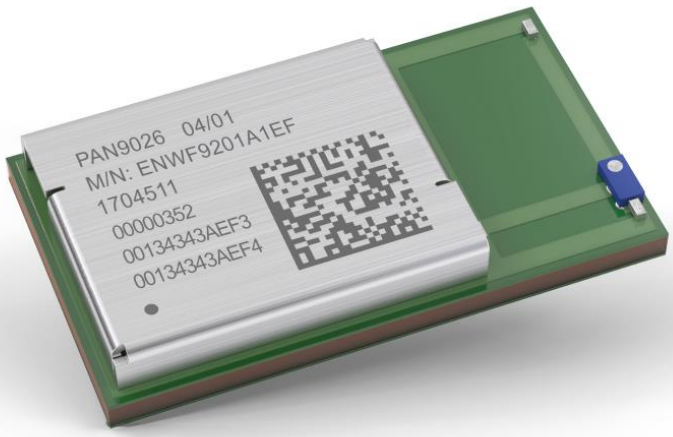
Panasonic

PAN9026

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

Product Specification

Rev. 1.0



Wireless Modules

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

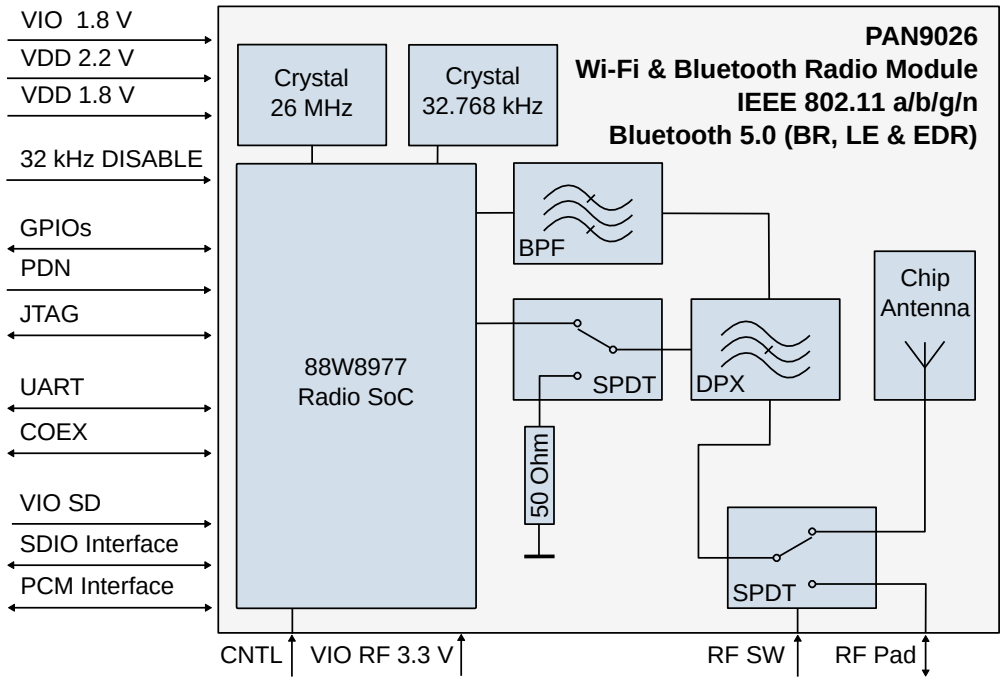


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Table of Contents

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 Change PM: ⇨ 2.3.1 Power Configuration Example with 3.3 V Host Operation Include values: ⇨ 4.3.2 Current Consumption, 4.4.3.2 Transmitter Section RF Characteristics Remove section: ⇨ 4.3.7.2 TDM Interface Additional models: ⇨ 7.1 Ordering Information Add section: ⇨ 7.2 Acronyms and Abbreviations

1.3 Use of Symbols

Symbol	Description
	**Note** Indicates important information for the proper use of the product. Non-observance can lead to errors.
	**Attention** Indicates important notes that, if not observed, can put the product’s functionality at risk.
⇨ [chapter number] [chapter title]	**Cross reference** Indicates cross references within the document. **Example:** 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

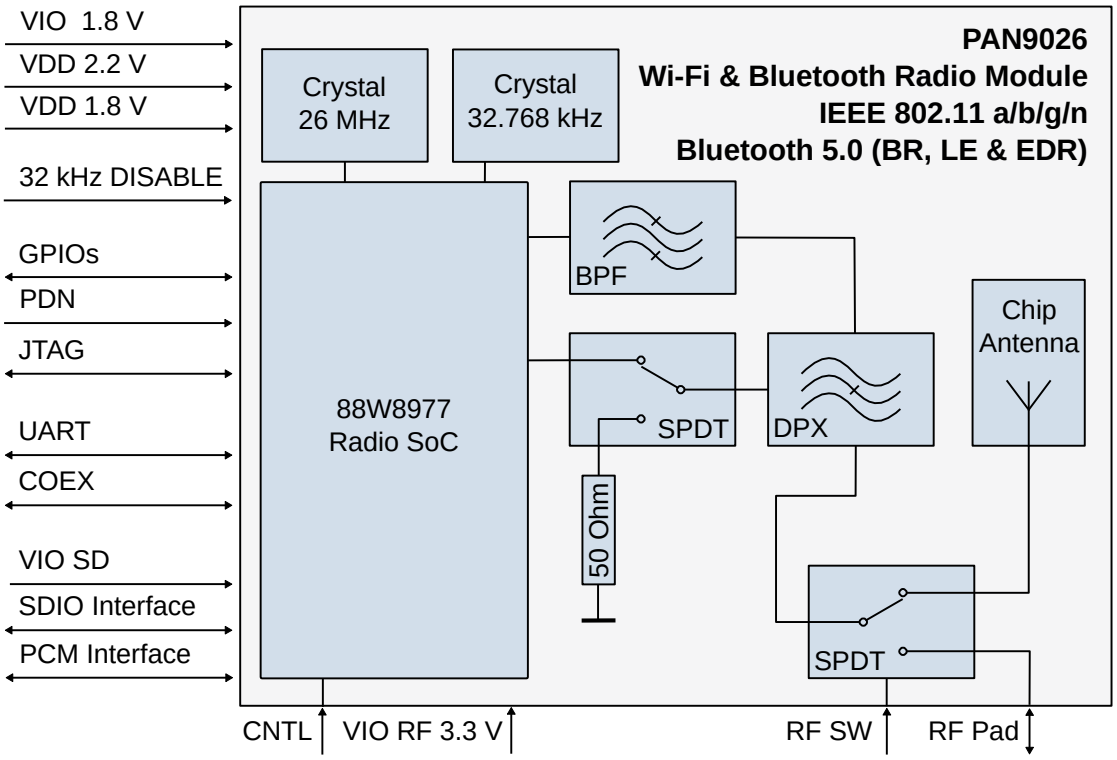
The PAN9026 is a dual band 2.4/5 GHz 802.11 a/b/g/n Wi-Fi radio module with integrated Bluetooth BR/EDR/LE, specifically designed for highly integrated and cost-effective applications. The simultaneous and independent operation of the two standards enables high data rates (802.11n) and low-power operation (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.

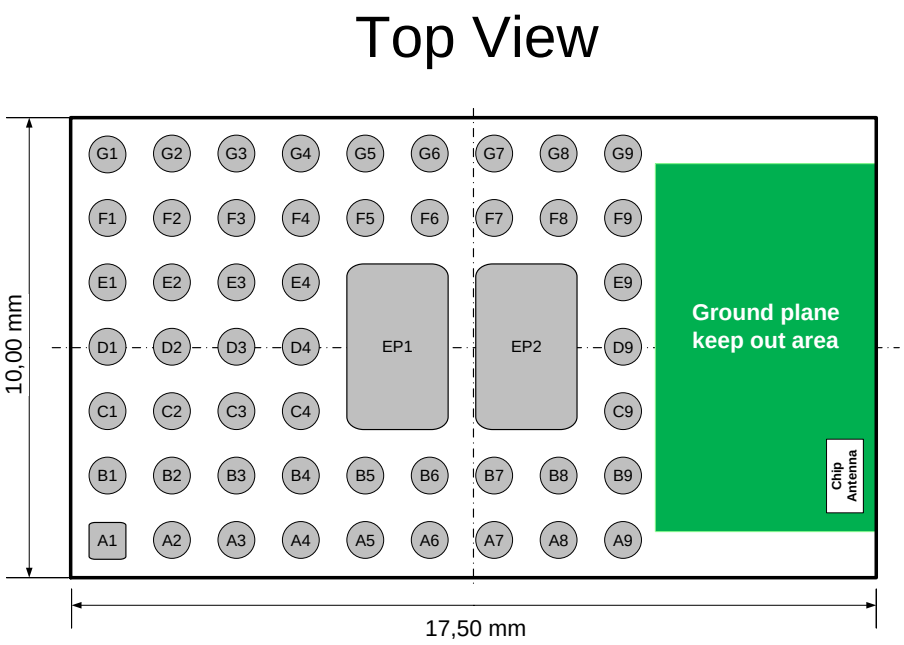
Further information on the variants and versions ⇨ 7.1 Ordering Information.

2.1 Block Diagram



2.2 Pin Configuration

Pin Assignment



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

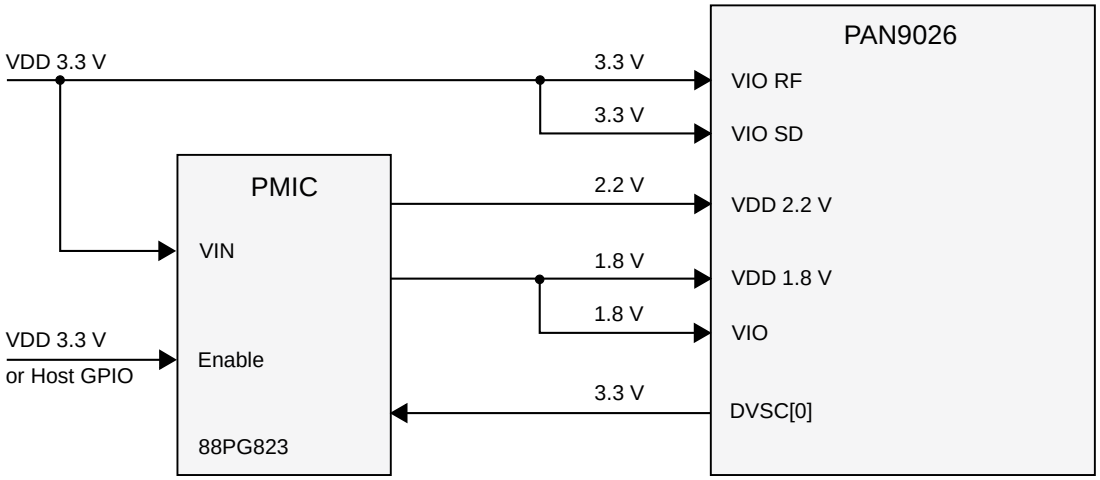
The control pin is used as configuration input to set parameters following a reset. The definition of the pin changes immediately after a reset to its usual function. To set a configuration bit to 0, attach a 100 kΩ resistor from the pin to ground. No external circuitry is required to set a configuration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

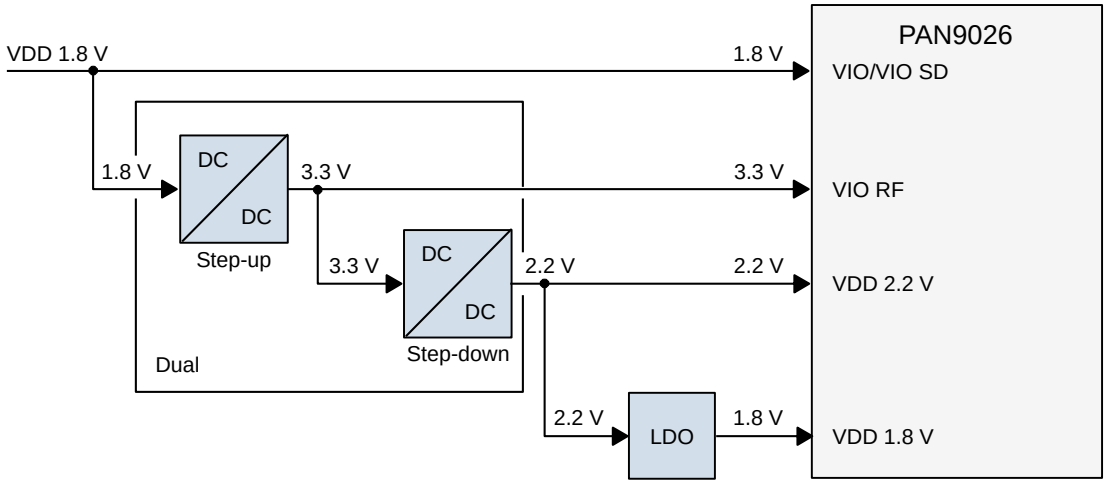
The configuration of the control pin is used for the firmware boot option. The software reads and boots accordingly.

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. • FIFO mode permanently selected for transmit and receive operations • Two pins for transmit and receive operations • Two flow control pins • 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. • Supports SDIO 3.0 Standard • 1-bit SDIO or 4-bit SDIO transfer modes with full clock range up to 100 MHz • On-chip memory used for CIS • Special interrupt register for information exchange • 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) • Each GPIO controlled independently • 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 • Programmed during production process of device • 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 • PCM bit width size of 8 bits or 16 bits • Up to four slots with configurable bit width and start positions • 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.

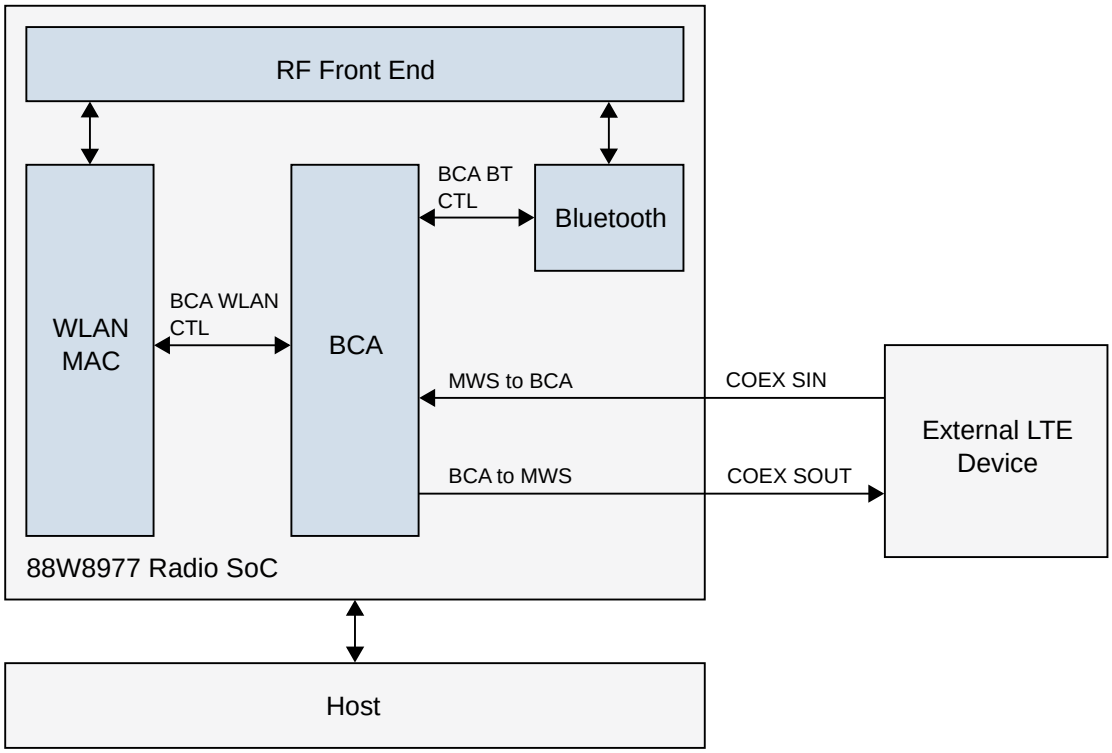
2.7.2 External Mobile Wireless System (LTE/ZigBee) and BCA Exchange

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.

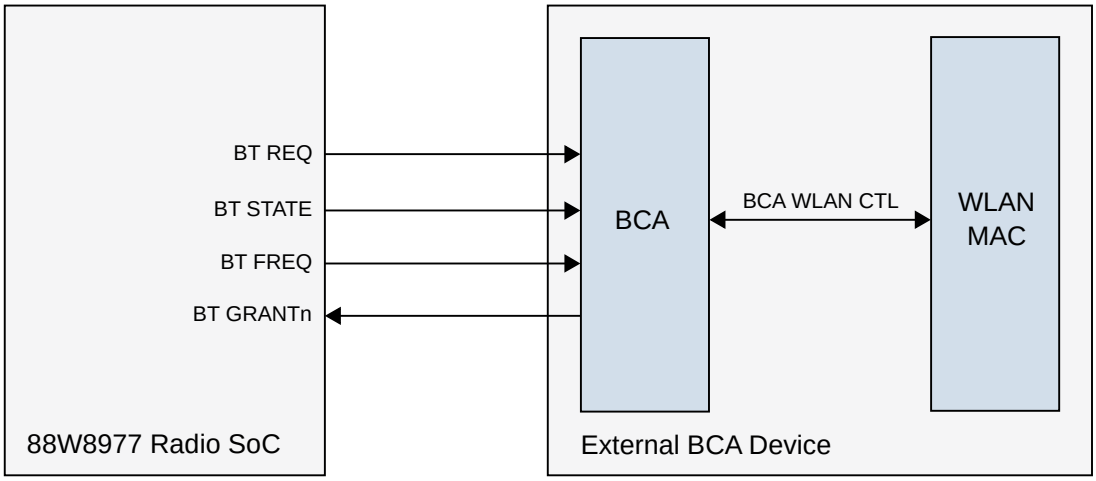
WCI-2 is a 2-wire transport interface. An internal coexistence is used to exchange request/grant with the BCA.

2.7.3 System Configuration

External MWS Device



External BCA Device



2.7.4 WCI-2 Interface

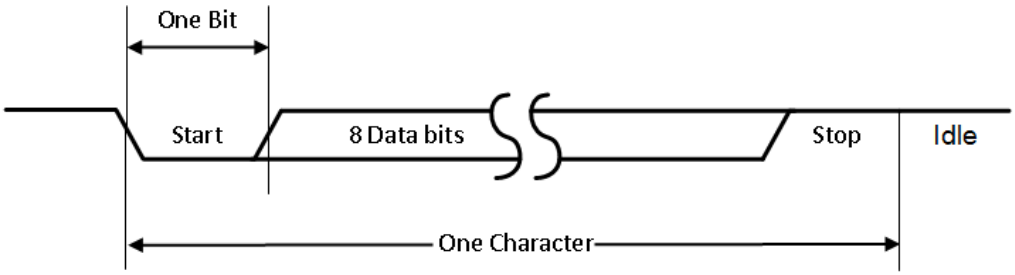
The coexistence interface includes a Mobile Wireless System (MWS) transport controller to accommodate a 2-wire, UART-based serial transport interface. This interface is a standard full-duplex UART (TXD and RXD) carrying logical signals framed as UART characters. In addition, it allows support of multiple 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 • Programmable decision policies and transaction lock behavior for various use cases • Interface with external or on-chip Bluetooth device • Support Bluetooth 1.1 or Bluetooth 1.2 AFH • WLAN-/Bluetooth-coordinated low-power design • Enhanced information sharing between WLAN and Bluetooth for combo systems • WLAN/Bluetooth/MWS (LTE/ZigBee) coexistence support
Arbitration	• Contention resolved by a customizable decision matrix that allows independent grant decision for each device • Vectors for the decision matrix: – WLAN priority (2-bit) – WLAN direction – Bluetooth priority (1- or 2-bit) – Bluetooth direction – Bluetooth frequency in/out band – MWS priority (2-bit) – 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. 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: – WLAN TX and Bluetooth TX – WLAN TX and Bluetooth RX – WLAN RX and Bluetooth TX – WLAN RX and Bluetooth RX Interference combinations where WLAN and Bluetooth share the same antenna: – 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. – 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. – 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. – WLAN RX and Bluetooth RX (both OOB and IB) have no impact on each other, the decision matrix grants both. Interference combinations where WLAN and Bluetooth have their own antenna: – WLAN TX and Bluetooth TX in OOB situation have little interference impact on each other, the decision matrix grants both. – 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. – 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. – 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. – 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. – 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. – WLAN RX and Bluetooth RX (both OOB and IB) have no impact on each other, the decision matrix grants both. For the devices running in a basic shared antenna configuration, the linear switching imposes restrictions on simultaneous transfer. Reasonable policies include: – WLAN and Bluetooth are never granted at the same time – Decision matrix grants a device based on relative packet priorities and direction – Priority order: High > Medium High > Medium > Low – For equal priority contention, select one device to win, that optimizes the usage case 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: • Selection of certain types of communication always treated as high priority • Selection of individual frames marked with high priority • Real-time signaling of the next slot marked with high priority • 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: • Packet-based request signaling with direction and priority information • 1- or 2-bit priority signaling to support 4 priority levels • Multiple WLAN RX request trigger sources, including early prediction • WLAN TX request cancellation and abort if grant denied or revoked in middle of request • 802.11n A-MPDU treated as single packet
Packet Classification	• Programmable mask allows each frame type to be mapped to a priority • Default setting puts response frames (ACK), beacons, and QoS frames as high priority • WLAN TX and RX have separate priority mask
Queue Classification	• Programmable mask allows each transmit queue to be mapped to a priority • 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) • 802.11b data rates 5.5 and 11 Mbps (CCK) • 802.11a/g data rates 6, 9, 12, 18, 24, 36, 48, and 54 Mbps (OFDM) • 802.11b/g performance enhancements • 802.11n with maximum data rates up to 72 Mbps (20 MHz channel) and 150 Mbps (40 MHz channel) • 802.11e quality of service (QoS) • 802.11h transmit power control • 802.11h DFS radar pulse detection • 802.11i enhanced security (WEP, WPA, WPA2) • 802.11k radio resource measurement • 802.11mc precise indoor location and navigation • 802.11n block acknowledgment extension • 802.11r fast hand-off for AP roaming • 802.11u Hotspot 2.0 (STA mode only) • 802.11v TIM frame transmission/reception • 802.11w protected management frames • Support clients (stations) implementing IEEE Power Save mode
WLAN MAC	• Frame exchange at the MAC level to deliver data • Received frame filtering and validation (CRC) • Generation of MAC header and trailer information (MPDUs) • Fragmentation of data frames (MSDUs) • Access mechanism support for fair access to shared wireless medium through: – Distributed Coordination Function (DCF) – Enhanced Distributed Channel Access (EDCA) • A-MPDU aggregation/de-aggregation • 20/40 MHz channel coexistence • RIFS burst receive • Management information base • Radio resource measurement • Quality of service • Block acknowledgement • Dynamic frequency selection • TIM frame TX and RX • Multiple BSS/Station • Transmit rate adaption • Transmit power control

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

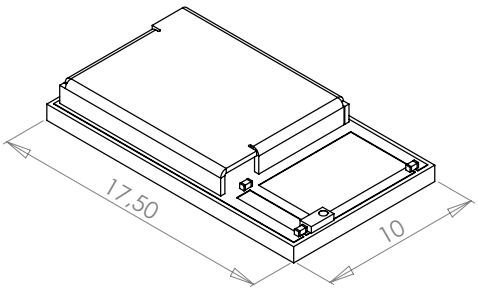
Type	Features
General	• Supports Bluetooth 5.0 • Shared Tx/Rx path for Bluetooth • Digital Audio Interface including PCM interface for voice application • Bluetooth and WLAN coexistence • WLAN/Bluetooth Coexistence (BCA) protocol support
Bluetooth Classic (BR/EDR)	• Bluetooth Classic with BT Class 1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

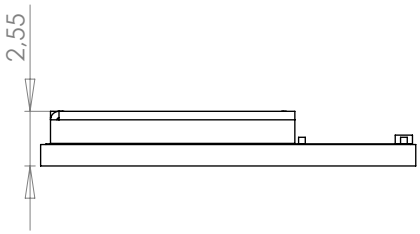
Type	Features
Bluetooth Low Energy (LE)	• Broadcaster, Observer, Central, and Peripheral roles • Supports link layer topology to be master and slave (connects up to 16 links) • Shared RF with BR/EDR • Encryption AES support • Hardware support for intelligent Adaptive Frequency Hopping (AFH) • LE Privacy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

3 Detailed Description

3.1 Dimensions

All dimensions are in millimeters.



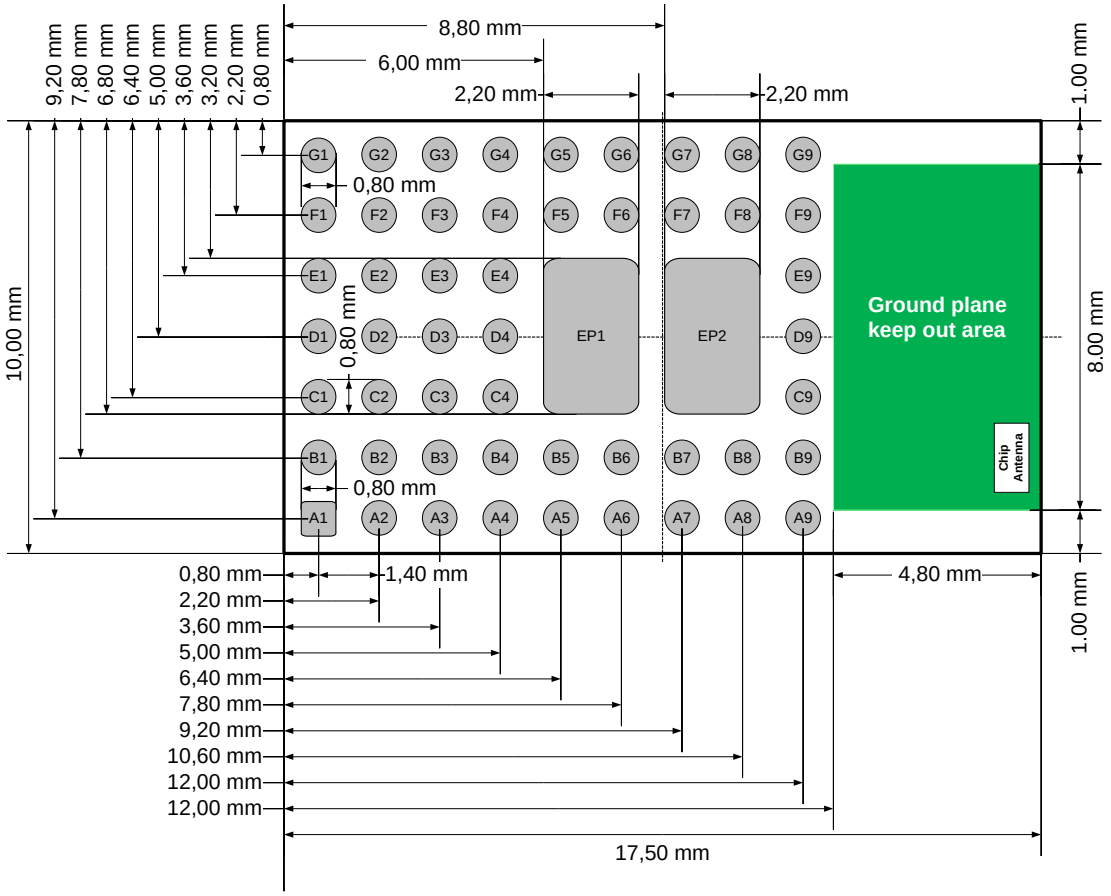


No.	Item	Dimension	Tolerance	Remark
1	Width	10.00	± 0.35	
2	Length	17.50	± 0.35	
3	Height	2.55	± 0.20	with case

3.2 Footprint

The outer dimensions have a tolerance of ± 0.35 mm.

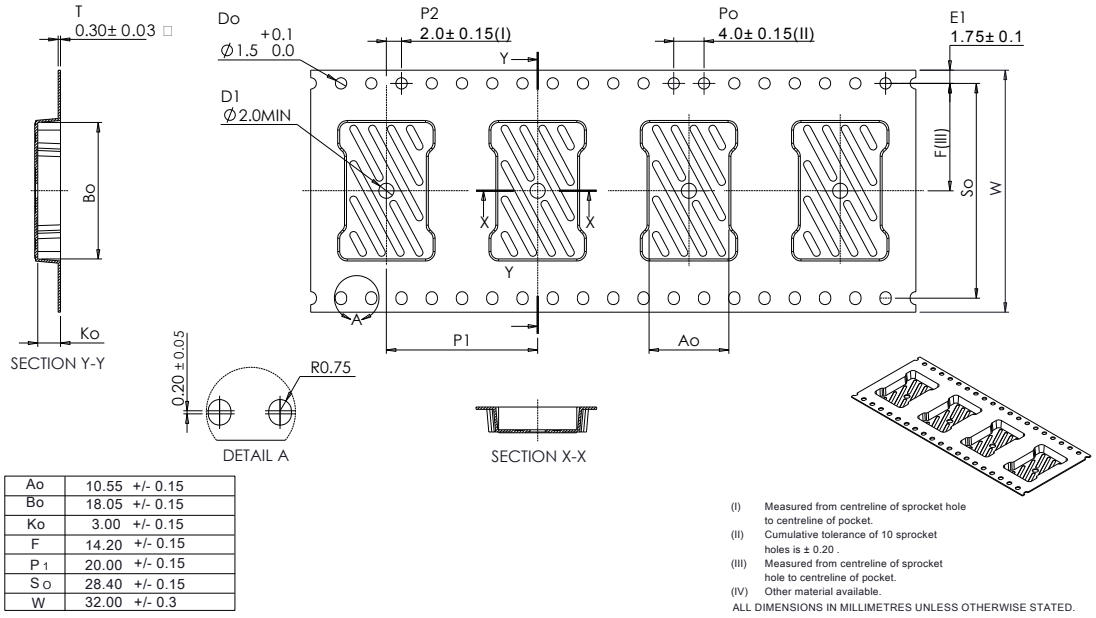
Top View



3.3 Packaging

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

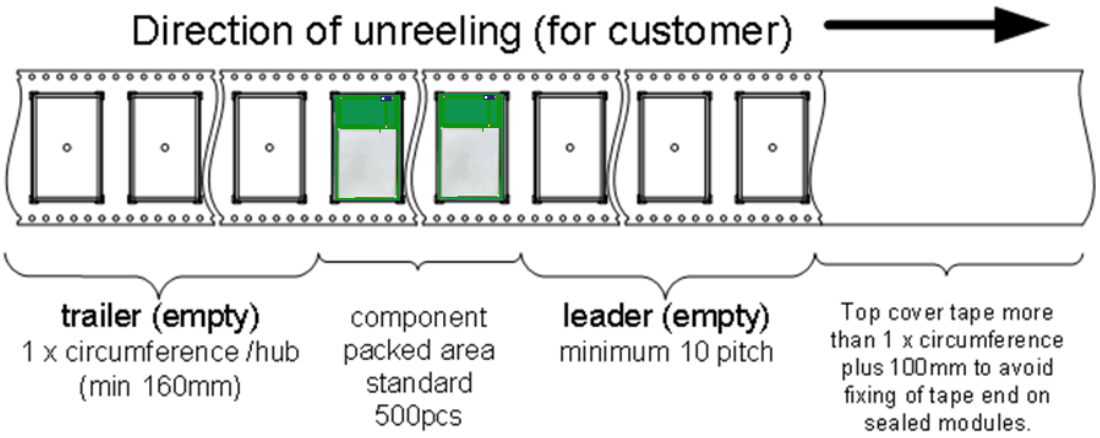
3.3.1 Tape Dimensions



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.

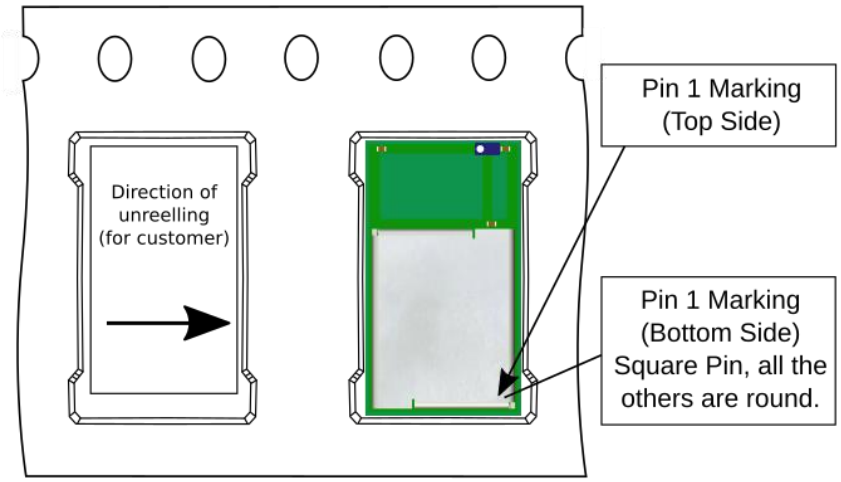
3.3.2 Packing in Tape



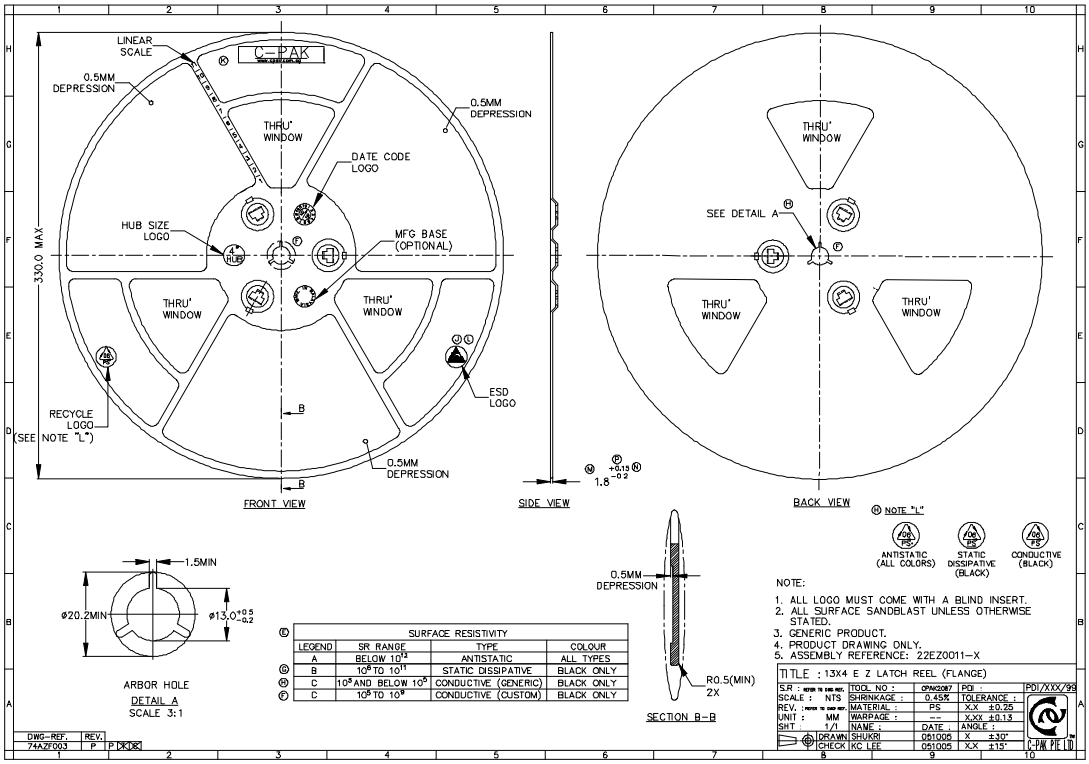
Empty spaces in the component packed area shall be less than two per reel and those spaces shall not be consecutive.

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

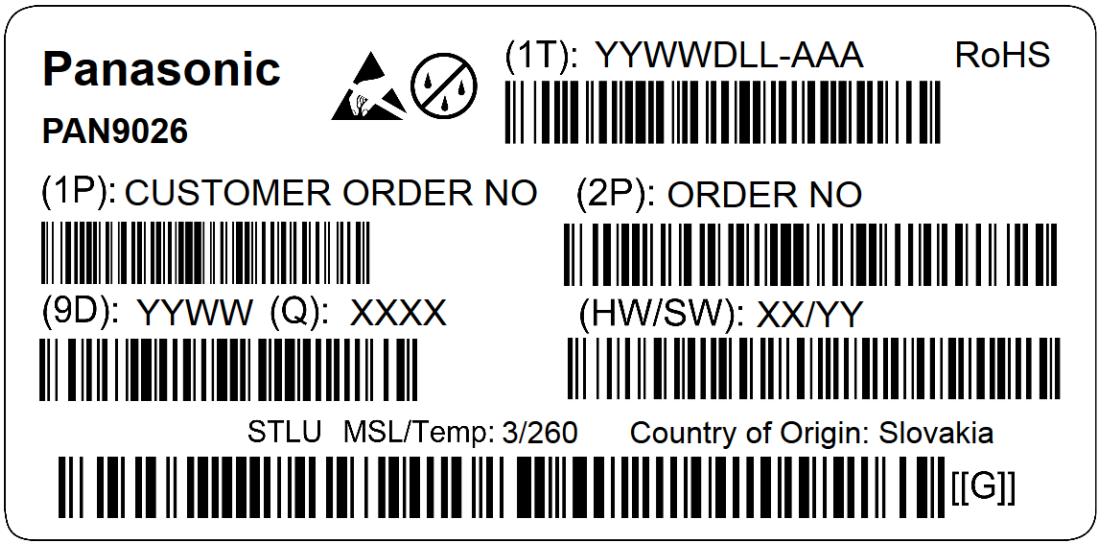


3.3.4 Reel Dimension



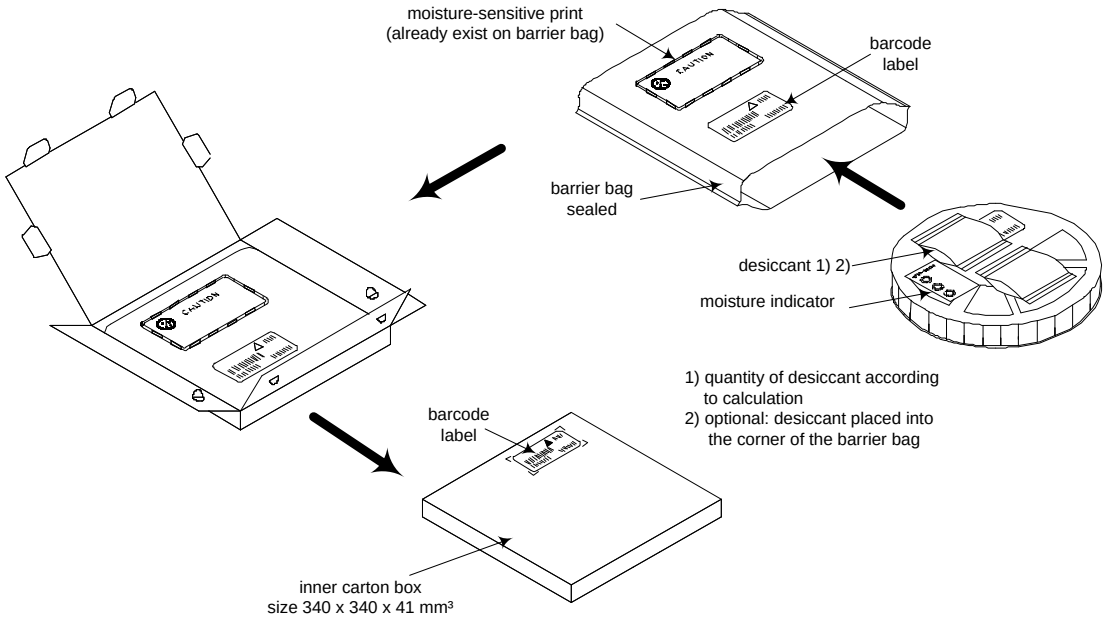
3.3.5 Package Label

Example



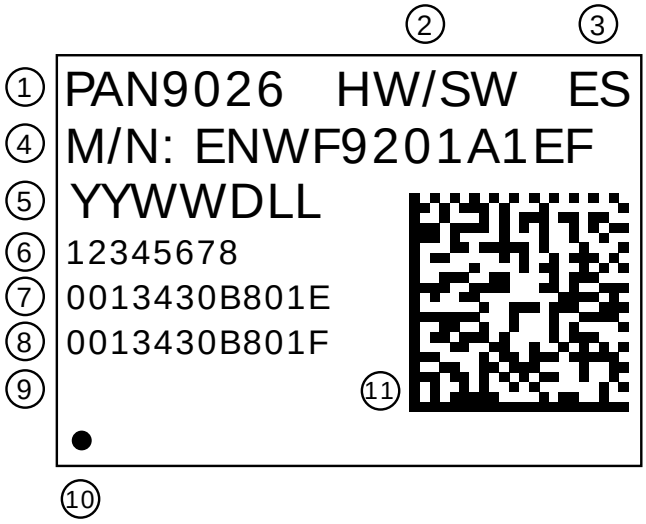
(1T)	Lot code
(1P)	Customer order number, if applicable
(2P)	Order number
(9D)	Date code
(Q)	Quantity
(HW/SW)	Hardware/software version

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

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 100 ms (Average[15])		2		mA
$I_{VDD2V2 @ IEEE-PS}$				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.

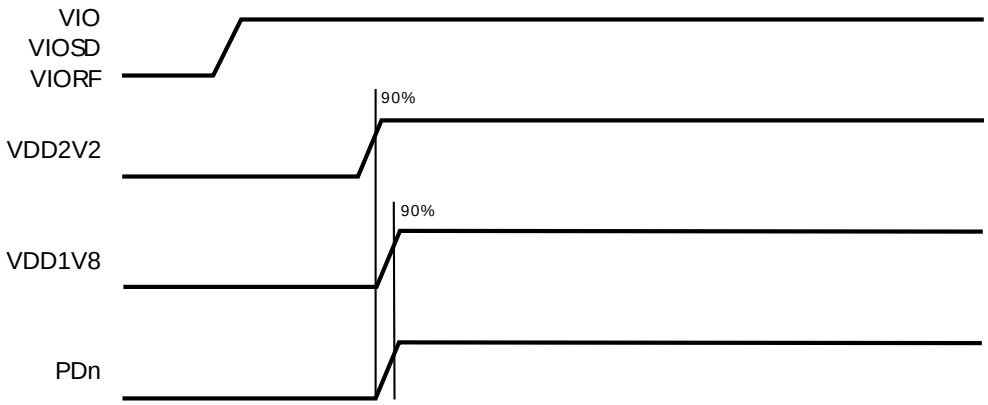
[14] In IEEE Power Save the device automatically wakes up on beacons. If it is a DTIM value of 1 along with a beacon interval of 100 ms, the device wakes up every 100 ms.

[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

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

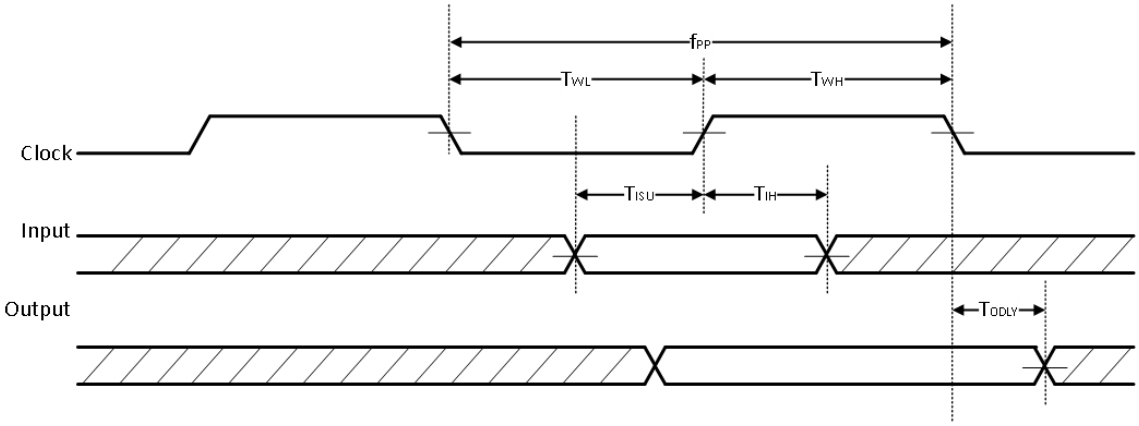
SDIO Timing Data – Default and High-Speed Modes (VIOSD 3.3 V)[16,17]

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 ≤ 40 pF (1 card)	High-speed			14	ns
T_{OH}	Output hold time	High-speed	2.5			ns

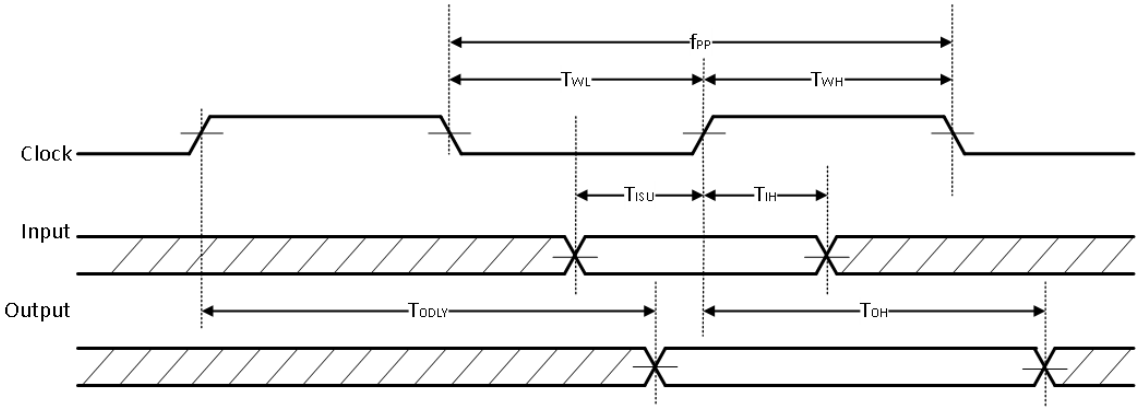
[16] For SDIO 2.0 running at 50 MHz clock frequency, a supply voltage VIOSD of 1.8 V is recommended.

[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)



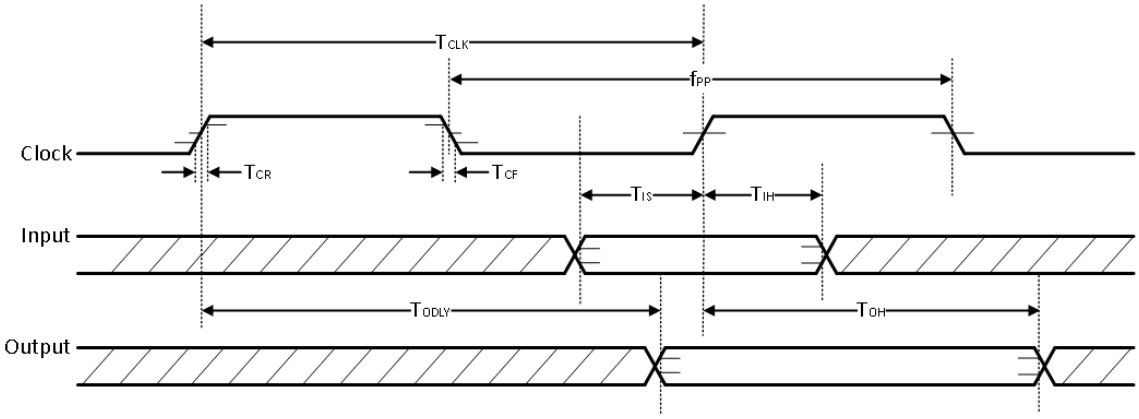
SDIO Protocol Timing Diagram – High-Speed Mode (VIOSD 3.3 V)



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 ≤ 30 pF	SDR12/SDR25/ SDR50			7.5	ns
T_{OH}	Output hold time CL = 15 pF	SDR12/SDR25/ SDR50	1.5			ns

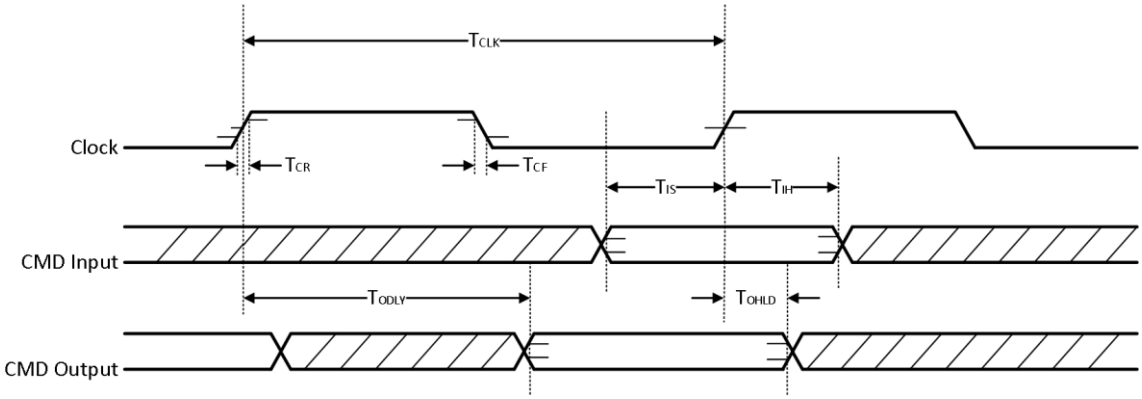
SDIO Protocol Timing Diagram – SDR12, SDR25, SDR50 Modes (VIOSD 1.8 V)



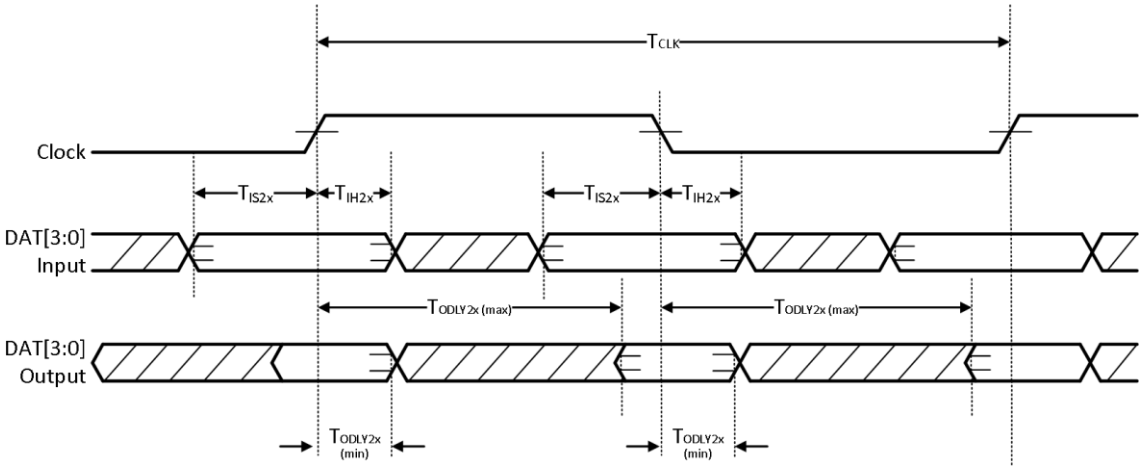
SDIO Timing Data – DDR50 Mode (VIOSD 1.8 V)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Units
Clock						
T_{CLK}	Clock time 50 MHz (max) between rising edges	DDR50	20			ns
T_{CR}, T_{CF}	Rise time, fall time T_{CR}, T_{CF} < 4.00 ns (max) at 50 MHz, 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 $C_{CARD} \leq$ 10 pF (1 card)	DDR50	6			ns
T_{IH}	Input hold time $C_{CARD} \leq$ 10 pF (1 card)	DDR50	0.8			ns
CMD Output (referenced to clock rising edge)						
T_{ODLY}	Output delay time during data transfer mode $C_L \leq$ 30 pF (1 card)	DDR50			13.7	ns
T_{OHLD}	Output hold time $C_L \geq$ 15 pF (1 card)	DDR50	1.5			ns
DAT[3:0] Input (referenced to clock rising and falling edge)						
T_{IS2x}	Input setup time $C_{CARD} \leq$ 10 pF (1 card)	DDR50	3			ns
T_{IH2x}	Input hold time $C_{CARD} \leq$ 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 $C_L \leq$ 25 pF (1 card)	DDR50			7	ns
T_{ODLY2x} (min)	Output hold time $C_L \geq$ 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

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)

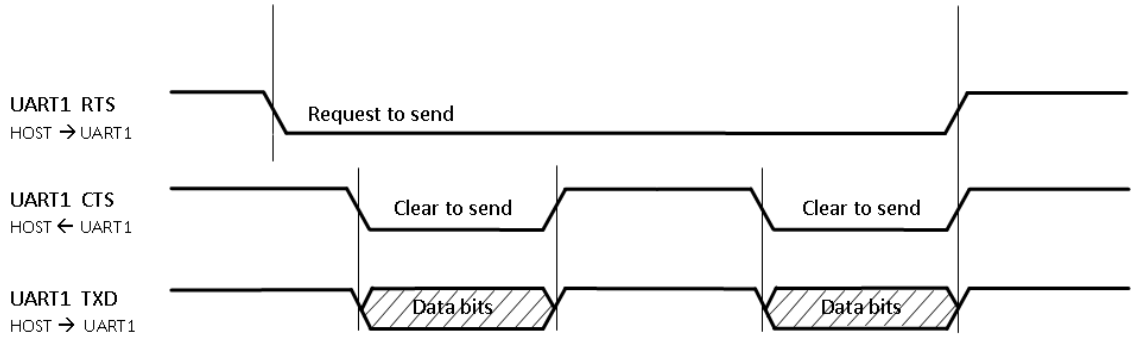
Interface Transport Settings

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.

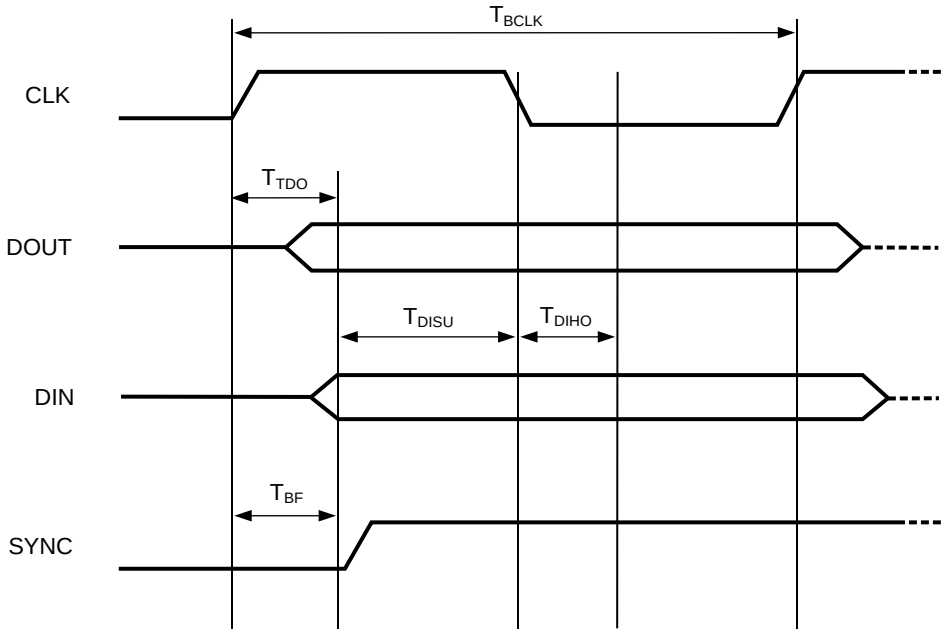
When in PCM slave mode, the interface has both PCM_CLK and PCM_SYNC as inputs, thereby letting another unit on the PCM bus generate the signals.

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

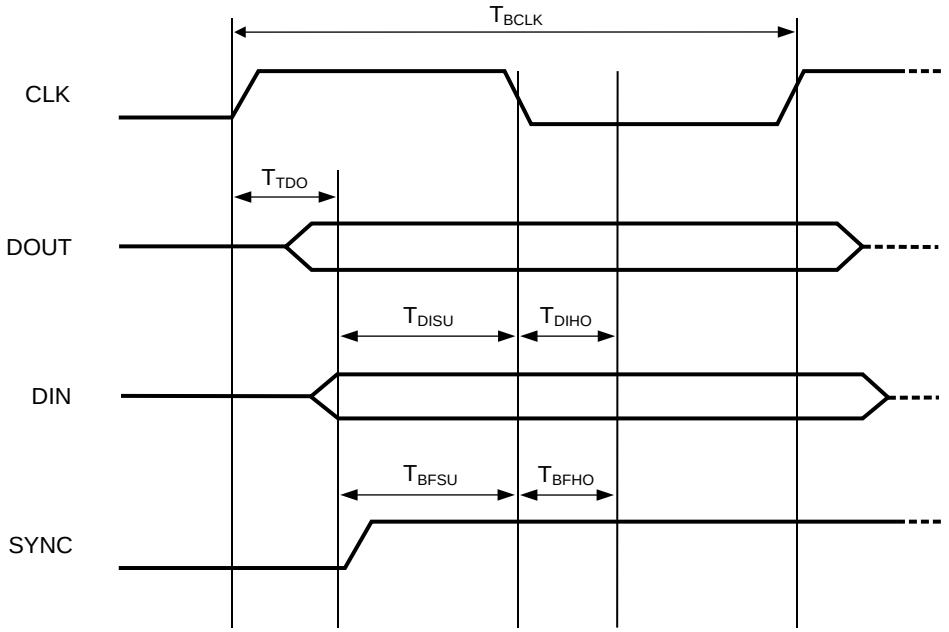
PCM Timing Diagram – Master Mode



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

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

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				+16		dBm
Spectrum mask	f_C ± 11 MHz				-30	dBr
	f_C ± 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 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			+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				-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)

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)

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)

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 ± 21 MHz				-20	dBr
	f_C ± 40 MHz				-28	dBr
	f_C ± 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

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 ± 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 %		-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) Interfering Signal Power	GFSK RSL = -67 dBm 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) Interfering Signal Power	GFSK RSL = -67 dBm 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

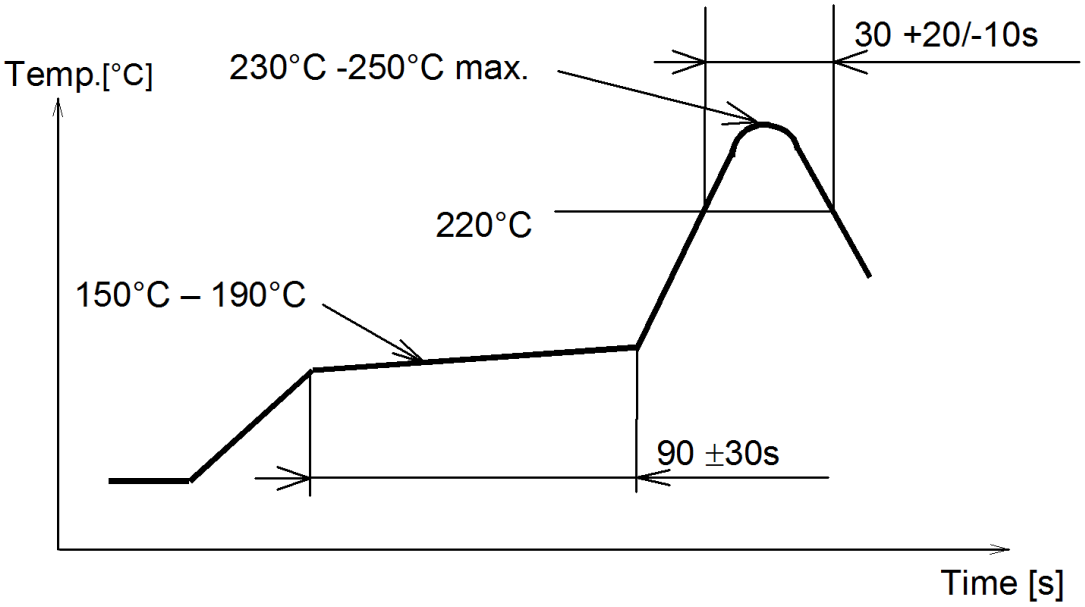
4.5 Reliability Tests

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

- 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



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