W-LAN+Bluetooth Combo Module Data Sheet

Infineon Chipset CYW54590
for 802.11a/b/g/n/ac 2x2 MIMO
+ Bluetooth 5.2

MP P/N : LBEE5XV2BZ-883
Sample P/N : LBEE5XV2BZ-SMP

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Revision History

Revision Code	Date	Description	Comments
-	Dec. 15, 2021	First Issue	
A	Jun. 15, 2022	Title Page 4 Page 5 Page 8 Page 50	Adding MP part number Block Diagram Adding specification temperature Revising typo in pin description Revising regulatory certification

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1. SCOPE

This specification is applied to the IEEE802.11a/b/g/n/ac W-LAN 2x2 MIMO + Bluetooth 5.2 combo module.

2. KEY FEATURE

- Infineon CYW54590 inside
- Compliant with IEEE802.11a/b/g/n/ac, 5G MIMO
- Compliant with Bluetooth specification v5.2
- Supports standard SDIO Interface for WLAN
- Interface support for Bluetooth is Host Controller Interface (HCI)
- Surface mount type 11.4 x 8.9 mm (Typical), H = 1.4 mm(Max.)
- Weight: 0.36g
- MSL: 3
- RoHS compliant

3. BLOCK DIAGRAM
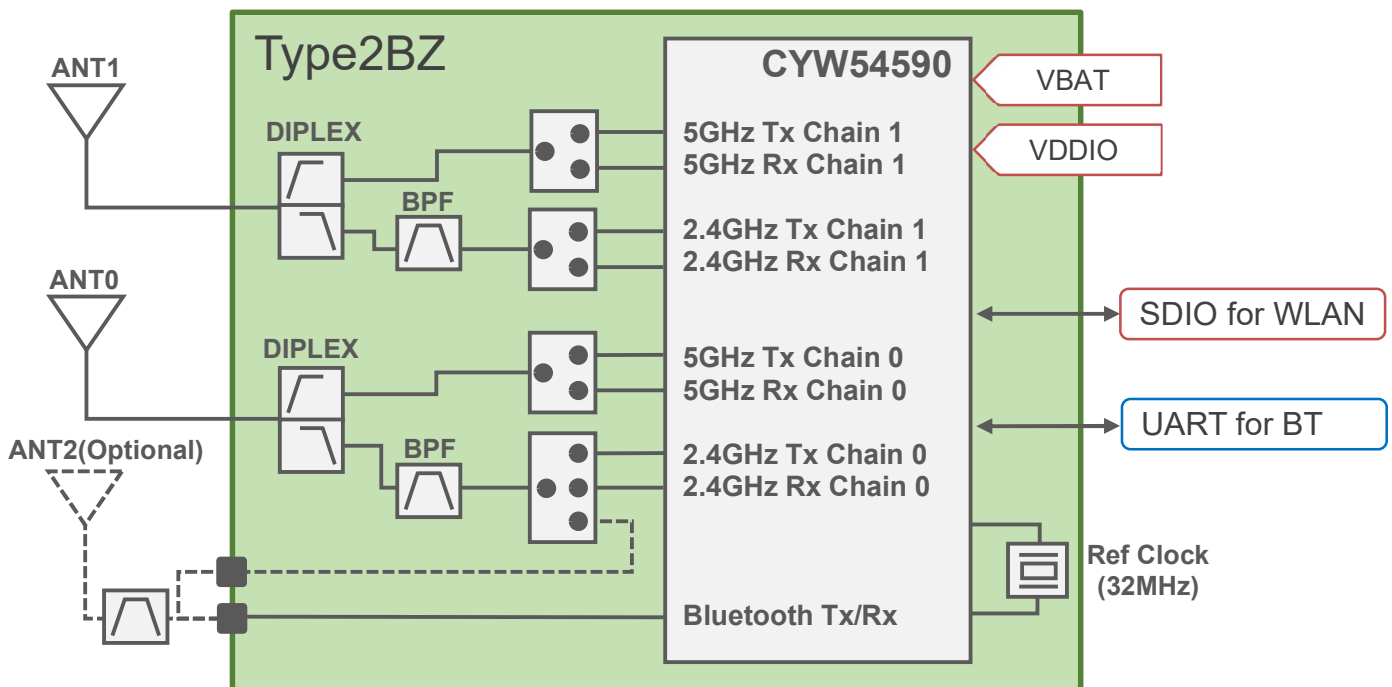
4. SAMPLE ORDERING INFORMATION

Ordering Part Number	Description
LBEE5XV2BZ-883	MP Part Number
LBEE5XV2BZ-SMP	In case of sample order
LBEE5XV2BZ-EVK	Evaluation Kit

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5. ABSOLUTE MAXIMUM RATINGS

Parameter		Min	Max	Unit
Storage Temperature		-40	+85	deg.C
Supply Voltage	VBAT	-0.5	+6.0	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 is set within operating condition.

6. OPERATING CONDITION

Parameter		Min	Typ	max	Unit
Operating Temperature		-40	25	85	deg.C
Specification Temperature		-10	25	70	deg.C
Operating Voltage	VBAT	3.0	3.3	4.8	V
	VDDIO	1.62	1.8 or 3.3	3.63	V

Note) Min. voltage of VBAT is sensitive to get RF performance, so please keep min. voltages level at the input of these module terminals, otherwise RF performance significantly goes worse.

7. EXTERNAL LPO_IN SIGNAL REQUIREMENT

Parameter	External LPO_IN Clock	Unit
Nominal input frequency	32.768	kHz
Frequency accuracy	+/-250	ppm
Duty cycle	30-70	%
Input signal amplitude	200 - 3300	mV, p-p
Signal type	Square-wave or sine-wave	-
Input impedance[1]	> 100k	ohm
	< 5	pF
Clock jitter (during initial start-up)	<10,000	ppm

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[1] When power is applied or switch off.

8. DIMENSIONS, MARKING AND TERMINAL CONFIGURATIONS

<Top View>

LBEE5XV2BZ

SSXXXXXXX

123456789

muRata

<Bottom View>

<Side View>
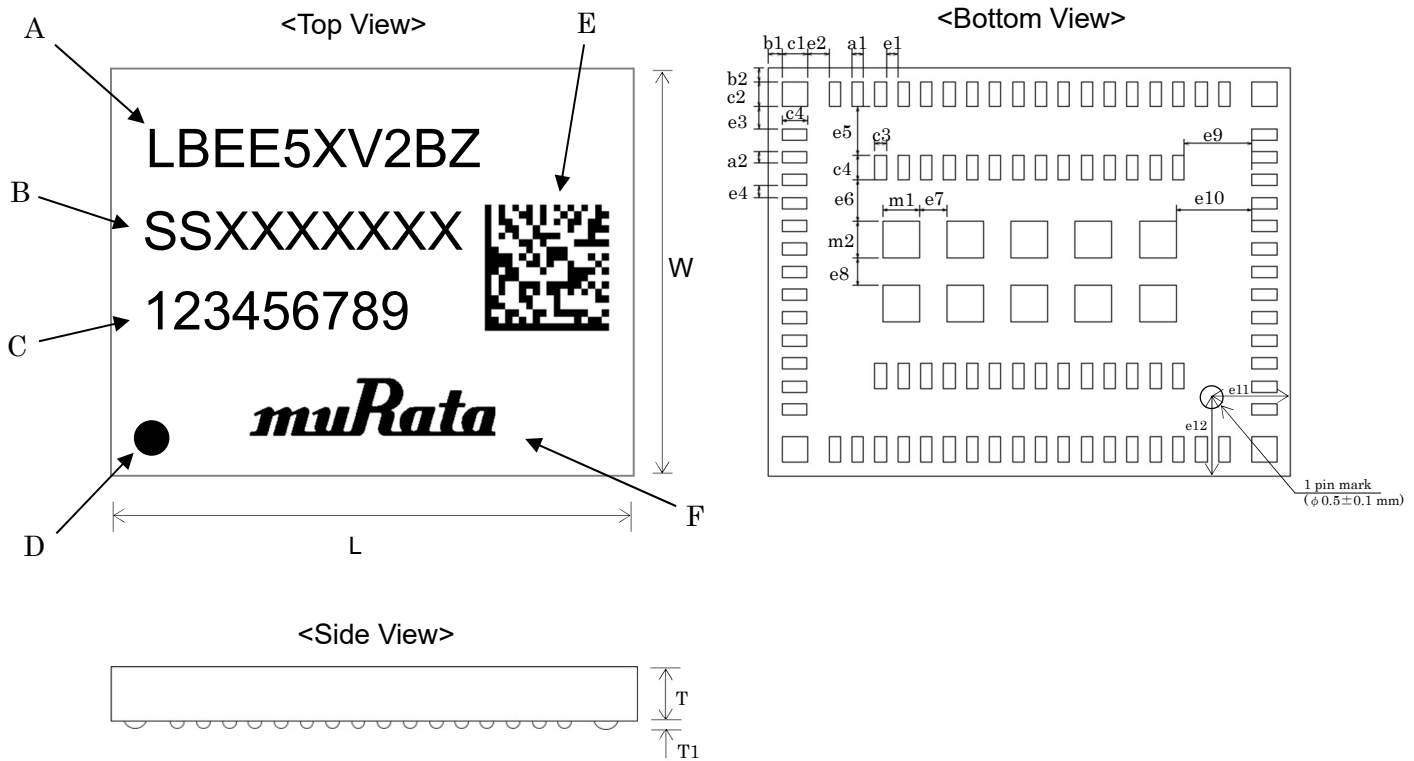
Marking	Meaning
A	Module Part Number
B	Inspection Number
C	Serial Number
D	Pin 1 Marking
E	2D code
F	Murata Logo

Mark	Dimensions	Mark	Dimensions	Mark	Dimensions	Mark	Dimensions
L	11.4 ± 0.2	W	8.9 ± 0.2	T	1.4 max.	T1	0.04 typ.
a1	0.25 ± 0.1	a2	0.25 ± 0.1	b1	0.3 ± 0.2	b2	0.3 ± 0.2
c1	0.55 ± 0.1	c2	0.55 ± 0.1	c3	0.25 ± 0.1	c4	0.55 ± 0.1
e1	0.25 ± 0.1	e2	0.475 ± 0.1	e3	0.475 ± 0.1	e4	0.25 ± 0.1
e5	1.05 ± 0.1	e6	0.9 ± 0.1	e7	0.6 ± 0.1	e8	0.6 ± 0.1
e9	1.475 ± 0.1	e10	1.65 ± 0.1	e11	1.787 ± 0.2	e12	1.609 ± 0.2
m1	0.8 ± 0.1	m2	0.8 ± 0.1				

(unit : mm)

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9. MODULE PIN DESCRIPTIONS

<TOP VIEW>
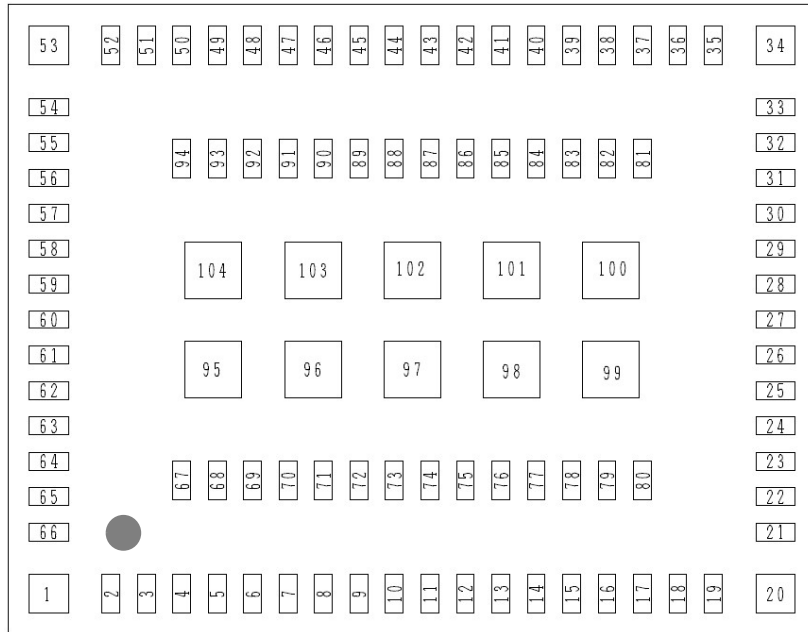
No.	Terminal Name	No.	Terminal Name	No.	Terminal Name
1	GND	31	RF_SW_CTRL11	61	SDIO_DATA_3
2	GPIO_17	32	GND	62	SDIO_DATA_2
3	GPIO_18	33	ANT_1	63	SDIO_DATA_1
4	GPIO_19	34	GND	64	GND
5	WL_REG_ON	35	GND	65	VBAT
6	BT_REG_ON	36	BT_UART_RTS_N	66	VBAT
7	GND	37	BT_UART_CTS_N	67-73	GND
8	VDDIO	38	BT_UART_RXD	74	BT_PCM_IN
9	GND	39	BT_UART_TXD	75	BT_PCM_OUT
10	GND	40	GPIO_5	76	BT_PCM_CLK
11	GND	41	GPIO_4	77	BT_PCM_SYNC
12	BT_OUT	42	GPIO_7	78	GND
13	GND	43	GPIO_6	79	RF_SW_CTRL4
14	BT_IN	44	NC	80	GND
15	GND	45	NC	81	RF_SW_CTRL12
16	RF_SW_CTRL5	46	NC	82	BT_GPIO_5
17	GND	47	GND	83	BT_GPIO_4
18	GND	48	NC	84	BT_GPIO_2
19	ANT_0	49	NC	85	BT_GPIO_3
20	GND	50	GND	86	GPIO_3
21	GND	51	NC	87	JTAG_SEL
22	BT_HOST_WAKE	52	NC	88	GPIO_2
23	BT_DEV_WAKE	53	GND	89	GPIO_1
24	CLK_REQ	54	NC	90	GPIO_0
25	LPO_IN	55	NC	91	GPIO_8
26	BT_I2S_DO	56	GND	92	GPIO_9
27	BT_I2S_DI	57	VDDIO	93	GPIO_10
28	BT_I2S_CLK	58	SDIO_CMD	94	GPIO_11
29	BT_I2S_WS	59	SDIO_CLK	95-104	GND
30	GND	60	SDIO_DATA_0		

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No.	Pin name	Type	Connection to IC pin name	Description
1	GND	-	-	Ground
2	GPIO_17	I/O	GPIO_17	Programmable GPIO Pin
3	GPIO_18	I/O	GPIO_18	Programmable GPIO Pin
4	GPIO_19	I/O	GPIO_19	Programmable GPIO Pin
5	WL_REG_ON	I	WL_REG_ON	Used by PMU to power up or power down the internal CYW54590 regulators used by the WLAN section. Also, when deasserted, this pin holds the WLAN section in reset. This pin has an internal 200k ohm pull-down resistor that is enabled by default. It can be disabled through programming.
6	BT_REG_ON	I	BT_REG_ON	Used by PMU to power up or power down the internal CYW54590 regulators used by the Bluetooth section. Also, when deasserted, this pin holds the Bluetooth section in reset. This pin has an internal 200k ohm pull-down resistor that is enabled by default. It can be disabled through programming.
7	GND	-	-	Ground
8	VDDIO	I	SYS_VDDIO WCC_VDDIO BT_VDDO VDDIO	IO supply
9	GND	-	-	Ground
10	GND	-	-	Ground
11	GND	-	-	Ground
12	BT_OUT			
13	GND	-	-	Ground
14	BT_IN			
15	GND	-	-	Ground
16	RF_SW_CTRL5	O	O	Programmable RF switch control lines. The control lines are programmable via the driver and NVRAM file.
17	GND	-	-	Ground
18	GND	-	-	Ground
19	ANT_0	-	-	RF Port for WLAN (2.4GHz & 5GHz) and BT
20	GND	-	-	Ground
21	GND	-	-	Ground
22	BT_HOST_WAKE	O	BT_HOST_WAKE	Host wake-up: Signal from the module to the host indicating that the module requires attention.
23	BT_DEV_WAKE	I	BT_DEV_WAKE	Bluetooth device wake-up: Signal from the host to the module indicating that the host requires attention.
24	CLK_REQ	I/O	CLK_REQ	Reference clock request (shared by BT and WLAN). If not used, this can be no-connect.
25	LPO_IN	I	LPO_IN	External sleep clock input (32.768 kHz)
26	BT_I2S_DO	I/O	BT_I2S_DO	I^{2}S data output
27	BT_I2S_DI	I/O	BT_I2S_DI	I^{2}S data input
28	BT_I2S_CLK	I/O	BT_I2S_CLK	I^{2}S clock, can be master (output) or slave (input).
29	BT_I2S_WS	I/O	BT_I2S_WS	I^{2}S WS, can be master (output) or slave (input).
30	GND	-	-	Ground
31	RF_SW_CTRL11	O	RF_SW_CTRL11	Programmable RF switch control lines. The control lines are programmable via the driver and NVRAM file.

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32	GND	-	-	Ground
33	ANT_1			RF Port for WLAN (2.4GHz & 5GHz)
34	GND	-	-	Ground
35	GND	-	-	Ground
36	BT_UART_RTS_N	O	BT_UART_RTS_N	UART request-to-send. Active-low request-to-send signal for the HCI UART interface. BT LED control pin.
37	BT_UART_CTS_N	I	BT_UART_CTS_N	UART clear-to-send. Active-low clear-to-send signal for the HCI UART interface.
38	BT_UART_RXD	I	BT_UART_RXD	UART serial input. Serial data input for the HCI UART interface.
39	BT_UART_TXD	O	BT_UART_TXD	UART serial output. Serial data output for the HCI UART interface.
40	GPIO_5		GPIO_5	Programmable GPIO pins.
41	GPIO_4		GPIO_4	
42	GPIO_7		GPIO_7	
43	GPIO_6		GPIO_6	
44	NC	-	-	No Connect
45	NC	-	-	No Connect
46	NC	-	-	No Connect
47	GND	-	-	Ground
48	NC	-	-	No Connect
49	NC	-	-	No Connect
50	GND	-	-	Ground
51	NC	-	-	No Connect
52	NC	-	-	No Connect
53	GND	-	-	Ground
54	NC	-	-	No Connect
55	NC	-	-	No Connect
56	GND	-	-	Ground
57	VDDIO_SD	PWR	VDDIO_SD	1.8V–3.3V supply for SDIO pads.
58	SDIO_CMD	I/O	SDIO_CMD	SDIO command line.
59	SDIO_CLK	I	SDIO_CLK	SDIO clock input.
60	SDIO_DATA_0	I/O	SDIO_DATA_0	SDIO data line 0.
61	SDIO_DATA_3	I/O	SDIO_DATA_3	SDIO data line 3.
62	SDIO_DATA_2	I/O	SDIO_DATA_2	SDIO data line 2.
63	SDIO_DATA_1	I/O	SDIO_DATA_1	SDIO data line 1.
64	GND	-	-	Ground
65	VBAT	PWR	SR_VDDBAT5V	VBAT supply
66			LDO_VDDBAT5V	
67-73	GND	-	-	Ground
74	BT_PCM_IN	I	BT_PCM_IN	PCM data input.
75	BT_PCM_OUT	O	BT_PCM_OUT	PCM data output.
76	BT_PCM_CLK	I/O	BT_PCM_CLK	PCM clock; can be master (output) or slave (input).
77	BT_PCM_SYNC	I/O	BT_PCM_SYNC	PCM sync; can be master (output) or slave (input).
78	GND	-	-	Ground

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79	RF_SW_CTRL4	O	RF_SW_CTRL4	Programmable RF switch control lines. The control lines are programmable via the driver and NVRAM file.
80	GND	-	-	Ground
81	RF_SW_CTRL12	O	RF_SW_CTRL12	Programmable RF switch control lines. The control lines are programmable via the driver and NVRAM file.
82	BT_GPIO_5	I/O	BT_GPIO_5	Bluetooth general-purpose I/O.
83	BT_GPIO_4	I/O	BT_GPIO_4	
84	BT_GPIO_2	I/O	BT_GPIO_2	
85	BT_GPIO_3	I/O	BT_GPIO_3	
86	GPIO_3	I/O	GPIO_3	Programmable GPIO pins.
87	JTAG_SEL	I/O	JTAG_SEL	JTAG select: pull high to select the JTAG interface. If the JTAG interface is not used this pin may be left floating or connected to ground.
88	GPIO_2	I/O	GPIO_2	Programmable GPIO pins.
89	GPIO_1	I/O	GPIO_1	
90	GPIO_0	I/O	GPIO_0	
91	GPIO_8	I/O	GPIO_8	
92	GPIO_9	I/O	GPIO_9	
93	GPIO_10	I/O	GPIO_10	
94	GPIO_11	I/O	GPIO_11	
95-104	GND	-	-	Ground

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10. REFERENCE PERIPHERAL CIRCUIT
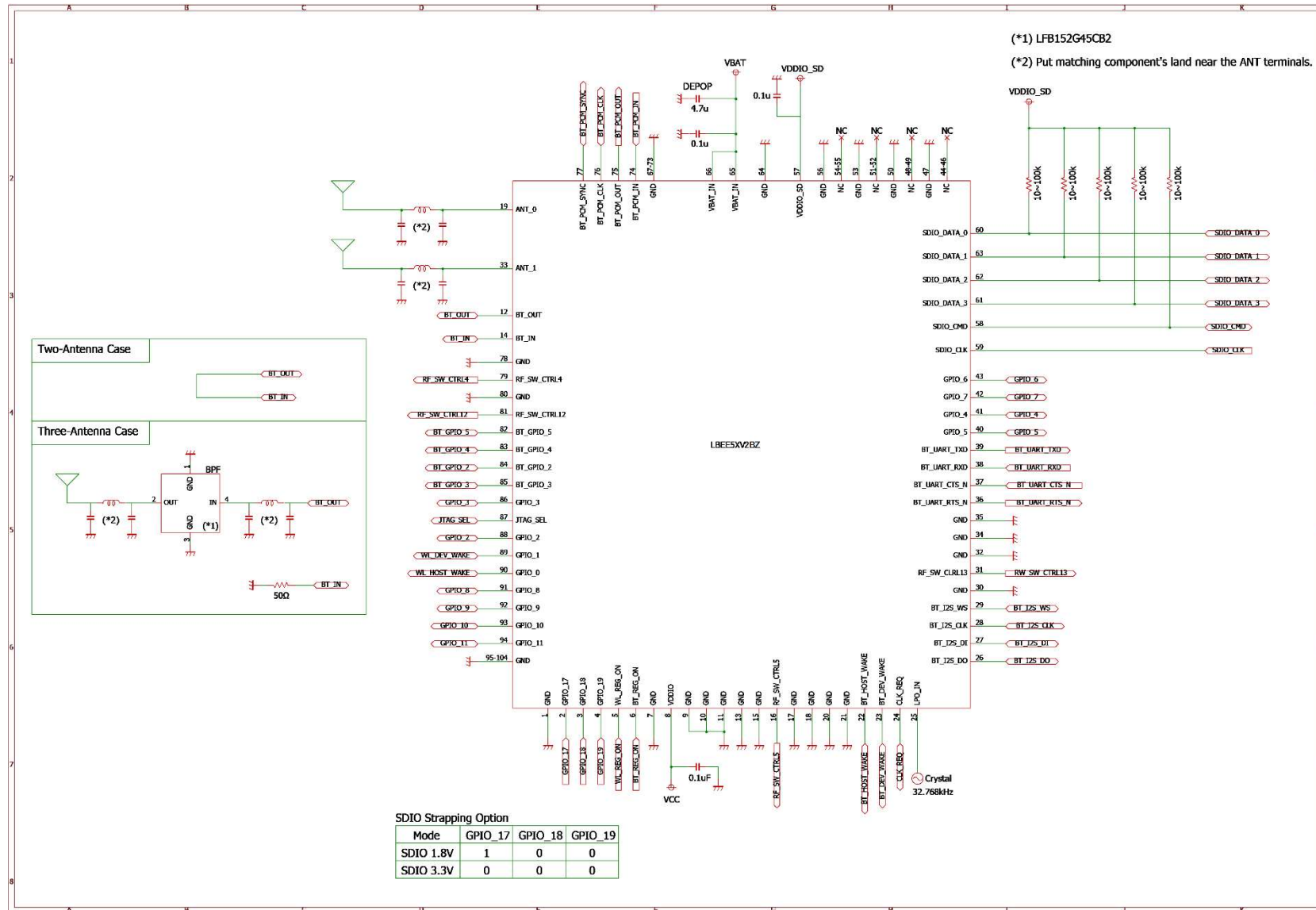
11. I/O States

The following notations are used in I/O State Table.

- I: Input signal
- O: Output signal
- I/O: Input/Output signal
- PU = Pulled up
- PD = Pulled down
- NoPull = Neither pulled up nor pulled down
- Where applicable, the default value is shown in bold brackets (for example, [default value])

I/O State Table

Name	I/O	Keeper	Active Mode	Low Power State/Sleep (All Power Present)	Power-down (BT_REG_ON and WL_REG_ON Held Low)	Out-of-Reset; Before SW Download (BT_REG_ON High; WL_REG_ON High)	Power-down (WL_REG_ON High and BT_REG_ON=0) and VDDIOs Are Present	Power Rail
WL_REG_ON BT_REG_ON	I	N	I: PD Pull-down can be disabled	I: PD Pull-down can be disabled	I: PD (of 200K)	I: PD (of 200K)	I: PD (of 200K)	–
GPIO_0	I/O	Y	I/O: PU, PD, NoPull Programmable [PD]	I/O: PU, PD, NoPull Programmable [PD]	High-Z, NoPull	I: PD	I: PD	VDDIO
GPIO_1	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPull	I: NoPull	VDDIO
GPIO_2	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPullb	I: NoPull	VDDIO
GPIO_3	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPullb	I: NoPull	VDDIO
GPIO_4	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPullb	I: NoPull	VDDIO
GPIO_5	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPullb	I: NoPull	VDDIO
GPIO_6	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPullb	I: NoPull	VDDIO
GPIO_7	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPull	I: NoPull	VDDIO
GPIO_8	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPull	I: NoPull	VDDIO
GPIO_9	I/O	Y	I/O: PU, PD, NoPull Programmable [PU]	I/O: PU, PD, NoPull Programmable [NoPull]	I: PU	I: PU	I:PU	VDDIO

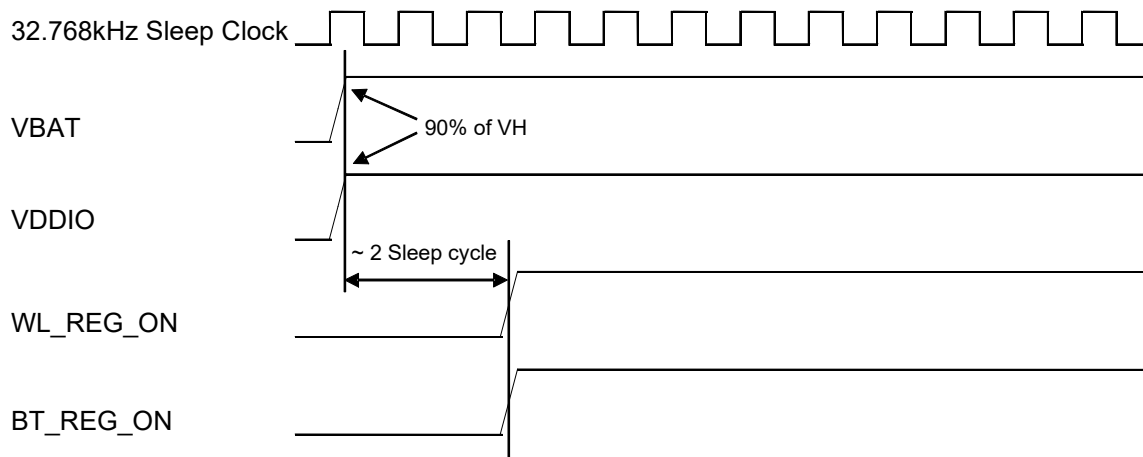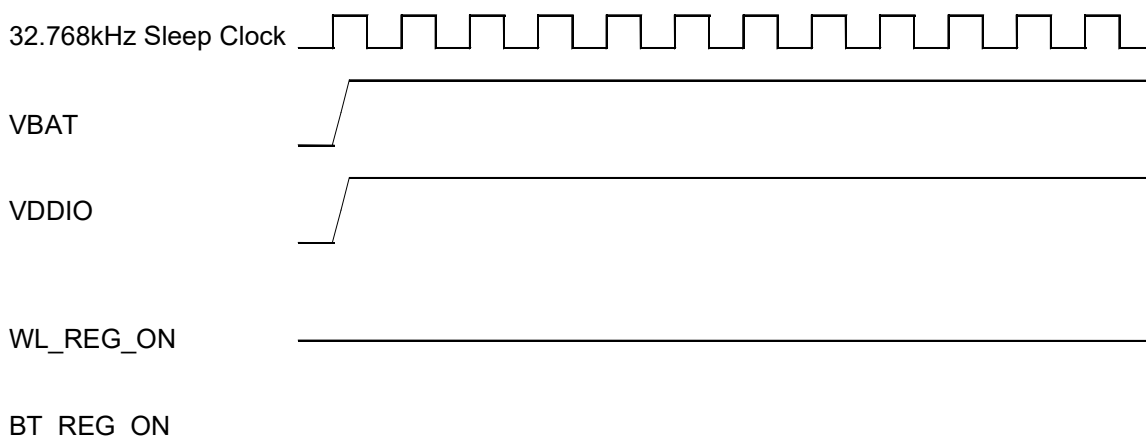| GPIO_10	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPull	I: NoPull	VDDIO
GPIO_11	I/O	Y	I/O: PU, PD, NoPull Programmable [PU]	I/O: PU, PD, NoPull Programmable [PU]	I: PU	I: PU	I:PU	VDDIO
GPIO_17	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPull	I: NoPull	VDDIO
GPIO_18	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPull	I: NoPull	VDDIO
GPIO_19	I/O	Y	I/O: PU, PD, NoPull Programmable [NoPull]	I/O: PU, PD, NoPull Programmable [NoPull]	High-Z, NoPull	I: NoPull	I: NoPull	VDDIO
RF_SW_CTRL_X	O	N	O: NoPull	O: NoPull	High-Z, NoPull	O: NoPull	O: NoPull	VDDIO_RF
CLK_REQ	O	Y	Open drain or push-pull (programmable).Active high.	Open drain or push-pull (programmable).Active high.	High-Z, NoPull	Open drain. Active high	Open drain. Active high	BT_VDDO
BT_HOST_WAKE	O	Y	Input/Output; PU, PD, NoPull (programmable)	Input/Output; PU, PD, NoPull (programmable)	High-Z, NoPull	Input, PU	Input, PD	BT_VDDO
BT_DEV_WAKE	I	Y	Input/Output; PU, PD, NoPull (programmable)	Input/Output; PU, PD, NoPull (programmable)	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_GPIO_2 BT_GPIO_3	I/O	Y	Input/Output; PU, PD, NoPull (programmable)	Input/Output; PU, PD, NoPull (programmable)	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_GPIO_4 BT_GPIO_5	I/O	Y	Input/Output; PU, PD, NoPull (programmable)	Input/Output; PU, PD, NoPull (programmable)	High-Z, NoPull	Input, PU	Input, PU	BT_VDDO
BT_UART_CTS_N	I	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	Input, PU	Input, PU	BT_VDDO
BT_UART_RTS_N	O	Y	Output, NoPull	Output, NoPull	High-Z, NoPull	Input, PU	Input, PU	BT_VDDO
BT_UART_RXD	I	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	Input, PU	Input, PU	BT_VDDO
BT_UART_TXD	O	Y	Output, NoPull	Output, NoPull	High-Z, NoPull	Input, PU	Input, PU	BT_VDDO
BT_PCM_CLK	I/O	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_PCM_IN	I/O	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_PCM_OUT	I/O	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_PCM_SYNC	I/O	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_I^{2}S_CLK	I/O	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	High-Z, NoPull	High-Z, NoPull	BT_VDDO
BT_I^{2}S_DO	I/O	Y	Output, NoPull	Output, NoPull	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_I^{2}S_DI	I/O	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	Input, PD	Input, PD	BT_VDDO
BT_I^{2}S_WS	I/O	Y	Input, NoPull	Input, NoPull	High-Z, NoPull	High-Z, NoPull	High-Z, NoPull	BT_VDDO

12. POWER SEQUENCE

12.1. POWER ON SEQUENCE

- VBAT and VDDIO 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 fast or be held high before VBAT is high.
- WL_REG_ON and BT_REG_ON should be up after sleep clock oscillation is stabilized.
- Please proceed reset by WL_REG_ON and BT_REG_ON until it starts normally if it doesn't wake from sleep property or it is presented with uncertain status.
- Please keep repeats power off sequence and power on sequence several times until it started normally.
- The CYW54590 has an internal Power-on reset (POR) circuit. The device will be held in reset for a maximum of 110 ms after internal regulators and VDDIO have passed the POR threshold. Wait at least 150 ms after WL_REG_ON is driven high before initiating SDIO accesses.

12.1.1. Power On Sequence for WLAN = ON and BT = ON

12.1.2. Power On Sequence for WLAN = OFF and BT = OFF

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12.1.3. Power On Sequence for WLAN = ON and BT = OFF

32.768kHz Sleep Clock

VBAT — 90% of VH

VDDIO

~ 2 Sleep cycle

WL_REG_ON

BT_REG_ON

12.1.4. Power On Sequence for WLAN = OFF and BT = ON

32.768kHz Sleep Clock

VBAT — 90% of VH

VDDIO

~ 2 Sleep cycle

WL_REG_ON

BT_REG_ON

12.1.5. Power Off Sequence

- VDDIO should be down before or at the same time as VBAT. VBAT should NOT be down earlier than VDDIO low. VDDIO becomes low state is prior to VBAT low.
- VBAT and VDDIO should be down after WL_REG_ON and BT_REG_ON are low. Waiting time from REG_ON down to power supply off is not prescribed.
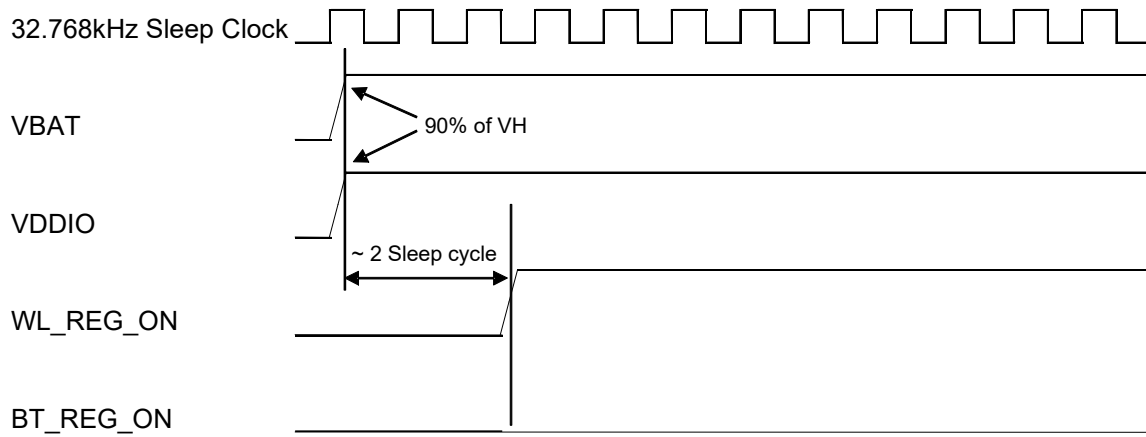
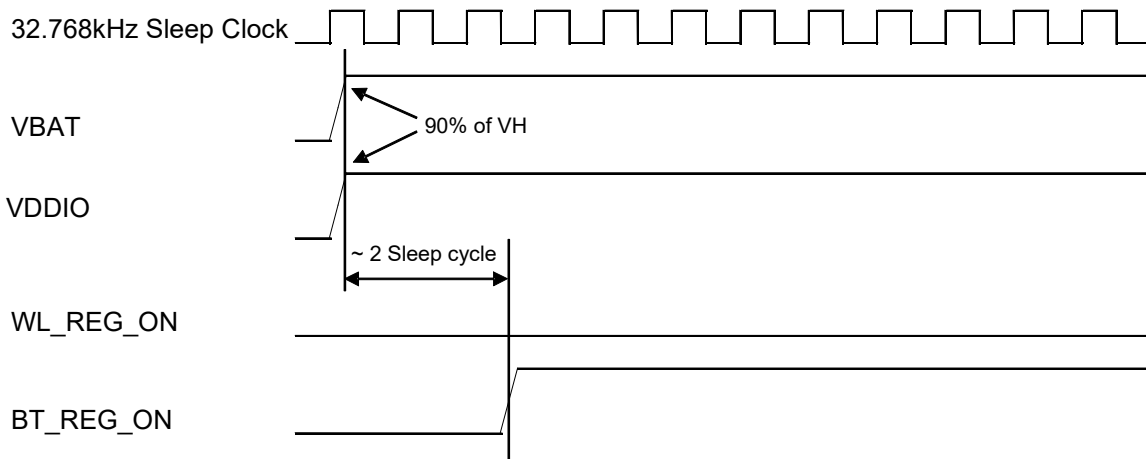## 12.1.6. Power Off Sequence for WLAN = ON and BT = ON

12.1.7. Power Off Sequence for WLAN = OFF and BT = OFF

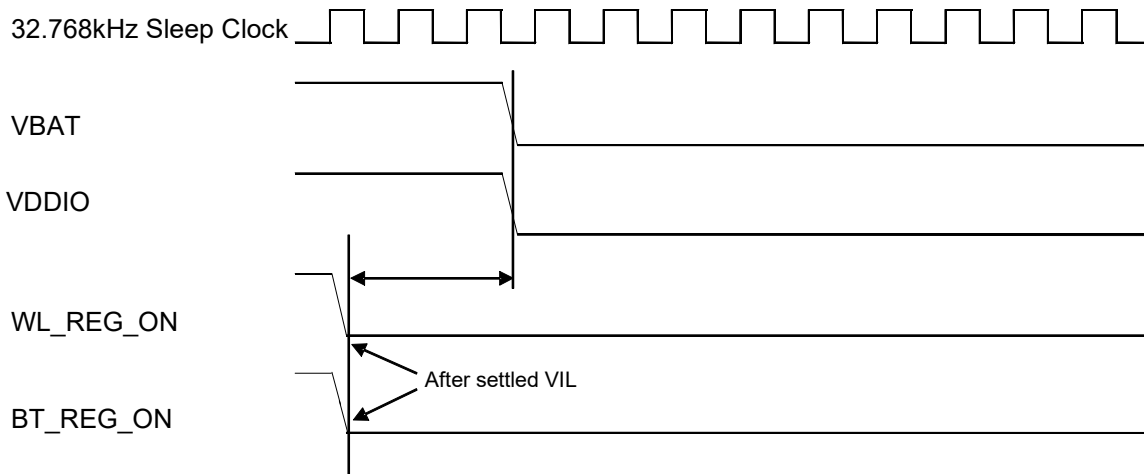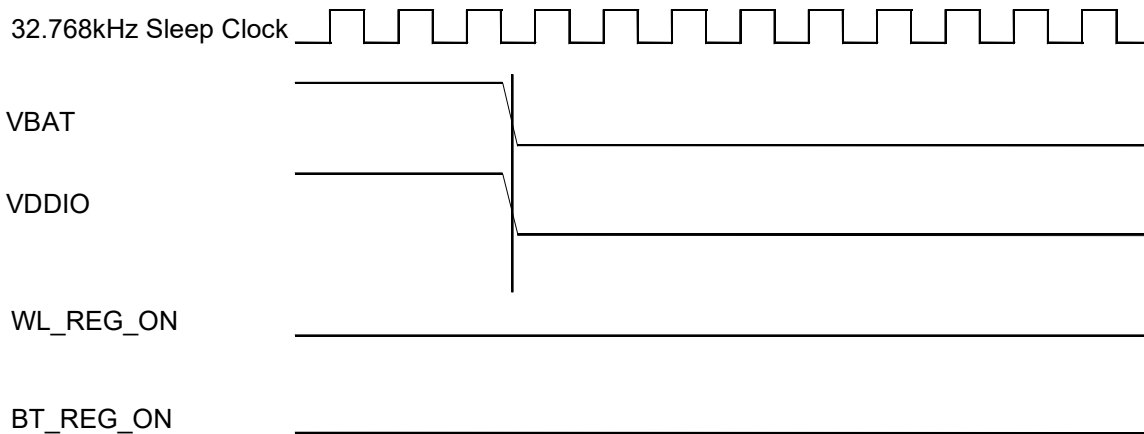### 12.1.8. Power Off Sequence for WLAN = ON and BT = OFF
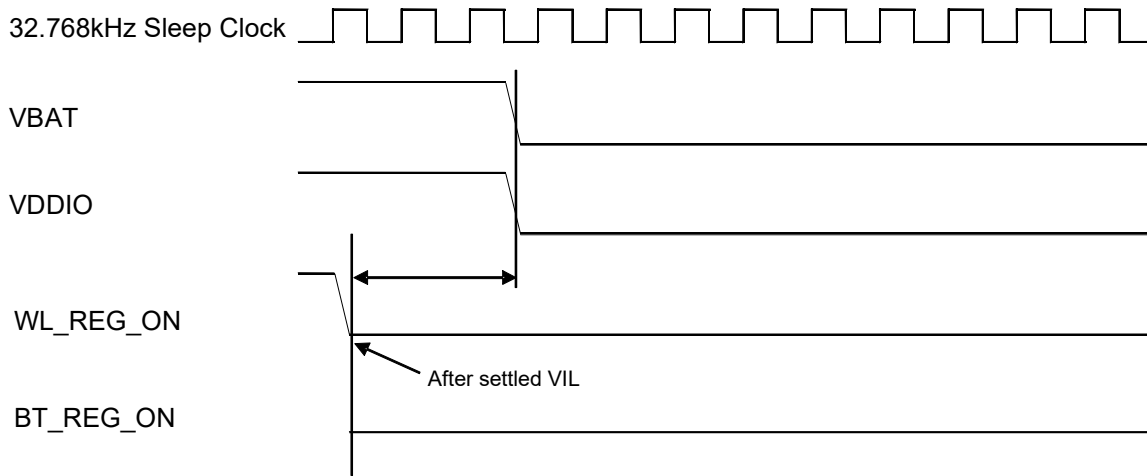
12.1.9. Power Off Sequence for WLAN = OFF and BT = ON
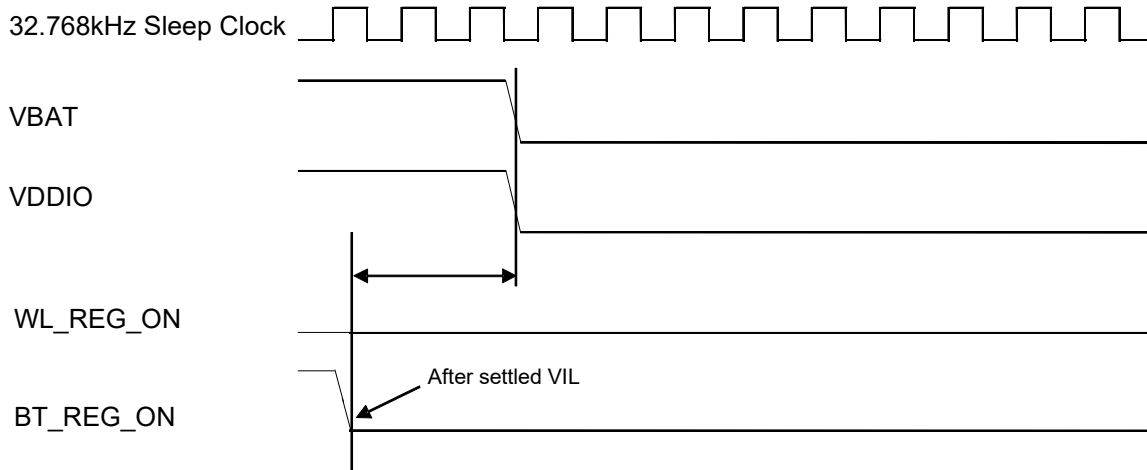
13. INTERFACE TIMING AND AC CHARACTERISTICS

13.1. Bluetooth UART Timing
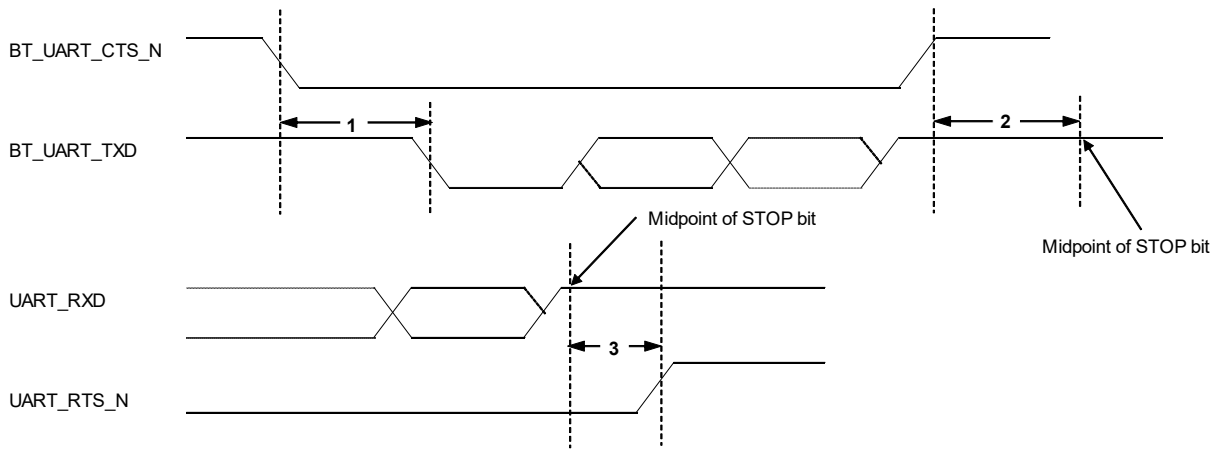
Reference	Description	Min	Typ	Max	Unit
1	Delay time, UART_CTS_N low to UART_TXD valid	-	-	1.5	Bit periods
2	Setup time, UART_CTS_N high before midpoint of stop bit	-	-	0.5	Bit periods
3	Delay time, midpoint of stop bit to UART_RTS_N high	-	-	0.5	Bit periods

13.2. Bluetooth Startup Signaling Sequence
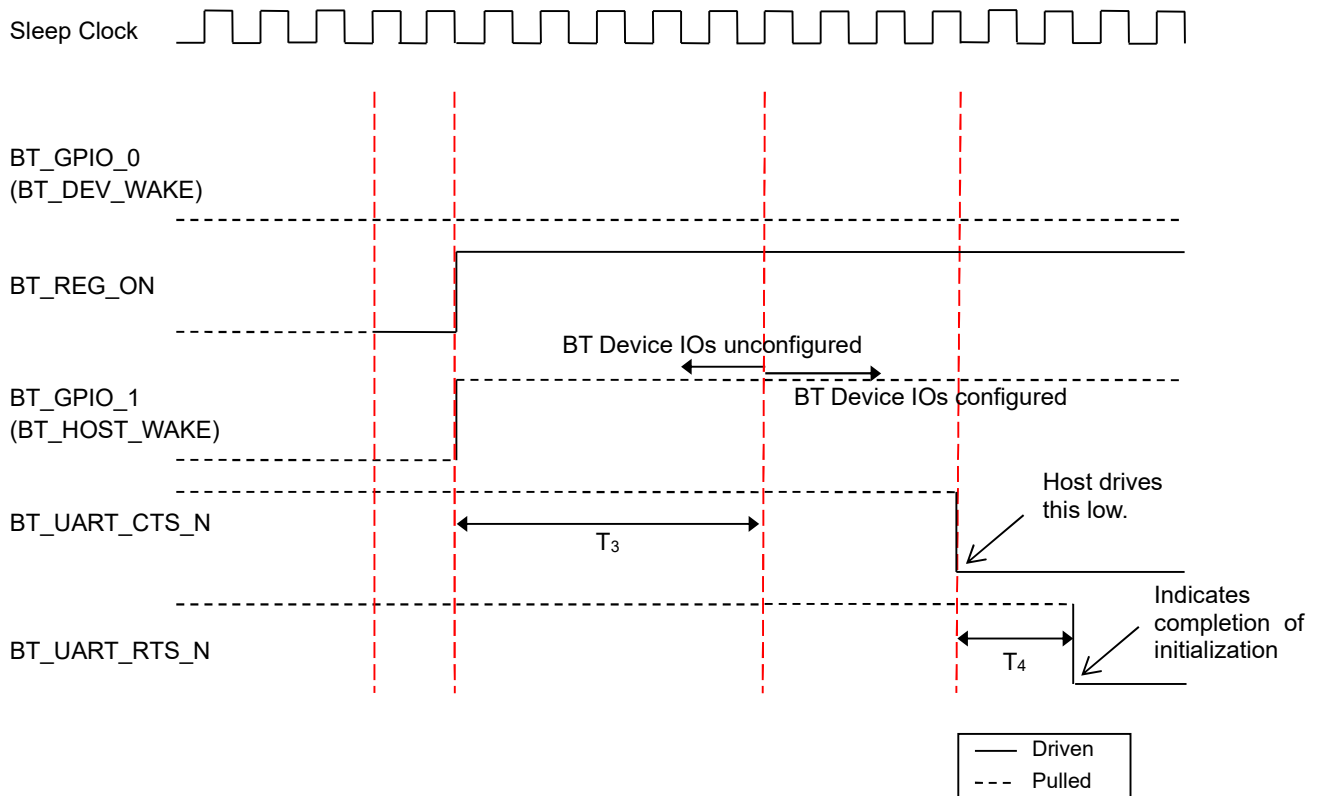
Reference	Description	Min	Typ	Max	Unit
T_3	Time for the BT device to settle its IOs after BT_REG_ON is asserted.	-	-	40.0	ms
T_4	Time for the BT device to drive UART_RTS_N low after the host drives UART_CTS_N low	-	-	10.0	ms

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13.3. Bluetooth PCM Interface Timing

Data Formatting

The IC used in the module may be configured to generate and accept several different data formats. For conventional narrowband speech mode, the IC uses 13 of the 16 bits in each PCM frame. The location and order of these 13 bits can be configured to support various data formats on PCM interface. The remaining three bits are ignored on the input and may be filled with 0s, 1s, a sigh bit, or a programmed value on the output. The default format is 13bit 2's complement data, left justified, and clocked MSB first.

Wideband Speech Support

When the host encodes wideband speech (WBS) packets in transparent mode, the encoded packets are transferred over the PCM bus for an eSCO voice connection. In this mode, the PCM bus is typically configured in master mode for a 4kHz sync rate with 16-bit samples, resulting in a 64 kbps bit rate. The IC also supports slave transparent mode using a proprietary rate-matching scheme. IN SBC-code mode, linear 16-bit data at 16kHz (256kbps rate) is transferred over the PCM bus.

Short Frame Sync, Master Mode

Reference	Description	Min	Typ	Max	Unit
1	PCM bit clock frequency	-	-	12.0	MHz
2	PCM bit clock High	41.0	-	-	ns
3	PCM bit clock Low	41.0	-	-	ns
4	PCM_SYNC delay	0	-	25.0	ns
5	PCM_OUT delay	0	-	25.0	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	-	25.0	ns

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Short Frame Sync, Slave Mode

Reference	Description	Min	Typ	Max	Unit
1	PCM bit clock frequency	-	-	12.0	MHz
2	PCM bit clock High	41.0	-	-	ns
3	PCM bit clock Low	41.0	-	-	ns
4	PCM_SYNC setup	8.0	-	-	ns
5	PCM_SYNC hold	8.0	-	-	ns
6	PCM_OUT delay	0	-	25.0	ns
7	PCM_IN setup	8.0	-	-	ns
8	PCM_IN hold	8.0	-	-	ns
9	Delay from rising edge of PCM_BCLK during last bit period to PCM_OUT becoming high impedance.	0	-	25.0	ns

Long Frame Sync, Master Mode

Reference	Description	Min	Typ	Max	Unit
1	PCM bit clock frequency	-	-	12.0	MHz
2	PCM bit clock High	41.0	-	-	ns
3	PCM bit clock Low	41.0	-	-	ns
4	PCM_SYNC delay	0	-	25.0	ns
5	PCM_OUT delay	0	-	25.0	ns
6	PCM_IN setup	8.0	-	-	ns
7	PCM_IN hold	8.0	-	-	ns
8	Delay from rising edge of PCM_BCLK during last bit period to PCM_OUT becoming high impedance	0	-	25.0	ns

Long Frame Sync, Slave Mode

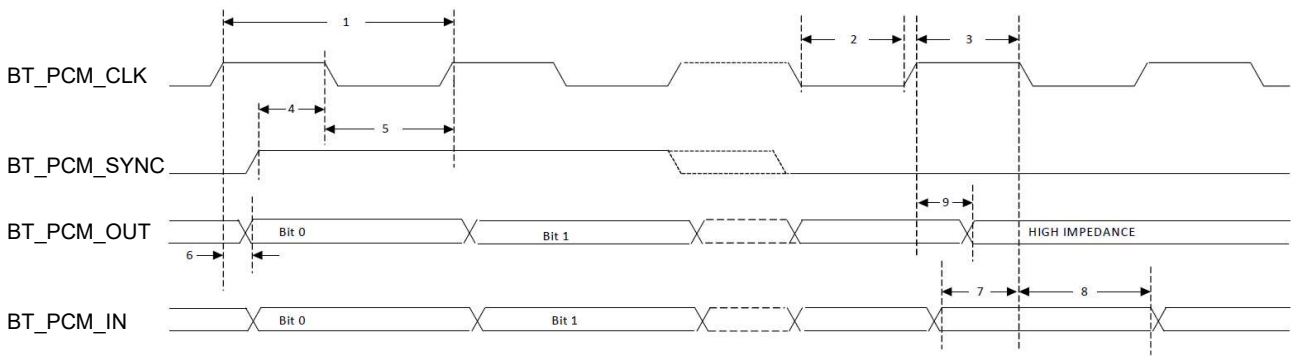| Reference	Description	Min	Typ	Max	Unit
1	PCM bit clock frequency	-	-	12.0	MHz
2	PCM bit clock High	41.0	-	-	ns
3	PCM bit clock Low	41.0	-	-	ns
4	PCM_SYNC setup	8.0	-	-	ns
5	PCM_SYNC hold	8.0	-	-	ns
6	PCM_OUT delay	0	-	25.0	ns
7	PCM_IN setup	8.0	-	-	ns
8	PCM_IN hold	8.0	-	-	ns
9	Delay from rising edge of PCM_BCLK during last bit period to PCM_OUT becoming high impedance.	0	-	25.0	ns

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13.4. Bluetooth I²S Interface Timing

The IC used in the module supports I²S format. The module supports only PCM digital audio ports through I²S format.

The I²S signals are:
- •I²S clock: I²S SCK (Module pin: BT_PCM_CLK)
- •I²S Word Select: I²S WS (Module pin: BT_PCM_SYNC)
- •I²S Data Out: I²S SDO (Module pin: BT_PCM_OUT)
- •I²S Data In: I²S SDI (Module pin: BT_PCM_IN)

I²S SCK and I²S WS become outputs in master mode and inputs in slave mode, while I²S SDO always stays as an output. The channel word length is 16 bits and the data is justified so that the MSB of the let-channel data is aligned with the MSB of the I²S bus, per the I²S specification. The MSB of each data word is transmitted one bit clock cycle after the I²S WS transition, synchronous with the falling edge of bit clock. Left-channel data is transmitted when I²S WS is low, and right-channel data is transmitted when I²S WS is high. Data bits sent by the CYW89335 are synchronized with the falling edge of I²S_SCK and should be sampled by the receiver on the rising edge of I²S_SCK.

The clock rate in master mode is either of the following:

    48 kHz x 32 bits per frame = 1.536 MHz
    48 kHz x 50 bits per frame = 2.400 MHz

The master clock is generated from the input reference clock using a N/M clock divider.

In the slave mode, any clock rate is supported to a maximum of 3.072 MHz.

Timing for I²S Transmitters and Receivers

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

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

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

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

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

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

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

Note

The time periods specified in below figures are defined by the transmitter speed. The receiver specifications must match transmitter performance.

I²S Transmitters Timing
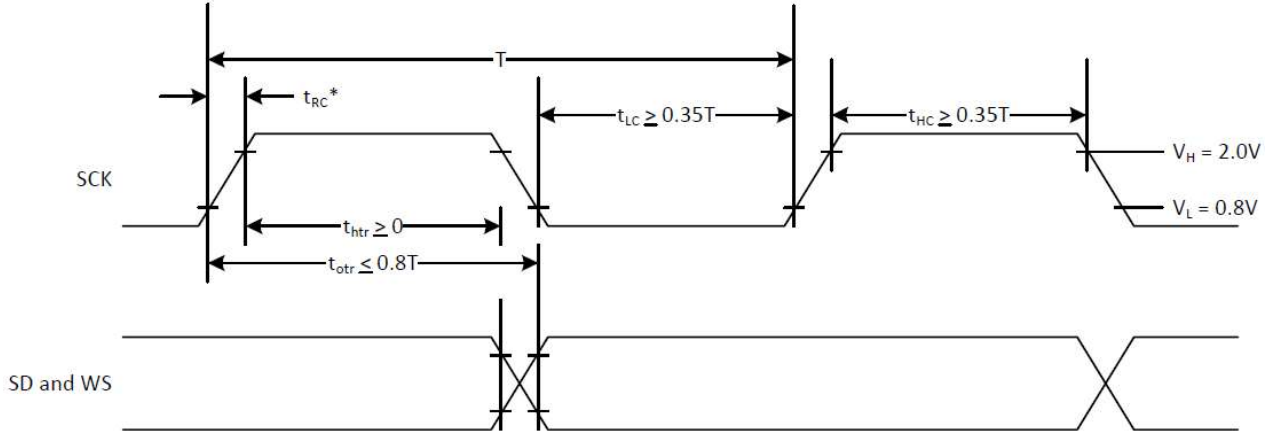
T = Clock period
T_{tr} = Minimum allowed clock period for transmitter
$T = T_{tr}$
* t_{RC} is only relevant for transmitters in slave mode.

I²S Receiver Timing
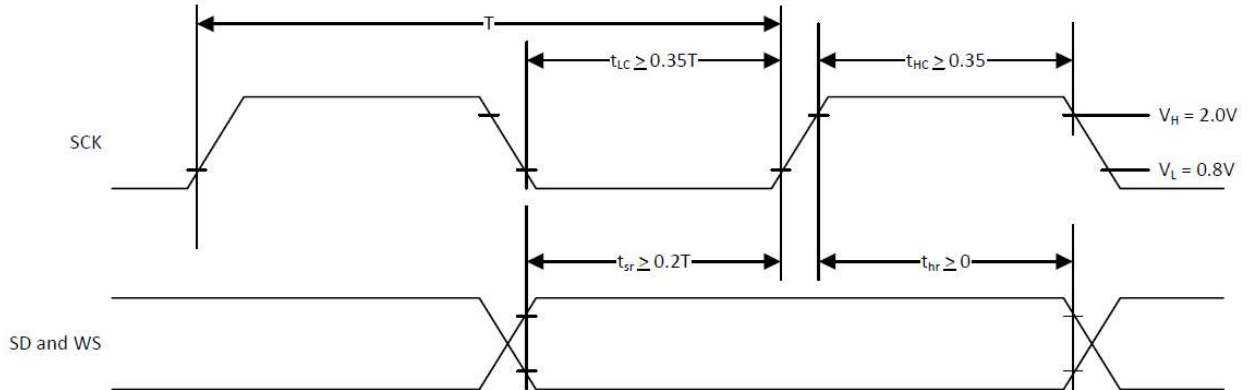
T = Clock period
T_r = Minimum allowed clock period for transmitter
$T > T_r$

13.5. WLAN SDIO Timing

13.5.1. SDIO Default Mode Timing
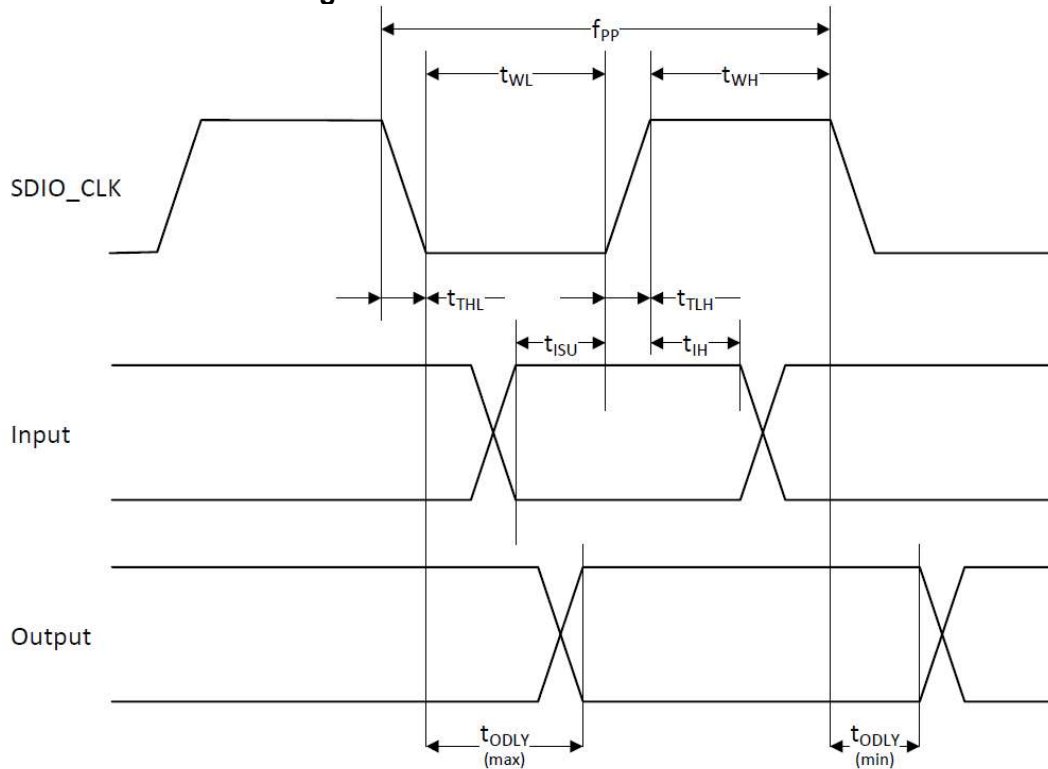
SDIO Bus Timing[a] Parameters (Default Mode)

Parameter	Symbol	Min	Typ	Max	Unit
SDIO CLK (All values are referred to minimum VIH and maximum VIL[b]					
Frequency - Data Transfer Mode	fPP	0	-	25	MHz
Frequency - Identification Mode	fOD	0	-	400	kHz
Clock Low Time	tWL	10.0	-	-	ns
Clock High Time	tWH	10.0	-	-	ns
Clock Rise Time	tTLH	-	-	10.0	ns
Clock low Time	tTHL	-	-	10.0	ns
Inputs: CMD, DAT (referenced to CLK)					
Input Setup Time	tISU	5.0	-	-	ns
Input Hold Time	tIH	5.0	-	-	ns
Outputs: CMD, DAT (referenced to CLK)					
Output Delay time - Data Transfer Mode	tODLY	0	-	14.0	ns
Output Delay time - Identification Mode	tODLY	0	-	50.0	ns

(a). Timing is based on CL $\leq$ 40pF load on CMD and Data.
(b). Min (Vih) = 0.7*VIO and max (Vil) = 0.2*VIO.

13.5.2. SDIO High-Speed Mode Timing
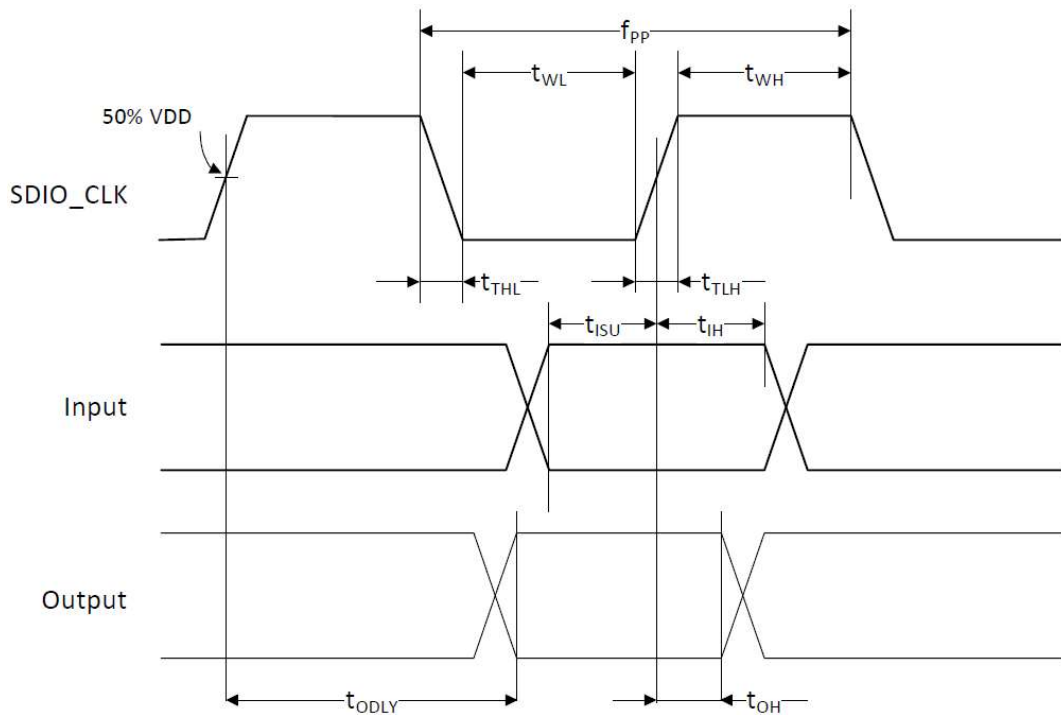
SDIO Bus Timing[a] Parameters (High-Speed Mode)

Parameter	Symbol	Min	Typ	Max	Unit
SDIO CLK (All values are referred to minimum VIH and maximum VIL[b])					
Frequency - Data Transfer Mode	fPP	0	-	50	MHz
Frequency - Identification Mode	fOD	0	-	400	kHz
Clock Low Time	tWL	7.0	-	-	ns
Clock High Time	tWH	7.0	-	-	ns
Clock Rise Time	tTLH	-	-	3.0	ns
Clock low Time	tTHL	-	-	3.0	ns
Inputs: CMD, DAT (referenced to CLK)					
Input Setup Time	tISU	6.0	-	-	ns
Input Hold Time	tIH	2.0	-	-	ns
Outputs: CMD, DAT (referenced to CLK)					
Output Delay time - Data Transfer Mode	tODLY	-	-	14.0	ns
Output Delay time - Identification Mode	tOH	2.5.0	-	-	ns
Total system capacitance (each line)	CL	-	-	40.0	pF

(a). Timing is based on CL $\leq$ 40pF load on CMD and Data.
(b). Min (Vih) = 0.7*VIO and max (Vil) = 0.2*VIO.

13.5.3. SDIO Bus Timing Specifications in SDR Modes

Clock Timing

SDIO Clock Timing (SDR Modes)
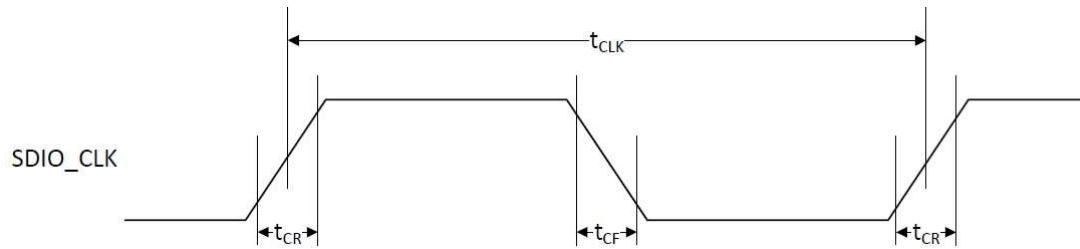
SDIO Bus Clock Timing Parameters (SDR Modes)

Parameter	Symbol	Min.	Max	Unit	Comments
-	t_{CLK}	40.0	-	ns	SDR12 mode
		20.0	-	ns	SDR25 mode
		10.0	-	ns	SDR50 mode
		4.8	-	ns	SDR104 mode
-	t_{CR}, t_{CF}	-	$0.2 \times t_{CLK}$	ns	t_{CR}, t_{CF}<2.00ns(max)@100MHz, C_{CARD}=10pF t_{CR}, t_{CF}<0.96ns(max)@208MHz, C_{CARD}=10pF
Clock duty	-	30.0	70.0	%	-

Device Input Timing

SDIO Bus Input Timing (SDR Modes)
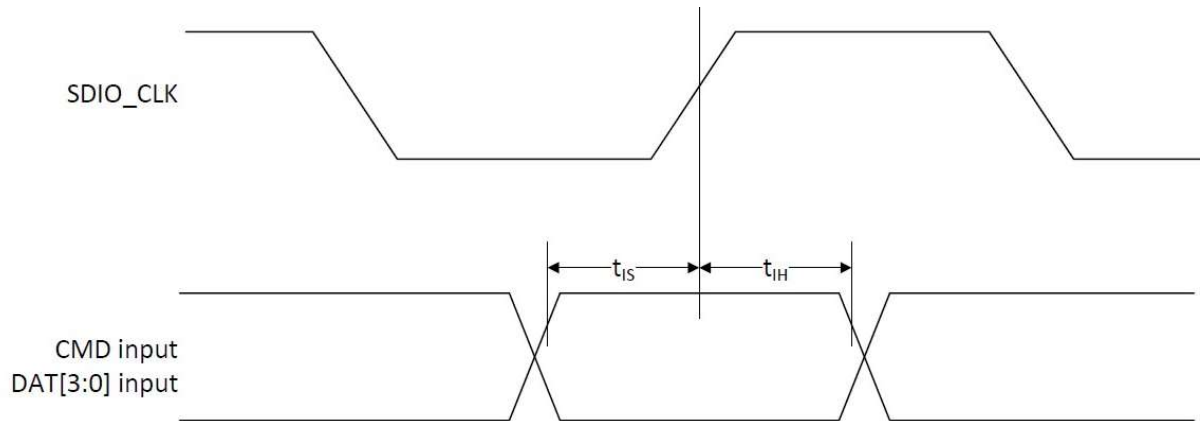
SDIO Bus Input Timing Parameters (SDR Modes)

Symbol	Min	Max	Unit	Comments
SDR104 Mode				
t_{IS}	1.4	-	ns	C_{CARD}=10pF, VCT=0.975V
t_{IH}	0.8	-	ns	C_{CARD}=5pF, VCT=0.975V
SDR50 Mode				
t_{IS}	3.0	-	ns	C_{CARD}=10pF, VCT=0.975V
t_{IH}	0.8	-	ns	C_{CARD}=5pF, VCT=0.975V
SDR25 Mode				
t_{IS}	3.0	-	ns	C_{CARD}=10pF, VCT=0.975V
t_{IH}	0.8	-	ns	C_{CARD}=5pF, VCT=0.975V
SDR12 Mode				
t_{IS}	3.0	-	ns	C_{CARD}=10pF, VCT=0.975V
t_{IH}	0.8	-	ns	C_{CARD}=5pF, VCT=0.975V

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Device Output Timing

SDR Modes up to 100MHz
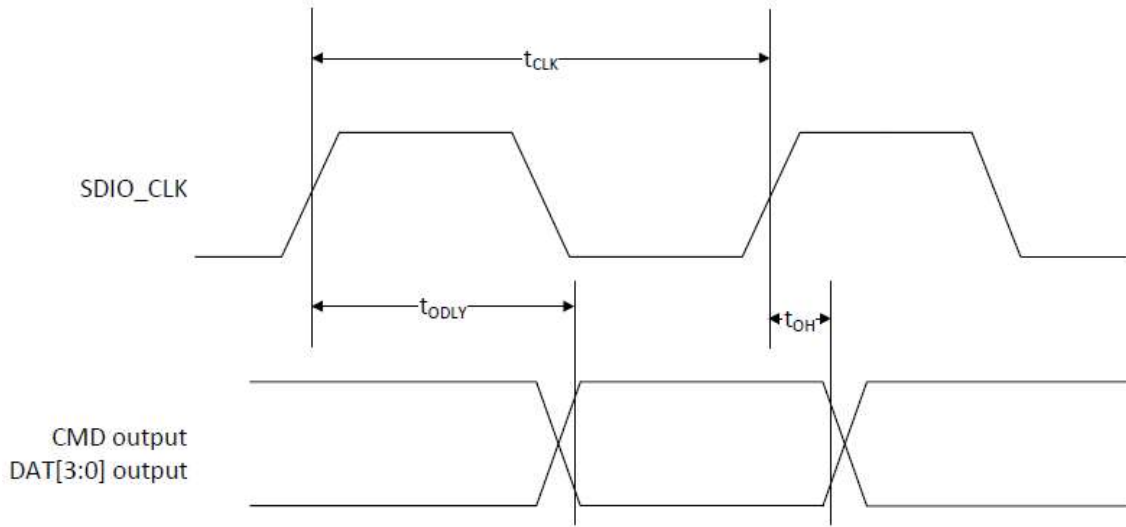
SDIO Bus Output Timing Parameters (SDR Modes up to 100MHz)

Symbol	Min	Max	Unit	Comments
tODLY		7.5	ns	tCLK≧10ns CL=30pF using driver typeB for SDR50
tODLY		14.0	ns	tCLK≧20ns CL=40pF using for SDR12, SDR25
tOH	1.5		ns	Hold time at the tODLY(min)CL=15pF

SDR Modes 100MHz to 208MHz
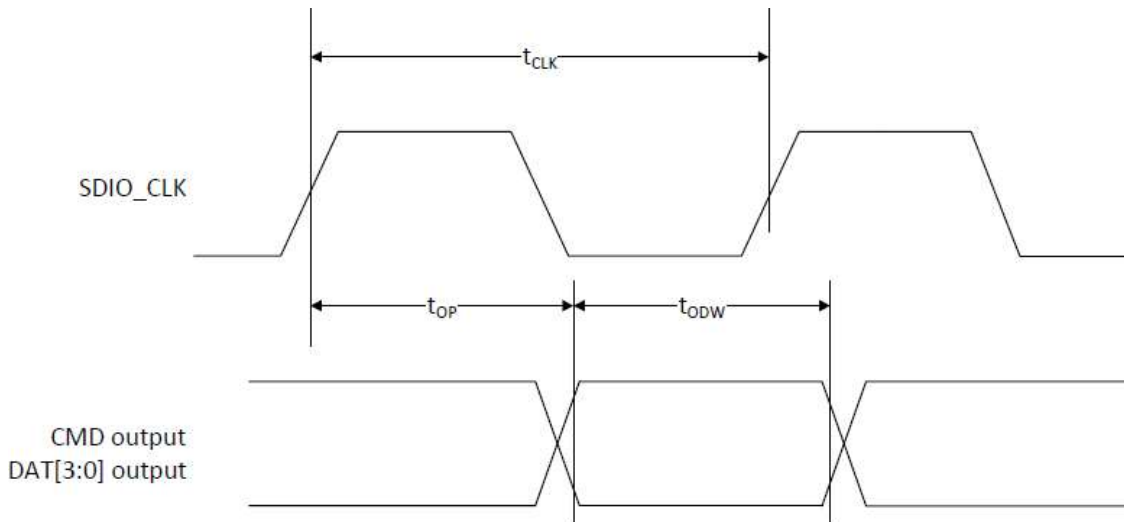
SDIO Bus Output Timing Parameters (SDR Modes 100MHz to 208MHz)

Symbol	Min	Max	Unit	Comments
tOP	0	2	UI	Card output phase
Δ tOP	-350	+1550	Ps	Delay variation due to temp change after tuning
tODW	0.60	-	UI	tODW=2.88ns@208MHz

・ Δ tOP=+1550ps for junction temperature of Δ tOP=90 degrees during operation.
・ Δ tOP=-350ps for junction temperature of Δ tOP=-20 degrees during operation.
・ Δ tOP=+2600ps for junction temperature of Δ tOP=-20 to +125 degrees during operation

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Data valid window

Sampling point after tuning

$\Delta t_{OP} = 1550\ ps$

Data valid window

$\Delta t_{OP} = -350\ ps$

Sampling point after card junction heating by +90°C from tuning temperature

Data valid window

Sampling point after card junction cooling by −20°C from tuning temperature
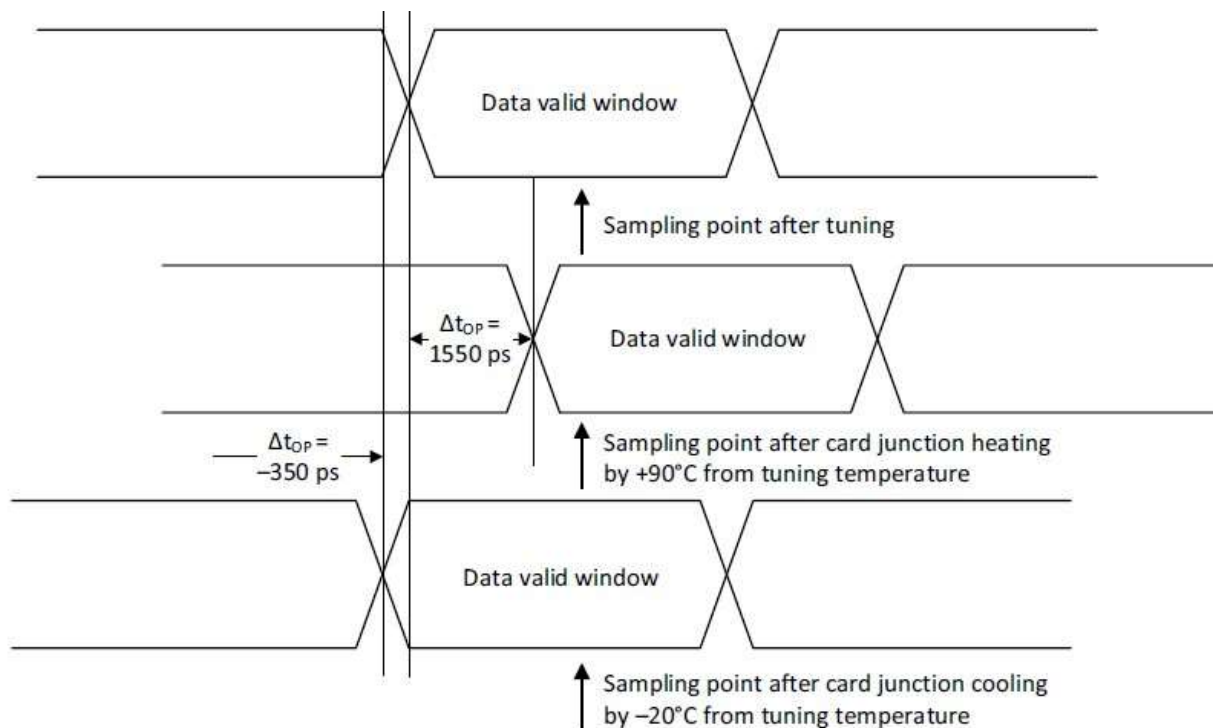
14. ELECTORICAL CHARACTERISTICS

14.1. DC/RF Characteristics for IEEE802.11b - 2.4G

Normal Condition : 25deg.C, VBAT =3.3V.
11Mbps mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11b-2.4GHz			
Mode	DSSS / CCK			
Channel frequency (spacing)	2412 to 2472 MHz (5MHz)			
Data rate	1, 2, 5.5,11Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**Unit**
(a) Tx mode	-	370	470	mA
(b) Rx mode	-	100	150	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**Unit**
Power Levels	14.5	17	19.5	dBm
Spectrum Mask				
(a) 1st side lobes	-	-	-30	dBr
(b) 2nd side lobes	-	-	-50	dBr
Power-on/off ramp	-	-	2.0	usec
RF Carrier Suppression	15	-	-	dB
Modulation Accuracy	-	-	35	%
Frequency tolerance	-20	-	20	ppm
Spurious Emissions (BW=100kHz)				
(a) 30Hz≦f<1000MHz	-	-	-36	dBm
(b) 1000MHz≦f<12750MHz	-	-	-30	dBm
(c) 1800MHz<f≦1900MHz	-	-	-47	dBm
(d) 5150MHz<f≦5300MHz	-	-	-47	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**Unit**
Minimum Input Level (FER< 8%)	-	-	-76	dBm
Maximum Input Level (FER ≤ 8%)	-10	-	-	dBm
Adjacent Channel Rejection (FER ≤ 8%)	35	-	-	dB

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14.2. DC/RF Characteristics for IEEE802.11g - 2.4G

Normal Condition : 25deg.C, VBAT =3.3V.
54Mbps mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11g-2.4GHz			
Mode	OFDM			
Channel frequency (spacing)	2412 to 2472 MHz (5MHz)			
Data rate	6, 9, 12, 18, 24, 36, 48, 54Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**unit**
(a) Tx mode	-	330	430	mA
(b) Rx mode	-	100	150	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**unit**
Power Levels	12.5	15	17.5	dBm
Spectrum Mask				
(a) at fc +/- 11MHz	-	-	-20	dBr
(b) at fc +/- 20MHz	-	-	-28	dBr
(c) at fc ≥ +/-30MHz	-	-	-40	dBr
Constellation Error	-	-	-25	dB
Frequency tolerance	-20		20	ppm
Spurious Emissions (BW=100kHz)				
(a) 30Hz≦f<1000MHz	-	-	-36	dBm
(b) 1000MHz≦f<12750MHz	-	-	-30	dBm
(c) 1800MHz<f≦1900MHz	-	-	-47	dBm
(d) 5150MHz<f≦5300MHz	-	-	-47	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**unit**
Minimum Input Level (PER ≤ 10%)	-	-	-65	dBm
Maximum Input Level (PER ≤ 10%)	-20	-	-	dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1	-	-	dB

14.3. DC/RF Characteristics for IEEE802.11n - 2.4GHz

Normal Condition : 25deg.C, VBAT =3.3V.

65Mbps (MCS7 – HT 20MHz) mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11n-2.4GHz			
Mode	OFDM			
Channel frequency (spacing)	2412 to 2472 MHz (5MHz)			
Data rate	6.5, 13, 19.5, 26, 39, 52, 58.5, 65Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**unit**
(a) Tx mode	-	330	430	mA
(b) Rx mode	-	100	150	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**unit**
Power Levels	12.5	15	17.5	dBm
Spectrum Mask				
(a) at fc +/- 11MHz	-	-	-20	dBr
(b) at fc +/- 20MHz	-	-	-28	dBr
(c) at fc $\geq$ +/-30MHz	-	-	-45	dBr
Constellation Error (measured at enhanced mode)	-	-	-27	dB
Frequency tolerance	-20	-	20	ppm
Spurious Emissions (BW=100kHz)				
(a) 30Hz$\leqq$f<1000MHz	-	-	-36	dBm
(b) 1000MHz$\leqq$f<12750MHz	-	-	-30	dBm
(c) 1800MHz<f$\leqq$1900MHz	-	-	-47	dBm
(d) 5150MHz<f$\leqq$5300MHz	-	-	-47	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**unit**
Minimum Input Level (PER $\leq$ 10%)	-	-	-64	dBm
Maximum Input Level (PER $\leq$ 10%)	-20	-	-	dBm
Adjacent Channel Rejection (PER $\leq$ 10%)	-2	-	-	dB

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14.4. DC/RF Characteristics for IEEE802.11a - 5GHz

Normal Condition : 25deg.C, VBAT =3.3V.
54Mbps mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11a-5GHz			
Mode	OFDM			
Channel frequency (spacing)	5180 - 5825MHz			
Data rate	6, 9, 12, 18, 24, 36, 48, 54Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**Unit**
(a) Tx mode	-	400	500	mA
(b) Rx mode	-	120	170	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**Unit**
Power Levels	11.5	14	16.5	dBm
Spectrum Mask				
(a) at fc +/- 11MHz	-	-	-20	dBr
(b) at fc +/- 20MHz	-	-	-28	dBr
(c) at fc $\geq$ +/-30MHz	-	-	-40	dBr
Constellation Error	-	-	-25	dB
Frequency tolerance	-20		20	ppm
Spurious Emissions (BW=100kHz)				
(a) 30Hz$\leqq$f<1000MHz	-	-	-36	dBm
(b) 1000MHz$\leqq$f<26000MHz	-	-	-30	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**Unit**
Minimum Input Level (PER $\leq$ 10%)	-	-	-65	dBm
Maximum Input Level (PER $\leq$ 10%)	-30	-	-	dBm
Adjacent Channel Rejection (PER < 10%)	-1			dB

14.5. DC/RF Characteristics for IEEE802.11n(HT 20MHz) - 5GHz

Normal Condition : 25deg.C, VBAT =3.3V.
65Mbps (MCS7 – HT 20MHz) mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11n-5GHz			
Mode	OFDM			
Channel frequency (spacing)	5180 - 5825MHz			
Data rate	6.5, 13, 19.5, 26, 39, 52, 58.5, 65Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**Unit**
(a) Tx mode	-	380	480	mA
(b) Rx mode	-	120	170	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**Unit**
Power Levels	10.5	13	15.5	dBm
Spectrum Mask				
(a) at fc +/- 11MHz	-	-	-20	dBr
(b) at fc +/- 20MHz	-	-	-28	dBr
(c) at fc $\geq$ +/-30MHz	-	-	-40	dBr
Constellation Error (measured at enhanced mode)	-	-	-27	dB
Frequency tolerance	-20		20	ppm
Spurious Emissions (BW=100kHz)				
(a) 30Hz$\leqq$f<1000MHz	-	-	-36	dBm
(b) 1000MHz$\leqq$f<26000MHz	-	-	-30	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**Unit**
Minimum Input Level (PER $\leq$ 10%)	-	-	-64	dBm
Maximum Input Level (PER $\leq$ 10%)	-30	-	-	dBm
Adjacent Channel Rejection (PER < 10%)	16	-	-	dB

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14.6.   DC/RF Characteristics for IEEE802.11n(HT 40MHz) - 5GHz

Normal Condition : 25deg.C, VBAT =3.3V.
135Mbps (MCS7 – HT 40MHz) mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11n-5GHz			
Mode	OFDM			
Channel frequency (spacing)	5180 - 5825MHz			
Data rate	13.5,27,40.5,54,81,108,121.5,135Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**Unit**
(a) Tx mode	-	410	510	mA
(b) Rx mode	-	140	190	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**Unit**
Power Levels	9.5	12	14.5	dBm
Spectrum Mask				
(a) at fc +/- 21MHz	-	-	-20	dBr
(b) at fc +/- 40MHz	-	-	-28	dBr
(c) at fc $\geq$ +/-60MHz	-	-	-40	dBr
Constellation Error (measured at enhanced mode)	-	-	-27	dB
Frequency tolerance	-20		20	ppm
Spurious Emissions (BW=100kHz)				
(a) 30Hz$\leqq$f<1000MHz	-	-	-36	dBm
(b)1000MHz$\leqq$f<26000MHz	-	-	-30	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**Unit**
Minimum Input Level (PER $\leq$ 10%)	-	-	-61	dBm
Maximum Input Level (PER $\leq$ 10%)	-30	-	-	dBm
Adjacent Channel Rejection (PER < 10%)	-2			dB

14.7. DC/RF Characteristics for IEEE802.11ac(HT 40MHz) - 5GHz

Normal Condition : 25deg.C, VBAT =3.3V.
180Mbps (MCS9 – HT 40MHz) mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11ac-5GHz			
Mode	OFDM			
Channel frequency (spacing)	5190 - 5795MHz			
Data rate	13.5,27,40.5,54,81,108,121.5,135,162,180Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**Unit**
(a) Tx mode	-	420	520	mA
(b) Rx mode	-	140	200	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**Unit**
Power Levels	7.5	10	12.5	dBm
Spectrum Mask				
(a) at fc +/- 21MHz	-	-	-20	dBr
(b) at fc +/- 40MHz	-	-	-28	dBr
(c) at fc $\geq$ +/-60MHz	-	-	-40	dBr
Constellation Error (measured at enhanced mode)	-	-	-32	dB
Frequency tolerance	-20		20	ppm
Spurious Emissions (BW=100kHz)				
(a) 30Hz$\leqq$f<1000MHz	-	-	-36	dBm
(b) 1000MHz$\leqq$f<26000MHz	-	-	-30	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**Unit**
Minimum Input Level (PER $\leq$ 10%)	-	-	-54	dBm
Maximum Input Level (PER $\leq$ 10%)	-30	-	-	dBm

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14.8. DC/RF Characteristics for IEEE802.11ac(HT 80MHz) - 5GHz

Normal Condition : 25deg.C, VBAT =3.3V.

390Mbps (MCS9 – HT 80MHz) mode unless otherwise specified.

Items	Contents			
Specification	IEEE802.11ac-5GHz			
Mode	OFDM			
Channel frequency (spacing)	5210 - 5775MHz			
Data rate	29.3,58.5,87.8,117,175.5,234,263.3,292.5,351,390 Mbps			
Current Consumption	**Min.**	**Typ.**	**Max.**	**Unit**
(a) Tx mode	-	440	540	mA
(b) Rx mode	-	180	250	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**Unit**
Power Levels	7.5	10	12.5	dBm
Spectrum Mask				
(a) at fc +/- 41MHz	-	-	-20	dBr
(b) at fc +/- 80MHz	-	-	-28	dBr
(c) at fc $\geq$ +/-120MHz	-	-	-40	dBr
Constellation Error (measured at enhanced mode)	-	-	-32	dB
Spurious Emissions (BW=100kHz)				
(a) 30Hz$\leqq$f<1000MHz	-	-	-36	dBm
(b)1000MHz$\leqq$f<26000MHz	-	-	-30	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**Unit**
Minimum Input Level (PER $\leq$ 10%)	-	-	-51	dBm
Maximum Input Level (PER $\leq$ 10%)	-30	-	-	dBm
Adjacent Channel Rejection (PER < 10%)	-9			dB

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14.9. DC/RF Characteristics for Bluetooth

Normal conditions : 25 deg.C, VBAT = 3.3V

Items	Contents			
Bluetooth specification (power class)	Version 5.2 (Class2)			
Channel frequency (spacing)	2402 to 2480 MHz (1MHz)			
Current Consumption	**Min.**	**Typ.**	**Max.**	**unit**
(a) DH5 Packet 50% Rx/Tx slot duty cycle	-	50	65	mA
(b) 2DH5 Packet 50% Rx/Tx slot duty cycle	-	40	55	mA
(c) 3DH5 Packet 50% Rx/Tx slot duty cycle	-	40	45	mA
Transmitter	**Min.**	**Typ.**	**Max.**	**Unit**
Output Power (at 1DH5)	7.5	11	14.5	dBm
Frequency range	2400	-	2483.5	MHz
20dB bandwidth	-		1	MHz
Adjacent Channel Power [1]				
(a) [M-N] =2	-	-	-20	dBm
(b) [M-N] ≥3	-	-	-40	dBm
Modulation characteristics				
(a) Modulation $\Delta f1avg$	140	-	175	kHz
(b) Modulation $\Delta f2max$	115	-	-	kHz
(c) Modulation $\Delta f2avg / \Delta f1avg$	0.8	-	-	
Carrier Frequency Drift				
(a) 1slot	-25	-	+25	kHz
(b) 3slot / 5slot	-40	-	+40	kHz
(c) Maximum drift rate	-20	-	+20	kHz/50us
EDR Relative Power	-4	-	+1	dB
EDR Carrier Frequency Stability and Modulation Accuracy				
(a) ωi	-75	-	+75	kHz
(b) $\omega i + \omega o$	-75	-	+75	kHz
(c) ωo	-10	-	+10	kHz
(d) RMS DEVM (DQPSK)	-	-	20	%
(e) Peak DEVM (DQPSK)	-	-	35	%
(f) 99% DEVM (DQPSK)	-	-	30	%
(g) RMS DEVM (8DPSK)	-	-	13	%
(h) Peak DEVM (8DPSK)	-	-	25	%
(i) 99% DEVM (8DPSK)	-	-	20	%
Spurious Emissions (BW=100kHz)				
(a) 30Hz≦f<1000MHz	-	-	-36	dBm
(b)1000MHz≦f<12750MHz	-	-	-30	dBm
(c) 1800MHz<f≦1900MHz	-	-	-47	dBm
(d) 5150MHz<f≦5300MHz	-	-	-47	dBm
Receiver	**Min.**	**Typ.**	**Max.**	**unit**
Sensitivity (BER≦0.1%)	-	-	-80	dBm
Maximum Input Level (BER≦0.1%)	-20	-	-	dBm
EDR Sensitivity (BER≦0.007%)				
(a) 8DPSK	-	-	-70	dBm

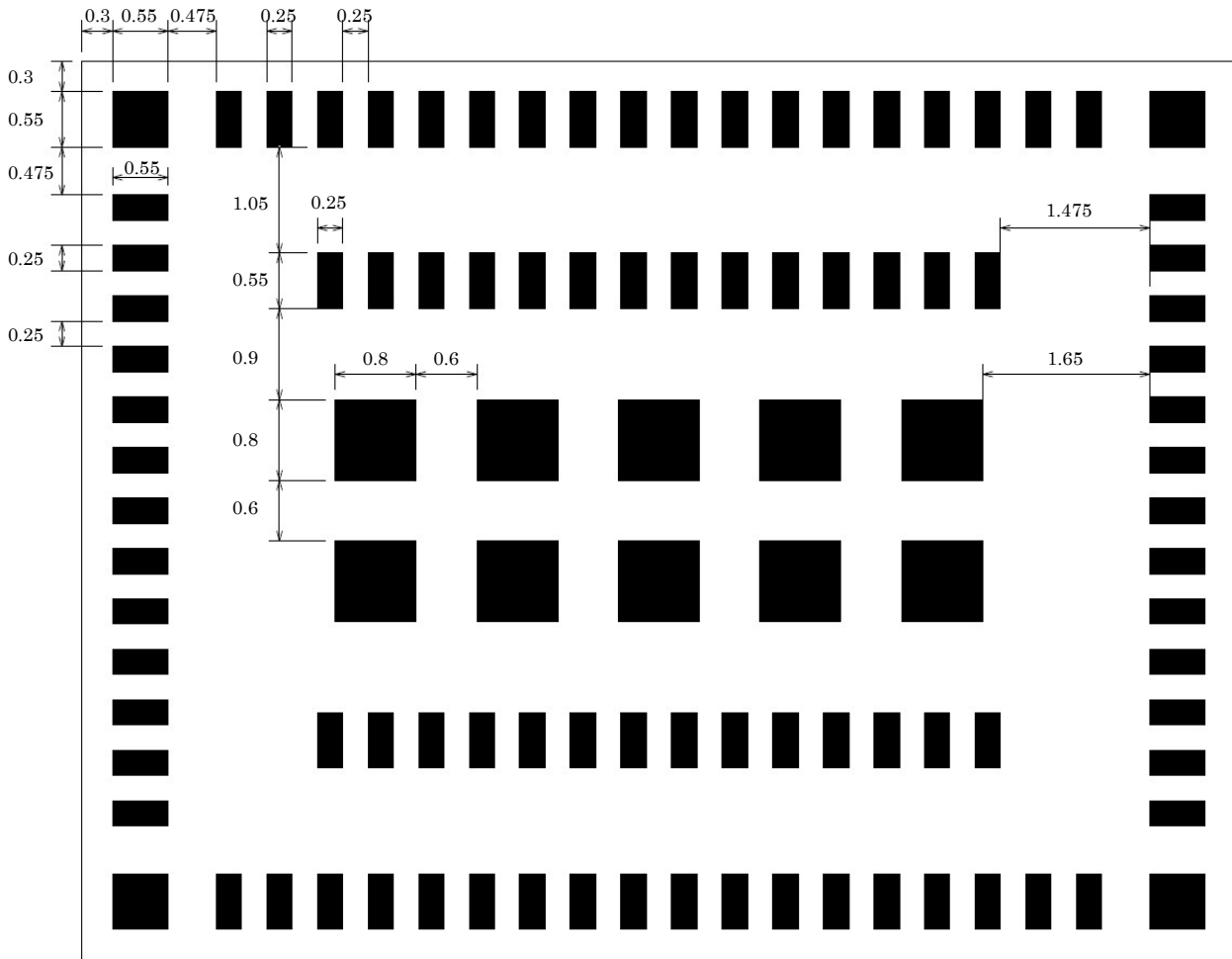*1: Up to three spurious responses within Bluetooth limits are allowed.

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14.10. DC/RF Characteristics for Bluetooth (LE)

Conditions : 25deg.C, VBAT=3.3V

Items	Contents			
Bluetooth specification (power class)	Version 5.2(LE)			
Channel frequency (spacing)	2402 to 2480 MHz (2MHz)			
Number of RF Channel	40			
Current Consumption	**Min.**	**Typ.**	**Max.**	**Unit**
(a) Tx mode	-	30	45	mA
(b) Rx mode	-	15	25	mA
Item / Condition	**Min.**	**Typ.**	**Max.**	**Unit**
Center Frequency	2402	-	2480	MHz
Channel Spacing	-	2	-	MHz
Number of RF channel	-	40	-	-
Output power	0	3	7.5	dBm
Modulation Characteristics				
1) $\Delta f1_{avg}$	225	-	275	kHz
2) $\Delta f2_{max}$ (at 99.9%)	185	-	-	kHz
3) $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8	-	-	-
Carrier frequency offset and drift				
1) Frequency offset	-	-	150	kHz
2) Frequency drift	-	-	50	kHz
3) Drift rate	-	-	20	kHz
Receiver sensitivity (PER < 30.8%)	-	-	-70	dBm
Maximum input signal level (PER < 30.8%)	-10	-	-	dBm
PER Report Integrity (-30dBm input)	50	-	65.4	%

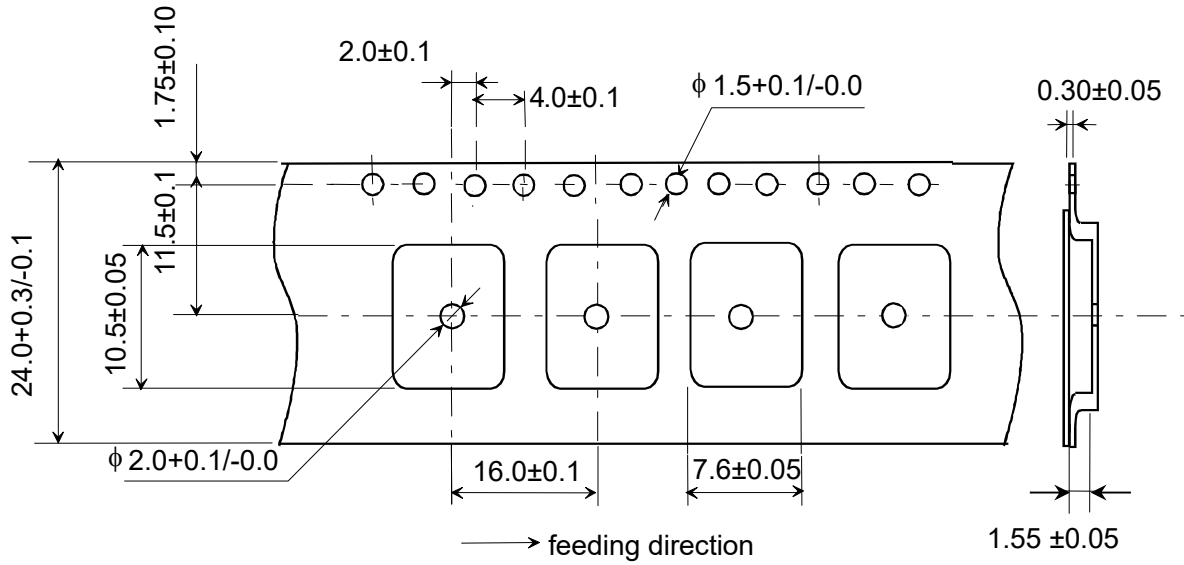< Specification may be changed by Murata without notice >
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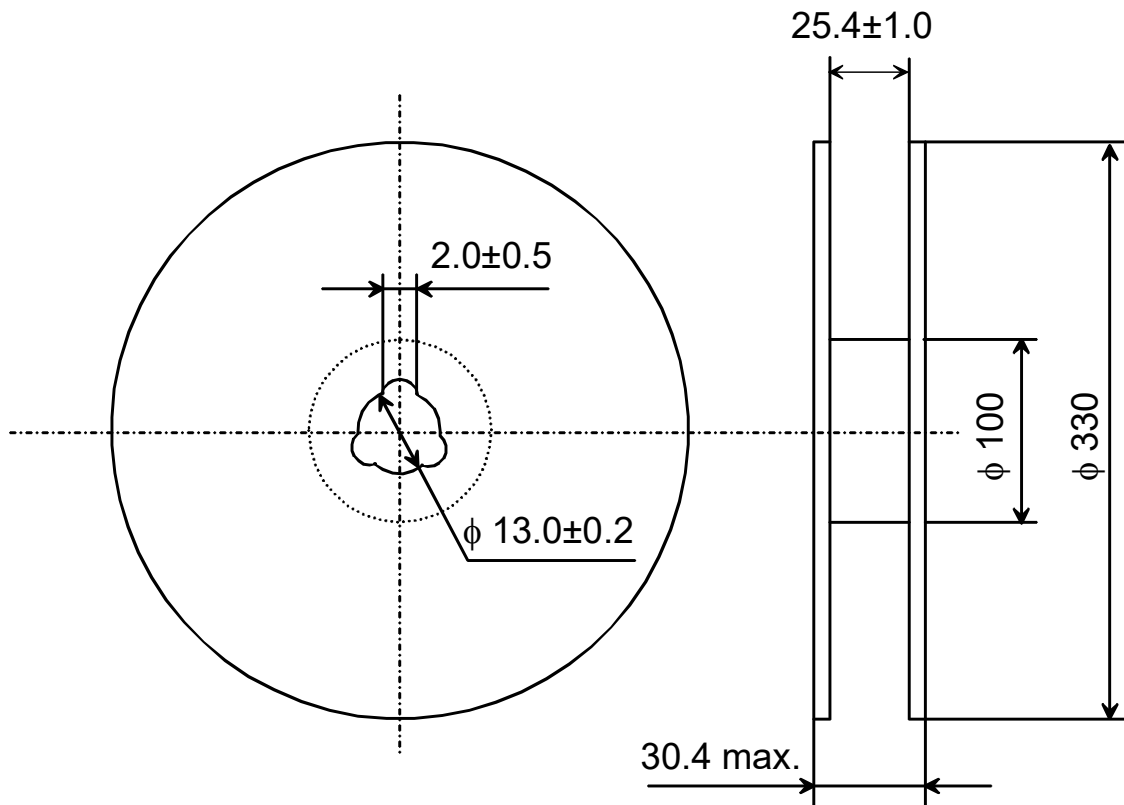
15. Land Pattern

Top View. Unit : mm

16. TAPE AND REEL PACKING

(1) Dimensions of Tape (Plastic tape)

feeding direction
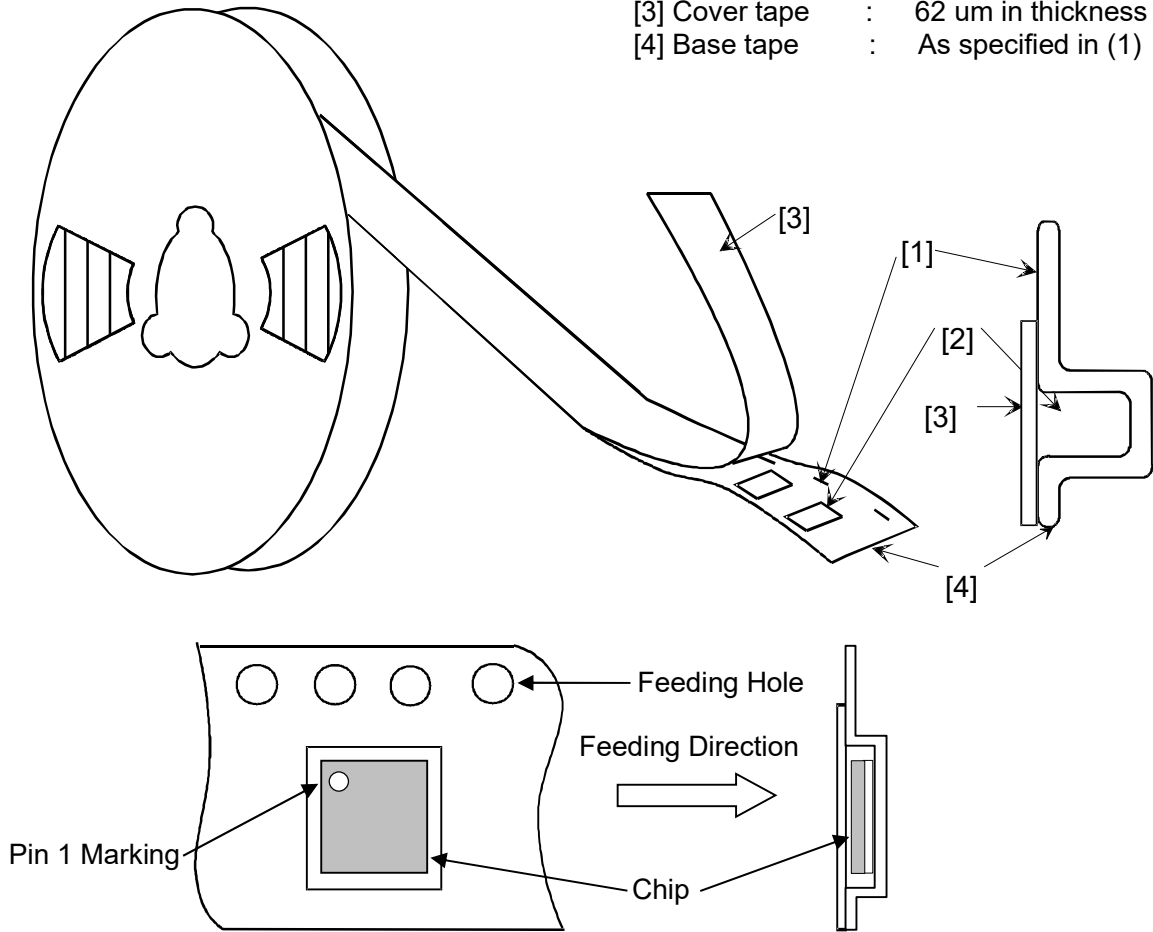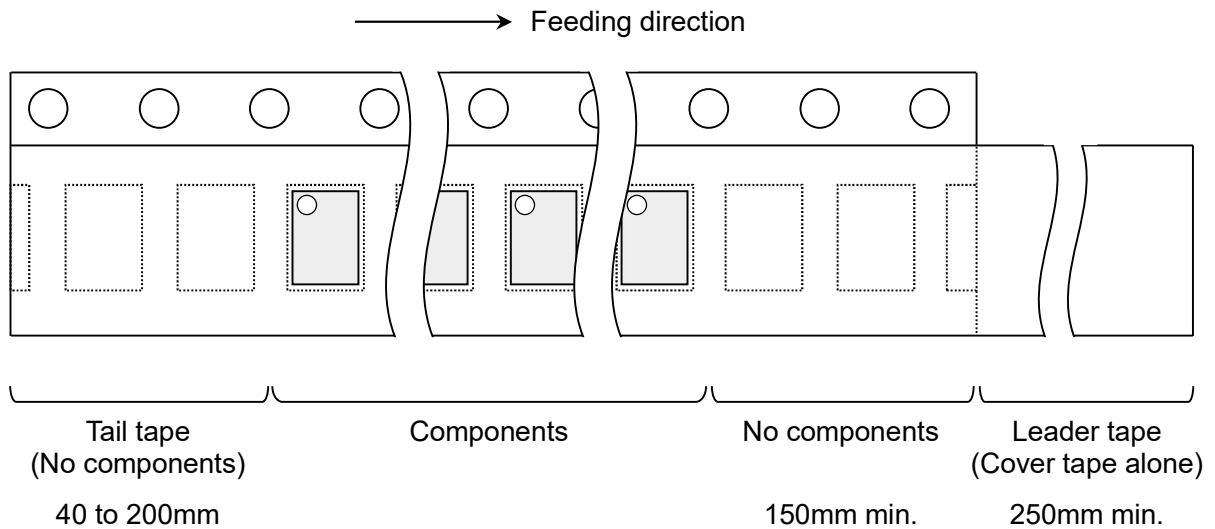
(2) Dimensions of Reel

(3) Taping Diagrams

[1] Feeding Hole   :   As specified in (1)
[2] Hole for chip   :   As specified in (1)
[3] Cover tape   :   62 um in thickness
[4] Base tape   :   As specified in (1)

[3]

[1]

[2]

[3]

[4]

Feeding Hole

Feeding Direction

Pin 1 Marking

Chip

(4) Leader and Tail tape

Feeding direction

Tail tape (No components)	Components	No components	Leader tape (Cover tape alone)
40 to 200mm		150mm min.	250mm min.

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(5) The tape for chips are wound clockwise, the feeding holes to the right side as the tape is pulled toward the user.

(6) The cover tape and base tape are not adhered at no components area for 250mm min.

(7) Tear off strength against pulling of cover tape: 5N min.

(8) Packaging unit : 1000pcs./ reel

(9) material - Base tape   : Plastic
              Reel   : Plastic
              Cover tape, cavity tape and reel are made the anti-static processing.

(10) Peeling of force: 1.1N max. in the direction of peeling as shown below.
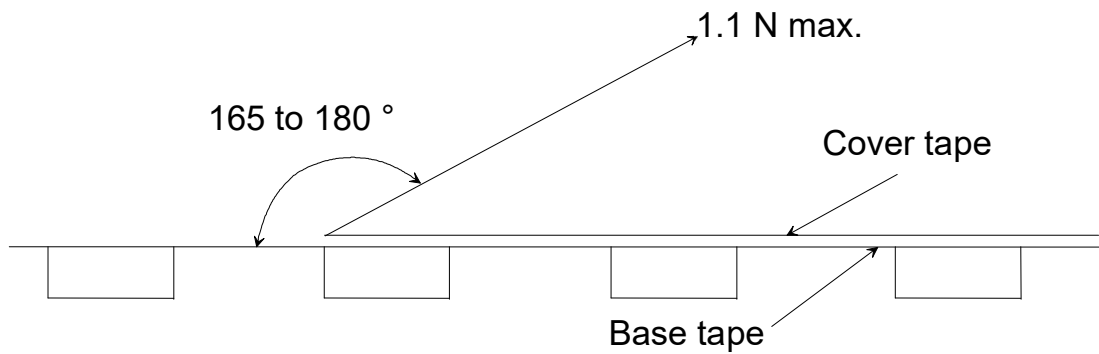
(11) PACKAGE (Humidity proof packing)
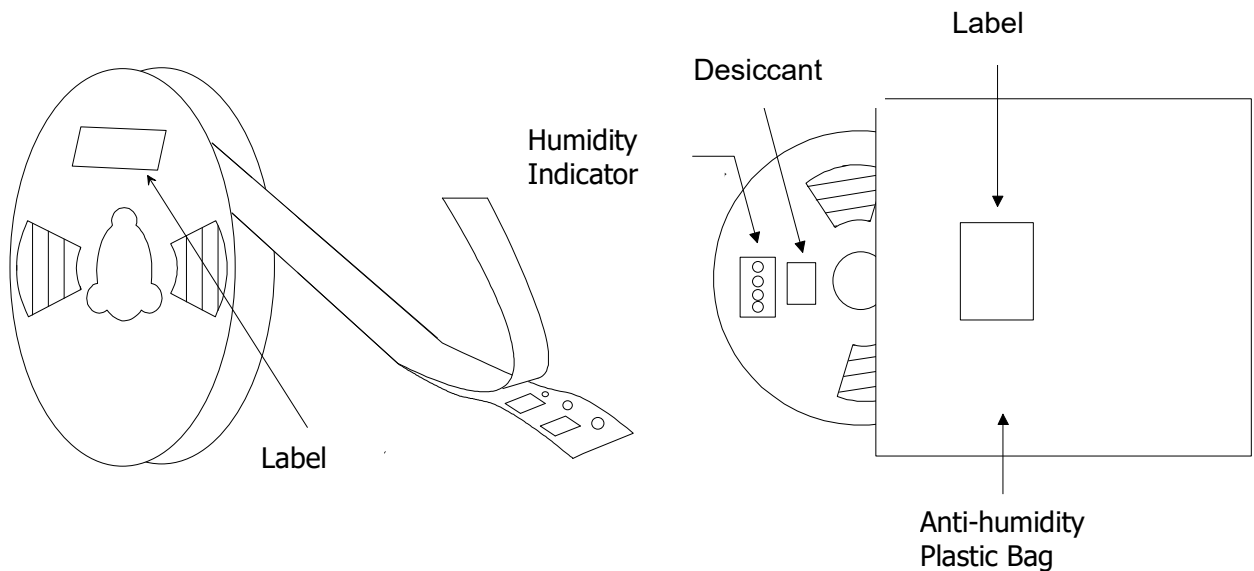
Tape and reel must be sealed with the anti-humidity plastic bag. The bag contains the desiccant and the humidity indicator.

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17. NOTICE
17.1. Storage Conditions:

Please use this product within 6month after receipt.
- The product shall be stored without opening the packing under the ambient temperature from 5 to 35deg.C and humidity from 20 to 70%RH.
(Packing materials, in particular, may be deformed at the temperature over 40deg.C.)
- The product left more than 6months after reception, it needs to be confirmed the solderability before used.
- The product shall be stored in non corrosive gas (Cl_2, NH_3, SO_2, No_x, etc.).
- Any excess mechanical shock including, but not limited to, sticking the packing materials by sharp object and dropping the product, shall not be applied in order not to damage the packing materials.

This product is applicable to MSL3 (Based on JEDEC Standard J-STD-020)
- After the packing opened, the product shall be stored at ≤30deg.C / ≤60%RH and the product shall be used within 168hours.
- When the color of the indicator in the packing changed, the product shall be baked before soldering.

        Baking condition: 125+5/-0deg.C, 24hours, 1time
The products shall be baked on the heat-resistant tray because the materials (Base Tape, Reel Tape and Cover Tape) are 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 bear hands that may result in poor solder ability and destroy 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 is as Murata's standard. The characteristics of products may vary depending on the pattern drawing method, grounding method, land dimensions, land forming method of the NC terminals and the PCB material and thickness. Therefore, be sure to verify the characteristics in the actual set. When using non-standard lands, contact Murata beforehand.

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 the following figure.
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.

Reflow soldering standard conditions (Example)
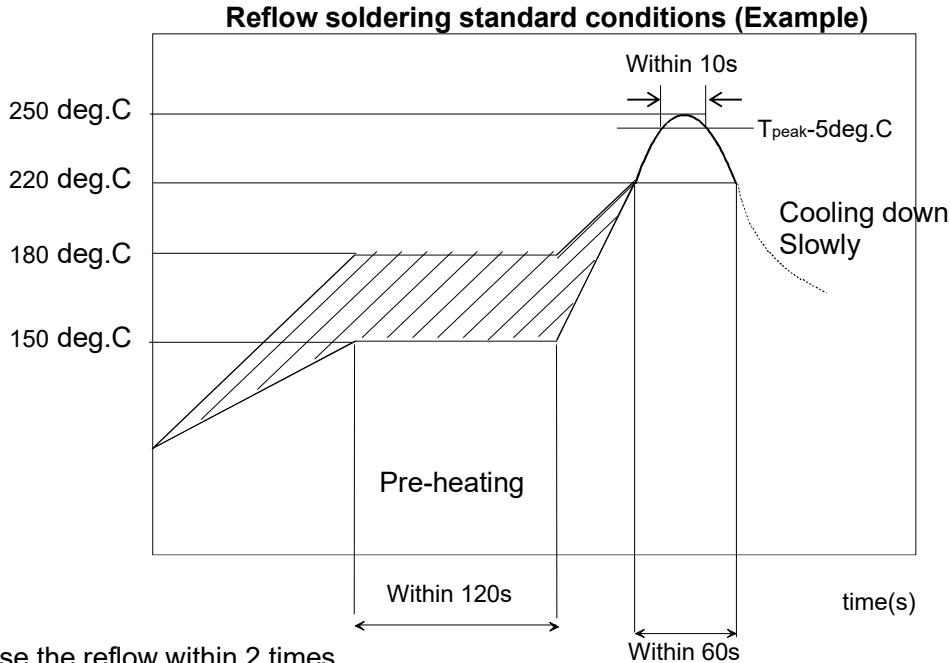
Please use the reflow within 2 times.
Use rosin type flux or weakly active flux with a chlorine content of 0.2 wt % or less.

17.6. Cleaning:

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

17.7. Operational Environment Conditions:

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

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

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

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

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17.8.   Input Power Capacity:

Products shall be used in the input power capacity as specified in this specification.
Inform Murata beforehand, in case that 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.

WE HEREBY DISCLAIMS 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.

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 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 the above contents, you should inquire our sales.

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Appendix

User Manual
For FCC

Model Name: LBEE5XV2BZ
FCC ID: VPYLBEE5XV1XA

Since this module is not sold to general end users directly, 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)

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove
this RF module in the end user's manual of the end product which integrates this module.
The end user manual shall include all required regulatory information/warning as shown in User manual.

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

Contains Transmitter Module FCC ID:VPYLBEE5XV1XA or Contains FCC ID: VPYLBEE5XV1XA

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

*If it is difficult to describe this statement on the host product due to the size, please describe in the User's manual.
please describe in the user's manual and also either describe on the device packaging or on a removable label attached to the device.

●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.

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

When installing it in a portable equipment.
It is necessary to take a SAR test with your set mounting this module.
Class II permissive change application is necessary using the SAR report.
Please contact Murata.

Note)
Portable equipment: Equipment for which the spaces between human body and antenna are used within 20cm.
Mobile equipment: Equipment used at position in which the spaces between human body and antenna exceeded 20cm.

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 discontinue transmission in case of either absence of information to transmit or operational failure.

Frequency Tolerance: ±20 ppm

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For ISED

Model Name: "LBEE5XV2BZ_SANT", "LBEE5XV2BZ_DANT"

IC Number: 772C-LBEE5XV1XA

Since this module is not sold to general end users directly, 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).
The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove
this RF module in the end user's manual of the end product which integrates this module.
The end user manual shall include all required regulatory information/warning as shown in User manual.

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

Contains IC: 772C-LBEE5XV1XA

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

・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".

●If the final product use the following frequency, please note that there is a limit.

for indoor use only (5150-5250MHz band)
Pour usage intérieur seulement (5150-5250MHz band)

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

This device complies with Industry Canada's applicable license-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.
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.

●When installing it in a mobile equipment.

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 20cm or more away from person's body.
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.

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●**When installing it in a portable equipment.**
It is necessary to take a SAR test with your set mounting this module.
Class 4 permissive change application is necessary using the SAR report.
Please contact Murata.

Note)
Portable equipment: Equipment for which the spaces between human body and antenna are used within 20cm.
Mobile equipment: Equipment used at position in which the spaces between human body and antenna exceeded 20cm.

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 discontinue transmission in case of either absence of information to transmit or operational failure.
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.

This radio transmitter (IC Number: 772C-LBEE5XV1XA) has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.
Le présent émetteur radio (IC Number: 772C-LBEE5XV1XA) a été approuvé par Innovation, Sciences et Développement économique 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 pour

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●RF Power
Please ask Murata

●Operation mode and frequency band

WLAN	STA	2.4GHz	11b/g/n/ac	HT20	1ch-11ch
		5GHz	11a	HT20	W52/53/56/58 with ch144/142/138 DFS (Device without Radar detection capability) No TPC
			11n	HT20/40	
			11ac	VHT20/40/80	
	AP	2.4GHz	11b/g/n/ac	HT20	1ch-11ch
		5GHz	11a	HT20	W52/58 with ch144/142/138 No TPC
			11n	HT20/40	
			11ac	VHT20/40/80	
BT	BR / EDR / LE (1/2Mbps)				

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●Theory of Operation-Channel List

Frequency of operation			Scan	Ad-hoc mode
2.4GHz	11b/g/n (HT20)	2412-2462MHz	Active	Yes
	BT	2402-2480MHz	N/A	N/A
	BLE	2402-2480MHz	N/A	N/A
W52	11a/n/ac ((V)HT20)	5180-5240MHz	Active	Yes
	11n/ac ((V)HT40)	5190-5230MHz	Active	Yes
	11ac (VHT80)	5210MHz	Active	Yes
W53	11a/n/ac ((V)HT20)	5260-5320MHz	Passive	No
	11n/ac ((V)HT40)	5270-5310MHz	Passive	No
	11ac (VHT80)	5290MHz	Passive	No
W56	11a/n/ac ((V)HT20)	5500-5720MHz *	Passive	No
	11n/ac ((V)HT40)	5510-5710MHz *	Passive	No
	11ac (VHT80)	5530-5690MHz *	Passive	No
W58	11a/n/ac ((V)HT20)	5745-5825MHz	Active	Yes
	11n/ac ((V)HT40)	5755-5795MHz	Active	Yes
	11ac (VHT80)	5775MHz	Active	Yes

* The frequency band 5600MHz-5640MHz (11a/n/ac 20M band), 5590MHz-5630MHz (11n/ac 40M band) and 5610MHz (11ac 80M band) is restricted in ISED.
Notes: End users cannot modify the software because F/W & driver are installed in device.

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● Antenna

■ Certified Antenna information

		P/N	Form factor	Type	Gain (dBi)	
					2.4Ghz	5Ghz
1	Molex	146153	u.FL/flexible	dipole	3.2	4.25
2	Molex	146187	u.FL/flexible	dipole	3.4	4.75

■ Please perform the antenna design that followed the specifications of the antenna.
■ About the signal line between an antenna and a module
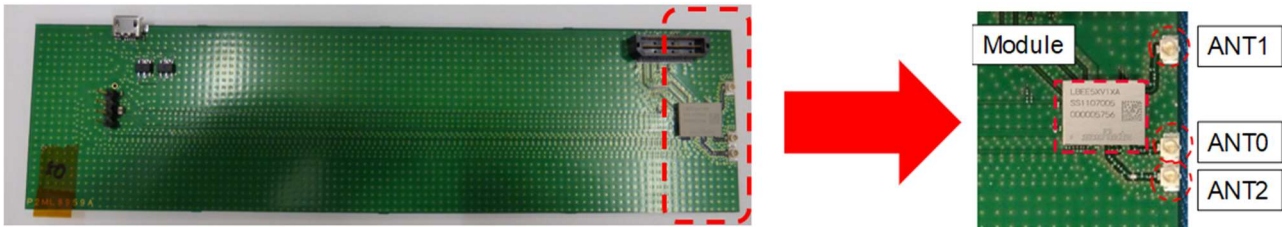It is a 50-ohm line design.
Fine tuning of return loss etc. can be performed using a matching network.
However, it is required to check "Class1 change" and "Class2 change"
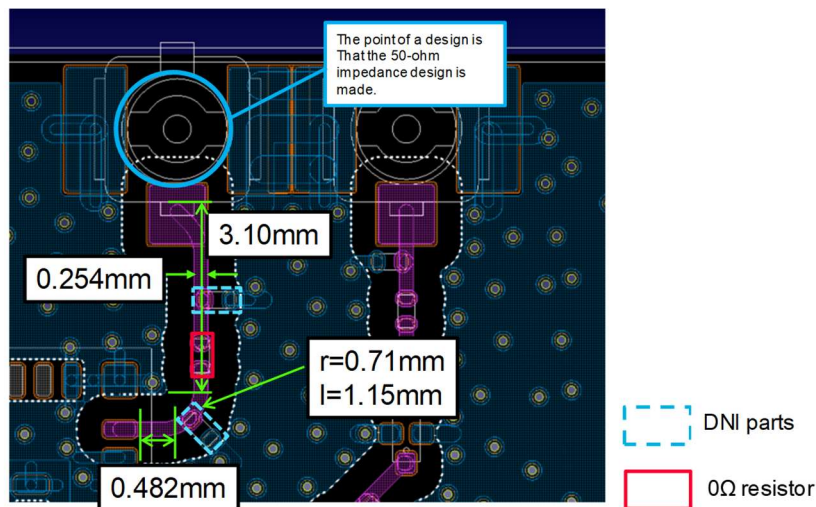which the authorities define then.
The concrete contents of a check are the following three points.
1) It is the same type as the antenna type of antenna specifications.
2) An antenna gain is lower than a gain given in antenna specifications.
3) The emission level is not getting worse.
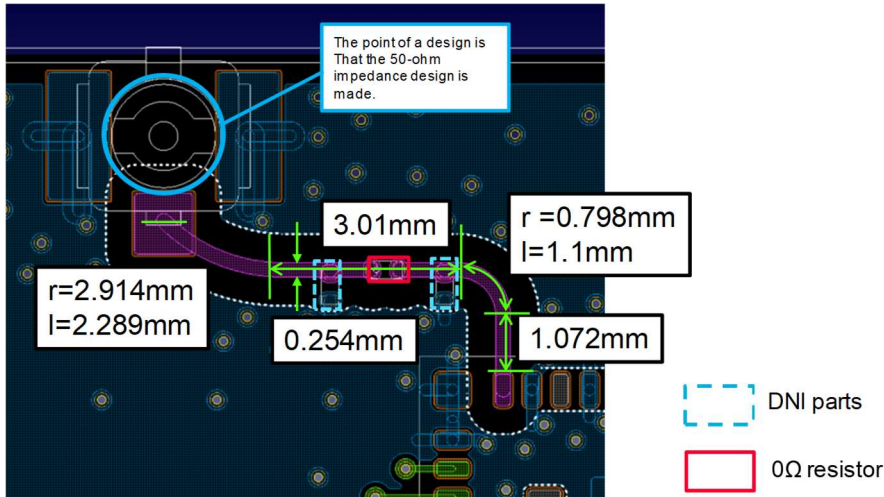The following is the design of the EVB used for the test.
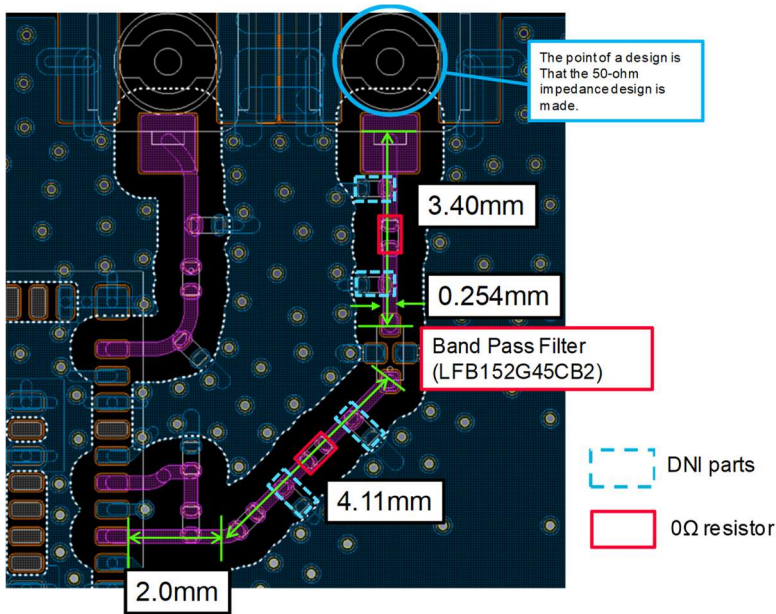

ANT0

Note)
DNI: Do Not Insert
r: Line radius
l: Line length

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ANT1

The point of a design is
That the 50-ohm
impedance design is
made.

3.01mm

r =0.798mm
l=1.1mm

r=2.914mm
l=2.289mm

0.254mm

1.072mm

DNI parts

0Ω resistor

ANT2

The point of a design is
That the 50-ohm
impedance design is
made.

3.40mm

0.254mm

Band Pass Filter
(LFB152G45CB2)

4.11mm

2.0mm

DNI parts

0Ω resistor

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For Japan

Application Model Name: LBEE5XV2BZ
Certification Number: 007-AJ0192

R 007-AJ0192

W52/53 is for indoor use only

This module is a product that has been authorized construction design certification based on the following Certificate of Construction Type.
[(Warning) In the 5 GHz frequency band, three types of 5.2 GHz / 5.3 GHz / 5.6 GHz bands (W52 / W53 / W56) can be used.
Outdoor use of the 5.2 GHz / 5.3 GHz band wireless LAN (W52 / W53) is prohibited by the Certificate of Construction Type.]
W53 / W56 for STA function only.

●It is recommended to describe the following contents in the end product or user manual.
　・[This product has built-in specified radio equipment which received construction design certification (certification number: 007-AJ0192) 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.]

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