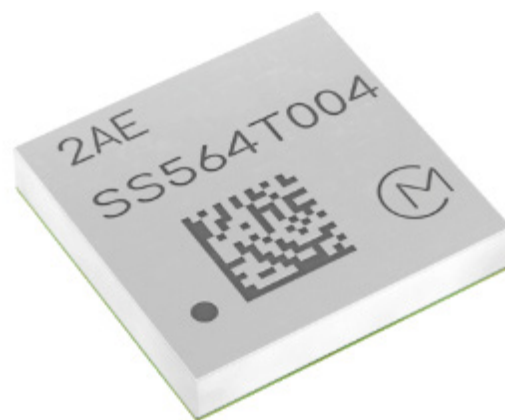


# Type 2AE Wi-Fi® + Bluetooth® Module

Infineon CYW4373E Chipset for 802.11a/b/g/n/ac +  
Bluetooth 5.2 Datasheet - Rev. M

- Design Name: Type 2AE
- Module P/N: LBEE5PK2AE-564



## Table of Contents

1 Scope .....	8
2 Key Features .....	8
3 Ordering Information .....	8
4 Block Diagram .....	9
5 Certification Information .....	10
5.1 Radio Certification .....	10
5.2 Bluetooth Qualification .....	10
6 Dimensions, Markings and Terminal Configurations .....	11
7 Module Pin Descriptions .....	12
7.1 Module Pin Layout .....	12
7.2 Pin Descriptions .....	13
7.3 SDIO Pin Descriptions .....	16
8 Absolute Maximum Ratings .....	17
9 Operating Conditions .....	17
9.1 Operating Conditions .....	17
9.2 External Sleep Clock Requirements .....	18
10 Power-On Sequence .....	18
10.1 Power-On Sequence for WLAN ON and BT ON .....	18
10.2 Power-On Sequence for WLAN ON and BT OFF .....	19
10.3 Power-On Sequence for WLAN OFF and BT ON .....	19
10.4 Power-On Sequence for WLAN OFF and BT OFF .....	20
11 Digital I/O Requirements .....	20
11.1 Digital I/O Pins .....	20
11.2 RF Switch Control Output Pins .....	21
12 Interface Timing .....	21
12.1 SDIO Timing - Default Mode .....	21
12.2 SDIO Timing - High Speed Mode .....	22
12.3 SDIO BUS Timing Specifications in SDR Mode .....	23
12.3.1 Clock Timing .....	23
12.3.2 Card Input Timing .....	24
12.3.3 Card Output Timing .....	25
12.4 SDIO Timing Specifications in DDR50 Mode .....	27
12.4.1 SDIO Clock Timing .....	27
12.4.2 SDIO Data Timing .....	27
12.5 UART Timing - Default Mode .....	28

12.6 Bluetooth PCM Timing .....	29
12.6.1 Short Frame Sync - Master Mode.....	29
12.6.2 Short Frame Sync - Slave Mode.....	30
12.6.3 Long Frame Sync - Master Mode .....	31
12.6.4 Long Frame Sync - Slave Mode .....	32
12.6.5 Short Frame Sync - Burst Mode .....	33
12.6.6 Long Frame Sync - Burst Mode.....	34
13 DC/RF Characteristics .....	35
13.1 DC/RF Characteristics for IEEE 802.11b - 2.4 GHz.....	35
13.1.1 High-Rate Condition for IEEE 802.11b - 2.4 GHz .....	35
13.1.2 Low-Rate Condition for IEEE 802.11b - 2.4 GHz.....	36
13.2 DC/RF Characteristics for IEEE 802.11g - 2.4GHz.....	37
13.2.1 High-Rate Condition for IEEE 802.11g - 2.4 GHz .....	37
13.2.2 Low-Rate Condition for IEEE 802.11g - 2.4 GHz .....	38
13.3 DC/RF Characteristics for IEEE 802.11n - 2.4 GHz.....	39
13.3.1 High-Rate Condition for IEEE 802.11n - 2.4 GHz .....	39
13.3.2 Low-Rate Condition for IEEE 802.11n - 2.4 GHz .....	40
13.4 DC/RF Characteristics for IEEE 802.11a - 5 GHz.....	41
13.4.1 High-Rate Condition for IEEE 802.11a - 5 GHz .....	41
13.4.2 Low-Rate Condition for IEEE 802.11a - 5 GHz.....	42
13.5 DC/RF Characteristics for IEEE 802.11n (HT20) - 5 GHz.....	43
13.5.1 High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz .....	43
13.5.2 Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz.....	44
13.6 DC/RF Characteristics for IEEE 802.11ac (VHT20) - 5 GHz .....	45
13.6.1 High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz .....	45
13.6.2 Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz.....	46
13.7 DC/RF Characteristics for IEEE 802.11n (HT40) - 5 GHz.....	47
13.7.1 High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz .....	47
13.7.2 Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz.....	48
13.8 DC/RF Characteristics for IEEE 802.11ac (VHT40) - 5 GHz .....	49
13.8.1 High-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz .....	49
13.8.2 Low-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz.....	50
13.9 DC/RF Characteristics for IEEE 802.11ac (VHT80) - 5 GHz .....	51
13.9.1 High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz .....	51
13.9.2 Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz.....	52
13.10 DC/RF Characteristics for Bluetooth.....	53
13.11 DC/RF Characteristics for Bluetooth Low Energy .....	54

14 Land Pattern .....	55
15 Radio Regulatory Certification by Country for LBEE5PK2AE .....	56
15.1 Japan .....	56
15.1.1 Power Level for Japan .....	56
15.1.2 Theory of Operation for Japan .....	57
15.2 FCC .....	58
15.2.1 Information to Display on Host Device and User Manual .....	58
15.2.2 Compliance with FCC requirement 15.407(c) .....	59
15.2.3 Equipment Installation for FCC .....	59
15.2.4 Power Levels for FCC .....	60
15.2.5 Theory of Operation for FCC and ISED .....	61
15.3 ISED .....	62
15.3.1 Information to Display on Host Device and User Manual .....	62
15.3.2 Antenna Installation in End Product .....	63
15.3.3 Mobile Equipment Installation for ISED .....	64
15.3.4 Antenna .....	64
15.3.5 Power Levels for ISED .....	64
15.4 Europe .....	65
15.4.1 Power Levels for Europe .....	65
15.4.2 Theory of Operation for Europe .....	66
16 Tape and Reel Packing .....	67
16.1 Dimensions of Tape (Plastic Tape) .....	67
16.2 Dimension of Reel .....	68
16.3 Taping Diagrams .....	69
16.4 Leader and Tail Tape .....	70
16.5 Humidity Proof Packaging .....	71
17 Notice .....	72
17.1 Storage Conditions .....	72
17.2 Handling Conditions .....	72
17.3 Standard PCB Design (Land Pattern and Dimensions): .....	72
17.4 Notice for Chip Placer .....	73
17.5 Soldering Conditions .....	73
17.6 Cleaning .....	73
17.7 Operational Environment Condition .....	74
17.8 Input Power Capacity .....	74
18 Preconditions to Use Our Products .....	75
Revision History .....	77

## Figures

Figure 1: Block Diagram .....	9
Figure 2: Dimensions, Markings and Terminal Configurations .....	11
Figure 3: Structure .....	12
Figure 4: Pin Assignments - Top View .....	12
Figure 5: SDIO Modes .....	16
Figure 6: Power-On Sequence - WLAN ON and BT ON .....	18
Figure 7: Power-On Sequence - WLAN ON and BT OFF .....	19
Figure 8: Power-On Sequence - WLAN OFF and BT ON .....	19
Figure 9: Power-On Sequence - WLAN OFF and BT OFF .....	20
Figure 10: SDIO Timing Diagram - Default Mode .....	21
Figure 11: SDIO Timing Diagram – High Speed Mode .....	22
Figure 12: Clock Timing Diagram - SDR Mode .....	23
Figure 13: Card Input Timing Diagram - SDR Mode .....	24
Figure 14: SDIO Bus Output Timing Diagram - SDR Modes up to 100 MHz .....	25
Figure 15: SDIO Bus Output Timing Diagram - SDR Modes 100 MHz to 208 MHz .....	26
Figure 16: $\Delta$ top Consideration for Variable Data Window - SDR 104 Mode .....	26
Figure 17: SDIO Clock Timing Diagram - DDR50 Mode .....	27
Figure 18: SDIO Data Timing Diagram - DDR50 Mode .....	27
Figure 19: UART Timing Diagram - Default Mode .....	28
Figure 20: Short Frame Sync Signal - Master Mode .....	29
Figure 21: Short Frame Sync Signal - Slave Mode .....	30
Figure 22: Long Frame Sync Signal - Master Mode .....	31
Figure 23: Long Frame Sync Signal - Slave Mode .....	32
Figure 24: Short Frame Sync Signal - Burst Mode .....	33
Figure 25: Long Frame Sync Signal - Burst Mode .....	34
Figure 26: Land Pattern (Unit: mm) .....	55
Figure 27: Dimensions of Tape (Unit: mm) .....	67
Figure 28: Dimensions of Reel (Unit: mm) .....	68
Figure 29: Taping Diagrams .....	69
Figure 30: Taping Diagrams (Close Up) .....	69
Figure 31: Leader and Tail Tape .....	70
Figure 32: Peeling Force .....	70
Figure 33: Humidity Proof Packaging .....	71
Figure 34: Reflow Soldering Standard Conditions (Example) .....	73

## Tables

Table 1: Document Conventions .....	7
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Table 2: Ordering Information .....	8
Table 3: Radio Certification.....	10
Table 4: Markings .....	11
Table 5: Dimensions .....	11
Table 6: Terminal Configurations .....	13
Table 7: Pin Descriptions .....	13
Table 8: SDIO Pin Descriptions .....	16
Table 9: Strapping Options .....	17
Table 10: Ratings.....	17
Table 11: Operating Conditions .....	17
Table 12: External LPO Signal Requirements.....	18
Table 13: Digital I/O Pins .....	20
Table 14: RF Switch Control Output Pins.....	21
Table 15: SDIO Timing Data - Default Mode.....	21
Table 16: SDIO Timing Data - High Speed Mode.....	22
Table 17: Clock Timing Parameters - SDR Mode.....	23
Table 18: Card Input Timing Parameters - SDR Mode.....	24
Table 19: SDIO Bus Output Timing Parameters - SDR Modes up to 100 MHz .....	25
Table 20: SDIO Bus Output Timing Parameters - SDR Modes 100 MHz to 208 MHz .....	26
Table 21: SDIO Clock Timing Parameters - DDR50 Mode.....	27
Table 22: SDIO Data Timing Parameters - DDR50 Mode .....	28
Table 23: UART Timing Parameters - Default Mode .....	28
Table 24: Common Baud Rate Examples .....	29
Table 25: Short Frame Sync Signal Parameters - Master Mode .....	29
Table 26: Short Frame Sync Signal Parameters - Slave Mode .....	30
Table 27: Long Frame Sync Signal Parameters - Master Mode.....	31
Table 28: Long Frame Sync Signal Parameters - Slave Mode .....	32
Table 29: Short Frame Sync Signal Parameters - Burst Mode.....	33
Table 30: Long Frame Sync Signal Parameters - Burst Mode.....	34
Table 31: DC/RF Characteristics Files .....	35
Table 32: Characteristics Values for IEEE 802.11b - 2.4 GHz.....	35
Table 33: High-Rate Condition for IEEE 802.11b - 2.4 GHz.....	35
Table 34: Low-Rate Condition for IEEE 802.11b - 2.4 GHz.....	36
Table 35: Characteristics Values for IEEE 802.11g - 2.4 GHz.....	37
Table 36: High-Rate Condition for IEEE 802.11g - 2.4 GHz.....	37
Table 37: Low-Rate Condition for IEEE 802.11g - 2.4 GHz.....	38
Table 38: Characteristics Values for IEEE 802.11n - 2.4 GHz.....	39
Table 39: High-Rate Condition for IEEE 802.11n - 2.4 GHz.....	39
Table 40: Low-Rate Condition for IEEE 802.11n - 2.4 GHz.....	40
Table 41: Characteristics Values for IEEE 802.11a - 5 GHz.....	41

Table 42: High-Rate Condition for IEEE 802.11a - 5 GHz.....	41
Table 43: Low-Rate Condition for IEEE 802.11a - 5 GHz.....	42
Table 44: Characteristics Values for IEEE 802.11n (HT20) - 5 GHz.....	43
Table 45: High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz.....	43
Table 46: Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz.....	44
Table 47: Characteristics Values for IEEE 802.11ac (VHT20) - 5 GHz .....	45
Table 48: High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz.....	45
Table 49: Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz.....	46
Table 50: Characteristics Values for IEEE 802.11n (HT40) - 5 GHz.....	47
Table 51: High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz.....	47
Table 52: Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz.....	48
Table 53: Characteristics Values for IEEE 802.11ac (VHT40) - 5 GHz .....	49
Table 54: High-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz.....	49
Table 55: Low-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz.....	50
Table 56: Characteristics Values for IEEE 802.11ac (VHT80) - 5 GHz .....	51
Table 57: High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz.....	51
Table 58: Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz.....	52
Table 59: DC/RF Characteristics for Bluetooth .....	53
Table 60: DC/RF Characteristics for BLE.....	54
Table 61: Japan Power Level 2.4 GHz WLAN Per Antenna Port .....	56
Table 62: Japan Power Level 2.4GHz BT/BLE Per Antenna Port .....	57
Table 63: Japan Power Level 5 GHz WLAN Per Antenna Port .....	57
Table 64: Japan Theory of Operation for WLAN .....	57
Table 65: Japan Theory of Operation for Bluetooth.....	58
Table 66: FCC/ISED Power Level 2.4 GHz WLAN Per Antenna Port.....	60
Table 67: FCC Power Level 2.4 GHz BT/BLE Per Antenna Port.....	60
Table 68: FCC Power Level 5 GHz WLAN Per Antenna Port.....	60
Table 69: FCC/ISED Theory of Operation for WLAN .....	61
Table 70: FCC/ISED Theory of Operation for Bluetooth.....	61
Table 71: ISED Power Level 2.4 GHz WLAN Per Antenna Port.....	64
Table 72: ISED Power Level 2.4 GHz BT/BLE Per Antenna Port.....	65
Table 73: ISED Power Level 5 GHz WLAN Per Antenna Port.....	65
Table 74: Europe Power Level 2.4 GHz WLAN Per Antenna Port.....	65
Table 75: Europe Power Level 2.4 GHz BT/BLE Per Antenna Port.....	66
Table 76: Europe Power Level 5 GHz WLAN Per Antenna Port.....	66
Table 77: Europe Theory of Operation for WLAN.....	66
Table 78: Europe Theory of Operation for Bluetooth.....	67
Table 79: Taping Specifications .....	69

## About This Document

Type 2AE is a small and very high-performance module based on Infineon CYW4373E combo chipset which supports Wi-Fi 802.11a/b/g/n/ac + Bluetooth 5.2 BR/EDR/LE. This datasheet describes Type 2AE 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
	<b>Warning Note</b> Indicates very important note. Users are strongly recommended to review.
	<b>Info Note</b> Intended for informational purposes. Users should review.
	<b>Menu Reference</b> Indicates menu navigation instructions. <b>Example:</b> Insert → Tables → Quick Tables → Save Selection to Gallery 
	<b>External Hyperlink</b> This symbol indicates a hyperlink to an external document or website. <b>Example:</b> <a href="#">Murata</a>  Click on the text to open the external link.
	<b>Internal Hyperlink</b> This symbol indicates a hyperlink within the document. <b>Example:</b> <a href="#">Scope</a>  Click on the text to open the link.
<code>Console input/output or code snippet</code>	<b>Console I/O or Code Snippet</b> This text <b>Style</b> denotes console input/output or a code snippet.
<code># Console I/O comment // Code snippet comment</code>	<b>Console I/O or Code Snippet Comment</b> This text <b>Style</b> denotes a console input/output or code snippet comment. <ul style="list-style-type: none"> <li>• Console I/O comment (preceded by "#") is for informational purposes only and does not denote actual console input/output.</li> <li>• Code Snippet comment (preceded by "//") may exist in the original code.</li> </ul>




## 1 Scope

This specification characterizes the IEEE 802.11a/b/g/n/ac + Bluetooth 5.2 BR/EDR/LE combo module.

## 2 Key Features

- ◆ Infineon CYW4373E 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 5.2
- ◆ For supported Bluetooth functions, refer to [Bluetooth SIG site](#) 
- ◆ WLAN interface: SDIO 3.0, USB 2.0 (shared)
- ◆ Bluetooth interface: HCI UART, USB 2.0 (shared) and PCM
- ◆ Reference Clock: Reference clock embedded.
- ◆ Temperature Range: -40 °C to 85 °C
- ◆ Dimensions: 8.0 x 7.8 x 1.15 mm
- ◆ Weight: 0.2 g
- ◆ MSL: 3
- ◆ Surface-mount type
- ◆ RoHS compliant



This product is moisture sensitive. Please check the detail in [Section 17.1 Storage Condition](#) 

## 3 Ordering Information

Table 2: Ordering Information

Ordering Part Number	Description
LBEE5PK2AE-564	Module order
LBEE5PK2AE-SMP	Sample module order (If module samples are not available through distribution, contact Murata referencing this part number)
EAR00388	Embedded Artists Type 2AE M.2 EVB (default EVB available through distribution)
LBEE5PK2AE-EVB	Murata Type 2AE EVB (contact Murata as this is special order item)

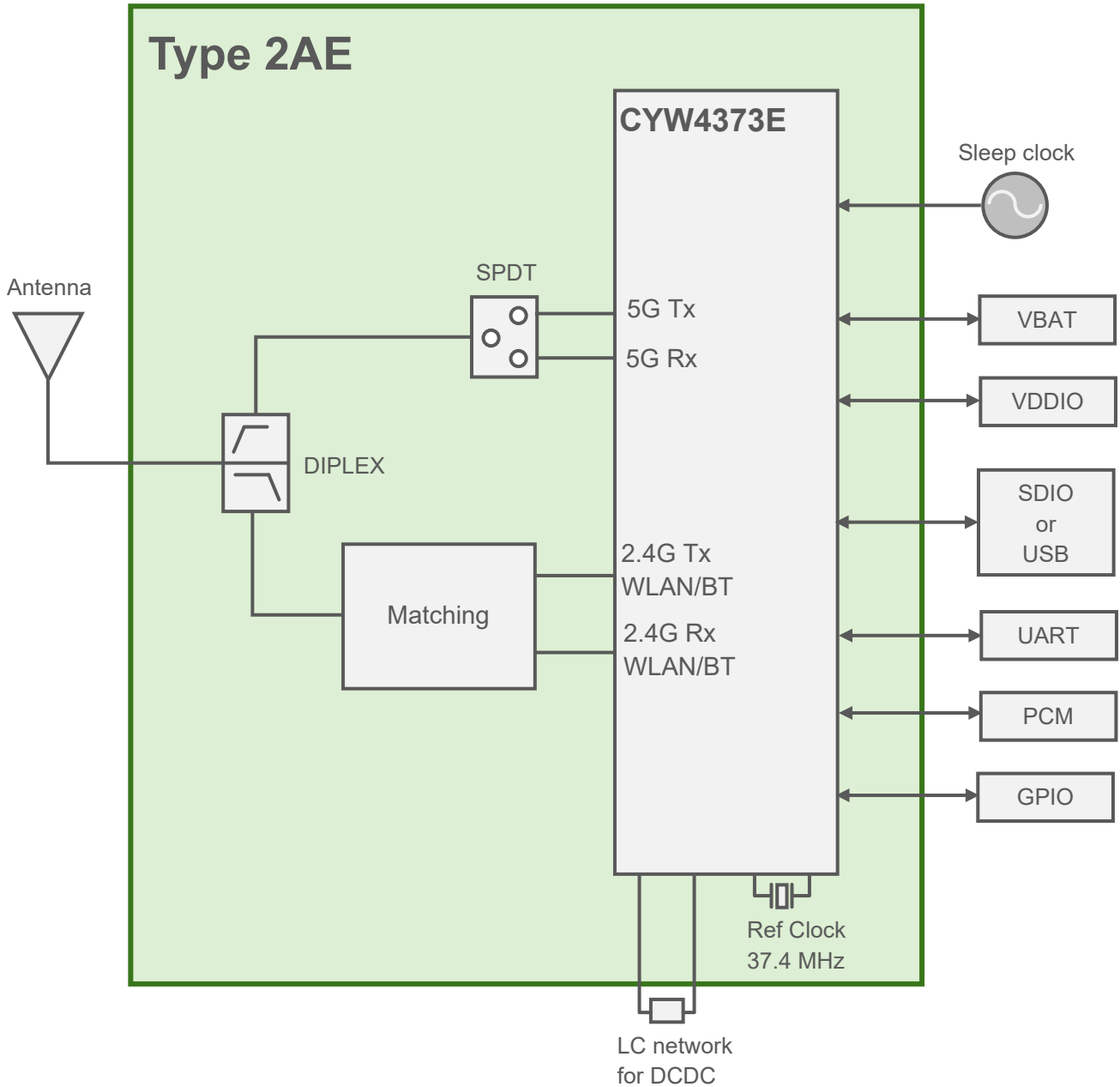


“Type 2AE” is the design name of this module. Design name may be used in certification test report.

## 4 Block Diagram

Figure 1 shows the Type 2AE internal block diagram.

Figure 1: Block Diagram



## 5 Certification Information

This section describes the radio and Bluetooth certification information.


### 5.1 Radio Certification

**Table 3** shows the certification information for different countries.

**Table 3: Radio Certification**


Country	ID	Country Code
USA (FCC)	VPYLB2AE	US/0
Canada (IC)	772C-LB2AE	CA/0
Europe	EN300328 v2.2.2 ,301893 v2.1.1, EN300440 v2.2.1 conducted test report is prepared.	DE/0
Japan	Japanese type certification is prepared. R 007-AL0056	JP/0



Please follow user/installation manual in [Section 15](#) .

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

### 5.2 Bluetooth Qualification

- QDID: 173411
- For supported Bluetooth functions, refer to [Bluetooth SIG site](#) 

## 6 Dimensions, Markings and Terminal Configurations

This section has information on dimensions, markings, and terminal configurations for Type 2AE.

Figure 2: Dimensions, Markings and Terminal Configurations

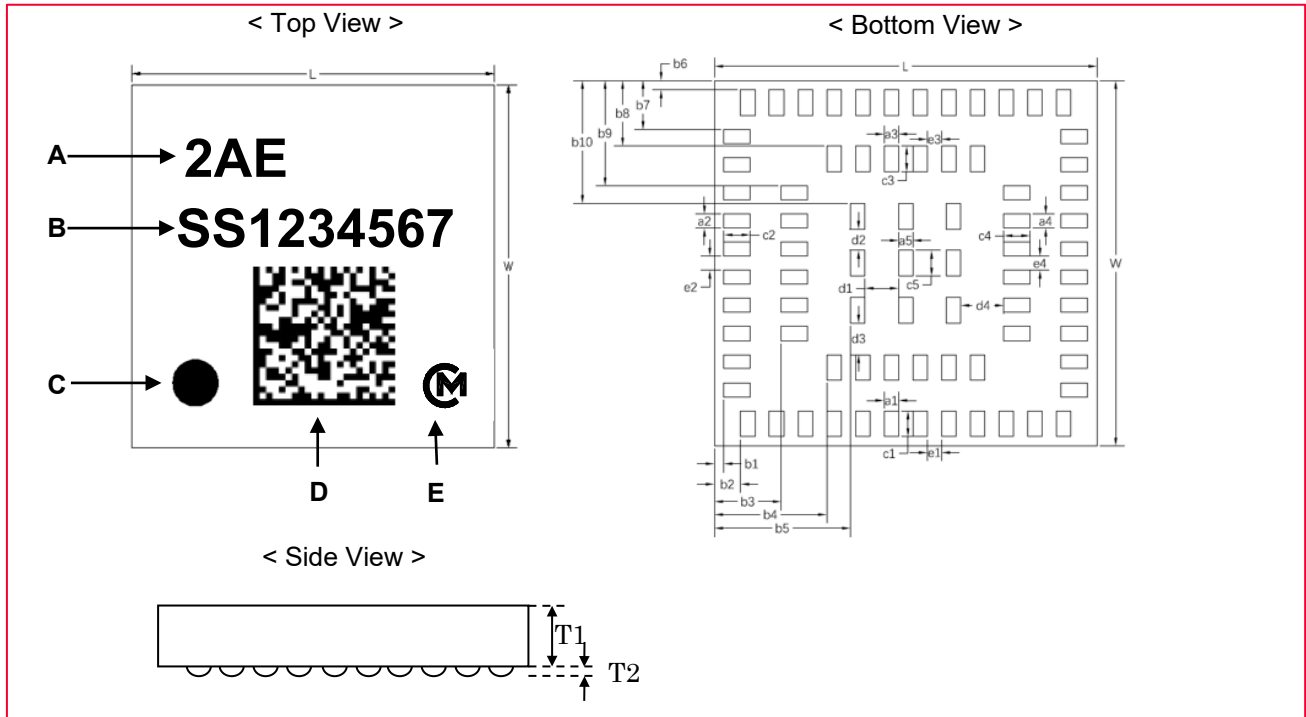


Table 4 and Table 5 describes the Type 2AE markings and dimensions.

Table 4: Markings

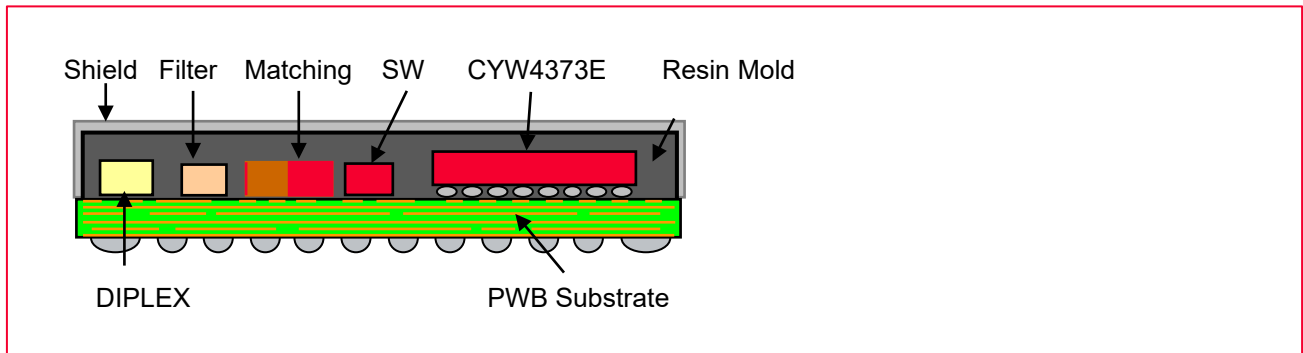
Marking	Meaning
A	Module Type
B	Inspection Number
C	Pin 1 Marking
D	2D Code (Internal Use)
E	Murata Logo

Table 5: Dimensions

Mark	Dimensions (mm)	Mark	Dimensions (mm)	Mark	Dimensions (mm)
L	8.00 ± 0.20	W	7.80 ± 0.20	T1	1.15 maximum
a1	0.30 ± 0.10	a2	0.30 ± 0.10	a3	0.30 ± 0.10
a4	0.30 ± 0.10	a5	0.30 ± 0.10	b1	0.30 ± 0.15
b2	0.55 ± 0.15	b3	1.50 ± 0.15	b4	2.35 ± 0.15
b5	2.85 ± 0.15	b6	0.30 ± 0.15	b7	1.05 ± 0.15
b8	1.50 ± 0.15	b9	2.25 ± 0.15	b10	2.675 ± 0.15
c1	0.45 ± 0.10	c2	0.45 ± 0.10	c3	0.45 ± 0.10
c4	0.45 ± 0.10	c5	0.45 ± 0.10	d1	0.70 ± 0.10
d2	0.55 ± 0.10	d3	0.725 ± 0.10	d4	0.90 ± 0.10
e1	0.30 ± 0.10	e2	0.30 ± 0.10	e3	0.30 ± 0.10
e4	0.30 ± 0.10			T2	0.045 ± 0.025

Figure 3 shows the structure.

Figure 3: Structure



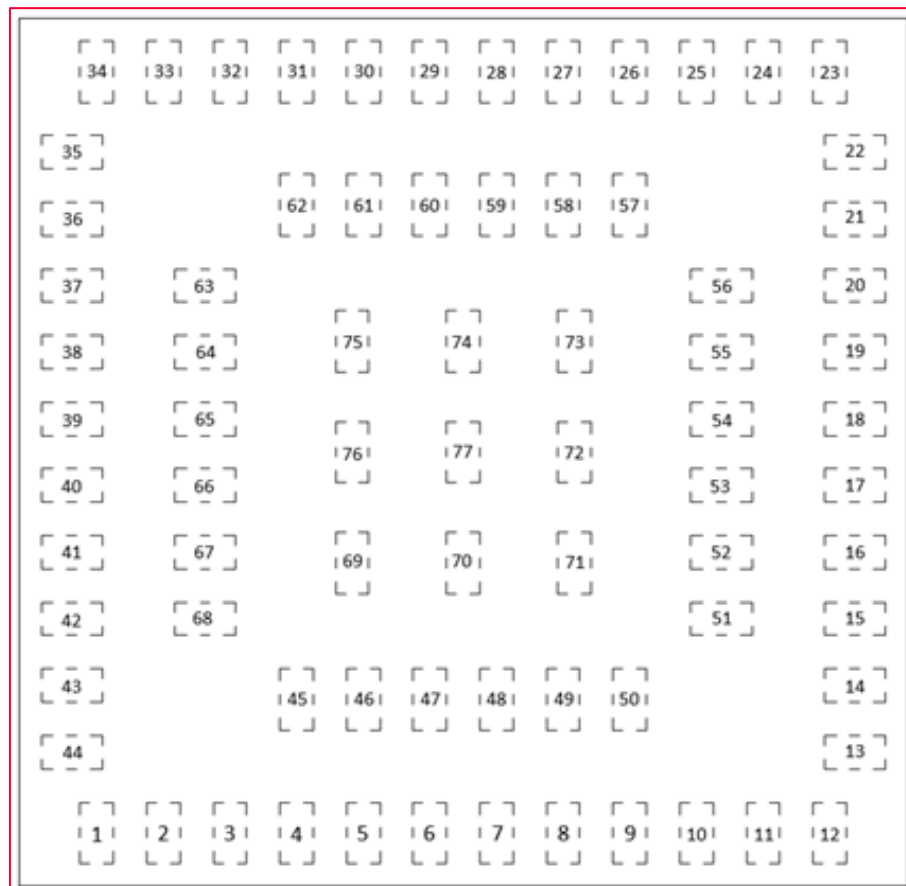
## 7 Module Pin Descriptions

This section has the pin descriptions of Type 2AE and pin assignments layout descriptions.

### 7.1 Module Pin Layout

This section has the terminal configurations and pin assignments layout of Type 2AE. The pin assignment (top view) layout is shown in Figure 4.

Figure 4: Pin Assignments - Top View



**Table 6** illustrates the terminal configurations for Type 2AE.

**Table 6: Terminal Configurations**

No.	Terminal Name	No.	Terminal Name	No.	Terminal Name	No.	Terminal Name
1	GND	21	GND	41	GND	61	NC
2	SR_VLX	22	WL_ANT	42	VDDIO	62	NC
3	VBAT	23	GND	43	VIN_LDO	63	TRST_L
4	WL_REG_EN	24	GND	44	NC	64	JTAG_TDI
5	LPO_IN	25	RF_SW_CTRL_5	45	GPIO_1	65	JTAG_TDO
6	BT_PCM_IN	26	RF_SW_CTRL_0	46	USB2_DM	66	JTAG_TCK/SWCLK
7	BT_PCM_CLK	27	GND	47	USB2_DP	67	JTAG_TMS/SWDIO
8	BT_PCM_SYNC	28	SDIO_CMD	48	USB2_MONCDR	68	BT_REG_EN
9	BT_PCM_OUT	29	SDIO_DATA_1	49	USB2_AVDD33	69	GND
10	BT_UART_TXD	30	SDIO_DATA_0	50	USB2_RREF	70	GND
11	BT_UART_CTS_N	31	SDIO_DATA_3	51	BT_DEV_WAKE	71	GND
12	BT_UART_RXD	32	SDIO_DATA_2	52	WL_HOST_WAKE	72	GND
13	BT_UART_RTS_N	33	SDIO_CLK	53	JTAG_SEL	73	GND
14	GND	34	GND	54	STRAP_1	74	GND
15	NC	35	NC	55	STRAP_2	75	GND
16	GND	36	NC	56	STRAP_0	76	GND
17	BT HOST WAKE	37	NC	57	GND	77	GND
18	BT_GPIO_2	38	NC	58	NC		
19	BT_GPIO_3	39	NC	59	NC		
20	BT_GPIO_5	40	NC	60	NC		

## 7.2 Pin Descriptions

**Table 7** describes Type 2AE pin descriptions.

**Table 7: Pin Descriptions**

No.	Terminal Name	Type	Connection to IC Terminal	Description
1	GND			
2	SR_VLX	PO	SR_VLX	CBUCK switching regulator output. Refer to Reference circuit for details of the inductor and capacitor required in this output.
3	VBAT	PI	SR_VDDBAT5V/LDO_VDDB AT5V	Supply to internal Power source of VBAT.
4	WL_REG_EN	I	WL_REG_ON	Used by PMU to power-up or power down the internal CYW4373E regulators used by the WLAN section. Also, when de-asserted, this pin holds the WLAN section in reset. This pin has an internal 200 kΩ pull-down resistor that is enabled by default. It can be disabled through programming.
5	LPO_IN	I	LPO_IN	External Sleep clock input (32.768 kHz)
6	BT_PCM_IN	I	BT_PCM_IN	PCM data input.
7	BT_PCM_CLK	I/O	BT_PCM_CLK	PCM clock; can be master(output) or slave(input).

No.	Terminal Name	Type	Connection to IC Terminal	Description
8	BT_PCM_SYNC	I/O	BT_PCM_SYNC	PCM sync; can be master(output) or slave(input).
9	BT_PCM_OUT	O	BT_PCM_OUT	PCM data output.
10	BT_UART_TXD	O	BT_UART_TXD	UART serial output. Serial data output for the HCI UART interface.
11	BT_UART_CTS_N	I	BT_UART_CTS_N	UART clear-to-send. Active-low clear- to-send signal for the HCI UART interface.
12	BT_UART_RXD	I	BT_UART_RXD	UART serial input. Serial data input for the HCI UART interface.
13	BT_UART_RTS_N	O	BT_UART_RTS_N	UART request-to-send. Active - low request - to-send signal for the HCI UART interface.
14	GND			
15	NC			
16	GND			
17	BT HOST WAKE	I/O	BT HOST WAKE	Host wake-up. Signal from the CYW4373E to the host indicating that the CYW4373E requires attention. The polarity of this signal is software configurable and can be asserted high or low.
18	BT_GPIO_2	I/O	BT_GPIO_2	Bluetooth general-purpose I/O.
19	BT_GPIO_3	I/O	BT_GPIO_3	Bluetooth general-purpose I/O.
20	BT_GPIO_5	I/O	BT_GPIO_5	Bluetooth general-purpose I/O.
21	GND			
22	WL_ANT	RF		RF output for WLAN/BT
23	GND			
24	GND			
25	RF_SW_CTRL_5	O	RF_SW_CTRL_5	Programmable RF switch control lines. The control lines are programmable via the driver and NVRAM file.
26	RF_SW_CTRL_0	O	RF_SW_CTRL_0	Programmable RF switch control lines. The control lines are programmable via the driver and NVRAM file.
27	GND	-	-	
28	SDIO_CMD	I/O	SDIO_CMD	SDIO command line
29	SDIO_DATA_1	I/O	SDIO_DATA_1	SDIO data line 1
30	SDIO_DATA_0	I/O	SDIO_DATA_0	SDIO data line 0
31	SDIO_DATA_3	I/O	SDIO_DATA_3	SDIO data line 3
32	SDIO_DATA_2	I/O	SDIO_DATA_2	SDIO data line 2
33	SDIO_CLK	I	SDIO_CLK	SDIO clock input
34	GND			
35	NC			
36	NC			
37	NC			
38	NC			
39	NC			
40	NC			
41	GND			
42	VDDIO	PI	VDDIO/BT_VDDO	Supply for PMU, BT, WLAN, SDIO.

No.	Terminal Name	Type	Connection to IC Terminal	Description
43	VIN_LDO	PI	LDO_VDD1P5/WRF_AFE_VDD1P35/WRF_XTAL_VDD1P35/WRF_PMU_VDD1P35	Input for: LDO_VDD1P5/WRF_AFE_VDD1P35/ WRF_XTAL_VDD1P35/WRF_PMU_VDD1P35
44	NC			
45	GPIO_1	I/O	GPIO_1	Programmable GPIO Pin
46	USB2_DM	I/O	USB2_DM	Data minus of shared USB2.0 port.
47	USB2_DP	I/O	USB2_DP	Data plus of shared USB2.0 port.
48	USB2_MONCDR	O	USB2_MONCDR	CDR monitor for debug.
49	USB2_AVDD33	PI	USB2_AVDD33	Power Supply for shared USB2.0. When VBAT is between 3.6V to 4.8V connect to external 3.3V power supply. When VBAT is 3.3V connect directly to VBAT.
50	USB2_RREF	I/O	USB2_RREF	Bandgap reference resistor. 4.75 kΩ +/-1% for USB. DNI for SDIO.
51	BT_DEV_WAKE	I	BT_DEV_WAKE	Bluetooth device wake-up: Signal from the host to the CYW4373E indicating that the host requires attention. The polarity of this signal is software configurable and can be asserted high or low.
52	WL_HOST_WAKE	O	GPIO_0	Programmable GPIO Pin
53	JTAG_SEL	I	JTAG_SEL	JTAG select. This pin should be kept NO CONNECT or connect to ground if the JTAG interface is not used. It must be high to select SWD OR JTAG. When JTAG_SEL = 1: <ul style="list-style-type: none"> <li>• GPIO_2 is TCK</li> <li>• GPIO_3 is TMS</li> <li>• GPIO_4 is TDIO</li> <li>• GPIO_5 is TDO</li> <li>• GPIO_6 is TRST_L</li> </ul>
54	STRAP_1	I	STRAP_1	0: SDIO only
55	STRAP_2	I	STRAP_2	USB_DISABLE <ul style="list-style-type: none"> <li>• 1: USB disable</li> <li>• 0: USB enable</li> </ul>
56	STRAP_0	I	STRAP_0	SDIO_PADVDDIO sel
57	GND			
58	NC			
59	NC			
60	NC			
61	NC			
62	NC			
63	TRST_L	I/O	GPIO_6	GPIO_6 is TRST_L
64	JTAG_TDI	I/O	GPIO_4	GPIO_4 is TDI
65	JTAG_TDO	I/O	GPIO_5	GPIO_5 is TDO
66	JTAG_TCK/SWCLK	I/O	GPIO_2	GPIO_2 is TCK/SWCLK
67	JTAG_TMS/SWDIO	I/O	GPIO_3	GPIO_3 is TMS/SWDIO
68	BT_REG_EN	I	BT_REG_ON	Used by PMU to power-up or power down the internal CYW4373E regulators used by the Bluetooth section. Also, when de-asserted, this pin holds the Bluetooth section in



No.	Terminal Name	Type	Connection to IC Terminal	Description
				reset. This pin has an internal 200 kΩ pull-down resistor that is enabled by default. It can be disabled through programming.
69	GND			
70	GND			
71	GND			
72	GND			
73	GND			
74	GND			
75	GND			
76	GND			
77	GND			

### 7.3 SDIO Pin Descriptions

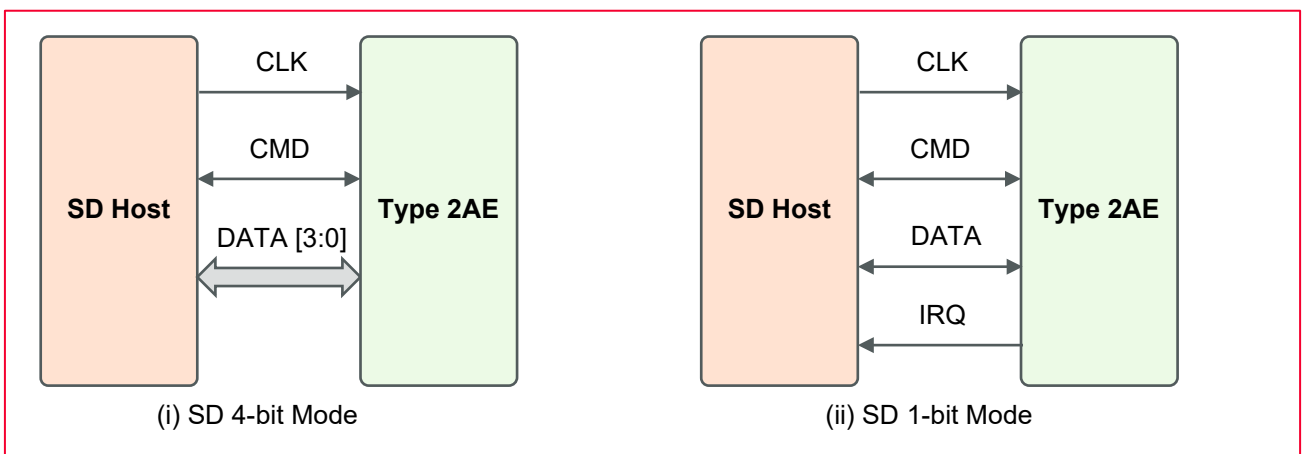
**Table 8** shows the SDIO pin descriptions.

**Table 8: SDIO Pin Descriptions**

No.	Pin Name	(i) SD 4-bit Mode		(ii) SD 1-bit Mode	
33	SDIO_CLK	CLK	Clock	CLK	Clock
30	SDIO_D0	DATA0	Data line 0	DATA	Data line
29	SDIO_D1	DATA1	Data line 1 /Interrupt	IRQ	Interrupt
32	SDIO_D2	DATA2	Data line 2	NC	Not used
31	SDIO_D3	DATA3	Data line 3	NC	Not used
28	SDIO_CMD	CMD	Command line	CMD	Command line

**Figure 5** shows the signal connections to the SDIO modes.

**Figure 5: SDIO Modes**



**Table 9** has the strapping options for Type 2AE module pins.

**Table 9: Strapping Options**

Mode Select	STRAP_2	STRAP_1	STRAP_0
USB	0	0	0
SDIO only	1	0	<ul style="list-style-type: none"> <li>• <b>0</b> = SDIO is 3.3V</li> <li>• <b>1</b> = SDIO is 1.8V</li> </ul>

## 8 Absolute Maximum Ratings

The absolute minimum and maximum ratings are shown in **Table 10**.

**Table 10: Ratings**

Parameter		Minimum	Maximum	Unit
Storage Temperature		-40	+85	°C
Supply Voltage	VBAT	-0.5	5.5	V
	VDDIO	-0.5	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.

## 9 Operating Conditions

### 9.1 Operating Conditions

The operating conditions are shown **Table 11**.

**Table 11: Operating Conditions**

Parameter		Minimum	Typical	Maximum	Unit
Operating Temperature Range <sup>1</sup>		-40	+25	+85	°C
Supply Voltage	VBAT	3.13 <sup>2</sup>	3.3	3.5 <sup>3</sup>	V
	VDDIO	1.62	1.8	1.98	V
		2.97	3.3	3.63	V

<sup>1</sup> Functionality is guaranteed but specifications require derating at extreme temperatures.

<sup>2</sup> CYW4373E is functional across this range of voltages. Optimal RF performance specified in the data sheet, however, is guaranteed only for VBAT = 3.3V +/- 5%.

<sup>3</sup> The maximum continuous voltage is 4.8V

## 9.2 External Sleep Clock Requirements

External LPO signal requirements are shown in **Table 12**.

**Table 12: 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	mV, p-p
Signal type	Square-wave or sinewave	
Input impedance <sup>4</sup>	> 100k < 5	$\Omega$ pF
Clock jitter (during initial start-up)	<10,000	ppm

## 10 Power-On Sequence

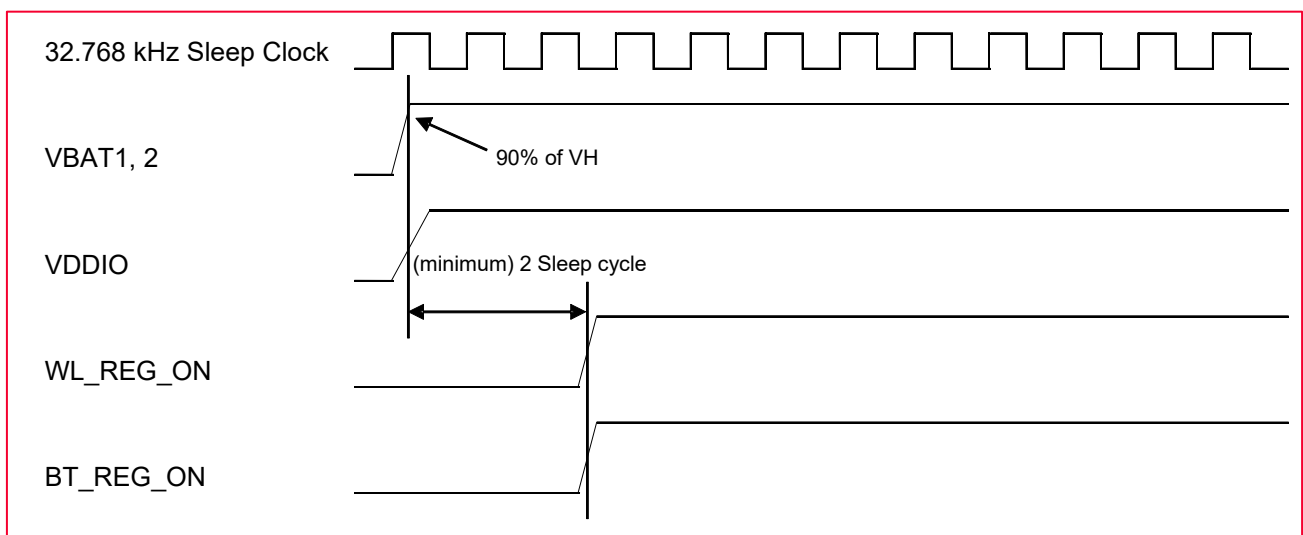
This section describes the power-on sequences along with their parameters.

### 10.1 Power-On Sequence for WLAN ON and BT ON

For power-on sequence for WLAN ON and BT ON:

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

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



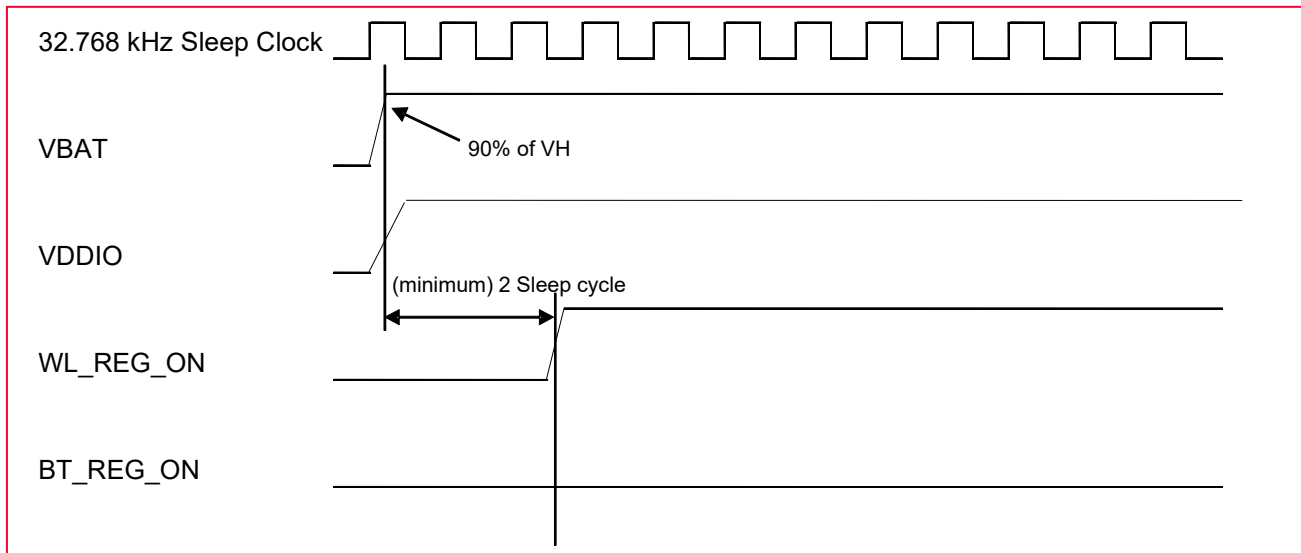
<sup>4</sup> When the power is applied or switched off.

## 10.2 Power-On Sequence for WLAN ON and BT OFF

For power-on sequence for WLAN ON and BT OFF:

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

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

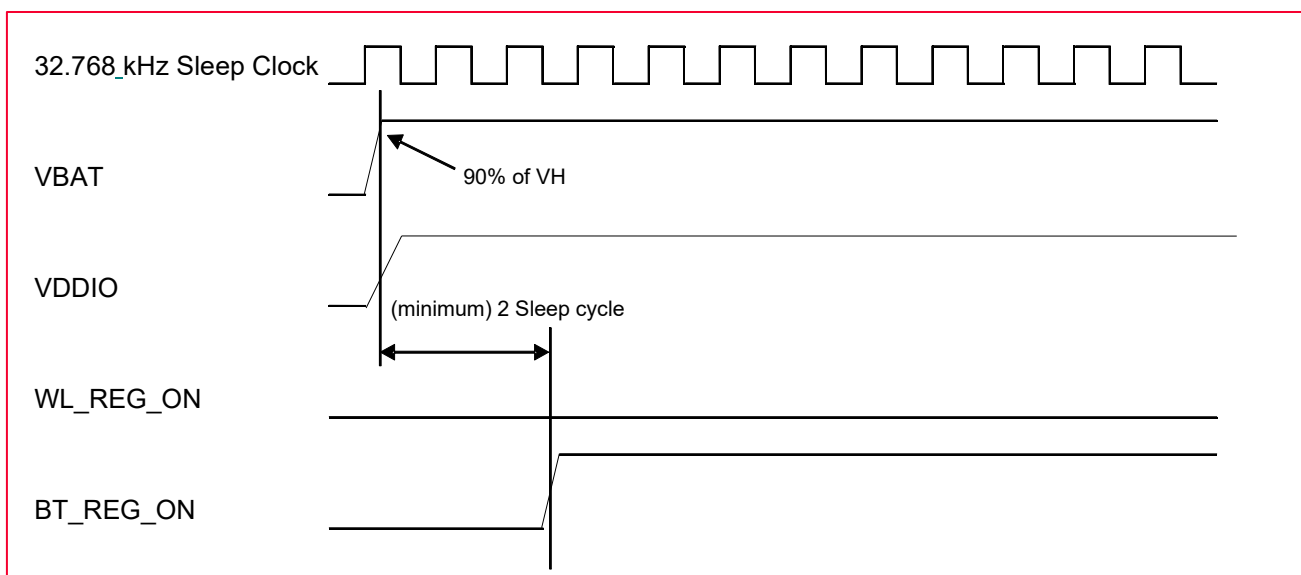


## 10.3 Power-On Sequence for WLAN OFF and BT ON

For power-on sequence for WLAN OFF and BT ON:

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

**Figure 8: Power-On Sequence - WLAN OFF and BT ON**

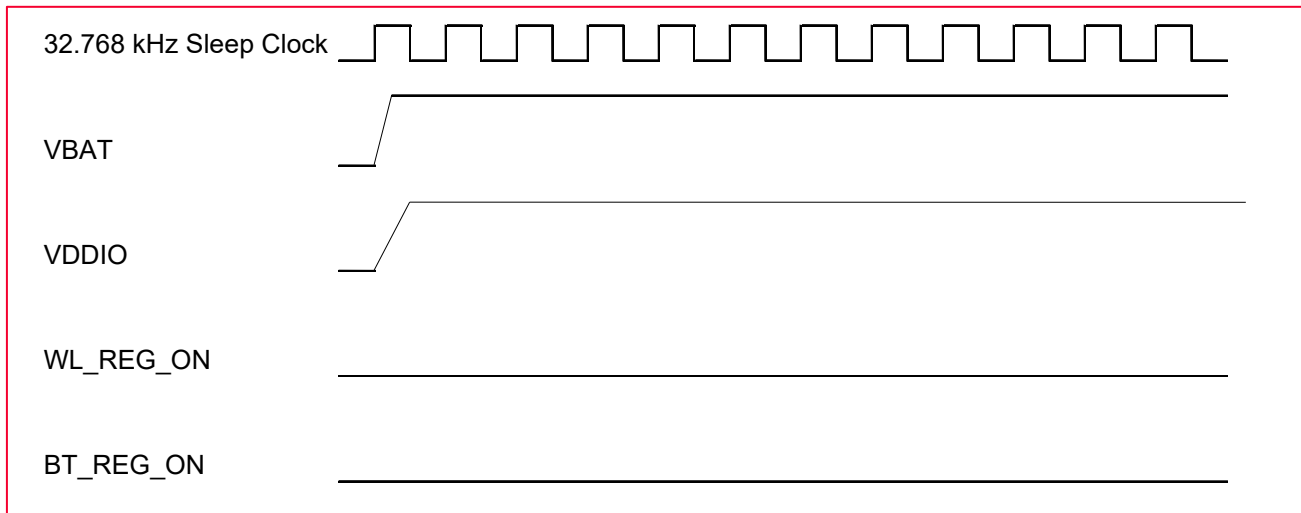


## 10.4 Power-On Sequence for WLAN OFF and BT OFF

For power-on sequence for WLAN OFF and BT OFF:

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

**Figure 9: Power-On Sequence - WLAN OFF and BT OFF**



## 11 Digital I/O Requirements

This section describes the digital input/output pins and related parameters.

### 11.1 Digital I/O Pins

**Table 13** describes the digital input/output pins and related parameters.

**Table 13: Digital I/O Pins**

Digital I/O Pins	Symbol	Minimum	Typical	Maximum	Unit
For VDDIO = 1.8V					
• Input high voltage	$V_{IH}$	0.65xVDDIO			V
• Input low voltage	$V_{IL}$			0.35xVDDIO	V
• Output high voltage @ 2.0 mA	$V_{OH}$	VDDIO-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	$V_{OH}$	VDDIO-0.40			V
• Output low voltage @ 2.0 mA	$V_{OL}$			0.40	V

## 11.2 RF Switch Control Output Pins

**Table 14** provides information about the RF switch control output pins.

**Table 14: RF Switch Control Output Pins**

RF Switch Control Output Pins	Symbol	Minimum	Typical	Maximum	Unit
For VDDIO_RF = 3.3V:					
• Output high voltage @ 2.0 mA	V <sub>OH</sub>	VDDIO-0.40			V
• Output low voltage @ 2.0 mA	V <sub>OL</sub>			0.40	V
Output capacitance	C <sub>out</sub>			5	pF

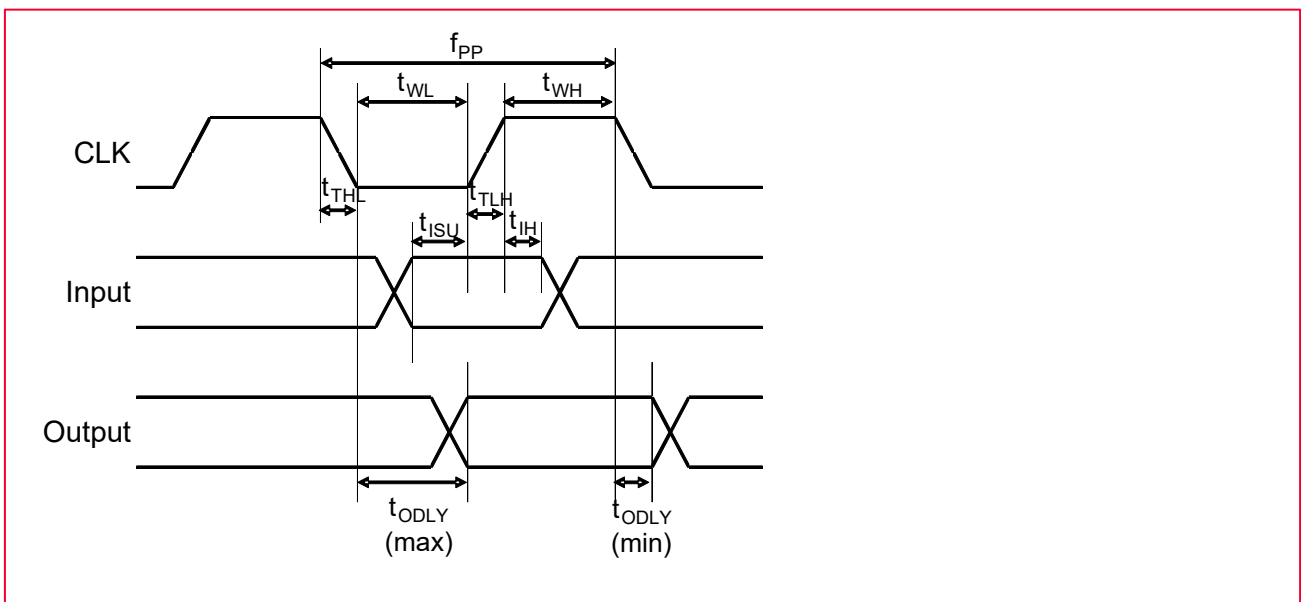
## 12 Interface Timing

This section describes the interface timing for SDIO, Bluetooth, and PCM, their speed modes, related parameters, and graphs.

### 12.1 SDIO Timing - Default Mode

The SDIO default timing diagram and data are shown in **Figure 10** and **Table 15**.

**Figure 10: SDIO Timing Diagram - Default Mode**



**Table 15: SDIO Timing Data - Default Mode**

Parameter	Symbol	Minimum	Typical	Maximum	Unit
<b>Clock CLK (All values are referred to minimum VIH and maximum VIL)</b>					
Frequency-Data Transfer Mode	$f_{PP}$	0		25	MHz
Frequency-Identification Mode	$f_{OD}$	0		400	kHz

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Clock Low Time	$t_{WL}$	10			ns
Clock High Time	$t_{WH}$	10			ns
Clock Rise Time	$t_{TLH}$			10	ns
Clock Fall Time	$t_{THL}$			10	ns
<b>Inputs: CMD, DAT (referenced to CLK)</b>					
Input Setup Time	$t_{ISU}$	5			ns
Input Hold Time	$t_{IH}$	5			ns
<b>Outputs: CMD, DAT (referenced to CLK)</b>					
Output Delay Time-Data Transfer Mode	$t_{ODLY}$	0		14	ns
Output Delay Time-Identification Mode	$t_{ODLY}$	0		50	ns

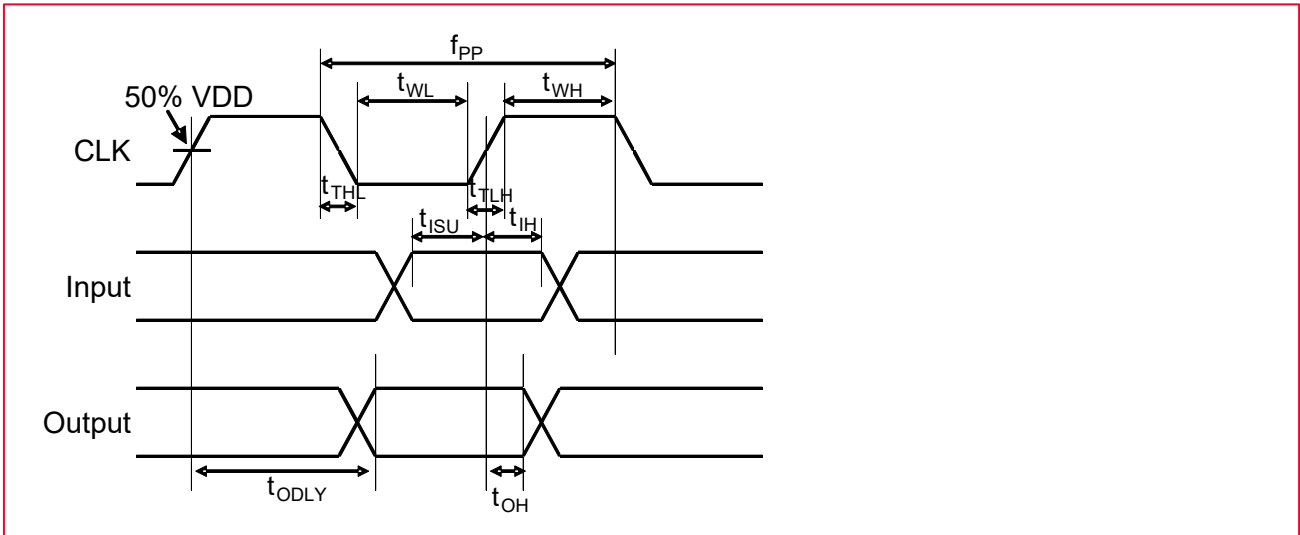


- Timing is based on  $CL < 40$  pF load on CMD and Data.
- Minimum ( $V_{ih}$ ) =  $0.7 \cdot V_{DDIO}$  and maximum ( $V_{il}$ ) =  $0.2 \cdot V_{DDIO}$ .

## 12.2 SDIO Timing - High Speed Mode

The SDIO high speed timing diagram and data are shown in **Figure 11** and **Table 16**.

**Figure 11: SDIO Timing Diagram – High Speed Mode**



**Table 16: SDIO Timing Data - High Speed Mode**

Parameter	Symbol	Minimum	Typical	Maximum	Unit
<b>Clock CLK (All values are referred to minimum VIH and maximum VIL)</b>					
Frequency-Data Transfer Mode	$f_{PP}$	0		50	MHz
Frequency-Identification Mode	$f_{OD}$	0		400	kHz
Clock Low Time	$t_{WL}$	7			ns

Parameter	Symbol	Minimum	Typical	Maximum	Unit
Clock High Time	$t_{WH}$	7			ns
Clock Rise Time	$t_{TLH}$			3	ns
Clock Fall Time	$t_{THL}$			3	ns
<b>Inputs: CMD, DAT (referenced to CLK)</b>					
Input Setup Time	$t_{ISU}$	6			ns
Input Hold Time	$t_{IH}$	2			ns
<b>Outputs: CMD, DAT (referenced to CLK)</b>					
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\*VDDIO and maximum (Vil) = 0.2\*VDDIO.

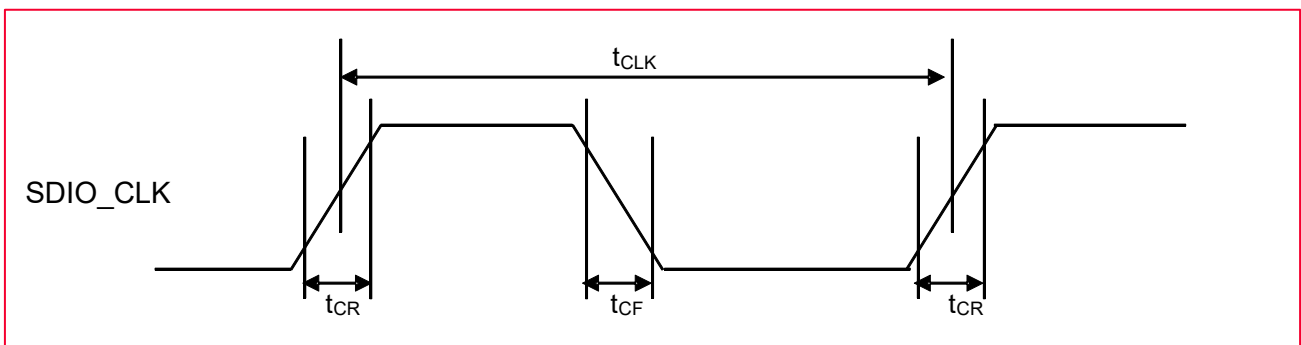
## 12.3 SDIO BUS Timing Specifications in SDR Mode

This section describes the SDIO BUS timing specifications in SDR Mode.

### 12.3.1 Clock Timing

The clock timing diagram and parameters are shown in **Figure 12** and **Table 17**.

**Figure 12: Clock Timing Diagram - SDR Mode**



**Table 17: 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
	$t_{CR}, t_{CF}$		$0.2 \times t_{CLK}$	ns	$t_{CR}, t_{CF} < 2.00$ ns (maximum) @ 100 MHz, cCARD = 10 pF $t_{CR}, t_{CF} < 0.96$ ns (maximum) @ 208 MHz, cCARD = 10 pF

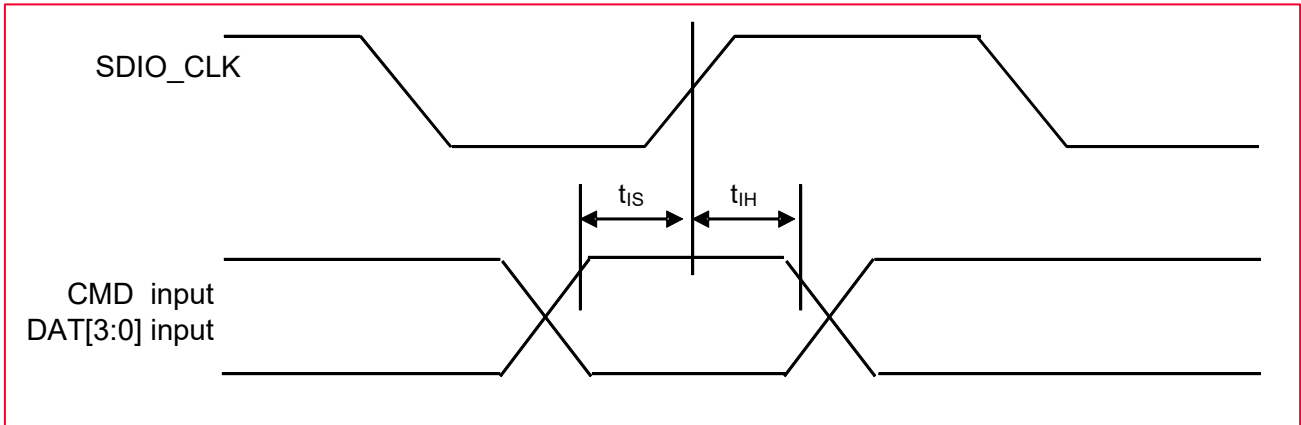


Parameter	Symbol	Minimum	Maximum	Unit	Comments
Clock duty Cycle		30	70	%	

### 12.3.2 Card Input Timing

The card input timing diagram and parameters are shown in **Figure 13** and **Table 18**.

**Figure 13: Card Input Timing Diagram - SDR Mode**



**Table 18: 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

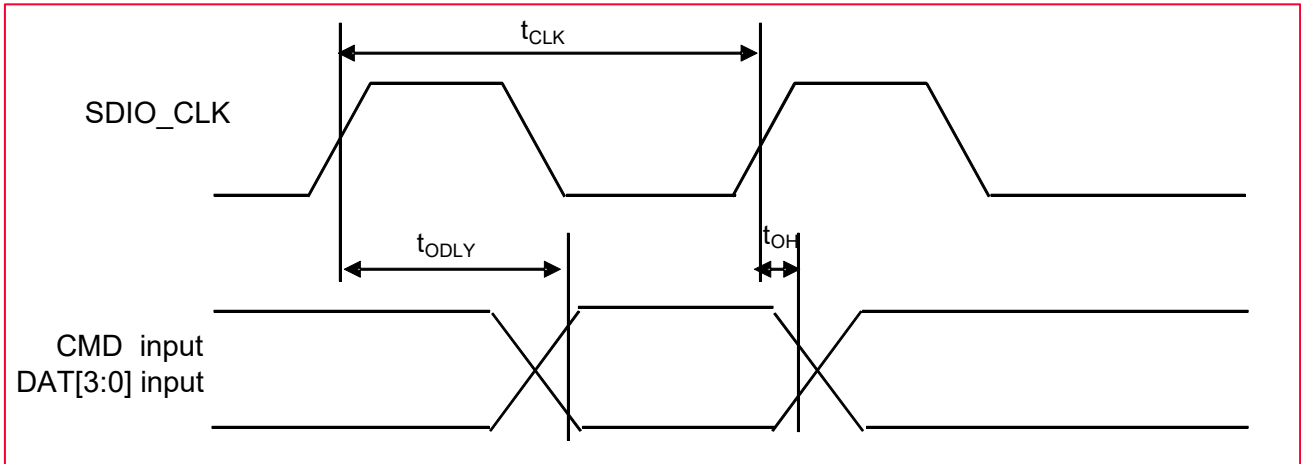
### 12.3.3 Card Output Timing

This section describes SDIO bus output timing.

#### 12.3.3.1 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 14** and **Table 19** respectively.

**Figure 14: SDIO Bus Output Timing Diagram - SDR Modes up to 100 MHz**



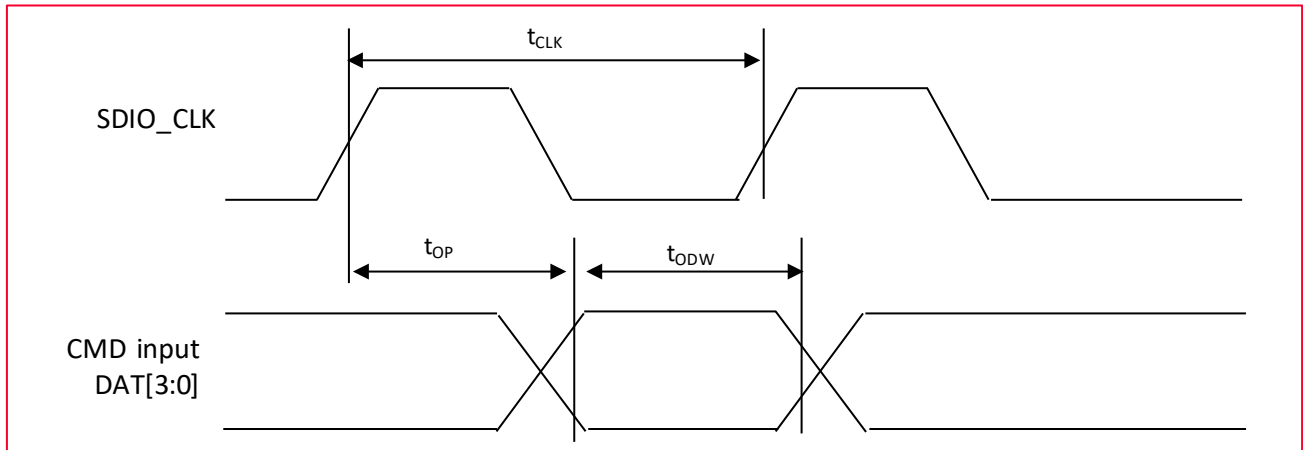
**Table 19: SDIO Bus Output Timing Parameters - SDR Modes up to 100 MHz**

Symbol	Minimum	Maximum	Unit	Comments
t <sub>ODLY</sub>		7.5	ns	t <sub>CLK</sub> ≥ 10 ns CL = 30 pF using driver type B for SDR50
t <sub>ODLY</sub>		14.0	ns	t <sub>CLK</sub> ≥ 20 ns CL = 40 pF using for SDR12, SDR25
t <sub>OH</sub>	1.5		ns	Hold time at the t <sub>ODLY</sub> (min) CL = 15 pF

### 12.3.3.2 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 15** and **Table 20** respectively.

**Figure 15: SDIO Bus Output Timing Diagram - SDR Modes 100 MHz to 208 MHz**



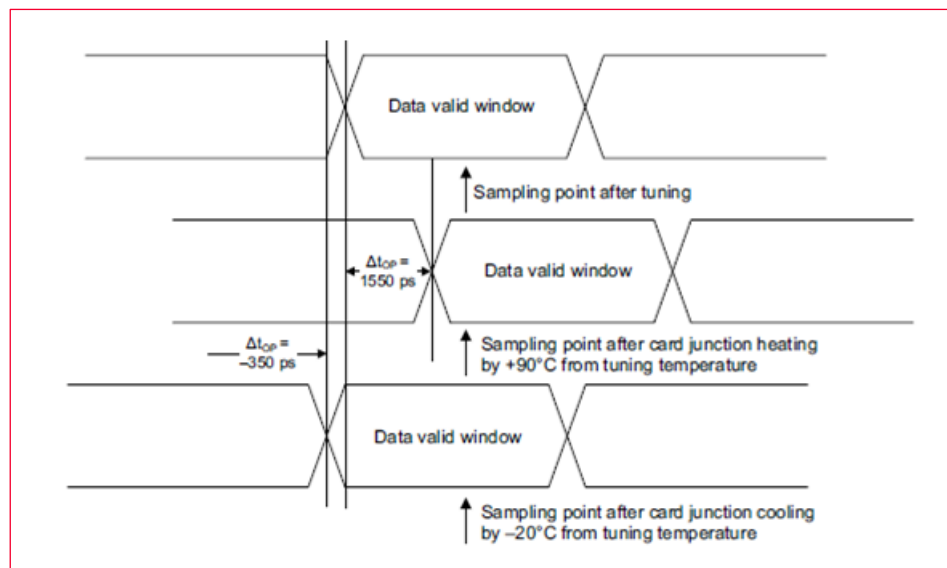
**Table 20: SDIO Bus Output Timing Parameters - SDR Modes 100 MHz to 208 MHz**

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

- $\Delta t_{OP} = +1550 \text{ ps}$  for junction temperature of  $\Delta t_{OP} = 90 \text{ }^\circ\text{C}$  during operation.
- $\Delta t_{OP} = -350 \text{ ps}$  for junction temperature of  $\Delta t_{OP} = -20 \text{ }^\circ\text{C}$  during operation.
- $\Delta t_{OP} = +2600 \text{ ps}$  for junction temperature of  $\Delta t_{OP} = -20 \text{ }^\circ\text{C}$  to  $+125 \text{ }^\circ\text{C}$  during operation

**Figure 16** shows  $\Delta t_{OP}$  consideration for variable data window at SDR 104 mode.

**Figure 16:  $\Delta t_{OP}$  Consideration for Variable Data Window - SDR 104 Mode**



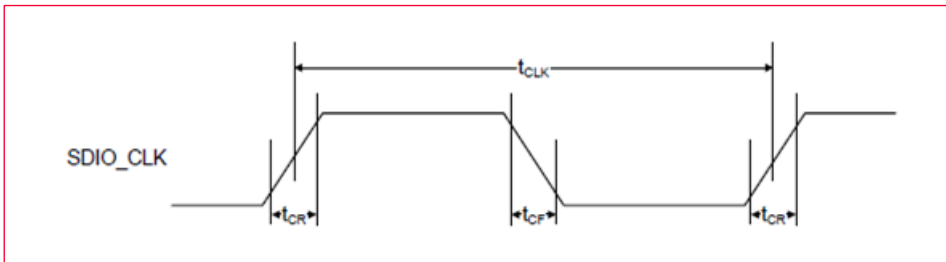
## 12.4 SDIO Timing Specifications in DDR50 Mode

This section describes SDIO clock timing and SDIO data timing.

### 12.4.1 SDIO Clock Timing

This section provides information about SDIO clock timing at DDR50 mode. The diagram and parameters are shown in **Figure 17** and **Table 21** respectively.

**Figure 17: SDIO Clock Timing Diagram - DDR50 Mode**



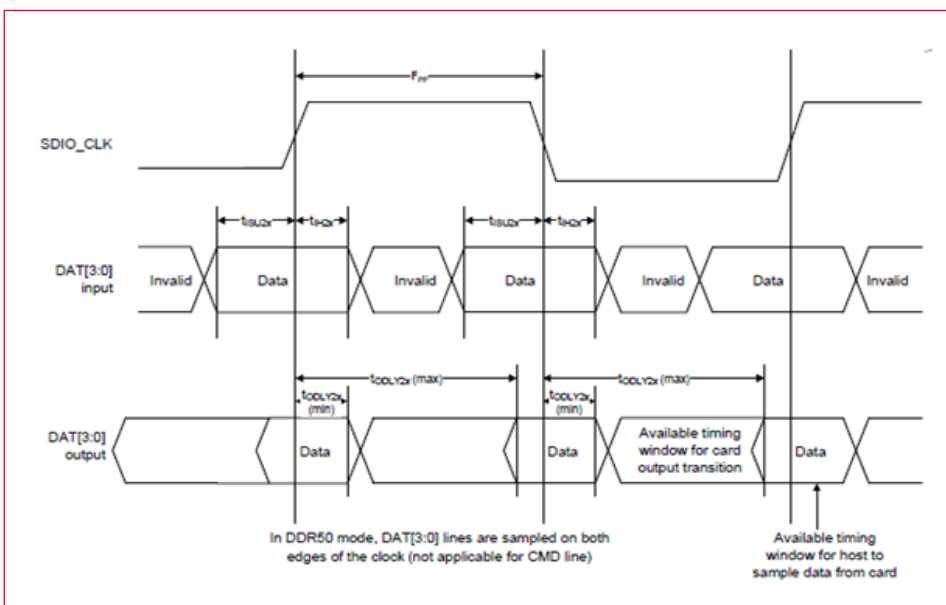
**Table 21: SDIO Clock Timing Parameters - DDR50 Mode**

Parameter	Symbol	Minimum	Maximum	Unit	Comments
	$t_{CLK}$	20		ns	DDR50 mode
	$t_{CR}, t_{CF}$		$0.2 \times t_{CLK}$	ns	$t_{CR}, t_{CF} < 4.00\text{ns}(\text{max})@50\text{MHz}$ , $c_{Card} = 10\text{pF}$
Clock duty cycle		45	55	%	

### 12.4.2 SDIO Data Timing

This section provides information about SDIO data timing at DDR50 mode. The diagram and parameters are shown in **Figure 18** and **Table 22** respectively.

**Figure 18: SDIO Data Timing Diagram - DDR50 Mode**



**Table 22: SDIO Data Timing Parameters - DDR50 Mode**

Parameter	Symbol	Minimum	Maximum	Unit	Comments
<b>Input CMD</b>					
Input setup time	t <sub>ISU</sub>	6		ns	Ccard < 10 pF (1 card)
Input hold time	t <sub>IH</sub>	0.8		ns	Ccard < 10 pF (1 card)
<b>Output CMD</b>					
Output delay time	t <sub>ODLY</sub>		13.7	ns	Ccard < 30 pF (1 card)
Output hold time	t <sub>OH</sub>	1.5		ns	Ccard < 15 pF (1 card)
<b>Input DAT</b>					
Input setup time	t <sub>ISU2x</sub>	3		ns	Ccard < 10 pF (1 card)
Input hold time	t <sub>IH2x</sub>	0.8		ns	Ccard < 10 pF (1 card)
<b>Output DAT</b>					
Output delay time	t <sub>ODLY2x</sub>		7.5	ns	Ccard < 25 pF (1 card)
Output hold time	t <sub>OH2x</sub>	1.5		ns	Ccard < 15 pF (1 card)

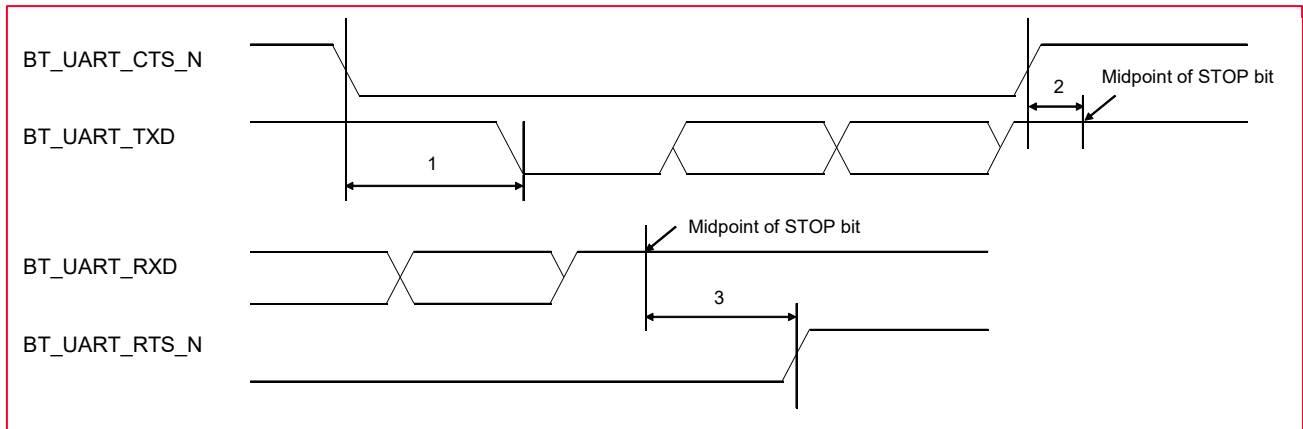
## 12.5 UART Timing - Default Mode

The UART is a standard 4-wire interface (RX, TX, RTS, and CTS) with adjustable baud rates from 9600 bps to 4.0 Mbps. The UART supports the Bluetooth 4.2 UART HCI specification: H4, a custom Extended H4, and H5. The default baud rate is 115.2 K baud.

The UART operates correctly with the host UART as long as the combined baud rate error of the two devices is within ±2%.

UART timing (default mode) diagram and parameters are shown in **Figure 19** and **Table 23**.

**Figure 19: UART Timing Diagram - Default Mode**



**Table 23: UART Timing Parameters - Default Mode**

Reference	Description	Minimum	Typical	Maximum	Unit
1	Delay time, UART_CTS_N low to UART_TXD valid			1.5	Bit periods
2	Setup time, UART_CTS_N high before midpoint of stop bit			0.5	Bit periods
3	Delay time, midpoint of stop bit to UART_RTS_N high			0.5	Bit periods

Examples of some common baud rates are shown in **Table 24**.

**Table 24: Common Baud Rate Examples**

Desired Rate	Actual Rate set in the module	Error (%)
4000000	4000000	0.00
3000000	3000000	0.00
921600	923077	0.16
115200	115385	0.16
57600	57692	0.16
9600	9600	0.00

## 12.6 Bluetooth PCM Timing

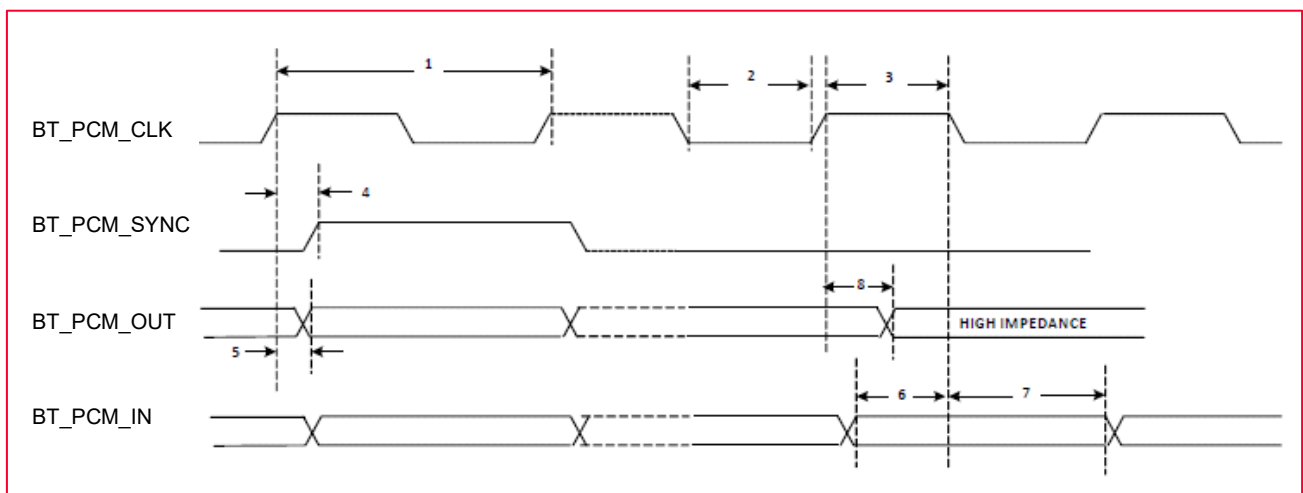
The PCM Interface can connect to linear PCM Codec devices. In master or slave mode. In master mode, the module generates the PCM\_CLK and PCM\_SYNC signals, and in slave mode, these signals are provided by another master on the PCM interface and are inputs to the modules.

The PCM interface supports both short- and long-frame synchronization in both master and slave modes. In short-frame synchronization mode, the frame synchronization signal is an active-high pulse at the audio frame rate that is a single-bit period in width and is synchronized to the rising edge of the bit clock. The PCM slave looks for a high on the falling edge of the bit clock and expects the first bit of the first slot to start at the next rising edge of the clock. In long-frame synchronization mode, the frame synchronization signal is again an active-high pulse at the audio frame rate; however, the duration is three-bit periods, and the pulse starts coincident with the first bit of the first slot.

### 12.6.1 Short Frame Sync - Master Mode

**Figure 20** and **Table 25** shows the Bluetooth PCM short frame sync data signal and parameters in master mode respectively.

**Figure 20: Short Frame Sync Signal - Master Mode**



**Table 25: 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

Reference	Description	Minimum	Typical	Maximum	Unit
4	PCM_SYNC delay	0		25	ns
5	PCM_OUT delay	0		25	ns
6	PCM_IN setup	8			ns
7	PCM_IN hold	8			ns
8	Delay from rising edge of PCM_BCLK during last bit period to PCM_OUT becoming high impedance.	0		25	ns

### 12.6.2 Short Frame Sync - Slave Mode

Figure 21 and Table 26 shows PCM short frame sync data signal and its parameters in slave mode respectively.

Figure 21: Short Frame Sync Signal - Slave Mode

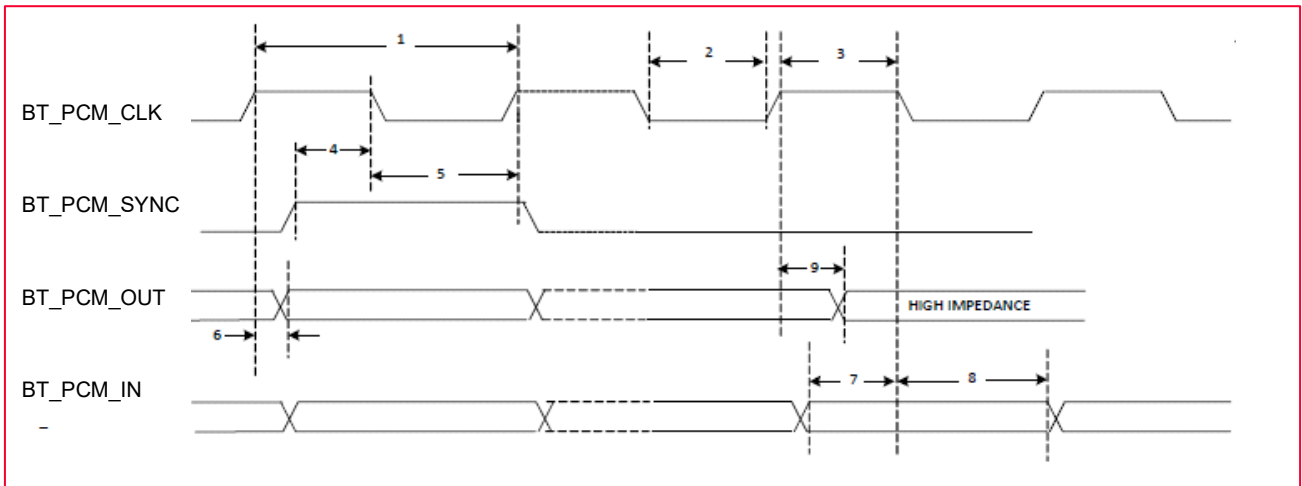


Table 26: Short Frame Sync Signal Parameters - Slave Mode

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

### 12.6.3 Long Frame Sync - Master Mode

Figure 22 and Table 27 shows PCM long frame sync signal and its parameters in slave mode.

Figure 22: Long Frame Sync Signal - Master Mode

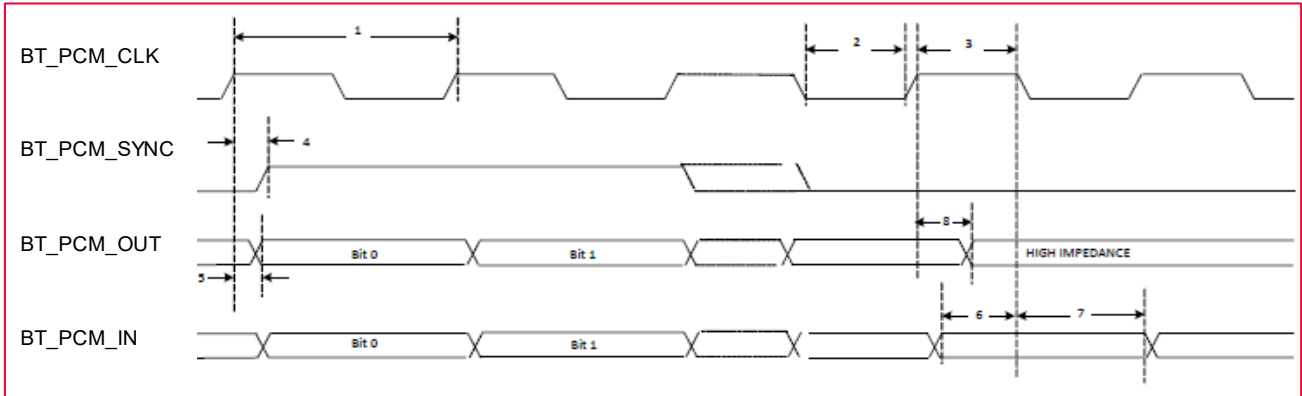


Table 27: Long Frame Sync Signal Parameters - Master Mode

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	PCM_SYNC delay	0	-	25	ns
5	PCM_OUT delay	0	-	25	ns
6	PCM_IN setup	8	-	-	ns
7	PCM_IN hold	8	-	-	ns
8	Delay from rising edge of PCM_BCLK during last bit period to PCM_OUT becoming high impedance	0	-	25	ns



### 12.6.4 Long Frame Sync - Slave Mode

Figure 23 and Table 28 shows PCM long frame sync signal and parameters in slave mode.

Figure 23: Long Frame Sync Signal - Slave Mode

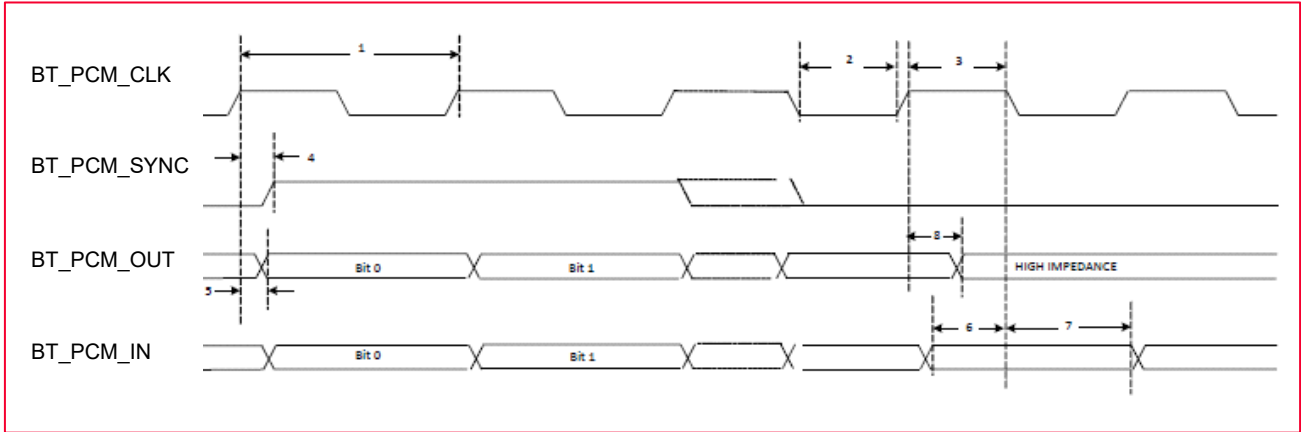


Table 28: Long Frame Sync Signal Parameters - Slave Mode

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	PCM_SYNC setup	8			ns
5	PCM_SYNC hold	8			ns
6	PCM_OUT delay	0		25	ns
7	PCM_IN setup	8			ns
8	PCM_IN hold	8			ns
9	Delay from rising edge of PCM_BCLK during last bit period to PCM_OUT becoming high impedance.	0		25	ns

### 12.6.5 Short Frame Sync - Burst Mode

Figure 24 and Table 29 shows PCM short frame sync signal and its parameters in burst mode.

Figure 24: Short Frame Sync Signal - Burst Mode

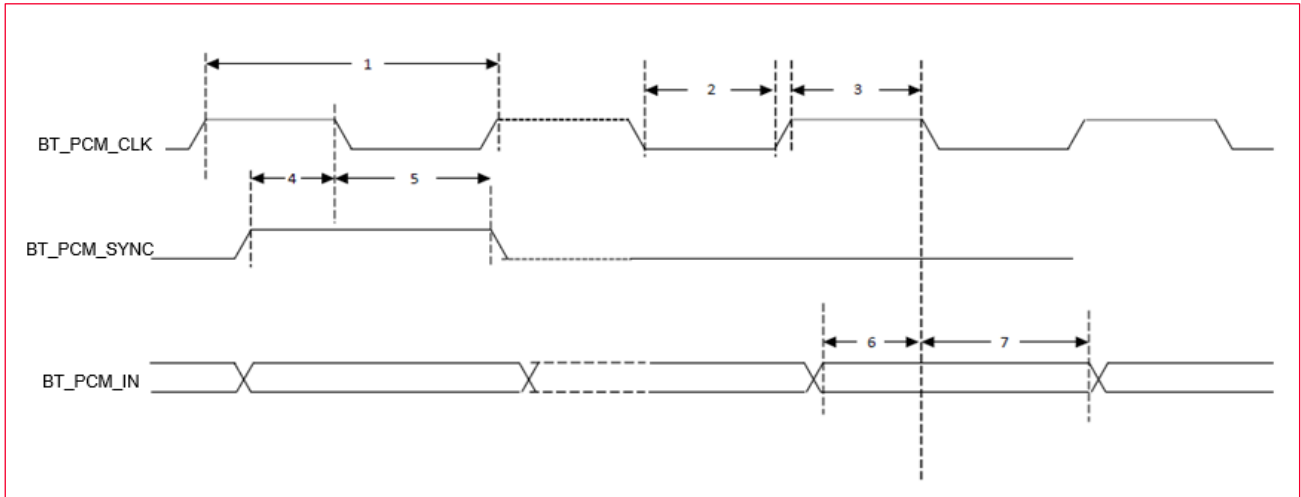


Table 29: Short Frame Sync Signal Parameters - Burst Mode

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	PCM_SYNC setup	8			ns
5	PCM_SYNC hold	8			ns
6	PCM_IN setup	8			ns
7	PCM_IN hold	8			ns

### 12.6.6 Long Frame Sync - Burst Mode

Figure 25 and Table 30 shows PCM long frame sync signal and parameters in burst mode.

Figure 25: Long Frame Sync Signal - Burst Mode

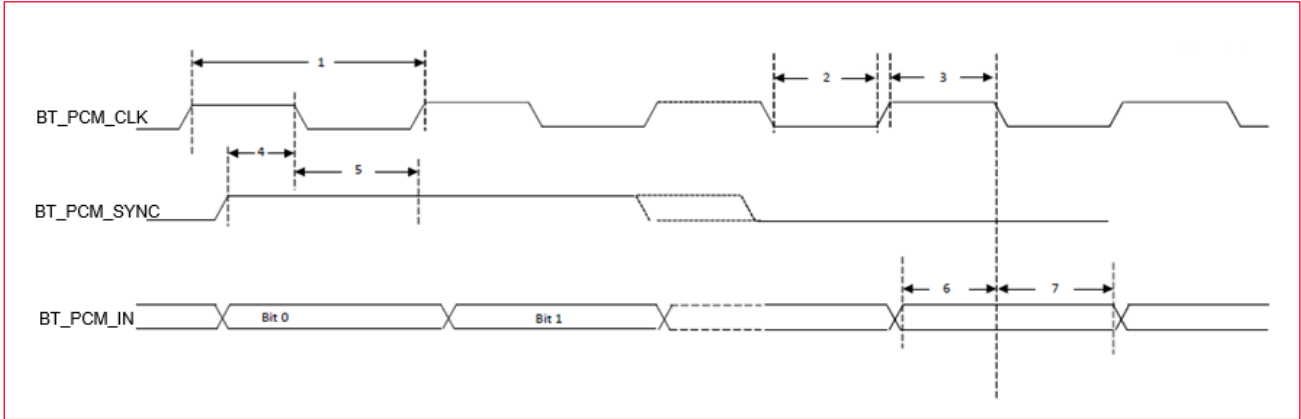


Table 30: Long Frame Sync Signal Parameters - Burst Mode

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	PCM_SYNC setup	8			ns
5	PCM_SYNC hold	8			ns
6	PCM_IN setup	8			ns
7	PCM_IN hold	8			ns

## 13 DC/RF Characteristics

ALL DC/RF characteristics for Type 2AE are defined by the following files.

**Table 31: DC/RF Characteristics Files**

Filenames	Description
WLAN: nvram file	cyfmac4373-sdio.txt
BT: hcd file	4373A0_Generic_UART_37_4MHz_wlbg_a_BU_sLNA_202107091730_0x800.hcd

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

**Table 32: Characteristics Values for IEEE 802.11b - 2.4 GHz**

Items	Contents
Specification	IEEE 802.11b
Mode	DSSS / CCK
Channel Frequency	2412 - 2472 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, VDDIO = 3.3V, Output power setting = 17 dBm, 11 Mbps mode

**Table 33: 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) <sup>5</sup>		350		mA
• Rx mode		55		mA
TX Characteristics <sup>5</sup>	Minimum	Typical	Maximum	Unit
Output Power	14.5	17	19.5	dBm
Spectrum Mask Margin				
• 1 <sup>st</sup> side lobes (-30 dBr)	0			dB
• 2 <sup>nd</sup> side lobes (-50 dBr)	0			dB
Power-on and Power-down ramp			2.0	μs
RF Carrier Suppression	15			dB
Modulation Accuracy (EVM)			35	%
Frequency Tolerance	-20		20	ppm
Out band Spurious Emissions				
1. 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
Annotation:				
• 47 MHz to 74 MHz (BW = 100 kHz)			-54	dBm
• 87.5 MHz to 118 MHz (BW = 100 kHz)			-54	dBm
• 174 MHz to 230 MHz (BW = 100 kHz)			-54	dBm
• 470 MHz to 862 MHz (BW = 100 kHz)			-54	dBm
2. 1 GHz to 12.75 GHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit

<sup>5</sup> Defined when output power setting is 17 dBm at Murata module antenna pad.

Items	Contents			
Minimum Input Level Sensitivity			-76	dBm
Maximum Input Level (FER ≤ 8%)	-10			dBm
Adjacent Channel Rejection (FER ≤ 8%)	35			dB

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

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

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

Items	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode (1024 byte, 20μs interval) <sup>6</sup>		340		mA
• Rx mode		55		mA
TX Characteristics <sup>6</sup>	Minimum	Typical	Maximum	Unit
Output Power	14.5	17	19.5	dBm
Spectrum Mask Margin				
• 1 <sup>st</sup> side lobes (-30 dBr)	0			dB
• 2 <sup>nd</sup> side lobes (-50 dBr)	0			dB
Power-on and Power-down Ramp			2.0	μs
RF Carrier Suppression	15			dB
Modulation Accuracy (EVM)			35	%
Frequency Tolerance	-20		20	ppm
Out band Spurious Emissions				
1. 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
Annotations:				
• 47 MHz to 74 MHz (BW = 100 kHz)			-54	dBm
• 87.5 MHz to 118 MHz (BW = 100 kHz)			-54	dBm
• 174 MHz to 230 MHz (BW = 100 kHz)			-54	dBm
• 470 MHz to 862 MHz (BW = 100 kHz)			-54	dBm
2. 1 GHz to 12.75 GHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level Sensitivity			-76	dBm
Maximum Input Level (FER ≤ 8%)	-10			dBm
Adjacent Channel Rejection (FER ≤ 8%)	35			dB

<sup>6</sup> Defined when output power setting is 17 dBm at Murata module antenna pad

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

**Table 35: Characteristics Values for IEEE 802.11g - 2.4 GHz**

Items	Contents
Specification	IEEE 802.11g
Mode	OFDM
Channel Frequency	2412 - 2472 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, VDDIO = 3.3V, Output power setting = 16 dBm, 54 Mbps mode

**Table 36: High-Rate Condition for IEEE 802.11g - 2.4 GHz**

Items	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>7</sup>		290		mA
• Rx mode		55		mA
TX Characteristics <sup>7</sup>	Minimum	Typical	Maximum	Unit
Output Power	13.5	16	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)			-25	dB
Frequency Tolerance	-20		20	ppm
Out Band Spurious Emissions				
1. 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
Annotation				
• 47 MHz to 74 MHz (BW = 100 kHz)			-54	dBm
• 87.5 MHz to 118 MHz (BW = 100 kHz)			-54	dBm
• 174 MHz to 230 MHz (BW = 100 kHz)			-54	dBm
• 470 MHz to 862 MHz (BW = 100 kHz)			-54	dBm
2. 1 GHz to 12.75 GHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level Sensitivity			-65	dBm
Maximum Input Level (PER $\leq$ 10%)	-20			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-1			dB

<sup>7</sup> Defined when output power setting is 16 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, VDDIO = 3.3V, Output power setting = 18 dBm, 6 Mbps mode

**Table 37: Low-Rate Condition for IEEE 802.11g - 2.4 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>8</sup>		310		mA
• Rx mode		55		mA
<b>TX Characteristics<sup>8</sup></b>				
Output Power	15.5	18	20.5	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
Out Band Spurious Emissions				
1. 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
Annotations:				
• 47 MHz to 74 MHz (BW = 100 kHz)			-54	dBm
• 87.5 MHz to 118 MHz (BW = 100 kHz)			-54	dBm
• 174 MHz to 230 MHz (BW = 100 kHz)			-54	dBm
• 470 MHz to 862 MHz (BW = 100 kHz)			-54	dBm
2. 1 GHz to 12.75 GHz (BW = 1 MHz)			-30	dBm
<b>Rx Characteristics</b>				
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER $\leq$ 10%)	-20			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	16			dB

<sup>8</sup> Defined when output power setting is 18 dBm at Murata module antenna pad

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

**Table 38: Characteristics Values for IEEE 802.11n - 2.4 GHz**

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

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 14 dBm, MCS7

**Table 39: High-Rate Condition for IEEE 802.11n - 2.4 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>9</sup>		280		mA
• Rx mode		55		mA
<b>TX Characteristics<sup>9</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	11.5	14	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)			-27	dB
Frequency Tolerance	-20		20	ppm
Out band Spurious Emissions				
1. 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
Annotations:				
• 47 MHz to 74 MHz (BW = 100 kHz)			-54	dBm
• 87.5 MHz to 118 MHz (BW = 100 kHz)			-54	dBm
• 174 MHz to 230 MHz (BW = 100 kHz)			-54	dBm
• 470 MHz to 862 MHz (BW = 100 kHz)			-54	dBm
2. 1 GHz to 12.75 GHz (BW = 1 MHz)			-30	dBm
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-64	dBm
Maximum Input Level (PER $\leq$ 10%)	-20			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-2			dB

<sup>9</sup> Defined when output power setting is 14 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, VDDIO = 3.3V, Output power setting = 16 dBm, MCS0

**Table 40: Low-Rate Condition for IEEE 802.11n - 2.4 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>10</sup>		300		mA
• Rx mode		55		mA
<b>TX Characteristics<sup>10</sup></b>				
Output Power	13.5	16	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM)			-5	dB
Frequency Tolerance	-20		20	ppm
Out band Spurious Emissions				
1. 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
Annotations:				
• 47 MHz to 74 MHz (BW = 100 kHz)			-54	dBm
• 87.5 MHz to 118 MHz (BW = 100 kHz)			-54	dBm
• 174 MHz to 230 MHz (BW = 100 kHz)			-54	dBm
• 470 MHz to 862 MHz (BW = 100 kHz)			-54	dBm
2. 1 GHz to 12.75 GHz (BW = 1 MHz)			-30	dBm
<b>Rx Characteristics</b>				
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER $\leq$ 10%)	-20			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	16			dB

<sup>10</sup> Defined when output power setting is 16 dBm at Murata module antenna pad

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

**Table 41: 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

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 14 dBm, 54 Mbps

**Table 42: High-Rate Condition for IEEE 802.11a - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
<ul style="list-style-type: none"> <li>Tx mode (1024 byte, 20 <math>\mu</math>s interval)<sup>11</sup></li> </ul>		290		mA
<ul style="list-style-type: none"> <li>Rx mode</li> </ul>		70		mA
<b>TX Characteristics<sup>11</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	12	14	16	dBm
Spectrum Mask Margin				
<ul style="list-style-type: none"> <li>9 MHz to 11 MHz (0 ~ -20 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>11 MHz to 20 MHz (-20 ~ -28 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>20 MHz to 30 MHz (-28 ~ -40 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>30 MHz to 33 MHz (-40 dBr)</li> </ul>	0			dB
Constellation Error (EVM)			-25	dB
Frequency Tolerance	-20		20	ppm
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-65	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-1			dB

<sup>11</sup> Defined when output power setting is 14 dBm at Murata module antenna pad

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

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

**Table 43: Low-Rate Condition for IEEE 802.11a - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>12</sup>		310		mA
• Rx mode		70		mA
<b>TX Characteristics<sup>12</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	14	16	18	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
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	16			dB

<sup>12</sup> Defined when output power setting is 16 dBm at Murata module antenna pad

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

**Table 44: Characteristics Values for IEEE 802.11n (HT20) - 5 GHz**

Items	Contents
Specification	IEEE 802.11n
Mode	OFDM
Channel Frequency	5180 to 5825 MHz
Data Rate	MCS0 - MCS7

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 14 dBm, MCS7

**Table 45: High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
<ul style="list-style-type: none"> <li>Tx mode (1024 byte, 20 <math>\mu</math>s interval)<sup>13</sup></li> </ul>		280		mA
<ul style="list-style-type: none"> <li>Rx mode</li> </ul>		70		mA
<b>TX Characteristics<sup>13</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	12	14	16	dBm
Spectrum Mask Margin				
<ul style="list-style-type: none"> <li>9 MHz to 11 MHz (0 ~ -20 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>11 MHz to 20 MHz (-20 ~ -28 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>20 MHz to 30 MHz (-28 ~ -40 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>30 MHz to 33 MHz (-40 dBr)</li> </ul>	0			dB
Constellation Error (EVM)			-27	dB
Frequency Tolerance	-20		20	ppm
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-64	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-2			dB

<sup>13</sup> Defined when output power setting is 14 dBm at Murata module antenna pad

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 16 dBm, MCS0

**Table 46: Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>14</sup>		300		mA
• Rx mode		70		mA
<b>TX Characteristics<sup>14</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	14	16	18	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
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	16			dB

<sup>14</sup> Defined when output power setting is 16 dBm at Murata module antenna pad

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

**Table 47: Characteristics Values for IEEE 802.11ac (VHT20) - 5 GHz**

Items	Contents
Specification	IEEE 802.11ac
Mode	OFDM
Channel Frequency	5180 to 5825 MHz
Data Rate	MCS0 - MCS8

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 13 dBm, MCS8

**Table 48: High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
<ul style="list-style-type: none"> <li>Tx mode (1024 byte, 20 <math>\mu</math>s interval)<sup>15</sup></li> </ul>		280		mA
<ul style="list-style-type: none"> <li>Rx mode</li> </ul>		70		mA
<b>TX Characteristics<sup>15</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	11	13	15	dBm
Spectrum Mask Margin				
<ul style="list-style-type: none"> <li>9 MHz to 11 MHz (0 ~ -20 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>11 MHz to 20 MHz (-20 ~ -28 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>20 MHz to 30 MHz (-28 ~ -40 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>30 MHz to 33 MHz (-40 dBr)</li> </ul>	0			dB
Constellation Error (EVM)			-30	dB
Frequency Tolerance	-20		20	ppm
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-59	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-7			dB

<sup>15</sup> Defined when output power setting is 13 dBm at Murata module antenna pad

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 16 dBm, MCS0

**Table 49: Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>16</sup>		300		mA
• Rx mode		70		mA
<b>TX Characteristics<sup>16</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	14	16	18	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
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	16			dB

<sup>16</sup> Defined when output power setting is 16 dBm at Murata module antenna pad

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

**Table 50: 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

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 13 dBm, MCS7, HT 40 MHz

**Table 51: High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
<ul style="list-style-type: none"> <li>Tx mode (1024 byte, 20 <math>\mu</math>s interval)<sup>17</sup></li> </ul>		320		mA
<ul style="list-style-type: none"> <li>Rx mode</li> </ul>		80		mA
<b>TX Characteristics<sup>17</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	11	13	15	dBm
Spectrum Mask Margin				
<ul style="list-style-type: none"> <li>19 MHz to 21 MHz (0 ~ -20 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>21 MHz to 40 MHz (-20 ~ -28 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>40 MHz to 60 MHz (-28 ~ -45 dBr)</li> </ul>	0			dB
<ul style="list-style-type: none"> <li>60 MHz to 80 MHz (-45 dBr)</li> </ul>	0			dB
Constellation Error (EVM)			-27	dB
Frequency Tolerance	-20		20	ppm
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-61	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-2			dB

<sup>17</sup> Defined when output power setting is 13 dBm at Murata module antenna pad



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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 14 dBm, MCS0, HT 40 MHz

**Table 52: Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 μs interval) <sup>18</sup>		350		mA
• Rx mode		80		mA
<b>TX Characteristics<sup>18</sup></b>				
Output Power	12	14	16	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
<b>Rx Characteristics</b>				
Minimum Input Level Sensitivity			-79	dBm
Maximum Input Level (PER <10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

<sup>18</sup> Defined when output power setting is 14 dBm at Murata module antenna pad

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

**Table 53: 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

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 11 dBm, MCS9, VHT 40 MHz

**Table 54: High-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>19</sup>		320		mA
• Rx mode		80		mA
<b>TX Characteristics<sup>19</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	9	11	13	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)			-32	dB
Frequency Tolerance	-20		20	ppm
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-54	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-9			dB

<sup>19</sup> Defined when output power setting is 11 dBm at Murata module antenna pad

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 14 dBm, MCS0, VHT 40 MHz

**Table 55: Low-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 $\mu$ s interval) <sup>20</sup>		350		mA
• Rx mode		80		mA
<b>TX Characteristics<sup>20</sup></b>				
Output Power	12	14	16	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
<b>Rx Characteristics</b>				
Minimum Input Level Sensitivity			-54	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	16			dB

<sup>20</sup> Defined when output power setting is 14 dBm at Murata module antenna pad

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

**Table 56: 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

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 11 dBm, MCS9, VHT 80 MHz

**Table 57: High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 μs interval) <sup>21</sup>		340		mA
• Rx mode		105		mA
<b>TX Characteristics<sup>21</sup></b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power	9	11	13	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			-32	dB
Frequency Tolerance	-20		20	ppm
<b>Rx Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Minimum Input Level Sensitivity			-51	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

<sup>21</sup> Defined when output power setting is 11 dBm at Murata module antenna pad

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

**Conditions:** 25 °C, VBAT = 3.3V, VDDIO = 3.3V, Output power setting = 13 dBm, MCS0, VHT 80 MHz

**Table 58: Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz**

Items	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode (1024 byte, 20 μs interval) <sup>22</sup>		380		mA
• Rx mode		105		mA
<b>TX Characteristics<sup>22</sup></b>				
Output Power	11	13	15	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			-5	dB
Frequency Tolerance	-20		20	ppm
<b>Rx Characteristics</b>				
Minimum Input Level Sensitivity			-76	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

<sup>22</sup> Defined when output power setting is 13 dBm at Murata module antenna pad

## 13.10 DC/RF Characteristics for Bluetooth

Conditions: 25 °C, VBAT = 3.3V, VDDIO = 3.3V

Table 59: DC/RF Characteristics for Bluetooth

Items	Contents			
Bluetooth Specification (power class)	Version 5.2			
Channel Frequency (spacing)	2402 to 2480 MHz (1 MHz)			
Current Consumption	Minimum	Typical	Maximum	Unit
• Tx = Rx = DH5 (fully occupied)		55		mA
• Tx = Rx = 2DH5 (fully occupied)		45		mA
• Tx = Rx = 3DH5 (fully occupied)		45		mA
<b>Transmitter</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
Output Power@DH5	6	10	14	dBm
Frequency range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power <sup>23</sup>				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
<b>Modulation Characteristics</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
• Modulation $\Delta f_{1\text{avg}}$	140		175	kHz
• Modulation $\Delta f_{2\text{max}}$	115			kHz
• Modulation $\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}$	0.8	1		
<b>Carrier Frequency Drift</b>	<b>Minimum</b>	<b>Typical</b>	<b>Maximum</b>	<b>Unit</b>
• 1slot	-25		+25	kHz
• 3slot / 5slot	-40		+40	kHz
• Maximum drift rate			20	kHz/50 $\mu$ s
EDR Relative Power	-4		1	dB
EDR Carrier Frequency Stability and Modulation Accuracy				
• $\omega_i$	-75		75	kHz
• $\omega_i + \omega_o$	-75		75	kHz
• $\omega_o$	-10		10	kHz
• RMS DEVM (DQPSK)			20	%
• Peak DEVM (DQPSK)			35	%
• 99% DEVM (DQPSK)			30	%
• RMS DEVM (8DPSK)			13	%
• Peak DEVM (8DPSK)			25	%
• 99% DEVM (8DPSK)			20	%
Spurious Emissions				
1. 30 MHz to 1 GHz (BW = 100 kHz)			-36	dBm
Annotations:				
• 47 MHz to 74 MHz (BW = 100 kHz)			-54	dBm
• 87.5 MHz to 118 MHz (BW = 100 kHz)			-54	dBm

<sup>23</sup> Up to three spurious responses within Bluetooth limits are allowed.

Items	Contents			
<ul style="list-style-type: none"> <li>174 MHz to 230 MHz (BW = 100 kHz)</li> <li>470 MHz to 862 MHz (BW = 100 kHz)</li> </ul>			-54	dBm
			-54	dBm
2. 1 GHz to 12.75 GHz (BW = 1 MHz)			-30	dBm
Receiver	Minimum	Typical	Maximum	Unit
BDR Sensitivity (BER ≤ 0.1%)			-80	dBm
EDR Sensitivity (BER ≤ 0.007%) @8DPSK			-77	dBm
C/I Performance (BER ≤ 0.1%) <sup>24</sup>				
<ul style="list-style-type: none"> <li>co-channel</li> </ul>			11	dB
<ul style="list-style-type: none"> <li>1 MHz</li> </ul>			0	dB
<ul style="list-style-type: none"> <li>2 MHz</li> </ul>			-30	dB
<ul style="list-style-type: none"> <li>3 MHz</li> </ul>			-40	dB
<ul style="list-style-type: none"> <li>image (+4 MHz)</li> </ul>			-9	dB
<ul style="list-style-type: none"> <li>image +/- 1 MHz</li> </ul>			-20	dB
Maximum Input Level (BER ≤ 0.1%)	-20			dBm

## 13.11 DC/RF Characteristics for Bluetooth Low Energy

Conditions: 25 °C, VBAT = 3.3V, VDDIO = 3.3V

Table 60: DC/RF Characteristics for BLE

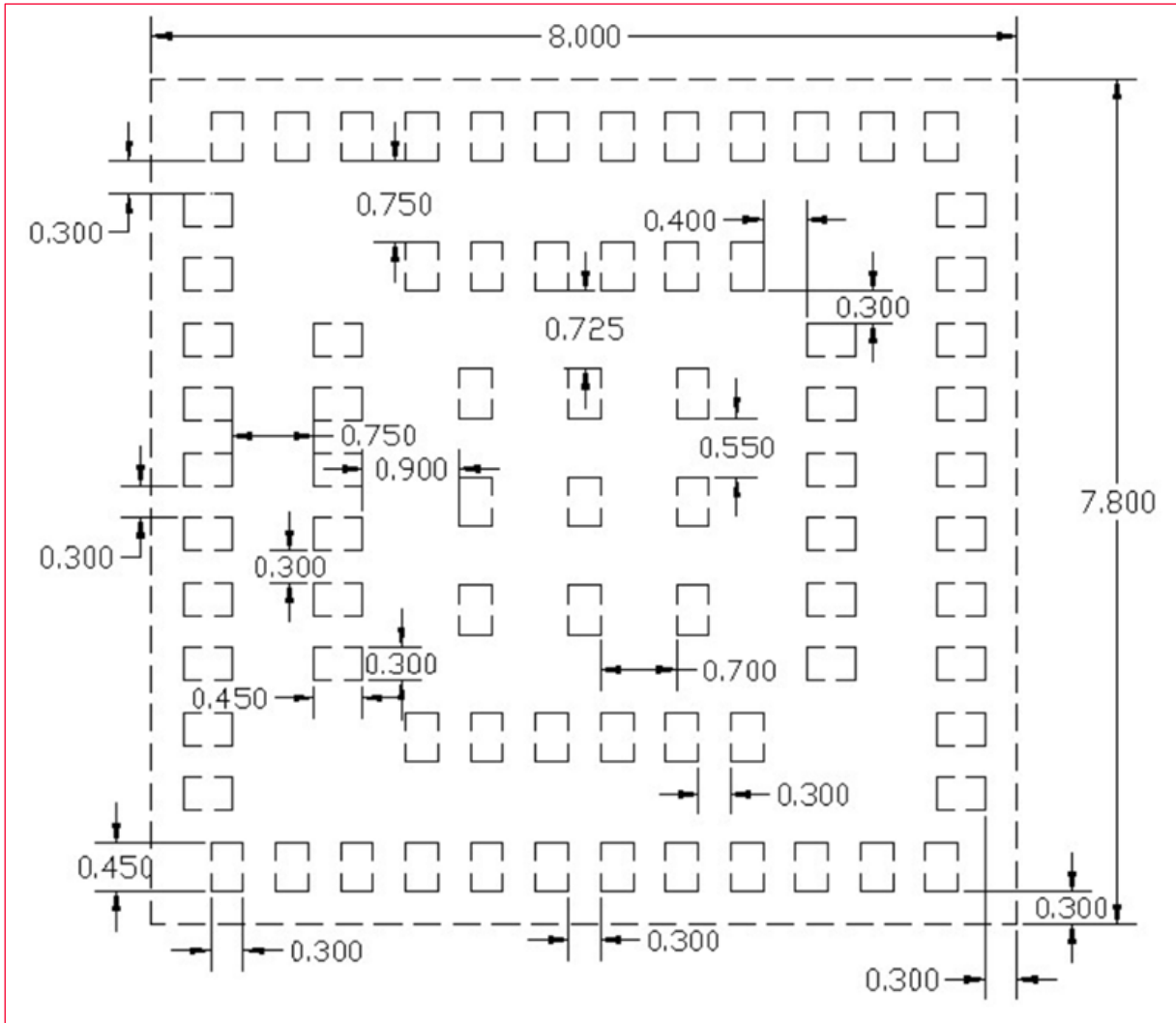
Items	Contents			
Bluetooth Specification (power class)	Version 5.2(LE)			
Channel Frequency (spacing)	2402 to 2480 MHz (2 MHz)			
Number of RF Channel	40			
Item / Condition	Minimum	Typical	Maximum	Unit
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF Channel		40		
Output Power		8		dBm
Modulation Characteristics				
<ul style="list-style-type: none"> <li><math>\Delta f_{1\text{avg}}</math></li> </ul>	225		275	kHz
<ul style="list-style-type: none"> <li><math>\Delta f_{2\text{max}}</math> (at 99.9%)</li> </ul>	185			kHz
<ul style="list-style-type: none"> <li><math>\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}</math></li> </ul>	0.8			
Carrier Frequency Offset and Drift				
<ul style="list-style-type: none"> <li>Frequency Offset</li> </ul>			150	kHz
<ul style="list-style-type: none"> <li>Frequency Drift</li> </ul>			50	kHz
<ul style="list-style-type: none"> <li>Drift Rate</li> </ul>			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	%

<sup>24</sup> Up to five spurious responses within Bluetooth limits are allowed.

## 14 Land Pattern

The land pattern (in mm) is shown in **Figure 26**.

**Figure 26: Land Pattern (Unit: mm)**



This land pattern is for reference purpose only. Consult your manufacturing group to ensure your company's manufacturing guidelines are met.



## 15 Radio Regulatory Certification by Country for LBEE5PK2AE

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


- Japan
- FCC
- ISED
- Europe

### 15.1 Japan

Regarding Japan Certificate of Construction Type of LBEE5PK2AE




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 is 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: 007-AL0056) 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.

#### 15.1.1 Power Level for Japan

**Table 61** and **Table 62** show the per antenna port power table for 2.4 GHz for WLAN and Bluetooth. **Table 63** shows the per antenna port power table for 5 GHz WLAN.

**Table 61: Japan Power Level 2.4 GHz WLAN Per Antenna Port**

Mode	Data Rate	Typical Output Power (dBm)
<b>Channels</b>		<b>1 ~ 13</b>
11b	All Rates	16
11g	6 ~ 36 Mbps	18
	48 ~ 54 Mbps	16
11n HT20	MCS0 ~ MCS4	16
	MCS5 ~ MCS7	14

Table 62: Japan Power Level 2.4GHz BT/BLE Per Antenna Port

Mode	Maximum Tune Up Tolerance (dBm)
DH5	10.0 ± 4.0
2DH5	6.0 ± 4.0
3DH5	6.0 ± 4.0
BLE	8.0 ± 4.0

Table 63: Japan Power Level 5 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)		
		36 ~ 48	52 ~ 64	100 ~ 144
<b>Channels</b>		<b>36 ~ 48</b>	<b>52 ~ 64</b>	<b>100 ~ 144</b>
11a	6 ~ 18 Mbps	15	12	16
	24 ~ 54 Mbps	14	12	14
11n HT20	MCS0 ~ MCS2	15	12	16
	MCS3 ~ MCS7	14	12	14
11ac VHT20	MCS0 ~ MCS2	15	12	16
	MCS3 ~ MCS7	14	12	14
	MCS8	13	12	13
<b>Channels</b>		<b>38 ~ 46</b>	<b>54 ~ 62</b>	<b>102 ~ 142</b>
11n HT40	MCS0 ~ MCS2	14	13	14
	MCS3 ~ MCS7	13	13	13
11ac VHT40	MCS0 ~ MCS2	14	13	14
	MCS3 ~ MCS7	13	13	13
	MCS8 ~ MCS9	11	11	11
<b>Channels</b>		<b>42 ~ 138</b>		
11ac VHT80	MCS0 ~ MCS7	13		
	MCS8 ~ MCS9	11		

## 15.1.2 Theory of Operation for Japan

Table 64 and Table 65 show the theory of operation for WLAN and Bluetooth.

Table 64: Japan Theory of Operation for WLAN

Frequency of Operation		Scan	Ad-hoc Mode	
2.4 GHz	11b/g/n (HT20)	2412 - 2472 MHz	Active	Yes
W52	11a/n/ac ((V)HT20)	5180 - 5240 MHz	Active	Yes
	11n/ac ((V)HT40)	5190 - 5230 MHz	Active	Yes
	11ac (HT80)	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 - 5700 MHz	Passive	No
	11n/ac ((V)HT40)	5510 - 5670 MHz	Passive	No
	11ac (VHT80)	5530 - 5610 MHz	Passive	No

Table 65: Japan Theory of Operation for Bluetooth

Frequency of Operation		Scan	Ad-hoc Mode
BR	2402 ~ 2480 MHz	N/A	N/A
EDR	2402 ~ 2480 MHz	N/A	N/A
LE	2402 ~ 2480 MHz	N/A	N/A

## 15.2 FCC

Regarding FCC modular approval of LBEE5PK2AE

- **Model Name:** LBEE5PK2AE
- **FCC ID:** VPYLB2AE

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: VPYLB2AE or Contains FCC ID: VPYLB2AE



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, it 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. Several special packets are initiated by the MAC. 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 discontinues transmission in case of either absence of information to transmit or operational failure.



Frequency Tolerance:  $\pm 20$  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 it in a portable equipment. Please describe the following warning to the manual.



- It is necessary to take a SAR test with your set mounting this module (except to use only Bluetooth V5.2 (BDR/EDR/LE)).
- Class II permissive change application is necessary using the SAR report. Please contact Murata.



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 high levels 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. LBEE5PK2AE-564 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.

### 15.2.3.2 Mobile Equipment

Equipment used at position in which the spaces between human body and antenna exceeded 20 cm. When installing it 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 20 cm or more away from person's body.

## 15.2.4 Power Levels for FCC

**Table 66** and **Table 67** show the per antenna port power table for 2.4 GHz for WLAN and Bluetooth. **Table 68** shows the per antenna port power table for 5 GHz WLAN.

**Table 66: FCC/ISED Power Level 2.4 GHz WLAN Per Antenna Port**

Mode	Data Rate	Typical Output Power (dBm)				
		Channels	1	2 ~ 3	4 ~ 8	9 ~ 10
11b	All Rates	16	17	17	17	16
11g	All Rates	9	9	16	9	9
11n HT20	MCS0 ~ MCS4	8	8	16	8	8
	MCS5 ~ MCS7	8	8	14	8	8

**Table 67: FCC Power Level 2.4 GHz BT/BLE Per Antenna Port**

Mode	Maximum Tune Up Tolerance (dBm)
DH5	10.0 ± 4.0
2DH5	6.0 ± 4.0
3DH5	6.0 ± 4.0
BLE	8.0 ± 4.0

**Table 68: FCC Power Level 5 GHz WLAN Per Antenna Port**

Mode	Data Rate	Typical Output Power (dBm)						
		Channels	36	40 ~ 60	64	100	104~136	140
11a	6 ~ 18 Mbps	14	16	14	13	16	13	16
	24 ~ 54 Mbps	14	14	14	13	14	13	14
11n HT20	MCS0 ~ MCS2	14	16	14	12	16	12	16
	MCS3 ~ MCS7	14	14	14	12	14	12	14
11ac VHT20	MCS0 ~ MCS2	14	16	14	12	16	12	16
	MCS3 ~ MCS7	14	14	14	12	14	12	14
	MCS8	13	13	13	12	13	12	13
<b>Channels</b>		<b>38</b>	<b>46 ~ 54</b>	<b>62</b>	<b>102</b>	<b>110~126</b>	<b>134</b>	<b>142~159</b>
11n HT40	MCS0 ~ MCS2	10	14	10	10	14	10	14
	MCS3 ~ MCS7	10	13	10	10	13	10	13
11ac VHT40	MCS0 ~ MCS2	10	14	10	10	14	10	14
	MCS3 ~ MCS7	10	13	10	10	13	10	13
	MCS8 ~ MCS9	10	11	10	10	11	10	11
<b>Channels</b>		<b>42~ 155</b>						
11ac VHT80	MCS0 ~ MCS9	11						

## 15.2.5 Theory of Operation for FCC and ISED

**Table 69** and **Table 70** show the theory of operation for WLAN and Bluetooth.

**Table 69: FCC/ISED Theory of Operation for WLAN**

Frequency of Operation			Scan	Ad-hoc Mode
2.4 GHz	11b/g/n (HT20)	2412 - 2462 MHz	Active	Yes
W52	11a/n/ac ((V)HT20)	5180 - 5240 MHz	Active	Yes
	11n/ac ((V)HT40)	5190 - 5230 MHz	Active	Yes
	11ac (HT80)	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	Passive	No
	11n/ac ((V)HT40)	5510 - 5710 MHz	Passive	No
	11ac (VHT80)	5530 - 5690 MHz	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

**Table 70: FCC/ISED Theory of Operation for Bluetooth**

Frequency of Operation		Scan	Ad-hoc Mode
BR	2402 ~ 2480 MHz	N/A	N/A
EDR	2402 ~ 2480 MHz	N/A	N/A
LE	2402 ~ 2480 MHz	N/A	N/A



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



End users cannot modify the software because firmware & driver are installed in device.

## 15.3 ISED

- **HVIN:** LBEE5PK2AE
- **IC Number:** 772C-LB2AE

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-LB2AE

#### 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 licence-exempt RSSs. Operation is subject to the following two conditions:

- (1) This device may not cause interference; and
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

##### 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:

- 1) l'appareil ne doit pas produire de brouillage;
- 2) 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. Several special packets are initiated by the MAC. 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 discontinues 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 this statement 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 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-LB2AE) 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 PCB Gain: +3.0 dBi	Dipole Gain: +3.4 dBi
: 5 GHz	Monopole PCB Gain: +3.3 dBi	Dipole Gain: +4.75 dBi

#### French Version

Le présent émetteur radio (IC Number: 772C-LB2AE) 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 PCB Gain: +3.0 dBi	Dipole Gain: +3.4 dBi
: 5 GHz	Monopole PCB Gain: +3.3 dBi	Dipole Gain: +4.75 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.

<p><b>English Version</b></p> <p>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.</p>
<p><b>French Version</b></p> <p>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.</p>

### 15.3.4 Antenna

Please refer to the antenna specification or please contact Murata for the detail designation of how to design the Antenna trace. The recommended antenna for Type 2AE module is shown below.

Model name	LBEE5PK2AE
Antenna model name	Type2AE-Trace Antenna
Antenna vendor	Murata Manufacturing Co.,Ltd.
Antenna type	Monopole PCB antenna
Antenna gain	+3.0 dBi @ 2.4 GHz
	+3.3 dBi @ 5 GHz
Frequency	2400-2483.5 MHz
	5150-5850 MHz

### 15.3.5 Power Levels for ISED

**Table 71** and **Table 72** show the per antenna port power table for 2.4 GHz for WLAN and Bluetooth. **Table 73** shows the per antenna port power table for 5 GHz WLAN.

**Table 71: ISED Power Level 2.4 GHz WLAN Per Antenna Port**

Mode	Data Rate	Typical Output Power (dBm)				
		1	2 ~ 3	4 ~ 8	9 ~ 10	11
<b>Channels</b>						
11b	All Rates	16	17	17	17	16
11g	All Rates	9	9	16	9	9
11n HT20	MCS0 ~ MCS4	8	8	16	8	8
	MCS5 ~ MCS7	8	8	14	8	8

Table 72: ISED Power Level 2.4 GHz BT/BLE Per Antenna Port

Mode	Maximum Tune Up Tolerance (dBm)
DH5	10.0 ± 4.0
2DH5	6.0 ± 4.0
3DH5	6.0 ± 4.0
BLE	8.0 ± 4.0

Table 73: ISED Power Level 5 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)								
Channels		36	40 ~ 60	64	100	104 ~ 116	120 ~ 128	132 ~ 136	140	144 ~ 165
11a	6 ~ 18 Mbps	14	16	14	13	16		16	13	16
	24 ~ 54 Mbps	14	14	14	13	14		14	13	14
11n HT20	MCS0 ~ MCS2	14	16	14	12	16		16	12	16
	MCS3 ~ MCS7	14	14	14	12	14		14	12	14
11ac VHT20	MCS0 ~ MCS2	14	16	14	12	16		16	12	16
	MCS3 ~ MCS7	14	14	14	12	14		14	12	14
	MCS8	13	13	13	12	13		13	12	13
Channels		38	46 ~ 54	62	102	110~126	134	142~159		
11n HT40	MCS0 ~ MCS2	10	14	10	10	14	10	14		
	MCS3 ~ MCS7	10	13	10	10	13	10	13		
11ac VHT40	MCS0 ~ MCS2	10	14	10	10	14	10	14		
	MCS3 ~ MCS7	10	13	10	10	13	10	13		
	MCS8 ~ MCS9	10	11	10	10	11	10	11		
Channels		42 ~ 58		106		122		138 ~ 155		
11ac VHT80	MCS0 ~ MCS9	11		11				11		

## 15.4 Europe

This section describes the CE certification information for Type 2AE module.

### 15.4.1 Power Levels for Europe

**Table 74** and **Table 75** show the per antenna port power table for 2.4 GHz for WLAN and Bluetooth. **Table 76** shows the per antenna port power table for 5 GHz WLAN.

Table 74: Europe Power Level 2.4 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)
Channels		1 ~ 13
11b	All Rates	14
11g	All Rates	16
11n HT20	MCS0 ~ MCS4	16
	MCS5 ~ MCS7	14

Table 75: Europe Power Level 2.4 GHz BT/BLE Per Antenna Port

Mode	Maximum Tune Up Tolerance (dBm)
DH5	10.0 ± 4.0
2DH5	6.0 ± 4.0
3DH5	6.0 ± 4.0
BLE	8.0 ± 4.0

Table 76: Europe Power Level 5 GHz WLAN Per Antenna Port

Mode	Data Rate	Typical Output Power (dBm)			
Channels		36 ~ 48	52 ~ 64	100 ~ 140	149 ~ 165
11a	6 ~ 18 Mbps	16	13	13	8
	24 ~ 54 Mbps	14	13	13	8
11n HT20	MCS0 ~ MCS2	16	13	13	8
	MCS3 ~ MCS7	14	13	13	8
11ac VHT20	MCS0 ~ MCS2	16	13	13	8
	MCS3 ~ MCS7	14	13	13	8
	MCS8	13	13	13	8
Channels		38 ~ 46	54 ~ 62	102 ~ 134	151 ~ 159
11n HT40	MCS0 ~ MCS2	14	13	13	8
	MCS3 ~ MCS7	13	13	13	8
11ac VHT40	MCS0 ~ MCS2	14	13	13	8
	MCS3 ~ MCS7	13	13	13	8
	MCS8	11	11	11	8
Channels		42 ~ 58	106 ~ 122	155	
11ac VHT80	MCS0 ~ MCS7	13	13	8	
	MCS8 ~ MCS9	11	11	8	

## 15.4.2 Theory of Operation for Europe

Table 77 and Table 78 show the theory of operation for WLAN and Bluetooth.

Table 77: Europe Theory of Operation for WLAN

Frequency of Operation		Scan	Ad-hoc Mode	
2.4 GHz	11b/g/n (HT20)	2412 - 2472 MHz	Active	Yes
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 - 5700 MHz	Passive	No
	11n/ac ((V)HT40)	5510 - 5670 MHz	Passive	No
	11ac (VHT80)	5530 - 5610 MHz	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

**Table 78: Europe Theory of Operation for Bluetooth**

Frequency of Operation		Scan	Ad-hoc Mode
BR	2402 ~ 2480 MHz	N/A	N/A
EDR	2402 ~ 2480 MHz	N/A	N/A
LE	2402 ~ 2480 MHz	N/A	N/A

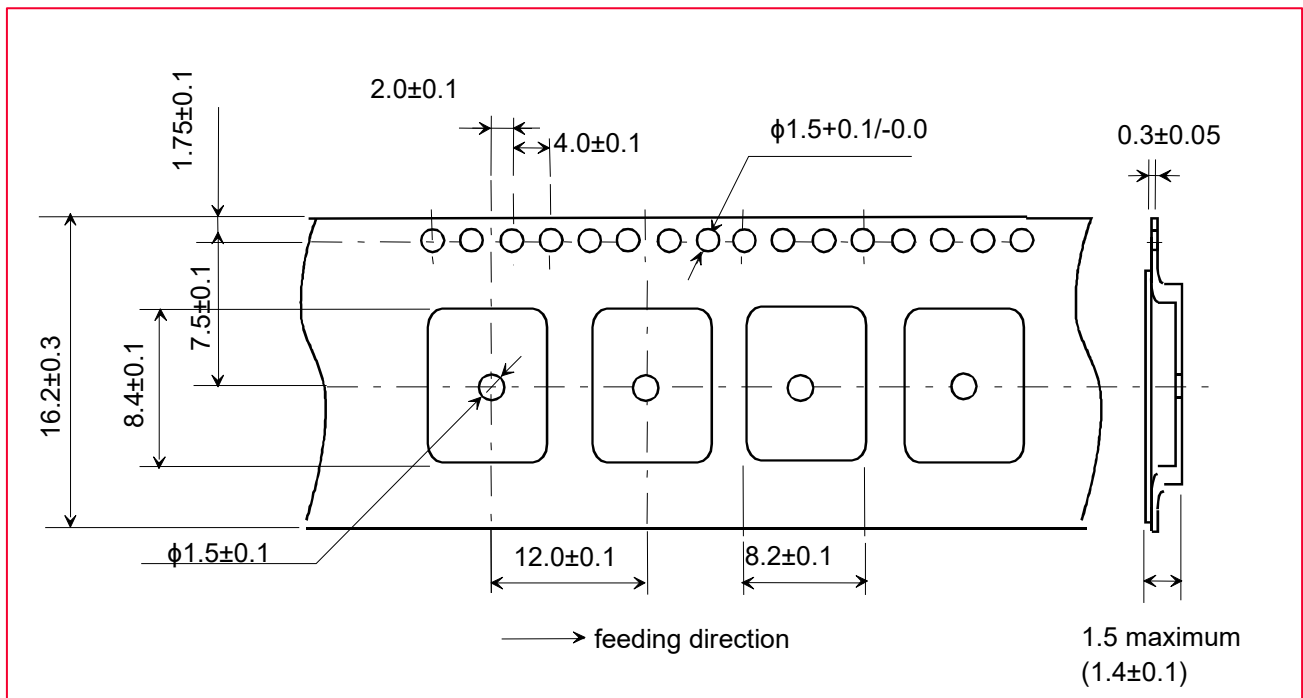
## 16 Tape and Reel Packing

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)<sup>25</sup>.

**Figure 27: Dimensions of Tape (Unit: mm)**

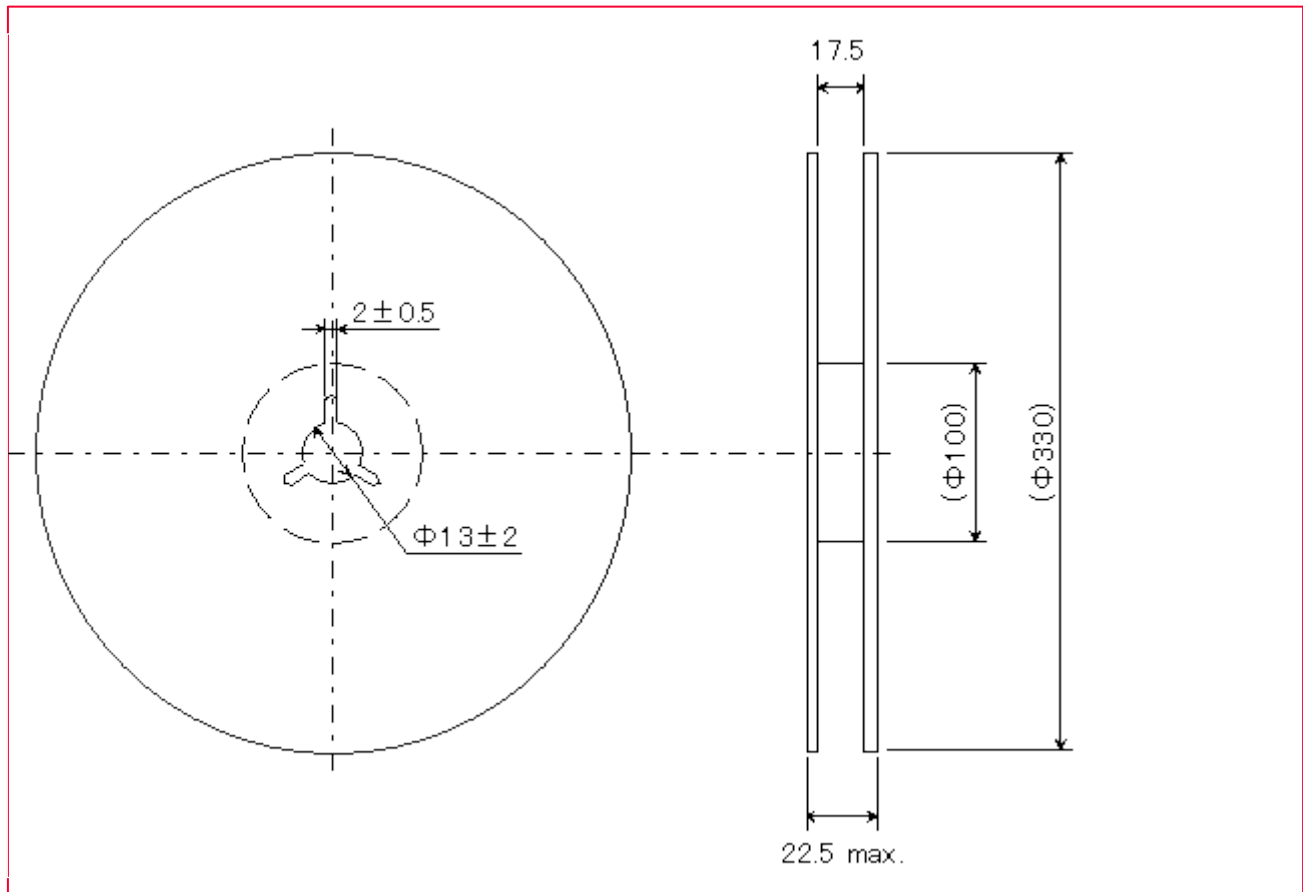


<sup>25</sup> Cumulative tolerance of maximum  $40.0 \pm 0.15$  mm every 10 pitches

## 16.2 Dimension of Reel

Figure 28 shows the reel dimensions.

Figure 28: Dimensions of Reel (Unit: mm)



### 16.3 Taping Diagrams

Figure 29 shows the tapings diagrams and Figure 30 shows the close up.

Figure 29: Taping Diagrams

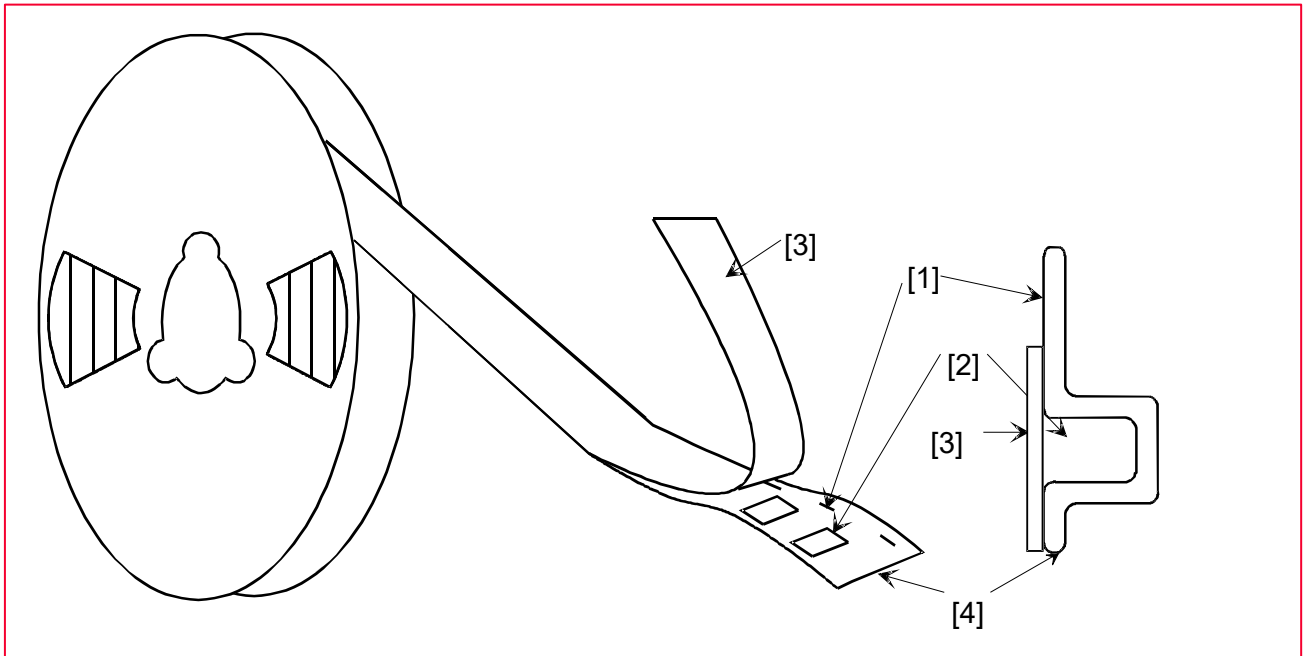
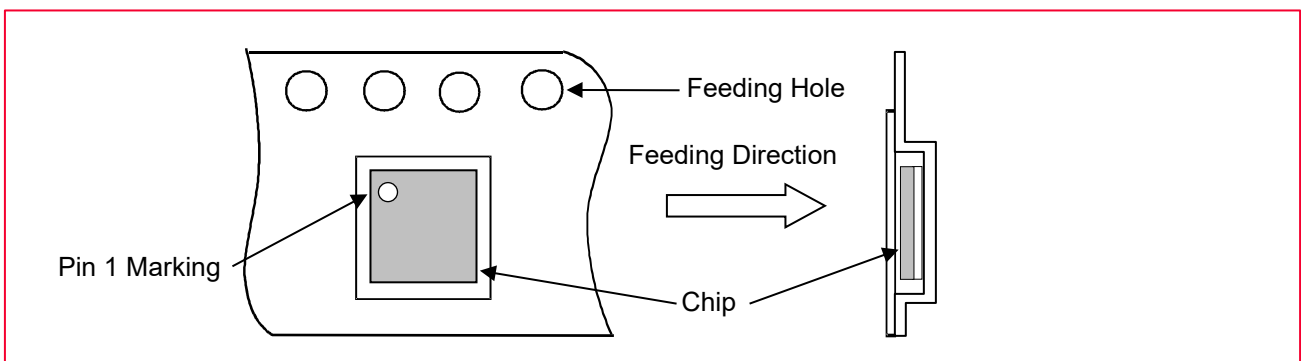


Table 79 shows the taping specifications.

Table 79: Taping Specifications

Mark	Description
1	Feeding hole: As specified in <a href="#">Dimensions of Tape (Plastic tape)</a> ☞.
2	Hole for Chip: As specified in <a href="#">Dimensions of Tape (Plastic tape)</a> ☞.
3	Cover tape: 62 μm in thickness.
4	Base tape: As specified in <a href="#">Dimensions of Tape (Plastic tape)</a> ☞.

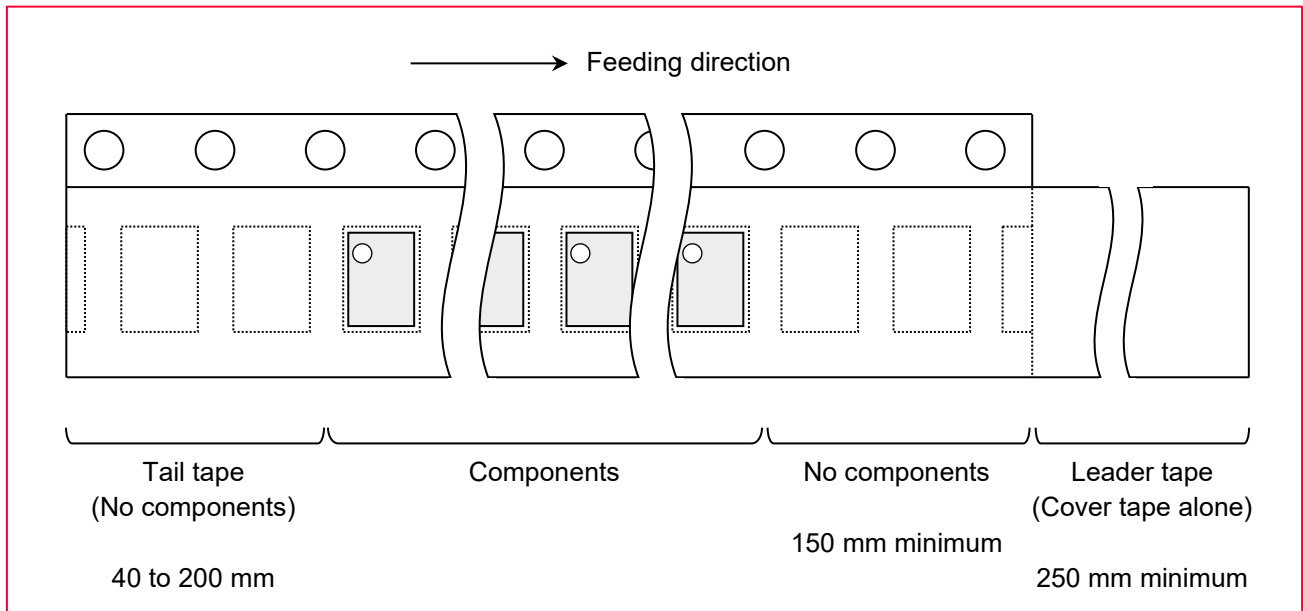
Figure 30: Taping Diagrams (Close Up)



## 16.4 Leader and Tail Tape

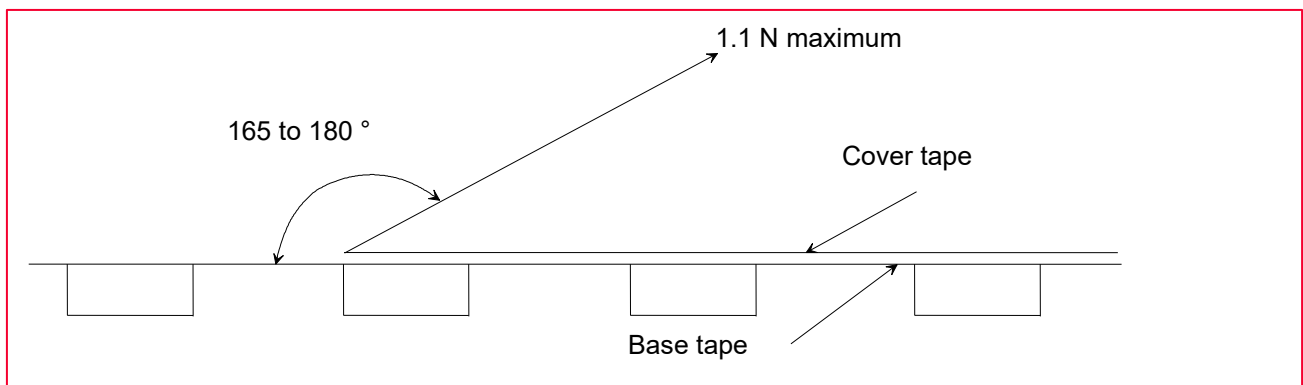
The leader and tail tape are shown in **Figure 31**.

**Figure 31: 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.
- Packaging unit: 1000 pcs. / Reel
- Tape 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 in **Figure 32**.

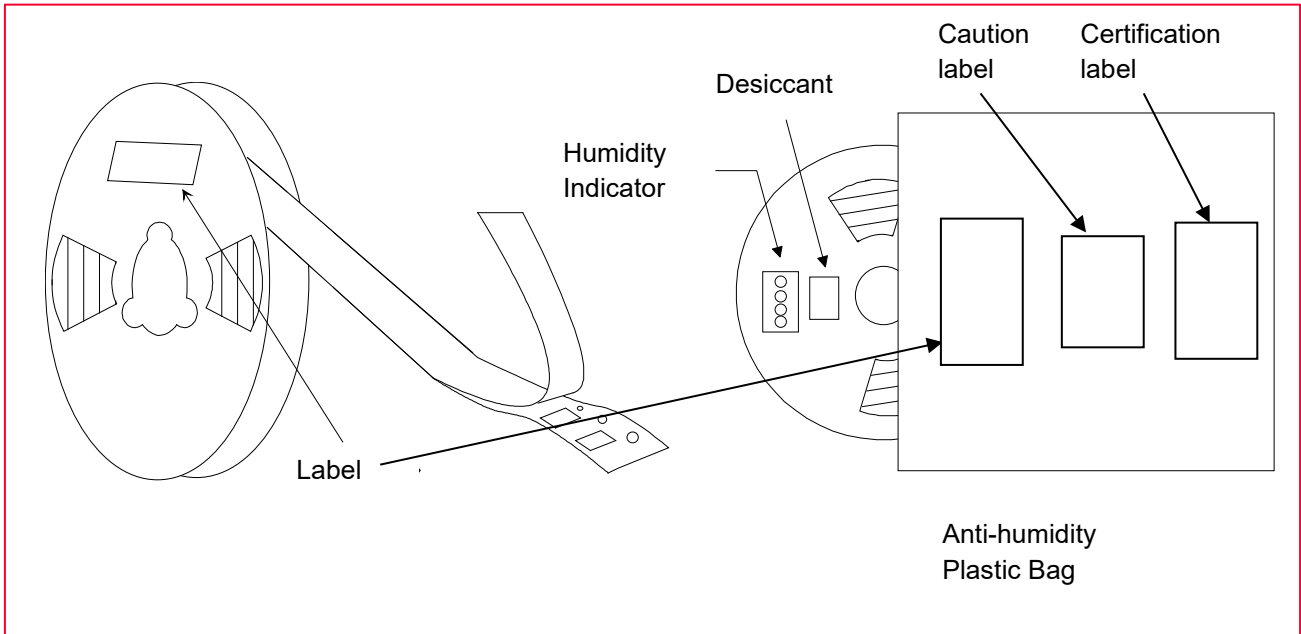
**Figure 32: Peeling Force**



## 16.5 Humidity Proof Packaging

Figure 33 shows the humidity proof packaging.

Figure 33: 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 and keep under the ambient temperature from 5 to 35 °C and humidity from 20 ~ 70 %RH (Packing materials may be deformed at the temperature over 40 °C).
- The product left more than 6 months after receipt, the solderability needs to be confirmed before it is used.
- The product shall be stored in non-corrosive gas (Cl<sub>2</sub>, NH<sub>3</sub>, SO<sub>2</sub>, NO<sub>x</sub>, 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<sup>26</sup> (Based on IPC/JEDEC J-STD-020)
  - After the packing is opened, the product shall be stored at <30 °C / <60 %RH and the product shall be used within 168 hours.
- Please record and manage the time after opening.
  - Product should be repacked with desiccating agent immediately after use.
  - 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.

### 17.2 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, the characteristics of products may change. Do not touch products with bare hands that may result in poor solder ability.

### 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 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.

<sup>26</sup> For the MSL standard, see IPC/JEDEC J-STD-020 (can be downloaded from [www.jedec.org](http://www.jedec.org) .

If the storage environment is not conducted above standard conditions, it will cause some issue (e.g., Operation issue, Overcurrent, Malfunction) we shall not be responsible for that.

Before using, please refer to [Preconditions to Use Our Products](#) .

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

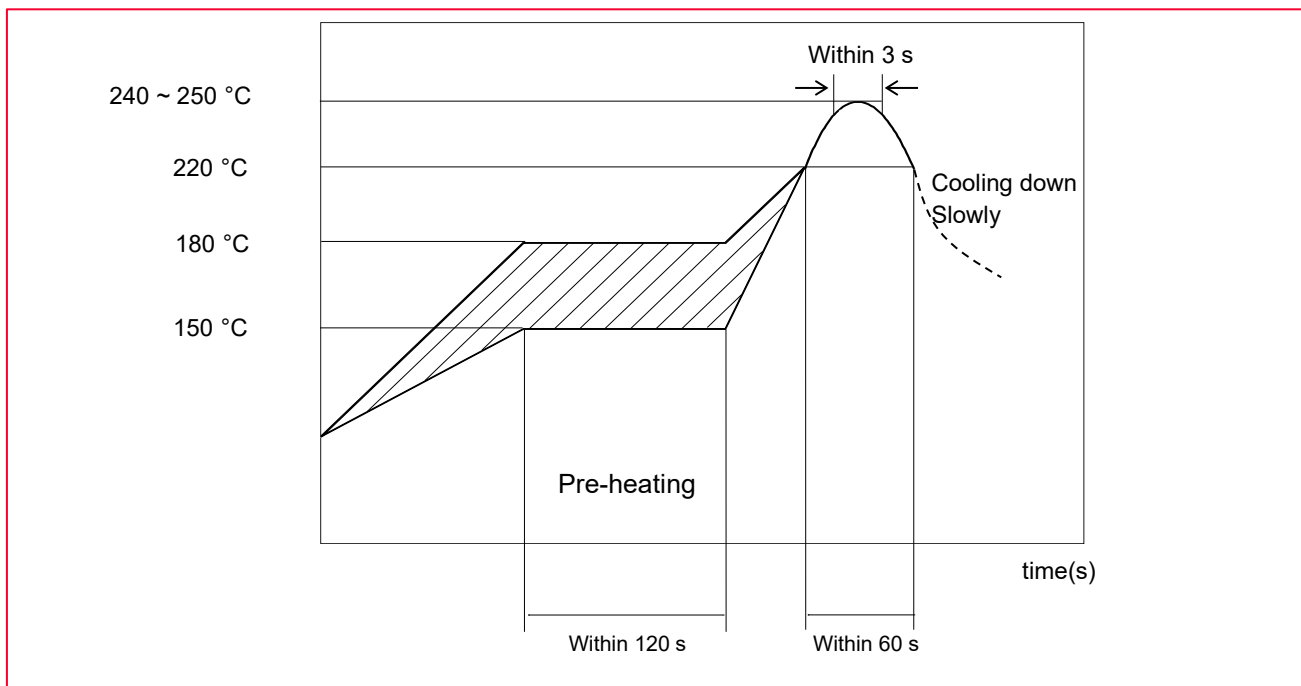
When placing products on the PCB, products may be stressed and broken by uneven forces from a worn-out chucking locating claw or a suction nozzle. To prevent products from damage, be sure to follow the specifications for the maintenance of the chip placer being used. For the positioning of products on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

## 17.5 Soldering Conditions

The recommendation conditions of soldering are shown in **Figure 34**.

When products are immersed in solvent after mounting, pay special attention to maintain the temperature difference within 100 °C. 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 34: 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

This product is moisture sensitive therefore, cleaning is not permitted. If any cleaning process is done the customer is responsible for any issues or failures caused by such process.

## 17.7 Operational Environment Condition

Murata products are designed to work for electronic products under normal environmental conditions (ambient temperature, humidity, and pressure). Therefore, products will not have any problems when used under the similar conditions to the conditions mentioned above.

However, if products are used under the following circumstances, it may damage products and leakage of electricity and may result in abnormal temperature occurrence.

- In an atmosphere containing corrosive gas (CL<sub>2</sub>, NH<sub>3</sub>, SO<sub>x</sub>, NO<sub>x</sub>, 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, make sure to 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.

## 17.8 Input Power Capacity

Products shall be used in the input power capacity as specified in this specification.



Inform Murata advance, 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.

Please note that the only warranty that we provide regarding the products is its conformance to the specifications provided herein. Accordingly, we shall not be responsible for any defects in products or equipment incorporating such products, which are caused under the conditions other than those specified in this specification.

WE HEREBY DISCLAIM ALL OTHER WARRANTIES REGARDING THE PRODUCTS, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, THAT THEY ARE DEFECT-FREE, OR AGAINST INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS.

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The product shall not be used in any application listed below which requires especially high reliability for the prevention of such defect as may directly cause damage to the third party's life, body or property. You acknowledge and agree that, if you use our products in such applications, we will not be responsible for any failure to meet such requirements. Furthermore, YOU AGREE TO INDEMNIFY AND DEFEND US AND OUR AFFILIATES AGAINST ALL CLAIMS, DAMAGES, COSTS, AND EXPENSES THAT MAY BE INCURRED, INCLUDING WITHOUT LIMITATION, ATTORNEY FEES AND COSTS, DUE TO THE USE OF OUR PRODUCTS AND THE SOFTWARE IN SUCH APPLICATIONS.

- Aircraft equipment.
- 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.

We expressly prohibit you from analyzing, breaking, reverse-engineering, remodeling altering, and reproducing our product. Our product cannot be used for the product which is prohibited from being manufactured, used, and sold by the regulations and laws in the world.

We do not warrant or represent that any license, either express or implied, is granted under any our patent right, copyright, mask work right, or our other intellectual property right relating to any combination, machine, or process in which our products or services are used. Information provided by us regarding third-party products or services does not constitute a license from us to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from us under our patents or other intellectual property.

Please do not use our products, our technical information and other data provided by us for the purpose of developing of mass-destruction weapons and the purpose of military use.

Moreover, you must comply with "foreign exchange and foreign trade law", the "U.S. export administration regulations", etc.

Please note that we may discontinue the manufacture of our products, due to reasons such as end of supply of materials and/or components from our suppliers.

By signing on specification sheet or approval sheet, you acknowledge that you are the legal representative for your company and that you understand and accept the validity of the contents herein. When you are not able to return the signed version of specification sheet or approval sheet within 30 days from receiving date of specification sheet or approval sheet, it shall be deemed to be your consent on the content of specification sheet or approval sheet. Customer acknowledges that engineering samples may deviate from specifications and may contain defects due to their development status. We reject any liability or product warranty for engineering samples. In particular we disclaim liability for damages caused by

- The use of the engineering sample other than for evaluation purposes, particularly the installation or integration in the product to be sold by you,
- Deviation or lapse in function of engineering sample,
- Improper use of engineering samples.

We disclaim any liability for consequential and incidental damages.

If you can't agree with the above contents, please contact sales.

## Revision History

Revision Code	Date	Changed Item	Comment
-	2020.07.09	First Issue	
A	2020.12.10	1. Scope 8. Absolute Maximum Ratings 9. Operating Conditions 13. DC / RF Characteristics 16. Tape and Reel Packing 17.6 Cleaning 15. Radio Regulatory Certification by Country for LBEE5PK2AE	<ul style="list-style-type: none"> <li>• Update</li> <li>• Update</li> <li>• Update</li> <li>• Update</li> <li>• Update</li> <li>• Update</li> <li>• Updated regulatory statement</li> </ul>
B	2020.12.17	3. Ordering Information 6. Dimensions, Marking and Terminal Configurations 13. DC/RF Characteristics 13.7.2 Low-Rate Condition for IEEE 802.11n(HT40) – 5 GHz 16. Tape and Reel Packing	<ul style="list-style-type: none"> <li>• Corrected part number</li> <li>• Correction</li> <li>• Correction</li> <li>• Correction</li> <li>• Correction</li> </ul>
C	2021.04.30	13. DC / RF Characteristics	<ul style="list-style-type: none"> <li>• Update</li> </ul>
D	2021.12.17	6. Dimensions, Marking and Terminal Configurations	<ul style="list-style-type: none"> <li>• Updated module height</li> </ul>
E	2021.12.29	7.2 Pin Descriptions	<ul style="list-style-type: none"> <li>• Updated bandgap reference resistor to 4.75K ohm +/-1%.</li> </ul>
F	2022.02.16	1. Scope 5.2 Bluetooth Qualification	<ul style="list-style-type: none"> <li>• Updated BT 5.2</li> <li>• Updated Bluetooth QDID</li> </ul>
G	2022.04.06	2. Key Features 4. Block Diagram 7.1 Module Pin Layout 7.4 Strapping Option 13. DC / RF Characteristics	<ul style="list-style-type: none"> <li>• Updated host interface.</li> <li>• Update</li> <li>• Updated terminal configuration.</li> <li>• Update</li> <li>• Update</li> </ul>
H	2022.06.14	1. Scope	<ul style="list-style-type: none"> <li>• Updated IC P/N</li> </ul>
I	2022.08.18	13. DC/RF Characteristics	<ul style="list-style-type: none"> <li>• Update</li> </ul>
J	2022.11.01	5. Certification information 7.2 Pin Descriptions  Reference schematic 15. Radio Regulatory Certification by Country for LBEE5PK2AE	<ul style="list-style-type: none"> <li>• Update</li> <li>• Updated JTEG_SEL description.</li> <li>• Update</li> <li>• Updated Add APPENDIX of user/installation manual.</li> <li>• Removed Primary</li> </ul>
K	2022.11.30	Reference schematic 13. DC/RF Characteristics	<ul style="list-style-type: none"> <li>• Corrected strap setting for USB.</li> <li>• Revised Wi-Fi RX current</li> </ul>
L	2023.09.13	1. Scope  3. Ordering Information 6. Dimensions, Marking and Terminal Configurations Reference Circuit Appendix	<ul style="list-style-type: none"> <li>• Updated information. Created new section 'Key Features'.</li> <li>• Renamed part number section.</li> <li>• Created new section 'Module Pin Descriptions'</li> <li>• Moved section to HW app note.</li> <li>• Moved Appendix information into Sections 15 and 16.</li> <li>• Added transmit power tables.</li> <li>• Moved antenna sections to HW app note.</li> </ul> <p>Updated to new format</p>

Revision Code	Date	Changed Item	Comment
M	2024.07.04	7.3 SDIO Pin Descriptions	<ul style="list-style-type: none"><li>Revised the Pin No of the SDIO signal</li></ul>



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