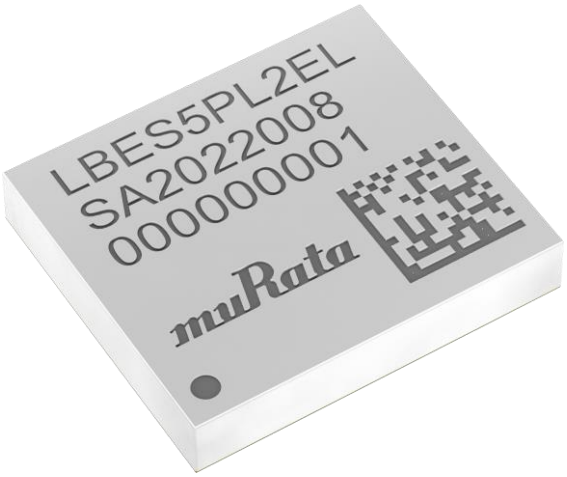
Datasheet

Wi-Fi® + Bluetooth® + 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. G

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

1 Scope

This specification characterizes the IEEE 802.11 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 802.11a/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

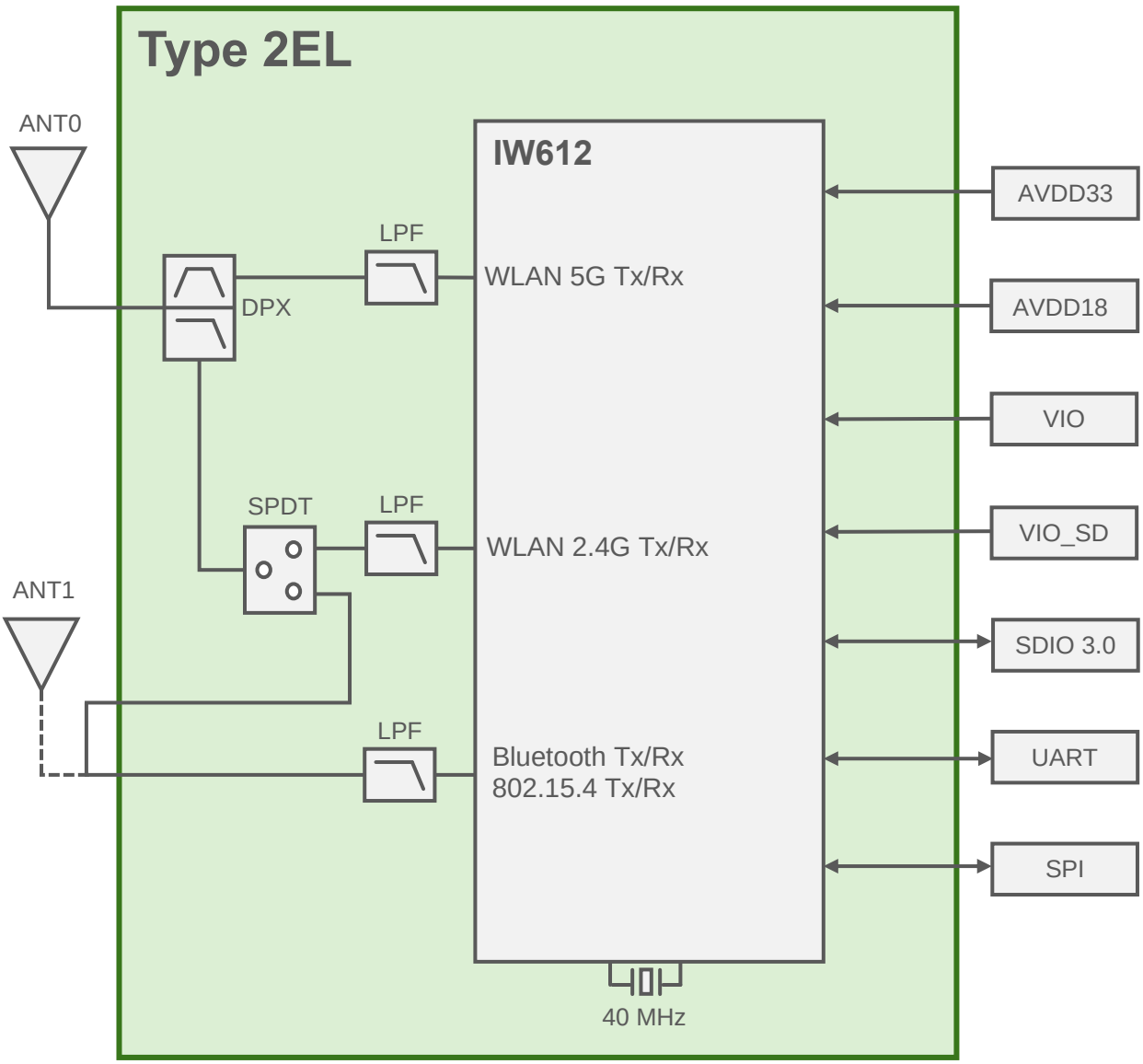
Ordering Part Number	Description
LBES5PL2EL-923	Module order
LBES5PL2EL-SMP	Sample module order (If module samples are not available through distribution, contact Murata referencing this part number)
EAR00409	Embedded Artists Type 2EL M.2 EVB (default EVB available through distribution)
LBES5PL2EL-EVB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

Table 3 shows the radio certification information.

Table 3: Radio Certification

Country	ID	Country Code
USA	TBD	US
Canada	TBD	CA
Europe	TBD	DE
Japan	TBD	JP

5.2 Bluetooth Qualification

- QDID: 202018

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

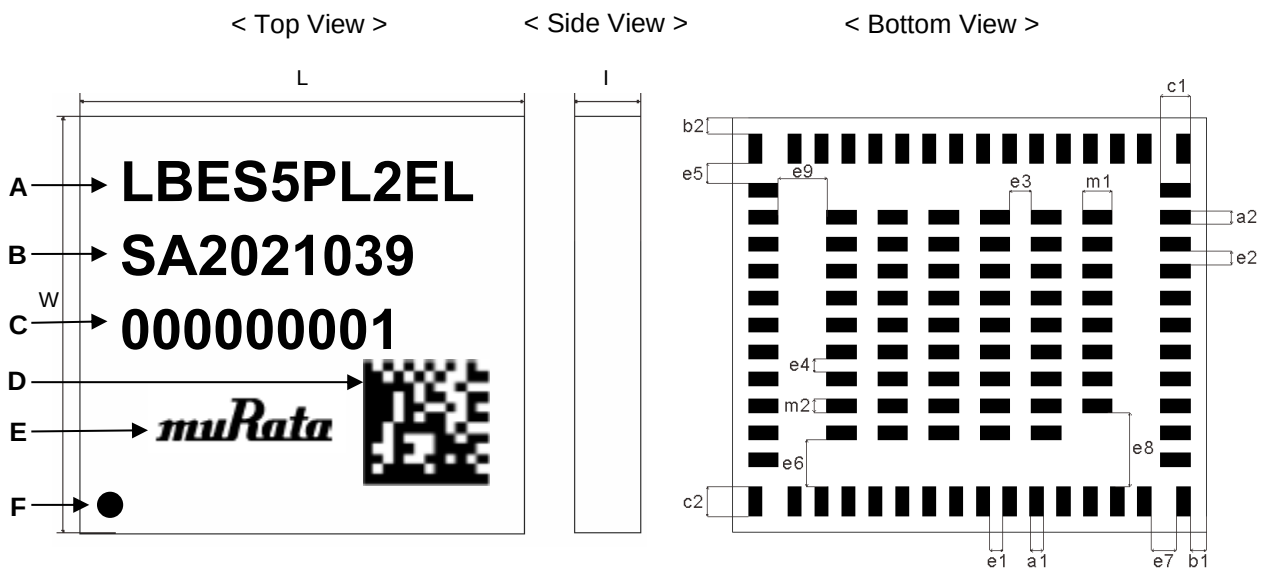


Table 4 describes the Type 2EL markings.

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.

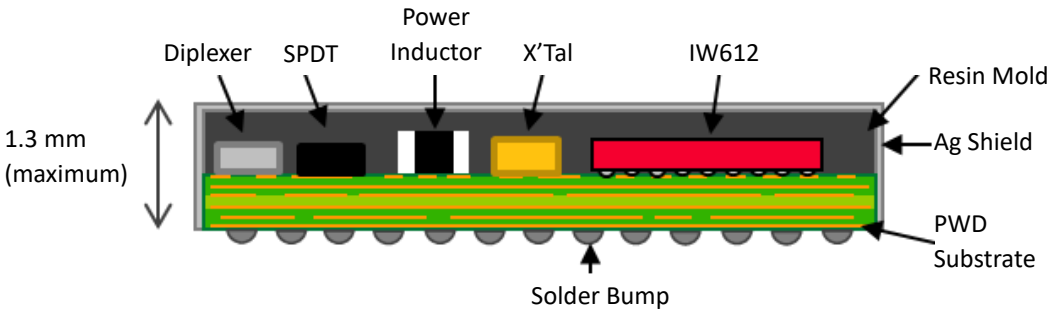
Table 5: Dimensions

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

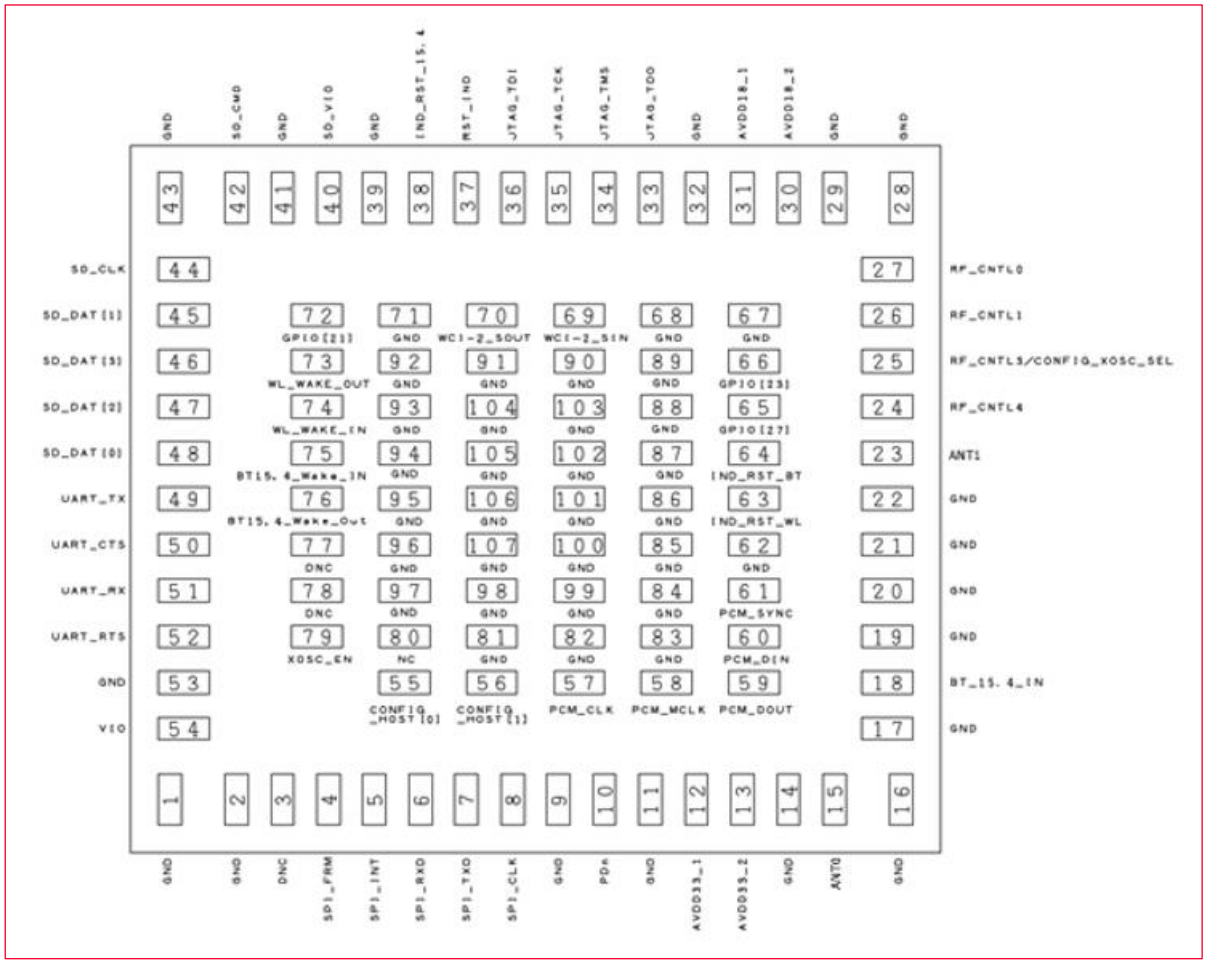


Table 6 lists the Type 2EL terminal configurations.

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	DNC	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

No.	Terminal Name	No.	Terminal Name	No.	Terminal Name	No.	Terminal Name
14	GND	42	SD_CMD	70	WCI-2_SOUT	98	GND
15	ANT0	43	GND	71	GND	99	GND
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	DNC	105	GND
22	GND	50	UART_CTS	78	DNC	106	GND
23	ANT1	51	UART_RX	79	XOSC_EN	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	GPIO[13]/SPI_FRM	SPI frame input signal Multi-functional pin: GPIO[13] input/output
5	SPI_INT	I/O	GPIO[20]/SPI_INT	SPI interrupt output signal. Multi-functional pin: GPIO[20] input/output
6	SPI_RXD	I/O	GPIO[14]/SPI_RXD	SPI receive input signal Multi-functional pin: GPIO[14] input/output
7	SPI_TXD	I/O	GPIO[15]/SPI_TXD	SPI transmit output signal Multi-functional pin: GPIO[15] input/output
8	SPI_CLK	I/O	GPIO[12]/SPI_CLK	SPI clock input signal Multi-functional pin: GPIO[12] input/output
9	GND			Ground
10	PDn	I	PDn	Full Power-down (input) (active low) 0 = full power-down mode 1 = normal mode • PDn can accept an input of 1.8V to 4.5V

No.	Terminal Name	Type	Connection to IC Terminal	Description
				• 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.
11	GND			Ground
12	AVDD33_1	Power	AVDD33	Power supply
13	AVDD33_2	Power	AVDD33	Power supply
14	GND			Ground
15	ANT0	I/O		ANT0 is WLAN output and it's also used for BT/802.15.4 output when Shared ANT 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 shared ANT mode.
24	RF_CNTL4	I/O		RF control line 4
25	RF_CNTL3/ CONFIG_XOSC_SEL			Reference clock frequency select RF control line 3
26	RF_CNTL1	O		RF control line 1
27	RF_CNTL0	O		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 Multi-functional pin: GPIO[22] input/output

No.	Terminal Name	Type	Connection to IC Terminal	Description
38	IND_RST_15.4	I/O	GPIO[24]/ IND_RST_15.4	Independent software reset for 802.15.4 radio[1] Multi-functional pin: GPIO[24] input/output
39	GND			Ground
40	SD_VIO	Power		Power supply
41	GND			Ground
42	SD_CMD	I/O		
43	GND			Ground
44	SD_CLK	I	SD_CLK	
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	GPIO[11]/UART_TX	UART serial output signal Multi-functional pin: GPIO[11] input/output
50	UART_CTS	I/O	GPIO[8]/UART_CTS	UART clear-to-send input signal Multi-functional pin: GPIO[8] input/output
51	UART_RX	I/O	GPIO[10]/UART_RX	UART serial input signal Multi-functional pin: GPIO[10] input/output
52	UART_RTS	I/O	GPIO[9]/UART_RTS	UART request-to-send output signal Multi-functional pin: GPIO[9] input/output
53	GND			Ground
54	VIO	Power		Power supply
55	CONFIG_HOST[0]	I/O	CONFIG_HOST[0]	Firmware Boot Option Refer to sec 7.3 Configuration Pins
56	CONFIG_HOST[1]	I/O	CONFIG_HOST[1]	Firmware Boot Option Refer to sec 7.3 Configuration Pins
57	PCM_CLK	I/O	GPIO[4]/PCM_CLK	PCM clock signal. GPIO[4] input/output • Central mode: output • Peripheral mode: input
58	PCM_MCLK	I/O	GPIO[3]/PCM_MCLK	PCM codec main clock signal (optional). GPIO[3] input/output Optional clock used for some codecs. Derived from PCM_CLK.
59	PCM_DOUT	I/O	GPIO[5]/PCM_DOUT	PCM transmit data signal (output). *Connect to PCM audio codec input data (for playback). GPIO[5] input/output
60	PCM_DIN	I/O	GPIO[6]/PCM_DIN	PCM transmit data signal (input). *Connect to PCM audio codec output data (for recording). GPIO[6] input/output
61	PCM_SYNC	I/O	GPIO[7]/PCM_SYNC	PCM sync pulse signal. GPIO[7] input/output • Central mode: output

[1] 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
				• Peripheral mode: input
62	GND			Ground
63	IND_RST_WL	I/O	GPIO[1]/IND_RST_WL	Independent software reset for Wi-Fi Multi-functional pin: GPIO[1] input/output
64	IND_RST_BT	I/O	GPIO[2]/IND_RST_BT	Independent software reset for Bluetooth *1 Multi-functional pin: GPIO[2] input/output
65	Reserved	I/O	GPIO[27]	Programable GPIO Pin
66	Reserved	I/O	GPIO[23]	Programable 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
71	GND			Ground
72	SD_INT	I/O	GPIO[21]/SD_INT	Out-of-band SDIO interface interrupt signal. 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	XOSC_EN	I/O	GPIO[0]/XOSC_EN	Oscillator Enable (output) (active high) Used to enable an external oscillator. XOSC_EN signal can be used ONLY when an external oscillator clock is used. • 0 = disable external oscillator • 1 = enable external oscillator Note: Muxed with GPIO[0].
80	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	90kΩ
SPI_INT	VIO	tristate	input	input	drive low	Yes	nominal PU	90kΩ
SPI_RXD	VIO	tristate	input	input	tristate	Yes	nominal PU	90kΩ
SPI_TXD	VIO	tristate	output low	output low	drive low	yes	nominal PU	90kΩ
SPI_CLK	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ
RST_IND	VIO	tristate	output high	output low	tristate	yes	nominal PU	90kΩ
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	90kΩ
UART_CTS	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ
UART_RX	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ
UART_RTS	VIO	tristate	output high	output high	drive high	yes	nominal PU	90kΩ
PCM_CLK	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
PCM_MCLK	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ
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	90kΩ
IND_RST_WL	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ
IND_RST_BT	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ
GPIO[27]	VIO	tristate	input	input	tristate	yes	weak PU	800kΩ
GPIO[23]	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ

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	90kΩ
WCI-2_SOUT	VIO	tristate	input	input	tristate	yes	nominal PU	90kΩ
SD_INT	VIO	tristate	output high	output low	drive low	yes	nominal PU	90kΩ
WL_WAKE_OUT	VIO	tristate	input	input	drive low	yes	nominal PU	90kΩ
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	90kΩ
XOSC_EN	VIO	tristate	input	input	drive low	yes	nominal PU	90kΩ
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	90kΩ
SD_CMD	VIO_SD	tristate	input	input	tristate	yes	nominal PU	90kΩ
SD_CLK	VIO_SD	tristate	input	input	tristate	yes	nominal PU	90kΩ
SD_DAT[1]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	90kΩ
SD_DAT[3]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	90kΩ
SD_DAT[2]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	90kΩ
SD_DAT[0]	VIO_SD	tristate	input	input	tristate	yes	nominal PU	90kΩ
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

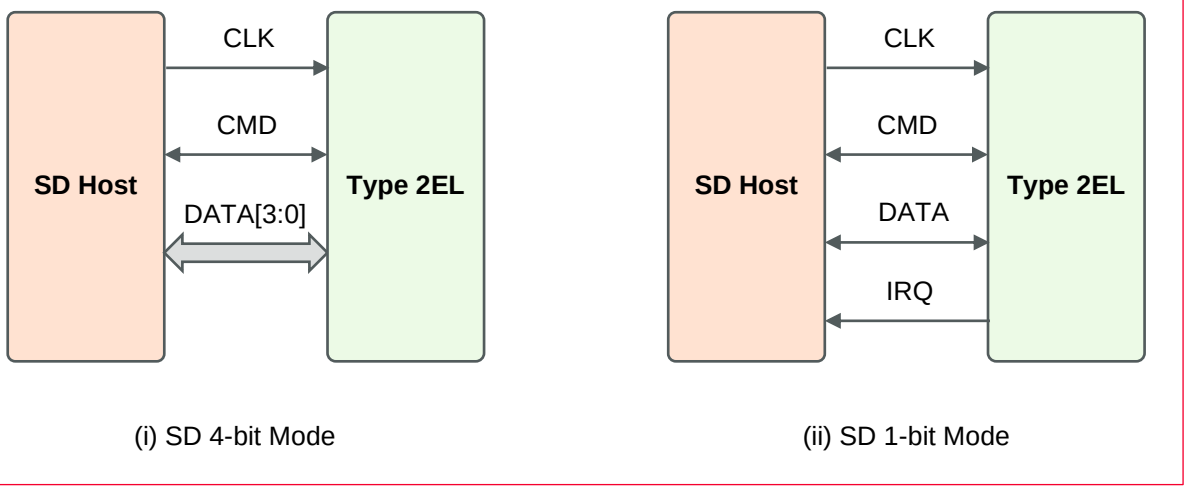
Table 10 shows the SDIO pin descriptions.

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

Parameter		Minimum	Maximum	Unit
			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 External Sleep Clock Requirements

Type 2EL external sleep clock requirement parameters are described in **Table 13**.

Table 13: External Sleep Clock Requirements

Parameter	Minimum	Typical	Maximum	Unit
Clock frequency range/accuracy • CMOS input clock signal type • ±250 ppm (initial, aging, temperature)		32.768		kHz
Phase noise requirement (@ 100 kHz)		-125		dBc/Hz
Cycle jitter		1.5		ns (RMS)
Slew rate limit (10-90%)			100	ns
Duty cycle tolerance	20		80	%

9.3 Digital I/O Requirements

The digital I/O requirements are listed in **Table 14**.

Table 14: 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
V_{IH}	Input high voltage		0.7 * VIO		VIO + 0.4	V
V_{IL}	Input low voltage		-0.4		0.3 * VIO	V
V_{HYS}	Input hysteresis		100			mV
V_{OH}	Output high voltage		VIO - 0.4			V
V_{OL}	Output low voltage				0.4	V

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 6 shows the power-on sequence graph.

Figure 6: Power-On Sequence Graph

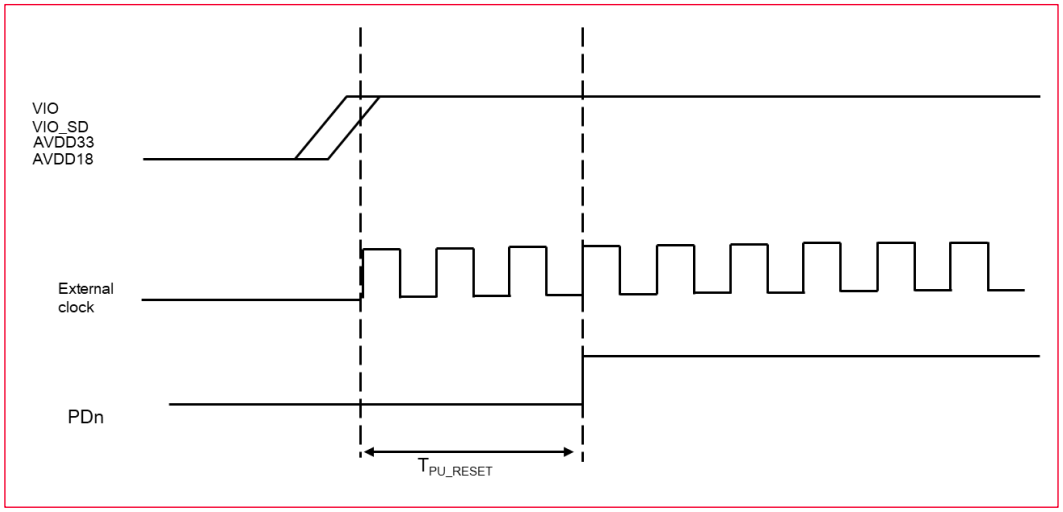


Table 15 shows the PDn pin (power-off) specifications. Power remains high at PDn assertion.

Table 15: PDn Pin Specifications

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.

10.2 Power-Off Sequence

Figure 7 shows the power-off sequence graph.

Figure 7: Power-Off Sequence Graph

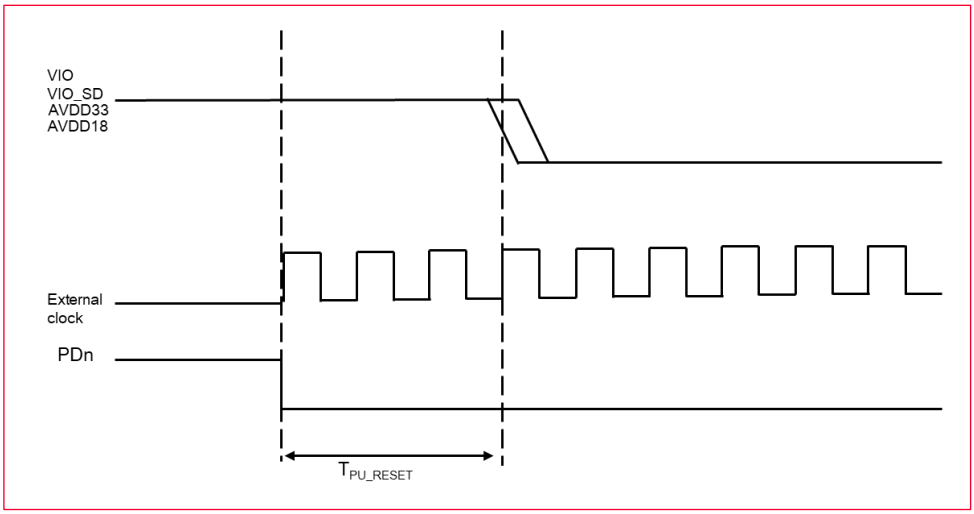


Table 16 shows the power-off sequence parameters.

Table 16: Power-Off Sequence Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{VIO_AVDD}	Power up timing of VIO, VIO_SD, AVDD33, and VIO18					ms
T_{PU_RESET}	Valid power to PDn de-asserted					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 8 shows hot reset sequence graph.

Figure 8: Host Reset Sequence Graph

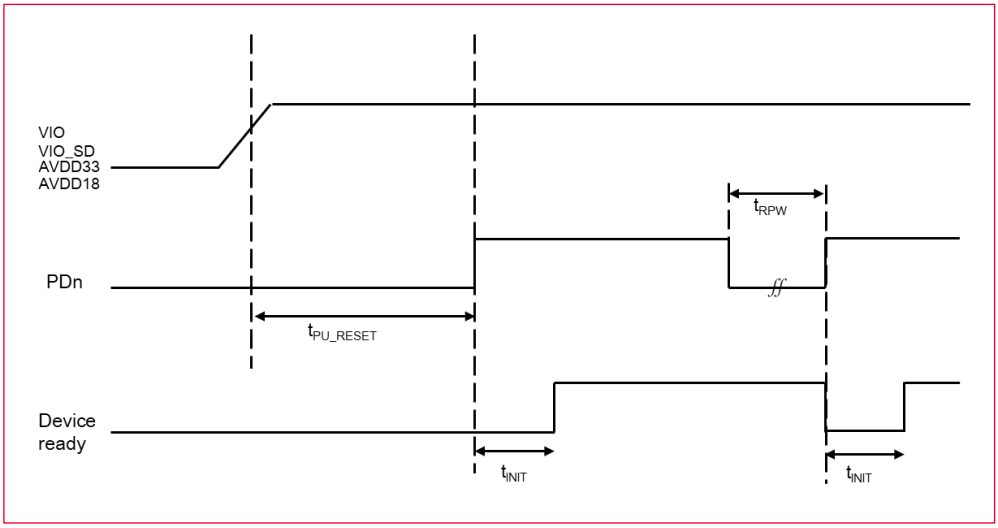


Table 17: Host Reset Sequence Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
t_{PU_RESET}	Valid power to PDn de-asserted		0			ms
t_{PRW}	PDn pulse width		1			µs
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

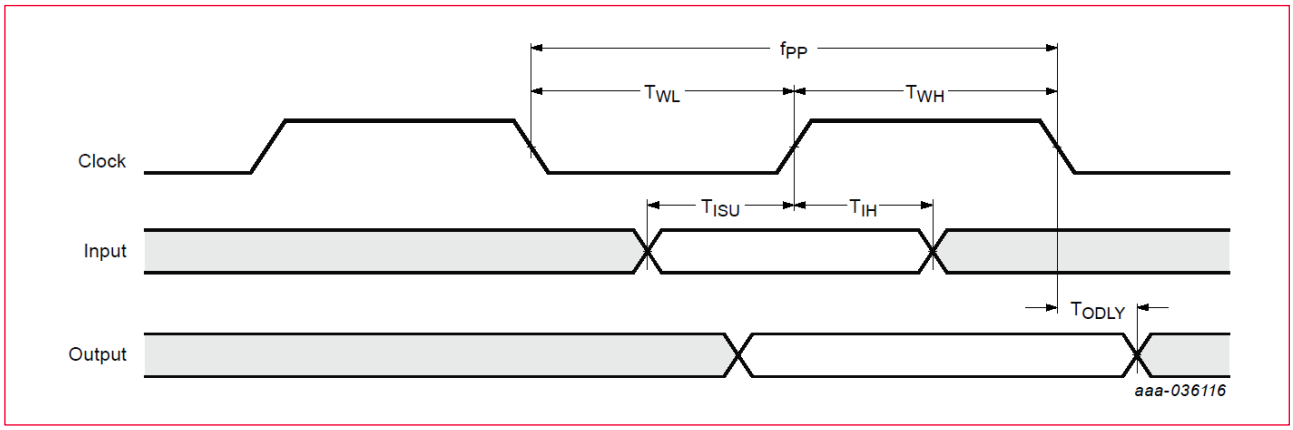
This section describes the SDIO timing (default and high-speed mode), UART timing (default mode), and Bluetooth PCM timing.

11.1 SDIO Timing

11.1.1 Default Speed Mode

Figure 9 describes the SDIO protocol timing diagram in default speed mode.

Figure 9: SDIO Protocol Timing Diagram - Default Mode



11.1.2 High Speed Mode

Figure 10 describes the SDIO protocol timing diagram in high-speed mode.

Figure 10: SDIO Protocol Timing Diagram - High Speed Mode

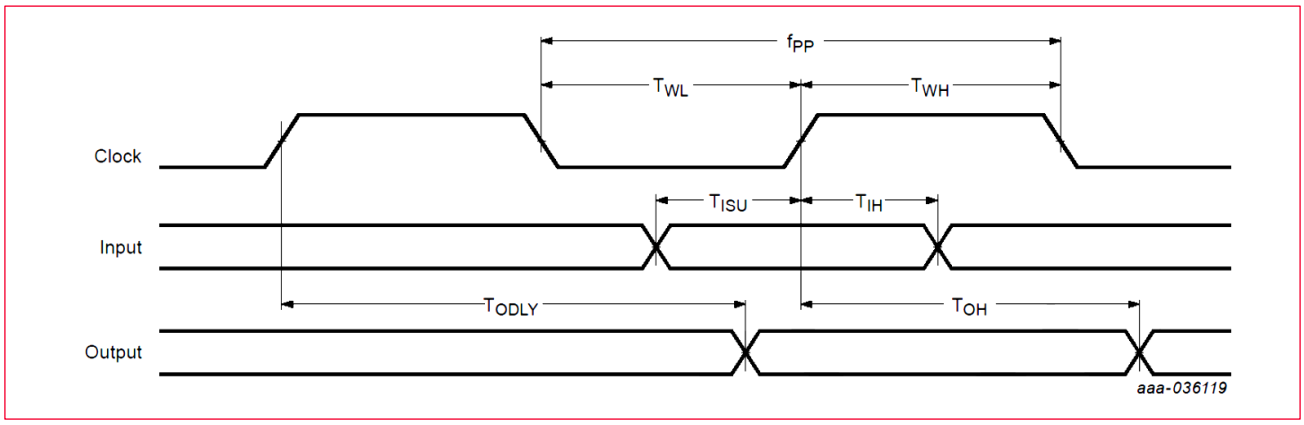


Table 18 describes the parameters for SDIO protocol timing parameters.

Table 18: SDIO Protocol Timing Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
f_{PP}	Clock frequency	Normal	0		25	MHz
		High-speed	0		50	MHz
T_{WL}	Clock low time	Normal	10			ns
		High-speed	7			ns
T_{WH}	Clock high time	Normal	10			ns
		High-speed	7			ns
T_{ISU}	Input setup time	Normal	5			ns
		High-speed	6			ns
T_{IH}	Input hold time	Normal	5			ns
		High-speed	2			ns
T_{OLDY}	Output delay time	Normal			14	ns
	CL ≤ 40 pF (1 card)	High-speed			14	ns
T_{OH}	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 11 shows SDIO protocol timing diagram for SDR12, SDR25, SDR50 Mode (up to 100 MHz) at 1.8V.

Figure 11: SDIO Protocol Timing Diagram - SDR12, SDR25, SDR50 Modes

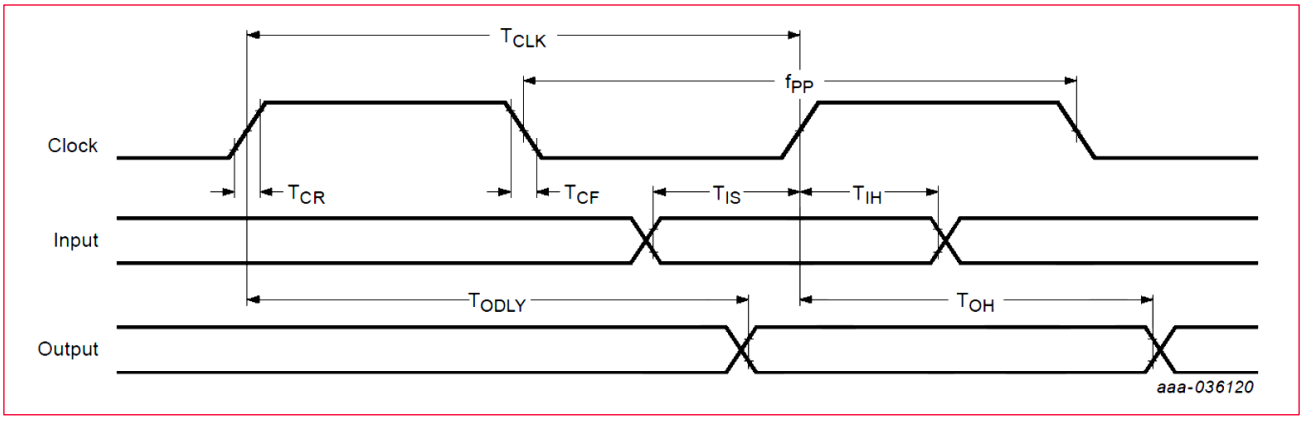


Table 19 describes SDIO protocol timing data for SDR12, SDR25, SDR50 Mode (up to 100 MHz) at 1.8V.

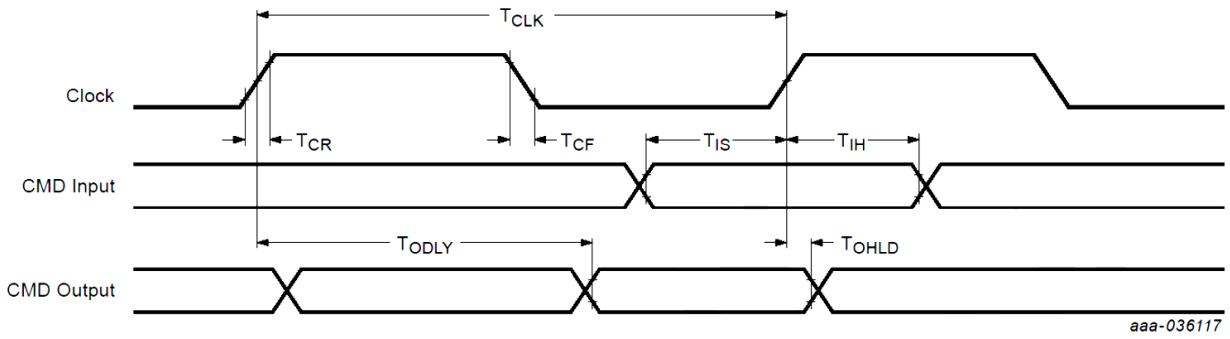
Table 19: SDIO Protocol Timing Parameters - SDR12, SDR25, SDR50 Modes

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			MHz
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*T_{CLK}	ns
T_{OLDY}	Output delay time CL ≤ 15 pF	SDR12/25/50			7.5	ns
T_{OH}	Input setup time	SDR12/25/50	1.5			ns

11.1.4 DDR50 Mode at 50 MHz (1.8V)

Figure 12 shows the SDIO CMD timing diagram for DDR50 mode at 50 MHz.

Figure 12: 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 13 shows the SDIO data timing diagram for DDR50 Mode.

Figure 13: SDIO Data Timing Diagram - DDR50 Mode

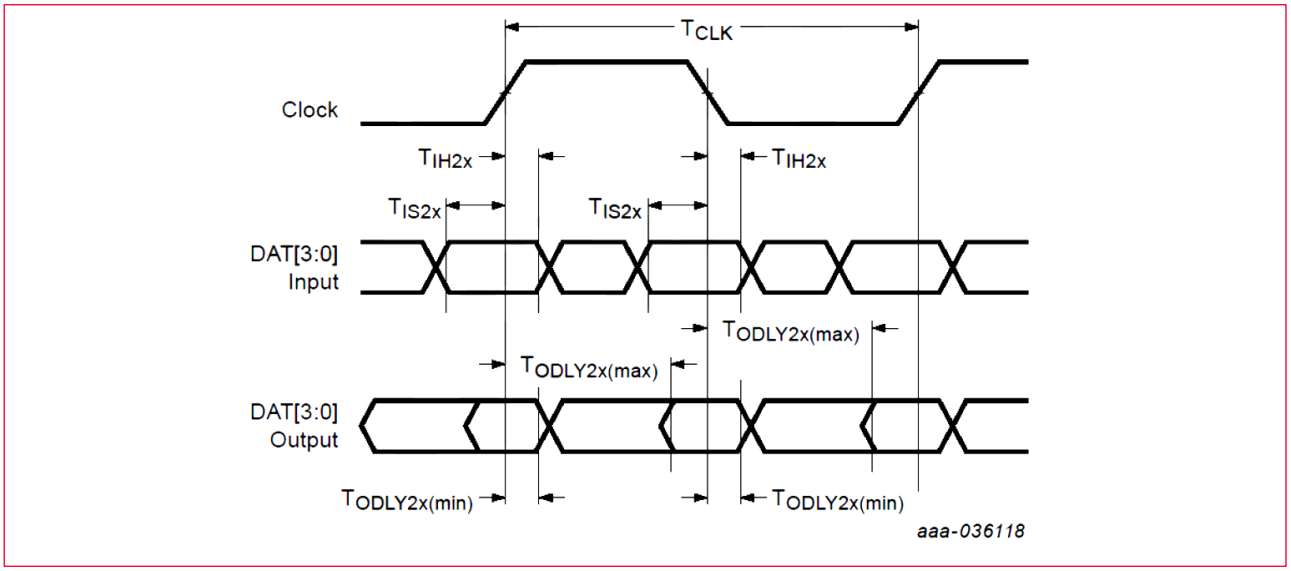


Table 20 describes the parameters for SDIO data timing for DDR50 mode.

Table 20: SDIO Data Timing Parameters - DDR50 Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
Clock						
T_{CLK}	Clock time 50 MHz (maximum) between rising edge	DDR50	20			ns
T_{CR}, T_{CF}	Rise time, fall time T_{CR}, T_{CF} < 4.00 ms(maximum) at 50 MHz	DDR50	3		0.2*T_{CLK}	ns
		DDR50	45		55	%
CMD Input (referenced to clock rising edge)						
T_{IS}	Input setup time C_{CARD} ≤ 10 pF (1card)	DDR50	6			ns
T_{IH}	Input hold time C_{CARD} ≤ 10 pF (1card)	DDR50	0.8			ns
CMD Output (referenced to clock rising edge)						
T_{ODLY}	Output delay time during data transfer mode CL ≤ 30 pF (1card)	DDR50			13.7	ns
T_{OHLD}	Output hold time CL ≤ 30 pF (1card)	DDR50	1.5			ns
DAT[3:0] Input (referenced to clock rising and falling edges)						
T_{IS2X}	Input setup time C_{CARD} ≤ 10 pF (1card)	DDR50	3			ns

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{IH2X}	Input hold time $C_{CARD} \leq 10$ pF (1card)	DDR50	0.8			ns
DAT[3:0] Output (referenced to clock rising and falling edges)						
$T_{OLD2x\ (max)}$	Output delay time during data transfer mode $C_L \leq 25$ pF (1 card)	DDR50			7.0	ns
$T_{OLDY2x\ (min)}$	Output hold time $C_L \leq 15$ pF (1 card)	DDR50	1.5			ns

11.2 UART Timing (Default Mode)

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

Figure 14 shows UART timing diagram for default mode.

Figure 14: UART Timing Diagram - Default Mode

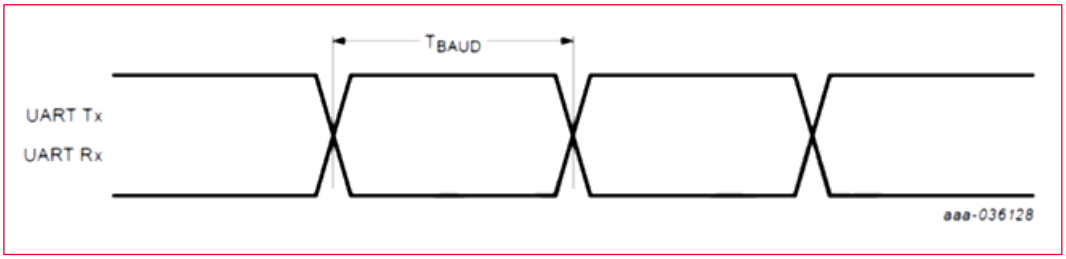


Table 21 describes the UART timing parameters for default mode.

Table 21: UART Timing Parameters - Default Mode

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{BAUD}	Baud rate	38.4 MHz	250			ns

The acceptable deviation from the UART Rx target baud rate is ±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 15 and **Figure 16** shows the Bluetooth PCM timing signals in master mode.

Figure 15: Bluetooth PCM Timing Data Signal - Master Mode

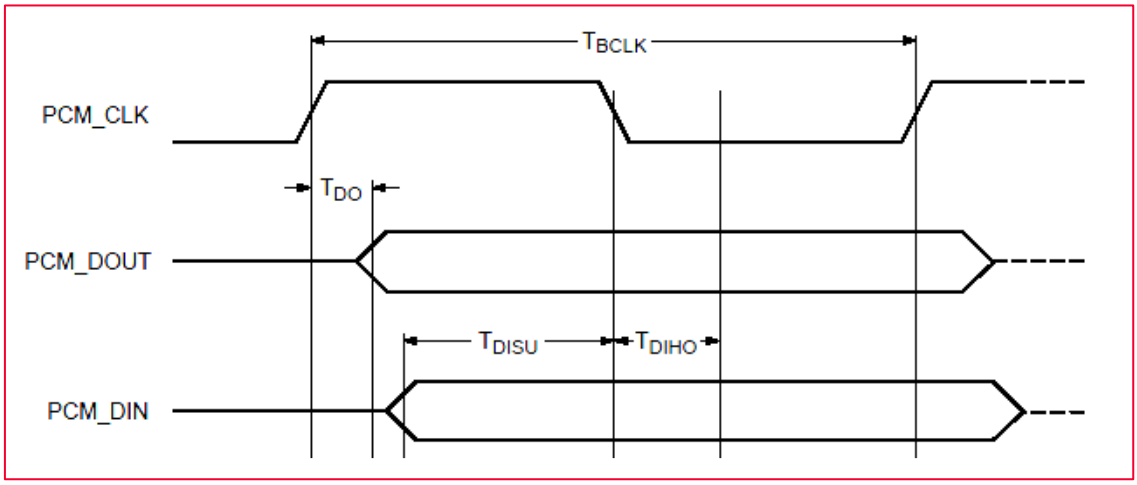


Figure 16: Bluetooth PCM Timing PCM_SYNC Signal - Master Mode

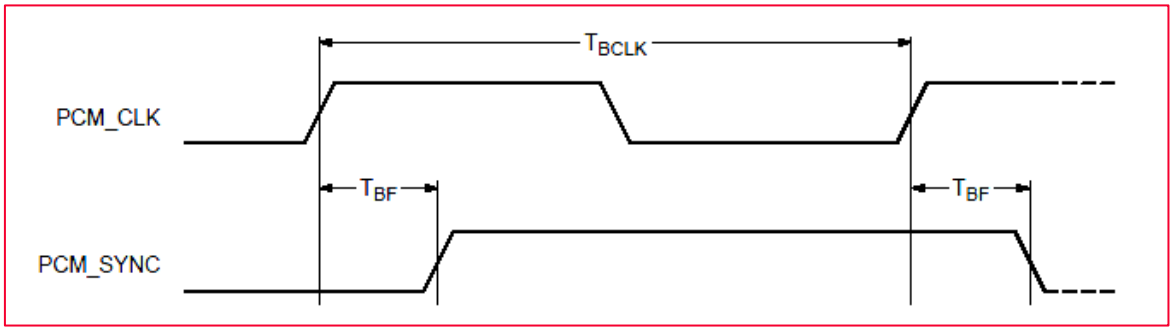


Table 22 describes the signal parameters in master mode.

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$_{BCLK}$	Bit clock duty cycle		0.4	0.5	0.6	
$T_{BCLK\ rise/fall}$	PCM_CLK rise/fall time			3		ns
T_{DO}	Delay from PCM_CLK rising edge to PCM_DOUT rising edge				15	ns
T_{DISU}	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 17 and **Figure 18** shows the Bluetooth PCM timing signals in slave mode.

Figure 17: Bluetooth PCM Timing Data Signal - Slave Mode

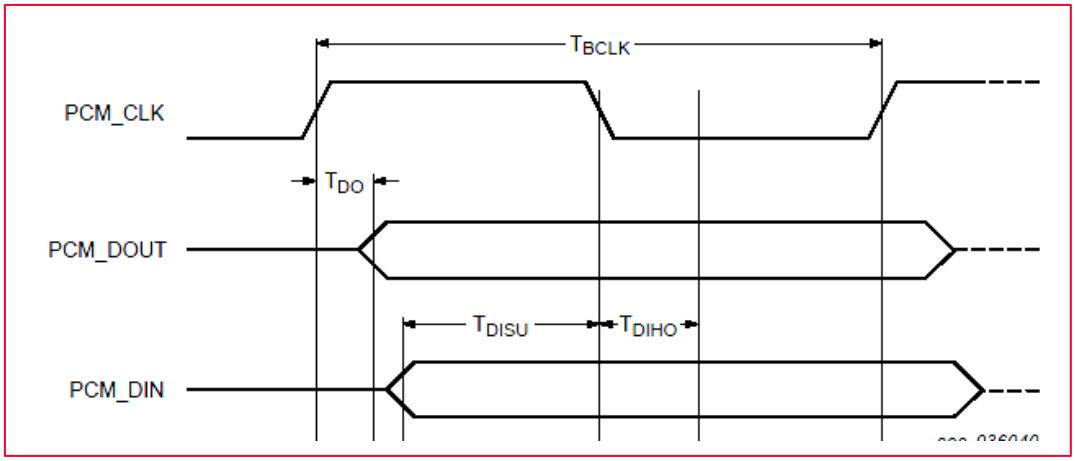


Figure 18: Bluetooth PCM Timing PCM_SYNC Signal - Slave Mode

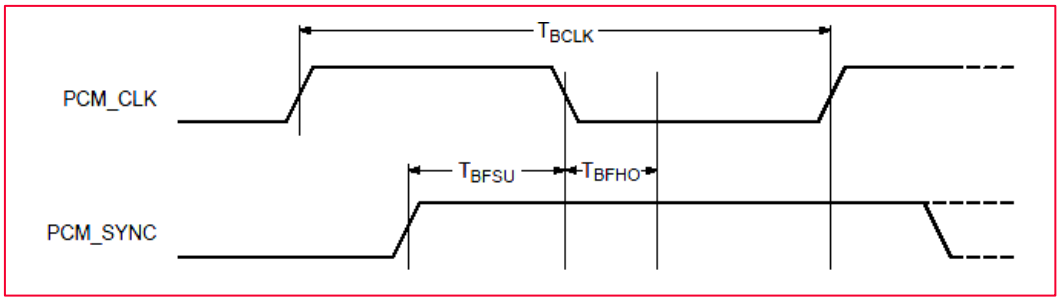


Table 23 describes the signal parameters in slave mode.

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 $Cycle_{BCLK}$	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_{DO}	Delay from PCM_CLK rising edge to PCM_DOUT rising edge				30	ns
T_{DISU}	Setup time for PCM_DIN before PCM_CLK falling edge		15			ns
T_{DIHO}	Hold time for PCM_DIN after PCM_CLK falling edge		10			ns
T_{BFSU}	Setup time for PCM_SYNC before PCM_CLK falling edge		15			ns
T_{BFHO}	Hold time for PCM_SYNC after PCM_CLK falling edge		10			ns

11.4 802.15.4 SPI Timing

Figure 19 shows 802.15.4 SPI timing graph.

Figure 19: 802.15.4 SPI Timing Graph

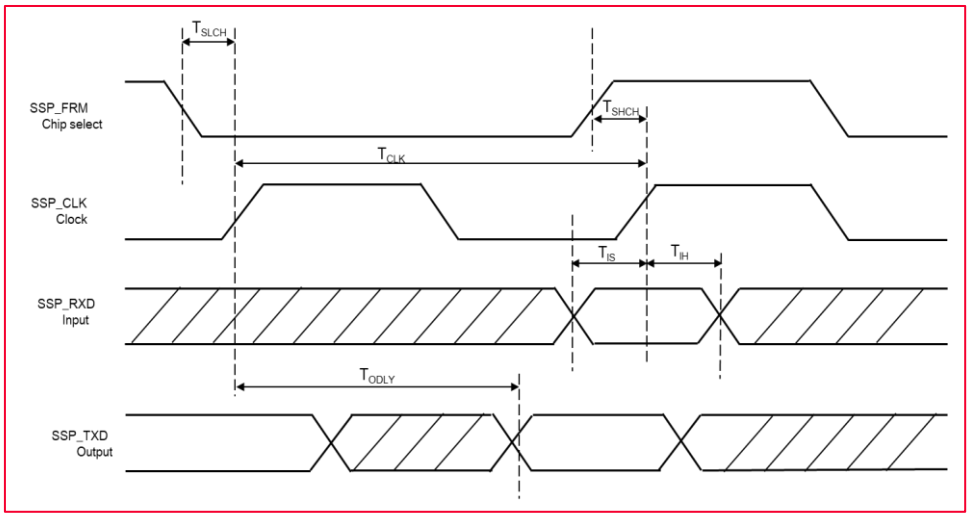


Table 24 describe 802.15.4 SPI timing parameters.

Table 24 : 802.15.4 SPI Timing Parameters

Symbol	Parameter	Condition	Minimum	Typical	Maximum	Unit
T_{SLCH}	Chip select setup time		12			ns
T_{SHCH}	Chip select hold time		12			ns
T_{CLK}	Clock period[2]		40			ns
T_{IS}	Input setup time		12			ns
T_{IH}	Input hold time		0			ns
T_{ODLY}	Output delay				12	ns

[2] The maximum SPI clock frequency is limited to 1MHz for Open thread implementations.

12 DC/RF Characteristics (TBD)

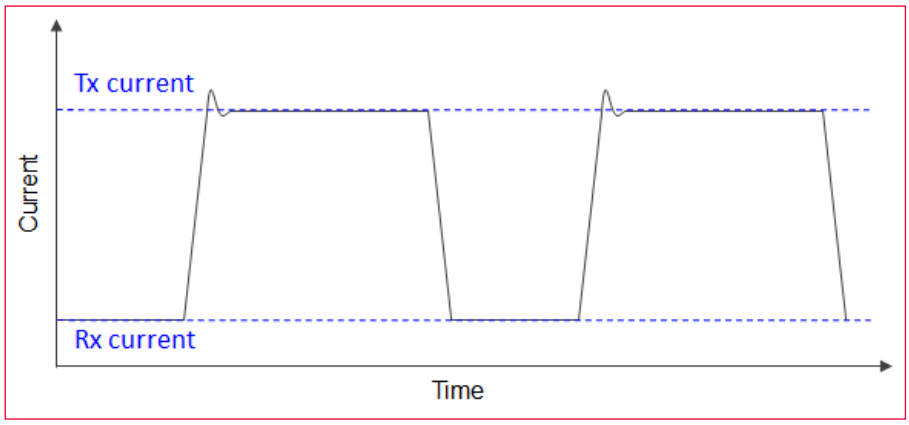
All DC/RF characteristics are defined by the following files:

Table 25: DC/RF Characteristics Files

Contents	Filenames
WLAN Tx Power	TBD
WLAN Regulatory Limit	TBD
Energy Detect	TBD
Bluetooth Power	TBD

Figure 20 shows the burst current definition.

Figure 20: 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 (TBD) 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		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power		18 (TBD)		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%)			-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 (TBD) 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		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	18 (TBD)	TBD	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 (TBD) 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		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	16 (TBD)	TBD	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 -74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 8 7.5 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%)			-65	dBm
Maximum Input Level (PER < 10%)	-20			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 (TBD) 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		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	16 (TBD)	TBD	dBm
Spectrum Mask Margin				
• 9 MHz to 11 MHz (0 ~ -20 dBr)	0			dB
• 11 MHz to 20 MHz (-20 ~ -28 dBr)	0			dB
• 20 MHz to 30 MHz (-28 ~ -40 dBr)	0			dB
• 30 MHz to 33 MHz (-40 dBr)	0			dB
Constellation Error (EVM)			-25	dB
Frequency Tolerance	-20		20	ppm
Spurious Emissions				
• 30 - 47 MHz (BW = 100 kHz)			-36	dBm
• 47 - 74 MHz (BW = 100 kHz)			-54	dBm
• 74 - 87.5 MHz (BW = 100 kHz)			-36	dBm
• 87.5 - 118 MHz (BW = 100 kHz)			-54	dBm
• 118 - 174 MHz (BW = 100 kHz)			-36	dBm
• 174 - 230 MHz (BW = 100 kHz)			-54	dBm
• 230 - 470 MHz (BW = 100 kHz)			-36	dBm
• 470 - 862 MHz (BW = 100 kHz)			-54	dBm
• 862 - 1000 MHz (BW = 100 kHz)			-36	dBm
• 1000 - 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%)	-20			dBm
Adjacent Channel Rejection (PER < 10%)	-1			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 - 2.4 GHz

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 15 dBm (TBD) 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		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	15 (TBD)	TBD	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%)	-2			dB

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

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

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

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	15 (TBD)	TBD	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**
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 (TBD) 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		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	13 (TBD)	TBD	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%)			-59	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

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 (TBD) 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		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	15 (TBD)	TBD	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

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

Table 38: 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

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

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

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

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	16 (TBD)	TBD	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%)			-65	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-1			dB

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

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

Table 40: Low-Rate Condition for IEEE 802.11a - 5 GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	16 (TBD)	TBD	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

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

Table 41: 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

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

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

Table 42: High-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Item	Contents			
DC Characteristics	Minimum	Typical	Maximum	Unit
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	Minimum	Typical	Maximum	Unit
Output Power	TBD	14 (TBD)	TBD	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

Item	Contents			
Minimum Input Level (PER ≤ 10%)			-64	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

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

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

Table 43: Low-Rate Condition for IEEE 802.11n (HT20) - 5 GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

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

Table 44: 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

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

Conditions: 25 °C, VBAT = 3.3V, VIO = 1.8V, Output power setting = 12 dBm (TBD) at module pad, MCS8 mode

Table 45: High-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	12 (TBD)	TBD	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

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

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

Table 46: Low-Rate Condition for IEEE 802.11ac (VHT20) - 5 GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

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

Table 47: 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

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

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

Table 48: High-Rate Condition for IEEE802.11ax (HE20) - 5GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	10 (TBD)	TBD	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%)			-59	dBm
Maximum Input Level (PER < 10%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-7			dB

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

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

Table 49: Low-Rate Condition for IEEE802.11ax (HE20) – 5GHz

Item	**Contents**			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

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

Table 50: 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

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

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

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

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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%)	-30			dBm
Adjacent Channel Rejection (PER ≤ 10%)	-2			dB

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

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

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

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

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

Table 53: 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

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

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

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

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	12 (TBD)	TBD	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

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

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

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

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

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

Table 56: 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

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

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

Table 57: High-Rate Condition for IEEE802.11ax (HE40) – 5GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	10 (TBD)	TBD	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

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

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

Table 58: Low-Rate Condition for IEEE802.11ax (HE40) – 5GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

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

Table 59: 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

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

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

Table 60: High-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	12 (TBD)	TBD	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

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

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

Table 61: Low-Rate Condition for IEEE 802.11ac (VHT80) - 5 GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

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

Table 62: Characteristics for IEEE802.11ax (HE80) - 5GHz

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

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

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

Table 63: High-Rate Condition for IEEE802.11ax (HE80) – 5GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	10 (TBD)	TBD	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

12.13.2 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 (TBD) at module pad, MCS0 mode

Table 64: Low-Rate Condition for IEEE802.11ax (HE80) – 5GHz

Item	Contents			
DC Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
DC Current				
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power	TBD	14 (TBD)	TBD	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

12.14 DC/RF Characteristics for Bluetooth

Table 65: 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

12.14.1 Basic Data Rate Condition

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

Table 66: Basic Data Rate Condition

Item	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx mode DH5		TBD	TBD	mA
• Rx mode DH5		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power @ DH5	TBD	13 (TBD)	TBD	dBm
Frequency Range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power[3]				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
Modulation Characteristics				
• Modulation $\Delta f1_{avg}$	140	151	175	kHz
• Modulation $\Delta f2_{max}$	115			kHz
• Modulation $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8	1		
Carrier Frequency Drift				
• 1 slot	-25		25	kHz
• 3 slot / 5 slot	-40		40	kHz
• Maximum drift rate			20	kHz/50 µs
Rx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
BR Sensitivity (BER ≤ 0.1%)		-96	-70	dBm
Maximum Input Level (BER ≤ 0.1%)	-20			dBm

[3] Up to three spurious responses within Bluetooth limits are allowed.

12.14.2 Enhanced Data Rate Condition

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

Table 67: Enhance Data Rate Condition

Item	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx Mode 2DH5		TBD	TBD	mA
• Rx Mode 2DH5		TBD	TBD	mA
• Tx Mode 3DH5		TBD	TBD	mA
• Rx Mode 3DH5		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Output Power @ DH5/3DH5	TBD	5 (TBD)	TBD	dBm
Frequency Range	2400		2483.5	MHz
20 dB bandwidth			1	MHz
Adjacent Channel Power[4]				
• [M-N] = 2			-20	dBm
• [M-N] ≥ 3			-40	dBm
EDR Relative Power	-4		1	dB
EDR Carrier Frequency Stability and Modulation Accuracy				
• ωi	-75		75	kHz
• ωi+ωo	-75		75	kHz
• ωo	-10		10	kHz
• RMS DEVM (DQPSK)			20	%
• Peak DEVM (DQPSK)			35	%
• 99% DEVM (DQPSK)			30	%
• RMS DEVM (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

[4] Up to three spurious responses within Bluetooth limits are allowed.

12.15 DC/RF Characteristics for Bluetooth Low Energy

Table 68: 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

12.15.1 1 Mbps PHY Condition

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

Table 69: 1 Mbps PHY Condition

Item	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF channel		40		
Output power	TBD	13 (TBD)	TBD	dBm
In-band emission				
• f_{TX} +/-2 MHz			-20	dBm
• f_{TX} +/-[3+n] MHz; n = 0,1,2…			-30	dBm
Modulation Characteristics				
• $\Delta f1_{avg}$	225		275	kHz
• $\Delta f2_{max}$ (at 99.9%)	185			kHz
• $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8			
Stable Modulation Characteristics				
• $\Delta f1_{avg}$	247.5		252.5	kHz
• $\Delta f2_{max}$ (at 99.9%)	185			kHz
• $\Delta f2_{avg}$g / $\Delta f1_{avg}$	0.8			
Carrier Frequency Offset and Drift				
• Frequency offset (f_n); n = 0,1, 2, 3…k	-150		150	kHz
• Frequency drift ($\|f_0-f_n\|$); n = 2, 3, 4…k			50	kHz
• Drift Rate				
• $\|f_1 - f_0\|$			23	kHz
• $\|f_n-f_{n-5}\|$; n = 6, 7, 8... 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

Item	Contents			
• 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	%

12.15.2 2 Mbps PHY Condition

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

Table 70: 2 Mbps PHY Condition

Item	Contents			
Current Consumption	**Minimum**	**Typical**	**Maximum**	**Unit**
• Tx mode		TBD	TBD	mA
• Rx mode		TBD	TBD	mA
Tx Characteristics	**Minimum**	**Typical**	**Maximum**	**Unit**
Center Frequency	2402		2480	MHz
Channel Spacing		2		MHz
Number of RF channel		40		
Output power	TBD	13 (TBD)	TBD	dBm
In-band emission				
• f_{TX} +/-4 MHz			-20	dBm
• f_{TX}+/-5 MHz			-20	dBm
• f_{TX}+/-[6+n] MHz; n=0,1,2…			-30	dBm
Modulation Characteristics				
• $\Delta f1_{avg}$	450		550	kHz
• $\Delta f2_{max}$ (at 99.9%)	370			kHz
• $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8			
Stable Modulation Characteristics				
• $\Delta f1_{avg}$	495		505	kHz
• $\Delta f2_{max}$ (at 99.9%)	370			kHz
• $\Delta f2_{avg}$ / $\Delta f1_{avg}$	0.8			
Carrier Frequency Offset and Drift				
• Frequency offset (f_n); n = 0, 1, 2, 3…k	-150		150	kHz
• Frequency drift ($\|f_0-f_n\|$); n = 2, 3, 4…k			50	kHz
• Drift Rate				
• |f1-f0|			23	kHz
• fn-fn-5|; n = 6, 7, 8…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

Item	Contents			
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	%

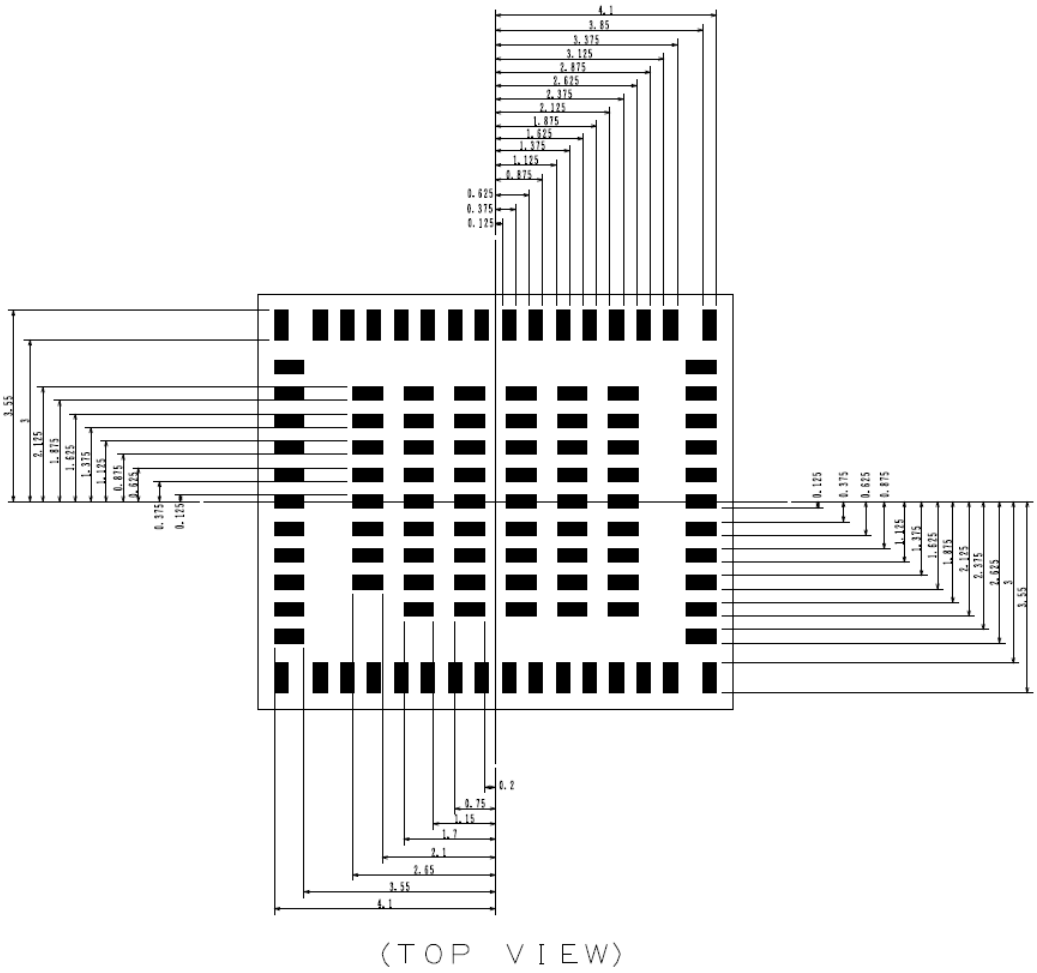
12.16 DC/RF Characteristics for 802.15.4

TBD

13 Land Pattern

Figure 21 shows land pattern of Type 2EL.

Figure 21: Land Pattern (Unit: mm)



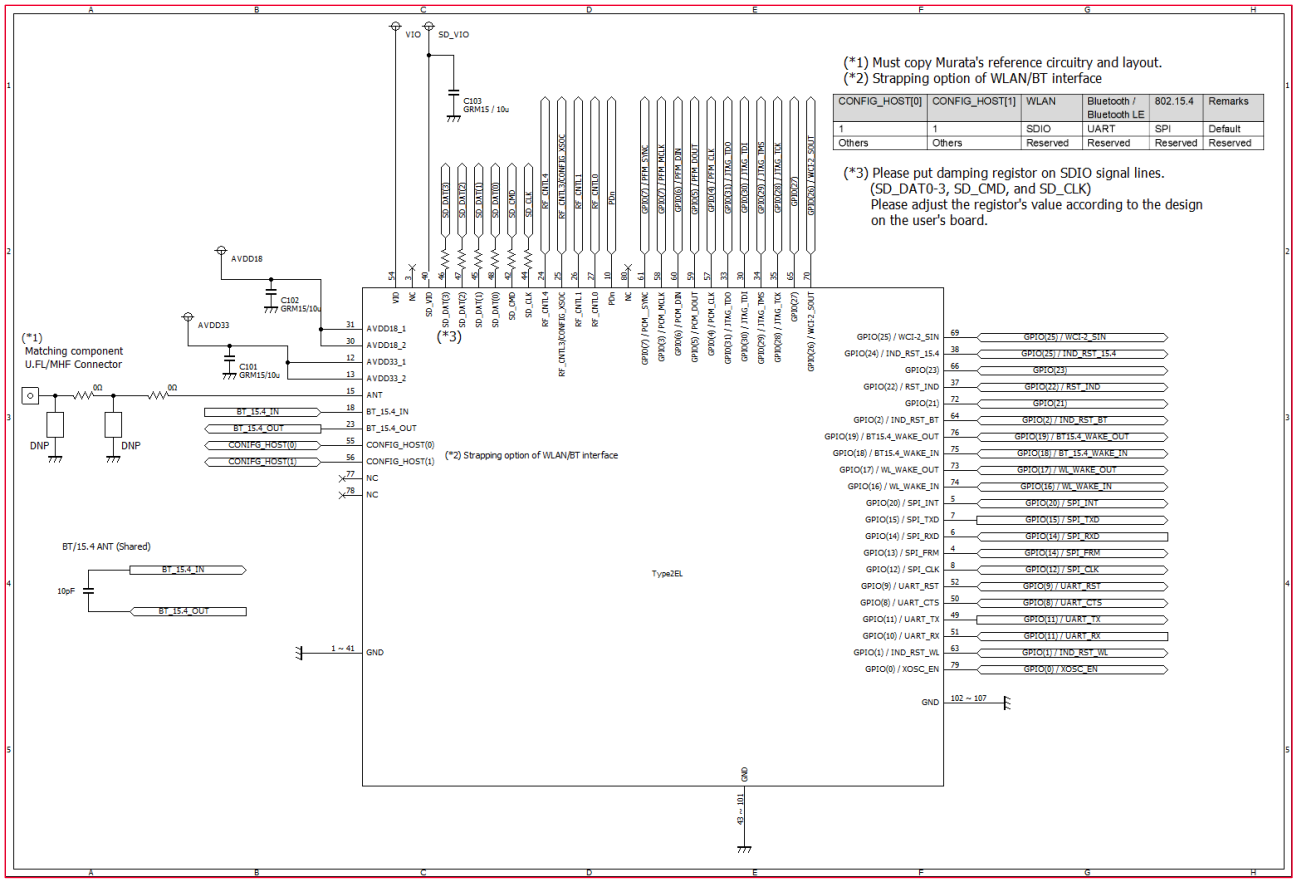
To avoid the short-circuit between the side shielding and a solder on the module land after the reflow, please locate the module land at 0.2 mm away from module outline as above figure.

14 Reference Circuit

14.1 u.FL/MHF Connector (Shared Antenna)

Figure 22 shows the u.FL/MHF connector for shared antenna.

Figure 22: u.FL/MHF Connector - Shared Antenna

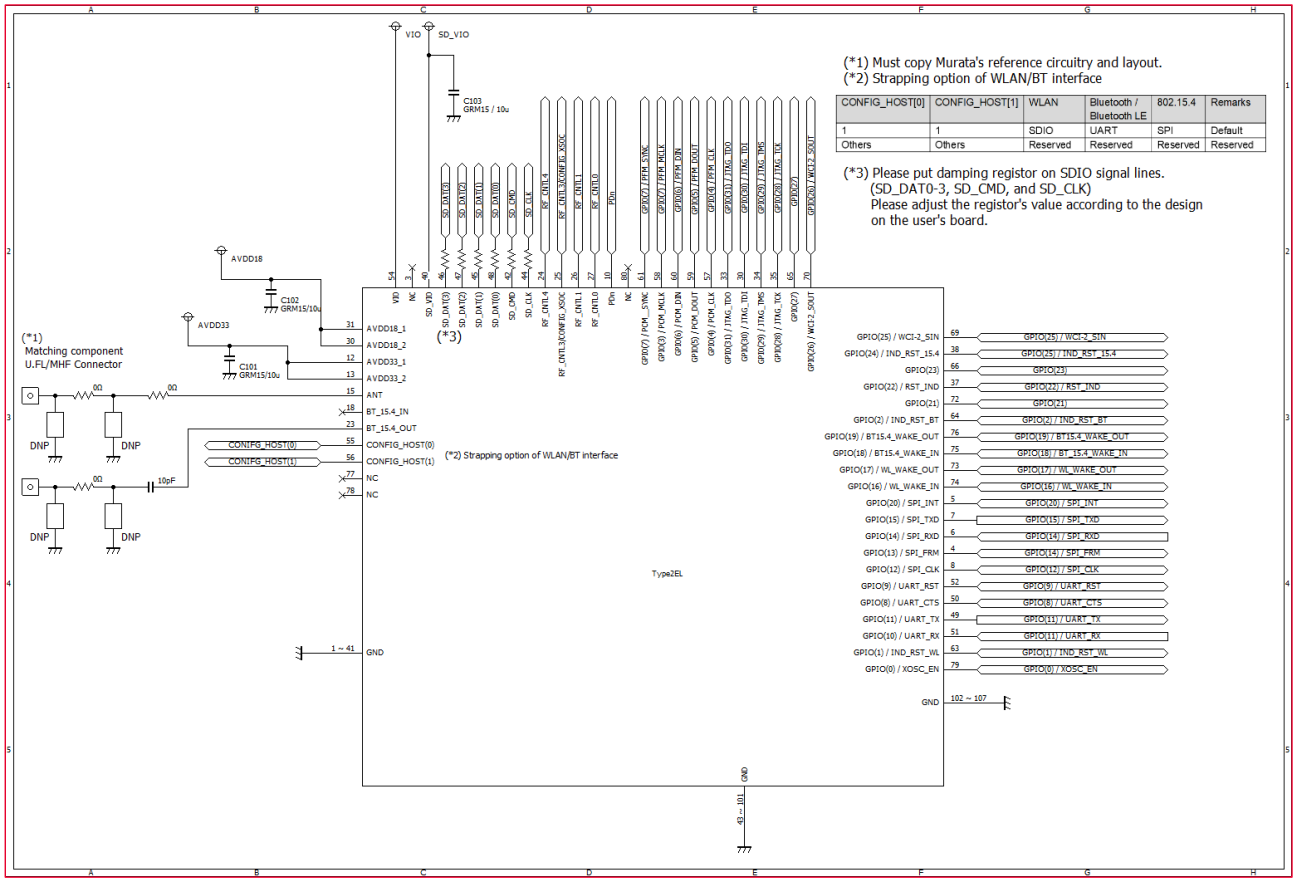


CONFIG_HOST[0]	CONFIG_HOST[1]	WLAN	Bluetooth / Bluetooth LE	802.15.4	Remarks
1	1	SDIO	UART	SPI	Default
Others	Others	Reserved	Reserved	Reserved	Reserved

14.2 u.FL/MHF Connector (Dedicated Antenna)

Figure 23 shows u.FL/MHF connector for dedicated antenna.

Figure 23: u.FL/MHF Connector - Dedicated Antenna

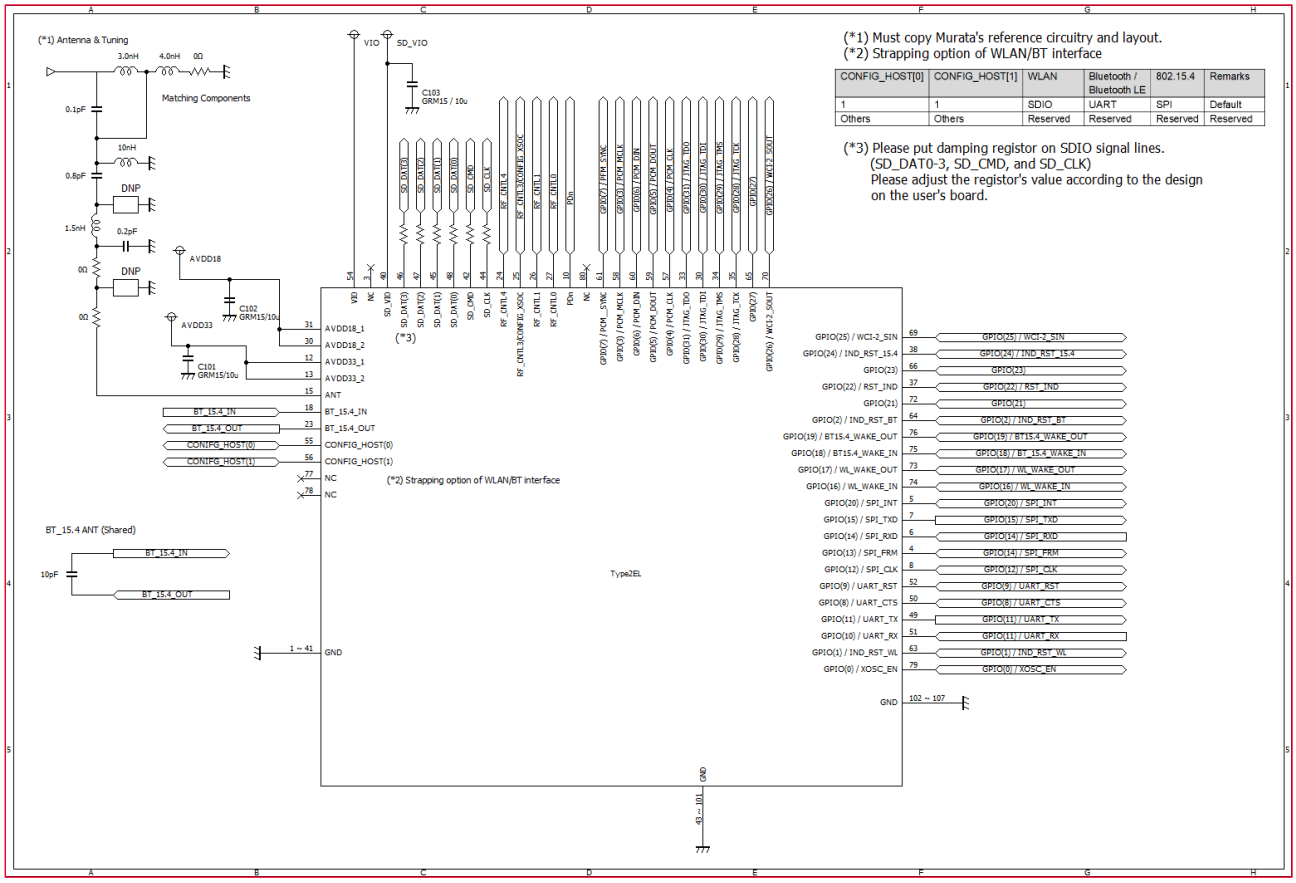


CONFIG_HOST[0]	CONFIG_HOST[1]	WLAN	Bluetooth / Bluetooth LE	802.15.4	Remarks
1	1	SDIO	UART	SPI	Default
Others	Others	Reserved	Reserved	Reserved	Reserved

14.3 Trace Antenna (Shared Antenna)

Figure 24 shows the trace antenna (shared antenna).

Figure 24: Trace Antenna - Shared Antenna

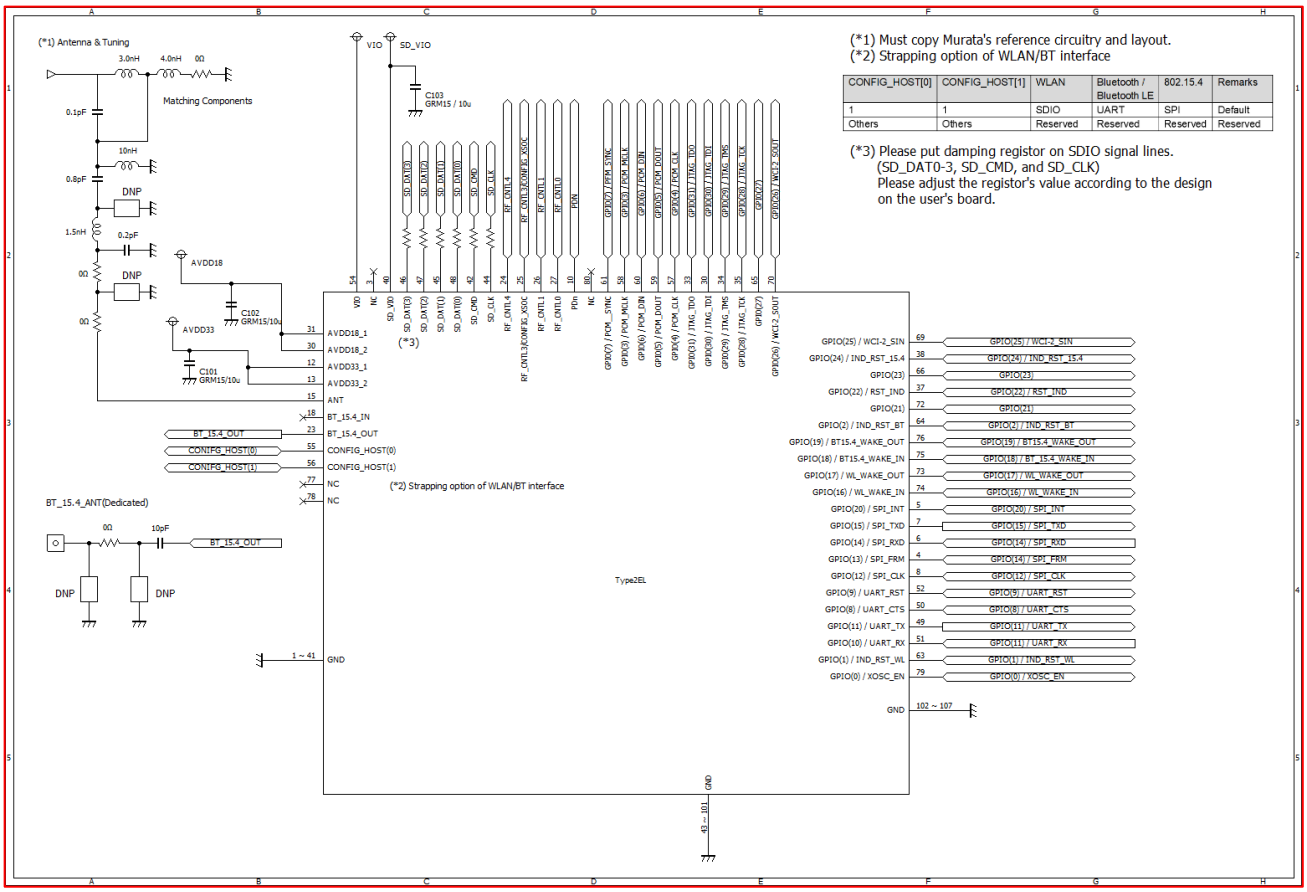


CONFIG_HOST[0]	CONFIG_HOST[1]	WLAN	Bluetooth / Bluetooth LE	802.15.4	Remarks
1	1	SDIO	UART	SPI	Default
Others	Others	Reserved	Reserved	Reserved	Reserved

14.4 Trace Antenna (Dedicated Antenna)

Figure 25 shows the trace antenna (dedicated antenna).

Figure 25: Trace Antenna - Dedicated Antenna



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

15 Tape and Reel Packing

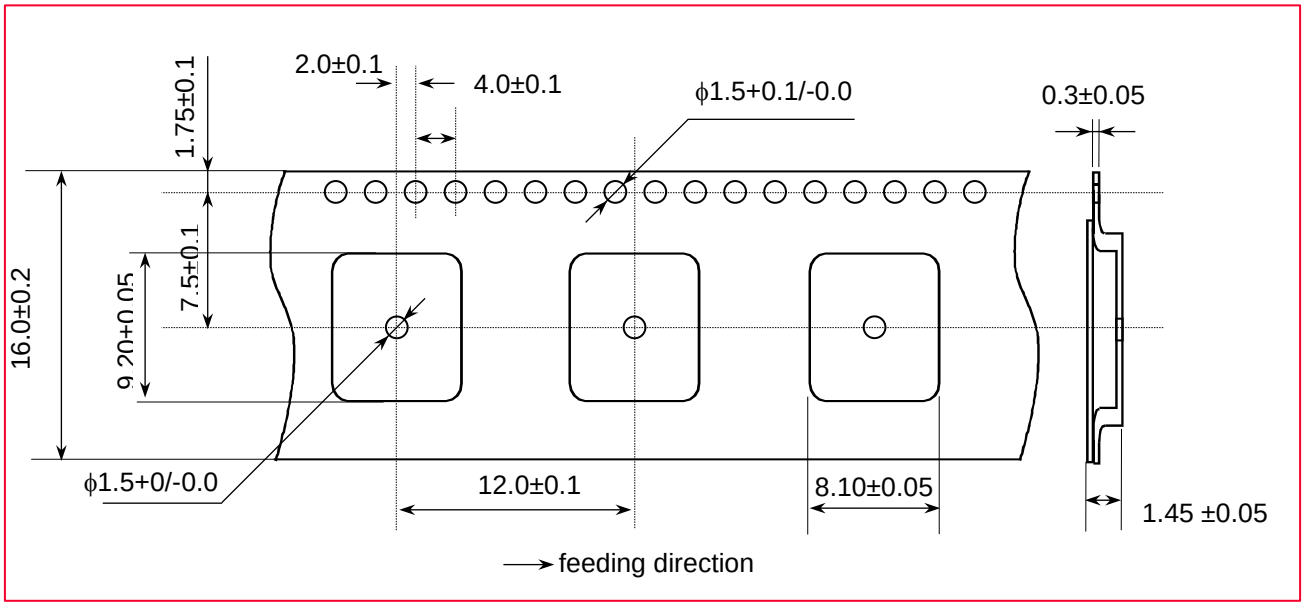
This section contains the following topics:

- Dimensions of Tape (Plastic tape)
- Dimensions of Reel
- Taping Diagrams
- Leader and tail tape
- Packaging

15.1 Dimensions of Tape (Plastic Tape)

Figure 26 is a graphical representation of the tape dimension (plastic tape)[5].

Figure 26: Dimensions of Tape (Plastic Tape)

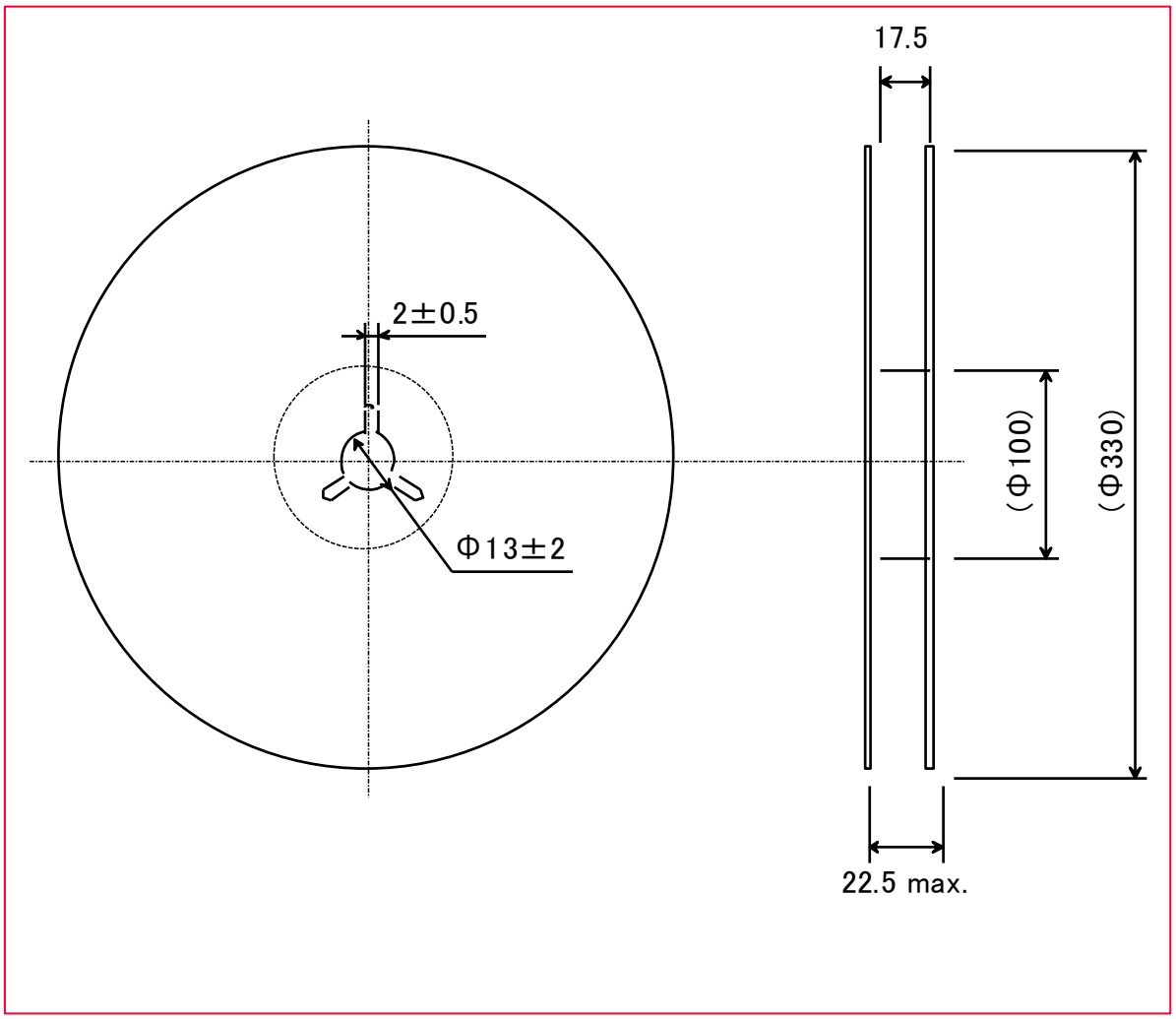


[5] Cumulative tolerance of maximum 40 +/- 0.15 mm for every 10 pitches.

15.2 Dimensions of Reel

Figure 27 shows the reel dimensions.

Figure 27: Dimensions of Reel (Unit: mm)



15.3 Taping Diagrams

Figure 28 shows the taping diagrams.

Figure 28: Taping Diagrams

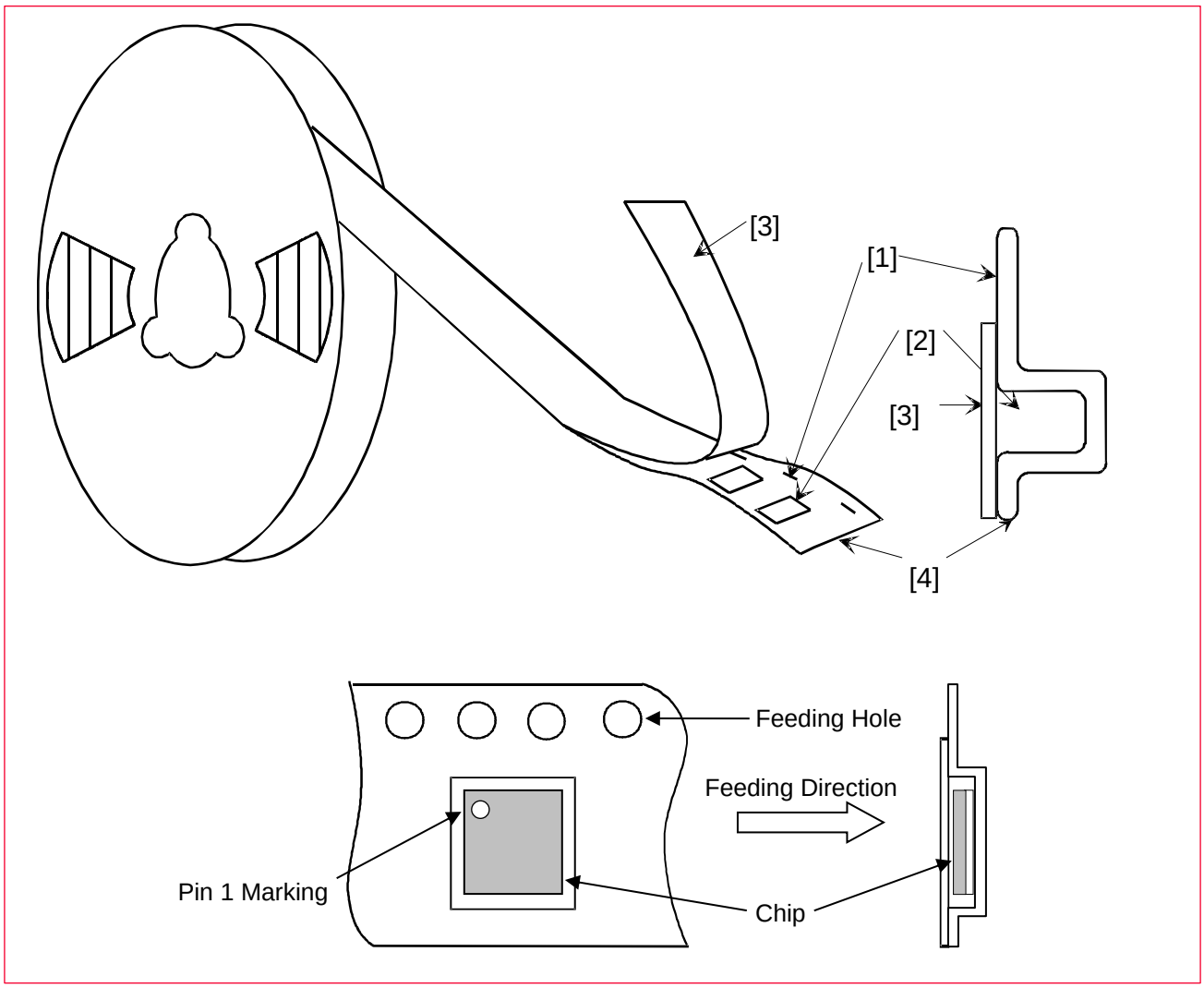


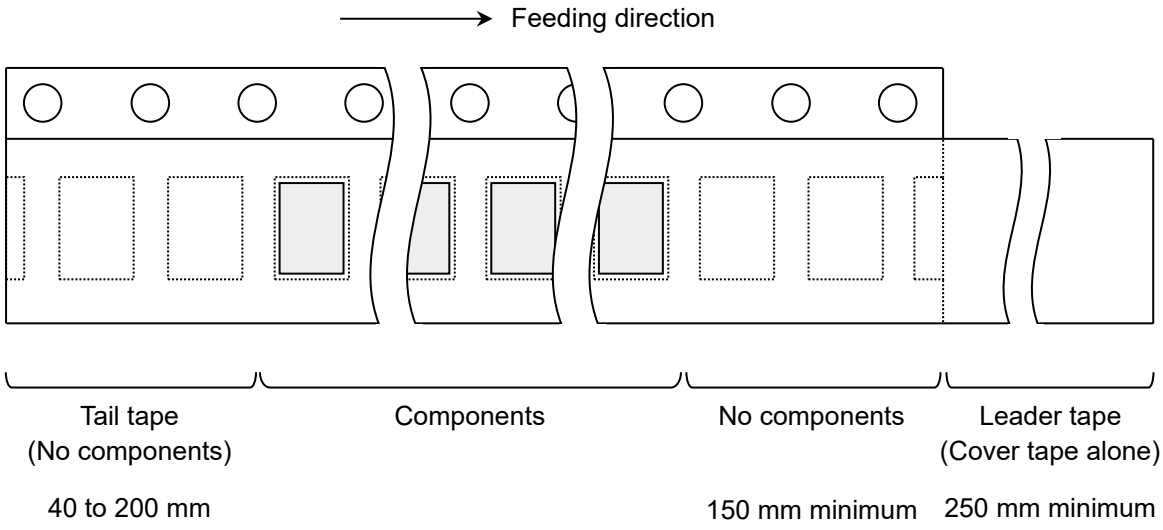
Table 71: Taping Specifications

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

15.4 Leader and Tail Tape

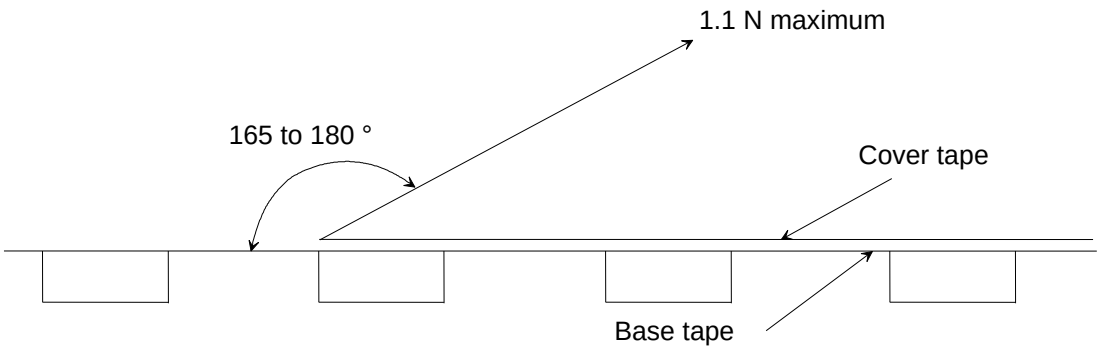
The leader and tail tape are shown in **Figure 29**

Figure 29: 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: 500 pcs./ reel
- Material
  - Base tape: Plastic
  - Real: 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 30**

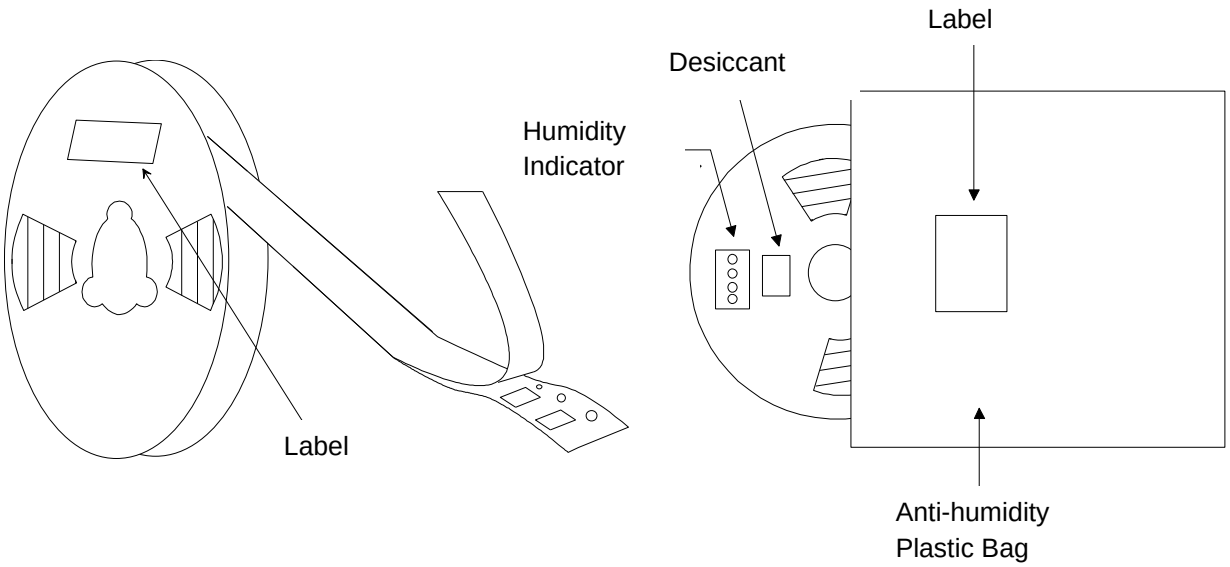
Figure 30: Peeling Force



15.5 Packaging (Humidity Proof Packing)

The packaging is shown in **Figure 31**

Figure 31: Humidity Proof Packing



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

16 Notice

16.1 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_2, NH_3, SO_2, NO_X, etc.).
  - Any excess mechanical shock including, but not limited to, sticking the packing materials by sharp object, and dropping the product, shall not be applied in order not to damage the packing materials.
- This product is applicable to MSL3 (Based on 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.

16.2 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.

16.3 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.

16.4 Notice for Chip Placer

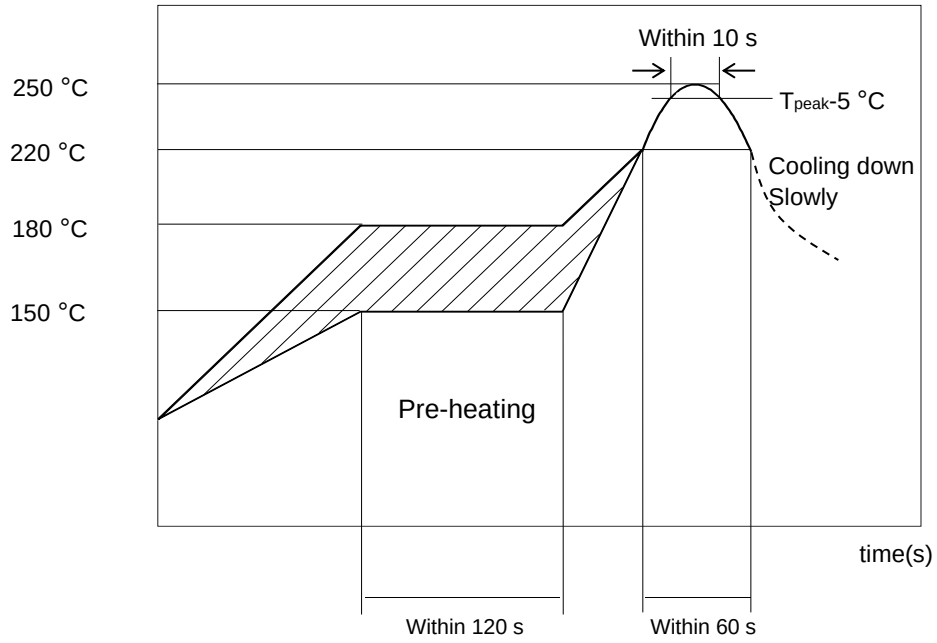
When placing products on the PCB, products may be stressed and broken by uneven forces from a worn-out chucking locating claw or a suction nozzle. To prevent products from damages, be sure to follow the specifications for the maintenance of the chip placer being used. For the positioning of products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

16.5 Soldering Conditions

The recommendation conditions of soldering are shown in **Figure 32**.

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 32: 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.

16.6 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.

16.7 Operational Environment Conditions

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

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

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

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

17 Precondition to Use Our Products

PLEASE READ THIS NOTICE BEFORE USING OUR PRODUCTS.

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

All the items and parameters in this product specification/datasheet/catalog have been prescribed on the premise that our product is used for the purpose, under the condition and in the environment specified in this specification. You are requested not to use our product deviating from the condition and the environment specified in this specification.

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

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

- Burning / explosion control equipment.
- Disaster prevention / crime prevention equipment.
- Transportation equipment (vehicles, trains, ships, elevator, etc.).
- Application of similar complexity and/ or reliability requirements to the applications listed in the above.
- We expressly prohibit you from analyzing, breaking, reverse-engineering, remodeling altering, and reproducing our product. Our product cannot be used for the product which is prohibited from being manufactured, used, and sold by the regulations and laws in the world.

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

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

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

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

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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	• Remove external sleep clock • Change SLP_CLK_IN to DNC • Change Pin name: ANT → ANT0, BT_15.4_OUT → ANT1 • Change SLP_CLK_IN to DNC • Change Pin name: ANT → ANT0, BT_15.4_OUT → ANT1 • Change SLP_CLK_IN to DNC • Change Pin name: ANT → ANT0, BT_15.4_OUT → ANT1
B	2022.09.05	4. Block Diagram 14. Reference Circuit	• Update • Update reference circuit based on latest information
C	2022.11.04	Bluetooth version 4 Block Diagram 8. Absolute Maximum Ratings	• Update to 5.3 • Update • Revise value
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	• Update the description of Pin #3 • Added comment on termination of open pins. • Update the sequence picture. • Add power down sequence. • Add hot reset sequence. • Add SPI I/F timing sequence. • Add 802.11ax 2.4GHz HE20, 5GHz HE 20/40/80 and low/high rate table • Add uFL/trace dedicated antenna circuit. • Update from TBD
E	2023.01.27	2. Key Features 3. Ordering Information 14. Reference Circuit 15. Notice	• Updated information. • Added Embedded Artists' M.2 module information. • Moved section to HW app note. • Moved section to before Preconditions section. Updated to new format
F	2023.02.02	12 DC/RF Characteristics	• Update Tx Power value
G	2023.02.13	5.2 Bluetooth Qualification 7.1 Pin Assignments 7.2 Pin Descriptions 7.4 Pin States	• Add QDID • 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") • Change pin name • Add description on PCM_DOUT/DIN • Change Pin name on Table 9: I/O State Table