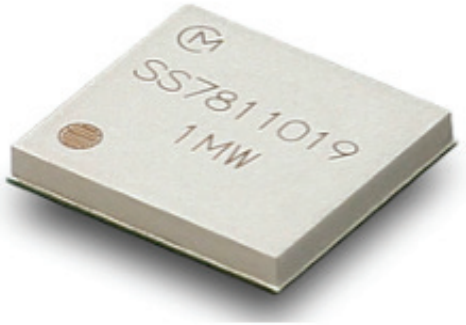
Datasheet

Type 1MW Wi-Fi® + Bluetooth® Module

Infineon CYW43455 Chipset for 802.11a/b/g/n/ac + Bluetooth 5.0 Datasheet - Rev. R

- Design Name: Type 1MW
- Module P/N: LBEE5HY1MW



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About This Document

Type 1MW is a small and high-performance module based on Infineon CYW43455 combo chipset which supports Wi-Fi 802.11b/g/n + Bluetooth 5.0 BR/EDR/LE. This datasheet describes Type 1MW 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; specifically 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 WLAN + Bluetooth 5.0 combo module.

2 Key Features

- Infineon CYW43455 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 5.0
- For supported Bluetooth functions, refer Bluetooth SIG site
- WLAN Interface: SDIO 3.0
- Bluetooth interface: HCI UART and PCM
- Temperature range: -30 °C to 85 °C
- Dimensions: 7.9 x 7.3 x 1.1 mm
- SAW filter inside
- Weight: 0.15 g
- MSL: 3
- Surface mount type
- RoHS compliant
- Reference Clock: Embedded

3 Ordering Information

Table 2 describes the ordering information.

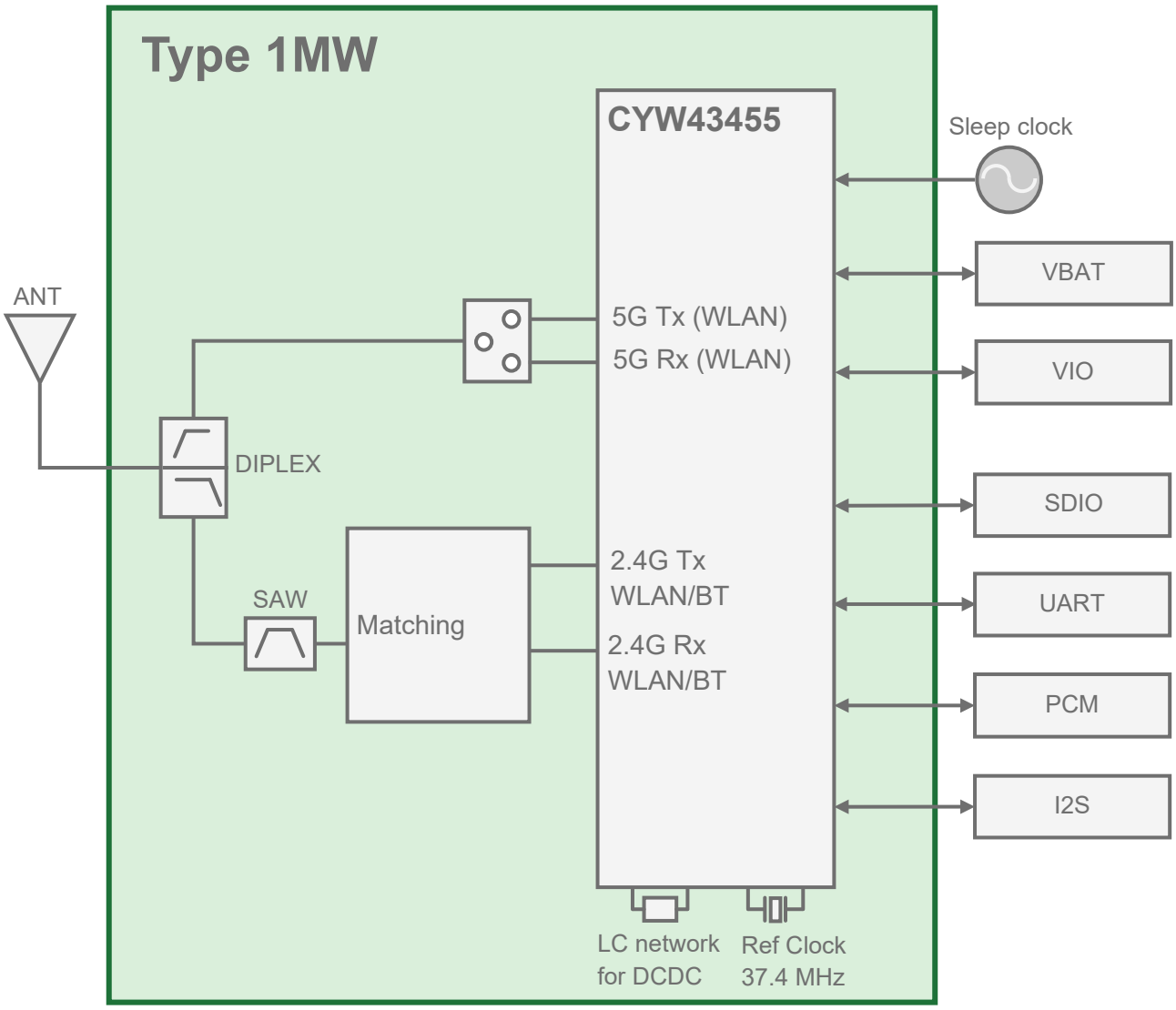
Table 2: Ordering Information

Ordering Part Number	Description
LBEE5HY1MW-230	Module order
LBEE5HY1MW-TEMP	Sample module order (If module samples are not available through distribution, contact Murata referencing this part number)
EAR00315	Embedded Artists Type 1MW M.2 EVB (default EVB available through distribution)
LBEE5HY1MW-TEMP-D	Murata Type 1MW EVK (contact Murata as this is special order item)

4 Block Diagram

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

Figure 1: Block Diagram



5 Certification Information

This section lists the certification information.

5.1 Radio Certification

Table 3 lists the radio certification information.

Table 3: Radio Certification

Country	ID	Country Code
USA (FCC)	VPYLBEE5HY1MW	US/0
Canada (IC)	772C-LBEE5HY1MW	CA/0
Europe	EN300328/301893 v2.1.1, EN300440 v2.2.0 conducted test report is prepared.	DE/0
Japan	R 001-P01220 (Japanese type certification is prepared.)	JP/0

Please follow installation/user manual in Section 15.

Each country code is defined by Murata Blob file. Please ask your contact person from Murata for details.

5.2 Bluetooth Qualification

- QDID: 118271
- For supported Bluetooth functions, refer to Bluetooth SIG site

6 Absolute Maximum Ratings

The minimum and maximum ratings are shown in **Table 4.**

Table 4: Ratings

Parameter		Minimum	Maximum	Unit
Storage Temperature		-40	85	°C
Supply Voltage	VBAT	0	5.0	V
	VIO	0	3.9	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.

7 Operating Conditions

This section describes the operating conditions and external sleep clock requirements.

7.1 Operating Conditions

The operating conditions are shown **Table 5**.

Table 5: Operating Conditions

Parameter		Minimum	Typical	Maximum	Unit
Operating Temperature Range[1]		-30	25	+85	°C
Supply Voltage	VBAT	3.2		4.2	V
	VIO 1.8V/3.3V	1.62		3.63	V

7.2 External Sleep Clock Requirements

The external LPO signal requirements are shown in **Table 6.**

Table 6: External LPO Signal Requirements

Parameter	External LPO Clock	Unit
Nominal Input Frequency	32.768	kHz
Frequency Accuracy	+/-200	ppm
Duty Cycle	30-70	%
Input Signal Amplitude	200 - 3300	mVp-p
Signal Type	Square-wave or sinewave	
Input Impedance[2]	> 100k < 5	Ω pF
Clock Jitter (during initial start-up)	<10,000	ppm

[1] Functionality is guaranteed but specifications require derating at extreme temperatures.
[2] When power is applied or switch off.

8 Dimensions, Markings and Terminal Configurations

This section has information on dimensions, markings, and terminal configurations for Type 1MW.

Figure 2 shows the dimensions, markings, and terminal configurations.

Figure 2: Dimensions, Markings and Terminal Configurations

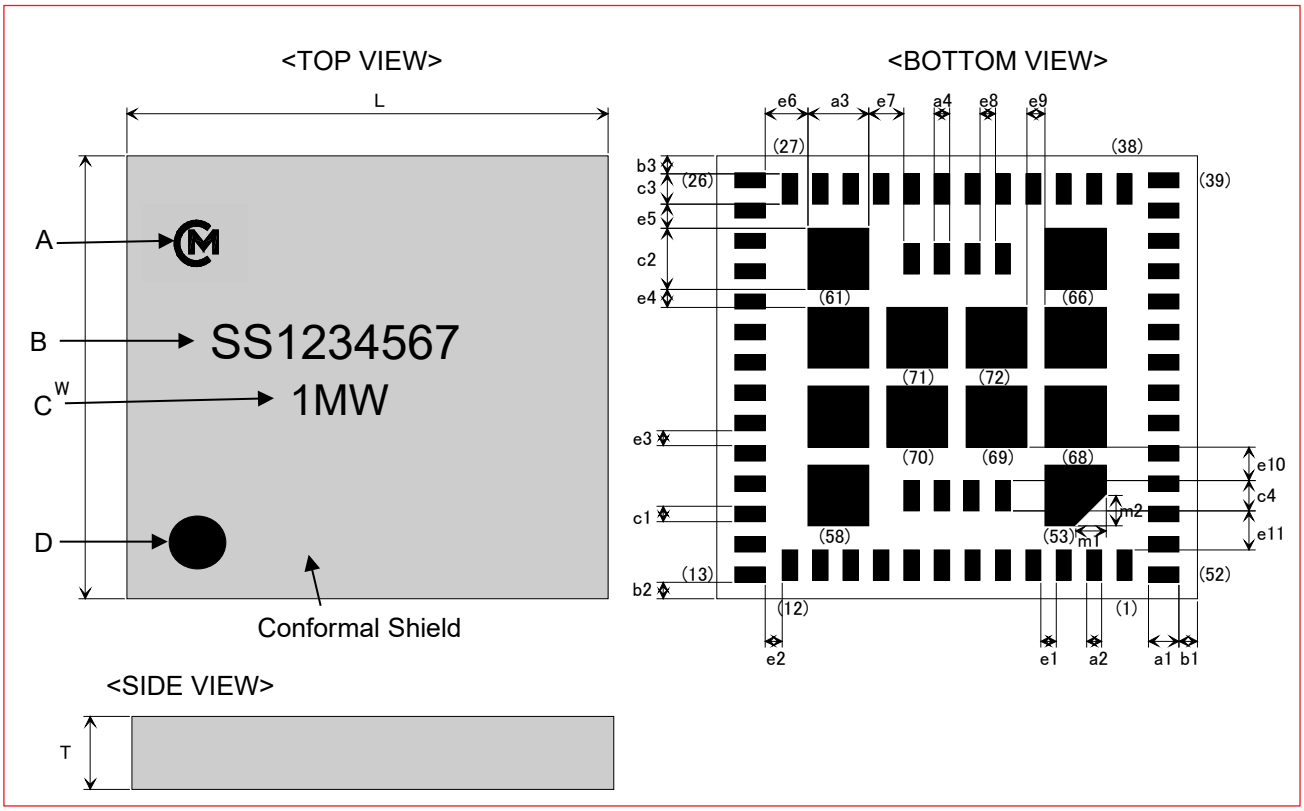


Table 7 shows the markings.

Table 7: Markings

Marking	Meaning
A	Murata Logo
B	Inspection Number
C	Module Type
D	Pin 1 Marking

Table 8 describes the dimensions of the markings.

Table 8: Dimensions

Mark	Dimensions (mm)	Mark	Dimensions (mm)	Mark	Dimensions (mm)
L	7.9 +/- 0.1	W	7.3 +/- 0.1	T	1.1 maximum
a1	0.5 +/- 0.1	a2	0.25 +/- 0.1	a3	1.0 +/- 0.1
a4	0.25 +/- 0.1	b1	0.3 +/- 0.1	b2	0.275 +/- 0.1
b3	0.3 +/- 0.1	c1	0.25 +/- 0.1	c2	1.0 +/- 0.1
c3	0.5 +/- 0.1	c4	0.5 +/- 0.1	e1	0.25 +/- 0.1
e2	0.275 +/- 0.1	e3	0.25 +/- 0.1	e4	0.3 +/- 0.1

Mark	Dimensions (mm)	Mark	Dimensions (mm)	Mark	Dimensions (mm)
e5	0.4 +/- 0.1	e6	0.7 +/- 0.1	e7	0.575 +/- 0.1
e8	0.25 +/- 0.1	e9	0.3 +/- 0.1	e10	0.55 +/- 0.1
e11	0.65 +/- 0.1	m1	0.5 +/- 0.1	m2	0.5 +/- 0.1

9 Module Pin Descriptions

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

9.1 Pin Assignments

The pin assignment (top view) layout is shown in **Figure 3**.

Figure 3: Pin Assignments Top View

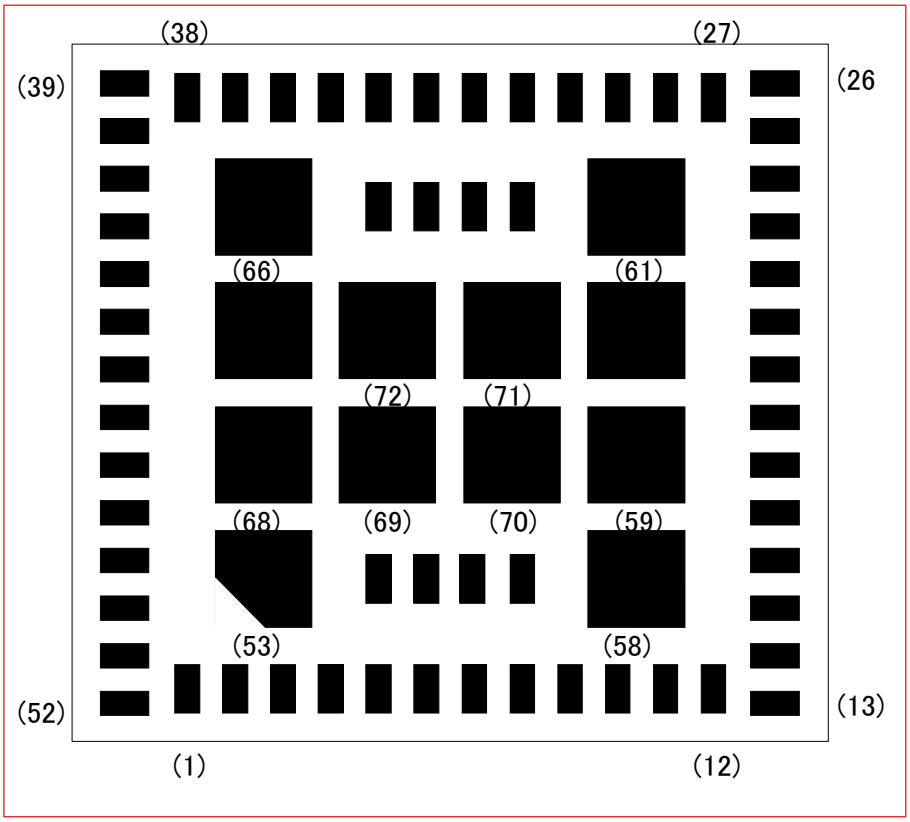


Table 9 illustrates the terminal configurations for Type 1MW.

Table 9: Terminal Configurations

No.	Terminal Name	No.	Terminal Name	No.	Terminal Name	No.	Terminal Name
1	GPIO_6	19	GND	37	I2S_CLK	55	GND
2	GPIO_0	20	SDIO_CLK	38	I2S_WS	56	GND
3	GPIO_3	21	GND	39	GND	57	JTAG_SEL
4	GPIO_5	22	VBAT_LDO	40	BT_DEV_WAKE	58	GND
5	GPIO_1	23	VBAT_SR	41	BT_HOST_WAKE	59	GND
6	GPIO_4	24	SR_PVSS	42	I2S_DI	60	GND
7	GPIO_2	25	VIN_LDO	43	NC	61	GND
8	BT_REG_ON	26	SR_PVSS	44	GND	62	BT_GPIO_4
9	WL_REG_ON	27	SR_PVSS	45	BT_UART_RXD	63	BT_GPIO_3
10	GND	28	SR_VLX	46	BT_UART_TXD	64	BT_GPIO_2
11	VIO	29	GND	47	BT_UART_RTS_N	65	BT_GPIO_5
12	GND	30	LPO_IN	48	BT_UART_CTS_N	66	GND
13	GND	31	GPIO_7	49	GND	67	GND
14	SDIO_DATA0	32	BT_PCM_IN	50	ANT	68	GND
15	SDIO_CMD	33	BT_PCM_SYNC	51	GND	69	GND
16	SDIO_DATA1	34	BT_PCM_OUT	52	GND	70	GND
17	SDIO_DATA2	35	BT_PCM_CLK	53	GND	71	GND
18	SDIO_DATA3	36	I2S_DO	54	NC	72	GND

9.2 Pin Descriptions

Table 10 describes Type 1MW Pins.

Table 10: Pin Descriptions

No.	Pin name	Type	System	Connection to IC Pin Name	Description
1	GPIO_6	I/O	WL	GPIO_6	Programmable GPIO Pin
2	GPIO_0	I/O	WL	GPIO_0	Programmable GPIO Pin
3	GPIO_3	I/O	WL	GPIO_3	Programmable GPIO Pin
4	GPIO_5	I/O	WL	GPIO_5	Programmable GPIO Pin
5	GPIO_1	I/O	WL	GPIO_1	Programmable GPIO Pin
6	GPIO_4	I/O	WL	GPIO_4	Programmable GPIO Pin
7	GPIO_2	I/O	WL	GPIO_2	Programmable GPIO Pin
8	BT_REG_ON	I	BT	BT_REG_ON	Used by PMU to power up or power down the internal CYW43455 regulators used by the BT section. Also, when de-asserted, this pin holds the BT section in reset. This pin has an internal 200k ohm pull-down resistor that is enabled by default. It can be disabled through programming.
9	WL_REG_ON	I	WL	WL_REG_ON	Used by PMU to power up or power down the internal CYW43455 regulators used by the WLAN section. Also, when de-asserted, this pin holds the WLAN section in reset. This pin has an internal 200k ohm pull-down resistor that is enabled by default. It can be disabled through programming.
10	GND				

No.	Pin name	Type	System	Connection to IC Pin Name	Description
11	VIO	I		VDDIO, VDDIO_SD, BT_VDDO	Supply for PMU, BT, WLAN, SDIO.
12	GND				
13	GND				
14	SDIO_DATA0	I/O	WL	SDIO_DATA0	SDIO data line 0
15	SDIO_CMD	I/O	WL	SDIO_CMD	SDIO command line
16	SDIO_DATA1	I/O	WL	SDIO_DATA1	SDIO data line 1
17	SDIO_DATA2	I/O	WL	SDIO_DATA2	SDIO data line 2
18	SDIO_DATA3	I/O	WL	SDIO_DATA3	SDIO data line 3
19	GND				
20	SDIO_CLK	I	WL	SDIO_CLK	SDIO clock input
21	GND				
22	VBAT_LDO	I		LDO_VDDBAT5V	Power supply
23	VBAT_SR	I		SR_VDDBAT5V	Power supply
24	SR_PVSS				Connect to GND
25	VIN_LDO	I		LDO_VDD1P5	LDO Input
26 27	SR_PVSS				Connect to GND
28	SR_VLX	O		SR_VLX	CBuck switching regulator output.
29	GND				
30	LPO_IN	I		LPO_IN	External sleep-clock input (32.768 kHz)
31	GPIO_7	I/O	WL	GPIO_7	Strapping option for SDIO I/F voltage: • **1** = 1.8V (NC) • **0** = 3.3V (Pull down with 10k ohm resister)
32	BT_PCM_IN	I	BT	BT_PCM_IN	PCM data input or SLIMbus transport sensing.
33	BT_PCM_SYNC	I/O	BT	BT_PCM_SYNC	PCM sync; can be master(output) or slave(input), or SLIMbus data.
34	BT_PCM_OUT	O	BT	BT_PCM_OUT	PCM data output
35	BT_PCM_CLK	I/O	BT	BT_PCM_CLK	PCM or SLIMbus clock; can be master(output) or slave(input).
36	I2S_DO	I/O	BT	BT_I2S_DO	I2S data output
37	I2S_CLK	I/O	BT	BT_I2S_CLK	I2S clock, can be master (output) or slave (input).
38	I2S_WS	I/O	BT	BT_I2S_WS	I2S WS; can be master (output) or slave (input).
39	GND				
40	BT_DEV_WAKE	I	BT	BT_DEV_WAKE	Bluetooth DEV_WAKE
41	BT_HOST_WAKE	O	BT	BT_HOST_WAKE	Bluetooth HOST_WAKE
42	I2S_DI	I/O	BT	BT_I2S_DI	I2S data input
43	NC				
44	GND				
45	BT_UART_RXD	I	BT	BT_UART_RXD	UART serial input. Serial data input for the HCI UART interface.
46	BT_UART_TXD	O	BT	BT_UART_TXD	UART serial output. Serial data output for the HCI UART interface.
47	BT_UART_RTS_N	O	BT	BT_UART_RTS_N	UART request-to-send. Active - low request - to-send signal for the HCI UART interface.
48	BT_UART_CTS_N	I	BT	BT_UART_CTS_N	UART clear-to-send. Active - low clear - to - send signal for the HCI UART interface.
49	GND				
50	ANT	I/O			

No.	Pin name	Type	System	Connection to IC Pin Name	Description
51	GND				
52	GND				
53	GND				
54	NC				
55	GND				
56	GND				
57	JTAG_SEL	I/O		JTAG_SEL	JTAG select. This pin must be connected to ground if the JTAG/SWD interface is not used. It must be high to select SWD OR JTAG. When JTAG_SEL = 1: • GPIO_2 is TCK/SWCLK • GPIO_3 is TMS/SWDIO • GPIO_4 is TDIO • GPIO_5 is TDO • GPIO_6 is TRST_L
58	GND				
59	GND				
60	GND				
61	GND				
62	BT_GPIO_4	I/O	BT	BT_GPIO_4	Bluetooth general-purpose I/O.
63	BT_GPIO_3	I/O	BT	BT_GPIO_3	Bluetooth general-purpose I/O.
64	BT_GPIO_2	I/O	BT	BT_GPIO_2	Bluetooth general-purpose I/O.
65	BT_GPIO_5	I/O	BT	BT_GPIO_5	Bluetooth general-purpose I/O.
66-72	GND				

10 Power-On Sequence

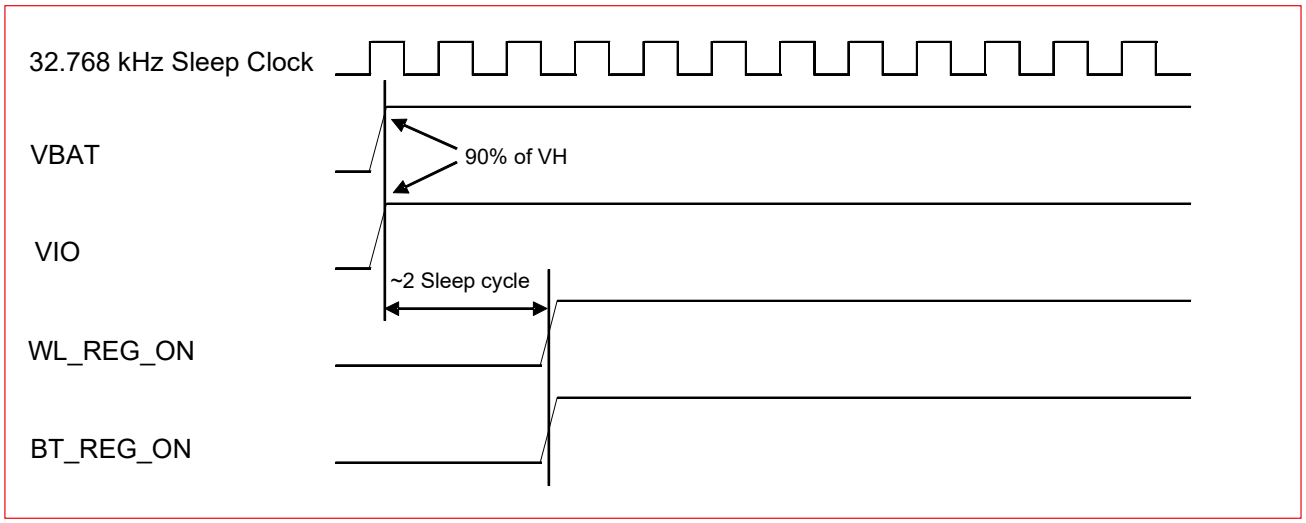
This section describes the power-on sequences along with their parameters.

- VBAT should not rise 10%-90% faster than 40 microsecond.
- VBAT should be up before or at the same time as VIO. VIO should not be present first or be held high before VBAT is high.

10.1 Power-On Sequence for WLAN ON and BT ON

Figure 4 shows the power-on sequence for WLAN on and BT on.

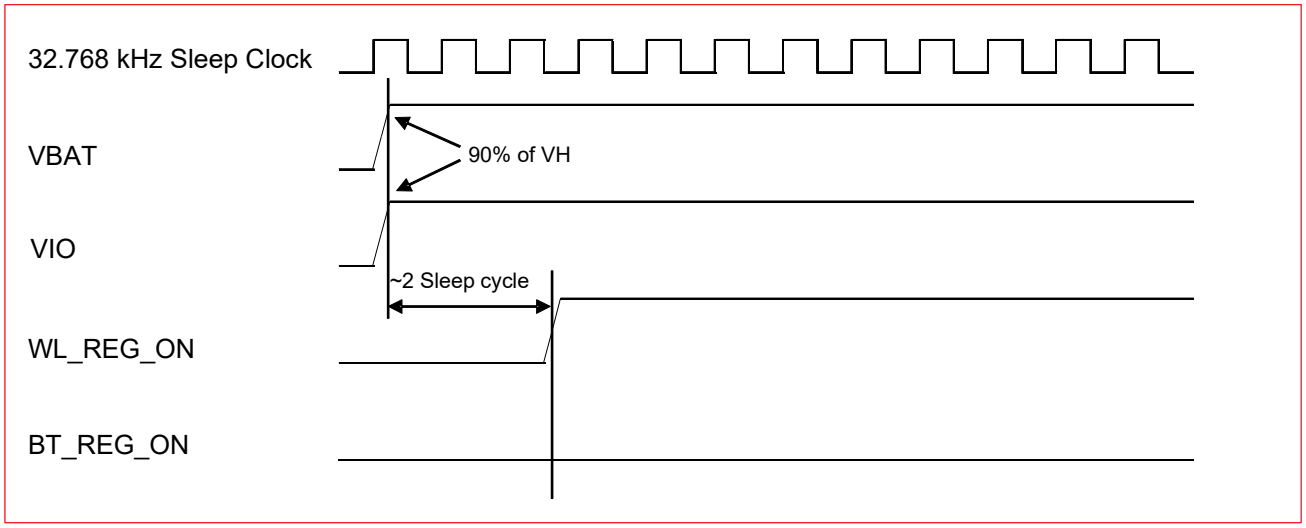
Figure 4: Power-On Sequence - WLAN ON and BT ON



10.2 Power-on Sequence for WLAN ON and BT OFF

Figure 5 shows power-on sequence for WLAN on and BT off.

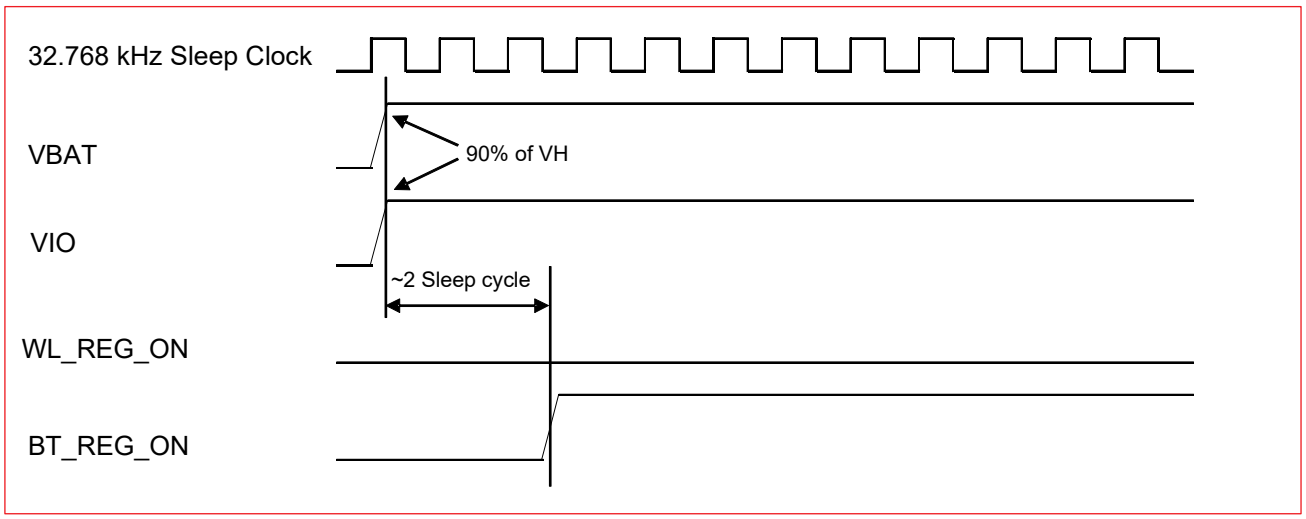
Figure 5: Power-On Sequence - WLAN ON and BT OFF



10.3 Power-On Sequence for WLAN OFF and BT ON

Figure 6 shows the power-on sequence for WLAN off and BT on.

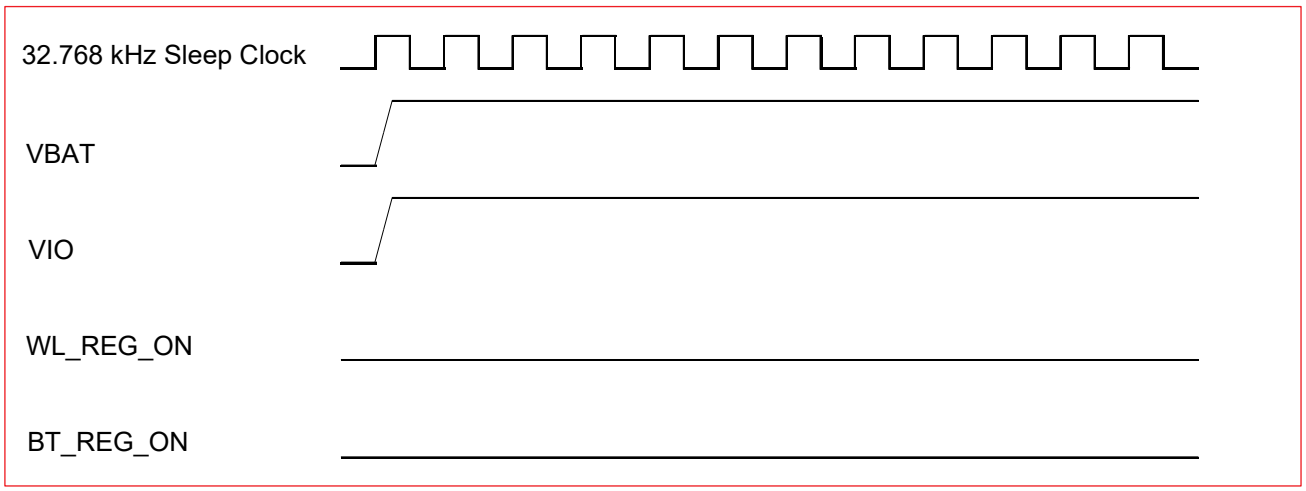
Figure 6: Power-On Sequence - WLAN OFF and BT ON



10.4 Power-On Sequence for WLAN OFF and BT OFF

Figure 7 shows the power on sequence for WLAN off and BT off.

Figure 7: Power-On Sequence - WLAN OFF and BT OFF



11 Digital I/O Requirements

Table 11 describes the digital input/output pins and related parameters.

Table 11: Digital I/O Pins

Digital I/O Pins	Symbol	Minimum	Typical	Maximum	Unit
For VIO = 1.8V					
• Input high voltage	V_{IH}	0.65xVIO			V
• Input low voltage	V_{IL}			0.35xVIO	V
• Output high voltage @ 2.0 mA	V_{OH}	VIO-0.45			V
• Output low voltage @ 2.0 mA	V_{OL}			0.45	V
For VDDIO = 3.3 V					
• Input high voltage	V_{IH}	2.00			V
• Input low voltage	V_{IL}			0.80	V
• Output high voltage @ 2.0 mA	V_{OH}	VIO-0.4			V
• Output low voltage @ 2.0 mA	V_{OL}			0.40	V

12 Interface Timing and AC Characteristics

This section describes the interface timing and AC Characteristics.

12.1 Bluetooth UART Timing

Figure 8 shows Bluetooth UART timing sequence.

Figure 8: Bluetooth UART Timing Sequence

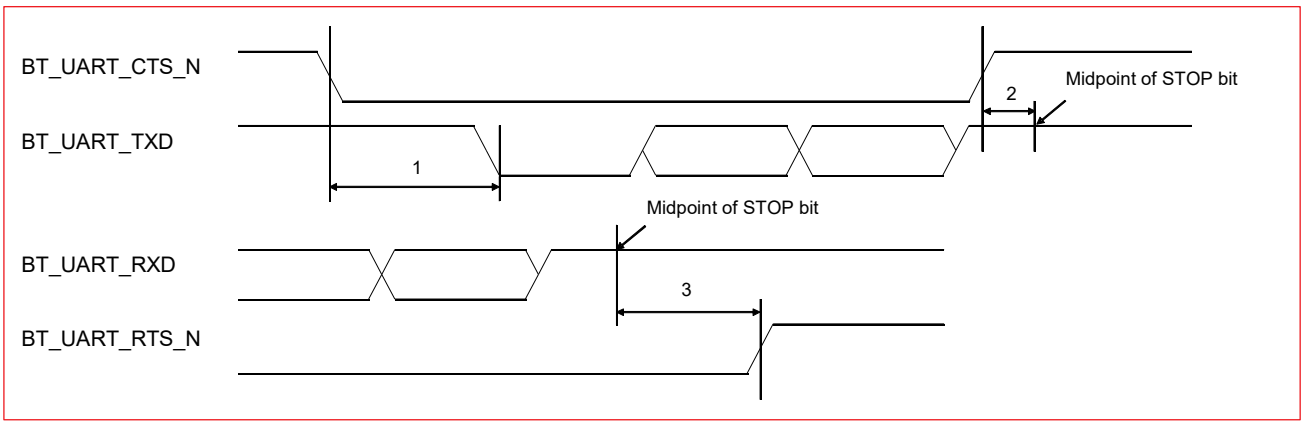


Table 12 describes the Bluetooth interface timing parameters.

Table 12: Bluetooth Interface Timing Parameters

Reference	Description	Minimum	Typical	Maximum	Unit
1	Delay time, BT_UART_CTS_N low to BT_UART_TXD valid			1.5	Bit periods
2	Setup time, BT_UART_CTS_N high before midpoint of stop bit			0.5	Bit periods
3	Delay time, midpoint of stop bit to BT_UART_RTS_N high.			0.5	Bit periods

12.2 Bluetooth PCM Interface Timing

This section describes the Bluetooth PCM interface timings for long frame, and short frame modes data signals and their parameters.

12.2.1 Short Frame Sync (Master Mode)

Figure 9 shows short frame sync signal in master mode.

Figure 9: Short Frame Sync Signal - Master Mode

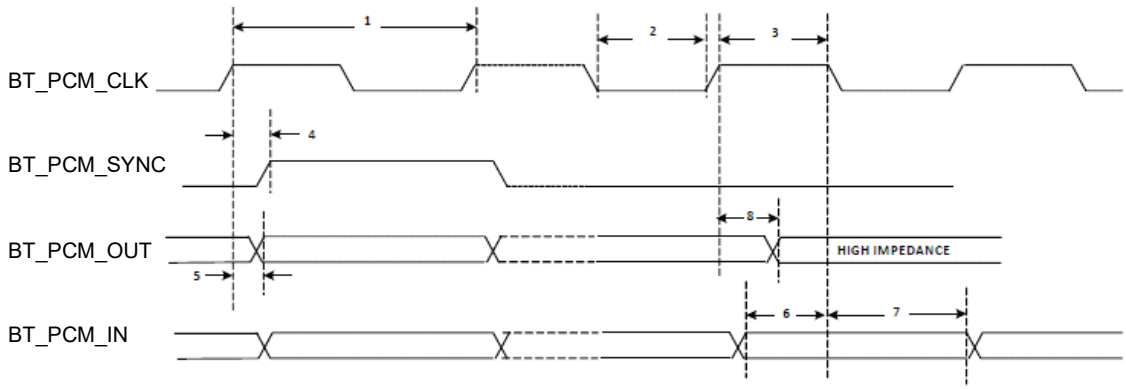


Table 13 describes short frame sync signal parameters in master mode.

Table 13: Short Frame Sync Signal Parameters - Master Mode

Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			12	MHz
2	PCM bit clock High	41			ns
3	PCM bit clock Low	41			ns
4	BT_PCM_SYNC delay	0		25	ns
5	BT_PCM_OUT delay	0		25	ns
6	BT_PCM_IN setup	8			ns
7	BT_PCM_IN hold	8			ns

Reference	Description	Minimum	Typical	Maximum	Unit
8	Delay from rising edge of BT_PCM_CLK during last bit period to BT_PCM_OUT becoming high impedance	0		25	ns

12.2.2 Short Frame Sync (Slave Mode)

Figure 10 shows the Bluetooth PCM short frame sync signal in slave mode.

Figure 10: Short Frame Sync Signal - Slave Mode

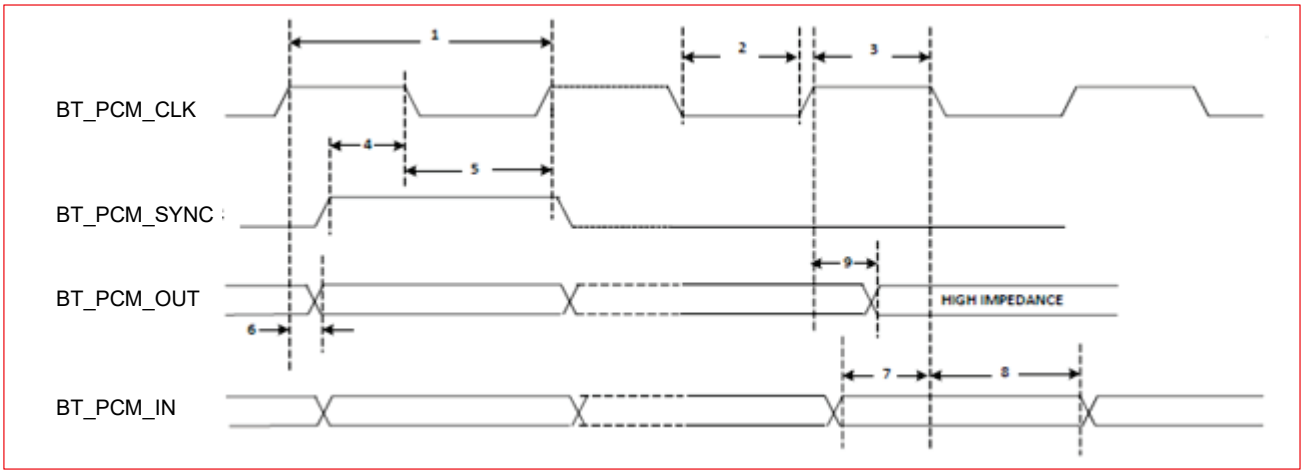


Table 14 describes the PCM short frame sync signal parameters in slave mode.

Table 14: Short Frame Sync Signal Parameters - Slave Mode

Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			12	MHz
2	PCM bit clock High	41			ns
3	PCM bit clock Low	41			ns
4	BT_PCM_SYNC setup	8			ns
5	BT_PCM_SYNC hold	8			ns
6	BT_PCM_OUT delay	0		25	ns
7	BT_PCM_IN setup	8			ns
8	BT_PCM_IN hold	8			ns
9	Delay from rising edge of BT_PCM_CLK during last bit period to BT_PCM_OUT becoming high impedance.	0		25	ns

12.2.3 Long Frame Sync (Master Mode)

Figure 11 shows long frame sync signal in master mode.

Figure 11: Long Frame Sync Signal - Master Mode

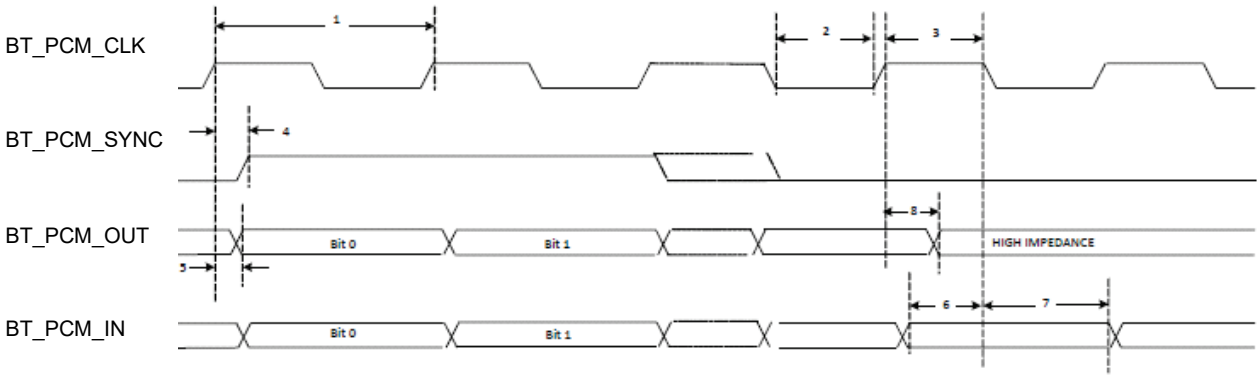


Table 15 describes long frame sync signal parameters in master mode.

Table 15: Long Frame Sync Signal Parameters - Master Mode

Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			12	MHz
2	PCM bit clock High	41			ns
3	PCM bit clock Low	41			ns
4	BT_PCM_SYNC delay	0		25	ns
5	BT_PCM_OUT delay	0		25	ns
6	BT_PCM_IN setup	8			ns
7	BT_PCM_IN hold	8			ns
8	Delay from rising edge of BT_PCM_CLK during last bit period to BT_PCM_OUT becoming high impedance.	0		25	ns

12.2.4 Long-Frame Sync (Slave Mode)

Figure 12 shows long frame sync signal in slave mode.

Figure 12: Long Frame Sync Signal - Slave Mode

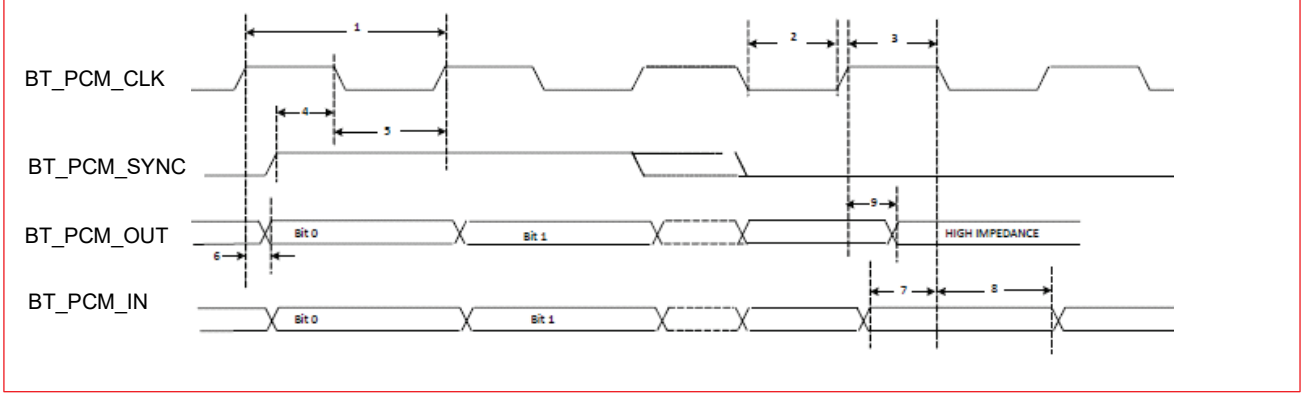


Table 16 describes long frame sync signal parameters in slave mode.

Table 16: Long Frame Sync Signal Parameters - Slave Mode

Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			12	MHz
2	PCM bit clock High	41			ns
3	PCM bit clock Low	41			ns
4	BT_PCM_SYNC setup	8			ns
5	BT_PCM_SYNC hold	8			ns
6	BT_PCM_OUT delay	0		25	ns
7	BT_PCM_IN setup	8			ns
8	BT_PCM_IN hold	8			ns
9	Delay from rising edge of BT_PCM_CLK during last bit period to BT_PCM_OUT becoming high impedance	0		25	ns

12.2.5 Short Frame Sync (Burst Mode)

Figure 13 shows short frame sync signal in burst mode.

Figure 13: Short Frame Sync Signal - Burst Mode

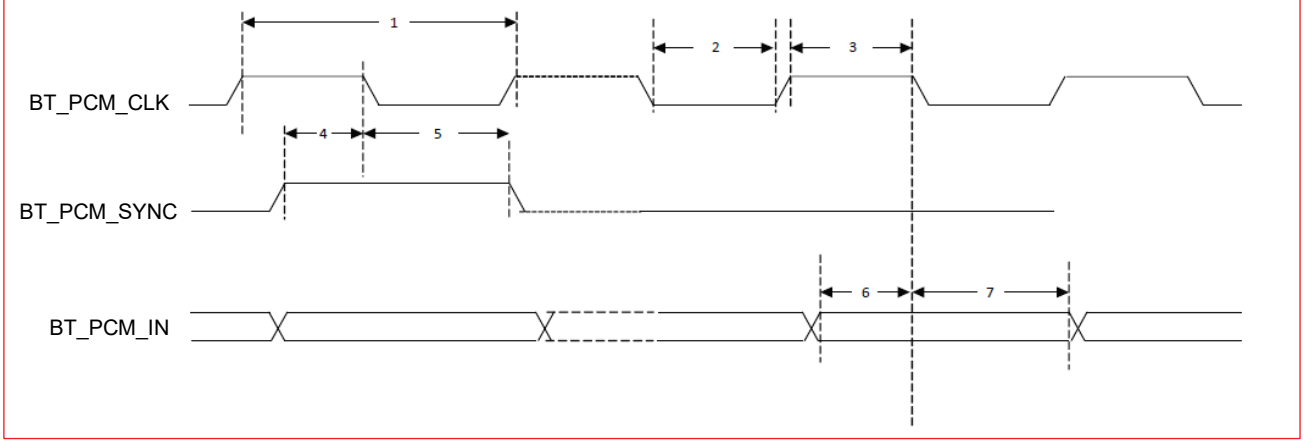


Table 17 describes short frame sync signal parameters in burst mode.

Table 17: Short Frame Sync Signal Parameters - Burst Mode

Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			24	MHz
2	PCM bit clock Low	20.8			ns
3	PCM bit clock High	20.8			ns
4	BT_PCM_SYNC setup	8			ns
5	BT_PCM_SYNC hold	8			ns
6	BT_PCM_IN setup	8			ns
7	BT_PCM_IN hold	8			ns

12.2.6 Long Frame Sync (Burst Mode)

Figure 14 shows the long frame sync signal in burst mode.

Figure 14: Long Frame Sync Signal - Burst Mode

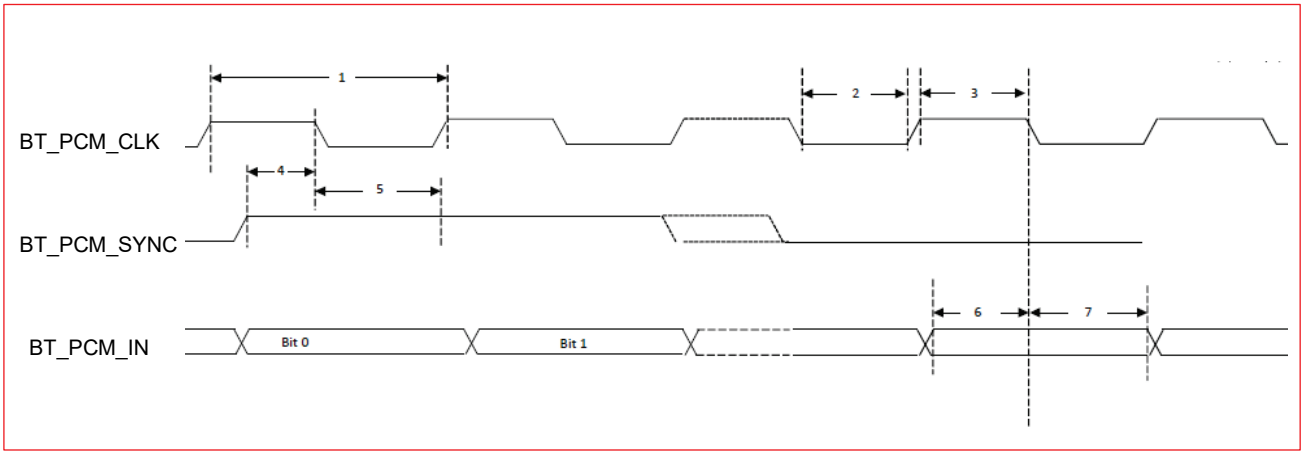


Table 18 describes long frame sync signal parameters in burst mode.

Table 18: Long Frame Sync Signal Parameters - Burst Mode

Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			24	MHz
2	PCM bit clock Low	20.8			ns
3	PCM bit clock High	20.8			ns
4	BT_PCM_SYNC setup	8			ns
5	BT_PCM_SYNC hold	8			ns
6	BT_PCM_IN setup	8			ns
7	BT_PCM_IN hold	8			ns

12.3 I²S Timing

Table 19 shows timing parameters for I²S transmitters and receivers along with their timing diagrams.

Table 19: I²S Transmitters and Receivers Timing Parameters

	Transmitter				Receiver				Notes
	Lower Limit		Upper Limit		Lower Limit		Upper Limit		
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
Clock Period T	T_{tr}				T_{tr}				a
Master Mode: Clock generated by transmitter or receiver									
HIGH t_{HC}	$0.35T_{tr}$				$0.35T_{tr}$				b
LOW t_{LC}	$0.35T_{tr}$				$0.35T_{tr}$				b
Slave Mode: Clock accepted by transmitter or receiver									
HIGH h_{TC}		$0.35T_{tr}$				$0.35T_{tr}$			c
LOW t_{LC}		$0.35T_{tr}$				$0.35T_{tr}$			c
Rise time t_{RC}			$0.15T_{tr}$						d
Transmitter									
Delay t_{dtr}				0.8T					e
Hold time t_{htr}	0								d
Receiver									
Setup time t_{sr}						$0.2T_r$			f
Hold time t_{hr}						0			f

I²S timing notes column in **Table 19** are explained below:

a) The system clock period T must be greater than T_{tr} and T_r because both the transmitter and receiver have to be able to handle the data transfer rate.

b) At all data rates in master mode, the transmitter or receiver generates a clock signal with a fixed mark/space ratio. For this reason, t_{HC} and t_{LC} are specified with respect to T.

c) In slave mode, the transmitter and receiver need a clock signal with minimum HIGH and LOW periods so that they can detect the signal. So long as the minimum periods are greater than $0.35T_r$, any clock that meets the requirements can be used.

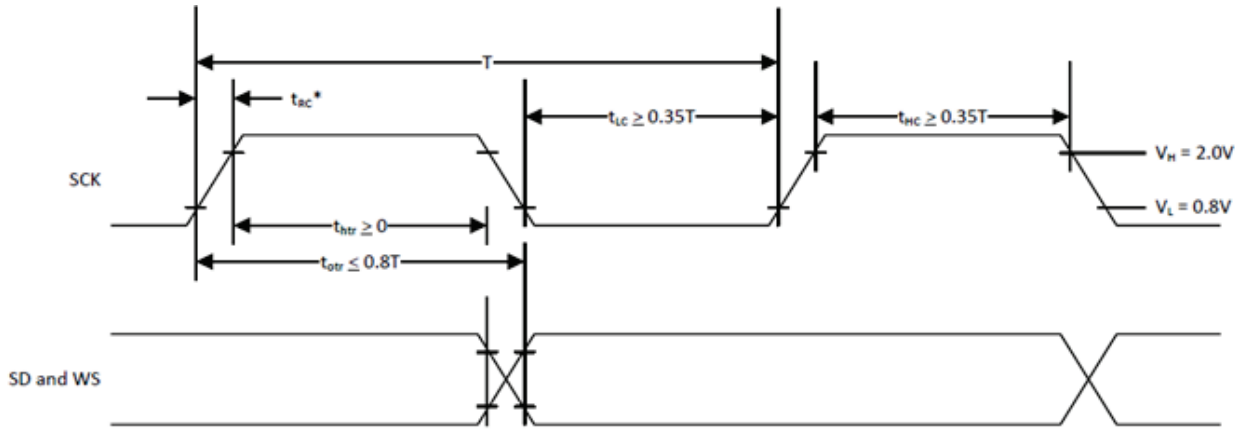
d) Because the delay(t_{dtr}) and the maximum transmitter speed (defined by T_{tr}) are related, a fast transmitter driven by a slow clock edge can result in t_{dtr} not exceeding t_{RC} which means t_{htr} becomes zero or negative. Therefore, the transmitter has to guarantee that t_{htr} is greater than or equal to zero, so long as the clock rise-time t_{RC} is not more than t_{RCmax}, where t_{RCmax} is not less than $0.15T_{tr}$.

e) To allow data to be clocked out on a falling edge, the delay is specified with respect to the rising edge of the clock signal and T, always giving the receiver sufficient setup time.

f) The data setup and hold time must not be less than the specified receiver setup and hold time.

Figure 15 shows the timing diagram for I²S transmitter.

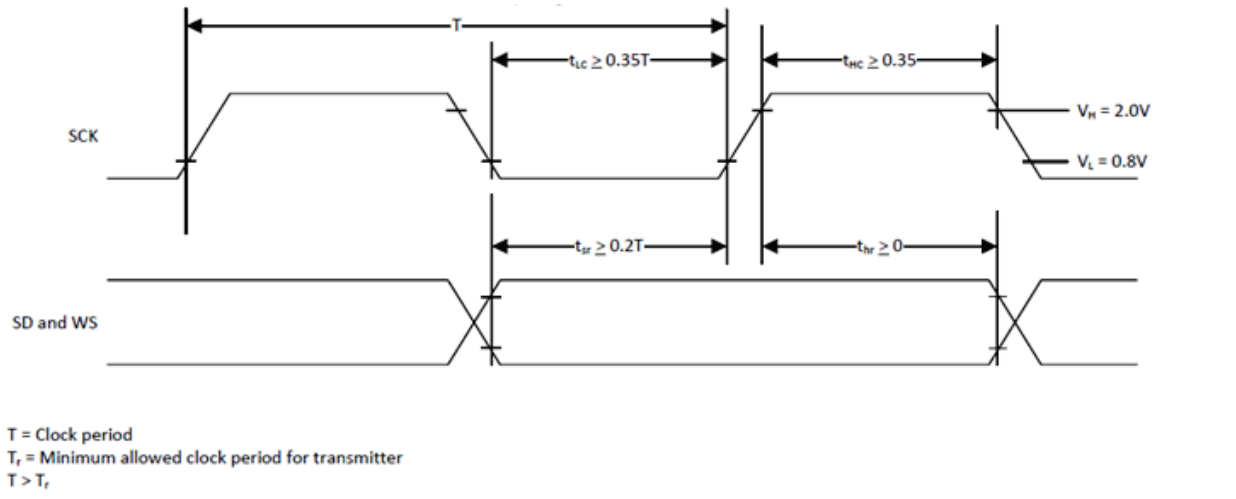
Figure 15: I²S Transmitter Timing Diagram



T = Clock period
T_{tr} = Minimum allowed clock period for transmitter
$T = T_{tr}$
* t_{RC} is only relevant for transmitters in slave mode.

Figure 16 shows the timing diagram for I²S receiver.

Figure 16: I²S Receiver Timing Diagram



T = Clock period
T_r = Minimum allowed clock period for transmitter
$T > T_r$

12.4 WLAN SDIO Timing

This section describes the WLAN SDIO signal timings at default and high-speed modes.

12.4.1 SDIO Timing (Default Mode)

Figure 17 shows the SDIO protocol timing diagram for default mode.

Figure 17: SDIO Protocol Timing Diagram - Default Mode

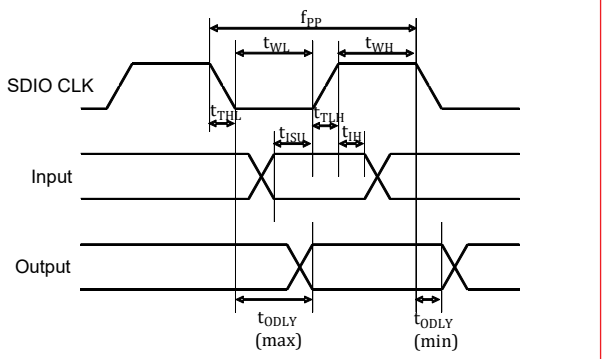


Table 20 describes SDIO timing default mode data.

Table 20: SDIO Timing Data - Default Mode

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SDIO Clock CLK (All values are referred to minimum VIH and Maximum VIL					
Frequency-Data Transfer Mode	f_{PP}	0		25	MHz
Frequency-Identification Mode	f_{OD}	0		400	kHz
Clock Low Time	t_{WL}	10			ns
Clock High Time	t_{WH}	10			ns
Clock Rise Time	t_{TLH}			10	ns
Clock Low Time	t_{THL}			10	ns
Inputs: CMD, DAT (referenced to CLK)					
Input Setup Time	t_{ISU}	5			ns
Input Hold Time	t_{IH}	5			ns
Outputs: CMD, DAT (referenced to CLK)					
Output Delay Time-Data Transfer Mode	t_{ODLY}	0		14	ns
Output Delay time-Identification Mode	t_{ODLY}	0		50	ns

- Timing is based on CL < 40 pF load on CMD and Data.
- Minimum (VIH) = 0.7*VDDIO and maximum (VIL) = 0.2*VDDIO.

12.4.2 SDIO Timing (High Speed Mode)

Figure 18 shows the SDIO protocol timing diagram for high-speed mode.

Figure 18: SDIO Protocol Timing Diagram - High Speed Mode

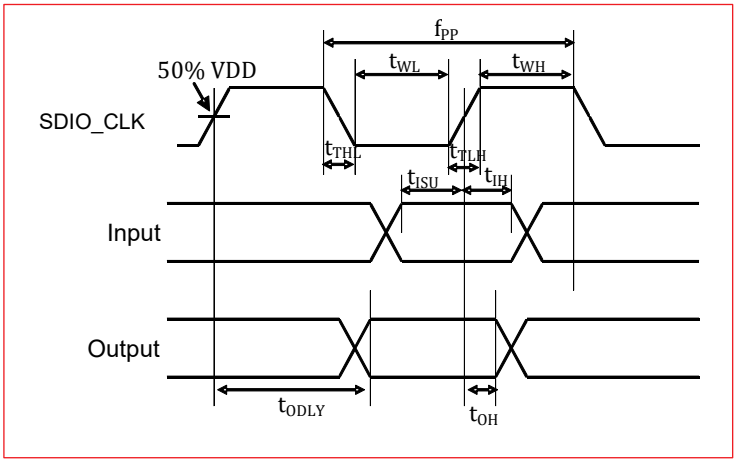


Table 21 shows SDIO timing data at high-speed mode.

Table 21: SDIO Timing Data – High Speed Mode

Parameter	Symbol	Minimum	Typical	Maximum	Unit
SDIO Clock CLK (All values are referred to minimum VIH and Maximum VIL					
Frequency-Data Transfer Mode	f_{PP}	0		50	MHz
Frequency-Identification Mode	f_{OD}	0		400	kHz
Clock Low Time	t_{WL}	7			ns
Clock High Time	t_{WH}	7			ns
Clock Rise Time	t_{TLH}			3	ns
Clock Low Time	t_{THL}			3	ns
Inputs: CMD, DAT (referenced to CLK)					
Input Setup Time	t_{ISU}	6			ns
Input Hold Time	t_{IH}	2			ns
Outputs: CMD, DAT (referenced to CLK)					
Output Delay Time-Data Transfer Mode	t_{ODLY}			14	ns
Output Hold time	t_{OH}	2.5			ns
Total System Capacitance (each line)	CL			40	pF

- Timing is based on CL < 40 pF load on CMD and Data
- Minimum (Vih) = 0.7*VIO and maximum (Vil) = 0.2*VIO

12.4.3 SDIO BUS Timing Specifications in SDR Modes

This section describes the SDIO BUS timing specifications in SDR Modes:

- Clock timing
- Card input timing
- Card output timing

12.4.3.1 Clock Timing (SDR Mode)

The clock timing diagram for SDR mode is shown in **Figure 19**.

Figure 19: Clock Timing Diagram - SDR Mode

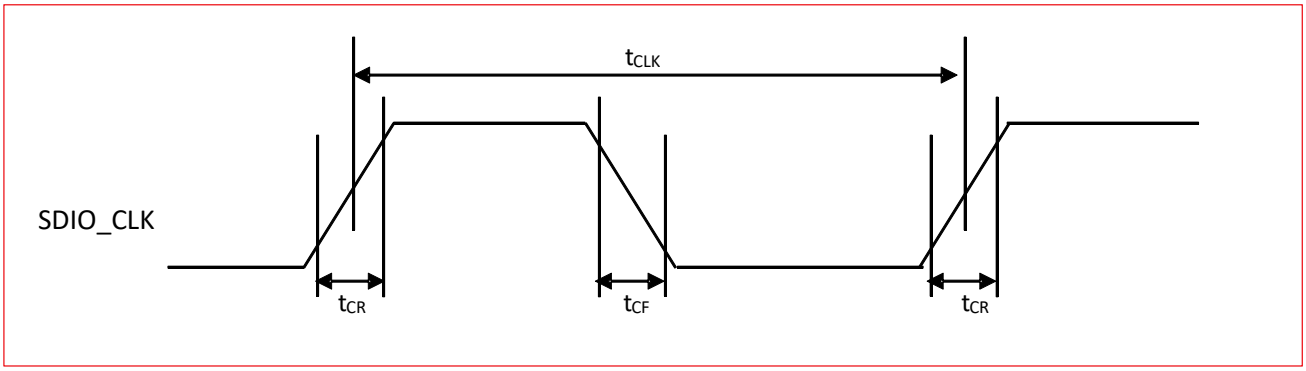


Table 22 describes the SDIO Bus clock timing parameters for SDR mode.

Table 22: Clock Timing Parameters – SDR Mode

Parameter	Symbol	Minimum	Maximum	Unit	Comments
	t_{CLK}	40		ns	SDR12 mode
		20		ns	SDR25 mode
		10		ns	SDR50 mode
		4.8		ns	SDR104 mode
	t_{CR}, t_{CF}		0.2 x t_{CLK}	ns	t_{CR}, t_{CF}<2.00ns (maximum) @ 100 MHz, cCARD = 10 pF t_{CR}, t_{CF} < 0.96ns (maximum) @ 208 MHz, cCARD = 10 pF
Clock duty Cycle		30	70	%	

12.4.3.2 Card Input Timing (SDR Mode)

The card input timing diagram for SDR mode is shown in **Figure 20**.

Figure 20: Card Input Timing Diagram - SDR Mode

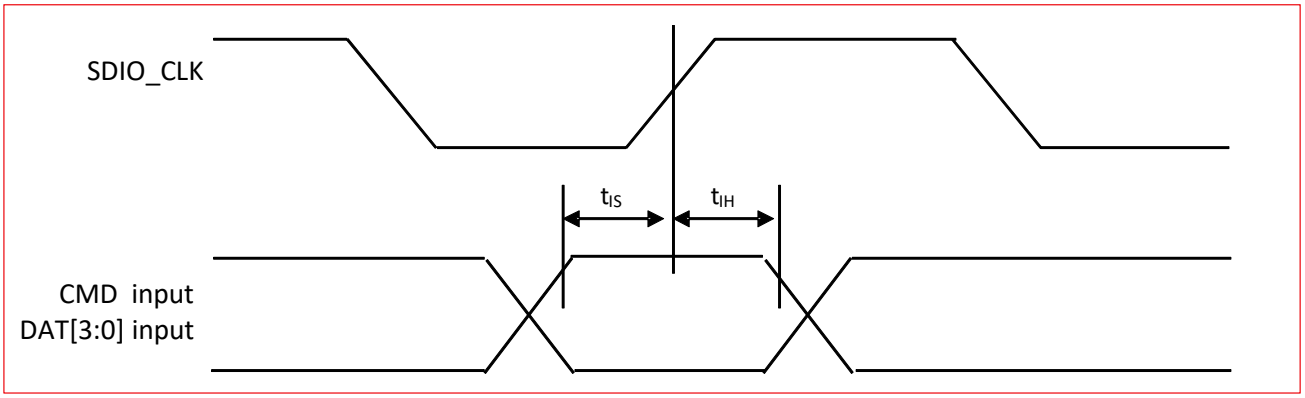


Table 23 describes SDIO Bus input timing parameters in SDR mode.

Table 23: Card Input Timing Parameters - SDR Mode

Symbol	Minimum	Maximum	Unit	Comments
SDR104 Mode				
t_{IS}	1.4		ns	cCARD = 10 pF, VCT = 0.975V
t_{IH}	0.8		ns	cCARD = 5 pF, VCT = 0.975V
SDR50 Mode				
t_{IS}	3.0		ns	cCARD = 10 pF, VCT = 0.975V
t_{IH}	0.8		ns	cCARD = 5 pF, VCT = 0.975V

12.4.3.3 Card Output Timing (SDR Modes up to 100 MHz)

This section describes SDIO bus output timing for two SDR modes.

12.4.3.3.1 SDIO Bus Output Timing - SDR Modes up to 100 MHz

SDIO bus output timing diagram and parameters at SDR modes up to 100 MHz are shown in **Figure 21** and **Table 24** respectively.

Figure 21: SDIO Bus Output Timing Diagram - SDR Modes up to 100 MHz

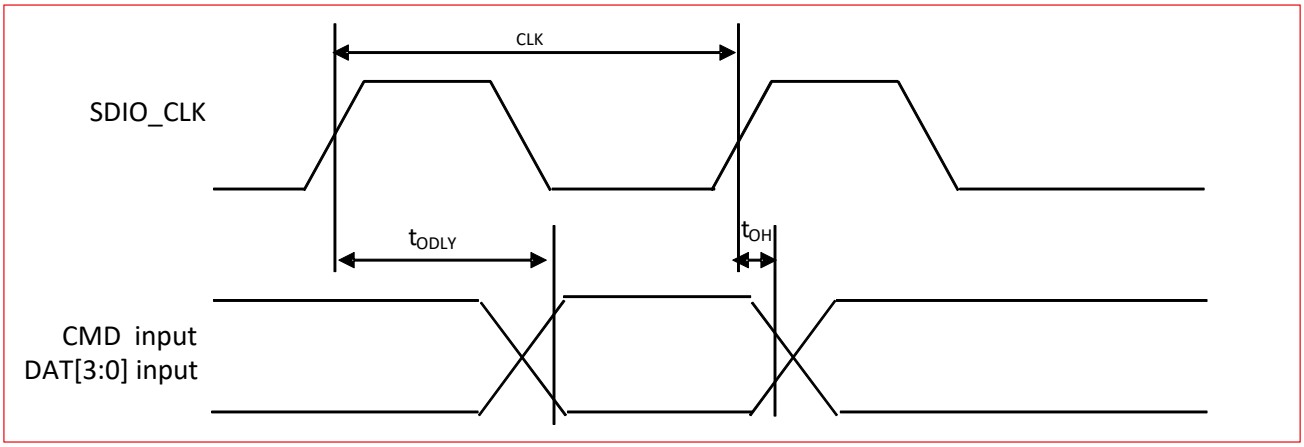


Table 24: SDIO Bus Output Timing Parameters - SDR Modes up to 100 MHz

Symbol	Minimum	Maximum	Unit	Comments
t_{ODLY}		7.5	ns	$t_{CLK} \geq$ 10 ns CL = 30 pF using driver type B for SDR50
t_{ODLY}		14.0	ns	$t_{CLK} \geq$ 20 ns CL = 40 pF using for SDR12, SDR25
t_{OH}	1.5		ns	Hold time at the t_{ODLY} (minimum) CL = 15 pF

12.4.3.3.2 SDIO Bus Output Timing - SDR Modes 100 MHz to 208 MHz

SDIO bus output timing diagram and parameters at SDR modes 100 MHz to 208 MHz are shown in **Figure 22** and **Table 25** respectively.

Figure 22: SDIO Bus Output Timing Diagram - SDR Modes 100 MHz to 208 MHz

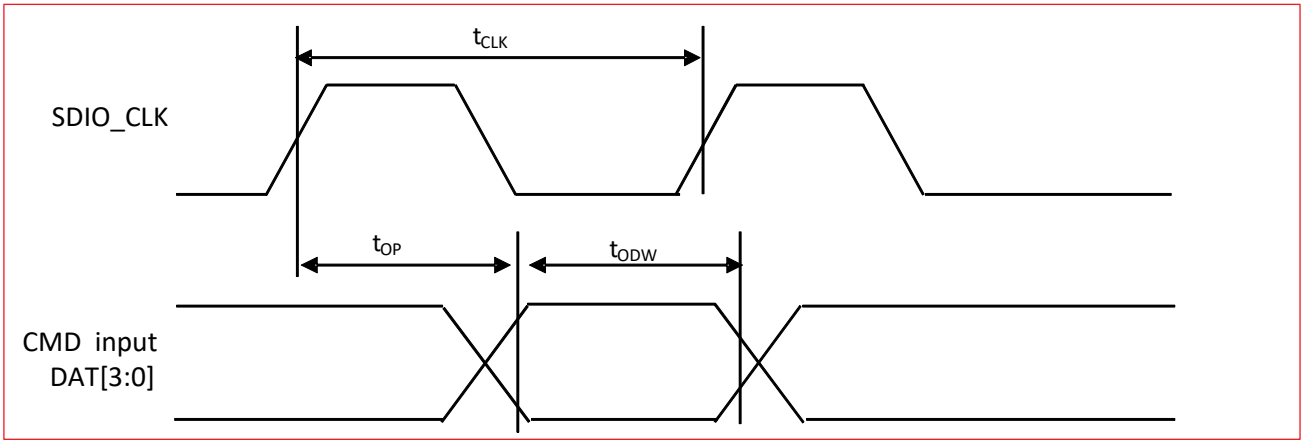


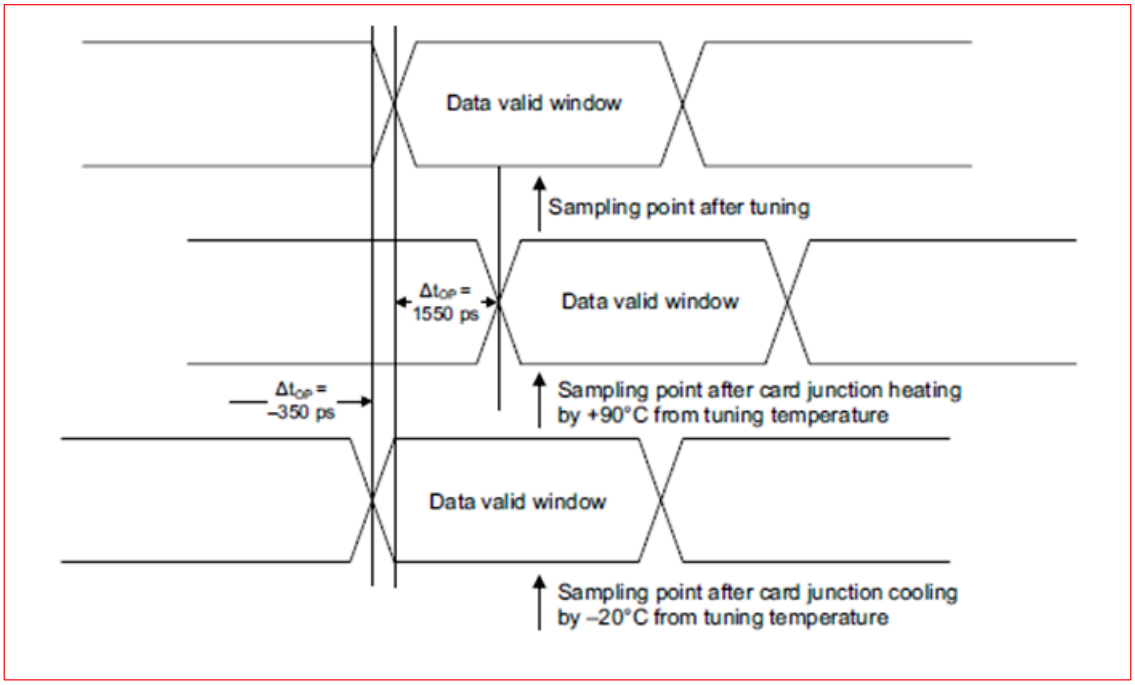
Table 25: SDIO Bus Output Timing Parameters - SDR Modes 100 MHz to 208 MHz

Symbol	Minimum	Maximum	Unit	Comments
t_{OP}	0	2	UI	Card output phase
Δt_{OP}	-350	+1550	ps	Delay variation due to temp change after tuning
t_{ODW}	0.60		UI	t_{ODW} = 2.88 ns @ 208 MHz

- Δtop = +1550 ps for junction temperature of Δtop = 90℃ during operation.
- Δtop = -350 ps for junction temperature of Δtop = -20℃ during operation.
- Δtop = +2600 ps for junction temperature of Δtop = -20℃ to +125℃ during operation

Figure 23 shows Δtop consideration for variable data window at SDR 104 mode.

Figure 23: Δtop Consideration for Variable Data Window - SDR 104 Mode



12.4.4 SDIO Timing Specifications in DDR50 Mode

This section describes SDIO clock timing and SDIO data timing.

12.4.4.1 SDIO Clock Timing

This section provides information about SDIO clock timing at DDR50 mode. The diagram and parameters are shown in **Figure 24** and **Table 26** respectively.

Figure 24: SDIO Clock Timing Diagram - DDR50 Mode

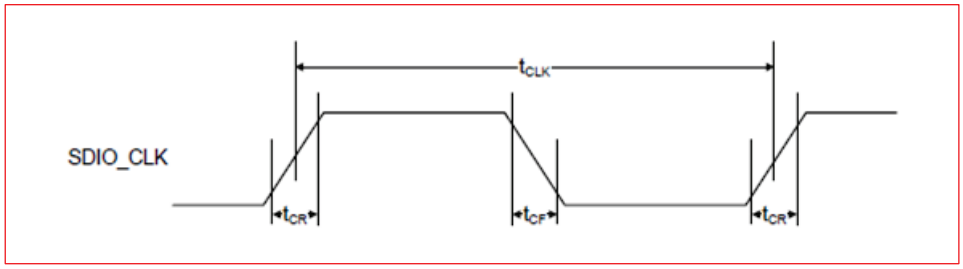


Table 26: SDIO Clock Timing Parameters - DDR50 Mode

Parameter	Symbol	Minimum	Maximum	Unit	Comments
	t_{CLK}	20		ns	DDR50 Mode
	t_{CR}, t_{CF}		0.2 x t_{CLK}	ns	t_{CR}, t_{CF} < 4.00 ns(maximum) @ 50 MHz, cCard = 10 pF
Clock duty cycle		45	55	%	

12.4.4.2 SDIO Data Timing

This section provides information about SDIO data timing at DDR50 mode. The diagram and parameters are shown in **Figure 25** and **Table 27** respectively.

Figure 25: SDIO Data Timing Diagram - DDR50 Mode

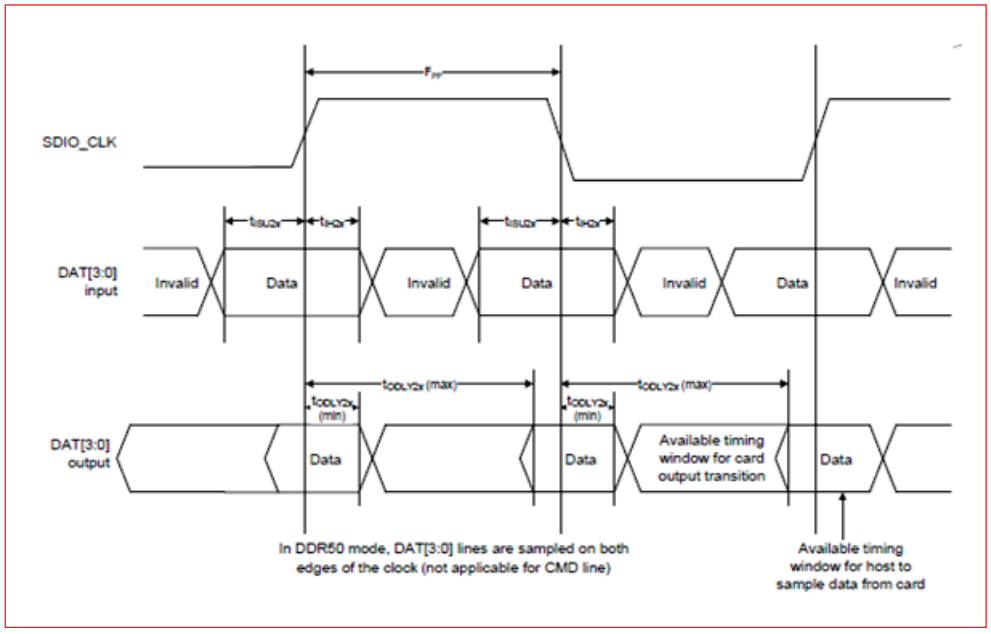


Table 27: SDIO Data Timing parameters - DDR50 Mode

Parameter	Symbol	Minimum	Maximum	Unit	Comments
Input CMD					
Input setup time	t_{ISU}	6		ns	C_{card} <10 pF (1 card)
Input hold time	t_{IH}	0.8		ns	C_{card} <10 pF (1 card)
Output CMD					
Output delay time	t_{ODLY}		13.7	ns	C_{card} < 30 pF (1 card)
Output hold time	t_{OH}	1.5		ns	C_{card} < 15 pF (1 card)
Input DAT					
Input setup time	t_{ISU2x}	3		ns	C_{card} < 10 pF (1 card)
Input hold time	t_{IH2x}	0.8		ns	C_{card} < 10 pF (1 card)
Output DAT					
Output delay time	t_{ODLY2x}		7.5	ns	C_{card} < 25 pF (1 card)
Output hold time	t_{OH2x}	1.5		ns	C_{card} < 15 pF (1 card)

13 DC/RF Characteristics

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

Table 28: Characteristic Values for IEEE 802.11b - 2.4 GHz

Items	Contents
Specification	IEEE 802.11b
Mode	DSSS / CCK
Frequency	2400 to 2483.5 MHz
Data Rate	1, 2, 5.5, 11 Mbps

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 17 dBm, 11 Mbps

Table 29: High-Rate Condition for IEEE 802.11b - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[3]			420	mA
• Rx mode			80	mA
TX Characteristics[3]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	14.5	17	19.5	dBm
Spectrum Mask Margin				
• 1st side lobes (-30 dBr)	0			dB
• 2nd side lobes (-50 dBr)	0			dB
Power-on/off ramp			2.0	µs
RF Carrier Suppression	15			dB
Modulation Accuracy			35	%
Frequency Tolerance	-20		20	ppm
Spurious Emissions (BW = 100 kHz)				
• 30-1000 MHz			-36	dBm
• 1000-12750 MHz			-30	dBm
• 1800-1900 MHz			-47	dBm
• 5150-5300 MHz			-47	dBm
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

[3] Defined when output power setting is 17 dBm at Murata module antenna pad.

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 17 dBm, 1 Mbps mode

Table 30: Low-Rate Condition for IEEE 802.11b - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[4]			430	mA
• Rx mode			80	mA
TX Characteristics[4]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	14.5	17	19.5	dBm
Spectrum Mask Margin				
• 1st side lobes (-30 dBr)	0			dB
• 2nd side lobes (-50 dBr)	0			dB
Power-On/Off Ramp			2.0	µs
RF Carrier Suppression	15			dB
Modulation Accuracy			35	%
Frequency Tolerance	-20		20	ppm
Spurious Emissions (BW = 100 kHz)				
• 30-1000 MHz			-36	dBm
• 1000-12750 MHz			-30	dBm
• 1800-1900 MHz			-47	dBm
• 5150-5300 MHz			-47	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (FER ≤ 8%)			-76	dBm
Maximum Input Level (FER ≤ 8%)	-4			dBm
Adjacent Channel Rejection (FER ≤ 8%)	35			dB

[4] Defined when output power setting is 17 dBm at Murata module antenna pad

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

Table 31: Characteristic Values for IEEE 802.11g - 2.4 GHz

Items	Contents
Specification	IEEE 802.11g
Mode	OFDM
Channel Frequency	2400 to 2483 MHz
Data Rate	6, 9, 12, 18, 24, 36, 48, 54 Mbps

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 13 dBm, 54 Mbps.

Table 32: High-Rate Conditions for IEEE 802.11g - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[5]			370	mA
• Rx mode			80	mA
TX Characteristics[5]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	10.5	13.0	15.5	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
Outband Spurious Emissions				
• 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
• 1 GHz to 12.75 GHz (BW = 100 kHz)			-30	dBm
• 1.8 GHz to 1.9 GHz (BW = 100 kHz)			-47	dBm
• 5.15 GHz to 5.3 GHz (BW = 100 kHz)			-47	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level (PER ≤ 10%)			-65	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

[5] Defined when output power setting is 13 dBm at Murata module antenna pad

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 16 dBm, 6 Mbps

Table 33: Low-Rate Condition for IEEE 802.11g - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[6]			420	mA
• Rx mode			80	mA
TX Characteristics[6]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	13.5	16.0	18.5	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
Outband Spurious Emissions				
• 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
• 1 GHz to 12.75 GHz (BW = 100 kHz)			-30	dBm
• 1.8 GHz to 1.9 GHz (BW = 100 kHz)			-47	dBm
• 5.15 GHz to 5.3 GHz (BW = 100 kHz)			-47	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%)	16			dB

[6] Defined when output power setting is 16 dBm at Murata module antenna pad

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

Table 34: Characteristic Values for IEEE 802.11n - 2.4 GHz

Items	Contents
Specification	IEEE 802.11n
Mode	OFDM
Channel Frequency	2400 to 2483.5 MHz
Data Rate	6.5, 13, 19.5, 26, 39, 52, 58.5, 65 Mbps

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 12 dBm, 65 Mbps (MCS7)

Table 35: High-Rate Condition for IEEE 802.11n - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[7]			360	mA
• Rx mode			80	mA
TX Characteristics[7]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	9.5	12.0	14.5	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)			-27	dB
Frequency Tolerance	-20		20	ppm
Outband Spurious Emissions				
• 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
• 1 GHz to 12.75 GHz (BW = 100 kHz)			-30	dBm
• 1.8 GHz to 1.9 GHz (BW = 100 kHz)			-47	dBm
• 5.15 GHz to 5.3 GHz (BW = 100 kHz)			-47	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

[7] Defined when output power setting is 12 dBm at Murata module antenna pad

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 14 dBm, 6.5 Mbps (MCS0)

Table 36: Low-Rate Condition for IEEE 802.11n - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx Mode (1024 byte, 20 µs interval)[8]			410	mA
• Rx Mode			80	mA
TX Characteristics[8]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	11.5	14.0	16.5	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)			-5	dB
Frequency Tolerance	-20		20	ppm
Outband Spurious Emissions				
• 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
• 1 GHz to 12.75 GHz (BW = 100 kHz)			-30	dBm
• 1.8 GHz to 1.9 GHz (BW = 100 kHz)			-47	dBm
• 5.15 GHz to 5.3 GHz (BW = 100 kHz)			-47	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%)	16			dB

[8] Defined when output power setting is 14 dBm at Murata module antenna pad

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

Table 37: Characteristic Values for IEEE 802.11a - 5 GHz

Items	Contents
Specification	IEEE 802.11a
Mode	OFDM
Channel Frequency	5180 to 5825 MHz
Data Rate	6, 9, 12, 18, 24, 36, 48, 54 Mbps

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 13 dBm, 54 Mbps

Table 38: High-Rate Condition for IEEE 802.11a - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[9]			330	mA
• Rx mode			100	mA
TX Characteristics[9]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	11.0	13.0	15.0	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
Outband Spurious Emissions				
• 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
• 1 GHz to 12.75 GHz (BW = 100 kHz)			-30	dBm
• 1.8 GHz to 1.9 GHz (BW = 100 kHz)			-47	dBm
• 5.15 GHz to 5.3 GHz (BW = 100 kHz)			-47	dBm
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

[9] Defined when output power setting is 13 dBm at Murata module antenna pad

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 15 dBm, 6 Mbps

Table 39: Low-Rate Condition for IEEE 802.11a - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[10]			360	mA
• Rx mode			100	mA
TX Characteristics[10]	**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)			-5	dB
Frequency Tolerance	-20		20	ppm
Outband Spurious Emissions				
• 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
• 1 GHz to 12.75 GHz (BW = 100 kHz)			-30	dBm
• 1.8 GHz to 1.9 GHz (BW = 100 kHz)			-47	dBm
• 5.15 GHz to 5.3 GHz (BW = 100 kHz)			-47	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%)	16			dB

[10] Defined when output power setting is 15 dBm at Murata module antenna pad

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

Table 40: Characteristic Values for IEEE 802.11n (HT40) - 5 GHz

Items	Contents
Specification	IEEE 802.11n (HT40)
Mode	OFDM
Channel Frequency	5190 to 5795 MHz
Data Rate	13.5, 27, 40.5, 54, 81, 108, 121.5, 135 Mbps

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 13 dBm, 135 Mbps (MCS7)

Table 41: High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx Mode (1024 byte, 20 µs interval)[11]			310	mA
• Rx Mode			110	mA
TX Characteristics[11]	**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 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM)			-27	dB
Frequency Tolerance	-20		20	ppm
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

[11] Defined when output power setting is 13.0 dBm at Murata module antenna pad

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 15 dBm, 13.5 Mbps (MCS0)

Table 42: Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx Mode (1024 byte, 20 µs interval)[12]			370	mA
• Rx Mode			110	mA
TX Characteristics[12]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	13.0	15.0	17.0	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)			-5	dB
Frequency Tolerance	-20		20	ppm
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%)	16			dB

[12] Defined when output power setting is 15 dBm at Murata module antenna pad

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

Table 43: Characteristic Values for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents
Specification	IEEE 802.11ac (VHT80)
Mode	OFDM
Channel Frequency	5210 to 5775 MHz
Data Rate	29.3, 58.5, 87.8, 117, 175.5, 234, 263.3, 292.5, 351, 390 Mbps

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 10 dBm, 390 Mbps (MCS9)

Table 44: High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[13]			340	mA
• Rx mode			130	mA
TX Characteristics[13]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	8.0	10.0	12.0	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)			-32	dB
Frequency Tolerance	-20		20	ppm
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

[13] Defined when output power setting is 10 dBm at Murata module antenna pad

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

Conditions: 25 °C, VBAT = 3.3V, Output power setting = 12 dBm, 29.3 Mbps (MCS0)

Table 45: Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)[14]			380	mA
• Rx mode			130	mA
TX Characteristics[14]	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	10.0	12.0	14.0	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)			-5	dB
Frequency Tolerance	-20		20	ppm
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%)	16			dB

[14] Defined when output power setting is 12 dBm at Murata module antenna pad

13.7 DC/RF Characteristics for Bluetooth

Conditions: 25 °C, VBAT = 3.3V

Table 46: DC/RF Characteristics for Bluetooth

Items		Contents			
Bluetooth Specification (power class)		Version 5.0 (Class1)			
Channel Frequency (spacing)		2402 to 2480 MHz (1 MHz)			
Transmitter		**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	BDR	3.0		10.5	dBm
	EDR	-1.5		6.0	dBm
Frequency Range		2400		2483.5	MHz
20 dB Bandwidth				1	MHz
Modulation Characteristics		**Minimum**	**Typical**	**Maximum**	**Unit**
• Modulation $\Delta f1_{avg}$		140		175	kHz
• Modulation $\Delta f2_{max}$		115			kHz
• Modulation $\Delta f2_{avg}$ / $\Delta f1_{avg}$		0.8			
Carrier Frequency Drift		**Minimum**	**Typical**	**Maximum**	**Unit**
• 1slot		-25		+25	kHz
• 3slot / 5slot		-40		+40	kHz
• Maximum drift rate		-20		+20	kHz/50µs
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 (π/4 DQPSK)				20	%
• Peak DEVM (π/4 DQPSK)				35	%
• 99% DEVM (π/4 DQPSK)				30	%
• RMS DEVM (8DPSK)				13	%
• Peak DEVM (8DPSK)				25	%
• 99% DEVM (8DPSK)				20	%
Spurious Emissions					
• 10 MHz ≤ f < 2387 MHz				-36	dBm
• 2387 MHz ≤ f < 2400 MHz				-30	dBm
• 2483.5 MHz < f ≤ 2496.5 MHz				-47	dBm
• 2496.5 MHz < f ≤ 8 GHz				-47	dBm
Receiver		**Minimum**	**Typical**	**Maximum**	**Unit**
Sensitivity (BER ≤ 0.1%)				-80	dBm
Maximum Input Level (BER ≤ 0.1%)		-20			dBm
EDR Sensitivity (BER ≤ 0.007%)					
• 8DPSK				-77	dBm

13.8 DC/RF Characteristics for Bluetooth Low Energy

Conditions: 25 °C, VBAT = 3.3V

Table 47: DC/RF Characteristics for BLE

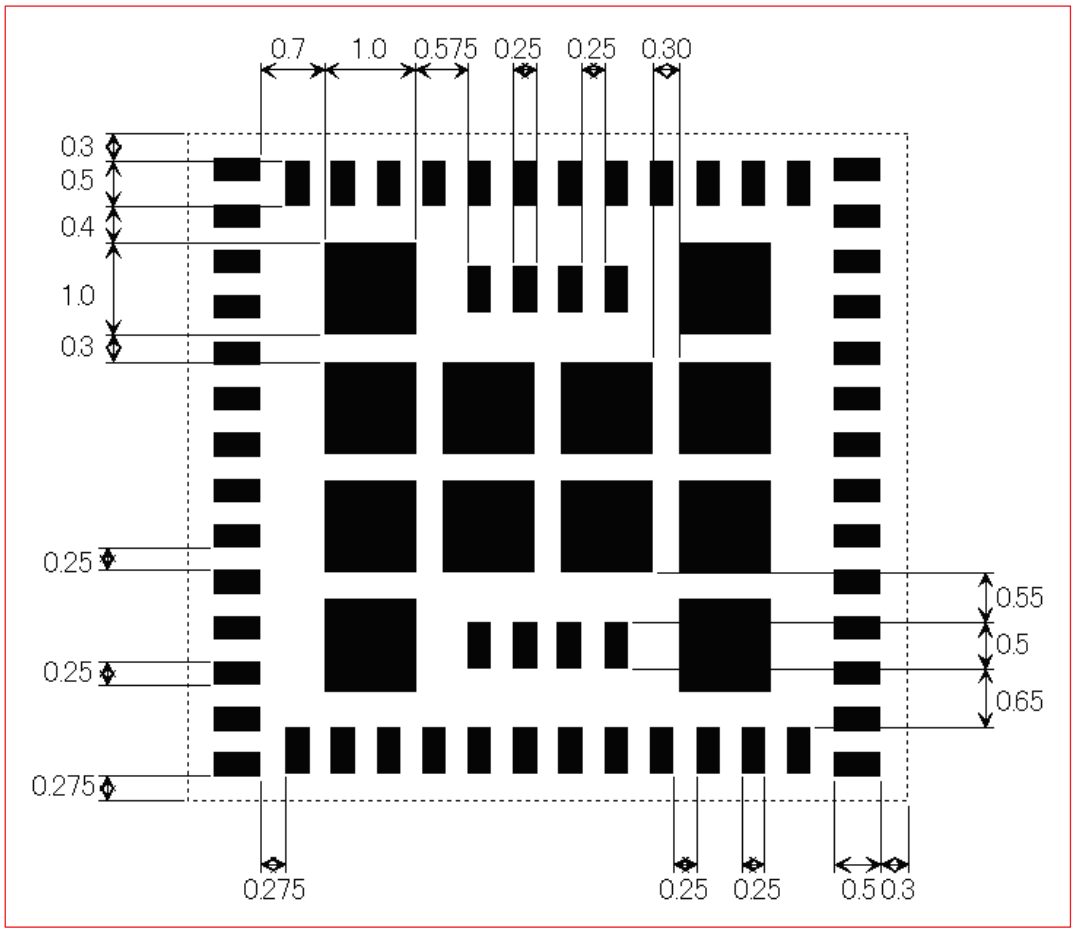
Items	Contents			
Bluetooth Specification (power class)	Version 5.0 (LE)			
Channel Frequency (spacing)	2402 to 2480 MHz (2 MHz)			
Number of RF Channel	40			
Item / Condition	**Minimum**	**Typical**	**Maximum**	**Unit**
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF channel		40		
Output Power	1.5		9.0	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	-150		150	kHz
• Frequency Drift			50	kHz
• Drift Rate			20	kHz
Receiver Sensitivity (PER < 30.8%)			-70	dBm
Maximum Input Signal Level (PER < 30.8%)	-10			dBm
PER Report Integrity (-30 dBm input)	50		65.4	%

The above-mentioned values have been obtained according to our own measuring methods and may very depend on the circuit, in which the component is actually incorporated. Therefore, you are kindly requested to test the performance of the component actually in your set.

14 Land Pattern

The land pattern is shown in **Figure 26.**

Figure 26: Land Pattern (Unit: mm)



To avoid the short-circuit between the side shielding and a solder on the module land after the reflow, please locate the module land at 0.2 mm away from module outline as **Figure 26**.

15 Radio Regulatory Certification by Country for VPYLBEE5HY1MW

This section includes regulatory certification information / user manual of the following regions:

- Japan
- FCC
- ISED
- Europe

15.1 Japan

This section describes the Japan Certificate of Construction Type of LBEE5HY1MW.

This module is a product that has been authorized construction design certification based on the following Certificate of Construction Type.

- In the 5 GHz frequency band, three types of 5.2 GHz / 5.3 GHz / 5.6 GHz bands (W52 / W53 / W56) can be used.
- Outdoor use of the 5.2 GHz / 5.3 GHz band wireless LAN (W52 / W53) is prohibited by the Certificate of Construction Type.
- W53 / W56 for STA function only.

It is recommended to describe the following contents in the end product or user manual.

- This product has built-in specified radio equipment which received construction design certification (certification number: 001-P01220) based on the Certificate of Construction.
- The W52 / W53 in the 5 GHz band is prohibited from outdoor use under the Japanese Certificate of Construction Type.

Table 48 and **Table 49** show the per antenna port power table for 2.4 GHz for WLAN and Bluetooth. **Table 50** shows the per antenna port power table for 5 GHz WLAN.

Table 48: Japan Power Level 2.4 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)
Channels		**1 ~ 13**
11b	All Rates	17.0
11g	6 ~ 24 Mbps	16.0
	36 ~ 54 Mbps	13.0
11n HT20	MCS0 ~ MCS4	14.0
	MCS5 ~ MCS7	12.0

Table 49: Japan Power Level 2.4 GHz BT/BLE Per Antenna Port

Frequency [MHz]	Output Power [dBm]		
	DH5	3DH5	BLE
2402	6.3	1.5	4.9
2440	6.0	2.0	5.1
2480	5.2	0.9	4.1

The Bluetooth power **Table 49** is valid for all regions (Japan, USA, Canada, and Europe).

Table 50: Japan Power Level 5 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)				
Channels		**36 ~ 40**	**44 ~ 56**	**60 ~ 104**	**108 ~ 132**	**136 ~ 140**
11a	6 ~ 24 Mbps	12.0	15.0	12.0	15.0	12.0
	36 ~ 54 Mbps	12.0	13.0	12.0	13.0	12.0
11n HT20	MCS0 ~ MCS3	12.0	15.0	12.0	15.0	12.0
	MCS4 ~ MCS7	12.0	13.0	12.0	13.0	12.0
11ac VHT20	MCS0 ~ MCS3	12.0	15.0	12.0	15.0	12.0
	MCS4 ~ MCS8	12.0	13.0	12.0	13.0	12.0
Channels		**38**	**46 ~ 54**	**62 ~ 102**	**110 ~ 126**	**134**
11n HT40	MCS0 ~ MCS3	10.0	15.0	10.0	15.0	10.0
	MCS4 ~ MCS7	10.0	13.0	10.0	13.0	10.0
11ac VHT40	MCS0 ~ MCS3	10.0	15.0	10.0	15.0	10.0
	MCS4 ~ MCS7	10.0	13.0	10.0	13.0	10.0
	MCS8 ~ MCS9	10.0	10.0	10.0	10.0	10.0
Channels		**42 ~ 122**				
11ac VHT80	MCS0 ~ MCS9	10.0				

15.2 FCC

- **Model Name:** LBEE5HY1MW
- **FCC ID:** VPYLBEE5HY1MW

This module is not directly sold to general end users. Therefore, there is no user manual of module.

For the details about this module, please refer to the specification sheet of module.

This module should be installed in the host device according to the interface specification (installation procedure).

15.2.1 Information to Display on Host Device and User Manual

15.2.1.1 Information on Host Device

The following information must be indicated on the host device of this module:

- Contains Transmitter Module FCC ID: VPYLBEE5HY1MW or Contains FCC ID: VPYLBEE5HY1MW

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference, and
- This device must accept any interference received, including interference that may cause undesired operation.

.

If it cannot be described on the host product, the information must be listed on both the host product manual and on the host product package or removable label.

15.2.1.2 Information in User Manual

The following statements must be described on the user manual of the host device of this module:

- **FCC CAUTION:** Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
- This transmitter must not be co-located or operated in conjunction with any other antenna or transmitter.

15.2.2 Compliance with FCC requirement 15.407(c)

Data transmission is always initiated by software, which is the passed down through the MAC, through the digital and analog baseband, and finally to the RF chip. The MAC initiates several special packets. These are the only ways the digital baseband portion will turn on the RF transmitter, which it then turns off at the end of the packet. Therefore, the transmitter will be on only while one of the aforementioned packets is being transmitted. In other words, this device automatically discontinue transmission in case of either absence of information to transmit or operational failure.

Frequency Tolerance: ±20 ppm

15.2.3 Equipment Installation for FCC

There are two types of installation for host device.

15.2.3.1 Portable Equipment

Equipment for which the spaces between human body and antenna are used within 20 cm. When installing the module in a portable equipment please describe the following warning to the manual.

The available scientific evidence does not show that any health problems are associated with using low power wireless devices. There is no proof, however, that these low power wireless devices are absolutely safe. Low power Wireless devices emit low levels of radio frequency energy (RF) in the microwave range while being used. Whereas elevated level of RF can produce health effects (by heating tissue), exposure

of low-level RF that does not produce heating effects causes no known adverse health effects. Many studies of low-level RF exposures have not found any biological effects. Some studies have suggested that some biological effects might occur, but such findings have not been confirmed by additional research. LBEE5HY1MW has been tested and found to comply with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines.

It is necessary to take a SAR test with your set mounting this module (except to use only Bluetooth V5.0 (BDR/EDR/LE).

Class II permissive change application is necessary using the SAR report. Please contact Murata.

15.2.3.2 Mobile Equipment

Equipment used at position in which the spaces between human body and antenna exceeded 20 cm. When installing the module in a mobile equipment please describe the following warning to the manual.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.

15.2.4 Power Levels for FCC and ISED

Table 51 shows the per antenna port power table for WLAN 2.4 GHz for USA and Canada. **Table 52** shows the per antenna port power table WLAN 5 GHz for USA and Canda.

Table 51: FCC/ISED Power Level 2.4 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)		
Channels		**1 ~ 2**	**3 ~ 9**	**10 ~ 11**
11b	All Rates	17.0	17.0	17.0
11g	6 ~ 24 Mbps	12.0	16.0	12.0
	36 ~ 54 Mbps	12.0	13.0	12.0
11n HT20	MCS0 ~ MCS4	12.0	14.0	12.0
	MCS5 ~ MCS7	12.0	12.0	12.0

Table 52: FCC/ISED Power Level 5 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)						
Channels		**36 ~ 40**	**44 ~ 56**	**60 ~ 104**	**108~132**	**136~153**	**157**	**161~165**
11a	6 ~ 24 Mbps	12.0	15.0	12.0	15.0	12.0	15.0	12.0
	36 ~ 54 Mbps	12.0	13.0	12.0	13.0	12.0	13.0	12.0
11n HT20	MCS0 ~ MCS3	12.0	15.0	12.0	15.0	12.0	15.0	12.0
	MCS4 ~ MCS7	12.0	13.0	12.0	13.0	12.0	13.0	12.0
11ac VHT20	MCS0 ~ MCS3	12.0	15.0	12.0	15.0	12.0	15.0	12.0
	MCS4 ~ MCS8	12.0	13.0	12.0	13.0	12.0	13.0	12.0
Channels		**38**	**46 ~ 54**	**62 ~ 102**	**110 ~ 126**	**134 ~ 159**		
11n HT40	MCS0 ~ MCS3	10.0	15.0	10.0	15.0	10.0		
	MCS4 ~ MCS7	10.0	13.0	10.0	13.0	10.0		
11ac VHT40	MCS0 ~ MCS3	10.0	15.0	10.0	15.0	10.0		
	MCS4 ~ MCS7	10.0	13.0	10.0	13.0	10.0		

	MCS8 ~ MCS9	10.0	10.0	10.0	10.0	10.0
Channels		**42 ~ 155**				
11ac VHT80	MCS0 ~ MCS9	10.0				

15.3 ISED

- **PMN**: LBEE5HY1MW
- **HVIN**: LBEE5HY1MW
- **IC Number**: 772C-LBEE5HY1MW

This module is not directly sold to general end users. Therefore, there is no user manual of module.

For the details about this module, please refer to the specification sheet of module.

This module should be installed in the host device according to the interface specification (installation procedure).

15.3.1 Information to Display on Host Device and User Manual

15.3.1.1 Information on Host Device

The following information must be indicated on the host device of this module.

- **Contains IC:** 772C-LBEE5HY1MW

15.3.1.2 Information in User Manual

The following statements must be described on the user manual of the host device of this module:

English Version

This device complies with Industry Canada's applicable license-exempt RSSs. Operation is subject to the following two conditions:

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

French Version

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

- l'appareil ne doit pas produire de brouillage.
- l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

English Version

Data transmission is always initiated by software, which is the passed down through the MAC, through the digital and analog baseband, and finally to the RF chip. The MAC initiates several special packets. These are the only ways the digital baseband portion will turn on the RF transmitter, which it then turns off at the end of the packet. Therefore, the transmitter will be on only while one of the aforementioned packets is being transmitted. In other words, this device automatically discontinue transmission in case of either absence of information to transmit or operational failure.

French Version

La transmission des données est toujours initiée par le logiciel, puis les données sont transmises par l'intermédiaire du MAC, par la bande de base numérique et analogique et, enfin, à la puce RF. Plusieurs paquets spéciaux sont initiés par le MAC. Ce sont les seuls moyens pour qu'une partie de la bande de base numérique active l'émetteur RF, puis désactive celui-ci à la fin du paquet. En conséquence, l'émetteur reste uniquement activé lors de la transmission d'un

des paquets susmentionnés. En d'autres termes, ce dispositif interrompt automatiquement toute transmission en cas d'absence d'information à transmettre ou de défaillance.

If it is difficult to describe on the host product due to the size, please describe in the User's manual.

In case of the final product which can be carried around to outdoor, the following indication is necessary to the final product.

- When the AP function is used In W52
  - At the time of a channel setting of W52, please indicate “for indoor use only”. During connecting, please show the channel number which connects.
  - And please indicate that the end user may find out "for indoor use only channel".
- When the STA function is used in channel 52, 54, 58, at the time of the channel 52 or 54 or 58 setting, please indicate “for indoor use only channel”.
  - During connecting, please show the channel number which connects.
  - And please indicate that the end user may find out "for indoor use only channel".

15.3.2 Antenna installation in End Product

If the antenna of the end product is removed, please describe the follow warning on the manual of the end product which contains this module.

English Version This radio transmitter (IC Number: 772C-LBEE5HY1MW) identify the device by certification number or model number if Category II) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device. : 2.4 GHz Monopole Gain: +0.1 dBi : 5 GHz Monopole Gain: -0.4 dBi
French Version Le présent émetteur radio (IC Number: 772C-LBEE5HY1MW) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur. Type d’antenne : 2.4 GHz Monopole Gain: +0.1 dBi : 5 GHz Monopole Gain: -0.4 dBi

If the final product uses the following frequency, please note that there is a limit:

English Version For indoor use only (5150-5250 MHz band and channel 52, 54, 58)
French Version Pour usage intérieur seulement (5150-5250 MHz band and channel 52, 54, 58)

15.3.3 Mobile Equipment Installation for ISED

When installing it in a mobile equipment. Please describe the following warning to the manual.

English Version This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment and meets RSS-102 of the IC radio frequency (RF) Exposure rules. This equipment should be installed and operated keeping the radiator at least 20 cm or more away from person's body.
French Version Cet équipement est conforme aux limites d'exposition aux rayonnements énoncées pour un environnement non contrôlé et respecte les règles d'exposition aux fréquences radioélectriques (RF) CNR-102 de l'IC. Cet équipement doit être installé et utilisé en gardant une distance de 20 cm ou plus entre le radiateur et le corps humain.

15.3.4 Antenna

Please refer to the antenna specification or contact Murata for the detail designation of how to design the antenna trace. The recommended antenna for Type 1MW module is shown below.

Model name	LBEE5HY1MW
Antenna model name	Type1MW-Antenna
Antenna manufacturer	Murata Manufacturing Co. Ltd.
Antenna type	Monopole pattern antenna
Antenna gain	+0.1 dBi @ 2442 MHz
	-0.4 dBi @ 5150 MHz
Frequency	2400 - 2483.5 MHz
	5150 - 5850 MHz

15.3.5 Theory of Operation for ISED - Channel List

Table 53 describes theory of operation with channel list.

Table 53: ISED Theory of Operation - Channel List

Frequency of Operation			Scan	Ad-hoc Mode
2.4 GHz	11b/g/n (HT20)	2412-2462 MHz	Active	Yes
	BT	2402-2480 MHz	N/A	N/A
	BLE	2402-2480 MHz	N/A	N/A
W52	11a/n/ac ((V)HT20)	5180-5240 MHz	Active	Yes
	11n/ac ((V)HT40)	5190-5230 MHz	Active	Yes
	11ac (VHT80)	5210 MHz	Active	Yes
W53	11a/n/ac ((V)HT20)	5260-5320 MHz	Passive	No
	11n/ac ((V)HT40)	5270-5310 MHz	Passive	No
	11ac (VHT80)	5290 MHz	Passive	No
W56	11a/n/ac ((V)HT20)	5500-5720 MHz[15]	Passive	No
	11n/ac ((V)HT40)	5510-5710 MHz[15]	Passive	No

[15] The frequency band 5600 MHz - 5640 MHz (11a/n/ac 20M band), 5590 MHz - 5630 MHz (11n/ac 40M band) and 5610 MHz (11ac 80M band) is restricted in ISED.

Frequency of Operation			Scan	Ad-hoc Mode
	11ac (VHT80)	5530-5690 MHz[15]	Passive	No
W58	11a/n/ac ((V)HT20)	5745-5825 MHz	Active	Yes
	11n/ac ((V)HT40)	5755-5795 MHz	Active	Yes
	11ac (VHT80)	5775 MHz	Active	Yes

End users cannot modify the software because F/W & driver are installed in device.

15.4 Europe

Table 54 shows the per antenna port power table for WLAN 2.4 GHz for Europe. **Table 55** shows the per antenna port power table WLAN 5 GHz for Europe.

Table 54: Europe Power Level 2.4 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)
Channels		**1 ~ 13**
11b	All Rates	17.0
11g	6 ~ 24 Mbps	16.0
	36 ~ 54 Mbps	13.0
11n HT20	MCS0 ~ MCS4	14.0
	MCS5 ~ MCS7	12.0

Table 55: Europe Power Level 5 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)					
Channels		**36 ~ 40**	**44 ~ 56**	**60 ~ 104**	**108 ~ 132**	**136 ~ 140**	**149 ~ 165**
11a	6 ~ 24 Mbps	12.0	15.0	12.0	15.0	12.0	11.0
	36 ~ 54 Mbps	12.0	13.0	12.0	13.0	12.0	11.0
11n HT20	MCS0 ~ MCS3	12.0	15.0	12.0	15.0	12.0	11.0
	MCS4 ~ MCS7	12.0	13.0	12.0	13.0	12.0	11.0
11ac VHT20	MCS0 ~ MCS3	12.0	15.0	12.0	15.0	12.0	11.0
	MCS4 ~ MCS8	12.0	13.0	12.0	13.0	12.0	11.0
Channels		**38**	**46 ~ 54**	**62 ~ 102**	**110 ~ 126**	**134 ~ 159**	
11n HT40	MCS0 ~ MCS3	10.0	15.0	10.0	15.0	10.0	
	MCS4 ~ MCS7	10.0	13.0	10.0	13.0	10.0	
11ac VHT40	MCS0 ~ MCS3	10.0	15.0	10.0	15.0	10.0	
	MCS4 ~ MCS7	10.0	13.0	10.0	13.0	10.0	
	MCS8 ~ MCS9	10.0	10.0	10.0	10.0	10.0	
Channels		**42 ~ 155**					
11ac VHT80	MCS0 ~ MCS9	10.0					

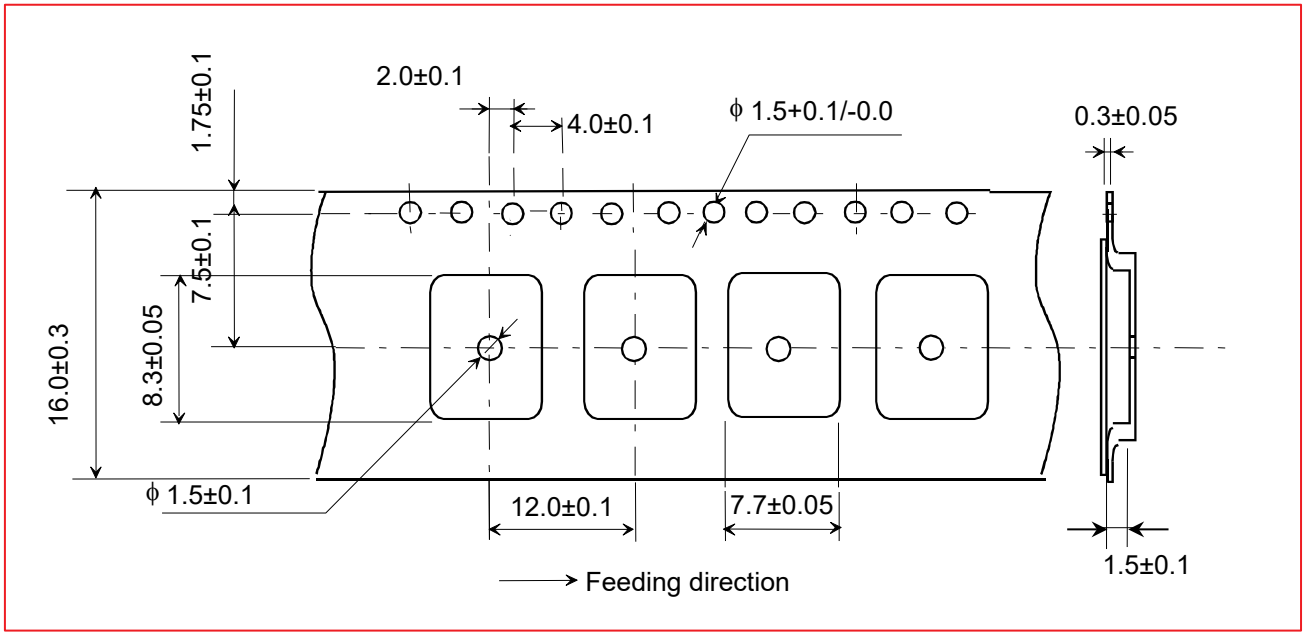
16 Tape and Reel Packing

This section provides the general specifications for tape and reel packing.

16.1 Dimensions of Tape (Plastic Tape)

Figure 27 is a graphical representation of the tape dimension (plastic tape).

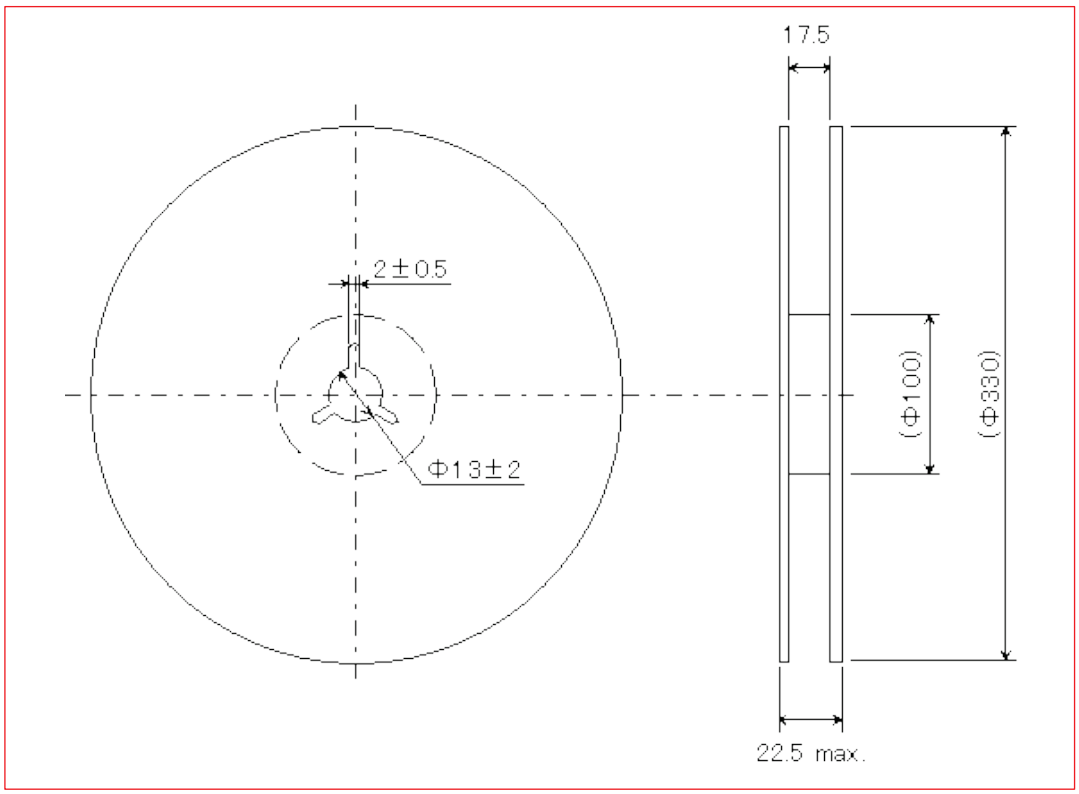
Figure 27: Dimensions of Tape (Plastic Tape)



16.2 Dimension of Reel

Figure 28 shows the reel dimensions.

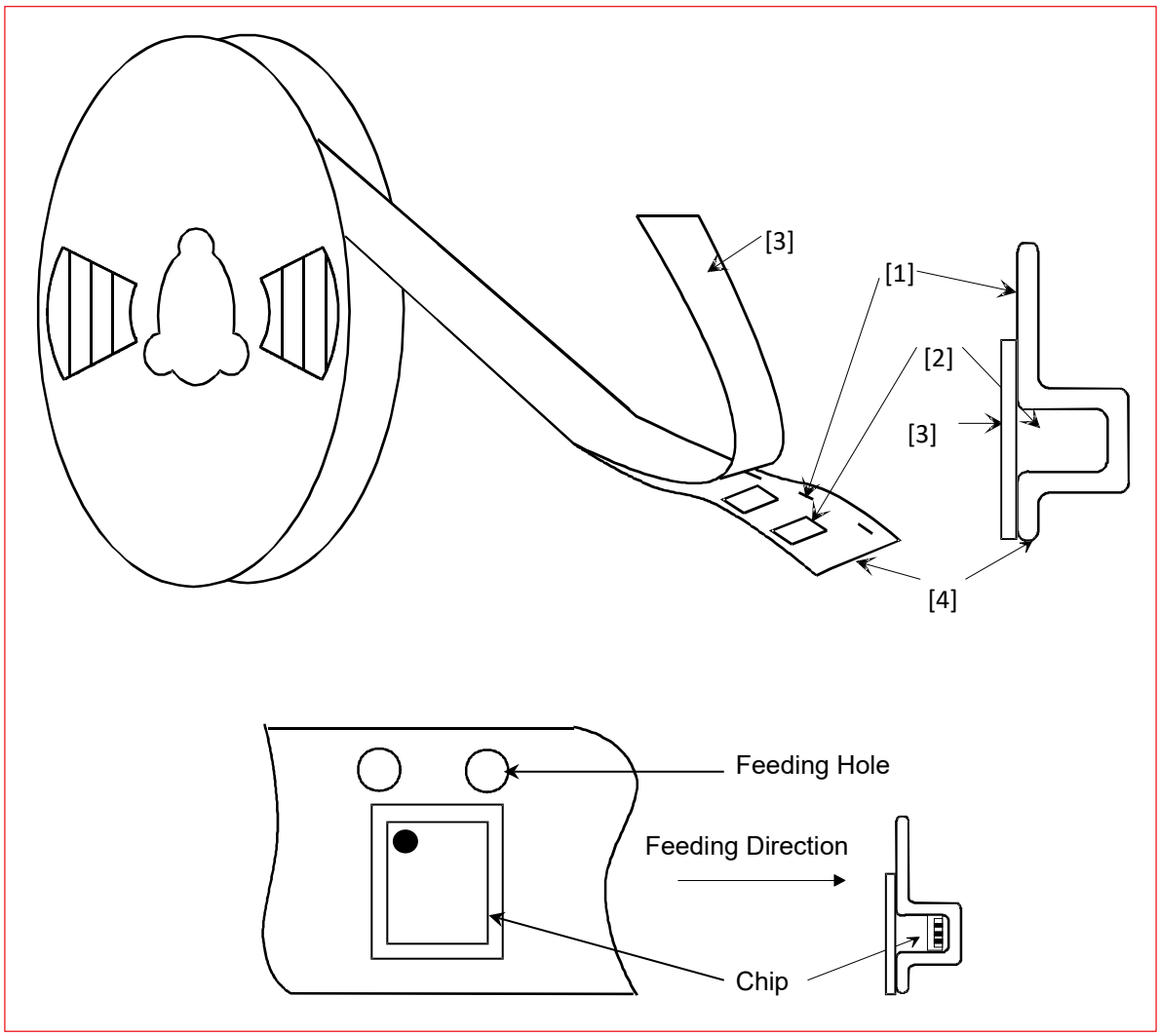
Figure 28: Dimensions of Reel



16.3 Taping Diagrams

Figure 29 shows the tapings diagrams.

Figure 29: Taping Diagrams



The taping specifications are described in **Table 56**.

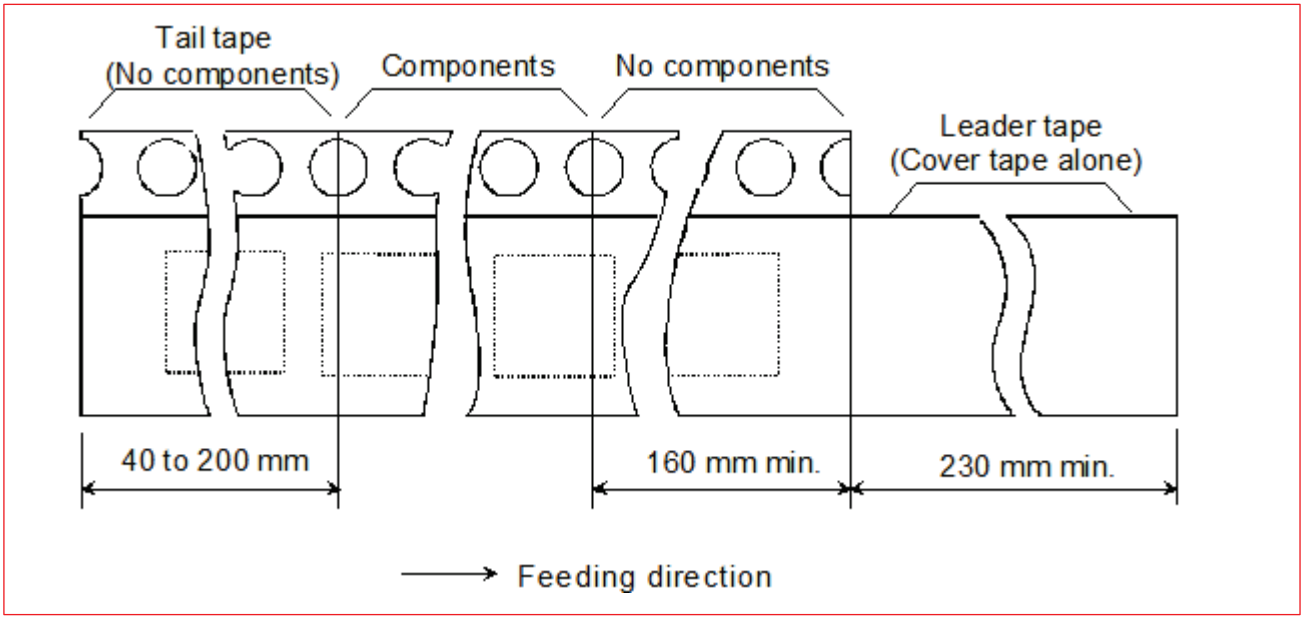
Table 56: Taping Specifications

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)

16.4 Leader and Tail Tape

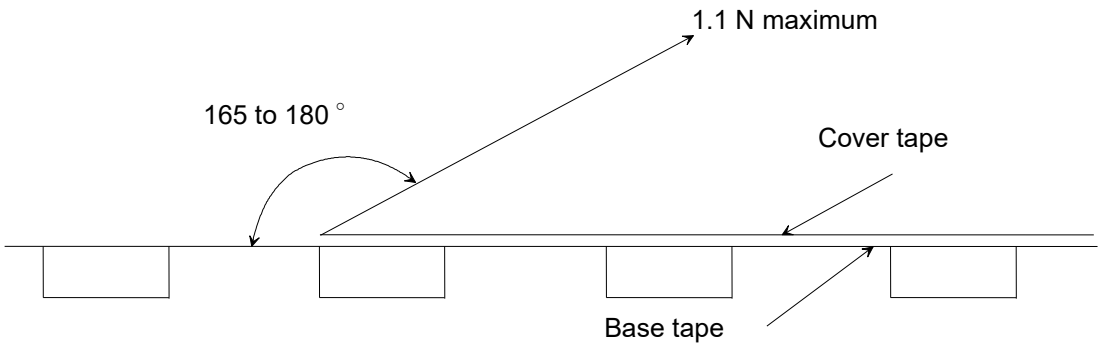
Cover tape, cavity tape and reel are made the anti-static processing. The leader and tail tape are shown in **Figure 30**.

Figure 30: Leader and Tail Tape



- The tape for chips is wound clockwise, the feeding holes to the right side as the tape is pulled toward the user.
- The cover tape and base tape are not adhered at no components area for 250 mm minimum.
- Tear off strength against pulling of cover tape: 5 N minimum.
- Packaging unit: 1,000 pcs/ reel
- Material:
  - Base tape: Plastic
  - Reel: Plastic
  - Cover tape, cavity tape and reel are made the anti-static processing.
- Peeling off force: 1.1 N maximum in the direction of peeling as shown below as shown in **Figure 31**.

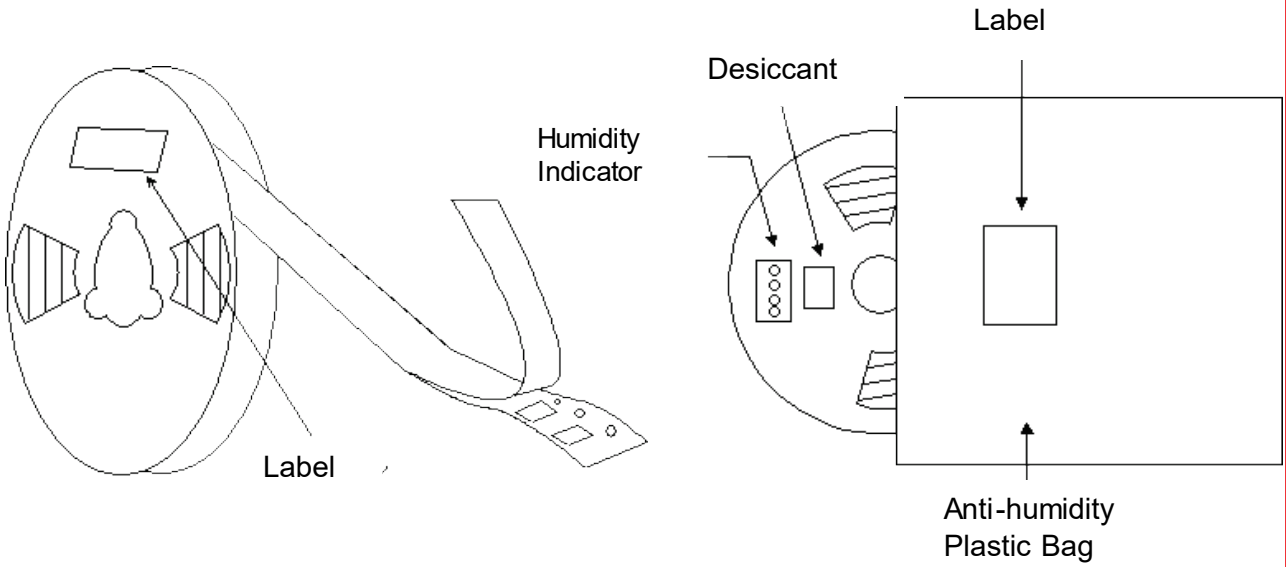
Figure 31: Peeling Force



16.5 Packaging (Humidity Proof Packing)

Figure 32 shows the humidity proof Packaging.

Figure 32: Humidity Proof Packaging



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

17 Notice

17.1 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 solderability of the product left idle for more than 6 months after receipt needs to be confirmed before it is 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 as that will damage the packing materials.
- This product is applicable to MSL3 (Based on JEDEC Standard J-STD-020)
  - After the packing is opened, the product shall be stored at ≤ 30 °C / ≤ 60 %RH and the product should be used within 168 hours after opening.
  - When the color of the indicator in the packing is 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.

17.2 Handling Conditions

- Be careful while handling or transporting products because excessive stress or mechanical shock may break the products.
- Handle with care if you suspect that 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 as that may cause poor solderability and destroy solderability by static electrical charge.

17.3 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 should be as per 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 in advance.

17.4 Notice for Chip Placer

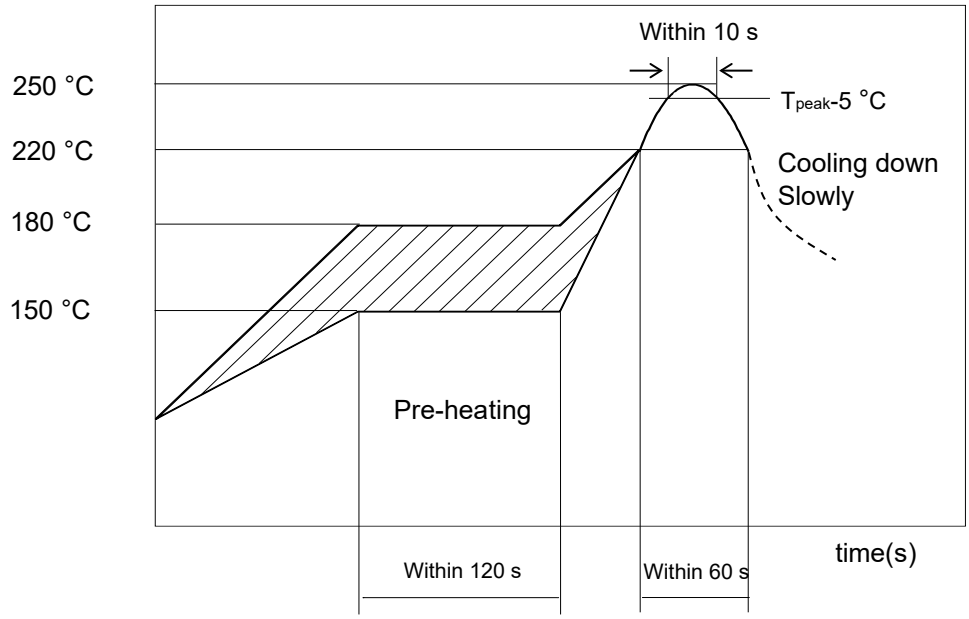
When placing products on the PCB, products may be stressed and broken by uneven forces from a worn-out chucking locating claw or a suction nozzle. To prevent products from damages, be sure to follow the specifications for the maintenance of the chip placer being used. For the positioning of products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

17.5 Soldering Conditions

The recommendation conditions of soldering are as in **Figure 33**.

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

Figure 33: 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.

17.6 Cleaning

Since this Product is Moisture Sensitive, cleaning is not recommended. If any cleaning process is done the customer is responsible for any issues or failures caused such process.

17.7 Operational Environment Conditions

Murata products are designed to work for electronic products under normal environmental conditions (ambient temperature, humidity, and pressure). Therefore, there is no problem in using the products under the above-mentioned conditions. However, using the products under the following circumstances may damage products and cause electricity leakage and abnormal temperature may occur:

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

If there is any chance of using the products under the conditions listed above, consult with Murata before actual use.

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

17.8 Input Power Capacity

Products shall be used in the input power capacity as specified in these specifications.

Inform Murata beforehand, in case that the components are used beyond such input power capacity range.

18 Preconditions to Use Our Products

PLEASE READ THIS NOTICE BEFORE USING OUR PRODUCTS.

Please make sure that your product has been evaluated and confirmed from the aspect of the fitness for the specifications of our product when our product is mounted to your product.

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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- Aerospace equipment.
- Undersea equipment.
- Power plant control equipment.
- Medical equipment.
- Traffic signal equipment.

- Burning / explosion control equipment.
- Disaster prevention / crime prevention equipment.
- 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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Moreover, you must comply with "foreign exchange and foreign trade law", the "U.S. export administration regulations", etc.

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Revision History

Revision Code	Date	Changed Item	Comment
	2016.10.03	Initial Release	
A	2017.04.26	1. Scope 2. Key Feature 14.7 DC/RF Characteristics for Bluetooth 14.8 DC/RF Characteristics for Bluetooth LE）	Changed BT version.
B	2017.05.19	2. Key Feature 8. Operating condition 12. Digital I/O Requirements 13. Electrical characteristics 15. Reference Circuit	• Changed IC vendor name. • corrected • Added • Corrected • Added
C	2017.08.02	Modify Bluetooth Specification Version	Modify Bluetooth Specification Version
D	2017.08.04	13. Finalize WLAN TBD Spec value	Finalize WLAN TBD Spec value
E	2017.08.17	15. Reference Circuit	Corrected
F	2017.09.04	14.3.2 Low-Rate Condition for IEEE 802.11g – 2.4 GHz	Corrected Power Levels
G	2018.01.10	8. Operating Condition	Changed VBAT minimum Voltage
H	2018.04.17	13. Electrical Characteristic	Updated
I	2018.04.23	13. Electrical Characteristic	Corrected
J	2018.06.13	6. Certification information 18. Radio Regulatory Certification by Country for VPYLBEE5HY1MW	• Added • Added
K	2018.11.29	13.9 DC/RF Characteristics for Bluetooth	Modify Bluetooth Specification Version 4.2 to 5.0
L	2018.12.28	15. Reference Circuit 17.5 Storage Conditions 17.6 Cleaning	Revised
M	2019.02.28	6. Europe certification information	Corrected
N	2019.05.16	6.1 Bluetooth Qualification 21. Preconditions to use Murata products 18. Radio Regulatory Certification by Country for VPYLBEE5HY1MW	• Added • Updated • Added user manual for Japan certification
O	2020.03.19	8. Operating Conditions	Updated Temperature Range to “-30~85”
P	2020.06.25	6. Radio Certification	Added Canada’s country code information.
Q	2022.06.10	2. Key Features	Silicon manufacturer name is revised
R	2022.12.10	1. Scope 2. Key Features 13. Reference Circuit Appendix	• Updated information. • Updated information. • Moved section to HW app note. • Moved Appendix information into Sections 16 and 17. Updated to new format