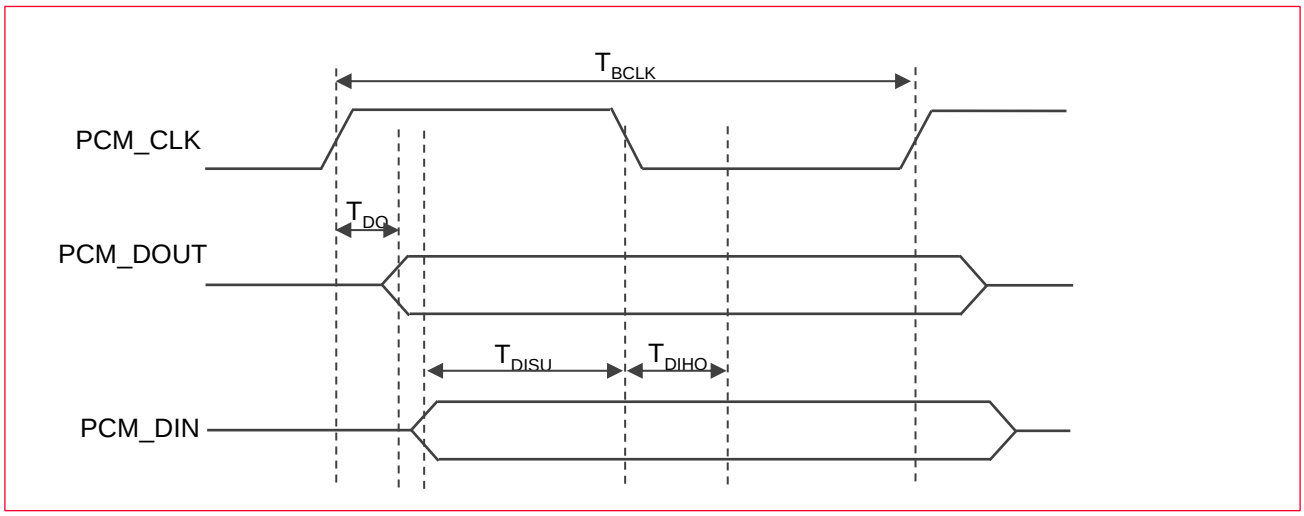


Figure 17: Bluetooth PCM_SYNC signal - Master Mode

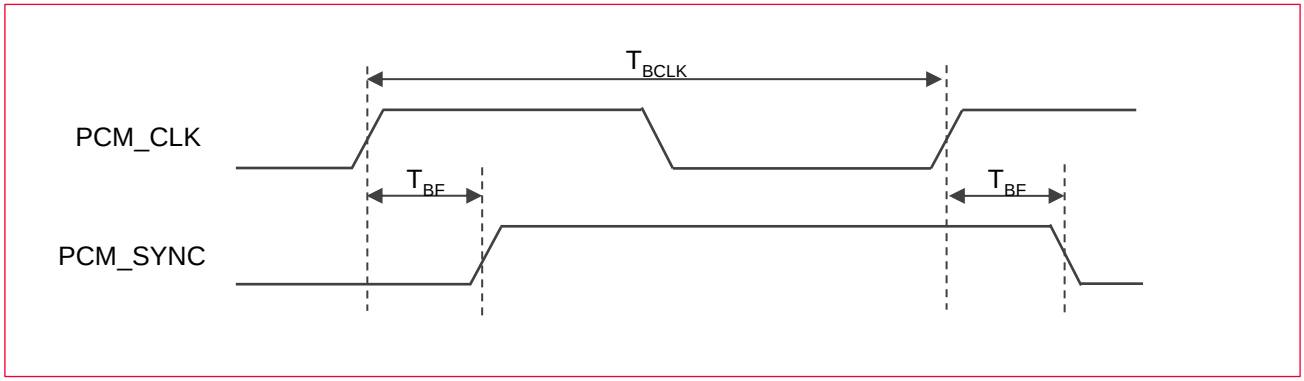


Table 23 lists information about the data and PCM_SYNC signals in master mode.

Table 23: Symbol Definition for Data Signal & PCM_SYNC Signal - Master Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{BCLK}	Bit clock frequency			2/2.048		MHz
Duty Cycle$_{BCLK}$	Bit clock duty cycle		0.4	0.5	0.6	
$T_{BCLK\ rise/fall}$	PCM_CLK rise/fall time			3		ns
T_{DO}	Delay from PCM_CLK rising edge to PCM_DOUT rising edge				15	ns
T_{DISU}	Setup time for PCM_DIN before PCM_CLK falling edge		20			ns
T_{DIHO}	Hold time for PCM_DIN after PCM_CLK falling edge		15			ns

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{BF}	Delay from PCM_CLK rising edge to PCM_SYNC rising edge				15	ns

11.3.2 Slave Mode

Figure 18 and **Figure 19** shows the timing diagram of slave mode for data and PCM_SYNC signals.

Figure 18: Bluetooth Data Signal - Slave Mode

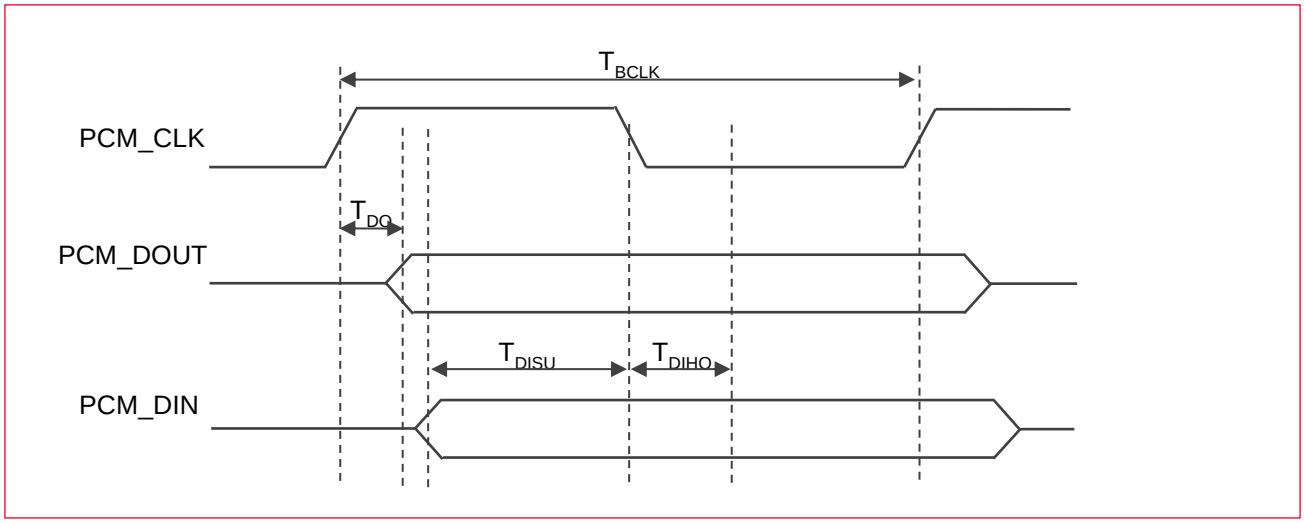


Figure 19: Bluetooth PCM_SYNC Signal - Slave Mode

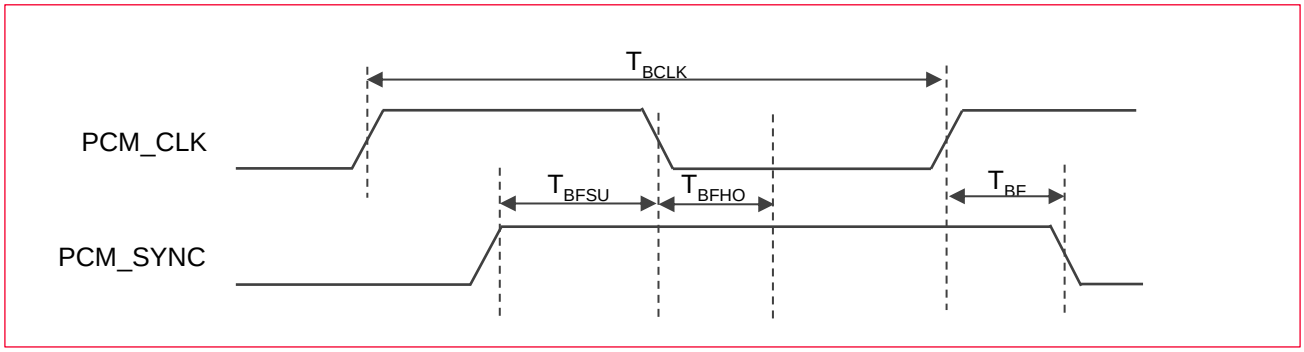


Table 24 lists information about the data and PCM_SYNC signals in slave mode.

Table 24: Symbol Definition for Data Signal & PCM_SYNC Signal - Slave Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{BCLK}	Bit clock frequency			2/2.048		MHz
Duty $Cycle_{BCLK}$	Bit clock duty cycle		0.4	0.5	0.6	
$T_{BCLK\ rise/fall}$	PCM_CLK rise/fall time			3		ns
T_{DO}	Delay from PCM_CLK rising edge to PCM_DOUT rising edge				30	ns

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{DISU}	Setup time for PCM_DIN before PCM_CLK falling edge		15			ns
T_{DIHO}	Hold time for PCM_DIN after PCM_CLK falling edge		10			ns
T_{BFSU}	Setup time for PCM_SYNC before PCM_CLK falling edge		15			ns
T_{BFHO}	Hold time for PCM_SYNC after PCM_CLK falling edge		10			ns

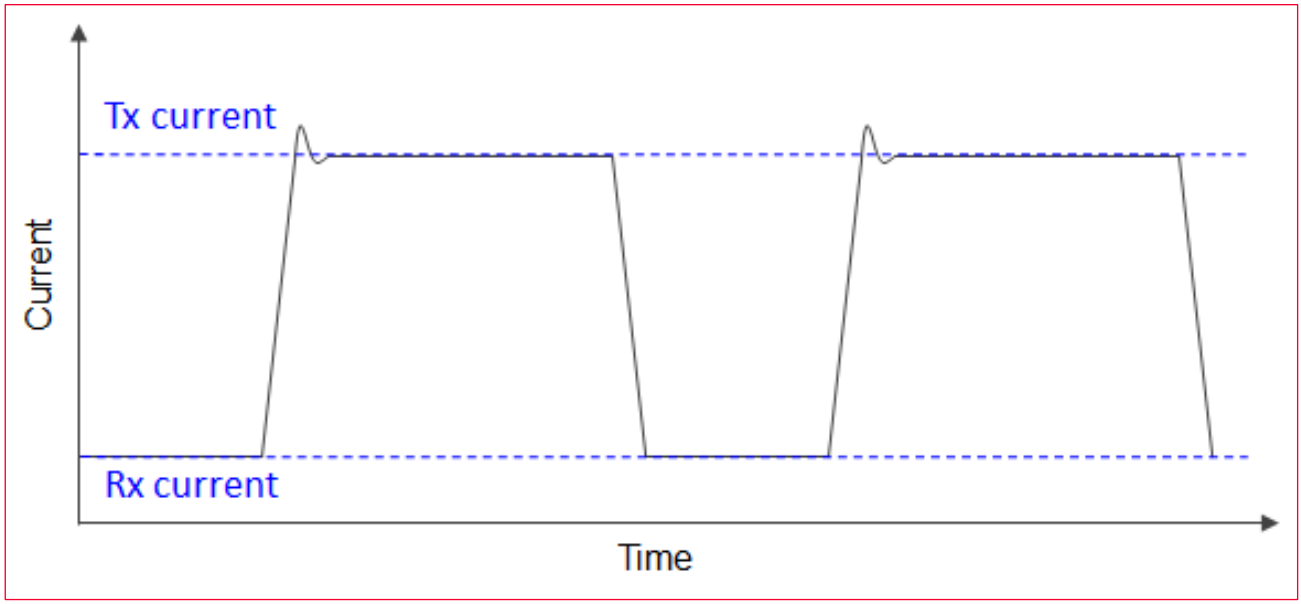
12 DC/RF Characteristics

All DC/RF characteristics are defined by following files as shown with file names in **Table 25**. **Figure 20** shows the burst current definition for Type 1ZM module.

Table 25: DC/RF Characteristics and Files

Characteristic	Filenames
WLAN Tx Power	txpower_US.bin, txpower_CA.bin, txpower_EU.bin, txpower_JP.bin
WLAN Regulatory Limit	db.txt
Energy Detect	ed_mac.bin
Bluetooth Power	bt_power_config_1.sh (Class 1)

Figure 20: Burst Current Definition



12.1 DC/RF Characteristics for IEEE 802.11b - 2.4 GHz

Table 26: Characteristics Values for IEEE 802.11b - 2.4 GHz

Items	Contents
Specification	IEEE 802.11b
Mode	DSSS / CCK
Channel Frequency	2412 to 2472 MHz
Data rate	1, 2, 5.5, 11 Mbps

12.1.1 High-Rate Condition for IEEE 802.11b - 2.4 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 17 dBm at module pad, 11 Mbps mode

Table 27: High-Rate Condition for IEEE 802.11b - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		384	535	mA
• Rx mode		64	76	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	15.0	17.0	19.0	dBm
Spectrum Mask Margin				
• 1st side lobes (-30dBr)	0			dB
• 2nd side lobes (-50dBr)	0			dB
Power-on/off ramp			2.0	µs
RF Carrier Suppression	15			dB
Modulation Accuracy			35	%
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm

Items	Contents			
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (FER ≤ 8%)			-76	dBm
Maximum Input Level (FER ≤ 8%)	-10			dBm
Adjacent Channel Rejection (FER < 8%)	35			dB

12.1.2 Low-Rate Condition for IEEE 802.11b - 2.4 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 17 dBm at module pad, 1 Mbps mode

Table 28: Low-Rate Condition for IEEE 802.11b - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		370	516	mA
• Rx mode		64	76	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	15.0	17.0	19.0	dBm
Spectrum Mask Margin				
• 1st side lobes (-30dBr)	0			dB
• 2nd side lobes (-50dBr)	0			dB
Power-on/off ramp			2.0	µs
RF Carrier Suppression	15			dB
Modulation Accuracy			35	%
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (FER ≤ 8%)			-80	dBm
Maximum Input Level (FER ≤ 8%)	-4			dBm

Items	Contents			
Adjacent Channel Rejection (FER < 8%)	35			dB

12.2 DC/RF Characteristics for IEEE 802.11g - 2.4 GHz

Table 29: Characteristics values for IEEE 802.11g - 2.4 GHz

Items	Contents
Specification	IEEE 802.11g
Mode	OFDM
Channel Frequency	2412 to 2472 MHz
Data rate	6, 9, 12, 18, 24, 36, 48, 54 Mbps

12.2.1 High-Rate Condition for IEEE 802.11g - 2.4 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 16 dBm at module pad, 54 Mbps mode

Table 30: High-Rate Condition for IEEE 802.11g - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		336	458	mA
• Rx mode		64	76	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	15.0	16.0	18.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER < 10%)			-65	dBm
Maximum Input Level (PER < 10%)	-20			dBm

Items	Contents			
Adjacent Channel Rejection (PER < 10%)	-1			dB

12.2.2 Low-Rate Condition for IEEE 802.11g - 2.4 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 17 dBm at module pad, 6 Mbps mode

Table 31: Low-Rate Condition for IEEE 802.11g - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		366	504	mA
• Rx mode		64	76	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	15.0	17.0	19.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER < 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-20			dBm
Adjacent Channel Rejection (PER < 10%)	-1			dB

12.3 DC/RF Characteristics for IEEE 802.11n - 2.4 GHz

Table 32: Characteristics values for IEEE 802.11n - 2.4 GHz

Items	Contents
Specification	IEEE 802.11n
Mode	OFDM
Channel Frequency	2412 to 2472 MHz
Data rate	MCS0 - MCS7

12.3.1 High-Rate Condition for IEEE 802.11n - 2.4 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 15 dBm at module pad, MCS7 mode

Table 33: High-Rate Condition for IEEE 802.11n - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		316	426	mA
• Rx mode		64	76	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	13.0	15.0	17.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-64	dBm
Maximum Input Level (PER < 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

12.3.2 Low-Rate Condition for IEEE 802.11n - 2.4 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 16 dBm at module pad, MCS0 mode

Table 34: Low-Rate Condition for IEEE 802.11n - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		342	466	mA
• Rx mode		64	76	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	14.0	16.0	18.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

12.4 DC/RF Characteristics for IEEE 802.11a - 5 GHz

Table 35: Characteristics Values for IEEE 802.11a - 5 GHz

Items	Contents
Specification	IEEE 802.11a
Mode	OFDM
Channel Frequency	5180 to 5240 MHz, 5260 to 5320 MHz, 5500 to 5720 MHz, 5745 to 5825 MHz
Data rate	6, 9, 12, 18, 24, 36, 48, 54 Mbps

12.4.1 High-Rate Condition for IEEE 802.11a - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 15 dBm at module pad, 54 Mbps mode

Table 36: High-Rate Condition for IEEE 802.11a - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		408	626	mA
• Rx mode		79	90	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	13.0	15.0	17.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm

Items	Contents			
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-65	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

12.4.2 Low-Rate Condition for IEEE 802.11a - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 15 dBm at module pad, 6 Mbps mode

Table 37: Low-Rate Condition for IEEE 802.11a - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		408	626	mA
• Rx mode		79	90	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	13.0	15.0	17.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**

Items	Contents			
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

12.5 DC/RF Characteristics for IEEE 802.11n (HT20) - 5 GHz

Table 38: Characteristics Values for IEEE 802.11n (HT20) - 5 GHz

Items	Contents
Specification	IEEE 802.11n
Mode	OFDM
Channel Frequency	5180 to 5240 MHz, 5260 to 5320 MHz, 5500 to 5720 MHz, 5745 to 5825 MHz
Data rate	MCS0 - MCS7

12.5.1 High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS7 mode

Table 39: High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		386	586	mA
• Rx mode		79	90	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm

Items	Contents			
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-64	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

12.5.2 Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS0 mode

Table 40: Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		386	586	mA
• Rx mode		79	90	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm

Items	Contents			
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

12.6 DC/RF Characteristics for IEEE 802.11ac (VHT20) - 5 GHz

Table 41: Characteristics Values for IEEE 802.11ac (VHT20) - 5 GHz

Items	Contents
Specification	IEEE 802.11ac
Mode	OFDM
Channel Frequency	5180 to 5240 MHz, 5260 to 5320 MHz, 5500 to 5720 MHz, 5745 to 5825 MHz
Data rate	MCS0 - MCS8

12.6.1 High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS8 mode

Table 42: High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		385	584	mA
• Rx mode		79	90	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-30	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-59	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

12.6.2 Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS0 mode

Table 43: Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		385	584	mA
• Rx mode		79	90	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

12.7 DC/RF Characteristics for IEEE 802.11n (HT40) - 5 GHz

Table 44: Characteristics Values for IEEE 802.11n (HT40) - 5 GHz

Items	Contents
Specification	IEEE 802.11n
Mode	OFDM
Channel Frequency	5190 to 5795 MHz
Data rate	MCS0 - MCS7

12.7.1 High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS7 mode

Table 45: High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		387	583	mA
• Rx mode		91	103	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm

Items	Contents			
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-61	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

12.7.2 Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS0 mode

Table 46: Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		387	583	mA
• Rx mode		91	103	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm

Items	Contents			
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-79	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

12.8 DC/RF Characteristics for IEEE 802.11ac (VHT40) - 5 GHz

Table 47: Characteristics Values for IEEE 802.11ac (VHT40) - 5 GHz

Items	Contents
Specification	IEEE 802.11ac
Mode	OFDM
Channel Frequency	5190 to 5795 MHz
Data rate	MCS0 - MCS9

12.8.1 High-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 13 dBm at module pad, MCS9 mode

Table 48: High-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		357	528	mA
• Rx mode		91	103	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	11.0	13.0	15.0	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -40 dBr)	0			dB
• 60 MHz to 80 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm

Items	Contents			
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-54	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 0%)	-9			dB

12.8.2 Low-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS0 mode

Table 49: Low-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		388	585	mA
• Rx mode		91	103	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -40 dBr)	0			dB
• 60 MHz to 80 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm

Items	Contents			
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-79	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

12.9 DC/RF Characteristics for IEEE 802.11ac (VHT80) - 5 GHz

Table 50: Characteristics Values for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents
Specification	IEEE 802.11ac
Mode	OFDM
Channel Frequency	5210 to 5775 MHz
Data rate	MCS0 - MCS9

12.9.1 High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 13 dBm at module pad, MCS9 mode

Table 51: High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		376	558	mA
• Rx mode		102	114	mA
Tx Characteristics -	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	11.0	13.0	15.0	dBm
Spectrum Mask Margin				
• 39 MHz to 41 MHz (0 ~ -20 dBr)	0			dB
• 41 MHz to 80 MHz (-20 ~ -28 dBr)	0			dB
• 80 MHz to 120 MHz (-28 ~ -40 dBr)	0			dB
• 120 MHz to 140 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-51	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

12.9.2 Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 14 dBm at module pad, MCS0 mode

Table 52: Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC current				
• Tx mode		406	611	mA
• Rx mode		102	114	mA
Tx Characteristics -	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12.0	14.0	16.0	dBm
Spectrum Mask Margin				
• 39 MHz to 41 MHz (0 ~ -20 dBr)	0			dB
• 41 MHz to 80 MHz (-20 ~ -28 dBr)	0			dB
• 80 MHz to 120 MHz (-28 ~ -40 dBr)	0			dB
• 120 MHz to 140 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-76	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

12.10 DC/RF Characteristics for Bluetooth

Table 53: Characteristics Values for Bluetooth

Items	Contents
Bluetooth specification (power class)	Version 5.1 (Class 1)
Channel frequency (spacing)	2402 - 2480 MHz (1 MHz)
Number of RF Channel	79

12.10.1 Basic Data Rate Condition

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V

Table 54: Basic Data Rate Condition

Items	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx mode DH5		91	115	mA
• Rx mode DH5		61	73	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power@DH5	0	3.0	6.0	dBm
Frequency range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power [11]				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
Modulation characteristics				
• Modulation $\Delta f1_{avg}$	140	151	175	kHz
• Modulation $\Delta f2_{max}$	115			kHz
• Modulation $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8	1		
Carrier Frequency Drift				
• 1slot	-25		25	kHz
• 3slot / 5slot	-40		40	kHz
• Maximum drift rate			20	kHz/50 µs
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
BR Sensitivity (BER ≤ 0.1%)		-96	-70	dBm
Maximum Input Level (BER ≤ 0.1%)	-20			dBm

[11] Up to three spurious responses within Bluetooth limits are allowed.

12.10.2 Enhanced Data Rate Condition

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V

Table 55: Enhanced Data Rate Condition

Items	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx mode 2DH5		87	107	mA
• Rx mode 2DH5		61	73	mA
• Tx mode 3DH5		87	107	mA
• Rx mode 3DH5		61	73	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power@2DH5/3DH5	-3.0	0	3.0	dBm
Frequency range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power[12]				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
EDR Relative Power	-4		1	dB
EDR Carrier Frequency Stability and Modulation Accuracy				
• ωi	-75		75	kHz
• ωi+ωo	-75		75	kHz
• ωo	-10		10	kHz
• RMS DEVM (DQPSK)			20	%
• Peak DEVM (QPSK)			35	%
• 99% DEVM (DQPSK)			30	%
• RMS DEVM (8DPSK)			13	%
• Peak DEVM (8DPSK)			25	%
• 99% DEVM (8DPSK)			20	%
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
EDR Sensitivity (BER ≤ 0.007%)@8DPSK		-88	-70	dBm
Maximum Input Level (BER ≤ 0.1%)	-20			dBm

[12] Up to three spurious responses within Bluetooth limits are allowed.

12.11 DC/RF Characteristics for Bluetooth Low Energy

Table 56: DC/RF Characteristics for Bluetooth Low Energy

Items	Contents
Bluetooth specification (power class)	Version 5.1 (Class 1.5)
Channel frequency (spacing)	2402 to 2480 MHz (2 MHz)
Number of RF Channel	40

12.11.1 1 Mbps PHY Condition

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V

Table 57: 1 Mbps PHY Condition

Items	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx mode		90	110	mA
• Rx mode		60	69	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF channel		40		
Output power	0	3	6	dBm
In-band emission				
• f_{TX}+/-2 MHz			-20	dBm
• f_{TX}+/-[3+n] MHz; n=0,1,2…			-30	dBm
Modulation Characteristics				
• $\Delta f1_{avg}$	225		275	kHz
• $\Delta f2_{max}$ (at 99.9%)	185			kHz
• $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8			
Carrier frequency offset and drift				
• Frequency offset (f_n); n=0,1,2,3…k	-150		150	kHz
• Frequency drift ($\|f_0-f_n\|$); n=2,3,4…k			50	kHz
• Drift rate				
• $\|f_1-f_0\|$			23	kHz
• $\|f_n-f_{n-5}\|$; n=6,7,8,…k			20	kHz
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm

Items	Contents			
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Receiver sensitivity (PER < 30.8%)		-97	-70	dBm
Maximum input signal level (PER < 30.8%)	-10			dBm
PER Report Integrity (-30 dBm input)	50		65.4	%

12.11.2 2 Mbps PHY Condition

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V

Table 58: 2 Mbps PHY Condition

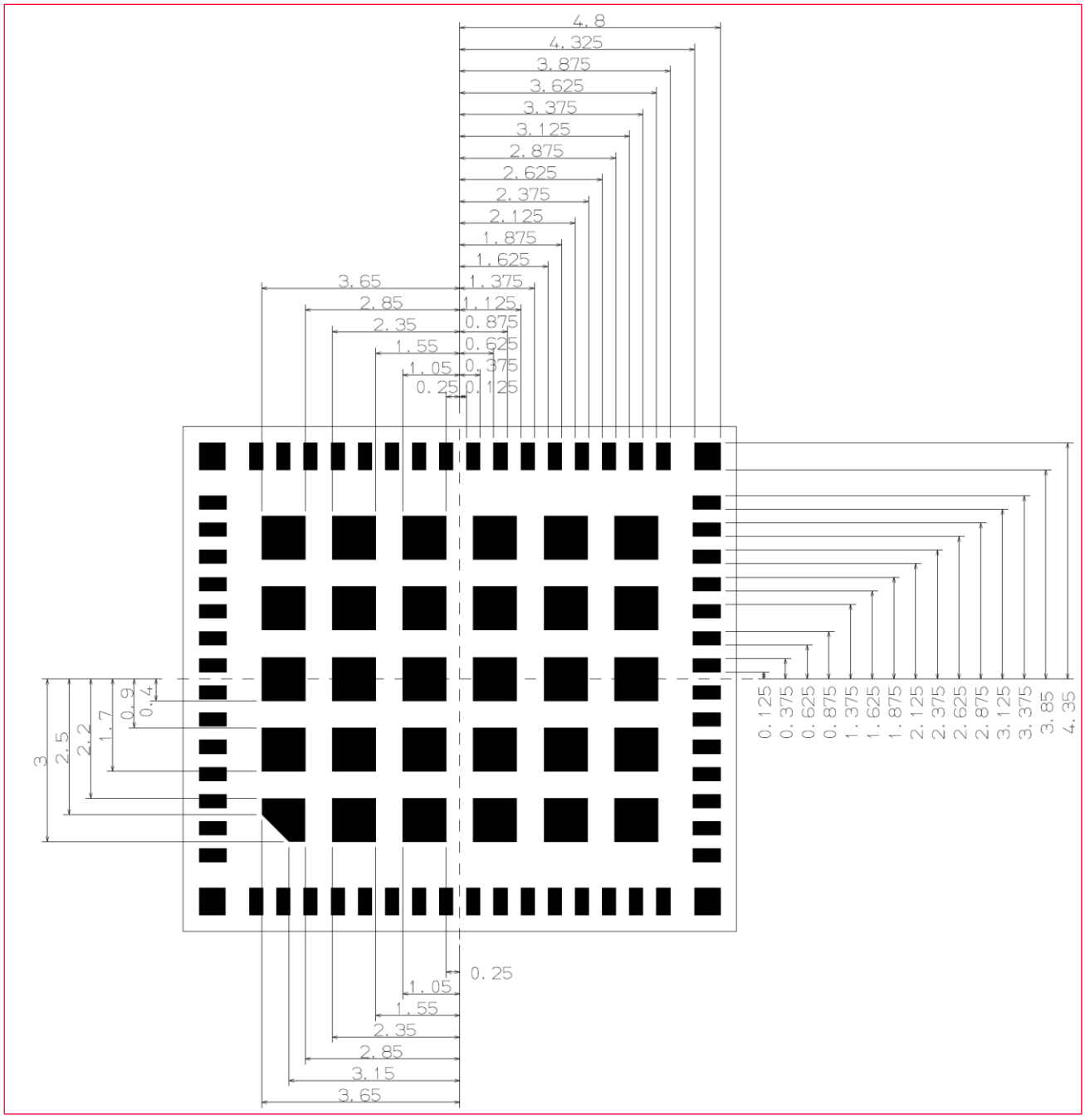
Items	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx mode		88	112	mA
• Rx mode		60	69	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF channel		40		-
Output power	0	3	6	dBm
In-band emission				
• f_{TX}+/-4 MHz			-20	dBm
• f_{TX}+/-5 MHz			-20	dBm
• f_{TX}+/-[6+n] MHz; n=0,1,2…			-30	dBm
Modulation Characteristics				
• $\Delta f1_{avg}$	450		550	kHz
• $\Delta f2_{max}$ (at 99.9%)	370			kHz
• $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8			
Carrier frequency offset and drift				
• Frequency offset (fn); n=0,1,2,3…k	-150		150	kHz
• Frequency drift ($\|f_0-f_n\|$); n=2,3,4…k			50	kHz
• Drift rate				

Items	Contents			
• |f1-f0|			23	kHz
• |fn-fn-5|; n=6,7,8,…k			20	kHz
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Receiver sensitivity (PER < 30.8%)		-97	-70	dBm
Maximum input signal level (PER < 30.8%)	-10			dBm
PER Report Integrity (-30 dBm input)	50		65.4	%

13 Land Patterns

Figure 21 shows the land patterns.

Figure 21: Land Patterns



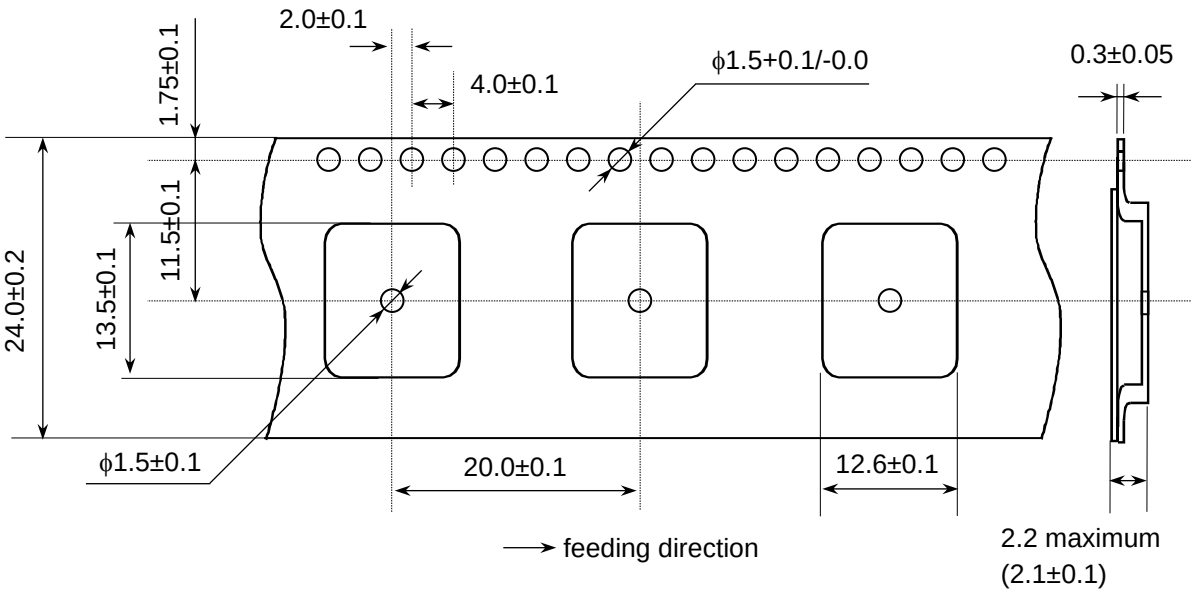
To avoid the short-circuit between the side shielding and solder on the module land after the reflow, please place the module land at 0.2 mm away from module outline, as shown in above figure.

14 Tape and Reel Packing

14.1 Dimensions of Tape (Plastic Tape)

Figure 22 is a graphical representation of the tape dimension (plastic tape)[13].

Figure 22: Dimensions of Tape (Unit: mm)

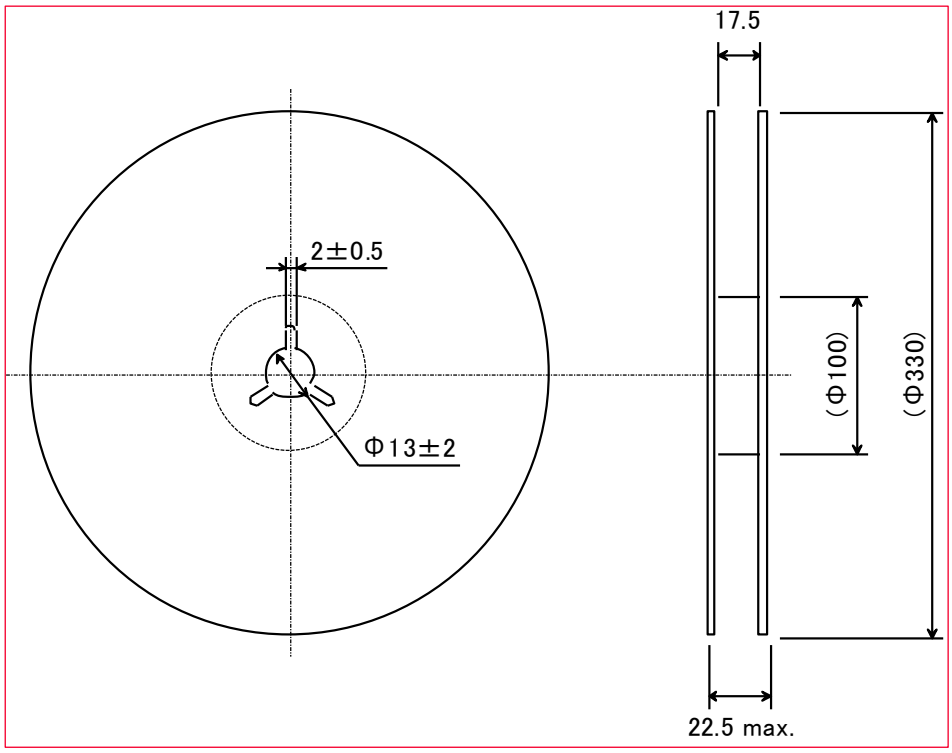


[13] Cumulative tolerance of maximum 40.0 ± 0.15 mm every 10 pitches

14.2 Dimensions of Reel

Figure 23 shows the reel dimensions.

Figure 23: Dimension of Reel (Unit: mm)



14.3 Taping Diagrams

Figure 24 shows the taping diagrams.

Figure 24: Taping Diagrams

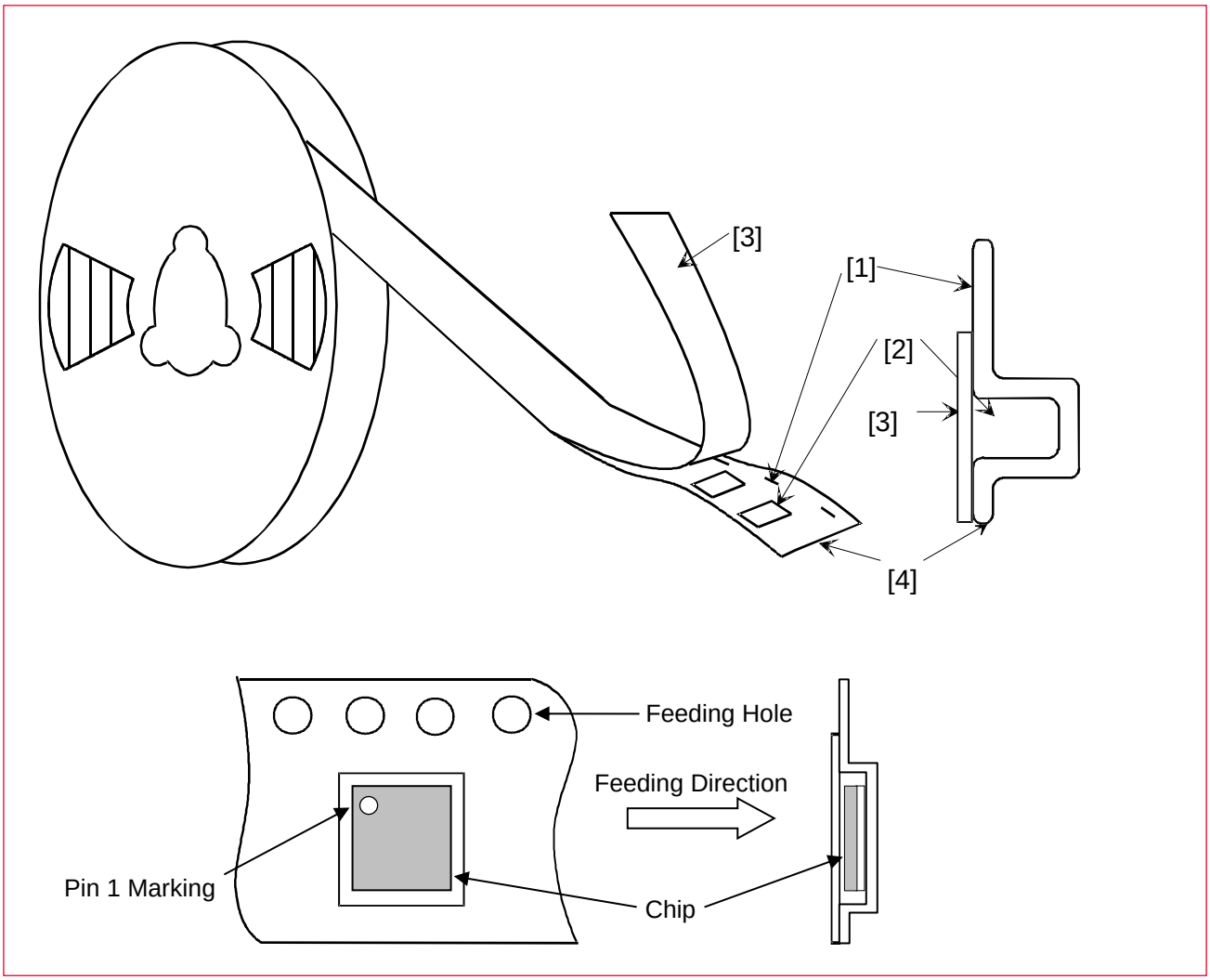


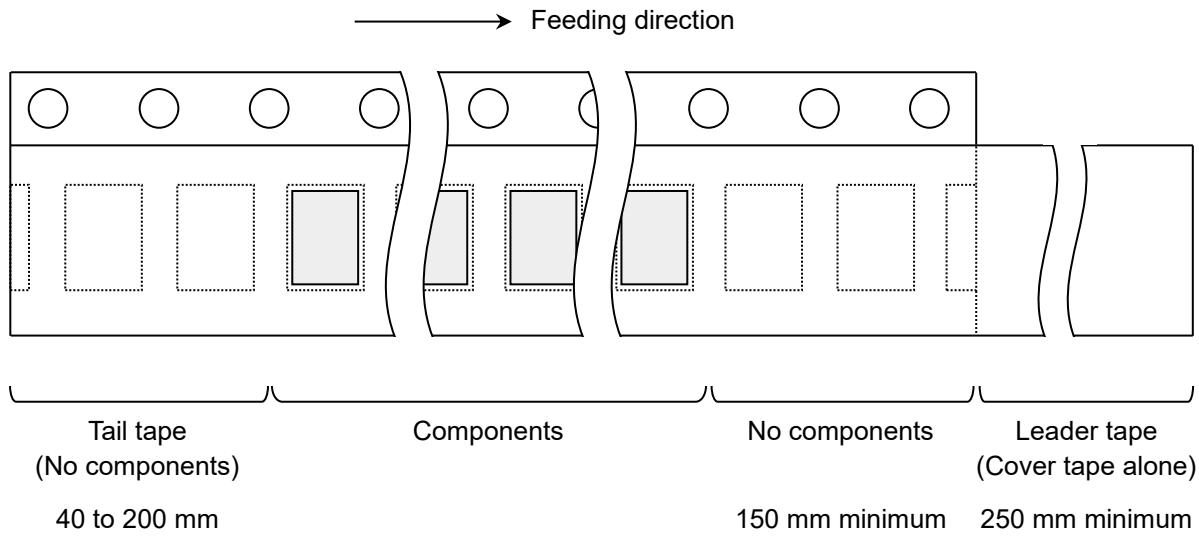
Table 59: Taping Specifications

Mark	Description
1	Feeding Hole. As specified in Dimensions of Tape (Plastic tape).
2	Hole for chip. As specified in Dimensions of Tape (Plastic tape).
3	Cover tape. 62 µm in thickness.
4	Base tape. As specified in Dimensions of Tape (Plastic tape).

14.4 Leader and Tail Tape

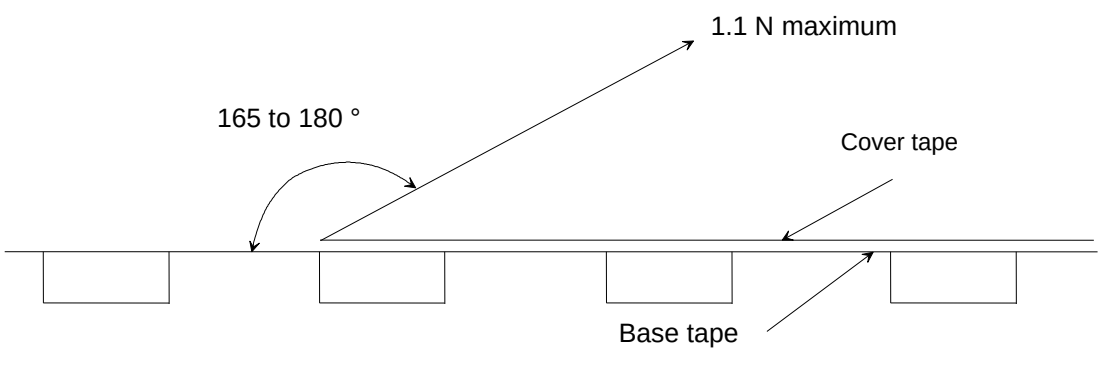
The leader and tail tape are shown in **Figure 25**.

Figure 25: Leader and Tail Tape



1. The tape for chips is wound clockwise, the feeding holes to the right side as the tape is pulled toward the user.
2. The cover tape and base tape are not adhered at no components area for 250 mm minimum.
3. Tear off strength against pulling of cover tape: 5 N minimum.
4. Packaging unit: 1000 pcs. / Reel
5. Material
   - Base tape: Plastic
   - Real: Plastic
   - Cover tape, cavity tape and reel are made the anti-static processing.
6. Peeling off force: 1.1 N maximum in the direction of peeling as shown in **Figure 26**.

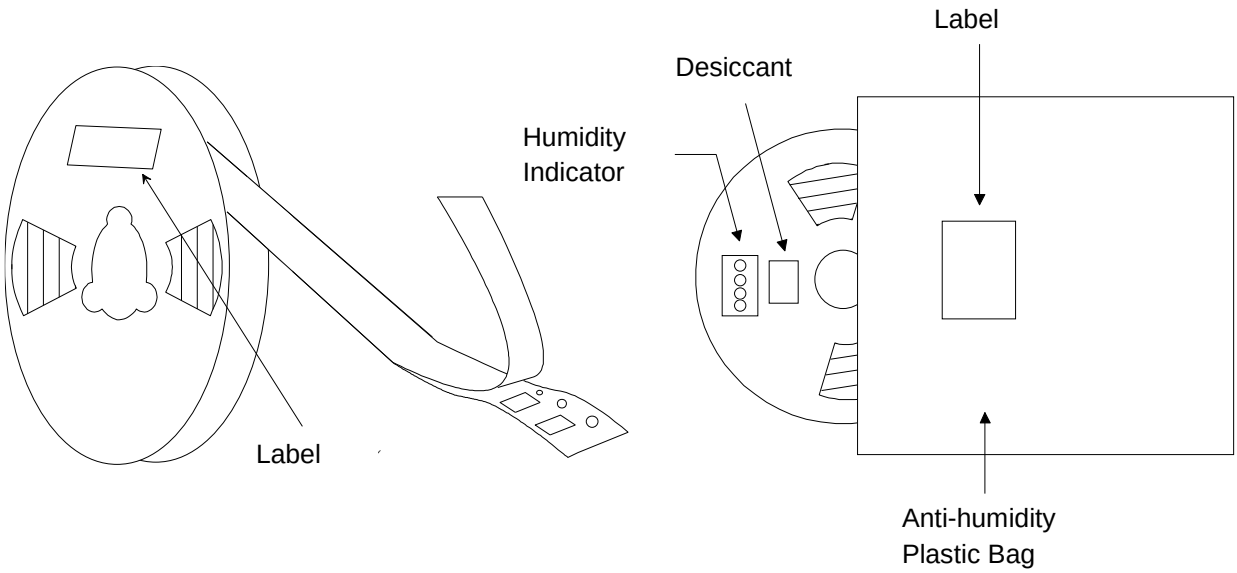
Figure 26: Peeling Off Force



14.5 Packaging (Humidity Proof Packing)

Figure 27 shows the humidity proof packaging.

Figure 27: Humidity Proof Packaging



Tape and reel must be sealed with the anti-humidity plastic bag. The bag contains the desiccant and the humidity indicator.

15 Notice

15.1 Storage Conditions

- Please use this product within 6 months after receipt.
  - The product shall be stored without opening the packing under the ambient temperature from 5 to 35 °C and humidity from 20 ~ 70 %RH (Packing materials, in particular, may be deformed at the temperature over 40 °C).
  - The product left more than 6 months after reception; it needs to be confirmed the solderability before used.
  - The product shall be stored in noncorrosive gas (Cl_2, NH_3, SO_2, NO_X, etc.).
  - Any excess mechanical shock including, but not limited to, sticking the packing materials by sharp object and dropping the product, shall not be applied in order not to damage the packing materials.
- This product is applicable to MSL3 (Based on IPC/JEDEC J-STD-020)
  - After the packing opened, the product shall be stored at <30 °C / <60 %RH and the product shall be used within 168 hours.
  - When the color of the indicator in the packing changed, the product shall be baked before soldering.
- Baking condition: 125 +5/-0 °C, 24 hours, 1 time
- The products shall be baked on the heat-resistant tray because the material (Base Tape, Reel Tape and Cover Tape) is not heat-resistant.

15.2 Handling Conditions

- Be careful in handling or transporting products because excessive stress or mechanical shock may break products.
- Handle with care if products may have cracks or damages on their terminals. If there is any such damage, the characteristics of products may change. Do not touch products with bare hands that may result in poor solder ability and destroy by static electrical charge.

15.3 Standard PCB Design (Land Pattern and Dimensions)

- All the ground terminals should be connected to the ground patterns. Furthermore, the ground pattern should be provided between IN and OUT terminals. Please refer to the specifications for the standard land dimensions.
- The recommended land pattern and dimensions is as Murata's standard. The characteristics of products may vary depending on the pattern drawing method, grounding method, land dimensions, land forming method of the NC terminals and the PCB material and thickness. Therefore, be sure to verify the characteristics in the actual set. When using non-standard lands, contact Murata beforehand.

15.4 Notice for Chip Placer

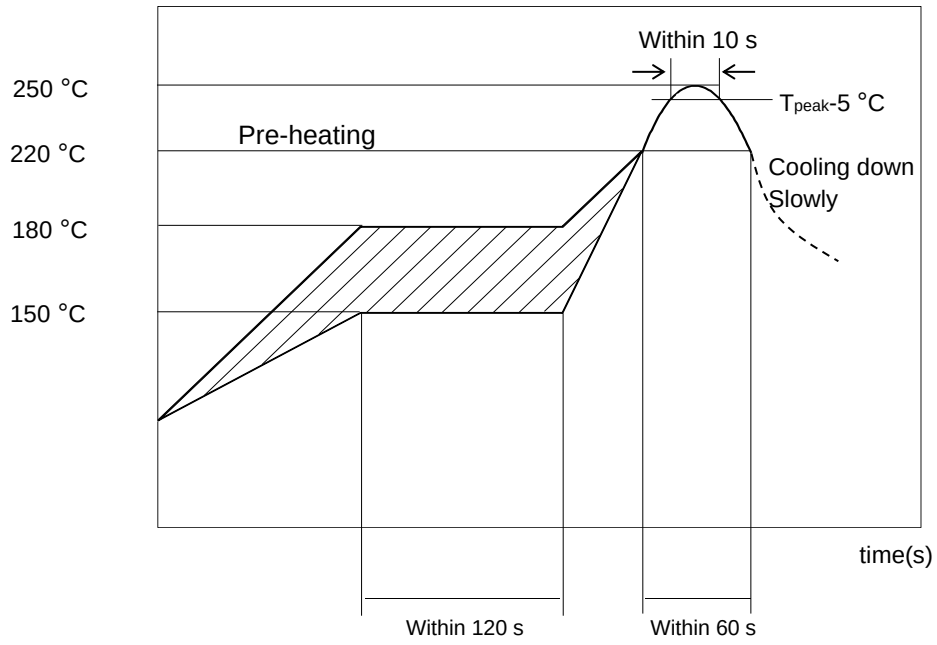
When placing products on the PCB, products may be stressed and broken by uneven forces from a worn-out chucking locating claw or a suction nozzle. To prevent products from damages, be sure to follow the specifications for the maintenance of the chip placer being used. For the positioning of products on the PCB, be aware that mechanical chucking may damage products.

15.5 Soldering Conditions

The recommendation conditions of soldering are shown in **Figure 28**.

Soldering must be carried out by the above-mentioned conditions to prevent products from damage. Set up the highest temperature of reflow within 260 °C. Contact Murata before use if concerning other soldering conditions.

Figure 28: Reflow soldering standard conditions (Example)



Please use the reflow within 2 times.

Use rosin type flux or weakly active flux with a chlorine content of 0.2 wt. % or less.

15.6 Cleaning

This Product is Moisture Sensitive; therefore, any cleaning is not recommended. If any cleaning process is done the customer is responsible for any issues or failures caused by the cleaning process.

15.7 Operational Environment Conditions

Products are designed to work for electronic products under normal environmental conditions (ambient temperature, humidity, and pressure). Therefore, products have no problems to be used under the similar conditions to the above-mentioned. However, if products are used under the following circumstances, it may damage products and leakage of electricity and abnormal temperature may occur.

- In an atmosphere containing corrosive gas (Cl_2, NH_3, SO_X, NO_X etc.).
- In an atmosphere containing combustible and volatile gases.
- Dusty place.
- Direct sunlight place.
- Water splashing place.
- Humid place where water condenses.
- Freezing place.

If there are possibilities for products to be used under the preceding clause, consult with Murata before actual use.

Do not apply static electricity or excessive voltage while assembling and measuring, as it might be a cause of degradation or destruction to apply static electricity to products.

16 Preconditions to Use Our Products

PLEASE READ THIS NOTICE BEFORE USING OUR PRODUCTS.

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All the items and parameters in this product specification/datasheet/catalog have been prescribed on the premise that our product is used for the purpose, under the condition and in the environment specified in this specification. You are requested not to use our product deviating from the condition and the environment specified in this specification.

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- Traffic signal equipment.

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- Transportation equipment (vehicles, trains, ships, elevator, etc.).
- Application of similar complexity and/ or reliability requirements to the applications listed in the above.
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Even in the unlikely event that an abnormality or malfunction occurs in this product under operating conditions that conform to the specifications, be sure to add an appropriate fail-safe function to the system to prevent secondary accidents.

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Revision History

Revision Code	Date	Changed Item	Comments
1	2019.10.25	First Issue	
2 (A)	2019.12.17	1. Scope 4. DIMENSIONS, MARKING AND TERMINAL CONFIGURATIONS 6.3 POWER ON SEQUENCE 11. LAND PATTERNS 12. REFERENCE CIRCUIT	• Added UART for Bluetooth • Updated • Updated • Updated • Added
3 (B)	2020.06.29	4. Added solder bumps 9. DC/RF Characteristics 12. Reference circuit	• Updated height to 1.30 mm and updated the figure of structure. • Correct typo of configuration pins • Added typical Target Power (TBD) • Updated schematic and correct typo
4 (C)	2020.08.07	9.10., 9.11. DC/RF Characteristics for Bluetooth / (LE)	• Defined Output power
5 (D)	2020.08.24	1. Scope 4. DIMENSIONS, MARKING AND TERMINAL CONFIGURATIONS	• Removed “Default” comment on SDIO of BT/BLE Host interface. • Updated Terminal configuration
6 (E)	2020.11.06	Updated to new format 5. CERTIFICATION CONDITIONS 6. DIMENSIONS, MARKING AND TERMINAL CONFIGURATIONS 8. Rating 9.1 Operating conditions 11.3 Bluetooth PCM Timing 14. REFERENCE CIRCUIT Appendix	• Added • Updated marking information. • Updated values. • Added Peak current • Update values. • Corrected typo of signal name “CONFIG_AUTO_REF_DET” • Defined Reference for U.FL/MHF and Reference for Trace Antenna • Added User manual and Antenna Installation Guide
7 (F)	2020.12.01	11.1.2 High Speed Mode 11.1.3 SDR12,25,50 Modes 11.2. High-Speed UART Specifications 11.3 Bluetooth PCM Timing 5.1 Radio Certification (Base IC datasheet revision: E)	• Corrected the diagram • Corrected the diagram • Updated • Updated • MIC Certification number is changed from “001-P01561” to “001-P01598”
8 (G)	2021.01.07	9.1 Operating conditions 5.1 Radio Certification 5.3 Bluetooth Qualification 12. DC / RF Characteristics Appendix	• Updated operating temperature from 75 to 85. • Added Tx Power limit file for each region • Added Bluetooth Power class setting file • Updated file names • Added configuration manual
9 (H)	2021.03.04	11.2 High-speed UART specifications Appendix - Trace Antenna Installation	• Added default baud rate information. • Added “F” values.

Revision Code	Date	Changed Item	Comments
10 (I)	2021.04.01	2. Key feature & 5.2 Bluetooth Qualification 7.2 Pin Descriptions 14. Reference circuit	• Added a comment on supported Bluetooth functions • Updated the description of PMIC_EN. • Added values of matching components
11 (J)	2021.04.26	7.2 Pin descriptions 7.3 Configuration pins 7.4 Pin States 10. Power Sequence	• Added comment to AVDD18 pin • Added comment on pull-up • Changed DVDD18 to AVDD18. Added Internal pull values • Separated Power ON Sequence and Power OFF Sequence
12 (K)	2021.12.14	7.4 Pin States 9.1 Operating Conditions 9.2 External Sleep Clock Requirements 10. Power Sequence	• Added SLP_CLK_IN • Defined IO current and Peak current • Added a comment • Defined timing parameters
13 (L)	2022.04.05	4. Block Diagram 11.1.1 Default Speed Mode 11.1.2 High Speed Mode 11.1.3 SDR12, SDR25, SDR50 Modes (up to 100 MHz) 11.1.4 SDR104 Mode (208 MHz) 11.1.5 DDR50 Mode (50 MHz)	• Revise the block diagram • Change the format of table. • Change the format of table. • Change the format of table. • Change the format of table. • Change the format of table.
14 (M)	2022.06.09	Appendix	• Translated Japanese to English.
15 (N)	2022.07.29	9.4 Package Thermal Conditions	• Added Package Thermal Conditions
16 (O)	2022.10.31	2. Key Features 3. Ordering Information 14. Reference Circuit Appendix	• Updated information • Added Embedded Artists' M.2 module information. • Moved section to HW app note. • Moved Appendix information into Sections 14 and 15. • Moved antenna sections to HW app note. • Added power table for Europe region. • Added Europe section from HW app note. Updated to new format
17 (P)	2023.01.13	7.4. Pin States 15. Radio Regulatory Certification by Country for LBEE5QD1ZM	• Added comments on termination of open pins. • Update Europe
18 (Q)	2023.03.10	7.2 Pin description	• Add comment into Pin 42:PMIC_EN
19 (R)	2023.03.24	9.3 PMIC_EN I/O Requirement	• Add sec9.3: PMIC_EN I/O Requirement, and Table14: PMIC_EN I/O Requirements
20 (S)	2024.07.12	5.1 Radio Certification 14 General for Radio Regulatory Certification for LBEE5QD1ZM and 15. Radio Regulatory Certification by Country for LBEE5QD1ZM	• Added NCC (TW) certification • Removed Radio Regulatory Certification information. Split this section to Radio Certification Application Note. Changed Section number of Notice and Preconditions to Use Our Products.

Revision Code	Date	Changed Item	Comments
21	2025.02.14	Revision History 6. Dimensions, Markings... 12. RF/DC Characteristics… 16. Preconditions to Use…	• Changed Revision rule • Added a structure figure and warning message • Corrected typo of spectrum mask • Removed stable modulation spec • Updated