

# Wi-Fi<sup>®</sup> + Bluetooth<sup>®</sup> + 802.15.4 Tri-Radio Module

NXP IW612 Chipset for 802.11a/b/g/n/ac/ax + Bluetooth 5.3 + IEEE 802.15.4 Datasheet - Rev. L

- Design Name: Type 2EL
- P/N: LBES5PL2EL-923



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## About This Document

Murata's Type 2EL is a small and very high-performance module based on NXP IW612 combo chipset, supporting IEEE 802.11a/b/g/n/ac/ax + Bluetooth 5.3 BR/EDR/LE + 802.15.4. This datasheet describes Type 2EL module in detail.



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









## Audience & Purpose

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

## Document Conventions

**Table 1** describes the document conventions.

**Table 1: Document Conventions**

Conventions	Description
	<b>Warning Note</b> Indicates very important note. Users are strongly recommended to review.
	<b>Info Note</b> Intended for informational purposes. Users should review.
	<b>Menu Reference</b> Indicates menu navigation instructions. <b>Example:</b> Insert → Tables → Quick Tables → Save Selection to Gallery 
	<b>External Hyperlink</b> This symbol indicates a hyperlink to an external document or website. <b>Example:</b> <a href="#">Embedded Artists AB</a>  Click on the text to open the external link.
	<b>Internal Hyperlink</b> This symbol indicates a hyperlink within the document. <b>Example:</b> <a href="#">Scope</a>  Click on the text to open the link.
<code>Console input/output or code snippet</code>	<b>Console I/O or Code Snippet</b> This text <b>Style</b> denotes console input/output or a code snippet.
<code># Console I/O comment // Code snippet comment</code>	<b>Console I/O or Code Snippet Comment</b> This text <b>Style</b> denotes a console input/output or code snippet comment. <ul style="list-style-type: none"> <li>• Console I/O comment (preceded by "#") is for informational purposes only and does not denote actual console input/output.</li> <li>• Code Snippet comment (preceded by "//") may exist in the original code.</li> </ul>



## 1 Scope

This specification characterizes the IEEE 802.11 a/b/g/n/ac/ax + Bluetooth 5.3 BR/EDR/LE + 802.15.4 tri-radio solution combo module.

## 2 Key Features

- ◆ NXP IW612 inside
- ◆ Supports IEEE 802.11 a/b/g/n/ac/ax specification: Dual band 2.4 GHz and 5 GHz Wi-Fi 6
- ◆ SISO with 20 MHz, 40 MHz, and 80 MHz channels
- ◆ Up to MCS11 data rates (601 Mbps)
- ◆ Supports Bluetooth specification version 5.3
- ◆ Supports IEEE 802.15.4
- ◆ WLAN interface: SDIO 3.0
- ◆ Bluetooth interface: HCI UART and PCM
- ◆ 802.15.4 interface: SPI
- ◆ Temperature Range: -40 °C to 85 °C
- ◆ Dimensions: 8.8 x 7.7 x 1.3 mm
- ◆ Weight: 0.22 g
- ◆ MSL: 3
- ◆ Surface-mount type
- ◆ RoHS compliant

## 3 Ordering Information

**Table 2** describes the ordering information.

**Table 2: Ordering Information**

Ordering Part Number	Description
LBES5PL2EL-923	Module order
LBES5PL2EL-SMP	Sample module order (If module samples are not available through distribution, contact Murata referencing this part number)
EAR00409	Embedded Artists Type 2EL M.2 EVB (default EVB available through distribution)
LBES5PL2EL-EVB	Murata Type 2EL M.2 EVB (contact Murata as this is special order item)

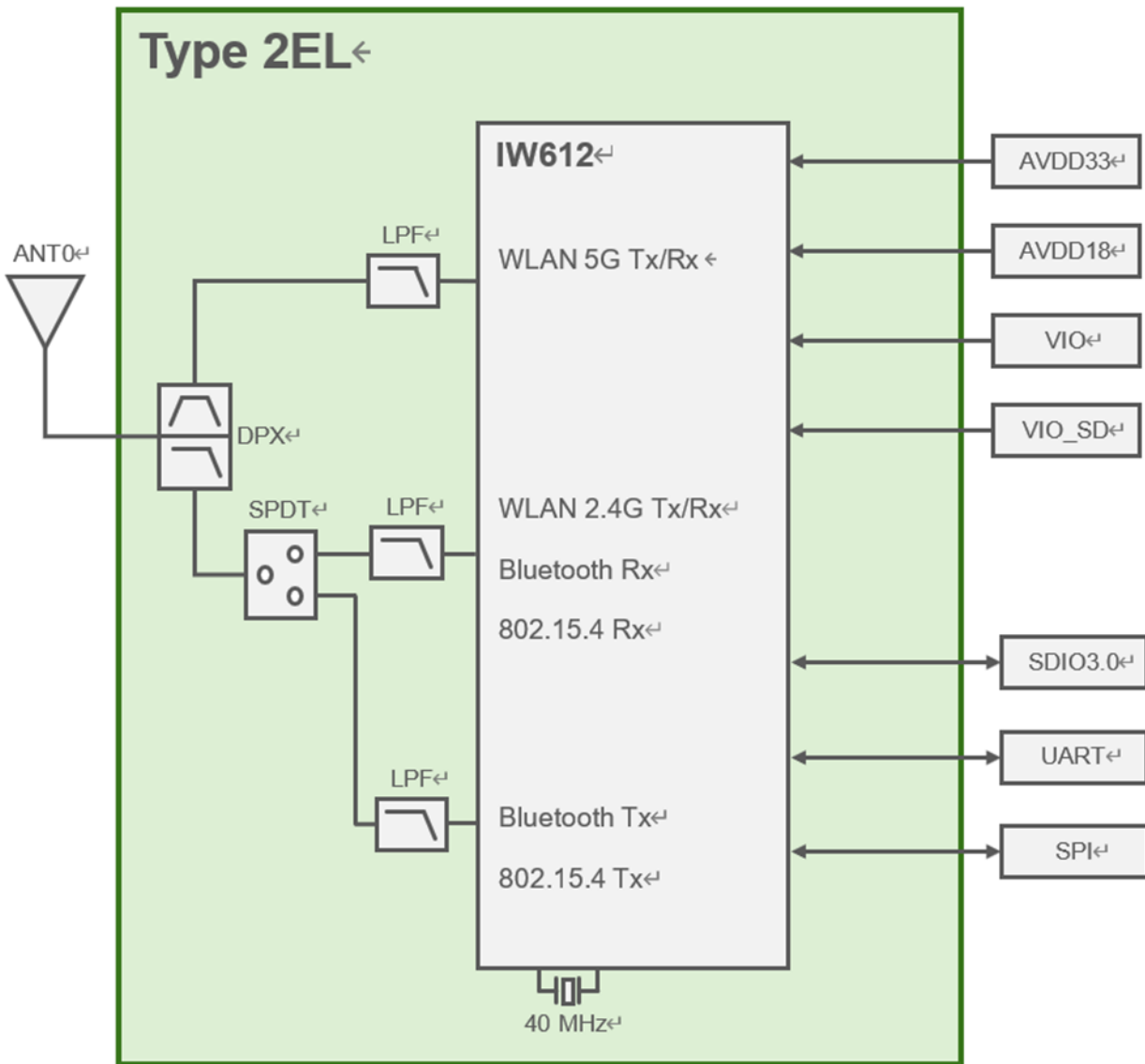


“Type 2EL” is design name of this module. Design name may be used in certification test report.

## 4 Block Diagram

The Type 2EL block diagram is presented in **Figure 1**.

**Figure 1: Block Diagram**



## 5 Certification Information

This section has information about radio and Bluetooth certification.

### 5.1 Radio Certification

Transmit output power setting is defined by “txpower\_XX.bin” The transmit power files are hosted at Murata GitHub for [Linux](#) and [FreeRTOS](#). Table 3 shows the transmit power file required for each region.

**Table 3: Transmit Power Limit Files**

Country	ID	Country Code	Tx Power Limit File	
			Linux	FreeRTOS
USA (FCC)	VPLYBES5PL2EL	US	txpower_US.bin	TBD
Canada (IC)	772C-LBES5PL2EL	CA	txpower_CA.bin	TBD
Europe	EN300328/301893, EN300440 conducted test report is prepared.	DE	txpower_EU.bin	TBD
Japan	Japanese type certification is prepared. R 001-P02018	JP	txpower_JP.bin	TBD

### 5.2 Radio Regulatory Certification by Country

Murata have prepared the document about Radio Regulatory Certification separately.

This document is designed to ensure that module manufacturers correctly communicate the necessary information to host manufacturers that incorporate their modules.

Refer to [\[Regulatory Information\] : Type 2EL Radio Law Approval Application Note](#) for Radio Law Certification user manual.



If you don't follow the rule written in Type 2EL Radio Law Approval Application Note, there is a risk of conflict Radio Law Certification.

Please be sure to check the document.

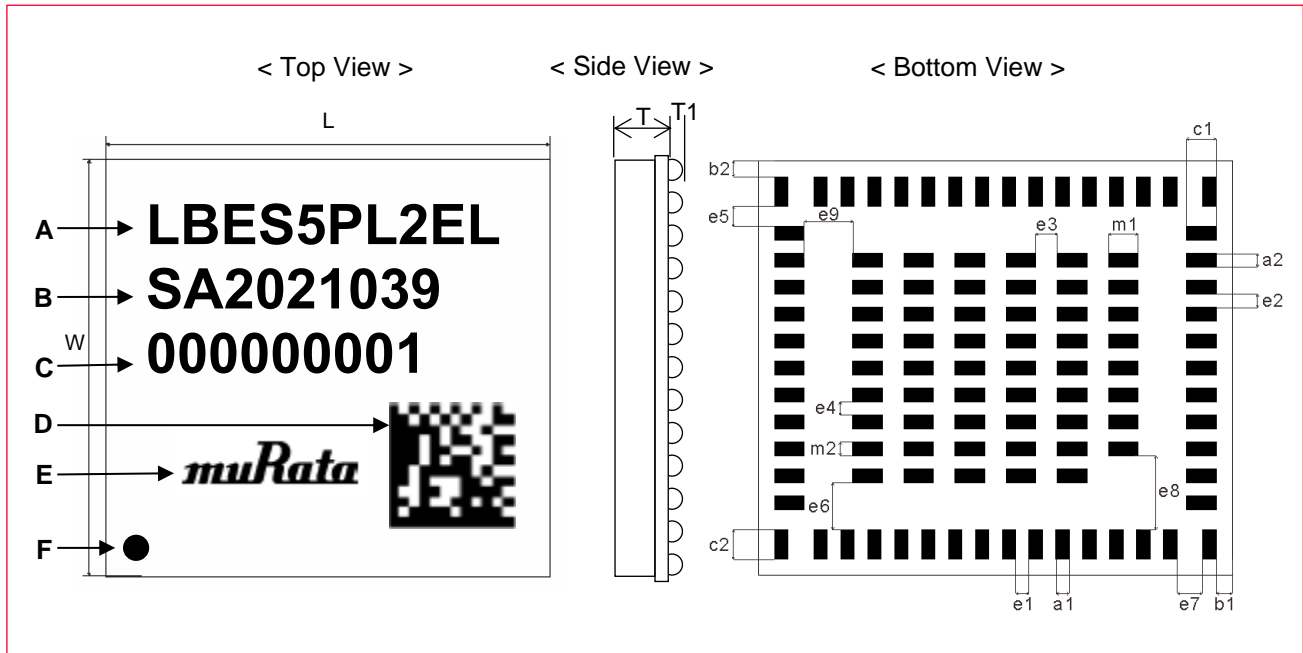
### 5.3 Bluetooth Qualification

- QDID: 202018
- Set Bluetooth Tx Power to Class 1 by using [bt\\_power\\_config\\_1.sh](#).
- For supported Bluetooth functions, refer to [Bluetooth SIG site](#).

## 6 Dimensions, Markings and Terminal Configurations

This section provides information about dimensions, markings, and terminal configuration for Type 2EL and the related parameters. **Figure 2** shows the dimensions, markings, and terminal configurations.

**Figure 2: Dimensions, Markings and Terminal Configurations**



**Table 4** describes the Type 2EL markings.

**Table 4: Markings**

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

**Table 5** describes the Type 2EL dimensions.

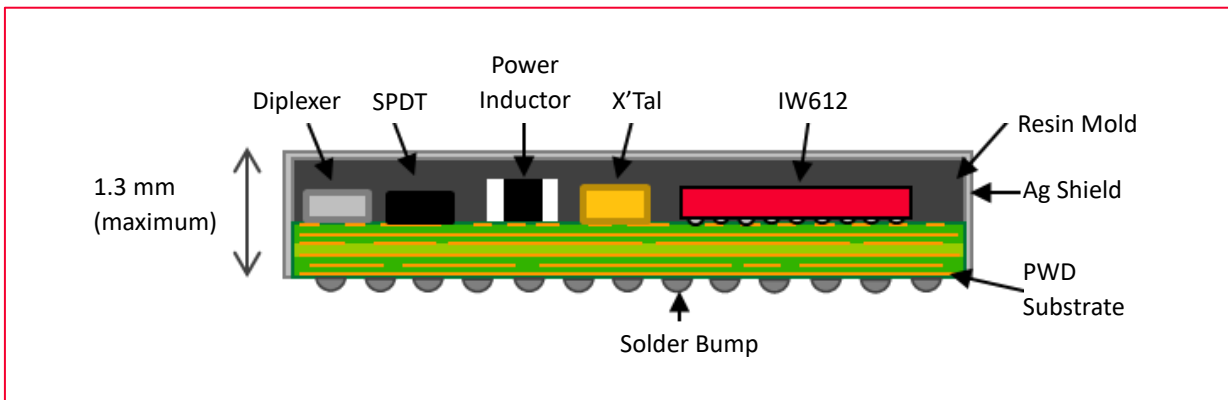
**Table 5: Dimensions**

Mark	Dimensions (mm)	Mark	Dimensions (mm)	Mark	Dimensions (mm)
L	8.8 +/- 0.2	W	7.7 +/- 0.2		
T	1.3 maximum	T1	0.04 typical (Bump)		
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

Mark	Dimensions (mm)	Mark	Dimensions (mm)	Mark	Dimensions (mm)
e1	0.25 +/- 0.1	e2	0.25 +/- 0.1	e3	0.4 +/- 0.1
e4	0.25 +/- 0.1	e5	0.375 +/- 0.1	e6	0.875 +/- 0.1
e7	0.475 +/- 0.1	e8	1.375 +/- 0.1	e9	0.9 +/- 0.1
m1	0.55 +/- 0.1	m2	0.25 +/- 0.1		

Figure 3 shows Type 2EL Structure.

Figure 3: Structure



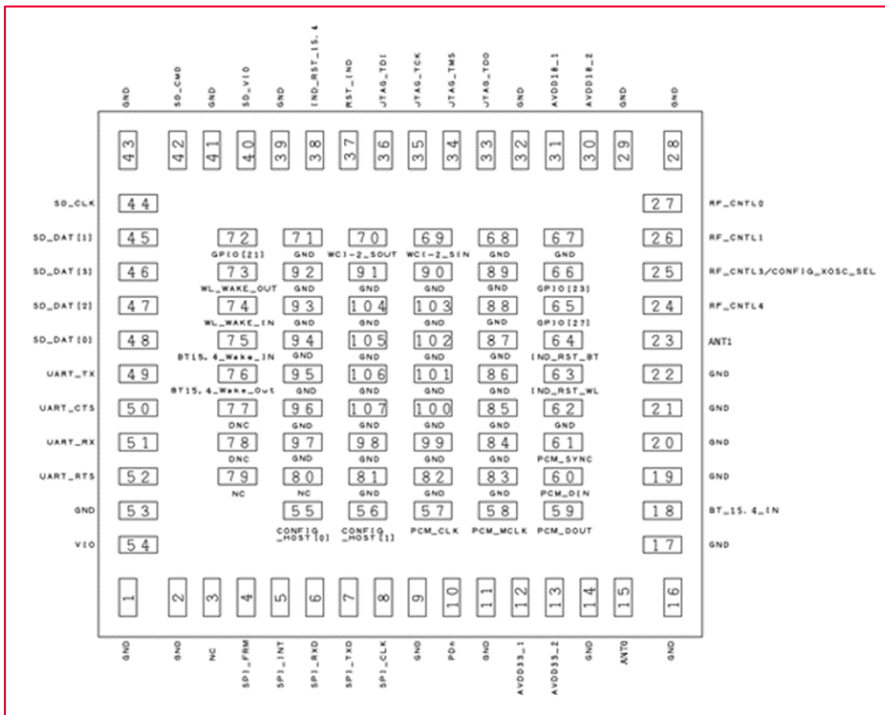
# 7 Module Pin Descriptions

This section includes the pin descriptions of Type 2EL and pin assignments layout descriptions.

## 7.1 Pin Assignments

This section describes the pin assignments to terminals. Type 2EL pin-assignment top view is presented in **Figure 4**.

**Figure 4: Pin Assignments (Top View)**



**Table 6** lists the Type 2EL terminal configurations.

**Table 6: Terminal Configurations**

No.	Terminal Name	No.	Terminal Name	No.	Terminal Name	No.	Terminal Name
1	GND	29	GND	57	PCM_CLK	85	GND
2	GND	30	AVDD18_2	58	PCM_MCLK	86	GND
3	NC	31	AVDD18_1	59	PCM_DOUT	87	GND
4	SPI_FRM	32	GND	60	PCM_DIN	88	GND
5	SPI_INT	33	Reserved	61	PCM_SYNC	89	GND
6	SPI_RXD	34	Reserved	62	GND	90	GND
7	SPI_TXD	35	Reserved	63	IND_RST_WL	91	GND
8	SPI_CLK	36	Reserved	64	IND_RST_BT	92	GND
9	GND	37	RST_IND	65	Reserved	93	GND
10	PDn	38	IND_RST_15.4	66	Reserved	94	GND
11	GND	39	GND	67	GND	95	GND
12	AVDD33_1	40	SD_VIO	68	GND	96	GND
13	AVDD33_2	41	GND	69	WCI-2_SIN	97	GND
14	GND	42	SD_CMD	70	WCI-2_SOUT	98	GND
15	ANT0	43	GND	71	GND	99	GND

No.	Terminal Name	No.	Terminal Name	No.	Terminal Name	No.	Terminal Name
16	GND	44	SD_CLK	72	SD_INT	100	GND
17	GND	45	SD_DAT[1]	73	WL_WAKE_OUT	101	GND
18	BT_15.4_IN	46	SD_DAT[3]	74	WL_WAKE_IN	102	GND
19	GND	47	SD_DAT[2]	75	BT15.4_WAKE_IN	103	GND
20	GND	48	SD_DAT[0]	76	BT15.4_WAKE_OUT	104	GND
21	GND	49	UART_TX	77	NC	105	GND
22	GND	50	UART_CTS	78	NC	106	GND
23	ANT1	51	UART_RX	79	NC	107	GND
24	RF_CNTL4	52	UART_RTS	80	NC		
25	RF_CNTL3/ CONFIG_XOSC_SEL	53	GND	81	GND		
26	RF_CNTL1	54	VIO	82	GND		
27	RF_CNTL0	55	CONFIG_HOST[0]	83	GND		
28	GND	56	CONFIG_HOST[1]	84	GND		

## 7.2 Pin Descriptions

Table 7 shows the pin descriptions.

Table 7: Pin Descriptions

No.	Terminal Name	Type	Connection to IC Terminal	Description
1	GND			Ground
2	GND			Ground
3	NC		NC	Not Connected
4	SPI_FRM	I/O	SPI_FRM	SPI frame input signal
5	SPI_INT	I/O	SPI_INT	SPI interrupt output signal.
6	SPI_RXD	I/O	SPI_RXD	SPI receive input signal
7	SPI_TXD	I/O	SPI_TXD	SPI transmit output signal
8	SPI_CLK	I/O	SPI_CLK	SPI clock input signal
9	GND			Ground
10	PDn	I	PDn	<p>Full Power-down (input) (active low)            0 = full power-down mode            1 = normal mode</p> <p>PDn can accept an input of 1.8V to 4.5V            PDn may be driven by the host            PDn must be high for normal operation            No internal pull-up on this pin.            This pin has an always-on internal weak pull-down.</p>
11	GND			Ground
12	AVDD33_1	Power	AVDD33	Power supply
13	AVDD33_2	Power	AVDD33	Power supply
14	GND			Ground

No.	Terminal Name	Type	Connection to IC Terminal	Description
15	ANT0	I/O		ANT0 is WLAN output and it's also used for BT/802.15.4 output when SANT mode.
16	GND			Ground
17	GND			Ground
18	BT_15.4_IN	I		BT/802.15.4 in (Feedback)
19	GND			Ground
20	GND			Ground
21	GND			Ground
22	GND			Ground
23	ANT1	O		ANT1 is BT/802.15.4 output, and it should be connected to BT_15.4_IN when SANT mode.
24	RF_CNTL4	I/O	RF_CNTL4	RF control line 4
25	RF_CNTL3/ CONFIG_XOSC_SEL	I/O	F_CNTL3/ CONFIG_XOSC_SEL	Reference clock frequency select 1=40 MHz RF control line 3
26	RF_CNTL1	O	RF_CNTL1	RF control line 1
27	RF_CNTL0	O	RF_CNTL0	RF control line 0
28	GND			Ground
29	GND			Ground
30	AVDD18_2	Power		Power supply
31	AVDD18_1	Power		Power supply
32	GND			Ground
33	Reserved	I/O	GPIO[31]/JTAG_TDO	Programable GPIO Pin. (JTAG_TDO) * NXP internal use only
34	Reserved	I/O	GPIO[29]/JTAG_TMS	Programable GPIO Pin. (JTAG_TMS) * NXP internal use only
35	Reserved	I/O	GPIO[28]/JTAG_TCK	Programable GPIO Pin. (JTAG_TCK) * NXP internal use only
36	Reserved	I/O	GPIO[30]/JTAG_TDI	Programable GPIO Pin. (JTAG_TDI) * NXP internal use only
37	RST_IND	I/O	GPIO[22]/RST_IND	Bluetooth/802.15.4 independent software reset indicator to host output Multi-functional pin: GPIO[22] input/output
38	IND_RST_15.4	I/O	GPIO[24]/ IND_RST_15.4	Independent software reset for 802.15.4 radio <sup>1</sup> input Multi-functional pin: GPIO[24] input/output
39	GND			Ground
40	SD_VIO	Power		Power supply
41	GND			Ground
42	SD_CMD	I/O	SD_CMD	SDIO 4-bit mode: Command/response (input/output) SDIO 1-bit mode: Command line (input/output)

<sup>1</sup> The request to reset either Bluetooth or 15.4 radio leads to reinitialization of both radios.



No.	Terminal Name	Type	Connection to IC Terminal	Description
43	GND			Ground
44	SD_CLK	I	SD_CLK	SDIO 4-bit mode: Clock input SDIO 1-bit mode: Clock input
45	SD_DAT[1]	I/O	SD_DAT[1]	SDIO 4-bit mode: Data line bit[1] SDIO 1-bit mode: Interrupt
46	SD_DAT[3]	I/O	SD_DAT[3]	SDIO 4-bit mode: Data line bit[3] SDIO 1-bit mode: Reserved
47	SD_DAT[2]	I/O	SD_DAT[2]	SDIO 4-bit mode: Data line bit[2] or read wait (optional) SDIO 1-bit mode: Read wait (optional)
48	SD_DAT[0]	I/O	SD_DAT[0]	SDIO 4-bit mode: Data line bit[0] SDIO 1-bit mode: Interrupt
49	UART_TX	I/O	UART_TX	UART serial output signal
50	UART_CTS	I/O	UART_CTS	UART clear-to-send input signal
51	UART_RX	I/O	UART_RX	UART serial input signal
52	UART_RTS	I/O	UART_RTS	UART request-to-send output signal
53	GND			Ground
54	VIO	Power		Power supply
55	CONFIG_HOST[0]	I	CONFIG_HOST[0]	Firmware Boot Option Refer to sec 7.3 Configuration Pins
56	CONFIG_HOST[1]	I	CONFIG_HOST[1]	Firmware Boot Option Refer to sec 7.3 Configuration Pins
57	PCM_CLK	I/O	GPIO[4]/PCM_CLK	GPIO[4] input/output PCM clock signal. • Central mode: output • Peripheral mode: input  I2S audio bit clock. . Central mode: output . Peripheral mode: input
58	PCM_MCLK	I/O	GPIO[3]/PCM_MCLK	GPIO[3] input/output PCM codec main clock signal (optional). Optional clock used for some codecs. Derived from PCM_CLK.  I2S clock output signal Optional clock used for some codecs. Derived from I2S_BCLK.
59	PCM_DOUT	I/O	GPIO[5]/PCM_DOUT	GPIO[5] input/output PCM transmit data signal (output). *Connect to PCM audio codec input data (for playback).  I2S_DOUT - I2S transmit data signal (output). I2S audio codec input data (for playback).
60	PCM_DIN	I/O	GPIO[6]/PCM_DIN	GPIO[6] input/output PCM transmit data signal (input). *Connect to PCM audio codec output data (for recording).  I2S_DIN - I2S receive data signal (input). PCM audio codec output data (for recording).

No.	Terminal Name	Type	Connection to IC Terminal	Description
61	PCM_SYNC	I/O	GPIO[7]/PCM_SYNC	GPIO[7] input/output PCM sync pulse signal (output if master, input if slave). • Central mode: output • Peripheral mode: input  I2S_LRCLK - I2S left/right clock (output if master, input if slave). • Central mode: output • Peripheral mode: input
62	GND			Ground
63	IND_RST_WL	I/O	GPIO[1]/IND_RST_WL	Independent software reset for Wi-Fi input Multi-functional pin: GPIO[1] input/output
64	IND_RST_BT	I/O	GPIO[2]/IND_RST_BT	Independent software reset for Bluetooth input *1 Multi-functional pin: GPIO[2] input/output
65	Reserved	I/O	GPIO[27]	Programmable GPIO Pin
66	Reserved	I/O	GPIO[23]	Programmable GPIO Pin
67	GND			Ground
68	GND			Ground
69	WCI-2_SIN	I/O	GPIO[25]/WCI-2_SIN	Input signal from external radio. Multi-functional pin: GPIO[25] input/output
70	WCI-2_SOUT	I/O	GPIO[26]/WCI-2_SOUT	Output signal to external radio. Multi-functional pin: GPIO[26] input/output External radio coexistence interface
71	GND			Ground
72	SD_INT	I/O	GPIO[21]/SD_INT	Out-of-band SDIO interface interrupt signal output. Multi-functional pin: GPIO[21] input/output
73	WL_WAKE_OUT	I/O	GPIO[17]/WL_WAKE_OUT	Wi-Fi radio wake-up output signal. Multi-functional pin: GPIO[17] input/output
74	WL_WAKE_IN	I/O	GPIO[16]/WL_WAKE_IN	Wi-Fi radio wake-up input signal. Multi-functional pin: GPIO[16] input/output
75	BT15.4_WAKE_IN	I/O	GPIO[18]/BT15.4_WAKE_IN	Bluetooth/802.15.4 radio wake-up input signal. Multi-functional pin: GPIO[18] input/output
76	BT15.4_WAKE_OUT	I/O	GPIO[19]/BT15.4_WAKE_OUT	Bluetooth/802.15.4 radio wake-up output signal. Multi-functional pin: GPIO[19] input/output
77	NC		NC	Not connected
78	NC		NC	Not connected
79	NC		NC	Not connected
80	NC		NC	Not connected
81-107	GND			Ground

## 7.3 Configuration Pins

**Table 8** describes the configuration pins.

**Table 8: Configuration Pins**

CONFIG_HOST[0]	CONFIG_HOST[1]	WLAN	Bluetooth / Bluetooth LE	802.15.4	Remarks
1	1	SDIO	UART	SPI	Default
Others	Others	Reserved	Reserved	Reserved	Reserved

## 7.4 Pin States

Pin states information for the tables below include:

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

**Table 9: I/O State Table**

Pin Name	Supply	No Pad Power State	Reset State	HW State	PD State	PD Prog	Internal PU/PD	Int'l Pull Value[Ω]
SPI_FRM	VIO	tristate	input	input	drive high	yes	nominal PU	100kΩ
SPI_INT	VIO	tristate	input	input	drive low	Yes	nominal PU	100kΩ
SPI_RXD	VIO	tristate	input	input	tristate	Yes	nominal PU	100kΩ
SPI_TXD	VIO	tristate	output low	output low	drive low	yes	nominal PU	100kΩ
SPI_CLK	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
RST_IND	VIO	tristate	output high	output low	tristate	yes	nominal PU	100kΩ
IND_RST_15.4	VIO	tristate	output low	output low	tristate	yes	weak PU	800kΩ
UART_TX	VIO	tristate	output high	output high	drive low	yes	nominal PU	100kΩ
UART_CTS	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
UART_RX	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
UART_RTS	VIO	tristate	output high	output high	drive high	yes	nominal PU	100kΩ
PCM_CLK	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
PCM_MCLK	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
PCM_DOUT	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
PCM_DIN	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
PCM_SYNC	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
IND_RST_WL	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
IND_RST_BT	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
GPIO[27]	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
GPIO[23]	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ

Pin Name	Supply	No Pad Power State	Reset State	HW State	PD State	PD Prog	Internal PU/PD	Int'l Pull Value[Ω]
WCI-2_SIN	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
WCI-2_SOUT	VIO	tristate	input	input	tristate	yes	nominal PU	100kΩ
SD_INT	VIO	tristate	output high	output low	drive low	yes	nominal PU	100kΩ
WL_WAKE_OUT	VIO	tristate	input	input	drive low	yes	nominal PU	100kΩ
WL_WAKE_IN	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
BT15.4_WAKE_IN	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
BT15.4_WAKE_OUT	VIO	tristate	input	input	drive low	yes	nominal PU	100kΩ
XOSC_EN	VIO	tristate	input	input	drive low	yes	nominal PU	100kΩ
RF_CNTL4	VIO	tristate	input	input	drive low	yes	weak PU	800kΩ
RF_CNTL3/ CONFIG_XOSC_SEL	VIO	tristate	input	input	drive high	yes	weak PU	800kΩ
RF_CNTL1	VIO	tristate	output high	output high	drive high	yes	weak PU	800kΩ
RF_CNTL0	VIO	tristate	output low	output low	drive low	yes	nominal PU	100kΩ
SD_CMD	VIO_SD	tristate	input	input	tristate	yes	nominal PU	100kΩ
SD_CLK	VIO_SD	tristate	input	input	tristate	yes	nominal PU	100kΩ
SD_DAT[1]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	100kΩ
SD_DAT[3]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	100kΩ
SD_DAT[2]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	100kΩ
SD_DAT[0]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	100kΩ
CONFIG_HOST[0]	AVDD18	tristate	input	input	tristate	no	weak PU	800kΩ
CONFIG_HOST[1]	AVDD18	tristate	input	input	tristate	no	weak PU	800kΩ
PDn	AVDD33						weak PD	51kΩ

## 7.5 SDIO Pin Descriptions

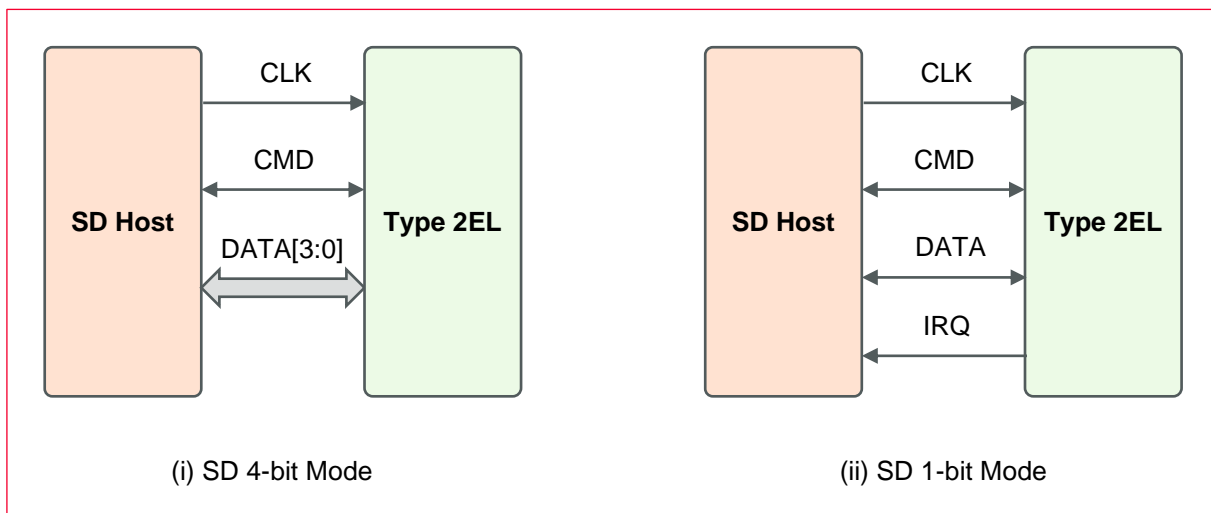
Table 10 shows the SDIO pin descriptions.

Table 10: SDIO Pin Descriptions

No.	Pin Name	(i) SD 4-bit Mode		(ii) SD 1-bit Mode	
4	SDIO_CLK	CLK	Clock	CLK	Clock
5	SDIO_D0	DATA0	Data line 0	DATA	Data line
45	SDIO_D1	DATA1	Data line 1	IRQ	Interrupt
3	SDIO_D2	DATA2	Data line 2	RW	Read wait (optional)
46	SDIO_D3	DATA3	Data line 3	NC	Reserved
6	SDIO_CMD	CMD	Command/response	CMD	Command line

Figure 5 shows the SDIO modes.

Figure 5: SDIO Pins



## 8 Absolute Maximum Ratings

**Table 11** describes the absolute maximum ratings.

**Table 11: Absolute Maximum Ratings**

Parameter	Minimum	Maximum	Unit
Storage Temperature	-50	+85	°C
Supply Voltage	AVDD33	3.96	V
	AVDD18	2.16	V
	SD_VIO 1.8V/3.3V	2.16	V
		3.96	V
	VIO 1.8V/3.3V	2.16	V
3.96		V	



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

## 9 Operating Conditions

### 9.1 Operating Conditions

Type 2EL operating conditions are described in **Table 12**.

**Table 12: Operating Conditions**

Parameter		Minimum	Typical	Maximum	Unit
Operating Temperature		-40	25	+85	°C
Supply Voltage	AVDD33	3.14	3.3	3.46	V
	AVDD18	1.71	1.8	1.89	V
	SD_VIO/VIO = 1.8V	1.71	1.8	1.89	V
	SD_VIO/VIO = 3.3V	3.14	3.3	3.46	V
Peak current	AVDD33			420	mA
	AVDD18			1009	mA



- Operation beyond the recommended operating conditions is neither recommended nor guaranteed.
- Peak current happens during DPD calibration when the firmware is downloaded.

### 9.2 Digital I/O Requirements

The digital I/O requirements are listed in **Table 13**.

**Table 13: Digital I/O Requirements Parameters**

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
VIO	I/O pad supply voltage		1.71	1.8	1.89	V
VIH	Input high voltage		0.7 * VIO		VIO + 0.4	V
VIL	Input low voltage		-0.4		0.3 * VIO	V
VHYS	Input hysteresis		100			mV
VOH	Output high voltage		VIO - 0.4			V
VOL	Output low voltage				0.4	V

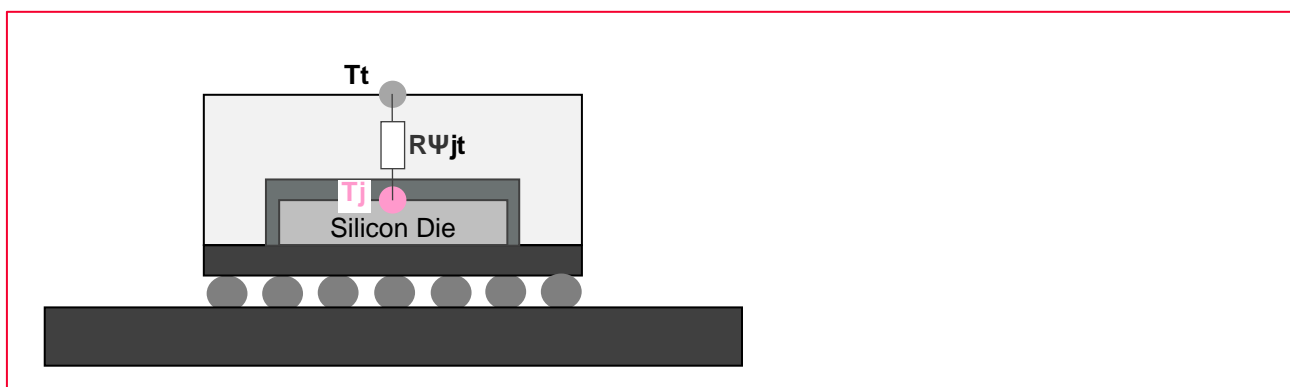
## 9.3 Package Thermal Conditions

- $R\psi_{jt} : 3.12 \text{ }^\circ\text{C/W}$
- $R\psi_{jt} = (T_j - T_t)/P$



$T_j$ : Junction temperature ( $^\circ\text{C}$ ),  $T_t$ : Top temperature ( $^\circ\text{C}$ ),  $P$ : Total Power Consumption (W)

Figure 6: Package Thermal Conditions





# 10 Power Sequence

## 10.1 Power-On Sequence

AVDD33, AVDD18, VIO, and VIO\_SD can be powered on with 0 second minimum. The PDn signal when it is asserted (low) while all power supplies to the devices are high.

Figure 7 shows the power-on sequence graph.

Figure 7: Power-On Sequence Graph

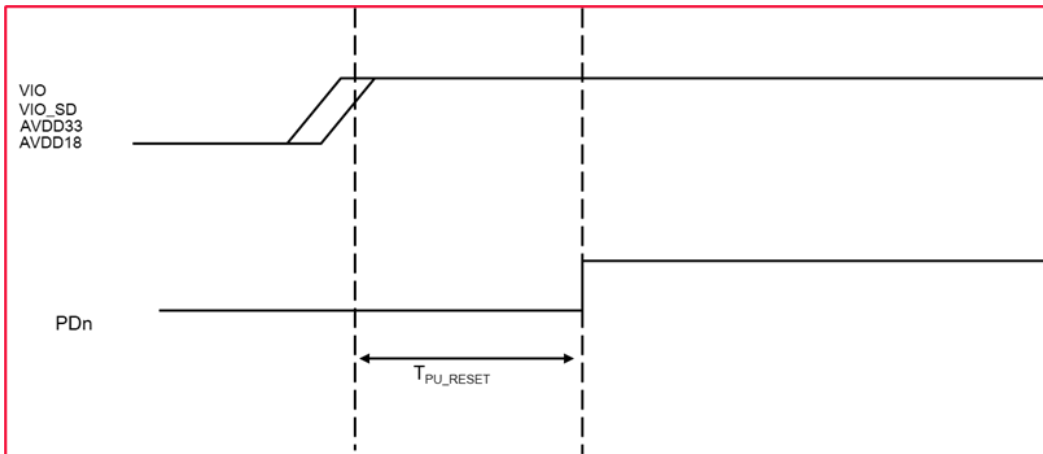


Table 14 shows the PDn pin (power-off) specifications. Power remains high at PDn assertion.

Table 14: PDn Pin Specifications

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T <sub>VIO_AVDD</sub>	Power up timing of VIO, VIO_SD, AVDD33, and VIO18		0			ms
T <sub>PU_RESET</sub>	Valid power to PDn de-asserted		0			ms
V <sub>IH</sub>	Input high voltage		1.4		4.5	V
V <sub>IL</sub>	Input low voltage		-0.4		0.5	V



Minimum value is guaranteed for a valid rest. Smaller values may put the device in an undefined state.

## 10.2 Power-Off Sequence

Figure 8 shows the power-off sequence graph.

Figure 8: Power-Off Sequence Graph

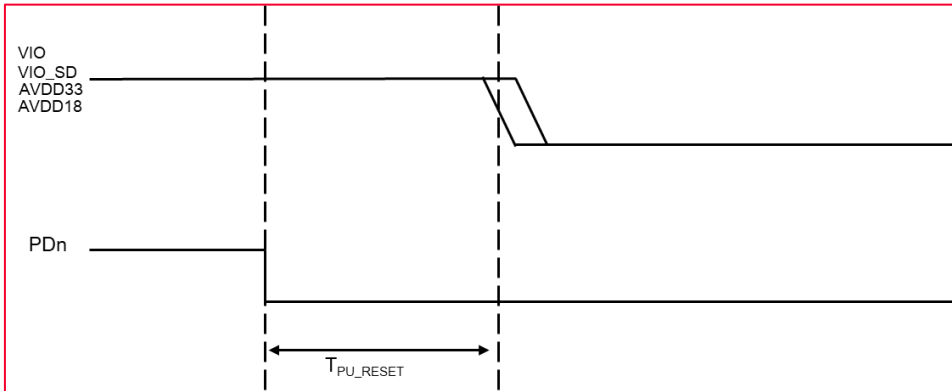


Table 15 shows the power-off sequence parameters.

Table 15: Power-Off Sequence Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
$T_{VIO\_AVDD}$	Power up timing of VIO, VIO_SD, AVDD33, and VIO18		0			ms
$T_{PU\_RESET}$	Valid power to PDn de-asserted		0			ms
$V_{IH}$	Input high voltage		1.4		4.5	V
$V_{IL}$	Input low voltage		- 0.4		0.5	V



Minimum value is guaranteed for a valid rest. Smaller values may put the device in an undefined state.

### 10.3 Host Reset Sequence

Figure 9 shows hot reset sequence graph.

Figure 9: Host Reset Sequence Graph

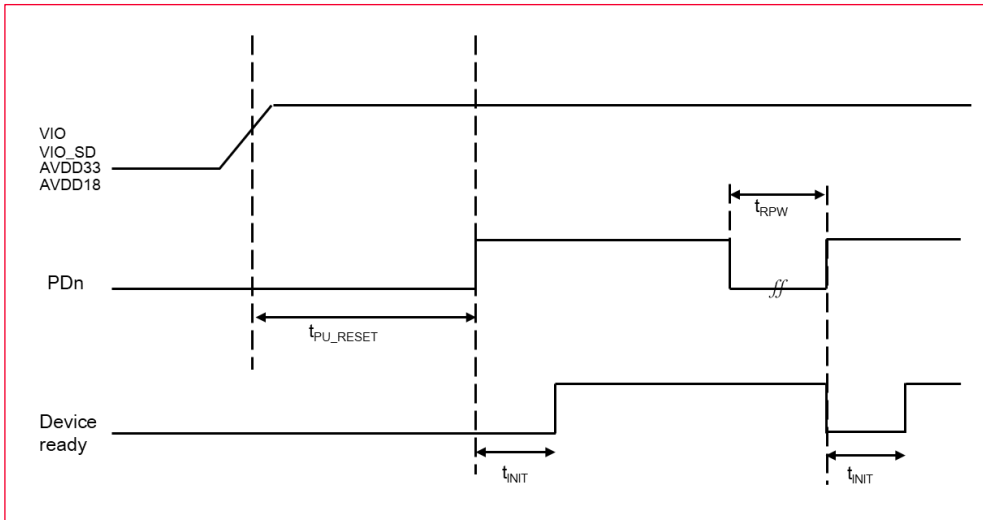


Table 16: Host Reset Sequence Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
$t_{PU\_RESET}$	Valid power to PDn de-asserted		0			ms
$t_{PRW}$	PDn pulse width		1			$\mu$ s
$t_{INIT}$	From PDn de-assertion to device ready (SDIO bus enumeration)		20			ms
$V_{IH}$	Input high voltage		1.4		4.5	V
$V_{IL}$	Input low voltage		-0.4		0.5	V



Minimum value guaranteed for a valid rest. Smaller values may put the device in an undefined state.

# 11 Interface Timing

This section describes interface timings:

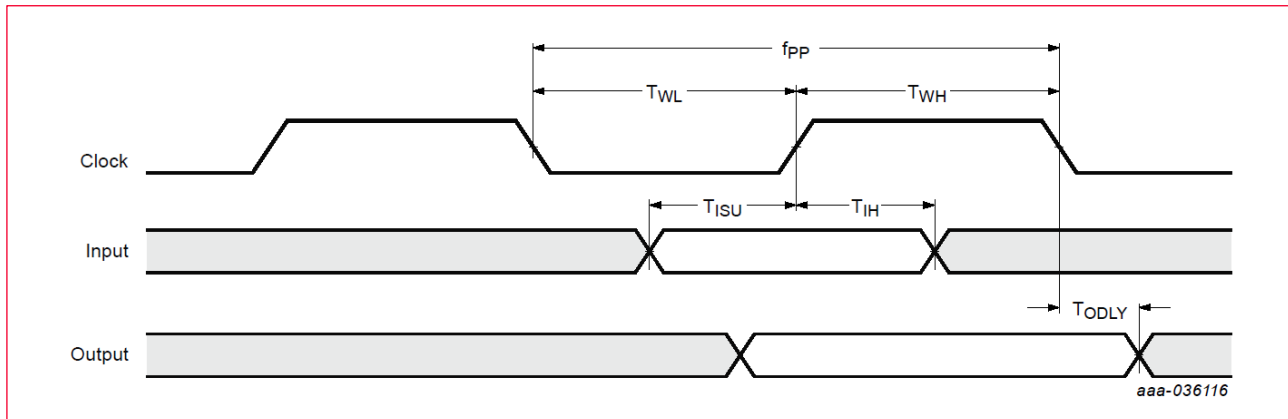
- SDIO timing (default and high-speed modes)
- SDIO protocol timings
- UART timing (default mode)
- Bluetooth PCM timing (master and slave mode)

## 11.1 SDIO Timing

### 11.1.1 Default Speed Mode

**Figure 10** describes the SDIO protocol timing diagram in default speed mode.

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



## 11.1.2 High Speed Mode

Figure 11 describes the SDIO protocol timing diagram in high-speed mode.

Figure 11: SDIO Protocol Timing Diagram - High Speed Mode

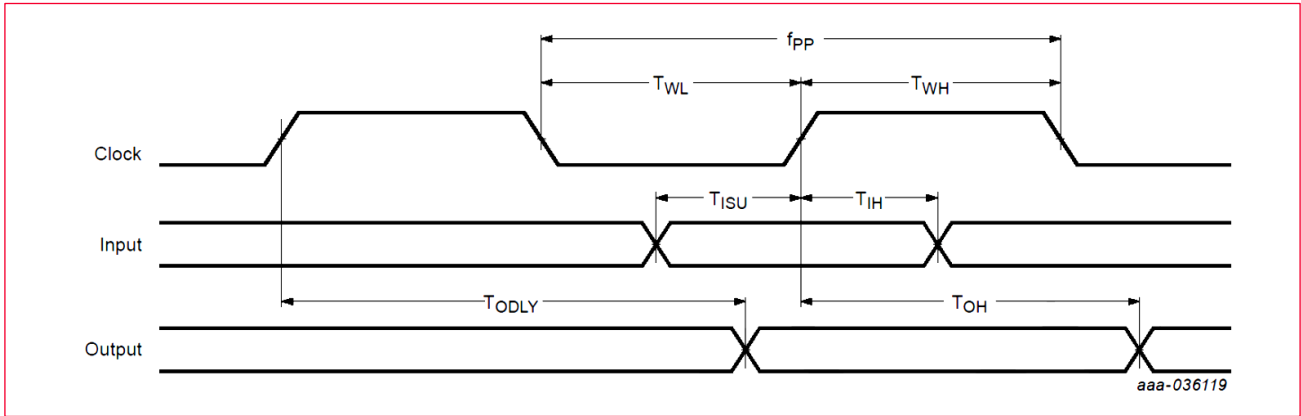


Table 17 describes the parameters for SDIO protocol timing parameters.

Table 17: SDIO Protocol Timing Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
f <sub>PP</sub>	Clock frequency	Normal	0		25	MHz
		High-speed	0		50	MHz
T <sub>WL</sub>	Clock low time	Normal	10			ns
		High-speed	7			ns
T <sub>WH</sub>	Clock high time	Normal	10			ns
		High-speed	7			ns
T <sub>ISU</sub>	Input setup time	Normal	5			ns
		High-speed	6			ns
T <sub>IH</sub>	Input hold time	Normal	5			ns
		High-speed	2			ns
T <sub>OLDY</sub>	Output delay time	Normal			14	ns
	CL ≤ 40 pF (1 card)	High-speed			14	ns
T <sub>OH</sub>	Output put hold time	High-speed	2.5			ns



For SDIO 2.0 running at 25 MHz and 50 MHz clock frequency, VIO\_SD must be 3.3V.

### 11.1.3 SDR12, SDR25, SDR50 Modes (up to 100 MHz) at 1.8V

Figure 12 shows SDIO protocol timing diagram for SDR12, SDR25, SDR50 Mode (up to 100 MHz) at 1.8V.

Figure 12: SDIO Protocol Timing Diagram - SDR12, SDR25, SDR50 Modes

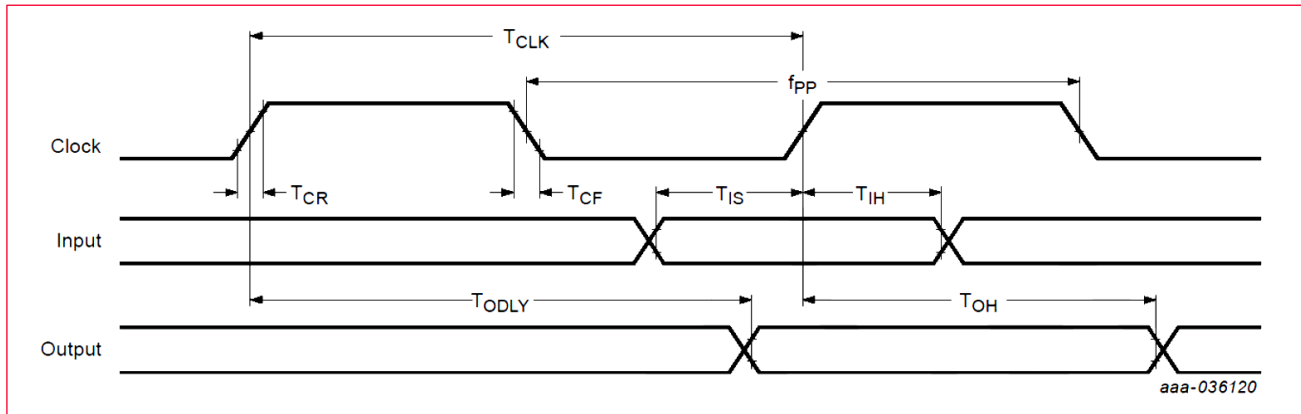


Table 18 describes SDIO protocol timing data for SDR12, SDR25, SDR50 Mode (up to 100 MHz) at 1.8V.

Table 18: SDIO Protocol Timing Parameters - SDR12, SDR25, SDR50 Modes

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
$f_{PP}$	Clock frequency	SDR12/25/50	25		100	MHz
$T_{IS}$	Input setup time	SDR12/25/50	3			ns
$T_{IH}$	Input hold time	SDR12/25/50	0.8			ns
$T_{CLK}$	Clock time	SDR12/25/50	10		40	ns
$T_{CR}, T_{CF}$	Rise time, fall time $T_{CR}, T_{CF} < 2$ ns (maximum) at 100 MHz $C_{CARD} = 10$ pF	SDR12/25/50			$0.2 \cdot T_{CLK}$	ns
$T_{ODLY}$	Output delay time $CL \leq 15$ pF	SDR12/25/50			7.5	ns
$T_{OH}$	Output hold time	SDR12/25/50	1.5			ns

### 11.1.4 SDR104 Modes (up to 208 MHz) at 1.8V

Figure 12 shows SDIO protocol timing diagram for SDR104 Mode (up to 208 MHz) at 1.8V.

Figure 13: SDIO Protocol Timing Diagram - SDR104 Mode

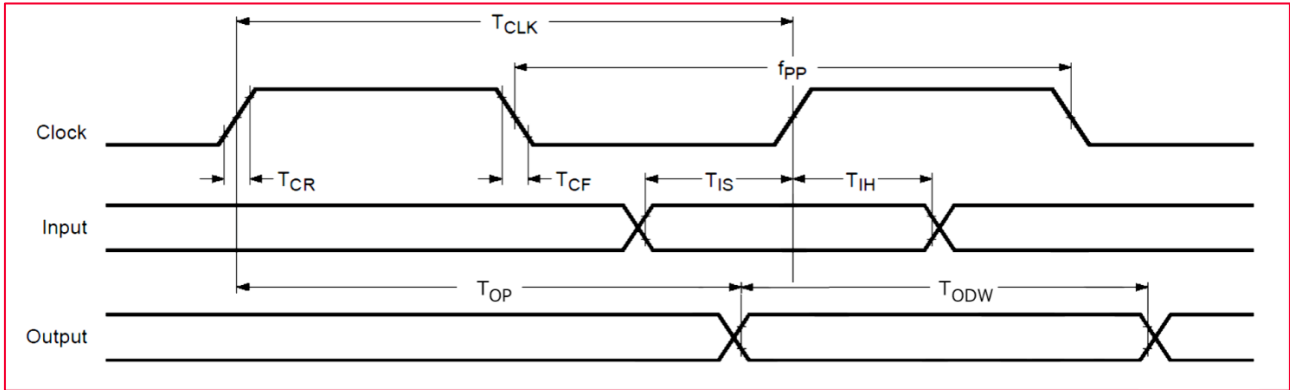


Table 18 describes SDIO protocol timing data for SDR104 Mode (up to 208 MHz) at 1.8V.

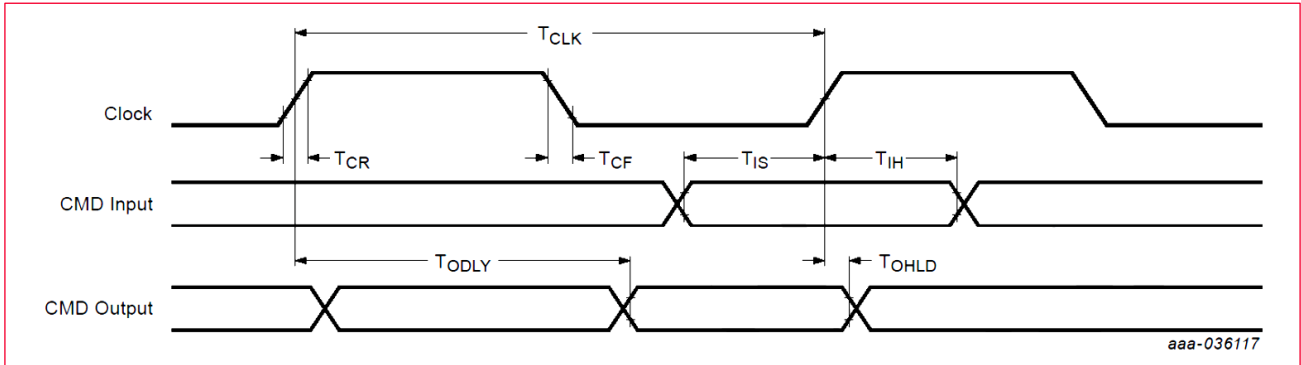
Table 19: SDIO Protocol Timing Parameters - SDR104 Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
$f_{PP}$	Clock frequency	SDR104	0		208	MHz
$T_{IS}$	Input setup time	SDR104	1.4			MHz
$T_{IH}$	Input hold time	SDR104	0.8			ns
$T_{CLK}$	Clock time	SDR104	4.8			ns
$T_{CR}, T_{CF}$	Rise time, fall time $T_{CR}, T_{CF} < 2$ ns (maximum) at 100 MHz $C_{CARD} = 10$ pF	SDR104			$0.2 \cdot T_{CLK}$	ns
$T_{OP}$	Output delay time $CL \leq 15$ pF	SDR104	0		2	ns
$T_{ODW}$	Input setup time	SDR104	2.88			ns

### 11.1.5 DDR50 Mode at 50 MHz (1.8V)

Figure 14 shows the SDIO CMD timing diagram for DDR50 mode at 50 MHz.

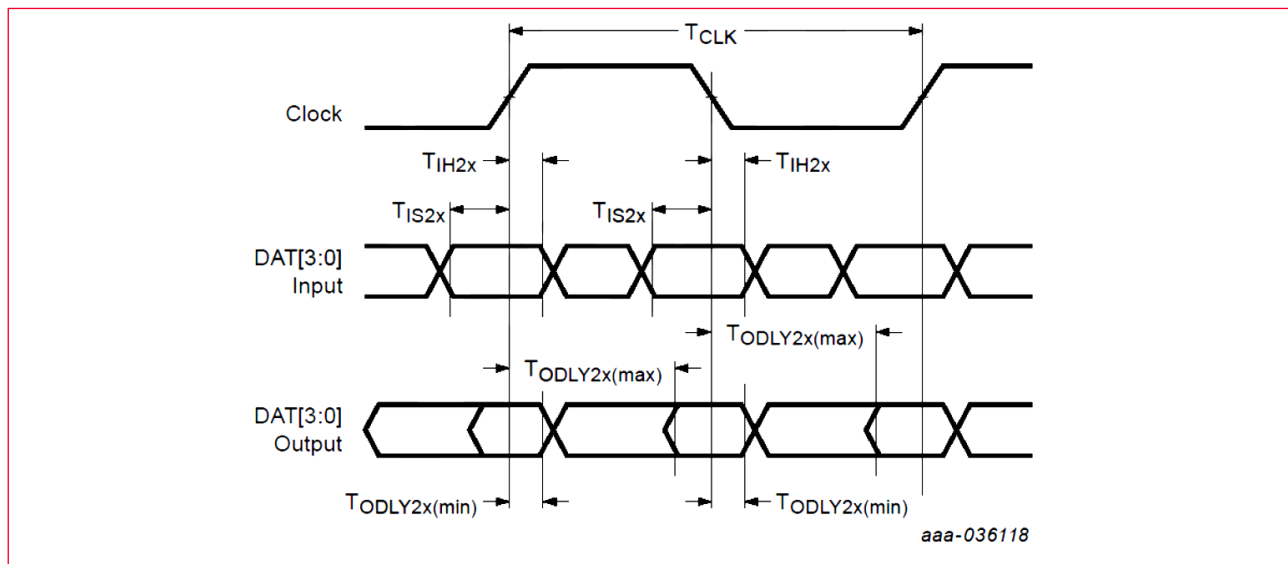
Figure 14: SDIO CMD Timing Diagram - DDR50 Mode



In DDR50 mode, DAT [3:0] lines are sampled on both edges of the clock (not applicable for CMD line).

Figure 15 shows the SDIO data timing diagram for DDR50 Mode.

Figure 15: SDIO Data Timing Diagram - DDR50 Mode





**Table 20** describes the parameters for SDIO data timing for DDR50 mode.

**Table 20: SDIO Data Timing Parameters - DDR50 Mode**

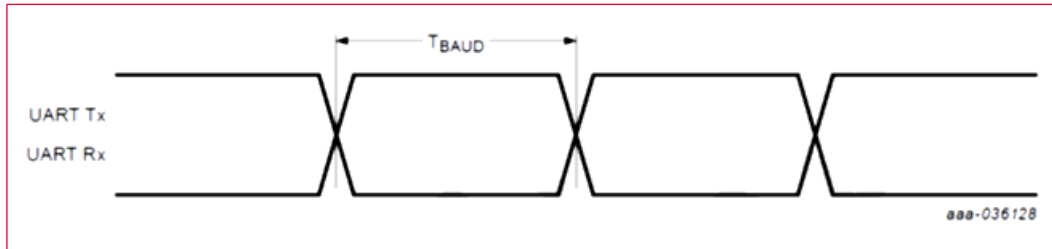
Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
Clock						
T <sub>CLK</sub>	Clock time 50 MHz (maximum) between rising edge	DDR50	20			ns
T <sub>CR</sub> , T <sub>CF</sub>	Rise time, fall time T <sub>CR</sub> , T <sub>CF</sub> < 4.00 ms(maximum) at 50 MHz	DDR50	3		0.2*T <sub>CLK</sub>	ns
		DDR50	45		55	%
CMD Input (referenced to clock rising edge)						
T <sub>IS</sub>	Input setup time C <sub>CARD</sub> ≤ 10 pF (1card)	DDR50	6			ns
T <sub>IH</sub>	Input hold time C <sub>CARD</sub> ≤ 10 pF (1card)	DDR50	0.8			ns
CMD Output (referenced to clock rising edge)						
T <sub>ODLY</sub>	Output delay time during data transfer mode C <sub>L</sub> ≤ 30 pF (1card)	DDR50			13.7	ns
T <sub>OHLd</sub>	Output hold time C <sub>L</sub> ≤ 30 pF (1card)	DDR50	1.5			ns
DAT[3:0] Input (referenced to clock rising and falling edges)						
T <sub>IS2X</sub>	Input setup time C <sub>CARD</sub> ≤ 10 pF (1card)	DDR50	3			ns
T <sub>IH2X</sub>	Input hold time C <sub>CARD</sub> ≤ 10 pF (1card)	DDR50	0.8			ns
DAT[3:0] Output (referenced to clock rising and falling edges)						
T <sub>OLD2x (max)</sub>	Output delay time during data transfer mode C <sub>L</sub> ≤ 25 pF (1 card)	DDR50			7.0	ns
T <sub>OLDY2x (min)</sub>	Output hold time C <sub>L</sub> ≤ 15 pF (1 card)	DDR50	1.5			ns

## 11.2 UART Timing (Default Mode)

Default baud rate is 115200 bps. Baud rate is configurable by the host stack.

**Figure 16** shows UART timing diagram for default mode.

**Figure 16: UART Timing Diagram - Default Mode**



**Table 21** describes the UART timing parameters for default mode.

**Table 21: UART Timing Parameters - Default Mode**

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T <sub>BAUD</sub>	Baud rate	38.4 MHz	250			ns



The acceptable deviation from the UART Rx target baud rate is  $\pm 3\%$ .

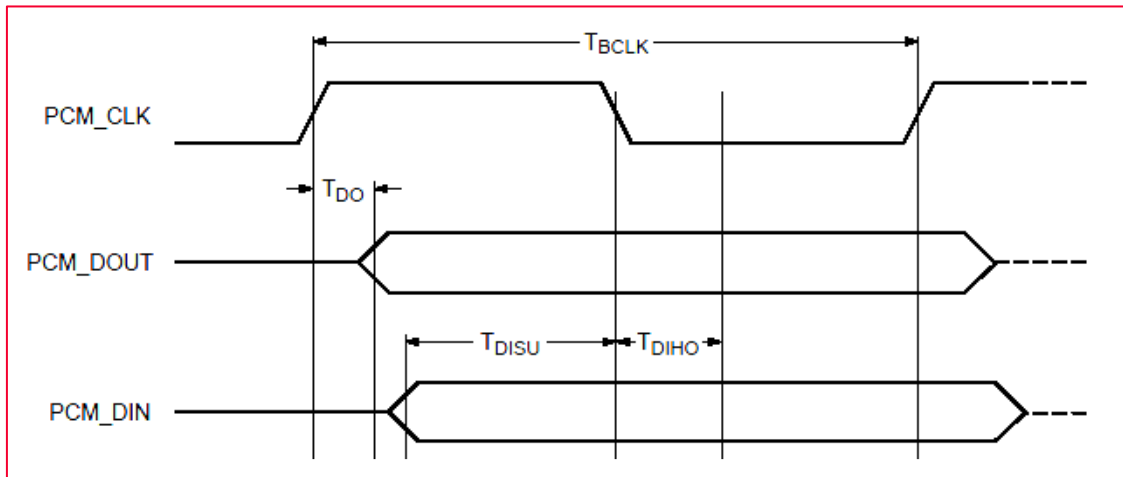
## 11.3 Bluetooth PCM Timing

This section describes the Bluetooth PCM timing data signal in master and slave mode.

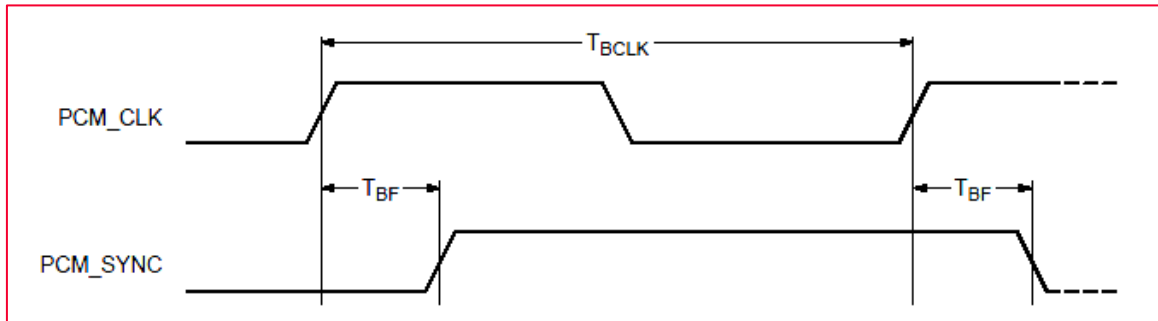
### 11.3.1 Master Mode

**Figure 17** and **Figure 18** shows the Bluetooth PCM timing signals in master mode.

**Figure 17: Bluetooth PCM Timing Data Signal - Master Mode**



**Figure 18: Bluetooth PCM Timing PCM\_SYNC Signal - Master Mode**



**Table 22** describes the signal parameters in master mode.

**Table 22: Symbol Definition for Data Signal & PCM\_SYNC Signal - Master Mode**

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
FBCLK	Bit clock frequency			2/2.048		MHz
Duty Cycle <sub>BCLK</sub>	Bit clock duty cycle		0.4	0.5	0.6	
T <sub>BCLK rise/fall</sub>	PCM_CLK rise/fall time			3		ns
T <sub>DO</sub>	Delay from PCM_CLK rising edge to PCM_DOUT rising edge				15	ns
T <sub>DISU</sub>	Setup time for PCM_DIN before PCM_CLK falling edge		20			ns

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
$T_{DIHO}$	Hold time for PCM_DIN after PCM_CLK falling edge		15			ns
$T_{BF}$	Delay from PCM_CLK rising edge to PCM_SYNC rising edge				15	ns

### 11.3.2 Slave Mode

Figure 19 and Figure 20 shows the Bluetooth PCM timing signals in slave mode.

Figure 19: Bluetooth PCM Timing Data Signal - Slave Mode

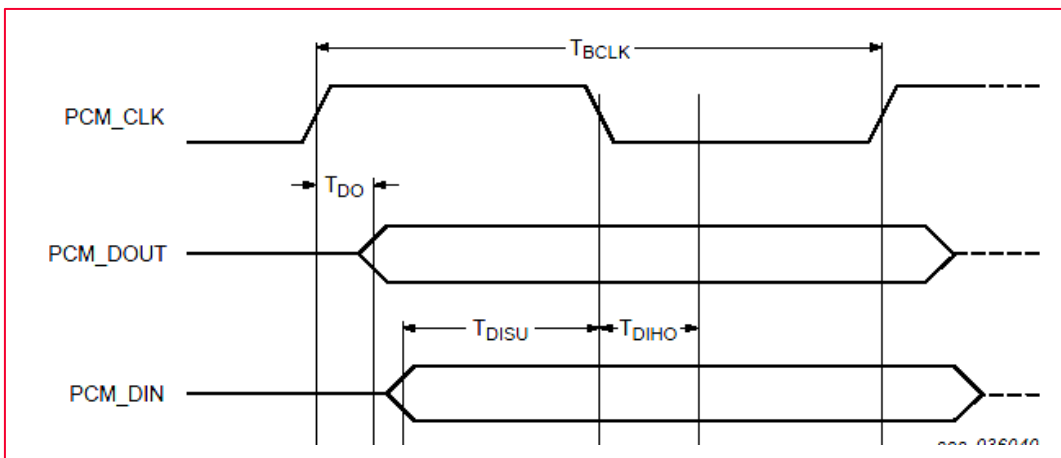


Figure 20: Bluetooth PCM Timing PCM\_SYNC Signal - Slave Mode

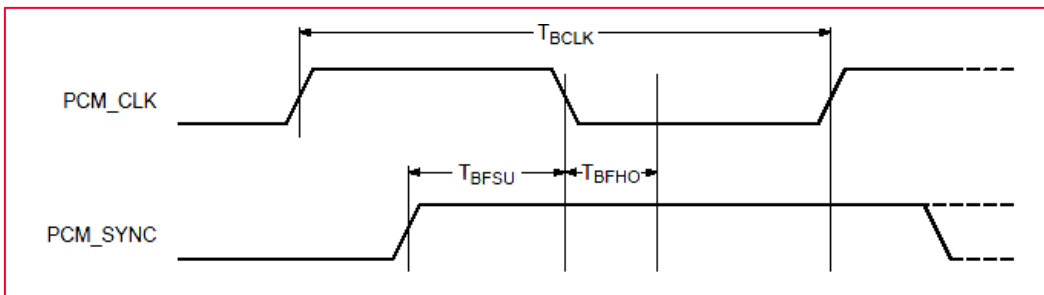


Table 23 describes the signal parameters in slave mode.

Table 23: Symbol Definition for Data Signal & PCM\_SYNC Signal - Slave Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
FBCLK	Bit clock frequency			2/2.048		MHz
Duty Cycle <sub>BCLK</sub>	Bit clock duty cycle		0.4	0.5	0.6	
$T_{BCLK\ rise/fall}$	PCM_CLK rise/fall time			3		ns

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T <sub>DO</sub>	Delay from PCM_CLK rising edge to PCM_DOUT rising edge				30	ns
T <sub>DISU</sub>	Setup time for PCM_DIN before PCM_CLK falling edge		15			ns
T <sub>DIHO</sub>	Hold time for PCM_DIN after PCM_CLK falling edge		10			ns
T <sub>BFSU</sub>	Setup time for PCM_SYNC before PCM_CLK falling edge		15			ns
T <sub>BFHO</sub>	Hold time for PCM_SYNC after PCM_CLK falling edge		10			ns

## 11.4 802.15.4 SPI Timing

Figure 21 shows 802.15.4 SPI timing graph.

Figure 21: 802.15.4 SPI Timing Graph

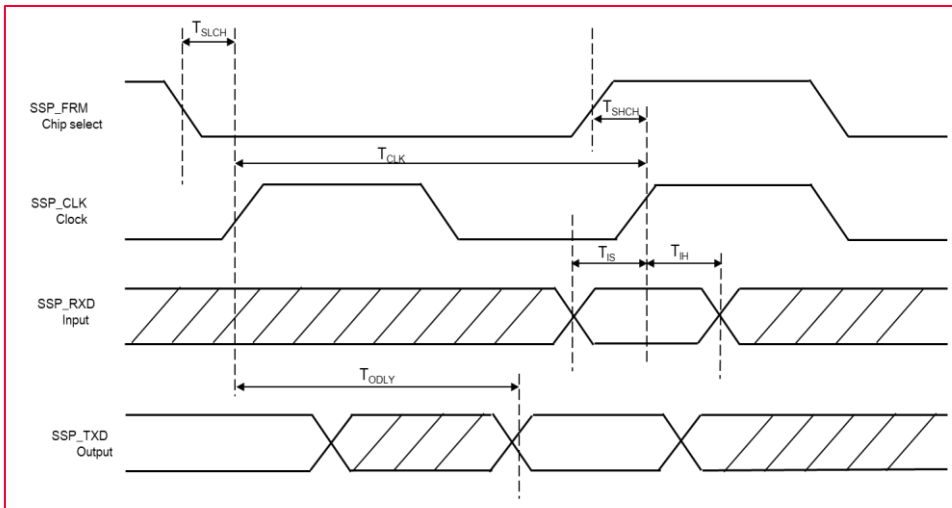


Table 24 describe 802.15.4 SPI timing parameters.

Table 24 : 802.15.4 SPI Timing Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T <sub>SLCH</sub>	Chip select setup time		12			ns
T <sub>SHCH</sub>	Chip select hold time		12			ns
T <sub>CLK</sub>	Clock period <sup>2</sup>		40			ns
T <sub>IS</sub>	Input setup time		12			ns
T <sub>IH</sub>	Input hold time		0			ns
T <sub>ODLY</sub>	Output delay				12	ns

<sup>2</sup> The maximum SPI clock frequency is limited to 1MHz for Open thread implementations.

## 12 DC/RF Characteristics

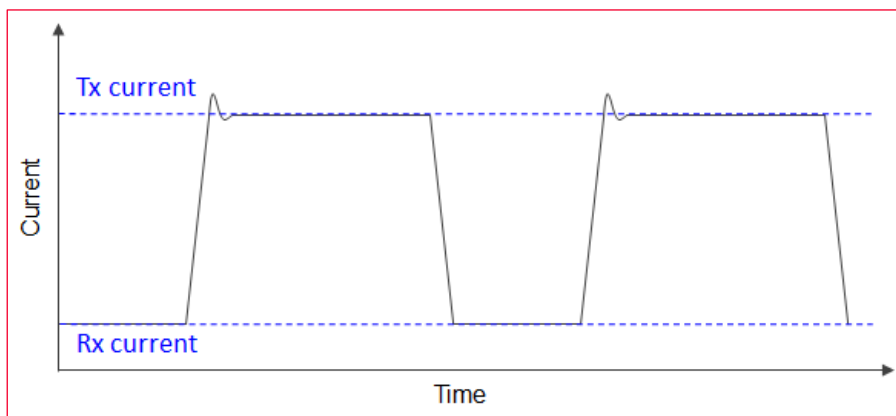
All DC/RF characteristics are defined by the following files:

**Table 25: DC/RF Characteristics Files**

Names	Country	Country Code	Configuration Files
WLAN Tx power configuration files	USA	US	txpower_US.bin
	Canada	CA	txpower_CA.bin
	Europe	DE	txpower_EU.bin
	Japan	JP	txpower_JP.bin
WLAN OFDMA RU Tx power configuration files	USA	US	rutxpower_US.bin
	Canada	CA	rutxpower_CA.bin
	Europe	DE	rutxpower_EU.bin
	Japan	JP	rutxpower_JP.bin
WLAN Regulatory Limit	-	-	db.txt
Energy Detect	-	-	ed_mac.bin
Bluetooth Power	USA	US	bt_power_config_US_CA_JP.sh
	Canada	CA	bt_power_config_US_CA_JP.sh
	Europe	DE	bt_power_config_EU.sh
	Japan	JP	bt_power_config_US_CA_JP.sh

**Figure 22** shows the burst current definition.

**Figure 22: Burst Current Definition**



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

**Table 26: Characteristic Values for IEEE 802.11b - 2.4 GHz**

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

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

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 18 dBm at module pad, 11 Mbps mode.

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

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		148	180	mA
• Tx mode Current 3.3V		234	290	mA
• Rx mode Current 1.8V		101	130	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
Output Power	16	18	20	dBm
Spectrum Mask Margin				
• 1st side lobes	0			dB
• 2nd side lobes	0			dB
Power-on/off ramp			2.0	μs
RF Carrier Suppression	15			dB
Modulation Accuracy			35	%
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
Minimum Input Level (FER ≤ 8%)			-76	dBm
Maximum Input Level (FER ≤ 8%)	-10			dBm
Adjacent Channel Rejection (FER < 8%)	35			dB

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

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 18dBm at module pad, 1 Mbps mode

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

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		146	180	mA
• Tx mode Current 3.3V		225	270	mA
• Rx mode Current 1.8V		101	130	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power	16	18	20	dBm
Spectrum Mask Margin				
• 1st side lobes	0			dB
• 2nd side lobes	0			dB
Power-on/off ramp			2.0	μs
RF Carrier Suppression	15			dB
Modulation Accuracy			35	%
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (FER ≤ 8%)			-80	dBm
Maximum Input Level (FER ≤ 8%)	-4			dBm
Adjacent Channel Rejection (FER < 8%)	35			dB



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

**Table 29: Characteristic Values for IEEE 802.11g - 2.4 GHz**

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

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

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

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

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		163	200	mA
• Tx mode Current 3.3V		197	240	mA
• Rx mode Current 1.8V		102	130	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
Output Power	14	16	18	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dB)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dB)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dB)	0			dB
• 30 MHz to 33 MHz (-40 dB)	0			dB
Constellation Error (EVM)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
Minimum Input Level (PER < 10%)			-65	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER < 10%)	-1			dB

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

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 16 dBm at module pad, 6 Mbps mode

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

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		164	200	mA
• Tx mode Current 3.3V		201	260	mA
• Rx mode Current 1.8V		102	130	mA
• Rx mode Current 3.3V		0.2	10	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 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER < 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER < 10%)	16			dB

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

**Table 32: Characteristic Values for IEEE 802.11n - 2.4 GHz**

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

### 12.3.1 High-Rate Condition for IEEE 802.11n(HT20) - 2.4 GHz

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

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

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		164	200	mA
• Tx mode Current 3.3V		188	230	mA
• Rx mode Current 1.8V		102	130	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
	Minimum	Typical	Maximum	Unit
Output Power	13	15	17	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-64	dBm
Maximum Input Level (PER < 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

## 12.3.2 Low-Rate Condition for IEEE 802.11n(HT20) - 2.4 GHz

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 15 dBm at module pad, MCS0 mode

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

Item	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode Current 1.8V		164	200	mA
• Tx mode Current 3.3V		188	230	mA
• Rx mode Current 1.8V		102	130	mA
• Rx mode Current 3.3V		0.2	10	mA
<b>Tx Characteristics</b>				
Output Power	13	15	17	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
<b>Rx Characteristics</b>				
7. Minimum Input Level (PER ≤ 10%)			-82	dBm
8. Maximum Input Level (PER < 10%)	-20			dBm
9. Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

## 12.4 DC/RF Characteristics for IEEE802.11ax (HE20) - 2.4GHz

**Table 35: Characteristic Values for IEEE802.11ax (HE20) – 2.4GHz**

Contents	Items
Specification	IEEE 802.11ax
Mode	OFDM
Channel Frequency	2412 to 2472 MHz
Data Rate	MCS0-MCS11

### 12.4.1 High-Rate Condition for IEEE802.11ax (HE20) – 2.4GHz

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 13 dBm at module pad, MCS11 mode

**Table 36: High-Rate Condition for IEEE802.11ax (HE20) – 2.4GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		165	200	mA
• Tx mode Current 3.3V		170	210	mA
• Rx mode Current 1.8V		102	130	mA
• Rx mode Current 3.3V		0.2	10	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-35	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-52	dBm
Maximum Input Level (PER < 10%)	-20			dBm

Adjacent Channel Rejection (PER ≤ 10%)	-14			dB
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## 12.4.2 Low-Rate Condition for IEEE802.11ax (HE20) – 2.4GHz

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 15 dBm at module pad, MCS0 mode

**Table 37: Low-Rate Condition for IEEE802.11ax (HE20) – 2.4GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		164	200	mA
• Tx mode Current 3.3V		192	240	mA
• Rx mode Current 1.8V		102	130	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power	13	15	17	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB

## 12.5 DC/RF Characteristics for IEEE 802.11n (HT40) – 2.4 GHz

**Table 38: Characteristic Values for IEEE 802.11n (HT40) – 2.4 GHz**

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

### 12.5.1 High-Rate Condition for IEEE 802.11n (HT40) – 2.4 GHz

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

**Table 39: High-Rate Condition for IEEE 802.11n (HT40) – 2.4 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		170	200	mA
• Tx mode Current 3.3V		185	230	mA
• Rx mode Current 1.8V		112	140	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
	Minimum	Typical	Maximum	Unit
Output Power	13	15	17	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 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 (PER ≤ 10%)			-61	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

## 12.5.2 Low-Rate Condition for IEEE 802.11n (HT40) – 2.4 GHz

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

**Table 40: Low-Rate Condition for IEEE 802.11n (HT40) – 2.4 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		170	200	mA
• Tx mode Current 3.3V		188	230	mA
• Rx mode Current 1.8V		112	140	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power	13	15	17	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-79	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	16			dB



## 12.6 DC/RF Characteristics for IEEE802.11ax (HE40) -2.4GHz

**Table 41: Characteristic Values for IEEE802.11ax (HE40) – 2.4GHz**

Contents	Items
Specification	IEEE 802.11ax
Mode	OFDM
Channel Frequency	2412 to 2472 MHz
Data Rate	MCS0 - MCS11

### 12.6.1 High-Rate Condition for IEEE802.11ax (HE40) – 2.4GHz

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 13 dBm at module pad, MCS11 mode

**Table 42: High-Rate Condition for IEEE802.11ax (HE40) – 2.4GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		158	190	mA
• Tx mode Current 3.3V		151	200	mA
• Rx mode Current 1.8V		112	140	mA
• Rx mode Current 3.3V		0.2	10	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) (Measured at enhanced mode)			-35	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-49	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-14			dB

## 12.6.2 Low-Rate Condition for IEEE802.11ax (HE40) – 2.4GHz

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

**Table 43: Low-Rate Condition for IEEE802.11ax (HE40) – 2.4GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		172	200	mA
• Tx mode Current 3.3V		188	230	mA
• Rx mode Current 1.8V		112	140	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power	13	15	17	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-79	dBm
Maximum Input Level (PER ≤ 10%)	-20			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-16			dB

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

**Table 44: Characteristic Values for IEEE 802.11a - 5 GHz**

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

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

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

**Table 45: High-Rate Condition for IEEE 802.11a - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		248	300	mA
• Tx mode Current 3.3V		240	310	mA
• Rx mode Current 1.8V		122	150	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
Minimum Input Level (PER ≤ 10%)			-65	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

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

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 16 dBm at module pad, 6 Mbps mode

**Table 46: Low-Rate Condition for IEEE 802.11a - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		250	300	mA
• Tx mode Current 3.3V		245	310	mA
• Rx mode Current 1.8V		122	150	mA
• Rx mode Current 3.3V		0.2	10	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

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

**Table 47: Characteristic Values for IEEE 802.11n (HT20) - 5 GHz**

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

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

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

**Table 48: High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		221	280	mA
• Tx mode Current 3.3V		209	280	mA
• Rx mode Current 1.8V		121	150	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
Output Power	Minimum	Typical	Maximum	Unit
	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 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 Input Level (PER ≤ 10%)	Minimum	Typical	Maximum	Unit
			-64	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

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

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

**Table 49: Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		221	280	mA
• Tx mode Current 3.3V		214	280	mA
• Rx mode Current 1.8V		121	150	mA
• Rx mode Current 3.3V		0.2	10	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

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

**Table 50: Characteristic Values for IEEE 802.11ac (VHT20) - 5 GHz**

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

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

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

**Table 51: High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		221	280	mA
• Tx mode Current 3.3V		209	280	mA
• Rx mode Current 1.8V		121	150	mA
• Rx mode Current 3.3V		0.2	10	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-30	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-59	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

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

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

**Table 52: Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		221	280	mA
• Tx mode Current 3.3V		212	280	mA
• Rx mode Current 1.8V		121	150	mA
• Rx mode Current 3.3V		0.2	10	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-30	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB



## 12.10 DC/RF Characteristics for IEEE802.11ax (HE20) - 5GHz

**Table 53: Characteristics Values for IEEE802.11ax (HE20) - 5GHz**

Contents	Items
Specification	IEEE 802.11ax
Mode	OFDM
Channel Frequency	5180 to 5240 MHz, 5260 to 5320 MHz, 5500 to 5720 MHz, 5745 to 5825 MHz
Data Rate	MCS0 - MCS11

### 12.10.1 High-Rate Condition for IEEE802.11ax (HE20) – 5GHz

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 10 dBm at module pad, MCS11 mode

**Table 54: High-Rate Condition for IEEE802.11ax (HE20) - 5GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		207	280	mA
• Tx mode Current 3.3V		169	230	mA
• Rx mode Current 1.8V		121	150	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
	Minimum	Typical	Maximum	Unit
Output Power	8	10	12	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-35	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-52	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

## 12.10.2 Low-Rate Condition for IEEE802.11ax (HE20) – 5GHz

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

**Table 55: Low-Rate Condition for IEEE802.11ax (HE20) – 5GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		222	280	mA
• Tx mode Current 3.3V		216	280	mA
• Rx mode Current 1.8V		121	150	mA
• Rx mode Current 3.3V		0.2	10	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 ~ -45 dBr)	0			dB
• 30 MHz to 33 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-5	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-82	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

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

**Table 56: Characteristic Values for IEEE 802.11n (HT40) - 5 GHz**

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

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

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

**Table 57: High-Rate Condition for IEEE 802.11n (HT40) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		231	290	mA
• Tx mode Current 3.3V		203	280	mA
• Rx mode Current 1.8V		140	170	mA
• Rx mode Current 3.3V		0.2	10	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) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-61	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

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

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

**Table 58: Low-Rate Condition for IEEE 802.11n (HT40) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		232	290	mA
• Tx mode Current 3.3V		205	280	mA
• Rx mode Current 1.8V		140	170	mA
• Rx mode Current 3.3V		0.2	10	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) (Measured at enhanced mode)			-27	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-79	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

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

**Table 59: Characteristic Values for IEEE 802.11ac (VHT40) - 5 GHz**

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

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

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 12 dBm at module pad, MCS9 mode

**Table 60: High-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz**

Item	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode Current 1.8V		225	290	mA
• Tx mode Current 3.3V		179	250	mA
• Rx mode Current 1.8V		141	170	mA
• Rx mode Current 3.3V		0.2	10	mA
<b>Tx Characteristics</b>	Minimum	Typical	Maximum	Unit
Output Power	10	12	14	dBm
<b>Spectrum Mask Margin</b>				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
<b>Spurious Emissions</b>				
• 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
<b>Rx Characteristics</b>	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-54	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

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

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

**Table 61: Low-Rate Condition for IEEE 802.11ac (VHT40) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		232	290	mA
• Tx mode Current 3.3V		206	280	mA
• Rx mode Current 1.8V		141	170	mA
• Rx mode Current 3.3V		0.2	10	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) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-79	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

## 12.13 DC/RF Characteristics for IEEE802.11ax (HE40) - 5GHz

**Table 62: Characteristic Values for IEEE802.11ax (HE40) - 5GHz**

Contents	Items
Specification	IEEE 802.11ax
Mode	OFDM
Channel Frequency	5190 to 5795 MHz
Data Rate	MCS0 - MCS11

### 12.13.1 High-Rate Condition for IEEE802.11ax (HE40) – 5GHz

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 10 dBm at module pad, MCS11 mode

**Table 63: High-Rate Condition for IEEE802.11ax (HE40) – 5GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		217	290	mA
• Tx mode Current 3.3V		162	230	mA
• Rx mode Current 1.8V		141	170	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
	Minimum	Typical	Maximum	Unit
Output Power	8	10	12	dBm
Spectrum Mask Margin				
• 19 MHz to 21 MHz (0 ~ -20 dBr)	0			dB
• 21 MHz to 40 MHz (-20 ~ -28 dBr)	0			dB
• 40 MHz to 60 MHz (-28 ~ -45 dBr)	0			dB
• 60 MHz to 80 MHz (-45 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-54	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

## 12.13.2 Low-Rate Condition for IEEE802.11ax (HE40) – 5GHz

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

**Table 64: Low-Rate Condition for IEEE802.11ax (HE40) – 5GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		234	290	mA
• Tx mode Current 3.3V		212	280	mA
• Rx mode Current 1.8V		141	170	mA
• Rx mode Current 3.3V		0.2	10	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) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-79	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB



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

**Table 65: Characteristic Values for IEEE 802.11ac (VHT80) - 5 GHz**

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

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

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 12 dBm at module pad, MCS9 mode

**Table 66: High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz**

Item	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode Current 1.8V		243	310	mA
• Tx mode Current 3.3V		177	250	mA
• Rx mode Current 1.8V		172	200	mA
• Rx mode Current 3.3V		0.2	10	mA
<b>Tx Characteristics</b>	Minimum	Typical	Maximum	Unit
Output Power	10	12	14	dBm
<b>Spectrum Mask Margin</b>				
• 39 MHz to 41 MHz (0 ~ -20 dBr)	0			dB
• 41 MHz to 80 MHz (-20 ~ -28 dBr)	0			dB
• 80 MHz to 120 MHz (-28 ~ -40 dBr)	0			dB
• 120 MHz to 140 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
<b>Spurious Emissions</b>				
• 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
<b>Rx Characteristics</b>	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-51	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

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

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

**Table 67: Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		250	310	mA
• Tx mode Current 3.3V		208	290	mA
• Rx mode Current 1.8V		172	200	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power	12	14	16	dBm
Spectrum Mask Margin				
• 39 MHz to 41 MHz (0~ -20 dBr)	0			dB
• 41 MHz to 80 MHz (-20~ -28 dBr)	0			dB
• 80 MHz to 120 MHz (-28~ -40 dBr)	0			dB
• 120 MHz to 140 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30-47 MHz (BW = 100 kHz)			-36	dBm
• 47-74 MHz (BW = 100 kHz)			-54	dBm
• 74-87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5-118 MHz (BW = 100 kHz)			-54	dBm
• 118-174 MHz (BW = 100 kHz)			-36	dBm
• 174-230 MHz (BW = 100 kHz)			-54	dBm
• 230-470 MHz (BW = 100 kHz)			-36	dBm
• 470-862 MHz (BW = 100 kHz)			-54	dBm
• 862-1000 MHz (BW = 100 kHz)			-36	dBm
• 1000-5150 MHz (BW = 1 MHz)			-30	dBm
• 5350-5470 MHz (BW = 1 MHz)			-30	dBm
• 5725-26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-76	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

## 12.15 DC/RF Characteristics for IEEE802.11ax (HE80) - 5GHz

**Table 68: Characteristics for IEEE802.11ax (HE80) - 5GHz**

Contents	Items
Specification	IEEE 802.11ax
Mode	OFDM
Channel Frequency	5210 to 5775 MHz
Data Rate	MCS0 - MCS11

### 12.15.1 High-Rate Condition for IEEE802.11ax (HE80) – 5GHz

**Conditions:** 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 10 dBm at module pad, MCS11 mode

**Table 69: High-Rate Condition for IEEE802.11ax (HE80) – 5GHz**

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		236	310	mA
• Tx mode Current 3.3V		161	220	mA
• Rx mode Current 1.8V		172	200	mA
• Rx mode Current 3.3V		0.2	10	mA
Tx Characteristics				
	Minimum	Typical	Maximum	Unit
Output Power	8	10	12	dBm
Spectrum Mask Margin				
• 39 MHz to 41 MHz (0 ~ -20 dBr)	0			dB
• 41 MHz to 80 MHz (-20 ~ -28 dBr)	0			dB
• 80 MHz to 120 MHz (-28 ~ -40 dBr)	0			dB
• 120 MHz to 140 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics				
	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-51	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

## 12.15.2 Low-Rate Condition for IEEE802.11ax (HE80) - 5GHz

**Normal Condition:** 25 °C, VBAT = 3.3V, MCS0 mode unless otherwise specified.

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

**Table 70: Low-Rate Condition for IEEE802.11ax (HE80) – 5GHz**

Item	Contents			
	Minimum	Typical	Maximum	Unit
<b>DC Characteristics</b>				
DC Current				
• Tx mode Current 1.8V		254	310	mA
• Tx mode Current 3.3V		211	290	mA
• Rx mode Current 1.8V		172	200	mA
• Rx mode Current 3.3V		0.2	10	mA
<b>Tx Characteristics</b>	Minimum	Typical	Maximum	Unit
Output Power	12	14	16	dBm
Spectrum Mask Margin				
• 39 MHz to 41 MHz (0 ~ -20 dBr)	0			dB
• 41 MHz to 80 MHz (-20 ~ -28 dBr)	0			dB
• 80 MHz to 120 MHz (-28 ~ -40 dBr)	0			dB
• 120 MHz to 140 MHz (-40 dBr)	0			dB
Constellation Error (EVM) (Measured at enhanced mode)			-32	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 5150 MHz (BW = 1 MHz)			-30	dBm
• 5350 - 5470 MHz (BW = 1 MHz)			-30	dBm
• 5725 - 26000 MHz (BW = 1 MHz)			-30	dBm
<b>Rx Characteristics</b>	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 10%)			-76	dBm
Maximum Input Level (PER ≤ 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-9			dB

## 12.16 DC/RF Characteristics for Bluetooth

**Table 71: Characteristics Values for Bluetooth**

Contents	Items
Bluetooth Specification (power class)	Version 5.3 (Class 1)
Channel Frequency (spacing)	2402 to 2480 MHz (1 MHz)
Number of RF Channel	79

### 12.16.1 Basic Data Rate Condition

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

**Table 72: Basic Data Rate Condition**

Item	Contents			
Current Consumption	Minimum	Typical	Maximum	Unit
• Tx mode DH5 Current 1.8V		323	390	mA
• Tx mode DH5 Current 3.3V		0.2	3	mA
• Rx mode DH5 Current 1.8V		123	150	mA
• Rx mode DH5 Current 3.3V		0.2	3	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power@DH5		13	16	dBm
Frequency Range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power <sup>3</sup>				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
Modulation Characteristics				
• Modulation $\Delta f_{1\text{avg}}$	140	151	175	kHz
• Modulation $\Delta f_{2\text{max}}$	115			kHz
• Modulation $\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}$	0.8	1		
Carrier Frequency Drift				
• 1 slot	-25		25	kHz
• 3 slot / 5 slot	-40		40	kHz
• Maximum drift rate			20	kHz/50 $\mu$ s
Rx Characteristics	Minimum	Typical	Maximum	Unit
BR Sensitivity (BER ≤ 0.1%)		-96	-70	dBm
Maximum Input Level (BER ≤ 0.1%)	-20			dBm

<sup>3</sup> Up to three spurious responses within Bluetooth limits are allowed.

## 12.16.2 Enhanced Data Rate Condition

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

Table 73: Enhance Data Rate Condition

Item	Contents			
Current Consumption	Minimum	Typical	Maximum	Unit
• Tx mode 2DH5 Current 1.8V		192	240	mA
• Tx mode 2DH5 Current 3.3V		0.2	3	mA
• Rx mode 2DH5 Current 1.8V		123	150	mA
• Rx mode 2DH5 Current 3.3V		0.2	3	mA
• Tx mode 3DH5 Current 1.8V		191	240	mA
• Tx mode 3DH5 Current 3.3V		0.2	3	mA
• Rx mode 3DH5 Current 1.8V		123	150	mA
• Rx mode 3DH5 Current 3.3V		0.2	3	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power@2DH5/3DH5		5	8	dBm
Frequency Range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power <sup>4</sup>				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
EDR Relative Power	-4		1	dB
EDR Carrier Frequency Stability and Modulation Accuracy				
• $\omega_i$	-75		75	kHz
• $\omega_i + \omega_o$	-75		75	kHz
• $\omega_o$	-10		10	kHz
• RMS DEVM (DQPSK)			20	%
• Peak DEVM (DQPSK)			35	%
• 99% DEVM (DQPSK)			30	%
• RMS DEVM (8 DPSK)			13	%
• Peak DEVM (8 DPSK)			25	%
• 99% DEVM (8 DPSK)			20	%
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
EDR Sensitivity (BER ≤ 0.007%) @ 8DPSK		-88	-70	dBm
Maximum Input Level (BER ≤ 0.1%)	-20			dBm

<sup>4</sup> Up to three spurious responses within Bluetooth limits are allowed.

## 12.17 DC/RF Characteristics for Bluetooth Low Energy

**Table 74: Characteristics Values for Bluetooth Low Energy**

Contents	Items
Bluetooth Specification (power class)	Version 5.3 (Class 1.5)
Channel Frequency (spacing)	2402 to 2480 MHz (2 MHz)
Number of RF Channel	40

## 12.17.1 1 Mbps PHY Condition

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

Table 75: 1 Mbps PHY Condition

Item	Contents			
Current Consumption	Minimum	Typical	Maximum	Unit
• Tx mode Current 1.8V		325	390	mA
• Tx mode Current 3.3V		0.2	3	
• Rx mode Current 1.8V		123	150	mA
• Rx mode Current 3.3V		0.2	3	
Tx Characteristics	Minimum	Typical	Maximum	Unit
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF channel		40		
Output power		13	16	dBm
In-band emission				
• $f_{TX} \pm 2$ MHz			-20	dBm
• $f_{TX} \pm [3+n]$ MHz; $n = 0, 1, 2, \dots$			-30	dBm
Modulation Characteristics				
• $\Delta f_{1avg}$	225		275	kHz
• $\Delta f_{2max}$ (at 99.9%)	185			kHz
• $\Delta f_{2avg} / \Delta f_{1avg}$	0.8			
Stable Modulation Characteristics				
• $\Delta f_{1avg}$	247.5		252.5	kHz
• $\Delta f_{2max}$ (at 99.9%)	185			kHz
• $\Delta f_{2avg} / \Delta f_{1avg}$	0.8			
Carrier Frequency Offset and Drift				
• Frequency offset ( $f_n$ ); $n = 0, 1, 2, 3, \dots, k$	-150		150	kHz
• Frequency drift ( $ f_0 - f_n $ ); $n = 2, 3, 4, \dots, k$			50	kHz
• Drift Rate				
• $ f_1 - f_0 $			23	kHz
• $ f_n - f_{n-5} $ ; $n = 6, 7, 8, \dots, k$			20	kHz
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Receiver sensitivity (PER < 30.8%)		-97	-70	dBm
Maximum input signal level (PER < 30.8%)	-10			dBm
PER Report Integrity (-30 dBm input)	50		65.4	%



## 12.17.2 2 Mbps PHY Condition

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

Table 76: 2 Mbps PHY Condition

Item	Contents			
Current Consumption	Minimum	Typical	Maximum	Unit
• Tx mode Current 1.8V		344	390	mA
• Tx mode Current 3.3V		0.2	3	mA
• Rx mode Current 1.8V		123	150	mA
• Rx mode Current 3.3V		0.2	3	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF channel		40		
Output power		13	16	dBm
In-band emission				
• $f_{TX} \pm 4$ MHz			-20	dBm
• $f_{TX} \pm 5$ MHz			-20	dBm
• $f_{TX} \pm [6+n]$ MHz; $n=0,1,2\dots$			-30	dBm
Modulation Characteristics				
• $\Delta f_{1\text{avg}}$	450		550	kHz
• $\Delta f_{2\text{max}}$ (at 99.9%)	370			kHz
• $\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}$	0.8			
Stable Modulation Characteristics				
• $\Delta f_{1\text{avg}}$	495		505	kHz
• $\Delta f_{2\text{max}}$ (at 99.9%)	370			kHz
• $\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}$	0.8			
Carrier Frequency Offset and Drift				
• Frequency offset ( $f_n$ ); $n = 0, 1, 2, 3\dots k$	-150		150	kHz
• Frequency drift ( $ f_0 - f_n $ ); $n = 2, 3, 4\dots k$			50	kHz
• Drift Rate				
• $ f_1 - f_0 $			23	kHz
• $f_n - f_{n-5}$ ; $n = 6, 7, 8\dots k$			20	kHz
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Receiver sensitivity (PER < 30.8%)		-97	-70	dBm
Maximum input signal level (PER < 30.8%)	-10			dBm
PER Report Integrity (-30 dBm input)	50		65.4	%

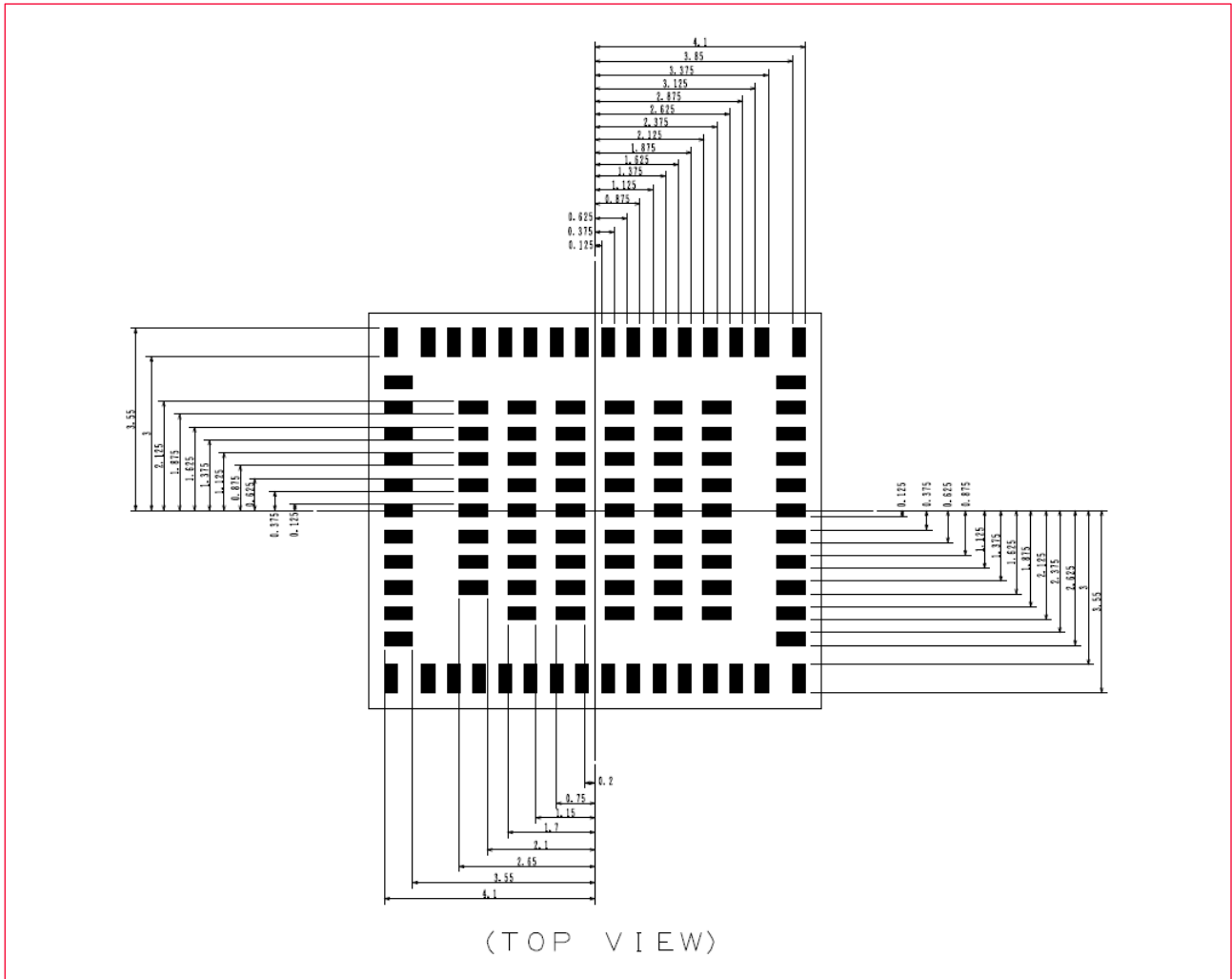
## 12.18 DC/RF Characteristics for 802.15.4

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode Current 1.8V		392	550	mA
• Tx mode Current 3.3V		0.2	3	mA
• Rx mode Current 1.8V		120	150	mA
• Rx mode Current 3.3V		0.2	3	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power	12	15	18	dBm
Spectrum Mask Margin				
Transmit power spectral density (PSD) mask	-	-	-30	dB
Modulation Accuracy	-	-	35	%
Frequency Tolerance	-40		40	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 12750 MHz (BW = 1 MHz)			-30	dBm
Rx Characteristics	Minimum	Typical	Maximum	Unit
Minimum Input Level (PER ≤ 1%)	-	-	-85	dBm
Maximum Input Level (FER ≤ 1%)	-20	-	-	dBm
Adjacent Channel Rejection (FER < 1%)	0	-	-	dB

# 13 Land Pattern

Figure 23 shows land pattern of Type 2EL.

Figure 23: Land Pattern (Unit: mm)



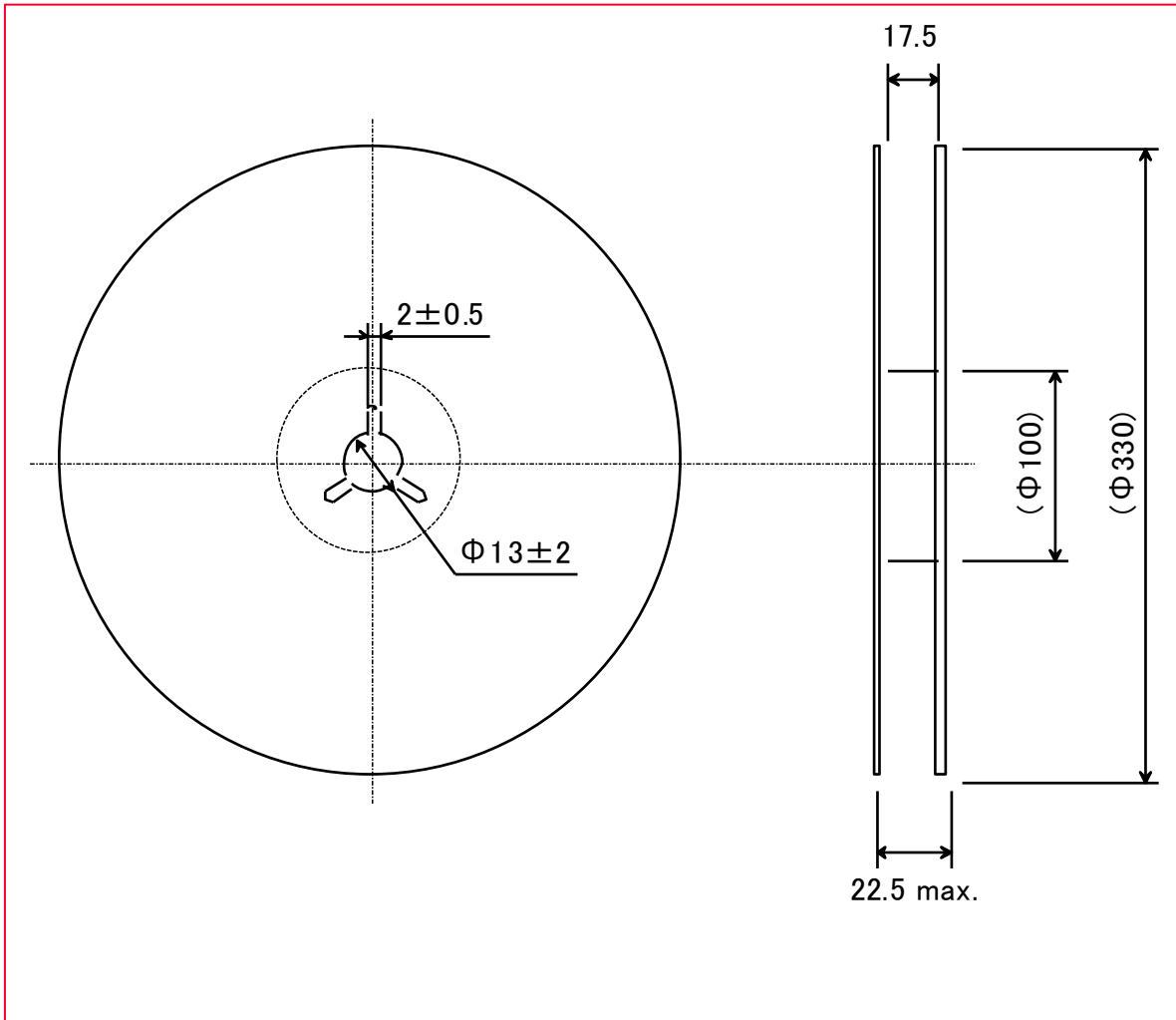
To avoid the short-circuit between the side shielding and a solder on the module land after the reflow, please locate the module land at 0.2 mm away from module outline as above figure.



## 14.2 Dimensions of Reel

Figure 25 shows the reel dimensions.

Figure 25: Dimensions of Reel (Unit: mm)



### 14.3 Taping Diagrams

Figure 26 shows the taping diagrams.

Figure 26: Taping Diagrams

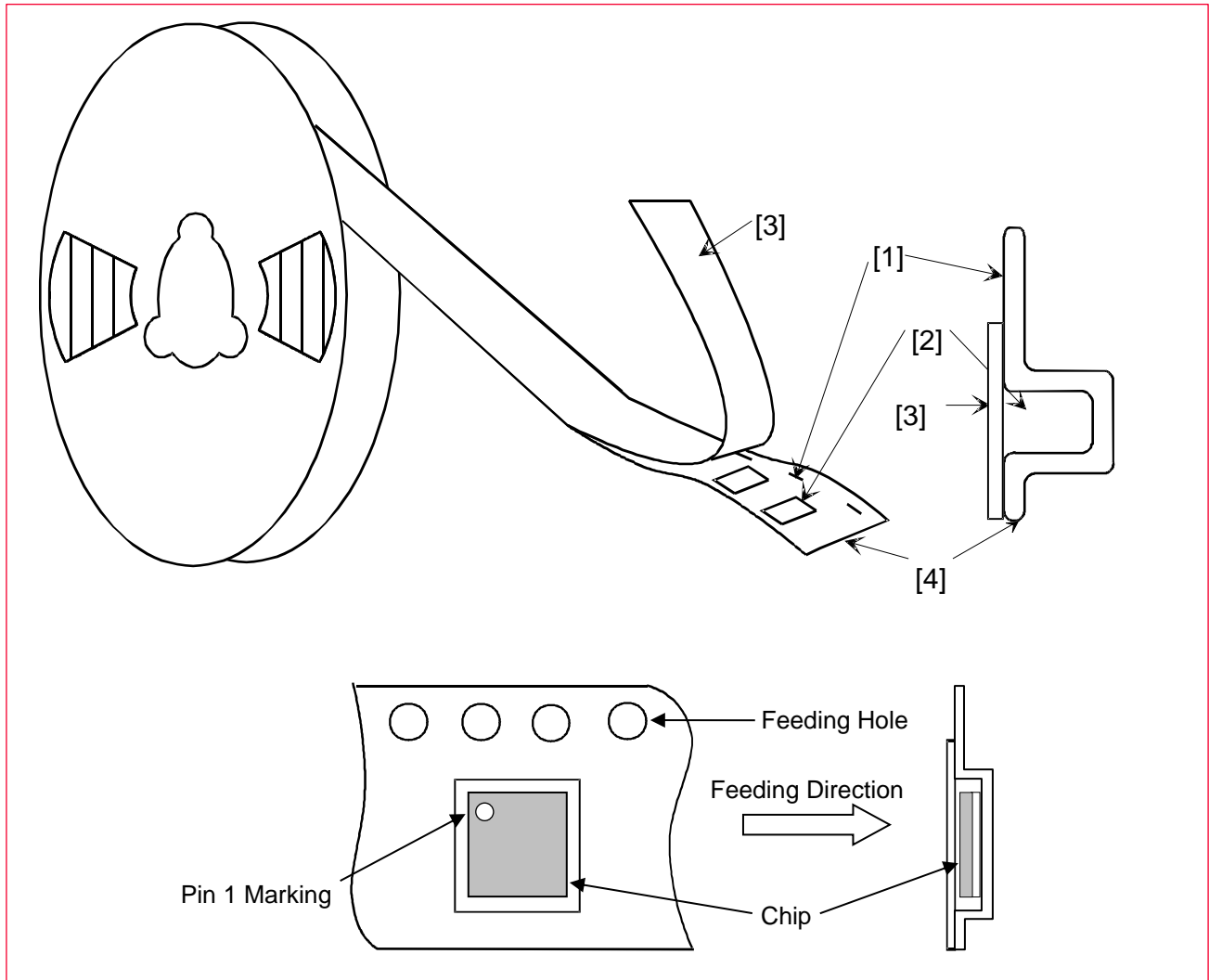


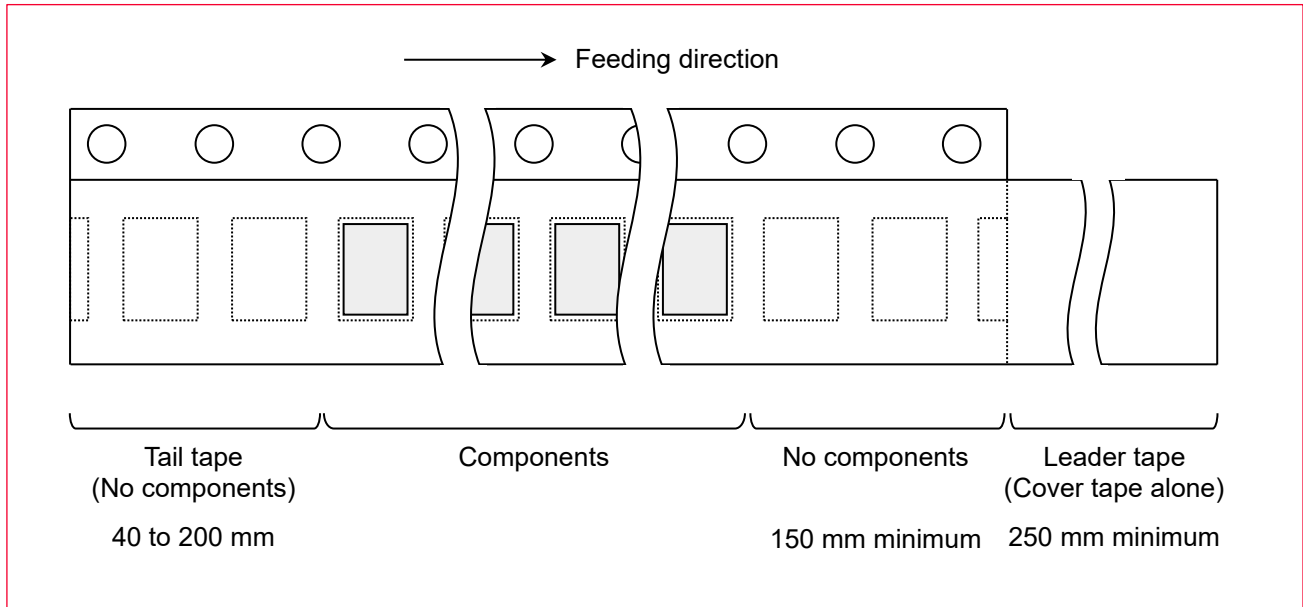
Table 77: Taping Specifications

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

## 14.4 Leader and Tail Tape

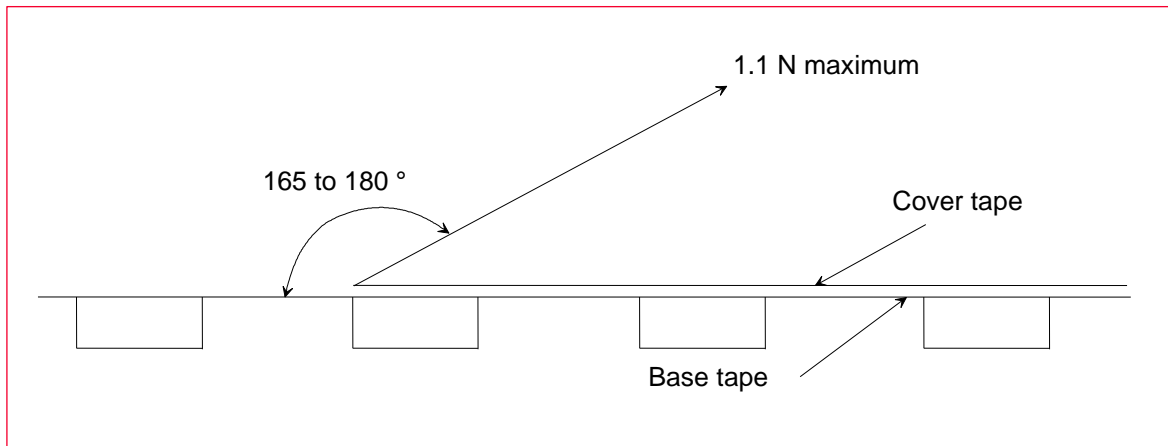
The leader and tail tape are shown in **Figure 27**

**Figure 27: Leader and Tail Tape**



- The tape for chips is wound clockwise, the feeding holes to the right side as the tape is pulled toward the user.
- The cover tape and base tape are not adhered at no components area for 250 mm minimum.
- Tear off strength against pulling of cover tape: 5 N minimum.
- Packaging unit: 1000 pcs./ reel
- Material
  - Base tape: Plastic
  - Reel: Plastic
  - Cover tape, cavity tape and reel are made the anti-static processing.
- Peeling off force: 1.1 N maximum. in the direction of peeling as shown in **Figure 28**

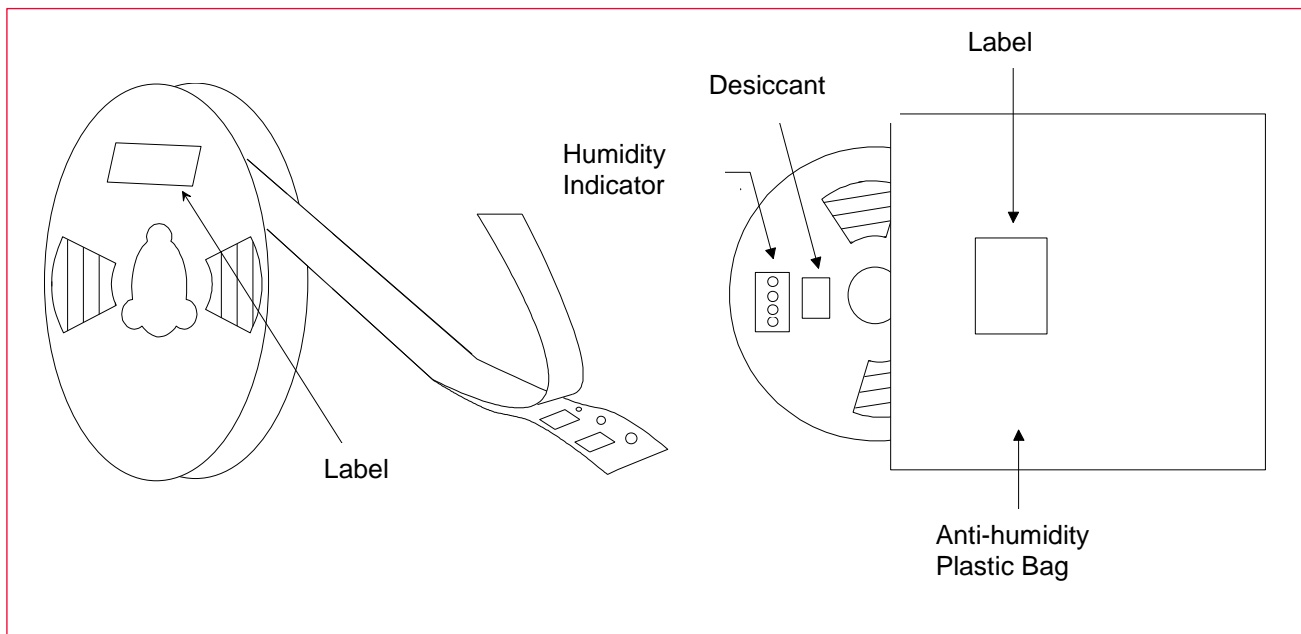
**Figure 28: Peeling Force**



## 14.5 Packaging (Humidity Proof Packing)

The packaging is shown in **Figure 29**

**Figure 29: Humidity Proof Packing**



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



## 15 Notice

### 15.1 Storage Conditions

- Please use this product within 6 months after receipt.
- The product shall be stored without opening the packing under the ambient temperature from 5 to 35 °C and humidity from 20 ~ 70 %RH (Packing materials, in particular, may be deformed at the temperature over 40 °C).
- The product left more than 6 months after reception; it needs to be confirmed the solderability before used.
- The product shall be stored in noncorrosive gas (Cl<sub>2</sub>, NH<sub>3</sub>, SO<sub>2</sub>, NO<sub>x</sub>, etc.).
- Any excess mechanical shock including, but not limited to, sticking the packing materials by sharp object, and dropping the product, shall not be applied in order not to damage the packing materials.
- This product is applicable to MSL3 (Based on IPC/JEDEC J-STD-020)
  - After the packing opened, the product shall be stored at <30 °C / <60 %RH and the product shall be used within 168 hours.
  - When the color of the indicator in the packing changed, the product shall be baked before soldering.
- Baking condition: 125 +5/-0 °C, 24 hours, 1 time
- The products shall be baked on the heat-resistant tray because the materials (Base Tape, Reel Tape and Cover Tape) are not heat-resistant.

### 15.2 Handling Conditions

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

### 15.3 Standard PCB Design (Land Pattern and Dimensions)

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

## 15.4 Notice for Chip Placer

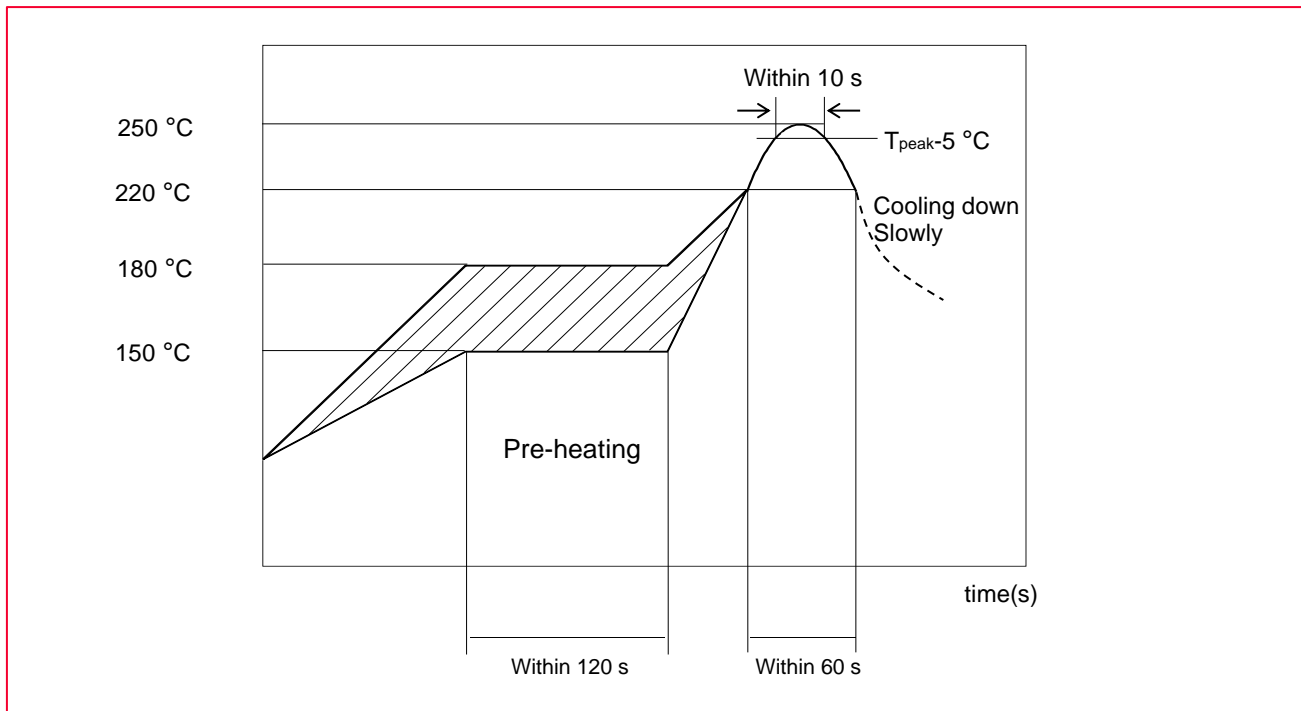
When placing products on the PCB, products may be stressed and broken by uneven forces from a worn-out chucking locating claw or a suction nozzle. To prevent products from damages, be sure to follow the specifications for the maintenance of the chip placer being used. For the positioning of products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

## 15.5 Soldering Conditions

The recommendation conditions of soldering are shown in **Figure 30**.

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

**Figure 30: Reflow soldering standard conditions (Example)**



Please use the reflow within 2 times.

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

## 15.6 Cleaning

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

## 15.7 Operational Environment Conditions

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

- In an atmosphere containing corrosive gas (Cl<sub>2</sub>, NH<sub>3</sub>, SO<sub>x</sub>, NO<sub>x</sub> etc.).
- In an atmosphere containing combustible and volatile gases.
- Dusty place.
- Direct sunlight place.
- Water splashing place.
- Humid place where water condenses.
- Freezing place.



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



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

## 16 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.

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- Undersea equipment.
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- Medical equipment.
- Traffic signal equipment.

- Burning / explosion control equipment.
- Disaster prevention / crime prevention equipment.
- Transportation equipment (vehicles, trains, ships, elevator, etc.).
- Application of similar complexity and/ or reliability requirements to the applications listed in the above.
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## Revision History

Revision Code	Date	Changed Item	Comments
	2021.12.14	First Issue	
A	2022.07.15	4. Block Diagram 7.1. Pin Assignments  7.2. Pin Descriptions  14. Reference Circuit	<ul style="list-style-type: none"> <li>Remove external sleep clock</li> <li>Change SLP_CLK_IN to DNC</li> <li>Change Pin name: ANT → ANT0, BT_15.4_OUT → ANT1</li> <li>Change SLP_CLK_IN to DNC</li> <li>Change Pin name: ANT → ANT0, BT_15.4_OUT → ANT1</li> <li>Change SLP_CLK_IN to DNC</li> <li>Change Pin name: ANT → ANT0, BT_15.4_OUT → ANT1</li> </ul>
B	2022.09.05	4. Block Diagram 14. Reference Circuit	<ul style="list-style-type: none"> <li>Update</li> <li>Update reference circuit based on latest information</li> </ul>
C	2022.11.04	Bluetooth version 4 Block Diagram 8. Absolute Maximum Ratings	<ul style="list-style-type: none"> <li>Update to 5.3</li> <li>Update</li> <li>Revise value</li> </ul>
D	2023.01.20	7.2 Pin Descriptions 7.4 Pin States  10.1 Power Up Sequence 10.2 Power Down Sequence 10.3 Hot Reset Sequence 11.4 802.15.4 SPI Timing 12 DC/RF Characteristics  14. Reference Circuit  16. Tape and Reel Packaging	<ul style="list-style-type: none"> <li>Update the description of Pin #3</li> <li>Added comment on termination of open pins.</li> <li>Update the sequence picture.</li> <li>Add power down sequence.</li> <li>Add hot reset sequence.</li> <li>Add SPI I/F timing sequence.</li> <li>Add 802.11ax 2.4GHz HE20, 5GHz HE 20/40/80 and low/high rate table</li> <li>Add uFL/trace dedicated antenna circuit.</li> <li>Update from TBD</li> </ul>
E	2023.01.27	2. Key Features 3. Ordering Information  14. Reference Circuit 15. Notice	<ul style="list-style-type: none"> <li>Updated information.</li> <li>Added Embedded Artists' M.2 module information.</li> <li>Moved section to HW app note.</li> <li>Moved section to before Preconditions section.</li> </ul> <p>Updated to new format</p>
F	2023.02.02	12 DC/RF Characteristics	<ul style="list-style-type: none"> <li>Update Tx Power value</li> </ul>
G	2023.02.13	5.2 Bluetooth Qualification 7.1 Pin Assignments  7.2 Pin Descriptions  7.4 Pin States	<ul style="list-style-type: none"> <li>Add QDID</li> <li>Change pin name on Table 6: Terminal Configurations (JTAG pins are changed to "Reserved", GPIO[21] to "SD_INT", GPIO[23] to "Reserved", and GPIO[27] to "Reserved")</li> <li>Change pin name</li> <li>Add description on PCM_DOUT/DIN</li> <li>Change Pin name on Table 9: I/O State Table</li> </ul>

Revision Code	Date	Changed Item	Comments
H	2023.5.30	4. Block Diagram 5.1 Radio Certification 7.4 Pin States 9.2 External Sleep Clock Requirements 10.1 Power-On Sequence 10.2 Power-Off Sequence 11.1.4 SDR104 Modes (up to 208 MHz) at 1.8V 12 DC/RF Characteristics 15 Radio Regulatory Certification by Country for LBES5PL2EL	<ul style="list-style-type: none"> <li>• Revise figure</li> <li>• Revise figure</li> <li>• Update Certification information</li> <li>• Int'l Pull Value 90k<math>\Omega</math> → 100k<math>\Omega</math></li> <li>• Remove this section</li> <li>• Revise figure</li> <li>• Update</li> <li>• Update information</li> <li>• Update</li> </ul>
I	2023.7.11	9.3 Package Thermal Conditions 14.3 Trace Antenna (Shared Antenna) 14.4 Trace Antenna (Dedicated Antenna)	<ul style="list-style-type: none"> <li>• Update</li> <li>• Revise figure</li> <li>• Revise figure</li> </ul>
J	2023.10.11	4 Block Diagram 5.1 Radio Certification 5.2 Radio Regulatory Certification by Country 6 Dimensions, Markings and Terminal Configurations 7.1 Pin Assignments 7.2 Pin Descriptions	<ul style="list-style-type: none"> <li>• Revise figure</li> <li>• Update Japan certification ID</li> <li>• Add new information.</li> <li>• Revise figure</li> <li>• Revise figure</li> <li>• Revise list</li> </ul>
K	2023.10.20	5.1 Radio Certification 5.2 Radio Regulatory Certification by Country	<ul style="list-style-type: none"> <li>• Revise ISED No.</li> <li>• Revise link name</li> </ul>
L	2024.1.25	12 DC/RF Characteristics 12.4.1 High-Rate Condition for IEEE 802.11ax (HE20) – 2.4GHz 12.5 DC/RF Characteristics for IEEE 802.11n (HT40) – 2.4 GHz 12.6 DC/RF Characteristics for IEEE 802.11ax (HE40) – 2.4GHz 12.8.1 High-Rate Condition for IEEE 802.11ax (HE20) – 5GHz 12.5.2 Low-Rate Condition for IEEE 802.11a - 5 GHz 14.4 Leader and Tail Tape	<ul style="list-style-type: none"> <li>• Add configuration files information.</li> <li>• Correct Minimum Input Level.</li> <li>• Add spec information.</li> <li>• Add spec information.</li> <li>• Correct Minimum Input Level.</li> <li>• Revise current power.</li> <li>• Correct packaging unit</li> </ul>



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