# WiFi+Bluetooth Combo Module Data Sheet

## NXP 88W9098 Chipset
## for 802.11a/b/g/n/ac/ax 2x2 MIMO + Bluetooth 5.3

## Design Name: Type1XL
## P/N : LBEE5ZZ1XL-774

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

# Revision History

| Rev Code | Date | Description | Comments |
|---|---|---|---|
| - | Nov. 20 2020 | First Issue | |
| A | Mar. 15 2021 | 5. Dimensions, Marking and Terminal Configurations<br>6.1. Pin Assignments | -Changed module size and pin function information. |
| B | Mar. 29 2021 | 5. Dimensions, Marking and Terminal Configurations<br>6.2. Pin Descriptions | -Changed module height and pin function information. |
| C | Apr. 5 2021 | 5. Dimensions, Marking and Terminal Configurations | -Corrected e5 value from 1.09 to 1.10mm. |
| D | Apr. 28 2021 | 5. Dimensions, Marking and Terminal Configurations<br>12. Reference Circuit | -Added Marking information.<br>-Added reference circuit. |
| E | May 5 2021 | 6.2. Pin Descriptions | -Corrected pin description |
| F | Jun. 14, 2021 | 5. Dimensions, Marking and Terminal Configurations | -Modified Marking information. |
| G | Oct.18, 2021 | 1. Scope<br>2. Key Features<br>3. Part Number<br>6. Dimensions, Marking and Terminal Configurations<br>7.1 Pin Assignments<br>7.2 Pin Descriptions<br>7.3 Configuration Pins<br>7.4 Pin State<br>7.5 SDIO Pin Descriptions<br>12. Land patterns | -Updated Bluetooth version<br>-Added a new section<br>-Added MP part number<br>-Updated terminal size and dimensions.<br>-Updated a diagram and Pin 235-238<br>-Updated Pin 235-238 and Pin 68<br>-Added a new section<br>-Added a new section<br>-Added a new section<br>-Added Land patter figure |
| H | Feb. 01, 2022 | 4. Block Diagram<br>9.1 Operating Conditions<br>7.4 Pin States<br>13. Reference Circuit | -Removed sleep clock input<br>-Defined IO Current<br>-Added PDn<br>-Applied change of Pin 235-238 and Pin 68. |
| I | Apr. 01, 2022 | 5.1 Radio Certification<br>5.2 Bluetooth Qualification<br>6. Dimensions, Marking and Terminal Configurations<br>9.1 Operating conditions<br>9.2 Digital I/O Requirements<br>9.3 Package thermal conditions<br>11. Host Interface Specification<br>12.14. DC/RF Characteristics for Bluetooth<br>12.15. DC/RF Characteristics for Bluetooth | -Added certification number<br>-Added qualification number<br>-Added module structure, Defined T1.<br>-Added Junction temperature<br>-Added this section<br>-Added this section<br>-Added this section<br>-Added test method<br>-Added test method |
| J | May. 09, 2022 | 6. Dimensions, Marking and Terminal Configurations<br>9.1 Operating conditions<br>12.DC/RF Characteristics | -Modified b3 measurement<br>-Defined max values of peak current.<br>-Defined current consumption and max input level |
| K | May. 31, 2022 | 7.2 Pin Descriptions<br>7.4 Pin States<br>14. Reference circuit | -Updated supply voltage level of IO pins (Power domain)<br>-Updated supply voltage level of IO pins (Power domain)<br>-Connect Pin 82 to GND. Added comment on GPIO22/23. |
| L | Aug.26,2022 | 7.2 Pin Descriptions<br>9.1 Operating Condition<br>9.3 Package Thermal Conditions<br>14 Reference Circuit | -Corrected descriptions of Pin 56, Pin 65 and Pin76<br>-Added Notes.<br>-Corrected value.<br>-Corrected connection of Pin 20 and 21. |

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⚠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.

## 1. Scope

This specification is applied to the IEEE802.11 a/b/g/n/ac/ax + Bluetooth 5.3 module.

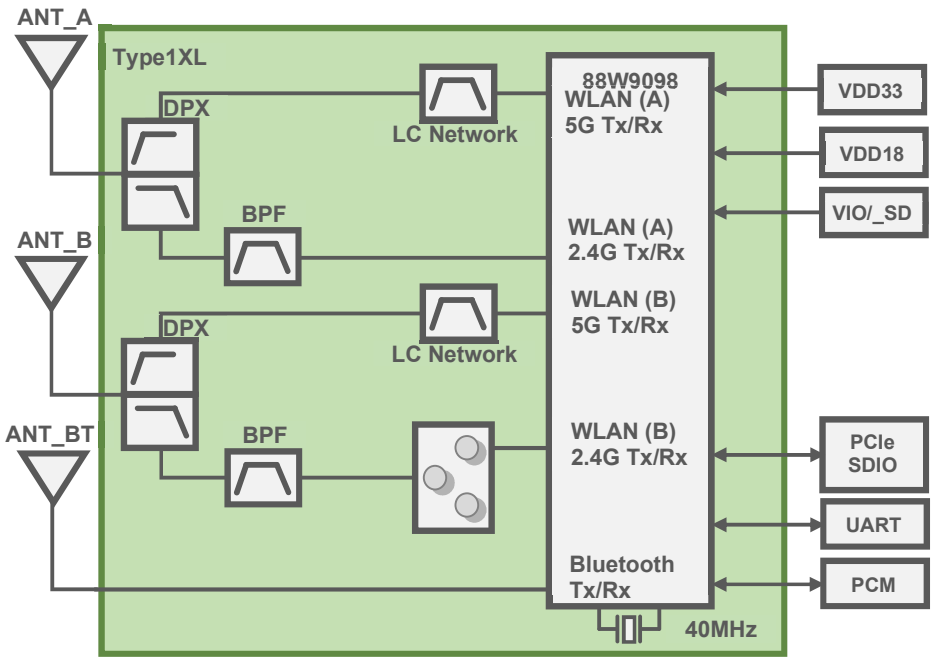
## 2. Key Features

- Module Size : 19.1(typ.) x 16.5(typ.) x 2.1(max.) mm
- Host Interface
  - WLAN : PCIe / SDIO
  - Bluetooth : UART
- IC P/N : NXP 88W9098
- Reference Clock : Reference clock embedded
- Weight : 1355 mg
- MSL : 3
- RoHS : This component can meet with RoHS compliance.

## 3. Part Number

| Ordering Part Number | Description |
|---|---|
| LBEE5ZZ1XL-774 | MP order |
| LBEE5ZZ1XL-SMP | In case of sample order |

## 4. Block Diagram



# 5. Certification Information

## 5.1. Radio Certification

### USA

FCC ID: VPYLBEE5ZZ1XL
Country Code: US

### Canada

IC: 772C-LBEE5ZZ1XL
Country Code: CA

### Europe

EN300328/301893, EN300440 conducted test report is prepared.
Country Code: DE

### Japan

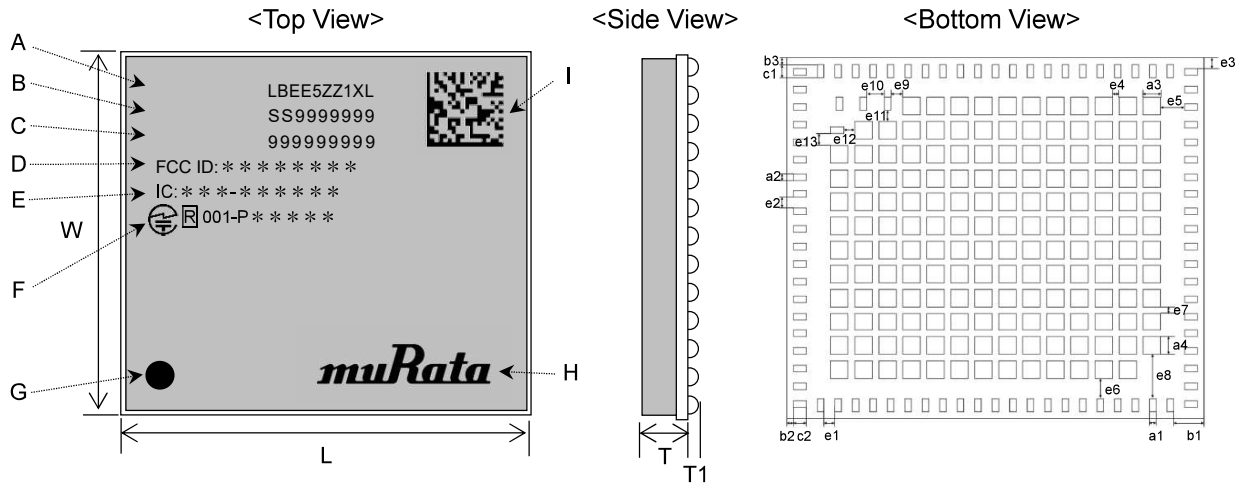
Japanese type certification is prepared.
Ⓡ 001-P01770
Country Code: JP

The each country code are defined by Murata's DB.txt file.
Please ask your contact person from Murata.

## 5.2. Bluetooth Qualification

QDID: 184816
*Set Bluetooth Tx Power to Class1 by using "bt_power_config_1.sh".
**See PICS for supported Bluetooth functions on Bluetooth SIG site

## 6. Dimensions, Marking and Terminal Configurations

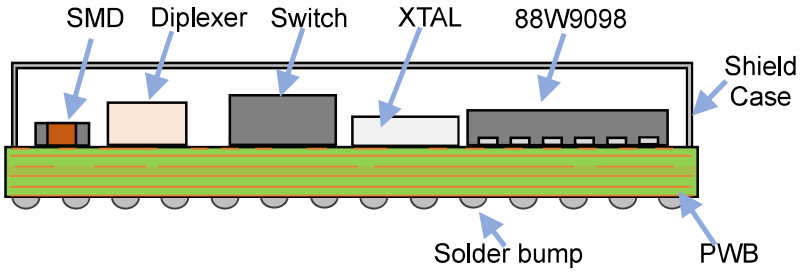



| Marking | Meaning |
|---|---|
| A | Module Type |
| B | Production Process Number |
| C | Serial Number |
| D | FCC ID |
| E | ISED ID |
| F | Japan certification mark & ID |
| G | Pin-1 Marking |
| H | Murata Logo |
| I | 2D code |

| Mark | Dimensions | Mark | Dimensions | Mark | Dimensions |
|---|---|---|---|---|---|
| L | 19.1 +/- 0.2 | W | 16.5 +/- 0.2 | T | 2.1 max |
| T1 | 0.45 typ. | a1 | 0.3 +/- 0.1 | a2 | 0.3 +/- 0.1 |
| a3 | 0.8 +/- 0.1 | a4 | 0.8 +/- 0.1 | b1 | 1.4 +/- 0.2 |
| b2 | 0.3 +/- 0.2 | b3 | 0.3 +/- 0.2 | c1 | 0.6 +/- 0.1 |
| c2 | 0.6 +/- 0.1 | e1 | 0.5 +/- 0.1 | e2 | 0.5 +/- 0.1 |
| e3 | 0.5 +/- 0.2 | e4 | 0.3 +/- 0.1 | e5 | 1.1 +/- 0.1 |
| e6 | 0.9 +/- 0.1 | e7 | 0.3 +/- 0.1 | e8 | 2.0 +/- 0.1 |
| e9 | 0.5 +/- 0.1 | e10 | 0.8 +/- 0.1 | e11 | 0.5 +/- 0.1 |
| e12 | 0.5 +/- 0.1 | e13 | 0.55 +/- 0.1 | — | — |

(unit : mm)

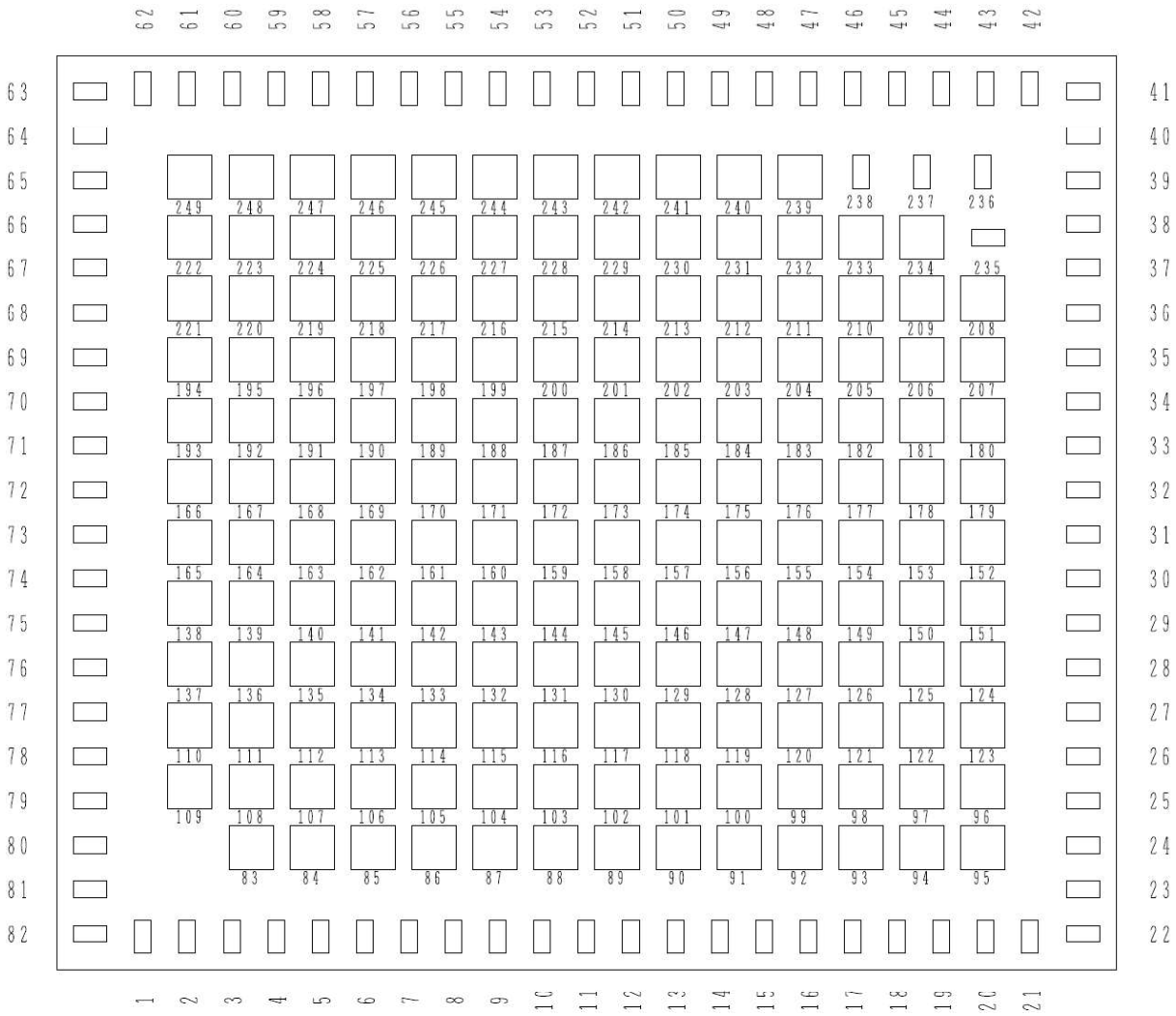
**Structure**



# 7. Module Pin Descriptions

## 7.1. Pin Assignments

<Top View>



| No. | Terminal Name | No. | Terminal Name | No. | Terminal Name |
|---|---|---|---|---|---|
| 1 | GND | 31 | GND | 61 | GPIO[26] |
| 2 | GND | 32 | NC | 62 | GPIO[27] |
| 3 | CONFIG_HOST[0] | 33 | NC | 63 | GND |
| 4 | CONFIG_HOST[1] | 34 | GND | 64 | GND |
| 5 | CONFIG_HOST[2] | 35 | VIO_SD | 65 | BT_RF_OUT |
| 6 | GPIO[1] | 36 | SD_CLK | 66 | GND |
| 7 | GPIO[0] | 37 | SD_CMD | 67 | GND |
| 8 | GPIO[14] | 38 | SD_D[0] | 68 | NC |
| 9 | GPIO[4] | 39 | SD_D[1] | 69 | GND |
| 10 | GPIO[6] | 40 | SD_D[2] | 70 | GPIO[22] |
| 11 | GPIO[5] | 41 | GND | 71 | GPIO[23] |
| 12 | GPIO[7] | 42 | SD_D[3] | 72 | GPIO[19] |
| 13 | GPIO[16] | 43 | PCIE_PERST_N | 73 | GPIO[18] |
| 14 | GPIO[15] | 44 | PCIE_CLKREQ_N | 74 | GPIO[17] |
| 15 | PDn | 45 | PCIE_WAKE_N | 75 | GND |
| 16 | GND | 46 | W_DISABLE1N | 76 | WL_B_ANT/<br>WL_B_BT_ANT |
| 17 | VDD33 | 47 | GPIO[31] | 77 | GND |
| 18 | VDD33 | 48 | GPIO[29] | 78 | GND |
| 19 | VIO | 49 | GPIO[30] | 79 | GND |
| 20 | VDD18 | 50 | GPIO[28] | 80 | WL_A_ANT |
| 21 | VDD18 | 51 | GPIO[3] | 81 | GND |
| 22 | GND | 52 | GPIO[2] | 82 | GND |
| 23 | PCIE_CLK_N | 53 | GPIO[11] | 83-234 | GND |
| 24 | PCIE_CLK_P | 54 | GPIO[10] | 235 | RF_CNTL0_N |
| 25 | GND | 55 | GPIO[9] | 236 | RF_CNTL3_P |
| 26 | PCIE_TX_P | 56 | GPIO[8] | 237 | RF_CNTL2_N |
| 27 | PCIE_TX_N | 57 | GPIO[12] | 238 | RF_CNTL1_P |
| 28 | GND | 58 | GPIO[13] | 239-248 | GND |
| 29 | PCIE_RX_N | 59 | GPIO[24] | 249 | NC |
| 30 | PCIE_RX_P | 60 | GPIO[25] | - | - |

## 7.2. Pin Descriptions

| No. | Terminal Name | Type | Power Supply | Description |
|---|---|---|---|---|
| (1) | GND | GND | - | Ground |
| (2) | GND | GND | - | Ground |
| (3) | CONFIG_HOST[0] | I | VDD18 | Host configuration options.<br>Selects the host interface used for Wi-Fi and Bluetooth.<br>See section 7.3.<br>Internal pull-up |
| (4) | CONFIG_HOST[1] | I | VDD18 | Host configuration options.<br>Selects the host interface used for Wi-Fi and Bluetooth.<br>See section 7.3.<br>Internal pull-up |
| (5) | CONFIG_HOST[2] | I | VDD18 | Host configuration options.<br>Selects the host interface used for Wi-Fi and Bluetooth.<br>See section 7.3.<br>Internal pull-down(51k ohm) on this pin |
| (6) | GPIO[1] | I/O | VIO | GPIO[1] |
| (7) | GPIO[0] | I/O | VIO | GPIO[0] |
| (8) | GPIO[14] | I/O | VIO | CONFIG_AUTO_REF_DET<br>GPIO[14]<br>Internal pull-down(51k ohm) on this pin<br>Keep open or input level high until finished power up sequence. |
| (9) | GPIO[4] | I/O | VIO | PCM Mode: Receive PCM input.<br>I2S Mode: Receive I2S input.<br>GPIO[4] |
| (10) | GPIO[6] | I/O | VIO | PCM Mode: PCM Clock<br>I2S Mode: I2S bit clock.<br>- Output if master<br>- Input if slave<br>GPIO[6] |
| (11) | GPIO[5] | I/O | VIO | PCM Mode: Transmit PCM output.<br>I2S Mode: Transmit I2S output.<br>GPIO[5] |
| (12) | GPIO[7] | I/O | VIO | PCM Mode: PCM frame sync.<br>I2S Mode: I2S left-right clock.<br>- Output if master<br>- Input if slave<br>GPIO[7] |
| (13) | GPIO[16] | I/O | VIO | GPIO[16]<br>Keep open or input level high until finished power up sequence. |
| (14) | GPIO[15] | I/O | VIO | GPIO[15]<br>Keep open or input level high until finished power up sequence. |
| (15) | PDn | I | VDD18 | Full power-down (input) (active low)<br>· 0 = full power-down mode<br>· 1 = normal operation mode<br>- PDn can accept an input of 1.8V to 4.5V<br>- PDn may be driven by the host<br>- PDn must be high for normal operation<br>No internal pull-up on this pin.<br>Connect to power down pin (GPIO) of host or tie to power rail. External host required to drive this pin high for normal operation mode. |
| (16) | GND | GND | - | Ground |
| (17) | VDD33 | P | - | 3.3V Voltage Input |
| (18) | VDD33 | P | - | 3.3V Voltage Input |
| (19) | VIO | P | - | 1.8V/3.3V Digital I/O Power Supply |
| (20) | VDD18 | P | - | 1.8V Voltage Input |
| (21) | VDD18 | P | - | 1.8V Voltage Input |
| (22) | GND | GND | - | Ground |
| (23) | PCIE_CLK_N | I | VDD18 | PCI Express Differential Clock Input—Negative |
| (24) | PCIE_CLK_P | I | VDD18 | PCI Express Differential Clock Input—Positive |
| (25) | GND | GND | - | Ground |
| (26) | PCIE_TX_P | O | VDD18 | PCI Express Transmit Data—Positive |
| (27) | PCIE_TX_N | O | VDD18 | PCI Express Transmit Data—Negative |
| (28) | GND | GND | - | Ground |
| (29) | PCIE_RX_N | I | VDD18 | PCI Express Receive Data—Negative |

| | | | | |
|---|---|---|---|---|
| (30) | PCIE_RX_P | I | VDD18 | PCI Express Receive Data—Positive |
| (31) | GND | GND | - | Ground |
| (32) | NC | - | - | No Connection |
| (33) | NC | - | - | No Connection |
| (34) | GND | GND | - | Ground |
| (35) | VIO_SD | P | - | 1.8V/3.3V Digital I/O SDIO power supply<br>• For SDIO ultra-high speed mode (25 to 208 MHz), VIO_SD must be 1.8V.<br>• For SDIO default mode (up to 25 MHz) and high-speed mode (up to 50 MHz), VIO_SD must be 1.8V or 3.3V. |
| (36) | SD_CLK | I | VIO_SD | **SDIO 4-bit Mode**: Clock input<br>**SDIO 1-bit Mode**: Clock input<br>Internal pull-up |
| (37) | SD_CMD | I/O | VIO_SD | **SDIO 4-bit Mode**: Command/response (input/output)<br>**SDIO 1-bit Mode**: Command line<br>Internal pull-up |
| (38) | SD_D[0] | I/O | VIO_SD | **SDIO 4-bit Mode**: Data line Bit[0]<br>**SDIO 1-bit Mode**: Data line<br>Internal pull-up |
| (39) | SD_D[1] | I/O | VIO_SD | **SDIO 4-bit Mode**: Data line Bit[1]<br>**SDIO 1-bit Mode**: Interrupt<br>Internal pull-up |
| (40) | SD_D[2] | I/O | VIO_SD | **SDIO 4-bit Mode**: Data line Bit[2] or read wait (optional)<br>**SDIO 1-bit Mode**: Read wait (optional)<br>Internal pull-up |
| (41) | GND | GND | - | Ground |
| (42) | SD_D[3] | I/O | VIO_SD | **SDIO 4-bit Mode**: Data line Bit[3]<br>**SDIO 1-bit Mode**: Reserved<br>Internal pull-up |
| (43) | PCIE_PERST_N | I | VIO | PCIe host indication to reset the device (input)(active low)<br>**Note**: Muxed with GPIO[20].(input/output)<br>Internal pull-up |
| (44) | PCIE_CLKREQ_N | I/O | VIO | PCIe clock request (input/output) (active low)<br>**Note**: An external pull-up (on host side) is required. |
| (45) | PCIE_WAKE_N | I/O | VIO | PCIe wake signal (input/output) (active low)<br>Note: An external pull-up (on host side) is required. |
| (46) | W_DISABLE1N | I | VIO | **GPIO Mode**: GPIO[21] (input/output)<br>**Default Mode**: W_DISABLE1n (input) (active low)<br>Host indication to disable the Wi-Fi function of the device. See GPIO[12] for W_DISABLE2n (input) (active low). |
| (47) | GPIO[31] | I/O | VIO | **GPIO Mode**: GPIO[31] (input/output)<br>**JTAG Mode**: JTAG_TDO, JTAG test data (output)<br>**Coexistence Mode**: UART_LTE_SOUT (LTE coexistence data output signal) |
| (48) | GPIO[29] | I/O | VIO | **GPIO Mode**: GPIO[29] (input/output)<br>**JTAG Mode**: JTAG_TMS, JTAG controller select (input) |
| (49) | GPIO[30] | I/O | VIO | **GPIO Mode**: GPIO[30] (input/output)<br>**JTAG Mode:** JTAG_TDI, JTAG test data (input)<br>**Coexistence Mode**: UART_LTE_SIN (LTE coexistence data input signal) |
| (50) | GPIO[28] | I/O | VIO | **GPIO Mode**: GPIO[28] (input/output)<br>**JTAG Mode**: JTAG_TCK, JTAG test clock (input) |
| (51) | GPIO[3] | I/O | VIO | **GPIO Mode**: GPIO[3] (input/output)<br>**LED Mode**: LED_OUT_BT (output)<br>**I2S Mode**: I2S_CCLK (output, optional)<br>**PCM Mode**: PCM_MCLK (output, optional) |
| (52) | GPIO[2] | I/O | VIO | **GPIO Mode**: GPIO[2] (input/output)<br>**LED Mode**: LED_OUT_WLAN (output) |
| (53) | GPIO[11] | I/O | VIO | **GPIO Mode**: GPIO[11] (input/output)<br>**UART Mode**: UART_RTSn (output) (active low) |
| (54) | GPIO[10] | I/O | VIO | **GPIO Mode**: GPIO[10] (input/output)<br>**UART Mode**: UART_CTSn (input) (active low) |
| (55) | GPIO[9] | I/O | VIO | **GPIO Mode**: GPIO[9] (input/output)<br>**UART Mode**: UART_SIN (input) |
| (56) | GPIO[8] | I/O | VIO | **GPIO Mode**: GPIO[8] (input/output)<br>**UART Mode**: UART_SOUT (output) |
| (57) | GPIO[12] | I/O | VIO | **GPIO Mode**: GPIO[12] (input/output)<br>**UART Mode**: UART_DSRn (input) (active low)<br>**Default Mode**: W_DISABLE2n (input) (active low)<br>Host indication to disable the Wi-Fi function of the device.<br>See GPIO[21] for W_DISABLE1n (input) (active low). |
| (58) | GPIO[13] | I/O | VIO | **GPIO Mode**: GPIO[13] (input/output)<br>**UART Mode**: UART_DTRn (output) (active low) |
| (59) | GPIO[24] | I/O | VIO | **GPIO Mode**: GPIO[24] (input/output) |
| (60) | GPIO[25] | I/O | VIO | **GPIO Mode**: GPIO[25] (input/output) |

| | | | | |
|---|---|---|---|---|
| (61) | GPIO[26] | I/O | VIO | **GPIO Mode**: GPIO[26] (input/output) |
| (62) | GPIO[27] | I/O | VIO | **GPIO Mode**: GPIO[27] (input/output) |
| (63) | GND | GND | - | Ground |
| (64) | GND | GND | - | Ground |
| (65) | BT_RF_OUT | RF | - | Bluetooth Transmit/Receive |
| (66) | GND | GND | - | Ground |
| (67) | GND | GND | - | Ground |
| (68) | NC | NC | - | NC |
| (69) | GND | GND | - | Ground |
| (70) | GPIO[22] | I/O | VDD33 | GPIO[22] |
| (71) | GPIO[23] | I/O | VDD33 | GPIO[23] |
| (72) | GPIO[19] | I/O | VIO | GPIO[19] |
| (73) | GPIO[18] | I/O | VIO | GPIO[18] |
| (74) | GPIO[17] | I/O | VIO | GPIO[17] |
| (75) | GND | GND | - | Ground |
| (76) | WL_B_ANT | RF | - | WLAN Transmit/Receive - Path B |
| (77) | GND | GND | - | Ground |
| (78) | GND | GND | - | Ground |
| (79) | GND | GND | - | Ground |
| (80) | WL_A_ANT | RF | | WLAN Transmit/Receive – Path A |
| (81) | GND | GND | - | Ground |
| (82) | GND | GND | - | Ground |
| (83)-(234) | GND | GND | - | Ground |
| (235) | RF_CNTL0_N | O | VDD33 | RF Control 0—RF Control Output Low (output) |
| (236) | RF_CNTL3_P | O | VDD33 | RF Control 3—RF Control Output High (output) |
| (237) | RF_CNTL2_N | O | VDD33 | RF Control 2—RF Control Output Low (output) |
| (238) | RF_CNTL1_P | O | VDD33 | RF Control 1—RF Control Output High (output) |
| (239)-(248) | GND | GND | - | Ground |
| (249) | NC | GND | - | No Connection |

## 7.3. Configuration Pins

| Strap Value | | | WLAN | Bluetooth/LE |
|---|---|---|---|---|
| CONFIG_HOST[2] | CONFIG_HOST[1] | CONFIG_HOST[0] | | |
| 0 | 0 | 0 | SDIO | UART |
| 0 | 0 | 1 | reserved | reserved |
| 0 | 1 | 0 | reserved | reserved |
| 0 | 1 | 1 | PCIe | UART |
| 1 | 0 | 0 | reserved | reserved |
| 1 | 0 | 1 | reserved | reserved |
| 1 | 1 | 0 | reserved | reserved |
| 1 | 1 | 1 | 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.

**I/O State Table**

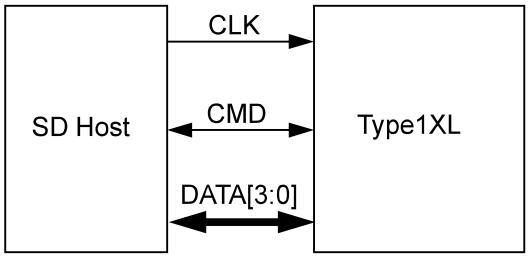
| Pin Name | Supply | No Pad Power State[1] | Reset State | HW State | PD State | PD Prog | Internal PU/PD | Int'l Pull Value[Ω] |
|---|---|---|---|---|---|---|---|---|
| GPIO[0] | VIO | tristate | output | output | drive low | yes | nominal PU | 100K |
| GPIO[1] | VIO | tristate | input | input | tristate | yes | weak PU | 800K |
| GPIO[2] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[3] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[4] | VIO | tristate | input | input | tristate | yes | weak PU | 800K |
| GPIO[5] | VIO | tristate | input | input | tristate | yes | weak PU | 800K |
| GPIO[6] | VIO | tristate | input | input | tristate | yes | weak PU | 800K |
| GPIO[7] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[8] | VIO | tristate | input | input | drive low | yes | nominal PU | 100K |
| GPIO[9] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[10] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[11] | VIO | tristate | input | input | drive high | yes | nominal PU | 100K |
| GPIO[12] | VIO | tristate | input | input | tristate | yes | nominal PD | 100K |
| GPIO[13] | VIO | tristate | input | input | drive high | yes | nominal PU | 100K |
| GPIO[14] | VIO | tristate | input | input | tristate | yes | weak PU | 800K |
| GPIO[15] | VIO | tristate | input | input | drive high | yes | weak PU | 800K |
| GPIO[16] | VIO | tristate | input | input | tristate | yes | weak PD | 800K |
| GPIO[17] | VIO | tristate | input | input | tristate | yes | weak PD | 800K |
| GPIO[18] | VIO | tristate | input | input | tristate | yes | weak PD | 800K |
| GPIO[19] | VIO | tristate | input | input | tristate | yes | weak PU | 800K |
| GPIO[20] | VIO | tristate | input | input | drive high | yes | nominal PU | 100K |
| GPIO[21] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[22] | VDD33 | tristate | input | input | drive high | yes | weak PU | 800K |
| GPIO[23] | VDD33 | tristate | input | input | drive low | yes | weak PU | 800K |
| GPIO[24] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[25] | VIO | tristate | input | input | drive high | yes | nominal PU | 100K |
| GPIO[26] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[27] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[28] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[29] | VIO | tristate | input | input | tristate | yes | nominal PD | 100K |
| GPIO[30] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| GPIO[31] | VIO | tristate | input | input | tristate | yes | nominal PU | 100K |
| SD_CLK | VIO | tristate | input | input | tristate | no | nominal PU | 100K |
| SD_CMD | VIO | tristate | input | input | tristate | no | nominal PU | 100K |
| SD_D[0] | VIO | tristate | input | input | tristate | no | nominal PU | 100K |
| SD_D[1] | VIO | tristate | input | input | tristate | no | nominal PU | 100K |
| SD_D[2] | VIO | tristate | input | input | tristate | no | nominal PU | 100K |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SD_D[3] | VIO | tristate | input | input | tristate | no | nominal PU | 100K |
| PCIE_CLKP | AVDD18 | - | - | - | - | - | - | - |
| PCIE_CLKN | AVDD18 | - | - | - | - | - | - | - |
| PCIE_TXP | AVDD18 | - | - | - | - | - | - | - |
| PCIE_TXN | AVDD18 | - | - | - | - | - | - | - |
| PCIE_RXP | AVDD18 | - | - | - | - | - | - | - |
| PCIE_RXN | AVDD18 | - | - | - | - | - | - | - |
| PCIE_WAKE_N | VIO | tristate | input | output | n/a | n/a | n/a | - |
| PCIE_CLKREQ_N | VIO | tristate | input | output | n/a | n/a | n/a | - |
| PCIE_PERST_N | VIO | tristate | input | intput | drive high | yes | nominal PU | 100K |
| CONFIG_HOST[0] | AVDD18 | tristate | input | input | tristate | no | weak PU | 800K |
| CONFIG_HOST[1] | AVDD18 | tristate | input | input | tristate | no | weak PU | 800K |
| CONFIG_HOST[2] | AVDD18 | tristate | input | input | tristate | no | weak PU | 800K |
| RF_CNTL0_N | VDD33 | tristate | input | output | drive low | yes | nominal PU | 100K |
| RF_CNTL1_P | VDD33 | tristate | input | output | drive low | yes | weak PU | 800K |
| RF_CNTL2_N | VDD33 | tristate | input | output | drive low | yes | weak PU | 800K |
| RF_CNTL3_P | VDD33 | tristate | input | output | drive low | yes | weak PU | 800K |
| PDn | AVDD18 | - | - | - | - | - | - | - |

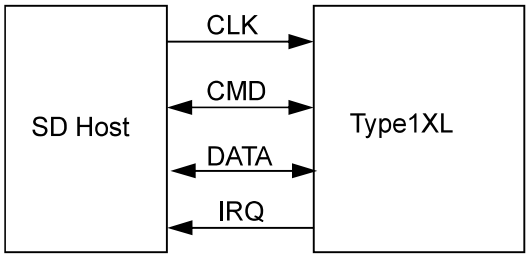
[1] Maximum input voltage is 0.4V when VIO has no power (or in uncertain situations).

## 7.5. SDIO Pin Descriptions

| No. | Pin Name | (i) SD 4-bit Mode | | (ii) SD 1-bit Mode | |
|---|---|---|---|---|---|
| 55 | SD_CLK | CLK | Clock | CLK | Clock |
| 59 | SD_D[0] | DATA0 | Data line 0 | DATA | Data line |
| 61 | SD_D[1] | DATA1 | Data line 1 /Interrupt | IRQ | Interrupt |
| 63 | SD_D[2] | DATA2 | Data line 2 | NC | Not used |
| 65 | SD_D[3] | DATA3 | Data line 3 | NC | Not used |
| 57 | SD_CMD | CMD | Command line | CMD | Command line |



(i) SD 4-bit Mode



(ii) SD 1-bit Mode

## 8. Absolute Maximum Ratings

| Parameter | | Min | Max | Unit |
|---|---|---|---|---|
| Storage Temperature | | -40 | +85 | deg.C |
| Supply Voltage | VDD33 | - | 3.63 | V |
| | VDD18 | - | 2.16 | V |
| | VIO (1.8V) | - | 1.98 | V |
| | VIO(3.3V) | - | 3.63 | V |
| | VIO_SD(1.8V) | - | 1.98 | V |
| | VIO_SD(3.3V) | - | 3.63 | 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 Condition

### 9.1. Operating Condition

| Parameter | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Operating Temperature Range[1] | Ta | -40 | +25 | +85 | deg.C |
| | Tj | - | - | +125 | deg.C |
| Supply Voltage | VDD33 | 3.14 | 3.3 | 3.46 | V |
| | VDD18 | 1.71 | 1.8 | 1.89 | V |
| | VIO | 1.71 | 1.8 | 1.89 | V |
| | | 3.14 | 3.3 | 3.46 | V |
| | VIO_SD | 1.71 | 1.8 | 1.89 | V |
| | | 3.14 | 3.3 | 3.46 | V |
| IO Current | VIO&VIO_SD | - | 0.1 | 0.5 | mA |
| Peak current* | VDD33 | - | 1150 | 1200 | mA |
| | VDD18 | - | 1873 | 2000 | mA |

Note) Operation beyond the recommended operating conditions is neither recommended nor guaranteed.

*Peak current of VDD33 and VDD18 is happen during DPD calibration when the firmware is downloaded.

### 9.2. 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 |

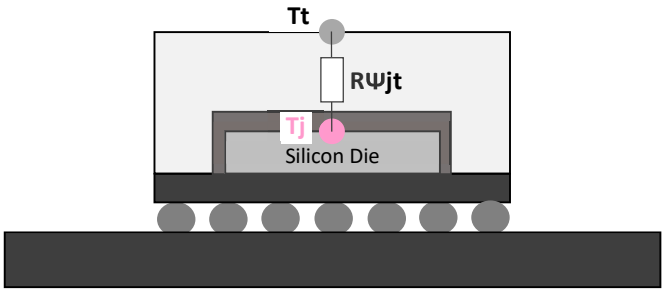
[1] Functionality is guaranteed but specifications require derating at extreme temperatures

## 9.3. Package Thermal Conditions

RΨjt：3.6℃/W

RΨjt = (Tj - Tt)/P

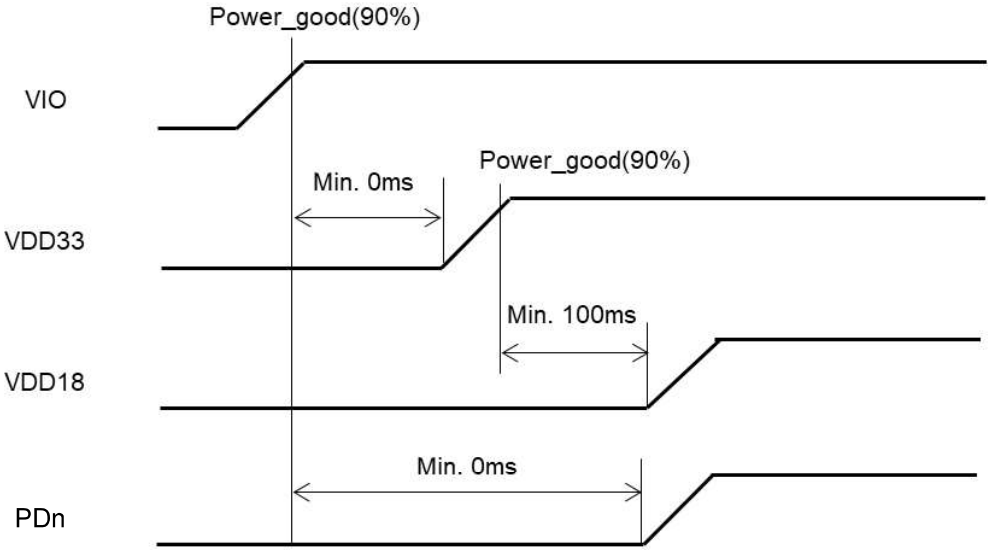
*Tj: Junction temperature(℃), Tt: Top temperature(℃), P: Total Power Consumption (W)



## 10. Power-Up / Power-Down Sequence

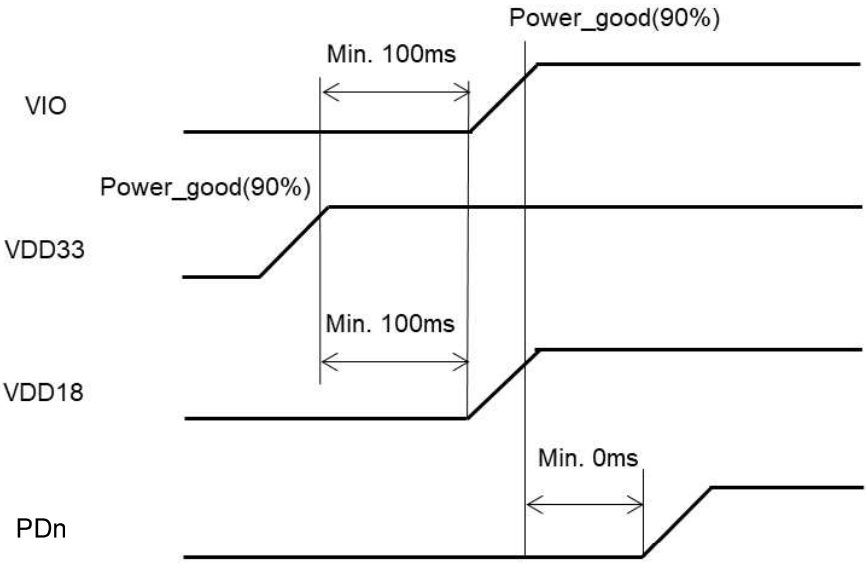
### 10.1. Power-Up Sequence

(1) VIO=3.3V




Ramp-up time of VIO must be <100ms.
Ramp-up time of VDD33 must be <100ms.
Ramp-up time of VDD18 must be <100ms.

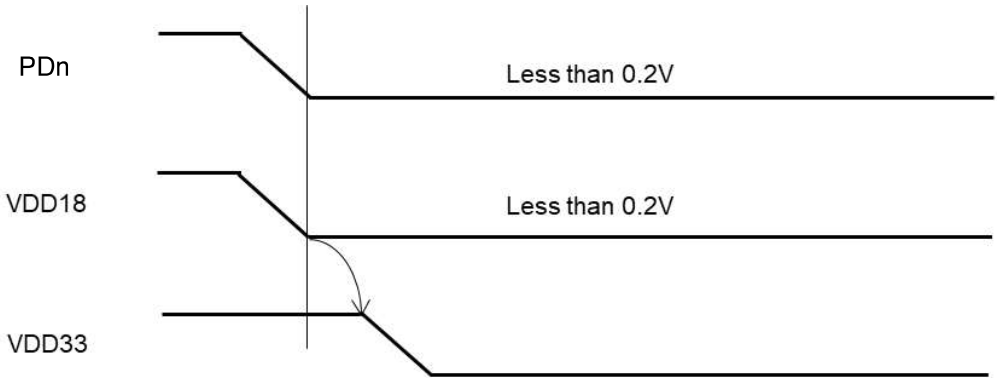
(2) VIO=1.8V




Ramp-up time of VIO must be <100ms.
Ramp-up time of VDD33 must be <100ms.
Ramp-up time of VDD18 must be <100ms.

VIO should be the same as VDD18 or earlier. After power_good state of VDD33, then VIO can ramp up. At that time VDD18 can be the same or later than VIO.

## 10.2. Power-Down Sequence




To reduce leakage, ramp down VDD18 before VDD33 when powering down the SoC.
It is not required specific timing for VIO for its power-down.

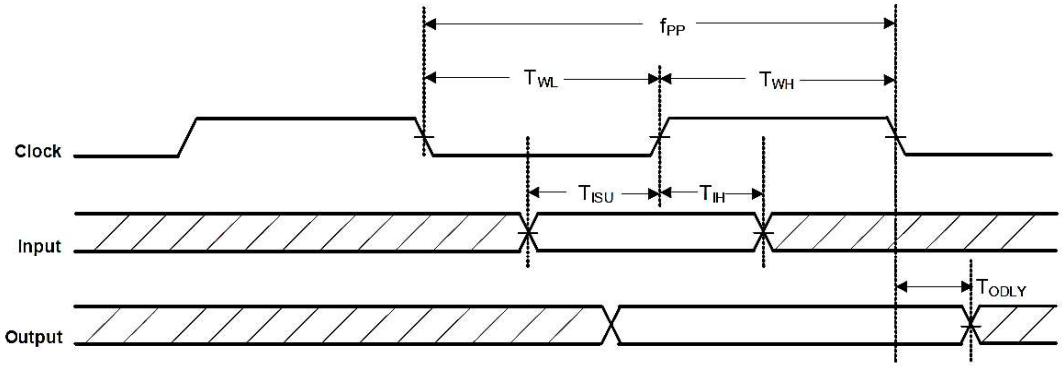
# 11. Host Interface Specification

## 11.1. SDIO Specifications

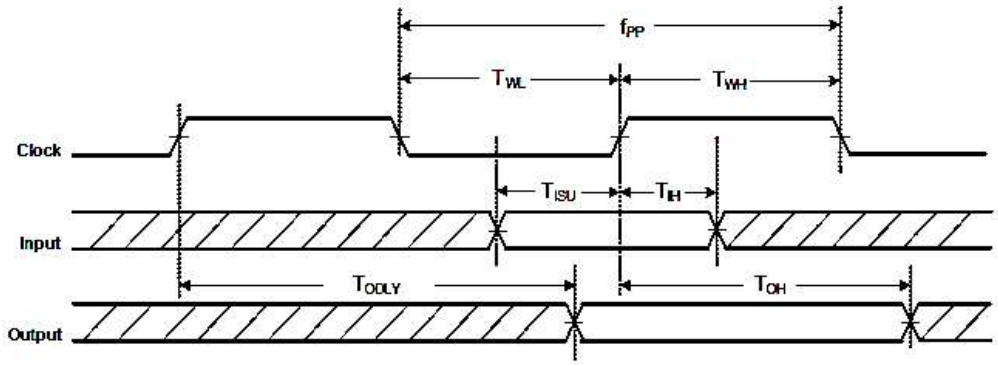
The SDIO host interface pins are powered from the VIO_SD voltage supply.
The SDIO electrical specifications are identical for 4-bit SDIO and 1-bit SDIO transfer modes.

### 11.1.1. Default Speed, High-Speed Modes

**SDIO Protocol Timing Diagram—Default Speed Mode (3.3V)**




**SDIO Protocol Timing Diagram—High Speed Mode (3.3V)**



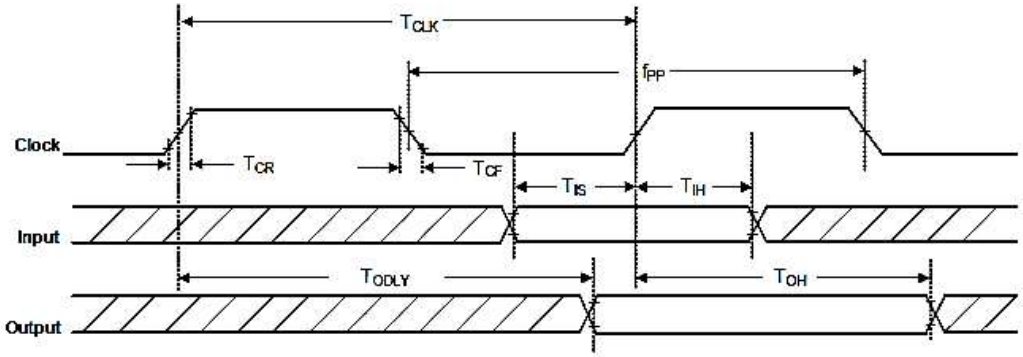

**SDIO Timing Data—Default Speed, High-Speed Modes (3.3V)**

**Note:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $f_{PP}$ | 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 ≤ 40 pF (1 card) | High-speed | - | - | 14 | ns |
| $T_{OH}$ | Output hold time | High-speed | 2.5 | - | - | ns |

### 11.1.2. SDR12, SDR25, SDR50 Modes (up to 100 MHz) (1.8 V)

**SDIO protocol Timing Diagram—SDR12, SDR25, SDR50 Modes (up to 100 MHz) (1.8 V)**



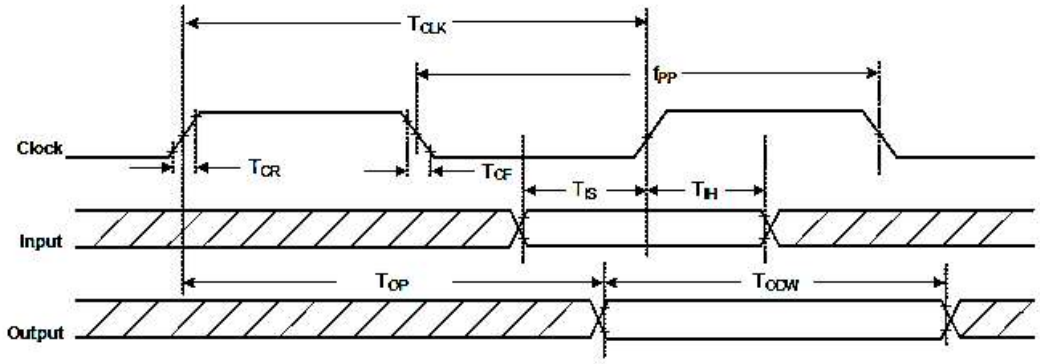

**SDIO Timing Data—SDR12, SDR25, SDR50 Modes (up to 100 MHz) (1.8 V)**

**Note:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified.

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $f_{PP}$ | 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<br>TCR, TCF< 2ns(max)<br>at 100 MHz<br>CCARD=10 pF | SDR12/25/50 | - | - | 0.2*$T_{CLK}$ | ns |
| $T_{ODLY}$ | Output dekay time<br>CL ≤ 30pF | SDR12/25/50 | - | - | 7.5 | ns |
| $T_{OH}$ | Output hold time<br>CL=15 pF | SDR12/25/50 | 1.5 | - | - | ns |

### 11.1.3. SDR104 Mode (208 MHz) (1.8 V)

**SDIO Protocol Timing Diagram—SDR104 Mode (208 MHz)**



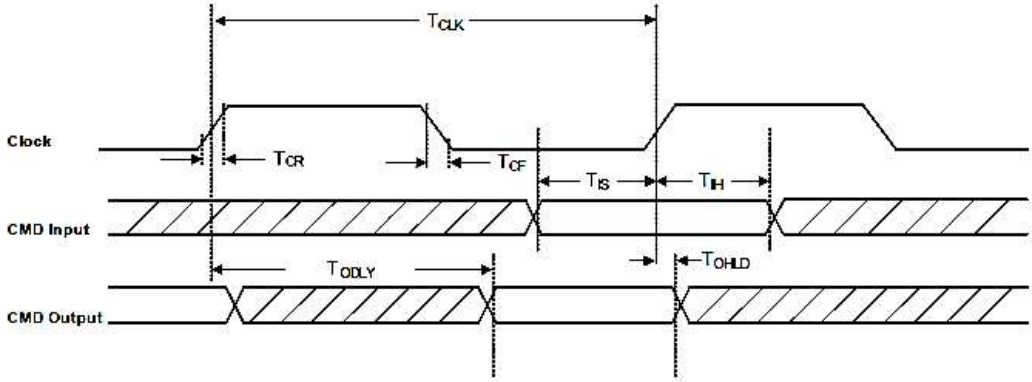

**SDIO Timing Data—SDR104 Mode (208 MHz)**

**Note:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified.

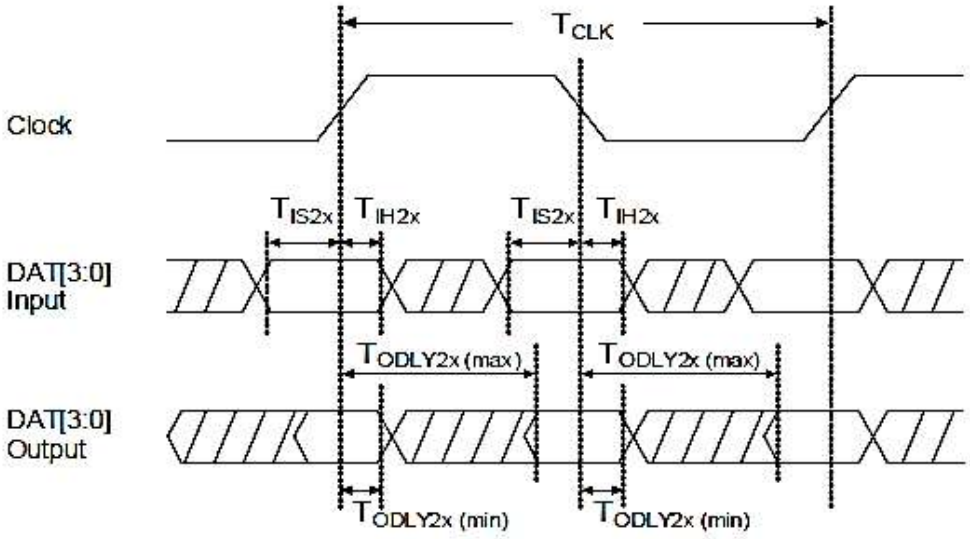
| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $f_{PP}$ | Clock frequency | SDR104 | 0 | - | 208 | MHz |
| $T_{IS}$ | Input setup time | SDR104 | 1.4 | - | - | ns |
| $T_{IH}$ | Input hold time | SDR104 | 0.8 | - | - | ns |
| $T_{CLK}$ | Clock time | SDR104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

### 11.1.4. DDR50 Mode (50 MHz) (1.8 V)

**SDIO CMD Timing Diagram—DDR50 Mode (50 MHz)**




**SDIO DAT[3:0] Timing Diagram—DDR50 Mode (50 MHz)**



### SDIO Timing Data—DDR50 Mode (50 MHz)

**Note:** Over full range of values specified in the Recommended Operating Conditions unless otherwise specified

| Symbol | Parameter | Condition | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| Clock | | | | | | |
| $T_{CLK}$ | Clock time<br>50 MHz (max) between rising edges | DDR50 | 20 | - | - | ns |
| $T_{CR}$, $T_{CF}$ | Rise time, fall time<br>$T_{CR}$, $T_{CF}$< 4.00 ns(max) at 50 MHz<br>$C_{CARD}$=10 pF | DDR50 | - | - | 0.2*$T_{CLK}$ | ns |
| Clock Duty | - | DDR50 | 45 | - | 55 | % |
| **CMD Input (referenced to clock rising edge)** | | | | | | |
| $T_{IS}$ | Input setup time<br>$C_{CARD}$ ≤ 10 pF (1 card) | DDR50 | 6 | - | - | ns |
| $T_{IH}$ | Input hold time<br>$C_{CARD}$ ≤ 10 pF (1 card) | DDR50 | 0.8 | - | - | ns |
| **CMD Output (referenced to clock rising edge)** | | | | | | |
| $T_{ODLY}$ | Output delay time during data transfer mode<br>$C_L$ ≤ 30 pF (1 card) | DDR50 | - | - | 13.7 | ns |
| $T_{OHLD}$ | Output hold time<br>$C_L$ ≥ 15 pF (1 card) | DDR50 | 1.5 | - | - | ns |
| **DAT[3:0] Input (referenced to clock rising and falling edges)** | | | | | | |
| $T_{IS2x}$ | Input setup time<br>$C_{CARD}$ ≤ 10 pF (1 card) | DDR50 | 3 | - | - | ns |
| $T_{IH2x}$ | Input hold time<br>$C_{CARD}$ ≤ 10 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<br>$C_L$ ≤ 25 pF (1 card) | DDR50 | - | - | 7.0 | ns |
| $T_{ODLY2x}$ (min) | Output hold time<br>$C_L$ ≥ 15 pF (1 card) | DDR50 | 1.5 | - | - | ns |

## 11.2. PCI Express Specifications

The PCI Express host interface pins are powered from the AVDD18 voltage supply.

### 11.2.1. Differential Tx Output Electricals

**PCI Express Tx Output Specifications Data—2.5 GT/s**

**Note:** In accordance with PCI Express Base Specification, Revision 2.1 March 4. 2009.

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| UI | Unit Interval (UI)<br>The specified UI is equivalent to a tolerance of ±300 ppm for each Refclk source. Period does not account for SSC induced variations. | 399.88 | -- | 400.12 | ps |
| $V_{TX-DIFF-PP}$ | Differential peak-to-peak Tx voltage swing $V_{TX-DFFpp} = 2*\|V_{TXD+} - V_{TXD-}\|$ | 0.8 | -- | 1.2 | V |
| $V_{TX-DIFF-PP-LOW}$ | Low power differential peak-to-peak tTx voltage swing $V_{TX-DFFpp} = 2*\|VT_{XD+} - V_{TXD-}$ | 0.4 | -- | 1.2 | V |
| $V_{TX-DE-RATIO-3.5dB}$ | Tx de-emphasis level ratio (3.5 dB) | 3.0 | -- | 4.0 | dB |
| $T_{TX-EYE}$ | Tx eye including all jitter sources | 0.75 | -- | -- | UI |
| $T_{TX-EYE-MEDIAN-to-MAX-JITTER}$ | Maximum time between jitter median and maximum deviation from median | -- | -- | 0.125 | UI |
| $T_{TX-RISE-FALL}$ | Tx rise/fall time<br>Measured differentially from 20% to 80% of swing. | 0.125 | -- | -- | UI |
| $RL_{TX-DIFF}$ | Tx package plus Si differential return loss | 10 | -- | -- | dB |
| $RL_{TX-CM}$ | Tx package plus Si common mode return loss | 6 | -- | -- | dB |
| $V_{TX-CM-AC-P}$ | Tx AC common mode voltage | -- | 20 | -- | mV |
| $I_{TX-SHORT}$ | Tx short circuit current limit | -- | -- | 90 | mA |
| $V_{TX-DC-CM}$ | Tx DC common mode voltage | 0 | -- | 3.6 | V |
| $V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$ | Absolute delta of DC common mode voltage during L0 and electrical idle | 0 | -- | 100 | mV |
| $V_{TX-IDLE-DIFF-AC-p}$ | Electrical idle differential peak output voltage | 0 | -- | 20 | mV |
| $V_{TX-RCV-DETECT}$ | Voltage change allowed during receiver detection | -- | -- | 600 | mV |
| $T_{TX-IDLE-MIN}$ | Minimum time spent in electrical idle | 20 | -- | -- | ns |
| $T_{TX-IDLE-SET-TO-IDLE}$ | Maximum time to transition to a valid electrical idle after sending an electrical idle ordered set | -- | -- | 8 | ns |
| $T_{TX-IDLE-TO-DIFF-DATA}$ | Maximum time to transition to valid diff signaling after leaving electrical idle | -- | -- | 8 | ns |
| $T_{CROSSLINK}$ | Crosslink random timeout | -- | -- | 1.0 | ms |
| $C_{TX}$ | AC coupling capacitor | 75 | -- | 200 | nF |

**PCI Express Tx Output Specifications Data—5 GT/s**

**Note:** In accordance with PCI Express Base Specification, Revision 2.1 March 4, 2009.

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| UI | Unit Interval (UI)<br>The specified UI is equivalent to a tolerance of ±300 ppm for each Refclk source. Period does not account for SSC induced variations. | 199.94 | -- | 200.06 | ps |
| $V_{TX-DIFFpp}$ | Differential peak-to-peak Tx voltage swing $V_{TX-DFFpp} = 2*\|V_{TXD+} - V_{TXD-}\|$ | 0.8 | -- | 1.2 | V |
| $V_{TX-DIFFpp-LOW}$ | Low power differential peak-to-peak Tx voltage swing $V_{TX-DFFpp} = 2*\|VT_{XD+} - V_{TXD-}\|$ | 0.4 | -- | 1.2 | V |
| $V_{TX-DE-RATIO-3.5dB}$ | Tx de-emphasis level ratio (3.5 dB) | 3.0 | -- | 4.0 | dB |
| $V_{TX-DE-RATIO-6dB}$ | Tx de-emphasis level ratio (6 dB) | 5.5 | -- | 6.5 | dB |
| $T_{MIN-PULSE}$ | Instantaneous lone pulse width<br>Measured relative to rising/falling pulse. | 0.9 | -- | -- | UI |
| $T_{TX-EYE}$ | Tx eye including all jitter sources | 0.75 | -- | -- | UI |
| $T_{TX-HF-DJ-DD}$ | Tx deterministic jitter > 1.5 MHz<br>Deterministic jitter only. | -- | -- | 0.15 | UI |
| $T_{TX-LF-RMS}$ | Tx RMS jitter < 1.5 MHz<br>Total energy measured over a 10 kHz—1.5 MHz range. | -- | 3.0 | -- | Ps RMS |
| $T_{TX-RISE-FALL}$ | Tx rise/fall time<br>Measured differentially from 20% to 80% of swing. | 0.15 | -- | -- | UI |
| $RL_{TX-DIFF}$ | Tx package plus Si differential return loss (1.25-2.5 GHz) | 10 | -- | -- | dB |
| | Tx package plus Si differential return loss (0.05-1.25 GHz) | 8 | -- | -- | |
| $RL_{TX-CM}$ | Tx package plus Si common mode return loss | 6 | -- | -- | dB |
| $V_{TX-CM-AC-PP}$ | Tx AC common mode voltage | -- | -- | 100 | mVPP |
| $I_{TX-SHORT}$ | Tx short circuit current limit | -- | -- | 90 | mA |
| $V_{TX-DC-CM}$ | Tx DC common mode voltage | 0 | -- | 3.6 | V |
| $V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$ | Absolute delta of DC common mode voltage during L0 and electrical idle | 0 | -- | 100 | mV |
| $V_{TX-IDLE-DIFF-AC-p}$ | Electrical idle differential peak output voltage<br>$V_{TX-IDLE-DIFF-DC} = \|V_{TX-Idle-D+} - V_{TX-Idle-D-}\| \leq 20$ mV | 0 | -- | 20 | mV |
| $V_{TX-IDLE-DIFF-DC}$ | DC Electrical idle differential peak output voltage<br>$V_{TX-IDLE-DIFF-DC} = \|V_{TX-Idle-D+} - V_{TX-Idle-D-}\| \leq 5$ mV | 0 | -- | 5 | mV |
| $V_{TX-RCV-DETECT}$ | Voltage change allowed during receiver detection | -- | -- | 600 | mV |
| $T_{TX-IDLE-MIN}$ | Minimum time spent in electrical idle | 20 | -- | -- | ns |
| $T_{TX-IDLE-SET-TO-IDLE}$ | Maximum time to transition to a valid electrical idle after sending an electrical idle ordered set | -- | -- | 8 | ns |
| $T_{TX-IDLE-TO-DIFF-DATA}$ | Maximum time to transition to valid differential signaling after leaving electrical idle | -- | -- | 8 | ns |
| $T_{CROSSLINK}$ | Crosslink random timeout | -- | -- | 1.0 | ms |
| $C_{TX}$ | AC coupling capacitor | 75 | -- | 200 | nF |

### 11.2.2. Differential Rx Input Electricals

**PCI Express Rx Input Specifications Data—2.5 GT/s**

**Note:** In accordance with PCI Express Base Specification, Revision 2.1 March 4, 2009.

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| UI | Unit Interval (UI)<br>UI does not account for SSC induced variations. | 399.88 | -- | 400.12 | ps |
| $V_{RX-DIFF-PP-CC}$ | Differential Rx peak-to-peak voltage for common Refclk Rx architecture | 0.175 | -- | 1.2 | V |
| $V_{RX-DIFF-PP-DC}$ | Differential Rx peak-to-peak voltage for data clocked Rx architecture | 0.175 | -- | 1.2 | V |
| $T_{RX-EYE}$ | Rx eye time opening<br>Minimum eye time at Rx pins to yield a $10^{-12}$ BER. | 0.40 | -- | -- | UI |
| $T_{RX-EYE-MEDIAN-to-MAX-JITTER}$ | Maximum time delta between median and deviation from median | -- | -- | 0.3 | UI |
| $V_{RX-CM-ACp}$ | AC peak common mode input voltage | -- | -- | 150 | mV |
| $RL_{RX-DIFF}$ | Differential return loss | 15 | -- | -- | dB |
| $RL_{RX-CM}$ | Common mode return loss | 0 | -- | 3.6 | dB |
| $Z_{RX-DIFF-DC}$ | DC differential input impedance | 80 | 100 | 120 | W |
| $Z_{RX-DC}$ | DC input impedance | 40 | 50 | 60 | W |
| $Z_{RX-HIGH-IMP-DC}$ | Powered down DC input impedance | 200 | -- | -- | kΩ |
| $V_{RX-IDLE-DET-DIFF-p-p}$ | Electrical idle detect threshold | 65 | -- | 175 | mV |
| $T_{RX-IDLE-DET-DIFF-ENTERTIME}$ | Unexpected electrical idle enter detect threshold integration time | -- | -- | 10 | ms |
| $L_{RX-SKEW}$ | Total skew | -- | -- | 20 | ns |

**PCI Express Rx Input Specifications Data—5 GT/s**

**Note:** In accordance with PCI Express Base Specification, Revision 2.1 March 4, 2009.

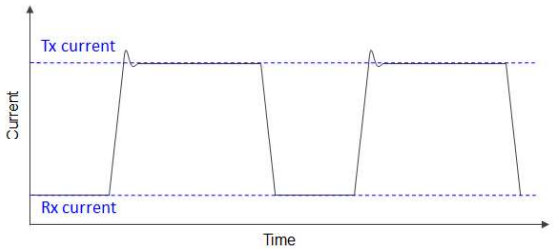
| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| UI | Unit Interval (UI)<br>UI does not account for SSC induced variations. | 199.94 | -- | 200.06 | ps |
| $V_{RX-DIFF-PP-CC}$ | Differential Rx peak-to-peak voltage for common Refclk Rx architecture | 0.120 | -- | 1.2 | V |
| $V_{RX-DIFF-PP-DC}$ | Differential Rx peak-to-peak voltage for data clocked Rx architecture | 0.100 | -- | 1.2 | V |
| $T_{RX-TJ-CC}$ | Maximum Rx inherent total timing error for common Refclk Rx architecture | -- | -- | 0.40 | UI |
| $T_{RX-TJ-DC}$ | Maximum Rx inherent total timing error for data clocked Rx architecture | -- | -- | 0.34 | UI |
| $T_{RX-DJ-DD-CC}$ | Maximum Rx inherent deterministic timing error for common Refclk Rx architecture | | -- | 0.30 | UI |
| $T_{RX-DJ-DD-DC}$ | Maxximum Rx inherent deterministic timing error for data clocked Rx architeuture | | -- | 0.24 | UI |
| $T_{RX-MIN-PLISE}$ | Minimum width pulse at Rx<br>Measured to account for worst Tj at $10^{-12}$ BER. | 0.6 | -- | -- | UI |
| $V_{RX-CM-ACp}$ | AC peak common mode input voltage | -- | -- | 150 | mV |
| $RL_{RX-DIFF}$ | Differential return loss | 15 | -- | -- | dB |
| $RL_{RX-CM}$ | Common mode return loss | 0 | -- | 3.6 | dB |
| $Z_{RX-DIFF-DC}$ | DC differential input impedance | 80 | 100 | 120 | W |
| $Z_{RX-DC}$ | DC input impedance | 40 | 50 | 60 | W |
| $Z_{RX-HIGH-IMP-DC}$ | Powered down DC input impedance | 200 | -- | -- | kΩ |
| $V_{RX-IDLE-DET-DIFF-p-p}$ | Electrical idle detect threshold | 65 | -- | 175 | mV |
| $T_{RX-IDLE-DET-DIFF-ENTERTIME}$ | Unexpected electrical idle enter detect threshold integration time | -- | -- | 10 | ms |
| $L_{RX-SKEW}$ | Total skew | -- | -- | 20 | ns |

## 12. DC / RF Characteristics

・ALL DC/RF characteristics are defined by following file.

| | |
|---|---|
| WLAN Tx Power | txpower_US.bin, txpower_CA.bin, txpower_EU.bin, txpower_JP.bin |
| WLAN Regulatory Limit | db.txt |
| Energy Detect | ed_mac.bin |
| Bluetooth Power | bt_power_config_1.sh (Class1) |

・Burst current definition



### 12.1. 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 |

#### 12.1.1. High Rate Condition for IEEE802.11b – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=18dBm, 11Mbps mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | Min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 220 | - | mA |
| | VDD18(MIMO) | - | 370 | - | mA |
| | VDD33(MIMO) | - | 450 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | Min. | Typ. | Max. | Unit |
| 2. Output Power | | 16 | 18 | 20 | 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≤ 8%) | | - | - | -76 | dBm |
| 10. Maximum Input Level (FER ≤ 8%) | | -10 | - | - | dBm |
| 11. Adjacent Channel Rejection (FER< 8%) | | 35 | - | - | dB |

### 12.1.2. Low Rate Condition for IEEE802.11b – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=18dBm, 1Mbps mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | Min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 210 | - | mA |
| | VDD18(MIMO) | - | 370 | - | mA |
| | VDD33(MIMO) | - | 450 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | Min. | Typ. | Max. | Unit |
| 2. Output Power | | 16 | 18 | 20 | 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≤ 8%) | | - | - | -80 | dBm |
| 10. Maximum Input Level (FER ≤ 8%) | | -10 | - | - | dBm |
| 11. Adjacent Channel Rejection (FER< 8%) | | 35 | - | - | dB |

## 12.2. 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 |

### 12.2.1. High Rate Condition for IEEE802.11g – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, 54Mbps mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | Min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 300 | - | mA |
| | VDD33 | - | 180 | - | mA |
| | VDD18(MIMO) | - | 410 | - | mA |
| | VDD33(MIMO) | - | 370 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | Min. | Typ. | Max. | Unit |
| 2. Output Power | | 14 | 16 | 18 | 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 |

### 12.2.2. Low Rate Condition for IEEE802.11g – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=17dBm, 6Mbps mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | Min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 300 | - | mA |
| | VDD33 | - | 200 | - | mA |
| | VDD18(MIMO) | - | 410 | - | mA |
| | VDD33(MIMO) | - | 420 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | Min. | Typ. | Max. | Unit |
| 2. Output Power | | 15 | 17 | 19 | 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%) | | - | - | -82 | dBm |
| 8. Maximum Input Level (PER < 10%) | | -20 | - | - | dBm |
| 9. Adjacent Channel Rejection(PER< 10%) | | -1 | - | - | dB |

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

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

#### 12.3.1. High Rate Condition for IEEE802.11n – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=15dBm, MCS7 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 300 | - | mA |
| | VDD33 | - | 170 | - | mA |
| | VDD18(MIMO) | - | 410 | - | mA |
| | VDD33(MIMO) | - | 330 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 13 | 15 | 17 | 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 |

### 12.3.2. Low Rate Condition for IEEE802.11n – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 300 | - | mA |
| | VDD33 | - | 190 | - | mA |
| | VDD18(MIMO) | - | 410 | - | mA |
| | VDD33(MIMO) | - | 380 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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%) | | - | - | -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 - 2.4GHz

| | |
|---|---|
| Specification | IEEE802.11ax |
| Mode | OFDM |
| Channel Frequency | 2412 - 2472MHz |
| Data rate | MCS0-MCS11 |

### 12.4.1. High Rate Condition for IEEE802.11ax – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=13dBm, MCS11 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 300 | - | mA |
| | VDD33 | - | 150 | - | mA |
| | VDD18(MIMO) | - | 410 | - | mA |
| | VDD33(MIMO) | - | 300 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 11 | 13 | 15 | 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) | | - | - | -35 | 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%) | | - | - | -69 | dBm |
| 8. Maximum Input Level (PER < 10%) | | -20 | - | - | dBm |
| 9. Adjacent Channel Rejection(PER≤ 10%) | | -2 | - | - | dB |

### 12.4.2. Low Rate Condition for IEEE802.11ax – 2.4GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 300 | - | mA |
| | VDD33 | - | 190 | - | mA |
| | VDD18(MIMO) | - | 420 | - | mA |
| | VDD33(MIMO) | - | 390 | - | mA |
| 2) Rx mode | VDD18 | - | 280 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 300 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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) | | - | - | -19 | 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%) | | - | - | -69 | dBm |
| 8. Maximum Input Level (PER < 10%) | | -20 | - | - | dBm |
| 9. Adjacent Channel Rejection(PER≤ 10%) | | -2 | - | - | dB |

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

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

### 12.5.1. High Rate Condition for IEEE802.11a – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, 54Mbps mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 230 | - | mA |
| | VDD18(MIMO) | - | 620 | - | mA |
| | VDD33(MIMO) | - | 460 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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)<br>(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 |

### 12.5.2. Low Rate Condition for IEEE802.11a – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=17dBm, 6Mbps mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode* | VDD18 | - | 430 | - | mA |
| | VDD33 | - | 260 | - | mA |
| | VDD18(MIMO) | - | 610 | - | mA |
| | VDD33(MIMO) | - | 510 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 15 | 17 | 19 | 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%) | | - | - | -82 | dBm |
| 8. Maximum Input Level (PER < 10%) | | -30 | - | - | dBm |
| 9. Adjacent Channel Rejection (PER≤ 10%) | | -1 | - | - | dB |

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

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

### 12.6.1. High Rate Condition for IEEE802.11n(HT20) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS7 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 240 | - | mA |
| | VDD18(MIMO) | - | 620 | - | mA |
| | VDD33(MIMO) | - | 450 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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)<br>(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 |

### 12.6.2. Low Rate Condition for IEEE802.11n(HT20) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 250 | - | mA |
| | VDD18(MIMO) | - | 630 | - | mA |
| | VDD33(MIMO) | - | 470 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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%) | | - | - | -82 | dBm |
| 8. Maximum Input Level (PER < 10%) | | -30 | - | - | dBm |
| 9. Adjacent Channel Rejection (PER≤ 10%) | | -2 | - | - | dB |

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

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

### 12.7.1. High Rate Condition for IEEE802.11ac(VHT20) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=15dBm, MCS8 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 370 | - | mA |
| | VDD33 | - | 220 | - | mA |
| | VDD18(MIMO) | - | 560 | - | mA |
| | VDD33(MIMO) | - | 420 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 13 | 15 | 17 | 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)<br>(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 |

### 12.7.2. Low Rate Condition for IEEE802.11ac(VHT20) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 250 | - | mA |
| | VDD18(MIMO) | - | 640 | - | mA |
| | VDD33(MIMO) | - | 470 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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%) | | - | - | -82 | dBm |
| 8. Maximum Input Level (PER < 10%) | | -30 | - | - | dBm |
| 9. Adjacent Channel Rejection (PER≤ 10%) | | -7 | - | - | dB |

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

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

### 12.8.1. High Rate Condition for IEEE802.11n(HT40) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS7 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 410 | - | mA |
| | VDD33 | - | 240 | - | mA |
| | VDD18(MIMO) | - | 630 | - | mA |
| | VDD33(MIMO) | - | 440 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 350 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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 |

### 12.8.2. Low Rate Condition for IEEE802.11n(HT40) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 410 | - | mA |
| | VDD33 | - | 250 | - | mA |
| | VDD18(MIMO) | - | 650 | - | mA |
| | VDD33(MIMO) | - | 470 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 350 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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%) | | - | - | -79 | dBm |
| 8. Maximum Input Level (PER ≤ 10%) | | -30 | - | - | dBm |
| 9. Adjacent Channel Rejection (PER ≤ 10%) | | -2 | - | - | dB |

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

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

### 12.9.1. High Rate Condition for IEEE802.11ac(VHT40) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=15, MCS9 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 380 | - | mA |
| | VDD33 | - | 210 | - | mA |
| | VDD18(MIMO) | - | 570 | - | mA |
| | VDD33(MIMO) | - | 410 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 350 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 13 | 15 | 17 | 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 |

### 12.9.2. Low Rate Condition for IEEE802.11ac(VHT40) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 410 | - | mA |
| | VDD33 | - | 250 | - | mA |
| | VDD18(MIMO) | - | 650 | - | mA |
| | VDD33(MIMO) | - | 470 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 350 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 14 | 16 | 18 | 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%) | | - | - | -79 | dBm |
| 8. Maximum Input Level (PER ≤ 10%) | | -30 | - | - | dBm |
| 9. Adjacent Channel Rejection (PER ≤ 10%) | | -9 | - | - | dB |

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

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

### 12.10.1. High Rate Condition for IEEE802.11ac(VHT80) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=14dBm, MCS9 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 200 | - | mA |
| | VDD18(MIMO) | - | 600 | - | mA |
| | VDD33(MIMO) | - | 380 | - | mA |
| 2) Rx mode | VDD18 | - | 350 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 420 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 12 | 14 | 16 | 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 |

### 12.10.2. Low Rate Condition for IEEE802.11ac(VHT80) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=15dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 230 | - | mA |
| | VDD18(MIMO) | - | 630 | - | mA |
| | VDD33(MIMO) | - | 440 | - | mA |
| 2) Rx mode | VDD18 | - | 350 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 420 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | min. | Typ. | Max. | Unit |
| 2. Output Power | | 13 | 15 | 17 | 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) | | - | - | -19 | 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%) | | - | - | -76 | dBm |
| 7. Maximum Input Level (PER ≤ 10%) | | -30 | - | - | dBm |
| 8. Adjacent Channel Rejection (PER ≤ 10%) | | -9 | - | - | dB |

## 12.11. DC/RF Characteristics for IEEE802.11ax(HE 20MHz)-5GHz

| | |
|---|---|
| Specification | IEEE802.11ax |
| Mode | OFDM |
| Channel Frequency | 5180 to 5240MHz,<br>5260 to 5320MHz,<br>5500 to 5720MHz,<br>5745 to 5825MHz |
| Data rate | MCS0-MCS11 |

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

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=14dBm, MCS11 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 380 | - | mA |
| | VDD33 | - | 210 | - | mA |
| | VDD18(MIMO) | - | 560 | - | mA |
| | VDD33(MIMO) | - | 400 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 12 | 14 | 16 | 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)<br>(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 |

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

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 250 | - | mA |
| | VDD18(MIMO) | - | 640 | - | mA |
| | VDD33(MIMO) | - | 480 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 320 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | min. | Typ. | Max. | Unit |
| 2. Output Power | | 14 | 16 | 18 | 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) | | - | - | -19 | 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%) | | - | - | -76 | dBm |
| 7. Maximum Input Level (PER ≤ 10%) | | -30 | - | - | dBm |
| 8. Adjacent Channel Rejection (PER ≤ 10%) | | -9 | - | - | dB |

## 12.12. DC/RF Characteristics for IEEE802.11ax(HE 40MHz)-5GHz

| | |
|---|---|
| Specification | IEEE802.11ax |
| Mode | OFDM |
| Channel Frequency | 5210 - 5775MHz |
| Data rate | MCS0-MCS11 |

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

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=14dBm, MCS11 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 390 | - | mA |
| | VDD33 | - | 210 | - | mA |
| | VDD18(MIMO) | - | 560 | - | mA |
| | VDD33(MIMO) | - | 400 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 350 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 12 | 14 | 16 | 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 |

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

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=16dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 420 | - | mA |
| | VDD33 | - | 250 | - | mA |
| | VDD18(MIMO) | - | 660 | - | mA |
| | VDD33(MIMO) | - | 480 | - | mA |
| 2) Rx mode | VDD18 | - | 320 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 350 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | min. | Typ. | Max. | Unit |
| 2. Output Power | | 14 | 16 | 18 | 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%) | | - | - | -76 | dBm |
| 7. Maximum Input Level (PER ≤ 10%) | | -30 | - | - | dBm |
| 8. Adjacent Channel Rejection (PER ≤ 10%) | | -9 | - | - | dB |

## 12.13. DC/RF Characteristics for IEEE802.11ax(HE 80MHz)-5GHz

| | |
|---|---|
| Specification | IEEE802.11ax |
| Mode | OFDM |
| Channel Frequency | 5210 - 5775MHz |
| Data rate | MCS0-MCS11 |

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

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=14dBm, MCS11 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 200 | - | mA |
| | VDD18(MIMO) | - | 600 | - | mA |
| | VDD33(MIMO) | - | 400 | - | mA |
| 2) Rx mode | VDD18 | - | 350 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 420 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | **min.** | **Typ.** | **Max.** | **Unit** |
| 2. Output Power | | 12 | 14 | 16 | 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 |

### 12.13.2. Low Rate Condition for IEEE802.11ax(HE80) – 5GHz

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V, Output power setting=15dBm, MCS0 mode

| Items | | Contents | | | |
|---|---|---|---|---|---|
| - DC Characteristics - | | min. | Typ. | Max. | Unit |
| 1. DC current | | | | | |
| 1) Tx mode | VDD18 | - | 400 | - | mA |
| | VDD33 | - | 230 | - | mA |
| | VDD18(MIMO) | - | 640 | - | mA |
| | VDD33(MIMO) | - | 440 | - | mA |
| 2) Rx mode | VDD18 | - | 350 | - | mA |
| | VDD33 | - | 0.2 | - | mA |
| | VDD18(MIMO) | - | 420 | - | mA |
| | VDD33(MIMO) | - | 0.2 | - | mA |
| - Tx Characteristics - | | min. | Typ. | Max. | Unit |
| 2. Output Power | | 13 | 15 | 17 | 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%) | | - | - | -76 | dBm |
| 7. Maximum Input Level (PER ≤ 10%) | | -30 | - | - | dBm |
| 8. Adjacent Channel Rejection (PER ≤ 10%) | | -9 | - | - | dB |

## 12.14. DC/RF Characteristics for Bluetooth

### 12.14.1. Basic Data Rate Condition

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V,

| Items | | Contents | | | |
|---|---|---|---|---|---|
| Bluetooth specification (power class) | | Version 5.3 | | | |
| Channel frequency (spacing) | | 2402 to 2480 MHz (1MHz) | | | |
| Current Consumption | | Min. | Typ. | Max. | unit |
| 1) Tx mode DH5 | VDD18 | - | 45 | - | mA |
| | VDD33 | - | 0.2 | - | |
| 2) Rx mode DH5 | VDD18 | - | 20 | - | mA |
| | VDD33 | - | 0.2 | - | |
| - Tx Characteristics - | | Min. | Typ. | Max. | Unit |
| Output Power@DH5 | | 0 | 3 | 6 | dBm |
| Frequency range | | 2400 | - | 2483.5 | MHz |
| 20dB bandwidth | | - | | 1 | MHz |
| Adjacent Channel Power *1 | | | | | |
| 1) [M-N] =2 | | - | - | -20 | dBm |
| 2) [M-N] ≥3 | | - | - | -40 | dBm |
| Modulation characteristics | | | | | |
| 1) Modulation Δf1avg | | 140 | 151 | 175 | kHz |
| 2) Modulation Δf2max | | 115 | | - | kHz |
| 3) Modulation Δf2avg / Δf1avg | | 0.8 | 1 | - | |
| Carrier Frequency Drift | | | | | |
| 1) 1slot | | -25 | - | 25 | kHz |
| 2) 3slot / 5slot | | -40 | - | 40 | kHz |
| 3) Maximum drift rate | | | - | 20 | kHz/50us |
| - Rx Characteristics - | | Min. | Typ. | Max. | unit |
| BDR Sensitivity (BER≤0.1%) | | - | -91 | -86 | dBm |
| C/I Performance (BER≤0.1%) *2 | | | | | |
| 1) co-channel | | - | - | 11 | dB |
| 2) 1MHz | | - | - | 0 | dB |
| 3) 2MHz | | - | - | -30 | dB |
| 4) 3MHz | | - | - | -40 | dB |
| 5) image (+4MHz) | | - | - | -9 | dB |
| 6) image +/- 1MHz | | - | - | -20 | dB |
| Maximum Input Level (BER≤0.1%) | | -20 | - | - | dBm |

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

### 12.14.2. Enhanced Data Rate Condition

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V,

| Items | | Contents | | | |
|---|---|---|---|---|---|
| Bluetooth specification (power class) | | Version 5.3 | | | |
| Channel frequency (spacing) | | 2402 to 2480 MHz (1MHz) | | | |
| Current Consumption | | Min. | Typ. | Max. | unit |
| 1) Tx mode 2DH5 | VDD18 | - | 45 | - | mA |
| | VDD33 | - | 0.2 | - | |
| 2) Rx mode 2DH5 | VDD18 | - | 20 | - | mA |
| | VDD33 | - | 0.2 | - | |
| 3) Tx mode 3DH5 | VDD18 | - | 45 | - | mA |
| | VDD33 | - | 0.2 | - | |
| 4) Rx mode 3DH5 | VDD18 | - | 20 | - | mA |
| | VDD33 | - | 0.2 | - | |
| - Tx Characteristics - | | Min. | Typ. | Max. | Unit |
| Output Power@2DH5/3DH5 | | -3 | 0 | 3 | dBm |
| Frequency range | | 2400 | - | 2483.5 | MHz |
| 20dB bandwidth | | - | | 1 | MHz |
| Adjacent Channel Power *1 | | | | | |
| 1) [M-N] =2 | | - | - | -20 | dBm |
| 2) [M-N] ≥3 | | - | - | -40 | dBm |
| EDR Relative Power | | -4 | - | 1 | dB |
| EDR Carrier Frequency Stability and Modulation Accuracy | | | | | |
| 1) ωi | | -75 | - | 75 | kHz |
| 2) ωi+ωo | | -75 | - | 75 | kHz |
| 3) ωo | | -10 | - | 10 | kHz |
| 4) RMS DEVM (DQPSK) | | - | - | 20 | % |
| 5) Peak DEVM (DQPSK) | | - | - | 35 | % |
| 6) 99% DEVM (DQPSK) | | - | - | 30 | % |
| 7) RMS DEVM (8DPSK) | | - | - | 13 | % |
| 8) Peak DEVM (8DPSK) | | - | - | 25 | % |
| 9) 99% DEVM (8DPSK) | | - | - | 20 | % |
| 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 |
| EDR Sensitivity (BER≤0.007%)@8DPSK | | - | -88 | -82 | dBm |
| C/I Performance (BER≤0.1%) *2 | | | | | |
| 1) co-channel | | - | - | 11 | dB |
| 2) 1MHz | | - | - | 0 | dB |
| 3) 2MHz | | - | - | -30 | dB |
| 4) 3MHz | | - | - | -40 | dB |
| 5) image (+4MHz) | | - | - | -9 | dB |
| 6) image +/- 1MHz | | - | - | -20 | dB |
| Maximum Input Level (BER≤0.1%) | | -20 | - | - | dBm |

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

## 12.15. DC/RF Characteristics for Bluetooth Low Energy

### 12.15.1. 1Mbps PHY Condition

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V,

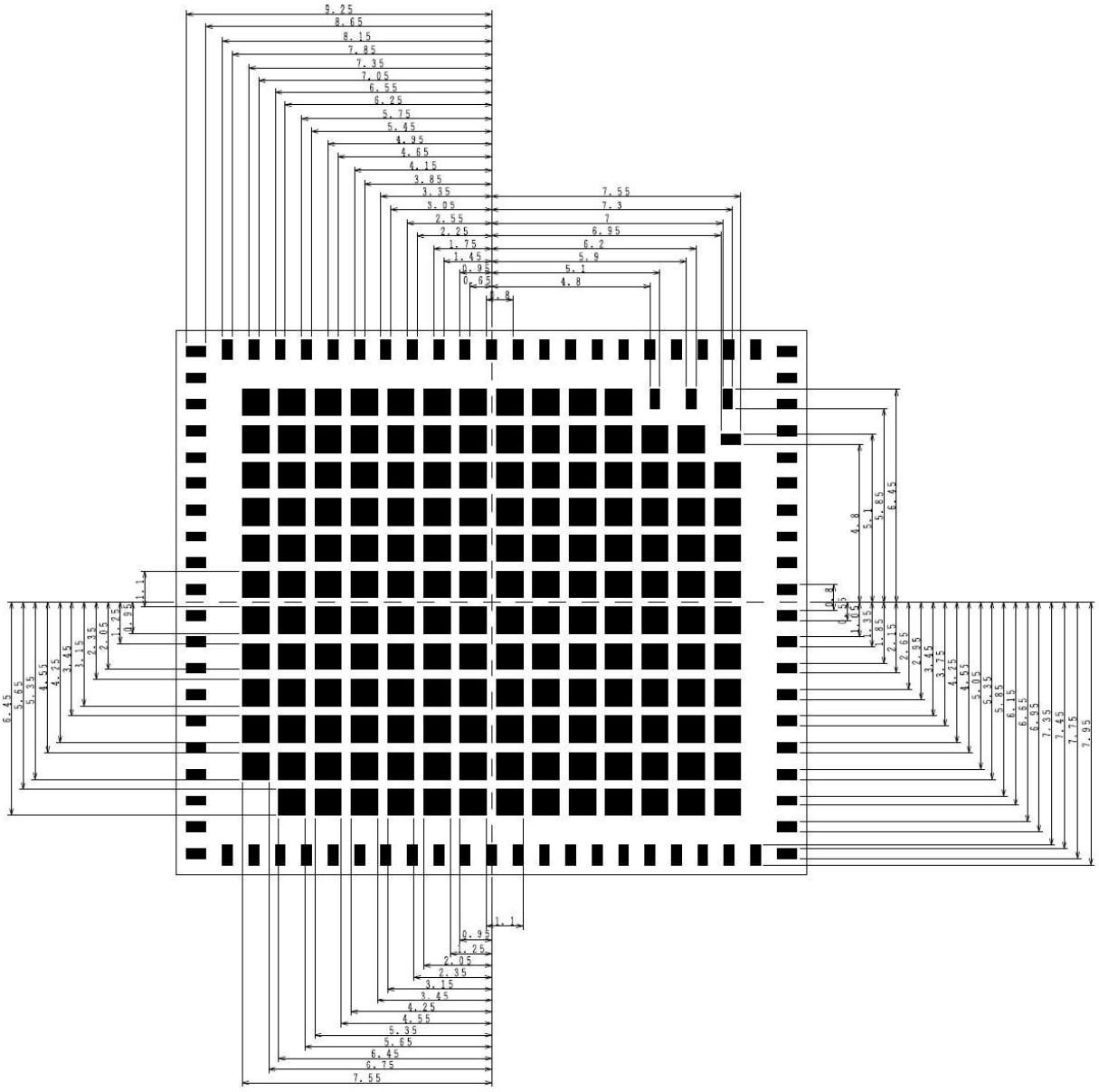
| Items | | Contents | | | |
|---|---|---|---|---|---|
| Bluetooth specification (power class) | | Version 5.3 | | | |
| Channel frequency (spacing) | | 2402 to 2480 MHz (2MHz) | | | |
| Number of RF Channel | | 40 | | | |
| Current Consumption | | Min. | Typ. | Max. | Unit |
| 1) Tx mode | VDD18 | - | 60 | - | mA |
| | VDD33 | - | 0.2 | - | |
| 2) Rx mode | VDD18 | - | 20 | - | mA |
| | VDD33 | - | 0.2 | - | |
| - Tx Characteristics - | | Min. | Typ. | Max. | Unit |
| Center Frequency | | 2402 | - | 2480 | MHz |
| Channel Spacing | | - | 2 | - | MHz |
| Number of RF channel | | - | 40 | - | - |
| Output power | | 0 | 3 | 6 | dBm |
| Modulation Characteristics | | | | | |
| 1) $\Delta f1_{avg}$ | | 225 | - | 275 | kHz |
| 2) $\Delta f2_{max}$ (at 99.9%) | | 185 | - | - | kHz |
| 3) $\Delta f2_{avg}$ / $\Delta f1_{avg}$ | | 0.8 | - | - | - |
| Carrier frequency offset and drift | | | | | |
| 1) Frequency offset | | - | - | 150 | kHz |
| 2) Frequency drift | | - | - | 50 | kHz |
| 3) Drift rate | | - | - | 20 | kHz |
| 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%) | | - | -95 | -90 | dBm |
| Maximum input signal level (PER < 30.8%) | | -10 | - | - | dBm |
| PER Report Integrity (-30dBm input) | | 50 | - | 65.4 | % |

### 12.15.2. 2Mbps PHY Condition

Conditions : 25deg.C, VDD33=3.3V, VDD18=1.8V VIO=1.8V,

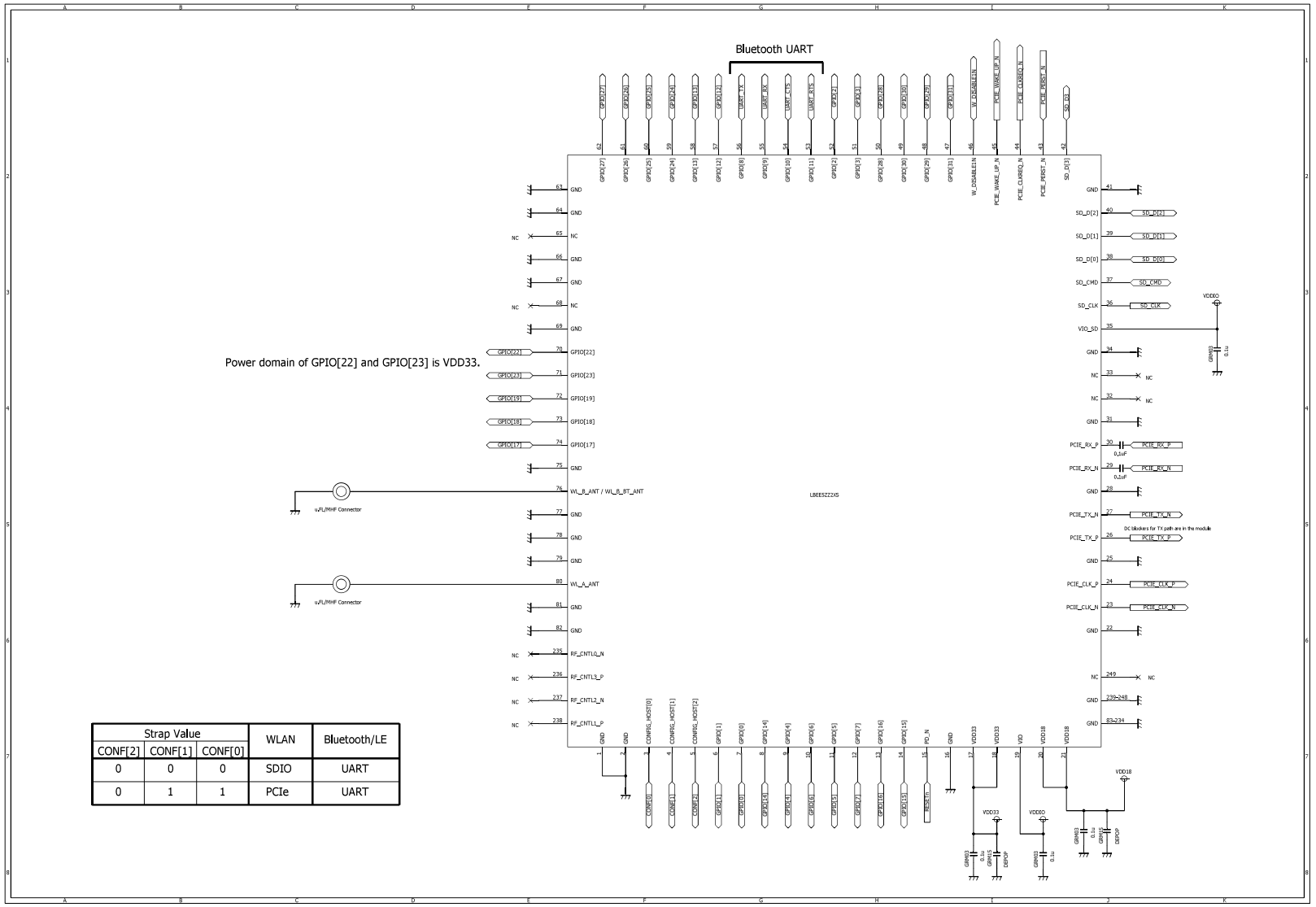
| Items | | Contents | | | |
|---|---|---|---|---|---|
| Bluetooth specification (power class) | | Version 5.3 | | | |
| Channel frequency (spacing) | | 2402 to 2480 MHz (2MHz) | | | |
| Number of RF Channel | | 40 | | | |
| Current Consumption | | Min. | Typ. | Max. | Unit |
| 1) Tx mode | VDD18 | - | 60 | - | mA |
| | VDD33 | - | 0.2 | - | |
| 2) Rx mode | VDD18 | - | 20 | - | mA |
| | VDD33 | - | 0.2 | - | |
| - Tx Characteristics - | | **Min.** | **Typ.** | **Max.** | **Unit** |
| Center Frequency | | 2402 | - | 2480 | MHz |
| Channel Spacing | | - | 2 | - | MHz |
| Number of RF channel | | - | 40 | - | - |
| Output power | | 0 | 3 | 6 | dBm |
| Modulation Characteristics | | | | | |
| 1) $\Delta f1_{avg}$ | | 225 | - | 275 | kHz |
| 2) $\Delta f2_{max}$ (at 99.9%) | | 185 | - | - | kHz |
| 3) $\Delta f2_{avg}$ / $\Delta f1_{avg}$ | | 0.8 | - | - | - |
| Carrier frequency offset and drift | | | | | |
| 1) Frequency offset | | - | - | 150 | kHz |
| 2) Frequency drift | | - | - | 50 | kHz |
| 3) Drift rate | | - | - | 20 | kHz |
| 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%) | | - | -95 | -90 | dBm |
| Maximum input signal level (PER < 30.8%) | | -10 | - | - | dBm |
| PER Report Integrity (-30dBm input) | | 50 | - | 65.4 | % |

## 13. Land Patterns



(unit : mm)

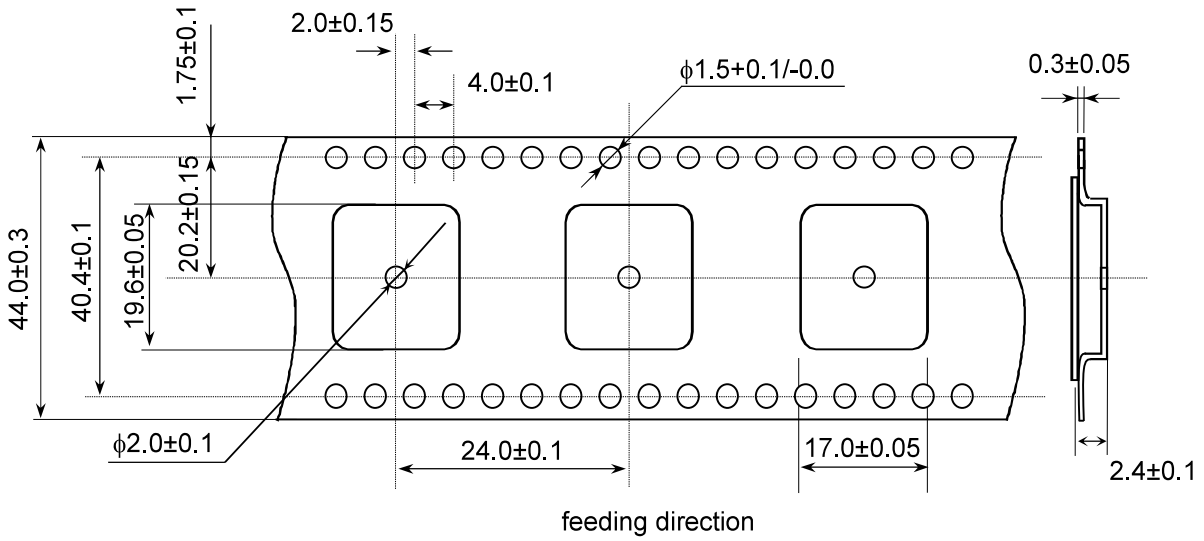
## 14. Reference Circuit



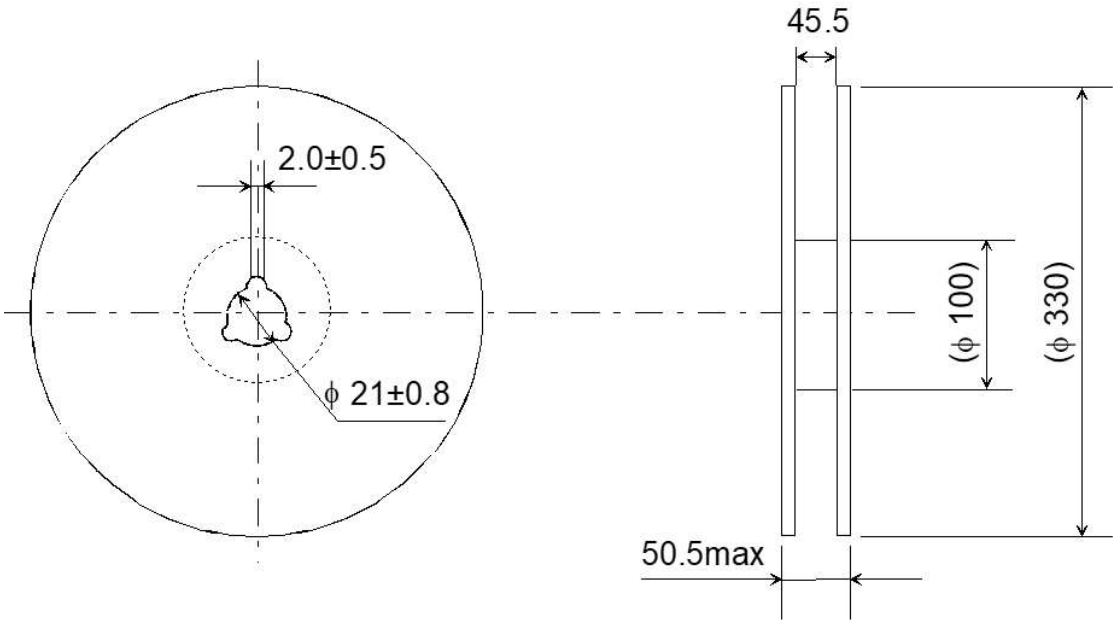

| Strap Value | | | WLAN | Bluetooth/LE |
|---|---|---|---|---|
| CONF[2] | CONF[1] | CONF[0] | | |
| 0 | 0 | 0 | SDIO | UART |
| 0 | 1 | 1 | PCIe | UART |

## 15. Tape and Reel Packing

(1) Dimensions of Tape (Plastic tape)




(2) Dimensions of Reel




(unit : mm)

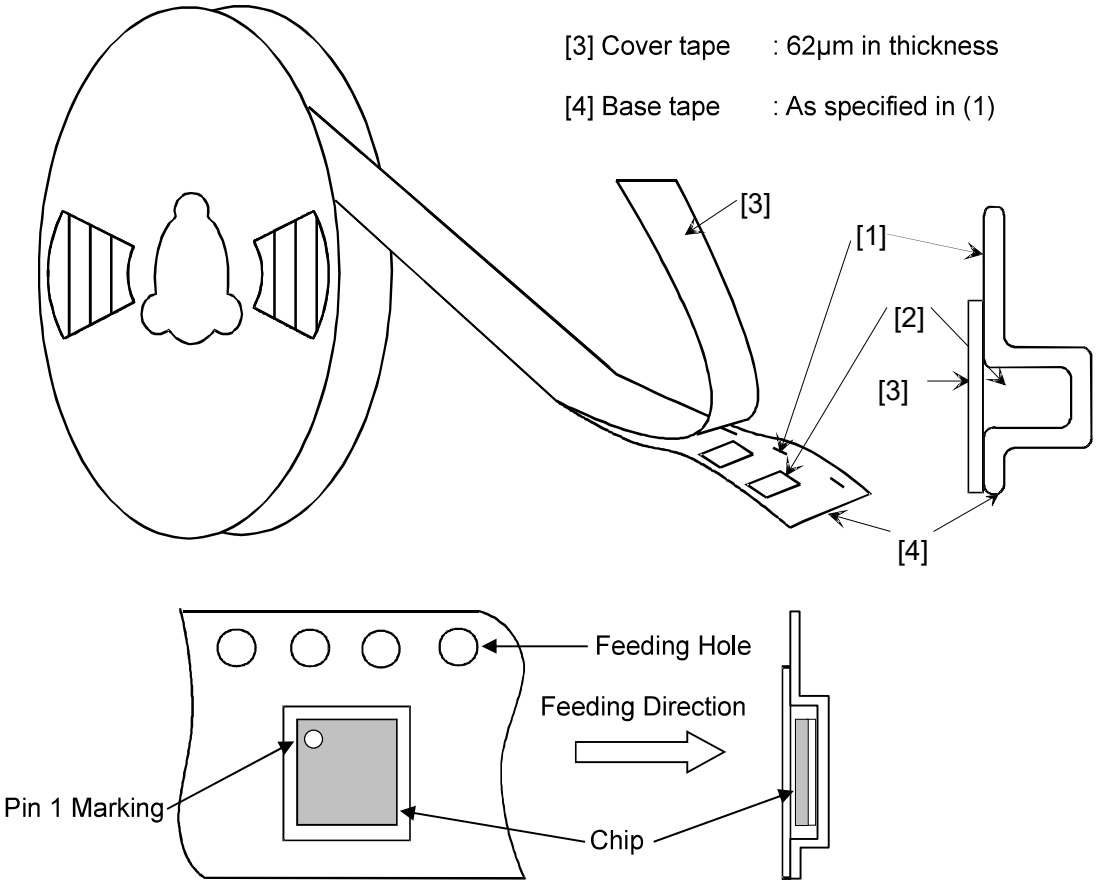
(3) Taping Diagrams

[1] Feeding Hole : As specified in (1)

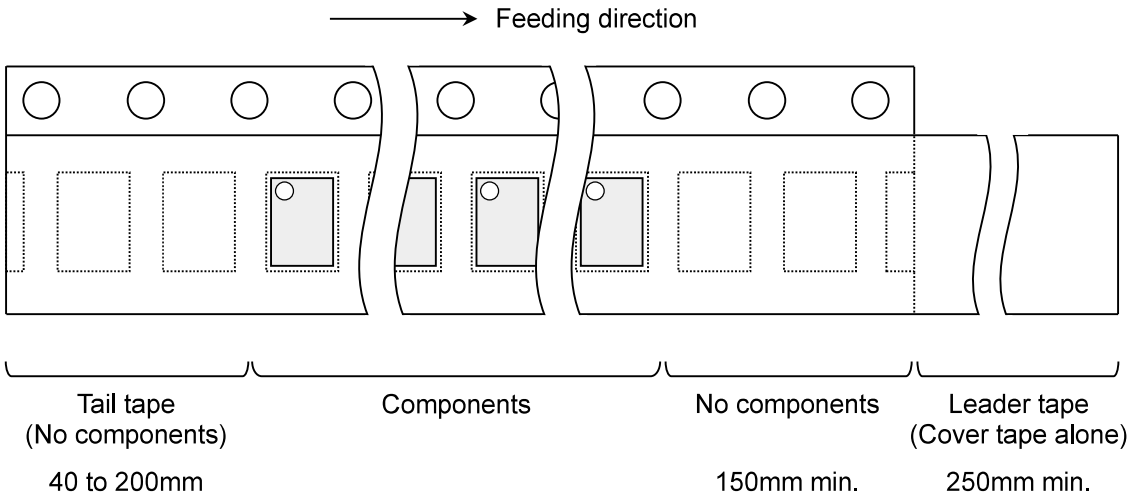
[2] Hole for chip : As specified in (1)

[3] Cover tape : 62μm in thickness

[4] Base tape : As specified in (1)




(4) Leader and Tail tape




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

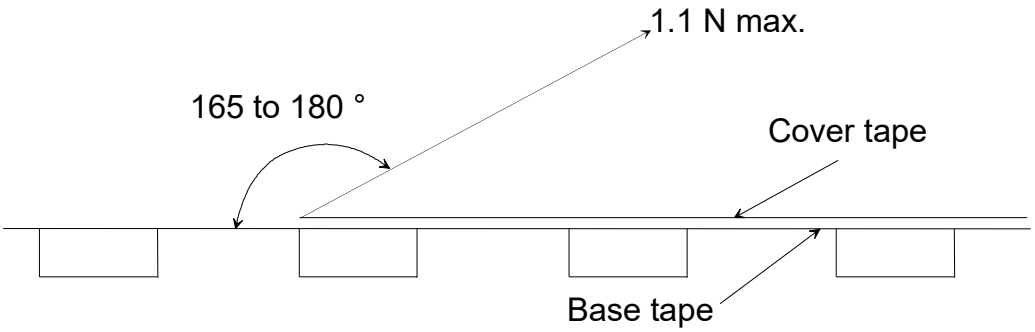
(6) The cover tape and base tape are not adhered at no components area for 250mm min.

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

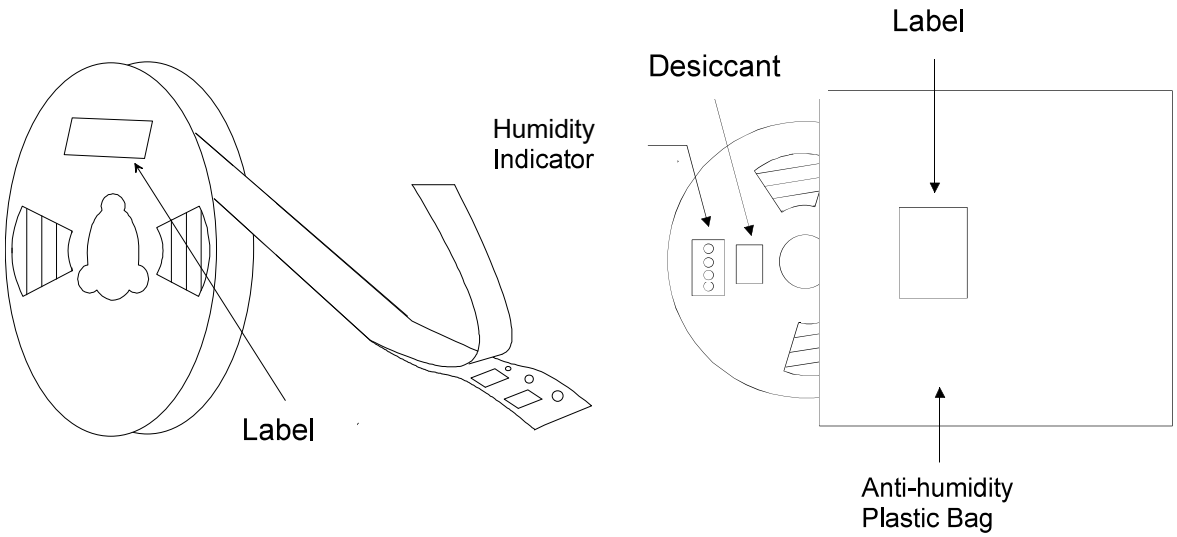
(8) Packaging unit : 500 pcs./ reel

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

(10) Peeling of force : 1.1N max. in the direction of peeling as shown below.




(11) Packaging (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 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.

## 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, 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.

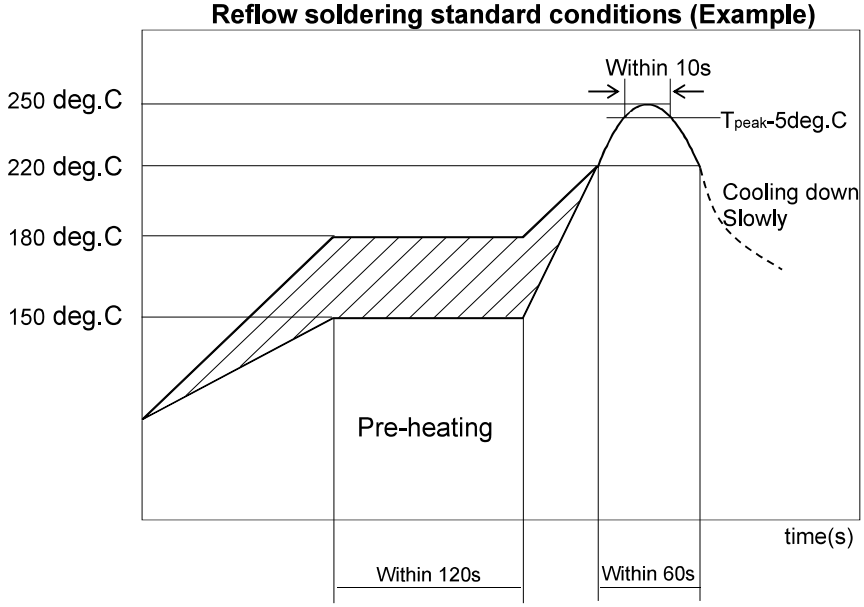
## 16.4. Notice for Chip Placer:

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

**Reflow soldering standard conditions (Example)**




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

### 16.6. 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.

### 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.

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.

## 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.

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.

You agree that you will use any and all software or program code (including but not limited to hcd, firmware, nvram, and blob) we may provide or to be embedded into our product ("Software") provided that you use the Software bundled with our product. YOU AGREE THAT THE SOFTWARE SHALL BE PROVIDED TO YOU "AS- IS" BASIS, MURATA MAKES NO REPRESENTATIONS OR WARRANTIES THAT THE SOFTWARE IS ERROR-FREE OR WILL OPERATE WITHOUT INTERRUPTION. AND MORE, MURATA MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED WITH RESPECT TO THE SOFTWARE. MURATA EXPRESSLY DISCLAIM ANY AND ALL WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE NOR THE WARRANTY OF TITLE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS.

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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 AND THE SOFTWARE IN SUCH APPLICATIONS.

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

We expressly prohibit you from analyzing, breaking, reverse-engineering, remodeling altering, and reproducing our product.

Our product cannot be used for the product which is prohibited from being manufactured, used, and sold by the regulations and laws in the world.

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

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

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

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

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

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-improper use of engineering samples.

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