Shelly X module X2 datasheet

Datasheet version v10.0

Hardware version V012



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Features

CPU and On-Chip Memory

- ESP32-C3 embedded, 32-bit RISC-V single-core processor, up to 160 MHz
- 384 KB ROM
- 400 KB SRAM (16 KB for cache)
- 8 KB SRAM in RTC
- 8 MB flash in chip package

*The flash is integrated into the chip's package. Flash supports more than **100,000 program/erase cycles** and more than **20 years** data retention time.*

Wi-Fi

- IEEE **802.11 b/g/n**-compliant
- Center frequency range of operating channel: **2412 ~ 2484** MHz
- Supports 20 MHz, 40 MHz bandwidth in 2.4 GHz band
- 1T1R mode with data rate up to **150 Mbps**
- Simultaneous support for Infrastructure BSS in Station mode, SoftAP mode, Station + SoftAP mode, and promiscuous mode

Note that when the chip scans in Station mode, the SoftAP channel will change along with the Station channel

Bluetooth®

- Bluetooth LE
- Internal co-existence mechanism between Wi-Fi and Bluetooth to share the same antenna
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
- Advertising extensions
- Multiple advertisement sets
- Channel selection algorithm #2

Peripherals

- Up to **9 configurable IOs**
- Support for UART communication via JS interface, more protocols will be supported in the future
- Temperature & humidity sensor support - DS18B20 & DHT22

Integrated Components on Module

- **40 MHz** crystal oscillator

Antenna

- On-board PCB antenna

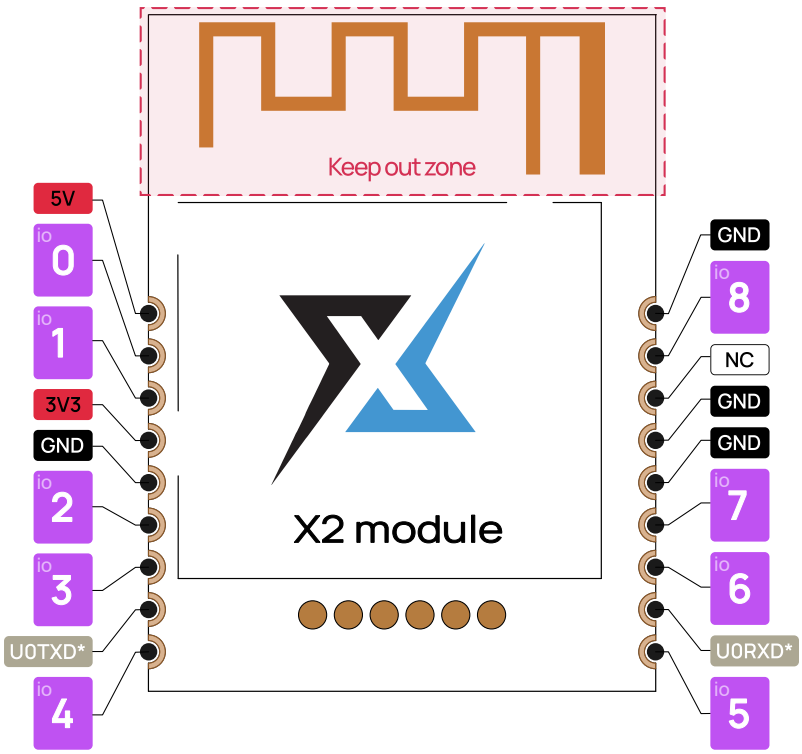
Operating conditions

- Power Supply: **3.3–3.6 V DC** (5 V DC input supported via **internal regulation**)
- Operating ambient temperature: **–40°C ~ 105 °C**

Ambient temperature specifies the recommended temperature range of the environment immediately outside the Shelly module.

Module overview

IO layout



Keep out zone

The exact dimesions are marked in the Module dimesnions schematic.

Special purpose IOs

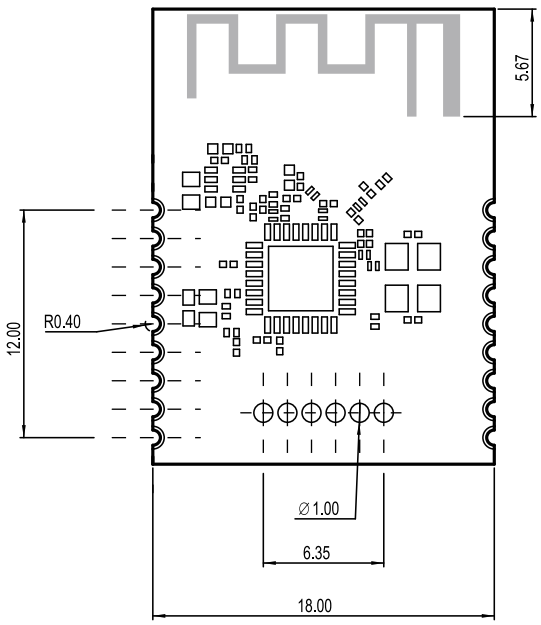
The U0RXD and the U0TXD are service IOs for system diagnostics and communication, and should not be used for any other purposes.

Note: Silkscreen IO labels may not match the current firmware. Refer to this datasheet for accurate pin assignments.

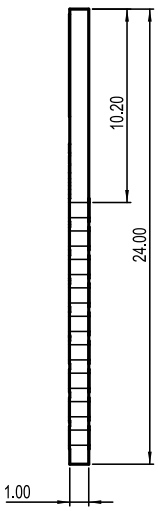
Module dimensions

Units: mm

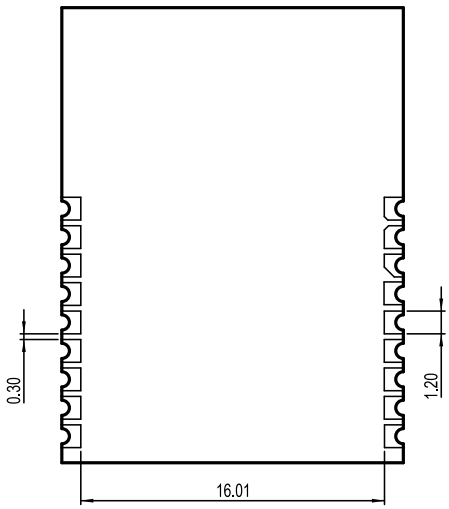
Front view



Side view



Back view



Electrical Characteristics

Absolute Maximum Ratings

Stresses above those listed in **Table 1 Absolute Maximum Ratings** may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under **Table 2 Recommended Operating Conditions** is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Symbol	Parameter	Min	Max	Unit
VDD33	Power supply voltage	-0.3	3.6	V
TSTORE	Storage temperature	−40	105	°C

Table 1: Absolute Maximum Ratings

Recommended Operating Conditions

Symbol	Parameter	Min	Typ.	Max	Unit
VDD33	Power supply voltage	3.0	3.3	3.6	V
I_{VDD}	Current delivered by external power supply min	0.5	—	—	A
T_A	Operating ambient temperature	−40	—	105	°C

Table 2: Recommended Operating Conditions

DC Characteristics (3.3 V, 25 °C)

Symbol	Parameter	Min	Typ.	Max	Unit
C_{IN}	Pin capacitance	—	2	—	pF
V_{IH}	High-level input voltage	0.75 × VDD[1]	—	VDD[1] + 0.3	V
V_{IL}	Low-level input voltage	−0.3	—	0.25 × VDD[1]	V
I_{IH}	High-level input current	—	—	50	nA
I_{IL}	Low-level input current	—	—	50	nA
V_{OH}[2]	High-level output voltage	0.8 × VDD[1]	—	—	V
V_{OL}[2]	Low-level output voltage	—	—	0.1 × VDD[1]	V
I_{OH}	High-level source current (VDD[1] = 3.3 V, V_{OH} >= 2.64 V, PAD_DRIVER = 3)	—	40	—	mA
I_{OL}	Low-level sink current (VDD[1] = 3.3 V, V_{OL} =0.495 V, PAD_DRIVER = 3)	—	28	—	mA
R_{PU}	Pull-up resistor	—	45	—	kΩ
R_{PD}	Pull-down resistor	—	45	—	kΩ
V_{IH_nRST}	Chip reset release voltage	0.75 × VDD[1]	—	VDD[1] + 0.3	V
V_{IL_nRST}	Chip reset voltage	−0.3	—	0.25 × VDD[1]	V

Table 3: DC Characteristics (3.3 V, 25 °C)

[1] VDD is the I/O voltage for pins of a particular power domain.

[2] VOH and VOL are measured using high-impedance load.

Current Consumption Characteristics

Current Consumption in Active Mode

The current consumption measurements are taken with a 3.3 V supply at 25 °C ambient temperature.

TX current consumption is rated at a 100% duty cycle.

RX current consumption is rated when the peripherals are disabled and the CPU idle.

Wi-Fi (2.4 GHz) in Active Mode

Work mode	Description		Peak (mA)
Active (RF working)	TX	802.11b, 1 Mbps, @20.5 dBm	350
		802.11g, 54 Mbps, @18 dBm	295
		802.11n, HT20, MCS7, @17.5 dBm	290
		802.11n, HT40, MCS7, @17 dBm	290
	RX	802.11b/g/n, HT20	82
		802.11n, HT40	84

Table 4: Current Consumption for Wi-Fi (2.4 GHz) in Active Mode

Bluetooth LE in Active Mode

Work Mode	RF Condition	Description	Peak (mA)
Active (RF working)	TX	Bluetooth LE @ 20.0 dBm	340
		Bluetooth LE @ 9.0 dBm	190
		Bluetooth LE 0 dBm	170
		Bluetooth LE @ –15.0 dBm	100
	RX	Bluetooth LE	86

Table 5: Current Consumption for Bluetooth LE in Active Mode

Current Consumption in Other Modes

Modem sleep mode

Mode	CPU Frequency (MHz)	Description	Typ	
			All Peripherals Clocks Disabled (mA)	All Peripherals Clocks Enabled (mA)[1]
Modem-sleep[2,3]	160	CPU is idle	16	21
		CPU is running	23	28
	80	CPU is idle	13	18
		CPU is running	17	22

Table 6: Current Consumption in Modem-sleep Mode

[1] *In practice, the current consumption might be different depending on which peripherals are enabled.*

[2] *In Modem-sleep mode, Wi-Fi is clock gated.*

[3] *In Modem-sleep mode, the consumption might be higher when accessing flash. For a flash rated at 80 Mbit/s, in SPI 2-line mode the consumption is 10 mA.*

Low power modes

Mode	Description	Typ (µA)
Light-sleep	VDD_SPI and Wi-Fi are powered down, and all GPIOs are high-impedance	130
Deep-sleep	RTC timer + RTC memory	5
Power off	CHIP_EN is set to low level, the chip is powered off	1

Table 7: Current Consumption in Low-Power Modes

RF Characteristics

The RF data is measured at the antenna port, where RF cable is connected, including the front-end loss. The external antennas used for the tests on the modules with external antenna connectors have an impedance of 50 Ω.

Devices should operate in the center frequency range allocated by regional regulatory authorities.

Unless otherwise stated, the RF tests are conducted with a 3.3 V (±5%) supply at 25 ^{0}C ambient temperature.

Wi-Fi Radio

Name	Description
Center frequency range of operating channel	2412 ~ 2484 MHz
Wi-Fi wireless standard	IEEE 802.11b/g/n

Table 8: Wi-Fi RF Characteristics

Wi-Fi RF Transmitter (TX) Characteristics

TX Power with Spectral Mask and EVM Meeting 802.11 Standards

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	20.5	—
802.11b, 11 Mbps	—	20.5	—
802.11g, 6 Mbps	—	20.0	—
802.11g, 54 Mbps	—	18.0	—
802.11n, HT20, MCS0	—	19.0	—
802.11n, HT20, MCS7	—	17.5	—
802.11n, HT40, MCS0	—	18.5	—
802.11n, HT40, MCS7	—	17.0	—

Table 9: TX Power with Spectral Mask and EVM Meeting 802.11 Standards

TX EVM Test

Rate	Min (dB)	Typ (dB)	Limit (dB)
802.11b, 1 Mbps, 20.5 dBm	—	–24.5	–10
802.11b, 11 Mbps, @20.5 dBm	—	–25.0	–10
802.11g, 6 Mbps, @20 dBm	—	–23.0	–5
802.11g, 54 Mbps, 18 dBm	—	–28.0	–25
802.11n, HT20, MCS0, @19 dBm	—	–23.5	–5
802.11n, HT20, MCS7, @17.5 dBm	—	–30.5	–27
802.11n, HT40, MCS0, 18.5 dBm	—	–26.5	–5
802.11n, HT40, MCS7, @17 dBm	—	–30.5	–27

Table 10: TX EVM Test[1]

[1] *EVM is measured at the corresponding typical TX power provided in* ***Table 9 TX Power with Spectral Mask and EVM Meeting 802.11 Standards*** *above.*

Wi-Fi RF Receiver (RX) Characteristics

For RX tests, the PER (packet error rate) limit is 8% for 802.11b, and 10% for 802.11g/n.

RX Sensitivity

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	-98.0	—
802.11b, 2 Mbps	—	-96.0	—
802.11b, 5.5 Mbps	—	-93.0	—
802.11b, 11 Mbps	—	-88.6	—
802.11g, 6 Mbps	—	-92.8	—
802.11g, 9 Mbps	—	-91.8	—
802.11g, 12 Mbps	—	-90.8	—
802.11g, 18 Mbps	—	-88.4	—
802.11g, 24 Mbps	—	-85.4	—
802.11g, 36 Mbps	—	-82.0	—
802.11g, 48 Mbps	—	-77.8	—
802.11g, 54 Mbps	—	-76.2	—
802.11n, HT20, MCS0	—	-92.6	—
802.11n, HT20, MCS1	—	-90.6	—
802.11n, HT20, MCS2	—	-88.0	—
802.11n, HT20, MCS3	—	-84.8	—
802.11n, HT20, MCS4	—	-81.6	—
802.11n, HT20, MCS5	—	-77.4	—
802.11n, HT20, MCS6	—	-75.6	—
802.11n, HT20, MCS7	—	-74.4	—
802.11n, HT40, MCS0	—	-90.0	—
802.11n, HT40, MCS1	—	-87.6	—
802.11n, HT40, MCS2	—	-84.8	—
802.11n, HT40, MCS3	—	-81.8	—
802.11n, HT40, MCS4	—	-78.4	—
802.11n, HT40, MCS5	—	-74.2	—
802.11n, HT40, MCS6	—	-72.6	—
802.11n, HT40, MCS7	—	-71.2	—

Table 11: RX Sensitivity

Maximum RX level

Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	5	—
802.11b, 11 Mbps	—	5	—
802.11g, 6 Mbps	—	5	—
802.11g, 54 Mbps	—	0	—
802.11n, HT20, MCS0	—	5	—
802.11n, HT20, MCS7	—	0	—
802.11n, HT40, MCS0	—	5	—
802.11n, HT40, MCS7	—	0	—

Table 12: Maximum RX Level

RX Adjacent channel rejection

Rate	Min (dB)	Typ (dB)	Max (dB)
802.11b, 1 Mbps	—	35	—
802.11b, 11 Mbps	—	35	—
802.11g, 6 Mbps	—	31	—
802.11g, 54 Mbps	—	14	—
802.11n, HT20, MCS0	—	31	—
802.11n, HT20, MCS7	—	13	—
802.11n, HT40, MCS0	—	19	—
802.11n, HT40, MCS7	—	8	—

Table 13: RX Adjacent Channel Rejection

Bluetooth 5 (LE) Radio

Bluetooth LE RF Transmitter (TX) Characteristics

Bluetooth LE RF Characteristics

Name	Description
Center frequency range of operating channel	2402 ~ 2480 MHz
RF transmit power range	−24.0 ~ 20.0 dBm

Table 14: Bluetooth LE RF Characteristics

Bluetooth LE - Transmitter Characteristics - 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	−37.62	—	dBm
	F = F0 ± 3 MHz	—	−41.95	—	dBm
	F = F0 ± > 3 MHz	—	−44.48	—	dBm
Modulation characteristics	$\Delta f1_{avg}$	—	245.00	—	kHz
	$\Delta f2_{max}$	—	208.00	—	kHz
	$\Delta f2_{avg}/\Delta f1_{avg}$	—	0.93	—	—
Carrier frequency offset	—	—	−9.00	—	kHz
Carrier frequency drift	$\lvert f_0 - f_n \rvert_{n=2,3,4,...k}$	—	1.17	—	kHz
	$\lvert f_1 - f_0 \rvert$	—	0.30	—	kHz
	$\lvert f_n - f_{n-5} \rvert_{n=6,7,8,...k}$	—	4.90	—	kHz

Table 15: Bluetooth LE - Transmitter Characteristics - 1 Mbps

Bluetooth LE - Transmitter Characteristics - 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 4 MHz	—	−43.55	—	dBm
	F = F0 ± 5 MHz	—	−45.26	—	dBm
	F = F0 ± > 5 MHz	—	−47.00	—	dBm
Modulation characteristics	$\Delta f1_{avg}$	—	497.00	—	kHz
	$\Delta f2_{max}$	—	398.00	—	kHz
	$\Delta f2_{avg}/\Delta f1_{avg}$	—	0.95	—	—
Carrier frequency offset	—	—	−9.00	—	kHz

Carrier frequency drift	$\|f_0 - f_n\|_{n=2,3,4,...k}$	—	0.46	—	kHz
	$\|f_1 - f_0\|$	—	0.70	—	kHz
	$\|f_n - f_{n-5}\|_{n=6,7,8,...k}$	—	6.80	—	kHz

Table 16: Bluetooth LE - Transmitter Characteristics - 2 Mbps

Bluetooth LE - Transmitter Characteristics - 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	–37.90	—	dBm
	F = F0 ± 3 MHz	—	–41.00	—	dBm
	F = F0 ± > 3 MHz	—	–42.50	—	dBm
Modulation characteristics	$\Delta f1_{avg}$	—	252.00	—	kHz
	$\Delta f1_{max}$	—	200.00	—	kHz
Carrier frequency offset	—	—	–13.70	—	kHz
Carrier frequency drift	$\|f_0 - f_n\|_{n=1,2,3,...k}$	—	1.52	—	kHz
	$\|f_0 - f_3\|$	—	0.65	—	kHz
	$\|f_n - f_{n-3}\|_{n=7,8,9,...k}$	—	0.70	—	kHz

Table 17: Bluetooth LE - Transmitter Characteristics - 125 Kbps

Bluetooth LE - Transmitter Characteristics - 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	F = F0 ± 2 MHz	—	–37.90	—	dBm
	F = F0 ± 3 MHz	—	–41.30	—	dBm
	F = F0 ± > 3 MHz	—	–42.80	—	dBm
Modulation characteristics	$\Delta f2_{avg}$	—	220.00	—	kHz
	$\Delta f2_{max}$	—	205.00	—	kHz
Carrier frequency offset	—	—	–11.90	—	kHz
Carrier frequency drift	$\|f_0 - f_n\|_{n=1,2,3,...k}$	—	1.37	—	kHz
	$\|f_0 - f_3\|$	—	1.09	—	kHz
	$\|f_n - f_{n-3}\|_{n=7,8,9,...k}$	—	0.51	—	kHz

Table 18: Bluetooth LE - Transmitter Characteristics - 500 Kbps

Bluetooth LE RF Receiver (RX) Characteristics

Bluetooth LE - Receiver Characteristics - 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-96	—	dBm
Maximum received signal @30.8% PER	—	—	10	—	dBm
Co-channel C/I	—	—	8	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	-4	—	dB
	F = F0 – 1 MHz	—	-3	—	dB
	F = F0 + 2 MHz	—	-32	—	dB
	F = F0 – 2 MHz	—	-36	—	dB
	F ≥F0 + 3 MHz[1]	—	—	—	dB
	F ≤F0 – 3 MHz	—	-39	—	dB
Image frequency	—	—	-29	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	-38	—	dB
	F = F_{image} – 1 MHz	—	-34	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	-9	—	dBm
	2003 MHz ~ 2399 MHz	—	-18	—	dBm
	2484 MHz ~ 2997 MHz	—	-16	—	dBm
	3000 MHz ~ 12.75 GHz	—	-6	—	dBm
Intermodulation	—	—	-44	—	dBm

Table 19: Bluetooth LE - Receiver Characteristics - 1 Mbps

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz.

Bluetooth LE - Receiver Characteristics - 2 Mbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-93	—	dBm
Maximum received signal @30.8% PER	—	—	0	—	dBm
Co-channel C/I	—	—	10	—	dB
Adjacent channel selectivity C/I	F = F0 + 2 MHz	—	-7	—	dB
	F = F0 – 2 MHz	—	-7	—	dB
	F = F0 + 4 MHz[1]	—	—	—	dB
	F = F0 – 4 MHz	—	-34	—	dB
	F ≥F0 + 6 MHz	—	-39	—	dB

	F ≤F0 – 6 MHz	—	–39	—	dB
Image frequency	—	—	–27	—	dB
Adjacent channel to image frequency	F = F_{image} + 2 MHz	—	–39	—	dB
	F = F_{image} – 2 MHz(2)	—	—	—	dB
Out-of-band blocking performance	30 MHz ~ 2000 MHz	—	–17	—	dBm
	2003 MHz ~ 2399 MHz	—	–19	—	dBm
	2484 MHz ~ 2997 MHz	—	–16	—	dBm
	3000 MHz ~ 12.75 GHz	—	–22	—	dBm
Intermodulation	—	—	–40	—	dBm

Table 20: Bluetooth LE - Receiver Characteristics - 2 Mbps

[1] Refer to the value of Image frequency.

[2] Refer to the value of Adjacent channel selectivity C/I when F = F0 + 2 MHz.

Bluetooth LE - Receiver Characteristics - 125 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	–104	—	dBm
Maximum received signal @30.8% PER	—	—	10	—	dBm
Co-channel C/I	—	—	2	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	–6	—	dB
	F = F0 – 1 MHz	—	–5	—	dB
	F = F0 + 2 MHz	—	–40	—	dB
	F = F0 – 2 MHz	—	–42	—	dB
	F ≥F0 + 3 MHz(1)	—	—	—	dB
	F ≤F0 – 3 MHz	—	–46	—	dB
Image frequency	—	—	–34	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	–44	—	dB
	F = F_{image} – 1 MHz	—	–37	—	dB

Table 21: Bluetooth LE - Receiver Characteristics - 125 Kbps

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz.

Bluetooth LE - Receiver Characteristics - 500 Kbps

Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-99	—	dBm
Maximum received signal @30.8% PER	—	—	10	—	dBm
Co-channel C/I	—	—	3	—	dB
Adjacent channel selectivity C/I	F = F0 + 1 MHz	—	-5	—	dB
	F = F0 – 1 MHz	—	-7	—	dB
	F = F0 + 2 MHz	—	-39	—	dB
	F = F0 – 2 MHz	—	-40	—	dB
	F ≥ F0 + 3 MHz(1)	—	—	—	dB
	F ≤ F0 – 3 MHz	—	-40	—	dB
Image frequency	—	—	-34	—	dB
Adjacent channel to image frequency	F = F_{image} + 1 MHz	—	-43	—	dB
	F = F_{image} – 1 MHz	—	-38	—	dB

Table 22: Bluetooth LE - Receiver Characteristics - 500 Kbps

[1] Refer to the value of Adjacent channel to image frequency when F = F_{image} – 1 MHz.

Revision history

Date	Version	Release notes
2025-05-09	v9.0	1. IOs updated; 2 NC IOs replaced with NTC and System button (Sys btn). 2. Added Revision history table. 3. The dimension drawing replaced with an enhanced version.
2026-08-07	v10.0	1. The total supported IO has increased from 7 to 9 following a firmware update. The IOs layout has been revised accordingly. 2. Added note regarding silkscreen IO labels possibly not matching current firmware.