

Shelly MOD1 datasheet

Datasheet version 5

Hardware revision V1.2

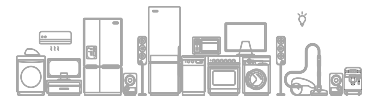
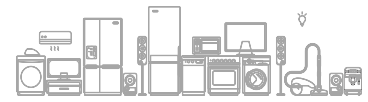


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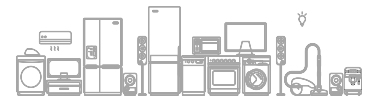


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Features

CPU and On-Chip Memory

- ESP32-C3FH4 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
- 4 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
- Wi-Fi Multimedia (WMM)
- TX/RX A-MPDU, TX/RX A-MSDU
- Immediate Block ACK
- Fragmentation and defragmentation
- Transmit opportunity (TXOP)
- Automatic Beacon monitoring (hardware TSF)
- 4 × virtual Wi-Fi interfaces
- 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: Bluetooth 5
- Speed: 125 Kbps, 500 Kbps, 1 Mbps, 2 Mbps
- Advertising extensions
- Multiple advertisement sets
- Channel selection algorithm #2
- Internal co-existence mechanism between Wi-Fi and Bluetooth to share the same antenna

Peripherals

- Up to 8 digital inputs or outputs, usable by the firmware platform
- 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

- Operating voltage/Power supply: 3.0 ~ 3.6 V
- Operating ambient temperature: -40 ~ 105 °C

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

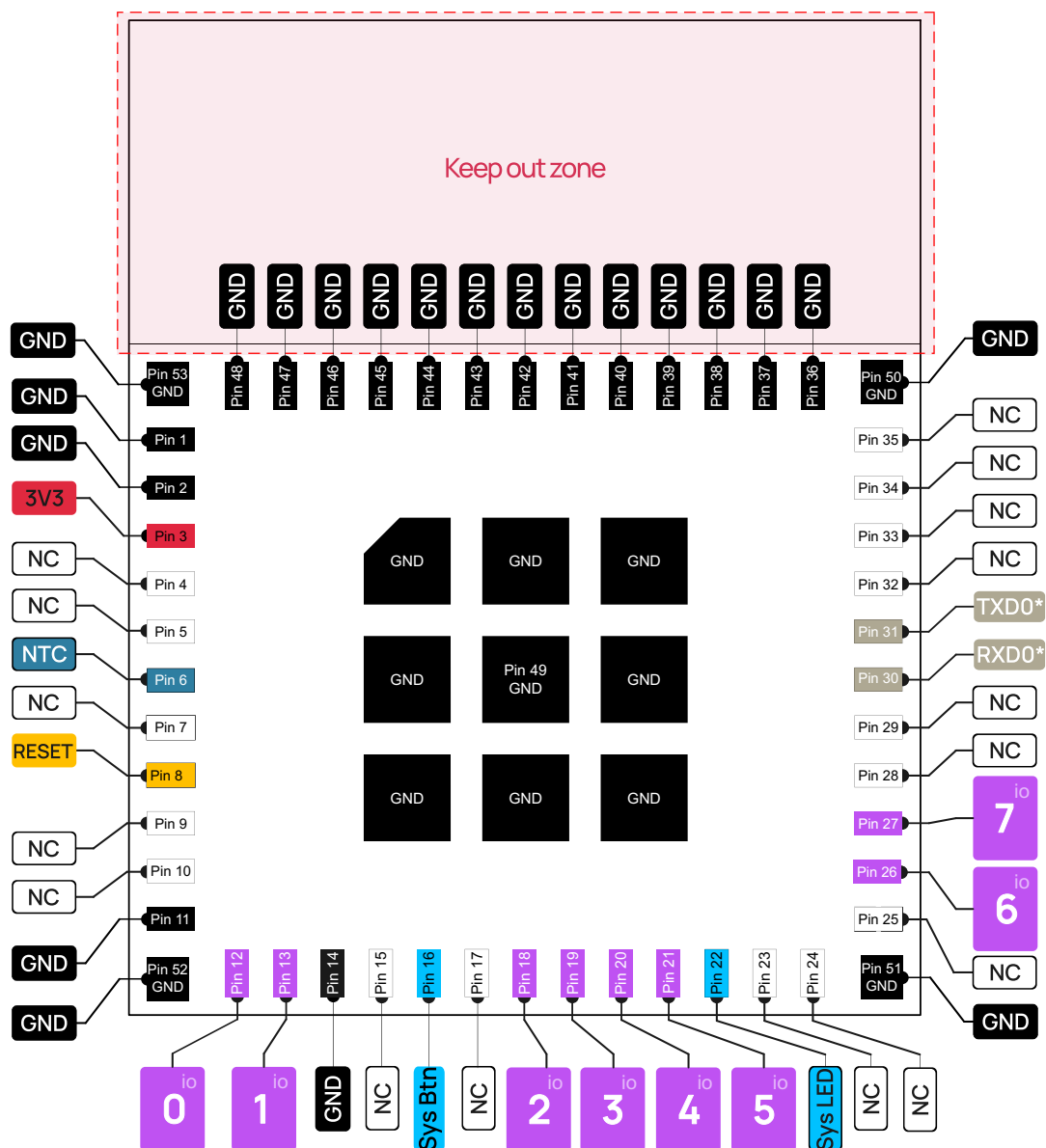
Certificates

- CE RED
- RoHS
- FCC



Module overview

IO layout



Keep out zone

Antenna keep out zone. The exact dimensions are marked in the Module dimensions schematic.

Special purpose I/Os

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



Module dimensions

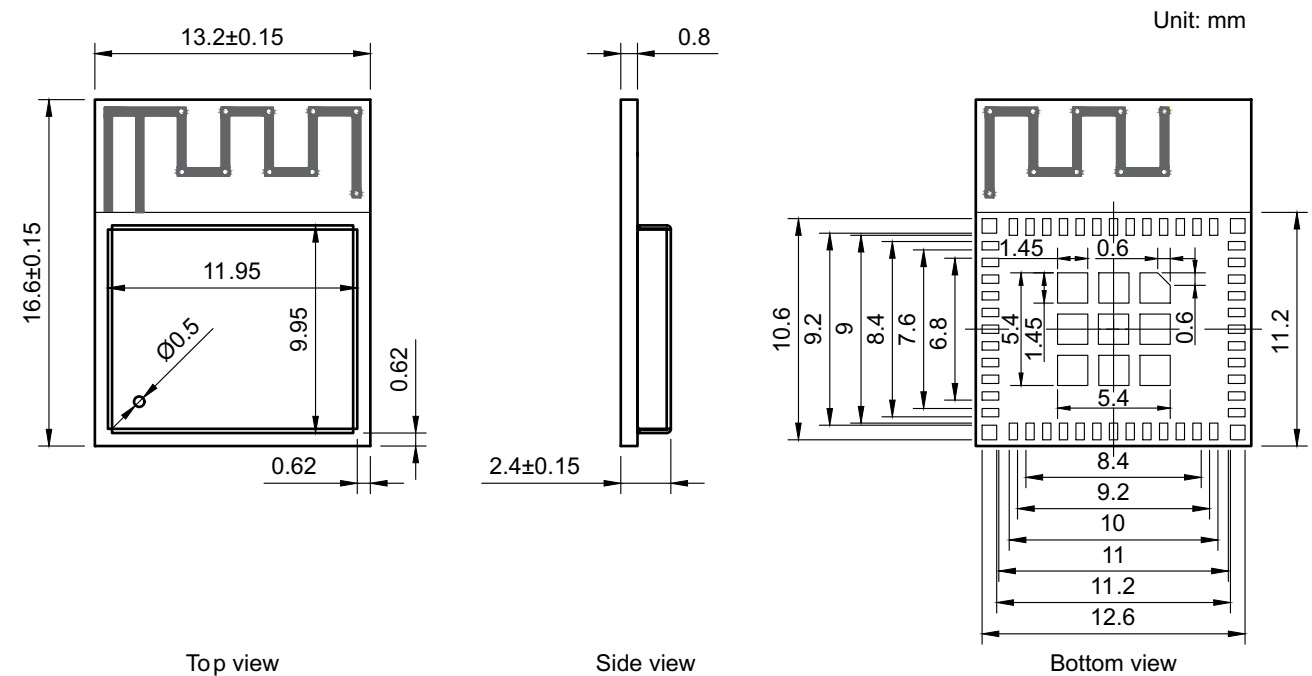
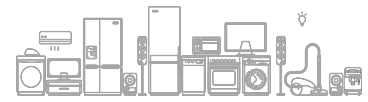


Figure 1: Shelly MOD1 Dimensions



Electrical Characteristics

Absolute Maximum Ratings

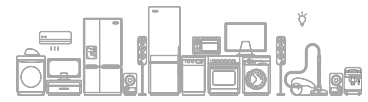
Symbol	Parameter	Min	Max	Unit
VDD33	Power supply voltage	-0.3	3.6	V
T _{STORE}	Storage temperature	-40	105	°C

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	0.5	—	—	A
T _A	Operating ambient temperature	-40	—	105	°C

Table 2: Recommended Operating Conditions



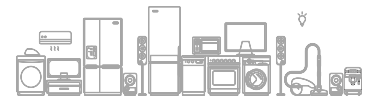
DC Characteristics (3.3 V, 25 °C)

Symbol	Parameter	Min	Typ.	Max	Unit
C_{IN}	Pin capacitance	—	2	—	pF
V_{IH}	High-level input voltage	$0.75 \times VDD^1$	—	$VDD^1 + 0.3$	V
V_{IL}	Low-level input voltage	-0.3	—	$0.25 \times VDD^1$	V
I_{IH}	High-level input current	—	—	50	nA
I_{IL}	Low-level input current	—	—	50	nA
V_{OH}^2	High-level output voltage	$0.8 \times VDD^1$	—	—	V
V_{OL}^2	Low-level output voltage	—	—	$0.1 \times VDD^1$	V
I_{OH}	High-level source current ($VDD^1 = 3.3$ V, $V_{OH} \geq 2.64$ 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	—	k Ω
R_{PD}	Pull-down resistor	—	45	—	k Ω
V_{IH_nRST}	Chip reset release voltage (CHIP_EN voltage is within the specified range)	$0.75 \times VDD^1$	—	$VDD^1 + 0.3$	V
V_{IL_nRST}	Chip reset voltage (CHIP_EN voltage is within the specified range)	-0.3	—	$0.25 \times VDD^1$	V

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

¹ VDD - voltage from a power pin of a respective power domain.

² V_{OH} and V_{OL} 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

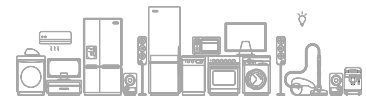
Work mode	Description		Peak (mA)
Active (RF working)	TX	802.11b, 1 Mbps, @20.5 dBm	350
		802.11g, 54 Mbps, @18 dBm	295
		802.11n, HT20, MCS7, @17.5 dBm	290
		802.11n, HT40, MCS7, @17 dBm	290
	RX	802.11b/g/n, HT20	82
		802.11n, HT40	84

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 ($\pm 5\%$) supply at 25 $^{\circ}\text{C}$ 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	—

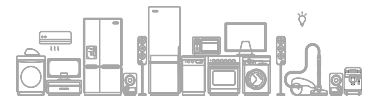
Table 9: TX Power with Spectral Mask and EVM Meeting 802.11 Standards

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 Test¹

¹ EVM is measured at the corresponding typical TX power provided in table TX Power with Spectral Mask and EVM Meeting 802.11 Standards above.



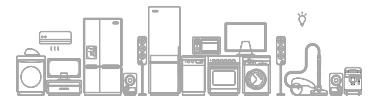
Wi-Fi RF Receiver (RX) Characteristics

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

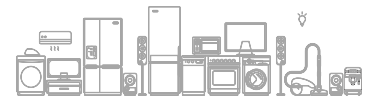
Rate	Min (dBm)	Typ (dBm)	Max (dBm)
802.11b, 1 Mbps	—	5	—
802.11b, 11 Mbps	—	5	—
802.11g, 6 Mbps	—	5	—
802.11g, 54 Mbps	—	0	—
802.11n, HT20, MCS0	—	5	—
802.11n, HT20, MCS7	—	0	—
802.11n, HT40, MCS0	—	5	—
802.11n, HT40, MCS7	—	0	—

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

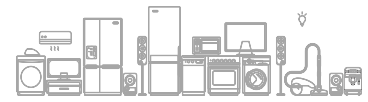
Bluetooth LE - Transmitter Characteristics - 1 Mbps

Parameter	Description	Min	Typ	Max	Unit
In-band emissions	$F = F_0 \pm 2 \text{ MHz}$	—	-37.62	—	dBm
	$F = F_0 \pm 3 \text{ MHz}$	—	-41.95	—	dBm
	$F = F_0 \pm > 3 \text{ MHz}$	—	-44.48	—	dBm
Modulation characteristics	$\Delta f_{1\text{avg}}$	—	245.00	—	kHz
	$\Delta f_{2\text{max}}$	—	208.00	—	kHz
	$\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}$	—	0.93	—	—
Carrier frequency offset	—	—	-9.00	—	kHz
Carrier frequency drift	$ f_0 - f_n _{n=2,3,4,\dots,k}$	—	1.17	—	kHz
	$ f_1 - f_0 $	—	0.30	—	kHz
	$ f_n - f_{n-5} _{n=6,7,8,\dots,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	$F = F_0 \pm 4 \text{ MHz}$	—	-43.55	—	dBm
	$F = F_0 \pm 5 \text{ MHz}$	—	-45.26	—	dBm
	$F = F_0 \pm > 5 \text{ MHz}$	—	-47.00	—	dBm
Modulation characteristics	$\Delta f_{1\text{avg}}$	—	497.00	—	kHz
	$\Delta f_{2\text{max}}$	—	398.00	—	kHz
	$\Delta f_{2\text{avg}} / \Delta f_{1\text{avg}}$	—	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

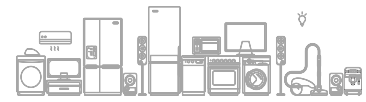
Parameter	Description	Min	Typ	Max	Unit
In-band emissions	$F = F_0 \pm 2 \text{ MHz}$	—	-37.90	—	dBm
	$F = F_0 \pm 3 \text{ MHz}$	—	-41.00	—	dBm
	$F = F_0 \pm > 3 \text{ MHz}$	—	-42.50	—	dBm
Modulation characteristics	$\Delta f_{1\text{avg}}$	—	252.00	—	kHz
	$\Delta f_{1\text{max}}$	—	200.00	—	kHz
Carrier 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	$F = F_0 \pm 2 \text{ MHz}$	—	-37.90	—	dBm
	$F = F_0 \pm 3 \text{ MHz}$	—	-41.30	—	dBm
	$F = F_0 \pm > 3 \text{ MHz}$	—	-42.80	—	dBm
Modulation characteristics	$\Delta f_{2\text{avg}}$	—	220.00	—	kHz
	$\Delta f_{2\text{max}}$	—	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

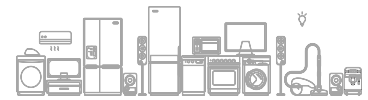
Parameter	Description	Min	Typ	Max	Unit
Sensitivity @30.8% PER	—	—	-96	—	dBm
Maximum received signal @30.8% PER	—	—	10	—	dBm
Co-channel C/I	—	—	8	—	dB
Adjacent channel selectivity C/I	$F = F_0 + 1 \text{ MHz}$	—	-4	—	dB
	$F = F_0 - 1 \text{ MHz}$	—	-3	—	dB
	$F = F_0 + 2 \text{ MHz}$	—	-32	—	dB
	$F = F_0 - 2 \text{ MHz}$	—	-36	—	dB
	$F \geq F_0 + 3 \text{ MHz}^{(1)}$	—	—	—	dB
	$F \leq F_0 - 3 \text{ MHz}$	—	-39	—	dB
Image frequency	—	—	-29	—	dB
Adjacent channel to image frequency	$F = F_{\text{image}} + 1 \text{ MHz}$	—	-38	—	dB
	$F = F_{\text{image}} - 1 \text{ MHz}$	—	-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 $F = F_{\text{image}} - 1 \text{ MHz}$

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	$F = F_0 + 2 \text{ MHz}$	—	-7	—	dB
	$F = F_0 - 2 \text{ MHz}$	—	-7	—	dB
	$F = F_0 + 4 \text{ MHz}^{(1)}$	—	—	—	dB
	$F = F_0 - 4 \text{ MHz}$	—	-34	—	dB
	$F \geq F_0 + 6 \text{ MHz}$	—	-39	—	dB



	$F \leq F_0 - 6 \text{ MHz}$	—	-39	—	dB
Image frequency	—	—	-27	—	dB
Adjacent channel to image frequency	$F = F_{\text{image}} + 2 \text{ MHz}$	—	-39	—	dB
	$F = F_{\text{image}} - 2 \text{ MHz}^{(2)}$	—	—	—	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.

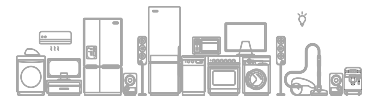
² Refer to the value of Adjacent channel selectivity C/I when $F = F_0 + 2 \text{ MHz}$

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	$F = F_0 + 1 \text{ MHz}$	—	-6	—	dB
	$F = F_0 - 1 \text{ MHz}$	—	-5	—	dB
	$F = F_0 + 2 \text{ MHz}$	—	-40	—	dB
	$F = F_0 - 2 \text{ MHz}$	—	-42	—	dB
	$F \geq F_0 + 3 \text{ MHz}^{(1)}$	—	—	—	dB
	$F \leq F_0 - 3 \text{ MHz}$	—	-46	—	dB
Image frequency	—	—	-34	—	dB
Adjacent channel to image frequency	$F = F_{\text{image}} + 1 \text{ MHz}$	—	-44	—	dB
	$F = F_{\text{image}} - 1 \text{ MHz}$	—	-37	—	dB

Table 21: Bluetooth LE - Receiver Characteristics - 125 Kbps

¹ Refer to the value of Adjacent channel to image frequency when $F = F_{\text{image}} - 1 \text{ MHz}$



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	$F = F_0 + 1 \text{ MHz}$	—	-5	—	dB
	$F = F_0 - 1 \text{ MHz}$	—	-7	—	dB
	$F = F_0 + 2 \text{ MHz}$	—	-39	—	dB
	$F = F_0 - 2 \text{ MHz}$	—	-40	—	dB
	$F \geq F_0 + 3 \text{ MHz}^{(1)}$	—	—	—	dB
	$F \leq F_0 - 3 \text{ MHz}$	—	-40	—	dB
Image frequency	—	—	-34	—	dB
Adjacent channel to image frequency	$F = F_{\text{image}} + 1 \text{ MHz}$	—	-43	—	dB
	$F = F_{\text{image}} - 1 \text{ MHz}$	—	-38	—	dB

Table 22: Bluetooth LE - Receiver Characteristics - 500 Kbps

¹ Refer to the value of Adjacent channel to image frequency when $F = F_{\text{image}} - 1 \text{ MHz}$



PCB Layout Recommendations

PCB Land pattern

Unit: mm

- Via for thermal pad
- Pad

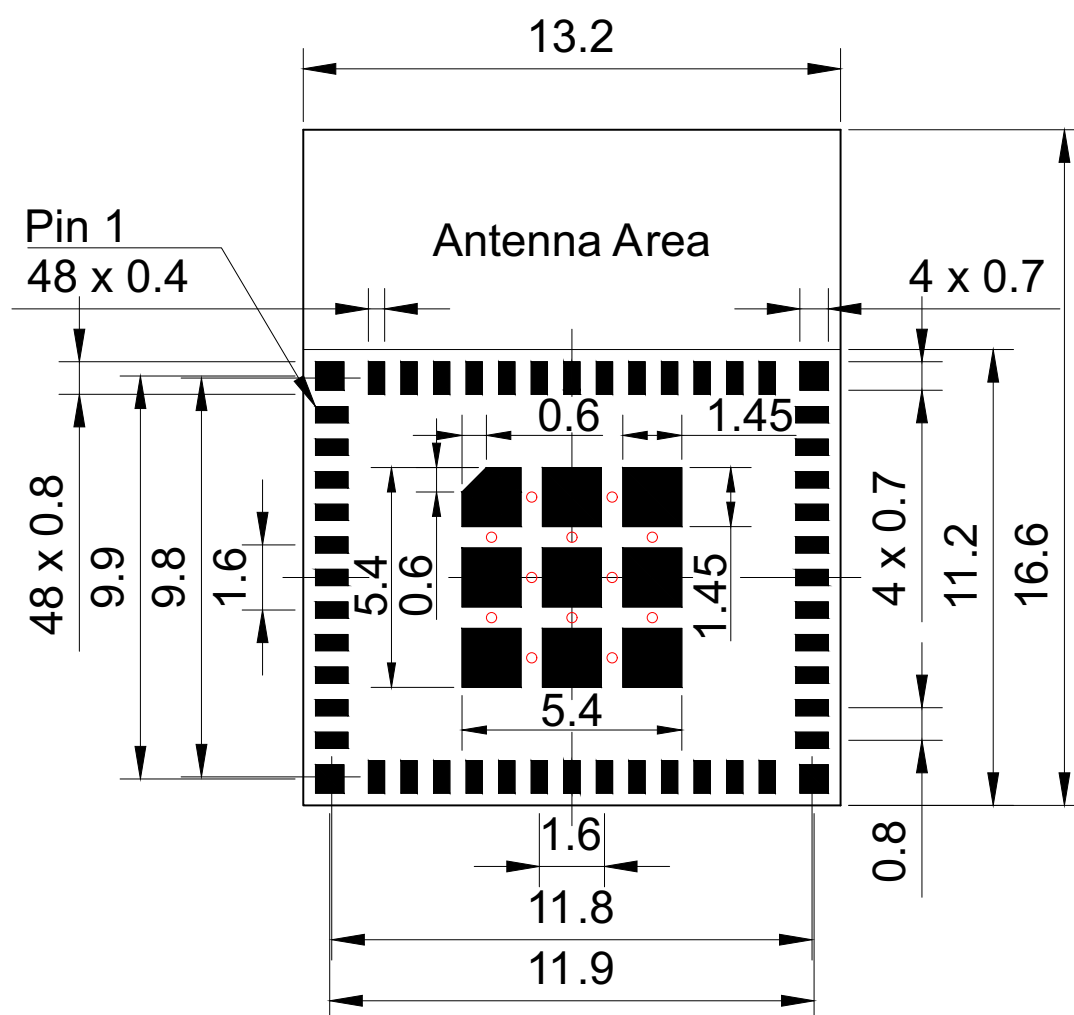


Figure 2: Shelly MOD1 Recommended PCB Land Pattern