Datasheet

Type 2AE Wi-Fi™ + Bluetooth® Module

Infineon CYW4373E Chipset for 802.11a/b/g/n/ac + Bluetooth 5.2 Datasheet - Rev. 16

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

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

1 Scope

This specification 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
- Total Fit : 343

This product is moisture sensitive. Please check the detail in Section 17.1 Storage Condition

3 Ordering Information

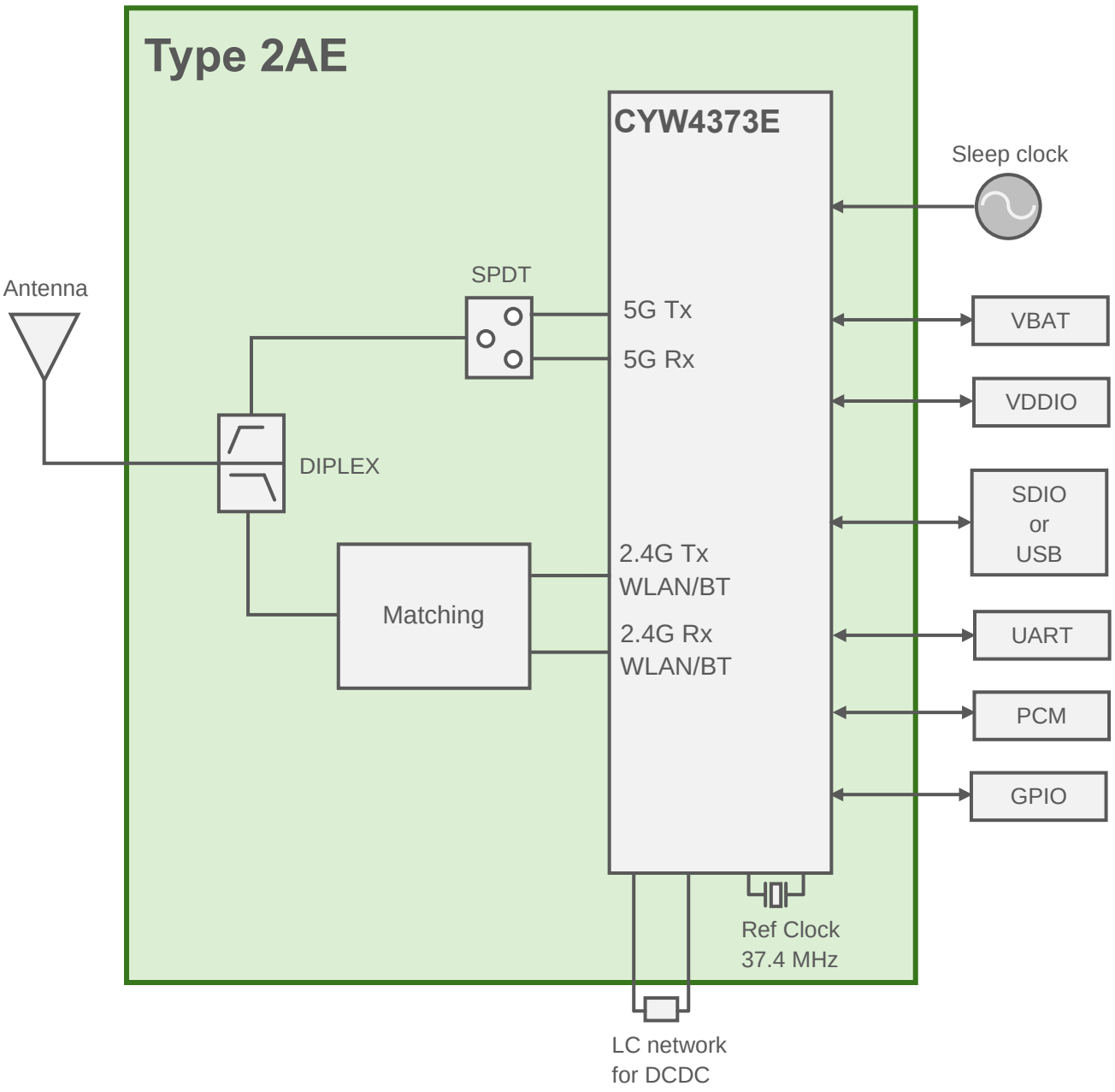
Table 2: Ordering Information

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)

4 Block Diagram

Figure 1 shows the Type 2AE internal block diagram.

Figure 1: Block Diagram



5 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

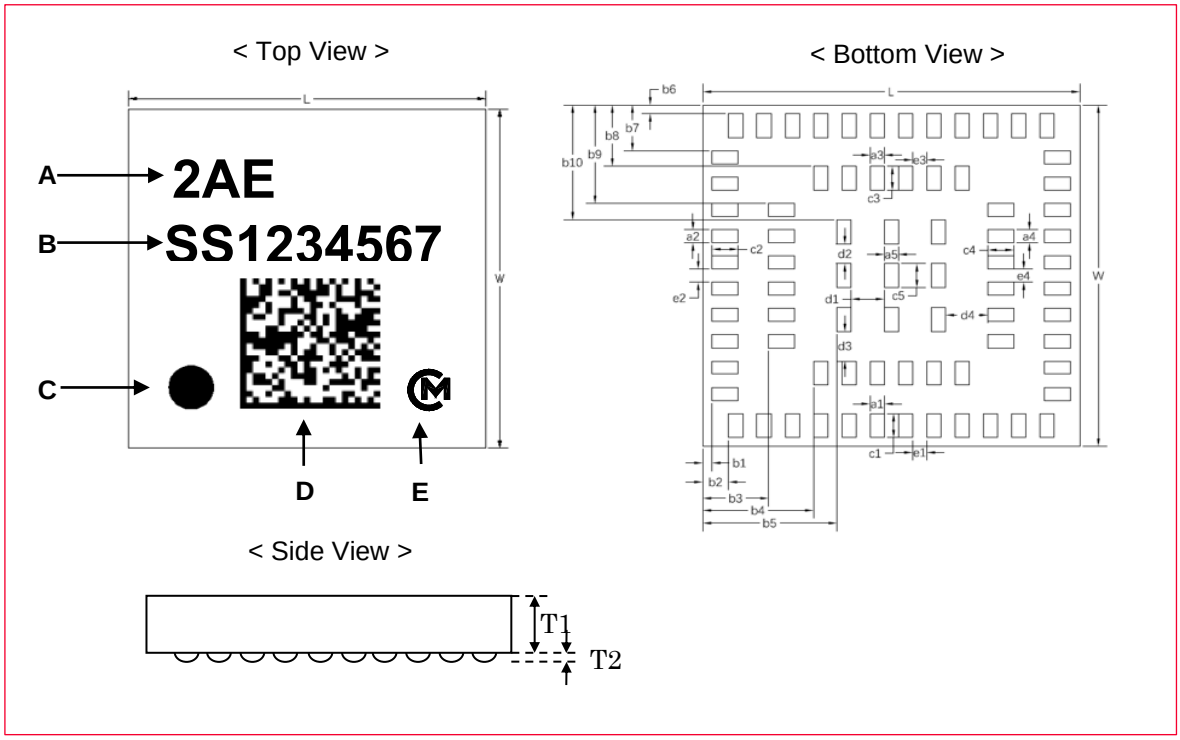


Table 3 and **Table 4** describes the Type 2AE markings and dimensions.

Table 3: Markings

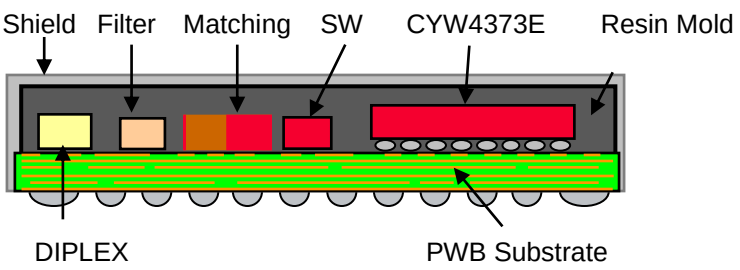
Marking	Meaning
A	Module Type
B	Inspection Number
C	Pin 1 Marking
D	2D Code (Internal Use)
E	Murata Logo

Table 4: 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



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

6 Module Pin Descriptions

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

6.1 Pin Assignments

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

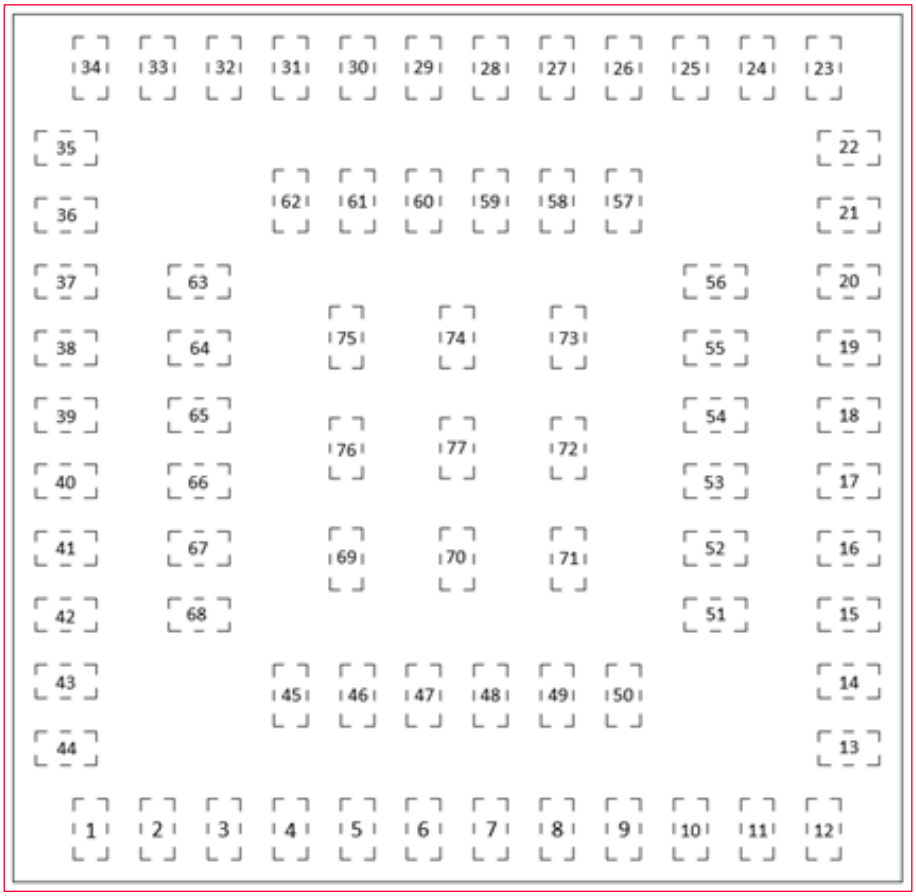


Table 5 illustrates the terminal configurations for Type 2AE.

Table 5: 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		

6.2 Pin Descriptions

Table 6 describes Type 2AE pin descriptions.

Table 6: 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_VDDBAT5V	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).
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.

No.	Terminal Name	Type	Connection to IC Terminal	Description
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.
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.

No.	Terminal Name	Type	Connection to IC Terminal	Description
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: • GPIO_2 is TCK • GPIO_3 is TMS • GPIO_4 is TDIO • GPIO_5 is TDO • GPIO_6 is TRST_L
54	STRAP_1	I	STRAP_1	0: SDIO only
55	STRAP_2	I	STRAP_2	USB_DISABLE • 1: USB disable • 0: USB enable
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 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			

No.	Terminal Name	Type	Connection to IC Terminal	Description
71	GND			
72	GND			
73	GND			
74	GND			
75	GND			
76	GND			
77	GND			

6.3 SDIO Pin Descriptions

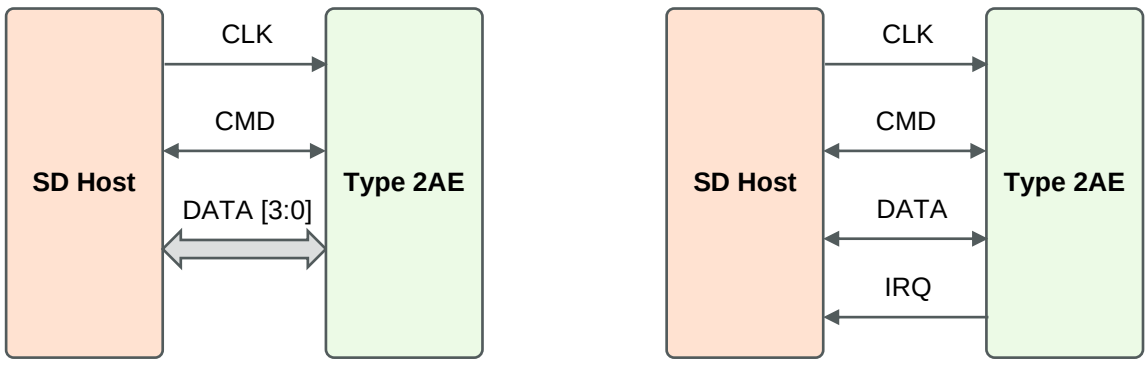
Table 7 shows the SDIO pin descriptions.

Table 7: 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



7 Absolute Maximum Ratings

The absolute minimum and maximum ratings are shown in **Table 8.**

Table 8: 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.

8 Operating Conditions

8.1 Operating Conditions

The operating conditions are shown **Table 9**.

Table 9: Operating Conditions

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

9 External Sleep Clock Requirements

External LPO signal requirements are shown in **Table 10**.

Table 10: 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[4]	> 100k < 5	Ω pF
Clock jitter (during initial start-up)	<10,000	ppm

[1] Functionality is guaranteed but specifications require derating at extreme temperatures.
[2] 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%.
[3] The maximum continuous voltage is 4.8V
[4] When the power is applied or switched off.

10 Strapping Options

Table 11 has the strapping options for Type 2AE module pins.

Table 11: Strapping Options

Mode Select	STRAP_2	STRAP_1	STRAP_0
USB	0	0	0
SDIO only	1	0	• **0** = SDIO is 3.3V • **1** = SDIO is 1.8V

11 Power-On Sequence

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

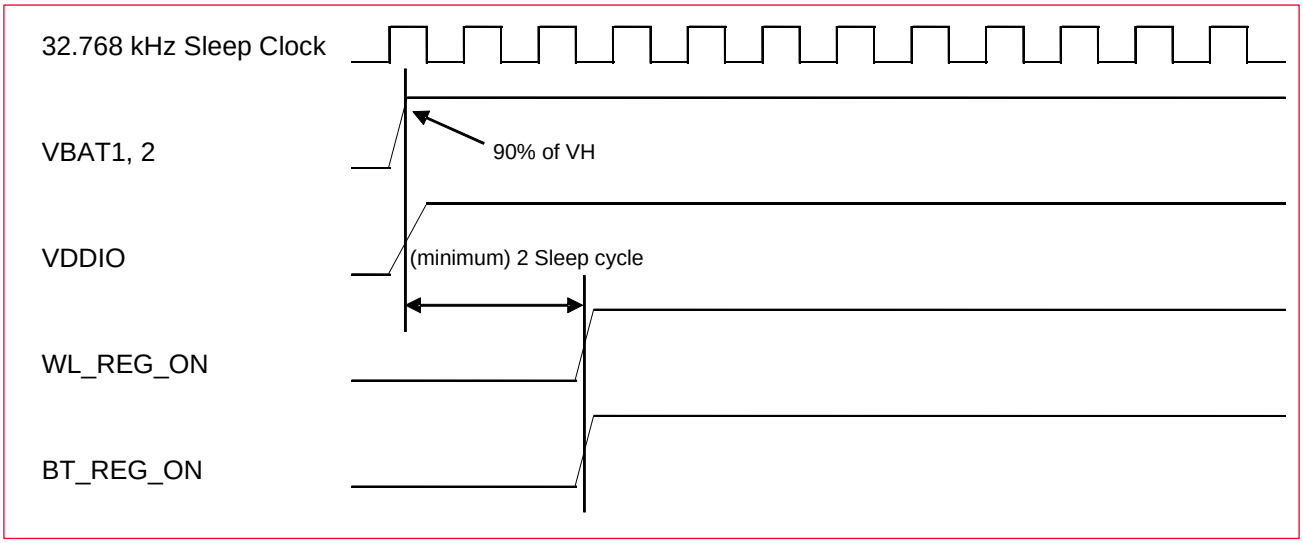
11.1 Power-On Sequence for WLAN ON and BT ON

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 shows the power-on sequence for WLAN ON and BT ON.

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



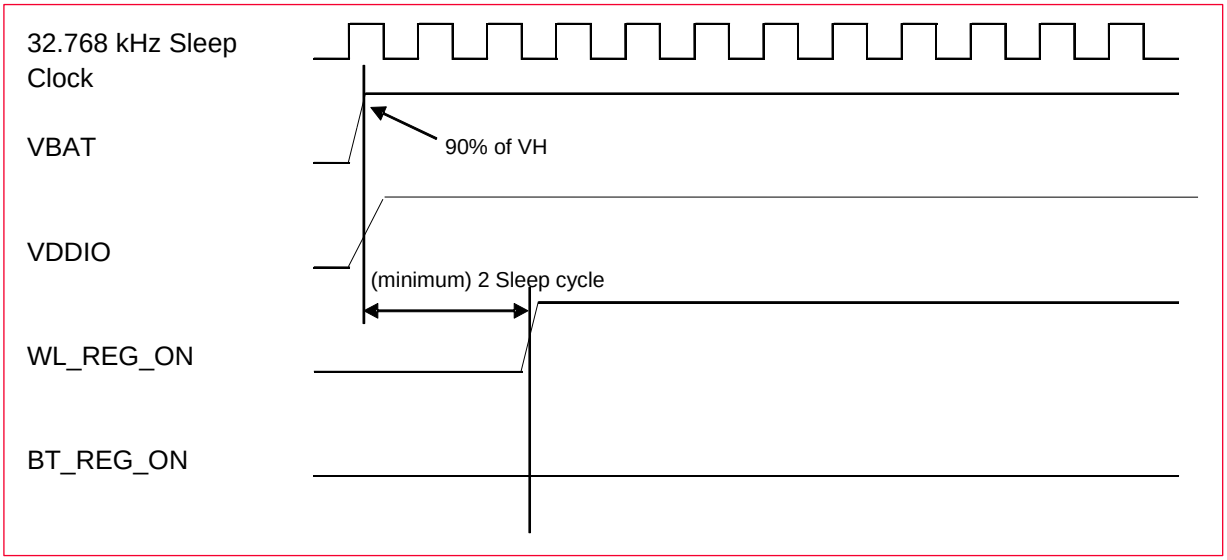
11.2 Power-On Sequence for WLAN ON and BT OFF

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 shows the power-on sequence for WLAN ON and BT OFF.

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



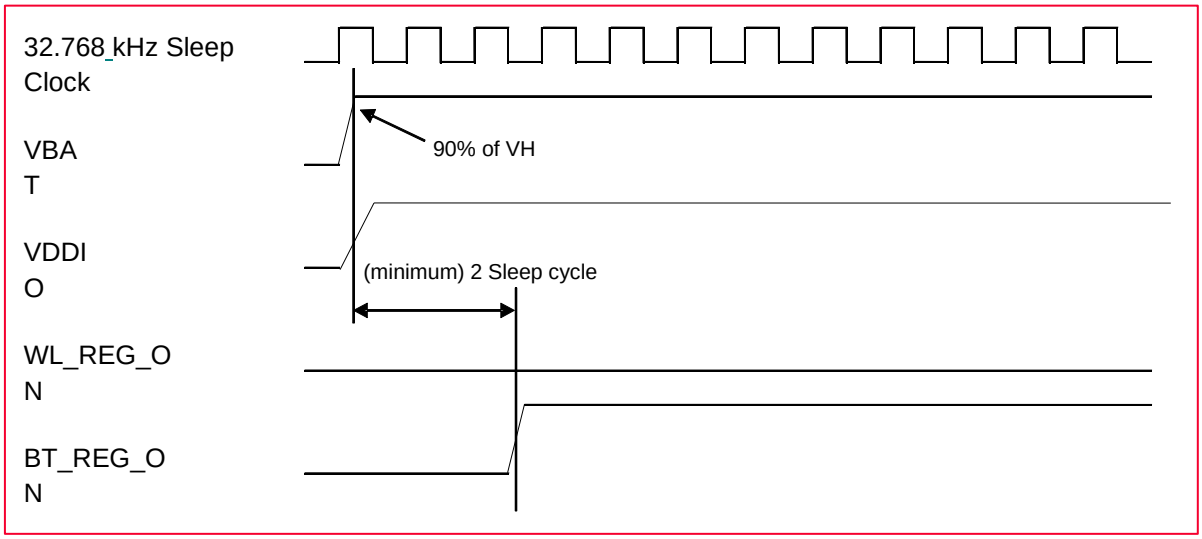
11.3 Power-On Sequence for WLAN OFF and BT ON

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 shows the power-on sequence for WLAN OFF and BT ON.

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

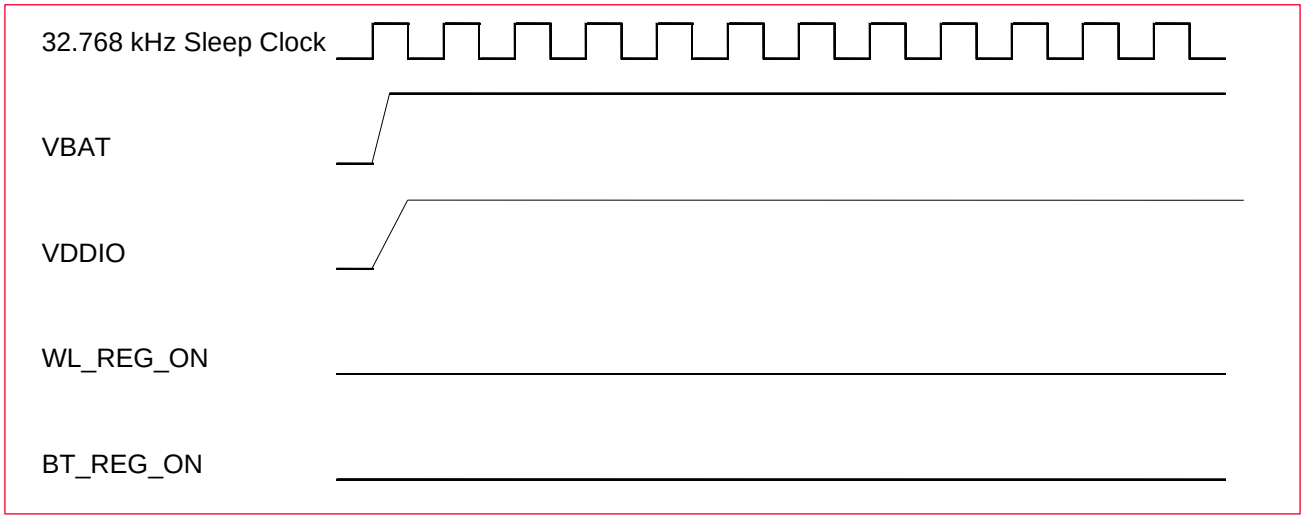


11.4 Power-On Sequence for WLAN OFF and BT OFF

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



12 Digital I/O Requirements

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

12.1 Digital I/O Pins

Table 12 describes the digital input/output pins and related parameters.

Table 12: 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

12.2 RF Switch Control Output Pins

Table 13 provides information about the RF switch control output pins.

Table 13: 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_{OH}	VDDIO-0.40			V
• Output low voltage @ 2.0 mA	V_{OL}			0.40	V
Output capacitance	C_{out}			5	pF

13 Interface Timing

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

13.1 SDIO Timing - Default Mode

The SDIO default timing diagram and data are shown in **Figure 10** and **Table 14**.

Figure 10: SDIO Timing Diagram - Default Mode

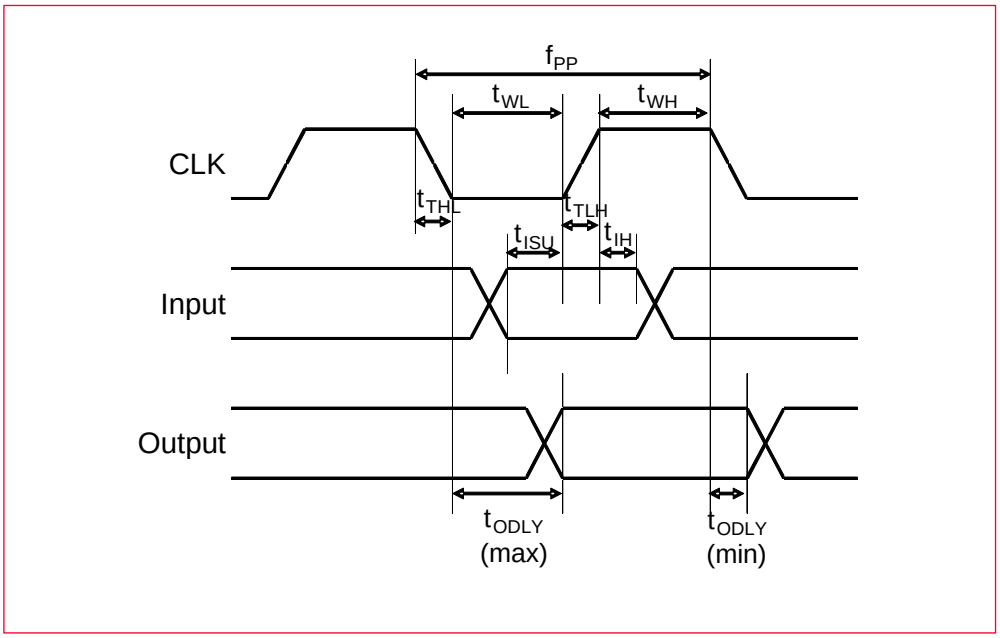


Table 14: SDIO Timing Data - Default Mode

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

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

13.2 SDIO Timing - High Speed Mode

The SDIO high speed timing diagram and data are shown in **Figure 11** and **Table 15**.

Figure 11: SDIO Timing Diagram – High Speed Mode

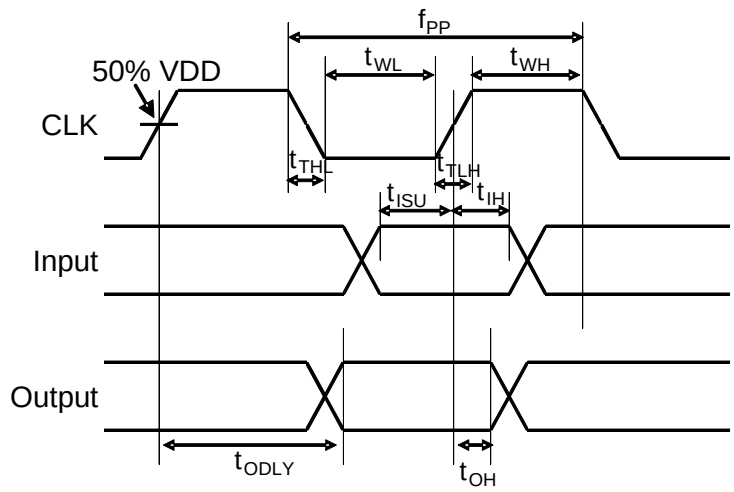


Table 15: SDIO Timing Data - High Speed Mode

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

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

13.3 SDIO BUS Timing Specifications in SDR Mode

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

13.3.1 Clock Timing

The clock timing diagram and parameters are shown in **Figure 12** and **Table 16**.

Figure 12: Clock Timing Diagram - SDR Mode

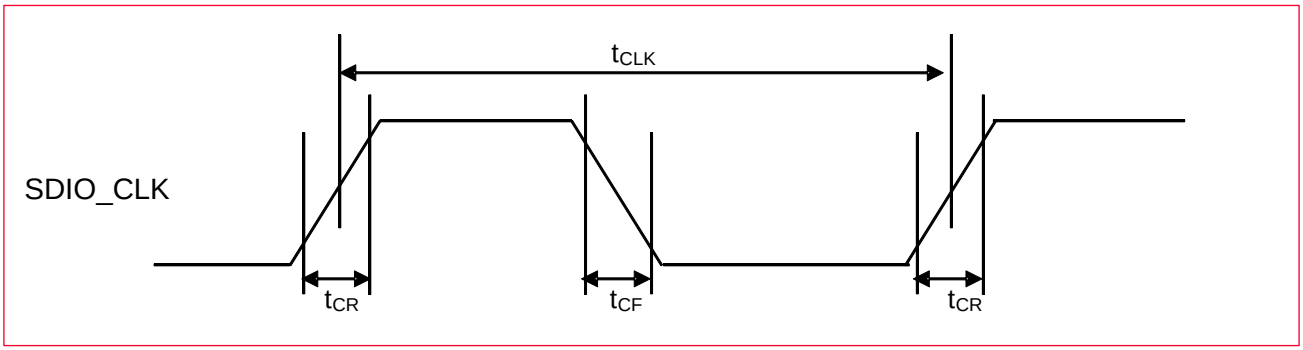


Table 16: Clock Timing Parameters - SDR Mode

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

13.3.2 Card Input Timing

The card input timing diagram and parameters are shown in **Figure 13** and **Table 17**.

Figure 13: Card Input Timing Diagram - SDR Mode

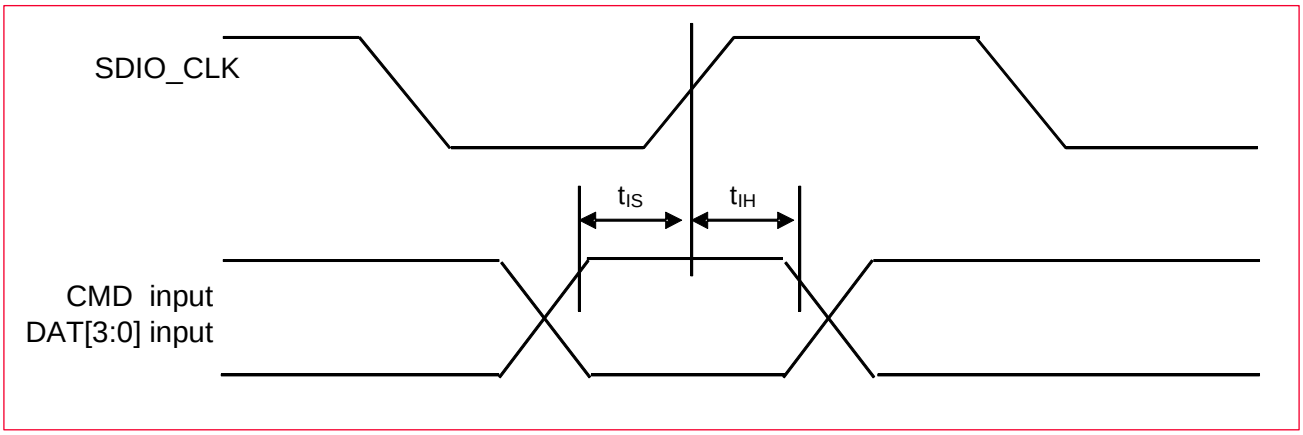


Table 17: Card Input Timing Parameters - SDR Mode

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

13.3.3 Card Output Timing

This section describes SDIO bus output timing.

13.3.3.1 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 18 respectively**.**

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

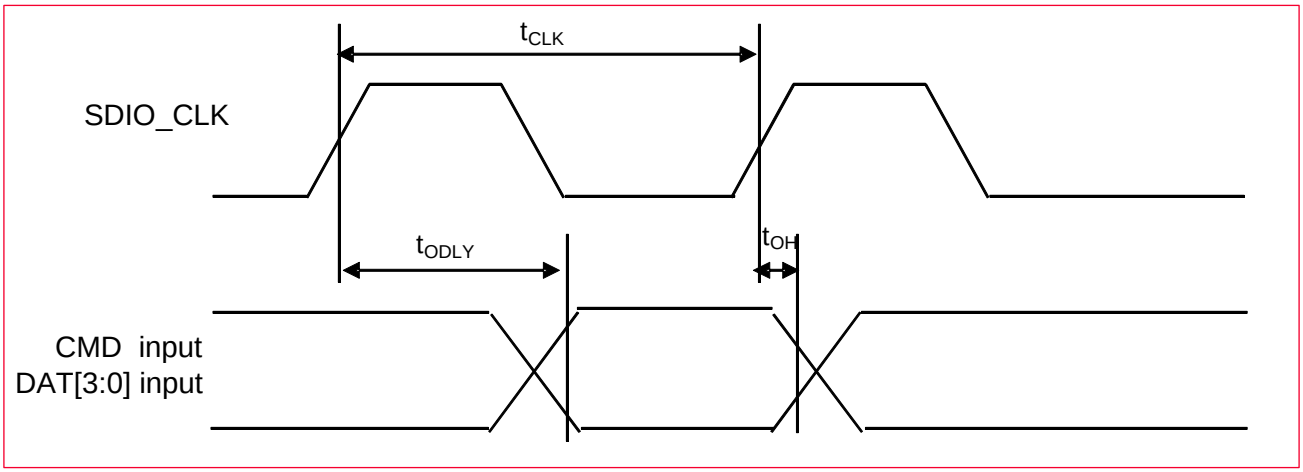


Table 18: SDIO Bus Output Timing Parameters - SDR Modes up to 100 MHz

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

13.3.3.2 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 19** respectively.

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

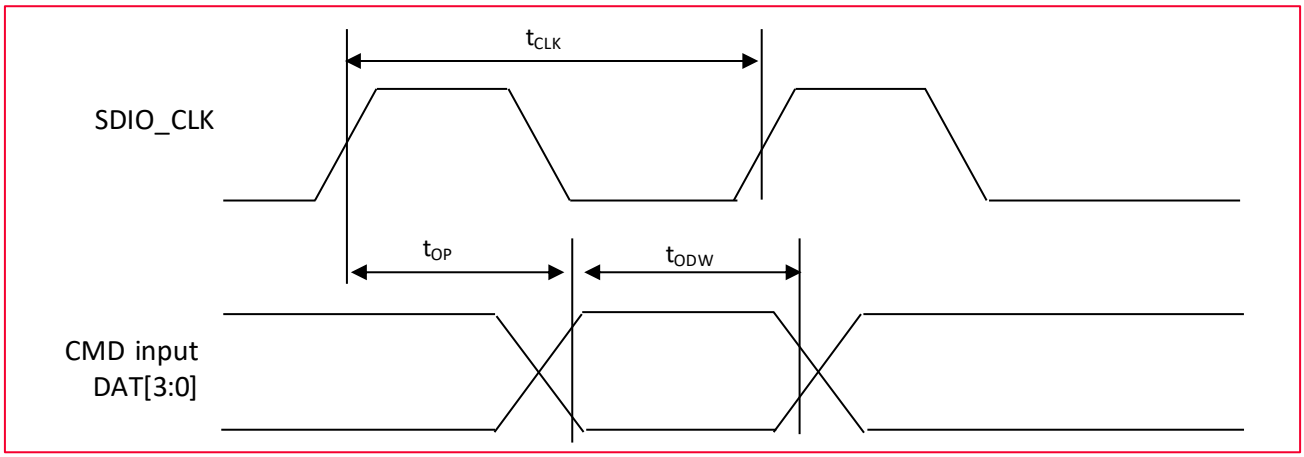


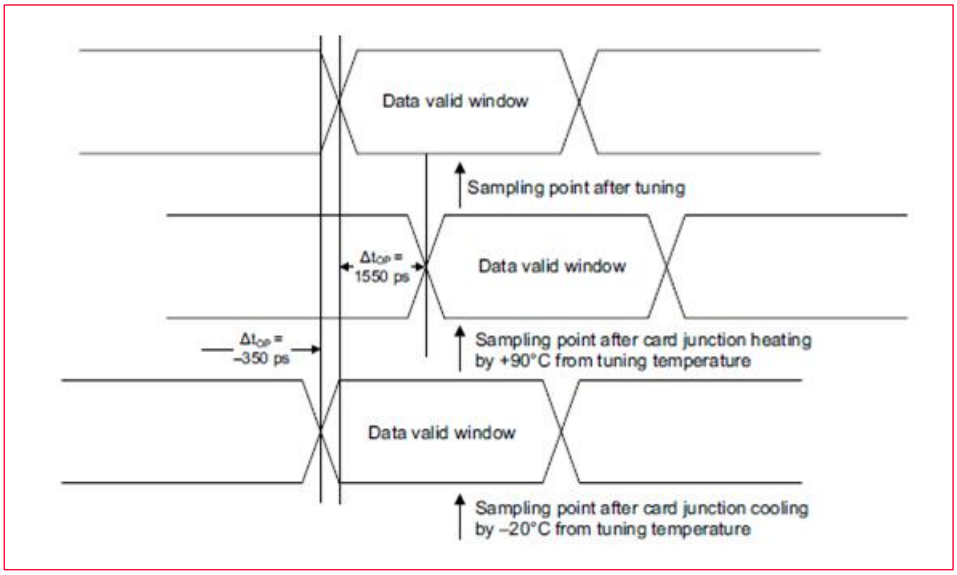
Table 19: SDIO Bus Output Timing Parameters - SDR Modes 100 MHz to 208 MHz

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

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

Figure 16 shows Δtop consideration for variable data window at SDR 104 mode.

Figure 16: Δtop Consideration for Variable Data Window - SDR 104 Mode



13.4 SDIO Timing Specifications in DDR50 Mode

This section describes SDIO clock timing and SDIO data timing.

13.4.1 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 20** respectively.

Figure 17: SDIO Clock Timing Diagram - DDR50 Mode

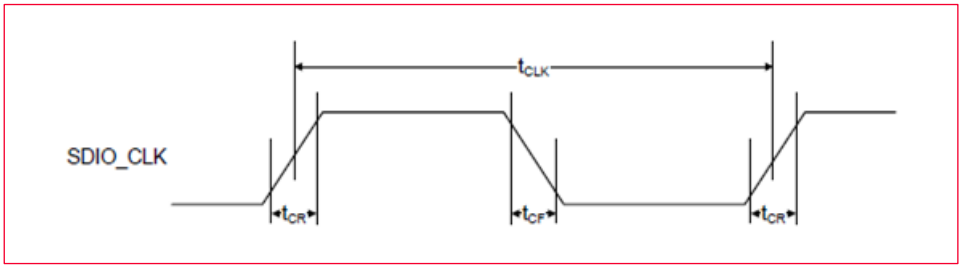


Table 20: SDIO Clock Timing Parameters - DDR50 Mode

Parameter	Symbol	Minimum	Maximum	Unit	Comments
	t_{CLK}	20		ns	DDr50 mode
	t_{CR}, t_{CF}		0.2 x t_{CLK}	ns	t_{CR}, t_{CF}<4.00ns(max) @ 50MHz, cCard = 10 pF
Clock duty cycle		45	55	%	

13.4.2 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 21** respectively.

Figure 18: SDIO Data Timing Diagram - DDR50 Mode

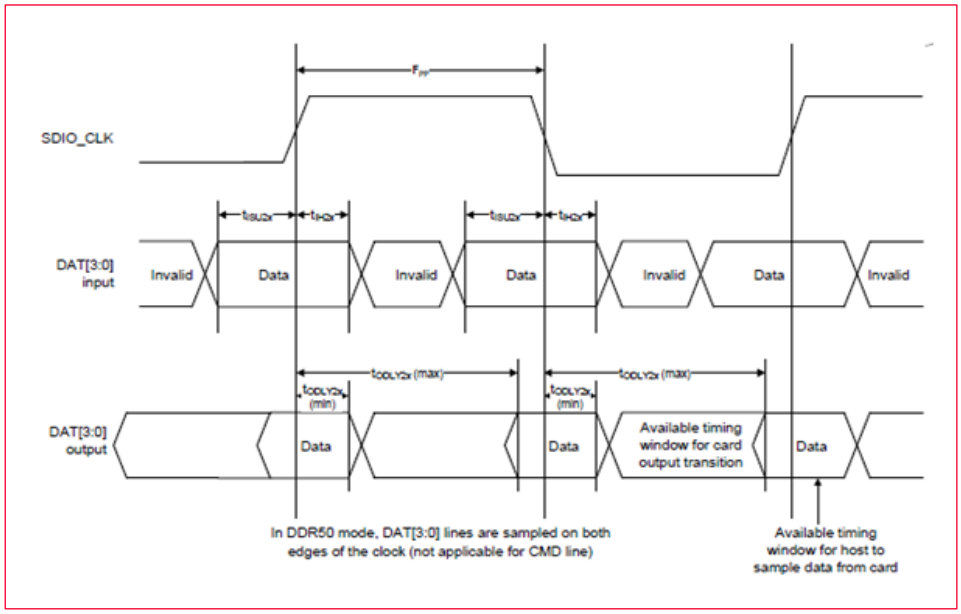


Table 21: SDIO Data Timing Parameters - DDR50 Mode

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

13.5 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 22**.

Figure 19: UART Timing Diagram - Default Mode

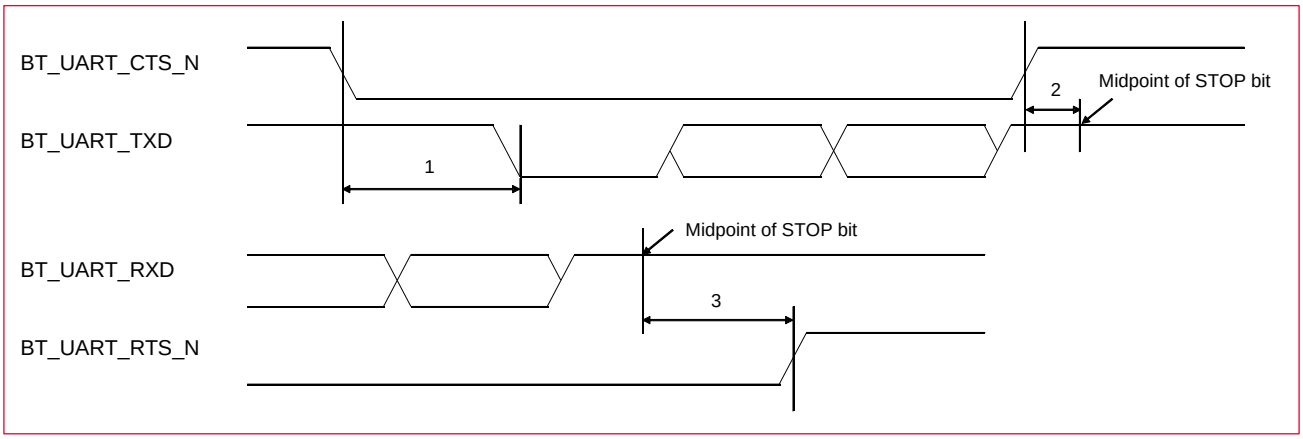


Table 22: UART Timing Parameters - Default Mode

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 23**.

Table 23: 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

13.6 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.

13.6.1 Short Frame Sync - Master Mode

Figure 20 and **Table 24** shows the Bluetooth PCM short frame sync data signal and parameters in master mode respectively.

Figure 20: Short Frame Sync Signal - Master Mode

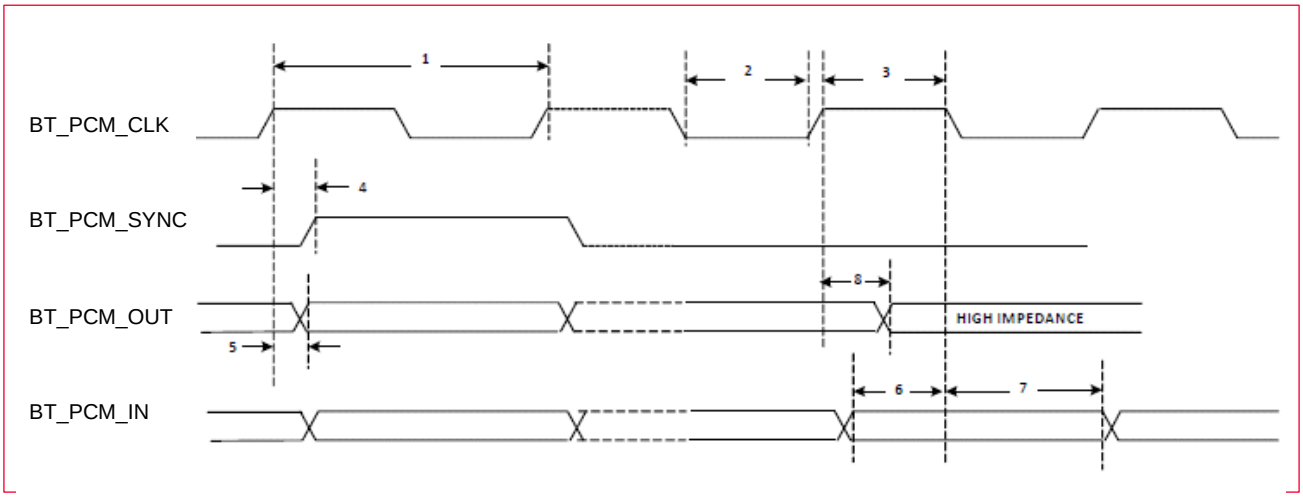


Table 24: Short Frame Sync Signal Parameters - Master Mode

Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			12	MHz
2	PCM bit clock High	41			ns
3	PCM bit clock Low	41			ns
4	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

13.6.2 Short Frame Sync - Slave Mode

Figure 21 and **Table 25** shows PCM short frame sync data signal and its parameters in slave mode respectively.

Figure 21: Short Frame Sync Signal - Slave Mode

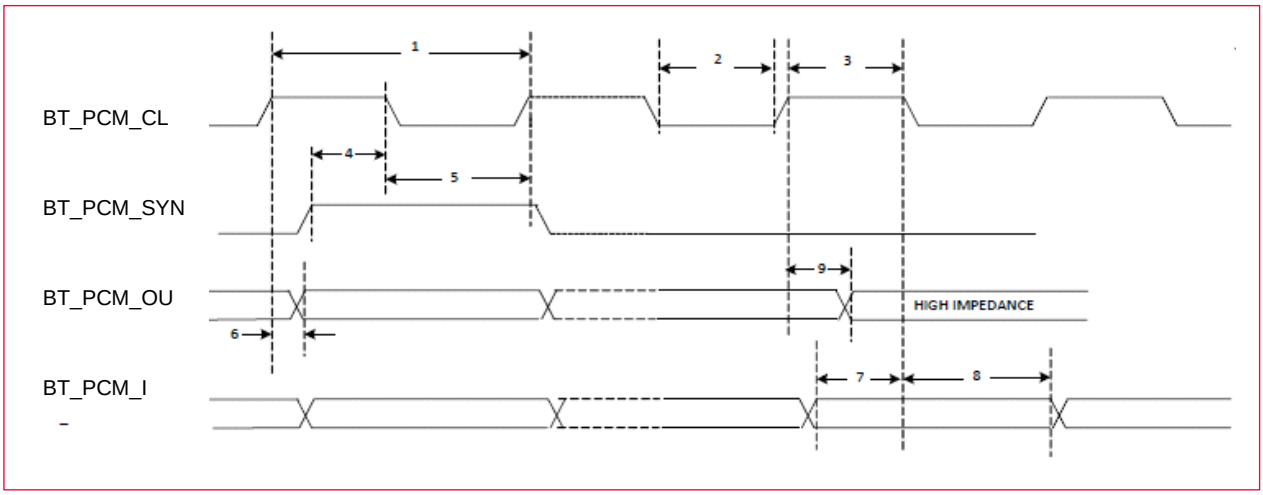


Table 25: Short Frame Sync Signal Parameters - Slave Mode

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

13.6.3 Long Frame Sync - Master Mode

Figure 22 and

Table 26 shows PCM long frame sync signal and its parameters in slave mode.

Figure 22: Long Frame Sync Signal - Master Mode

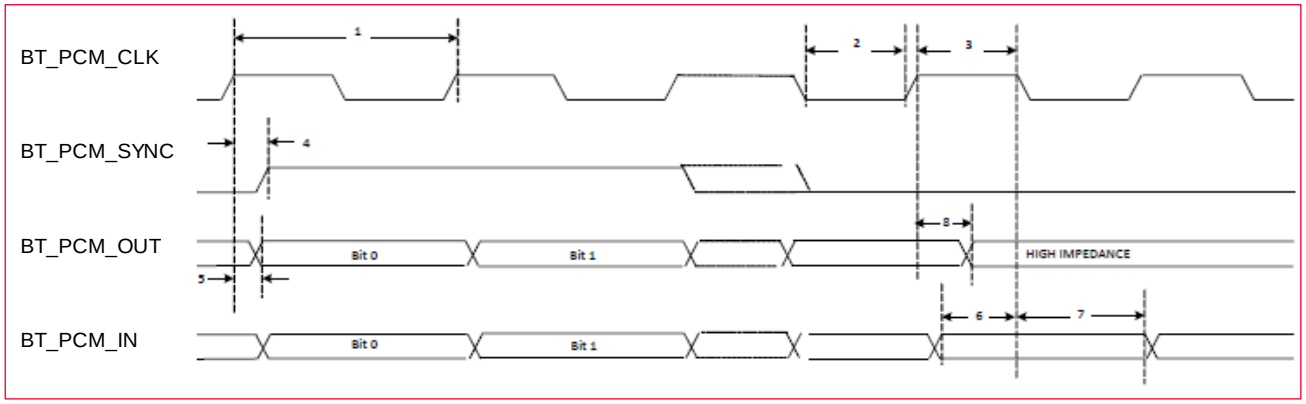


Table 26: Long Frame Sync Signal Parameters - Master Mode

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

13.6.4 Long Frame Sync - Slave Mode

Figure 23 and **Table 27** shows PCM long frame sync signal and parameters in slave mode.

Figure 23: Long Frame Sync Signal - Slave Mode

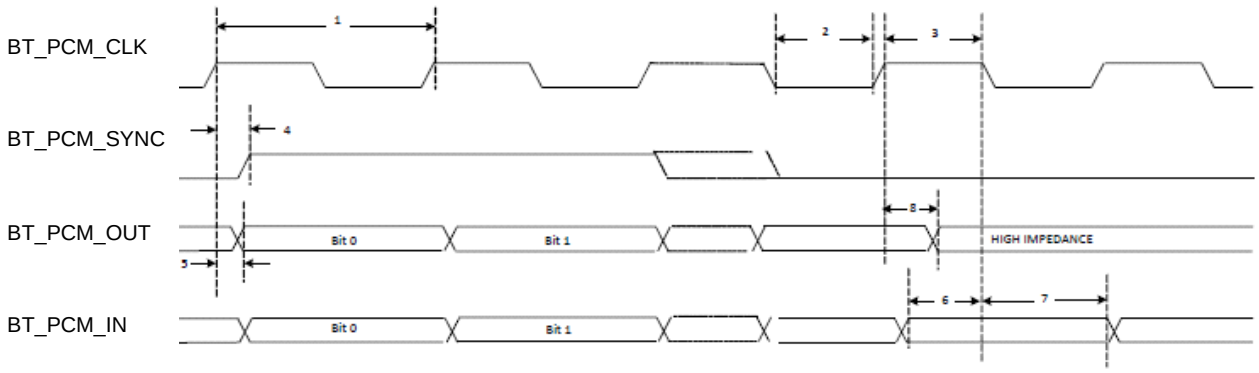


Table 27: Long Frame Sync Signal Parameters - Slave Mode

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

13.6.5 Short Frame Sync - Burst Mode

Figure 24 and **Table 28** shows PCM short frame sync signal and its parameters in burst mode.

Figure 24: Short Frame Sync Signal - Burst Mode

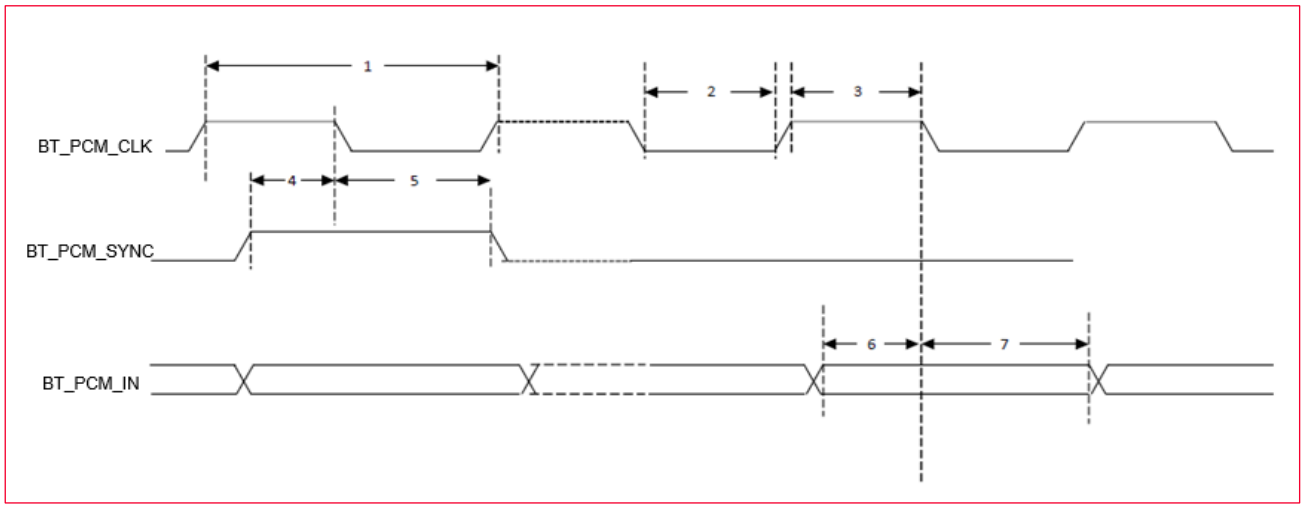


Table 28: Short Frame Sync Signal Parameters - Burst Mode

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

13.6.6 Long Frame Sync - Burst Mode

Figure 25 and **Table 29** shows PCM long frame sync signal and parameters in burst mode.

Figure 25: Long Frame Sync Signal - Burst Mode

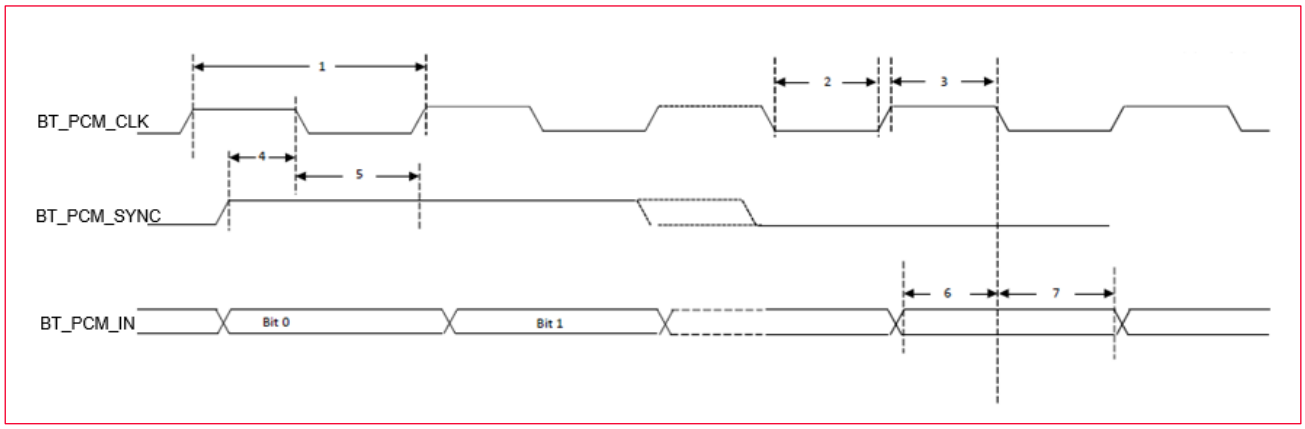


Table 29: Long Frame Sync Signal Parameters - Burst Mode

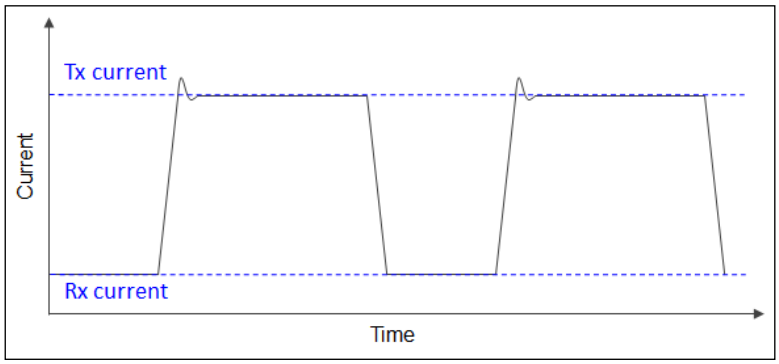
Reference	Description	Minimum	Typical	Maximum	Unit
1	PCM bit clock frequency			24	MHz
2	PCM bit clock Low	20.8			ns
3	PCM bit clock High	20.8			ns
4	PCM_SYNC setup	8			ns
5	PCM_SYNC hold	8			ns
6	PCM_IN setup	8			ns
7	PCM_IN hold	8			ns

14 DC/RF Characteristics

This section describes the electrical characteristics of the Type 2AE module.

Burst current definition is shown in **Figure 26**.

Figure 26: Burst Current Definition



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

Table 30: 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

14.1.1 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 31: 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)		350		mA
• Rx mode		55		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	14.5	17	19.5	dBm
Spectrum Mask Margin				
• 1st side lobes (-30 dBr)	0			dB
• 2nd side lobes (-50 dBr)	0			dB
Power-on 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				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW =100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-76	dBm
Maximum Input Level (FER ≤ 8%)	-10			dBm
Adjacent Channel Rejection (FER ≤ 8%)	35			dB

14.1.2 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 32: 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)		340		mA
• Rx mode		55		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	14.5	17	19.5	dBm
Spectrum Mask Margin				
• 1st side lobes (-30 dBr)	0			dB
• 2nd side lobes (-50 dBr)	0			dB
Power-on 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				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW =100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-76	dBm
Maximum Input Level (FER ≤ 8%)	-10			dBm
Adjacent Channel Rejection (FER ≤ 8%)	35			dB

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

Table 33: 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

14.2.1 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 34: 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 µs interval)		290		mA
• Rx mode		55		mA
TX Characteristics	**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				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW =100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-65	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

14.2.2 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 35: Low-Rate Condition for IEEE 802.11g - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		310		mA
• Rx mode		55		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW =100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

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

Table 36: 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

14.3.1 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 37: High-Rate Condition for IEEE 802.11n - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		280		mA
• Rx mode		55		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW =100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-64	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

14.3.2 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 38: Low-Rate Condition for IEEE 802.11n - 2.4 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		300		mA
• Rx mode		55		mA
TX Characteristics	**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 ~ -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				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW =100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

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

Table 39: 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

14.4.1 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 40: High-Rate Condition for IEEE 802.11a - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		290		mA
• Rx mode		70		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12	14	16	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-65	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

14.4.2 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 41: Low-Rate Condition for IEEE 802.11a - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		310		mA
• Rx mode		70		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

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

Table 42: 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

14.5.1 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 43: High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		280		mA
• Rx mode		70		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	12	14	16	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)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-64	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

14.5.2 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 44: Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		300		mA
• Rx mode		70		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

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

Table 45: 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

14.6.1 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 46: High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		280		mA
• Rx mode		70		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	11	13	15	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)			-30	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-59	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

14.6.2 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 47: Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		300		mA
• Rx mode		70		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

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

Table 48: 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

14.7.1 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 49: High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		320		mA
• Rx mode		80		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	11	13	15	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-61	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

14.7.2 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 50: Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		350		mA
• Rx mode		80		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-79	dBm
Maximum Input Level (PER <10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

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

Table 51: 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

14.8.1 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 52: High-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		320		mA
• Rx mode		80		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-54	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

14.8.2 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 53: Low-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		350		mA
• Rx mode		80		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-54	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

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

Table 54: 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

14.9.1 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 55: High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		340		mA
• Rx mode		105		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 1 00 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-51	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

14.9.2 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 56: Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Items	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode (1024 byte, 20 µs interval)		380		mA
• Rx mode		105		mA
TX Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
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
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Minimum Input Level Sensitivity			-76	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

14.10 DC/RF Characteristics for Bluetooth

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

Table 57: 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
Transmitter	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power @ DH5	6	10	14	dBm
Frequency range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
Modulation Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
• Modulation $\Delta f1_{avg}$	140		175	kHz
• Modulation $\Delta f2_{max}$	115			kHz
• Modulation $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8	1		
Carrier Frequency Drift	**Minimum**	**Typical**	**Maximum**	**Unit**
• 1slot	-25		+25	kHz
• 3slot / 5slot	-40		+40	kHz
• Maximum drift rate			20	kHz/50µs
EDR Relative Power	-4		1	dB
EDR Carrier Frequency Stability and Modulation Accuracy				
• ωi	-75		75	kHz
• ωi + ωo	-75		75	kHz
• ωo	-10		10	kHz
• RMS DEVM (DQPSK)			20	%
• Peak DEVM (DQPSK)			35	%
• 99% DEVM (DQPSK)			30	%
• RMS DEVM (8DPSK)			13	%
• Peak DEVM (8DPSK)			25	%
• 99% DEVM (8DPSK)			20	%
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm

Items	Contents			
• 1000 - 12750 MHz (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%)				
• co-channel			11	dB
• 1 MHz			0	dB
• 2 MHz			-30	dB
• 3 MHz			-40	dB
• image (+4 MHz)			-9	dB
• image +/- 1 MHz			-20	dB
Maximum Input Level (BER ≤ 0.1%)	-20			dBm

Adjacent Channel Power: Up to three spurious responses within Bluetooth limits are allowed.

14.11 DC/RF Characteristics for Bluetooth Low Energy

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

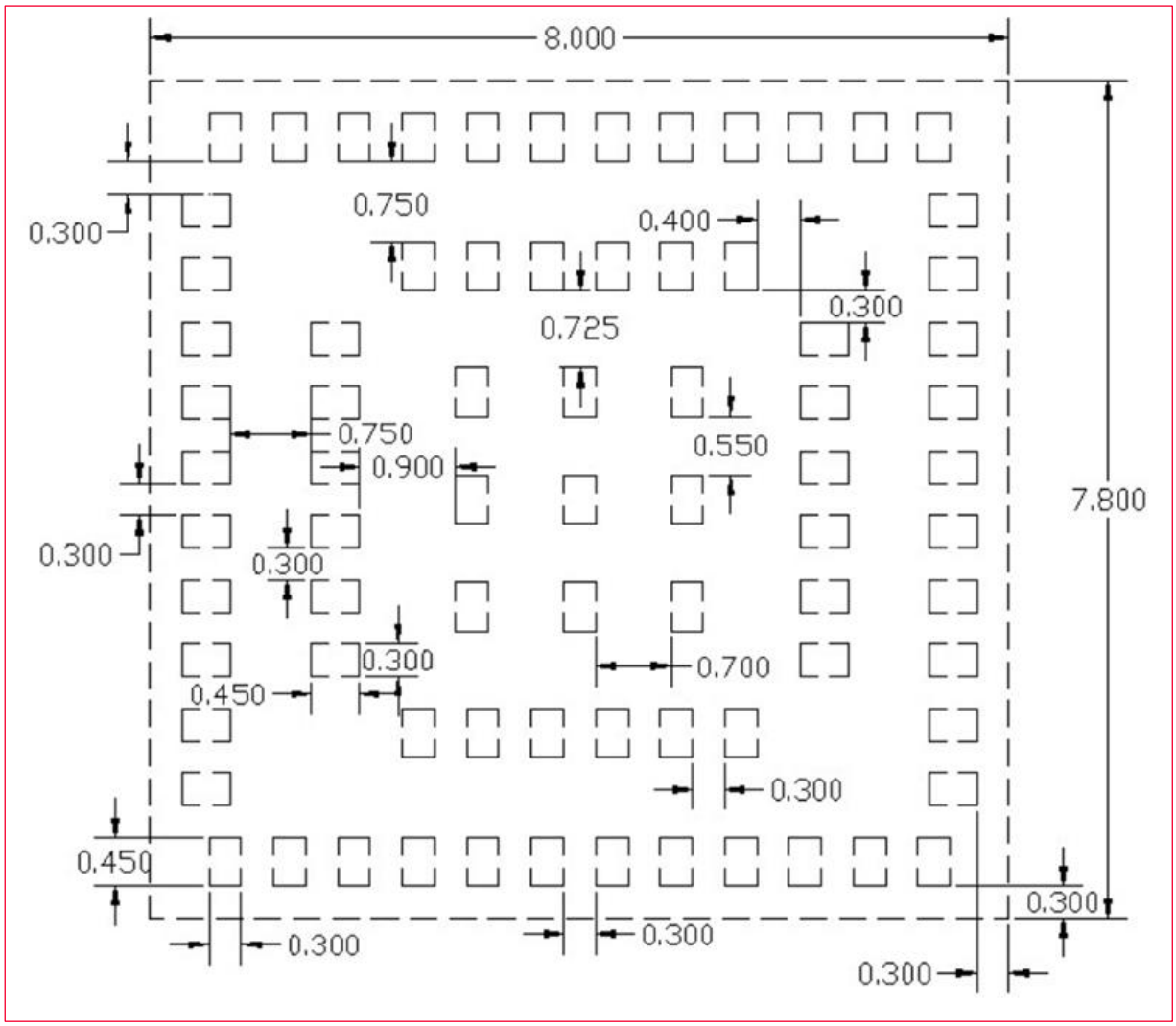
Table 58: DC/RF Characteristics for BLE

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				
• $\Delta f1_{avg}$	225		275	kHz
• $\Delta f2_{max}$ (at 99.9%)	185			kHz
• $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8			
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
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	%

15 Land Pattern

The land pattern (in mm) is shown in **Figure 27.**

Figure 27: 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.

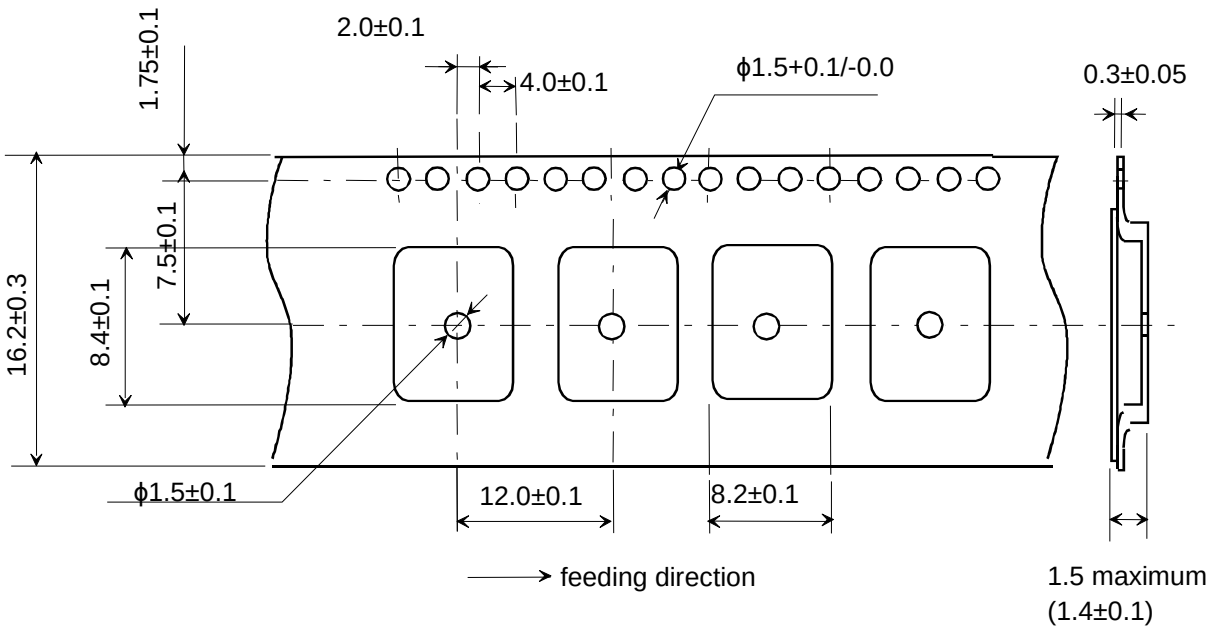
16 Tape and Reel Packing

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

16.1 Dimensions of Tape (Plastic Tape)

Figure 28 is a graphical representation of the tape dimension (plastic tape)[5].

Figure 28: Dimensions of Tape (Unit: mm)

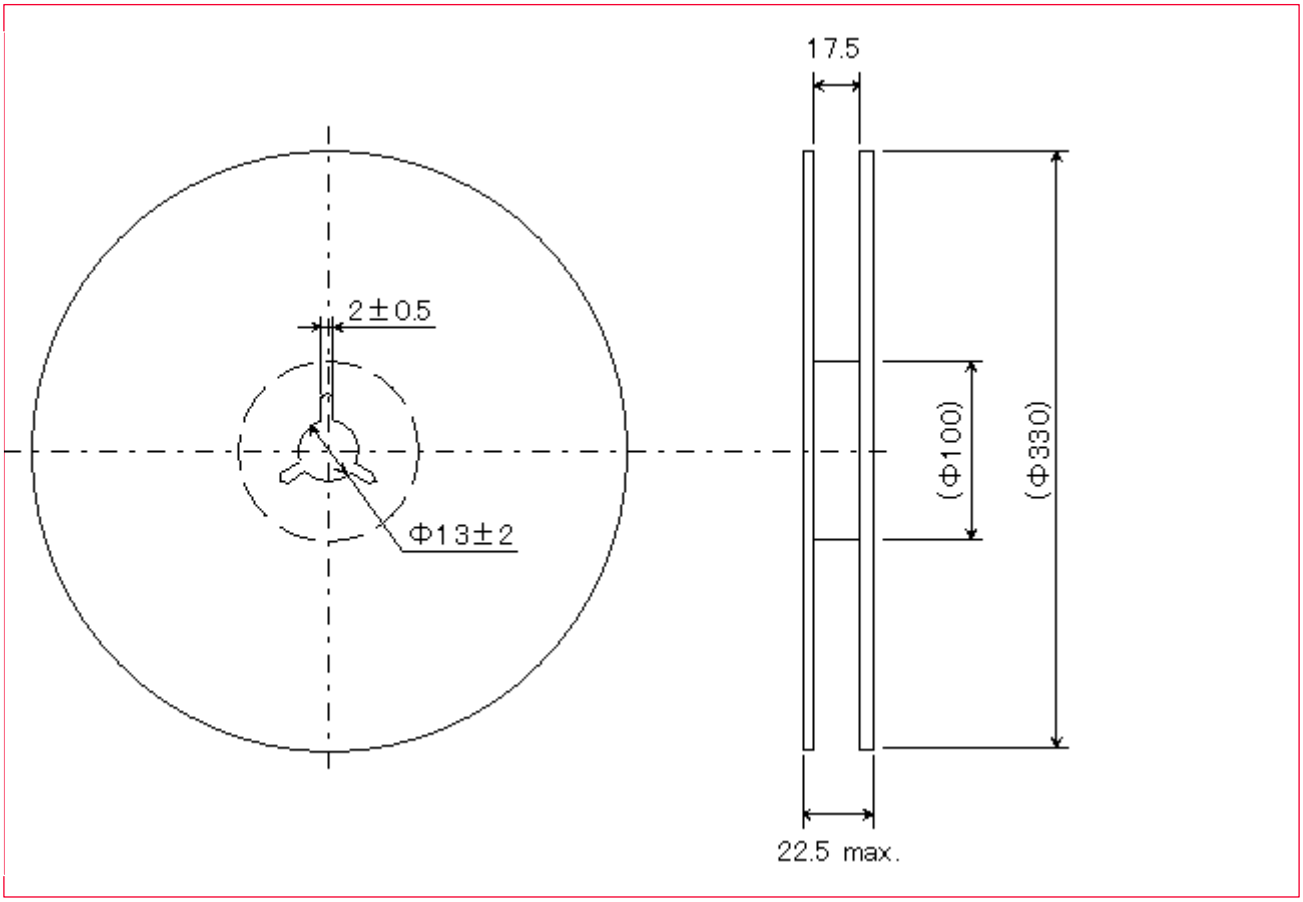


[5] Cumulative tolerance of maximum 40.0 ± 0.15 mm every 10 pitches

16.2 Dimension of Reel

Figure 29 shows the reel dimensions.

Figure 29: Dimensions of Reel (Unit: mm)



16.3 Taping Diagrams

Figure 30 shows the tapings diagrams and **Figure 31** shows the close up.

Figure 30: Taping Diagrams

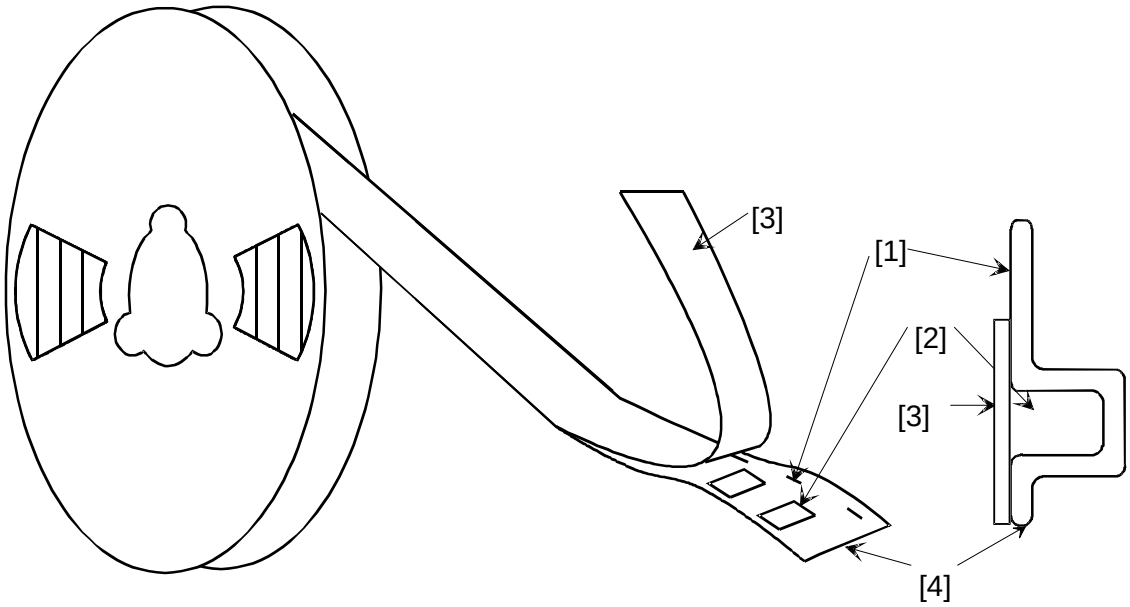
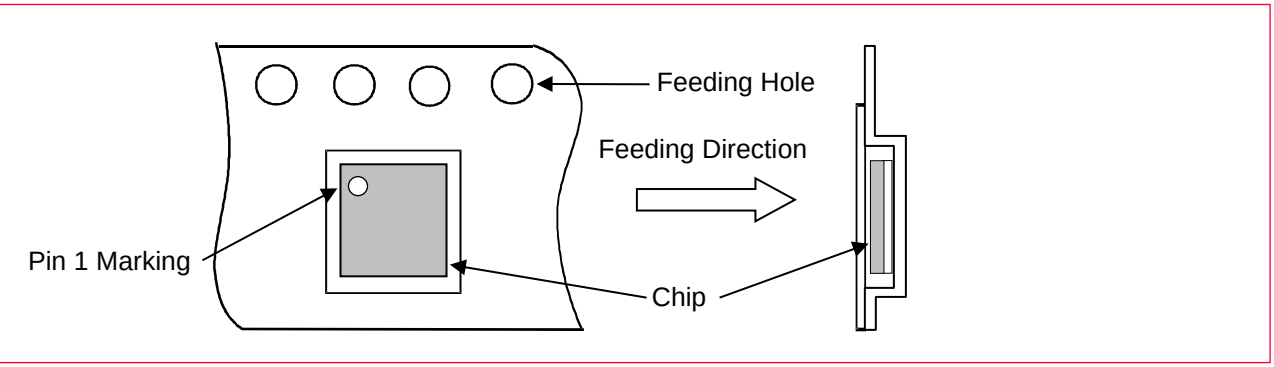


Table 59 shows the taping specifications.

Table 59: Taping Specifications

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

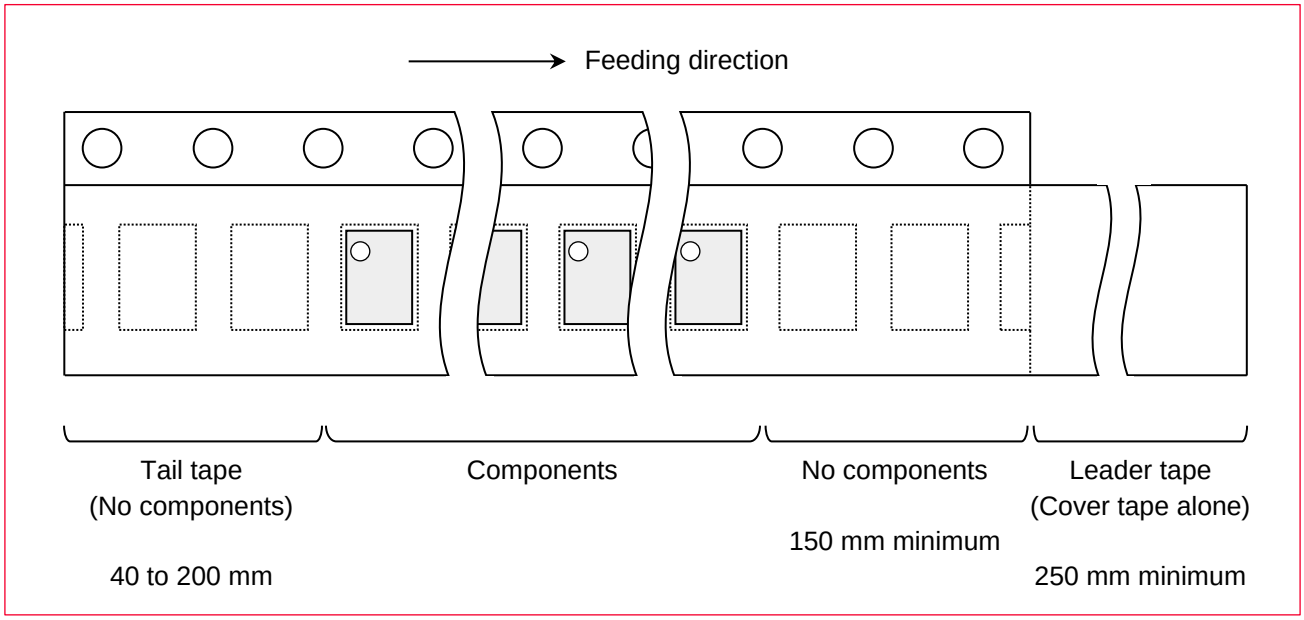
Figure 31: Taping Diagrams (Close Up)



16.4 Leader and Tail Tape

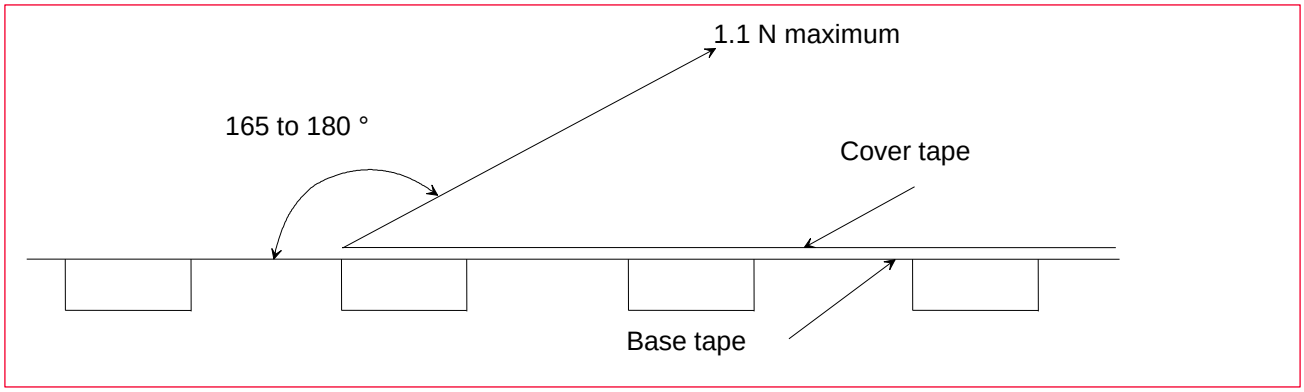
The leader and tail tape are shown in **Figure 32**.

Figure 32: 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 33**.

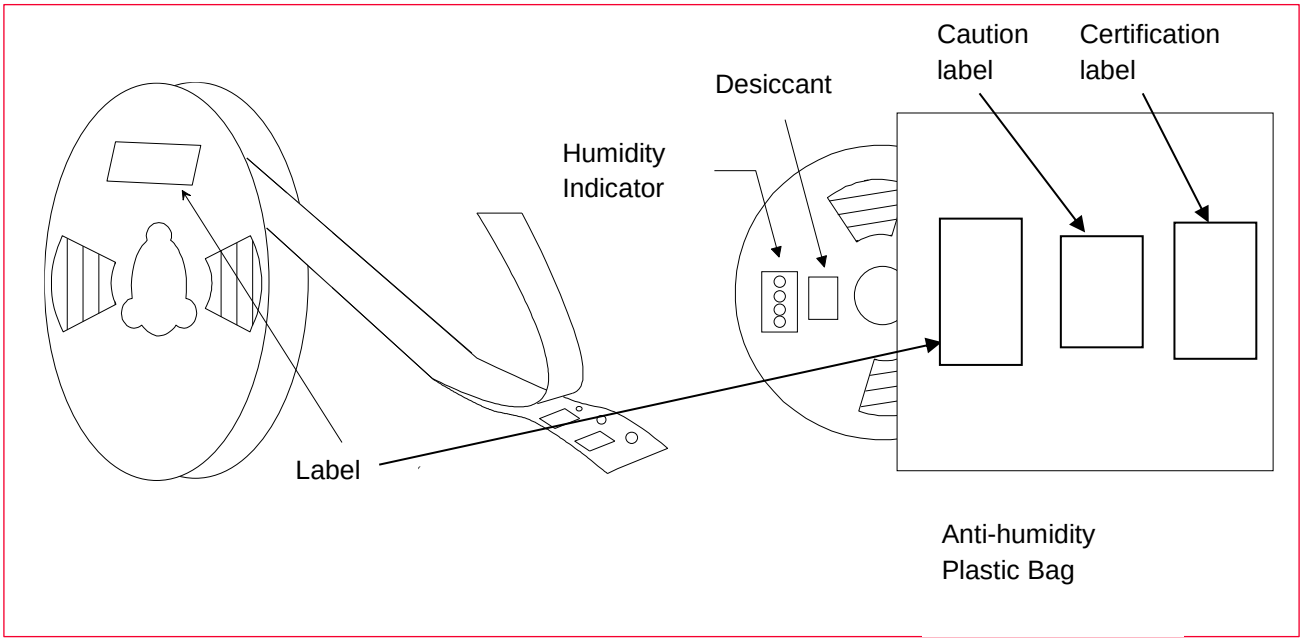
Figure 33: Peeling Force



16.5 Humidity Proof Packaging

Figure 34 shows the humidity proof packaging.

Figure 34: 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 must be stored without opening the packing under the ambient temperature from 5 to 35 °C and humidity from 20 ~ 70 %RH.

- Packing materials, in particular, may be deformed at the temperature over 40 °C

- The solderability of the product left idle for more than 6 months after receipt needs to be confirmed before it is used.
- The product must be stored in noncorrosive gas (Cl_2, NH_3, SO_2, NO_X, etc.).
- Any excess mechanical shock including, but not limited to, sticking the packing materials by sharp object, and dropping the product, must not be applied as that will damage the packing materials.

This product is applicable to MSL3 (Based on JEDEC Standard J-STD-020)

- After the packing is opened, the product must be stored at <30 °C / <60 %RH and the product *should be* used within 168 hours after opening.
- When the color of the indicator in the packing is changed, the product *should be* baked before soldering.
  - **Baking condition:** 125 +5/-0 °C, 24 hours, 1 time

- The products must be baked on the heat-resistant tray because the material (Base Tape, Reel Tape and Cover Tape) is not heat-resistant.

17.2 Handling Conditions

Be careful while handling or transporting products because excessive stress or mechanical shock may break the products.

Handle with care if you suspect that products may have cracks or damages on their terminals. If there is any such damage, the characteristics of products may change. *Do not touch* products with bare hands as that may cause poor solderability and cause damage by static electrical charge.

17.3 Standard PCB Design (Land Pattern and Dimensions)

All the ground terminals should be connected to the ground patterns. Furthermore, the ground pattern should be provided between IN and OUT terminals. Please refer to the specifications for the standard land dimensions.

The recommended land pattern and dimensions should be as per Murata's standard. The characteristics of products may vary depending on the pattern drawing method, grounding method, land dimensions, land forming method of the NC terminals and the PCB material and thickness. Therefore, be sure to verify the characteristics in the actual set.

- When using non-standard lands, contact Murata in advance.

17.4 Notice for Chip Placer

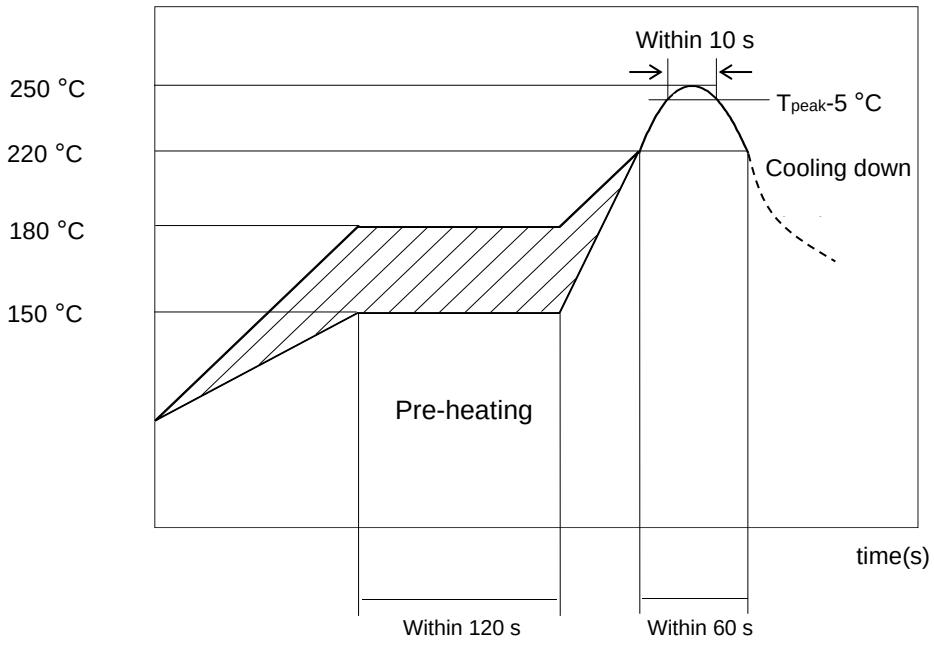
When placing products on the PCB, products may be stressed and broken by uneven forces from a worn-out chucking locating claw or a suction nozzle. To prevent products from damages, be sure to follow the specifications for the maintenance of the chip placer being used. For the positioning of products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

17.5 Soldering Conditions

The recommendation conditions of soldering are as in **Figure 35**.

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

Figure 35: Reflow Soldering Standard Conditions (Example)



- Please use the reflow within 2 times.
- Use rosin type flux or weakly active flux with a chlorine content of 0.2 wt. % or less.

17.6 Cleaning

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

17.7 Operational Environment Conditions

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

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

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

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

17.8 Input Power Capacity

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

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

18 Precondition 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.

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- 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.

Even in the unlikely event that an abnormality or malfunction occurs in this product under operating conditions that conform to the specifications, be sure to add an appropriate fail-safe function to the system to prevent secondary accidents.

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Revision History

Revision Code	Date	Changed Item	Comment
1	Jul 09, 2020	First Issue	
2 (A)	Dec 10, 2020	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	• Update • Update • Update • Update • Update • Update • Updated regulatory statement
3 (B)	Dec 17, 2020	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	• Corrected part number • Correction • Correction • Correction • Correction
4 (C)	Apr 04, 2021	13. DC / RF Characteristics	• Update
5 (D)	Dec 17, 2021	6. Dimensions, Marking and Terminal Configurations	• Updated module height
6 (E)	Dec 29, 2021	7.2 Pin Descriptions	• Updated bandgap reference resistor to 4.75K ohm +/-1%.
7 (F)	Feb 02, 2022	1. Scope 5.2 Bluetooth Qualification	• Updated BT 5.2 • Updated Bluetooth QDID
8 (G)	Apr 06, 2022	2. Key Features 4. Block Diagram 7.1 Module Pin Layout 7.4 Strapping Option 13. DC / RF Characteristics	• Updated host interface. • Update • Updated terminal configuration. • Update • Update
9 (H)	Jun 14, 2022	1. Scope	• Updated IC P/N
10 (I)	Aug 18, 2022	13. DC/RF Characteristics	• Update
11 (J)	Nov 01, 2022	5. Certification information 7.2 Pin Descriptions Reference schematic 15. Radio Regulatory Certification by Country for LBEE5PK2AE	• Update • Updated JTEG_SEL description. • Update • Updated Add APPENDIX of user/installation manual. • Removed Primary
12 (K)	Nov 30, 2022	Reference schematic 13. DC/RF Characteristics	• Corrected strap setting for USB. • Revised Wi-Fi RX current
13 (L)	Sep 13, 2023	1. Scope 3. Ordering Information 6. Dimensions, Marking and Terminal Configurations Reference Circuit Appendix	• Updated information. Created new section ‘Key Features’. • Renamed part number section. • Created new section ‘Module Pin Descriptions’ • Moved section to HW app note. • Moved Appendix information into Sections 15 and 16. • Added transmit power tables. • Moved antenna sections to HW app note.

Revision Code	Date	Changed Item	Comment
			Updated to new format
14 (M)	Jul 04, 2024.	7.3 SDIO Pin Descriptions	• Revised the Pin No of the SDIO signal
15 (N)	Sep 10, 2024	2. Key Future 3 Ordering Information 15. Radio Regulatory Certification by Country for LBEE5PK2AE	• Add Fit Value • Remove 2AE-EVB pats No • Remove certification information
16	Aug 8, 2025	15 DC/RF Characteristics 17 Notice 18 Precondition to Use Our Products	• Format changed • Format changed • Format changed • Updated (Base IC datasheet revision: A)