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PAN9019A

Wi-Fi 6 Dual Band 2.4 GHz/5 GHz, Bluetooth® and 802.15.4 Module

Product Specification

Rev. 0.2

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Overview

The PAN9019A is a 2.4 GHz and 5 GHz ISM band Wi-Fi, Bluetooth, and 802.15.4 radio module, which allows easy integration of Wi-Fi, Bluetooth, and 802.15.4 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, Bluetooth, and 802.15.4 combo module
- Supports WPA3 security
- 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 5.2 (including LE and long range)
- WCI-2 and 5-wire PTA coexistence interfaces
- Generic interfaces include SDIO 3.0, high-speed UART and SPI 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® IW612 WLAN 2.4 GHz and 5 GHz, Bluetooth and 802.15.4 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

Document Acceptance

By signing the Product Specification, you acknowledge that you are a legal representative for your company and that you understand and accept the validity of the contents herein.

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

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

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- Improper use of the Engineering Sample.

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Table of Contents

1 About This Document

1.1 Purpose and Audience

This Product Specification provides details on the functional, operational, and electrical characteristics of the Panasonic PAN9019A module. It is intended for hardware design, application, and Original Equipment Manufacturers (OEM) engineers.

The product is referred to as "PAN9019A" and "module" within this document.

1.2 Revision History

Revision	Date	Modifications/Remarks
0.1	2023-04-06	Preliminary version

0.2	2023-05-12	Updated chapters:
		
		⇨ 2.3 WLAN Features: Changed enumeration of Footnotes
		
		⇨ 4.4.1 WLAN Current Consumption: Added Tx current consumption
		
		⇨ 4.5.1 WLAN Radio Specification: Added supported channels
		
		⇨ 4.5.2 WLAN RF Characteristics
		  – Added specifications to all tables
		  – Corrected supply voltage information in info boxes
		
		⇨ 4.5 RF Electrical Characteristics
		  – Added ⇨ 4.5.3 Bluetooth RF Characteristics
		  – Added ⇨ 4.5.4 802.15.4 RF Characteristics
		
		⇨ 7.2 Contact Details
		
		⇨ 2.2 Pin Configuration: Updated picture "pin assignment"
		
		⇨ 3.2 Footprint: Updated picture "footprint"

1.3 Use of Symbols

Symbol	Description
(i)	**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 ⇨ 7.2.2 Product Information.

2 Overview

The PAN9019A 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 BR/EDR/Low Energy (LE) and 802.15.4 radio, specifically designed for highly integrated and cost-effective applications. The independent operation of the three standards enables 802.11ax data rates with High Efficiency (HE) and low-power operation (Bluetooth LE and 802.15.4).

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/802.15.4 system parameters are pre-stored on the one-time-programmable memory of the PAN9019A 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, Bluetooth, and 802.15.4 wireless connectivity allows high throughput applications for industrial devices and appliances. The combination of Wi-Fi, Bluetooth, and 802.15.4 provides the highest flexibility for connectivity.

For related documents please refer to ⇨ 7.2.2 Product Information.

For further information on the variants and versions please refer to ⇨ 7.1 Ordering Information.

2.1   Block Diagram
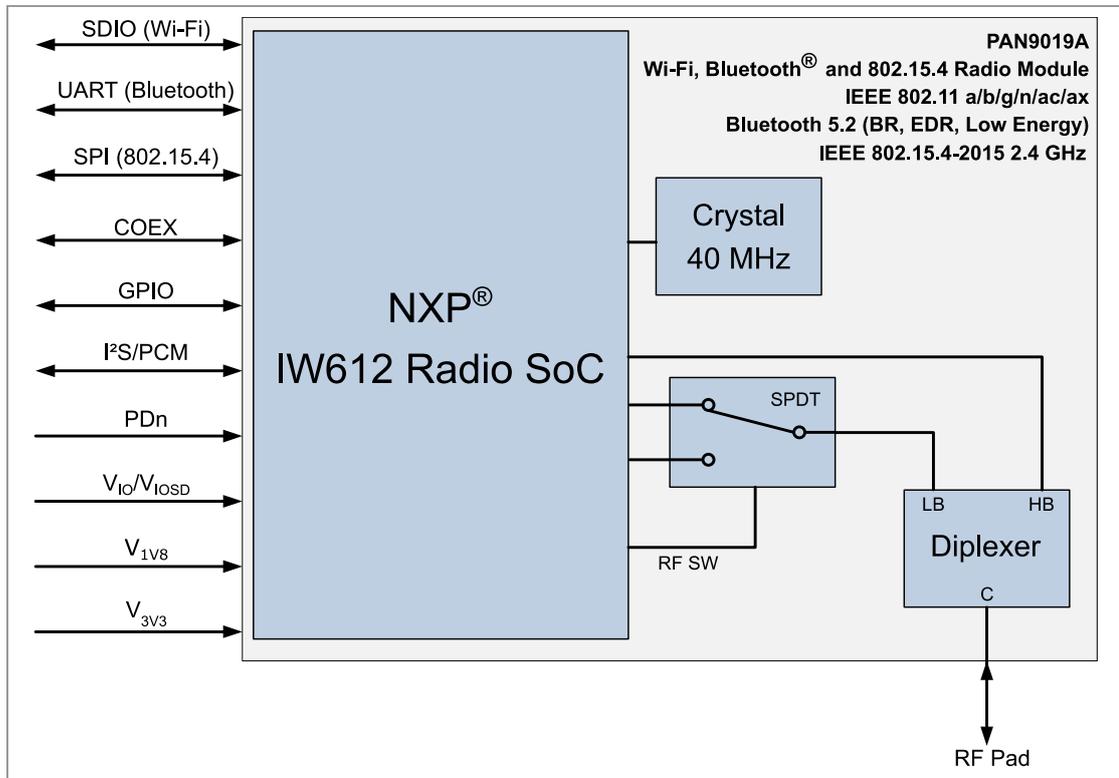
2.2 Pin Configuration

Pin Assignment

Top View
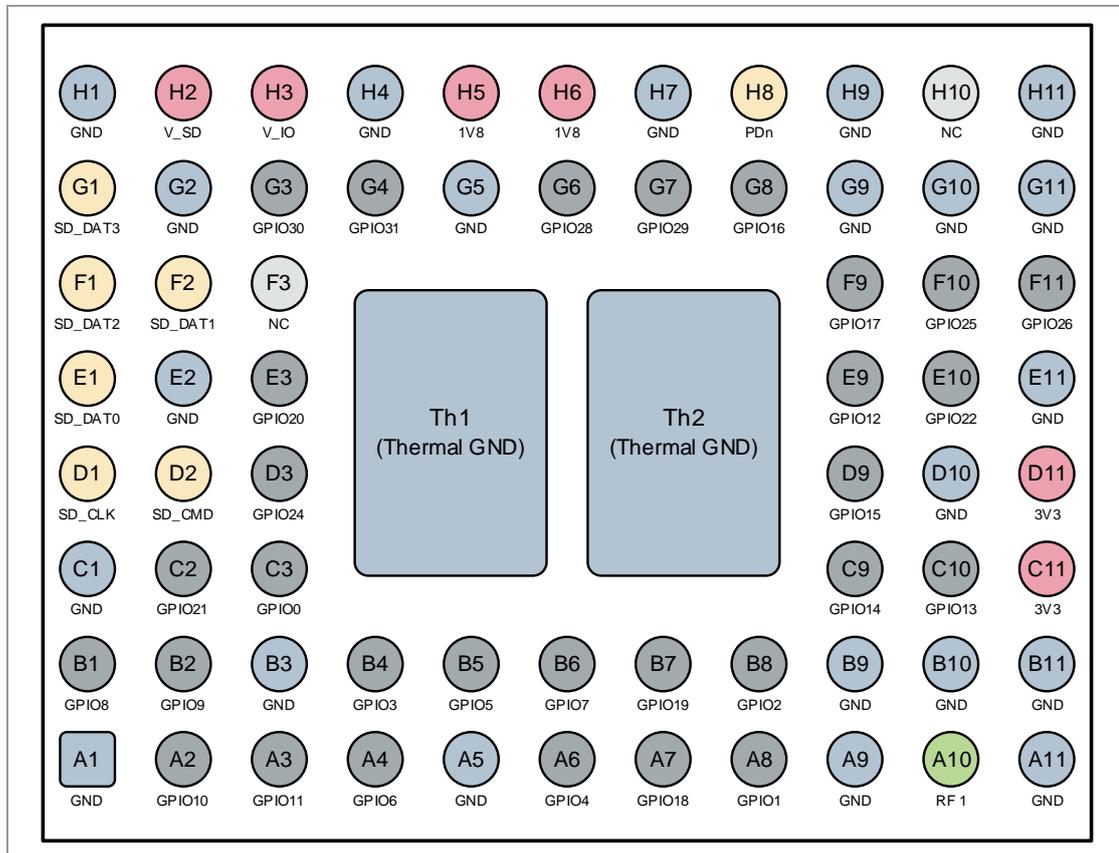
Pin Functions

No.	Pin Name	Pin Type	Description
A1	GND	Ground Pin	Connect to ground
A2	GPIO10	Digital I/O	GPIO[10] / UART_RX
A3	GPIO11	Digital I/O	GPIO[11] / UART_TX
A4	GPIO6	Digital I/O	GPIO[6] / PCM_DIN / I2S_DIN
A5	GND	Ground Pin	Connect to ground
A6	GPIO4	Digital I/O	GPIO[4] / PCM_CLK / I2S_BCLK
A7	GPIO18	Digital I/O	GPIO[18] / BT_15.4_WAKE_IN
A8	GPIO1	Digital I/O	GPIO[1] / IND_RST_WL
A9	GND	Ground Pin	Connect to ground
A10	RF1	Analog	RF bottom pad

No.	Pin Name	Pin Type	Description
A11	GND	Ground Pin	Connect to ground
B1	GPIO8	Digital I/O	GPIO[8] / UART_CTS
B2	GPIO9	Digital I/O	GPIO[9] / UART_RTS
B3	GND	Ground Pin	Connect to ground
B4	GPIO3	Digital I/O	GPIO[3] / PCM_MCLK / I2S_CCLK
B5	GPIO5	Digital I/O	GPIO[5] / PCM_DOUT / I2S_DOUT
B6	GPIO7	Digital I/O	GPIO[7] / PCM_SYNC / I2S_LRCLK
B7	GPIO19	Digital I/O	GPIO[19] / BT_15.4_WAKE_OUT
B8	GPIO2	Digital I/O	GPIO[2] / IND_RST_BT
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	GPIO[21] / SD_INT
C3	GPIO0	Digital I/O	GPIO[0] / XOSC_EN
C9	GPIO14	Digital I/O	GPIO[14] / EXT_GNT / SPI_RXD
C10	GPIO13	Digital I/O	GPIO[13] / EXT_REQ / SPI_FRM
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	GPIO[24] / IND_RST_15.4
D9	GPIO15	Digital I/O	GPIO[15] / EXT_PRI / SPI_TXD
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	GPIO[20] / EXT_FREQ / SPI_INT
E9	GPIO12	Digital I/O	GPIO[12] / EXT_STATE / SPI_CLK
E10	GPIO22	Digital I/O	GPIO[22] / RST_IND
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

No.	Pin Name	Pin Type	Description
F9	GPIO17	Digital I/O	GPIO[17] / WL_WAKE_OUT
F10	GPIO25	Digital I/O	GPIO[25] / WCI-2_SIN
F11	GPIO26	Digital I/O	GPIO[26] / WCI-2_SOUT
G1	SD_DAT3	Digital I/O	SDIO data[3] signal
G2	GND	Ground Pin	Connect to ground
G3	GPIO30	Digital I/O	GPIO[30] / JTAG_TDI
G4	GPIO31	Digital I/O	GPIO[31] / JTAG_TDO
G5	GND	Ground Pin	Connect to ground
G6	GPIO28	Digital I/O	GPIO[28] / JTAG_TCK
G7	GPIO29	Digital I/O	GPIO[29] / JTAG_TMS
G8	GPIO16	Digital I/O	GPIO[16] / WL_WAKE_IN
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 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 • 802.11u Hotspot 2.0 (STA mode only) • 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)

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

Type	Features
	• Multiple-BSS/Station • 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 • 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 dup/quad modes) − 802.11g (including dup 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, Bluetooth, and 802.15.4

WLAN Encryption	• Support of WPA3, WPA2, and WPA
	• 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

2.4   Bluetooth Features

Type	Features
General	• Supports Bluetooth 5.2 and Bluetooth Low Energy features • Shared RF pad with Wi-Fi and 802.15.4 • Simultaneous receive with Wi-Fi and 802.15.4 • Coexistence with Wi-Fi and 802.15.4
Bluetooth Classic (BR/EDR)	• Bluetooth 5.2 features • Class 1 and class 2 support • Integrated high power PA up to +19 dBm transmit power for Bluetooth LE and 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 and peripheral 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

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[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)	• 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 • Isochronous channels (ISOC) supporting LE Audio and Auracast™ Broadcast Audio

2.5   802.15.4 Features

Type	Features
802.15.4 Key Features	• IEEE 802.15.4-2020 compliant supporting Thread in 2.4 GHz band • Support for Matter over Thread • MAC accelerator with packet formatting, CRCs, address check, auto acknowledgements and timers • Programmable packet filtering for lower power consumption • Timestamp for transmit and receive packets • Received Signal Strength Indication (RSSI) of received packets • Integrated high power PA up to +21 dBm transmit power • 128-bit AES security • Simultaneous receive with Wi-Fi and Bluetooth

3   Detailed Description

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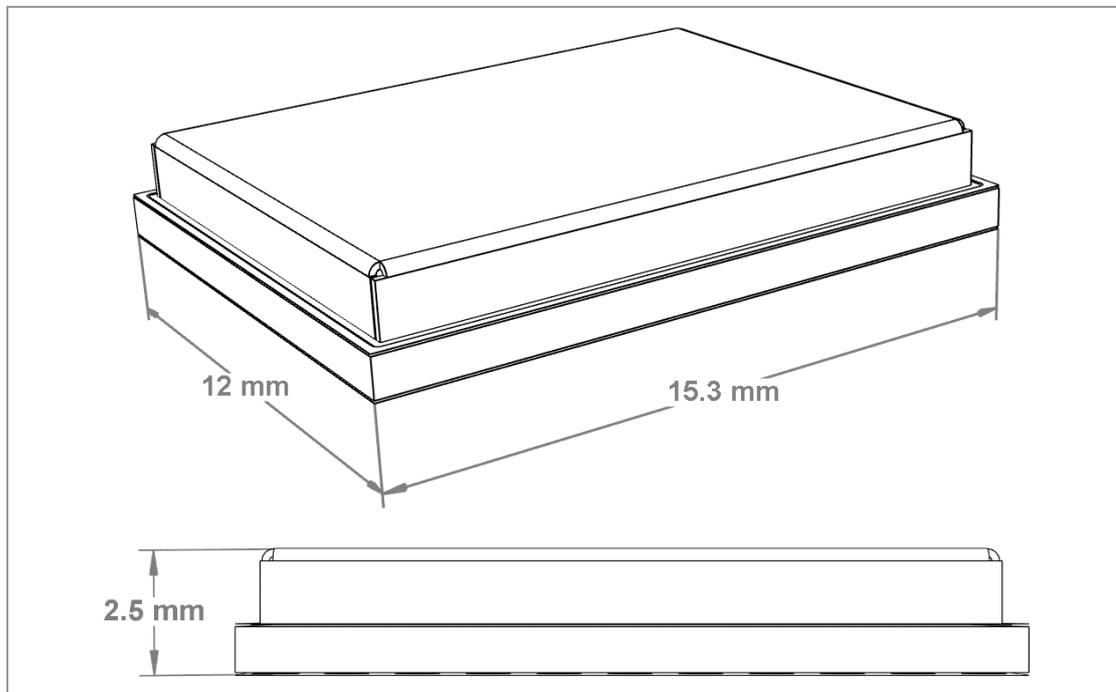
Item	Dimension (mm)	Tolerance (mm)	Remark
Width	12.00	±0.35	
Length	15.30	±0.35	
Height	2.50	±0.20	With case

3.2 Footprint

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

> ⓘ All dimensions are in mm.

Top View
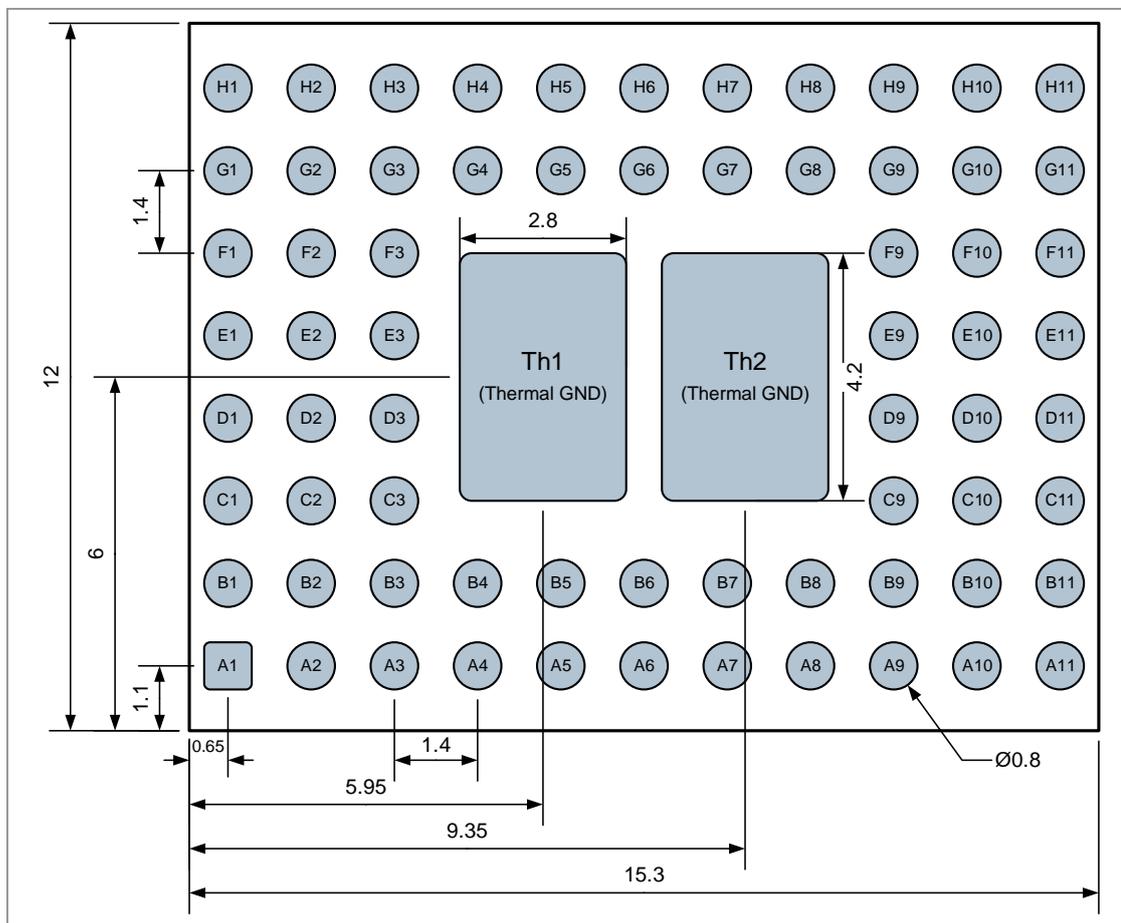
3.3 Packaging

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

(I)   Measured from centreline of sprocket hole to centreline of pocket.
(II) Cumulative tolerance of 10 sprocket holes is ± 0.20 .
(III) Measured from centreline of sprocket hole to centreline of pocket.
(IV) Other material available.

ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED.

3.3.2 Packing in Tape

Direction of unreeling (for customer)

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

component packed area standard 500pcs

leader (empty) min. 10 pitch

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

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

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

3.3.3   Component Direction
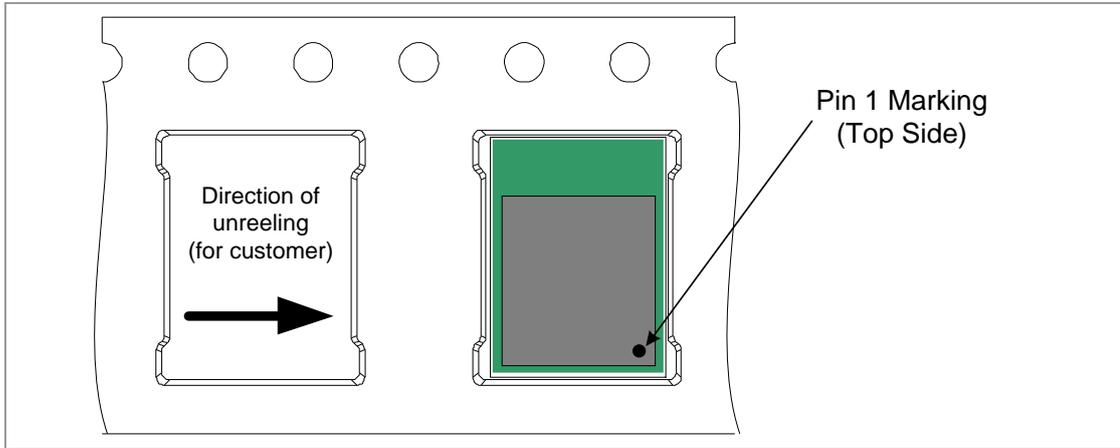
3.3.4   Reel Dimension
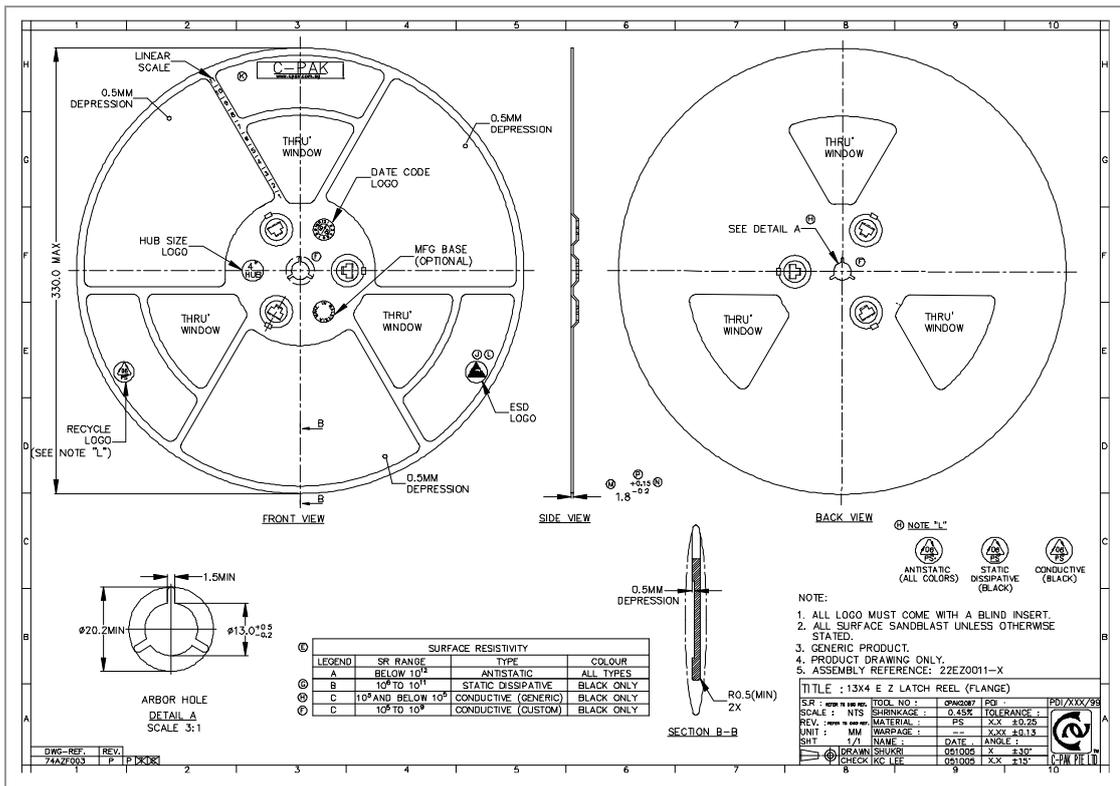
3.3.5   Package Label

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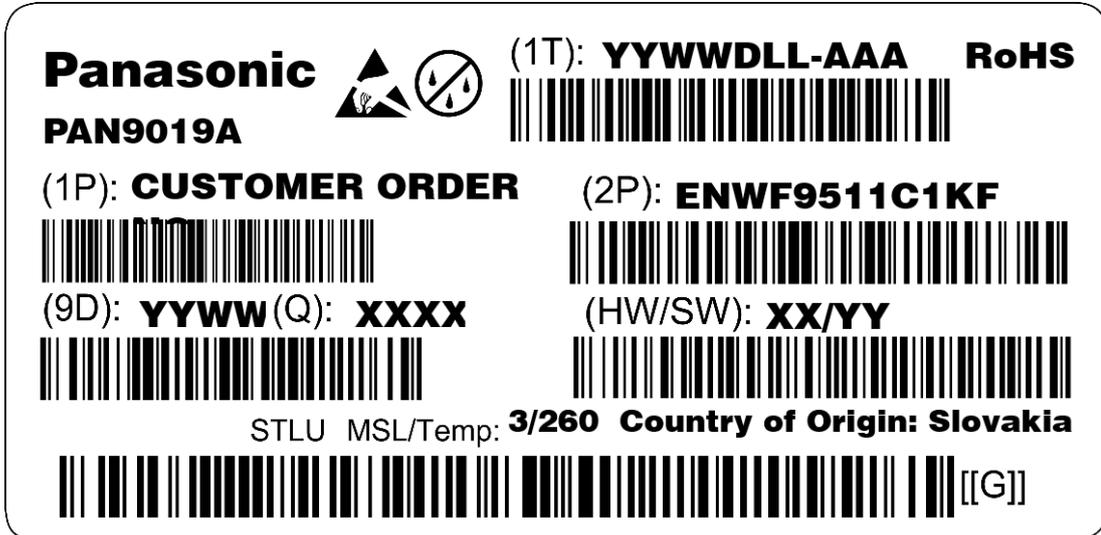
(1T)	Lot code
(1P)	Customer order number, if applicable
(2P)	Order number
(9D)	Date code
(Q)	Quantity
(HW/SW)	Hardware/software version

3.3.6   Total Package
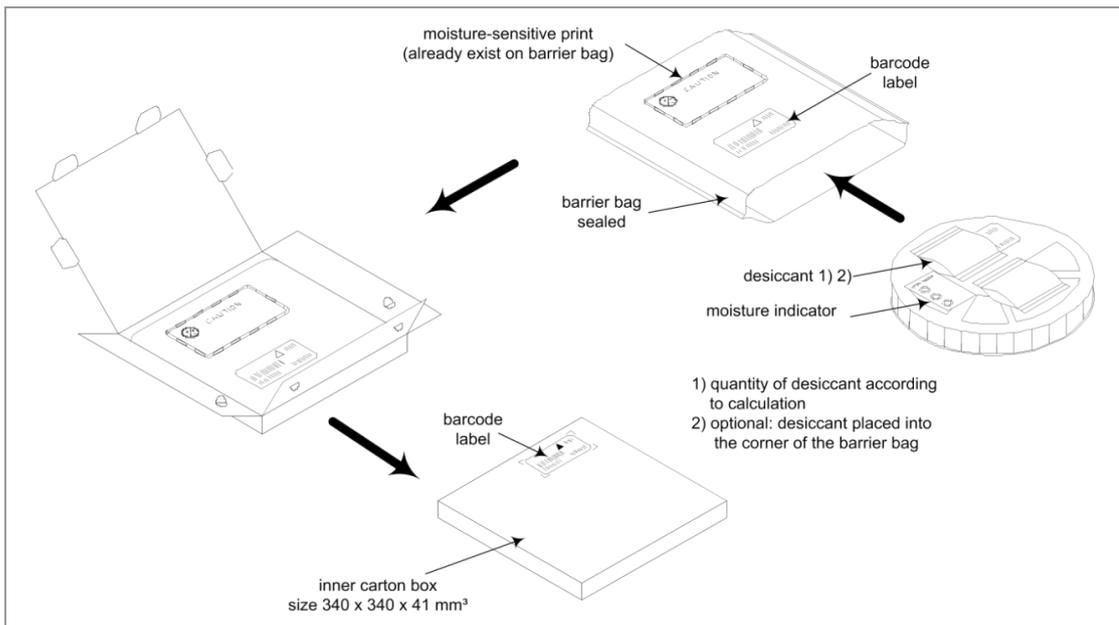
3.4   Case Marking

Example:
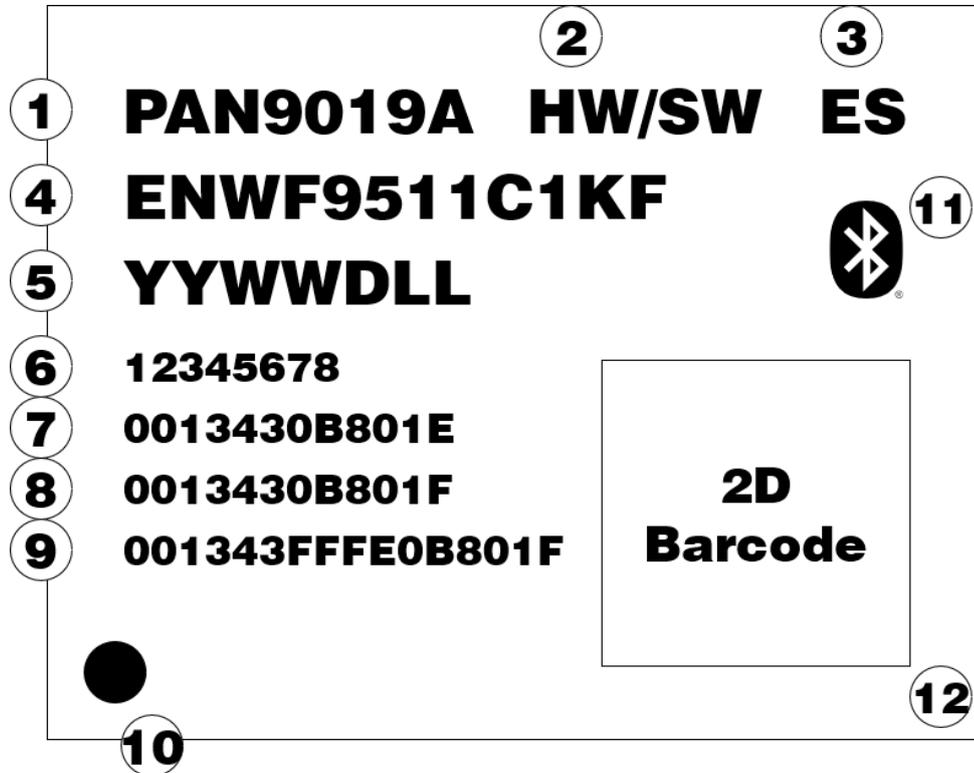
1	Brand name
2	Hardware/Software Version
3	Engineering Sample (optional)
4	Model Name/ENW Number
5	Lot Code
6	Serial Number
7	MAC Address
8	Bluetooth Device Address
9	8 Byte MAC Address (802.15.4)
10	Pin 1 Marking
11	Bluetooth SIG Logo
12	2D Barcode

4 Specification

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

4.1 Default Test Conditions

(i)	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			TBD	V
		According to charged device model (CDM), JEDEC STD 22, method C101			TBD	V
PRF	RF Input Level	Wi-Fi 802.11b DSSS			0.47	dBm
		Wi-Fi 802.11b DSSS			0.47	dBm
		Wi-Fi OFDM			-9.7	dBm
		Bluetooth BR 1 Mbps			-3	dBm
		Bluetooth EDR 2 Mbps and 3 Mbps			-6	dBm
		Bluetooth LE			-3	dBm
		802.15.4			-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
fREFCLK1	WLAN/MCU Crystal Fundamental Frequency	Frequency tolerance < ±20 ppm over operating temperature and process		40		MHz

4.4 Current Consumption

> (i) The current consumption depends on the user scenario and on the setup and timing in the power modes.

> (i) 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 and 802.15.4 only	0.25	0.14	mA
	Deep sleep mode - Wi-Fi only	0.36	0.08	mA
	Deep sleep mode - Wi-Fi, Bluetooth, and 802.15.4	0.41	0.14	mA
Maximum Active Current Consumption	5 GHz, 802.11a, 6 Mbps at 19 dBm + Bluetooth LE/802.15.4 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 LE/802.15.4 transmit at 21 dBm	644	0.43	mA
	5 GHz digital predistortion (DPD) + Bluetooth LE/802.15.4 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 LE, 1Mbps at 0 dBm	43	0.33	mA
	Bluetooth LE, 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 BR, DH5, 1 Mbps	39	0.33	mA
	Bluetooth LE, 1 Mbps	39	0.33	mA

4.4.3   802.15.4 Current Consumption

Parameter	Condition	Typ. at 1.8 V	Typ. at 3.3 V	Unit
Active Transmit	At 0 dBm	43	0.33	mA
	At 10 dBm	89	0.33	mA
	At 21 dBm	362	0.33	mA
Active Receive		27	0.33	mA

4.5   RF Electrical Characteristics

4.5.1   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
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

Parameter	Operation Mode				Specification
	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	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 / 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 / 103.2 / 114.7 / 129 / 143.4 Mbps
		MCS0~11	HE40	3.2 µs GI	14.6 / 29.3 / 43.9 / 58.5 / 87.8 / 117 / 131.6 / 146.3 / 175.5 / 195 / 219.4 / 243.8 Mbps
				1.6 µs GI	16.3 / 32.5 / 48.8 / 65 / 97.5 / 130 / 146.3 / 162.5 / 195 / 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 / 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 / 72.1 / 108.1 / 144.1 / 216.2 / 288.2 / 324.3 / 360.3 / 432.4 / 480.4 / 540.4 / 600.5 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 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 Channel 2.4 GHz[5]	IEEE 802.11 b	20 MHz			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
	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

[5] To comply with the relevant regulatory requirements, please refer to the "PAN9019A Module Integration Guide".

Parameter	Operation Mode		Specification
Supported Channel 5 GHz[5]	IEEE 802.11a/n/ac/ax	20 MHz	184[6], 187[6], 188[6], 192[6], 196[6], 8, 11, 12, 16, 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

4.5.2   WLAN RF Characteristics

4.5.2.1   IEEE 802.11b (RF Characteristics)

> (i) 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			+18[7]		dBm
Spectrum Mask	fC±11 MHz			-30	dBr
	fC±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

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[6] These channels are located in the 4 GHz band.

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

4.5.2.2   IEEE 802.11g (RF Characteristics)

> ℹ️ 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	6 Mbps~18 Mbps			17[7]		dBm
	24 Mbps~36 Mbps			17[7]		dBm
	48 Mbps~54 Mbps			17[7]		dBm
Spectrum Mask	fC±11 MHz				-20	dBr
	fC±20 MHz				-28	dBr
	fC±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

4.5.2.3   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	MCS0~MCS2			17[7]		dBm
	MCS3~MCS4			17[7]		dBm
	MCS5~MCS7			17[7]		dBm
Spectrum Mask	fC±11 MHz				-20	dBr
	fC±20 MHz				-28	dBr
	fC±30 MHz				-45	dBr
Transmitter Center Frequency Leakage					-15	dB
Transmitter Spectral Flatness			-4		+4	dB
Constellation Error (EVM)	BPSK, CR 1/2 (MCS0)				-5	dB
	QPSK, CR 1/2 (MCS1)				-10	dB
	QPSK, CR 3/4 (MCS2)				-13	dB
	16-QAM, CR 1/2 (MCS3)				-16	dB
	16-QAM, CR 3/4 (MCS4)				-19	dB
	64-QAM, CR 2/3 (MCS5)				-22	dB
	64-QAM, CR 3/4 (MCS6)				-25	dB
	64-QAM, CR 5/6 (MCS7)				-27	dB
Minimum Receive Sensitivity[8]	MCS0	PER ≤ 10 %		-92	-82	dBm
	MCS7	PER ≤ 10 %		-72	-64	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[9]	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

---

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

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

4.5.2.4 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	MCS0~MCS2			17^7		dBm
	MCS3~MCS4			17^7		dBm
	MCS5~MCS7			17^7		dBm
Spectrum Mask	fC±21 MHz				-20	dBr
	fC±40 MHz				-28	dBr
	fC±60 MHz				-45	dBr
Transmitter Center Frequency Leakage					-20	dB
Transmitter Spectral Flatness			-4		+4	dB
Constellation Error (EVM)	BPSK, CR 1/2 (MCS0)				-5	dB
	QPSK, CR 1/2 (MCS1)				-10	dB
	QPSK, CR 3/4 (MCS2)				-13	dB
	16-QAM, CR 1/2 (MCS3)				-16	dB
	16-QAM, CR 3/4 (MCS4)				-19	dB
	64-QAM, CR 2/3 (MCS5)				-22	dB
	64-QAM, CR 3/4 (MCS6)				-25	dB
	64-QAM, CR 5/6 (MCS7)				-27	dB
Minimum Receive Sensitivity[10]	MCS0	PER ≤ 10 %		-89	-79	dBm
	MCS7	PER ≤ 10 %		-70	-61	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[11]	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

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

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

4.5.2.5   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	MCS0~MCS2			17[7]		dBm
	MCS3~MCS4			17[7]		dBm
	MCS5~MCS7			17[7]		dBm
	MCS8~MCS9			15[7]		dBm
	MCS10~MCS11			15[7]		dBm
Spectrum Mask	fC±10.5 MHz				-20	dBr
	fC±20 MHz				-28	dBr
	fC±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
	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[12]	MCS0	PER ≤ 10 %		-92	-82	dBm
	MCS11	PER ≤ 10 %		-63	-52	dBm

---

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

Parameter		Condition	Min.	Typ.	Max.	Unit
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[13]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.5.2.6   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	MCS0~MCS2			17^7		dBm
	MCS3~MCS4			17^7		dBm
	MCS5~MCS7			17^7		dBm
	MCS8~MCS9			15^7		dBm
	MCS10~MCS11			15^7		dBm
Spectrum Mask	fC±20.5 MHz				-20	dBr
	fC±40 MHz				-28	dBr
	fC±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

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

Parameter		Condition	Min.	Typ.	Max.	Unit
Minimum Receive Sensitivity[14]	MCS0	PER ≤ 10 %		-89	-79	dBm
	MCS11	PER ≤ 10 %		-61	-49	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[15]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.5.2.7   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	6 Mbps~18 Mbps			17[7]		dBm
	24 Mbps~36 Mbps			16[7]		dBm
	48 Mbps~54 Mbps			16[7]		dBm
Spectrum Mask	fC±11 MHz				-20	dBr
	fC±20 MHz				-28	dBr
	fC±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

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

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

Parameter		Condition	Min.	Typ.	Max.	Unit
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

4.5.2.8　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	MCS0~MCS2			16[7]		dBm
	MCS3~MCS4			16[7]		dBm
	MCS5~MCS7			16[7]		dBm
Spectrum Mask	fC±11 MHz				-20	dBr
	fC±20 MHz				-28	dBr
	fC±30 MHz				-40	dBr
Transmitter Center Frequency Leakage					-15	dB
Transmitter Spectral Flatness			-4		+4	dB
Constellation Error (EVM)	BPSK, CR 1/2 (MCS0)				-5	dB
	QPSK, CR 1/2 (MCS1)				-10	dB
	QPSK, CR 3/4 (MCS2)				-13	dB
	16-QAM, CR 1/2 (MCS3)				-16	dB
	16-QAM, CR 3/4 (MCS4)				-19	dB
	64-QAM, CR 2/3 (MCS5)				-22	dB
	64-QAM, CR 3/4 (MCS6)				-25	dB
	64-QAM, CR 5/6 (MCS7)				-27	dB
Minimum Receive Sensitivity[16]	MCS0	PER ≤ 10 %		-93	-82	dBm
	MCS7	PER ≤ 10 %		-74	-64	dBm

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

Parameter		Condition	Min.	Typ.	Max.	Unit
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[17]	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

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

> **ⓘ** Assume 3V3 = 3.3 V, 1V8 = 1.8 V, $T_{am\,b}$ = 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	MCS0~MCS2			16[7]		dBm
	MCS3~MCS4			16[7]		dBm
	MCS5~MCS7			16[7]		dBm
Spectrum Mask	fC±21 MHz				-20	dBr
	fC±40 MHz				-28	dBr
	fC±60 MHz				-40	dBr
Transmitter Center Frequency Leakage					-20	dB
Transmitter Spectral Flatness			-4		+4	dB
Constellation Error (EVM)	BPSK, CR 1/2 (MCS0)				-5	dB
	QPSK, CR 1/2 (MCS1)				-10	dB
	QPSK, CR 3/4 (MCS2)				-13	dB
	16-QAM, CR 1/2 (MCS3)				-16	dB
	16-QAM, CR 3/4 (MCS4)				-19	dB
	64-QAM, CR 2/3 (MCS5)				-22	dB
	64-QAM, CR 3/4 (MCS6)				-25	dB
	64-QAM, CR 5/6 (MCS7)				-27	dB
Minimum Receive Sensitivity[18]	MCS0	PER ≤ 10 %		-90	-79	dBm
	MCS7	PER ≤ 10 %		-71	-61	dBm

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

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

Parameter		Condition	Min.	Typ.	Max.	Unit
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[19]	MCS0	PER ≤ 10 %	16			dB
	MCS7	PER ≤ 10 %	-2			dB

4.5.2.10 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	MCS0~MCS2			16[7]		dBm
	MCS3~MCS4			16[7]		dBm
	MCS5~MCS7			16[7]		dBm
	MCS8~MCS9			13[7]		dBm
Spectrum Mask	fC±11 MHz				-20	dBr
	fC±20 MHz				-28	dBr
	fC±30 MHz				-40	dBr
Transmitter Center Frequency Leakage					-17,48	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
	MCS0	PER ≤ 10 %		-93	-82	dBm

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

Parameter	Condition	Min.	Typ.	Max.	Unit
Minimum Receive Sensitivity[20]	MCS8	PER ≤ 10 %		-70	-59	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[21]	MCS0	PER ≤ 10 %	16			dB
	MCS8	PER ≤ 10 %	-8			dB

4.5.2.11 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	MCS0~MCS2			16[7]		dBm
	MCS3~MCS4			16[7]		dBm
	MCS5~MCS7			16[7]		dBm
	MCS8~MCS9			13[7]		dBm
Spectrum Mask	fC±21 MHz				-20	dBr
	fC±40 MHz				-28	dBr
	fC±60 MHz				-40	dBr
Transmitter Center Frequency Leakage					-20.57	dB
Transmitter Spectral Flatness			-4		+4	dB

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

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

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[22]	MCS0	PER ≤ 10 %		-90	-79	dBm
	MCS9	PER ≤ 10 %		-66	-54	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[23]	MCS0	PER ≤ 10 %	16			dB
	MCS9	PER ≤ 10 %	-9			dB

4.5.2.12 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	MCS0~MCS2			13[7]		dBm
	MCS3~MCS4			13[7]		dBm
	MCS5~MCS7			13[7]		dBm
	MCS8~MCS9			13[7]		dBm
Spectrum Mask	fC±41 MHz				-20	dBr
	fC±80 MHz				-28	dBr
	fC±120 MHz				-40	dBr
Transmitter Center Frequency Leakage					-23.8	dB

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

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

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
Minimum Receive Sensitivity[24]	MCS0	PER ≤ 10 %		-86	-76	dBm
	MCS9	PER ≤ 10 %		-63	-51	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[25]	MCS0	PER ≤ 10 %	16			dB
	MCS9	PER ≤ 10 %	-9			dB

4.5.2.13   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	MCS0~MCS2			16[7]		dBm
	MCS3~MCS4			16[7]		dBm
	MCS5~MCS7			16[7]		dBm
	MCS8~MCS9			13[7]		dBm
	MCS10~MCS11			10[7]		dBm

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

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

Parameter		Condition	Min.	Typ.	Max.	Unit
Spectrum Mask	fC±10.5 MHz				-20	dBr
	fC±20 MHz				-28	dBr
	fC±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
	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[26]	MCS0	PER ≤ 10 %		-94	-82	dBm
	MCS11	PER ≤ 10 %		-64	-52	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[27]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.5.2.14 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

---

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

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

Parameter		Condition	Min.	Typ.	Max.	Unit
Transmit Output Power	MCS0~MCS2			16[7]		dBm
	MCS3~MCS4			16[7]		dBm
	MCS5~MCS7			16[7]		dBm
	MCS8~MCS9			13[7]		dBm
	MCS10~MCS11			10[7]		dBm
Spectrum Mask	fC±20.5 MHz				-20	dBr
	fC±40 MHz				-28	dBr
	fC±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[28]	MCS0	PER ≤ 10 %		-90	-79	dBm
	MCS11	PER ≤ 10 %		-62	-49	dBm
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[29]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

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

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

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

> (i) 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	MCS0~MCS2			13[7]		dBm
	MCS3~MCS4			13[7]		dBm
	MCS5~MCS7			13[7]		dBm
	MCS8~MCS9			13[7]		dBm
	MCS10~MCS11			10[7]		dBm
Spectrum Mask	fC±40.5 MHz				-20	dBr
	fC±80 MHz				-28	dBr
	fC±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[30]	MCS0	PER ≤ 10 %		-87	-76	dBm
	MCS11	PER ≤ 10 %		-59	-46	dBm

---

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

Parameter		Condition	Min.	Typ.	Max.	Unit
Maximum Input Level				-9.7		dBm
Adjacent Channel Rejection[31]	MCS0	PER ≤ 10 %	16			dB
	MCS11	PER ≤ 10 %	-14			dB

4.5.3   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.

4.5.3.1   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

---

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

Parameter	Condition		Min.	Typ.	Max.	Units
	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 RSL = -67 dBm BER ≤ 0.1 % Long Range S = 2 (500 kbps)	C/I (Co-channel)			17	dB
		C/I (1 MHz)			11	dB
		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

4.5.3.2   Transmitter Section RF Characteristics

Parameter	Condition	Min.	Typ.	Max.	Units
RF frequency range		2 400		2 483.5	MHz
Maximum output power	Basic Rate (BR)		+4		dBm
	Enhanced Data Rate (EDR)		+4		dBm
	Low energy (LE)		+4		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
	± 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

4.5.4   802.15.4 RF Characteristics

> (i) 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.

4.5.4.1   Receiver Section RF Characteristics

Parameter	Condition		Min.	Typ.	Max.	Units
RF frequency range			2 400		2 483.5	MHz
RF Maximum Input Level				-3		dBm
Interference Performance C/I Ratio	PER ≤ 1 %	C/I (±20 MHz)			30	dB
		C/I (±15MHz)			30	dB
		C/I (±10MHz)			30	dB
		C/I (±5 MHz)			0	dB

Parameter	Condition		Min.	Typ.	Max.	Units
Minimum Receive Sensitivity	PER ≤ 10 % Payload 127 bytes			-102	-85	dBm

4.5.4.2 Transmitter Section RF Characteristics

Parameter	Condition	Min.	Typ.	Max.	Units
RF frequency range		2 400		2 483.5	MHz
Maximum output power			+4		dBm
Gain range			-20 to +22		dB
Gain resolution			1		dB
Error Vector Magnitude (EVM)			11		%

4.6   Reliability Tests

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

No.	Item	Limit	Condition
1	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

4.7 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
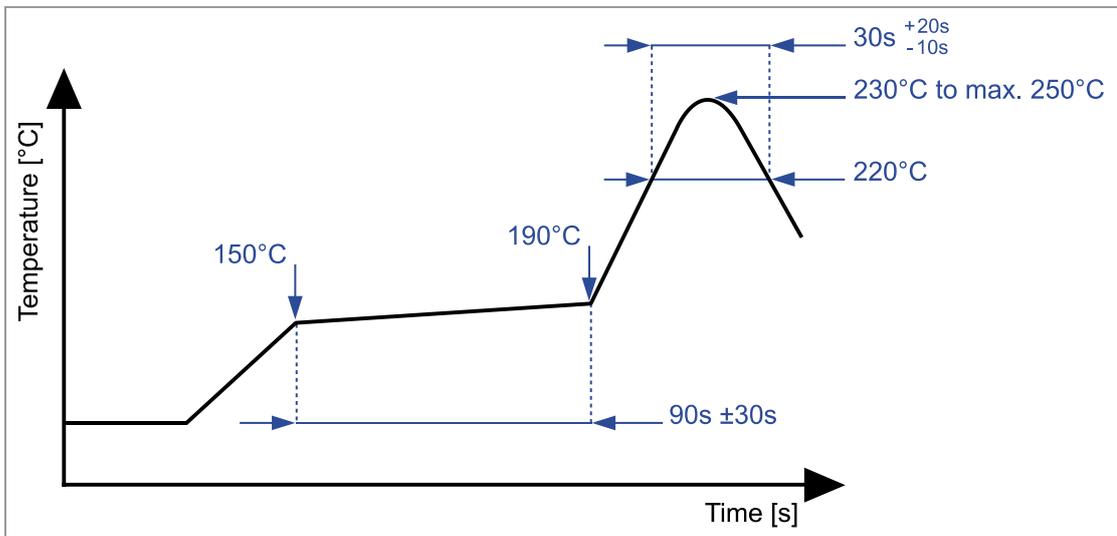
5 Cautions

⚠️ 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 ⇨ 4.7 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.

> (i)   For further information please refer to the Panasonic website ⇨ 7.2.2 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

6.1 Federal Communications Commission (FCC) for US

TBD

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

TBD

6.3 European Conformity According to RED (2014/53/EU)

TBD

6.4 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 ⇨ 7.2.2 Product Information.

7　Appendix

7.1　Ordering Information

Variants and Versions

Order Number	Brand Name	Description	MOQ[32]
ENWF9511C1KF [33]	PAN9019A	Wi-Fi 6 Dual Band 2.4 GHz/5 GHz, Bluetooth® and 802.15.4 Module	500

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[32] 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.

[33] Samples are available on customer demand.

7.2 Contact Details

7.2.1 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/.

7.2.2 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