Panasonic
INDUSTRY

PAN9019

Wi-Fi 6 Dual Band 2.4 GHz/5 GHz and Bluetooth® Module

Product Specification

Rev. 1.0



Wireless Connectivity

Overview

The PAN9019 is a 2.4 GHz and 5 GHz ISM band Wi-Fi and Bluetooth radio module, which allows the easy integration of Wi-Fi and Bluetooth based technologies into various electronic devices.

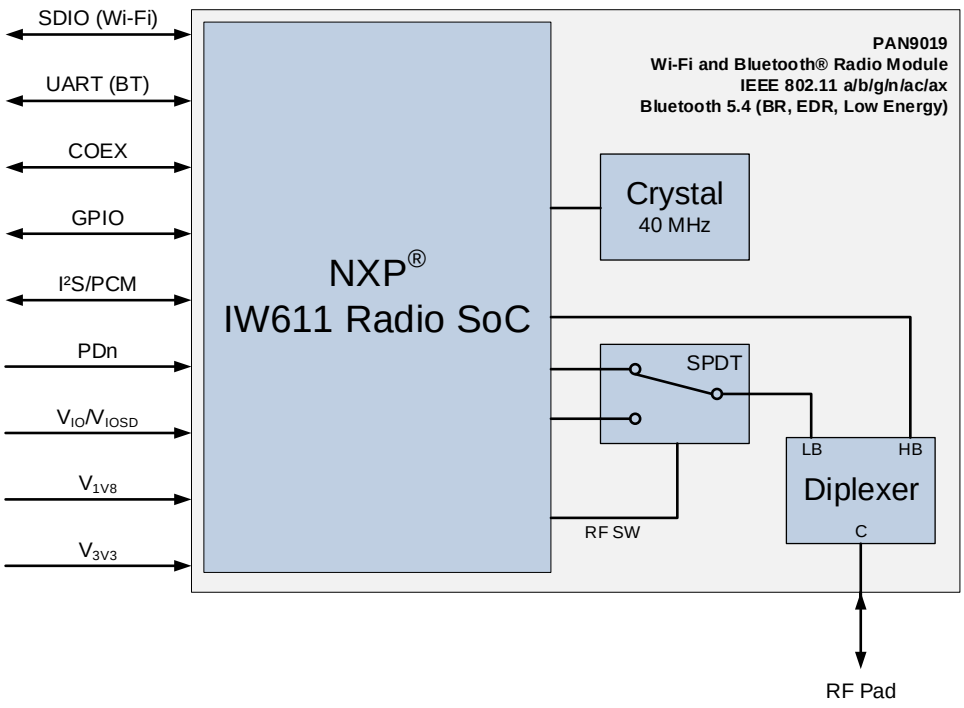
Features

- Dual band 2.4 GHz and 5 GHz 802.11 a/b/g/n/ac/ax Wi-Fi and Bluetooth combo module
- Supports WPA3 personal and enterprise security
- Authenticated and secured boot
- 802.11e Quality of Service is supported for multimedia application
- IEEE 802.11ax, 1×1 spatial stream with data rates up to 600 Mbps (MCS11, 80 MHz channel bandwidth)
- OFDMA (UL/DL) and MU-MIMO (UL/DL)
- Bluetooth 5.4
- WCI-2 and 5-wire PTA coexistence interfaces
- Generic interfaces include SDIO 3.0 and high-speed UART for host processor connection
- OS driver support for RTOS, Linux®, and Android®

Characteristics

- Surface Mount Type (SMT): 15.3 mm × 12 mm × 2.5 mm
- NXP® IW611 WLAN 2.4 GHz and 5 GHz and Bluetooth single-chip solution inside
- Rx sensitivity: -98 dBm at IEEE 802.11b 1 Mbps
- IEEE 802.11ax 20 MHz, 40 MHz, 80 MHz channel bandwidth
- Power supply: 1.8 V and 3.3 V
- SDIO 1 bit or 4 bit
- Wide temperature range: -40 °C to 85 °C

Block Diagram



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Information on Software

The PAN9019 module does not contain any software ex works, i.e. software is provided by 3rd party suppliers only. The essential software resources can be found on the partner website of NXP Seminconductors https://www.nxp.com/.

PIDEU provides a factory software programming service for your customized firmware; for further information please reach out to your local sales contact this regarding ⇨ 7.3.1 Contact Us.

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1 About This Document

1.1 Purpose and Audience

This Product Specification provides details on the functional, operational, and electrical characteristics of the Panasonic PAN9019 module. It is intended for hardware design, application, and Original Equipment Manufacturers (OEM) engineers.

The product is referred to as “PAN9019” and “module” within this document.

1.2 Revision History

Revision	Date	Modifications/Remarks
0.1	2023-05-12	Preliminary version
1.0	2024-05-24	Added secured boot to Feature overview Change “WPA3” → “WPA3 personal and enterprise” in the Feature overview Slight changes ⇨ 2 Overview Added ⇨ 2.4 Audio-Interfaces Added ⇨ 2.5 Coexistence Added ⇨ 4.5 Interfaces Added ⇨ 7.1 Channels and Power Settings per Country Updated tables ⇨ 4.6 RF Electrical Characteristics Added content ⇨ 6 Regulatory and Certification Information Changed Bluetooth 5.2 → Bluetooth 5.4 Added ⇨ 3.3.6 Regulatory Label Added ⇨ 3.5 Labelling of M.2 Cards Added order numbers of M.2 cards ⇨ 7.2 Ordering Information Added data rates and supported RUs for 11ax OFDMA and Extended Range ⇨ 4.6.1 WLAN Radio Specification Added LE PHY data rates ⇨ 2.7 Bluetooth Features Updated disclaimer: added “Information on Software” Added certification overview ⇨ 6 Regulatory and Certification Information Updated article for Safety/Health ⇨ 6.3 Conformity According to Radio Equipment Directive (RED-2014/53/EU) for Europe ⇨ 6.4 United Kingdom Conformity According to Statutory Instrument (SI-2017/1206) ⇨ 6.6 Conformity According to Regulatory Compliance Mark (RCM) for New Zealand and Australia

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

For related documents please refer to the Panasonic website ⇨ 7.3.2 Product Information.

2 Overview

The PAN9019 is a dual band 2.4 GHz and 5 GHz 802.11 a/b/g/n/ac/ax Wi-Fi radio module with integrated Bluetooth Basic Rate (BR) / Enhanced Data Rate (EDR) / Low Energy (LE), specifically designed for highly integrated and cost effective applications. The independent operation of the two standards enables 802.11ax data rates with High Efficiency (HE) and low-power operation (Bluetooth LE).

Latest technologies like multiuser MIMO and OFDMA improve the efficiency in large networks, while the 1024 QAM modulation allows high data rates. Integrated power management, a fast dual core CPU, 802.11i/w security standard support, and high-speed data interfaces deliver the performance for the speed, reliability, and quality requirements of next generation products.

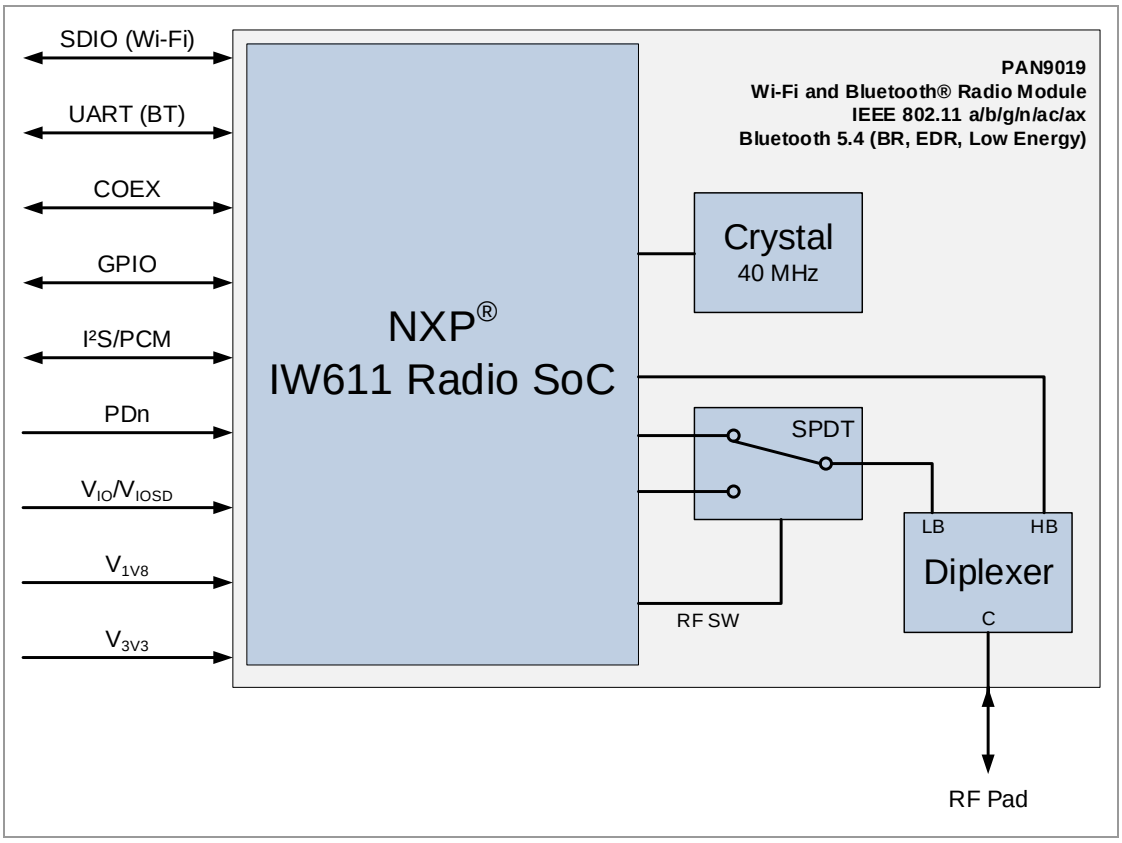
Tx power calibration data and Wi-Fi/Bluetooth system parameters are pre stored on the one-time-programmable memory of the PAN9019 during production at Panasonic. Thus, the module reduces design, test, and calibration effort resulting in reduced time to market compared to discrete solutions.

Integrating Wi-Fi and Bluetooth wireless connectivity allows high throughput applications for industrial devices and appliances. The combination of Wi-Fi and Bluetooth provides the highest flexibility for connectivity.

For related documents please refer to ⇨ 7.3.2 Product Information.

For further information on the variants and versions please refer to ⇨ 7.2 Ordering Information.

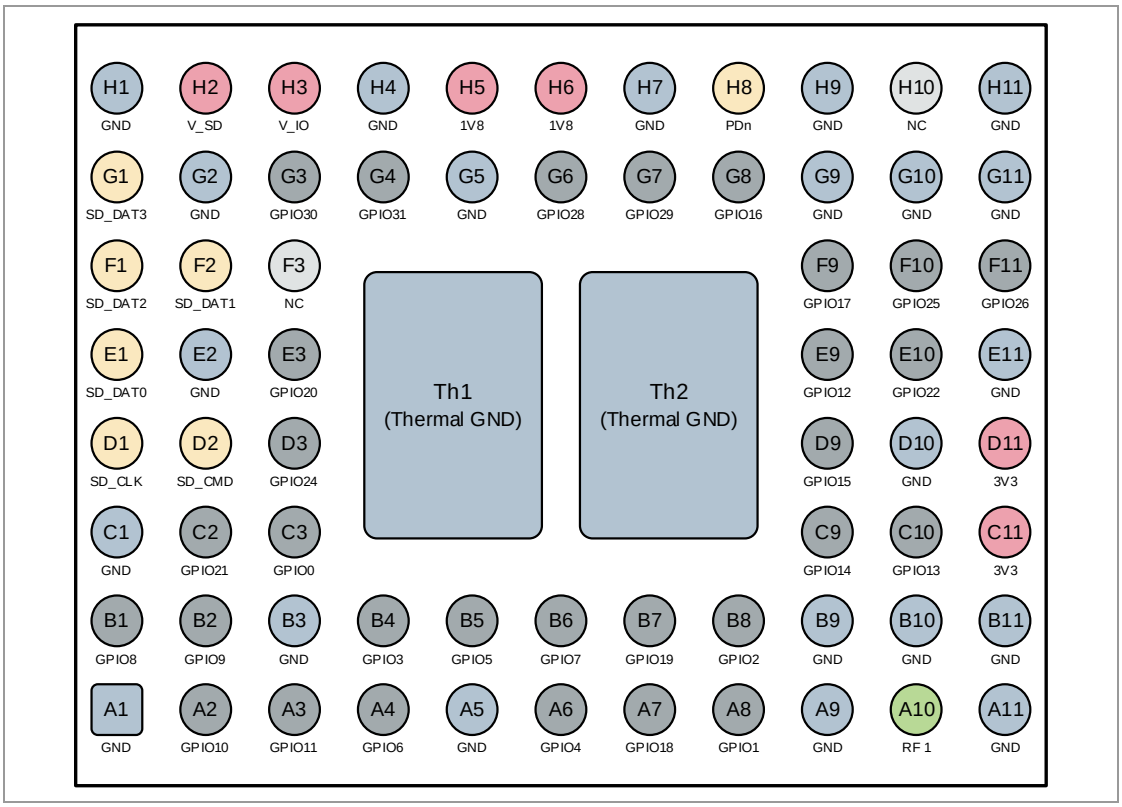
2.1 Block Diagram



2.2 Pin Configuration

Pin Assignment

Top View



Pin Functions

No.	Pin Name	Pin Type	Description
A1	GND	Ground Pin	Connect to ground
A2	GPIO10	Digital I/O	General Purpose I/O GPIO[10]
	UART_RX	Digital Input	UART data input from the host controller
A3	GPIO11	Digital I/O	General Purpose I/O GPIO[11]
	UART_TX	Digital Output	UART data output to the host controller
A4	GPIO6	Digital I/O	General Purpose I/O GPIO[6]
	PCM_DIN	Digital Input	PCM data input
	I2S_DIN	Digital Input	I²S data input
A5	GND	Ground Pin	Connect to ground
A6	GPIO4	Digital I/O	General Purpose I/O GPIO[4]
	PCM_CLK	Digital I/O	PCM clock

No.	Pin Name	Pin Type	Description
	I2S_BCLK	Digital I/O	I²S bit clock
A7	GPIO18	Digital I/O	General Purpose I/O GPIO[18]
	BT_WAKE_IN	Digital Input	Bluetooth wake-up input
A8	GPIO1	Digital I/O	General Purpose I/O GPIO[1]
	IND_RST_WL	Digital Input	Independent reset of the Wi-Fi subsystem
A9	GND	Ground Pin	Connect to ground
A10	RF1	Analog	RF bottom pad
A11	GND	Ground Pin	Connect to ground
B1	GPIO8	Digital I/O	General Purpose I/O GPIO[8]
	UART_CTS	Digital Input	UART clear-to-send input from the host controller
B2	GPIO9	Digital I/O	General Purpose I/O GPIO[9]
	UART_RTS	Digital Output	UART request-to-send output to the host controller
B3	GND	Ground Pin	Connect to ground
B4	GPIO3	Digital I/O	General Purpose I/O GPIO[3]
	PCM_MCLK	Digital Output	PCM codec main clock
	I2S_CCLK	Digital Output	I²S codec main clock
B5	GPIO5	Digital I/O	General Purpose I/O GPIO[5]
	PCM_DOUT	Digital Output	PCM data output
	I2S_DOUT	Digital Output	I²S data output
B6	GPIO7	Digital I/O	General Purpose I/O GPIO[7]
	PCM_SYNC	Digital I/O	PCM synchronization pulse signal
	I2S_LRCLK	Digital I/O	I²S audio left-right clock
B7	GPIO19	Digital I/O	General Purpose I/O GPIO[19]
	BT_WAKE_OUT	Digital Output	Bluetooth wake-up output (wake-on-Bluetooth)
B8	GPIO2	Digital I/O	General Purpose I/O GPIO[2]
	IND_RST_BT	Digital Input	Independent reset of the Bluetooth subsystem
B9	GND	Ground Pin	Connect to ground
B10	GND	Ground Pin	Connect to ground
B11	GND	Ground Pin	Connect to ground
C1	GND	Ground Pin	Connect to ground
C2	GPIO21	Digital I/O	General Purpose I/O GPIO[21]
	SD_INT	Digital Output	SDIO interrupt output signal
C3	GPIO0	Digital I/O	General Purpose I/O GPIO[0]

No.	Pin Name	Pin Type	Description
	XOSC_EN	Digital Output	Oscillator enable output
C9	GPIO14	Digital I/O	General Purpose I/O GPIO[14]
	EXT_GNT	Digital Output	PTA external radio grant output
C10	GPIO13	Digital I/O	General Purpose I/O GPIO[13]
	EXT_REQ	Digital Input	PTA external radio request input
C11	3V3	Power Supply	Connect to 3.3 V
D1	SD_CLK	Digital I/O	SDIO clock signal
D2	SD_CMD	Digital I/O	SDIO command signal
D3	GPIO24	Digital I/O	General Purpose I/O GPIO[24]
D9	GPIO15	Digital I/O	General Purpose I/O GPIO[15]
	EXT_PRI	Digital Input	PTA external radio priority input
D10	GND	Ground Pin	Connect to ground
D11	3V3	Power Supply	Connect to 3.3 V
E1	SD_DAT0	Digital I/O	SDIO data[0] signal
E2	GND	Ground Pin	Connect to ground
E3	GPIO20	Digital I/O	General Purpose I/O GPIO[20]
	EXT_FREQ	Digital Input	PTA external radio frequency input
E9	GPIO12	Digital I/O	General Purpose I/O GPIO[12]
	EXT_STATE	Digital Input	PTA external radio state input
E10	GPIO22	Digital I/O	General Purpose I/O GPIO[22]
E11	GND	Ground Pin	Connect to ground
F1	SD_DAT2	Digital I/O	SDIO data[2] signal
F2	SD_DAT1	Digital I/O	SDIO data[1] signal
F3	NC	NC	Do not connect
F9	GPIO17	Digital I/O	General Purpose I/O GPIO[17]
	WL_WAKE_OUT	Digital Output	Wi-Fi wake-up output (wake-on-wlan)
F10	GPIO25	Digital I/O	General Purpose I/O GPIO[25]
	WCI-2_SIN	Digital Input	WCI-2 serial data input
F11	GPIO26	Digital I/O	General Purpose I/O GPIO[26]
	WCI-2_SOUT	Digital Output	WCI-2 serial data output
G1	SD_DAT3	Digital I/O	SDIO data[3] signal
G2	GND	Ground Pin	Connect to ground
G3	GPIO30	Digital I/O	General Purpose I/O GPIO[30]

No.	Pin Name	Pin Type	Description
	JTAG_TDI	Digital Input	JTAG data input
G4	GPIO31	Digital I/O	General Purpose I/O GPIO[31]
	JTAG_TDO	Digital Output	JTAG data output
G5	GND	Ground Pin	Connect to ground
G6	GPIO28	Digital I/O	General Purpose I/O GPIO[28]
	JTAG_TCK	Digital Input	JTAG clock input
G7	GPIO29	Digital I/O	General Purpose I/O GPIO[29]
	JTAG_TMS	Digital Input	JTAG mode select input
G8	GPIO16	Digital I/O	General Purpose I/O GPIO[16]
	WL_WAKE_IN	Digital Input	Wi-Fi wake-up input
G9	GND	Ground Pin	Connect to ground
G10	GND	Ground Pin	Connect to ground
G11	GND	Ground Pin	Connect to ground
H1	GND	Ground Pin	Connect to ground
H2	V_{SD}	Power Supply	SD interface IO voltage Connect to 1.8 V or 3.3 V
H3	V_{IO}	Power Supply	IO voltage Connect to 1.8 V or 3.3 V
H4	GND	Ground Pin	Connect to ground
H5	1V8	Power Supply	Connect to 1.8 V
H6	1V8	Power Supply	Connect to 1.8 V
H7	GND	Ground Pin	Connect to ground
H8	PDn	Digital Input	Power down pin (active low)
H9	GND	Ground Pin	Connect to ground
H10	NC	NC	Do not connect or connect to GND
H11	GND	Ground Pin	Connect to ground
Th1	Thermal GND	Ground Pin	Connect to ground for heat dissipation
Th2	Thermal GND	Ground Pin	Connect to ground for heat dissipation

2.3 Host Interface

There are two major host interfaces to operate the PAN9019's radios. A SDIO interface is connected to the Wi-Fi sub-system's CPU, while a high-speed UART interface is the Bluetooth sub-system's major interface. Both can be operated independently.

Type	Features
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 208 MHz • Allows card to interrupt host
High-speed UART interface	The device supports a high-speed Universal Asynchronous Receiver/Transmitter (UART) interface. • Two pins for transmit and receive operations • Two flow control pins • Interrupt triggers for low-power, high throughput operation

SDIO Pin Assignment

Pin No.	Signal Name	Direction	Type	Description
D1	SD_CLK	Input	SDIO 3.0 Voltage Level: V_{SD}	SDIO clock signal
D2	SD_CMD	Output/Input		SDIO command 1-bit mode: command/response 4-bit mode: command
E1	SD_DAT0	Output/Input		Data line 0 1-bit mode: Data line 4-bit mode: Data bit [0]
F2	SD_DAT1	Output/Input		Data line 1 1-bit mode: Interrupt 4-bit mode: Data bit [1]
F1	SD_DAT2	Output/Input		Data line 2 1-bit mode: Read wait (optional) 4-bit mode: Data bit [2]
G1	SD_DAT3	Output/Input		Data line 3 1-bit mode: Reserved 4-bit mode: Data bit [3]

UART Pin Assignment

Pin No.	Signal Name	Direction	Type	Description
A3	UART_TX	Output	Host Controller Interface (HCI) Voltage Level: V_{IO}	Transmit data output to host
A2	UART_RX	Input		Receive data input from host
B2	UART_RTS	Output		Request to send (active low) to host
B1	UART_CTS	Input		Clear to send (active low) from host

For further information please refer to ⇨ 4.5.1 Host Interface.

2.4 Audio-Interfaces

The PAN9019 provides two audio interfaces that can be used to receive audio data from the Bluetooth sub-system and directly transmit it to an audio codec or vice-versa. These are an Inter IC Sound (I²S) and a Pulse Coded Modulation (PCM) interface. The configuration of the audio interfaces is done via vendor specific Host Controller Interface (HCI) commands.

The I²S and PCM audio interfaces can be used for speech over Bluetooth applications like the Hands Free Profile (HFP).

2.4.1 I²S Interface

The device supports an Inter IC Sound (I²S) interface for audio transmission and reception.

Type	Features
I²S Interface	• Central (master) or peripheral (slave) mode • I²S (Inter-IC Sound) interface for audio data connection to Analog-to-Digital Converters (ADC) and Digital-to-Analog Converters (DAC) • 3-state I²S interface capability • Supports clock speeds of 4.096 MHz, 2.048 MHz, and 2 MHz

The I²S interface can be connected via following pins. Please see ⇨ 2.2 Pin Configuration for information on the pin location and alternative pin functions. Please note that the I²S pins are shared with the PCM pins.

Pin No.	Signal Name	Direction	Voltage Level	Description
B4	I2S_CCLK	Output	V_{IO}	I²S codec main clock signal (optional). Optional clock used for some codecs. Derived from I2S_BCLK.
A4	I2S_DIN	Input	V_{IO}	I²S data from audio codec to PAN9019
B5	I2S_DOUT	Output	V_{IO}	I²S data from PAN9019 to audio codec

Pin No.	Signal Name	Direction	Voltage Level	Description
A6	I2S_BCLK	Output/Input	V_{IO}	I²S audio bit clock: • Central mode: Output • Peripheral mode: Input
B6	I2S_LRCLK	Output/Input	V_{IO}	I²S audio left-right clock: • Central mode: Output • Peripheral mode: Input

Please refer to ⇨ 4.5.2.1 I²S Interface for specifications.

2.4.2 PCM Interface

The device supports a Pulse Code Modulation (PCM) interface for audio transmission and reception.

Type	Features
PCM Interface	• Central (master) or peripheral (slave) mode • PCM bit width size of 8 bits or 16 bits • Up to four slots with configurable bit width and start positions • 3-state PCM interface capability • PCM short frame and long frame synchronization • Supports clock speeds of 4.096 MHz, 2.048 MHz, and 2 MHz

The PCM interface can be connected via following pins. Please see ⇨ 2.2 Pin Configuration for information on the pin location and alternative pin functions. Please note that the PCM pins are shared with the I²S pins.

Pin No.	Signal Name	Direction	Voltage Level	Description
B5	PCM_DOUT	Output	V_{IO}	PCM data from PAN9019 to audio codec
A6	PCM_CLK	Output/Input	V_{IO}	PCM clock signal • Central mode: Output • Peripheral mode: Input
B4	PCM_MCLK	Output	V_{IO}	PCM codec main clock signal (optional). Optional clock used for some codecs, derived from PCM_CLK
A4	PCM_DIN	Input	V_{IO}	PCM data from audio codec to PAN9019
B6	PCM_SYNC	Output/Input	V_{IO}	PCM sync pulse signal • Central mode: Output • Peripheral mode: Input

Please refer to ⇨ 4.5.2.2 PCM Interface for specifications.

2.5 Coexistence

The coexistence of the Wi-Fi and Bluetooth radio inside the PAN9019 is managed by the central hardware Packet Traffic Arbiter (PTA). It interfaces with the internal radios and controls the internal RF switches. Following table shows which operations can be performed simultaneously during one arbitration time slot. The PTA arbitrates the listed scenarios automatically.

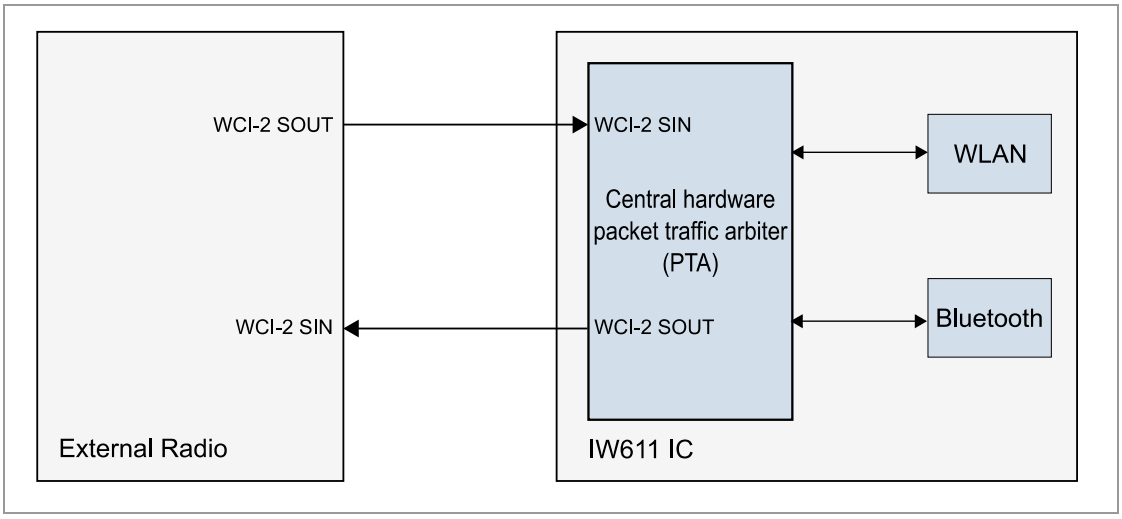
Scenario Enumeration	Bluetooth	Wi-Fi 2.4 GHz	Wi-Fi 5 GHz
1	TX	-	TX or RX
2	-	TX	-
3	RX	RX	-
3	RX	-	TX or RX

In addition to the internal radios, the PTA can operate one external radio. There are two interfaces for the coexistence with an external radio. The first is a WCI-2 interface following the specifications of the Bluetooth Special Interest Group (Bluetooth SIG) Core Specification Volume 7 (Wireless Coexistence Volume). As a second option, the PTA external interface can be used. Both are described in the following.

2.5.1 WCI-2 External Coexistence Interface

Based on the Bluetooth SIG 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) device.

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.



An external MWS can be connected to pins F10 and F11 of the PAN9019. Please see ⇨ 2.2 Pin Configuration for information on the pin location and alternative pin functions.

Pin No.	Signal Name	Direction	Voltage Level	Description
F10	WCI-2_SIN	Input	V_{IO}	Serial data from external radio
F11	WCI-2_SOUT	Output	V_{IO}	Serial data to external radio

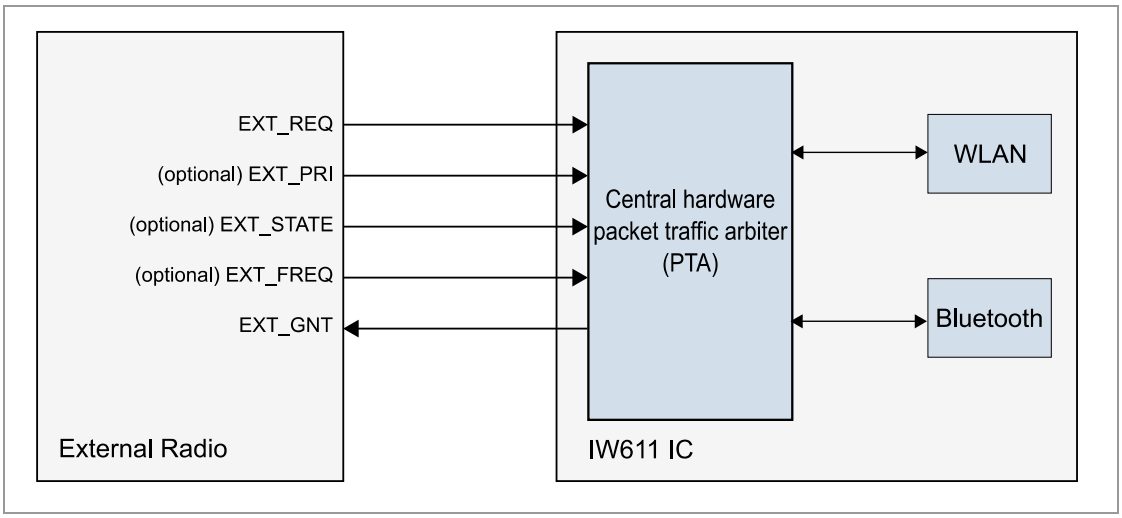
Specifications of the WCI-2 interface are documented in chapter ⇨ 4.5.3.1 WCI-2 Interface Specification. Moreover, the Bluetooth Core Specification describes the standard interface in Volume 7, Part A and Part C.

The WCI-2 interface is enabled via the mlan utility. Please use following command for enabling the interface. The default baud rate is 3 000 000.

```
./mlanutl mlan0 hostcmd config/robust_btc.conf
external_coex_uart_gpio_config
external_coex_uart_gpio_config={
  CmdCode=0x00e0
  Action:2=1                        // 0x0 get, 0x1 set
  RSVD:2=0
  RobustCoexTlvType:2=0x0238        // TLV ID
  RobustCoexTlvLength:2={
  Enabled:1=0x07                    // 0x08 disable, 0x07 enable
                                    // UART + GPIO feature
  ExtCoexHwIntWci2:1=0x01           // 0x00 disable, 0x01 enable
                                    // (coex uart interface)
 }
}
```

2.5.2 PTA External Coexistence Interface

An external radio can be connected to the PAN9019 PTA external interface to realize the coexistence management. The PTA external interface consists of five signals that directly connect with the central hardware Packet Traffic Arbiter PTA). Two of the five signal lines are mandatory: Request (EXT_REQ) and Grant (EXT_GNT). The remaining lines can be used to obtain additional information from the external radio.



An external radio can be connected to the pins listed in the table below. Please see ⇨ 2.2 Pin Configuration for further information on the pin location and alternative pin functions.

Pin No.	Signal Name	Direction	Voltage Level	Description
C10	EXT_REQ	Input	V_{IO}	Request from the external radio
D9	EXT PRI	Input	V_{IO}	(optional) External radio input priority signal
E9	EXT_STATE	Input	V_{IO}	(optional) External radio state input signal High: Tx; Low: Rx
E3	EXT_FREQ	Input	V_{IO}	(optional) External radio frequency input signal High: Overlap; Low: Non-overlap
C9	EXT_GNT	Output	V_{IO}	Grant signal to the external radio

Specifications of the PTA external interface are documented in chapter ⇨ 4.5.3.2 PTA External Interface Specification.

2.6 WLAN Features

Type	Features
IEEE 802.11/Standards	• 802.11 data rates: 1 Mbps and 2 Mbps (DSSS) • 802.11b data rates: 5.5 Mbps and 11 Mbps (CCK) • 802.11a/g data rates: 6 / 9 / 12 / 18 / 24 / 36 / 48 / 54 Mbps (OFDM) • 802.11n with maximum data rates: up to 72 Mbps (20 MHz channel) and 150 Mbps (40 MHz channel) • 802.11ac with maximum data rates: up to 86.7 Mbps (20 MHz channel), 200 Mbps (40 MHz channel) and 433 Mbps (80 MHz channel) • 802.11ax with maximum data rates: up to 143.4 Mbps (20 MHz channel), 286.8 Mbps (40 MHz channel) and 600.5 Mbps (80 MHz channel) • 802.11d operation in additional regulatory domains • 802.11az accurate ranging[1] • 802.11e quality of service • 802.11h transmit power control • 802.11h DFS radar pulse detection • 802.11k radio resource measurement • 802.11mc precise indoor location positioning[1] • 802.11r fast hand-off for AP roaming • 802.11v BTM frame transmission/reception • 802.11w protected management frames • 802.11y ECSA • 802.11z tunneled direct link setup • Fully supports clients (stations) implementing IEEE Power Save mode
WLAN MAC	• 802.11ax 1x1 MU-MIMO MAC • Trigger Frame Formats – Basic trigger frame – MU-BAR, MU-RTS, Beamforming Report Poll (BFRP), BSR Poll (BSRP) trigger variant – Trigger frame MAC padding • HE Variants of HT Control – Basic format – UL Power Headroom – Receive Operation Mode control subfield • HE MU Frame Exchange Sequences • MU Acknowledgment (ACK) • M-BA and C-BA variants in BA frames • MU-RTS/CTS procedures • Target Wait Time Scheduling • HE Dual-NAV • UL Carrier Sensing • Buffer Status Reports in response to BSRP trigger frames • Operating Mode Indication (OMI) • Multiple-BSS/Station

[1] This feature is supported by the hardware, but it can be only used, if the utilized NXP software package supports it.

Type	Features
	• A-MPDU Rx (de-aggregation) and Tx (aggregation) (supports single-MPDU A-MPDU) • Reduced Inter-Frame Spacing (RIFS) receive • Management information base counters • Radio resource measurement counters • Quality of service queues • Block acknowledgment extension • Dynamic Frequency Selection (DFS) • Long and short preamble generation on a frame-by-frame basis for 802.11b frames • Transmit rate adaptation • Transmit power control (TPC) • Mobile hotspot
WLAN Baseband	• 802.11ax 1x1 MU-MIMO baseband, backward compatible with 802.11ac/n/a/g/b technology • Bandwidth support – 20 MHz – 40 MHz – 80 MHz • Modulation and Coding Schemes (MCS) – 802.11ax: MCS0~11 – 802.11ac: MCS0~9 – 802.11n: MCS0~7 – Dual Sub-Carrier Modulation (DCM): MCS0 – BCC and LDPC coding • Frame Formats – 802.11ax HE_SU (Tx/Rx) – 802.11ax HE_MU (Rx) – 802.11ax HE_ER_SU (Tx/Rx) – 802.11ax HE_TB (Tx) – 802.11ac VHT – 802.11n HT – 802.11a (including duplicate/quadruplicate modes) – 802.11g (including duplicate mode) – 802.11b • Uplink MU-MIMO Tx as STA • Downlink MU-MIMO Rx as STA • 802.11ax/ac/n Explicit Beamformee: Supports sounding feedback for up to 4x4 Beamformer • Aggressive Packet Extension • Range Extension • Receiver Beam Change

Type	Features
	• Guard Interval Modes – 1× HE-LTF with 0.8 us GI – 1× HE-LTF with 1.6 us GI (for UL TB PPDU) – 2× HE-LTF with 0.8 us GI – 2× HE-LTF with 1.6 us GI – 4× HE-LTF with 3.2 us GI – 4× HE-LTF with 0.8 us GI • Dynamic Frequency Selection (DFS) (radar detection) • Optional 802.11ac and 802.11n MIMO features: – 20/40/80 MHz coexistence with middle-packet detection (GI detection) for enhanced CCA – LDPC transmission and reception for both 802.11ac and 802.11n – Short guard interval (0.4 us) – RIFS on receive path for 802.11n packets – VHT MU-PPDU (receive) • Spectral intelligence – Spectrum monitoring – DFS assist to reduce false detections – Interference identification/classification • Power save features
WLAN Radio and Frontend	• 5 GHz and 2.4 GHz Wi-Fi band operation • 802.11ax 1x1 MU-MIMO on-chip RF radio • Shared RF bottom pad for WLAN and Bluetooth
WLAN Encryption	• Supports WPA2 and WPA3 personal and enterprise • Data Frame Encryption/Decryption – Advanced Encryption Standard (AES)/Counter-Mode/CBC-MAC Protocol (CCMP) – Advanced Encryption Standard (AES)/Galois/Counter Mode Protocol (GCMP) – WLAN Authentication and Privacy Infrastructure (WAPI) • Management Frame Encryption/Decryption for broadcast/multicast packets – Advanced Encryption Standard (AES)/Cipher-based Message Authentication Code (CMAC) – BIP-GMAC • Management Frame Encryption/Decryption for unicast packets – AES/CCMP – AES/GCMP

2.7 Bluetooth Features

Type	Features
General	• Supports Bluetooth 5.4 Basic Rate (BR), Enhanced Data Rate (EDR) and Low Energy (incl. long range) features • Shared RF pad with Wi-Fi • Simultaneous receive with Wi-Fi • Coexistence with Wi-Fi
Bluetooth Basic Rate (BR) and Enhanced Data Rate (EDR)	• Bluetooth 5.4 features • Class 1 and class 2 support • Integrated high power PA up to +19 dBm transmit power for Bluetooth BR[2][3][4] • Integrated high power PA up to +10 dBm transmit power for EDR[4] • BR/EDR packet types – 1 Mbps (GFSK) – 2 Mbps (π/4-DQPSK) – 3 Mbps (8-DPSK) • I^2S/PCM interface for voice applications • Fully functional Bluetooth baseband-AFH, forward error correction, header error control, access code correlation, CRC, encryption bit stream generation, and whitening • Interlaced scan for faster connection setup • Simultaneous active ACL connection support • Automatic ACL packet type selection • Full central (master) and peripheral (slave) piconet support • Scatternet support • Standard UART HCI transport layer • HCI layer to integrate with profile stack • SCO/eSCO links with hardware accelerated audio signal processing and hardware supported PPEC algorithm for speech quality improvement • All standard SCO/eSCO voice coding • A2DP support • All standard pairing, authentication, link key, and encryption operations • Standard Bluetooth power-saving mechanisms (hold, sniff modes, and sniff subrating) • Enhanced Power Control (EPC) • Channel Quality Driven Data Rate (CQDDR) • Wideband Speech (WBS) support (2 WBS links) • Encryption (AES) support

[2] Meets the Bluetooth SIG requirement of maximum power difference between GFSK and QPSK portions of the EDR packet to < 10 dB.

[3] The maximum Tx power is limited to 14 dBm for Bluetooth LE long range packets.

[4] The maximum output power that must be set to meet the regulatory requirements can differ from this value.

Type	Features
Bluetooth Low Energy (LE)	• Bluetooth LE 5.4 • Integrated high power PA up to +19 dBm transmit power for Bluetooth LE[5][6][7] • Supported Bluetooth Low Energy PHY data rates – 1 Mbps (GFSK) – 2 Mbps (GFSK) • Supported Bluetooth Low Energy Long Range PHY data rates – 125 kbps (GFSK; Coding: S=8) – 500 kbps (GFSK; Coding: S=2) • Supports up to 16 simultaneous central/peripheral connections • Wi-Fi/Bluetooth coexistence protocol support • Shared RF with BR/EDR • Encryption (AES) support • Intelligent Adaptive Frequency Hopping (AFH) • Bluetooth LE Privacy 1.3 • Bluetooth LE Secure Connection • Bluetooth LE Data Length Extension • Bluetooth LE Advertising Extension for improved capacity • Bluetooth LE Long Range (125/500 kbps) • Bluetooth LE 2 Mbps • Bluetooth LE power control • Bluetooth LE isochronous channels (ISOC)[8]

[5] Meets the Bluetooth SIG requirement of maximum power difference between GFSK and QPSK portions of the EDR packet to < 10 dB.

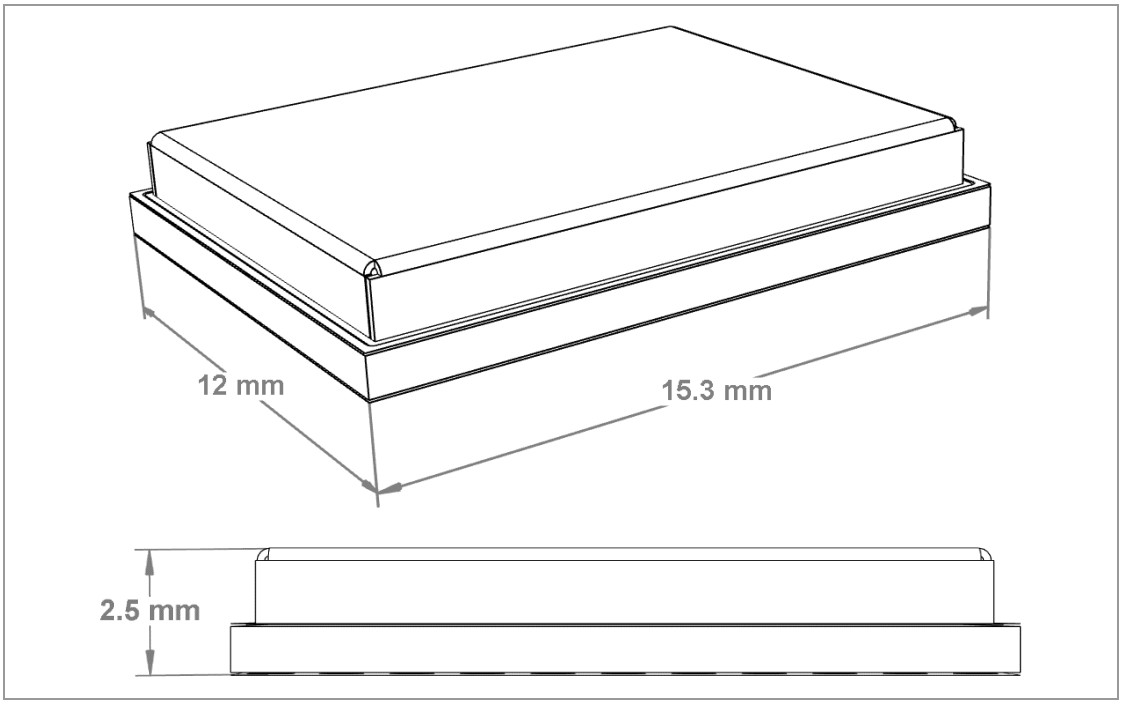
[6] The maximum Tx power is limited to 14 dBm for Bluetooth LE long range packets.

[7] The maximum output power that must be set to meet the regulatory requirements can differ from this value.

[8] Bluetooth LE audio supported with external host running Low Complexity Communication codec (LC3) through HCI interface

3 Detailed Description

3.1 Dimensions

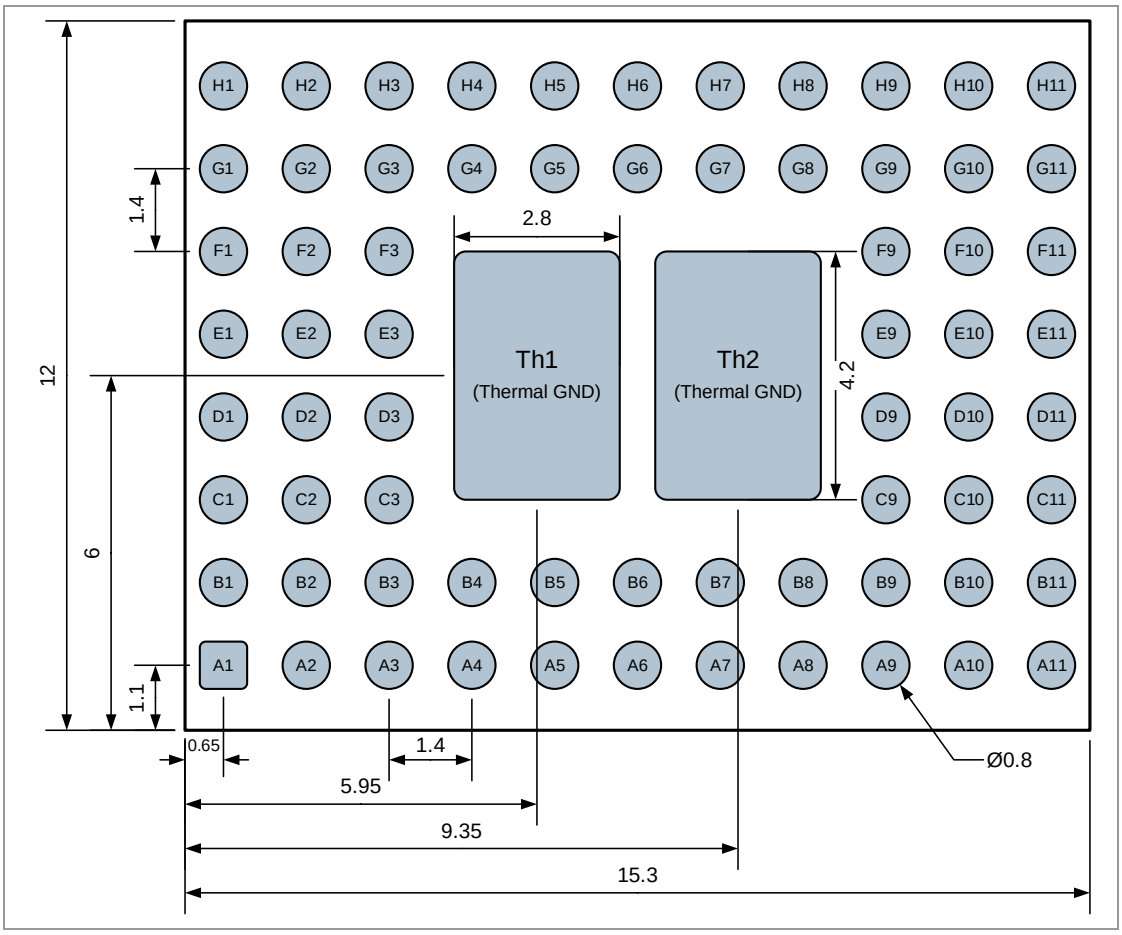


Item	Dimension (mm)	Tolerance (mm)	Remark
Width	12.00	±0.35	
Length	15.30	±0.35	
Height	2.50	±0.20	With case

3.2 Footprint

All dimensions are in mm.

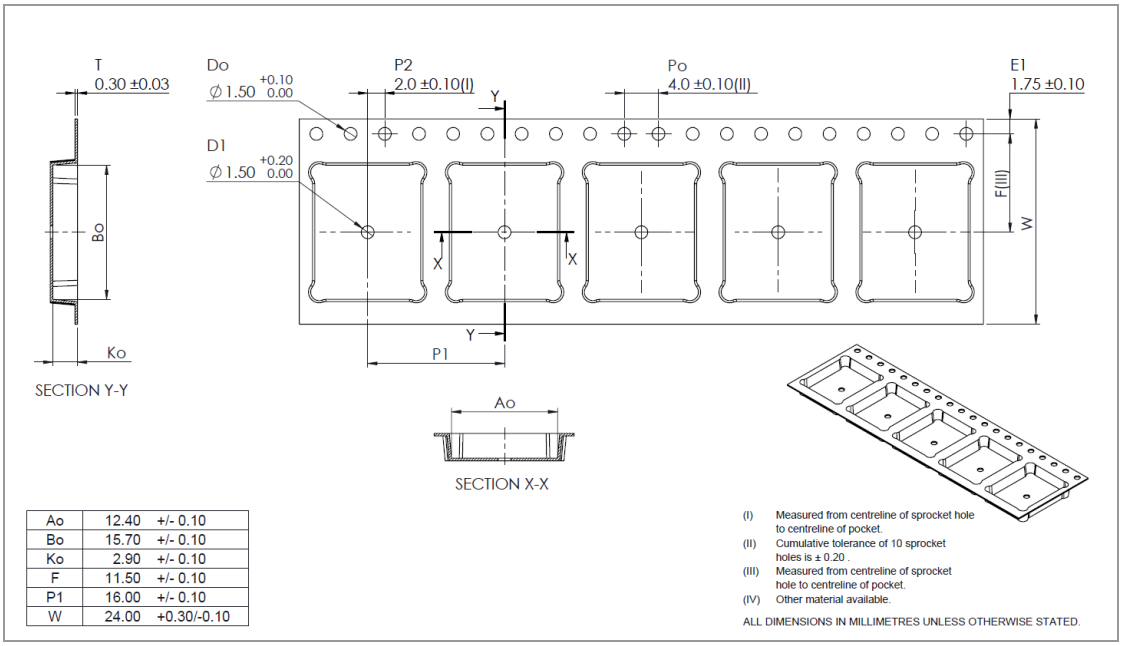
Top View



3.3 Packaging

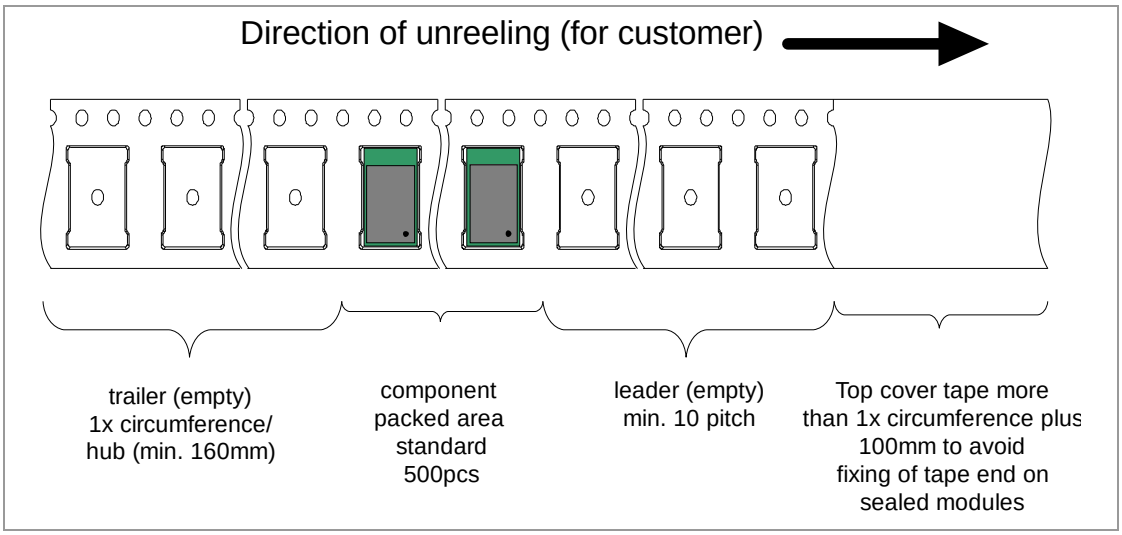
The module is a mass production status product and will be delivered in the package described below.

3.3.1 Tape Dimensions



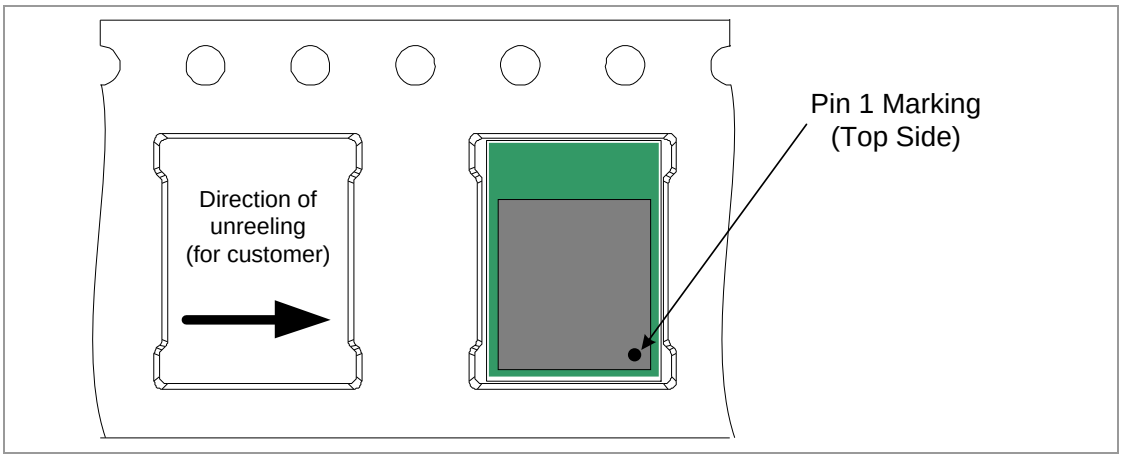
Ao	12.40	+/- 0.10
Bo	15.70	+/- 0.10
Ko	2.90	+/- 0.10
F	11.50	+/- 0.10
P1	16.00	+/- 0.10
W	24.00	+0.30/-0.10

3.3.2 Packing in Tape

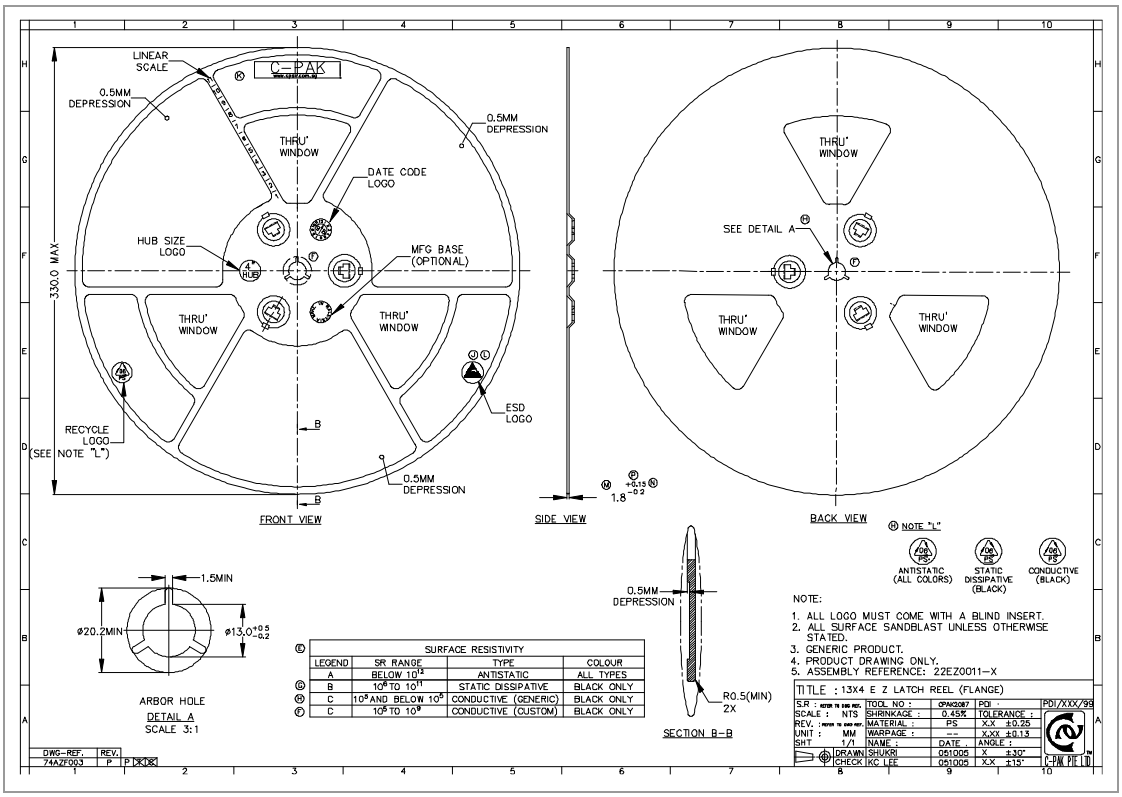


There might be at maximum two non-consecutive empty spaces in the component packed area per reel.

3.3.3 Component Direction

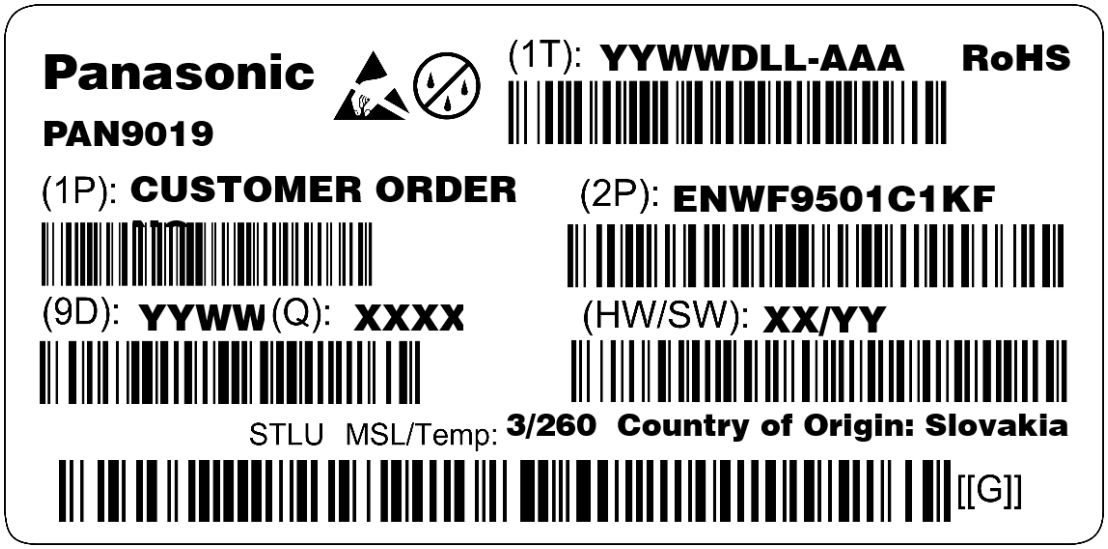


3.3.4 Reel Dimension



3.3.5 Package Label

Example:

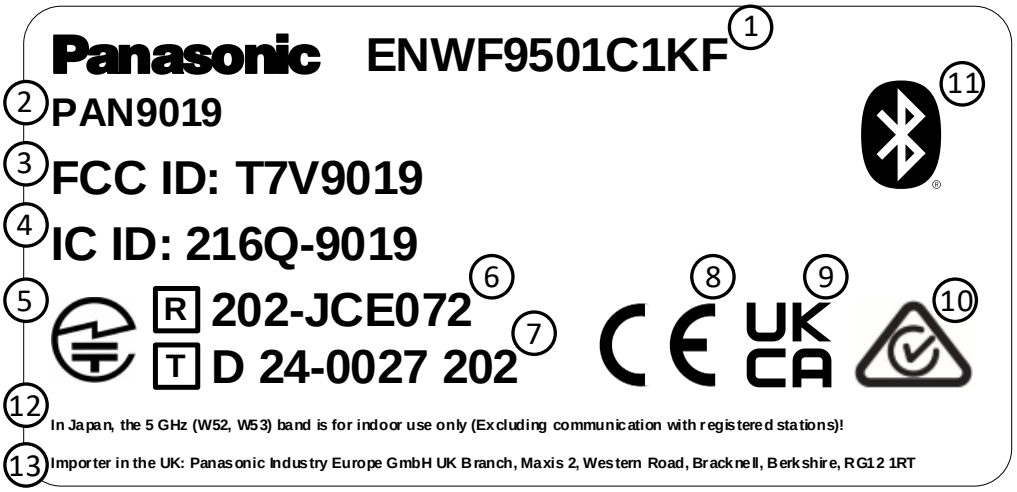


(1T)	Lot code
(1P)	Customer order number, if applicable
(2P)	Order number
(9D)	Date code
(Q)	Quantity
(HW/SW)	Hardware/software version

3.3.6 Regulatory Label

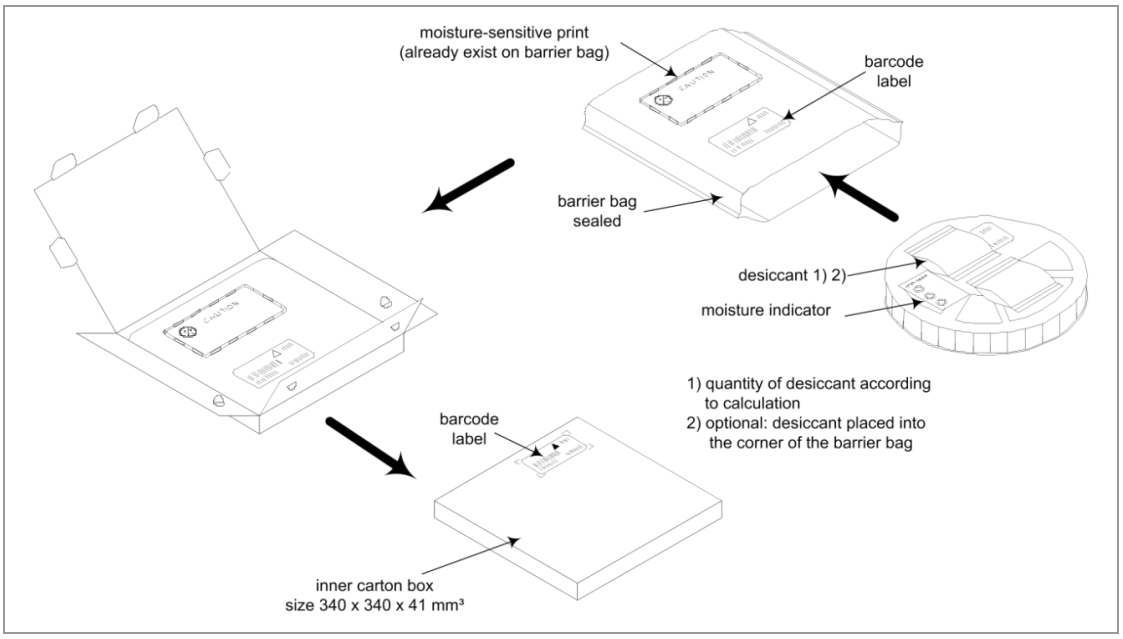
Example:

> The Radio Law (RL) and Telecommunication Business Law (TBL) IDs for Japan are not registered yet! The Japanese modular approval is only valid for modules that are shipped with a regulatory label that contains the RL and TBL IDs and the MIC conformity mark!



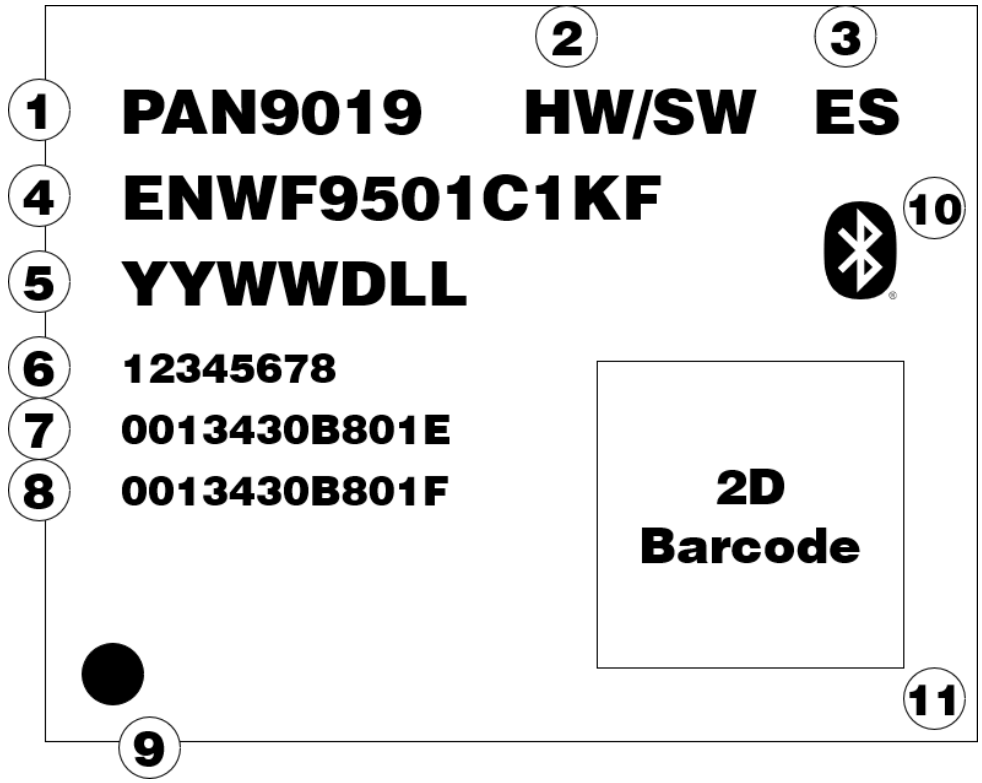
1	Product Number
2	Marketing Name
3	FCC ID
4	IC ID
5	MIC Conformity Mark
6	MIC Radio Law ID
7	MIC Telecommunication Business Law ID
8	CE Mark
9	UK-CA Mark
10	RCM Mark
11	UK Importer Address
12	Bluetooth SIG Logo

3.3.7 Total Package



3.4 Case Marking

Example:



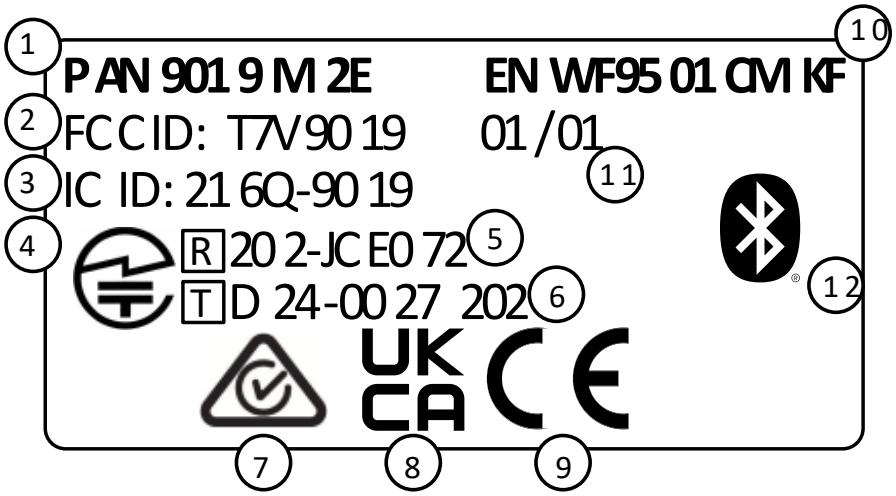
1	Brand Name
2	Hardware/Software Version
3	Engineering Sample (optional)
4	Model Name/ENW Number
5	Lot Code
6	Serial Number
7	MAC Address
8	Bluetooth Device Address
9	Pin 1 Marking
10	Bluetooth SIG Logo
11	2D Barcode

3.5 Labelling of M.2 Cards

3.5.1 ENWF9501CMKF

Example:

> The Radio Law (RL) and Telecommunication Business Law (TBL) IDs for Japan are not registered yet! The Japanese modular approval is only valid for modules that are shipped with a regulatory label that contains the RL and TBL IDs and the MIC conformity mark!

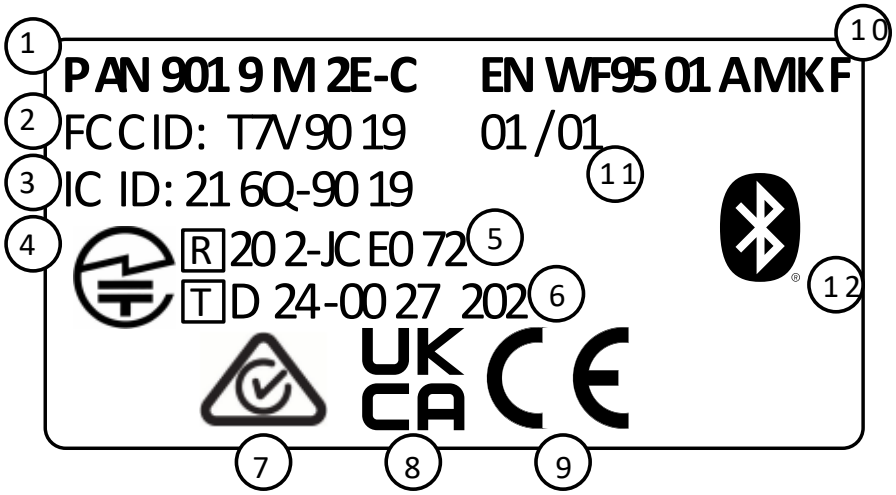


1	Marketing Name
2	FCC ID
3	IC ID
4	MIC Conformity Mark
5	MIC Radio Law ID
6	MIC Telecommunication Business Law ID
7	RCM mark
8	UK-CA mark
9	CE mark
10	Product Number
11	Hardware/Software Version
12	Bluetooth SIG Logo

3.5.2 ENWF9501AMKF

Example:

> The Radio Law (RL) and Telecommunication Business Law (TBL) IDs for Japan are not registered yet! The Japanese modular approval is only valid for modules that are shipped with a regulatory label that contains the RL and TBL IDs and the MIC conformity mark!



1	Marketing Name
2	FCC ID
3	IC ID
4	MIC Conformity Mark
5	MIC Radio Law ID
6	MIC Telecommunication Business Law ID
7	RCM mark
8	UK-CA mark
9	CE mark
10	Product Number
11	Hardware/Software Version
12	Bluetooth SIG Logo

4 Specification

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

4.1 Default Test Conditions

Temperature: 25 °C ± 10 °C
Humidity: 40 % to 85 % RH
Supply Voltage: 3.3 V, 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.	Unit
T_{STOR}	Storage Temperature		-40		85	°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	Wi-Fi 802.11b DSSS			0.47	dBm
		Wi-Fi 802.11b CCK			0.47	dBm
		Wi-Fi OFDM			-9.7	dBm
		Bluetooth Basic Rate 1 Mbps			-3	dBm
		Bluetooth Enhanced Data Rate 2 Mbps and 3 Mbps			-6	dBm
		Bluetooth Low Energy			-3	dBm
3V3	Maximum Voltage				3.96	V
1V8					2.16	V
V_{IO}		1.8 V analog power supply			2.16	V
		3.3 V analog power supply			3.96	V

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{SD}		1.8 V analog power supply			2.16	V
		3.3 V analog power supply			3.96	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.	Unit
T_A	Ambient Operating Temperature Range	Industrial grade	-40		85	°C
3V3	Recommended supply voltage		3.14	3.3	3.46	V
1V8			1.71	1.8	1.89	V
V_{IO}		1.8 V analog power supply	1.71	1.8	1.89	V
V_{IO}		3.3 V analog power supply	3.14	3.3	3.46	V
V_{SD}		1.8 V analog power supply	1.71	1.8	1.89	V
V_{SD}		3.3 V analog power supply	3.14	3.3	3.46	V

4.3.1 Digital Pin Characteristics

4.3.1.1 V_{IO} with 1.8V or 3.3V Operation

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{IH}	High Level Input Voltage		0.7*V_{IO}		V_{IO} + 0.4	V
V_{IL}	Low Level Input Voltage		-0.4		0.3*V_{IO}	V
V_{HYS}	Input hysteresis		100			mV
V_{OH}	High Level Output Voltage		V_{IO} - 0.4			V
V_{OL}	Low Level Output Voltage				0.4	V

4.3.1.2 V_{SD} with 1.8V or 3.3V Operation

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{IH}	High Level Input Voltage		0.7*V_{SD}		V_{SD} + 0.4	V
V_{IL}	Low Level Input Voltage		-0.4		0.3*V_{SD}	V
V_{HYS}	Input hysteresis		100			mV
V_{OH}	High Level Output Voltage		V_{SD} - 0.4			V
V_{OL}	Low Level Output Voltage				0.4	V
$R_{PU/PD}$	Internal nominal pull-up/pull-down resistance		70	100	140	kΩ

4.3.2 Internal Operating Frequencies

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$f_{REFCLK1}$	WLAN/MCU Crystal Fundamental Frequency	Frequency tolerance < ±20 ppm over operating temperature and aging		40		MHz

4.4 Current Consumption

The current consumption depends on the user scenario and on the setup and timing in the power modes.

Following supply configuration was used for obtaining the current consumption values in this chapter:

- 1V8: Connected to 1.8 V power supply
- 3V3: Connected to 3.3 V power supply
- V_{IO}: Connected to 3.3 V power supply
- V_{SD}: Connected to 1.8 V power supply

Parameter	Condition	Typ. at 1.8 V	Typ. at 3.3 V	Unit
Power Down	-	0.019	0.078	mA
Sleep Mode	Deep sleep mode - Bluetooth only	0.25	0.14	mA
	Deep sleep mode - Wi-Fi only	0.36	0.08	mA
	Deep sleep mode - Wi-Fi and Bluetooth	0.41	0.14	mA
Maximum Active Current Consumption	5 GHz, 802.11a, 6 Mbps at 19 dBm + Bluetooth Low Energy transmit at 21 dBm	580	280	mA
Peak Current Consumption	Peak current during device initialization	496	368	mA
	5 GHz 802.11ax 80 MHz, MCS11 receive + Bluetooth Low Energy transmit at 21 dBm	644	0.43	mA
	5 GHz digital predistortion (DPD) + Bluetooth Low Energy transmit at 21 dBm	900	368	mA

4.4.1 WLAN Current Consumption

Parameter	Condition	Typ. At 1.8 V	Typ. at 3.3 V	Unit
Active Transmit	2.4 GHz, 802.11b, 20 MHz, 11 Mbps at 18 dBm	142	205	mA
	2.4 GHz, 802.11g, 20 MHz, 54 Mbps at 17dBm	150	166	mA
	2.4 GHz, 802.11n, 40 MHz, MCS7 at 17 dBm	149	144	mA
	2.4 GHz, 802.11ax, 40 MHz, MCS11 at 15 dBm	145	115	mA
	5 GHz, 802.11a, 20 MHz, 54 Mbps at 17 dBm	198	202	mA
	5 GHz, 802.11n, 40 MHz, MCS7 at 16 dBm	195	160	mA
	5 GHz, 802.11ac, 80 MHz, MCS9 at 13 dBm	192	109	mA
	5 GHz, 802.11ax, 80 MHz, MCS11 at 10 dBm	192	97	mA
Active Receive	2.4 GHz, 802.11b, 20 MHz, 11 Mbps	91	0.3	mA
	2.4 GHz, 802.11g, 20 MHz, 54 Mbps	101	0.3	mA
	2.4 GHz, 802.11n, 40 MHz, MCS7	126	0.3	mA
	2.4 GHz, 802.11ax, 40 MHz, MCS11	128	0.3	mA
	5 GHz, 802.11a, 20 MHz, 54 Mbps	116	0.3	mA
	5 GHz, 802.11n, 40 MHz, MCS7	139	0.3	mA
	5 GHz, 802.11ac, 80 MHz, MCS9	177	0.3	mA
	5 GHz, 802.11ax, 80 MHz, MCS11	180	0.3	mA
IEEE Power Save Mode	2.4 GHz, DTIM-1, Beacon interval 100 ms, 1 Mbps	2.52	0.08	mA
	2.4 GHz, DTIM-10, Beacon interval 100 ms, 1 Mbps	0.72	0.08	mA
	5 GHz, DTIM-1, Beacon interval 100 ms, 6 Mbps	1.57	0.08	mA
	5 GHz, DTIM-10, Beacon interval 100 ms, 6 Mbps	0.66	0.08	mA

4.4.2 Bluetooth Current Consumption

Parameter	Condition	Typ. at 1.8 V	Typ. at 3.3 V	Unit
Active Transmit	Bluetooth Low Energy, 1Mbps at 0 dBm	43	0.33	mA
	Bluetooth Low Energy, 1Mbps at 4 dBm	48	0.33	mA
	Bluetooth DH5 at 0 dBm	43	0.33	mA
	Bluetooth DH5 at 4 dBm	48	0.33	mA
Active Receive	Bluetooth Basic Rate, DH5, 1 Mbps	39	0.33	mA
	Bluetooth Low Energy, 1 Mbps	39	0.33	mA

4.5 Interfaces

4.5.1 Host Interface

4.5.1.1 SDIO Interface

The SDIO Interface pins are powered from the V_{SD} voltage supply with 3.3 V or 1.8 V. The SDIO electrical specifications are identical for the 1-bit and 4-bit SDIO modes.

For DC specifications please refer to “Digital Pin Characteristics” ⇨ 4.3 Recommended Operating Conditions.

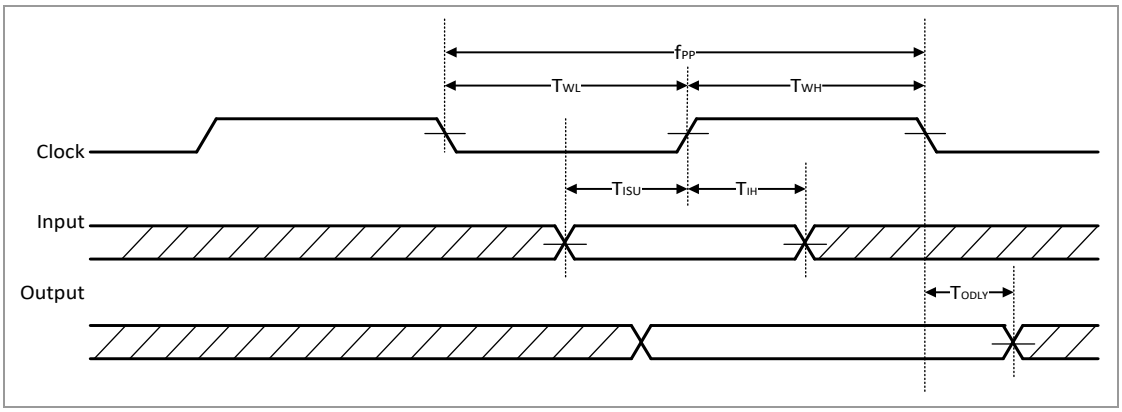
SDIO Timing Data – Default and High-Speed Modes (V_{SD} 3.3 V)[9,10]

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{PP}	Clock frequency	Normal	0		25	MHz
		High-speed	0		50	MHz
T_{WL}	Clock low time	Normal	10			ns
		High-speed	7			ns
T_{WH}	Clock high time	Normal	10			ns
		High-speed	7			ns
T_{ISU}	Input setup time	Normal	5			ns
		High-speed	6			ns
T_{IH}	Input hold time	Normal	5			ns
		High-speed	2			ns
T_{ODLY}	Output delay time	Normal			14	ns
	CL ≤ 40 pF (1 card)	High-speed			14	ns
T_{OH}	Output hold time	High-speed	2.5			ns

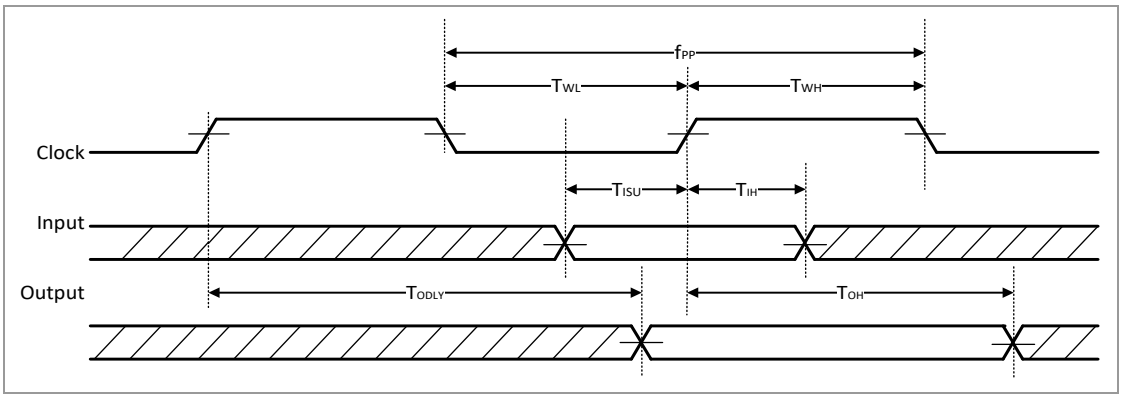
[9] For SDIO 2.0 running at 50 MHz clock frequency, a supply voltage V_{SD} of 1.8 V is recommended.

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

SDIO Protocol Timing Diagram – Default Speed Mode (V_{SD} 3.3 V)



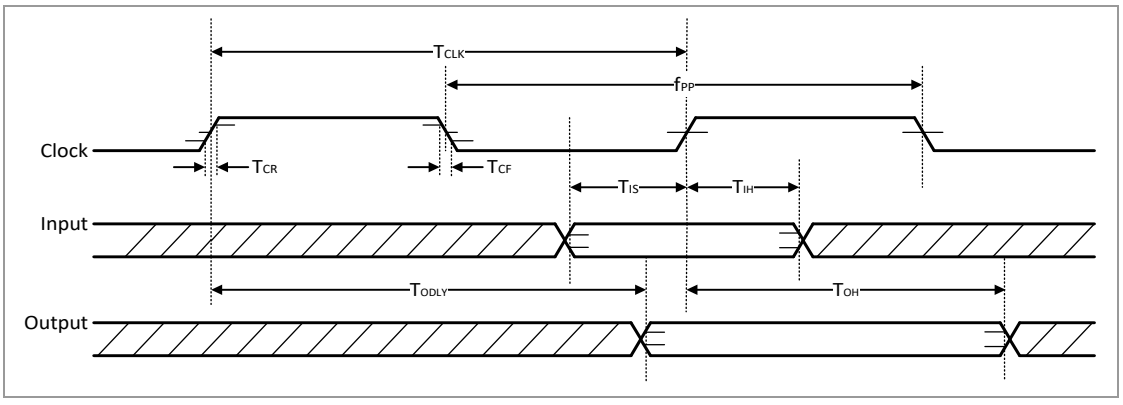
SDIO Protocol Timing Diagram – High-Speed Mode (V_{SD} 3.3 V)



SDIO Timing Data – SDR12, SDR25, SDR50 Modes (V_{SD} 1.8 V)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{PP}	Clock frequency	SDR12	0		25	MHz
		SDR25	0		50	MHz
		SDR50	0		100	MHz
T_{IS}	Input setup time	SDR12	5			ns
		SDR25	6			ns
		SDR50	3			ns
T_{IH}	Input hold time	SDR12	6			ns
		SDR25	2			ns
		SDR50	0.8			ns
T_{CLK}	Clock time	SDR12	40		40	ns
		SDR25	10		20	ns
		SDR50	10		10	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			14	ns
		SDR25			14	
		SDR50			7.5	
T_{OH}	Output hold time CL ≤ 15 pF	SDR12/SDR25/SDR50	1.5			ns

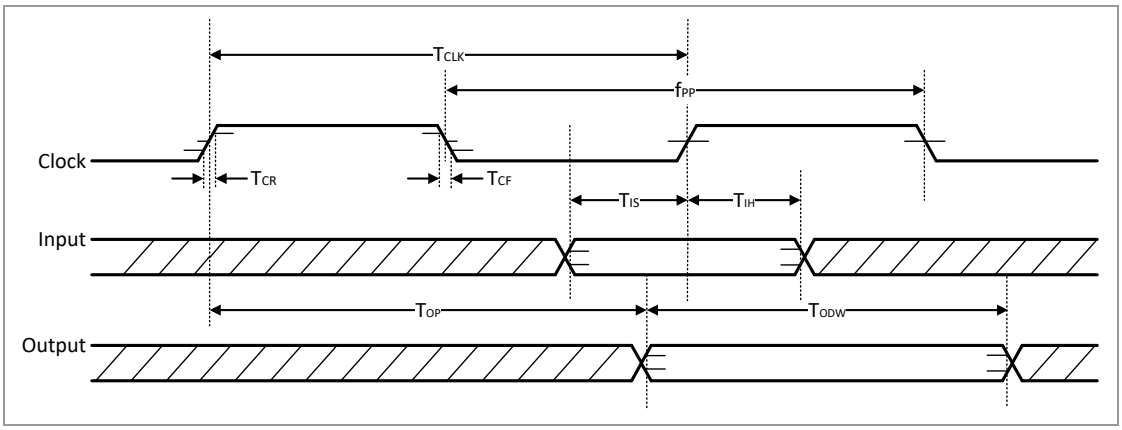
SDIO Protocol Timing Diagram – SDR12, SDR25, SDR50 Modes (V_{SD} 1.8 V)



SDIO Timing Data – SDR104 Mode (V_{SD} 1.8 V)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{PP}	Clock frequency	SDR104	0		208	MHz
T_{IS}	Input setup time	SDR104	1.4			ns
T_{IH}	Input hold time	SDR104	0.8			ns
T_{CLK}	Clock time	SDR104	4.8			ns
T_{CR}, T_{CF}	Rise time, fall time T_{CR}, T_{CF} < 0.96 ns (max) at 208 MHz C_{CARD} = 10 pF	SDR104			0.2 T_{CLK}	ns
T_{OP}	Card output phase	SDR104	0		2	ns
T_{ODW}	Output timing of variable data window	SDR104	2.88			ns

SDIO Protocol Timing Diagram – SDR104 Mode (V_{SD} 1.8 V)

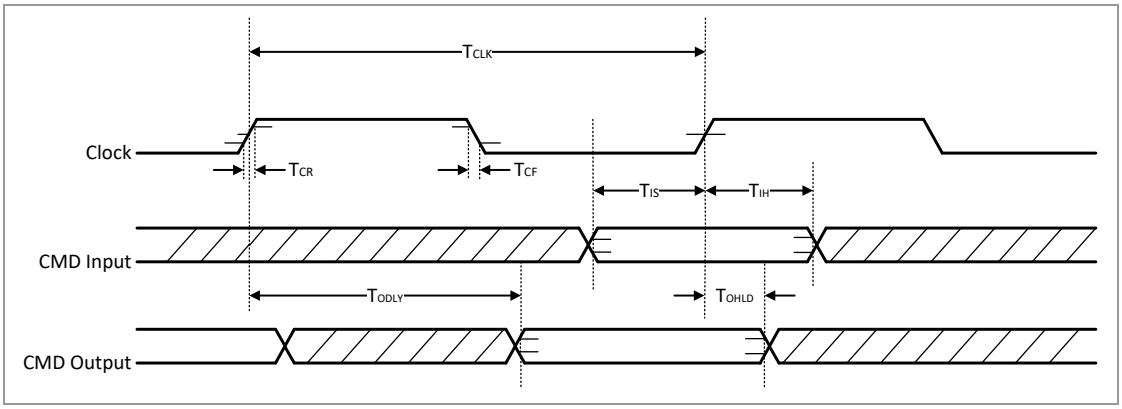


SDIO Timing Data – DDR50 Mode (V_{SD} 1.8 V)

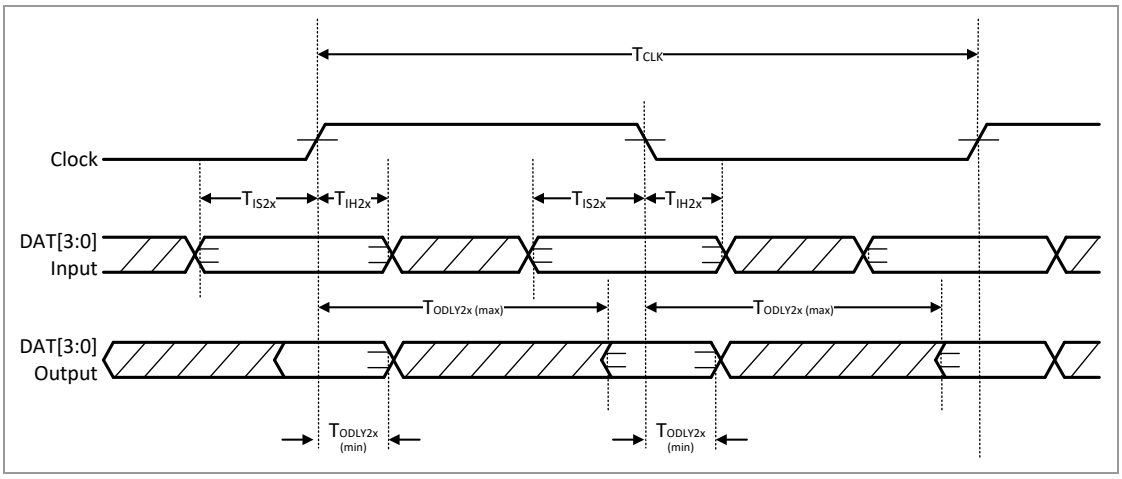
Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Clock						
T_{CLK}	Clock time 50 MHz (max) between rising edges	DDR50	20			ns
T_{CR}, T_{CF}	Rise time, fall time T_{CR}, T_{CF} < 4.00 ns (max) at 50 MHz C_{CARD} = 10 pF	DDR50			0.2 T_{CLK}	ns
Clock Duty		DDR50	45		55	%
CMD Input (referenced to clock rising edge)						
T_{IS}	Input setup time $C_{CARD} \leq$ 10 pF (1 card)	DDR50	6			ns

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
T_{IH}	Input hold time $C_{CARD} \leq 10$ pF (1 card)	DDR50	0.8			ns
CMD Output (referenced to clock rising edge)						
T_{OLDY}	Output delay time during data transfer mode $C_L \leq 30$ pF (1 card)	DDR50			13.7	ns
T_{OHLD}	Output hold time $C_L \leq 15$ pF (1 card)	DDR50	1.5			ns
DAT[3:0] Input (referenced to clock rising and falling edges)						
T_{IS2x}	Input setup time $C_{CARD} \leq 10$ 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 edges)						
TODLY2x (max)	Output delay time during data transfer mode $C_L \leq 25$ pF (1 card)	DDR50			7	ns
TODLY2x (min)	Output hold time $C_L \leq 15$ pF (1 card)	DDR50	1.5			ns

SDIO CMD Timing Diagram – DDR50 Mode (V_{SD} 1.8 V, 50 MHz)



SDIO DAT[3:0] Timing Diagram – DDR50 Mode (V_{SD} 1.8 V, 50 MHz)



4.5.1.2 High-Speed UART Interface

The High-Speed UART Interface pins are powered from the V_{IO} voltage supply with 3.3 V or 1.8 V.

For DC specifications please refer to “Digital Pin Characteristics” ⇨ 4.3 Recommended Operating Conditions.

Interface Transport Settings

Item	Range	Default	Comment
Baud Rate	Max. 4 000 000	115 200	Baud
Data Bits	5 ~ 8	8	LSB first
Parity Bits	0 ~ 4	0	
Stop Bits	1/1.5/2	1	

Timing Specifications

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
T_{BAUD}	Baud time	40 MHz input clock	250	-	-	ns
Δ_{BAUD}	Deviation from the target baud rate		-	-	3	%

4.5.2 Audio Interface

The I²S and PCM audio interfaces can be used for speech over Bluetooth applications like the Hands Free Profile (HFP).

4.5.2.1 I²S Interface

The I²S Interface supports two modes of operation:

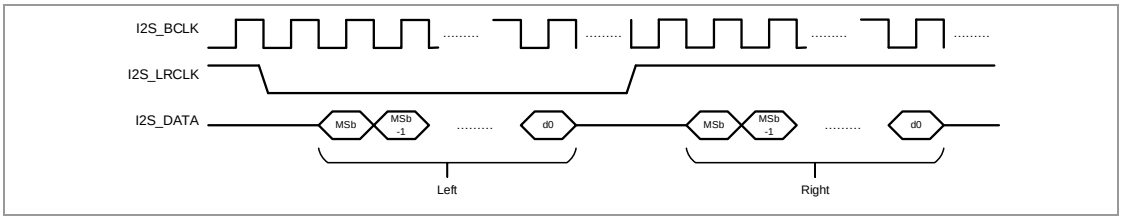
- I²S master: Central mode
- I²S slave: Peripheral mode

In I²S central mode, the interface uses an audio input clock of 4.096 MHz or 2.048 MHz to provide the appropriate codec main clock (I2S_CCLK) and bit clock (I2S_BCLK) frequency to match the sampling rates of each audio data format. The sampling rates can be 8 kHz to 16 kHz.

In I²S peripheral mode, the interface does not provide the bit clock (I2S_BCLK) but it can provide the codec main clock (I2S_CCLK).

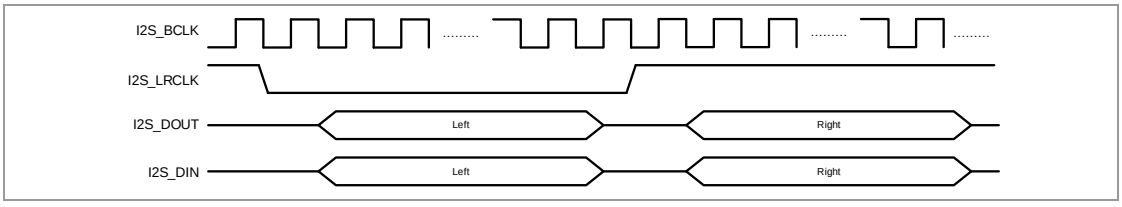
I²S Protocol Specification

Below, the I²S protocol is shown. The data is sent with the Most Significant Bit (MSb) first. Please note that the signal I2S_DATA represents both, the I2S_DIN and I2S_DOUT signal.

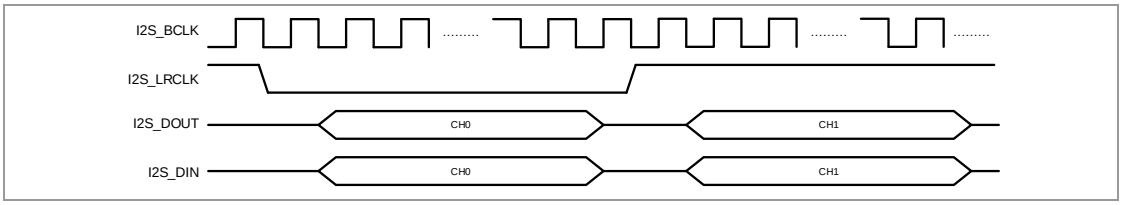


The PAN9019 supports mono and dual channel modes.

In mono-channel mode, by default the left channel is used for data.



In dual-channel mode, the two channels are supported on two time slots.



4.5.2.2 PCM Interface

Modes of Operation

The PCM Interface supports two modes of operation:

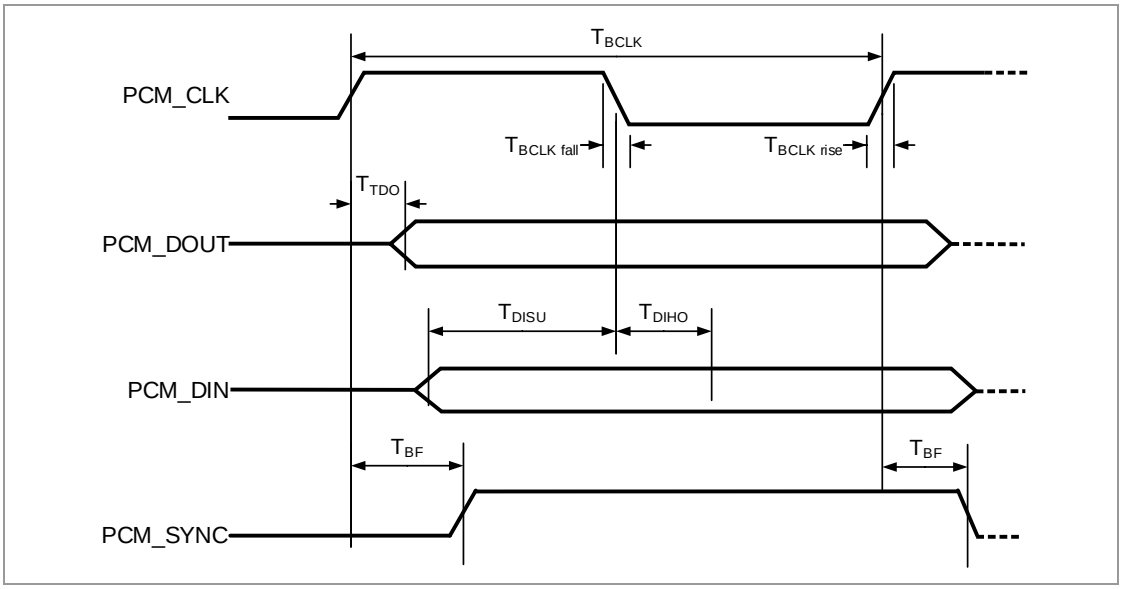
- PCM master: Central mode
- PCM slave: Peripheral mode

In PCM central mode, the interface generates a 2 MHz or a 2.048 MHz PCM_CLK and an 8 kHz PCM_SYNC signal. An alternative PCM master mode is available that uses an externally generated PCM_CLK, but still generate 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.

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

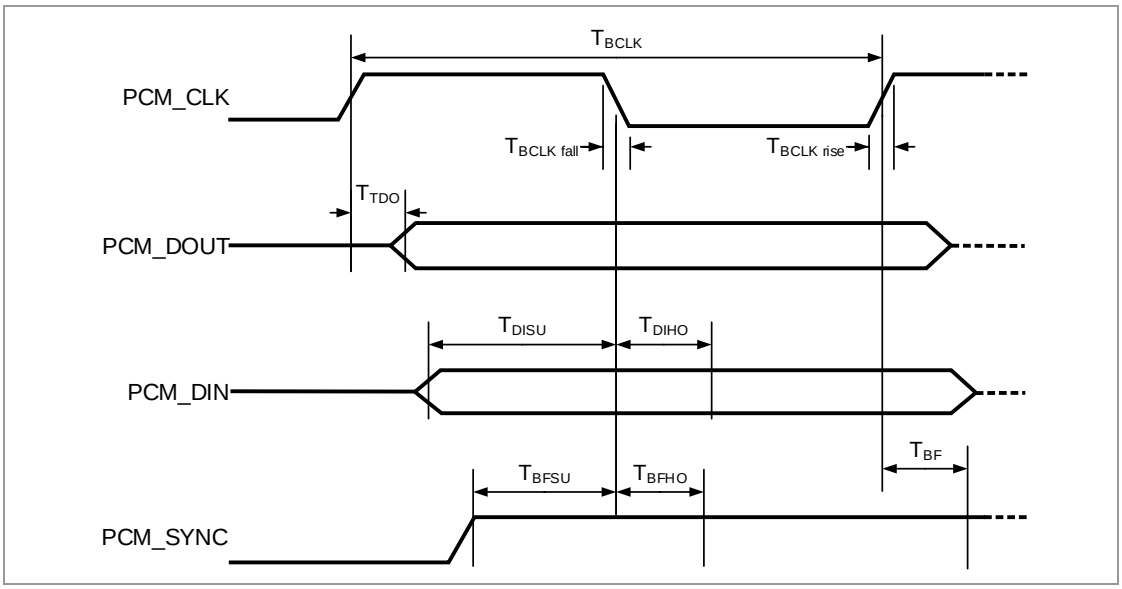
The PCM interface consists of up to four PCM slots (time-divided) preceded by a PCM synchronization signal. Each PCM slot can be 8 bits or 16 bits wide. The slots can be separated in time, but they are not required to follow immediately after another. The timing is relative to PCM_SYNC.

PCM Timing Data – Central Mode



Symbol	Parameter	Min.	Typ.	Max.	Unit
$1/T_{BCLK} = f_{BCLK}$	Bit clock frequency	2	2/2.048	2.048	MHz
$DutyCycle_{BCLK}$	Bit clock duty cycle	0.4	0.5	0.6	-
$T_{BCLK\ rise/fall}$	PCM_CLK rise / fall time	-	3	-	ns
T_{DO}	Delay from PCM_CLK risign edge to PCM_DOUT rising edge	-	-	15	ns
T_{DISU}	Setup time for PCM_DIN before PCM_CLK falling edge	20	-	-	ns
T_{DIHO}	Hold time for PCM_DIN after PCM_CLK falling edge	15	-	-	ns
T_{BF}	Delay from PCM_CLK rising edge to PCM_SYNC rising edge	-	-	15	ns

PCM Timing Data – Peripheral Mode



Symbol	Parameter	Min.	Typ.	Max.	Unit
$1/T_{BCLK} = f_{BCLK}$	Bit clock frequency	0.512	2/2.048	4	MHz
$DutyCycle_{BCLK}$	Bit clock duty cycle	0.4	0.5	0.6	-
$T_{BCLK\ rise/fall}$	PCM_CLK rise / fall time	-	3	-	ns
T_{DO}	Delay from PCM_CLK risign edge to PCM_DOUT rising edge	-	-	30	ns
T_{DISU}	Setup time for PCM_DIN before PCM_CLK falling edge	15	-	-	ns
T_{DIHO}	Hold time for PCM_DIN after PCM_CLK falling edge	10	-	-	ns
T_{BFSU}	Setup time for PCM_SYNC before PCM_CLK falling edge	15	-	-	ns
T_{BFHO}	Hold time for PCM_SYNC after PCM_CLK falling edge	10	-	-	ns

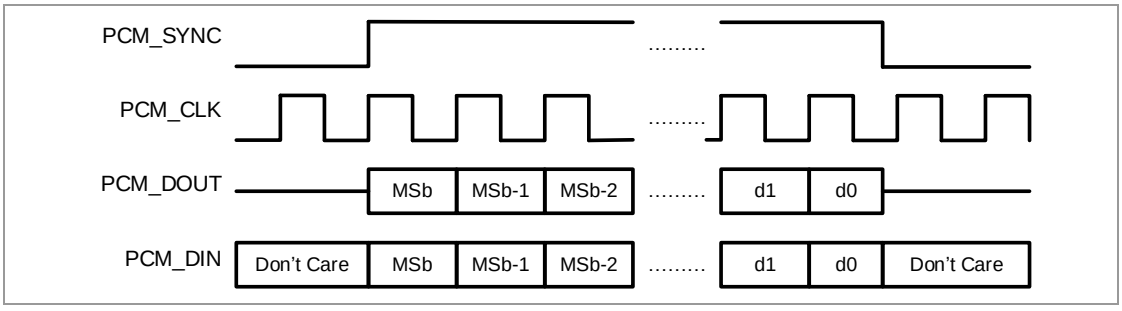
PCM Protocol Specification

The PCM protocol supports short and long frame synchronization and mono or dual channel operation.

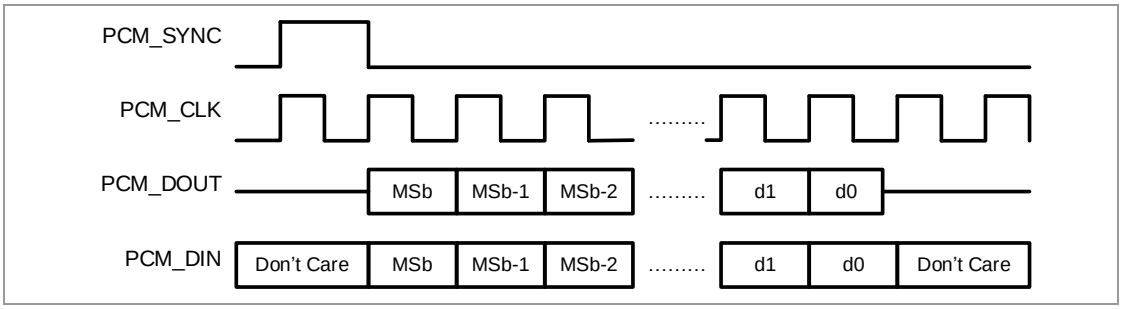
Long and short synchronization operations are illustrated in the two pictures below. The first shows a protocol with a long frame synchronization and the second with short frame synchronization. The Most Significant Bits (MSb) are marked by MSb-n to be independent from the protocol length. Please note that the protocols are shown from central mode perspective.

The least significant bits are marked with their data bit index (e.g. d0). In case of the long frame synchronization, the output and input data transmission start with the assertion of the PCM_SYNC signal and both data streams end with the de-assertion of the synchronization signal[11].

If short frame synchronization is used, the PCM_SYNC line is asserted for the period of one clock cycle. The falling edge of PCM_SYNC marks the start of the data transmission. Because the end of the data transfer is not explicitly communicated via the PCM_SYNC line, the last input data bit level must be applied until the end of the last clock cycle.

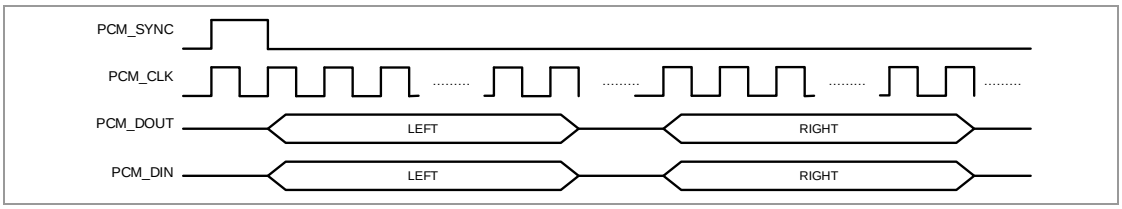


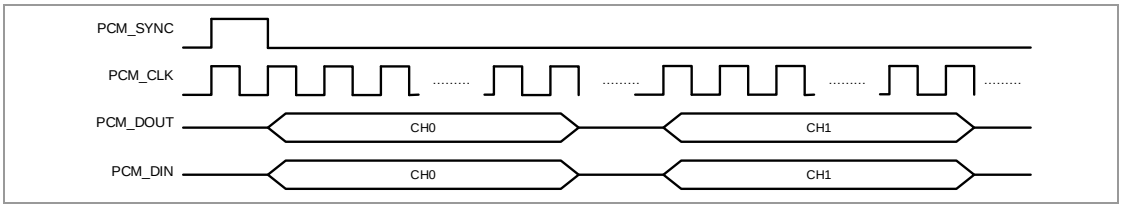
[11] In PCM central mode, PCM long frame synchronization is 1 clock wide. In PCM peripheral mode, PCM central long frame synchronization pattern is supported.



The mono and dual channel operation is independent from the frame synchronization length. Therefore, this is explained only for a short frame synchronization.

In mono-channel mode, by default the left channel is used for data (first picture below). In dual-channel mode, the two channels are supported on two time slots (second picture below).





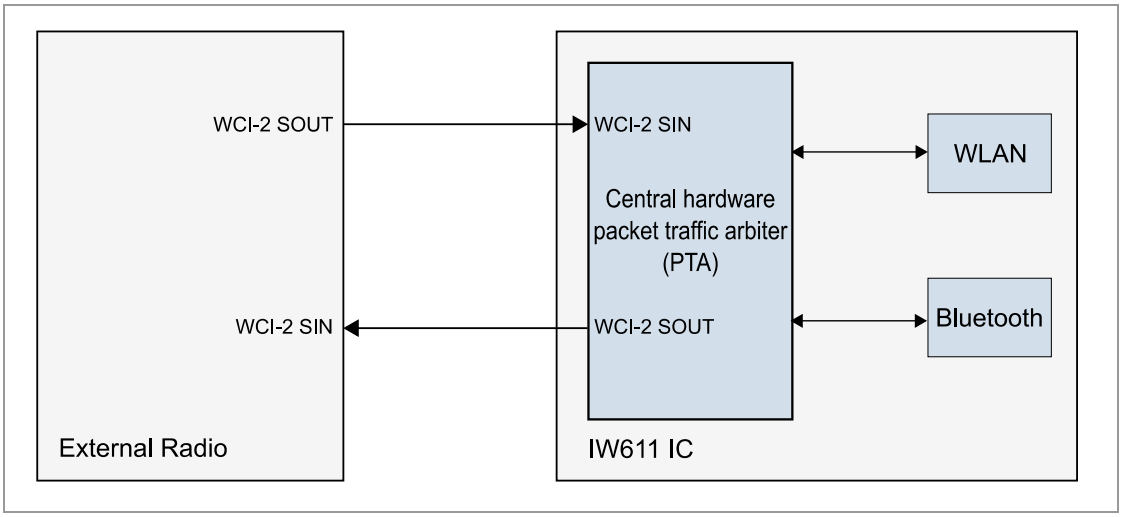
4.5.3 Coexistence Interfaces

4.5.3.1 WCI-2 Interface Specification

Interface and Transport Layer Description

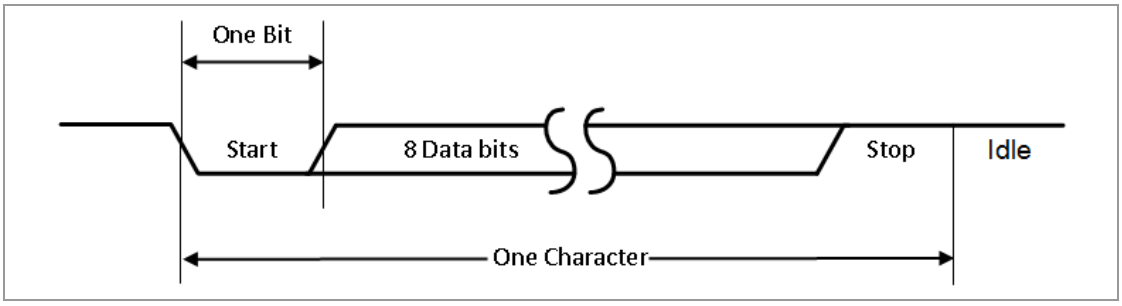
The Peripheral Interface pins are powered from the V_{IO} voltage supply with 3.3 V or 1.8 V.

The messaging is based on a standard UART format. Like the Rx and Tx lines of an UART interface, the SIN and SOUT lines must be crossed (null-modem connection):



For DC specifications please refer to ⇨ 4.3 Recommended Operating Conditions.

The interface specifications are shown below.



Item	Range	Comment
Baudrate	921 600 ~ 4 000 000 (default is 3 Mbaud)	Baud
Data Bits	8	LSB first
Parity Bits	0	No parity
Stop Bit	1	One stop bit
Flow Control	No	No flow control

One message consists of 8 bits and is thus sent with one single WCI-2 transmission. The three lower bits form the message type identifier and the remaining five contain the messages information. All messages are transmitted with the Least Significant Bit (LSB) first.

b0 (LSB)	b1	b2	b3	b4	b5	b6	b7 (MSB)
Type[0]	Type[1]	Type[2]	MSG[0]	MSG[1]	MSG[2]	MSG[3]	MSG[4]

An overview of all message types is given below. Details are described in the following sub-sections. During the communication, the PAN9019 acts as coexistence controller and the external radio as Mobile Wireless System (MWS) device.

Message Type Identicator	Direction	Message Type
0	Ext. Radio ↔ PAN9019	Real-Time Signaling Message
1	Ext. Radio ↔ PAN9019	Transport Control Message
2	Ext. Radio ↔ PAN9019	Transparent Data Message
3	Ext. Radio → PAN9019	MWS Inactivity Duration Message
4	Ext. Radio → PAN9019	MWS Scan Frequency Message
5	Ext. Radio → PAN9019 PAN9019 → Ext. Radio	Reserved for Future Use (RFU)
6	Not defined vendor message	
7	Ext. Radio → PAN9019	MWS Priority Message (vendor specific and optional)

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 MSG[4] (transition to stop bit). The content of the message depends on the direction of the message.

External Radio to PAN9019
If a real-time signaling message is sent from the external radio (also called MWS) to the PAN9019, the message is a request to operate:

- MWS_Rx = 1 indicates an external radio request to Rx
- MWS_Tx = 1 indicates an external radio request to Tx

Real-Time Signaling	MSG [0]	MSG [1]	MSG [2]	MSG [3]	MSG [4]
Type ident. = 0 Ext. radio to PAN9019	FRAME_SYNC	MWS_RX	MWS_TX	PATTERN [0]	PATTERN [1]



After the Real Time Signaling message was sent, the external radio can send an optional priority message of type 7. Please see the description of the message **MWS Priority Message (Vendor Specific)** for details.

PAN9019 to External Radio

The arbitration is controlled by the PAN9019 and by sending a real time signaling message to the external radio, the arbitration result is handed over:

- BT_Rx_Pri = 1: the Bluetooth radio Rx wins the arbitration and is in operation
- BT_Tx_On = 1: the Bluetooth radio Tx wins the arbitration and is in operation
- 802_Rx_Pri = 1: Wi-Fi Rx wins the arbitration and is in operation
- 802_Tx_On = 1: Wi-Fi Tx wins the arbitration and is in operation
- MSG[0-3] = 0: Operation is granted to the external radio

Real-Time Signaling	MSG [0]	MSG [1]	MSG [2]	MSG [3]	MSG [4]
Type ident. = 0 PAN9019 to ext. radio	BLUETOOTH _RX_PRI	BLUETOOTH _TX_ON	802_RX_PRI	802_TX_ON	RFU

Transport Control Message

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

Trasnport Control Message	MSG [0]	MSG [1]	MSG [2]	MSG [3]	MSG [4]
Type ident. = 1 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

Please note that this message type is currently not used.

Transparent data messages can contain vendor specific data. Because only four bits can be transmitted per messsage, the bit MSG[0] is used to define if the least significant or most significant nibble of a byte is sent.

Transparent Data Message	MSG [0]	MSG [1]	MSG [2]	MSG [3]	MSG [4]
Type ident. = 2	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 external radio (MWS device) to the PAN9019 (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:

$$\text{Inactivity_Duartion} = \text{DURATION} \cdot 5\,\text{ms}$$

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 external radio (MWS device) to the PAN9019 (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:

$$RF_FREQ_OFFSET = FREQ \cdot 10\,MHz$$

If BAND is set to “0” the RF_FREQ_OFFSET is the negative value from the lower edge of the ISM band. 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.

MWS Priority Message (Vendor Specific)

After requesting operation by sending a real-time signaling message, the external radio can indicate the priority of the operation by sending an optional priority message. There is one two-bit priority value for Rx and Tx operation respectively. A high value indicates a high priority.

Real-Time Signaling	MSG [0]	MSG [1]	MSG [2]	MSG [3]	MSG [4]
Ext. radio to PAN9019 (Signal)	0	MWS_TX_PRI[0]	MWS_TX_PRI[1]	MWS_RX_PRI[0]	MWS_RX_PRI[1]

4.5.3.2 PTA External Interface Specification

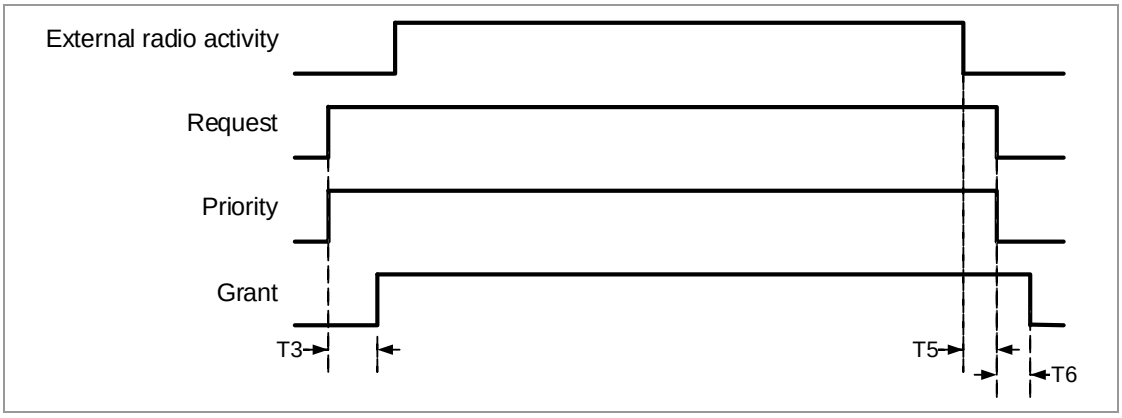


The Peripheral Interface pins are powered from the V_{IO} voltage supply with 3.3 V or 1.8 V.

For DC specifications please refer to ⇨ 4.3 Recommended Operating Conditions.

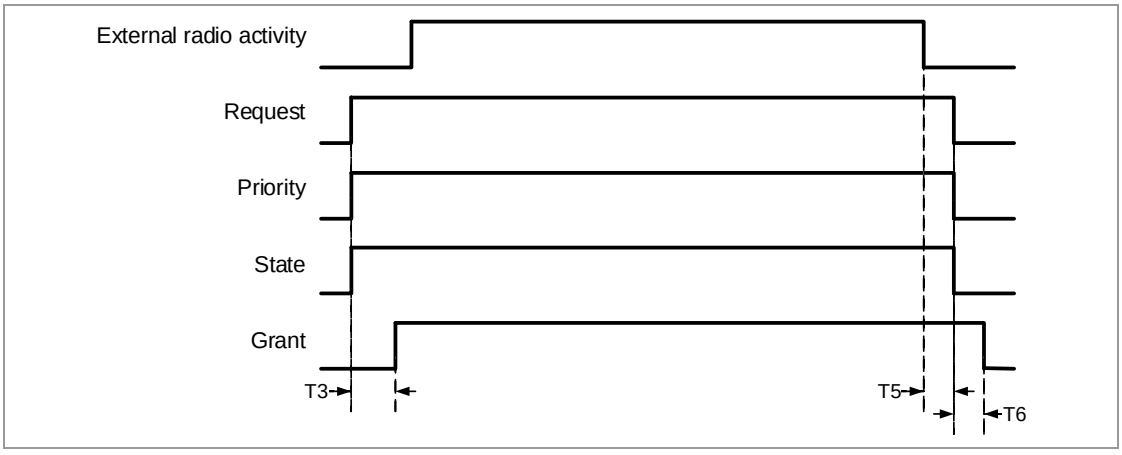
Timing specifications and a functional description of the pins are documented by the following examples.

In a first example, three lines are connected: Request, Priority (optional) and Grant. The external radio device requests to operate and indicates priority by asserting the respective lines. After all information (request and priority status) is available on the PAN9019, it takes the time T3 until the grant signal is applied. In this example, the requested operation is granted and the external radio can start its RF activity. After the operation has finished, the external radio signalized this to the PAN9019 by de-asserting the request and priority lines within T5. Finally, the PAN9019 Packet Traffic Arbiter (PTA) de-asserts the grant (T6).



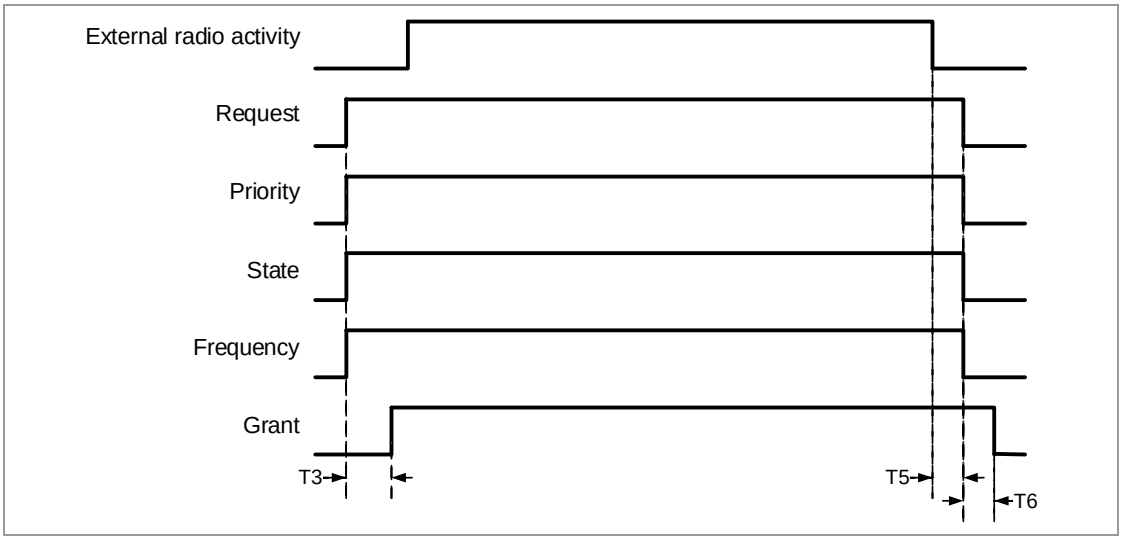
Parameter	Conditions	Min.	Typ.	Max.	Unit
T3	Time until the grant signal is activated after the priority and request information is available	0.1	-	0.4	µs
T5	De-assertion time after the end of the external radio's operation	-	-	-	µs
T6	De-assertion time of the grant signal after the request de-assertion	0.1	-	0.3	µs

By adding the optional State signal, the external radio can define, which operation it is requesting a grant for. A high signal means Tx, while a low signal means Rx. Besides this additional information, the procedure and timing are identical to the first example.



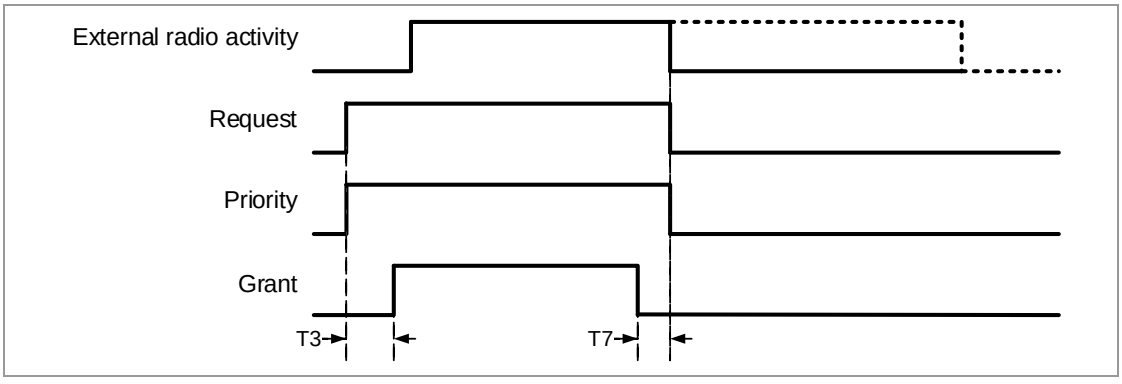
Parameter	Conditions	Min.	Typ.	Max.	Unit
T3	Time until the grant signal is activated after the priority, state and request information is available	0.1	-	0.4	µs
T5	De-assertion time after the end of the external radio's operation	-	-	-	µs
T6	De-assertion time of the grant signal after the request de-assertion	0.1	-	0.3	µs

As the second example, also the third example does not show differences in the basic function compared to the first. Instead, it adds further information about the frequency. A low level on the Frequency line indicates that the external radio requests to operate in a frequency range that does not overlap with the operation bandwidth of the PAN9019. In contrast, a high level means that the frequencies do overlap. The signal is intended for radios that use frequency hopping and can define a non-hopping window as a coexistence mechanism.



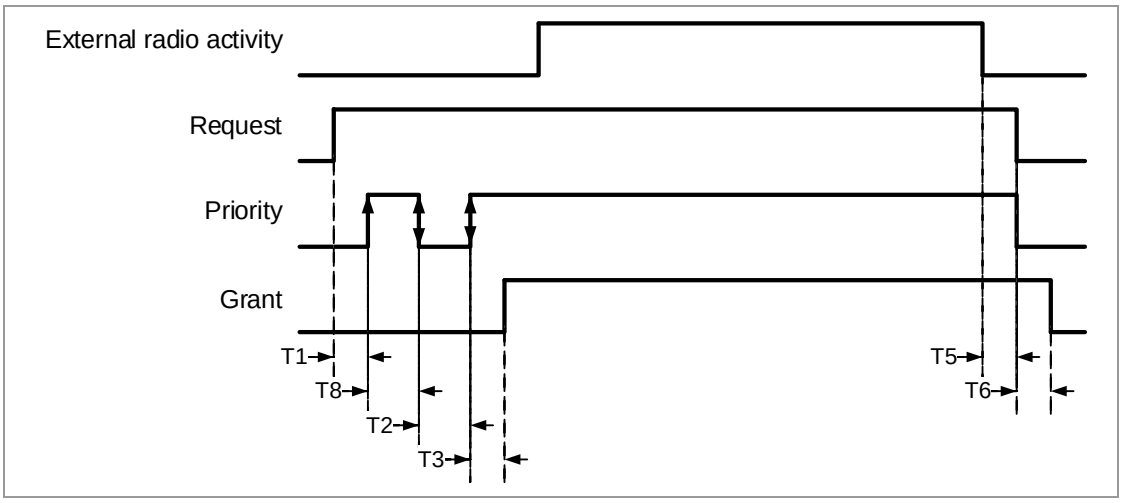
Parameter	Conditions	Min.	Typ.	Max.	Unit
T3	Time until the grant signal is activated after the priority, state, frequency and request information is available	0.1	-	0.4	µs
T5	De-assertion time after the end of the external radio's operation	-	-	-	µs
T6	De-assertion time of the grant signal after the request de-assertion	0.1	-	0.3	µs

During the operation of the external radio, the grant of operation can be withdrawn by the PAN9019, which is illustrated in the fourth example below. In this case, the external radio must stop its radio activity. The duration T7 between the de-assertion of the grant and deactivation of the external radio is not further defined.



Parameter	Conditions	Min.	Typ.	Max.	Unit
T3	Time until the grant signal is activated after the priority and request information is available	0.1	-	0.4	µs
T7	Time from the grant de-assertion to the end of the external radio's operation	-	-	-	µs

In the fifth example, the Priority line does not contain static information about only the priority, but it is sampled up to three times, which allow to receive three informational bits. After detecting the request from the external radio, it takes T1 until the PAN9019 samples the first information bit, which is the least significant priority bit (in case of a two-bit priority) or the one-bit priority information. If a two bit priority value is used, the second bit is samples after a further duration T8. T2 defines the time from the last received priority bit to the sampling of the Tx/Rx information.



Parameter	Conditions	Min.	Typ.	Max.	Unit
T1	Time from the priority assertion until priotity bit 0 is sampled	0	-	100	µs
T8	Optional: Priority bit 1 is sampled at T1 +T8 from Request assertion	0.025	-	100	µs
T2	Optional: Tx/Rx Info, if present on Priority pin, is sampled at T1+T2 (one priority bit on Priority pin) or T1+T8+T2 (two priority bits on Priority pin) from Request assertion.	0.025	-	100	µs
T3	Time until the grant signal is activated after the priority, Tx/Rx and request information is available	0.1	-	0.4	µs
T5	De-assertion time after the end of the external radio's operation	-	-	-	µs
T6	De-assertion time of the grant signal after the request de-assertion	0.1	-	0.3	µs

4.6 RF Electrical Characteristics

4.6.1 WLAN Radio Specification

Parameter	Operation Mode				Specification
Standard Conformance	IEEE 802.11/IEEE 802.11b				
	IEEE 802.11g/a				
	IEEE 802.11n				
	IEEE 802.11ac				
	IEEE 802.11ax				
Modulation	IEEE 802.11b				DSSS/CCK
	IEEE 802.11g/a				OFDM
	IEEE 802.11n				OFDM at MCS0~7
	IEEE 802.11ac				OFDM at MCS0~9 (MCS0~8 for 20 MHz channels)
	IEEE 802.11ax				OFDM at MCS0~11 OFDMA at MCS0~11
Physical Layer Data Rates	IEEE 802.11				1 Mbps and 2 Mbps at DSSS
	IEEE 802.11b				5.5 Mbps and 11 Mbps at DSSS/CCK
Supported Data Rates	IEEE 802.11g/a				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
	IEEE 802.11ac	MCS0~8	VHT20	LGI	6.5 / 13 / 19.5 / 26 / 39 / 52 / 58.5 / 65 / 78 Mbps
				SGI	7.2 / 14.4 / 21.7 / 28.9 / 43.3 / 57.8 / 65 / 72.2 / 86.7 Mbps
		MCS0~9	VHT40	LGI	13.5 / 27 / 40.5 / 54 / 81 / 108 / 121.5 / 135 / 162 / 180 Mbps
				SGI	15 / 30 / 45 / 60 / 90 / 120 / 135 / 150 / 180 / 200 Mbps
		MCS0~9	VHT80	LGI	29.3 / 58.5 / 87.8 / 117 / 175.5 / 234 / 263.3 / 292.5 / 351 / 390 Mbps
				SGI	32.5 / 65 / 97.5 130 / 195 / 260 / 292.5 / 325 / 390 / 433.3 Mbps
	IEEE 802.11ax Single User HE_SU	MCS0~11	HE20	3.2 µs GI	7.3 / 14.6 / 21.9 / 29.3 / 43.9 / 58.5 / 65.8 / 73.1 / 87.8 / 97.5 / 109.7 / 121.9 Mbps
				1.6 µs GI	8.1 / 16.3 / 24.4 / 32.5 / 48.8 / 65.0 / 73.1 / 81.3 / 97.5 / 108.3 / 121.9 / 135.4 Mbps
				0.8 µs GI	8.6 / 17.2 / 25.8 / 34.4 / 51.6 / 68.8 / 77.4 / 86.0 / 103.2 / 114.7 / 129.0 / 143.4 Mbps
		MCS0~11	HE40	3.2 µs GI	14.6 / 29.3 / 43.9 / 58.5 / 87.8 / 117.0 / 131.6 / 146.3 / 175.5 / 195.0 / 219.4 / 243.8 Mbps

Parameter	Operation Mode				Specification
				1.6 µs GI	16.3 / 32.5 / 48.8 / 65.0 / 97.5 / 130.0 / 146.3 / 162.5 / 195.0 / 216.7 / 243.8 / 270.8 Mbps
				0.8 µs GI	17.2 / 34.4 / 51.6 / 68.8 / 103.2 / 137.6 / 154.9 / 172.1 / 206.5 / 229.4 / 258.1 / 286.8 Mbps
		MCS0~11	HE80	3.2 µs GI	30.6 / 61.3 / 91.9 / 122.5 / 183.8 / 245 / 275.6 / 306.3 / 367.5 / 408.3 / 459.4 / 510.4 Mbps
				1.6 µs GI	34.0 / 68.1 / 102.1 / 136.1 / 204.2 / 272.2 / 306.3 / 340.3 / 408.3 / 453.7 / 510.4 / 567.1 Mbps
				0.8 µs GI	36.0 / 72.1 / 108.1 / 144.1 / 216.2 / 288.2 / 324.3 / 360.3 / 432.4 / 480.4 / 540.4 / 600.5 Mbps
	IEEE 802.11ax OFDMA HE_TB (Tx only) HE_MU (Rx only)	MCS0~11	26-RU	3.2 µs GI	0.8 / 1.5 / 2.3 / 3.0 / 4.5 / 6.0 / 6.8 / 7.5 / 9.0 / 10.0 / 11.3 / 12.5 Mbps
				1.6 µs GI	0.8 / 1.7 / 2.5 / 3.3 / 5.0 / 6.7 / 7.5 / 8.3 / 10.0 / 11.1 / 12.5 / 13.9 Mbps
				0.8 µs GI	0.9 / 1.8 / 2.6 / 3.5 / 5.3 / 7.1 / 7.9 / 8.8 / 10.6 / 11.8 / 13.2 / 14.7 Mbps
		MCS0~11	52-RU	3.2 µs GI	1.5 / 3.0 / 4.5 / 6.0 / 9.0 / 12.0 / 13.5 / 15.0 / 18.0 / 20.0 / 22.2 / 25.0 Mbps
				1.6 µs GI	1.7 / 3.3 / 5.0 / 6.7 / 10.0 / 13.3 / 15.0 / 16.7 / 20.0 / 22.2 / 25.0 / 27.8 Mbps
				0.8 µs GI	1.8 / 3.5 / 5.3 / 7.1 / 10.6 / 14.1 / 15.9 / 17.6 / 21.2 / 23.5 / 26.5 / 29.4 Mbps
		MCS0~11	106-RU	3.2 µs GI	3.2 / 6.4 / 9.6 / 12.8 / 19.1 / 25.5 / 28.7 / 31.9 / 38.3 / 42.5 / 47.8 / 53.1 Mbps
				1.6 µs GI	3.5 / 7.1 / 10.6 / 14.2 / 21.3 / 28.3 / 31.9 / 35.4 / 42.5 / 47.2 / 53.1 / 59.0 Mbps
				0.8 µs GI	3.8 / 7.5 / 11.3 / 15.0 / 22.5 / 30.0 / 33.8 / 37.5 / 45.0 / 50.0 / 56.3 / 62.5 Mbps
		MCS0~11	242-RU	3.2 µs GI	7.3 / 14.6 / 21.9 / 29.3 / 43.9 / 58.5 / 65.8 / 73.1 / 87.8 / 97.5 / 109.7 / 121.9 Mbps
				1.6 µs GI	8.1 / 16.3 / 24.4 / 32.5 / 48.8 / 65.0 / 73.1 / 81.3 / 97.5 / 108.3 / 121.9 / 135.4 Mbps
				0.8 µs GI	8.6 / 17.2 / 25.8 / 34.4 / 51.6 / 68.8 / 77.4 / 86.0 / 103.2 / 114.7 / 129.0 / 143.4 Mbps
		MCS0~11	484-RU	3.2 µs GI	14.6 / 29.3 / 43.9 / 58.5 / 87.8 / 117.0 / 131.6 / 146.3 / 175.5 / 195.0 / 219.4 / 243.8 Mbps
				1.6 µs GI	16.3 / 32.5 / 48.8 / 65.0 / 97.5 / 130.0 / 146.3 / 162.5 / 195.0 / 216.7 / 243.8 / 270.8 Mbps
				0.8 µs GI	17.2 / 34.4 / 51.6 / 68.8 / 103.2 / 137.6 / 154.9 / 172.1 / 206.5 / 229.4 / 258.1 / 286.8 Mbps

Parameter	Operation Mode				Specification
		MCS0~11	996-RU	3.2 µs GI	30.6 / 61.3 / 91.9 / 122.5 / 183.8 / 245.0 / 275.6 / 306.3 / 367.5 / 408.3 / 459.4 / 510.4 Mbps
				1.6 µs GI	34.0 / 68.1 / 102.1 / 136.1 / 204.2 / 272.2 / 306.3 / 340.3 / 408.3 / 453.7 / 510.4 / 567.1 Mbps
				0.8 µs GI	36.0 / 72.1 / 108.1 / 144.1 / 216.2 / 288.2 / 324.3 / 360.3 / 432.4 / 480.4 / 540.4 / 600.5 Mbps
	IEEE 802.11ax Extended Range HE_ER_SU	MCS0~2	242-RU	3.2 µs GI	7.3 / 14.6 / 21.9 / 29.3 Mbps
				1.6 µs GI	8.1 / 16.3 / 24.4 / 32.5 Mbps
				0.8 µs GI	8.6 / 17.2 / 25.8 / 34.4 Mbps
		MCS0	106-RU	3.2 µs GI	3.2 Mbps
				1.6 µs GI	3.5 Mbps
				0.8 µs GI	3.8 Mbps
Supported Bandwidth (BW)	IEEE 802.11n				20 MHz (HT20), 40 MHz (HT40)
	IEEE 802.11ac				20 MHz (VHT20), 40 MHz (VHT40), 80 MHz (VHT80)
	IEEE 802.11ax				20 MHz (HE20), 40 MHz (HE40), 80 MHz (HE80)
Supported Resource Units (RUs)	IEEE 802.11 ax Multiuser OFDMA				26 tone RUs (26-RU), 52 tone RUs (52-RU), 106 tone RUs (106-RU), 242 tone RUs (242-RU), 484 tone RUs (484-RU), 996 tone RUs (996-RU)
	IEEE 802.11 ax Singel User (SU) Extended Range (ER)				106 tone RU (106-RU – Partial Bandwidth), 242 tone RU (242-RU)
Supported Guard Interval	IEEE 802.11n/ac				400 ns (SGI), 800 ns (LGI)
	IEEE 802.11ax		1× HE-LTF 2× HE-LTF		0.8 µs, 1.6 µs
			4× HE-LTF		0.8 µs, 3.2 µs
Supported Channels 2.4 GHz[12]	IEEE 802.11 b		20 MHz		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
	IEEE 802.11 g/n/ax		20 MHz		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
	IEEE 802.11n/ax		40 MHz		3, 4, 5, 6, 7, 8, 9, 10, 11
Supported Channels 5 GHz[12]	IEEE 802.11a/n/ac/ax		20 MHz		36, 40, 44, 48, 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140, 144, 149, 153, 157, 161, 165, 169, 173, 177
	IEEE 802.11n/ac/ax		40 MHz		38, 46, 54, 62, 102, 110, 118, 126, 134, 142, 151, 159, 167, 175
	IEEE 802.11ac/ax		80 MHz		42, 58, 106, 122, 138, 155, 171

[12] Channels can be prohibited by regulatory policies. Please follow the instruction in the “PAN9019 / PAN9019A Module Integration Guide” for a compliant utilization of the module.

4.6.2 WLAN RF Characteristics

4.6.2.1 IEEE 802.11b (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range			2 400		2 483.5	MHz
Carrier Frequency Tolerance			-25		+25	ppm
Transmit Output Power[13]				+18		dBm
Spectrum Mask	f_C±11 MHz				-30	dBr
	f_C±22 MHz				-50	dBr
Power-on/Power-down Ramp				0.07	2	µs
RF Carrier Suppression					-15	dB
Error Vector Magnitude (EVM)	Peak				35	%
Minimum Receive Sensitivity	1 Mbps (DSSS)	PER ≤ 8 %		-98	-80	dBm
	11 Mbps (CCK)	PER ≤ 8 %		-89	-76	dBm
Maximum Input Level				0.47		dBm
Adjacent Channel Rejection		PER ≤ 8 %	35			dB

4.6.2.2 IEEE 802.11g (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range			2 400		2 483.5	MHz
Carrier Frequency Tolerance			-25		+25	ppm
Transmit Output Power[14]	6 Mbps~18 Mbps			16		dBm
	24 Mbps~36 Mbps			16		dBm
	48 Mbps~54 Mbps			16		dBm

[13] Please note that the actual maximum configurable output power depends on the used regulatory files.

[14] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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 %		-92	-82	dBm
	64-QAM, CR 3/4 (54 Mbps)	PER ≤ 10 %		-76	-65	dBm
Maximum Input Level				-9.7		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

4.6.2.3 IEEE 802.11n: BW 20 MHz (RF Characteristics at 2.4 GHz)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			2 400		2 483.5	MHz
Carrier Frequency Tolerance			-25		+25	ppm
Transmit Output Power[15]	MCS0~MCS2			15		dBm
	MCS3~MCS4			15		dBm
	MCS5~MCS7			15		dBm
Spectrum Mask	f_C±11 MHz				-20	dBr
	f_C ±20 MHz				-28	dBr
	f_C ±30 MHz				-45	dBr

[15] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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	MCS0	PER ≤ 10 %		-92	-82	dBm
	MCS7	PER ≤ 10 %		-72	-64	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

4.6.2.4 IEEE 802.11n: BW 40 MHz (RF Characteristics at 2.4 GHz)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			2 400		2 483.5	MHz
Carrier Frequency Tolerance			-25		+25	ppm
Transmit Output Power[16]	MCS0~MCS2			14		dBm
	MCS3~MCS4			14		dBm
	MCS5~MCS7			14		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

[16] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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	MCS0	PER ≤ 10 %		-89	-79	dBm
	MCS7	PER ≤ 10 %		-70	-61	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

4.6.2.5 IEEE 802.11ax: BW 20 MHz (RF Characteristics at 2.4 GHz)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			2 400		2 483.5	MHz
Carrier Frequency Tolerance			-25		+25	ppm
Transmit Output Power[17]	MCS0~MCS2			15		dBm
	MCS3~MCS4			15		dBm
	MCS5~MCS7			15		dBm
	MCS8~MCS9			13		dBm
	MCS10~MCS11			10		dBm
Spectrum Mask	fC±10.5 MHz				-20	dBr
	f_C ±20 MHz				-28	dBr
	f_C ±30 MHz				-40	dBr
Transmitter Center Frequency Leakage					-32	dB
Transmitter Spectral Flatness			-4		+4	dB
Constellation Error (EVM)	BPSK, CR 1/2 (MCS0)				-5	dB

[17] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
	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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
	1024-QAM, CR 3/4 (MCS10)				-35	dB
	1024-QAM, CR 5/6 (MCS11)				-35	dB
Minimum Receive Sensitivity[18]	MCS0	PER ≤ 10 %		-92	-82	dBm
	MCS11	PER ≤ 10 %		-63	-52	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[18]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.6.2.6 IEEE 802.11ax: BW 40 MHz (RF Characteristics at 2.4 GHz)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			2 400		2 483.5	MHz
Carrier Frequency Tolerance			-25		+25	ppm
Transmit Output Power[19]	MCS0~MCS2			14		dBm
	MCS3~MCS4			14		dBm
	MCS5~MCS7			14		dBm
	MCS8~MCS9			10		dBm
	MCS10~MCS11			10		dBm
Spectrum Mask	f_C ±20.5 MHz				-20	dBr
	f_C ±40 MHz				-28	dBr
	f_C ±60 MHz				-40	dBr

[18] 4x long training field (LTF), guard time = 3.2 µs

[19] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
Transmitter Center Frequency Leakage					-32	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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
	1024-QAM, CR 3/4 (MCS10)				-35	dB
	1024-QAM, CR 5/6 (MCS11)				-35	dB
Minimum Receive Sensitivity[20]	MCS0	PER ≤ 10 %		-89	-79	dBm
	MCS11	PER ≤ 10 %		-61	-49	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[20]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.6.2.7 IEEE 802.11a (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb}=25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[21]	6 Mbps~18 Mbps			16		dBm
	24 Mbps~36 Mbps			16		dBm
	48 Mbps~54 Mbps			16		dBm
Spectrum Mask	f_C ±11 MHz				-20	dBr
	f_C ±20 MHz				-28	dBr

[20] 4x long training field (LTF), guard time = 3.2 µs

[21] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
	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 %		-94	-82	dBm
	64-QAM, CR 3/4 (54 Mbps)	PER ≤ 10 %		-77	-65	dBm
Maximum Input Level				-9.7		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

4.6.2.8 IEEE 802.11n: BW 20 MHz (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 5 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[22]	MCS0~MCS2			15		dBm
	MCS3~MCS4			15		dBm
	MCS5~MCS7			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

[22] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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	MCS0	PER ≤ 10 %		-93	-82	dBm
	MCS7	PER ≤ 10 %		-74	-64	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

4.6.2.9 IEEE 802.11n: BW 40 MHz (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb}= 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 5 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[23]	MCS0~MCS2			14		dBm
	MCS3~MCS4			14		dBm
	MCS5~MCS7			14		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

[23] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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	MCS0	PER ≤ 10 %		-90	-79	dBm
	MCS7	PER ≤ 10 %		-71	-61	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

4.6.2.10 IEEE 802.11ac: BW 20 MHz (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 5 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[24]	MCS0~MCS2			15		dBm
	MCS3~MCS4			15		dBm
	MCS5~MCS7			15		dBm
	MCS8~MCS9			13		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					-17,48	dB
Transmitter Spectral Flatness			-4		+4	dB

[24] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
Minimum Receive Sensitivity	MCS0	PER ≤ 10 %		-93	-82	dBm
	MCS8	PER ≤ 10 %		-70	-59	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection	MCS0	PER ≤ 10 %	16			dB
	MCS8	PER ≤ 10 %	-8			dB

4.6.2.11 IEEE 802.11ac: BW 40 MHz (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 5 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[25]	MCS0~MCS2			14		dBm
	MCS3~MCS4			14		dBm
	MCS5~MCS7			14		dBm
	MCS8~MCS9			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					-20.57	dB
Transmitter Spectral Flatness			-4		+4	dB

[25] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
Minimum Receive Sensitivity	MCS0	PER ≤ 10 %		-90	-79	dBm
	MCS9	PER ≤ 10 %		-66	-54	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection	MCS0	PER ≤ 10 %	16			dB
	MCS9	PER ≤ 10 %	-9			dB

4.6.2.12 IEEE 802.11ac: BW 80 MHz (RF Characteristics)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[26]	MCS0~MCS2			14		dBm
	MCS3~MCS4			14		dBm
	MCS5~MCS7			14		dBm
	MCS8~MCS9			13		dBm
Spectrum Mask	f_C±41 MHz				-20	dBr
	f_C±80 MHz				-28	dBr
	f_C±120 MHz				-40	dBr
Transmitter Center Frequency Leakage					-23.8	dB
Transmitter Spectral Flatness			-4		+4	dB

[26] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
Minimum Receive Sensitivity	MCS0	PER ≤ 10 %		-86	-76	dBm
	MCS9	PER ≤ 10 %		-63	-51	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection	MCS0	PER ≤ 10 %	16			dB
	MCS9	PER ≤ 10 %	-9			dB

4.6.2.13 IEEE 802.11ax: BW 20 MHz (RF Characteristics at 5 GHz)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[27]	MCS0~MCS2			15		dBm
	MCS3~MCS4			15		dBm
	MCS5~MCS7			15		dBm
	MCS8~MCS9			13		dBm
	MCS10~MCS11			10		dBm
Spectrum Mask	f_C±10.5 MHz				-20	dBr
	f_C±20 MHz				-28	dBr
	f_C±30 MHz				-40	dBr
Transmitter Center Frequency Leakage					-32	dB

[27] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
	1024-QAM, CR 3/4 (MCS10)				-35	dB
	1024-QAM, CR 5/6 (MCS11)				-35	dB
Minimum Receive Sensitivity[28]	MCS0	PER ≤ 10 %		-94	-82	dBm
	MCS11	PER ≤ 10 %		-64	-52	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[28]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.6.2.14 IEEE 802.11ax: BW 40 MHz (RF Characteristics at 5 GHz)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[29]	MCS0~MCS2			14		dBm
	MCS3~MCS4			14		dBm
	MCS5~MCS7			14		dBm
	MCS8~MCS9			13		dBm
	MCS10~MCS11			10		dBm
Spectrum Mask	f_C±20.5 MHz				-20	dBr

[28] 4x long training field (LTF), guard time = 3.2 µs

[29] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
	f_C±40 MHz				-28	dBr
	f_C±60 MHz				-40	dBr
Transmitter Center Frequency Leakage					-32	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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
	1024-QAM, CR 3/4 (MCS10)				-35	dB
	1024-QAM, CR 5/6 (MCS11)				-35	dB
Minimum Receive Sensitivity[30]	MCS0	PER ≤ 10 %		-90	-79	dBm
	MCS11	PER ≤ 10 %		-62	-49	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[30]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.6.2.15 IEEE 802.11ax: BW 80 MHz (RF Characteristics at 5 GHz)

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

Parameter		Condition	Min.	Typ.	Max.	Unit
RF Frequency Range 2.4 GHz			4 900		5 895	MHz
Carrier Frequency Tolerance			-20		+20	ppm
Transmit Output Power[31]	MCS0~MCS2			14		dBm
	MCS3~MCS4			14		dBm

[30] 4x long training field (LTF), guard time = 3.2 µs

[31] Please note that the actual maximum configurable output power depends on the used regulatory files.

Parameter		Condition	Min.	Typ.	Max.	Unit
	MCS5~MCS7			14		dBm
	MCS8~MCS9			13		dBm
	MCS10~MCS11			10		dBm
Spectrum Mask	f_C±40.5 MHz				-20	dBr
	f_C±80 MHz				-28	dBr
	f_C±120 MHz				-40	dBr
Transmitter Center Frequency Leakage					-32	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
	256-QAM, CR 3/4 (MCS8)				-30	dB
	256-QAM, CR 5/6 (MCS9)				-32	dB
	1024-QAM, CR 3/4 (MCS10)				-35	dB
	1024-QAM, CR 5/6 (MCS11)				-35	dB
Minimum Receive Sensitivity[32]	MCS0	PER ≤ 10 %		-87	-76	dBm
	MCS11	PER ≤ 10 %		-59	-46	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[32]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.6.3 Bluetooth RF Characteristics

Assume 3V3 = 3.3 V, 1V8 = 1.8 V, T_{amb} = 25 °C, if nothing else stated.

50 Ω terminal load connected to the RF connector.

[32] 4x long training field (LTF), guard time = 3.2 µs

4.6.3.1 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 ≤ 0.1 %	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 ≤ 0.1 %	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
	GFSK RSL = -67 dBm BER ≤ 0.1 % 2 Mbps	C/I (Co-channel)			21	dB
		C/I (2 MHz)			15	dB
		C/I (3 MHz)			-17	dB
		C/I (≥6 MHz)			-27	dB
		C/I (Image)			-9	dB
		C/I (Image ± 2 MHz)			-15	dB
	GFSK RSL = -67 dBm BER ≤ 0.1 % Long Range S = 8 (125 kbps)	C/I (Co-channel)			12	dB
		C/I (1 MHz)			6	dB
		C/I (2 MHz)			-26	dB
		C/I (≥3 MHz)			-36	dB
		C/I (Image)			-18	dB
		C/I (Image ± 1 MHz)			-24	dB
	GFSK	C/I (Co-channel)			17	dB
		C/I (1 MHz)			11	dB

Parameter	Condition		Min.	Typ.	Max.	Units
	RSL = -67 dBm BER ≤ 0.1 % Long Range S = 2 (500 kbps)	C/I (2 MHz)			-21	dB
		C/I (≥3 MHz)			-31	dB
		C/I (Image)			-13	dB
		C/I (Image ± 1 MHz)			-19	dB
Minimum Receive Sensitivity	BR, DH5	BER ≤ 0.1 %		-96	-70	dBm
	EDR, 2DH5	BER ≤ 0.1 %		-96	-70	dBm
	EDR, 3DH5	BER ≤ 0.1 %		-90	-70	dBm
	LE, 1 Mbps	BER ≤ 0.1 %		-99	-70	dBm
	LE, 2 Mbps	BER ≤ 0.1 %		-96	-70	dBm
	LE-LR, S = 2	BER ≤ 0.1 % Payload < 37 bytes		-100	-75	dBm
	LE-LR, S = 8	BER ≤ 0.1 % Payload < 37 bytes		-105	-82	dBm
Out-of-band blocking (Classic) Interfering Signal Power	RSL = -67 dBm BER ≤ 0.1 %	30 MHz to 2 000 MHz			-10	dB
		2 GHz to 2.399 GHz			-27	dB
		2.484 GHz to 3 GHz			-27	dB
		3 GHz to 12.75 GHz			-10	dB
Out-of-band blocking (Low Energy) Interfering Signal Power	GFSK RSL = -67 dBm BER ≤ 0.1 %	30 MHz to 2 000 MHz			-30	dB
		2 GHz to 2.399 GHz			-35	dB
		2.484 GHz to 3 GHz			-35	dB
		3 GHz to 12.75 GHz			-30	dB

4.6.3.2 Transmitter Section RF Characteristics

Parameter	Condition	Min.	Typ.	Max.	Units
RF frequency range		2 400		2 483.5	MHz
Output power[33]	Basic Rate (BR)		+8		dBm
	Enhanced Data Rate (EDR)		+8		dBm
	Low energy (LE)		+8		dBm
Gain range	Basic Rate (BR)		-13.8 to 18.8		dB
	Enhanced Data Rate (EDR)		-22.4 to 9.7		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

[33] Please note that the maximum transmit power must be limited according to the country's or region's regulations. The "PAN9019 PAN9019A Module Integration Guide" describes the required settings.

Parameter	Condition		Min.	Typ.	Max.	Units
	± 2.5 MHz				-40	dBm
Spurious emission (LE) (in-band)	1 Mbps LR S = 2 LR S = 8	± 2 MHz, |M-N| = 2			-20	dBm
		± 3 MHz or greater, |M-N| ≥ 3			-30	dBm
	2 Mbps	± 4 MHz, |M-N| = 4			-20	dBm
		± 5 MHz, |M-N| = 5			-20	dBm
		± 6 MHz or greater, |M-N| ≥ 6			-30	dBm

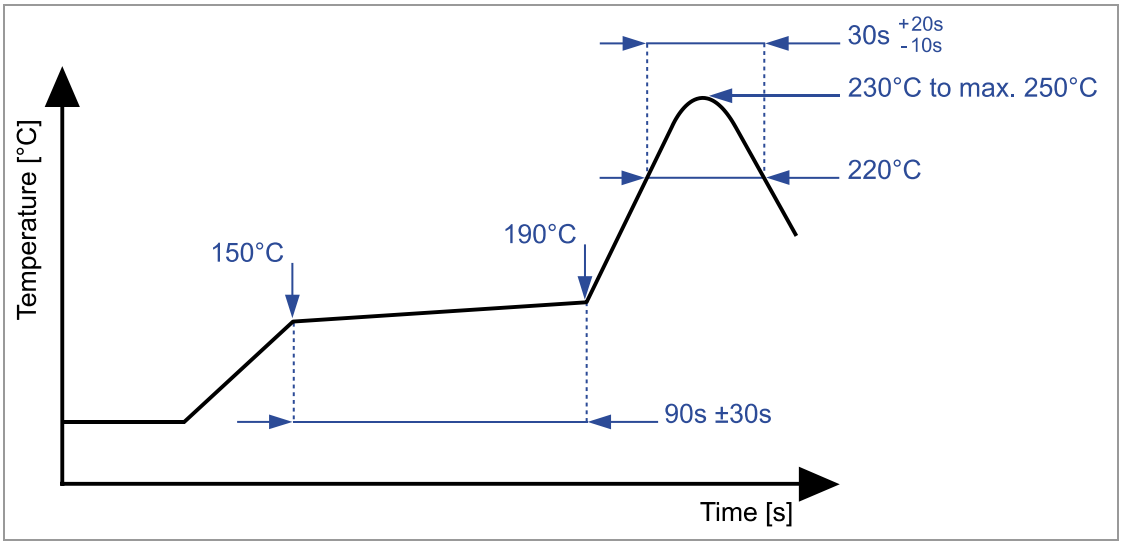
4.7 Reliability Tests

The measurements have been done after the test device has been exposed to room temperature and humidity for one hour.

No.	Item	Limit	Condition
1	Variable Vibration Test	Electrical parameters should be within specification	Freq.: 20~2 000 Hz, Acc.: 17-50 G, Sweep: 8 min, 2 hours, For: XYZ axis
2	Shock Drop Test		Drop parts on concrete from a height of 1 m for 3 times
3	Temperature Cycling Test		At -40 °C and 85 °C for 1 h/cycle Total = 300 cycles
4	Temperature Humidity Bias Test		At 60 °C, 85 % r.H., 300 h
5	Low Temperature Storage Life Test		At -40 °C, 300 h
6	High Temperature Storage Life Test		At 85 °C, 300 h

4.8 Recommended Soldering Profile

- Reflow permissible cycles: 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 module functions and damage to the module.

5.1 Design Notes

1. Follow the conditions written in this specification, especially the control signals of this module.
2. The supply voltage should abide by the maximum ratings (⇨ 4.2 Absolute Maximum Ratings).
3. 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).
4. This module should not be mechanically stressed when installed.
5. Keep this module away from heat. Heat is the major cause of decreasing the life time of these modules.
6. Avoid assembly and use of the target equipment in conditions where the module temperature may exceed the maximum tolerance.
7. Keep this module 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 ⇨ 4.8 Recommended Soldering Profile. Set up the temperature at the soldering portion of this module according to this reflow profile.
2. Carefully position the module so that the heat will not burn into printed circuit boards or affect other components that are susceptible to heat.
3. Carefully locate the module, to avoid an increased temperature caused by heat generated by neighboring components.
4. If a vinyl-covered wire comes into contact with the module, the wire cover will melt and generate toxic gas, damaging the insulation. Never allow contact between a vinyl cover and these modules to occur.
5. This module 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 module.

5.3 Usage Condition Notes

1. Take measures to protect the module against static electricity.
   If pulses or transient loads (a large load, which is suddenly applied) are applied to the modules, check and evaluate their operation before assembly of the final products.
2. Do not use dropped modules.
3. Do not touch, damage, or soil the pins.
4. Follow the recommended condition ratings about the power supply applied to this module.
5. Electrode peeling strength: Do not apply a force of more than 4.9 N in any direction on the soldered module.
6. Pressing on parts of the metal cover or fastening objects to the metal cover will cause damage.
7. These modules 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 modules in the following conditions or the performance characteristics of the module, 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 modules 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 module away from water, poisonous gas, and corrosive gas.
4. This module 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 module for other purposes than those listed in section ⇨ 5.3 Usage Condition Notes.
2. Be sure to provide an appropriate fail-safe function on your product to prevent any additional damage that may be caused by the abnormal function or the failure of the module.
3. This module has been manufactured without any ozone chemical controlled under the Montreal Protocol.
4. These modules are not intended for use under the special conditions shown below. Before using these modules 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 modules with new modules, because they may not be able to provide normal performance even if their electronic characteristics and appearances appear satisfactory.



For further information please refer to the Panasonic website ⇨ 7.3.2 Product Information.

5.7 Restricted Use

5.7.1 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.

5.7.2 Restricted End Use

This Panasonic Industrial Devices Europe GmbH product is not designed for any restricted activity that supports the development, production, handling usage, maintenance, storage, inventory or proliferation of any weapons or military use.

Transfer, export, re-export, usage or reselling of this product to any destination, end user or any end use prohibited by the European Union, United States or any other applicable law is strictly prohibited.

6 Regulatory and Certification Information

For the device the following certifications are available:

Certification		Status	Reference
FCC	for US	Available	⇨ 6.1 Federal Communications Commission (FCC) for US
ISED	for Canada	Available	⇨ 6.2 Innovation, Science, and Economic Development (ISED) for Canada
RED	for Europe	Available	⇨ 6.3 Conformity According to Radio Equipment Directive (RED-2014/53/EU) for Europe
UKCA	for United Kingdom	Available	⇨ 6.4 United Kingdom Conformity According to Statutory Instrument (SI-2017/1206)
MIC	for Japan	Pending	⇨ 6.5 Conformity According to Japanese Radio Act
SRRC	for China	Upon request	
KCC	for Korea	Upon request	
RCM	for Australia and New Zealand	Available	⇨ 6.6 Conformity According to Regulatory Compliance Mark (RCM) for New Zealand and Australia

For regions “upon request”, please reach out to your Sales contact for the most recent status of the certification process ⇨ 7.3.1 Contact Us.

6.1 Federal Communications Commission (FCC) for US

6.1.1 FCC Notice

The PAN9019 (ENWF9501C1KF) including the antennas, which are listed in ⇨ 6.1.5 Approved Antenna List, complies with Part 15 of the FCC Rules.

The device meets the requirements for modular transmitter approval as detailed in FCC public Notice DA00-1407. The transmitter operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

6.1.2 Caution



The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by Panasonic Industrial Devices Europe GmbH may void the user's authority to operate the equipment.



This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules.

These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

There is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna,
- Increase the separation between the equipment and receiver,
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected,
- Consult the dealer or an experienced radio/TV technician for help.

6.1.3 Label Requirements



The OEM must ensure that FCC labelling requirements are met. This includes a clearly visible label on the outside of the OEM enclosure specifying the appropriate Panasonic FCC identifier for this product as well as the FCC Notice above.

The FCC identifier is **FCC ID: T7V9019**.

This FCC identifier is valid for the PAN9019. The end product must in any case be labelled on the exterior with:

"Contains FCC ID: T7V9019".

6.1.4 Antenna Warning

The device is tested with a standard MHF4 connector and with the antenna listed below. When integrated into the OEM's product, these fixed antennas require installation preventing end users from replacing them with non-approved antennas. Any antenna not in the following table must be tested to comply with FCC Section 15.203 for unique antenna connectors and with Section 15.247 for emissions. The FCC identifier for the device with the antenna listed in ⇨ 6.1.5 Approved Antenna List is the same (**FCC ID: T7V9019**).

6.1.5 Approved Antenna List

6.1.5.1 Chip Antennas

The chip antennas listed in this section can be integrated in the carrier board's PCB. If utilized, the integration must follow the instructions of the "PAN9019 / PAN9019A Module Integration Guide".

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cable Variants
ANT162442DT-2001A2	TDK	Chip Antenna	2.1 dBi	2.3 dBi	50 Ohm trace • Min. length: 15 mm

6.1.5.2 PCB Antennas

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cable Options[34]
2JF1002P	2J	Flex PCB	4.2 dBi	8.0 dBi	-005MC137-MHF4L (50 mm) -010MC137-MHF4L (100 mm) -015MC137-MHF4L (150 mm) -020MC137-MHF4L (200 mm) -025MC137-MHF4L (250 mm) -030MC137-MHF4L (300 mm)
2JF0102P	2J	Flex PCB	2.2 dBi	3.8 dBi	-005MC137-MHF4L (50 mm) -010MC137-MHF4L (100 mm) -015MC137-MHF4L (150 mm) -020MC137-MHF4L (200 mm) -025MC137-MHF4L (250 mm) -030MC137-MHF4L (300 mm)
FXP830	Taoglas	Flex PCB	2.5 dBi	4.7 dBi	.54.0055C (55 mm) .54.0100C (100 mm) .54.0150C (150 mm) .54.0200C (200 mm)
W3P35X8W04	Kyocera AVX	PCB	2.3 dBi	5 dBi	-H050D3B0A (50 mm) -H100D3B0A (100 mm) -H150D3B0A (150 mm)
W3F35X8W01	Kyocera AVX	Flex PCB	2.3 dBi	5 dBi	-H050D3B0C (50 mm) -H100D3B0C (100 mm) -H150D3B0C (150 mm)
1001932PT	Kyocera AVX	Flex PCB	2.0 dBi	4.5 dBi	-AC10L0050 (50 mm) -AC10L0100 (100 mm)

[34] Cable option with MHF4L connector; Product number: [Part Number][Cable Option]

6.1.5.3 Terminal Mount Antennas

Part Number	Vendor	Type	Max. Gain (2.4 GHz band)	Max. Gain (5 GHz band)	Cables[35]
GW.51.5153	Taoglas	Terminal Mount	5.2 dBi	5.5 dBi	CAB.S140 (50 mm) CAB.S119 (100 mm) CAB.S141 (150 mm) CAB.S142 (200 mm) CAB.S143 (300 mm)
2JW1102-C943B	2J	Terminal Mount	4.1 dBi	3.9 dBi	C213GST-005MC137-MHF4L (50 mm) C213GST-010MC137-MHF4L (100 mm) C213GST-015MC137-MHF4L (150 mm) C213GST-020MC137-MHF4L (200 mm) C213GST-025MC137-MHF4L (250 mm) C213GST-030MC137-MHF4L (300 mm)
X9000294-W3DRMB	Kyocera AVX	Terminal Mount	3.2 dBi	4.5 dBi	ACM13-04LB030SAR00 (30 mm) ACM13-04LB050SAR00 (50 mm) ACM13-04LB100SAR00 (100 mm) ACM13-04LB150SAR00 (150 mm) ACM13-04LB200SAR00 (200 mm) ACM13-04LB300SAR00 (300 mm)
X9001748-W3DRMB	Kyocera AVX	Terminal Mount	3.2 dBi	3.6 dBi	ACM13-04LB030SAR00 (30 mm) ACM13-04LB050SAR00 (50 mm) ACM13-04LB100SAR00 (100 mm) ACM13-04LB150SAR00 (150 mm) ACM13-04LB200SAR00 (200 mm) ACM13-04LB300SAR00 (300 mm)
X9003019-W3DRMB (Black) X9003019-W3DRMW (White)	Kyocera AVX	Terminal Mount	2.8 dBi	4.9 dBi	ACM13-04LB030SAR00 (30 mm) ACM13-04LB050SAR00 (50 mm) ACM13-04LB100SAR00 (100 mm) ACM13-04LB150SAR00 (150 mm) ACM13-04LB200SAR00 (200 mm) ACM13-04LB300SAR00 (300 mm)

6.1.6 RF Exposure

To comply with FCC RF Exposure requirements, the OEM must ensure that only antennas from the Approved Antenna List are installed ⇨ 6.1.5 Approved Antenna List.

The preceding statement must be included as a “CAUTION” statement in manuals for products operating with the approved antennas in the previous table to alert users on FCC RF Exposure compliance.

Any notification to the end user of installation or removal instructions about the integrated radio module is not allowed.

The radiated output power of the PAN9019 with one of the listed antennas (**FCC ID: T7V9019**) is below the FCC radio frequency exposure limits. The PAN9019 shall be used in such a manner that the potential for human contact during normal operation is minimized.

End users may not be provided with the module installation instructions. OEM integrators and end users must be provided with transmitter operating conditions for satisfying RF exposure compliance.

6.1.7 Integration Instructions

This chapter gives integration instructions for host product manufacturers according to KDB 996369 D03 OEM Manual v01.

Section	Topic and Comment	
2.2	**List of applicable FCC rules**	
	47 CFR Section	Part 15C
	Frequency Band (MHz)	2 400 to 2 483.5
	Systems	Digital Transmission Systems operating within the 2 400 MHz to 2 483.5 MHz Band
	Reference/Requirement	15.247(a)(2), 15.247(b)(1), 15.207, 15.247(d), 15.247(e)
	Complied Module M/N	ENWF9501C1KF
	47 CFR Section	Part 15C
	Frequency Band (MHz)	2 400 to 2 483.5
	Systems	Frequency Hopping Systems operating within the 2 400 MHz to 2 483.5 MHz Band
	Reference/Requirement	15.247(a)(1), 15.247(a)(1)(iii), 15.247(b)(1), 15.207, 15.247(d)
	Complied Module M/N	ENWF9501C1KF

[35] MHF4L to RP-SMA (female) cable

	47 CFR Section	Part 15E
	Systems	Unlicensed National Information Infrastructure Devices in the 5 GHz Bands
	Reference Method	KDB 905462 D02 v02
	Reference/Requirement	15E.407(h)(2)
	Complied Module M/N	ENWF9501C1KF
2.3	**Summarize the specific operational use conditions**	
	Please refer to sections ⇨ 5 Cautions ⇨ 5.3 Usage Condition Notes, and ⇨ 6.1.5 Approved Antenna List.	
2.4	**Limited module procedures**	
	Not applicable, the module has a single-modular transmitter approval.	
2.5	**Trace antenna designs**	
	Not applicable, a chip antenna can be integrated on the carrier board or external antennas as listed in ⇨ 6.1.5 Approved Antenna List can be used. For guidance regarding the PCB layout requirements for module integration refer to the module integration guide linked in ⇨ 7.3.2 Product Information.	
2.6	**RF exposure considerations**	
	Mobile application, the end customer has to assure that the device has a distance of more than 20 cm from the human body under all circumstances.	
2.7	**Antennas**	
	Please refer to sections ⇨ 6.1.4 Antenna Warning and ⇨ 6.1.5 Approved Antenna List.	
2.8	**Label and compliance information**	
	Please refer to section ⇨ 6.1.3 Label Requirements.	
2.9	**Information on test modes and additional testing requirements**	
	The documents for integration guidance and compliance testing are available here ⇨ 7.3.2 Product Information.	
2.10	**Additional testing, Part 15 Subpart B disclaimer**	
	The single-modular transmitter is FCC authorized for the specific rule parts listed at section 2.2 “List of applicable FCC rules“. The host product manufacturer needs to also consider the FCC requirements for certified modular transmitter being used in the host product and maintain documentation on how the host product with the certified modular transmitter complies with the FCC rules. Host product manufacturers are responsible to follow the integration guidance and to perform a limited set of transmitter module verification testing, to ensure the end product is in compliance with the FCC rules. Also host product manufacturers are responsible for all additional equipment authorization and testing for technical requirements not covered by the module grant (e.g., unintentional radiator Part 15 Subpart B requirements, or transmitters used in the host that are not certified modules).	

6.2 Innovation, Science, and Economic Development (ISED) for Canada

English

The PAN9019 is licensed to meet the regulatory requirements of ISED.

License ID: **IC: 216Q-9019**

Manufacturers of mobile, fixed or portable devices incorporating this module are advised to clarify any regulatory questions and ensure compliance for SAR and/or RF exposure limits. Users can obtain Canadian information on RF exposure and compliance from www.ic.gc.ca.

This device has been designed to operate with the antennas listed in ⇨ 6.1.5 Approved Antenna List, having a maximum gain of 5.2 dBi for 2.4 GHz and 8.0 dBi for 5 GHz. Antennas not included in this list or having a gain greater than 5.2 dBi for 2.4 GHz and 8.0 dBi for 5 GHz are strictly prohibited for use with this device. The required antenna impedance is 50 ohms. The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Due to the model size, the IC identifier is displayed in the installation instruction only and it cannot be displayed on the module's label due to the limited size.

French

PAN9019 est garanti conforme aux dispositions règlementaires d'Industry Canada (ISED).

License: **IC: 216Q-9019**

Il est recommandé aux fabricants d'appareils fixes, mobiles ou portables de consulter la réglementation en vigueur et de vérifier la conformité de leurs produits relativement aux limites d'exposition aux rayonnements radiofréquence ainsi qu'au débit d'absorption spécifique maximum autorisé.

Des informations pour les utilisateurs sur la réglementation Canadienne concernant l'exposition aux rayonnements RF sont disponibles sur le site www.ic.gc.ca.

Ce produit a été développé pour fonctionner spécifiquement avec les antennes listées dans le tableau ⇨ 6.1.5 Approved Antenna List, présentant un gain maximum de 5.2 dBi pour 2.4 GHz et 8.0 dBi pour 5 GHz. Des antennes autres que celles listées ici, ou présentant un gain supérieur à 5.2 dBi pour 2.4 GHz et 8.0 dBi pour 5 GHz ne doivent en aucune circonstance être utilisées en combinaison avec ce produit. L'impédance des antennes compatibles est 50 Ohm. L'antenne utilisée avec ce produit ne doit ni être située à proximité d'une autre antenne ou d'un autre émetteur, ni être utilisée conjointement avec une autre antenne ou un autre émetteur.

En raison de la taille du produit, l'identifiant IC est fourni dans le manuel d'installation.

6.2.1 Radio Standards Specification RSS-247 Issue 3

The Radio Standards Specification RSS-247, Issue 3, Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices, replaces RSS-247, Issue 2, dated February 2017. It sets out certification requirements for radio apparatus operating in the bands 2 400 MHz to 2 483.5 MHz and 5 725 MHz to 5 850 MHz employing frequency hopping, digital modulation and/or a combination (hybrid) of both techniques. It also includes license exempt local area network (LE-LAN) devices operating in the bands 5 150 MHz to 5 250 MHz, 5 250 MHz to 5 350 MHz, 5 470 MHz to 5 725 MHz and 5 725 MHz to 5 850 MHz as specified in SP-5 150 MHz.

6.2.1.1 General

Equipment covered by the standard RSS-247 is classified as Category I equipment. Either a technical acceptance certificate (TAC) issued by the Certification and Engineering Bureau of Innovation, Science and Economic Development Canada (ISED) or a certificate issued by a certification body (CB) is required.

6.2.1.2 Certification Requirements

RSS-247 shall be used in conjunction with RSS-Gen, General Requirements for Compliance of Radio Apparatus, for general specifications and information relevant to the equipment for which this standard applies. Equipment certified under the standard is required to comply with the provisions in RSS‑Gen with respect to emissions falling within restricted frequency bands. These restricted frequency bands are listed in RSS‑Gen.

6.2.1.3 Measurement Method

In addition to the requirements in RSS-Gen and the requirements of the standard RSS-247, the method for measuring DTS devices is provided in ANSI C63.10.

6.2.1.4 FHS and DTS Operating in the Bands 2 400 MHz to 2 483.5 MHz

This section applies to frequency hopping systems (FHSs) in the bands 2 400 MHz to 2 483.5 MHz and 5 725 MHz to 5 850 MHz and digital transmission systems (DTSs) in the band 2 400 MHz to 2 483.5 MHz. Systems in these bands can be frequency hopping, digital transmission and/or a combination (hybrid) of both types. The digital transmission technology of DTSs or hybrid systems operating in the band 5 725 MHz to 5 850 MHz shall comply with the requirement in section Technical requirements for license-exempt local area network devices and digital transmission systems operating in the 5 GHz band.

RSS-247 Section	5.1
Frequency Band (MHz)	2 400 to 2 483.5
Systems	Frequency Hopping Systems (FHS)
Systems out of Scope	FHS operating in the band 5 725 MHz to 5 850 MHz Fixed point-to-point systems
Requirements	FHSs may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W. FHSs shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.
Complied Module M/N	ENWF9501C1KF

RSS-247 Section	5.2
Frequency Band (MHz)	2 400 to 2 483.5
Systems	Digital Transmission Systems (DTS)
Systems out of Scope	-
Requirements	The minimum 6 dB bandwidth shall be 500 kHz. The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. The maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W.
Complied Module M/N	ENWF9501C1KF

RSS-247 Section	5.3
Frequency Band (MHz)	2 400 to 2 483.5
Systems	Hybrid Systems
Systems out of Scope	Hybrid devices operating in the band 5 725 MHz to 5 850 MHz.
Requirements	With the digital transmission operation of the hybrid system turned off, the frequency hopping operation shall have an average time of occupancy on any frequency not exceeding 0.4 seconds within a duration in seconds equal to the number of hopping frequencies multiplied by 0.4. With the frequency hopping turned off, the digital transmission operation shall comply with the power spectral density requirements for digital modulation systems set out in section “5.2” ⇨ RSS-247 Section.
Complied Module M/N	ENWF9501C1KF

RSS-247 Section	5.4
Frequency Band (MHz)	2 400 to 2 483.5
Systems	FHSs operating in the band 2 400 to 2 483.5 MHz. DTSs employing digital modulation techniques operating in the band 2 400 MHz to 2 483.5 MHz.
Systems out of Scope	FHSs operating in the band 902 MHz to 928 MHz and 5 725 MHz to 5 850 MHz. DTSs employing digital modulation techniques operating in the bands 902 MHz to 928 MHz. Fixed point-to-point systems in the bands 2 400 MHz to 2 483.5 MHz and 5 725 MHz to 5 850 MHz. Transmitters operating in the band 2 400 MHz to 2 483.5 MHz, may employ antenna systems that emit multiple directional beams simultaneously or sequentially.
Requirements	Transmitter Output Power: The maximum peak conducted output power shall not exceed 1 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W. For DTSs employing digital modulation techniques operating in the band 2 400 MHz to 2 483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W.
Complied Module M/N	ENWF9501C1KF

RSS-247 Section	5.5
Frequency Band (MHz)	2 400 to 2 483.5
System	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating.
System out of Scope	-
Requirements	Unwanted Emissions: In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.
Complied Module M/N	ENWF9501C1KF

6.2.1.5 Requirements for LE-LAN and DTS Operating in the 5 GHz Band

The section provides standards for Licence-Exempt Local Area Network (LE-LAN) devices operating in the bands:

- 5 150 to 5 250 MHz,
- 5 250 to 5 350 MHz,
- 5 470 to 5 600 MHz,
- 5 650 to 5 725 MHz,
- 5 725 to 5 850 MHz

For DTSs operating in the band 5 725 MHz to 5 850 MHz that employ digital modulation technology, but are not designed for LE-LAN operation.

Devices with occupied bandwidths which overlap different bands shall comply with all operational requirements for each band.

RSS-247 Section	6.2.1
Frequency Band (MHz)	5 150 to 5 250
Device Type	LE-LAN devices are restricted to **indoor operation** only.
Devices out of Scope	OEM devices installed in vehicles.
Power Limits	Maximum e.i.r.p. shall not exceed 200 mW or 10+10 $\log_{10}$B dBm, whichever power is less. B is the 99 % emission bandwidth in megahertz. The e.i.r.p. spectral density shall not exceed 10 dBm in any 1 MHz band.
Unwanted Emission Limits	For transmitters with operating frequencies in the band 5 150 MHz to 5 250 MHz, all emissions outside the band 5 150 MHz to 5 350 MHz shall not exceed -27 dBm/MHz e.i.r.p. Any unwanted emissions that falls into the band 5 250 MHz to 5 350 MHz shall be attenuated below the channel power by at least 26 dB, when measured using a resolution bandwidth between 1 % and 5 % of the occupied bandwidth (i.e. 99 % bandwidth), above 5 250 MHz. The 26 dB bandwidth may fall into the 5 250 MHz to 5 350 MHz band; if the occupied bandwidth also falls within the 5 250 MHz to 5 350 MHz band, the transmission is considered as intentional and the devices shall comply with all requirements in the band 5 250 MHz to 5 350 MHz including implementing dynamic frequency selection (DFS) and transmit power control (TPC), on the portion of the emission that resides in the 5 250 MHz to 5 350 MHz band.
Complied Module M/N	ENWF9501C1KF

RSS-247 Section	6.2.2
Frequency Band (MHz)	5 250 to 5 350
Device Type	For devices, other than devices installed in vehicles.
Devices out of Scope	OEM devices installed in vehicles, outdoor fixed devices, and other devices having an e.i.r.p. grater than 200 mW.
Power Limits	The maximum conducted output power shall not exceed 250 mW or 11+10 $\log_{10}$B, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1 MHz band.
Unwanted Emission Limits	All emissions outside the band 5 250 MHz to 5 350 MHz shall not exceed -27 dBm/MHz e.i.r.p.; or: All emissions outside the band 5 150 MHz to 5 350 MHz shall not exceed -27 dBm/MHz e.i.r.p. and its power shall comply with the spectral power density for operation within the band 5 150 MHz to 5 250 MHz. The device shall be labelled or include in the user manual the following text “For indoor use only.”.

RSS-247 Section	6.2.3
Frequency Band (MHz)	5 470 to 5 600 and 5 650 to 5 725
Device Type	Devices shall not be capable of transmitting in the band 5 600 MHz to 5 650 MHz. This restriction is for the protection of Environment Canada’s weather radars operating in this band.
Devices out of Scope	N/A
Power Limits	The maximum conducted output power shall not exceed 250 mW or 11+10 $\log_{10}$B, dBm, whichever is less. The power spectral density shall not exceed 11 dBm in any 1 MHz band.
Unwanted Emission Limits	Emissions outside the band 5 470 MHz to 5 725 MHz shall not exceed -27 dBm/MHz e.i.r.p. Devices with bandwidth overlapping the band edge of 5 725 MHz can meet the emission limit of -27 dBm/MHz e.i.r.p. at 5 850 MHz instead of 5 725 MHz.
Complied Module M/N	ENWF9501C1KF

RSS-247 Section	6.2.4
Frequency Band (MHz)	5 725 to 5 850
Device Type	For equipment operating in the band 5 725 MHz to 5 850 MHz
Devices out of Scope	Fixed point-to-point devices and devices with antenna gain greater than 6 dBi.
Power Limits	The minimum 6 dB bandwidth shall be at least 500 kHz. The maximum conducted output power shall not exceed 1 W. The output power spectral density shall not exceed 30 dBm in any 500 kHz band.
Unwanted Emission Limits	Devices shall have e.i.r.p. of unwanted emissions comply with the following: • 27 dBm/MHz at frequencies from the band edges decreasing linearly to 15.6 dBm/MHz at 5 MHz above or below the band edges • 15.6 dBm/MHz at 5 MHz above or below the band edges decreasing linearly to 10 dBm/MHz at 25 MHz above or below the band edges • 10 dBm/MHz at 25 MHz above or below the band edges decreasing linearly to -27 dBm/MHz at 75 MHz above or below the band edges • -27 dBm/MHz at frequencies more than 75 MHz above or below the band edges
Complied Module M/N	ENWF9501C1KF

For further information about module variants and its supported channel table please refer to ⇨ 7.1 Channels and Power Settings per Country.

6.2.2 IC Notice

English

The device PAN9019 (⇨ 7.2 Ordering Information), including the antennas (⇨ 6.1.5 Approved Antenna List), complies with Canada RSS-GEN Rules. The device meets the requirements for modular transmitter approval as detailed in RSS-Gen.

Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

French

Le présent appareil PAN9019 (⇨ 7.2 Ordering Information), les antennes y compris (⇨ 6.1.5 Approved Antenna List), est conforme aux CNR-Gen d'Industrie Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes:

1. L'appareil ne doit pas produire de brouillage, et
2. L'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

6.2.3 Labeling and Documentation Requirements

English

Labeling Requirements

The OEM must ensure that IC labelling requirements are met. This includes a clearly visible label on the outside of the OEM's product enclosure and inside the user manual specifying the appropriate Panasonic IC identifier for this product as well as the IC Notice above.

The IC identifier is IC: 216Q-9019.

This IC identifier is valid for all PAN9019 modules ⇨ 7.2 Ordering Information. In any case, the end product must be labelled on the exterior with:

"Contains IC: 216Q-9019".

In any case, the user manual must include following statement:

"This device contains IC: 216Q-9019.

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.
2. This device must accept any interference, including interference that may cause undesired operation of the device."

French

Obligations d’étiquetage

Les fabricants d’équipement d’origine (FEO) – en anglais Original Equipment Manufacturer (OEM) – doivent s’assurer que les obligations d’étiquetage IC du produit final sont remplies. Ces obligations incluent une étiquette clairement visible à l’extérieur de l’emballage externe et dans le manuel de l’utilisateur, comportant l’identifiant IC du module Panasonic inclus, ainsi que la notification ci-dessus.

L’ identifiant IC est IC: 216Q-9019.

Cet identifiant est valide pour tous les modules PAN9019 ⇨ 7.2 Ordering Information. Dans tous les cas les produits finaux doivent indiquer sur leur emballage externe la mention suivante:

"Contient IC: 216Q-9019”.

Dans tous les cas les produits finaux doivent indiquer dans le manuel de l’utilisateur la mention suivante:

“Contient IC: 216Q-9019.

L’émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d’Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L’exploitation est autorisée aux deux conditions suivantes :

1. L’appareil ne doit pas produire de brouillage.
2. L’appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d’en compromettre le fonctionnement.”

6.3 Conformity According to Radio Equipment Directive (RED-2014/53/EU) for Europe

All modules described in this Product Specification comply with the standards according to the following LVD (2014/35/EU), EMC-D (2014/30/EU) together with RED (2014/53/EU) articles:

Safety/Health:	EN 62368-1: 2014/A11: 2017
	EN 62311: 2008
EMC:	EN 301 489-1 V2.2.3: 2019-11
	EN 301 489-17 V3.2.4: 2020-09
	EN 301 489-3 V2.3.2: 2023-01
Radio:	EN 300 328 V2.2.2: 2019-07
	EN 301 893 V2.1.1:2017-05
	EN 300 440 V2.2.1:2018-07

- Due to the model size, the CE marking is displayed in the installation instruction only and it cannot be displayed conform to regulation (EU) No. 765/2008 in 5 mm height on the module's label due to the limited space.
- The RED EU Type Examination Certificate No. **G0M-2309-2216-V01** issued by the EU Notified Body 0681 can be used for the OEM end product conformity assessment. If a Notified Body has been contracted for the end product conformity assessment, it should be noted that this EU Type Examination Certificate should be used for conformance assessment.

As a result of the conformity assessment procedure described in 2014/53/EU Directive, the end customer equipment should be labelled as follows:

CE



The end customer has to assure that the device has a distance of more than 20 cm from the human body under all circumstances.

The end customer equipment must meet the actual Safety/Health requirements according to RED.

PAN9019 and its model versions in the specified reference design can be used in all countries of the European Economic Area (Member States of the EU, European Free Trade Association States [Iceland, Liechtenstein, Norway]), Monaco, San Marino, Andorra, and Turkey.

6.3.1 Manufacturer's Details

Name	Panasonic Industrial Devices Europe GmbH
Postal Address - Street	Zeppelinstr. 19
Postal Address - Postal Code and City	21337 Lüneburg
Postal Address - Country	Germany

6.3.2 Radio Equipment Directive

The Radio Equipment Directive 2014/53/EU (RED) establishes a regulatory framework for placing radio equipment on the market. It ensures a Single Market for radio equipment by setting essential requirements for safety and health, electromagnetic compatibility, and the efficient use of the radio spectrum.

The RED aligned the previous Directive, the Radio and Telecommunication Terminal Equipment Directive 1999/5/EC (R&TTED), with the new legislative framework for the marketing of products. The RED is applicable as of 2016-06-13. It included a one-year transitional period, which ended on 2017-06-12 (Article 48). On 2017-06-20, the Commission Implementing Regulation (EU) 2017/1354 was adopted. This specifies how to present the information provided for in Article 10(10) of Directive 2014/53/EU.

Article 10(10) RED

In cases of restrictions on putting into service or of requirements for authorisation of use, information available on the packaging shall allow the identification of the Member States or the geographical area within a Member State where restrictions on putting into service or requirements for authorisation of use exist. Such information shall be completed in the instructions accompanying the radio equipment. The Commission may adopt implementing acts specifying how to present that information. Those implementing acts shall be adopted in accordance with the advisory procedure referred to in Article 45(2).

- **Class 1:**
  Radio equipment that can be operated without any restriction in EU, EEA, and EFTA. According to Article 8(1)b of the RED, it is clarified that no national radio interfaces specifications are required to be notified under RED;
- **Class 2:**
  Radio equipment subject to restrictions in one or more EU, EEA and EFTA countries where:
  - The technical parameters are not harmonised through EU, EEA, and EFTA;
  - The technical parameters are harmonised through EU, EEA and EFTA, and do not fall in above class 1 definition.

Radio equipment class means a class identifying particular categories of radio equipment which, under this Directive, are considered similar and those radio interfaces for which the radio equipment is designed.

Article 8 RED

Notification of radio interface specifications and assignment of radio equipment classes 1:

1) Member States shall notify, in accordance with the procedure set out in Directive 98/34/EC, the radio interfaces which they intend to regulate except:
   a) The radio interfaces which fully and without any deviation comply with the Commission decisions on the harmonised use of radio spectrum adopted pursuant to Decision No. 676/2002/EC; and
   b) The radio interfaces which, in accordance with implementing acts adopted pursuant to paragraph 2 of this Article, correspond to radio equipment which can be put into service and used without restrictions within the Union.

2) The Commission shall adopt implementing acts establishing the equivalence between notified radio interfaces and assigning a radio equipment class, details of which shall be published in the Official Journal of the European Union. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 45(3).

The Radio Interface Specifications Templates are provided for information in the EFIS database for applications which use is in harmonised radio spectrum, however with restrictions.

6.3.3 Equipment Classes

The PAN9019 is a radio module classified as class-1 or class-2 radio equipment depending on the frequency band in which it can operate. This equipment class is passed on the end-product which integrates the module.

Class 1

Class 1 radio equipment can be placed on the market and put into service without restrictions according to Article 1(3) of Commission Decision 2000/299/EC (Version 2018-01).

This radio module is defined as Class 1 radio equipment when it is restricted to operate in the following frequency bands:

Sub-class of Class 1	Application/Reference	Frequency Band (MHz)	Transmit Power/Power Density
22	Wideband Data Transmission Systems EN 300 328	2 400 to 2 483.5	100 mW e.i.r.p and 100 mW/100 kHz e.i.r.p. density applies when frequency hopping modulation is used, 10 mW/MHz e.i.r.p. density applies when other types of modulation are used.
54	Wireless Access Systems including Radio Local Area Networks (WAS/RLANs) EN 301 893	5 470 to 5 725	1 W mean e.i.r.p., 50 mW/MHz mean e.i.r.p. density in any 1 MHz band.
43	Non-Specific Short Range Devices EN 300 440	5 725 to 5 875	25 mW e.i.r.p.

Class 2

Class 2 radio equipment are restricted in accordance with Article 1(3) of Commission Decision 2000/299/EC1 if the equipment falls within the scope of Class 2.



The usage of PAN9019 module in a vehicular environment cannot be considered as **indoor use**.

This radio module is also defined as Class 2 radio equipment when it is restricted to operate in the following frequency bands:

Sub-class of Class 2	Application/Reference	Frequency Band (MHz)	Transmit Power/Power Density
H01	Wireless Access Systems including Radio Local Area Networks (WAS/RLANs) **Restricted to indoor use** EN 301 893	5 150 to 5 350	Max. 200 mW mean e.i.r.p. and max. 10 mW/MHz mean e.i.r.p. density in any 1 MHz band.

6.4 United Kingdom Conformity According to Statutory Instrument (SI-2017/1206)

All modules described in this Product Specification comply with the designated standards according to the following Regulations: Electrical Equipment (Safety) SI 2016/1101, EMC SI 2016/1091 together with Radio Equipment Regulation 2017 (RER) SI 2017/1206:

Safety/Health:	EN 62368-1: 2014/A11: 2017
	EN 62311: 2008
EMC:	EN 301 489-1 V2.2.3: 2019-11
	EN 301 489-17 V3.2.4: 2020-09
	EN 301 489-3 V2.3.2: 2023-01
Radio:	EN 300 328 V2.2.2: 2019-07
	EN 301 893 V2.1.1:2017-05
	EN 300 440 V2.2.1:2018-07

- Due to the model size, the UK marking is displayed in the installation instruction only and it cannot be displayed conform to SI 2017/1206 on the module's label due to the limited space.

- The RED EU Type Examination Certificate No. **G0M-2309-2216-V01** issued by the EU Notified Body 0681 can be used for the OEM end product conformity assessment. If a Notified Body has been contracted for the end product conformity assessment, it should be noted that this EU Type Examination Certificate should be used for conformance assessment.

As a result of the conformity assessment procedure described in SI 2017/1206 Directive, the end customer equipment should be labelled as as specified on www.gov.uk.





Restrictions or Requirements in the UK

The end customer has to assure that the device has a distance of more than 5 mm from the human body under all circumstances.

If the end customer application intends to use the PAN9019 in a distance smaller 5 mm from the human body, SAR evaluation has to be repeated by the OEM.

The end customer equipment must meet the actual Safety/Health requirements according to SI 2017/1206.

PAN9019 and its model versions in the specified reference design can be used in the UK.

6.5 Conformity According to Japanese Radio Act

TBD

6.6 Conformity According to Regulatory Compliance Mark (RCM) for New Zealand and Australia

6.6.1 Conformity According to AS/NZS 4268:2017 + A1:2021

Product Details

Brand Name	Model	Description	
Panasonic	PAN9019	Wi-Fi 6 Dual Band 2.4 GHz/5 GHz, Bluetooth Module	2 402 MHz to 2 483.5 MHz 5 150 MHz to 5 875 MHz

All modules described in this Product Specification comply with the standards according to the following articles:

Safety/Health:	EN 62368-1: 2014/A11: 2017
	EN 62311: 2008
EMC:	EN 301 489-1 V2.2.3: 2019-11
	EN 301 489-17 V3.2.4: 2020-09
	EN 301 489-3 V2.3.2: 2023-01
Radio:	AS/NZS 4268 : 2017
	EN 300 328 V2.2.2: 2019-07
	EN 301 893 V2.1.1:2017-05
	EN 300 440 V2.2.1:2018-07

6.6.2 Importing the PAN9019 and Supplier's Declaration of Conformity

All modules described in this Product Specification comply with the AS/NZS 4268:2017 + A1:2021 standard.

In accordance with the Radiocommunications Equipment (General) Rules 2021, this product is regarded as a component and is excluded from the scope of labelling. As a result, the importer acts as representative and must provide a Supplier's Declaration of Conformity (SDoC).

The importer is highly recommended to follow the 5 steps for suppliers on the ACMA website, which contains helpful information to identify which compliance and labeling regulations apply.

6.7 Bluetooth Special Interest Group (SIG)

The final Bluetooth end product listing needs to be created by using the following IDs:

Bluetooth Product	Project Name	Power Class		Model	Declaration ID	QDID
		BR/EDR	LE			
Controller Subsystem	PAN9019x Class I	1	1	ENWF95x1x1KF	D068415	240688

If the module is combined with a host stack that is Bluetooth qualified as "Host Subsystem" it is possible to list an “End Product” without any further qualification tests.

Bluetooth Marks

According to the Bluetooth SIG, the PAN9019 fulfills the criteria to label your product as a Bluetooth device:

For further information please refer to the Bluetooth website www.bluetooth.com.

6.8 RoHS and REACH Declaration

The latest declaration of environmental compatibility (Restriction of Hazardous Substances, RoHS and Registration, Evaluation, Authorisation and Restriction of Chemicals, 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 Channels and Power Settings per Country

7.1.1 EU

Radio	Bandwidth	Channels	Modulation	Power (dBm)
Wi-Fi 2.4 GHz	20 MHz	Single User		
		1	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		2-12	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		13	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	13
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		14	Not supported	-
		OFDMA Multi-User		
		1-13	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
	40 MHz	Single User		
		3	11n/ax: MCS 0-7	13
			11ax: MCS 8-11	9
		4-10	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	10
		11	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	9
		OFDMA Multi-User		

Radio	Bandwidth	Channels	Modulation	Power (dBm)
		3-11	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
Wi-Fi	20 MHz	Single User		
5 GHz		36	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		40-48	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	12
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		52-64	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	12
			11n/ac/ax: MCS 0-2	8
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		100	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		104-140	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		144	Not supported	
		149-173	11a: 6-54 Mbit/s 11n/ac/ax: MCS 0-7	6
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		177	Not supported	-

Radio	Bandwidth	Channels	Modulation	Power (dBm)
		OFDMA Multi-User		
		36-64	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		100	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
		104-140	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		149-173	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	6
			11ax MCS 0-11 OFDMA: 242-tone RU	6
	40 MHz	Single User		
		38	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		46	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		54-62	11n/ac/ax: MCS 0-7	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		102	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		110-134	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		142	Not supported	
		151-167	11n/ac/ax: MCS 0-7	6
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6

Radio	Bandwidth	Channels	Modulation	Power (dBm)
		175	Not supported	-
		OFDMA Multi-User		
		38	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	7
		40-62	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		102	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
			11ax MCS 0-11 OFDMA: 484-tone RU	3
		110-134	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		151-167	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	6
			11ax MCS 0-11 OFDMA: 242-tone RU	6
			11ax MCS 0-11 OFDMA: 484-tone RU	6
	80 MHz	Single User		
		42	11ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		58	11ac/ax: MCS 0-7	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		106	11ac/ax: MCS 0-7	11
			11ac/ax: MCS 8, 9	11
			11ax: MCS 10, 11	10

Radio	Bandwidth	Channels	Modulation	Power (dBm)
		122	11ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		138	Not supported	
		155	11ac/ax: MCS 0-7	6
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		171	Not supported	-
		OFDMA Multi-User		
		42-122	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
		155	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
Bluetooth	-	All	All	3

7.1.2 USA

Band	Bandwidth	Channels	Modulation	Power (dBm)
Wi-Fi	20 MHz	Single User		
2.4 GHz		1	11b: 1-11 Mbit/s	16
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	14
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		2	11b: 1-11 Mbit/s	17
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	15
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		3-9	11b: 1-11 Mbit/s	18

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11g: 6-54 Mbit/s	16
			11n/ax: MCS 0-7	15
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		10	11b: 1-11 Mbit/s	17
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	15
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		11	11b: 1-11 Mbit/s	16
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	14
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		12-14	Not supported	-
		OFDMA Multi-User		
		1-11	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
	40 MHz	Single User		
		3	11n/ax: MCS 0-7	13
			11ax: MCS 8-11	9
		4-8	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	10
		9	11n/ax: MCS 0-7	13
			11ax: MCS 8-11	9
		OFDMA Multi-User		
		3-9	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
5 GHz	20 MHz	Single User		
		36	11a: 6-54 Mbit/s	15
			11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	12

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax: MCS 10, 11	10
		40-60	11a: 6-54 Mbit/s	16
			11n/ac/ax: MCS 0-7	15
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		64	11a: 6-54 Mbit/s	15
			11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		100	11a: 6-54 Mbit/s	15
			11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		104-165	11a: 6-54 Mbit/s	16
			11n/ac/ax: MCS 0-7	15
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		169-177	Not supported	-
		OFDMA Multi-User		
		36-64	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		100	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
		104-165	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
	40 MHz	Single User		
		38	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		46, 54	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax: MCS 10, 11	10
		62	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		102	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		110-159	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		167, 175	Not supported	-
		OFDMA Multi-User		
		38	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	7
		40-62	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		102	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
			11ax MCS 0-11 OFDMA: 484-tone RU	3
		110-159	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
	80 MHz	Single User		
		42	11ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		58	11ac/ax: MCS 0-7	12

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		106	11ac/ax: MCS 0-7	10
			11ac/ax: MCS 8, 9	9
			11ax: MCS 10, 11	9
		122	11ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		138, 155	11ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		171	Not supported	-
		OFDMA Multi-User		
		42-155	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
Bluetooth	-	All	All	8

7.1.3 Canada

Band	Bandwidth	Channels	Modulation	Power (dBm)
Wi-Fi 2.4 GHz	20 MHz	Single User		
		1	11b: 1-11 Mbit/s	16
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	14
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		2	11b: 1-11 Mbit/s	17
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	15
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		3-9	11b: 1-11 Mbit/s	18
			11g: 6-54 Mbit/s	16
			11n/ax: MCS 0-7	15

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		10	11b: 1-11 Mbit/s	17
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	15
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		11	11b: 1-11 Mbit/s	16
			11g: 6-54 Mbit/s 11n/ax: MCS 0-7	14
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		12-14	Not supported	-
		OFDMA Multi-User		
		1-11	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
	40 MHz	Single User		
		3	11n/ax: MCS 0-7	13
			11ax: MCS 8-11	9
		4-8	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	10
		9	11n/ax: MCS 0-7	13
			11ax: MCS 8-11	9
		OFDMA Multi-User		
		3-9	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
Wi-Fi 5 GHz	20 MHz	Single User		
		36	11a: 6-54 Mbit/s	15
			11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		40-60	11a: 6-54 Mbit/s	16

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11n/ac/ax: MCS 0-7	15
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		64	11a: 6-54 Mbit/s	15
			11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		100	11a: 6-54 Mbit/s	15
			11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		104-116	11a: 6-54 Mbit/s	16
			11n/ac/ax: MCS 0-7	15
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		120-128	Not supported	-
		132-165	11a: 6-54 Mbit/s	16
			11n/ac/ax: MCS 0-7	15
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		169-177	Not supported	-
			OFDMA Multi-User	
		36-64	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		100	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
		104-116	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		132-165	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax MCS 0-11 OFDMA: 242-tone RU	9
	40 MHz	Single User		
		38	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		46, 54	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		62	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		102	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		110	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		118, 126	Not supported	-
		134-159	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		167, 175	Not supported	-
		OFDMA Multi-User		
		38	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	7
		40-62	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		102	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax MCS 0-11 OFDMA: 484-tone RU	3
		110	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		134-159	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
	80 MHz	Single User		
		42	11ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		58	11ac/ax: MCS 0-7	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		106	11ac/ax: MCS 0-7	10
			11ac/ax: MCS 8, 9	9
			11ax: MCS 10, 11	9
		138, 155	11ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		171	Not supported	-
		OFDMA Multi-User		
		42-106	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
		138-155	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax MCS 0-11 OFDMA: 996-tone RU	5
Bluetooth	-	All	All	8

7.1.4 Japan

Band	Bandwidth	Channels	Modulation	Power (dBm)	Estimated PSD (mW/MHz)
Wi-Fi 2.4 GHz	20 MHz	Single User			
		1	11b: 1-11 Mbit/s 11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14	1.26
			11n/ax: MCS 0-2	11	0.63
			11ax: MCS 8, 9	12	0.79
			11ax: MCS 10, 11	9	0.4
		2-12	11b: 1-11 Mbit/s 11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14	1.26
			11n/ax: MCS 0-2	11	0.63
			11ax: MCS 8, 9	13	1
			11ax: MCS 10, 11	10	0.5
		13	11b: 1-11 Mbit/s 11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14	1.26
			11n/ax: MCS 0-2	11	0.63
			11ax: MCS 8, 9	12	0.79
			11ax: MCS 10, 11	9	0.4
		14	Not supported	-	-
		OFDMA Multi-User			
		1-13	11ax MCS 0-11 OFDMA: 26-tone RU	3	0.8
			11ax MCS 0-11 OFDMA: 52-tone RU	6	0.8
			11ax MCS 0-11 OFDMA: 106tone RU	9	0.8
			11ax MCS 0-11 OFDMA: 242-tone RU	9	0.4
	40 MHz	Single User			
		3	11n/ax: MCS 0-7	13	0.5
			11ax: MCS 8-11	9	0.2

Band	Bandwidth	Channels	Modulation	Power (dBm)	Estimated PSD (mW/MHz)
		4-10	11n/ax: MCS 0-7	14	0.63
			11ax: MCS 8-11	10	0.25
		11	11n/ax: MCS 0-7	13	0.5
			11ax: MCS 8-11	9	0.2
		OFDMA Multi-User			
		3-11	11ax MCS 0-11 OFDMA: 26-tone RU	3	0.8
			11ax MCS 0-11 OFDMA: 52-tone RU	6	0.8
			11ax MCS 0-11 OFDMA: 106tone RU	9	0.8
			11ax MCS 0-11 OFDMA: 242-tone RU	9	0.4
			11ax MCS 0-11 OFDMA: 484-tone RU	9	0.2
Wi-Fi 5 GHz	20 MHz	Single User			
		36	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14	1.26
			11n/ac/ax: MCS 0-2	12	0.79
			11ac/ax: MCS 8, 9	12	0.79
			11ax: MCS 10, 11	10	0.5
		40-48	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14	1.26
			11n/ac/ax: MCS 0-2	12	0.79
			11ac/ax: MCS 8, 9	13	1
			11ax: MCS 10, 11	10	0.5
		52-64	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	12	0.79
			11n/ac/ax: MCS 0-2	8	0.32
			11ac/ax: MCS 8, 9	12	0.79
			11ax: MCS 10, 11	10	0.5
		100	11a: 6-54 Mbit/s 11n/ac/ax: MCS 0-7	14	1.26
			11ac/ax: MCS 8, 9	12	0.79
			11ax: MCS 10, 11	10	0.5
		104-144	11a: 6-54 Mbit/s 11n/ac/ax: MCS 0-7	14	1.26
			11ac/ax: MCS 8, 9	13	1

Band	Bandwidth	Channels	Modulation	Power (dBm)	Estimated PSD (mW/MHz)
			11ax: MCS 10, 11	10	0.5
		149-177	Not supported	-	-
			OFDMA Multi-User		
		36-64	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	7	0.5
			11ax MCS 0-11 OFDMA: 242-tone RU	9	0.4
		100	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	7	0.5
			11ax MCS 0-11 OFDMA: 242-tone RU	7	0.25
		104-144	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	7	0.5
			11ax MCS 0-11 OFDMA: 242-tone RU	9	0.4
	40 MHz		Single User		
		38	11n/ac/ax: MCS 0-7	13	0.5
			11ac/ax: MCS 8, 9	12	0.4
			11ax: MCS 10, 11	10	0.25
		46	11n/ac/ax: MCS 0-7	14	0.63
			11ac/ax: MCS 8, 9	13	0.5
			11ax: MCS 10, 11	10	0.25
		54-62	11n/ac/ax: MCS 0-7	12	0.4
			11ac/ax: MCS 8, 9	12	0.4
			11ax: MCS 10, 11	10	0.25
		102	11n/ac/ax: MCS 0-7	13	0.5
			11ac/ax: MCS 8, 9	12	0.4
			11ax: MCS 10, 11	10	0.25

Band	Bandwidth	Channels	Modulation	Power (dBm)	Estimated PSD (mW/MHz)
		110-142	11n/ac/ax: MCS 0-7	14	0.63
			11ac/ax: MCS 8, 9	13	0.5
			11ax: MCS 10, 11	10	0.25
		151-175	Not supported	-	-
			OFDMA Multi-User		
		38	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	7	0.5
			11ax MCS 0-11 OFDMA: 242-tone RU	9	0.4
			11ax MCS 0-11 OFDMA: 484-tone RU	7	0.13
		40-62	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	7	0.5
			11ax MCS 0-11 OFDMA: 242-tone RU	9	0.4
			11ax MCS 0-11 OFDMA: 484-tone RU	9	0.2
		102	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	7	0.5
			11ax MCS 0-11 OFDMA: 242-tone RU	7	0.25
			11ax MCS 0-11 OFDMA: 484-tone RU	3	0.05
		110-142	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	7	0.5

Band	Bandwidth	Channels	Modulation	Power (dBm)	Estimated PSD (mW/MHz)
			11ax MCS 0-11 OFDMA: 242-tone RU	9	0.4
			11ax MCS 0-11 OFDMA: 484-tone RU	9	0.2
	80 MHz	Single User			
		42	11ac/ax: MCS 0-7	12	0.2
			11ac/ax: MCS 8, 9	13	0.25
			11ax: MCS 10, 11	10	0.13
		58	11ac/ax: MCS 0-7	12	0.2
			11ac/ax: MCS 8, 9	12	0.2
			11ax: MCS 10, 11	10	0.13
		106	11ac/ax: MCS 0-7	11	0.16
			11ac/ax: MCS 8, 9	11	0.16
			11ax: MCS 10, 11	10	0.13
		122	11ac/ax: MCS 0-7	13	0.25
			11ac/ax: MCS 8, 9	13	0.25
			11ax: MCS 10, 11	10	0.13
		138	11ac/ax: MCS 0-7	14	0.32
			11ac/ax: MCS 8, 9	13	0.25
			11ax: MCS 10, 11	10	0.13
		155, 171	Not supported	-	-
		OFDMA Multi-User			
		42-138	11ax MCS 0-11 OFDMA: 26-tone RU	1	0.5
			11ax MCS 0-11 OFDMA: 52-tone RU	4	0.5
			11ax MCS 0-11 OFDMA: 106tone RU	5	0.32
			11ax MCS 0-11 OFDMA: 242-tone RU	5	0.16
			11ax MCS 0-11 OFDMA: 484-tone RU	5	0.08
			11ax MCS 0-11 OFDMA: 996-tone RU	5	0.04
Bluetooth	≈ 1 MHz	All	Basic Rate, Enhanced Data Rate, Low Energy 1 Mb/s and Low Energy Long Range	3	2
	≈ 2 MHz	All	Low Energy 2 Mb/s	3	1

7.1.5 Australia

Band	Bandwidth	Channels	Modulation	Power (dBm)
Wi-Fi 2.4 GHz	20 MHz	Single User		
		1	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		2-12	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		13	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	13
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		14	Not supported	-
		OFDMA Multi-User		
		1-13	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
	40 MHz	Single User		
		3	11n/ax: MCS 0-7	13
			11ax: MCS 8-11	9
		4-10	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	10
		11	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	9
		OFDMA Multi-User		
		3-11	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
Wi-Fi 5 GHz	20 MHz	Single User		
		36	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		40-48	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	12
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		52-64	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	12
			11n/ac/ax: MCS 0-2	8
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		100	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		104-116	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		120-128	Not supported	-
		132-140	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		144	Not supported	
		149-165	11a: 6-54 Mbit/s 11n/ac/ax: MCS 0-7	6

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		169-177	Not supported	-
		OFDMA Multi-User		
		36-64	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		100	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
		104-116	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		132-140	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		149-165	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	6
			11ax MCS 0-11 OFDMA: 242-tone RU	6
	40 MHz	Single User		
		38	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		46	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		54-62	11n/ac/ax: MCS 0-7	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		102	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10

Band	Bandwidth	Channels	Modulation	Power (dBm)
		110	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		118-126	Not supported	-
		134	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		142	Not supported	
		151-159	11n/ac/ax: MCS 0-7	6
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		167-175	Not supported	-
			OFDMA Multi-User	
		38	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	7
		40-62	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		102	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
			11ax MCS 0-11 OFDMA: 484-tone RU	3
		110	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		134	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		151-159	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	6
			11ax MCS 0-11 OFDMA: 242-tone RU	6
			11ax MCS 0-11 OFDMA: 484-tone RU	6
	80 MHz	Single User		
		42	11ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		58	11ac/ax: MCS 0-7	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		106	11ac/ax: MCS 0-7	11
			11ac/ax: MCS 8, 9	11
			11ax: MCS 10, 11	10
		122-138	Not supported	-
		155	11ac/ax: MCS 0-7	6
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		171	Not supported	-
		OFDMA Multi-User		
		42-106	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
		155	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
Bluetooth	-	All	All	3

7.1.6 New Zealand

Band	Bandwidth	Channels	Modulation	Power (dBm)
Wi-Fi 2.4 GHz	20 MHz	Single User		
		1	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		2-12	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	14
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		13	11b: 1-11 Mbit/s	13
			11g: 6-54 Mbit/s 11n/ax: MCS 3-7	13
			11n/ax: MCS 0-2	11
			11ax: MCS 8, 9	12
			11ax: MCS 10, 11	9
		14	Not supported	-
		OFDMA Multi-User		
		1-13	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
	40 MHz	Single User		
		3	11n/ax: MCS 0-7	13
			11ax: MCS 8-11	9
		4-10	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	10
		11	11n/ax: MCS 0-7	14
			11ax: MCS 8-11	9
		OFDMA Multi-User		
		3-11	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
Wi-Fi 5 GHz	20 MHz	Single User		
		36	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		40-48	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	12
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		52-64	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	12
			11n/ac/ax: MCS 0-2	8
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		100	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		104-116	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		120-128	Not supported	-
		132-140	11a: 6-54 Mbit/s 11n/ac/ax: MCS 3-7	14
			11n/ac/ax: MCS 0-2	10
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		144	Not supported	
		149-165	11a: 6-54 Mbit/s 11n/ac/ax: MCS 0-7	6

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		169-177	Not supported	-
		OFDMA Multi-User		
		36-64	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		100	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
		104-116	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		132-140	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
		149-165	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	6
			11ax MCS 0-11 OFDMA: 242-tone RU	6
	40 MHz	Single User		
		38	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		46	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		54-62	11n/ac/ax: MCS 0-7	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		102	11n/ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10

Band	Bandwidth	Channels	Modulation	Power (dBm)
		110	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		118-126	Not supported	-
		134	11n/ac/ax: MCS 0-7	14
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		142	Not supported	
		151-159	11n/ac/ax: MCS 0-7	6
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		167-175	Not supported	-
			OFDMA Multi-User	
		38	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	7
		40-62	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		102	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	7
			11ax MCS 0-11 OFDMA: 242-tone RU	7
			11ax MCS 0-11 OFDMA: 484-tone RU	3
		110	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		134	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	9
			11ax MCS 0-11 OFDMA: 242-tone RU	9

Band	Bandwidth	Channels	Modulation	Power (dBm)
			11ax MCS 0-11 OFDMA: 484-tone RU	9
		151-159	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	6
			11ax MCS 0-11 OFDMA: 106tone RU	6
			11ax MCS 0-11 OFDMA: 242-tone RU	6
			11ax MCS 0-11 OFDMA: 484-tone RU	6
	80 MHz	Single User		
		42	11ac/ax: MCS 0-7	13
			11ac/ax: MCS 8, 9	13
			11ax: MCS 10, 11	10
		58	11ac/ax: MCS 0-7	12
			11ac/ax: MCS 8, 9	12
			11ax: MCS 10, 11	10
		106	11ac/ax: MCS 0-7	11
			11ac/ax: MCS 8, 9	11
			11ax: MCS 10, 11	10
		122-138	Not supported	-
		155	11ac/ax: MCS 0-7	6
			11ac/ax: MCS 8, 9	6
			11ax: MCS 10, 11	6
		171	Not supported	-
		OFDMA Multi-User		
		42-106	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
		155	11ax MCS 0-11 OFDMA: 26-tone RU	3
			11ax MCS 0-11 OFDMA: 52-tone RU	5
			11ax MCS 0-11 OFDMA: 106tone RU	5
			11ax MCS 0-11 OFDMA: 242-tone RU	5
			11ax MCS 0-11 OFDMA: 484-tone RU	5
			11ax MCS 0-11 OFDMA: 996-tone RU	5
Bluetooth	-	All	All	3

7.2 Ordering Information

Variants and Versions

Order Number	Brand Name	Description	MOQ[36]
ENWF9501C1KF [37]	PAN9019	Wi-Fi 6 Dual Band 2.4 GHz/5 GHz and Bluetooth Module	500
ENWF9501CMKF	PAN9019 M2E	Wi-Fi 6 Dual Band 2.4 GHz/5 GHz and Bluetooth M.2 Key E Card (based on the module ENWF9501C1KF)	1
ENWF9501AMKF	PAN9019 M2E-C	Wi-Fi 6 Dual Band 2.4 GHz/5 GHz and Bluetooth M.2 Key E Card with Chip Antenna (based on the module ENWF9501C1KF)	1

[36] Abbreviation for Minimum Order Quantity (MOQ). The default MOQ for mass production is 500 pieces, fewer only on customer demand. Samples for evaluation can be delivered at any quantity via the distribution channels.

[37] Samples are available on customer demand.

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.connectivity@eu.panasonic.com

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

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

For information about evaluation tools, schematics, software development, and more, please visit the "Panasonic Wireless Connectivity Development Hub"

https://pideu.panasonic.de/development-hub/.

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

https://industry.panasonic.eu/

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

http://www.panasonic.com/rfmodules