

W-LAN+Bluetooth Combo Module Data Sheet

NXP 88W8987 Chipset
for 802.11a/b/g/n/ac + Bluetooth 5.1

Design Name: Type1ZM
Tentative P/N : LBEE5QD1ZM-TEMP

This Datasheet is preliminary version, and subject to change without notice.

Preliminary
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1. SCOPE

This specification is applied to the IEEE802.11a/b/g/n/ac W-LAN + Bluetooth 5.1 combo module.

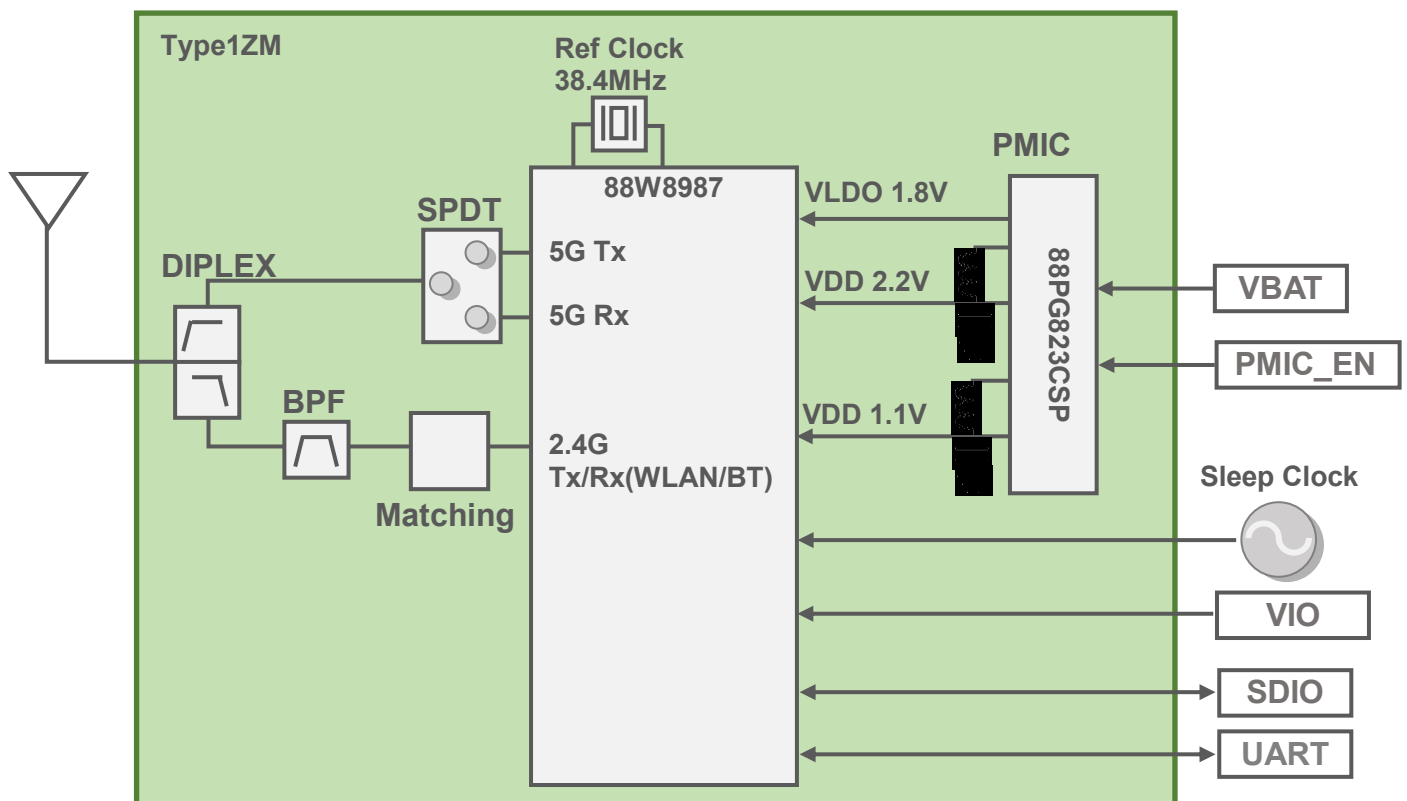
- Host Interface

- WLAN :SDIO
- BT/BLE :SDIO(Default) or UART
- IC P/N : Marvell 88W8987
- Reference Clock : Reference clock embedded
- Weight : TBD
- MSL : TBD
- RoHS : This component can meet with RoHS compliance.

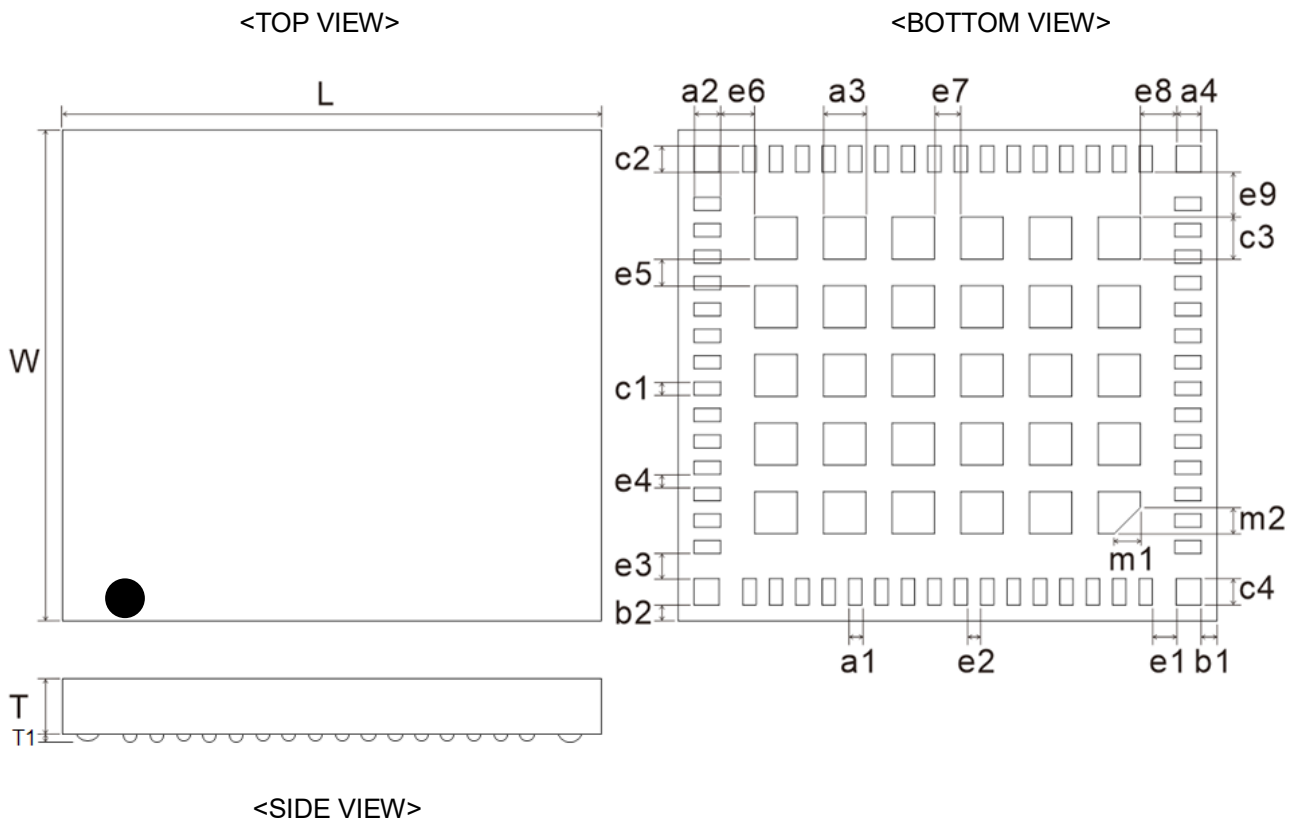
2. Part Number

Ordering Part Number	Description
LBEE5QD1ZM-TEMP	In case of sample order
LBEE5QD1ZM-TEMP-D	EVK

3. Block Diagram



4. DIMENSIONS, MARKING AND TERMINAL CONFIGURATIONS

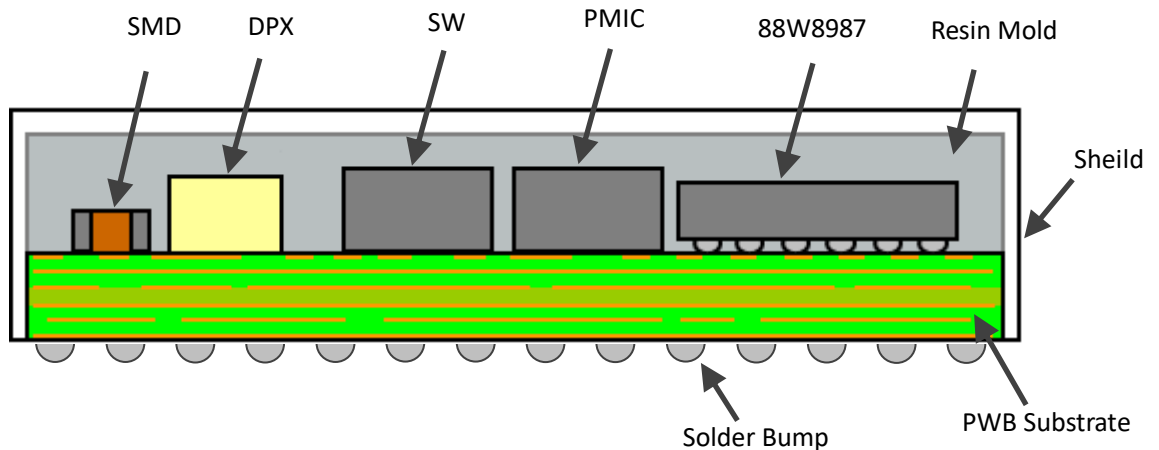


(unit : mm)

Mark	Dimensions	Mark	Dimensions	Mark	Dimensions
L	10.2 +/- 0.2	W	9.3 +/- 0.2	T	1.30 max.
a1	0.25 +/- 0.1	a2	0.5 +/- 0.1	a3	0.8 +/- 0.1
a4	0.475 +/- 0.1	b1	0.3 +/- 0.2	b2	0.3 +/- 0.2
c1	0.25 +/- 0.1	c2	0.5 +/- 0.1	c3	0.8 +/- 0.1
c4	0.5 +/- 0.1	e1	0.45 +/- 0.1	e2	0.25 +/- 0.1
e3	0.475 +/- 0.1	e4	0.25 +/- 0.1	e5	0.5 +/- 0.1
e6	0.65 +/- 0.1	e7	0.5 +/- 0.1	e8	0.65 +/- 0.1
e9	0.85 +/- 0.1	m1	0.5 +/- 0.1	m2	0.5 +/- 0.1
T1	0.045 typ.	—	—	—	—

* T dimension does not include height of solder bumps.

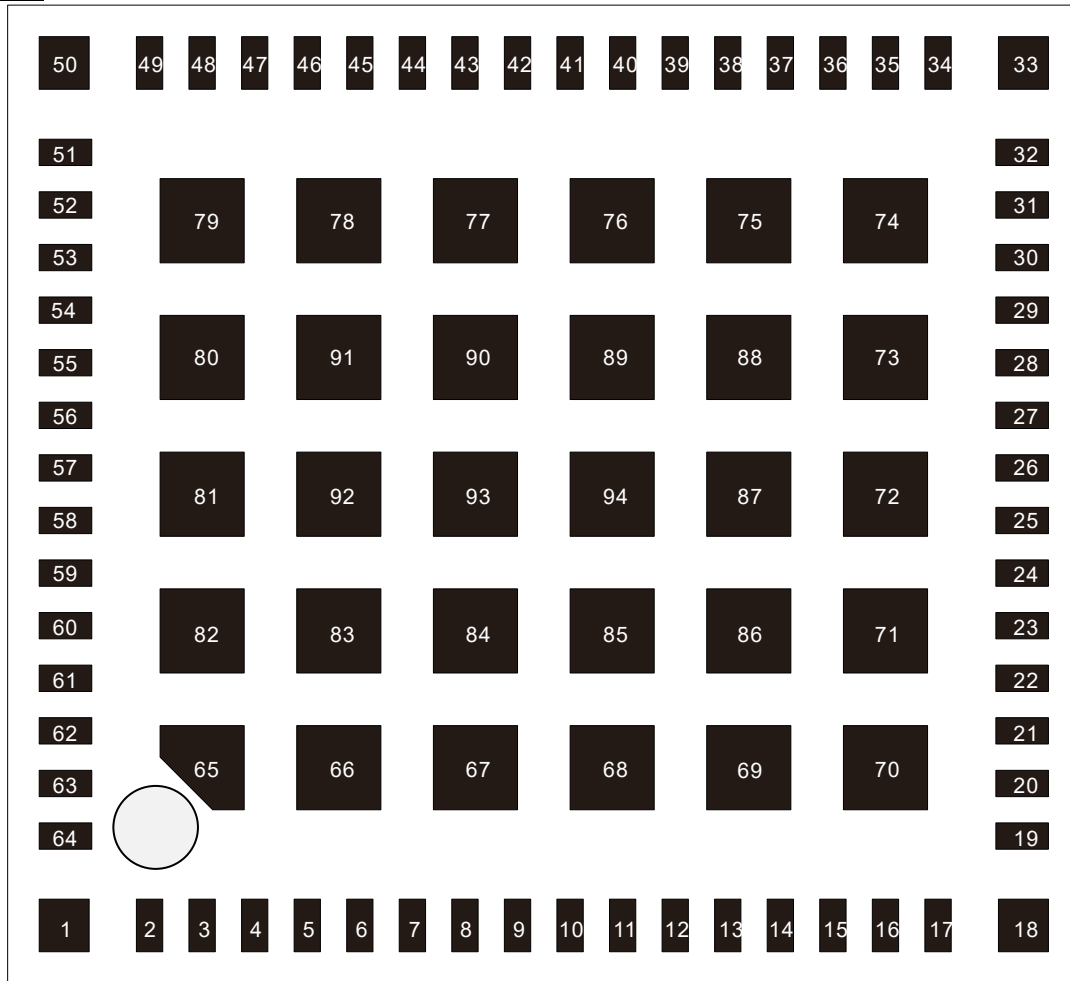
Structure



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Pin Layout

Top View



No	Pin name	No	Pin name	No	Pin name	No	Pin name
1	GND	18	GND	35	VBAT	52	GND
2	GND	19	GND	36	GND	53	SD_DAT2
3	GPIO19	20	RF	37	GND	54	SD_DAT3
4	GPIO18	21	GND	38	GPIO15	55	SD_DAT1
5	GPIO17	22	GND	39	GPIO14	56	SD_DAT0
6	GPIO16	23	CONFIG_AUTO_REF_DET	40	GPIO13	57	SD_CMD
7	GPIO7	24	GND	41	GPIO12	58	GND
8	GPIO0	25	GND	42	PMIC_EN	59	SD_CLK
9	GPIO6	26	GND	43	GND	60	GND
10	GPIO5	27	GPIO1	44	NC(PDn)	61	SLP_CLK_IN
11	GPIO4	28	GPIO2	45	GND	62	GND
12	CONFIG_HOST[0]	29	GPIO3	46	GPIO11	63	VIO
13	CONFIG_HOST[1]	30	GPIO20	47	GPIO10	64	GND
14	VDD18	31	GND	48	GPIO9	65 ~ 94	GND
15	GND	32	GND	49	GPIO8		
16	GND	33	GND	50	GND		
17	GND	34	VBAT	51	GND		

Terminal Configurations

No.	Pin name	Type	Connection to IC pin name	Description
1	GND	-	-	Ground
2	GND	-	-	Ground
3	GPIO19	I/O	GPIO[19](88W8987) DVS1(PMIC)	NC
4	GPIO18	I/O	GPIO[18](88W8987) DVS0(PMIC)	NC
5	GPIO17	I/O	GPIO[17]	Programmable GPIO Pin
6	GPIO16	I/O	GPIO[16]	Programmable GPIO Pin
7	GPIO7	I/O	GPIO[7]	Programmable GPIO Pin
8	GPIO0	I/O	GPIO[0]	Programmable GPIO Pin
9	GPIO6	I/O	GPIO[6]	Programmable GPIO Pin
10	GPIO5	I/O	GPIO[5]	Programmable GPIO Pin
11	GPIO4	I/O	GPIO[4]	Programmable GPIO Pin
12	CONFIG_HOST[0]	I	CONFIG_HOST[0]	Firmware Boot Options
13	CONFIG_HOST[1]	I	CONFIG_HOST[1]	
14	VDD18	O	AVDD18(88W8987) VLDO(PMIC)	NC
15	GND	-	-	Ground
16	GND	-	-	Ground
17	GND	-	-	Ground
18	GND	-	-	Ground
19	GND	-	-	Ground
20	RF	I/O	-	WLAN/Bluetooth Antenna
21	GND	-	-	Ground
22	GND	-	-	Ground
23	CONFIG_AUTO_REF_DET	I	CONFIG_AUTO_REF_DET	Reference Clock Frequency Detection Select 0 = reference clock frequency detection by CONFIG_XOSC_SEL(GPIO8) 1 = reference clock frequency detection using external sleep clock(Default/internal PU)(valid only when external sleep clock is used)
24	GND	-	-	Ground
25	GND	-	-	Ground
26	GND	-	-	Ground
27	GPIO1	I/O	GPIO[1]	Programmable GPIO Pin
28	GPIO2	I/O	GPIO[2]	Programmable GPIO Pin
29	GPIO3	I/O	GPIO[3]	Programmable GPIO Pin
30	GPIO20	I/O	GPIO[20]	Programmable GPIO Pin
31	GND	-	-	Ground
32	GND	-	-	Ground
33	GND	-	-	Ground
34	VBAT	I	PVIN(PMIC)	Power supply
35	VBAT	I	PVIN(PMIC)	Power supply
36	GND	-	-	Ground
37	GND	-	-	Ground
38	GPIO15	I/O	GPIO[15]	Programmable GPIO Pin
39	GPIO14	I/O	GPIO[14]	Programmable GPIO Pin

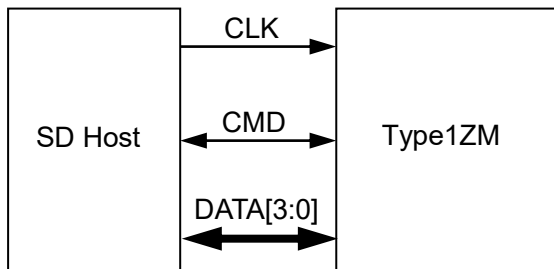
No.	Pin name	Type	Connection to IC Pin name	Description
40	GPIO13	I/O	GPIO[13]	Programmable GPIO Pin
41	GPIO12	I/O	GPIO[12]	Programmable GPIO Pin
42	PMIC_EN	I	EN(PMIC)	Enable Input for All Regulators - Logic high enables regulators and logic low disables regulators - When not in use, connect this pin to GND or connect a 0ohm resistor to GND Do not float this pin
43	GND	-	-	Ground
44	NC(PDn)	-	-	-
45	GND	-	-	Ground
46	GPIO11	I/O	GPIO[11]	Programmable GPIO Pin
47	GPIO10	I/O	GPIO[10]	Programmable GPIO Pin
48	GPIO9	I/O	GPIO[9]	Programmable GPIO Pin
49	GPIO8	I/O	GPIO[8]	Reference Clock Frequency Select Low when CONFIG_AUTO_REF_DET = 0 NC when CONFIG_AUTO_REF_DET = 1
50	GND	-	-	Ground
51	GND	-	-	Ground
52	GND	-	-	Ground
53	SD_DAT2	I/O	SD_DAT[2]	SDIO Data line Bit[2]
54	SD_DAT3	I/O	SD_DAT[3]	SDIO Data line Bit[3]
55	SD_DAT1	I/O	SD_DAT[1]	SDIO Data line Bit[1]
56	SD_DAT0	I/O	SD_DAT[0]	SDIO Data line Bit[0]
57	SD_CMD	I/O	SD_CMD	SDIO Command/response
58	GND	-	-	Ground
59	SD_CLK	I	SD_CLK	SDIO Clock input
60	GND	-	-	Ground
61	SLP_CLK_IN	I	SLP_CLK_IN	Sleep Clock input
62	GND	-	-	Ground
63	VIO	I	VIO VIO_RF VIO_SD	Power supply
64	GND	-	-	Ground
65~94	GND	-	-	Ground

Configuration Pins

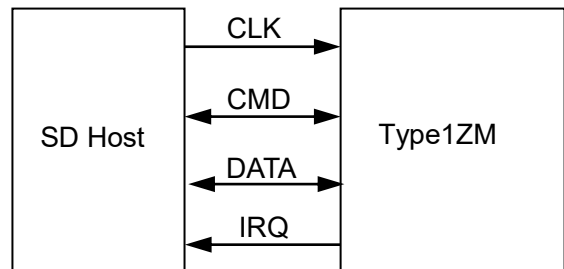
CONFIG_HOST[0]	CONFIG_HOST[1]	WLAN	Bluetooth	Remarks
1	1	SDIO	SDIO	Murata Default
0	1	SDIO	UART	-

SDIO Pin Description

No.	Pin Name	(i) SD 4-bit Mode		(ii) SD 1-bit Mode	
20	SDIO_CLK	CLK	Clock	CLK	Clock
17	SDIO_D0	DATA0	Data line 0	DATA	Data line
15	SDIO_D1	DATA1	Data line 1 /Interrupt	IRQ	Interrupt
16	SDIO_D2	DATA2	Data line 2	NC	Not used
14	SDIO_D3	DATA3	Data line 3	NC	Not used
18	SDIO_CMD	CMD	Command line	CMD	Command line



(i) SD 4-bit Mode



(ii) SD 1-bit Mode

5. Rating

Parameter		min.	max.	Unit
Storage Temperature		-40	85	deg.C
Supply Voltage	VBAT	0	6.0	V
	VIO	0	3.9	V

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

6. OPERATING CONDITION

6.1. Operating condition

Parameter		min.	typ.	max.	unit
Operating Temperature*1		-30	25	+75	deg.C
Supply Voltage	VBAT	2.7	-	4.8	V
	VIO	1.62	-	1.98	V

*1 Functionality is guaranteed but specifications require derating at extreme temperatures.

6.2. External LPO Signal Requirement

Symbol	Parameter	Min	Typ	Max	Unit
CLK	Clock frequency range/accuracy CMOS input clock signal type ± 250 ppm (initial , aging, temperature)	-	32.768	-	kHz
VIH	Input levels, where VIO = 1.8,2.5,3.3V	0.7*VIO	-	VIO+0.4	V
VIL		-0.4	-	0.3*VIO	V
PN	Phase Noise Requirement (@ 100kHz)	-	-125	-	dBc/Hz
Jc	Cycle jitter	-	1.5	-	ns(RMS)
SR	Slew rate limit (10-90%)	-	-	100	ns
DC	Duty cycle tolerance	20	-	80	%

6.3. POWER ON SEQUENCE

6.3.1. Power on Sequence

- VIO must be good (90%) at the same time PMIC_EN ramps up
- Rump-up time of VIO must be <100ms



7. Digital I/O Requirements

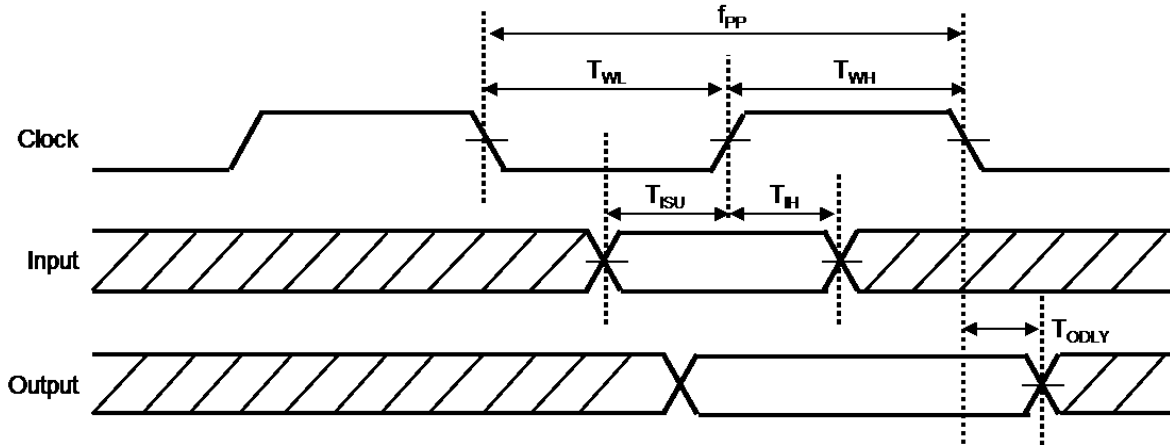
Symbol	Parameter	Condition	Min	Typ	Max	Unit
V _{IH}	Input high voltage	-	0.7*VIO	-	VIO+0.4	V
V _{IL}	Input low voltage	-	-0.4	-	0.3*VIO	V
V _{HYS}	Input hysteresis	-	100	-	-	mV
V _{OH}	Output high voltage	-	VIO-0.4	-	-	V
V _{OL}	Output low voltage	-	-	-	0.4	V

8. INTERFACE TIMING

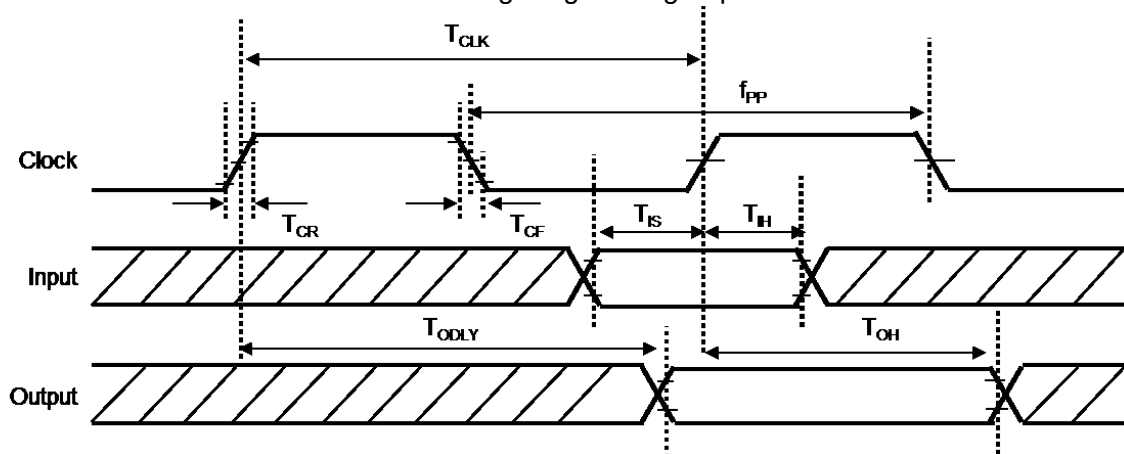
8.1. SDIO Timing

8.1.1. Default Speed, High-Speed Modes

SDIO Protocol Timing Diagram-Default Speed Mode



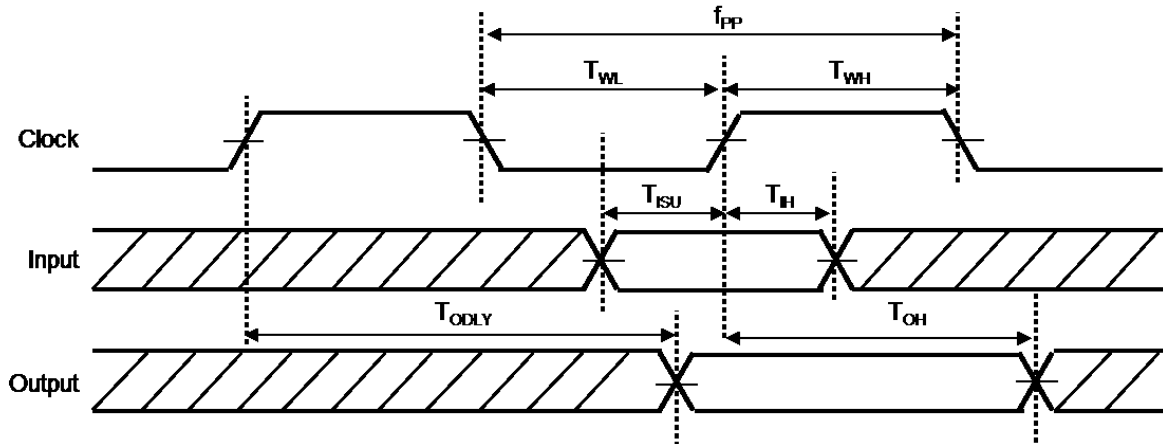
SDIO Protocol Timing Diagram-High Speed Mode



Symbol	Parameter	Condition	Min	Typ	Max	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_{ODLY}	Output delay time	Normal	-	-	14	ns
	$CL \leq 40pF$ (1 card)	High-speed	-	-	14	ns
T_{OH}	Output hold time	High-speed	2.5	-	-	ns

8.1.2. SDR12,SDR25,SDR50 Modes(up to 100 MHz)

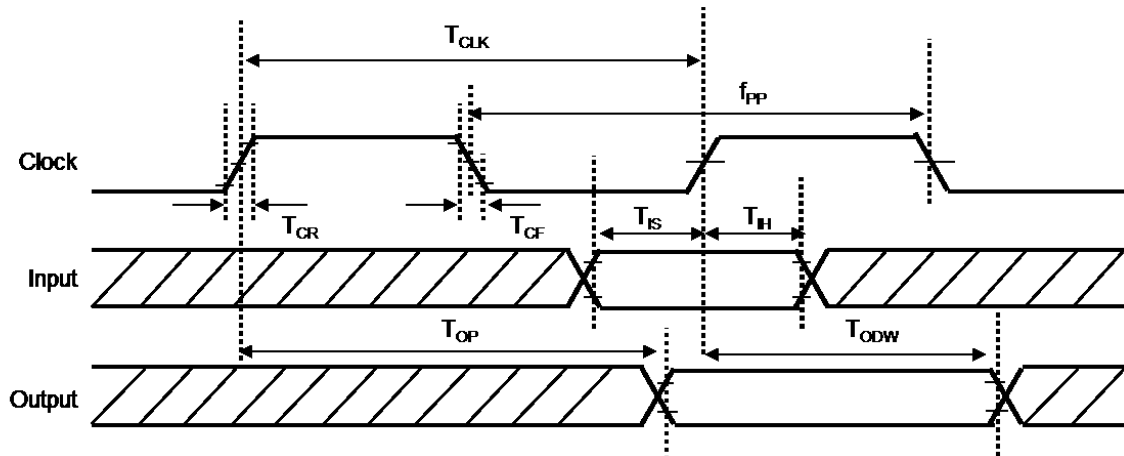
SDIO Protocol Timing Diagram-SDR12,SDR25,SDR50 Mode(up to 100MHz)



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

8.1.3. SDR104 Mode(208MHz)

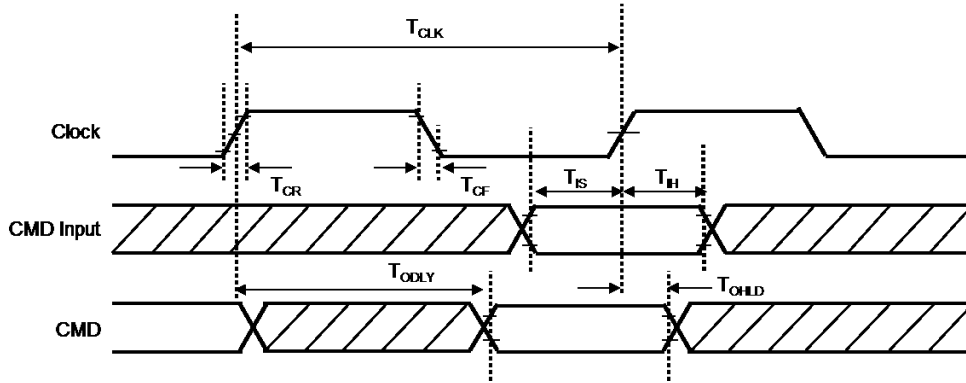
SDIO Protocol Timing Diagram-SDR104 Mode (208MHz)



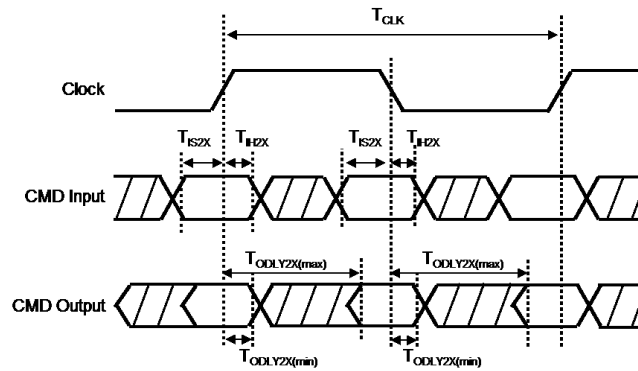
Symbol	Parameter	Condition	Min	Typ	Max	Unit
f_{PP}	Clock frequency	SDR104	0	-	208	MHz
T_{IS}	Input setup time	SDR104	1.4	-	-	ns
T_{IH}	Input hold time	SDR104	0.8	-	-	ns
T_{CLK}	Clock time	SDR104	4.8	-	-	ns
T_{CR}, T_{CF}	Rise time, fall time $T_{CR}, T_{CF} < 0.96\text{ns}(\text{max})$ at 208MHz $C_{CARD} = 10\text{pF}$	SDR104	-	-	$0.2 \cdot T_{CLK}$	ns
T_{OP}	Card output phase	SDR104	0	-	10	ns
T_{ODW}	Output timing of variable data window	SDR104	2.88	-	-	ns

8.1.4. DDR50 Mode(50MHz)

SDIO CMD Timing Diagram-DDR50 Mode (50MHz)



SDIO DATA Timing Diagram-DDR50 Mode (50MHz)



Symbol	Parameter	Condition	Min	Typ	Max	Unit
Clock						
T_{CLK}	Clock time 50MHz (max) between rising edge	DDR50	20	-	-	ns
T_{CR}, T_{CF}	Rise time, fall time $T_{CR}, T_{CF} < 4.00\text{ns(max)}$ at 50MHz $C_{CARD} = 10\text{pF}$	DDR50	-	-	$0.2 \cdot T_{CLK}$	ns
Clock Duty	-	DDR50	45	-	55	%
CMD Input (referenced to clock rising edge)						
T_{IS}	Input setup time $C_{CARD} \leq 10\text{pF(1 card)}$	DDR50	6	-	-	ns
T_{IH}	Input hold time $C_{CARD} \leq 10\text{pF(1 card)}$	DDR50	0.8	-	-	ns
CMD Input (referenced to clock rising edge)						
T_{ODLY}	Output delay time during data transfer mode $C_L \leq 30\text{pF(1 card)}$	DDR50	-	-	13.7	ns
$T_{OHL D}$	Output hold time $C_L \geq 15\text{pF(1 card)}$	DDR50	1.5	-	-	ns
DAT[3:0] Input (referenced to clock rising and falling edges)						
T_{IS2X}	Input setup time $C_{CARD} \leq 10\text{pF(1 card)}$	DDR50	3	-	-	ns
T_{IH2X}	Input hold time $C_{CARD} \leq 10\text{pF(1 card)}$	DDR50	0.8	-	-	ns
DAT[3:0] Output (referenced to clock rising and falling edges)						
$T_{ODLY2X(max)}$	Output delay time during data transfer mode $C_L \leq 25\text{pF(1 card)}$	DDR50	-	-	7	ns
$T_{ODLY2X(min)}$	Output hold time $C_L \geq 15\text{pF(1 card)}$	DDR50	1.5	-	-	ns

9. DC / RF Characteristics

9.1. DC/RF Characteristics for IEEE802.11b - 2.4GHz

Specification	IEEE802.11b
Mode	DSSS / CCK
Channel Frequency	2412 - 2472MHz
Data rate	1, 2, 5.5, 11Mbps

Normal Condition : 25deg.C, VBAT=3.3V. Output power setting=TBDdBm, 11Mbps.

Items	Contents			
- DC Characteristics -	Min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*2	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics *2 -	Min.	Typ.	Max.	Unit
2. Output Power	TBD	17 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 1st side lobes	0	-	-	dB
2) 2nd side lobes	0	-	-	dB
4. Power-on/off ramp	-	-	2.0	Usec
5. RF Carrier Suppression	15	-	-	dB
6. Modulation Accuracy	-	-	35	%
7. Frequency tolerance	-20		20	ppm
8. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-12750MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
9. Minimum Input Level (FER $\leq$ 8%)	-	-	-76	dBm
10. Maximum Input Level (FER $\leq$ 8%)	-10	-	-	dBm
11. Adjacent Channel Rejection (FER< 8%)	35	-	-	dB

*2: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

9.2. DC/RF Characteristics for IEEE802.11g - 2.4GHz

Specification	IEEE802.11g
Mode	OFDM
Channel Frequency	2412 - 2472MHz
Data rate	6, 9, 12, 18, 24, 36, 48, 54Mbps

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, 54Mbps

Items	Contents			
- DC Characteristics -	Min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*3	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*3 -	Min.	Typ.	Max.	Unit
2. Output Power	TBD	16 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 9MHz to 11MHz (0~ -20dBr)	0	-	-	dB
2) 11MHz to 20MHz (-20~ -28dBr)	0	-	-	dB
3) 20MHz to 30MHz (-28~ -40dBr)	0	-	-	dB
4) 30MHz to 33MHz (-40dBr)	0	-	-	dB
4. Constellation Error(EVM)	-	-	-25	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-12750MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
7. Minimum Input Level (PER < 10%)	-	-	-65	dBm
8. Maximum Input Level (PER < 10%)	-20	-	-	dBm
9. Adjacent Channel Rejection (PER< 10%)	-1	-	-	dB

*3: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

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

Specification	IEEE802.11n
Mode	OFDM
Channel Frequency	2412 - 2472MHz
Data rate	MCS0-MCS7

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, 65Mbps(MCS7)

Items	Contents			
- DC Characteristics -	Min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*4	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*4 -	Min.	Typ.	Max.	Unit
2. Output Power	TBD	15 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 9MHz to 11MHz (0~ -20dBr)	0	-	-	dB
2) 11MHz to 20MHz (-20~ -28dBr)	0	-	-	dB
3) 20MHz to 30MHz (-28~ -45dBr)	0	-	-	dB
4) 30MHz to 33MHz (-45dBr)	0	-	-	dB
4. Constellation Error (EVM) (measured at enhanced mode)	-	-	-27	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-12750MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
7. Minimum Input Level (PER ≤ 10%)	-	-	-64	dBm
8. Maximum Input Level (PER < 10%)	-20	-	-	dBm
9. Adjacent Channel Rejection (PER ≤ 10%)	-2	-	-	dB

*4: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

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

Specification	IEEE802.11a
Mode	OFDM
Channel Frequency	5180 to 5240MHz, 5260 to 5320MHz, 5500 to 5720MHz, 5745 to 5825MHz
Data rate	6, 9, 12, 18, 24, 36, 48, 54Mbps

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, 54Mbps

Items	Contents			
- DC Characteristics -	min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*5	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*5 -	min.	Typ.	Max.	Unit
2. Output Power	TBD	15 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 9MHz to 11MHz (0~ -20dBr)	0	-	-	dB
2) 11MHz to 20MHz (-20~ -28dBr)	0	-	-	dB
3) 20MHz to 30MHz (-28~ -45dBr)	0	-	-	dB
4) 30MHz to 33MHz (-45dBr)	0	-	-	dB
4. Constellation Error (EVM) (measured at enhanced mode)	-	-	-25	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-5150MHz (BW=1MHz)	-	-	-30	dBm
11) 5350-5470MHz (BW=1MHz)	-	-	-30	dBm
12) 5725-26000MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
7. Minimum Input Level (PER ≤ 10%)	-	-	-65	dBm
8. Maximum Input Level (PER < 10%)	-30	-	-	dBm
9. Adjacent Channel Rejection (PER ≤ 10%)	-1	-	-	dB

*5: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

9.5. DC/RF Characteristics for IEEE802.11n(HT20) - 5GHz

Specification	IEEE802.11n
Mode	OFDM
Channel Frequency	5180 to 5240MHz, 5260 to 5320MHz, 5500 to 5720MHz, 5745 to 5825MHz
Data rate	MCS0-MCS7

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, MCS7

Items	Contents			
- DC Characteristics -	min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*6	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*6 -	min.	Typ.	Max.	Unit
2. Output Power	TBD	14 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 9MHz to 11MHz (0~ -20dBr)	0	-	-	dB
2) 11MHz to 20MHz (-20~ -28dBr)	0	-	-	dB
3) 20MHz to 30MHz (-28~ -45dBr)	0	-	-	dB
4) 30MHz to 33MHz (-45dBr)	0	-	-	dB
4. Constellation Error (EVM) (measured at enhanced mode)	-	-	-27	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-5150MHz (BW=1MHz)	-	-	-30	dBm
11) 5350-5470MHz (BW=1MHz)	-	-	-30	dBm
12) 5725-26000MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
7. Minimum Input Level (PER ≤ 10%)	-	-	-64	dBm
8. Maximum Input Level (PER < 10%)	-30	-	-	dBm
9. Adjacent Channel Rejection (PER ≤ 10%)	-2	-	-	dB

*6: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

9.6. DC/RF Characteristics for IEEE802.11ac(HT20) - 5GHz

Specification	IEEE802.11ac
Mode	OFDM
Channel Frequency	5180 to 5240MHz, 5260 to 5320MHz, 5500 to 5720MHz, 5745 to 5825MHz
Data rate	MCS0-MCS8

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, MCS8

Items	Contents			
- DC Characteristics -	min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*7	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*7 -	min.	Typ.	Max.	Unit
2. Output Power	TBD	14 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 9MHz to 11MHz (0~ -20dBr)	0	-	-	dB
2) 11MHz to 20MHz (-20~ -28dBr)	0	-	-	dB
3) 20MHz to 30MHz (-28~ -45dBr)	0	-	-	dB
4) 30MHz to 33MHz (-45dBr)	0	-	-	dB
4. Constellation Error (EVM) (measured at enhanced mode)	-	-	-30	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-5150MHz (BW=1MHz)	-	-	-30	dBm
11) 5350-5470MHz (BW=1MHz)	-	-	-30	dBm
12) 5725-26000MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
7. Minimum Input Level (PER ≤ 10%)	-	-	-59	dBm
8. Maximum Input Level (PER < 10%)	-30	-	-	dBm
9. Adjacent Channel Rejection (PER ≤ 10%)	-7	-	-	dB

*7: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

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

Specification	IEEE802.11n
Mode	OFDM
Frequency	5190 to 5795MHz
Data rate	MCS0-MCS7

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, MCS7, HT 40MHz

Items	Contents			
- DC Characteristics -	min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*8	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*8 -	min.	Typ.	Max.	Unit
2. Output Power	TBD	14 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 19MHz to 21MHz (0~ -20dBr)	0	-	-	dB
2) 21MHz to 40MHz (-20~ -28dBr)	0	-	-	dB
3) 40MHz to 60MHz (-28~ -45dBr)	0	-	-	dB
4) 60MHz to 80MHz (-45dBr)	0	-	-	dB
4. Constellation Error (EVM) (measured at enhanced mode)	-	-	-27	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-5150MHz (BW=1MHz)	-	-	-30	dBm
11) 5350-5470MHz (BW=1MHz)	-	-	-30	dBm
12) 5725-26000MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
7. Minimum Input Level (PER ≤ 10%)	-	-	-61	dBm
8. Maximum Input Level (PER ≤ 10%)	-30	-	-	dBm
9. Adjacent Channel Rejection (PER ≤ 10%)	-2	-	-	dB

*8: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

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

Specification	IEEE802.11ac
Mode	OFDM
Frequency	5190 to 5795MHz
Data rate	MCS0-MCS9

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, MCS9 VHT 40MHz

Items	Contents			
- DC Characteristics -	min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*9	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*9 -	min.	Typ.	Max.	Unit
2. Output Power	TBD	13 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 19MHz to 21MHz (0~ -20dBr)	0	-	-	dB
2) 21MHz to 40MHz (-20~ -28dBr)	0	-	-	dB
3) 40MHz to 60MHz (-28~ -45dBr)	0	-	-	dB
4) 60MHz to 80MHz (-45dBr)	0	-	-	dB
4. Constellation Error (EVM) (measured at enhanced mode)	-	-	-32	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-5150MHz (BW=1MHz)	-	-	-30	dBm
11) 5350-5470MHz (BW=1MHz)	-	-	-30	dBm
12) 5725-26000MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
7. Minimum Input Level (PER ≤ 10%)	-	-	-54	dBm
8. Maximum Input Level (PER ≤ 10%)	-30	-	-	dBm
9. Adjacent Channel Rejection (PER ≤ 10%)	-9	-	-	dB

*9: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

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

Specification	IEEE802.11ac
Mode	OFDM
Channel Frequency	5210 - 5775MHz
Data rate	MCS0-MCS9

Normal Condition : 25deg.C, VBAT =3.3V. Output power setting=TBDdBm, MCS9, VHT 80MHz

Items	Contents			
- DC Characteristics -	min.	Typ.	Max.	Unit
1. DC current				
1) Tx mode*10	-	-	TBD	mA
2) Rx mode	-	-	TBD	mA
- Tx Characteristics*10 -	min.	Typ.	Max.	Unit
2. Output Power	TBD	13 (TBD)	TBD	dBm
3. Spectrum Mask Margin				
1) 39MHz to 41MHz (0~ -20dBr)	0	-	-	dB
2) 41MHz to 80MHz (-20~ -28dBr)	0	-	-	dB
3) 80MHz to 120MHz (-28~ -40dBr)	0	-	-	dB
4) 120MHz to 140MHz (-40dBr)	0	-	-	dB
4. Constellation Error (EVM) (measured at enhanced mode)	-	-	-32	dB
5. Frequency tolerance	-20		20	ppm
6. Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-5150MHz (BW=1MHz)	-	-	-30	dBm
11) 5350-5470MHz (BW=1MHz)	-	-	-30	dBm
12) 5725-26000MHz (BW=1MHz)	-	-	-30	dBm
- Rx Characteristics -	Min.	Typ.	Max.	Unit
6. Minimum Input Level (PER ≤ 10%)	-	-	-51	dBm
7. Maximum Input Level (PER ≤ 10%)	-30	-	-	dBm
8. Adjacent Channel Rejection (PER ≤ 10%)	-9	-	-	dB

*10: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

9.10. DC/RF Characteristics for Bluetooth

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

Items		Contents			
Bluetooth specification (power class)		Version 5.1 (Class1)			
Channel frequency (spacing)		2402 to 2480 MHz (1MHz)			
Tx Characteristics *11		Min.	Typ.	Max.	Unit
Output Power	BDR	TBD	TBD	TBD	dBm
	EDR	TBD	TBD	TBD	dBm
20dB bandwidth		-		1	MHz
Modulation characteristics					
(a) Modulation Δf_{1avg}		140	-	175	kHz
(b) Modulation Δf_{2max}		115		-	kHz
(c) Modulation $\Delta f_{2avg} / \Delta f_{1avg}$		0.8	-	-	
Carrier Frequency Drift					
(a) 1slot		-25	-	+25	kHz
(b) 3slot / 5slot		-40	-	+40	kHz
(c) Maximum drift rate		-20	-	+20	kHz/500s
EDR Relative Power		-4	-	+1	dB
EDR Carrier Frequency Stability and Modulation Accuracy					
(a) ω_i		-75	-	+75	kHz
(b) $\omega_i + \omega_o$		-75	-	+75	kHz
(c) ω_o		-10	-	+10	kHz
(d) RMS DEVM ($\pi/4$ DQPSK)		-	-	20	%
(e) Peak DEVM ($\pi/4$ DQPSK)		-	-	35	%
(f) 99% DEVM ($\pi/4$ DQPSK)		-	-	30	%
(g) RMS DEVM (8DPSK)		-	-	13	%
(h) Peak DEVM (8DPSK)		-	-	25	%
(i) 99% DEVM (8DPSK)		-	-	20	%
Spurious Emissions (BW=100kHz)					
(a) $10\text{MHz} \leq f < 2387\text{MHz}$		-	-	-36	dBm
(b) $2387\text{MHz} \leq f < 2400\text{MHz}$		-	-	-30	dBm
(c) $2483.5\text{MHz} < f \leq 2496.5\text{MHz}$		-	-	-47	dBm
(d) $2496.5\text{MHz} < f \leq 8\text{GHz}$		-	-	-47	dBm
Spurious Emissions					
1) 30-47MHz (BW=100kHz)		-	-	-36	dBm
2) 47-74MHz (BW=100kHz)		-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)		-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)		-	-	-54	dBm
5) 118-174MHz (BW=100kHz)		-	-	-36	dBm
6) 174-230MHz (BW=100kHz)		-	-	-54	dBm
7) 230-470MHz (BW=100kHz)		-	-	-36	dBm
8) 470-862MHz (BW=100kHz)		-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)		-	-	-36	dBm
10) 1000-12750MHz (BW=1MHz)		-	-	-30	dBm
Rx Characteristics		Min.	Typ.	Max.	Unit
Sensitivity (BER $\leq$ 0.1%)		-	-	-80	dBm
Maximum Input Level (BER $\leq$ 0.1%)		-20	-	-	dBm
EDR Sensitivity (BER $\leq$ 0.007%)					
(a) 8DPSK		-	-	-77	dBm

*11: Defined when output power setting is TBD dBm/BR and TBD dBm/EDR after matching components on Murata's EVB.

9.11. DC/RF Characteristics for Bluetooth (LE)

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

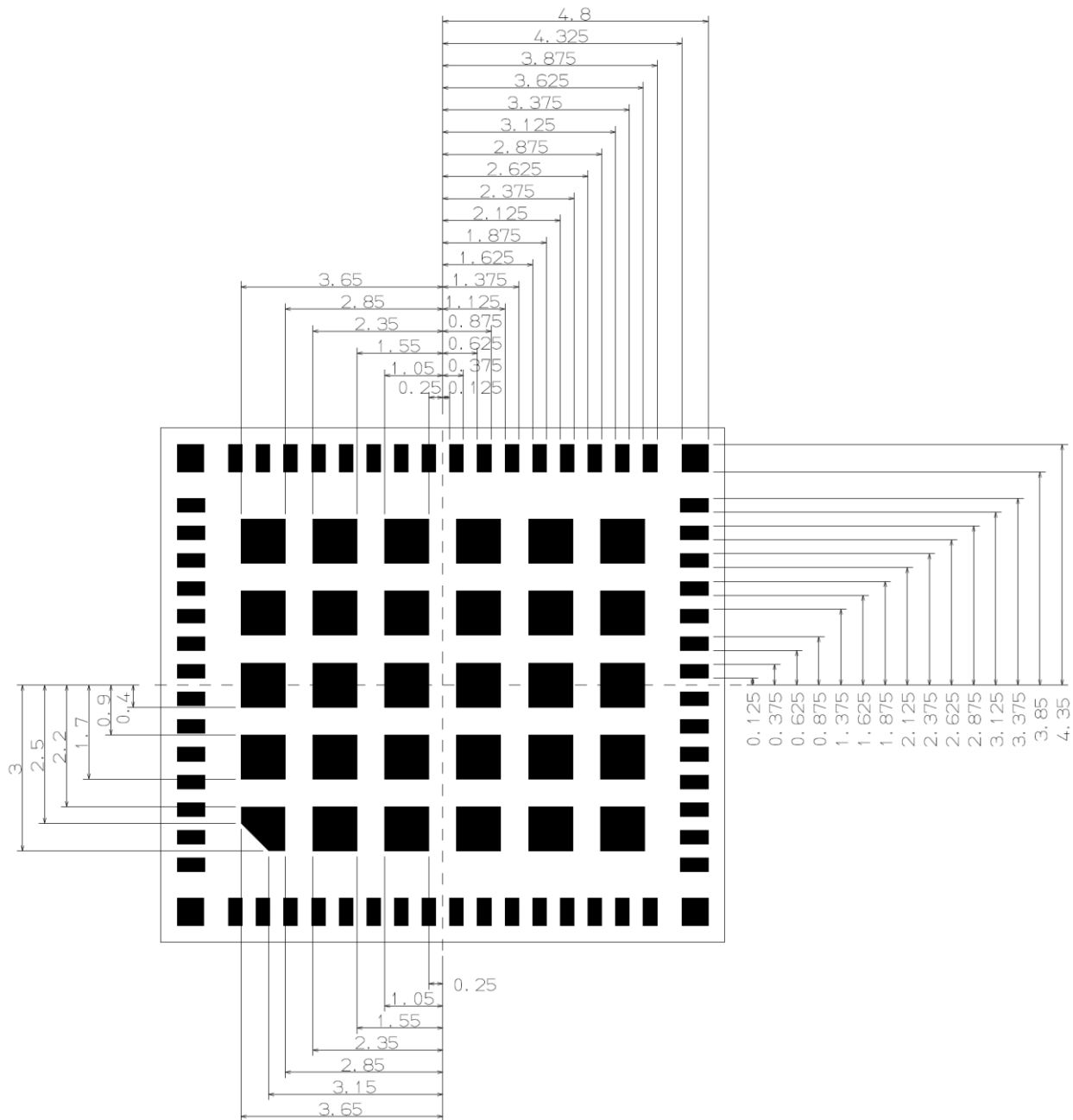
Items	Contents			
Bluetooth specification (power class)	Version 5.1 (LE)			
Channel frequency (spacing)	2402 to 2480 MHz (2MHz)			
Number of RF Channel	40			
Tx Characteristics *12	Min.	Typ.	Max.	Unit
Channel Spacing	-	2	-	MHz
Number of RF channel	-	40	-	-
Output power	TBD	TBD	TBD	dBm
Modulation Characteristics				
1) $\Delta f_{1\text{avg}}$	225	-	275	kHz
2) $\Delta f_{2\text{max}}$ (at 99.9%)	185	-	-	kHz
3) $\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}$	0.8	-	-	-
Carrier frequency offset and drift				
1) Frequency offset	-150	-	150	kHz
2) Frequency drift	-	-	50	kHz
3) Drift rate	-	-	20	kHz
Spurious Emissions				
1) 30-47MHz (BW=100kHz)	-	-	-36	dBm
2) 47-74MHz (BW=100kHz)	-	-	-54	dBm
3) 74-87.5MHz (BW=100kHz)	-	-	-36	dBm
4) 87.5-118MHz (BW=100kHz)	-	-	-54	dBm
5) 118-174MHz (BW=100kHz)	-	-	-36	dBm
6) 174-230MHz (BW=100kHz)	-	-	-54	dBm
7) 230-470MHz (BW=100kHz)	-	-	-36	dBm
8) 470-862MHz (BW=100kHz)	-	-	-54	dBm
9) 862-1000MHz (BW=100kHz)	-	-	-36	dBm
10) 1000-12750MHz (BW=1MHz)	-	-	-30	dBm
Rx Characteristics	Min.	Typ.	Max.	Unit
Receiver sensitivity (PER < 30.8%)	-	-	-70	dBm
Maximum input signal level (PER < 30.8%)	-10	-	-	dBm
PER Report Integrity (-30dBm input)	50	-	65.4	%

*12: Defined when output power setting is TBD dBm after matching components on Murata's EVB.

Note

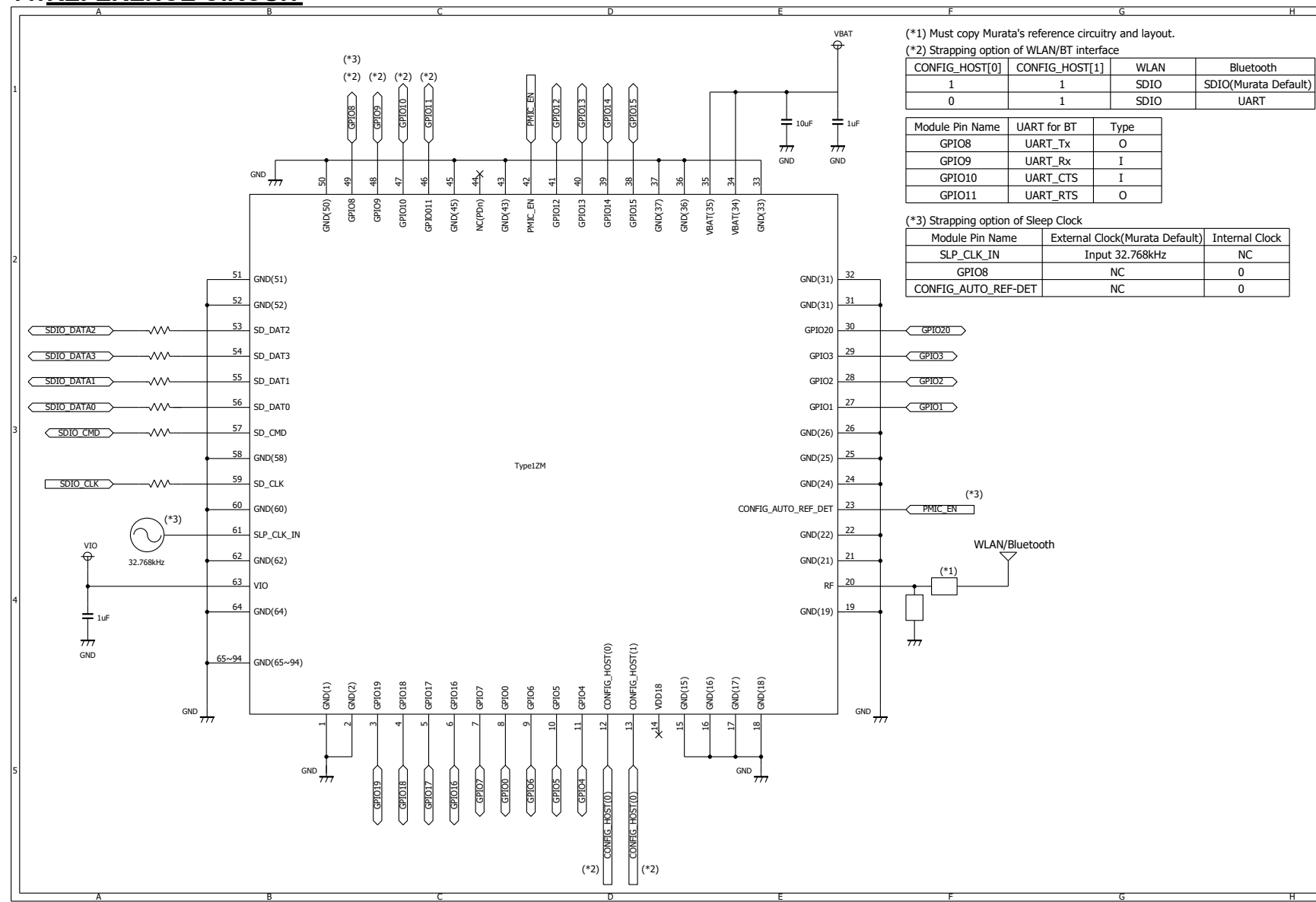
The above mentioned values have been obtained according to our own measuring methods and may very depend on the circuit, in which the component is actually incorporated. Therefore, you are kindly requested to test the performance of the component actually in your set.

10. LAND PATTERN (TOP VIEW)



* 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 0.2mm away from module outline as above figure.

11. REFERENCE CIRCUIT



12. TAPE AND REEL PACKING

TBD

13. NOTICE

13.1. Storage Conditions:

Please use this product within 6month after receipt.

- The product shall be stored without opening the packing under the ambient temperature from 5 to 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 6months after reception, it needs to be confirmed the solderbility before used.
- The product shall be stored in non corrosive gas (Cl₂, NH₃, SO₂, Nox, 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 material (Base Tape, Reel Tape and Cover Tape) are not heat-resistant.

13.2. Handling Conditions:

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

Handle with care if products may have cracks or damages on their terminals, the characteristics of products may change. Do not touch products with bare hands that may result in poor solder ability and destroy by static electrical charge.

13.3. 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.

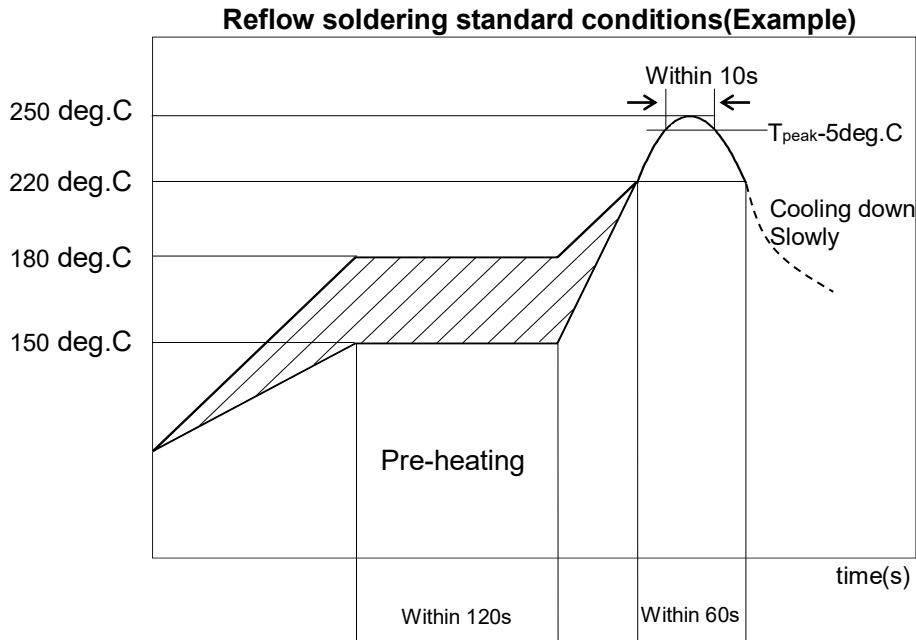
The recommended land pattern and dimensions is as Murata's standard. The characteristics of products may vary depending on the pattern drawing method, grounding method, land dimensions, land forming method of the NC terminals and the PCB material and thickness. Therefore, be sure to verify the characteristics in the actual set. When using non-standard lands, contact Murata beforehand.

13.4. 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.

13.5. Soldering Conditions:

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



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.

13.6. Cleaning:

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

13.7. Operational Environment Conditions:

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

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

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

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

14. PRECONDITION TO USE OUR PRODUCTS

PLEASE READ THIS NOTICE BEFORE USING OUR PRODUCTS.

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

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

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

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

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

- Aircraft equipment.
- Aerospace equipment
- Undersea equipment.
- Power plant control equipment
- Medical equipment.
- Transportation equipment (vehicles, trains, ships, elevator, etc.).
- Traffic signal equipment.
- Disaster prevention / crime prevention equipment.
- Burning / explosion control equipment
- Application of similar complexity and/ or reliability requirements to the applications listed in the above.

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

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

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

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

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

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

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- deviation or lapse in function of engineering sample,
- improper use of engineering samples.

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