# PAN9026

Wi-Fi Dual Band 2.4/5 GHz and Bluetooth Module

## Product Specification

Rev. 1.0

# Overview

The PAN9026 is a 2.4/5 GHz ISM band Wi-Fi and Bluetooth radio module, which includes a wireless radio for easy integration of Wi-Fi and Bluetooth connectivity into various electronic devices.

# Features

- Dual band 2.4/5 GHz 802.11 a/b/g/n Wi-Fi/BT combo module
- Supports 802.11i security standards through AES, CCMP, and more security mechanisms
- 802.11e Quality of Service is supported for multimedia applications
- IEEE 802.11n-compliant, 1x1 spatial stream with data rates up to MCS7 150 Mbps
- Bluetooth 5.0 (includes LE)
- Dual simultaneous and independent WLAN and Bluetooth operation
- Dynamic Rapid Channel Switching (DRCS) for simultaneous operation in 2.4 GHz and 5 GHz bands
- Indoor location and navigation with IEEE 802.11mc

- Power management with sleep clock
- Coexistence interface for arbitration of co-located WLAN, Bluetooth, or Mobile Wireless System (e.g. LTE)
- Generic interfaces include SDIO 3.0 and high-speed UART for host processor connection
- Software Linux driver

# Characteristics

- Surface Mount Type (SMT) 17.5 mm x 10.0 mm x 2.6 mm
- Marvell® 88W8977 WLAN 2.4/5 GHz and Bluetooth single-chip solution inside
- TX Power +16 dBm @ 802.11b
- RX Sensitivity -98 dBm @ 802.11b DSSS 1 Mbps
- IEEE 802.11n 20 MHz and 40 MHz channel bandwidth
- Long and Short Guard Interval support
- Power supply 3.3 V, 2.2 V, 1.8 V
- Current consumption Wi-Fi typical 400 mA @ TX and 70 mA @ RX
- SDIO 1-bit or 4-bit
- Wide temperature range of -30 to +85 °C

# Block Diagram
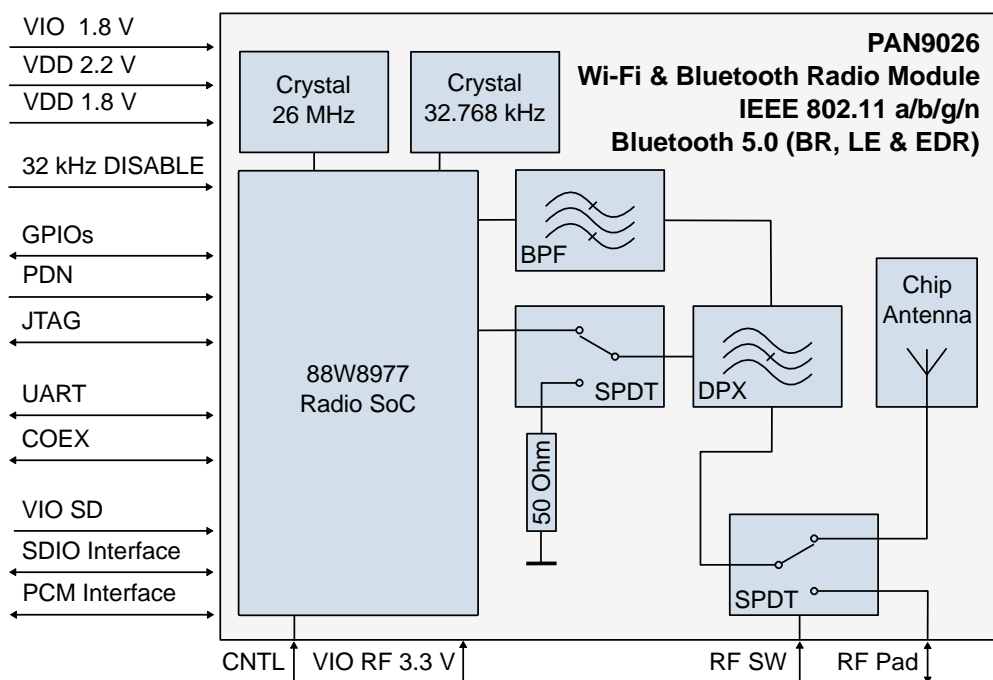
By purchase of any of the products described in this document the customer accepts the document's validity and declares their agreement and understanding of its contents and recommendations. Panasonic reserves the right to make changes as required at any time without notification. Please consult the most recently issued Product Specification before initiating or completing a design.

© Panasonic Industrial Devices Europe GmbH 2017.

This Product Description does not lodge the claim to be complete and free of mistakes.

## Engineering Samples (ES)

If Engineering Samples are delivered to the customer, these samples have the status "Engineering Samples". This means that the design of this product is not yet concluded. Engineering Samples may be partially or fully functional, and they may differ from the published Product Specification.

Engineering Samples are not qualified and they are not to be used for reliability testing or series production.

## Disclaimer

The customer acknowledges that samples may deviate from the Product Specification and may bear defects due to their status of development and the lack of qualification mentioned above.

Panasonic rejects any liability or product warranty for Engineering Samples. In particular, Panasonic disclaims liability for damages caused by:

- The use of the Engineering Sample other than for evaluation purposes, particularly the installation or integration in another product to be sold by the customer,
- Deviation or lapse in function of the Engineering Sample,
- Improper use of the Engineering Sample.

Panasonic Industrial Devices Europe GmbH disclaims any liability for consequential and incidental damages. In case of any queries regarding the Engineering Samples, please contact your local sales partner or the related product manager.

# Table of Contents

# 1 About This Document

## 1.1 Purpose and Audience

This Product Specification provides details on the functional, operational, and electrical characteristics of the Panasonic PAN9026 modules. It is intended for hardware design, application, and Original Equipment Manufacturers (OEM) engineers. The product is referred to as "the PAN9026" or "the module" within this document.

## 1.2 Revision History

| Revision | Date | Modifications/Remarks |
|---|---|---|
| 0.1 | 13.04.2017 | First preliminary version |
| 1.0 | 20.12.2017 | Change to Bluetooth 5.0: ⇨ Features, 2.1 Block Diagram, 2.9 Bluetooth, 7.1 Ordering Information<br>Change PM: ⇨ 2.3.1 Power Configuration Example with 3.3 V Host Operation<br>Include values: ⇨ 4.3.2 Current Consumption, 4.4.3.2 Transmitter Section RF Characteristics<br>Remove section: ⇨ 4.3.7.2 TDM Interface<br>Additional models: ⇨ 7.1 Ordering Information<br>Add section: ⇨ 7.2 Acronyms and Abbreviations |

## 1.3 Use of Symbols

| Symbol | Description |
|---|---|
| (i) | **Note**<br>Indicates important information for the proper use of the product.<br>Non-observance can lead to errors. |
| ⚠ | **Attention**<br>Indicates important notes that, if not observed, can put the product's functionality at risk. |
| ⇨ [chapter number] [chapter title] | **Cross reference**<br>Indicates cross references within the document.<br>**Example:**<br>Description of the symbols used in this document ⇨ 1.3 Use of Symbols. |

## 1.4 Related Documents

Please refer to the Panasonic website for related documents ⇨ 7.3.2 Product Information.

# 2  Overview

The PAN9026 is a dual band 2.4/5 GHz 802.11 a/b/g/n Wi-Fi radio module with integrated Bluetooth BR/EDR/LE, specifically designed for highly integrated and cost-effective applications. The simultaneous and independent operation of the two standards enables high data rates (802.11n) and low-power operation (Bluetooth Low Energy). Integrated power management, a fast dual-core CPU, 802.11i security standard support, and high-speed data interfaces deliver the performance for the speed, reliability, and quality requirements of next generation products. TX power calibration data and Wi-Fi/Bluetooth system parameters are pre-stored on the one-time-programmable memory of the PAN9026 during production at Panasonic. This simplifies passing the certification process for PAN9026 customers. Furthermore, the module reduces design, test, and calibration effort resulting in reduced time-to-market compared to discrete solutions.

Integrating Wi-Fi and Bluetooth wireless connectivity allows applications such as Smart Energy and home gateways to manage multiple devices and appliances. The combination of Wi-Fi and Bluetooth provides the highest flexibility for connectivity.


Please refer to the Panasonic website for related documents ⇨ 7.3.2 Product Information.

Further information on the variants and versions ⇨ 7.1 Ordering Information.

## 2.1   Block Diagram

VIO  1.8 V

VDD 2.2 V

VDD 1.8 V

32 kHz DISABLE

GPIOs

PDN

JTAG

UART

COEX

VIO SD

SDIO Interface

PCM Interface

**PAN9026**
**Wi-Fi & Bluetooth Radio Module**
**IEEE 802.11 a/b/g/n**
**Bluetooth 5.0 (BR, LE & EDR)**

Crystal 26 MHz

Crystal 32.768 kHz

88W8977 Radio SoC

BPF

SPDT

DPX

50 Ohm

Chip Antenna

SPDT

CNTL    VIO RF 3.3 V

RF SW    RF Pad
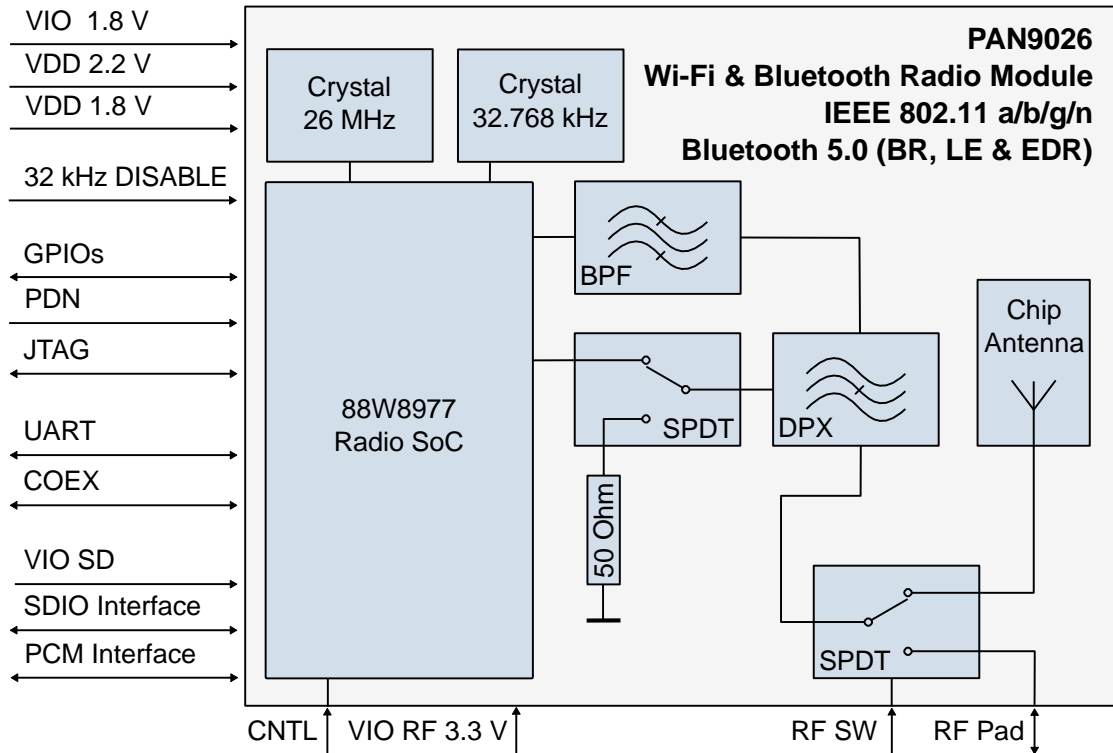
## 2.2 Pin Configuration

**Pin Assignment**

# Top View
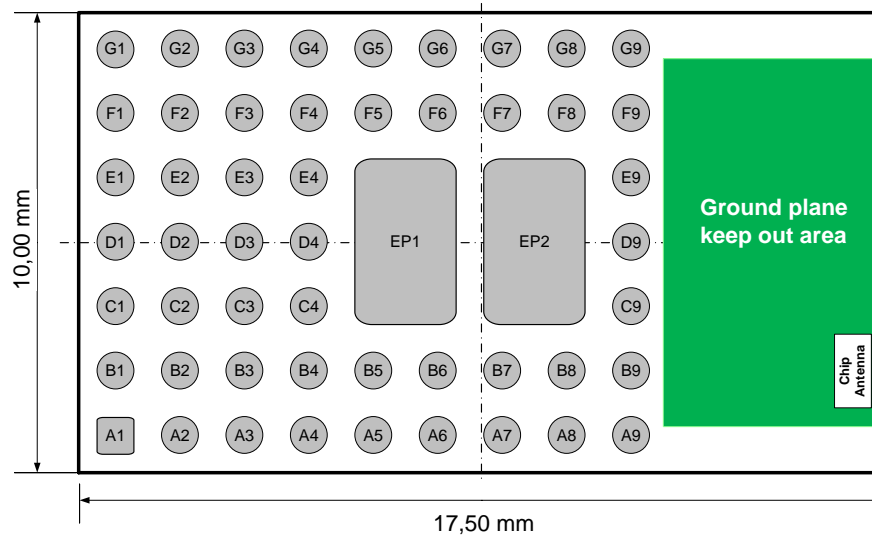


**Pin Functions**

| No | Pin Name | Pin Type | Description |
|---|---|---|---|
| A1 [1] | PCM_DOUT | Output signal | PCM data output signal |
| | IO5 | Digital I/O | General Purpose IO – GPIO[5] |
| A2 | 32KHZ_IN | NC | Do not connect |
| A3 | PDN | Input signal | Power down, active-low |
| A4 | VDD1V8 | Power | 1.7 V-1.9 V (typ. 1.8 V) power supply connection |
| A5 | VDD1V8 | Power | 1.7 V-1.9 V (typ. 1.8 V) power supply connection |
| A6 | VDD2V2 | Power | 2.1 V- 2.3 V (typ. 2.2 V) power supply connection |
| A7 | RF_SW1 | Input signal | RF Switch Pin 1 – logical voltage level to activate on-board antenna or RF Pad ⇨ RF-Switch Pins Function |
| A8 | GND | Ground pin | Connect to ground |
| A9 | RF_OUT | RF port | 50 Ω bottom pad to be activated by RF_SW1/RF_SW2 control voltage ⇨ RF-Switch Pins Function |
| B1 [1] | PCM_CLK | Input/output | PCM clock signal, output if PCM master, input if PCM slave |
| | IO6 | Digital I/O | General Purpose IO – GPIO[6] |

---

[1] Multi-purpose pins: After the firmware download, the pins (GPIO, Serial Interface, RF control) are programmed in functional mode with dedicated functionality.

| No | Pin Name | Pin Type | Description |
|---|---|---|---|
| B2 [1] | PCM_DIN | Input signal | PCM data input signal |
| | IO4 | Digital I/O | General Purpose IO – GPIO[4] |
| B3 [1] | PCM_SYNC [2] | Input/output | PCM Sync Pulse signal, output if PCM master, input if PCM slave |
| | IO7 [3] | Digital I/O | General Purpose IO – GPIO[7] |
| B4 | 32KHZ_EN | Input Signal | If using VIO 3.3V disable the internal 32.768 kHz crystal oscillator (100 Ω to GND) to use the SoC reference clock with lower accuracy |
| B5 | VDD2V2 | Power | 2.1 V-2.3 V (typ. 2.2 V) power supply connection |
| B6 | VDD2V2 | Power | 2.1 V-2.3 V (typ. 2.2 V) power supply connection |
| B7 | RF_SW2 | Input signal | RF Switch Pin 2 – logical voltage level to activate on-board antenna or RF Pad ⇨ RF-Switch Pins Function |
| B8 | GND | Ground pin | Connect to ground |
| B9 | GND | Ground pin | Connect to ground |
| C1 | IO2 | Digital I/O | General Purpose IO – GPIO[2] |
| | DVSC[0] | Output signal | Digital voltage scaling control for PMIC (VOUT 2.2V) ⇨ Power Configuration Example with 3.3 V Host Operation |
| C2 | IO3 | Digital I/O | General Purpose IO – GPIO[3] |
| | DVSC[1] | Output signal | Digital voltage scaling control for PMIC (VOUT 1.05V) - not used |
| C3 | IO1 | Digital I/O | General Purpose IO – GPIO[1] |
| C4 | COEX_SIN | Input signal | Serial data input from MWS modem or peripheral device |
| C9 | GND | Ground pin | Connect to ground |
| D1 | IO15 | Digital I/O | General Purpose IO – GPIO[15] |
| D2 | IO14 | Digital I/O | General Purpose IO – GPIO[14] |
| D3 | DNC_E3 | NC | Do not connect |
| D4 | COEX_SOUT | Output signal | Serial data output to MWS modem or peripheral device |
| D9 | GND | Ground pin | Connect to ground |
| E1 | SD_CLK | Digital I/O | For SDIO specific terminals ⇨ SDIO Pins Function |
| E2 | SD_CMD | Digital I/O | For SDIO specific terminals ⇨ SDIO Pins Function |
| E3 | IO0 | Digital I/O | General Purpose IO – GPIO[0] |
| E4 | DNC_E4 | NC | Do not connect |
| E9 | GND | Ground pin | Connect to ground |
| F1 | SD_DAT0 | Digital I/O | For SDIO specific terminals ⇨ SDIO Pins Function |

[2] PCM Mode: After enabling the mode by host command, the pin is used as PCM Audio Interface.

[3] GPIO Mode: After enabling the mode by host command, the pin is used as Multi-Purpose Interface.

| No | Pin Name | Pin Type | Description |
|---|---|---|---|
| F2 | SD_DAT1 | Digital I/O | For SDIO specific terminals ⇨ SDIO Pins Function |
| F3 [1] | UART_SOUT [4] | Output Signal | Serial data output to peripheral device |
| | IO8 [3] | Digital I/O | General Purpose IO – GPIO[8] |
| | BT_FREQ [5] | Input Signal | Information BT using channel which overlaps WLAN channel or not |
| F4 [1] | UART_SIN [4] | Input signal | Serial data input to peripheral device |
| | IO9 [3] | Digital I/O | General Purpose IO – GPIO[9] |
| | BT_STATE [5] | Input signal | Information BT_REQ priority (1- or 2-bit) and direction BT RX/TX |
| F5 [1] | UART_RTS [4] | Output signal | Request-to-Send output to peripheral device |
| | IO11 [3] | Digital I/O | General Purpose IO – GPIO[11] |
| | BT_REQ [5] | Input signal | BT device request access to medium |
| F6 | IO12 | Digital I/O | General Purpose IO – GPIO[12] |
| F7 | CNTL1 | Output signal | Do not connect |
| F8 | CNTL0 | Input signal | Keep open (DNC) if using SDIO interface for BT or connect with 100 kΩ to GND if using UART interface for BT ⇨ Control Pin Function |
| F9 | GND | Ground pin | Connect to ground |
| G1 | SD_DAT2 | Digital I/O | For SDIO specific terminals ⇨ SDIO Pins Function |
| G2 | SD_DAT3 | Digital I/O | For SDIO specific terminals ⇨ SDIO Pins Function |
| G3 | VIOSD | Power | 1.8 V or 3.3 V Digital I/O SDIO  power supply |
| G4 | VIO | Power | 1.8 V or 3.3 V power supply for General Purpose IO, if using VIO 3.3V disable  the internal 32.768 kHz crystal oscillator (Pin No B4) |
| G5 [1] | UART_CTS [4] | Input signal | Clear-to-send input from peripheral  device |
| | IO10 [3] | Digital I/O | General Purpose IO – GPIO[10] |
| | BT_GRANT [5] | Output signal | Indicate permission to transmit, low BT can transmit |
| G6 | IO13 | Digital I/O | General Purpose IO – GPIO[13] |
| G7 | VIORF | Power | 3.0 V – 3.6 V (typ. 3.3 V) power supply connection |
| G8 | DNC | NC | Do not connect |
| G9 | GND | Ground pin | Connect to ground |
| EP1 | EPAD1 | Thermal pin | Connect to ground |
| EP2 | EPAD2 | Thermal pin | Connect to gorund |

[4] UART mode: After the dedicated firmware download, the pin is used as Host Controller Interface (HCI) for Bluetooth.

[5] Bluetooth External Coexistence Mode: After enabling the mode by host command, the pin is used as Bluetooth external Coexistence Interface.

### SDIO Pins Function

| No | Pin Name | Pin Type | Description | |
|----|----------|----------|-------------|---|
| | | | **4-Bit Mode** | **1-Bit Mode** |
| E1 | SD_CLK | Digital I/O | Clock | Clock |
| E2 | SD_CMD | Digital I/O | Command Line | Command Line |
| F1 | SD_DAT0 | Digital I/O | Data Line bit [0] | Data Line |
| F2 | SD_DAT1 | Digital I/O | Data Line bit [1] or Interrupt (optional) | Interrupt |
| G1 | SD_DAT2 | Digital I/O | Data Line bit [2] or Read Wait (optional) | Read Wait (optional) |
| G2 | SD_DAT3 | Digital I/O | Data Line bit [3] | Not used |

### RF-Switch Pins Function

| No | Pin Name | Pin Type | Logical Level for Activation | |
|----|----------|----------|------------------------------|---|
| | | | **On-Board Chip Antenna** | **RF OUT Pin** |
| A7 | RF_SW1 | Input signal | 3.0 V-3.6 V (typ. 3.3 V) | GND (0 V) |
| B7 | RF_SW2 | Input signal | GND (0 V) | 3.0 V-3.6 V (typ. 3.3 V) |

### Control Pin Function

The control pin is used as configuration input to set parameters following a reset. The definition of the pin changes immediately after a reset to its usual function. To set a configuration bit to 0, attach a 100 kΩ resistor from the pin to ground. No external circuitry is required to set a configuration bit to 1.

| No | Pin Name | Pin Type | Strap Value | WLAN | BT/BLE | Firmware Download | | Number SDIO Functions |
|----|----------|----------|-------------|------|--------|-------------------|---|-----------------------|
| | | | | | | **Type** | **Mode** | |
| F8 | CNTL0 | Input Signal | 0 | SDIO | UART | SDIO+UART | Parallel/Serial | 1 (WLAN) |
| | | | 1 | SDIO | SDIO | SDIO+SDIO | Parallel/Serial | 2 (WLAN, BT) |

> ⓘ The configuration of the control pin is used for the firmware boot option. The software reads and boots accordingly.

## 2.3 Power Management

### 2.3.1 Power Configuration Example with 3.3 V Host Operation
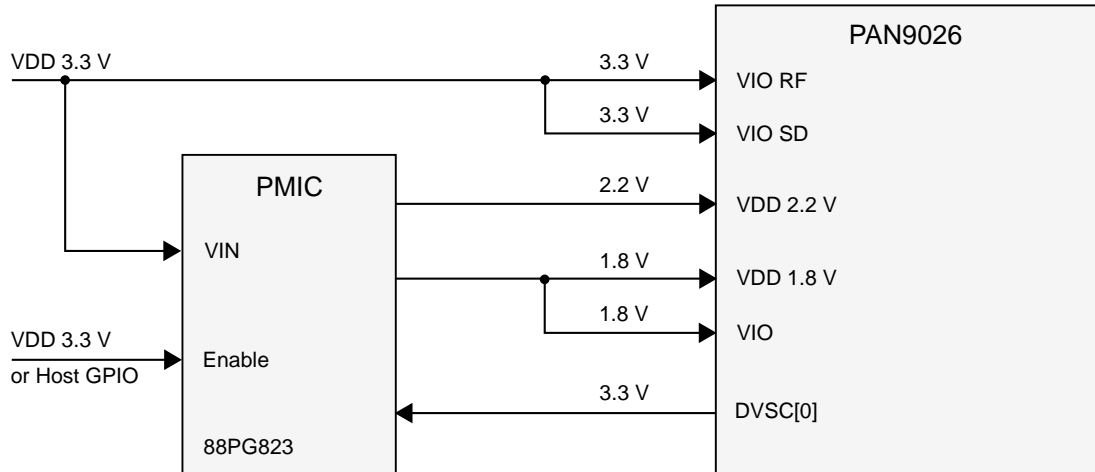


### 2.3.2 Power Configuration Example with 1.8 V Host Operation
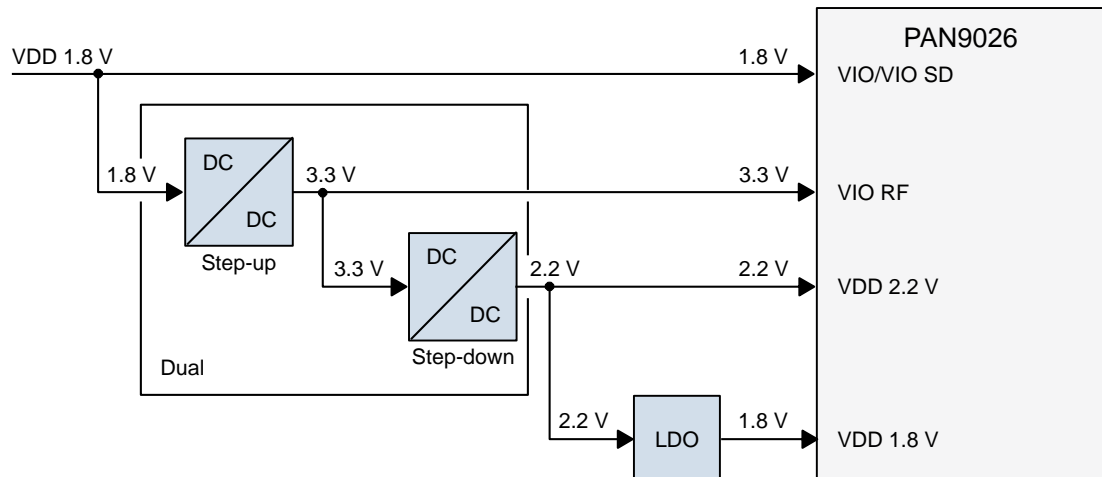


Further information ⇨ 4.3.4 Power-up Sequence.

## 2.4   Host Interfaces

The bus interface connects several host interface bus units to the CPU bus of the device through the internal bus. The connection of each unit is multiplexed with other bus units.

The high-speed UART interface is connected to the CPU bus through a separate bus.

| Type | Features |
|---|---|
| High-speed UART interface | The device supports a high-speed Universal Asynchronous Receiver/Transmitter (UART) interface, compliant with the industry standard 16550 specification.<br><br>• FIFO mode permanently selected for transmit and receive operations<br>• Two pins for transmit and receive operations<br>• Two flow control pins<br>• Interrupt triggers for low-power, high throughput operation |
| SDIO interface | The device supports an SDIO device interface that conforms to the industry standard SDIO full-speed card specification and allows a host controller using the SDIO bus protocol to access the device.<br><br>• Supports SDIO 3.0 Standard<br>• 1-bit SDIO or 4-bit SDIO transfer modes with full clock range up to 100 MHz<br>• On-chip memory used for CIS<br>• Special interrupt register for information exchange<br>• Allows card to interrupt host |

Further information ⇨ 4.3.5 Host Interface

## 2.5 Peripheral Bus Interface

The Peripheral Bus Unit (PBU) connects several low speed peripherals to the internal bus of the device. The device consists of the GPIO Interface and the One Time Programmable Memory.

| Type | Features |
|------|----------|
| General Purpose I/O (GPIO) Interface | • User-defined GPIOs (each configured to either input or output)<br>• Each GPIO controlled independently<br>• Each I/O configurable to output bit from GPIO_OUT |
| One Time Programmable Memory (OTP) | • Storing device-specific calibration data and hardware information like MAC/BD address, WLAN, and Bluetooth parameter<br>• Programmed during production process of device<br>• Device performs calibration when it is powered up |

Further information ⇨ 4.3.6 Peripheral Interface

## 2.6 PCM Interface

The device supports the PCM interface.

| Type | Features |
|---|---|
| PCM Interface | • Master or slave mode<br>• PCM bit width size of 8 bits or 16 bits<br>• Up to four slots with configurable bit width and start positions<br>• Short frame and long frame synchronization |

Further information ⇨ 4.3.7 Audio Interface

## 2.7 Coexistence

The implemented coexistence framework is based on the IEEE 802.15.2 recommended practice Packet Traffic Arbitration (PTA) scheme and the Bluetooth Special Interest Group (BTSIG) Core Specification Volume 7 (Wireless Coexistence Volume).

### 2.7.1 WLAN/Bluetooth Channel Information Exchange

Since Bluetooth and IEEE 802.11 b/g/n WLAN use the same 2.4 GHz frequency band, each can cause interference with another. The level of interference depends on the respective frequency channel used by Bluetooth and WLAN (other factors can impact interference, like Tx power and Rx sensitivity of the device).

In a system with both Bluetooth and WLAN, the common host receives information about WLAN channel usage and passes the information to the Bluetooth device. For Bluetooth 1.2 devices with Adaptive Frequency Hopping (AFH) enabled, the Bluetooth device can block channel usage that overlaps the WLAN channel in use.

When the Bluetooth device avoids all channels used by the WLAN, the impact of interference is reduced, but not completely eliminated. For Bluetooth 1.1 devices, the Bluetooth device cannot block WLAN channel usage. In this case, a Bluetooth Coexistence Arbiter (BCA) scheme at MAC level is required. The BCA scheme can also be used with Bluetooth 1.2 devices to further reduce the impact of interference to a minimum.

### 2.7.2 External Mobile Wireless System (LTE/ZigBee) and BCA Exchange

Based on the BTSIG Wireless Coexistence Volume, the device supports a Wireless Coexistence Interface 2 (WCI-2) protocol for WLAN/Bluetooth coexistence with an external Mobile Wireless System (MWS), such as a Long Term Evolution (LTE) or ZigBee device.

WCI-2 is a 2-wire transport interface. An internal coexistence is used to exchange request/grant with the BCA.

### 2.7.3 System Configuration

**External MWS Device**
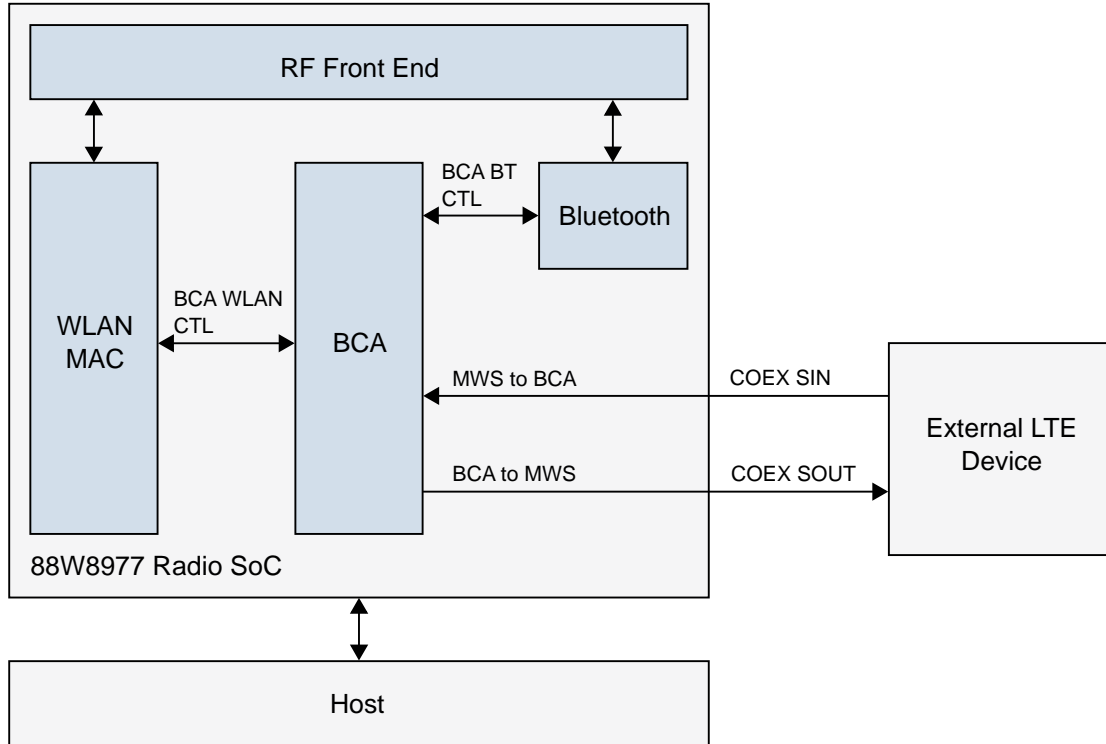


**External BCA Device**
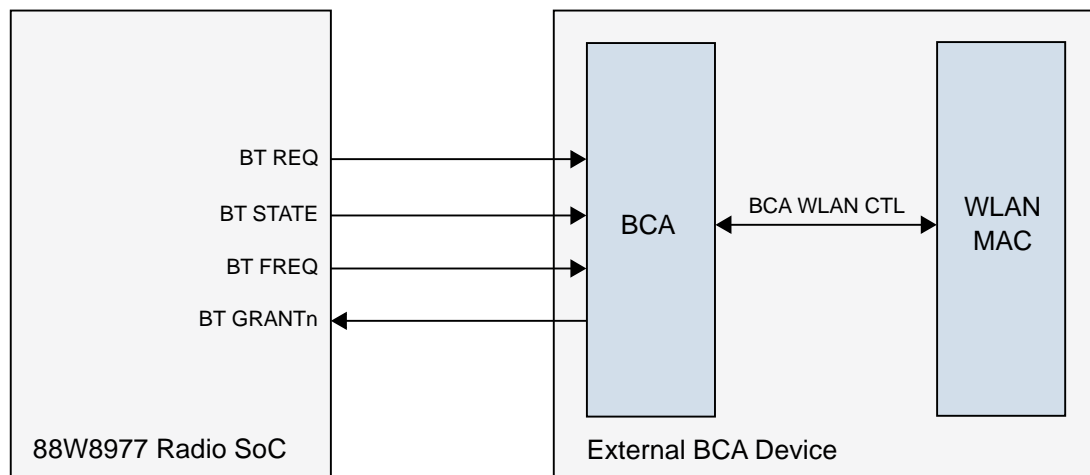
### 2.7.4  WCI-2 Interface

The coexistence interface includes a Mobile Wireless System (MWS) transport controller to accommodate a 2-wire, UART-based serial transport interface. This interface is a standard full-duplex UART (TXD and RXD) carrying logical signals framed as UART characters. In addition, it allows support of multiple logical channels.

#### Interface Signals

| Pin No | Signal Name | Specification Name | Pin Type | Description |
|--------|-------------|--------------------|----------|-------------|
| C4 | COEX_SIN | RXD | Input | Serial data from external MWS device |
| D4 | COEX_SOUT | TXD | Output | Serial data to external MWS device |

#### Signal Waveform Format

The messaging is based on a standard UART format. The UART signals should be connected like a null-modem. For example, the local TXD connected to the remote RXD and vice versa.
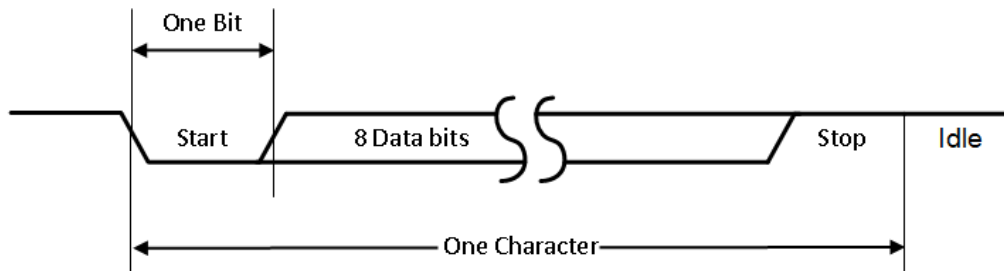


#### Interface Transport Settings

| Item | Range | Comment |
|------|-------|---------|
| Baudrate | 921 600 ~ 4 000 000 | Baud |
| Data Bits | 8 | LSB first |
| Parity Bits | 0 | No parity |
| Stop Bit | 1 | One stop bit |
| Flow Control | No | No flow control |

#### Supported Baud Rates

| Baud | | | |
|------|------|------|------|
| 921 600 | 2 000 000 | 3 000 000 | 4 000 000 |

**Real-Time Signaling Message**

The real-time signaling message is used to transport real-time signals over the 2-wire transport interface.

The real-time signaling message conveys the real-time signals (Bluetooth Core Specification, Volume 7, Part A) in one message. The time reference point for the real-time signaling message is the end of message bit 5 (transition to stop bit).

Defined real-time signaling messages include:

- Coexistence Controller to MWS device
- MWS device to Coexistence Controller

| Real-Time Signaling | MSG[0] | MSG[1] | MSG[2] | MSG[3] | MSG[4] |
|---|---|---|---|---|---|
| MWS to Coexistence Controller (Signal) | FRAME_SYNC | MWS_RX | MWS_TX | PATTERN[0] | PATTERN[1] |
| Coexistence Controller to MWS (Message) | BT_RX_PRI | BT_TX_ON | 802_RX_PRI | 802_TX_ON | RFU |

| Signal Name |
|---|
| FRAME_SYNC |
| MWS_RX |
| MWS_TX |
| PATTERN[1,0] |
| BT_RX_PRI |
| BT_TX_ON |
| 802_RX_PRI |
| 802_TX_ON |
| MWS_INACTIVITY_DURATION |
| MWS_SCAN_FREQUENCY_OFFSET |

### Transport Control Message

The transport control messages can modify the state and request state information of the MWS coexistence interface.

| Message | MSG[0] | MSG[1] | MSG[2] | MSG[3] | MSG[4] |
|---|---|---|---|---|---|
| Transport Control Message | RESEND_REAL_TIME | RFU | RFU | RFU | RFU |

| Signal Name | Description |
|---|---|
| RESEND_REAL_TIME | This bit is set if a device wants to get a status update of the real-time signals. The signal is usually used after wake-up from sleep of the transport interface to get an update of the real-time signals. |
| | If the receiving device's transport interface is awake it shall send a real-time message with the current status of the real-time signals within 4 UART character period. If the signal is not transmitted within 4 UART character periods, the device is considered asleep. |
| | If the receiving device's transport interface is not awake it shall not send a real-time message. |
| | Bluetooth initiated: |
| | If the MWS is currently scanning or has an ongoing inactivity duration, the MWS shall send a frequency scan message or an inactivity duration message after transmitting the real-time message. |
| | If the receiving device's transport interface is not awake it shall not send a frequency scan or inactivity duration message. |

### Transparent Data Message

The transport control messages can modify the state and request state information of the MWS coexistence interface.

| Message | MSG[0] | MSG[1] | MSG[2] | MSG[3] | MSG[4] |
|---|---|---|---|---|---|
| Transparent Data Message | NIBBLE_POSITION | DATA[0]/[4] | DATA[1]/[5] | DATA[2]/[6] | DATA[3]/[7] |

| Signal Name | Description |
|---|---|
| NIBBLE_POSITION | 0 = least significant nibble |
| | 1 = most significant nibble |
| DATA[n]; n=0 .. 7 | Data bits of the message octet |

## MWS Inactivity Duration Message

The inactivity duration messages is used to send the MWS_INACTIVITY_DURATION signal from the MWS device to the Coexistence Controller.

| Message | MSG[0] | MSG[1] | MSG[2] | MSG[3] | MSG[4] |
|---|---|---|---|---|---|
| MWS Inactivity Duration Message | DURATION[0] | DURATION[1] | DURATION[2] | DURATION[3] | DURATION[4] |

The idle duration is encoded in 5 bits given by the formula:

$$Inactivity\_Duration = DURATION * 5\,ms$$

Inactivity durarations smaller than 5 ms are not communicated.

If all bits are set to 1 the inactivity duration is infinite. If all bits are set to 0 or MWS_RX or MWS_TX are set to 1, the inactivity period ends.

## MWS Scan Frequency Offset Message

The MWS scan frequency offset message is used to send the MWS_SCAN_FREQUENCY_OFFSET signal from the MWS device to the Coexistence Controller.

| Message | MSG[0] | MSG[1] | MSG[2] | MSG[3] | MSG[4] |
|---|---|---|---|---|---|
| MWS Scan Frequency Offset | BAND | FREQ[0] | FREQ [1] | FREQ [2] | FREQ [3] |

The RF scan frequency is encoded in 5 bits given by the formula:

$$RF\_FREQ\_OFFSET = FREQ * 10\,MHz$$

If BAND is set to o the RF_FREQ_OFFSET is the negative value from the lower edge of the ISM band and if BAND is set to 1, RF_FREQ_OFFSET is the positive value from the top edge of the ISM band.

FREQ set to all 0 indicates the end of the scan period.

### 2.7.5   Bluetooth Coexistence Arbiter

| Type | Features |
|---|---|
| Capability | • Programmable coexistence interface timing, interface modes, and signal polarity to support a variety of external Bluetooth devices<br>• Programmable decision policies and transaction lock behavior for various use cases<br>• Interface with external or on-chip Bluetooth device<br>• Support Bluetooth 1.1 or Bluetooth 1.2 AFH<br>• WLAN-/Bluetooth-coordinated low-power design<br>• Enhanced information sharing between WLAN and Bluetooth for combo systems<br>• WLAN/Bluetooth/MWS (LTE/ZigBee) coexistence support |
| Arbitration | • Contention resolved by a customizable decision matrix that allows independent grant decision for each device<br>• Vectors for the decision matrix:<br>  – WLAN priority (2-bit)<br>  – WLAN direction<br>  – Bluetooth priority (1- or 2-bit)<br>  – Bluetooth direction<br>  – Bluetooth frequency in/out band<br>  – MWS priority (2-bit)<br>  – MWS direction |
| AFH | If AFH is enabled in the Bluetooth device, and there is a sufficient guard-band outside the WLAN operating frequency, the Bluetooth device uses the Out-Of-Band (OOB) channel with respect to the WLAN device. Otherwise, the Bluetooth device uses the In-Band (IB) and OOB channels with respect to the WLAN device.<br><br>The IB and OOB information is either provided by the Bluetooth device through the coexistence interface, or it can be provided through firmware controls in a shared-host system. IB/OOB is a vector in the decision matrix. |

| Type | Features |
|------|----------|
| Decision Policies | System configuration is a major consideration when planning decision policies. The configuration governs how RF paths are shared and how much interference will occur. Interference combinations include:<br>– WLAN TX and Bluetooth TX<br>– WLAN TX and Bluetooth RX<br>– WLAN RX and Bluetooth TX<br>– WLAN RX and Bluetooth RX<br><br>Interference combinations where WLAN and Bluetooth share the same antenna:<br>– WLAN TX and Bluetooth TX share same antenna, the decision matrix allows either WLAN or Bluetooth TX (both OOB and IB), based on relative packet priorities.<br>– WLAN TX and Bluetooth RX (both OOB and IB) have sizable interference impacts on Bluetooth RX, the decision matrix grants or denies WLAN TX based on relative packet priorities.<br>– WLAN RX and Bluetooth TX (both OOB and IB) have sizable interference impacts on WLAN RX, the decision matrix grants or denies Bluetooth TX based on relative packet priorities.<br>– WLAN RX and Bluetooth RX (both OOB and IB) have no impact on each other, the decision matrix grants both.<br><br>Interference combinations where WLAN and Bluetooth have their own antenna:<br>– WLAN TX and Bluetooth TX in OOB situation have little interference impact on each other, the decision matrix grants both.<br>– WLAN TX and Bluetooth TX in IB have sizable interference impact on each other, the decision matrix allows either WLAN or Bluetooth TX, based on relative packet priorities.<br>– WLAN TX and Bluetooth RX in OOB situation have little interference impact on each other, the decision matrix grants both provided there is enough antenna isolation between WLAN and Bluetooth antenna.<br>– WLAN TX and Bluetooth RX in IB situation have sizable interference impact on Bluetooth RX, the decision matrix grants or denies WLAN TX based on relative packet priorities.<br>– WLAN RX and Bluetooth TX in OOB situation have little interference impact on each other, the decision matrix grants both provided there is enough antenna isolation between WLAN and Bluetooth antenna.<br>– WLAN RX and Bluetooth TX in IB situation have sizable interference impact on WLAN RX, the decision matrix grants or denies Bluetooth TX based on relative packet priorities.<br>– WLAN RX and Bluetooth RX (both OOB and IB) have no impact on each other, the decision matrix grants both.<br><br>For the devices running in a basic shared antenna configuration, the linear switching imposes restrictions on simultaneous transfer. Reasonable policies include:<br>– WLAN and Bluetooth are never granted at the same time<br>– Decision matrix grants a device based on relative packet priorities and direction<br>– Priority order: High > Medium High > Medium > Low<br>– For equal priority contention, select one device to win, that optimizes the usage case<br><br>For the devices running in an enhanced shared antenna configuration, the linear switching imposes restrictions on some simultaneous transfers. |

| Type | Features |
|------|----------|
| Transaction Stopping | The arbiter allows control of what transfers can be stopped after an initial grant. If allowed, a transaction can be stopped for higher priority request. A transaction stop decision is a function of the decision policies and transaction stopping control. The transaction stopping control is configurable per device and direction. |

### 2.7.6 Bluetooth Capability

| Type | Features |
|---|---|
| Request Schemes | The PTA signals are directly controlled by the hardware to meet timing requirements of the Bluetooth radio. The software controls the type of traffic in priority mode. Mechanism enforced for control include:<br><br>• Selection of certain types of communication always treated as high priority<br>• Selection of individual frames marked with high priority<br>• Real-time signaling of the next slot marked with high priority<br>• Automatic hardware control based on the grant/denial history of the Bluetooth link |
| Timing Control | The PTA signal timing scheme is fully programmable relative to the Bluetooth packet timing. |

### 2.7.7 WLAN Capability

| Type | Features |
|------|----------|
| Capability | The WLAN device technology uses an internal coexistence interface to exchange request/grant with the BCA. Features include:<br><br>• Packet-based request signaling with direction and priority information<br>• 1- or 2-bit priority signaling to support 4 priority levels<br>• Multiple WLAN RX request trigger sources, including early prediction<br>• WLAN TX request cancellation and abort if grant denied or revoked in middle of request<br>• 802.11n A-MPDU treated as single packet |
| Packet Classification | • Programmable mask allows each frame type to be mapped to a priority<br>• Default setting puts response frames (ACK), beacons, and QoS frames as high priority<br>• WLAN TX and RX have separate priority mask |
| Queue Classification | • Programmable mask allows each transmit queue to be mapped to a priority<br>• Queue-based mapping is optional for software-generated frames only |

### 2.7.8 LTE (MWS) Capability

The device supports a BTSIG WCI-2 MWS coexistence signaling interface. The coexistence logical signaling is designed to enable a standard interface to allow an MWS device and a Coexistence Controller to exchange information and support cooperative coexistence.

The WCI-2 signals carry time-critical information such as the start point of an MWS frame. The logical coexistence signaling architecture also includes transparent data messaging and vendor specific data messaging mechanism to enable passing information to and from the collocated MWS device and Coexistence Controller when long latency (tens of milliseconds) cannot be tolerated.

Further information ⇨ 2.7.4 WCI-2 Interface

#### Coexistence Signals

The logical signals assist in time alignment, protecting MWS from interference and maximizing the usability of the Bluetooth radio.

#### Time-Critical Coexistence Signals

| Signal Name | Direction |
|---|---|
| FRAME_SYNC | MWS to Bluetooth |
| BT_RX_PRI | Bluetooth to MWS |
| BT_TX_ON | Bluetooth to MWS |
| 802_RX_PRI | Bluetooth to MWS |
| 802_TX_ON | Bluetooth to MWS |
| MWS_PATTERN | MWS to Bluetooth |
| MWS_RX | MWS to Bluetooth |
| MWS_TX | MWS to Bluetooth |
| MWS_INACTIVITY_DURATION | MWS to Bluetooth |
| MWS_SCAN_FREQUENCY_OFFSET | MWS to Bluetooth |
| MWS_TX_PRIL (MWS TX Priority Level) | MWS to Bluetooth |
| MWS_RX_PRIL (MWS RX Priority Level) | MWS to Bluetooth |

### 2.7.9 ZigBee (MWS) Coexistence Capability

ZigBee is based on the IEEE 802.15.4 standard and it is used by a suite of communication protocols to create Personal Area Networks (PANs) supporting home automation, lighting control, etc. ZigBee radios operate in the 2.4 GHz ISM band worldwide. Unlike Bluetooth, the ZigBee specification does not use AFH. When coexisting with WLAN/Bluetooth in the 2.4 GHz band, it is important to avoid co-channel (IB) operation of these radios.

The device re-uses the MWS coexistence interface to support ZigBee coexistence. The coexistence logical signaling is used to allow a ZigBee device and a WLAN/Bluetooth combo device to exchange information and support cooperative coexistence.

#### Coexistence Signals

The logical signals used for ZigBee and WLAN/Bluetooth coexistence are a subset of the LTE coexistence signaling. Considering the lower data rate of ZigBee packets, a lower baud rate may be chosen for the 2-wire UART physical interface. The BCA supports 3-way arbitration among ZigBee/WLAN/Bluetooth requests.

#### Coexistence Signals

| Signal Name | Direction |
|-------------|-----------|
| MWS_RX | MWS to Bluetooth |
| MWS_TX | MWS to Bluetooth |
| MWS_PATTERN | MWS to Bluetooth |
| MWS_RX_PRI | MWS to Bluetooth |
| MWS_TX_PRI | MWS to Bluetooth |
| 802_RX_PRI | Bluetooth to MWS |
| 802_TX_ON | Bluetooth to MWS |
| BT_RX_PRI | Bluetooth to MWS |
| BT_TX_ON | Bluetooth to MWS |

## 2.8 WLAN

| Type | Features |
|---|---|
| IEEE 802.11/ Standards | • 802.11 data rates 1 and 2 Mbps (DSSS)<br>• 802.11b data rates 5.5 and 11 Mbps (CCK)<br>• 802.11a/g data rates 6, 9, 12, 18, 24, 36, 48, and 54 Mbps (OFDM)<br>• 802.11b/g performance enhancements<br>• 802.11n with maximum data rates up to 72 Mbps (20 MHz channel) and 150 Mbps (40 MHz channel)<br>• 802.11e quality of service (QoS)<br>• 802.11h transmit power control<br>• 802.11h DFS radar pulse detection<br>• 802.11i enhanced security (WEP, WPA, WPA2)<br>• 802.11k radio resource measurement<br>• 802.11mc precise indoor location and navigation<br>• 802.11n block acknowledgment extension<br>• 802.11r fast hand-off for AP roaming<br>• 802.11u Hotspot 2.0 (STA mode only)<br>• 802.11v TIM frame transmission/reception<br>• 802.11w protected management frames<br>• Support clients (stations) implementing IEEE Power Save mode |
| WLAN MAC | • Frame exchange at the MAC level to deliver data<br>• Received frame filtering and validation (CRC)<br>• Generation of MAC header and trailer information (MPDUs)<br>• Fragmentation of data frames (MSDUs)<br>• Access mechanism support for fair access to shared wireless medium through:<br>  – Distributed Coordination Function (DCF)<br>  – Enhanced Distributed Channel Access (EDCA)<br>• A-MPDU aggregation/de-aggregation<br>• 20/40 MHz channel coexistence<br>• RIFS burst receive<br>• Management information base<br>• Radio resource measurement<br>• Quality of service<br>• Block acknowledgement<br>• Dynamic frequency selection<br>• TIM frame TX and RX<br>• Multiple BSS/Station<br>• Transmit rate adaption<br>• Transmit power control |

| Type | Features |
|------|----------|
| WLAN Baseband | • 802.11n 1x1 SISO (WLAN SoC with SISO RF radio)<br>• Backward compatibility with legacy 802.11a/b/g technology<br>• WLAN/Bluetooth LNA sharing<br>• PHY data rates up to 150 Mbps<br>• 20 MHz bandwidth/channel, 40 MHz bandwidth/channel, upper/lower 20 MHz bandwidth in 40 MHz channel, and 20 MHz duplicate legacy bandwidth in 40 MHz channel mode operation<br>• Modulation and Coding Scheme MCS 0 ~ 7 and MCS 32 (duplicate 6 Mbps)<br>• Dynamic frequency selection (radar detection)<br>  – Enhanced radar detection for short and long pulse radar<br>  – Enhanced AGC scheme for DFS channel<br>  – Japan DFS requirement for W53 and W56<br>• 802.11k Radio resource measurement<br>• 802.11n optional features:<br>  – 20/40 MHz coexistence<br>  – Space-Time-Block-Coding (STBC) one spatial stream reception and transmission<br>  – Short Guard Interval for both 20 and 40 MHz operation (TX/RX)<br>  – RIFS on receive path<br>  – Beamformer function and hardware acceleration<br>  – Greenfield TX/RX<br>• 802.11mc locationing<br>• Power save features |
| WLAN Radio | • Integrated direct-conversion radio<br>• 20 and 40 MHz channel bandwidth<br>• Shared WLAN/Bluetooth receive input scheme for 2.4 GHz band<br>• RX Path<br>  – On-chip gain selectable LNA with optimized noise figure and power consumpttion<br>  – High dynamic range AGC function in receive mode<br>• TX Path<br>  – Internal PA with power control<br>  – Optimized TX gain distribution for linearity and noise performance<br>• Local Oscillator with fine channel step |
| WLAN Encryption | • WEP 64-bit and 128-bit encryption with hardware TKIP processing (WPA)<br>• AES-CCMP hardware implementation as part of 802.11i security standard (WPA2)<br>• Enhanced AES engine performance<br>• Advanced encryption standard (AES)/Counter-Mode/CBC-MAC Protocol (CCMP)<br>• AES-Cipher-Based Message Authentication Code (CMAC) as part of the 802.11w security standard<br>• WLAN Authentication and Privacy Infrastructure (WAPI) |

## Operation Modes

| Parameter | Operation Mode | | | | Specification |
|---|---|---|---|---|---|
| Standard Conformance | IEEE 802.11/IEEE 802.11b | | | | |
| | IEEE 802.11a | | | | |
| | IEEE 802.11g | | | | |
| | IEEE 802.11n | | | | |
| Modulation | IEEE 802.11a | | | | OFDM |
| | IEEE 802.11b | | | | DSSS/CCK |
| | IEEE 802.11g | | | | OFDM |
| | IEEE 802.11n | | | | OFDM @ MCS0~7 and MCS32 (duplicate 6 Mbps) |
| Physical layer data rates | IEEE 802.11 | | | | 1, 2 Mbps @ DSSS |
| | IEEE 802.11b | | | | 5.5, 11 Mbps @ DSSS/CCK |
| Supported data rates | IEEE 802.11g | | | | 6, 9, 12, 18, 24, 36, 48, 54 Mbps |
| | IEEE 802.11a | | | | 6, 9, 12, 18, 24, 36, 48, 54 Mbps |
| | IEEE 802.11n | MCS0~7 | HT20 | LGI | 6.5, 13, 19.5, 26, 39, 52, 58.5, 65 Mbps |
| | | | | SGI | 7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2 Mbps |
| | | | HT40 | LGI | 13.5, 27, 40.5, 54, 81, 108, 121.5, 135 Mbps |
| | | | | SGI | 15, 30, 45, 60, 90, 120, 135, 150 Mbps |
| Supported bandwidth | IEEE 802.11n | | | | 20, 40 MHz (BW) |
| Supported channel mode operation | IEEE 802.11n | | | | 20 MHz BW/channel, 40 MHz BW/channel, upper/lower 20 MHz BW @ 40 MHz channel, 20 MHz duplicate legacy BW @ 40 MHz channel |
| Supported Guard Interval | IEEE 802.11n | | | | 400 ns (SGI), 800 ns (LGI) |

**Supported Channels and Frequencies**

| 2.4 GHz – IEEE 802.11b/g/n | | | | | |
|---|---|---|---|---|---|
| **20 MHz Channels** | | | **40 MHz Channels** | | |
| **Channel** | **Frequency** | **Unit** | **Channel** | **Frequency** | **Unit** |
| 1 | 2 412 | MHz | 1-5 | 2 422 | MHz |
| 2 | 2 417 | MHz | 2-6 | 2 427 | MHz |
| 3 | 2 422 | MHz | 3-7 | 2 432 | MHz |
| 4 | 2 427 | MHz | 4-8 | 2 437 | MHz |
| 5 | 2 432 | MHz | 5-9 | 2 442 | MHz |
| 6 | 2 437 | MHz | 6-10 | 2 447 | MHz |
| 7 | 2 442 | MHz | 7-11 | 2 452 | MHz |
| 8 | 2 447 | MHz | | | |
| 9 | 2 452 | MHz | | | |
| 10 | 2 457 | MHz | | | |
| 11 | 2 462 | MHz | | | |
| 12 | 2 467 | MHz | | | |
| 13 | 2 472 | MHz | | | |

| 5 GHz – IEEE 802.11a/n | | | | | |
|---|---|---|---|---|---|
| **20 MHz Channels** | | | **40 MHz Channels** | | |
| **Channel** | **Frequency** | **Unit** | **Channel** | **Frequency** | **Unit** |
| 36 | 5 180 | MHz | 36-40 | 5 190 | MHz |
| 40 | 5 200 | MHz | 44-48 | 5 230 | MHz |
| 44 | 5 220 | MHz | 52-56 | 5 270 | MHz |
| 48 | 5 240 | MHz | 60-64 | 5 310 | MHz |
| 52 | 5 260 | MHz | | | |
| 56 | 5 280 | MHz | | | |
| 60 | 5 300 | MHz | | | |
| 64 | 5 320 | MHz | | | |
| | | | | | |
| 100 | 5 500 | MHz | 100-104 | 5 510 | MHz |
| 104 | 5 520 | MHz | 108-112 | 5 550 | MHz |
| 108 | 5 540 | MHz | 116-120 | 5 590 | MHz |
| 112 | 5 560 | MHz | 124-128 | 5 630 | MHz |
| 116 | 5 580 | MHz | 132-136 | 5 670 | MHz |
| 120 | 5 600 | MHz | | | |
| 124 | 5 620 | MHz | | | |
| 128 | 5 640 | MHz | | | |
| 132 | 5 660 | MHz | | | |
| 136 | 5 680 | MHz | | | |
| 140 | 5 700 | MHz | | | |

| 5 GHz – IEEE 802.11a/n | | | | | |
|---|---|---|---|---|---|
| **20 MHz Channels** | | | **40 MHz Channels** | | |
| **Channel** | **Frequency** | **Unit** | **Channel** | **Frequency** | **Unit** |
| 149 | 5 745 | MHz | 149-153 | 5 755 | MHz |
| 153 | 5 765 | MHz | 157-161 | 5 795 | MHz |
| 157 | 5 785 | MHz | | | |
| 161 | 5 805 | MHz | | | |
| 165 | 5 825 | MHz | | | |

| 5 GHz – IEEE 802.11a/n (India and additional UNII Channels) | | | | | |
|---|---|---|---|---|---|
| **20 MHz Channels** | | | **40 MHz Channels** | | |
| **Channel** | **Frequency** | **Unit** | **Channel** | **Frequency** | **Unit** |
| 144 | 5 720 | MHz | 68-72 | 5 350 | MHz |
| 169[6] | 5 845 | MHz | 76-80 | 5 390 | MHz |
| 173 | 5 865 | MHz | 84-88 | 5 430 | MHz |
| 177 | 5 885 | MHz | 92-96 | 5 470 | MHz |
| 181 | 5 905 | MHz | 140-144 | 5 710 | MHz |
| | | | 165-169 | 5 835 | MHz |
| | | | 169-173[7] | 5 855 | MHz |
| | | | 173-177 | 5 875 | MHz |

---

[6] India channels that can be used in other countries as well

[7] India use only

## 2.9 Bluetooth

| Type | Features |
|------|----------|
| General | • Supports Bluetooth 5.0<br>• Shared Tx/Rx path for Bluetooth<br>• Digital Audio Interface including PCM interface for voice application<br>• Bluetooth and WLAN coexistence<br>• WLAN/Bluetooth Coexistence (BCA) protocol support |
| Bluetooth Classic (BR/EDR) | • Bluetooth Classic with BT Class 1 support<br>• Baseband and radio Basic Rate (BR) and Enhanced Data Rate (EDR) packet types with 1 Mbps (GFSK), 2 Mbps (π/4-DQPSK) and 3 Mbps (8DPSK)<br>• Fully functional Bluetooth baseband with:<br>– Adaptive Frequency Hopping (AFH)<br>– Forward error correction<br>– Header error control<br>– Access code correlation<br>– CRC<br>– Encryption bit stream generation<br>– Whitening<br>• Adaptive Frequency Hopping (AFH) including Packet Loss Rate (PLR)<br>• Interlaced scan for faster connection setup<br>• Simultaneous active ACL connection support<br>• Automatic ACL packet type selection<br>• Full master slave piconet support<br>• Scatternet support<br>• Standard UART and SDIO HCI transport layer<br>• SCO/eSCO links with hardware accelerated audio signal pocessing and hardware supported PPEC algorithm for speech quality improvement<br>• All standard SCO/eSCO voice coding<br>• All standard pairing, authentication, link key, and encryption operations<br>• Standard Bluetooth power saving mechanism (i.e. hold, sniff modes, and sniff-sub rating)<br>• Enhanced Power Control (EPC)<br>• Channel Quality Driven (CQD) data rate<br>• Wideband Speech (WBS) support (1 WBS link)<br>• Encryption (AES) support<br>• LTE/MWS coexistence |

| Type | Features |
|---|---|
| Bluetooth Low Energy (LE) | • Broadcaster, Observer, Central, and Peripheral roles<br>• Supports link layer topology to be master and slave (connects up to 16 links)<br>• Shared RF with BR/EDR<br>• Encryption AES support<br>• Hardware support for intelligent Adaptive Frequency Hopping (AFH)<br>• LE Privacy 1.2<br>• LE Secure Connection<br>• LE Data Length Extension<br>• LE Advertising Length Extension<br>• Direction Finding<br>    – Connection-oriented Angle of Arrival (AoA) |

# 3 Detailed Description

## 3.1 Dimensions

> (i) All dimensions are in millimeters.
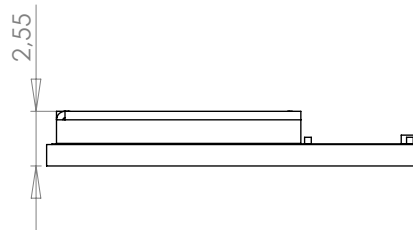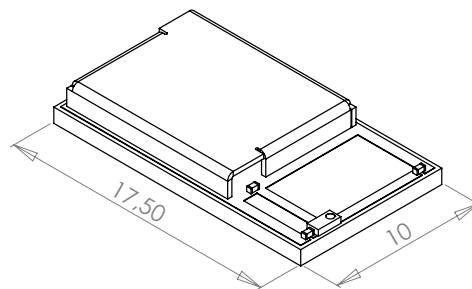


| No. | Item | Dimension | Tolerance | Remark |
|-----|------|-----------|-----------|--------|
| 1 | Width | 10.00 | ± 0.35 | |
| 2 | Length | 17.50 | ± 0.35 | |
| 3 | Height | 2.55 | ± 0.20 | with case |

## 3.2 Footprint

> ⓘ The outer dimensions have a tolerance of ± 0.35 mm.

# Top View
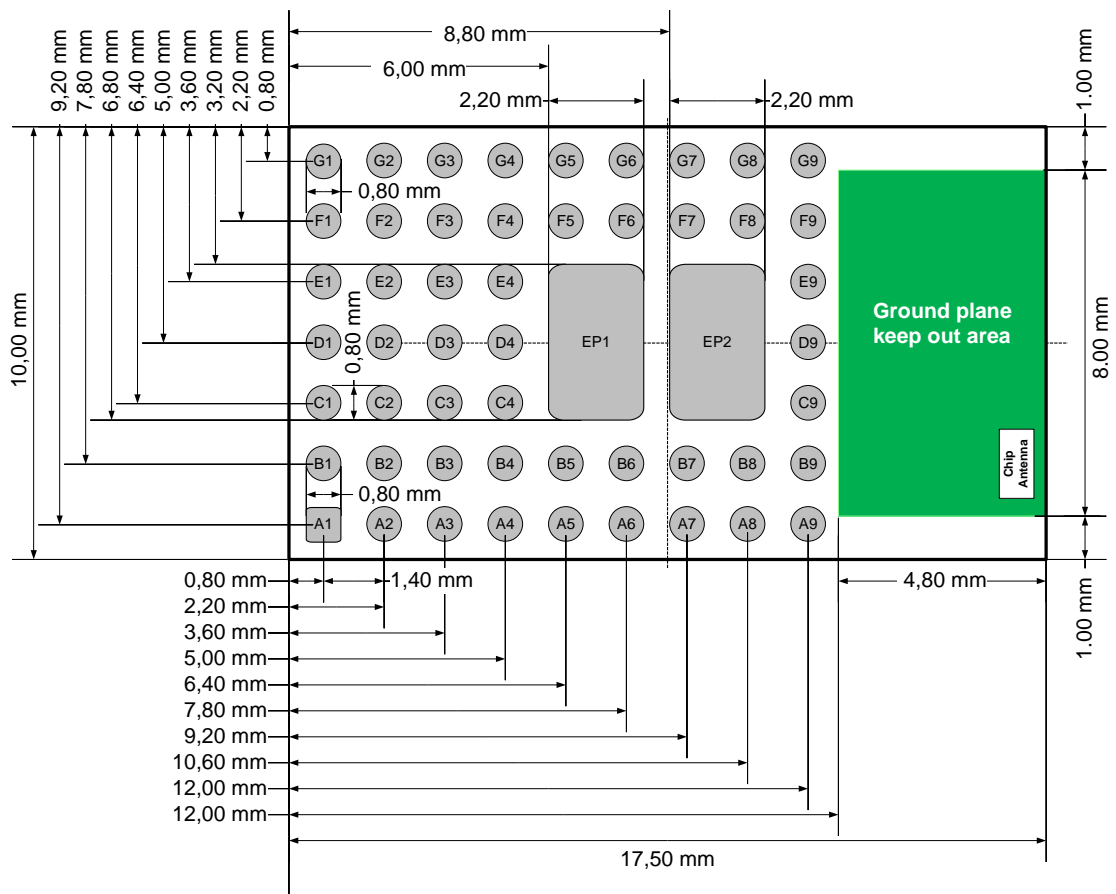
## 3.3 Packaging

The product is a mass production status product and will be delivered in the package described below.

### 3.3.1 Tape Dimensions



| Ao | 10.55 +/- 0.15 |
|----|----------------|
| Bo | 18.05 +/- 0.15 |
| Ko | 3.00 +/- 0.15 |
| F | 14.20 +/- 0.15 |
| P 1 | 20.00 +/- 0.15 |
| S O | 28.40 +/- 0.15 |
| W | 32.00 +/- 0.3 |

(I)     Measured from centreline of sprocket hole to centreline of pocket.
(II)    Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III)   Measured from centreline of sprocket hole to centreline of pocket.
(IV)   Other material available.
ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

### 3.3.2 Packing in Tape



Direction of unreeling (for customer)

trailer (empty)
1 x circumference /hub
(min 160mm)

component packed area standard 500pcs

leader (empty)
minimum 10 pitch

Top cover tape more than 1 x circumference plus 100mm to avoid fixing of tape end on sealed modules.

Empty spaces in the component packed area shall be less than two per reel and those spaces shall not be consecutive.

The top cover tape shall not be found on reel holes and it shall not stick out from the reel.

### 3.3.3  Component Direction
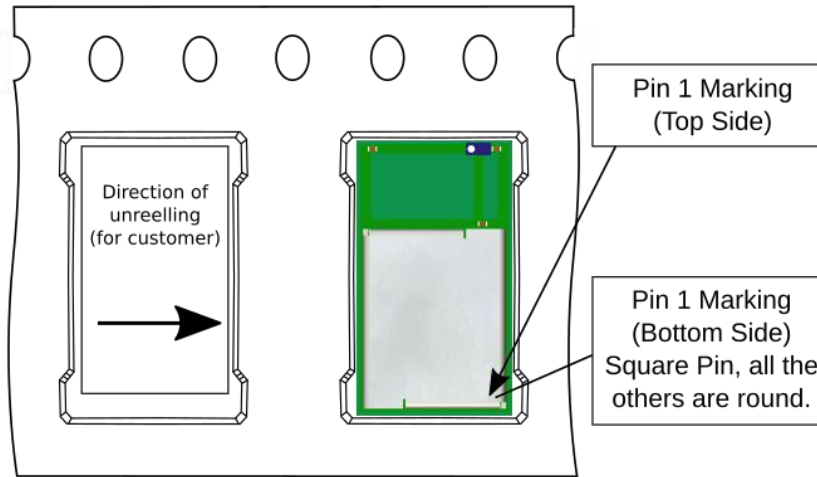


### 3.3.4  Reel Dimension
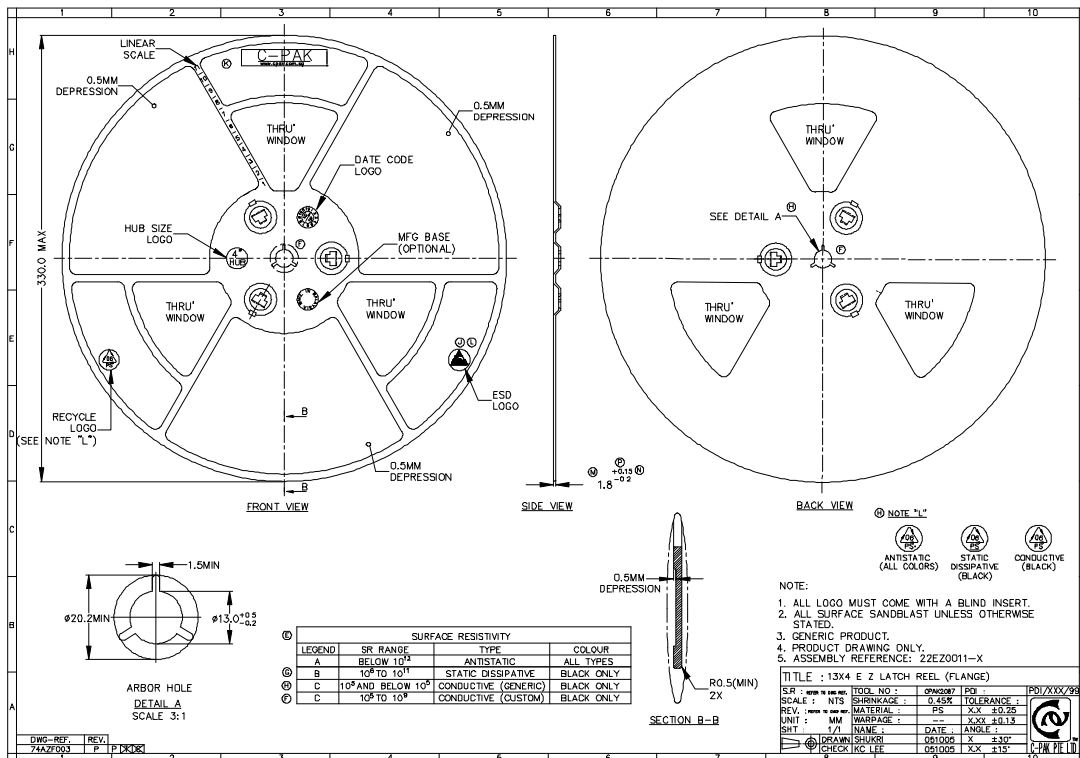
### 3.3.5  Package Label

**Example**
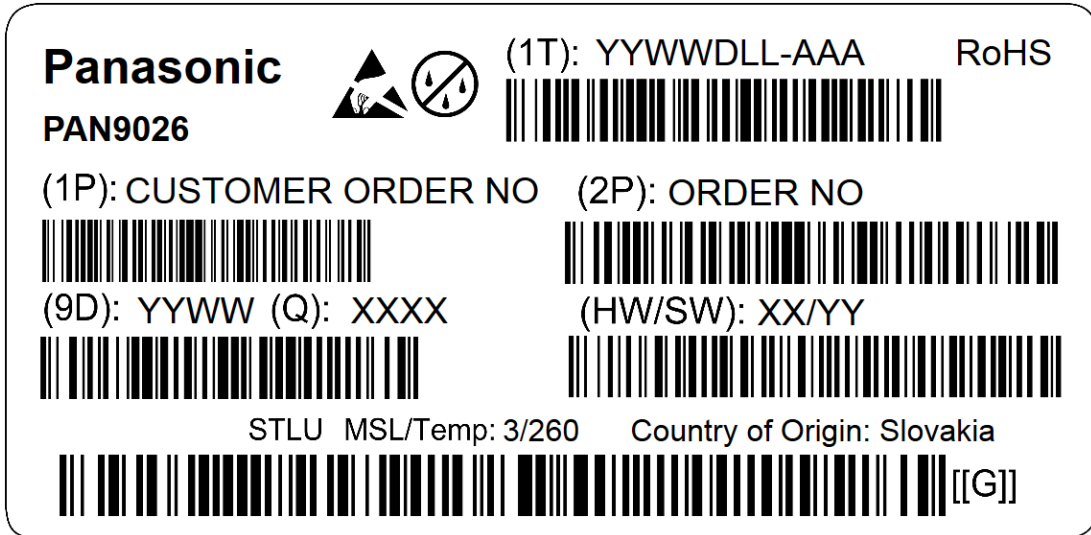


| (1T) | Lot code |
|---|---|
| (1P) | Customer order number, if applicable |
| (2P) | Order number |
| (9D) | Date code |
| (Q) | Quantity |
| (HW/SW) | Hardware/software version |

### 3.3.6  Total Package
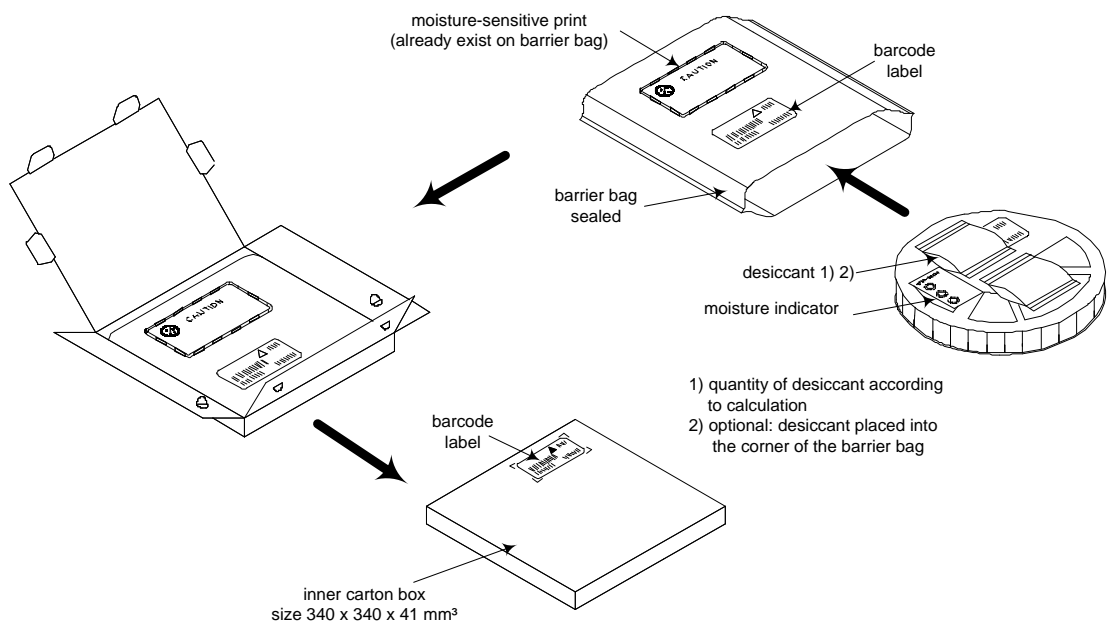
## 3.4 Case Marking

**Example for PAN9026 (top view)**
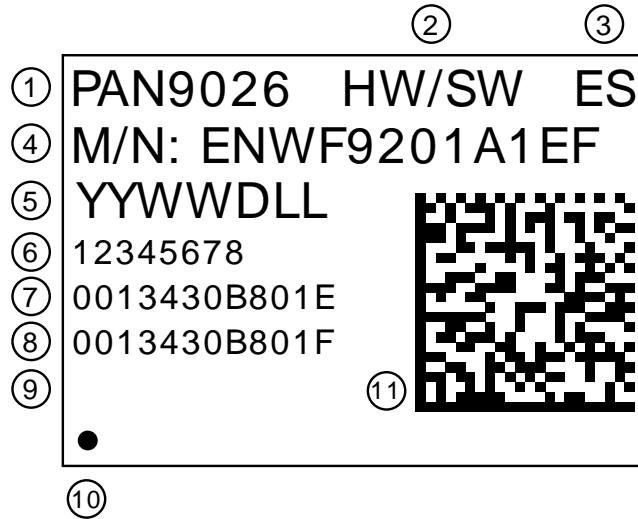


| 1 | Brand name |
| --- | --- |
| 2 | Hardware/Software version |
| 3 | Engineering Sample (optional) |
| 4 | Model Name/ENW number |
| 5 | Lot code |
| 6 | Serial number |
| 7 | WLAN MAC address |
| 8 | BD address |
| 9 | (Reserved) |
| 10 | Marking for Pin 1 |
| 11 | 2D barcode, for internal usage only |

# 4 Specification

All specifications are over temperature and process, unless indicated otherwise.

## 4.1 Default Test Conditions

Temperature:     25 ± 10 °C
Humidity:        40 to 85 % RH
Supply Voltage:  VDD2V2      = 2.2 V
                 VDD1V8      = 1.8 V
                 VIORF       = 3.3 V
                 VIOSD       = 3.3 V
                 VIO         = 1.8 V

## 4.2 Absolute Maximum Ratings

> ⚠️ The maximum ratings may not be exceeded under any circumstances, not even momentarily or individually, as permanent damage to the module may result.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|--------|-----------|-----------|------|------|------|-------|
| $T_{STOR}$ | Storage temperature | | -55 | | +125 | °C |
| $V_{ESD}$ | ESD robustness | All pads, according to human body model (HBM), JEDEC STD 22, method A114 | | | 1 000 | V |
| | | According to charged device model (CDM), JEDEC STD 22, method C101 | | | 500 | V |
| $P_{RF}$ | RF input level | | | | +20 | dBm |
| $V_{DD1V8}$ | Maximum voltage | Maximum power supply voltage from any pin with respect to $V_{SS}$ (GND) | | 1.8 | 1.98 | V |
| $V_{DD2V2}$ | | | | 2.2 | 2.3 | V |
| $V_{IOSD}$ | | | | 1.8 | 2.2 | V |
| | | | | 3.3 | 4.0 | V |
| $V_{IO}$ | | | | 1.8 | 2.2 | V |
| | | | | 3.3 | 4.0 | V |
| $V_{IORF}$ | | | | 3.3 | 4.0 | V |
| $V_{RF\_SW1/2}$ | | | | 3.3 | 4.0 | V |

## 4.3 Recommended Operating Conditions

> ⚠️ The maximum ratings may not be exceeded under any circumstances, not even momentarily or individually, as permanent damage to the module may result.

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| $T_A$ | Ambient operating temperature range | Extended grade | -30 | | +85 | °C |
| $V_{DD1V8}$ | 1V8 supply voltage[8] | VDD voltage on pins A4, A5 | 1.71 | 1.80 | 1.89 | V |
| $V_{DD2V2}$ | 2V2 supply voltage[8] | VDD voltage on pins A6, B5, B6 | 2.09 | 2.20 | 2.29 | V |
| $V_{IOSD}$ | Digital I/O VIOSD supply voltage[9] | Pin G3 with 1.8 V operation ⇨ SDIO Pins Function | 1.62 | 1.80 | 1.98 | V |
| | | Pin G3 with 3.3 V operation ⇨ SDIO Pins Function | 2.97 | 3.30 | 3.47 | V |
| $V_{IO}$ | Digital I/O VIO supply voltage | Pin G4 with 1.8 V operation | 1.62 | 1.80 | 1.98 | V |
| | | Pin G4 with 3.3 V operation Pin B4 connect to GND[10] | 2.97 | 3.30 | 3.47 | V |
| $V_{IORF}$ | Digital I/O VIORF supply voltage[8] | Pin G7 with 3.3 V operation | 2.97 | 3.30 | 3.47 | V |
| $V_{RF\_SW1/2}$ | VRF_SW1/2 switch voltage[8] | Pin A7, B7 with 3.3 V logical level switch operation ⇨ RF-Switch Pins Function | | 3.30 | 3.60 | V |

---

[8] The supply current must be limited to max. 1 A

[9] 1.8 V or 3.3 V supply voltage possible

[10] Connect the 32KHZ_EN pin via a 100 Ω resistor to ground to disable the internal 32.768 kHz crystal oscillator. The low power modes will then use the SoC reference clock, which has lower accuracy.

### 4.3.1 Digital Pin Characteristics

#### VIO with 1.8 V Operations[11]

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|--------|-----------|-----------|------|------|------|-------|
| $V_{IH}$ | High level input voltage | 1.8 V operation ($V_{IO}$ = 1.8 V) | $0.7\,V_{IO}$ | | $V_{IO}$ + 0.4 | V |
| $V_{IL}$ | Low level input voltage | 1.8 V operation ($V_{IO}$ = 1.8 V) | -0.4 | | $0.3\,V_{IO}$ | V |
| $V_{HYS}$ | Input hysteresis | | 100 | | | mV |
| $V_{OH}$ | High level ouput voltage | 1.8 V operation ($V_{IO}$ = 1.8 V) | $V_{IO}$ - 0.4 | | | V |
| $V_{HO}$ | Low level output voltage | 1.8 V operation ($V_{IO}$ = 1.8 V) | | | 0.4 | V |

#### VIO with 3.3 V Operations[11]

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|--------|-----------|-----------|------|------|------|-------|
| $V_{IH}$ | High level input voltage | 3.3 V operation ($V_{IO}$ = 3.3 V) | $0.7\,V_{IO}$ | | $V_{IO}$ + 0.4 | V |
| $V_{IL}$ | Low level input voltage | 3.3 V operation ($V_{IO}$ = 3.3 V) | -0.4 | | $0.3\,V_{IO}$ | V |
| $V_{HYS}$ | Input hysteresis | | 100 | | | mV |
| $V_{OH}$ | High level ouput voltage | 3.3 V operation ($V_{IO}$ = 3.3 V) | $V_{IO}$ - 0.4 | | | V |
| $V_{HO}$ | Low level output voltage | 3.3 V operation ($V_{IO}$ = 3.3 V) | | | 0.4 | V |

#### VIOSD 1.8 V Operation for SDIO I/F[11]

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|--------|-----------|-----------|------|------|------|-------|
| $V_{IH}$ | High level input voltage | 1.8 V operation ($V_{IOSD}$ = 1.8 V) | $0.7\,V_{IOSD}$ | | $V_{IOSD}$ +0.4 | V |
| $V_{IL}$ | Low level input voltage | 1.8 V operation ($V_{IOSD}$ = 1.8 V) | -0.4 | | $0.3\,V_{IOSD}$ | V |
| $V_{HYS}$ | Input hysteresis | | 100 | | | mV |
| $V_{OH}$ | High level ouput voltage | 1.8 V operation ($V_{IOSD}$ = 1.8 V) | $V_{IOSD}$ - 0.4 | | | V |
| $V_{HO}$ | Low level output voltage | 1.8 V operation ($V_{IOSD}$ = 1.8 V) | | | 0.4 | V |

---

[11] The capacitive load should not be larger than 50 pF for all I/Os when using the default driver strength settings. Large capacitance loads generally increase the overall current consumption.

### VIOSD 3.3 V Operation for SDIO I/F[11]

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|--------|-----------|-----------|------|------|------|-------|
| $V_{IH}$ | High level input voltage | 3.3 V operation ($V_{IOSD}$ = 3.3 V) | 0.7 $V_{IO\_SD}$ | | $V_{IO\_SD}$ +0.4 | V |
| $V_{IL}$ | Low level input voltage | 3.3 V operation ($V_{IOSD}$ = 3.3 V) | -0.4 | | 0.3 $V_{IO\_SD}$ | V |
| $V_{HYS}$ | Input hysteresis | | 100 | | | mV |
| $V_{OH}$ | High level ouput voltage | 3.3 V operation ($V_{IOSD}$ = 3.3 V) | $V_{IOSD}$ - 0.4 | | | V |
| $V_{HO}$ | Low level output voltage | 3.3 V operation ($V_{IOSD}$ = 3.3 V) | | | 0.4 | V |

For SDIO 3.0 standard modes SDR12, SDR25, SDR50, and DDR50, a supply voltage of VIOSD = 1.8 V should be used.

### 4.3.2 Current Consumption

(i) The current consumption depends on the user scenario, the setup and timing of the power modes. Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V, and $T_{amb}$ = 25 °C, if nothing else stated.

**General Current Consumption**

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| $I_{VDD1V8 @ PDn}$ | Power Down | Grounding of PDn pin | | 150 | | μA |
| $I_{VDD2V2 @ PDn}$ | | | | 5 | | μA |
| $I_{VDD1V8 @ DeepSleep}$ | WLAN / BT Deep Sleep | Low-power state used in sleep state | | 600 | | μA |
| $I_{VDD2V2 @ DeepSleep}$ | | | | 5 | | μA |
| $I_{VDD1V8 @ Firmware Init}$ | Firmware Initialization | Device Initialization | | 400 | | mA |
| $I_{VDD2V2 @ Firmware Init}$ | | | | 950 | | mA |

**WLAN Current Consumption**

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| $I_{VDD1V8 @ TX}$ | Active Transmit[12] | $P_{TX}$ = +15 dBm for 5 GHz band 802.11a @ 54 Mbps | | 230 | | mA |
| | | $P_{TX}$ = +14 dBm for 5 GHz band 802.11n 20M @ MCS7 | | 240 | | mA |
| | | $P_{TX}$ = +13 dBm for 5 GHz band 802.11n 40M @ MCS7 | | 250 | | mA |
| | | $P_{TX}$ = +16 dBm for 2.4 GHz band 802.11b @ 11 Mbps | | 175 | | mA |
| | | $P_{TX}$ = +15 dBm for 2.4 GHz band 802.11g @ 54 Mbps | | 180 | | mA |
| | | $P_{TX}$ = +14 dBm for 2.4 GHz band 802.11n 20M @ MCS7 | | 185 | | mA |
| $I_{VDD2V2 @ TX}$ | Active Transmit[12] | $P_{TX}$ = +15 dBm for 5 GHz band 802.11a @ 54 Mbps | | 180 | | mA |
| | | $P_{TX}$ = +14 dBm for 5 GHz band 802.11n 20M @ MCS7 | | 170 | | mA |
| | | $P_{TX}$ = +13 dBm for 5 GHz band 802.11n 40M @ MCS7 | | 160 | | mA |
| | | $P_{TX}$ = +16 dBm for 2.4 GHz band 802.11b @ 11 Mbps | | 240 | | mA |
| | | $P_{TX}$ = +15 dBm for 2.4 GHz band 802.11g @ 54 Mbps | | 190 | | mA |
| | | $P_{TX}$ = +14 dBm for 2.4 GHz band 802.11n 20M @ MCS7 | | 170 | | mA |

[12] Peak values for specified output power level and data rate with UDP traffic between the AP and Device (STA).

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| $I_{VDD1V8 @ RX}$ | Active Receive[13] | 5 GHz band 802.11a @ 54 Mbps | | 85 | | mA |
| | | 5 GHz band 802.11n 20M @ MCS7 | | 95 | | mA |
| | | 5 GHz band 802.11n 40M @ MCS7 | | 110 | | mA |
| | | 2.4 GHz band 802.11b @ 11 Mbps | | 65 | | mA |
| | | 2.4 GHz band 802.11g @ 54 Mbps | | 70 | | mA |
| | | 2.4 GHz band 802.11n 20M @ MCS7 | | 75 | | mA |
| $I_{VDD2V2 @ RX}$ | Active Receive[13] | 5 GHz band 802.11a/n | | 20 | | µA |
| | | 2.4 GHz band 802.11b/g/n | | 20 | | µA |
| $I_{VDD1V8 @ IEEE-PS}$ | IEEE Power Save[14] | DTIM = 1 with beacon interval | | 2 | | mA |
| $I_{VDD2V2 @ IEEE-PS}$ | | 100 ms (Average[15]) | | 20 | | µA |

## Bluetooth Current Consumption

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| $I_{VDD1V8 @ TX}$ | BT SCO HV3 | Peak, $P_{TX}$ = +4 dBm | | 55 | | mA |
| | BT ACL DH1 | Average, $P_{TX}$ = 0 dBm | | 25 | | mA |
| | BT ACL 3-DH5 | Average, $P_{TX}$ = 0 dBm | | 35 | | mA |
| | LE | $P_{TX}$ = 0 dBm | | 45 | | mA |
| $I_{VDD2V2 @ TX}$ | BT SCO HV3 | $P_{TX}$ = +4 dBm | | 15 | | µA |
| | BT ACL DH1 | $P_{TX}$ = 0 dBm | | 15 | | µA |
| | BT ACL 3-DH5 | $P_{TX}$ = 0 dBm | | 15 | | µA |
| | LE | $P_{TX}$ = 0 dBm | | 15 | | µA |
| $I_{VDD1V8 @ RX}$ | LE | Peak | | 30 | | mA |
| $I_{VDD2V2 @ RX}$ | LE | | | 5 | | µA |
| $I_{VDD1V8 @ Page Scan}$ | BT Page Scan | Peak | | 2.4 | | mA |
| $I_{VDD2V2 @ Page Scan}$ | | | | 5 | | µA |
| $I_{VDD1V8 @ PI Scan}$ | BT Page and Inquiry Scan | Peak | | 3.8 | | mA |
| $I_{VDD2V2 @ PI Scan}$ | | | | 5 | | µA |
| $I_{VDD1V8 @ LE Advertise}$ | LE Advertise in 1.28s Interval | Peak | | 1.5 | | mA |
| $I_{VDD2V2 @ LE Advertise}$ | | | | 5 | | µA |
| $I_{VDD1V8 @ LE Scan}$ | LE Scan with Interval 1.28 s | Peak | | 1.5 | | mA |
| $I_{VDD2V2 @ LE Scan}$ | | | | 5 | | µA |

---

[13] Peak values for specified data rate with UDP traffic between the Device (Client) and AP (Server). The WLAN/BT combo Firmware is downloaded and BT is in Deep Sleep.

[14] In IEEE Power Save the device automatically wakes up on beacons. If it is a DTIM value of 1 along with a beacon interval of 100 ms, the device wakes up every 100 ms.

[15] The average current is averaged over one cycle which includes sleep time and wake up time.

### 4.3.3 Internal Operating Frequencies

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| $f_{SYSCLK1}$ | CPU1/System /Encryption clock speed | Refers to clock speed of SoC's CPU1 | | | 160 | MHz |
| $f_{SYSCLK2}$ | CPU2 | Refers to clock speed of SoC's CPU2 | | | 64 | MHz |
| $f_{REFCLK1}$ | Crystal fundamental frequency | Frequency tolerance < ±10 ppm over operating temperature and process | | 26 | | MHz |
| $f_{SLEEPCLK}$ | Sleep Clock frequency | Frequency tolerance < ±20 ppm over operating temperature, aging and process, CMOS input clock signal type | | 32.768 | | kHz |

### 4.3.4 Power-up Sequence
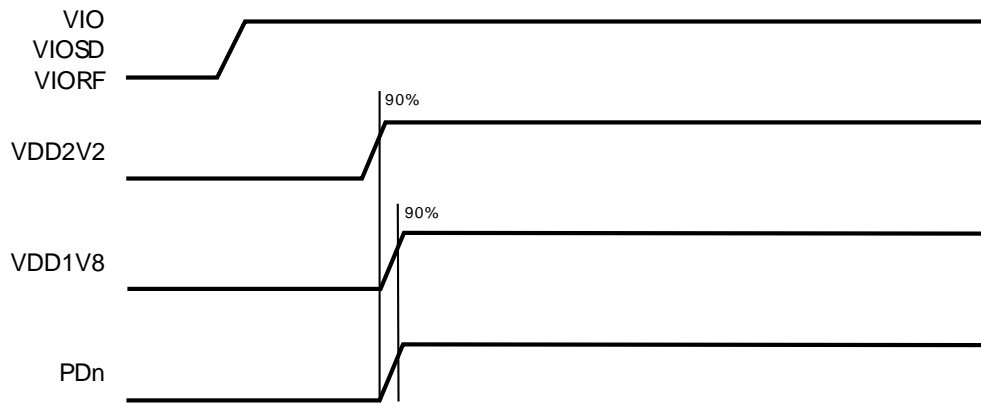


| Symbol | Parameter | Min. | Typ. | Max. | Units |
|--------|-----------|------|------|------|-------|
| $V_{DD1V8}$ | Voltage level of $V_{DD2V2}$ | 90 | | | % |
| PDn | Voltage level of $V_{DD2V2}$ | 90 | | | % |

### 4.3.5  Host Interface

### 4.3.5.1  SDIO Interface

> (i) The SDIO Interface pins are powered from the VIOSD voltage supply with either 3.3 V or 1.8 V. The SDIO electrical specifications are identical for the 1-bit and 4-bit SDIO modes.

DC specification ⇨ 4.3.1 Digital Pin Characteristics

**SDIO Timing Data – Default and High-Speed Modes (VIOSD 3.3 V)[16,17]**

| 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 |
| | $CL \leq 40$ pF (1 card) | High-speed | | | 14 | ns |
| $T_{OH}$ | Output hold time | High-speed | 2.5 | | | ns |

---

[16] For SDIO 2.0 running at 50 MHz clock frequency, a supply voltage VIOSD of 1.8 V is recommended.

[17] For SDIO 2.0 running at 25 MHz clock frequency, either 1.8 V or 3.3 V can be used.

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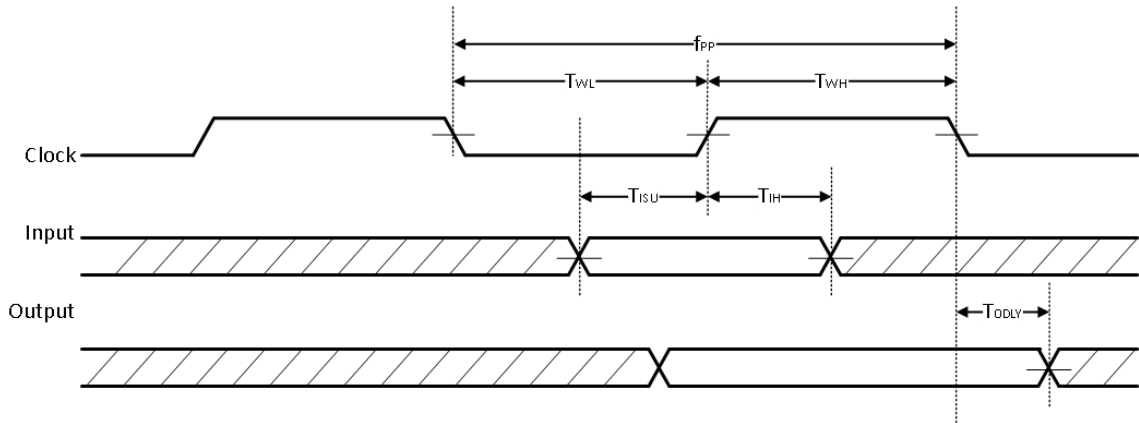


**SDIO Protocol Timing Diagram – High-Speed Mode (VIOSD 3.3 V)**
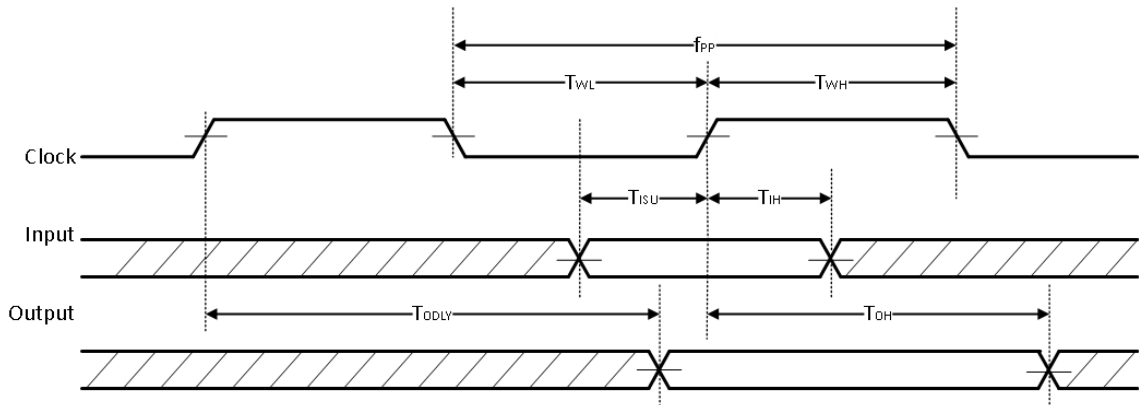
### SDIO Timing Data – SDR12, SDR25, SDR50 Modes (VIOSD 1.8 V)

| Symbol | Parameter | Condition | Min. | Typ. | Max. | Units |
|--------|-----------|-----------|------|------|------|-------|
| $f_{PP}$ | Clock frequency | SDR12/SDR25/ SDR50 | 25 | | 100 | MHz |
| $T_{IS}$ | Input setup time | SDR12/SDR25/ SDR50 | 3 | | | ns |
| $T_{IH}$ | Input hold time | SDR12/SDR25/ SDR50 | 0.8 | | | ns |
| $T_{CLK}$ | Clock time | SDR12/SDR25/ SDR50 | 10 | | 40 | ns |
| $T_{CR}$ , $T_{CF}$ | Rise time, fall time $T_{CR}$ , $T_{CF}$ < 2 ns (max) at 100 MHz $C_{CARD}$ = 10 pF | SDR12/SDR25/ SDR50 | | | 0.2 * $T_{CLK}$ | ns |
| $T_{ODLY}$ | Output delay time CL $\leq$ 30 pF | SDR12/SDR25/ SDR50 | | | 7.5 | ns |
| $T_{OH}$ | Output hold time CL = 15 pF | SDR12/SDR25/ SDR50 | 1.5 | | | ns |

### SDIO Protocol Timing Diagram – SDR12, SDR25, SDR50 Modes (VIOSD 1.8 V)
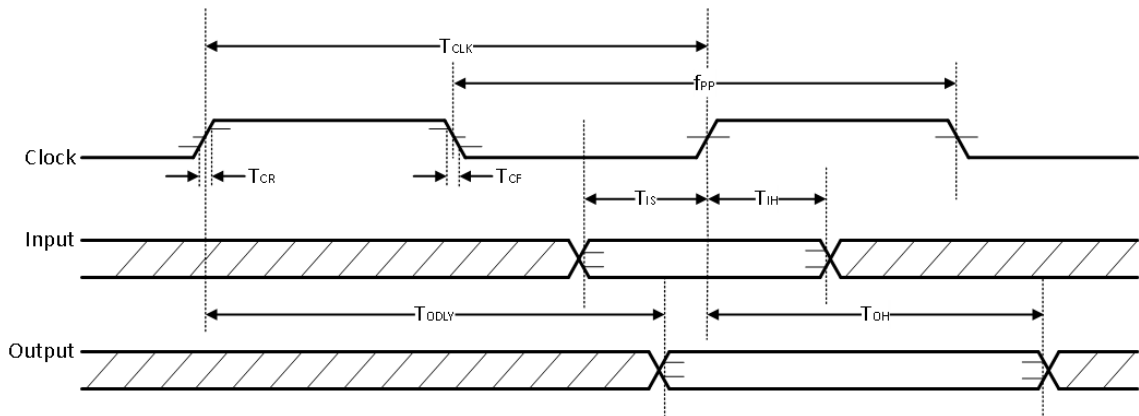
## SDIO Timing Data – DDR50 Mode (VIOSD 1.8 V)

| 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>$C_{CARD} \leq 10$ pF (1 card) | DDR50 | 6 | | | ns |
| $T_{IH}$ | Input hold time<br>$C_{CARD} \leq 10$ pF (1 card) | DDR50 | 0.8 | | | ns |
| **CMD Output (referenced to clock rising edge)** | | | | | | |
| $T_{ODLY}$ | Output delay time during data transfer mode<br>$C_L \leq 30$ pF (1 card) | DDR50 | | | 13.7 | ns |
| $T_{OHLD}$ | Output hold time<br>$C_L \geq 15$ pF (1 card) | DDR50 | 1.5 | | | ns |
| **DAT[3:0] Input (referenced to clock rising and falling edge)** | | | | | | |
| $T_{IS2x}$ | Input setup time<br>$C_{CARD} \leq 10$ pF (1 card) | DDR50 | 3 | | | ns |
| $T_{IH2x}$ | Input hold time<br>$C_{CARD} \leq 10$ pF (1 card) | DDR50 | 0.8 | | | ns |
| **DAT[3:0] Output (referenced to clock rising and falling edge)** | | | | | | |
| $T_{ODLY2x}$ (max) | Output delay time during data transfer mode<br>$C_L \leq 25$ pF (1 card) | DDR50 | | | 7 | ns |
| $T_{ODLY2x}$ (min) | Output hold time<br>$C_L \geq 15$ pF (1 card) | DDR50 | 1.5 | | | ns |

### SDIO CMD Timing Diagram – DDR50 Mode (VIOSD 1.8 V, 50 MHz)
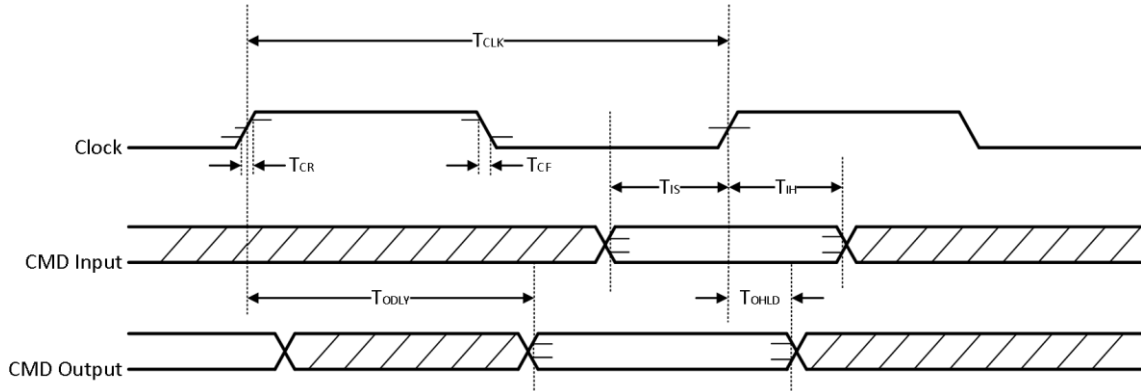


### SDIO DAT[3:0] Timing Diagram – DDR50 Mode[18] (VIOSD 1.8 V, 50 MHz)



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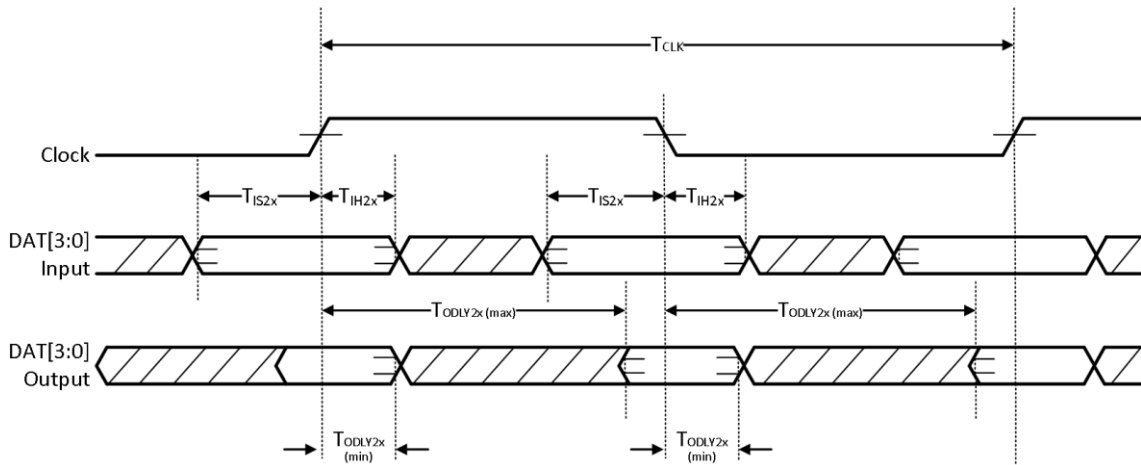
[18] In DDR50 mode, DAT[3:0] lines are sampled on both edges of the clock (not applicable for CMD line).

### 4.3.5.2    High-Speed UART Interface

> (i)    The High-Speed UART Interface pins are powered from the VIO voltage supply with 1.8 V.

DC specification ⇨ 4.3.1 Digital Pin Characteristics

The UART interface operation includes:

- Support data input/output operations for peripheral devices connected through a standard UART interface
- 4-wire data transfer (RXD, TXD, RTS, CTS)
- Programmable baud rate (1 200 bps to 4 Mbps)
- Data format (LSB first)
- Data bit: (5-8 bit)
- Parity bit: (0-4 bit)
- Stop bit: (1-2 bit)

**Interface Signals**

| Pin No | Signal Name | Specification Name | Type | Description |
|--------|-------------|--------------------|------|-------------|
| F3 | UART_SOUT | TXD | Host Controller Interface (HCI) | Transmit data output |
| F4 | UART_SIN | RXD | | Receive data input |
| F5 | UART_RTS | RTS | | Request to send (active low) |
| G5 | UART_CTS | CTS | | Clear to send (active low) |

### Interface Transport Settings

| Item | Range | Default | Comment |
|---|---|---|---|
| Baudrate | 1 200 ~ 4 000 000 | 3 000 000 | Baud |
| Data Bits | 5 ~ 8 | 8 | LSB first |
| Parity Bits | 0 ~ 4 | 0 | |
| Stop Bit | 1/1.5/2 | 1 | |

### Supported Baud Rates

| Baud | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 200 | 2 400 | 4 800 | 9 600 | 19 200 | 38 400 | 57 600 | 76 800 | 115 200 |
| 230 400 | 460 800 | 500 000 | 921 600 | 1 000 000 | 1 382 400 | 1 500 000 | 1 843 200 | 2 000 000 |
| 2 100 000 | 2 764 800 | 3 000 000 | 3 250 000 | 3 692 300 | 4 000 000 | | | |

### UART Timing Diagram
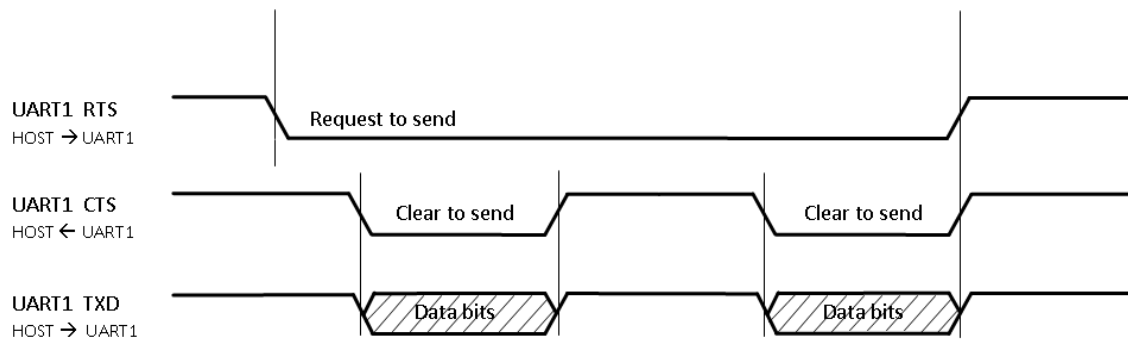
### 4.3.6 Peripheral Interface

> ⓘ The Peripheral Interface pins are powered from the VIO voltage supply with 1.8 V.

DC specification ⇨ 4.3.1 Digital Pin Characteristics

### 4.3.6.1 GPIO Interface

The General-Purpose I/O (GPIO) interface is used to implement user-defined input and output signals to and from the device, such as external interrupts and other user-defined I/Os.

**Configurable GPIOs**

| Function | GPIO Pin Name | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | IO0 | IO1 | IO2 | IO3 | IO12 | IO13 | IO14 | IO15 |
| GPIO IN | YES | YES | YES | YES | YES | YES | YES | YES |
| GPIO OUT | YES | YES | YES | YES | YES | YES | YES | YES |
| IRQ IN | YES | YES | YES | YES | YES | YES | YES | YES |

**LED Mode**

| Symbol | Parameter | Condition | Typ. | Units |
|---|---|---|---|---|
| $I_{OH}$ | Switching current high | Tristate on pin (requires pull-up) | Tristate when driving high | mA |
| $I_{OL}$ | Switching current low | @ 0.4 V | 10 | mA |

### 4.3.7 Audio Interface

#### 4.3.7.1 PCM Interface

**Interface Signals**

| Pin No | Signal Name | Specification Name | Type | Description |
|---|---|---|---|---|
| A1 | PCM_DOUT | DOUT | Output | PCM data |
| B1 | PCM_CLK | CLK | Input/Output | PCM clock signal, output if PCM master, input if PCM slave |
| B1 | PCM_MCLK | MCLK | Output | PCM clock signal (optional), optional clock used for some codecs, derived from PCM_CLK |
| B2 | PCM_DIN | DIN | Input | PCM data |
| B3 | PCM_SYNC | SYNC | Input/Output | PCM Sync pulse signal, output if PCM master, input if PCM slave |

**Modes of Operation**

The PCM Interface supports two modes of operation:

- PCM master
- PCM slave

When in PCM master mode, the interface generates a 2 MHz or a 2.048 MHz PCM_CLK and a 8 kHz PCM_SYNC signal. An alternative PCM master mode is available that uses an externally generated PCM_CLK, but still generates the 8 kHz PCM_SYNC. The external PCM_CLK must have a frequency that is an integer multiple of 8 kHz. Supported frequencies are in the 512 kHz to 4 MHz range.

When in PCM slave mode, the interface has both PCM_CLK and PCM_SYNC as inputs, thereby letting another unit on the PCM bus generate the signals.

The PCM interface consists of up to four PCM slots (time-devided) preceded by a PCM sync signal. Each PCM slot can be either 8 or 16 bits wide. The slots can be separated in time, but they are not required to follow immediately after another. The timing is relative to PCM_SYNC.

### PCM Timing Data – Master Mode

| Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|
| $F_{BCLK}$ | | 2/2.048 | | MHz |
| Duty Cycle$_{BCLK}$ | 0.4 | 0.5 | 0.6 | |
| $T_{BCLK \ rise/fall}$ | | 3 | | ns |
| $T_{DO}$ | | | 15 | ns |
| $T_{DISU}$ | 20 | | | ns |
| $T_{DIHO}$ | 15 | | | ns |
| $T_{BF}$ | | | 15 | ns |

### PCM Timing Diagram – Master Mode
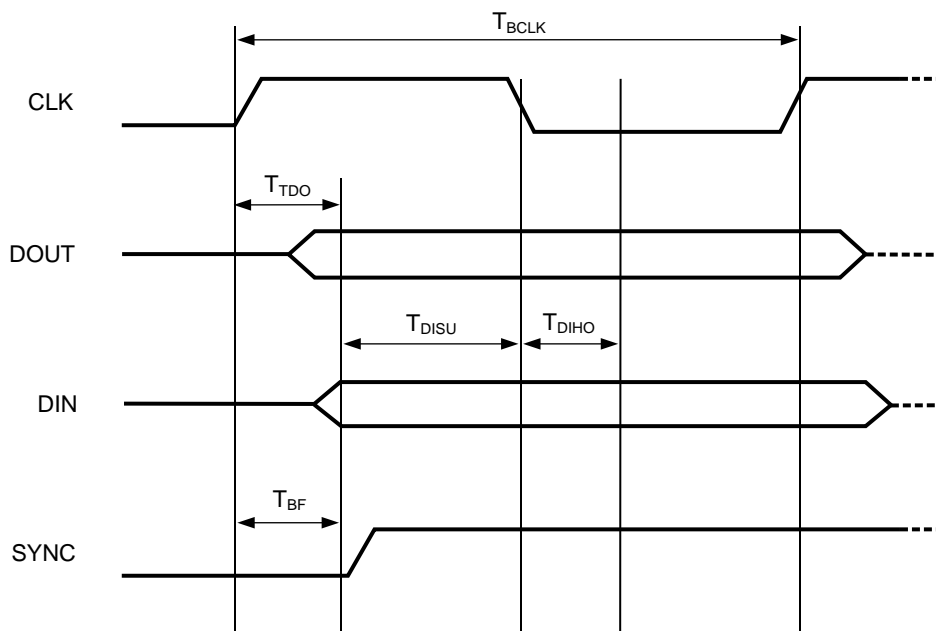
### PCM Timing Data – Slave Mode

| Symbol | Min. | Typ. | Max. | Units |
|---|---|---|---|---|
| $F_{BCLK}$ | | 2/2.048 | | MHz |
| Duty Cycle$_{BCLK}$ | 0.4 | 0.5 | 0.6 | |
| $T_{BCLK\ rise/fall}$ | | 3 | | ns |
| $T_{DO}$ | | | 30 | ns |
| $T_{DISU}$ | 15 | | | ns |
| $T_{DIHO}$ | 10 | | | ns |
| $T_{BFSU}$ | 15 | | | ns |
| $T_{BFHO}$ | 10 | | | ns |

### PCM Timing Diagram – Slave Mode
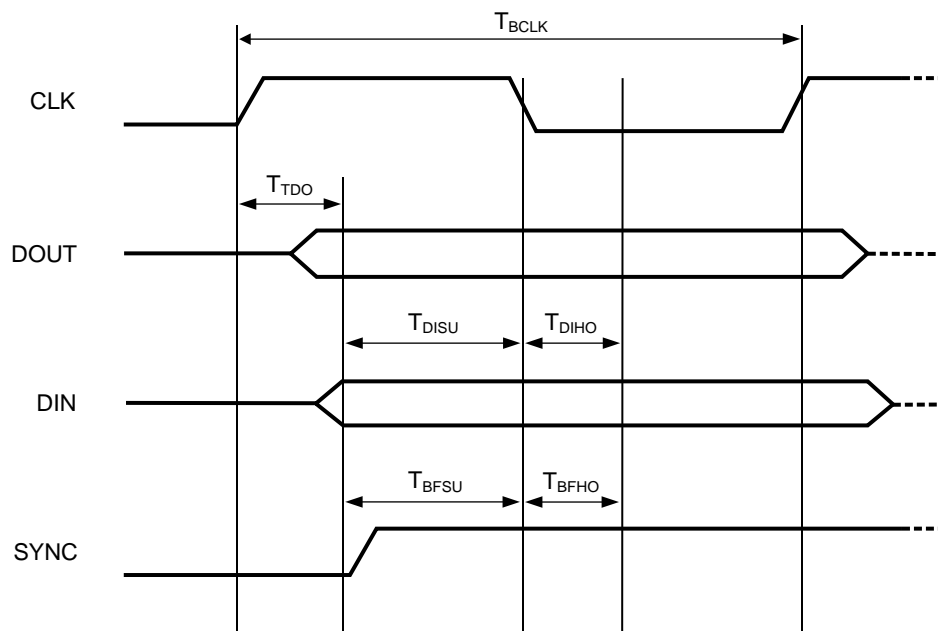
### 4.3.8   Coexistence Interface

> (i)   The Coexistence Interface pins are powered from the VIO voltage supply with 1.8 V.

DC specification ⇨ 4.3.1 Digital Pin Characteristics

## 4.4 RF Electrical Characteristics

### 4.4.1 WLAN Radio Specification

**Receive Mode**

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | 2.4 GHz – IEEE 802.11b/g/n | 2 400 | | 2 483.5 | MHz |
| | 5 GHz – IEEE 802.11a/n | 4 900 | | 5 925 | MHz |

**Transmit Mode**

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | 2.4 GHz – IEEE 802.11b/g/n | 2 400 | | 2 483.5 | MHz |
| | 5 GHz – IEEE 802.11a/n | 4 900 | | 5 925 | MHz |

### 4.4.2   WLAN RF Characteristics

### 4.4.2.1   RF Characteristics for IEEE 802.11b

> (i) Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V and $T_{amb}$ = 25 °C, if nothing else stated.
>
> 50 $\Omega$ terminal load connected to the RF connector.

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | | 2 400 | | 2 483.5 | MHz |
| Carrier frequency tolerance | | -25 | | +25 | ppm |
| Transmit output power | | | +16 | | dBm |
| Spectrum mask | $f_C \pm 11$ MHz | | | -30 | dBr |
| | $f_C \pm 22$ MHz | | | -50 | |
| Power-on/Power-down ramp | | | | 2 | µs |
| RF Carrier suppression | | | | -15 | dB |
| Error Vector Magnitude (EVM) | Peak | | | 35 | % |
| Minimum Receive Sensitivity | 1 Mbps (DSSS) | FER ≤ 8 % | | -98 | | dBm |
| | 2 Mbps (DSSS) | FER ≤ 8 % | | -93 | -80 | dBm |
| | 5.5 Mbps (CCK) | FER ≤ 8 % | | -91 | | dBm |
| | 11 Mbps (CCK) | FER ≤ 8 % | | -89 | -76 | dBm |
| Maximum Input Level | | FER ≤ 8 % | | | -10 | dBm |
| Adjacent Channel Rejection | | FER ≤ 8 % | 35 | | | dB |

#### 4.4.2.2 RF Characteristics for IEEE 802.11g

Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V and $T_{amb}$ = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | | 2 400 | | 2 483.5 | MHz |
| Carrier frequency tolerance | | -25 | | +25 | ppm |
| Transmit output power | 6 Mbps ~ 36 Mbps | | +16 | | dBm |
| | 48 Mbps ~ 54 Mbps | | +15 | | dBm |
| Spectrum mask | $f_C$ ± 11 MHz | | | -20 | dBr |
| | $f_C$ ± 20 MHz | | | -28 | dBr |
| | $f_C$ ± 30 MHz | | | -40 | dBr |
| Transmitter center frequency leakage | | | | -15 | dB |
| Transmitter Spectral Flatness | | -4 | | +4 | dB |
| Constellation Error (EVM) | BPSK, CR 1/2 (6 Mbps) | | | -5 | dB |
| | BPSK, CR 3/4 (9 Mbps) | | | -8 | dB |
| | QPSK, CR 1/2 (12 Mbps) | | | -10 | dB |
| | QPSK, CR 3/4 (18 Mbps) | | | -13 | dB |
| | 16-QAM, CR 1/2 (24 Mbps) | | | -16 | dB |
| | 16-QAM, CR 3/4 (36 Mbps) | | | -19 | dB |
| | 64-QAM, CR 2/3 (48 Mbps) | | | -22 | dB |
| | 64-QAM, CR 3/4 (54 Mbps) | | | -25 | dB |
| Minimum Receive Sensitivity | BPSK, CR 1/2 (6 Mbps) | PER ≤ 10 % | | -91 | -82 | dBm |
| | BPSK, CR 3/4 (9 Mbps) | PER ≤ 10 % | | -90 | -81 | dBm |
| | QPSK, CR 1/2 (12 Mbps) | PER ≤ 10 % | | -89 | -79 | dBm |
| | QPSK, CR 3/4 (18 Mbps) | PER ≤ 10 % | | -87 | -77 | dBm |
| | 16-QAM, CR 1/2 (24 Mbps) | PER ≤ 10 % | | -84 | -74 | dBm |
| | 16-QAM, CR 3/4 (36 Mbps) | PER ≤ 10 % | | -81 | -70 | dBm |
| | 64-QAM, CR 2/3 (48 Mbps) | PER ≤ 10 % | | -77 | -66 | dBm |
| | 64-QAM, CR 3/4 (54 Mbps) | PER ≤ 10 % | | -76 | -65 | dBm |
| Maximum Input Level | | PER ≤ 10 % | | | -20 | dBm |
| Adjacent channel rejection | BPSK, CR 1/2 (6 Mbps) | PER ≤ 10 % | 16 | | | dB |
| | 64-QAM, CR 3/4 (54 Mbps) | PER ≤ 10 % | -1 | | | dB |

### 4.4.2.3    RF Characteristics for IEEE 802.11n (BW 20 MHz, 2.4 GHz)

> Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V and $T_{amb}$ = 25 °C, if nothing else stated.
>
> 50 $\Omega$ terminal load connected to the RF connector.

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | 2.4 GHz | 2 400 | | 2 483.5 | MHz |
| Carrier frequency tolerance | | -25 | | +25 | ppm |
| Transmit output power | MCS0 ~ MCS2 | | | +15 | dBm |
| | MCS3 ~ MCS4 | | | +15 | dBm |
| | MCS5 ~ MCS7 | | | +14 | dBm |
| Spectrum mask | $f_C \pm 11$ MHz | | | -20 | dBr |
| | $f_C \pm 20$ MHz | | | -28 | dBr |
| | $f_C \pm 30$ MHz | | | -45 | dBr |
| Transmitter center frequency leakage | | | | -15 | dB |
| Transmitter Spectral Flatness | | -4 | | +4 | dB |
| Constellation Error (EVM) | BPSK, CR 1/2 (MCS0) | | | -5 | dB |
| | QPSK, CR 1/2 (MCS1) | | | -10 | dB |
| | QPSK, CR 3/4 (MCS2) | | | -13 | dB |
| | 16-QAM, CR 1/2 (MCS3) | | | -16 | dB |
| | 16-QAM, CR 3/4 (MCS4) | | | -19 | dB |
| | 64-QAM, CR 2/3 (MCS5) | | | -22 | dB |
| | 64-QAM, CR 3/4 (MCS6) | | | -25 | dB |
| | 64-QAM, CR 5/6 (MCS7) | | | -27 | dB |
| Minimum Receive Sensitivity[19] | 6.5 Mbps (MCS0) | PER ≤ 10 % | | -90 | -82 | dBm |
| | 13 Mbps (MCS1) | PER ≤ 10 % | | -88 | -79 | dBm |
| | 19.5 Mbps (MCS2) | PER ≤ 10 % | | -86 | -77 | dBm |
| | 26 Mbps (MCS3) | PER ≤ 10 % | | -83 | -74 | dBm |
| | 39 Mbps (MCS4) | PER ≤ 10 % | | -80 | -70 | dBm |
| | 52 Mbps (MCS5) | PER ≤ 10 % | | -76 | -66 | dBm |
| | 58.5 Mbps (MCS6) | PER ≤ 10 % | | -74 | -65 | dBm |
| | 65 Mbps (MCS7) | PER ≤ 10 % | | -73 | -64 | dBm |
| Maximum Input Level | | PER ≤ 10 % | | | -20 | dBm |
| Adjacent channel rejection[20] | 65 Mbps (MCS7) | PER ≤ 10 % | -2 | | | dB |

---

[19] The Minimum Sensitivity levels apply only to non-STBC modes, MCS 0~7, 800 ns LGI, and BCC.

[20] The Adjacent Channel Rejection levels apply only to non-STBC modes, MCS 0~7, 800 ns LGI, and BCC.

#### 4.4.2.4 RF Characteristics for IEEE 802.11n (BW 40 MHz, 2.4 GHz)

> (i) Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V and $T_{amb}$ = 25 °C, if nothing else stated.
>
> 50 Ω terminal load connected to the RF connector.

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | 2.4 GHz | 2 400 | | 2 483.5 | MHz |
| Carrier frequency tolerance | | -25 | | +25 | ppm |
| Transmit output power | MCS0 ~ MCS2 | | +14 | | dBm |
| | MCS3 ~ MCS4 | | +14 | | dBm |
| | MCS5 ~ MCS7 | | +13 | | dBm |
| Spectrum mask | $f_C$ ± 21 MHz | | | -20 | dBr |
| | $f_C$ ± 40 MHz | | | -28 | dBr |
| | $f_C$ ± 60 MHz | | | -45 | dBr |
| Transmitter center frequency leakage | | | | -20 | dB |
| Transmitter Spectral Flatness | | -4 | | +4 | dB |
| Constellation Error (EVM) | BPSK, CR 1/2 (MCS0) | | | -5 | dB |
| | QPSK, CR 1/2 (MCS1) | | | -10 | dB |
| | QPSK, CR 3/4 (MCS2) | | | -13 | dB |
| | 16-QAM, CR 1/2 (MCS3) | | | -16 | dB |
| | 16-QAM, CR 3/4 (MCS4) | | | -19 | dB |
| | 64-QAM, CR 2/3 (MCS5) | | | -22 | dB |
| | 64-QAM, CR 3/4 (MCS6) | | | -25 | dB |
| | 64-QAM, CR 5/6 (MCS7) | | | -27 | dB |
| Minimum Receive Sensitivity[19] | 13.5 Mbps (MCS0) | PER ≤ 10 % | | -86 | -79 | dBm |
| | 27 Mbps (MCS1) | PER ≤ 10 % | | -85 | -76 | dBm |
| | 40.5 Mbps (MCS2) | PER ≤ 10 % | | -83 | -74 | dBm |
| | 54 Mbps (MCS3) | PER ≤ 10 % | | -80 | -71 | dBm |
| | 81 Mbps (MCS4) | PER ≤ 10 % | | -77 | -67 | dBm |
| | 108 Mbps (MCS5) | PER ≤ 10 % | | -73 | -63 | dBm |
| | 121.5 Mbps (MCS6) | PER ≤ 10 % | | -71 | -62 | dBm |
| | 135 Mbps (MCS7) | PER ≤ 10 % | | -69 | -61 | dBm |
| Maximum Input Level | | PER ≤ 10 % | | | -20 | dBm |
| Adjacent channel rejection[20] | 135 Mbps (MCS7) | PER ≤ 10 % | -2 | | | dB |

### 4.4.2.5 RF Characteristics for IEEE 802.11n (BW 20 MHz, 5 GHz)

> ℹ️ Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V, and $T_{amb}$ = 25 °C, if nothing else stated.
>
> 50 Ω terminal load connected to the RF connector.

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | 5 GHz U-NII-1 | 5 150 | | 5 250 | MHz |
| | 5 GHz U-NII-2A | 5 250 | | 5 350 | MHz |
| | 5 GHz U-NII-2C | 5 470 | | 5 725 | MHz |
| | 5 GHz U-NII-3 | 5 725 | | 5 825 | MHz |
| Carrier frequency tolerance | | -20 | | +20 | ppm |
| Transmit output power | MCS0 ~ MCS2 | | +15 | | dBm |
| | MCS3 ~ MCS4 | | +15 | | dBm |
| | MCS5 ~ MCS7 | | +14 | | dBm |
| Spectrum mask | $f_C$ ± 11 MHz | | | -20 | dBr |
| | $f_C$ ± 20 MHz | | | -28 | dBr |
| | $f_C$ ± 30 MHz | | | -40 | dBr |
| Transmitter center frequency leakage | | | | -15 | dB |
| Transmitter Spectral Flatness | | -4 | | +4 | dB |
| Constellation Error (EVM) | BPSK, CR 1/2 (MCS0) | | | -5 | dB |
| | QPSK, CR 1/2 (MCS1) | | | -10 | dB |
| | QPSK, CR 3/4 (MCS2) | | | -13 | dB |
| | 16-QAM, CR 1/2 (MCS3) | | | -16 | dB |
| | 16-QAM, CR 3/4 (MCS4) | | | -19 | dB |
| | 64-QAM, CR 2/3 (MCS5) | | | -22 | dB |
| | 64-QAM, CR 3/4 (MCS6) | | | -25 | dB |
| | 64-QAM, CR 5/6 (MCS7) | | | -27 | dB |
| Minimum Receive Sensitivity[19] | 6.5 Mbps (MCS0) | PER ≤ 10 % | | -89 | -82 | dBm |
| | 13 Mbps (MCS1) | PER ≤ 10 % | | -88 | -79 | dBm |
| | 19.5 Mbps (MCS2) | PER ≤ 10 % | | -85 | -77 | dBm |
| | 26 Mbps (MCS3) | PER ≤ 10 % | | -82 | -74 | dBm |
| | 39 Mbps (MCS4) | PER ≤ 10 % | | -79 | -70 | dBm |
| | 52 Mbps (MCS5) | PER ≤ 10 % | | -74 | -66 | dBm |
| | 58.5 Mbps (MCS6) | PER ≤ 10 % | | -73 | -65 | dBm |
| | 65 Mbps (MCS7) | PER ≤ 10 % | | -71 | -64 | dBm |
| Maximum Input Level | | PER ≤ 10 % | | | -30 | dBm |
| Adjacent channel rejection[20] | 65 Mbps (MCS7) | PER ≤ 10 % | -2 | | | dB |

## 4.4.2.6 RF Characteristics for IEEE 802.11n (BW 40 MHz, 5 GHz)

> ℹ Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V, and $T_{amb}$ = 25 °C, if nothing else stated.
>
> 50 Ω terminal load connected to the RF connector.

| Parameter | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| RF frequency range | 5 GHz U-NII-1 | 5 150 | | 5 250 | MHz |
| | 5 GHz U-NII-2A | 5 250 | | 5 350 | MHz |
| | 5 GHz U-NII-2C | 5 470 | | 5 725 | MHz |
| | 5 GHz U-NII-3 | 5 725 | | 5 825 | MHz |
| Carrier frequency tolerance | | -20 | | +20 | ppm |
| Transmit output power | MCS0 ~ MCS2 | | +14 | | dBm |
| | MCS3 ~ MCS4 | | +14 | | dBm |
| | MCS5 ~ MCS7 | | +13 | | dBm |
| Spectrum mask | $f_C \pm 21$ MHz | | | -20 | dBr |
| | $f_C \pm 40$ MHz | | | -28 | dBr |
| | $f_C \pm 60$ MHz | | | -40 | dBr |
| Transmitter center frequency leakage | | | | -20 | dB |
| Transmitter Spectral Flatness | | -4 | | +4 | dB |
| Constellation Error (EVM) | BPSK, CR 1/2 (MCS0) | | | -5 | dB |
| | QPSK, CR 1/2 (MCS1) | | | -10 | dB |
| | QPSK, CR 3/4 (MCS2) | | | -13 | dB |
| | 16-QAM, CR 1/2 (MCS3) | | | -16 | dB |
| | 16-QAM, CR 3/4 (MCS4) | | | -19 | dB |
| | 64-QAM, CR 2/3 (MCS5) | | | -22 | dB |
| | 64-QAM, CR 3/4 (MCS6) | | | -25 | dB |
| | 64-QAM, CR 5/6 (MCS7) | | | -27 | dB |
| Minimum Receive Sensitivity[19] | 13.5 Mbps (MCS0) | PER ≤ 10 % | | -86 | -79 | dBm |
| | 27 Mbps (MCS1) | PER ≤ 10 % | | -85 | -76 | dBm |
| | 40.5 Mbps (MCS2) | PER ≤ 10 % | | -82 | -74 | dBm |
| | 54 Mbps (MCS3) | PER ≤ 10 % | | -79 | -71 | dBm |
| | 81 Mbps (MCS4) | PER ≤ 10 % | | -76 | -67 | dBm |
| | 108 Mbps (MCS5) | PER ≤ 10 % | | -72 | -63 | dBm |
| | 121.5 Mbps (MCS6) | PER ≤ 10 % | | -70 | -62 | dBm |
| | 135 Mbps (MCS7) | PER ≤ 10 % | | -69 | -61 | dBm |
| Maximum Input Level | | PER ≤ 10 % | | | -30 | dBm |
| Adjacent channel rejection[20] | 135 Mbps (MCS7) | PER ≤ 10 % | -2 | | | dB |

### 4.4.2.7 RF Characteristics for IEEE 802.11a

(i) Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V, and $T_{amb}$ = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

| Parameter | | Condition | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| RF frequency range | 5 GHz U-NII-1 | | 5 150 | | 5 250 | MHz |
| | 5 GHz U-NII-2A | | 5 250 | | 5 350 | MHz |
| | 5 GHz U-NII-2C | | 5 470 | | 5 725 | MHz |
| | 5 GHz U-NII-3 | | 5 725 | | 5 825 | MHz |
| Carrier frequency tolerance | | | -20 | | +20 | ppm |
| Transmit output power | 6 Mbps ~ 36 Mbps | | | +16 | | dBm |
| | 48 Mbps ~ 54 Mbps | | | +15 | | dBm |
| Spectrum mask | $f_C \pm 11$ MHz | | | | -20 | dBr |
| | $f_C \pm 20$ MHz | | | | -28 | dBr |
| | $f_C \pm 30$ MHz | | | | -40 | dBr |
| Transmitter center frequency leakage | | | | | -15 | dB |
| Transmitter Spectral Flatness | | | -4 | | +4 | dB |
| Constellation Error (EVM) | BPSK, CR 1/2 (6 Mbps) | | | | -5 | dB |
| | BPSK, CR 3/4 (9 Mbps) | | | | -8 | dB |
| | QPSK, CR 1/2 (12 Mbps) | | | | -10 | dB |
| | QPSK, CR 3/4 (18 Mbps) | | | | -13 | dB |
| | 16-QAM, CR 1/2 (24 Mbps) | | | | -16 | dB |
| | 16-QAM, CR 3/4 (36 Mbps) | | | | -19 | dB |
| | 64-QAM, CR 2/3 (48 Mbps) | | | | -22 | dB |
| | 64-QAM, CR 3/4 (54 Mbps) | | | | -25 | dB |
| Minimum Receive Sensitivity | BPSK, CR 1/2 (6 Mbps) | PER ≤ 10 % | | -90 | -82 | dBm |
| | BPSK, CR 3/4 (9 Mbps) | PER ≤ 10 % | | -90 | -81 | dBm |
| | QPSK, CR 1/2 (12 Mbps) | PER ≤ 10 % | | -89 | -79 | dBm |
| | QPSK, CR 3/4 (18 Mbps) | PER ≤ 10 % | | -86 | -77 | dBm |
| | 16-QAM, CR 1/2 (24 Mbps) | PER ≤ 10 % | | -84 | -74 | dBm |
| | 16-QAM, CR 3/4 (36 Mbps) | PER ≤ 10 % | | -80 | -70 | dBm |
| | 64-QAM, CR 2/3 (48 Mbps) | PER ≤ 10 % | | -76 | -66 | dBm |
| | 64-QAM, CR 3/4 (54 Mbps) | PER ≤ 10 % | | -75 | -65 | dBm |
| Maximum Input Level | | PER ≤ 10 % | | | -30 | dBm |
| Adjacent channel rejection | BPSK, CR 1/2 (6 Mbps) | PER ≤ 10 % | 16 | | | dB |
| | 64-QAM, CR 3/4 (54 Mbps) | PER ≤ 10 % | -1 | | | dB |

### 4.4.3 Bluetooth RF Characteristics

> ⓘ Assume $V_{DD2V2}$ = 2.2 V, $V_{DD1V8}$ = 1.8 V, $V_{IORF}$ = 3.3 V, $V_{IOSD}$ = 3.3 V, $V_{IO}$ = 1.8 V, and $T_{amb}$ = 25 °C, if nothing else stated.
>
> 50 Ω terminal load connected to the RF connector.

### 4.4.3.1 Receiver Section RF Characteristics

| Parameter | Condition | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| RF frequency range | | | 2 400 | | 2 483.5 | MHz |
| Interference Performance (Basic Rate)  C/I Ratio | GFSK  RSL = -67 dBm BER ≤ 0.1 % | C/I (Co-channel) | | | 11 | dB |
| | | C/I (1 MHz) | | | 0 | dB |
| | | C/I (2 MHz) | | | -30 | dB |
| | | C/I (3 MHz) | | | -40 | dB |
| | | C/I (Image) | | | -9 | dB |
| | | C/I (Image ± 1 MHz) | | | -20 | dB |
| Interference Performance (Enhanced Data Rate)  C/I Ratio | π/4-DQPSK  RSL = -67 dBm BER ≤ 0.01 % | C/I (Co-channel) | | | 13 | dB |
| | | C/I (1 MHz) | | | 0 | dB |
| | | C/I (2 MHz) | | | -30 | dB |
| | | C/I (3 MHz) | | | -40 | dB |
| | | C/I (Image) | | | -7 | dB |
| | | C/I (Image ± 1 MHz) | | | -20 | dB |
| | 8-DPSK  RSL = -67 dBm BER ≤ 0.01 % | C/I (Co-channel) | | | 21 | dB |
| | | C/I (1 MHz) | | | 5 | dB |
| | | C/I (2 MHz) | | | -25 | dB |
| | | C/I (3 MHz) | | | -33 | dB |
| | | C/I (Image) | | | 0 | dB |
| | | C/I (Image ± 1 MHz) | | | -13 | dB |
| Interference Performance (Low Energy)  C/I Ratio | GFSK  RSL = -67 dBm BER ≤ 0.1 %  1 Mbps | C/I (Co-channel) | | | 21 | dB |
| | | C/I (1 MHz) | | | 15 | dB |
| | | C/I (2 MHz) | | | -17 | dB |
| | | C/I (3 MHz) | | | -27 | dB |
| | | C/I (Image) | | | -9 | dB |
| | | C/I (Image ± 1 MHz) | | | -15 | dB |
| Minimum Receive Sensitivity | BR, DH1 | BER ≤ 0.1 % | | -94 | -70 | dBm |
| | EDR, 2DH1 | BER ≤ 0.01 % | | -90 | -70 | dBm |
| | LE, GFSK | BER ≤ 0.1 % | | -90 | -70 | dBm |

| Parameter | Condition | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Out-of-band blocking (Basic Rate)<br><br>Interfering Signal Power | GFSK<br><br>RSL = -67 dBm<br>BER ≤ 0.1 % | 30 MHz – 2 000 MHz | | | -10 | dBm |
| | | 2 GHz – 2.399 GHz | | | -27 | dBm |
| | | 2.484 GHz – 3 GHz | | | -27 | dBm |
| | | 3 GHz – 12.75 GHz | | | -10 | dBm |
| Out-of-band blocking (Low Energy)<br><br>Interfering Signal Power | GFSK<br><br>RSL = -67 dBm<br>BER ≤ 0.1 % | 30 MHz – 2 000 MHz | | | -30 | dBm |
| | | 2.003 GHz – 2.399 GHz | | | -35 | dBm |
| | | 2.484 GHz – 2.997 GHz | | | -35 | dBm |
| | | 3 GHz – 12.75 GHz | | | -30 | dBm |
| RSSI Range | Resolution = 1 dB | | | -90 | 0 | dBm |

## 4.4.3.2 Transmitter Section RF Characteristics

| Parameter | Condition | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| RF frequency range | | | 2 400 | | 2 483.5 | MHz |
| Maximum Output power | Basic Rate (BR) | | | +8 | +12 | dBm |
| | Enhanced Data Rate (EDR) | | | +4 | +8 | dBm |
| | Low Energy (LE) | | | 0 | +4 | dBm |
| Gain range | Gain control | | | 30 | | dB |
| Gain resolution | | | | 0.5 | | dB |
| Spurious emission (BR) (in-band) | ± 500 kHz | | | | -20 | dBc |
| | ± 2 MHz, \|M-N\| = 2 | | | | -20 | dBm |
| | ± 3 MHz or greater, \|M-N\| ≥ 3 | | | | -40 | dBm |
| Spurious emission (EDR) (in-band) | ± 1 MHz | | | | -26 | dBc |
| | ± 1.5 MHz | | | | -20 | dBm |
| | ± 2.5 MHz | | | | -40 | dBm |
| Spurious emission (LE) (in-band) | 1 Mbps | ± 2 MHz, \|M-N\| = 2 | | | -20 | dBm |
| | | ± 3 MHz or greater, \|M-N\| ≥ 3 | | | -30 | dBm |

## 4.5 Reliability Tests

The measurement should be done after the test device has been exposed to room temperature and humidity for one hour.

| No. | Item | Limit | Condition |
|-----|------|-------|-----------|
| 1 | Vibration test | Electrical parameter should be in specification | Freq.: 10~50 Hz; Amplitude: 1.5 mm; 20 min./cycle, 1 h each of XYZ axis |
| 2 | Shock test | See above | Dropped 3 times onto hard wood from a height of 1 m |
| 3 | Heat cycle test | See above | -40 °C for 30 min. and +85 °C for 30 min.; each temperature 300 cycles |
| 4 | Moisture test | See above | +60 °C, 90 % RH, 300 h |
| 5 | Low temp. test | See above | -40 °C, 300 h |
| 6 | High temp. test | See above | +85 °C, 300 h |

## 4.6 Recommended Soldering Profile

(i)
- Reflow permissible cycle: 2
- Opposite side reflow is prohibited due to module weight
- More than 75 percent of the soldering area shall be coated by solder
- The soldering profiles should be adhered to in order to prevent electrical or mechanical damage
- Soldering profile assumes lead-free soldering

Temp.[°C]

230°C -250°C max.

30 +20/-10s

220°C

150°C – 190°C

90 ±30s

Time [s]
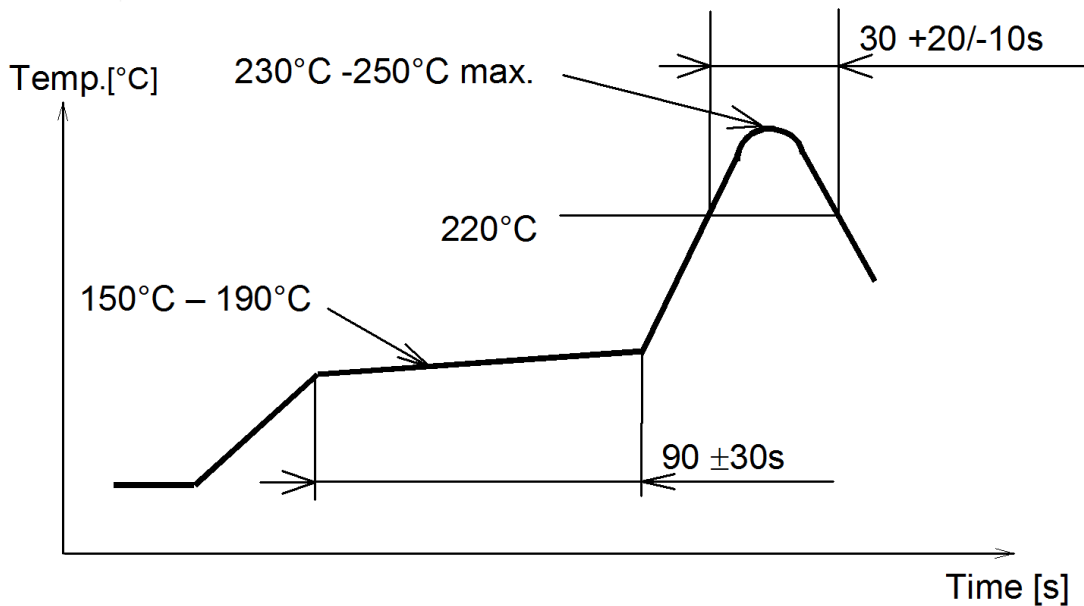
# 5 Cautions

> ⚠️ Failure to follow the guidelines set forth in this document may result in degrading of the product's functions and damage to the product.

## 5.1 Design Notes

1. Follow the conditions written in this specification, especially the control signals of this module.

2. The supply voltage must be free of AC ripple voltage (for example from a battery or a low noise regulator output). For noisy supply voltages, provide a decoupling circuit (for example a ferrite in series connection and a bypass capacitor to ground of at least 47 μF directly at the module).

3. This product should not be mechanically stressed when installed.

4. Keep this product away from heat. Heat is the major cause of decreasing the life of these products.

5. Avoid assembly and use of the target equipment in conditions where the product's temperature may exceed the maximum tolerance.

6. The supply voltage should not be exceedingly high or reversed. It should not carry noise and/or spikes.

7. Keep this product away from other high frequency circuits.

8. Refer to the recommended pattern when designing a board.

## 5.2 Installation Notes

1. Reflow soldering is possible twice based on the conditions set forth in ⇨ 4.6 Recommended Soldering Profile. Set up the temperature at the soldering portion of this product according to this reflow profile.

2. Carefully position the products so that their heat will not burn into printed circuit boards or affect the other components that are susceptible to heat.

3. Carefully locate these products so that their temperatures will not increase due to the effects of heat generated by neighboring components.

4. If a vinyl-covered wire comes into contact with the products, then the cover will melt and generate toxic gas, damaging the insulation. Never allow contact between the cover and these products to occur.

5. This product should not be mechanically stressed or vibrated when reflowed.

6. To repair the board by hand soldering, follow the conditions set forth in this chapter.

7. Do not wash this product.

8. Pressing on parts of the metal cover or fastening objects to the metal will cause damage to the unit.

## 5.3 Usage Condition Notes

1. Take measures to protect the unit against static electricity.
   If pulses or other transient loads (a large load applied in a short time) are applied to the products, check and evaluate their operation befor assembly on the final products.

2. Do not use dropped products.

3. Do not touch, damage or soil the pins.

4. Follow the recommended condition ratings about the power supply applied to this product.

5. Electrode peeling strength: Do not add pressure of more than 4.9 N when soldered on PCB.

6. Pressing on parts of the metal cover or fastening objects to the metal cover will cause damage.

7. These products are intended for general purpose and standard use in general electronic equipment, such as home appliances, office equipment, information, and communication equipment.

## 5.4 Storage Notes

1. The module should not be stressed mechanically during storage.

2. Do not store these products in the following conditions or the performance characteristics of the product, such as RF performance will be adversely affected:

   – Storage in salty air or in an environment with a high concentration of corrosive gas, such as $Cl_2$, $H_2S$, $NH_3$, $SO_2$, or $NO_X$,

   – Storage in direct sunlight,

   – Storage in an environment where the temperature may be outside the range of 5 °C to 35 °C, or where the humidity may be outside the 45 to 85 % range,

   – Storage of the products for more than one year after the date of delivery storage period: Please check the adhesive strength of the embossed tape and soldering after 6 months of storage.

3. Keep this product away from water, poisonous gas, and corrosive gas.

4. This product should not be stressed or shocked when transported.

5. Follow the specification when stacking packed crates (max. 10).

## 5.5 Safety Cautions

These specifications are intended to preserve the quality assurance of products and individual components.

Before use, check and evaluate the operation when mounted on your products. Abide by these specifications without deviation when using the products. These products may short-circuit. If electrical shocks, smoke, fire, and/or accidents involving human life are anticipated when a short circuit occurs, provide the following failsafe functions as a minimum:

1. Ensure the safety of the whole system by installing a protection circuit and a protection device.

2. Ensure the safety of the whole system by installing a redundant circuit or another system to prevent a single fault causing an unsafe status.

## 5.6 Other Cautions

1. Do not use the products for other purposes than those listed.

2. Be sure to provide an appropriate fail-safe function on your product to prevent an additional damage that may be caused by the abnormal function or the failure of the product.

3. This product has been manufactured without any ozone chemical controlled under the Montreal Protocol.

4. These products are not intended for uses other than under the special conditions shown below. Before using these products under such special conditions, carefully check their performance and reliability under the said special conditions to determine whether or not they can be used in such a manner:

   – In liquid, such as water, salt water, oil, alkali, or organic solvent, or in places where liquid may splash.

   – In direct sunlight, outdoors, or in a dusty environment.

   – In an environment where condensation occurs.

   – In an environment with a high concentration of harmful gas (e. g. salty air, HCl, $Cl_2$, $SO_2$, $H_2S$, $NH_3$, and $NO_X$).

5. If an abnormal voltage is applied due to a problem occurring in other components or circuits, replace these products with new products. They may not be able to provide normal performance even if their electronic characteristics and appearances appear satisfactory.

6. When you have any question or uncertainty, contact Panasonic.

## 5.7 Life Support Policy

This Panasonic Industrial Devices Europe GmbH product is not designed for use in life support appliances, devices, or systems where malfunction can reasonably be expected to result in a significant personal injury to the user, or as a critical component in any life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

Panasonic customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Panasonic Industrial Devices Europe GmbH for any damages resulting.

# 6 Regulatory and Certification Information

## 6.1 RoHS And REACH Declaration

The latest declaration of environmental compatibility (RoHS and REACH) for supplied products can be found on the Panasonic website in the "Downloads" section of the respective product ⇨ 7.3.2 Product Information.

# 7 Appendix

## 7.1 Ordering Information

### Variants and Versions

| Order Number | Brand Name | Description | MOQ[21] |
|---|---|---|---|
| ENWF9201A1EF | PAN9026 | Wif-Fi/Bluetooth radio module IEEE 802.11 a/b/g/n BT/BLE 5.0 with a ceramic chip-antenna, US version[22] | 1 000 |
| ENWF9202A1EF | PAN9026 | Wif-Fi/Bluetooth radio module IEEE 802.11 a/b/g/n BT/BLE 5.0 with a ceramic chip-antenna, EU version[23] | 1 000 |
| ENWF9201AZEF | PAN9026-ETU | PAN9026 SDIO Adapter with module ENWF9201A1EF | 1 |
| ENWF9201AYEF | PAN9026-KIT | PAN9026 Kit: 2x PAN9026 SDIO Adapter with module ENWF9201A1EF and 1x Case | 1 |

For further information please refer to our product documentation ⇨ 7.3.2 Product Information.

---

[21] Abbreviation for Minimum Order Quantity (MOQ). The standard MOQ for mass production is 1 000 pieces, fewer only on customer demand. Samples for evaluation can be delivered at any quantity via the distribution channels.

[22] The US version is restricted to FCC regulatory domain with blocked country code and Tx power table. The device does not support the channels 12 -13 in the 2.4 GHz band and any non-US channels.

[23] The EU version has preset the country code and Tx power table for European regulatory domain ETSI. The country code and Tx power table are not blocked and additionally the country codes and Tx power tables for Canada and US can be set.

## 7.2 Acronyms and Abbreviations

ACK .......................................................................................................*Acknowledgment*
ACL...................................................................................... *Asynchronous Connection-Less*
AES ................................................................................... *Advanced Encryption Standard*
AFH ...........................................................................................*Adaptive Frequency Hopping*
AGC ..................................................................................................*Automatic Gain Control*
A-MPDU .................................................................... *Aggregate-MAC Protocol Data Unit*
AoA....................................................................................................*Angle of Arrival*
AoD....................................................................................*Angle of Departure*
AP .................................................................................................... *Access Point*
BCA .............................................. *Beacon Collision Avoidance, Bluetooth Coexistence Arbiter*
BCC .......................................................................... B*inary Convolutional Code*
BD........................................................................................*Bluetooth Device*
BER ......................................................................................... *Bit Error Rate*
BPSK.......................................................................... *Binary Phase Shift Keying*
BR..............................................................................................*Basic Rate*
BSS ......................................................................................*Basic Service Set*
BT .................................................................................................*Bluetooth*
BTSIG.................................................................*Bluetooth Special Interest Group*
BW ......................................................................................... *Bandwidth*
CCK.................................................................... *Complementary Code Keying*
CCMP .................................................................. *CTR with CBC-MAC Protocol*
CDM ................................................................... *Charged Device Model*
CIS...............................................................................*Card Information Structure*
CMAC .................................................... *Cipher-Based Message Authentication Code*
CMD .....................................................................................*Command*
CMOS..........................................................*Complementary Metal-Oxide-Semiconductor*
CPU ................................................................................ *Central Processing Unit*
CQD.................................................................. *Channel Quality Driven*
CR ...........................................................................................*Code Rate*
CRC .......................................................................*Cyclic Redundancy Code*
CTR ........................................................................... *Counter Mode*
CTS ........................................................................................*Clear To Send*
DCF ....................................................................*Distributed Coordination Function*
DFS ............................................................... *Dynamic Frequency Selection*
DPSK........................................................... *Differential Phase Shift Keying*
DQPSK.............................................*Differential Quadrature Phase Shift Keying*
DSSS.................................................... *Direct Sequence Spread Spectrum*
DTIM..............................................*Delivery Traffic Indication Message*
EDCA ....................................................*Enhanced Distributed Channel Access*
EDR .................................................................*Enhanced Data Rate*
EPC ..........................................................*Enhanced Power Control*
ES .............................................................*Engineering Samples*
eSCO................................................*Embedded Synchronous Connection-Oriented*
ESD ...............................................................*Electro Static Discharge*
EVM................................................................*Error Vector Magnitude*
FER ............................................................................. *Frame Error Rate*
FIFO .......................................................................... *First In-First Out*
GFSK.......................................................... *Gaussian Frequency Shift Key or Keying*
GI ...................................................................................... *Guard Interval*
GPIO............................................................... *General Purpose IO*
HBM.................................................................*Human Body Model*
HT.......................................................................... *High Throughput*
IB ............................................................................................*In-Band*
IO ...................................................................... *Input Output*
ISM .................................................................*Industrial, Scientific, and Medical*

JEDEC ................................................................ *Joint Electronic Device Engineering Council*
LE ............................................................................................................. *Low Energy*
LGI ........................................................................................................ *Long Guard Interval*
LNA ...................................................................................................... *Low Noise Amplifier*
LP ............................................................................................................ *Low Power*
LSB ......................................................................................................*Least Significant Bit*
LTE ....................................................................................................*Long Term Evolution*
MAC ................................................................................................. *Medium Access Control*
MCS ...................................................................................... *Modulation and Coding Scheme*
MOQ ........................................................................................... *Minimum Order Quantity*
MPDU ............................................................................................*MAC Protocol Data Unit*
MSDU ........................................................................................... *MAC Service Data Unit*
MWS ..............................................................................................*Mobile Wireless System*
OEM ........................................................................................ *Original Equipment Manufacturers*
OFDM ......................................................... *Othorgonal Frequency Division Multiplexing*
OOB ...................................................................................................... *Out-Of-Band*
OTP ..............................................................................*One Time Programmable Memory*
PA ......................................................................................................... *Power Amplifier*
PAN ...................................................................................................... *Personal Area Network*
PBU ........................................................................................................ *Peripheral Bus Unit*
PCB ...................................................................................................... *Printed Circuit Board*
PCM ...................................................................................................... *Pulse Code Modulation*
PDn ...........................................................................................................*Power Down*
PER ....................................................................................................*Packet Error Rate*
PHY ........................................................................................................*Physical Layer*
PLR .......................................................................................................*Packet Loss Rate*
PPEC ........................................................................ *Pitch Period Error Concealment*
PTA .....................................................................................*Packet Traffic Arbitration*
QAM ..................................................................... *Quadrature Amplitude Modulation*
QoS .......................................................................................................*Quality of Service*
QPSK ..................................................................... *Quadrature Phase Shift Keying*
RH .........................................................................................................*Relative Humidity*
RIFS ........................................................................................*Reduced Interframe Space*
RSL......................................................................................................*Received Signal Level*
RSSI ....................................................................................*Recieve Signal Strength Indicator*
RX........................................................................................................*Receive or Receiver*
RXD ........................................................................................ *Request To Send, Receive Data*
SCO...................................................................................*Synchronous Connection-Oriented*
SDIO....................................................................................*Secure Digital Input Output*
SGI ....................................................................................*Short Guard Interval*
SISO ..................................................................................... *Single Input Single Output*
SMT ....................................................................................*Surface Mount Type*
STA.......................................................................................................*Station*
STBC .................................................................................... *Space-Time-Block-Coding*
STD .......................................................................................................*Standard*
TIM .......................................................................................*Traffic Indication Map*
TKIP...................................................................................*Temporal Key Integrity Protocol*
TX.......................................................................................*Transmit or Transmitter*
TXD .......................................................................................*Transmit Data*
UART....................................................................*Universal Asynchronous Receiver Transmitter*
UDP .......................................................................................*User Datagram Protocol*
WAPI .....................................................................*WLAN Authentication and Privacy Infrastructure*
WBS .......................................................................................*Wideband Speech*
WCI-2 ..................................................................... *Wireless Coexistence Interface 2*
WEP .......................................................................................*Wired Equivalent Privacy*
WLAN .......................................................................................*Wireless Local Area Network*
WPA .......................................................................................*Wi-Fi Protected Access*

## 7.3 Contact Details

### 7.3.1 Contact Us

Please contact your local Panasonic Sales office for details on additional product options and services:

For Panasonic Sales assistance in the **EU**, visit

https://eu.industrial.panasonic.com/about-us/contact-us

Email: wireless@eu.panasonic.com

For Panasonic Sales assistance in **North America**, visit the Panasonic Sales & Support Tool to find assistance near you at

https://na.industrial.panasonic.com/distributors

Please visit the **Panasonic Wireless Technical Forum** to submit a question at

https://forum.na.industrial.panasonic.com

### 7.3.2 Product Information

Please refer to the Panasonic Wireless Connectivity website for further information on our products and related documents:

For complete Panasonic product details in the **EU**, visit

http://pideu.panasonic.de/products/wireless-modules.html

For complete Panasonic product details in **North America**, visit

http://www.panasonic.com/rfmodules