RNWF02 Wi-Fi Module Data Sheet

RNWF02

Introduction

The RNWF02 Module is a low power 2.4 GHz IEEE® 802.11b/g/n compliant, fully RF certified wireless module designed for IoT (Internet of Things) applications. These modules are interfaced via a two-wire or four-wire UART interface with Microchip's simple ASCII-based AT commands for easy integration into most of the applications. The host microcontroller can dynamically configure the RNWF02 module with a few simple ASCII commands.

The Module operates at a single supply voltage V_{DD} (3.3V typical), certain Input Output (IOs) pins support a voltage range of 1.8-3.6V by supplying the V_{DDIO} pin separately.

The RNWF02 module is available with an on-board Printed Circuit Board (PCB) antenna or U.FL connector for an external antenna and with or without an integrated Microchip Trust&Go secure device.

Features

- Compliant with IEEE 802.11 b/g/n Single Spatial Stream of 20 MHz Channel Bandwidth
- Transmission Control Protocol/Internet Protocol (TCP/IP)-Based Connectivity Protocols Along with SSL and MQTT Capabilities.
- Supports STA Mode and Soft AP Functionality in IEEE 802.11 Infrastructure and IBSS Networks
- Protected Management Frame (PMF) Handled in Hardware, WPA3 Support
- Integrated Power Amplifier (PA) and TX/RX Switch and Power Management
- Internal Flash Memory to Store Firmware
- Immutable Secure Boot with Hardware Root of Trust
- Supports Host Assisted Over-the-Air (OTA) Firmware Update
- On-Chip Network Stack to Offload MCU
  - Network features – TCP, UDP, DHCP, ARP, HTTP, MQTT, IPv6 TLS 1.2/1.3 and DNS
  - Hardware accelerators for Wi-Fi® and TLS security to improve connection time
- Hardware Based Low-Power Modes with Support for Magic Packet-Based Snooze Mode
  - Low Power modes – Connected Sleep and Extreme Deep Sleep (XDS)
    - Extreme Deep Sleep (XDS) current < 1 µA
  - Fast host wake-up from Sleep mode by a pin or the host I/O transaction
  - Optional low-power secondary oscillator (RTCC oscillator) 32.768 KHz for real-time clock and calendar applications(2)
- Hardware-Based IEEE 802.15.2 Compliant Three-Wire Packet Traffic Arbitration (PTA) Interface for Wi-Fi/Bluetooth® Coexistence(2)
- UART Host Interface
- Secure Device Firmware Upgrade (DFU)
- Integrated Microchip Trust&Go Secure Device (Optional)

Security

- Hardware Accelerated Security Modes (CryptoMaster) with Built-in DMA Support
  - Encryption engines (AES and TDES with different NIST modes of operation):
    - Modes – Electronic Code Book (ECB), Cypher Block Chaining (CBC), Counter Mode (CTR), Cypher Feedback Mode (CFB) and Output Feedback Mode (OFB)
    - AES key sizes: 128b, 192b and 256b
  - Authentication engines:
    - SHA-1 and SHA-2
    - AES GCM (Galois/Counter mode)
    - HMAC and AES CMAC
  - On-chip oscillator for NDRNG generation
- Multi-Purpose Public Key Crypto Engine Supporting the Following Algorithms:
  - ECC/ECDH/ECDSA with standard NIST prime curves up to 521-bit, Curve25519 and Ed25519
  - RSA up to 2048-bit keys

Operating Conditions

- Operating Voltage (V_{DD}): 3.0-3.6V (3.3V Typical), (V_{DDIO}): 1.8-3.6V
- Operating Temperature: -40°C to 85°C

Module Variants

- PCB Antenna:
  - RNWF02PE
  - RNWF02PC
- U.FL Connector for External Antenna:
  - RNWF02UE
  - RNWF02UC

Package

- 28-Pin SMD Package with Shield CAN on Top
- Size: 21.7 mm x 14.7 mm x 2.1 mm

Applications

- Smart Factories/Control Devices
- Security Systems, CCTV
- Smart Homes/Lighting, Smart Locks
- Computing, Wi-Fi Dongles, Protocol Bridging
- Internet of Things (IoT) Sensor Tag
- Remote Control
- Wearable Smart Devices
- Industrial Control

Certifications

- RNWF02 Module is Planned to be Certified to FCC, ISED, UKCA and CE Radio Regulations
- RoHS and REACH Compliant

Notes:

1. Refer to the *RNWFXX Application Developer's Guide* for the latest supported features.
2. The RNWF02 module does not support the PTA interface and the RTCC oscillator function together. Refer to 2.1. Pin Details of RNWF02 Module for more details.

Table of Contents

1. Module Ordering Information

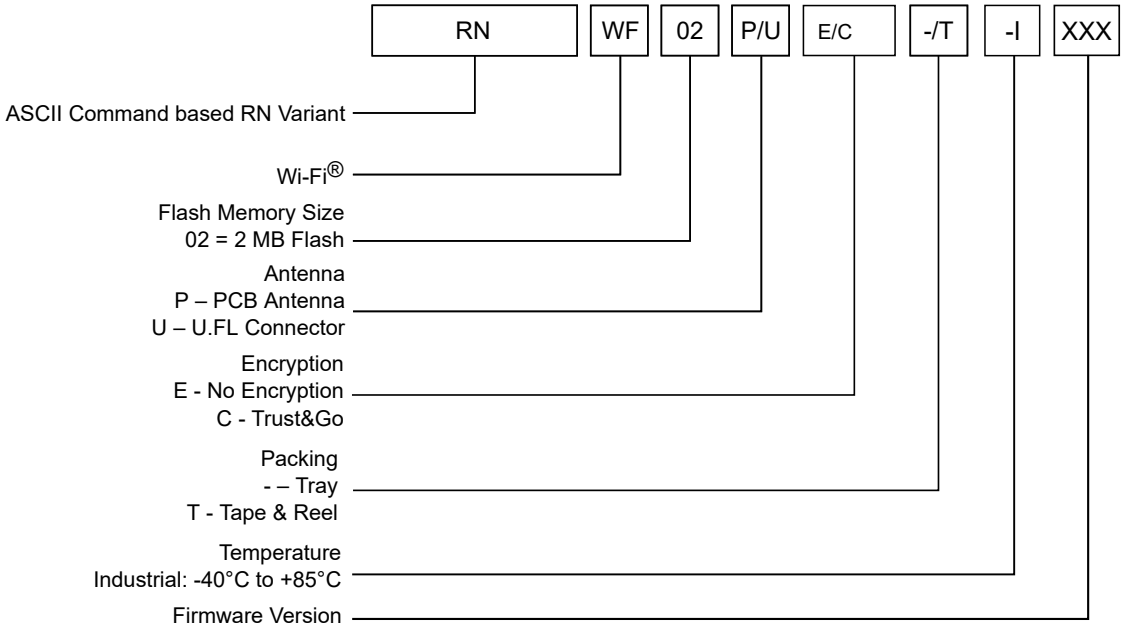
This chapter provides the ordering information of the RNWF02 module.

Table 1-1. RNWF02 Module Ordering Details

Module Name	Description	Ordering Code
RNWF02PE	RNWF02 Module with PCB antenna	RNWF02PE-I
		RNWF02PET-I
RNWF02PC	RNWF02 Module with PCB antenna and Trust&Go	RNWF02PC-I
		RNWF02PCT-I
RNWF02UE	RNWF02 Module with U.FL connector for external antenna	RNWF02UE-I
		RNWF02UET-I
RNWF02UC	RNWF02 Module with U.FL connector for external antenna and Trust&Go	RNWF02UC-I
		RNWF02UCT-I

The following figure illustrates the details of the RNWF02 module ordering information.

Figure 1-1. RNWF02 Module Ordering Information



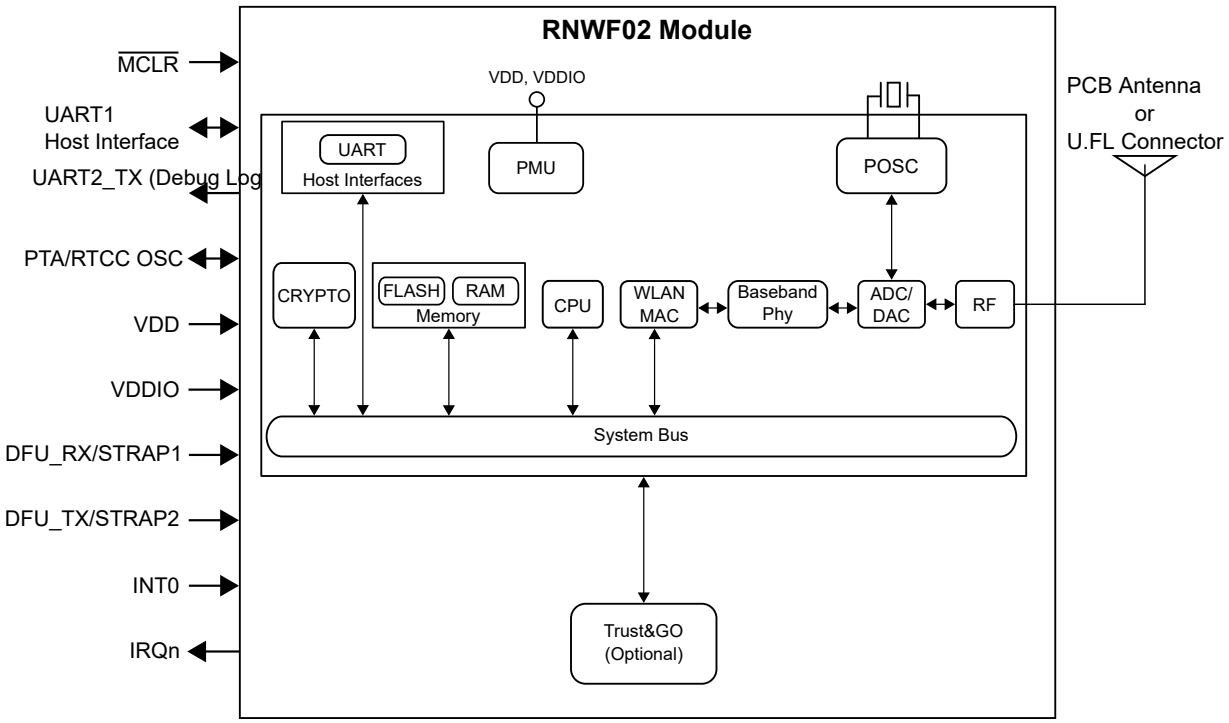
2. Device Overview

The RNWF02 module is a fully RF certified wireless module. The RNWF02 module is available with the following antenna variants:

- PCB antenna (RNWF02PE/RNWF02PC)
- U.FL connector (RNWF02UE/RNWF02UC) for external antenna

The following figure illustrates the RNWF02 module block diagram and various peripherals supported by the module.

Figure 2-1. RNWF02 Module Block Diagram



2.1 Pin Details of RNWF02 Module

This section provides details on pin diagrams and pinout table of RNWF02 module.

Figure 2-2. RNWF02 Module Pin Diagram (Bottom View)

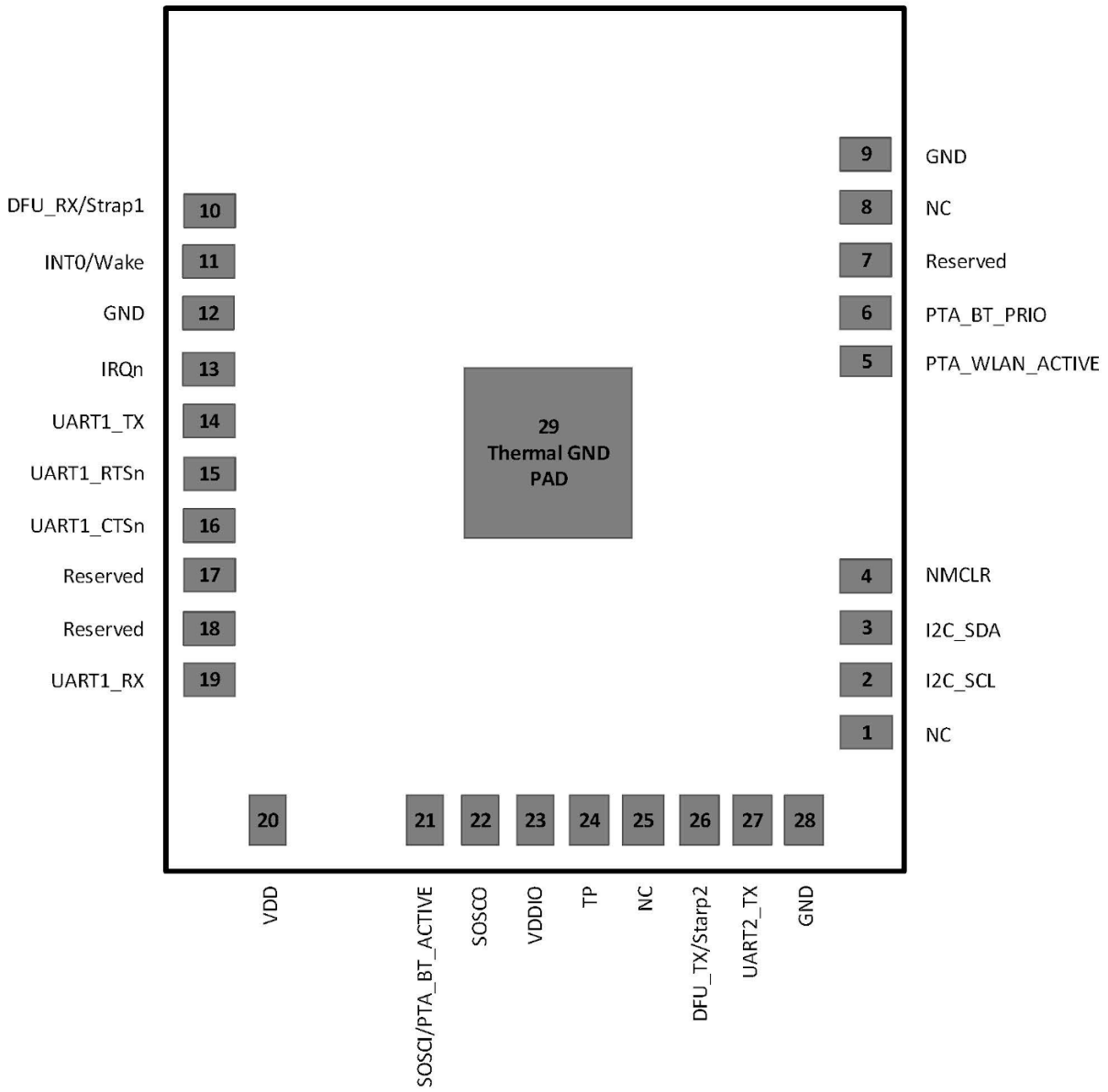


Table 2-1. RNWF02 Module Pinout Table

Pin Number	Pin Name	Pin Type	Pin Description
1	NC	—	No connection
2	I2C_SCL	I	I^2C clock connected to Trust&GO device. Recommended to connect external pull-up resistor of 1.2K.
3	I2C_SDA	I/O	I^2C data connected to Trust&GO device. Recommended to connect external pull-up resistor of 1.2K.
4	$\overline{MCLR}$	I	Master clear reset, active-low
5	PTA_WLAN_ACTIVE	O	PTA interface, WLAN_ACTIVE

.....continued

Pin Number	Pin Name	Pin Type	Pin Description
6	PTA_BT_PRIO	I/O	PTA interface, BT_PRIORITY
7	—	I/O	Reserved
8	NC	—	No connection
9	GND	P	Ground
10	DFU_RX/Strap1	I	For device firmware update receive pin. Recommended to connect to a pull-down resistor of 100K.
11	INT0/Wake	—	To wake-up the Wi-Fi® module from its Extreme Deep Sleep (XDS) mode by the host
12	GND	P	Ground
13	IRQn(2)	O	Interrupt request (active-low) from the Wi-Fi module to wake-up the host from its Sleep state
14	UART1_TX(2)	O	UART1 transmit, Host interface
15	UART1_RTSn	O	UART1 Request-to-Send (active low), Host interface
16	UART1_CTSn	I	UART1 Clear-to-Send (active-low), Host interface
17	—	I/O	Reserved
18	—	I/O	Reserved
19	UART1_RX(2)	I	UART1 receive, Host interface
20	VDD	P	VDD power supply (3.0-3.6V)
21	SOSCI/PTA_BT_ACTIVE (1)	I	RTCC oscillator input for 32.768 KHz external crystal/ PTA Interface BT_ACTIVE
22	SOSCO	O	RTCC oscillator output
23	VDDIO	P	I/O power supply (1.8-3.6V)
24	TP	P	Test point: 1.5V(3)
25	NC	—	No connection
26	DFU_TX/Strap2	I	For device firmware update receive pin. Recommended to connect to a pull-down resistor of 100K.
27	UART2_TX(2)	I/O	UART2 transmit signal for the debug log
28	GND	P	Ground
29	GND Paddle	P	Thermal ground pad

Notes:

1. This pin can be configured either as an oscillator input pin or as PTA BT_ACTIVE. The RNWF02 module does not support both the functionality together.
2. These pins support lower voltage by supplying the V_{DDIO} pin separately (1.8V - 3.6V).
3. Do not connect any signal to source the voltage.

2.2 Basic Connection Requirement

The RNWF02 module requires attention to a minimal set of device pin connections before proceeding with development.

Figure 2-3. RNWF02 Module Basic Connection and Interface Diagram

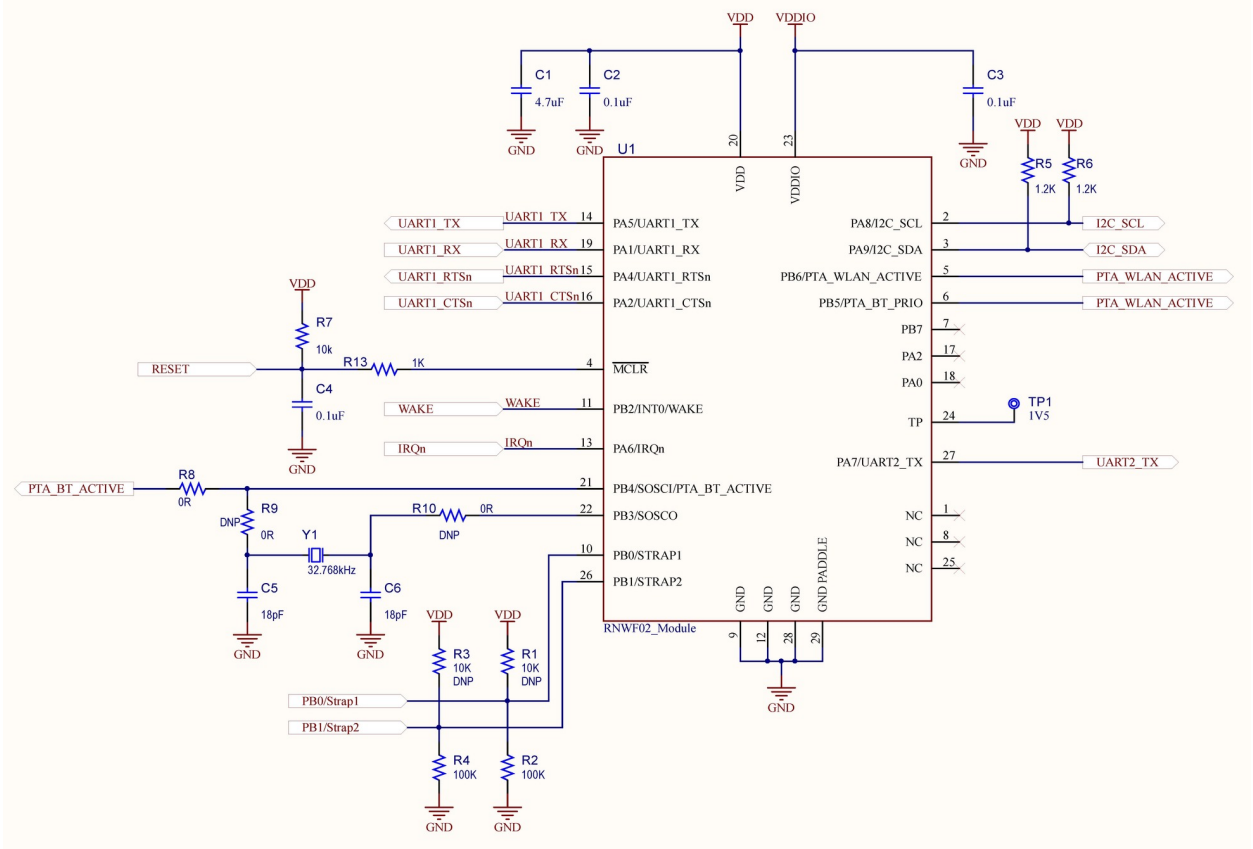


Table 2-2. Configuration Details

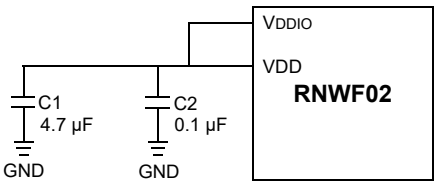
Configuration Details			
Module Pin10/Strap1	**Module Pin26/Strap2**	**Host Interface Selection**	**Description**
0	0	UART1	RNWF02 module with UART1
Note: The mentioned resistance values are only guidelines. For details on the application schematics, refer to the *RNWF02 Add On Board User's Guide* (DS5003575A).			

2.2.1 Power Supply Pin

It is recommended to add a bulk and a decoupling capacitor at the input supply Pin 20 (VDD), Pin 23 (VDDIO) and GND of the RNWF02 module.

VDD and VDDIO can be connected to the same supply for the typical 3.3V operation. For I/Os to operate at a lower voltage, typically 1.8V, VDDIO can be connected separately along with a decoupling capacitor.

Figure 2-4. Recommended Module Power Supply Connections



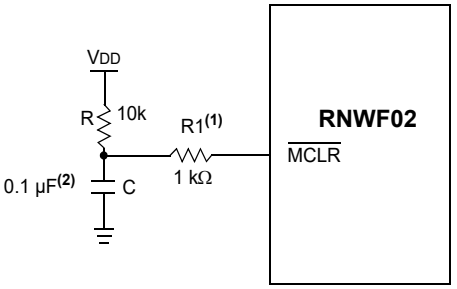
The value of the C1 and C2 capacitors may vary based on the application requirements and source of supply voltage. The C1 and C2 capacitor must be placed close to the pin.

2.2.2 Master Clear ($\overline{MCLR}$) Pin

The $\overline{MCLR}$ pin works as a device Reset.

Pulling the $\overline{MCLR}$ pin low generates a device Reset. The basic connection and interface diagram of the module illustrates a typical $\overline{MCLR}$ circuit. See *Module Basic Connection and Interface Diagram* in the *Basic Connection Requirement* from Related Links.

Figure 2-5. Example of $\overline{MCLR}$ Pin Connections



Notes:

1. 470Ω ≤ R1 ≤ 1 kΩ limits any current flowing into $\overline{MCLR}$ from the external capacitor C in the event of $\overline{MCLR}$ pin breakdown due to Electrostatic Discharge (ESD) or Electrical Overstress (EOS). Ensure that the $\overline{MCLR}$ pin V_{IH} and V_{IL} specifications are met without interfering with the Debug/ Programmer tools.
2. The capacitor can be sized to prevent unintentional Resets from brief glitches or to extend the device Reset period during POR.

Related Links

2.2. Basic Connection Requirement

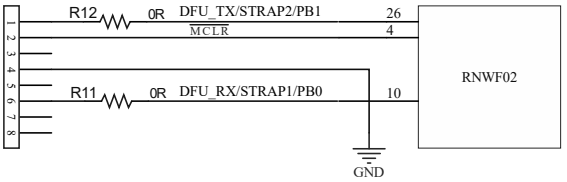
2.2.3 Device Firmware Update

The RNWF02 module is available for purchase with pre-programmed firmware. Microchip periodically releases the firmware to fix reported issues or to implement the latest feature support. There are two ways to perform a regular firmware update:

1. Serial DFU command-based update over UART
2. Host-assisted Over-the-Air (OTA) update

Note: For the serial DFU and OTA programming guidance, refer to the *RNWFXX Module Application Developer's Guide*.

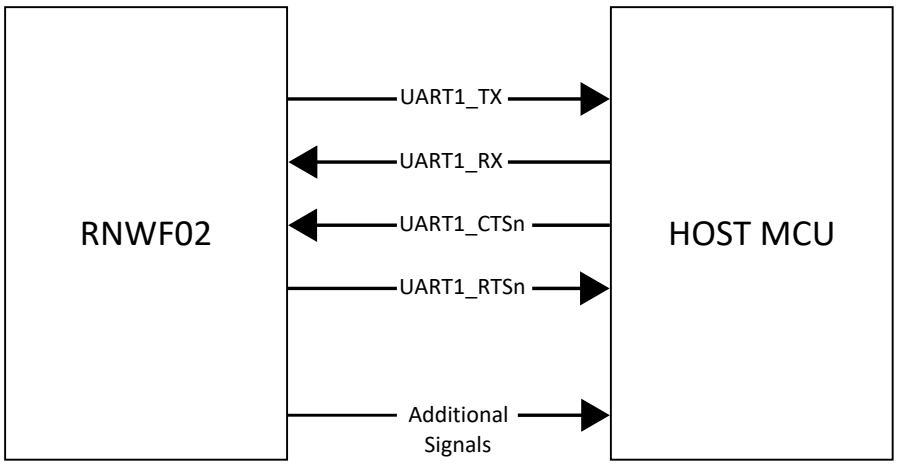
Figure 2-6. Basic Connection Diagram of DFU



2.2.4 Interface with Host Microcontroller

The RNWF02 module can be interfaced with the host microcontroller through the UART_TX and UART_RX data line and optional UART flow control signals UART_RTS and UART_CTS.

Figure 2-7. RNWF02 Module Host Interface Diagram



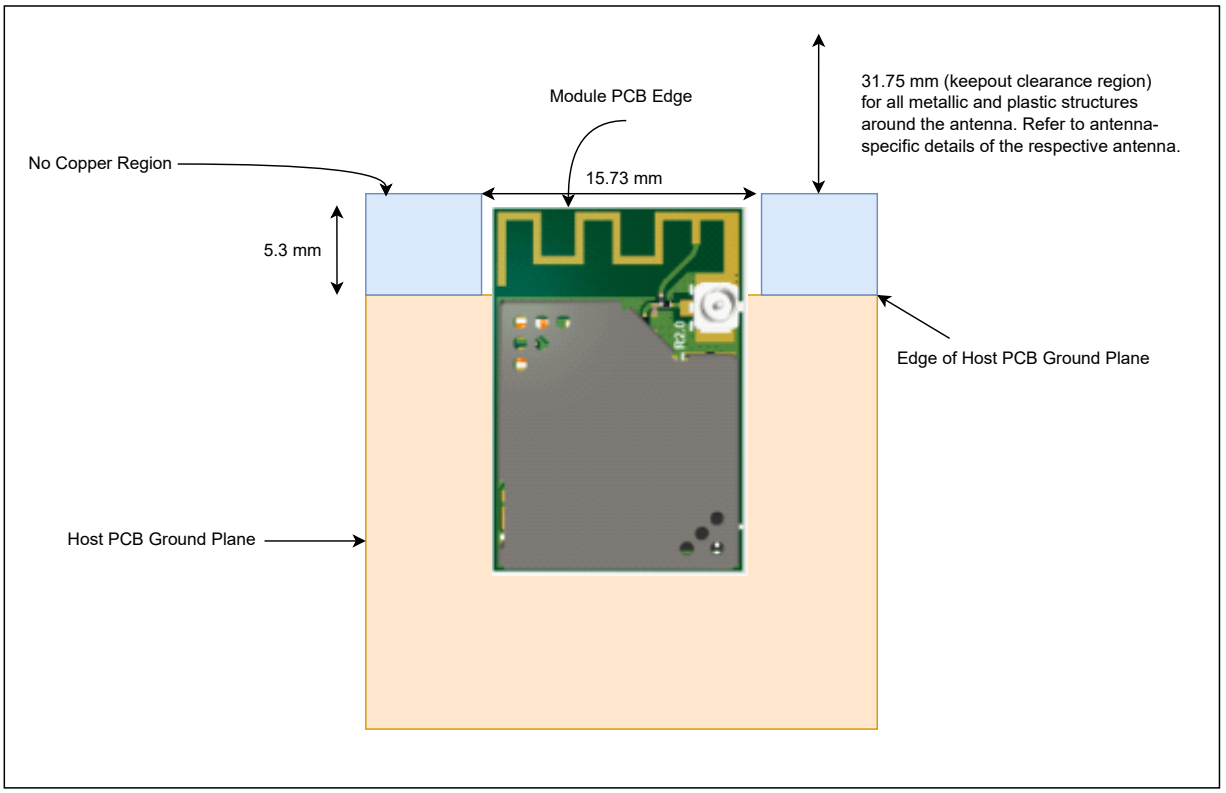
2.3 RNWF02 Module Placement Guidelines

- For any Wi-Fi product, the antenna placement affects the performance of the whole system. The antenna requires free space to radiate RF signals, and it must not be surrounded by the ground plane. Thus, for the best PCB antenna performance, it is recommended that the RNWF02PC/E module is placed at the edge of the host board.
- The RNWF02PC/RNWF02PE module ground outline edge must be aligned with the edge of the host board ground plane as shown in the following figure.
- A low-impedance ground plane for the RNWF02 module ensures the best radio performance (best range and lowest noise). The ground plane can be extended beyond the minimum recommendation as required for the host board EMC and noise reduction.
- For the best performance, keep metal structures and components (such as mechanical spacers, bump-on and so on) at least 31.75 mm away from the PCB trace antenna as illustrated in the following figure.
- The antenna on the RNWF02 module must not be placed in direct contact with or in close proximity to plastic casing or objects. Keep a minimum clearance of 10 mm in all directions around the PCB antenna as shown in the following figure. Keeping metallic and plastic objects close to the antenna can detune the antenna and reduce the performance of the device.
- Exposed GND pads on the bottom of the RNWF02 module must be soldered to the host board (see the *Example of Host Board on Top Layer* figure in the *RNWF02 Module Routing Guidelines* from Related Links).

- A PCB cutout or a copper keepout is required under the RF test point (see *RNWF02 Module Packaging Information* from Related Links).
- Copper keepout areas are required on the top layer under voltage test points (see *RNWF02 Module Packaging Information* from Related Links).
- Alternatively, the entire region, except the exposed ground paddle, can be solder-masked.

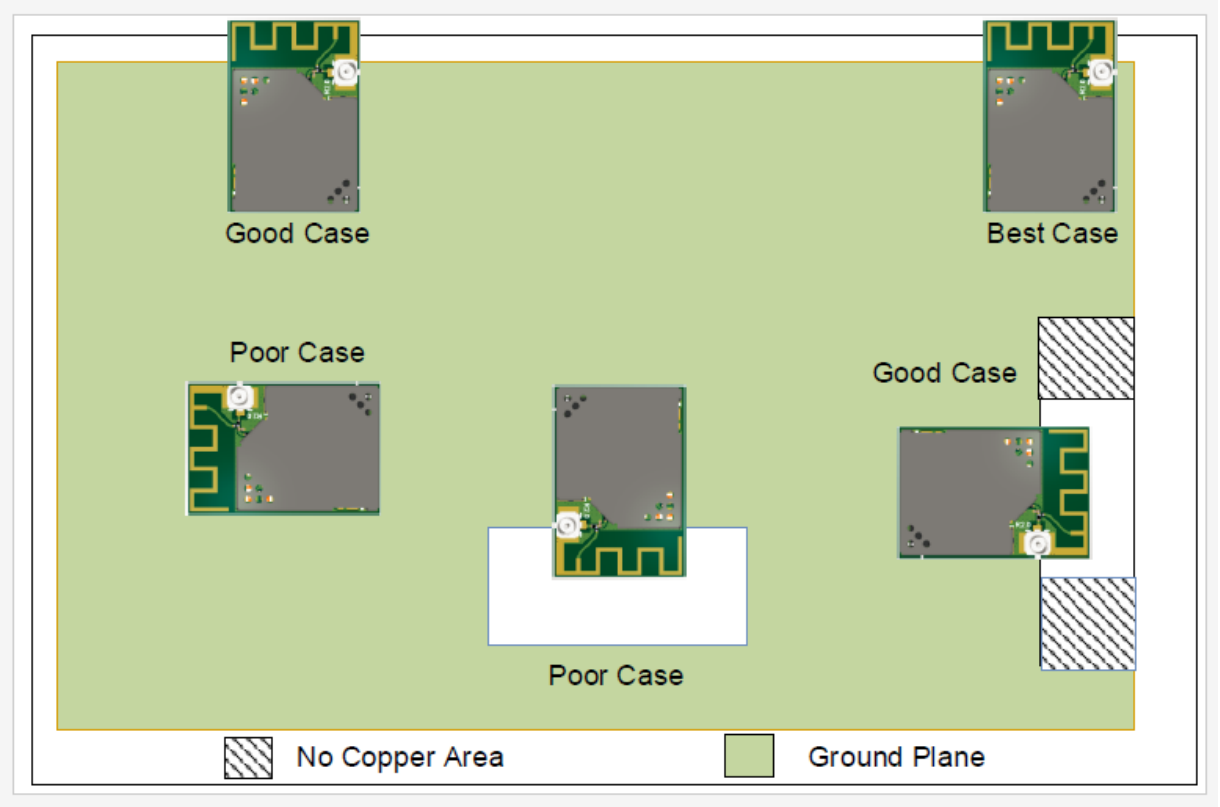
The following figure illustrates the examples of RNWF02 Module placement on a host board with a ground plane. Refer to the following figure for placement-specific guidance.

Figure 2-8. Module Placement Guidelines



The following figure illustrates the examples of the RNWF02 module placement on a host board with a ground plane. Refer to Figure 2-8 for placement-specific guidance.

Figure 2-9. RNWF02 Module Placement



Related Links

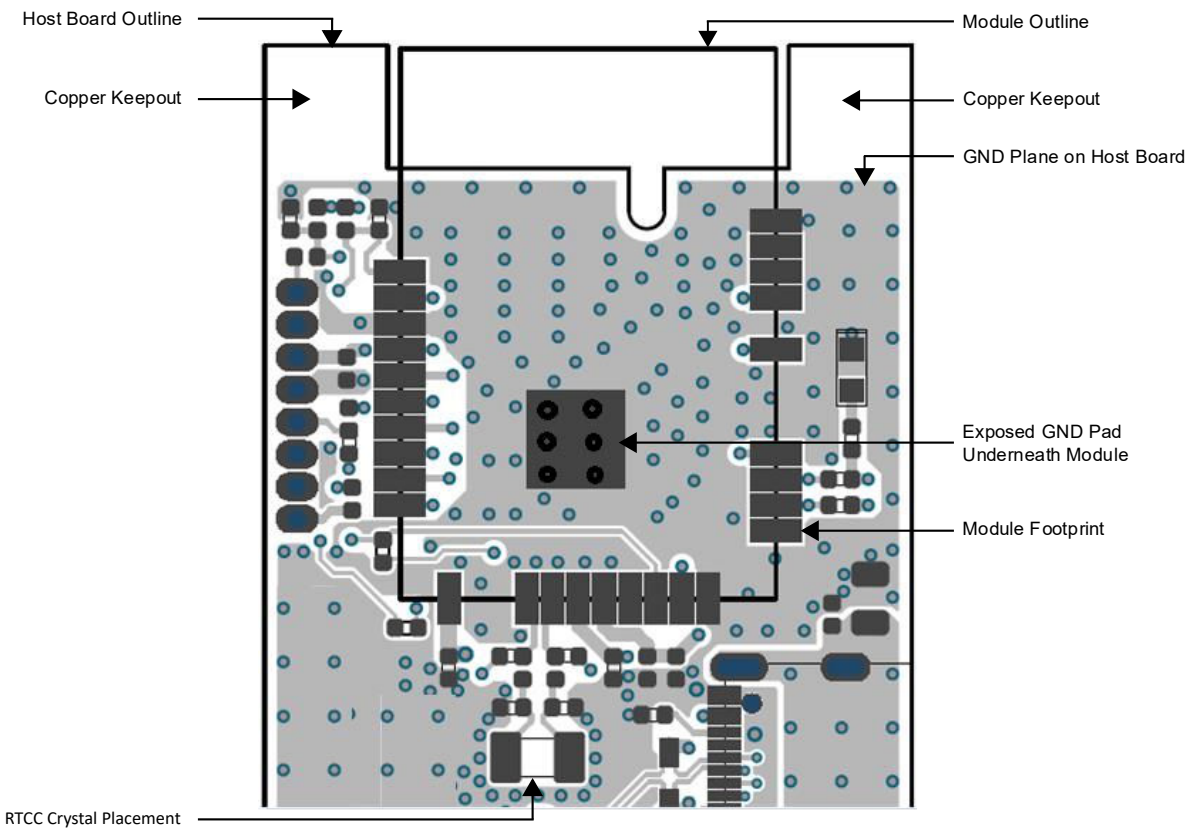
2.4. RNWF02 Module Routing Guidelines

4. RNWF02 Module Packaging Information

2.4 RNWF02 Module Routing Guidelines

- Use the multi-layer host board for routing signals on the inner layer and the bottom layer.
- The top layer (underneath the module) of the host board must be ground with as many GND vias as possible, shown in the following figure.
- Avoid fan-out of the signals under the module or antenna area. Use a via to fan-out signals to the edge of the RNWF02 module.
- For a better GND connection to the RNWF02 module, solder the exposed GND pads of the RNWF02 module on the host board.
- For the module GND pad, use a GND via of a minimum 10 mil (hole diameter) for good ground to all the layers and thermal conduction path.
- Having a series resistor on the host board for all GPIOs is recommended. These resistors must be placed close to the RNWF02 module. The following figure illustrates the placement of the series resistor.
- The SOSC crystal (32.768 kHz) on the host board must be placed close to the RNWF02 module and follow the shortest trace routing length with no vias (see the following figure).

Figure 2-10. Example of Host Board on Top Layer



2.5 RNWF02 Module RF Considerations

The overall performance of the system is significantly affected by the product design, environment and application. The product designer must ensure system-level shielding (if required) and verify the performance of the product features and applications.

Consider the following guidelines for optimal RF performance:

- The RNWF02 module must be positioned in a noise-free RF environment and must be kept far away from high-frequency clock signals and any other sources of RF energy.
- The antenna must not be shielded by any metal objects.
- The power supply must be clean and noise-free.
- Make sure that the width of the traces routed to GND, VDD rails are sufficiently large for handling peak TX current consumption.
  Note: The RNWF02 module includes RF shielding on top of the board as a standard feature.

2.6 RNWF02 Module Antenna Considerations

2.6.1 PCB Antenna

For the RNWF02PE/PC module, the PCB antenna is fabricated on the top copper layer and covered with a solder mask. The layers below the antenna do not have copper trace. It is recommended that the module be mounted on the edge of the host board and to have no PCB material below the antenna structure of the module and no copper traces or planes on the host board in that area.

The following table lists the technical specification of the PCB antenna when tested with the RNWF02 module mounted on the RNWF02 Add-On Board.

Table 2-3. PCB Antenna Specification for RNWF02 Module

Parameter	Specification
Operating frequency	2400-2485 MHz
Peak gain	1.18 dBi at 2410 MHz
Efficiency (average)	45%[1]

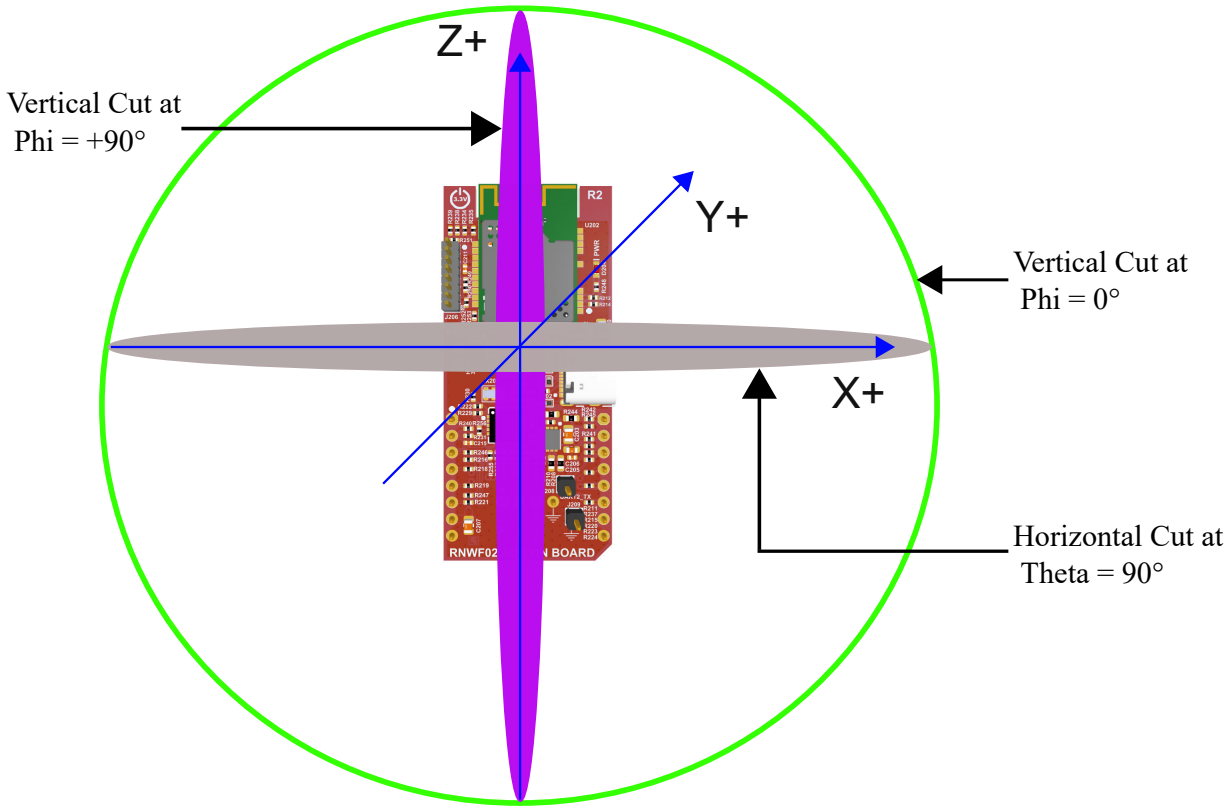
Note:

1. The size of the RNWF02 Add-On Board is 25.4 mm x 57.2 mm. The antenna efficiency will improve with larger ground plane base boards. The same antenna achieved an average efficiency of 69% with a base board size of 85 mm x 40 mm. If the best case routing guidelines are followed on a larger ground plane application board, the efficiency will be better.

PCB Antenna Radiation Pattern

The following figure illustrates the module orientation in the measurement system for the PCB antenna radiation pattern.

Figure 2-11. Module Orientation for Radiation Pattern Measurement



Antenna Radiation Pattern

The following figures illustrate the 2D cross section of the antenna radiation pattern.

Figure 2-12. Antenna Radiation Pattern when Phi = 0°

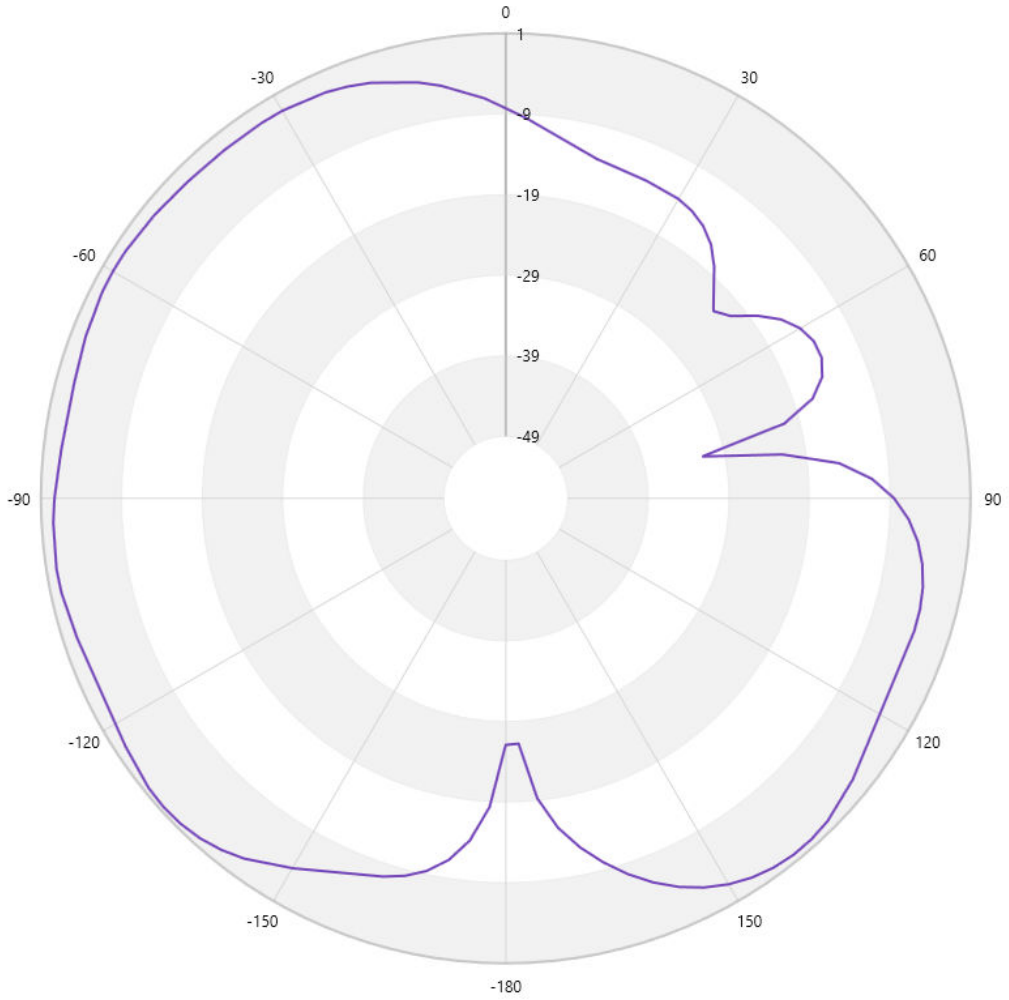


Figure 2-13. Antenna Radiation Pattern when Phi = 90°

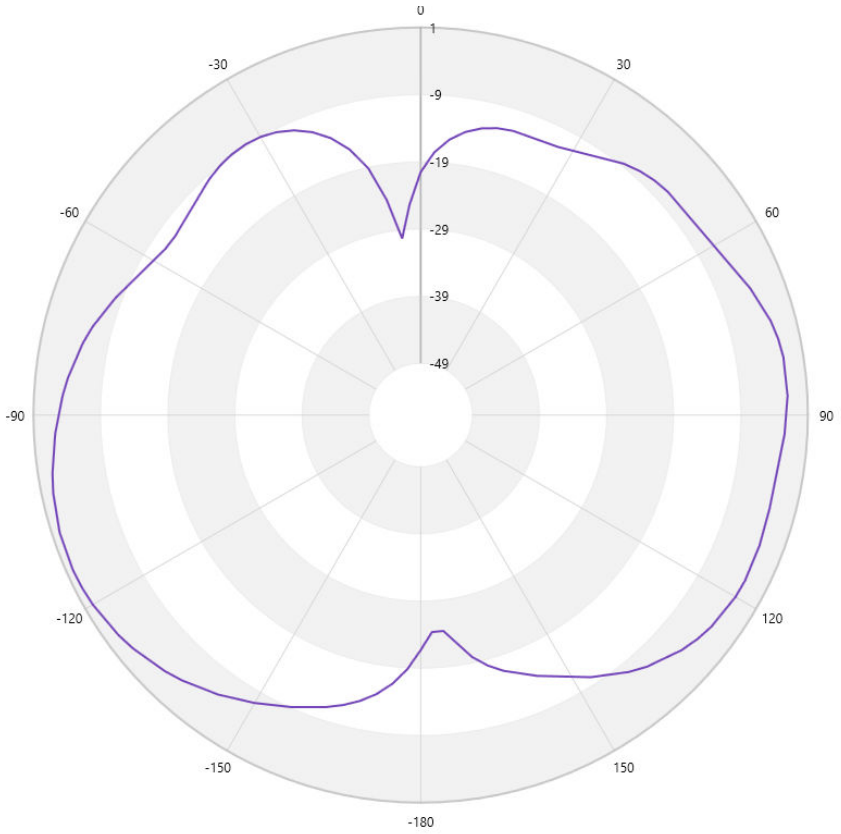
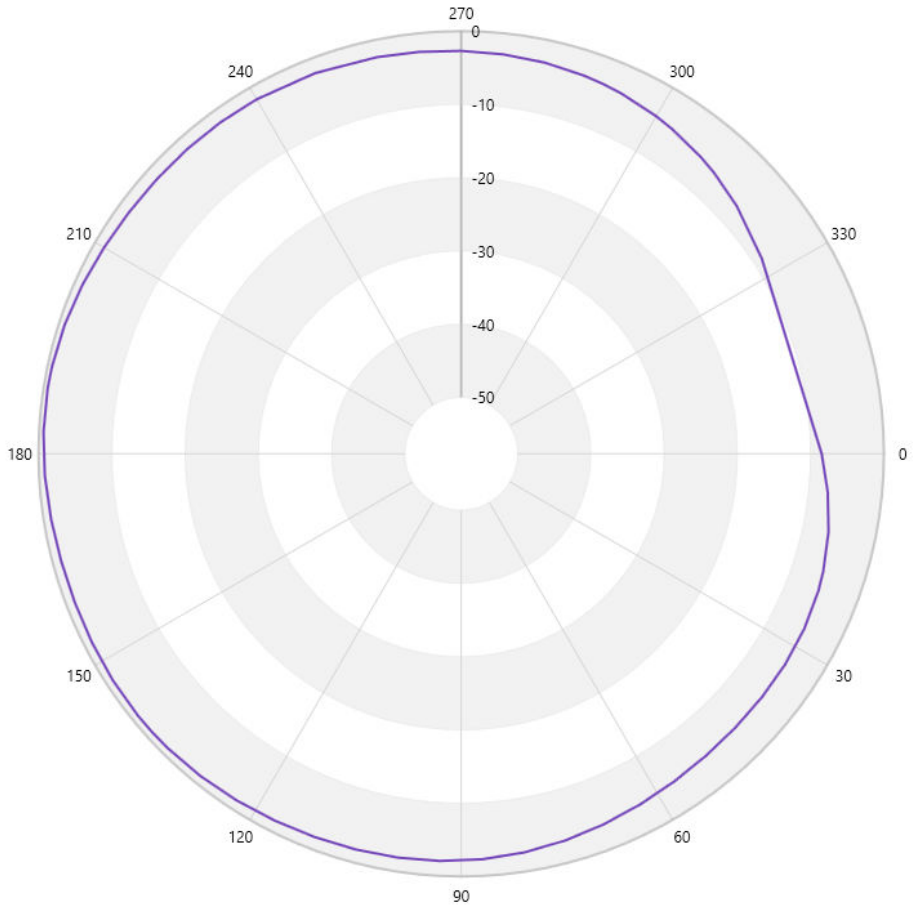


Figure 2-14. Antenna Radiation Pattern when Theta = 90°



2.6.2 External Antenna Placement Recommendations

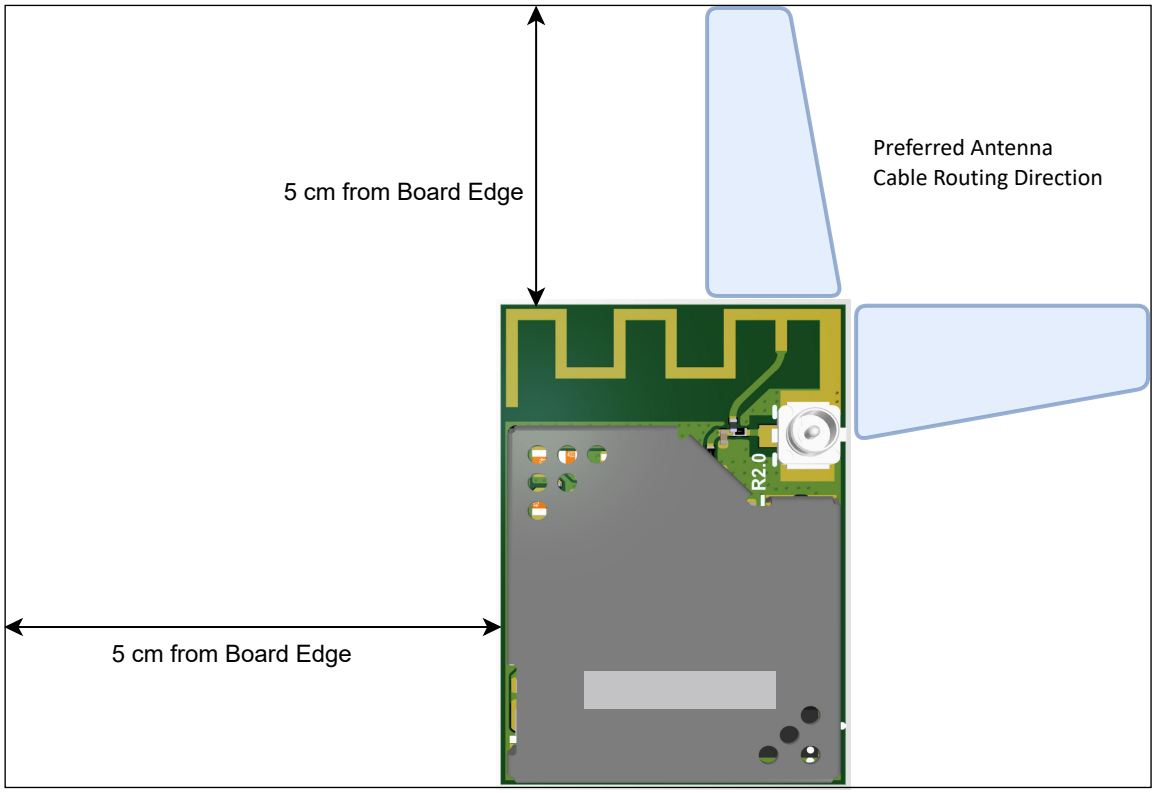
The user must ensure the following for the placement of the antenna and its cable:

- Do not route the antenna cable over circuits generating electrical noise on the host board or alongside or underneath the module. The recommendation is to route the cable straight out of the module.
- Do not place the antenna in direct contact or in close proximity of the plastic casing/objects.
- Do not enclose the antenna within a metal shield.
- The user must keep any components capable of radiating noise, signals or harmonics in the 2.4-2.5 GHz frequency range away from the antenna and, if feasible, provide shielding for such components. Any noise radiated from the host board in this frequency band degrades the sensitivity of the module.
- Place the antenna at a distance greater than 5 cm away from the module. The following figure illustrates the antenna keepout area (do not place the antenna in this area). This recommendation is based on an open-air measurement and does not take into account any metal shielding of the customer end product. When a metal enclosure is used, the antenna can be located closer to the RNWF02 module.

These recommendations are based on an open-air measurement and do not take into account any metal shielding of the customer end product. When a metal enclosure is used, the antenna can be located closer to the RNWF02 module.

The following figure illustrates how the antenna cable must be routed depending on the location of the antenna with respect to the RNWF02 PCB. There are two possible options for the optimum routing of the cable.

Figure 2-15. RNWF02 Module Antenna Placement Guidelines



Note: These are generic guidelines and the recommendation is that customers can check and fine-tune the antenna positioning in the final host product based on RF performance.

2.6.2.1 External Antennas

The RNWF02/UE/UC modules have an ultra-small surface mount U.FL connector for an external antenna connection. The choice of antenna is limited to the antenna types that the module is tested and approved for.

The RNWF02/UE/UC modules are approved to use with the antennas listed in the following table. It is permissible to use a different antenna, provided it is the same antenna type, has the same antenna gain (equal or less than) and similar in-band and out-of-band characteristics are present (refer to antenna specification sheet for cutoff frequencies).

If other antenna types are used, the OEM installer must conduct the necessary assessments and authorize the antenna with the respective regulatory agencies and ensure compliance.

Table 2-4. RNWF02 Module Approved External Antenna List with Antenna Gain

Antenna Number	Part Number	Manufacturer	Antenna Gain (dBi)	Antenna Type	Regulatory Certification		Cable Length
					FCC/ISED(2) (3)	CE	
1	WXE2400-SM	TE Connectivity/Laird External Antennas	3	Dipole	x	x	SMA TO U.FL cable length of 100 mm
2	W3525B100	Pulse	2	PCB	x	x	254 mm
3	ANT-2.4-CW-RCL-SMA	TE Connectivity/Linx Technologies	2.3	Dipole	x	x	SMA to U.FL cable length of 100 mm
4	RFA-02-C2M2-SMA-D034	Alead/Aristotle	2	Dipole	x	x	SMA to U.FL cable length of 100 mm

Notes:

1. 'x' denotes the antennas covered under the certification.
2. If the end product using the module is designed to have an antenna port that is accessible to the end user, a unique (non-standard) antenna connector (as permissible by FCC) must be used (for example, RP (Reverse Polarity)-SMA socket).
3. If an RF coaxial cable is used between the module RF output and the enclosure, a unique (non-standard) antenna connector must be used in the enclosure wall to interface with the antenna.
4. Contact the antenna vendor for detailed antenna specifications to review the suitability to the end product operating environment and to identify alternatives.
5. If any external antenna is used other than the recommended antennas in the list, it may need an extra step of post-calibration on the customer's application board.

2.7 RNWF02 Module Reflow Profile Information

The RNWF02 module was assembled using the IPC/JEDEC J-STD-020 standard lead-free reflow profile. The RNWF02 module can be soldered to the host board using standard leaded or lead-free solder reflow profiles. To avoid damaging the module, adhere to the following recommendations:

- For solder reflow recommendations, refer to the *AN233 Solder Reflow Recommendation Application Note* (DS00233).
- Do not exceed a peak temperature (TP) of 250°C.
- For specific reflow profile recommendations from the vendor, refer to the *Solder Paste Data Sheet*.
- Use no-clean flux solder paste.
- Do not wash as moisture can be trapped under the shield.
- Use only one flow. If the PCB requires multiple flows, apply the module on the final flow.

2.7.1 Cleaning

The exposed GND pad helps to self-align the module, avoiding pad misalignment. The recommendation is to use the no clean solder pastes. Ensure full drying of no-clean paste fluxes as a result of the reflow process. As per the recommendation by the solder paste vendor, this requires longer reflow profiles and/or peak temperatures toward the high end of the process window. The uncured flux residues can lead to corrosion and/or shorting in accelerated testing and possibly the field.

2.8 RNWF02 Module Assembly Considerations

The RNWF02 module is assembled with an EMI shield to ensure compliance with EMI emission and immunity rules. The EMI shield is made of a tin-plated steel (SPTE) and is not hermetically sealed. Solutions like IPA and similar solvents can be used to clean the RNWF02 module. However, do not use the cleaning solutions that contain acid on the module.

2.8.1 Conformal Coating

The modules are not intended for use with a conformal coating, and the customer assumes all risks (such as the module reliability, performance degradation and so on) if a conformal coating is applied to the modules.

3. Electrical Specifications

This chapter provides the electrical specifications and the characteristics of the RNWF02 Module across the operating temperature range of the product.

3.1 RNWF02 Module Absolute Maximum Ratings

The following table provides details about the list of absolute maximum ratings for the RNWF02 module. Exposure to these maximum rating conditions for extended periods can affect the device's reliability. Functional operation of the device at these or any other conditions above the parameters indicated in the operation listings of this specification is not implied.

Table 3-1. Absolute Maximum Ratings

Parameter	Value
Ambient temperature under bias(1)	-40°C to +85°C
Storage temperature	-65°C to +150°C
Voltage on V_{DD} with respect to GND	-0.3V to +4.0V
Voltage on any pin(s) with respect to GND	-0.3V to (V_{DD}+0.3V)
Voltage on (Pin 13-19 and 27) with respect to GND	-0.3V to (V_{DDIO}+0.3V)
Maximum current out of GND pins(2)	500 mA
Maximum current into V_{DD} pins(2)	500 mA
ESD Qualification	
Human Body Model (HBM) per JESD22-A114	2000V
Charged Device Model (CDM) (ANSI/ESD STM 5.3.1)	±500V

Notes:

1. The preceding table provides the list of stresses that can cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied.
2. Maximum allowable current is a function of the device's maximum power dissipation.

3.2 Thermal Specifications

Table 3-2. Thermal Operating Conditions

Rating	Symbol	Min.	Typ	Max.	Unit
Industrial Temperature Devices:					
Operating ambient temperature range	T_A	-40	—	+85	°C
Operating junction temperature range	T_J	-40	—	+125	°C

Table 3-3. Recommended Operating Voltages

Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Unit	Conditions
DC_1	V_{DD}	V_{DD} voltage range	3	3.3	3.6	V	—
DC_4	V_{DDIO}	V_{DDIO} voltage range	1.8	3.3	3.6	V	Module pins (13-19 and 27) only. All other I/Os are at V_{DD}.
DC_7	GNDDB	Common EDP ground reference	V_{SS}	V_{SS}	V_{SS}	V	—

3.3 RNWF02 Module DC Characteristics

3.3.1 I/O Pin DC Electrical Specifications

Table 3-4. I/O Pin DC Electrical Specifications

DC Characteristics			Standard Operating Conditions: V_{DD} = V_{DDIO} = 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**				
Param. No.	Symbol	Characteristics	Min.	Typ.(1)	Max.	Units	Conditions
DI_1	V_{IL}	Input low voltage I/O pins	GND	—	0.2*V_{DDIO}	V	—
DI_3	V_{IH}	Input high voltage	0.8*V_{DDIO}	—	V_{DDIO}	V	—
DI_5	V_{OL}	Output low voltage	—	—	0.4	V	—
DI_9	V_{OH}	Output high voltage	2.4	—	—	V	—
		Output high voltage	1	—	—	V	V_{DDIO} = 1.8V
DI_13	I_{IL}	Input pin leakage current	-1	—	+1	µA	—

3.3.2 Wi-Fi Current Consumption

Table 3-5. Wi-Fi Current Consumption DC Electrical Specifications

DC Characteristics(1)(2)				Standard Operating Conditions: V_{DD}=V_{DDIO}= 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**				
Param. No.	Symbol	Device States	Code Rate	Output Power (Typ.) (dBm)	Current (Typ.) (mA)(3)	Max.	Units	Conditions
IWF_TX	I_{DD}	On_Transmit(5)	802.11b 1 Mbps	19	266	—	mA	V_{DD} = V_{DDIO} = 3.3V
			802.11b 1 Mbps	14	243	—		
			802.11b 11 Mbps	20	268	—		
			802.11g 6 Mbps	19	269	—		
			802.11g 54 Mbps	16	236	—		
			802.11n MCS0	17	239	—		
			802.11n MCS7	17	238	—		
			802.11n MCS7	15.5	233	—		
			802.11n MCS7	10.5	224	—		
IWF_RX	I_{DD}	On_Receive	802.11b 1 Mbps	—	80	—		
			802.11n MCS7	—	86			

.....continued

DC Characteristics[1][2]				Standard Operating Conditions: V_{DD}=V_{DDIO}= 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**				
Param. No.	Symbol	Device States	Code Rate	Output Power (Typ.) (dBm)	Current (Typ.) (mA)[3]	Max.	Units	Conditions

Notes:

1. Measured along with the RF matching network (assume 50Ω impedance)
2. The test conditions for I_{DD} current measurements are as follows:
   - CPU, Flash panel and SRAM data memory are operational
   - CPU is operating at 50 MHz
   - CPU is in Wi-Fi RF Test mode
   - All peripheral modules are disabled (ON bit = 0) but the associated PMD bit is cleared
   - WDT and FSCM are disabled
   - All I/O pins are configured as inputs and pulled to V_{DD}
   - $\overline{MCLR}$ = V_{DD}
3. Data in the "Typ." column is at 3.3V, 25°C unless otherwise stated.
4. This parameter is characterized, but not tested in manufacturing.
5. Tested at channel 7 in Fixed mode gain.

3.3.3 Extreme Deep Sleep (XDS) Current Consumption

Table 3-6. Extreme Deep Sleep (XDS) Current Consumption

DC Characteristics			Standard Operating Conditions: V_{DD} = V_{DDIO} = 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**			
Param. No.	Symbol	Characteristics	Typ[1]	Max.	Units	Conditions
XDSPWR_1	I_{DD_XDS}[2]	I_{DD} in XDS mode	0.7	—	µA	V_{DD} = V_{DDIO} = 3.3V

Notes:

1. Typical values at 25°C only
2. Conditions:
   - All peripherals inactive
   - All IO configured as input and pulled down internally

3.4 RNWF02 Module AC Characteristics

3.4.1 XOSC32 RTCC Oscillator AC Electrical Specifications

Table 3-7. XOSC32 RTCC Oscillator AC Electrical Specifications

AC Characteristics			Standard Operating Conditions: V_{DD} = V_{DDIO} = 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions[1]
XOSC32_1	FOSC_XOSC32	XOSC32 oscillator crystal frequency	—	32.768	—	kHz	SOSCI, SOSCO RTCC oscillator

.....continued

AC Characteristics			Standard Operating Conditions: V_{DD} = V_{DDIO} = 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions(1)
XOSC32_15	TOSC32	TOSC32 = 1/FOSC_XOSC32	—	—	—	µs	See parameter XOSC32_1 for FOSC_XOSC32 value
XOSC32_21	XCLK32_DC	Ext clock oscillator duty cycle	—	50	—	%	—

Notes:

1. Crystal oscillator requirements:
   - Crystal load capacitance = 12 pF
   - Maximum Drive level = 200 µW
2. This parameter is characterized but not tested in manufacturing.

3.4.2 Power on Reset AC Electrical Specifications

Table 3-8. Power on Reset AC Electrical Specifications

AC Characteristics			Standard Operating Conditions: V_{DD} = V_{DDIO} = 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions
DC_11	VPOR	V_{DD} start voltage to ensure internal POR signal	1.45	—	1.65	V	—
DC_12	SVDD	V_{DD} rise rate to ensure internal POR signal	0.03	—	0.115	V/ms	0-3.0V in 0.1s
DC_13	TRST	External Reset valid active pulse width	2	—	—	us	—

3.5 RNWF02 Module Radio Specifications

Table 3-9. RNWF02 Module Radio Specifications

Feature	Description
WLAN standards	IEEE® 802.11b, IEEE 802.11g, and IEEE 802.11n
Frequency range	2.412 GHz ~ 2.472 GHz (2400 ~ 2483.5 MHz ISM band)
Number of channels	11 for North America and 13 for Europe and Japan

3.5.1 RNWF02 Module Receiver Performance

Table 3-10. RNWF02 Module Receiver Performance Characteristics(1)

RF Characteristics			Standard Operating Conditions: V_{DD}=V_{DDIO}= 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**			
Param. No.	Characteristics	Description(5)	Min.	Typ	Max.	Units
WF_RX_1	Frequency	—	2412	—	2472	MHz
WF_RX_2	Sensitivity 802.11b	1 Mbps DSSS	—	-97	—	dBm
		2 Mbps DSSS	—	-93	—	
		5.5 Mbps DSSS	—	-92	—	
		11 Mbps DSSS(6)	—	-88	—	

.....continued

RF Characteristics			Standard Operating Conditions: V_{DD}=V_{DDIO}= 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**			
Param. No.	**Characteristics**	**Description[5]**	**Min.**	**Typ**	**Max.**	**Units**
WF_RX_3	Sensitivity 802.11g	6 Mbps OFDM	—	-91	—	dBm
		9 Mbps OFDM	—	-90	—	
		12 Mbps OFDM	—	-88	—	
		18 Mbps OFDM	—	-86	—	
		24 Mbps OFDM	—	-83	—	
		36 Mbps OFDM	—	-80	—	
		48 Mbps OFDM	—	-75	—	
		54 Mbps OFDM[6]	—	-74	—	
WF_RX_4	Sensitivity 802.11n (Bandwidth at 20 MHz) (Both long GI and short GI)	MCS 0	—	-89	—	dBm
		MCS 1	—	-86	—	
		MCS 2	—	-84	—	
		MCS 3	—	-81	—	
		MCS 4	—	-78	—	
		MCS 5	—	-74	—	
		MCS 6	—	-72	—	
		MCS 7[6]	—	-70	—	
WF_RX_5	Maximum receive signal level	1, 2 Mbps DSSS	8	—	—	dBm
		5.5, 11 Mbps DSSS	8	—	—	
		6 Mbps OFDM	-1.5	—	—	
		54 Mbps OFDM	-8.5	—	—	
		MCS 0	-0.5	—	—	
		MCS 7	-8.5	—	—	
WF_RX_6	Adjacent channel rejection	1 Mbps DSSS (30 MHz offset)	43.5	—	—	dB
		11 Mbps DSSS (25 MHz offset)	38.5	—	—	
		6 Mbps OFDM (25 MHz offset)	46.5	—	—	
		54 Mbps OFDM (25 MHz offset)	28.5	—	—	
		MCS 0 – 20 MHz Bandwidth (25 MHz offset)	45.5	—	—	
		MCS 7 – 20 MHz Bandwidth (25 MHz offset)	25.5	—	—	
WF_RX_7	RSSI accuracy	—	-5	—	5	dB

.....continued

RF Characteristics			Standard Operating Conditions: V_{DD}=V_{DDIO}= 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**			
Param. No.	Characteristics	Description(5)	Min.	Typ	Max.	Units

Notes:

1. Measured after RF matching network (assume 50Ω impedance)
2. RF performance is ensured at 3.3V, 25°C, with a 2-3 dB change at boundary conditions.
3. The availability of some specific channels and/or operational frequency bands are country-dependent and must be programmed in the host product at the factory to match the intended destination. Regulatory bodies prohibit exposing the settings to the end user. This requirement needs to be taken care of via host implementation.
4. The host product manufacturer must ensure that the RF behavior adheres to the certification (for example, FCC, ISED) requirements when the module is installed in the final host product.
5. This parameter is characterized but not tested in manufacturing.
6. This parameter is characterized and tested in manufacturing.

3.5.2 RNWF02 Module Transmitter Performance

Table 3-11. RNWF02 Module Transmitter Performance Characteristics

RF Characteristics			Standard Operating Conditions: V_{DD}=V_{DDIO}= 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**			
Param. No.	Characteristics	Description(8)	Min.	Typ(3)	Max.	Units
WF_TX_1	Frequency	—	2412	—	2472	MHz
WF_TX_2	Output power(1)(2) 802.11b	1 Mbps DSSS(9)	—	19	—	dBm
		2 Mbps DSSS	—	19	—	
		5.5 Mbps DSSS	—	20	—	
		11 Mbps DSSS	—	20	—	
WF_TX_3	Output power(1)(2) 802.11g	6 Mbps OFDM	—	19	—	dBm
		9 Mbps OFDM	—	19	—	
		12 Mbps OFDM	—	19	—	
		18 Mbps OFDM	—	19	—	
		24 Mbps OFDM	—	19	—	
		36 Mbps OFDM	—	18	—	
		48 Mbps OFDM	—	17.5	—	
		54 Mbps OFDM(9)	—	17	—	
WF_TX_4	Output power(1)(2) 802.11n (Bandwidth at 20 MHz)	MCS 0	—	18	—	dBm
		MCS 1	—	18	—	
		MCS 2	—	18	—	
		MCS 3	—	17.5	—	
		MCS 4	—	17.5	—	
		MCS 5	—	17	—	
		MCS 6	—	17	—	
		MCS 7(9)	—	17	—	
WF_TX_5	Transmit Power Control (TPC) accuracy	—	—	±2(2)	—	dB

.....continued

RF Characteristics			Standard Operating Conditions: V_{DD}=V_{DDIO}= 3.0V to 3.6V (unless otherwise stated) Operating Temperature: **-40°C ≤ T_A ≤ +85°C for Industrial**			
Param. No.	Characteristics	Description[8]	Min.	Typ[3]	Max.	Units
WF_TX_6	Harmonic output power (Radiated, Regulatory mode)	2nd	—	42	74[7]	dBuV/m
		3rd	—	Below noise floor	74[7]	

Notes:

1. Measured at IEEE® 802.11 specification compliant EVM/Spectral mask
2. Measured after RF matching network (assume 50Ω impedance)
3. RF performance is ensured at 3.3V, 25°C, with a 2-3 dB change at boundary conditions.
4. With respect to TX power, different (higher/lower) RF output power settings can be used for specific antennas and/or enclosures, in which case, re-certification can be required. Program the custom gain table to control the transmit power using the MCHPRT3 tool.
5. The availability of some specific channels and/or operational frequency bands are country-dependent and must be programmed in the host product at the factory to match the intended destination. Regulatory bodies prohibit exposing the settings to the end user. This requirement needs to be taken care of via host implementation.
6. The host product manufacturer must ensure that the RF behavior adheres to the certification (for example, FCC, ISED) requirements when the module is installed in the final host product.
7. FCC Radiated Emission limits (Restricted Band)
8. This parameter is characterized but not tested in manufacturing.
9. This parameter is characterized and tested in manufacturing.

3.5.3 RNWF02 Module Receiver and Transmitter Characteristics Graphs

Figure 3-1. Receive Current vs Temperature, MCS7, Channel 7, 3.3V

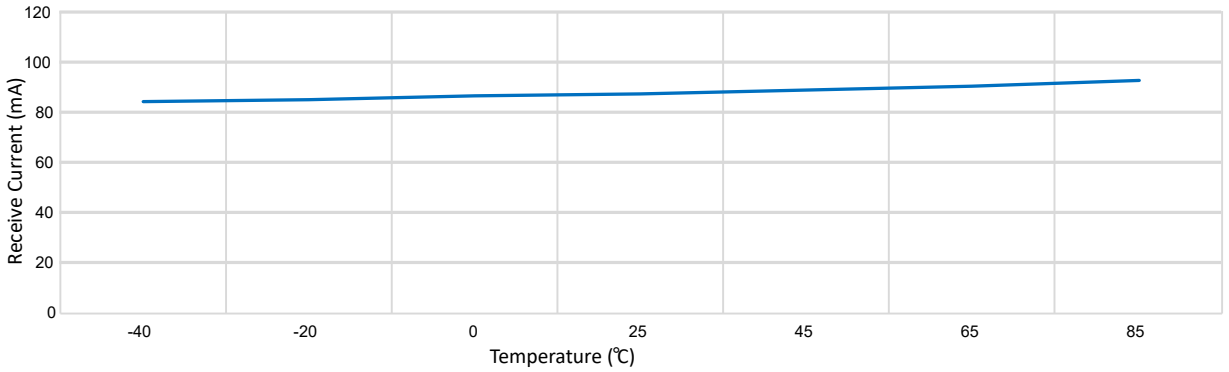


Figure 3-2. Receive Current vs Receive Signal Power, MCS7, Channel 7, 3.3V, 25℃

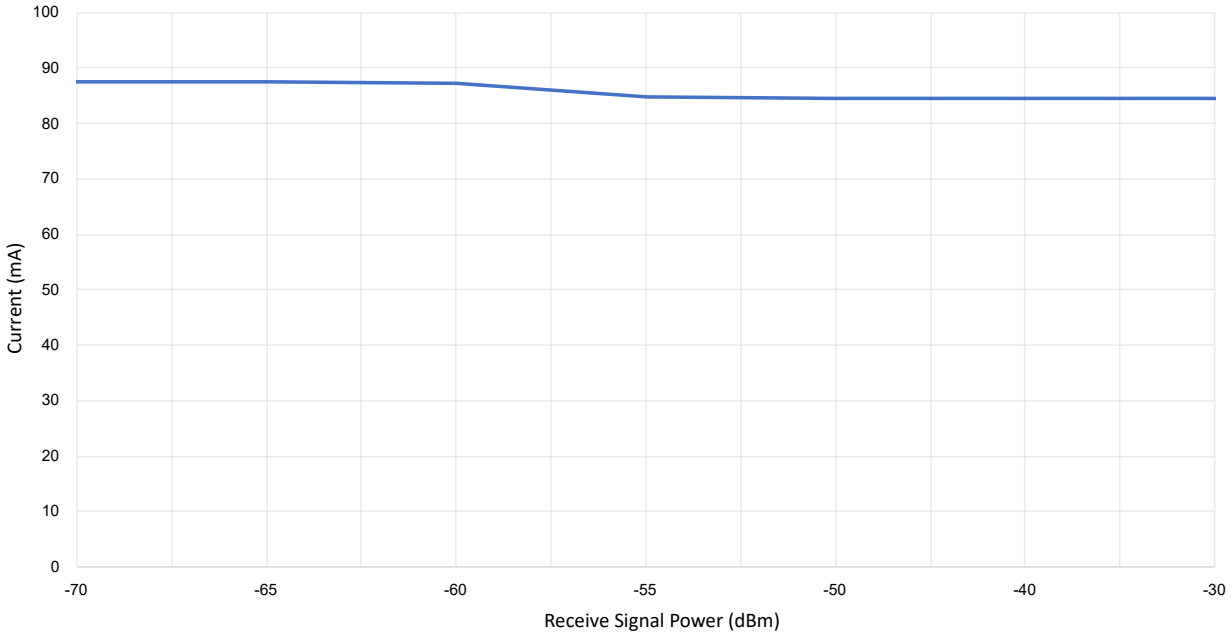


Figure 3-3. Transmit Current vs Temperature, MCS7, Channel 7, 3.3V

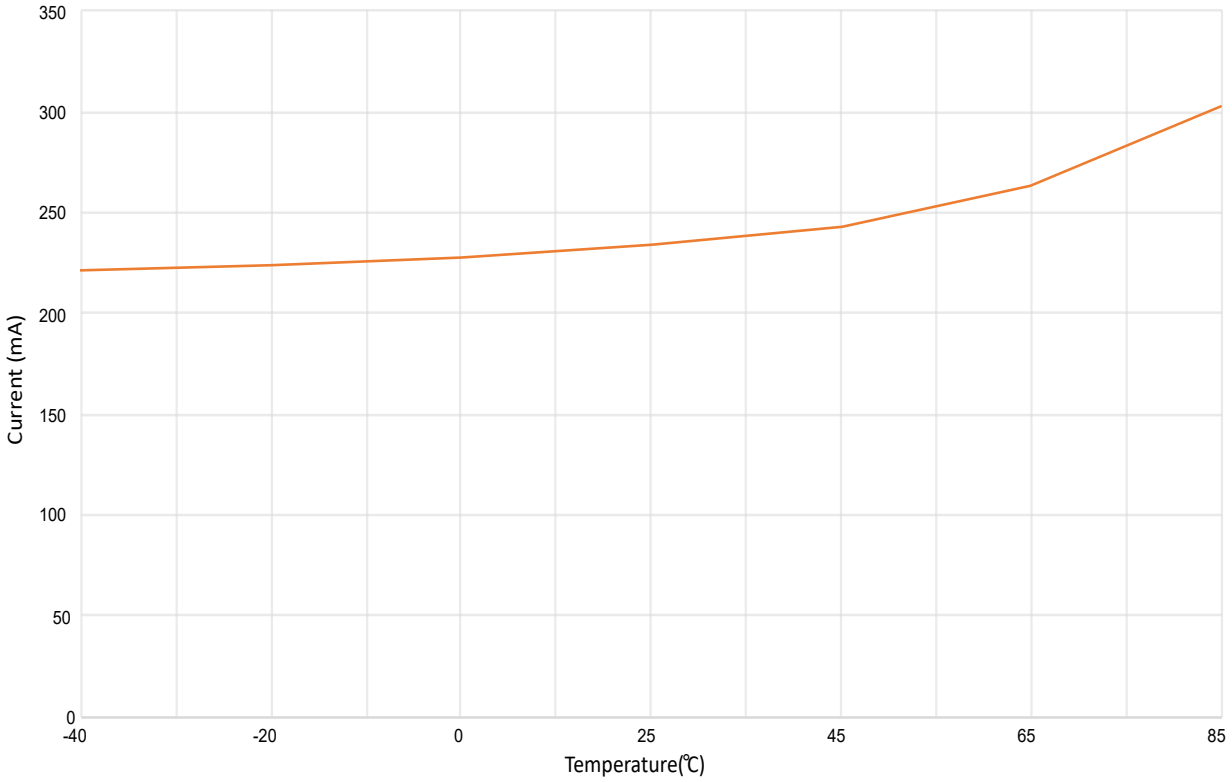


Figure 3-4. Transmit Current vs Transmit Output Power, MCS7, Channel 7, 3.3V, 25℃

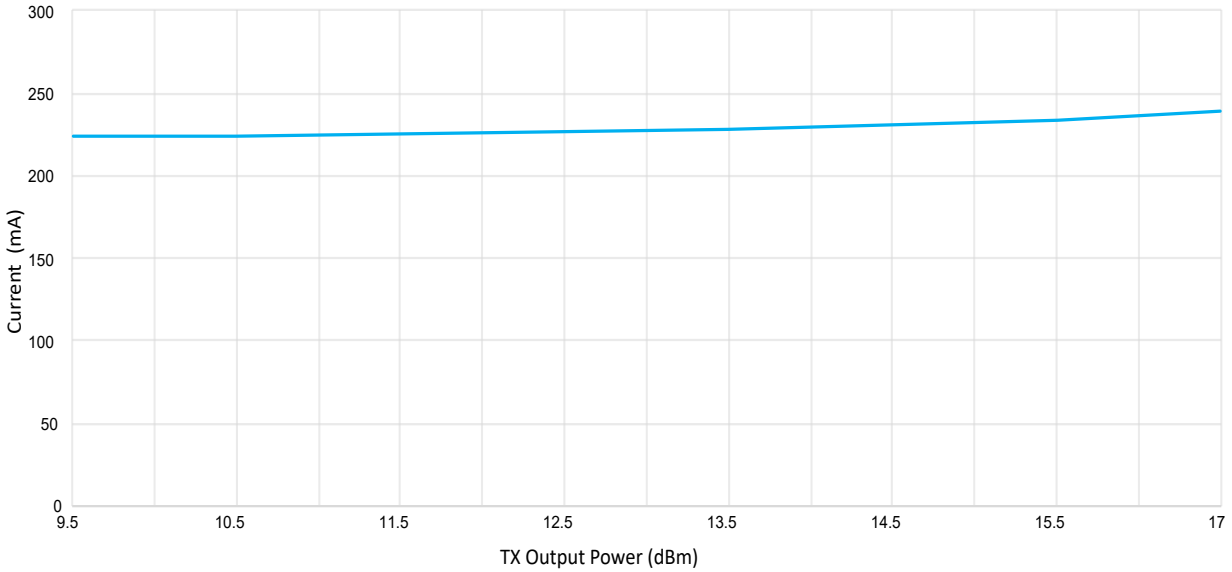


Figure 3-5. Transmit Power vs Voltage, 1M, Channel 7, 3.3V, 25℃

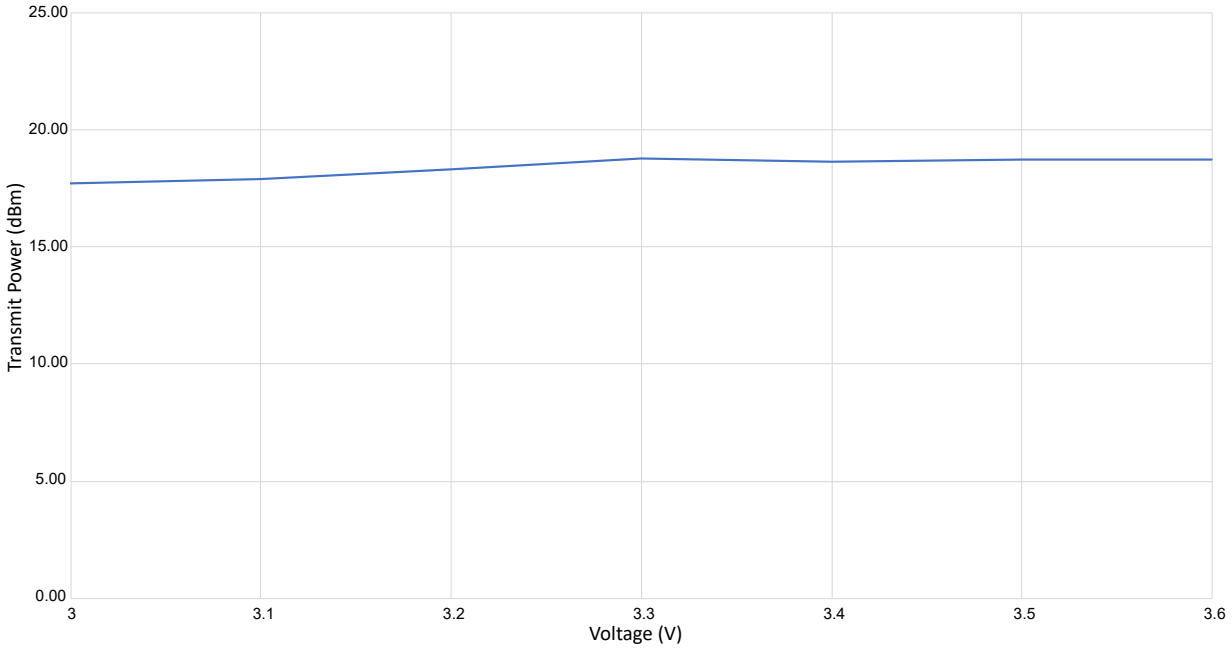


Figure 3-6. Transmit Power vs Temperature, 1M, Channel 7, 3.3V

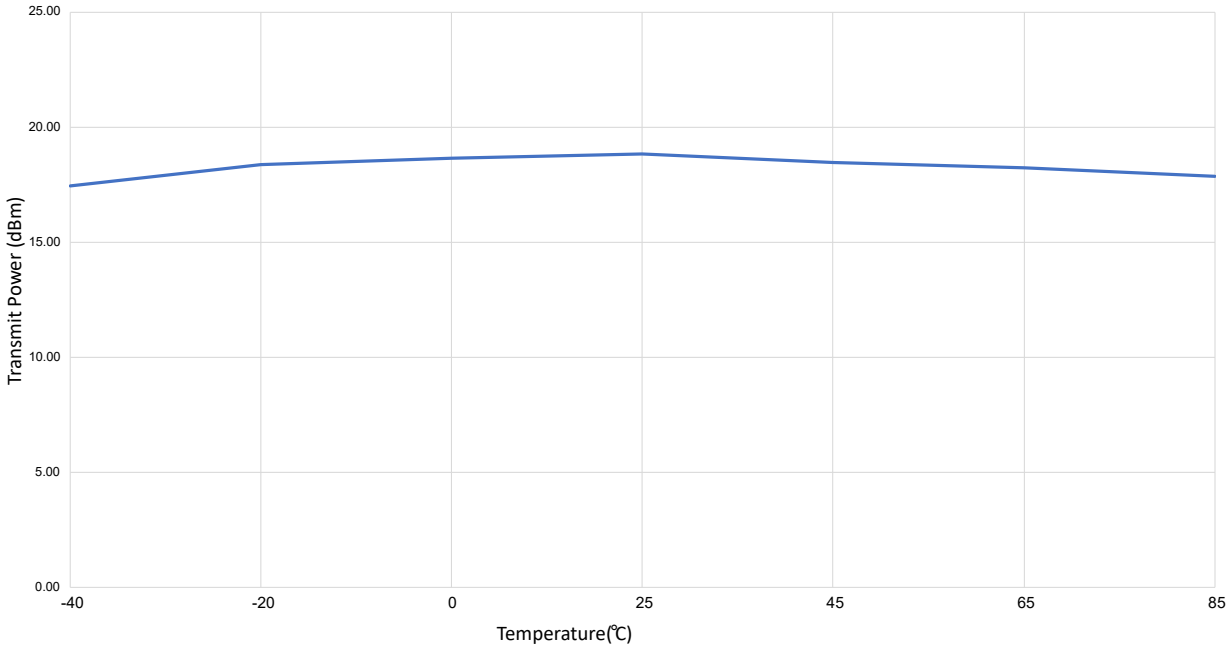


Figure 3-7. Transmit Power vs Channel, 1M, Channel 7, 3.3V, 25℃

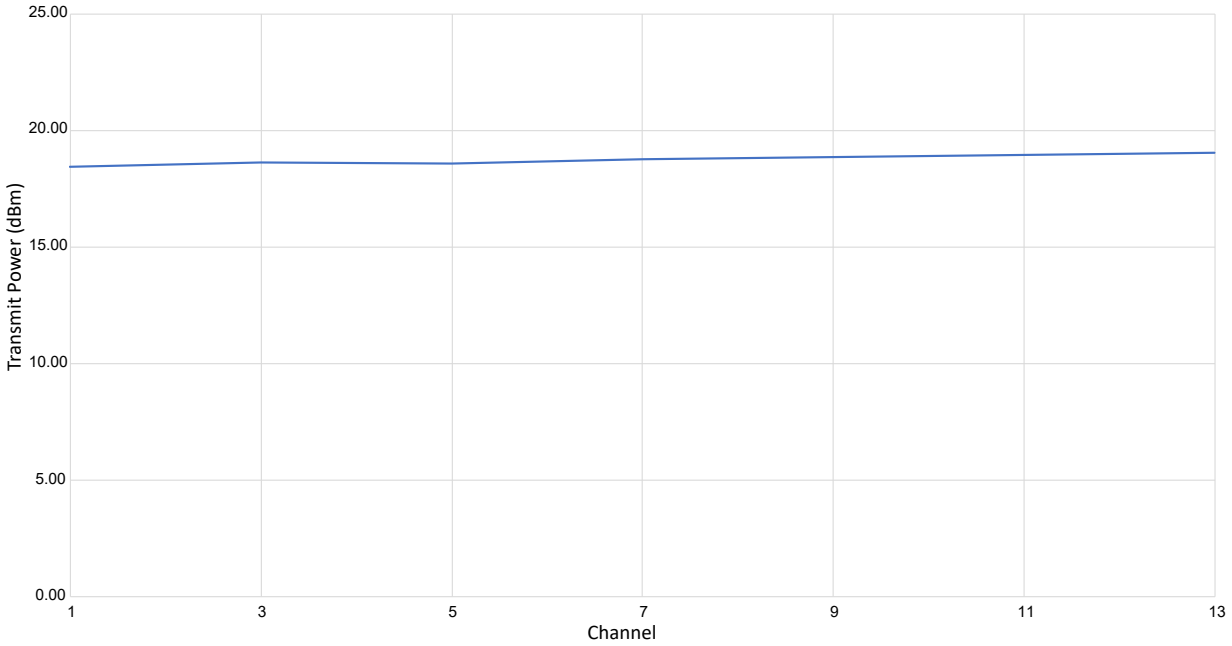


Figure 3-8. RX RSSI vs RX Input Power, MCS7, 3.3V, 25℃

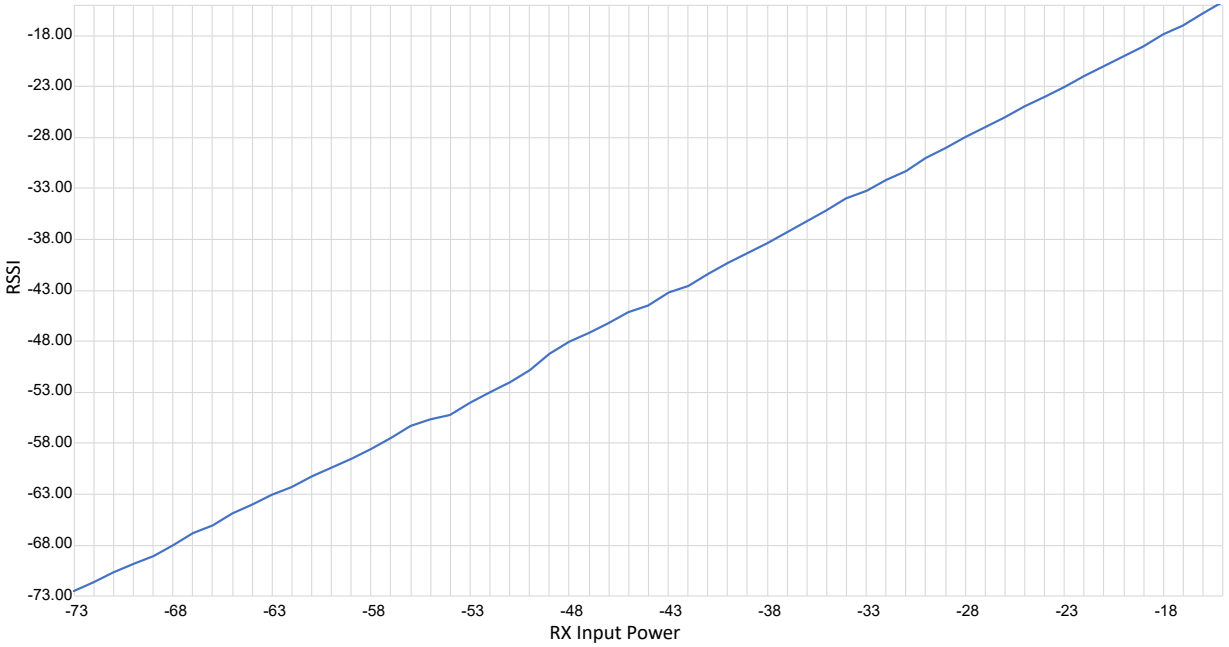


Figure 3-9. RX Sensitivity vs Channel, MCS7, 3.3V, 25℃

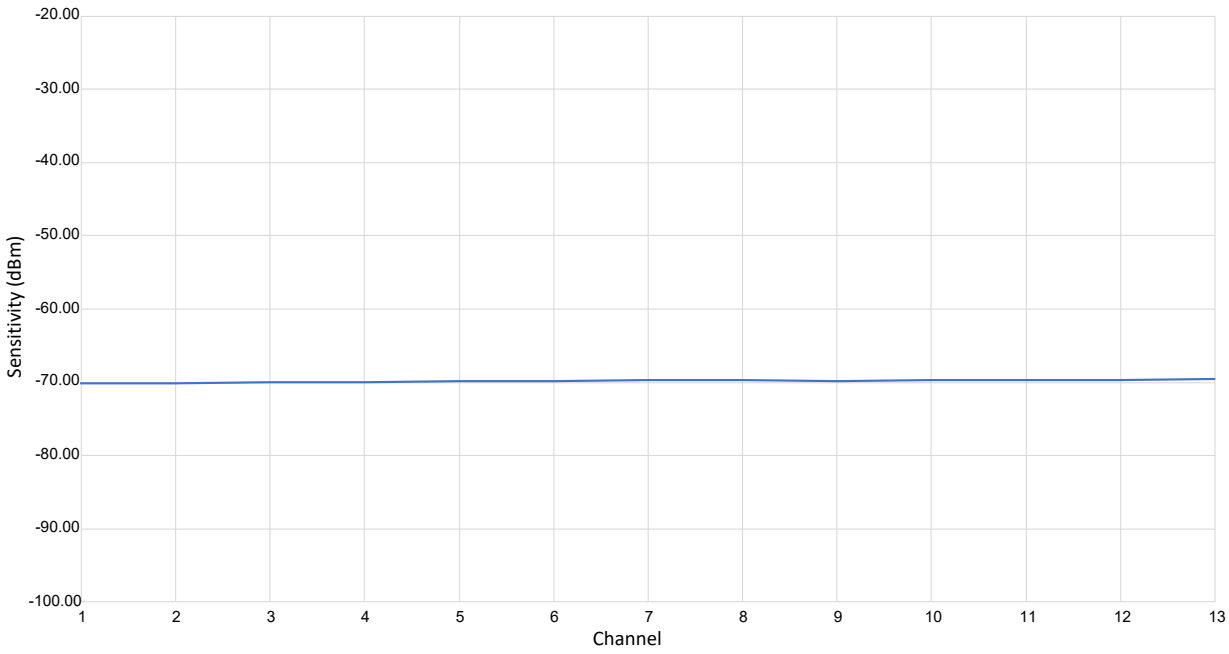


Figure 3-10. Receive Sensitivity vs Voltage, MCS7, Channel 7, 3.3V, 25℃

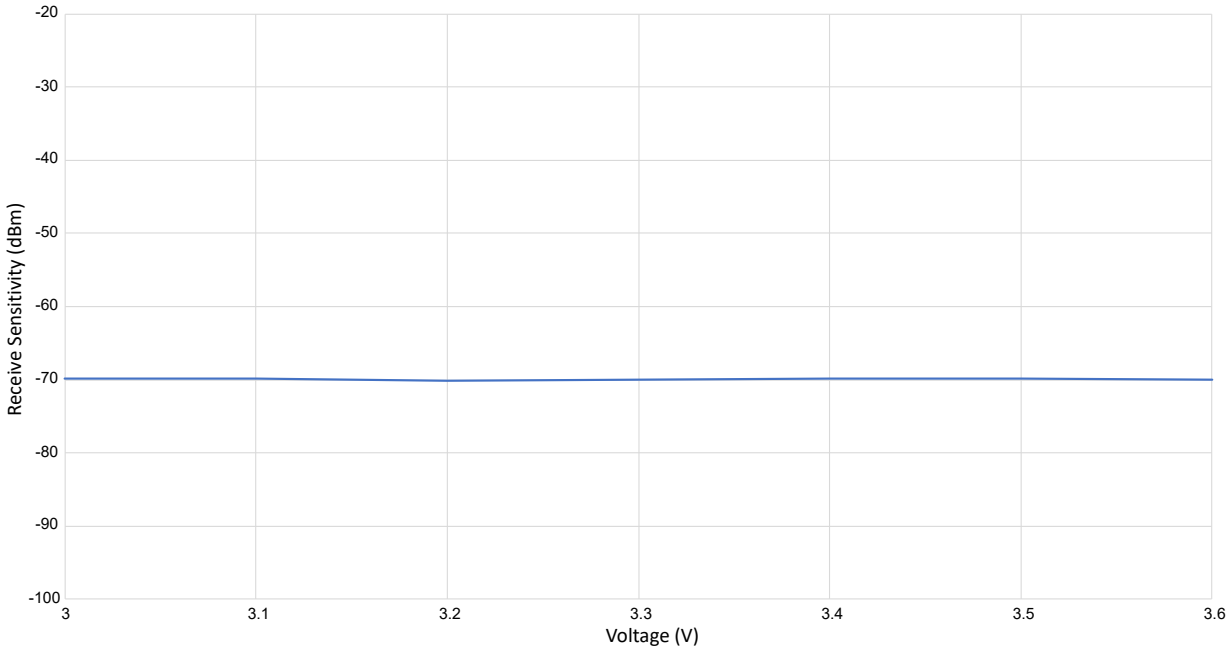
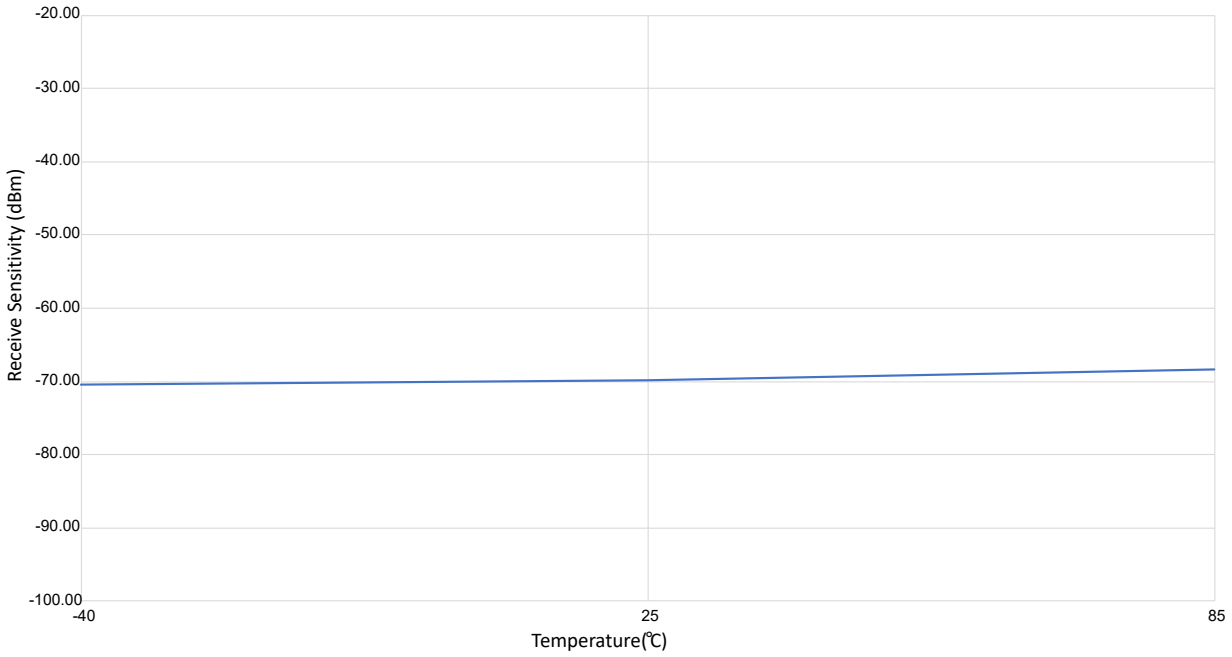


Figure 3-11. Receive Sensitivity vs Temperature, MCS7, Channel 7, 3.3V



4. RNWF02 Module Packaging Information

4.1 RNWF02 Module Packaging Marking

Figure 4-1. RNWF02 Module Packaging Marking

Legend:

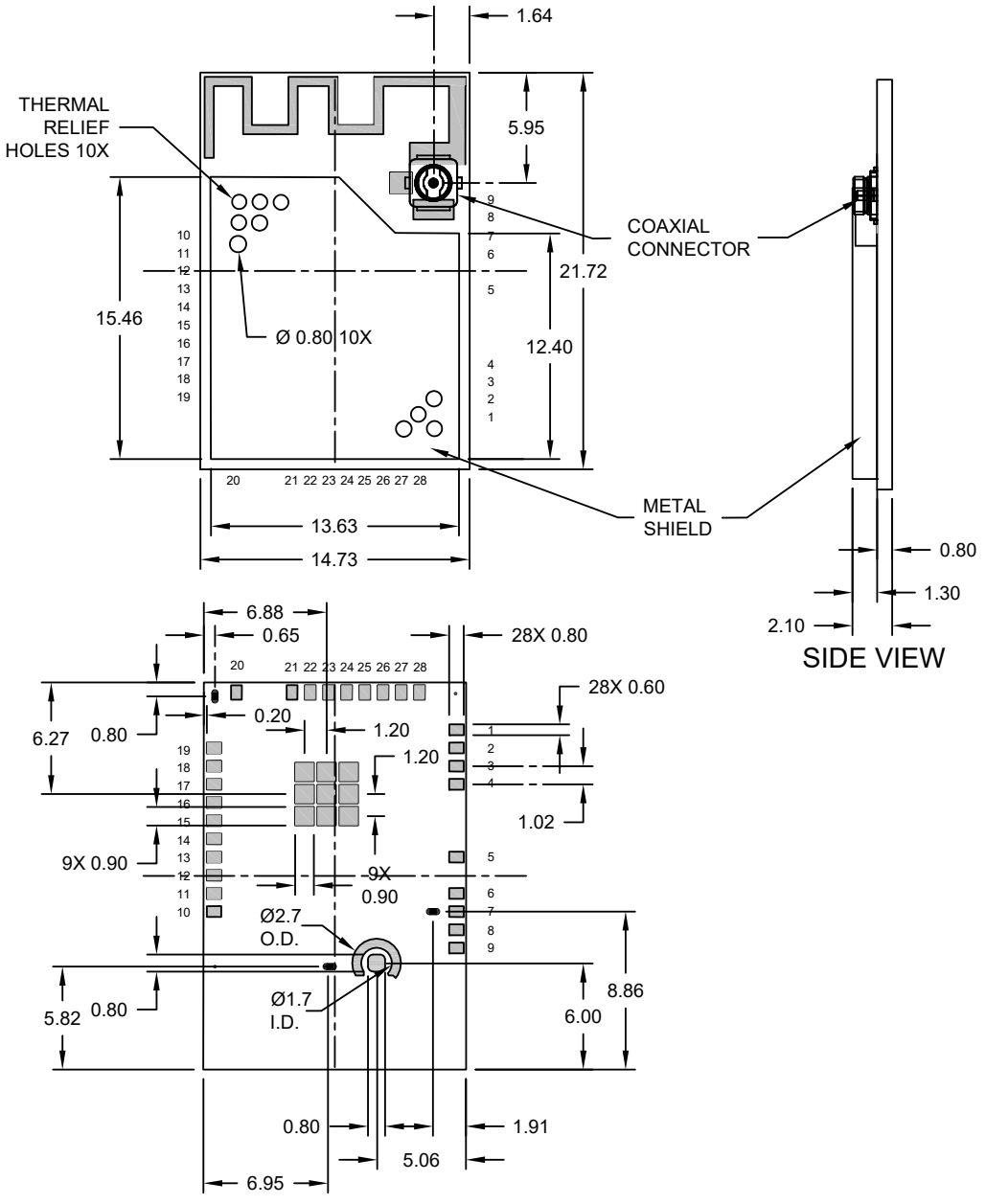
XX....X	Module part number and version and regulatory designator
YY:	Year code (last 2 digits of calendar year)
WW	Week code (week of January 1 is week "01")
NNN	Alphanumeric traceability code

4.2 RNWF02 Module Packaging Dimension

This section provides the package dimension details of the RNWF02 module.

28-Lead PCB Module (TEC) - 14.73x21.72x2.1 mm Body [MODULE] With Metal Shield and Coaxial Connector

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



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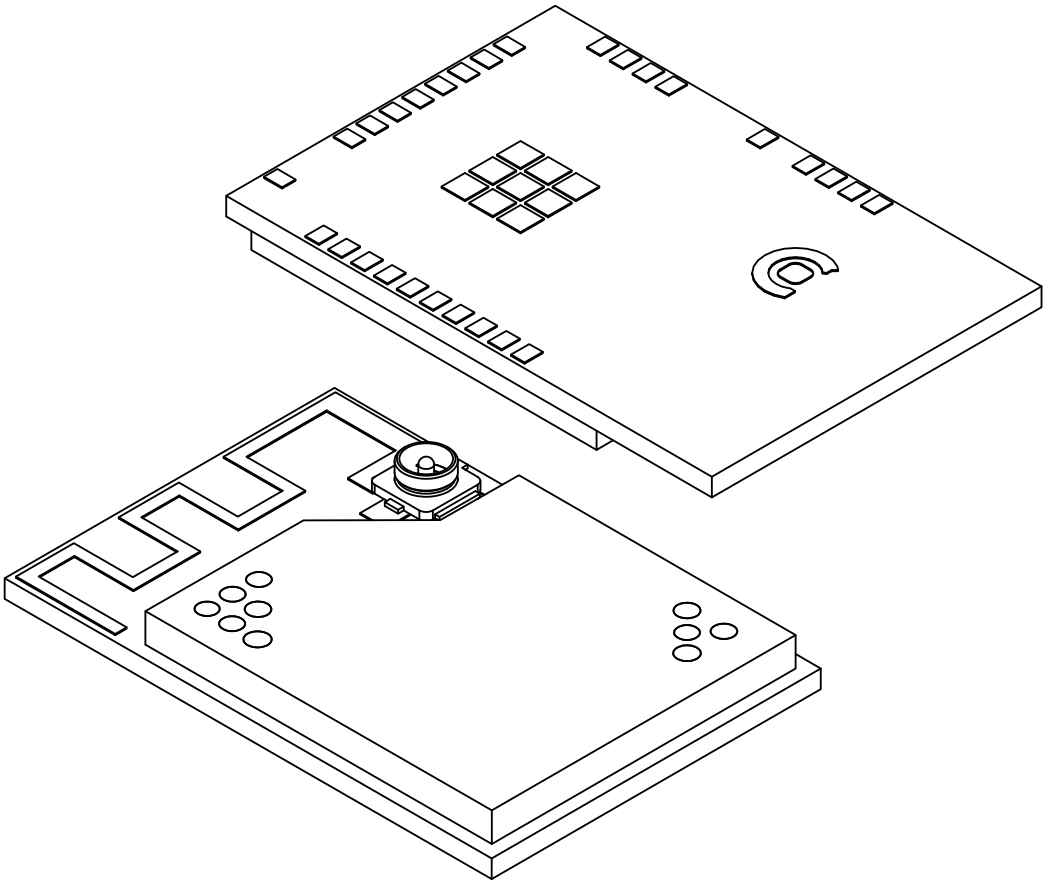
28-Lead PCB Module (TEC) - 14.73x21.72x2.1 mm Body [MODULE] With Metal Shield and Coaxial Connector

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



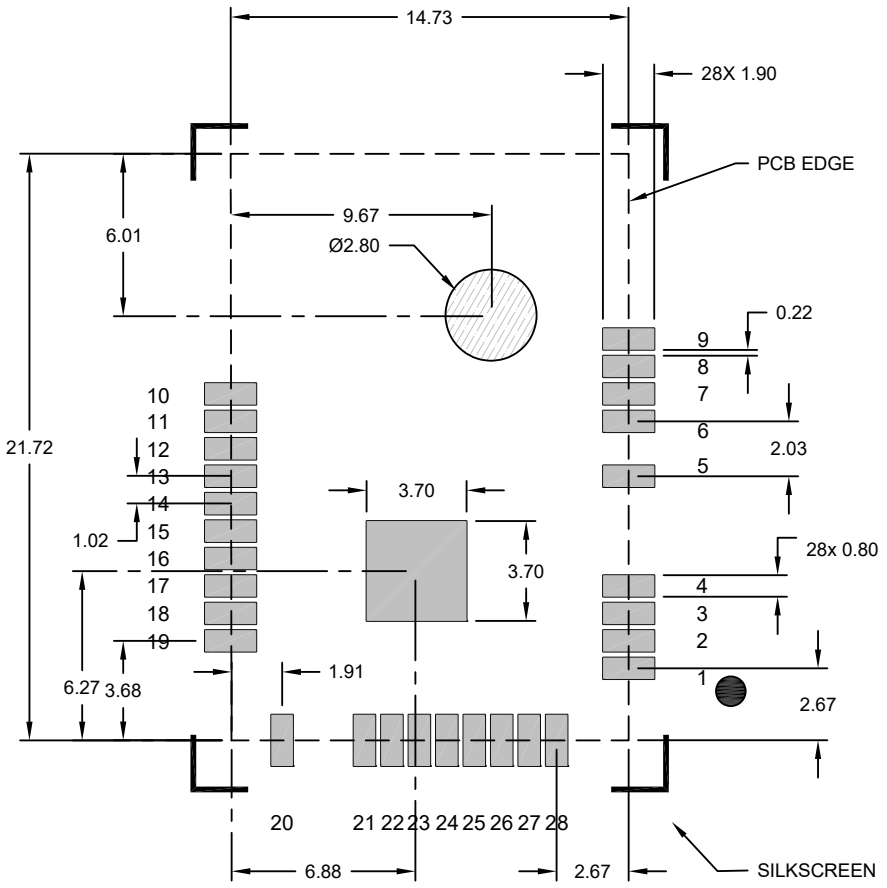
Notes:

1. All dimensions are in Millimeters.

Microchip Technology Drawing C04-21567 Rev B Sheet 2 of 2

28-Lead PCB Module (TEC) - 14.73x21.72x2.1 mm Body [MODULE] With Metal Shield and Coaxial Connector

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Notes:

1. All dimensions are in millimeters.
2. Keep these areas free from routes and exposed copper. Ground fill with solder mask may be placed here.

Microchip Technology Drawing C04-23567 Rev B

5. Appendix A: Acronyms and Abbreviations

Table 5-1. Acronyms and Abbreviations

Acronyms	Abbreviations
ADC	Analog-to-Digital Converter
AES	Advanced Encryption Standard
ASCII	American Standard Code for Information Interchange
CBC	Cypher Block Chaining
CDM	Charged Device Model
CFB	Cypher Feedback Mode
CLK	Clock
CMD	Command
CPU	Central Processing Unit
CTR	Counter Mode
CTS	Clear-to-Send
DAC	Digital-to-Analog Converter
DC	Direct Current
DES	Data Encryption Standard
DFU	Device Firmware Update
DNP	Do Not Populate
ECB	Electronic Code Book
ECC	Elliptic-Curve Cryptography
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
ESD	Electrostatic Discharge
ESR	Effective Series Resistance
EVM	Error Vector Magnitude
FCC	Federal Communications Commission
GND	Ground
GPIO	General Purpose I/O
HBM	Human Body Model
HPA	High Power Amplifiers
HTTP	Hypertext Transfer Protocol
I2C	Inter-Integrated Circuit
IP	Internet Protocol
I/O	Input Output
IPWR	Idle Current
IRQn	Interrupt Request (active-low)
ISED	Innovation, Science and Economic Development
ISM	International Safety Management Certification
LNA	Low Noise Amplifier
LPRC	Low Power RC Oscillator
$\overline{\text{MCLR}}$	Master Clear Input Active Low
MSB	Most Significant Bit
NC	No Connection
NDRNG	Non Deterministic Random Number Generator

.....continued

Acronyms	Abbreviations
NIST	National Institute of Standards and Technology
OEM	Original Equipment Manufacturer
OFB	Output Feedback Mode
OFDM	Orthogonal Frequency Division Multiplexing
OTA	Over-the-Air
OTP	One Time Programmable
PA	Power Amplifier
PCB	Printed Circuit Board
PMF	Protected Management Frame
PMU	Power Management Unit
POR	Power-on Reset
POSC	Primary Oscillator
PRIO	Priority
PSM	Pulse Skipping Mode
PTA	Packet Traffic Arbitration
PWM	Pulse Width Modulation
RF	Radio Frequency
ROM	Read Only Memory
RP	Reverse Polarity
RSSI	Receive Signal Strength Indication
RTC	Real Time Counter
RTCC	Real Time Clock Calendar
RTS	Request-to-Send
RX	Receive
SMA	SubMiniature Connector
SMD	Surface Mount Device
SOSC	Secondary Oscillator
SOSCO	Secondary Oscillator Output
SRAM	Static Random Access Memory
SSL	Secure Sockets Layer
STM	Standard Test Method
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TP	Test Point
TPC	Transmit Power Control
TX	Transmit
UART	Universal Asynchronous Receiver/Transmitter
UDP	Unified Data Packet
VQFN	Very Thin Quad Flat No-lead
WCM	Wi-Fi® Context Memory
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access
XDS	Extended Deep Sleep
XLP	Extreme Low-Power
XOSC	Crystal Oscillator

6. Document Revision History

The revision history describes the changes that were implemented in the document. The changes are listed by revision, starting with the most current publication.

Table 6-1. Document Revision History

Revision	Date	Section	Description
A	11/2023	Document	Initial Revision

Microchip Information

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