

Introduction

The WILCS02IC is a single chip 2.4 GHz and IEEE 802.11b/g/n-compliant solution with integrated High Power Amplifier (HPA), Low-Noise Amplifier (LNA) and Radio Frequency (RF) switches for TX/RX control. It is a Link Controller IC with a hardware-based security accelerator.

The WILCS02 is a fully RF and Wi-Fi Alliance[®]-certified wireless module based on the WILCS02IC. The device provides Secure Digital Input Output (SDIO) or Serial Peripheral Interface (SPI) to interface with the host controller.

The WILCS02IC and WILCS02 Module operates at a single supply voltage V_{DD} and V_{DDIO} (3.3V typical).

The WILCS02 Module is available with either an on-board Printed Circuit Board (PCB) antenna or U.FL connector for an external antenna.

Note: The WILCS02IC must be programmed with the appropriate Link Controller firmware version to meet the specification described in the data sheet.

WILCS02IC and WILCS02 Module Features

- IEEE 802.11 b/g/n, Single Stream (1x1) 20 MHz Bandwidth WLAN Link
 - Compatible with Wi-Fi[®] 6/7 2.4 GHz band
- Protected Management Frame (PMF) Handled in Hardware, WPA3 Support
- Integrated Power Amplifier (PA), TX/RX Switch and Power Management
- Internal Flash Memory (Up to 2 MB) to Store Firmware
- Immutable Secure Boot with Hardware Root of Trust
- Supports Host-Assisted Firmware Side-Loading
- Hardware-Based IEEE 802.15.2 Compliant Three-Wire Packet Traffic Arbitration (PTA) Interface for Wi-Fi/Bluetooth[®] Coexistence⁽²⁾
- SDIO or SPI (SDIO Based SPI; SDIO-SPI) Host Interface on a Supported Linux Host System
- Secure Device Firmware Upgrade (DFU)

Security

- Hardware-Accelerated Security Modes (CryptoMaster) with Built-in Direct Memory Access (DMA) Support
 - Encryption engines (Advanced Encryption Standard (AES) and Triple Data Encryption Standard (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 Non Deterministic Random Number Generator (NDRNG)
- Multi-Purpose Public Key Crypto Engine Supporting the Following Algorithms:
 - Elliptic-Curve Cryptography (ECC)/ECDH/ECDSA with standard NIST prime curves up to 521-bit, Curve25519 and Ed25519
 - RSA up to 2048-bit keys

Operating Conditions

- **WILCS021C**
 - Operating Voltage V_{DD} , V_{DDIO} : 3.0-3.6V (3.3V Typical)
 - Operating Temperature: -40°C to 105°C
 - AEC-Q100 Grade 2 qualified
- **WILCS02 Module**
 - Operating Voltage V_{DD} , V_{DDIO} : 3.0-3.6V (3.3V Typical)
 - Operating Temperature: -40°C to 85°C

Module Variants

- PCB Antenna:
 - WILCS02PE
- U.FL Connector for External Antenna:
 - WILCS02UE

Package

- **WILCS021C**
48-pin Very Thin Quad Flat No-lead (VQFN)
Size: 7 mm x 7 mm x 0.9 mm
- **WILCS02 Module**
28-pin Surface Mount Device (SMD) Package with RF Shield 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
- Remote Control
- Wearable Smart Devices
- Industrial Control

Certifications

- WILCS02 Module Certified to FCC, ISCED, CE, UKCA, MIC, KCC and NCC Radio Regulations and Wi-Fi Alliance
- RoHS and REACH Compliant

Notes:

1. For more details about the latest supported features and current Linux driver release notes for all available features, refer to the [WILCS02 Application Developer's Guide](#).
2. Either the PTA functionality or the RTCC oscillator can be used. For more details, refer to the [Pin Details of WILCS02 Module](#).

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1. Ordering Information

This chapter provides the ordering information of the WILCS02IC and the WILCS02 Modules.

1.1 WILCS02IC Ordering Information

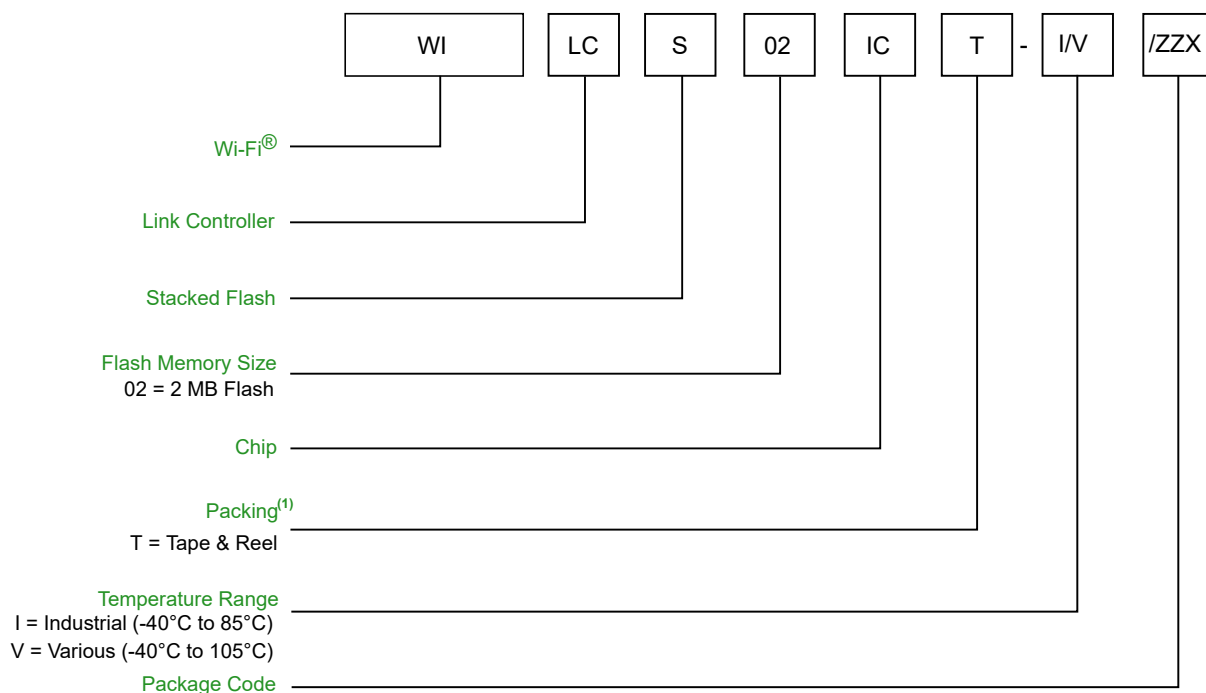
This section provides the ordering information of the WILCS02IC.

Table 1-1. WILCS02IC Ordering Details

SoC Name	Pin and Package	Description	Ordering Code
WILCS02IC	48-pin VQFN (7 mm x 7 mm x 0.9 mm)	32-bit Link Controller IC with Wireless Local Area Network (WLAN) connectivity and hardware-based security accelerator with 2 MB stacked Flash	WILCS02IC-I/ZZX
			WILCS02ICT-I/ZZX
			WILCS02IC-V/ZZX
			WILCS02ICT-V/ZZX

The following figure illustrates the details of the WILCS02IC ordering information.

Figure 1-1. WILCS02IC Ordering Information



Notes:

1. By default, the WILCS02IC comes with Tray packing
2. The WILCS02IC must be programmed with the appropriate Link Controller firmware version to meet the specification described in the data sheet.

1.2 WILCS02 Module Ordering Information

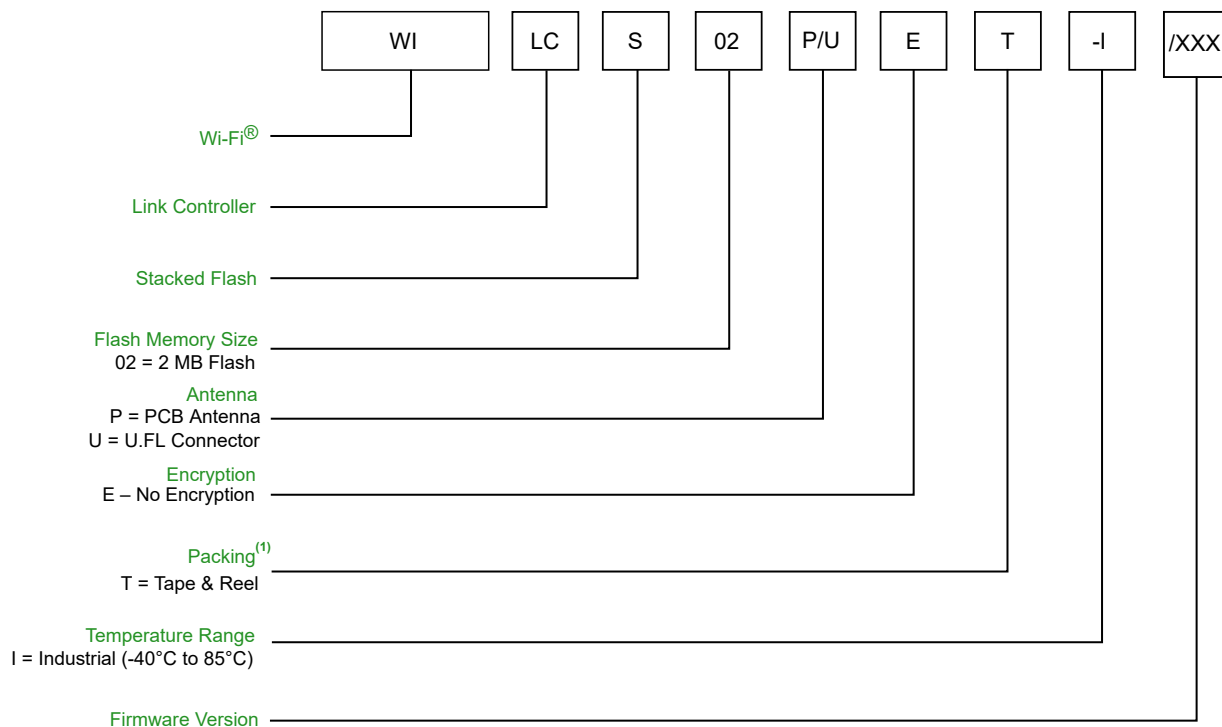
This chapter provides the ordering information of the WILCS02 Module.

Table 1-2. WILCS02 Module Ordering Details

Module Name	Description	Ordering Code
WILCS02PE	Wi-Fi [®] Link Controller module with PCB Antenna	WILCS02PE-I/XXX
WILCS02UE	Wi-Fi Link Controller module with U.FL connector for external Antenna	WILCS02UE-I/XXX

The following figure illustrates the details of the WILCS02 Module ordering information.

Figure 1-2. WILCS02 Module Ordering Information



Note:

1. By default, the WILCS02 Module comes with Tray packing

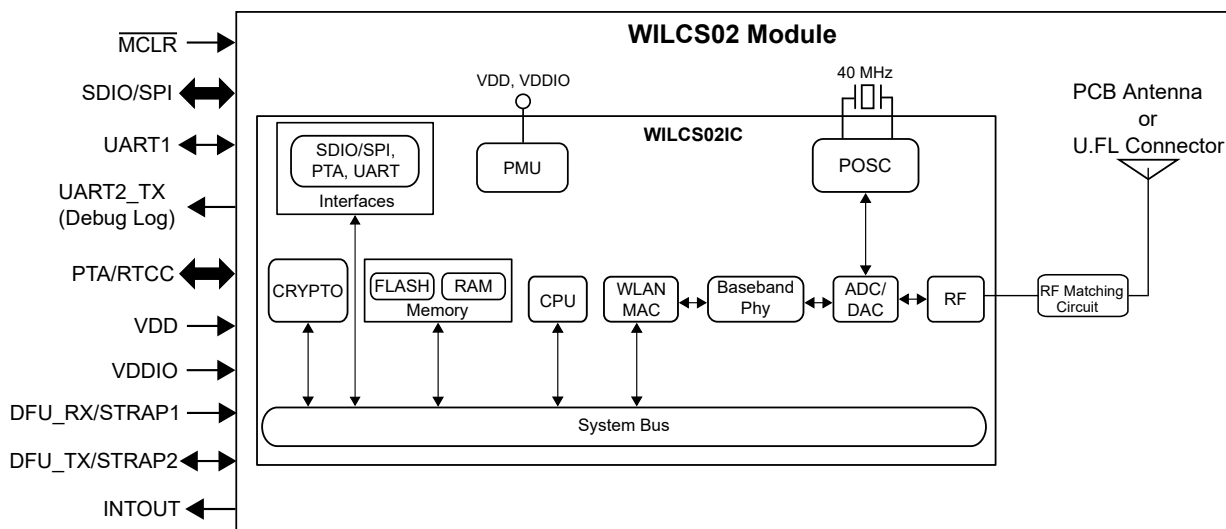
2. Device Overview

The WILCS02IC is a single chip 2.4 GHz and IEEE[®] 802.11b/g/n-compliant solution with integrated high-power PA, LNA and RF switches for TX/RX control. The WILCS02 is a fully RF and Wi-Fi Alliance[™]-certified module based on WILCS02IC available with the following antenna variants:

- PCB antenna (WILCS02PE)
- U.FL connector (WILCS02UE) for external antenna

The following figure illustrates the WILCS02IC and WILCS02 Module block diagram and various peripherals supported by these devices.

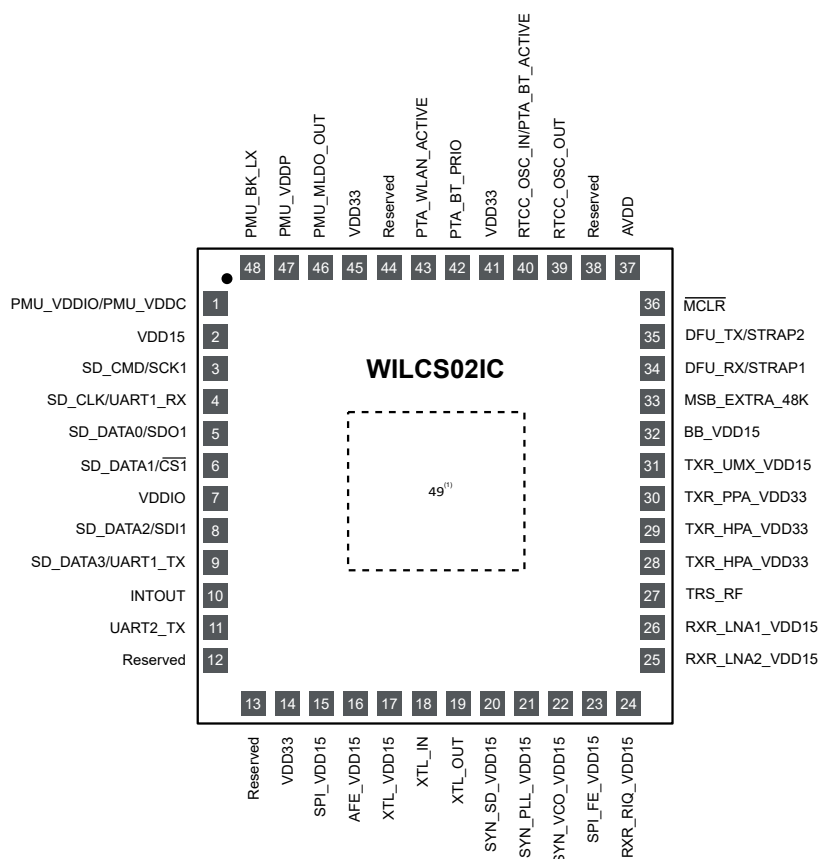
Figure 2-1. WILCS02 Module Block Diagram



2.1 Pin Details of WILCS02IC

This section provides details on pin diagrams and the pinout table of WILCS02IC.

Figure 2-2. WILCS02IC Pin Diagram



Note:

1. Thermal Ground Pad is located on the opposite side (bottom view).

Table 2-1. WILCS02IC Pinout Table

Pin Number	Pin Name	Pin Type	Description
1	PMU_VDDIO/ PMU_VDDC	P	Input power supply to the on-chip PMU I/O and PMU Core section (3.0-3.6V, 3.3V typical)
2	VDD15	P	1.5V input supply voltage Connect to 1.5V on-chip PMU output
3	SD_CMD/SCK1	I	SDIO, Command Connect to the SDIO command of the host device SPI1, Serial Clock Connect to the SPI Clock of the host device
4	SD_CLK/UART1_RX ⁽⁵⁾	I	SDIO, Clock Connect to the SDIO clock of the host device Used for external antenna calibration Connect this signal to a test point or a pin header

Table 2-1. WILCS02IC Pinout Table (continued)

Pin Number	Pin Name	Pin Type	Description
5	SD_DATA0/SDO1	I/O	SDIO, Data0 Connect to the SDIO data0 of the host device
		O	SPI1, Serial Data Out Connect to the Serial Data In of the host device
6	SD_DATA1/CS1	I/O	SDIO Data 1 Connect to the SDIO data1 of the host device
		I	SPI1 Chip Select (Active-low) Connect to the Chip Select of the host device
7	VDDIO	P	Input supply voltage to I/O Port (3.0-3.6V, 3.3V typical)
8	SD_DATA2/SDI1	I/O	SDIO, Data 2 Connect to the SDIO data2 of the host device
		I	SPI1, Serial Data In Connect to Serial Data Out of the host device
9	SD_DATA3/UART1_TX ⁽⁵⁾	I/O	SDIO Data 3 Connect to the SDIO data3 of the host device
		O	Used for external antenna calibration Connect this signal to a test point or a pin header
10	INTOUT	O	Interrupt request (Active-low) from the Wi-Fi [®] device
11	UART2_TX	O	UART2 Transmit signal to print the firmware debug log
12	Reserved	I/O	Reserved pin, do not connect
13	Reserved	I/O	Reserved pin, do not connect
14	VDD33	P	Input supply voltage for the Main Power Domain (3.0-3.6V, 3.3V typical)
15	SPI_VDD15	P	1.5V input supply voltage to the RF internal SPI logic block Connect to 1.5V on-chip PMU output
16	AFE_VDD15	P	1.5V input supply voltage to RF Analog Front-End Connect to 1.5V on-chip PMU output
17	XTL_VDD15	P	1.5V input supply voltage to primary oscillator section Connect to 1.5V on-chip PMU output
18	XTL_IN	I	40 MHz primary oscillator crystal input
19	XTL_OUT	O	40 MHz primary oscillator crystal output
20	SYN_SD_VDD15	P	1.5V input supply voltage to RF Synthesizer/SD Connect to 1.5V on-chip PMU output
21	SYN_PLL_VDD15	P	1.5V Input supply voltage to RF Synthesizer/PLL Connect to 1.5V on-chip PMU output
22	SYN_VCO_VDD15	P	1.5V input supply voltage to RF Synthesizer/VCO Connect to 1.5V on-chip PMU output
23	SPI_FE_VDD15	P	1.5V input supply voltage to the RFIP Front-End and internal SPI logic block Connect to 1.5V on-chip PMU output
24	RXR_RIQ_VDD15	P	1.5V input supply voltage to RF IQ Mixer/RXR Connect to 1.5V on-chip PMU output
25	RXR_LNA2_VDD15	P	1.5V input supply voltage to LNA stage-2 Connect to 1.5V on-chip PMU output

Table 2-1. WILCS021C Pinout Table (continued)

Pin Number	Pin Name	Pin Type	Description
26	RXR_LNA1_VDD15	P	1.5V input supply voltage to LNA stage-1 Connect to 1.5V on-chip PMU output
27	TRS_RF	I/O	RF transmit/receive
28	TXR_HPA_VDD33	P	Input power supply to High-Power Amplifier (HPA) on the Transmitter (3.0-3.6V, 3.3V typical)
29	TXR_HPA_VDD33	P	
30	TXR_PPA_VDD33	P	Input power supply to Pre-Power Amplifier (PPA) on the Transmitter (3.0-3.6V, 3.3V typical)
31	TXR_UMX_VDD15	P	1.5V input supply voltage to RF Upconverter Mixer/TXR Connect to 1.5V on-chip PMU output
32	BB_VDD15	P	1.5V input supply voltage to RF Base Band section Connect to 1.5V on-chip PMU output
33	MSB_EXTRA_48K	O	Connect a pull-down resistor of 48.7K with 1% tolerance, to create a constant current reference for internal analog/RF blocks
34	DFU_RX/STRAP1	I	Device Firmware Update, receive signal Host interface configuration strapping1 pin. Connect to a pulled-low resistor of 100K for the SDIO interface or pulled-high resistor of 10K for the SPI.
35	DFU_TX/STRAP2	O	Device Firmware Update, transmit signal
		I	Host interface configuration strapping2 pin. Connect to a pulled-high resistor of 10K for future upgrades.
36	MCLR	I	Master Clear Reset Input (Active low)
37	AVDD	P	Input power supply to Analog Block (3.0-3.6V, 3.3V typical)
38	Reserved ⁽⁶⁾	I/O	Reserved pin Connect to an I/O pin (tri-stated) of a host device or to an external switch for future use.
39	RTCC_OSC_OUT ⁽⁴⁾	O	32.768 KHz RTCC oscillator output
40	RTCC_OSC_IN/ PTA_BT_ACTIVE ⁽³⁾⁽⁴⁾	I	32.768 KHz RTCC Oscillator input PTA interface, Bluetooth® Coexistence device active indication input to WILCS021C
41	VDD33	P	Input supply voltage for the Main Power Domain (3.0-3.6V, 3.3V typical)
42	PTA_BT_PRIO	I	PTA interface, Bluetooth Coexistence device priority indication input to WILCS021C.
43	PTA_WLAN_ACTIVE	O	PTA interface, WILCS021C WLAN active indication output to Bluetooth Coexistence device
44	Reserved	I/O	Reserved pin Do not connect.
45	VDD33	P	Input supply voltage for the Main Power Domain (3.0-3.6V, 3.3V typical)
46	PMU_MLDO_OUT ⁽²⁾	P	1.5V output of on-chip PMU MLDO
47	PMU_VDDP	P	Input power supply to the on-chip PMU (3.0-3.6V, 3.3V typical)
48	PMU_BK_LX	P	1.5V output of on-chip PMU Buck Regulator Connect to an external LC filter (L = 4.7 uH and C = 10 uF)
49	GND	P	Thermal ground paddle

Table 2-1. WILCS02IC Pinout Table (continued)

Pin Number	Pin Name	Pin Type	Description
Notes:			
1.	Refer to the reference design package for exact pin mapping and signal connection.		
2.	Do not connect any external 1.5V supply.		
3.	The WILCS02IC can support either RTCC_OSC_IN or PTA_BT_ACTIVE functionality at a time, so either RTCC or PTA feature can be used.		
4.	Current firmware does not support the Real Time Clock Calendar (RTCC) Oscillator function; it is recommended to have an option to mount the RTCC Oscillator in the design to upgrade with the future version of firmware releases.		
5.	For more details, refer to the <i>WILCS02 Module External Antenna Calibration Guide</i> (DS50003751).		
6.	Do not leave this pin unconnected. Follow as described in the Pin Description column for future upgrade.		

2.2 Pin Details of WILCS02 Module

This section provides details on pin diagrams and the pinout table of the WILCS02 Module.

Figure 2-3. WILCS02 Module Pin Diagram

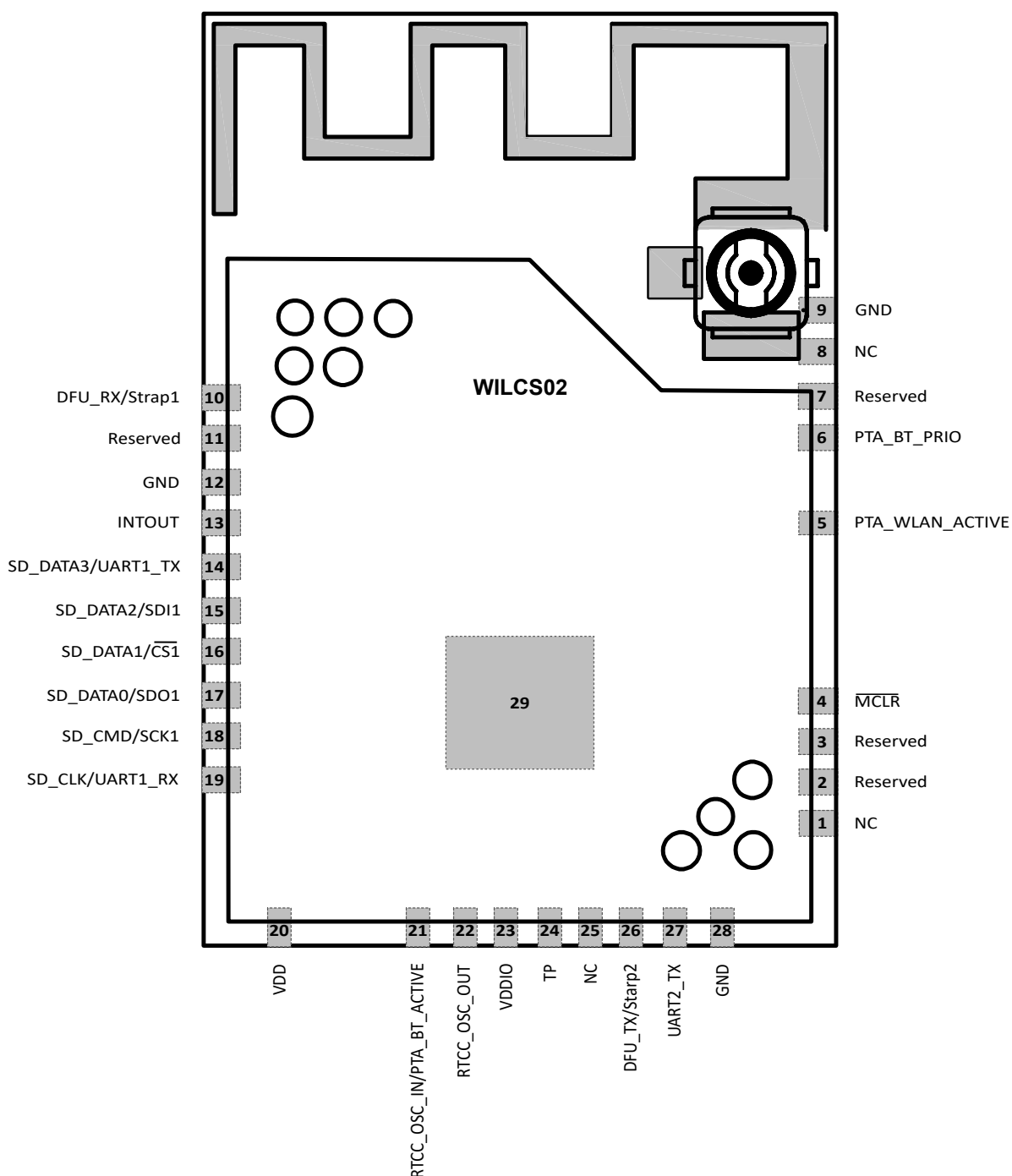


Table 2-2. WILCS02 Module Pinout Table

Pin Number	Pin Name	Pin Type	Pin Description
1	NC	—	No connection

Table 2-2. WILCS02 Module Pinout Table (continued)

Pin Number	Pin Name	Pin Type	Pin Description
2	Reserved	I/O	Reserved pin Do not connect.
3	Reserved	I/O	Reserved pin Do not connect.
4	MCLR	I	Master Clear Reset Input (Active low)
5	PTA_WLAN_ACTIVE	O	PTA interface, WLAN Active indication output to Bluetooth® Coexistence device
6	PTA_BT_PRIO	I	PTA interface, Bluetooth Coexistence device priority indication input to WILCS02
7	Reserved	I/O	Reserved pin Do not connect.
8	NC	—	No connection.
9	GND	P	Ground
10	DFU_RX/STRAP1	I	Device Firmware Update, receive signal Host interface configuration, Strapping1 pin. Connect to a pulled-low resistor of 100K for the SDIO interface or a pulled-high resistor of 10K for the SPI.
11	Reserved ⁽⁵⁾	—	Reserved pin Connect to an I/O pin (tri-stated) of a host device or to an external switch for future use.
12	GND	P	Ground
13	INTOUT	O	Interrupt request (Active-low) from the Wi-Fi® module
14	SD_DATA3/UART1_TX ⁽⁴⁾	I/O	SDIO, Data3 Connect to the SDIO data3 of the host device.
		O	Used for external antenna calibration Connect this signal to a test point or a pin header.
15	SD_DATA2/SDI1	I/O	SDIO, Data2 Connect to the SDIO data2 of the host device.
		I	SPI1, Serial Data In Connect to Serial Data Out of the host device.
16	SD_DATA1/CS1	I/O	SDIO, Data1 Connect to the SDIO data1 of the host device.
		I	SPI1, Chip Select (Active-low) Connect to the Chip Select of the host device.
17	SD_DATA0/SDO1	I/O	SDIO, Data0 Connect to the SDIO data0 of the host device.
		O	SPI1, Serial Data Out Connect to the Serial Data In of the host device.
18	SD_CMD/SCK1	I	SDIO, command Connect to the SDIO command of the host device.
			SPI1, Serial Clock Connect to the SPI Clock of the host device.

Table 2-2. WILCS02 Module Pinout Table (continued)

Pin Number	Pin Name	Pin Type	Pin Description
19	SD_CLK/UART1_RX ⁽⁴⁾	I	SDIO, Clock Connect to the SDIO clock of the host device. Used for external antenna calibration Connect this signal to a test point or a pin header.
20	VDD	P	VDD power supply (3.0-3.6V)
21	RTCC_OSC_IN/ PTA_BT_ACTIVE ⁽¹⁾⁽³⁾	I	32.768 KHz RTCC Oscillator input PTA interface, Bluetooth Coexistence device active indication input to WILCS02
22	RTCC_OSC_OUT ⁽³⁾	O	32.768 KHz RTCC Oscillator output
23	VDDIO	P	I/O power supply (3.0-3.3V)
24	TP	P	PMU Output Test point: 1.5V ⁽²⁾
25	NC	—	No connection
26	DFU_TX/STRAP2	O	Device Firmware Update, transmit signal
		I	Host interface configuration, Strapping2 pin. Connect to a pulled-high resistor of 10K for future upgrades.
27	UART2_TX	O	UART2 transmit signal for the firmware log. UART setting: 460,800 baud, 8N1 and no flow control
28	GND	P	Ground
29	GND Paddle	P	Thermal ground paddle

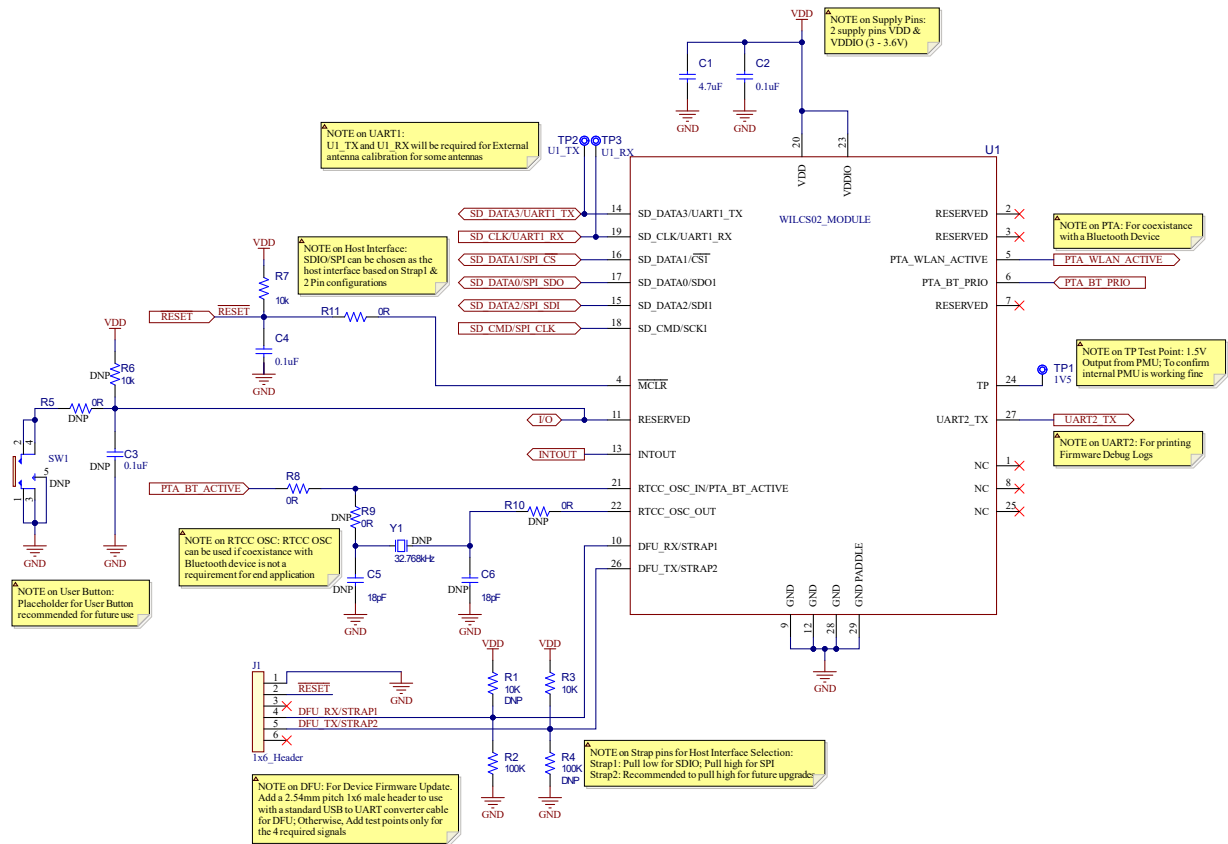
Notes:

1. The WILCS02 Module can support either RTCC_OSC_IN or PTA_BT_ACTIVE functionality at a time, so, either the RTCC or PTA feature can be used.
2. Do not connect any external 1.5V supply.
3. Current firmware does not support the RTCC Oscillator function; it is recommended to have an option to mount the RTCC Oscillator in the design to upgrade with the future version of firmware releases.
4. For more details, refer to the *WILCS02 Module External Antenna Calibration Guide* ([DS50003751](#))
5. Do not leave this pin unconnected. Follow as described in the Pin Description column for future upgrades.

2.3 Basic Connection Requirement

The WILCS02 Module requires attention to a minimal set of device pin connections before proceeding with development.

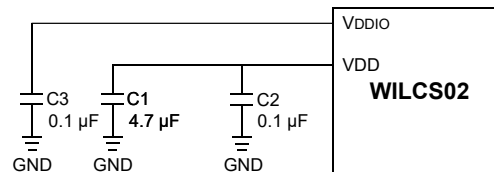
Figure 2-4. WILCS02 Module Basic Connection and Interface Diagram



2.3.1 Power Supply Pin

It is recommended to add a bulk and a decoupling capacitor at the input supply Pin 20 (V_{DD}), Pin 23 (V_{DDIO}) and GND of the WILCS02 Module.

Figure 2-5. Recommended Module Power Supply Connections



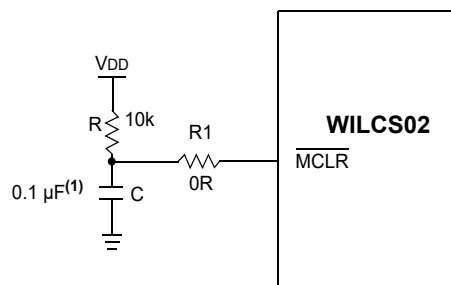
The value of the C1, C2 and C3 capacitors may vary based on the application requirements and source of supply voltage. The C1, C2 and C3 capacitors must be placed close to the pin.

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

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

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

Figure 2-6. Example of $\overline{\text{MCLR}}$ Pin Connections



Note:

1. The capacitor can be sized to prevent unintentional Resets from brief glitches or to extend the device Reset period during Power-on Reset (POR).

Related Links

[Basic Connection Requirement](#)

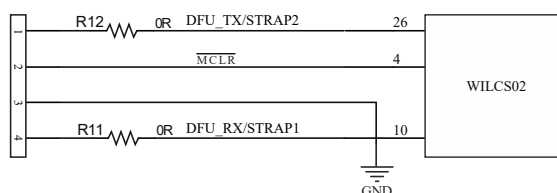
2.3.3 Device Firmware Update

The WILCS02 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. Firmware Sideload

Note: For the serial DFU and Firmware Sideload programming guidance, refer to the [WILCS02 Module Application Developer's Guide](#).

Figure 2-7. Basic Connection Diagram of DFU



2.3.4 Interface with Host Microcontroller

The WILCS02 Module can be interfaced with the host microcontroller through the SDIO/SPI signals along with additional signals.

Figure 2-8. WILCS02 Module SDIO Host Interface Diagram

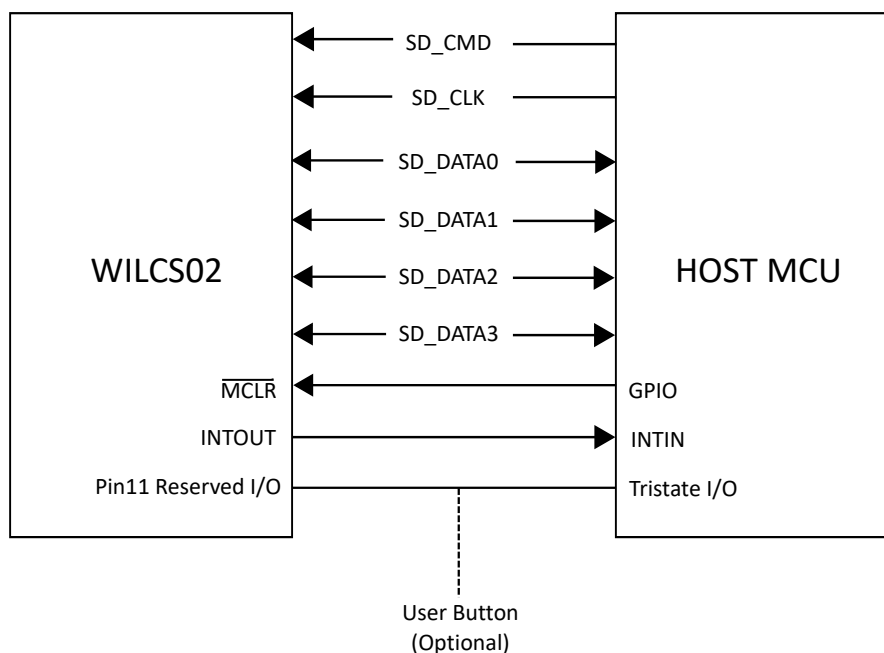
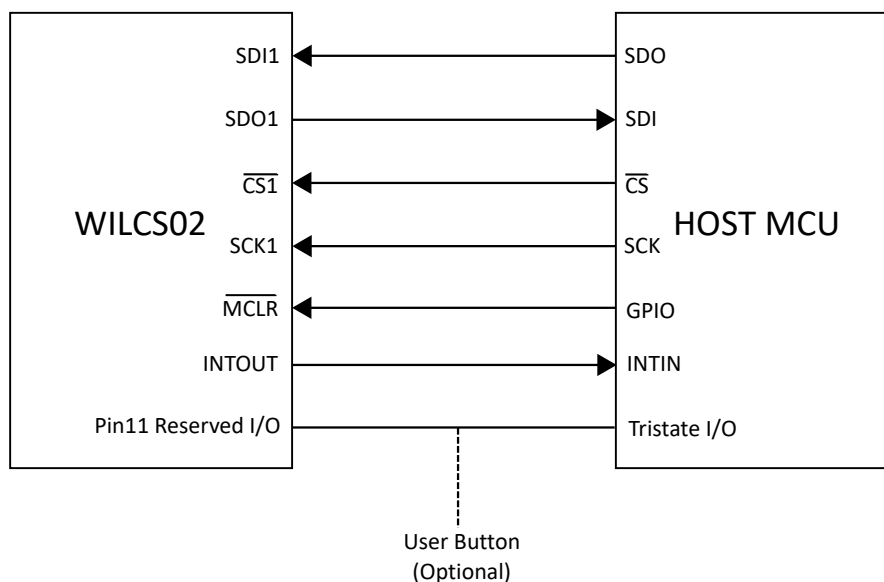


Figure 2-9. WILCS02 Module SDIO-SPI Host Interface Diagram



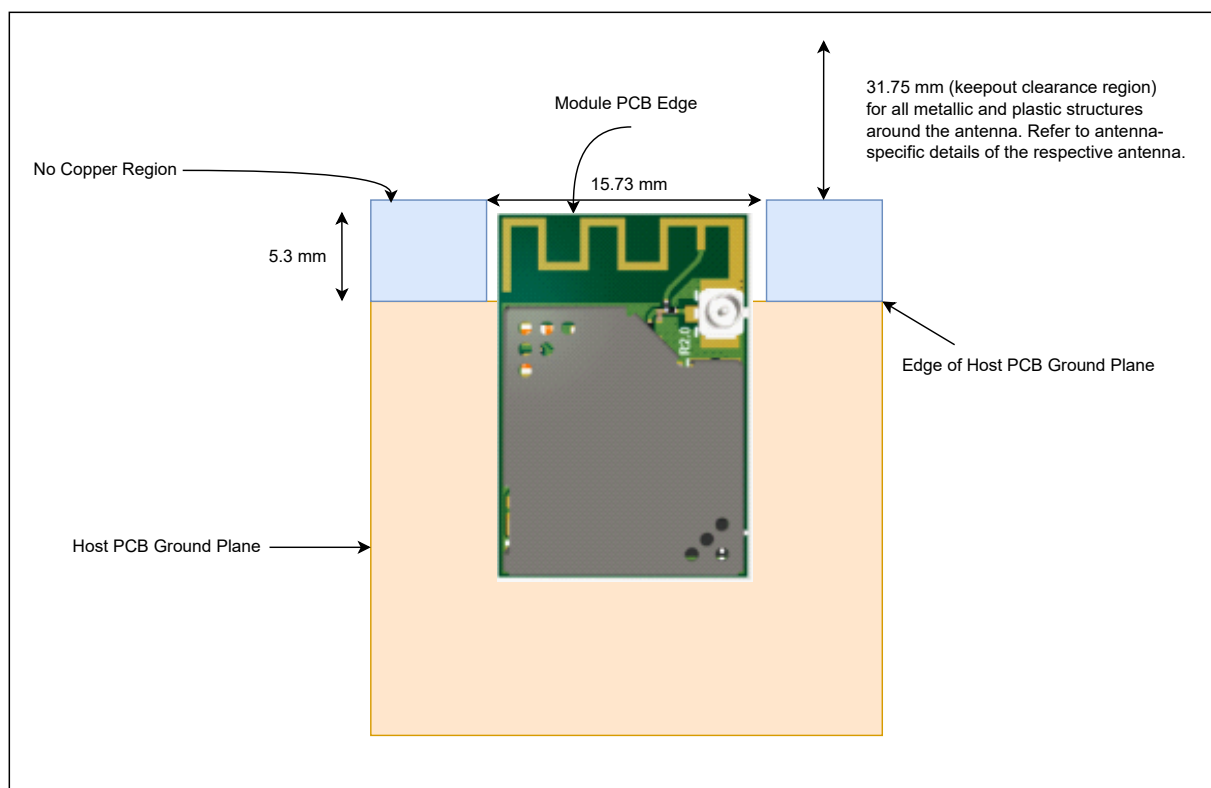
2.4 WILCS02 Module Placement Guidelines

- 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 WILCS02PE Module is placed at the edge of the host board.
- The WILCS02PE Module ground outline edge must be aligned with the edge of the host board ground plane as illustrated in the following figure.

- A low-impedance ground plane for the WILCS02 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 Electro-Magnetic Compatibility (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 WILCS02 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 illustrated 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 WILCS02 Module must be soldered to the host board (see the *Example of Host Board on Top Layer* figure in the *WILCS02 Module Routing Guidelines* from Related Links).
- A PCB cutout or a copper keepout is required under the RF test point (see *WILCS02 Module Packaging Information* from Related Links).
- Copper keepout areas are required on the top layer under voltage test points (see *WILCS02 Module Packaging Information* from Related Links).
- Alternatively, the entire region, except the exposed ground paddle, can be solder-masked.

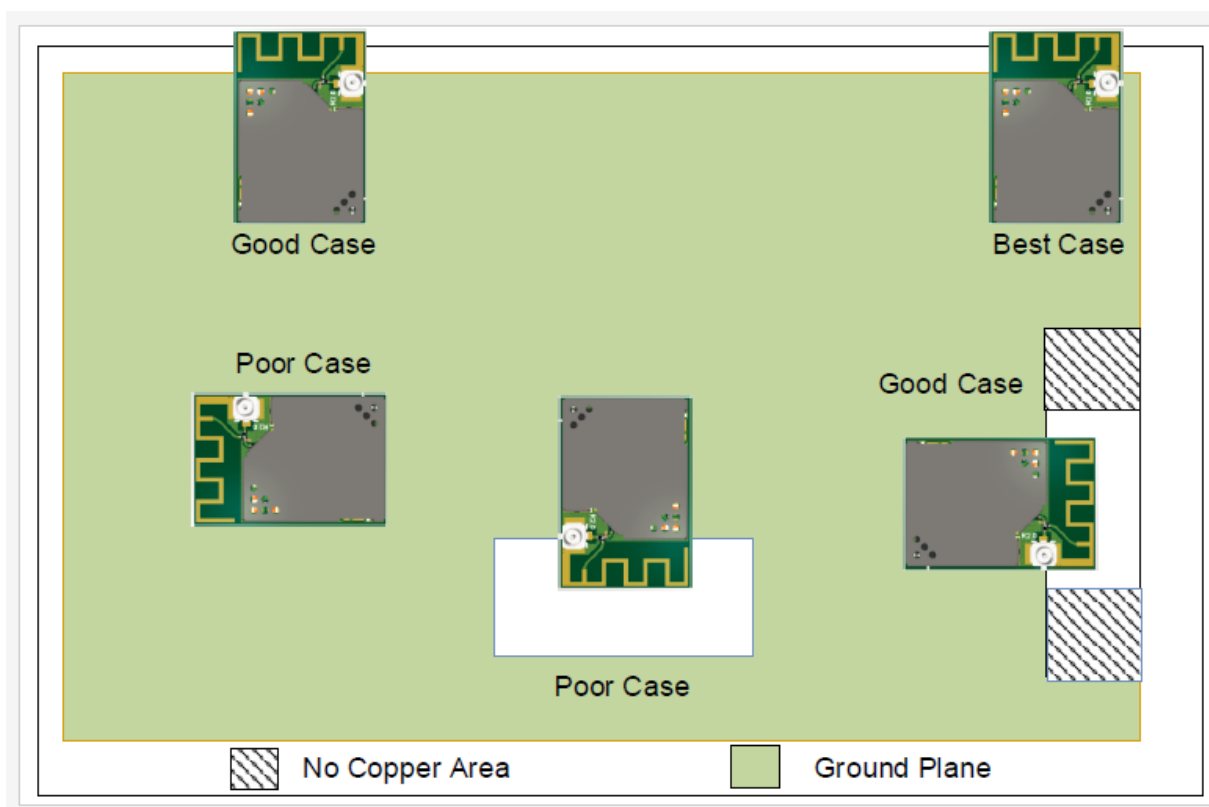
The following figure illustrates the examples of WILCS02 Module placement on a host board with a ground plane. Refer to the following figure for placement-specific guidance.

Figure 2-10. Module Placement Guidelines



The following figure illustrates the examples of the WILCS02 Module placement on a host board with a ground plane. Refer to [Figure 2-10](#) for placement-specific guidance.

Figure 2-11. WILCS02 Module Placement



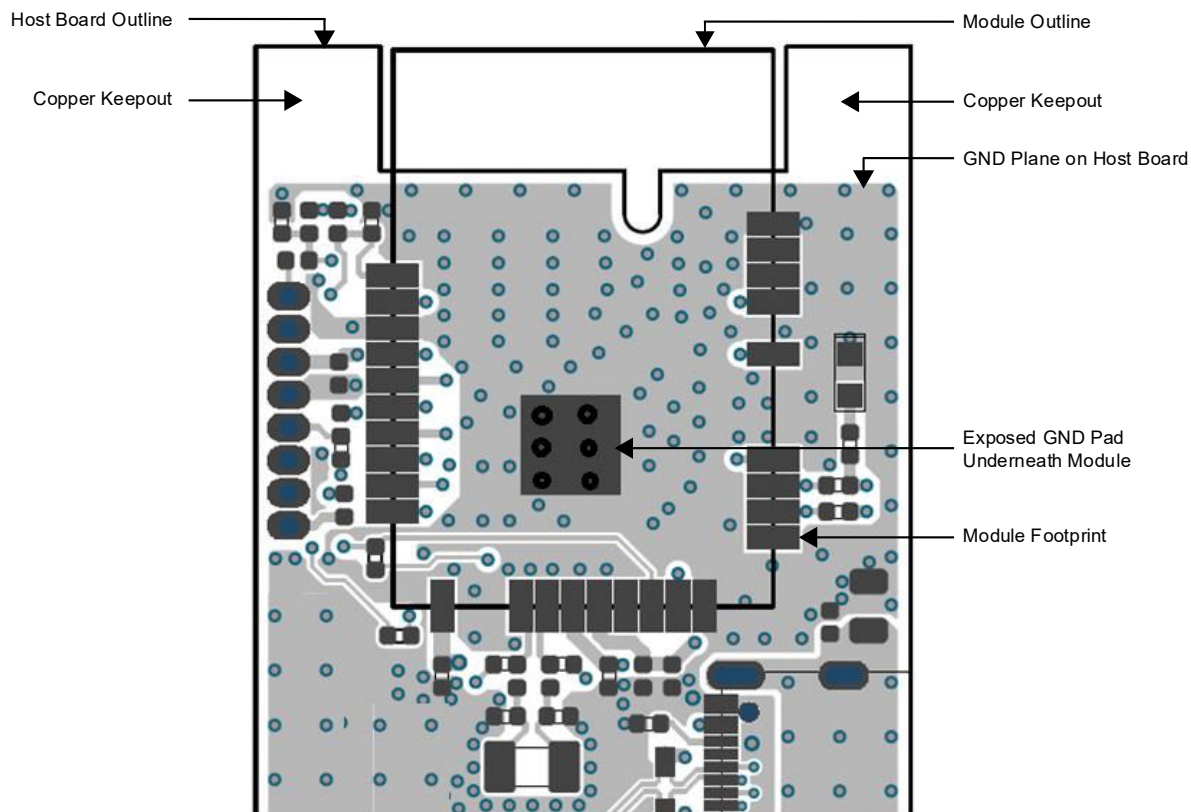
Related Links

[WILCS02 Module Packaging Information](#)

2.5 WILCS02 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, as illustrated 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 WILCS02 Module.
- For a better GND connection to the WILCS02 Module, solder the exposed GND pads of the WILCS02 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 reserved pins and digital interface pins is recommended. These resistors must be placed close to the WILCS02 Module.

Figure 2-12. Example of Host Board on Top Layer



2.6 WILCS02 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 WILCS02 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 WILCS02 Module includes RF shielding on top of the board as a standard feature.

2.7 WILCS02 Module Antenna Considerations

2.7.1 PCB Antenna

For the WILCS02PE Module, the PCB antenna is fabricated on the top copper layer. The layers below the antenna do not have a 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 WILCS02 Module mounted on the WILCS02 Wi-Fi® Link Controller SD Board.

Table 2-3. PCB Antenna Specification for WILCS02 Module

Parameter	Specification
Operating frequency	2400-2485 MHz
Peak gain	1.18 dBi at 2445 MHz
Efficiency (average)	68.83% ¹

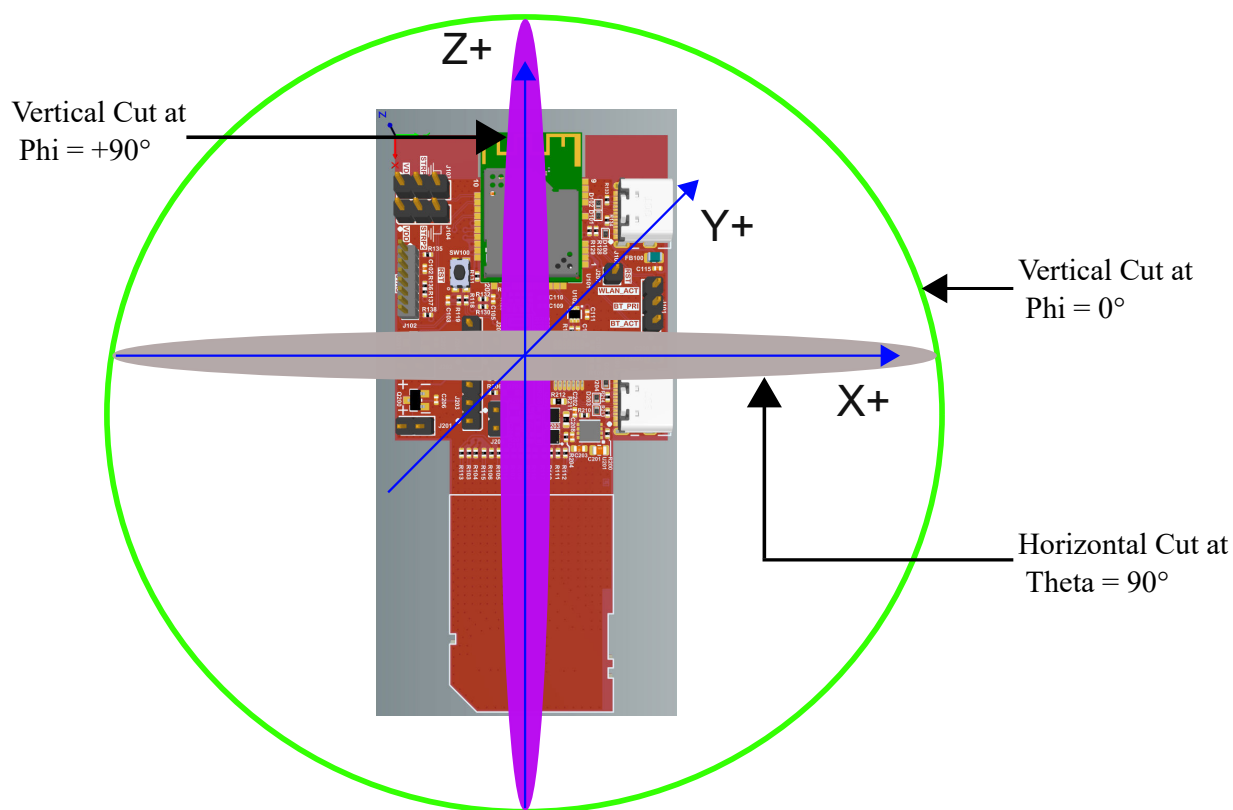
Note:

1. The size of the WILCS02 Wi-Fi® Link Controller SD Board is 85 mm x 40 mm. The antenna efficiency will improve with larger ground plane baseboards. 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 2-13. Module Orientation for Radiation Pattern Measurement



3D Antenna Radiation Pattern

The following figures illustrate the 3D cross section of the antenna radiation pattern.

Figure 2-14. 3D Antenna Radiation Pattern (Slant View)

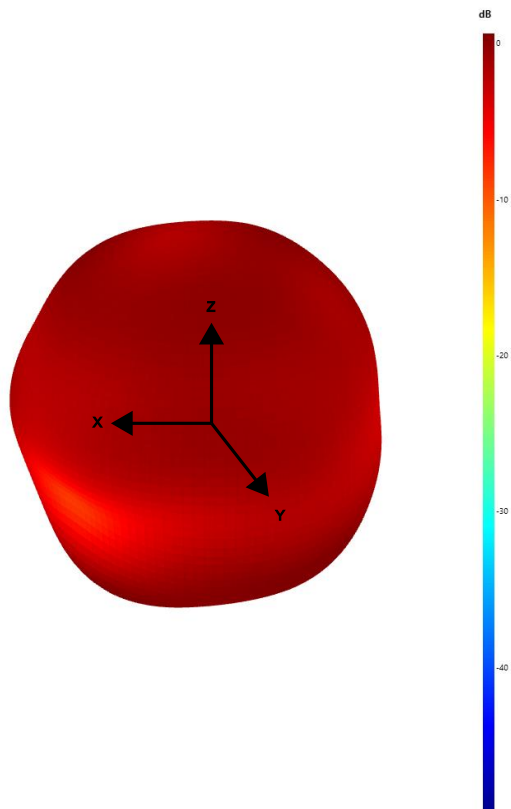


Figure 2-15. 3D Antenna Radiation Pattern (XY View)

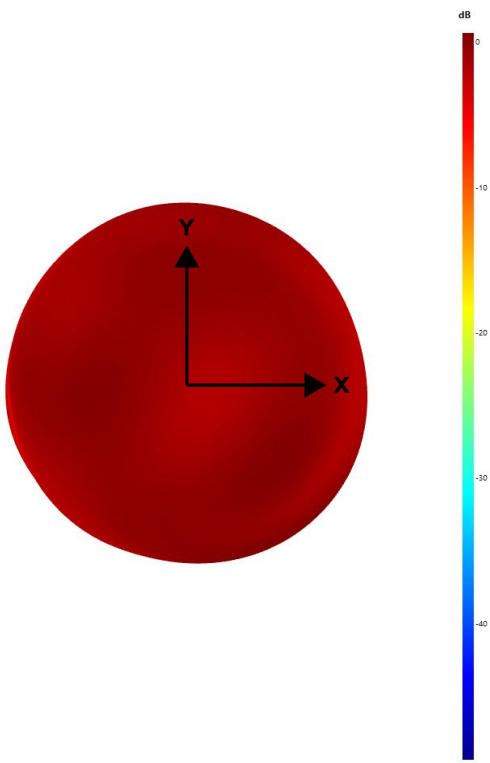


Figure 2-16. 3D Antenna Radiation Pattern (XZ View)

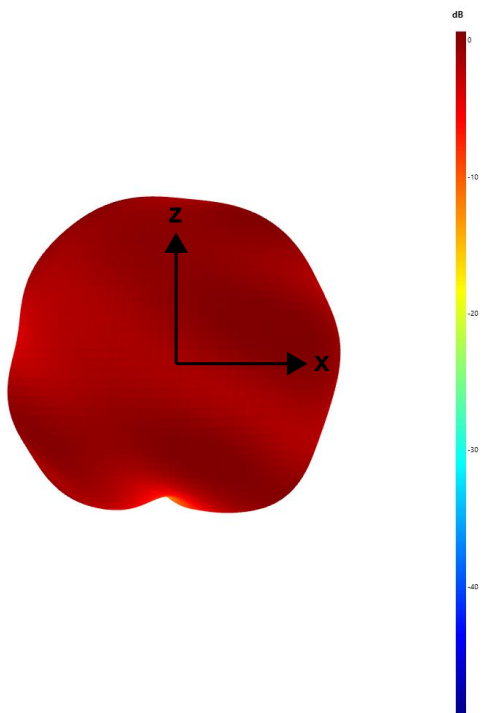
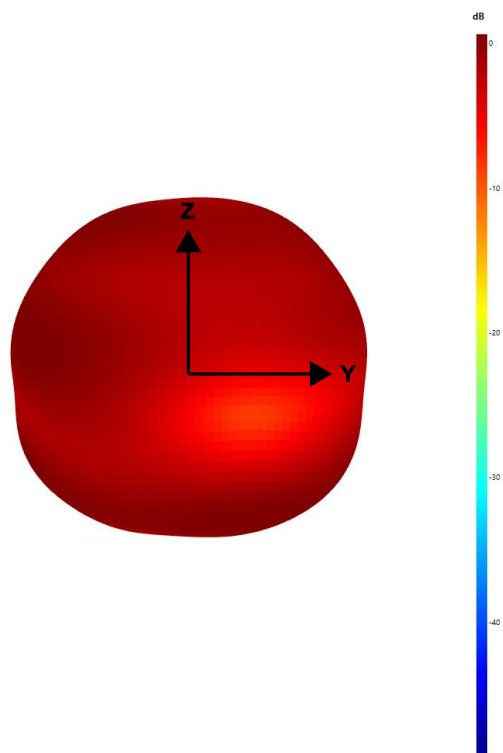


Figure 2-17. 3D Antenna Radiation Pattern (YZ View)



2D Antenna Radiation Pattern

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

Figure 2-18. Antenna Radiation Azimuth Plane Pattern @ Theta = 90°

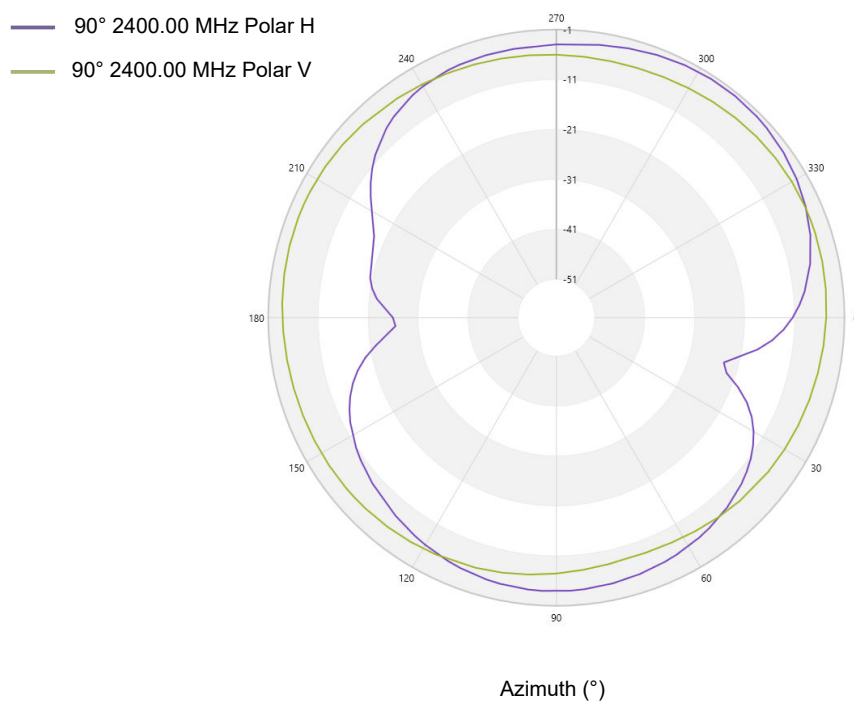


Figure 2-19. Antenna Radiation Elevated Plane Pattern @ $\Phi = 0^\circ$

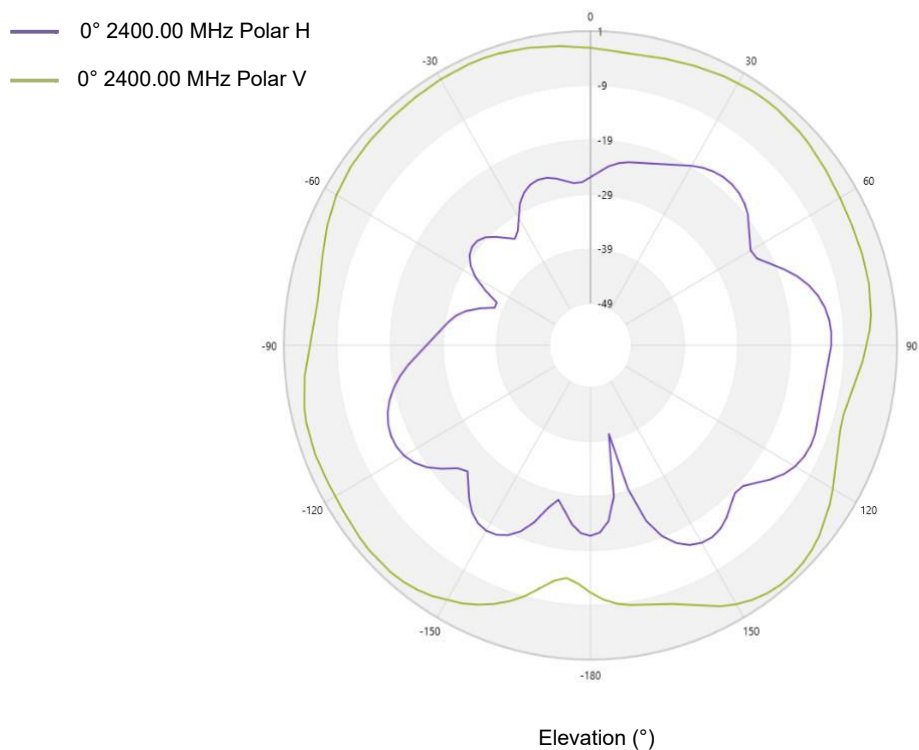
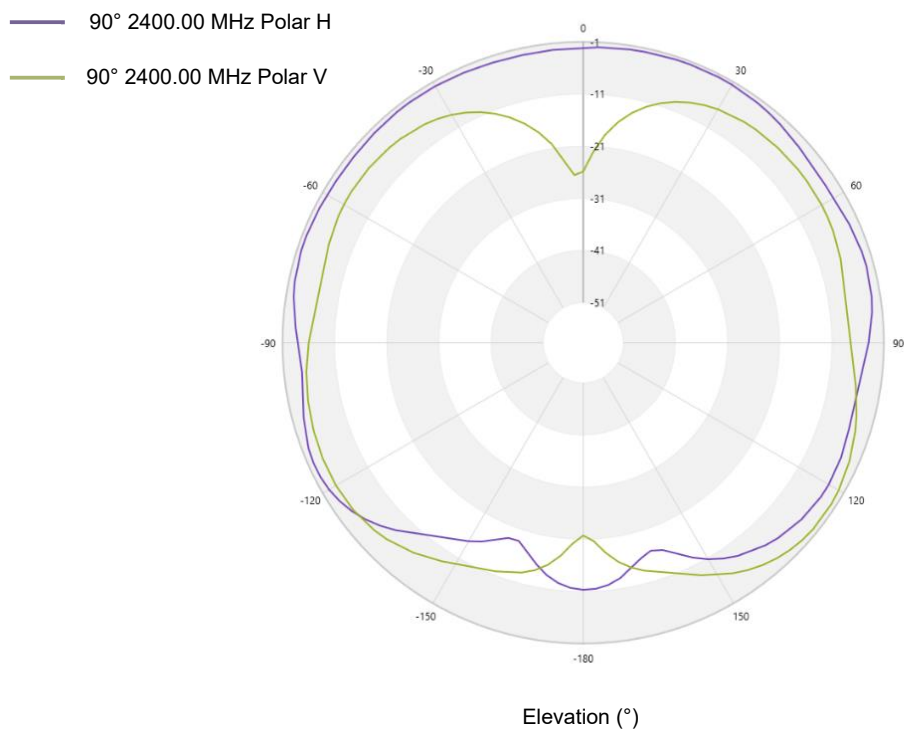


Figure 2-20. Antenna Radiation Elevated Plane Pattern @ $\Phi = 90^\circ$



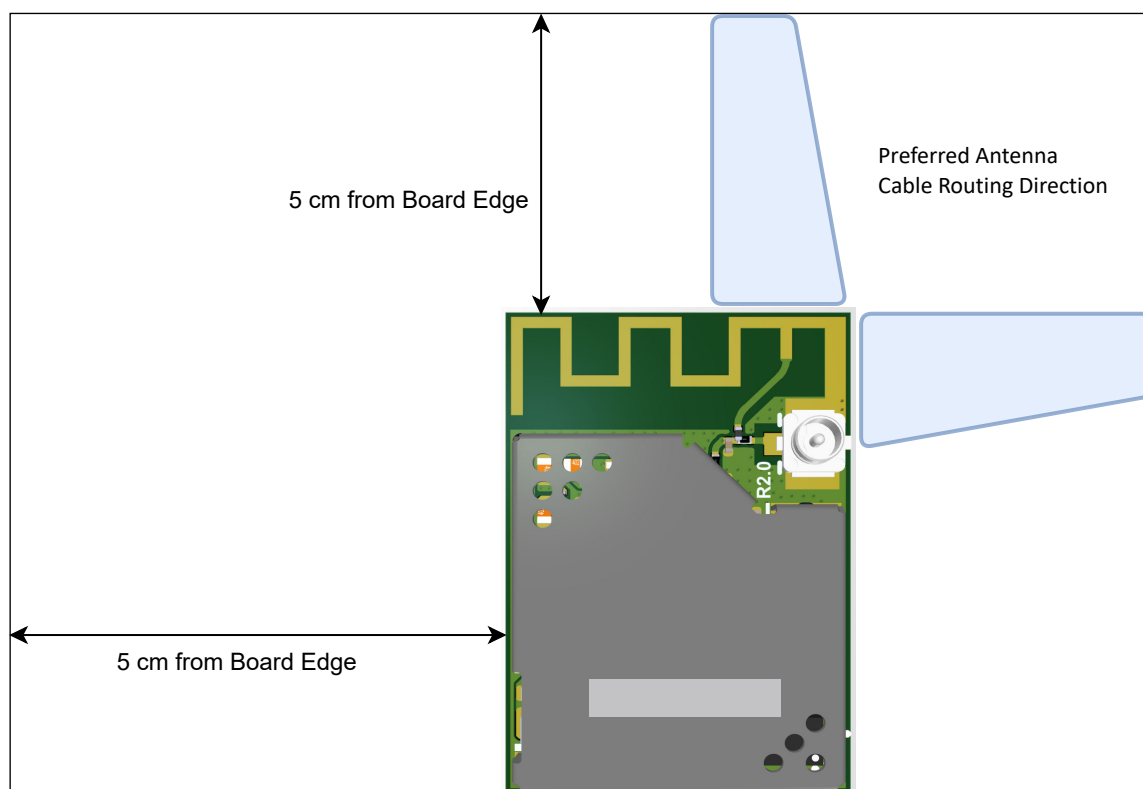
2.7.2 External Antenna Placement Recommendations

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 WILCS02 Module.

The following figure illustrates how the antenna cable must be routed depending on the location of the antenna with respect to the WILCS02 PCB. There are two possible options for the optimum routing of the cable.

Figure 2-21. WILCS02 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.

2.7.2.1 External Antennas

The WILCS02UE Module has 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 WILCS02UE Module is 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 the antenna specification sheet for cutoff frequencies).

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

Table 2-4. WILCS02 Module Approved External Antenna List with Antenna Gain

Antenna No.	Part Number	Manufacturer	Antenna Gain (dBi)	Antenna Type	Regulatory Certification	
					FCC/ISED ⁽²⁾ (3)	CE
1	WXE2400	TE Connectivity/Laird External Antennas	3	Dipole	x	x
2	ANT-2.4-CW-RCL-RPS	TE Connectivity/Linx Technologies	2.3	Dipole	x	x
3	RFA-02-C2M2-D034	Alead	2	Dipole	x	x
4	RFA-02-L2H1	Aristotle	2	Dipole	x	x
5	RFA-02-C2H1-D034	Alead	2	Dipole	x	x
6	RFA-02-D3	Aristotle	2	Dipole	x	x
7	RFDPA870920IMLB301 ⁽⁵⁾	Walsin	1.84	Dipole	x	x
8	RFDPA870920IMAB302 ⁽⁵⁾	Walsin	1.82	Dipole	x	x
9	RFDPA870920IMAB305	Walsin	1.82	Dipole	x	x
10	RFDPA870910IMAB308 ⁽⁵⁾	Walsin	2	Dipole	x	x
11	RFA-02-C2M2	Aristotle	2	Dipole	x	x
12	RN-SMA-S-RP ⁽⁵⁾	Microchip	0.56	Dipole	x	x
13	W1049B030 ⁽⁵⁾	Pulse	2	Dipole	x	x
14	RN-SMA4-RP	Microchip	2.2	Dipole	x	x

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, Reverse Polarity (RP))-SubMiniature version A Connector (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 of these antennas are used, an additional post-calibration step is required on the customer's application board. For more details, refer to the *WILCS02 Module External Antenna Calibration Guide* ([DS50003751](#)).

2.8 WILCS02 Module Reflow Profile Information

The WILCS02 Module was assembled using the IPC/JEDEC J-STD-020 standard lead-free reflow profile. The WILCS02 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.

2.8.1 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.

2.9 WILCS02 Module Assembly Considerations

The WILCS02 Module is assembled with an Electro-Magnetic Interference (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 WILCS02 Module. However, do not use the cleaning solutions that contain acid on the module.

2.9.1 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 WILCS02IC and the WILCS02 Module across the operating temperature range of the product.

3.1 WILCS02IC Electrical Specifications

This section provides the electrical specifications and the characteristics of the WILCS02IC.

3.1.1 WILCS02IC Absolute Maximum Ratings

The following table provides details about the list of absolute maximum ratings for the WILCS02IC device. Exposure to these maximum rating conditions for extended periods can affect device 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 ^(1,2)	-40°C to +105°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 any pin, with respect to GND	-0.3V to (V _{DDIO} +0.3V)
Maximum current out of GND pins	300 mA
Maximum current into V _{DD} pins ⁽²⁾	300 mA
Maximum current sunk by all ports	150 mA
Maximum current sourced by all ports ⁽²⁾	150 mA
ESD Qualification	
Human Body Model (HBM) per JESD22-A114	±2000V
Charged Device Model (CDM) (ANSI/ESD STM 5.3.1) (All pins / Corner pins)	±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.	

3.1.2 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
Various Temperature Devices:					
Operating ambient temperature range	T _A	-40	—	+105	°C
Operating junction temperature range ⁽¹⁾	T _J	-40	—	+125	°C
Power Dissipation:					
Internal chip power dissipation: P _{INT} = (V _{DDIO} × (IDD – ∑ IOH)) + (V _{DD} × IDD)	P _D	P _{INT} + P _{I/O}			W
Maximum allowed power dissipation	P _{DMAX}	(T _J – T _A)/θ _{JA}			W

Table 3-2. Thermal Operating Conditions (continued)

Rating	Symbol	Min.	Typ	Max.	Unit
Note:					
1. Junction temperature can exceed 125°C under these ambient conditions.					

Table 3-3. Thermal Packaging Characteristics

Characteristics	Symbol	Typ	Max.	Unit
Thermal resistance, 48-pin VQFN (7 mm x 7 mm x 0.9 mm) package	θ_{JA}	21	—	°C/W
Note: Junction-to-ambient thermal resistance, θ_{JA} numbers are based on JEDEC 252P achieved by package simulations.				

Table 3-4. 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	3	3.3	3.6	V	—
DC_7	GND	Common EDP ground reference	V_{SS}	V_{SS}	V_{SS}	V	—

3.1.3 Maximum Clock Frequencies AC Electrical Specifications

Table 3-5. Maximum Clock Frequencies 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 -40°C ≤ T_A ≤ +105°C for V-temp	
Param. No.	Symbol	Characteristics	Max.	Units
FCLK_1	F_{CY}	Frequency of system clock	80	MHz
Note: By default, the device runs at maximum frequency.				

3.1.4 WILCS02IC DC Characteristics

3.1.4.1 I/O Pin DC Electrical Specifications

Table 3-6. 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 -40°C ≤ T_A ≤ +105°C for V-temp				
Param. No.	Symbol	Characteristics	Min.	Typ. (1)	Max.	Units	Conditions
DI_1	V_{IL}	Input low voltage I/O pins	GND	—	$0.2 \cdot V_{DDIO}$	V	—
DI_3	V_{IH}	Input high voltage non-5V tolerant I/O pins	$0.8 \cdot V_{DDIO}$	—	V_{DDIO}	V	—
DI_5	V_{OL}	Output low voltage	—	—	0.4	V	$V_{DDIO} = 3.3V$ at $I_{OL} \leq 10$ mA
DI_9	V_{OH}	Output high voltage	2.4	—	—	V	$V_{DDIO} = 3.3V$ at $I_{OH} \leq 10$ mA

Table 3-6. I/O Pin DC Electrical Specifications (continued)

DC Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0V$ to $3.6V$ (unless otherwise stated)				
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp				
Param. No.	Symbol	Characteristics	Min.	Typ. (1)	Max.	Units	Conditions
DI_13	I_{IL}	Input pin leakage current	-1	—	+1	μA	—
Note:							
1. This parameter is characterized but not tested in manufacturing.							

3.1.4.2 WILCS021C Wi-Fi® Current Consumption

Table 3-7. 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 -40°C ≤ T _A ≤ +105°C for V-temp				
Param. No.	Symbol	Device States	Code Rate	Output Power (Typ.) (dBm)	Current (Typ.) (mA)	Max.	Units	Conditions
IWF_TX	I _{DD}	On_Transmit	802.11b 1 Mbps	19	288	—	mA	V _{DD} = V _{DDIO} = 3.3V
			802.11b 1 Mbps	13	263	—		
			802.11b 11 Mbps	20	289	—		
			802.11g 6 Mbps	19	287	—		
			802.11g 54 Mbps	17	263	—		
			802.11n MCS0	18	279	—		
			802.11n MCS7	17	262	—		
			802.11n MCS7	11	249	—		
IWF_RX	I _{DD}	On_Receive	802.11b 1 Mbps	—	88	—		
			802.11n MCS7	—	94	—		
Notes:								
1. Tested on channel 7 using an internal test firmware that provides manual control of the data rate. In the Application mode firmware, the data rate is selected automatically based on the RSSI and other variables.								
2. Data in the “Typ.” column is at 3.3V, 25°C unless otherwise stated.								
3. These parameters are characterized but not tested in manufacturing.								

3.1.5 WILCS02IC AC Characteristics

3.1.5.1 External XTAL POSC 40 MHz AC Electrical Specifications

Table 3-8. External XTAL POSC 40 MHz AC Electrical Specifications

AC Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0V$ to $3.6V$ (unless otherwise stated)				
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp				
Param. No.	Symbol ⁽¹⁾	Characteristics	Min.	Typ	Max.	Units	Conditions
XOSC_1	FOSC_XOSC	XOSC crystal frequency	—	40	—	MHz	XIN, XOUT primary oscillator
XOSC_1A	TOSC	TOSC = 1/FOSC_XOSC	—	—	—	ns	See parameter XOSC_1 for FOSC_XOSC value

Note:

1. This parameter is characterized but not tested in manufacturing.

3.1.5.2 SDIO Controller and SDIO-SPI AC Timing Specifications

Figure 3-1. SDIO Controller and SDIO-SPI AC Timing Diagram

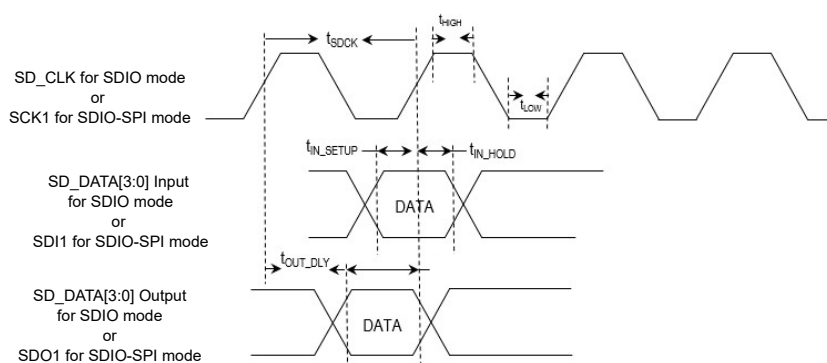


Table 3-9. SDIO Controller AC Timing Specifications

AC Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0V$ to $3.6V$ (unless otherwise stated)				
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp				
Param. No.	Symbol	Characteristics	Min.	Typ	Max.	Units	Conditions ⁽¹⁾
SD_5	t_{SDCK}	Clock frequency	0	—	50	MHz	
SD_7	t_{DUTY}	Duty cycle	—	50	—	%	—
SD_9	t_{HIGH}	Clock high time	8.5	—	—	ns	—
SD_11	t_{LOW}	Clock low time	8.5	—	—	ns	—
SD_13	t_{RISE}	Clock rise time	—	—	5	—	—
SD_15	t_{FALL}	Clock fall time	—	—	5	—	—
SD_17	t_{IN_SETUP}	Input setup time	6	—	—	ns	—
SD_19	t_{IN_HOLD}	Input hold time	1	—	—	ns	—
SD_21	t_{OUT_DLY}	Output delay time	3	—	13	ns	$V_{DDIO} = 3.3V$, $C_{LOAD} = 15\text{ pF (Max)}$

Table 3-9. SDIO Controller AC Timing Specifications (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 -40°C ≤ T _A ≤ +105°C for V-temp				
Param. No.	Symbol	Characteristics	Min.	Typ	Max.	Units	Conditions ⁽¹⁾
Notes:							
1. All output pins with 15 pF load							
2. The maximum clock frequency specified is limited by the SDIO Host interface internal design; actual maximum clock frequency can be lower and depends on the specific PCB layout.							

3.1.5.3 Power-on Reset AC Electrical Specifications

Table 3-10. 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	T(nRST)	External Reset valid active pulse width	3	—	—	us	—

3.1.6 WILCS02IC Radio Specifications

Table 3-11. WILCS02IC 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

3.1.6.1 WILCS02IC Receiver Performance

Table 3-12. WILCS02IC 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 -40°C ≤ T _A ≤ +105°C for V-temp			
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	—	-94	—	
		5.5 Mbps CCK	—	-93	—	
		11 Mbps CCK ⁽⁶⁾	—	-89	—	

Table 3-12. WILCS021C Receiver Performance Characteristics⁽¹⁾ (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 -40°C ≤ T _A ≤ +105°C for V-temp			
Param. No.	Characteristics	Description ⁽⁵⁾	Min.	Typ	Max.	Units
WF_RX_3	Sensitivity 802.11g	6 Mbps OFDM	—	-92	—	dBm
		9 Mbps OFDM	—	-91	—	
		12 Mbps OFDM	—	-89	—	
		18 Mbps OFDM	—	-87	—	
		24 Mbps OFDM	—	-84	—	
		36 Mbps OFDM	—	-81	—	
		48 Mbps OFDM	—	-76	—	
		54 Mbps OFDM ⁽⁶⁾	—	-75	—	
WF_RX_4	Sensitivity 802.11n (Bandwidth at 20 MHz) (Both long GI and short GI)	MCS 0	—	-90	—	dBm
		MCS 1	—	-87	—	
		MCS 2	—	-85	—	
		MCS 3	—	-82	—	
		MCS 4	—	-79	—	
		MCS 5	—	-74	—	
		MCS 6	—	-73	—	
		MCS 7 ⁽⁶⁾	—	-71	—	
WF_RX_5	Maximum receive signal level	1, 2 Mbps DSSS	-3	—	—	dBm
		5.5, 11 Mbps CCK	-3	—	—	
		6 Mbps OFDM	-3	—	—	
		54 Mbps OFDM	-7.2	—	—	
		MCS 0	-3	—	—	
		MCS 7	-7	—	—	
WF_RX_6	Adjacent channel rejection	1 Mbps DSSS (30 MHz offset)	43.5	—	—	dB
		11 Mbps CCK (25 MHz offset)	39.5	—	—	
		6 Mbps OFDM (25 MHz offset)	39.5	—	—	
		54 Mbps OFDM (25 MHz offset)	21.5	—	—	
		MCS 0 – 20 MHz Bandwidth (25 MHz offset)	38.5	—	—	
		MCS 7 – 20 MHz Bandwidth (25 MHz offset)	19.5	—	—	
WF_RX_7	RSSI accuracy	—	-5	—	5	dB

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, ISDE) 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.

3.1.6.2 WILCS02IC Transmitter Performance

Table 3-13. WILCS02IC Transmitter Performance Characteristics

RF Characteristics			Standard Operating Conditions: $V_{DD}=V_{DDIO}= 3.0V$ to $3.6V$ (unless otherwise stated)			
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ 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 CCK	—	20	—	
		11 Mbps CCK	—	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	—	—	$\pm 2^{(2)}$	—	dB
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, recertification 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.

3.1.6.3 WILCS02IC Receiver and Transmitter Characteristics Graphs

Figure 3-2. Receive Current vs Temperature, MCS7, Channel 7, 3.3V

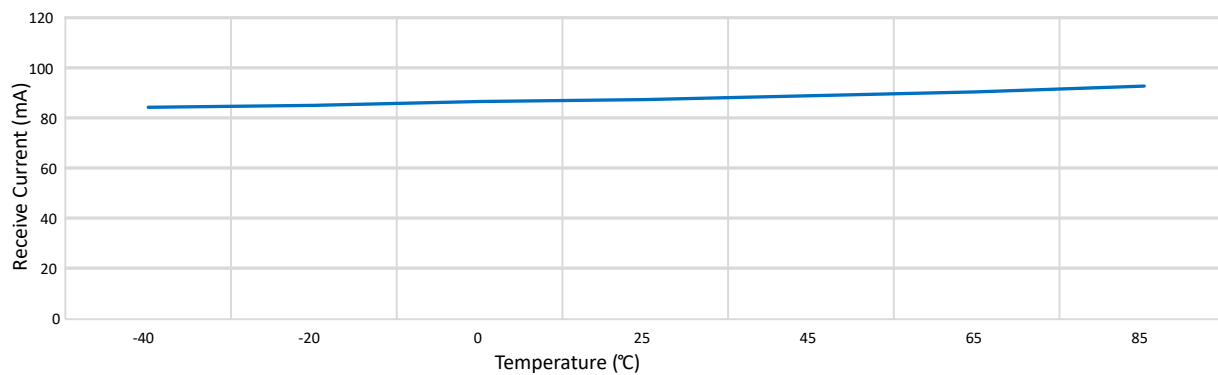


Figure 3-3. Receive Current vs Receive Signal Power, MCS7, Channel 7, 3.3V, 25°C

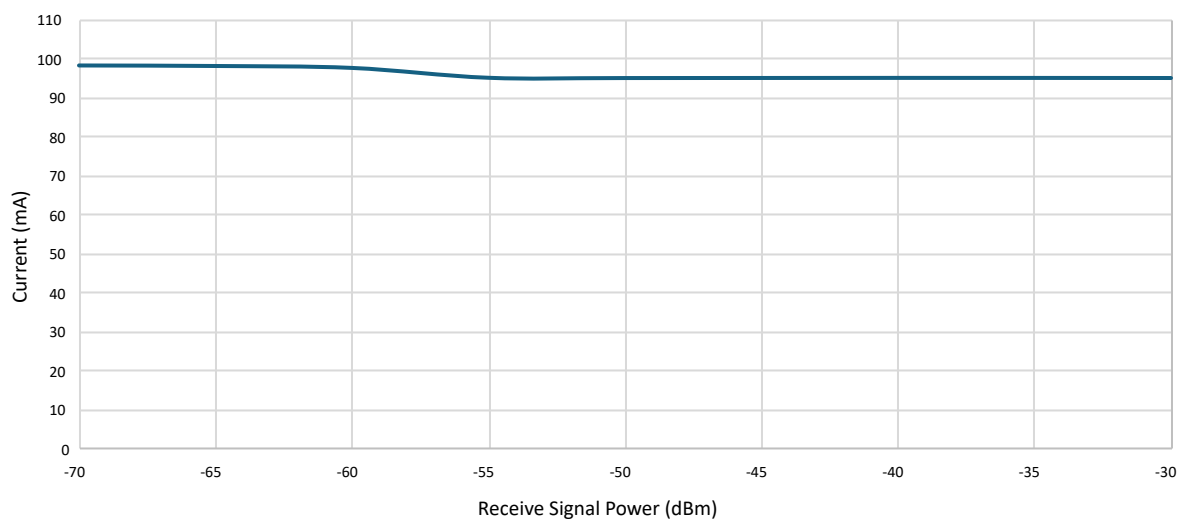


Figure 3-4. Transmit Current vs Temperature, MCS7, Channel 7, 3.3V

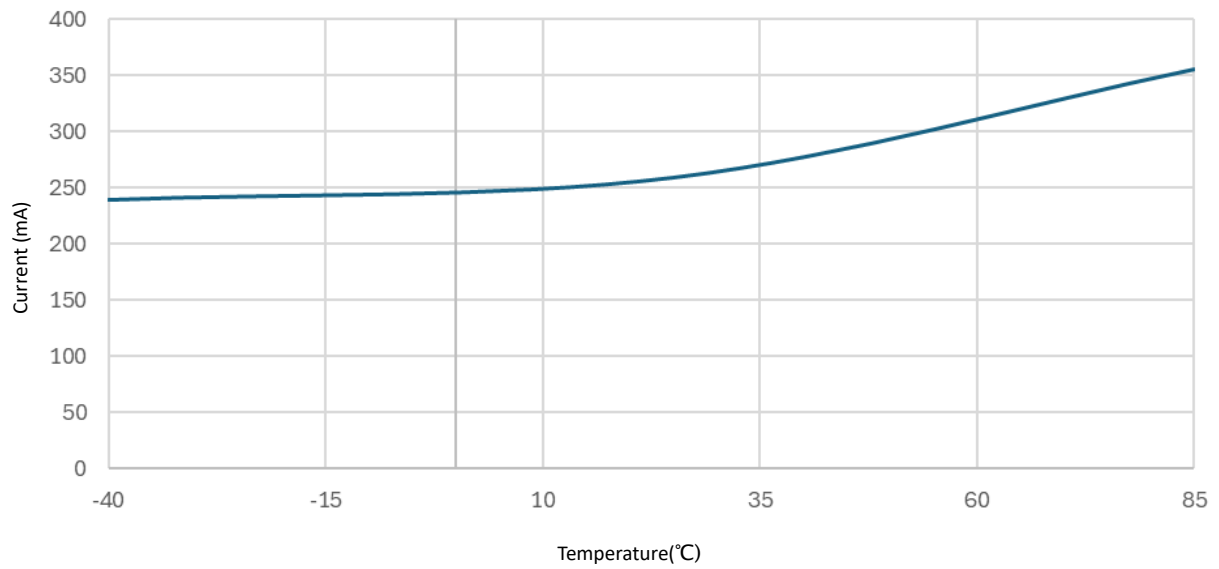


Figure 3-5. Transmit Current vs Transmit Output Power, MCS7, Channel 7, 3.3V, 25°C

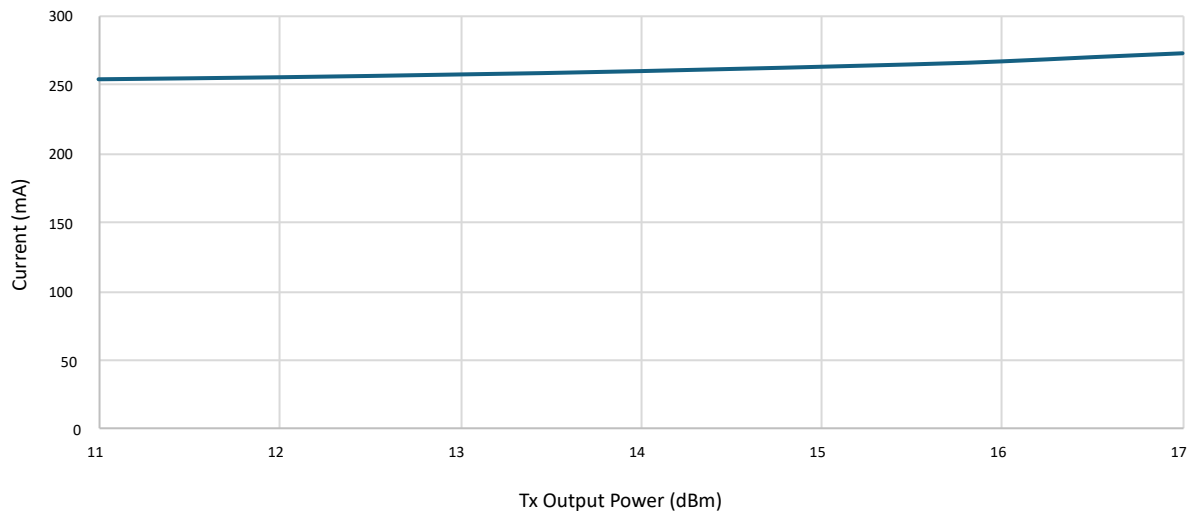


Figure 3-6. Transmit Power vs Voltage, 11b, 1Mbps, Channel 7, 25°C

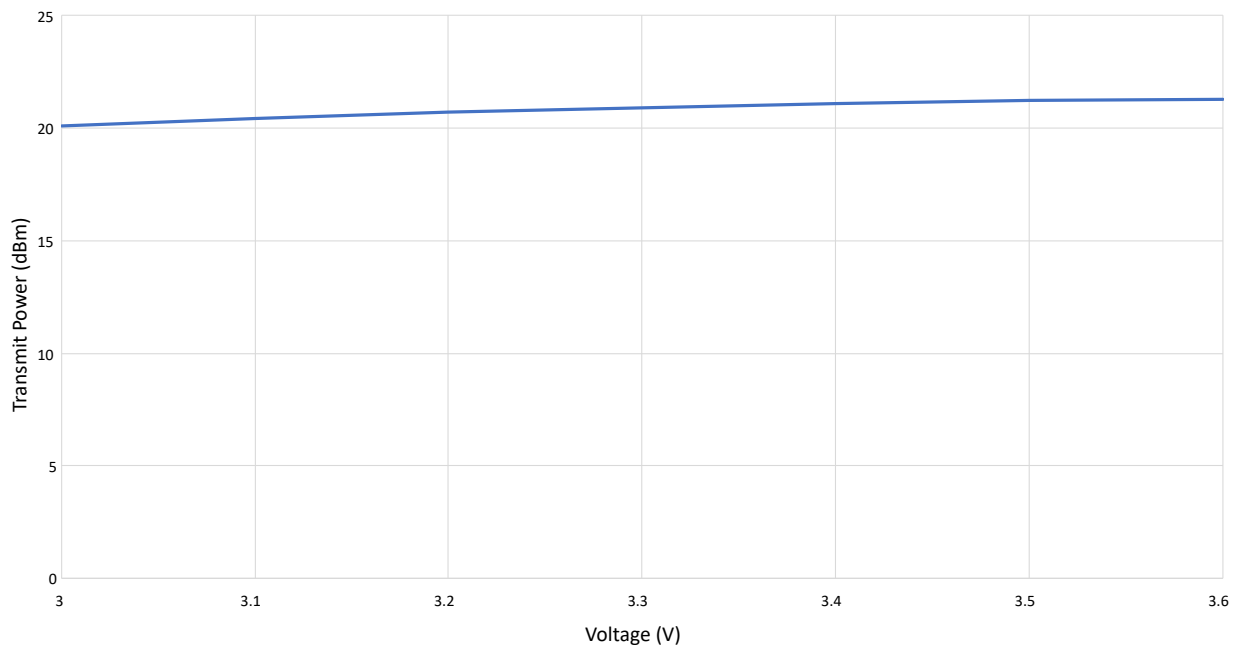


Figure 3-7. Transmit Power vs Temperature, 11b, 1Mbps, Channel 7, 3.3V, 25°C

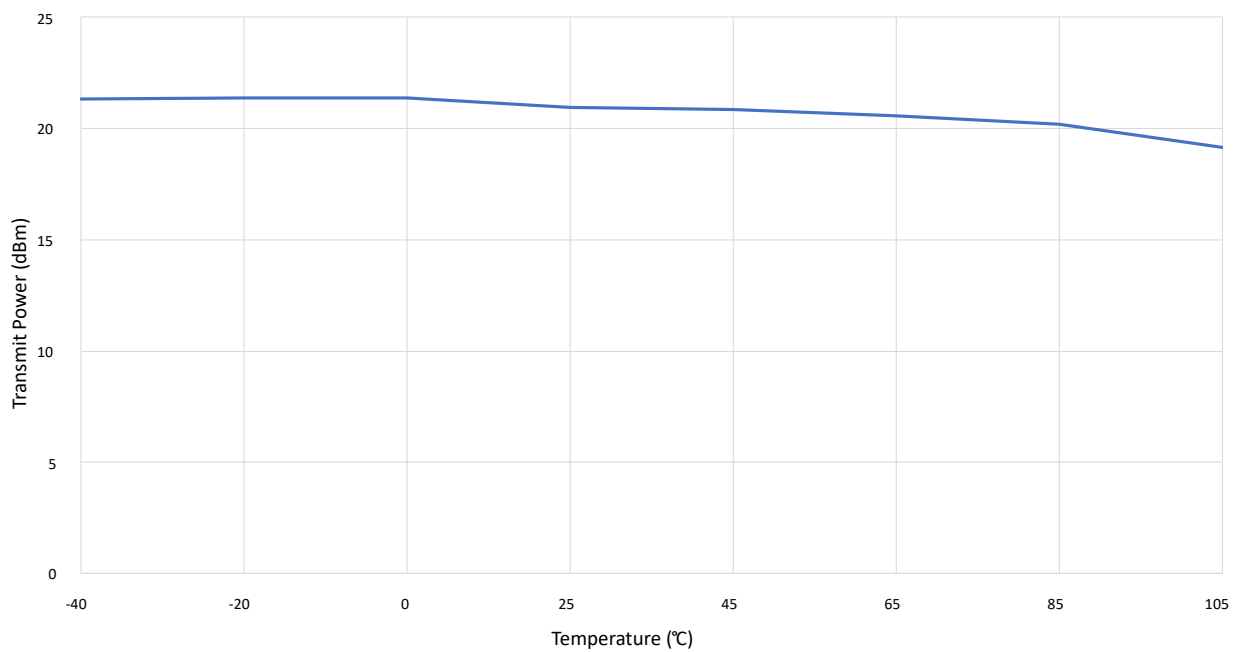


Figure 3-8. Transmit Power vs Channel, 1Mbps, 3.3V, 25°C

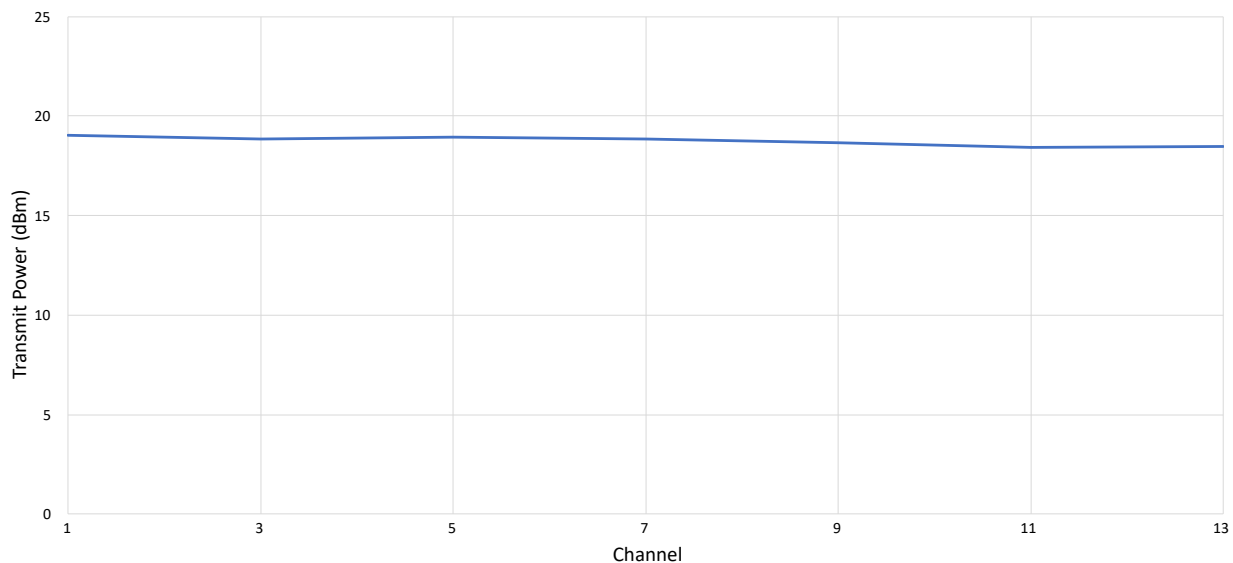


Figure 3-9. RSSI vs Received Signal Power, MCS7, Channel7, 3.3V, 25°C

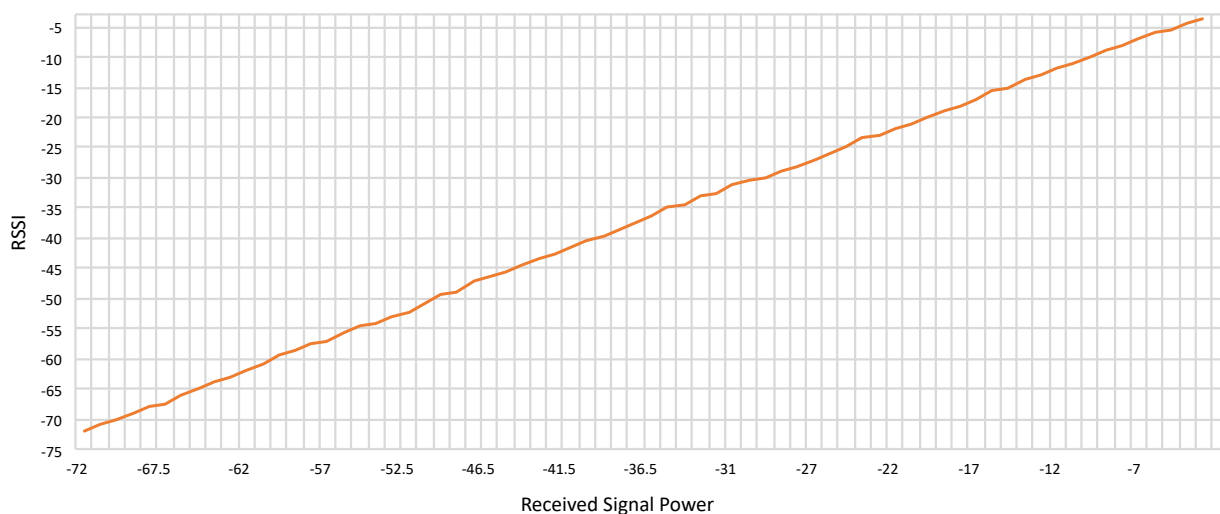


Figure 3-10. RX Sensitivity vs Channel, MCS7, 3.3V, 25°C

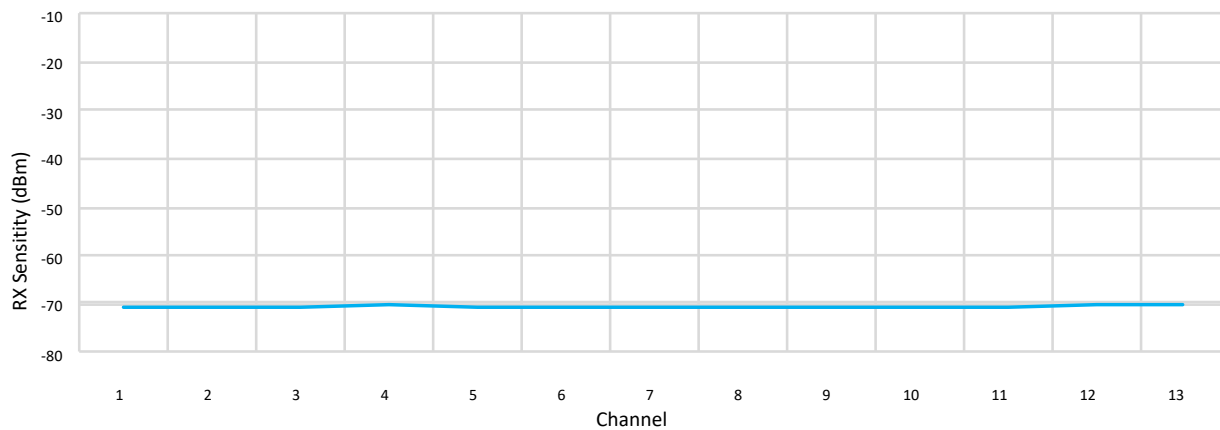
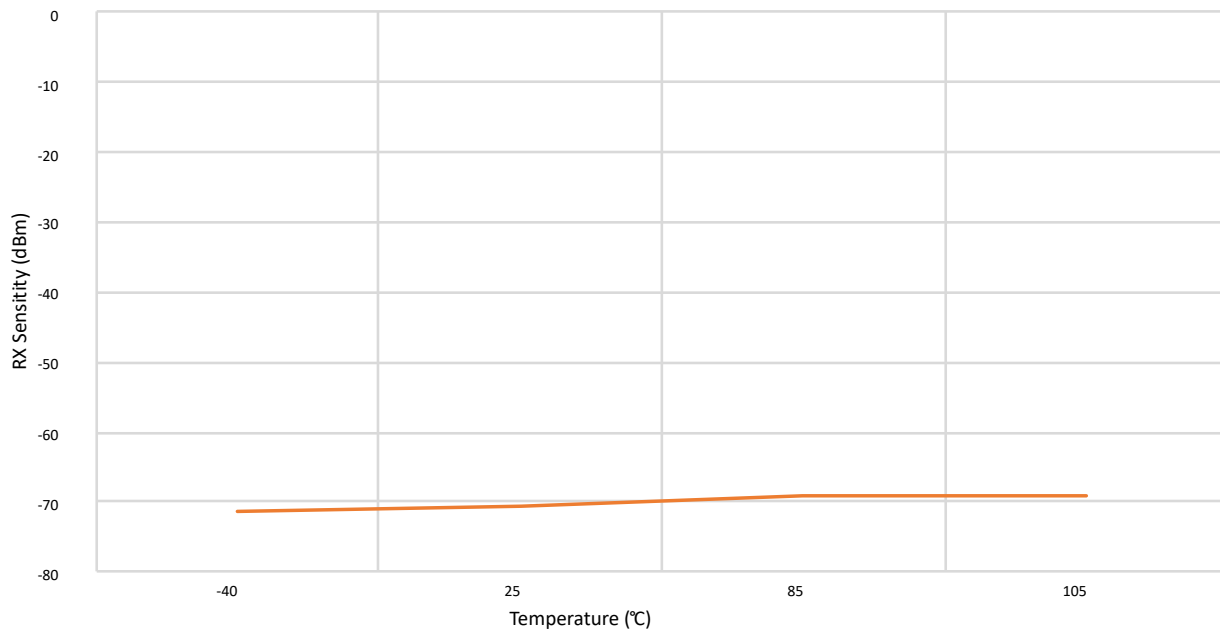


Figure 3-11. RX Sensitivity vs Temperature, MCS7, Channel 7, 3.3V



3.2 WILCS02 Module Electrical Specifications

This chapter provides the electrical specifications and the characteristics of the WILCS02 Module across the operating temperature range of the product.

3.2.1 WILCS02 Module Absolute Maximum Ratings

The following table provides details about the list of absolute maximum ratings for the WILCS02 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 3-14. 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.	

3.2.2 Thermal Specifications

Table 3-15. 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 3-16. 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	3	3.3	3.6	V	—
DC_7	GNDDB	Common EDP ground reference	V _{SS}	V _{SS}	V _{SS}	V	—

3.2.3 WILCS02 Module AC and DC Characteristics

For WILCS02 Module AC and DC Electrical Characteristics, refer to [WILCS02IC Electrical Specifications](#).

3.2.3.1 Wi-Fi® Current Consumption

Table 3-17. 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: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial				
Param. No.	Symbol	Device States	Code Rate	Output Power (Typ.) (dBm)	Current (Typ.) (mA) ⁽²⁾	Max.	Units	Conditions
IWF_TX	I_{DD}	On_Transmit	802.11b 1 Mbps ⁽⁴⁾	19	304	—	mA	$V_{DD} = V_{DDIO} = 3.3V$
			802.11b 1 Mbps ⁽⁴⁾	13	270	—		
			802.11b 11 Mbps ⁽³⁾	20	311	—		
			802.11g 6 Mbps ⁽⁴⁾	19	310	—		
			802.11g 54 Mbps ⁽³⁾	17	274	—		
			802.11n MCS0 ⁽⁴⁾	18	300	—		
			802.11n MCS7 ⁽³⁾	17	273	—		
			802.11n MCS7 ⁽⁴⁾	11	252	—		
IWF_RX	I_{DD}	On_Receive	802.11b 1 Mbps ⁽⁴⁾	—	92	—		
			802.11n MCS7 ⁽³⁾	—	98	—		

Notes:

1. Tested on channel 7 using an internal test firmware that provides manual control of data rate. In the Application mode firmware, the data rate is selected automatically based on the RSSI and other variables.
2. Data in the "Typ." column is at 3.3V, 25°C unless otherwise stated.
3. These parameters are tested in manufacturing.
4. These parameters are characterized but not tested in manufacturing.

3.2.4 WILCS02 Module Radio Specifications

Table 3-18. WILCS02 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

3.2.4.1 WILCS02 Module Receiver Performance

Table 3-19. WILCS02 Module Receiver Performance Characteristics⁽¹⁾

RF Characteristics			Standard Operating Conditions: $V_{DD}=V_{DDIO}= 3.0V$ to $3.6V$ (unless otherwise stated) Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial			
Param. No.	Characteristics	Description ⁽⁵⁾	Min.	Typ	Max.	Units
WF_RX_1	Frequency	—	2412	—	2472	MHz

Table 3-19. WILCS02 Module Receiver Performance Characteristics⁽¹⁾ (continued)

RF Characteristics			Standard Operating Conditions: $V_{DD}=V_{DDIO}= 3.0V$ to $3.6V$ (unless otherwise stated)			
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial			
Param. No.	Characteristics	Description ⁽⁵⁾	Min.	Typ	Max.	Units
WF_RX_2	Sensitivity 802.11b	1 Mbps DSSS	—	-97	—	dBm
		2 Mbps DSSS	—	-93	—	
		5.5 Mbps CCK	—	-92	—	
		11 Mbps CCK ⁽⁶⁾	—	-88	—	
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	-3	—	—	dBm
		5.5, 11 Mbps CCK	-3	—	—	
		6 Mbps OFDM	-3	—	—	
		54 Mbps OFDM	-8.5	—	—	
		MCS 0	-3	—	—	
		MCS 7	-8.5	—	—	
WF_RX_6	Adjacent channel rejection	1 Mbps DSSS (30 MHz offset)	43.5	—	—	dB
		11 Mbps CCK (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

Table 3-19. WILCS02 Module Receiver Performance Characteristics⁽¹⁾ (continued)

RF Characteristics			Standard Operating Conditions: $V_{DD}=V_{DDIO}= 3.0V$ to $3.6V$ (unless otherwise stated)			
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ 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 $3.3V$, $25^{\circ}C$, 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, ISCED) 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.						

3.2.4.2 WILCS02 Module Transmitter Performance

Table 3-20. WILCS02 Module Transmitter Performance Characteristics

RF Characteristics			Standard Operating Conditions: $V_{DD}=V_{DDIO}= 3.0V$ to $3.6V$ (unless otherwise stated)			
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ 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 CCK	—	20	—	
		11 Mbps CCK	—	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	—	—	$\pm 2^{(2)}$	—	dB

Table 3-20. WILCS02 Module Transmitter Performance Characteristics (continued)

RF Characteristics			Standard Operating Conditions: $V_{DD}=V_{DDIO}= 3.0V$ to $3.6V$ (unless otherwise stated) Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ 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 Error Vector Magnitude (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, ISSED) 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.

3.2.4.3 WILCS02 Module Receiver and Transmitter Characteristics Graphs

Figure 3-12. Receive Current vs Temperature, MCS7, Channel 7, 3.3V

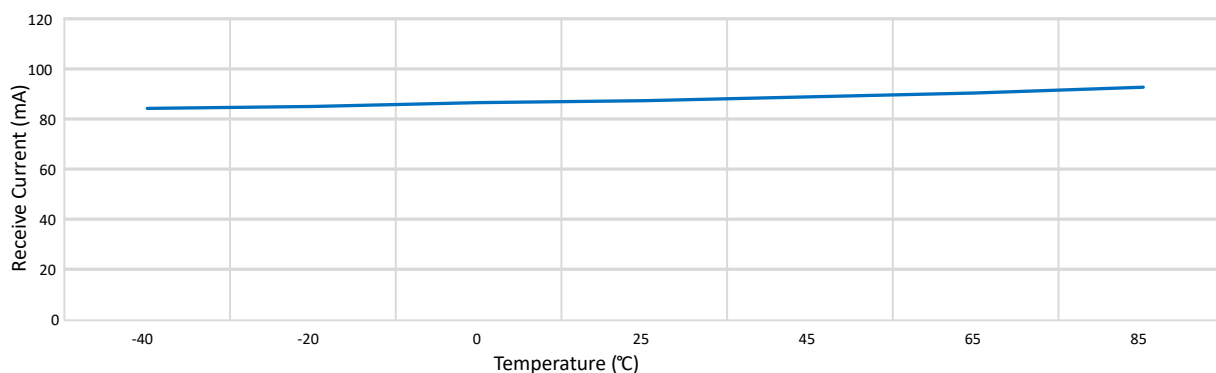


Figure 3-13. Receive Current vs Receive Signal Power, MCS7, Channel 7, 3.3V, 25°C

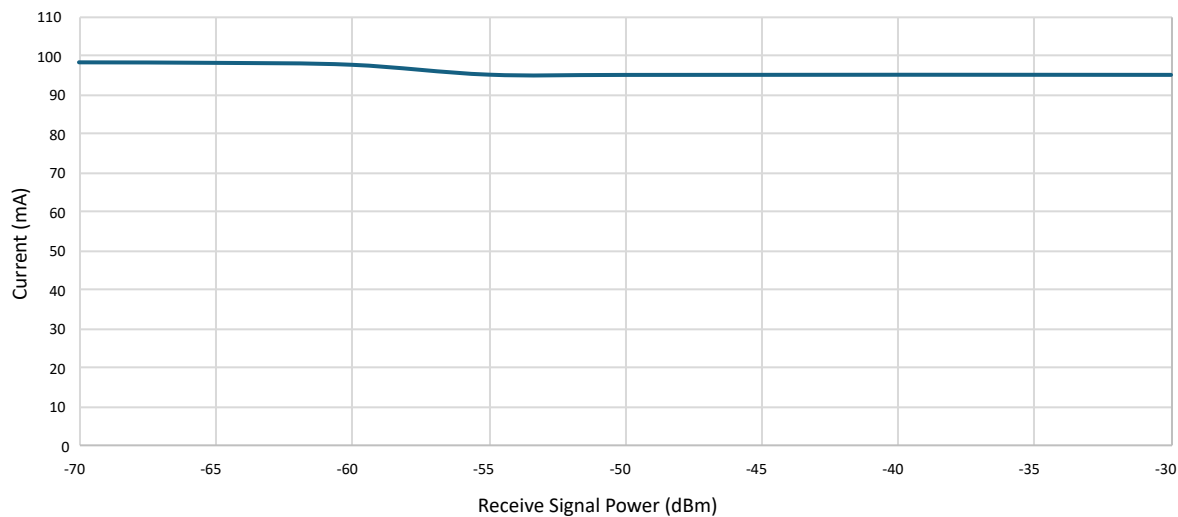


Figure 3-14. Transmit Current vs Temperature, MCS7, Channel 7, 3.3V

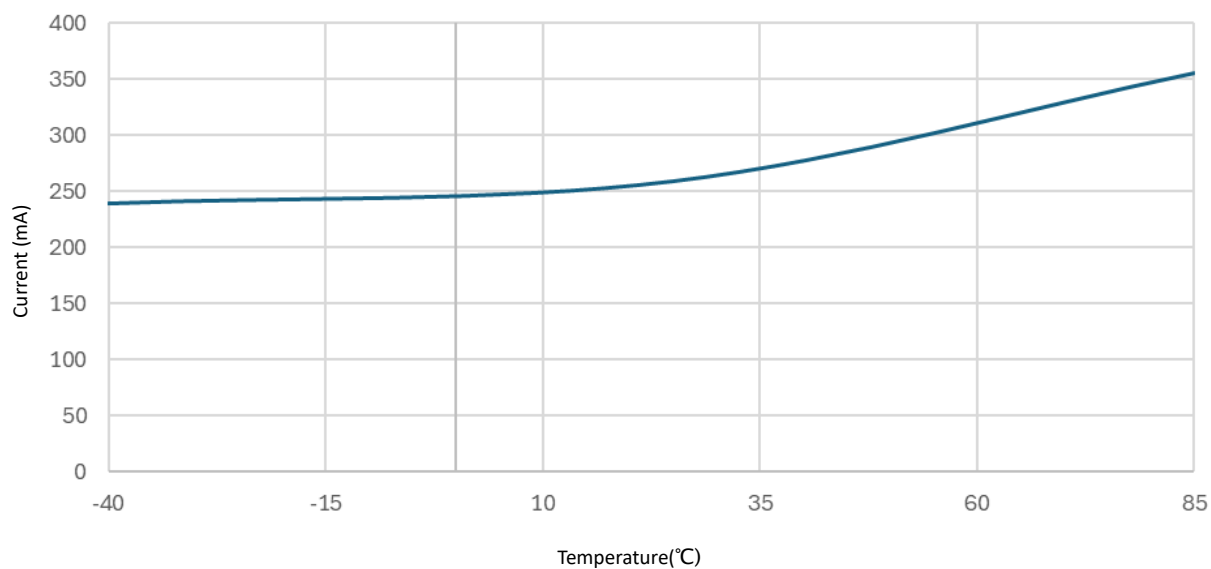


Figure 3-15. Transmit Current vs Transmit Output Power, MCS7, Channel 7, 3.3V, 25°C

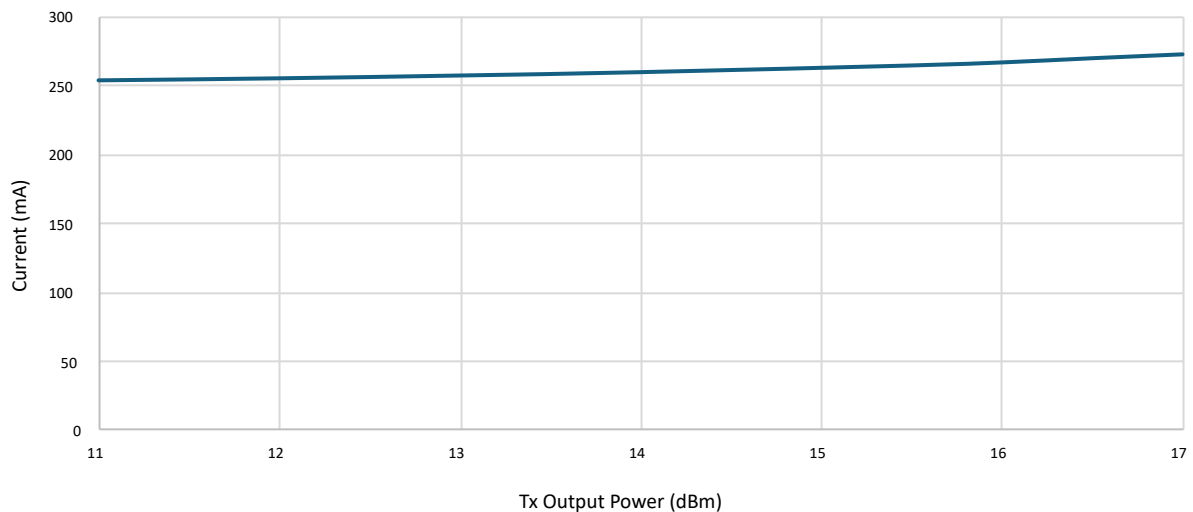


Figure 3-16. Transmit Power vs Voltage, 1M, Channel 7, 3.3V, 25°C

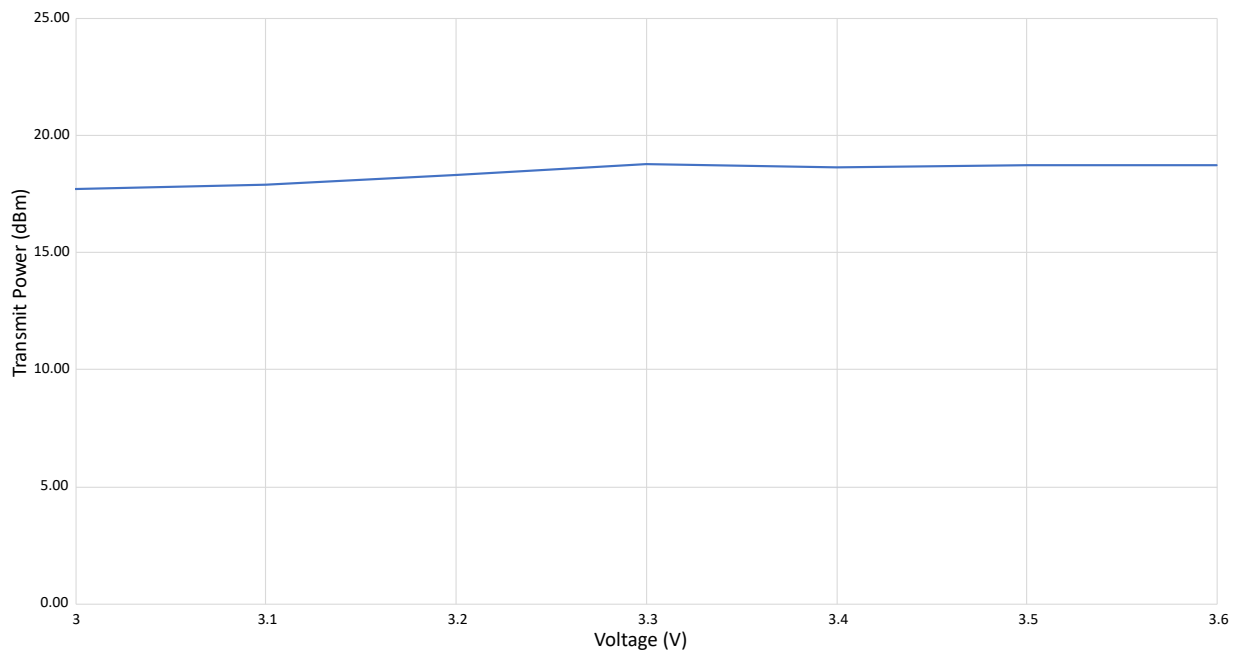


Figure 3-17. Transmit Power vs Temperature, 1M, Channel 7, 3.3V

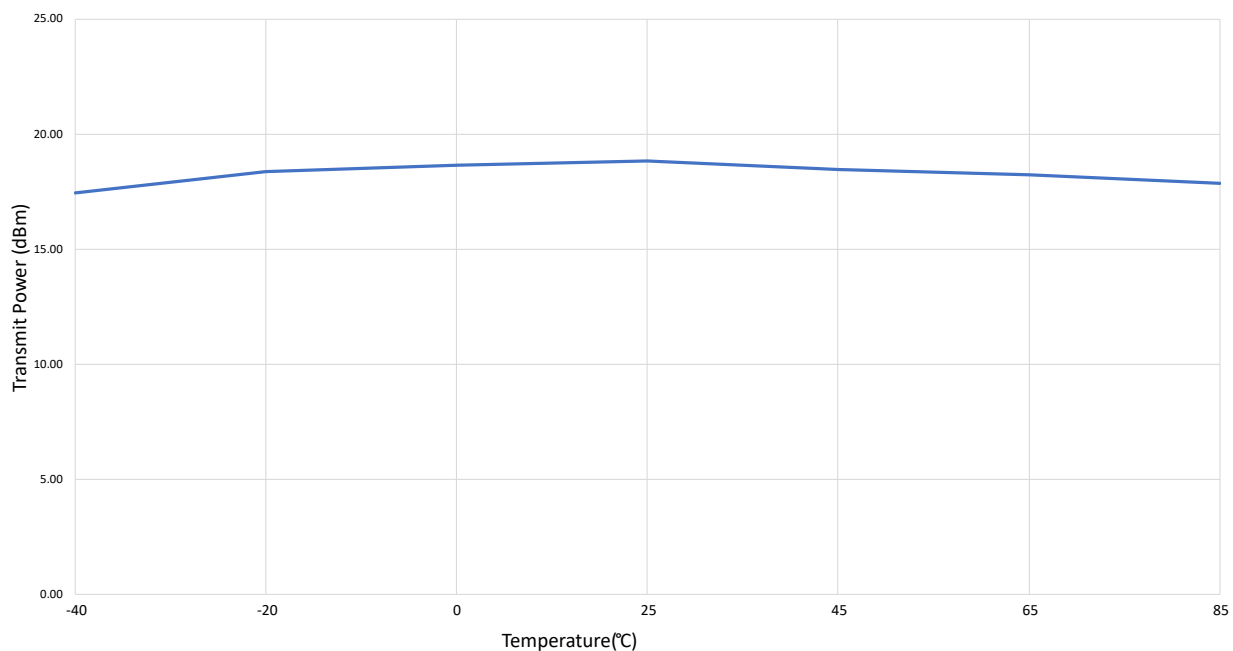


Figure 3-18. Transmit Power vs Channel, 1M, Channel 7, 3.3V, 25°C

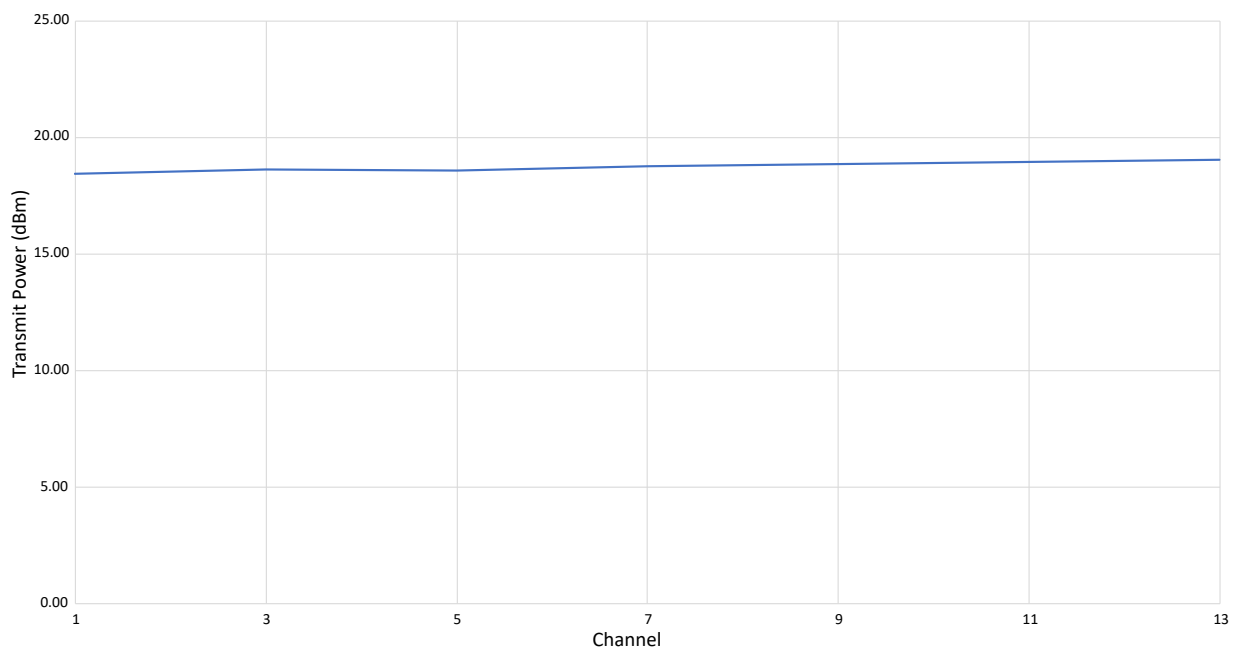


Figure 3-19. RX RSSI vs RX Input Power, MCS7, 3.3V, 25°C

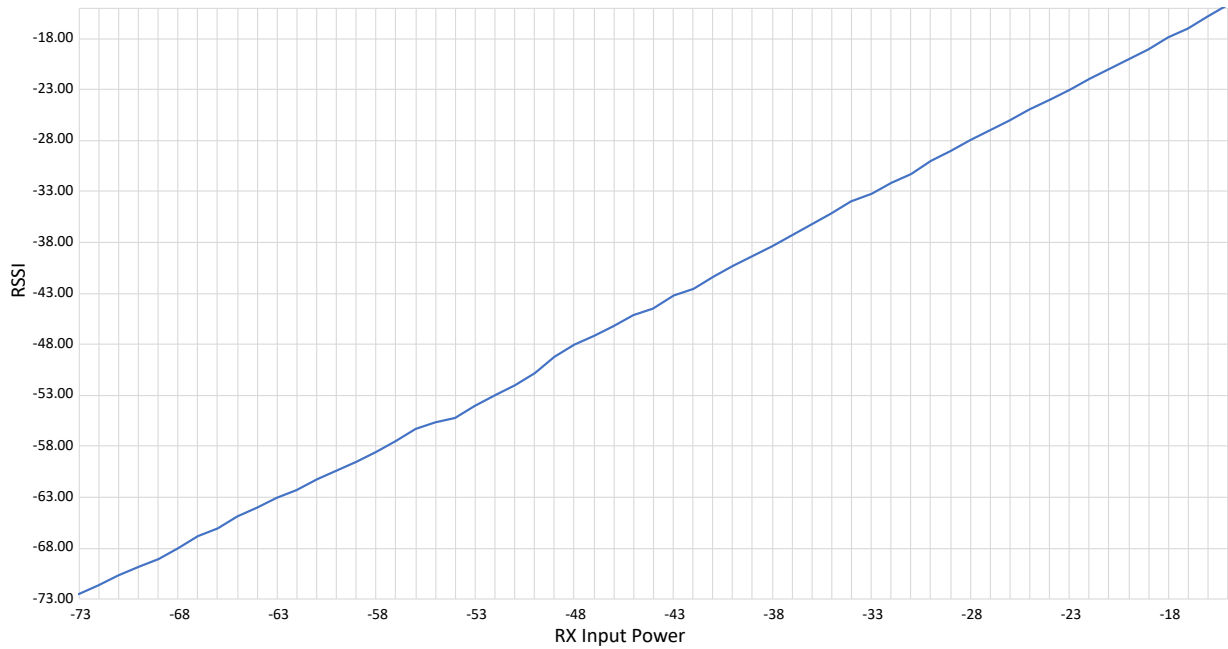


Figure 3-20. RX Sensitivity vs Channel, MCS7, 3.3V, 25°C

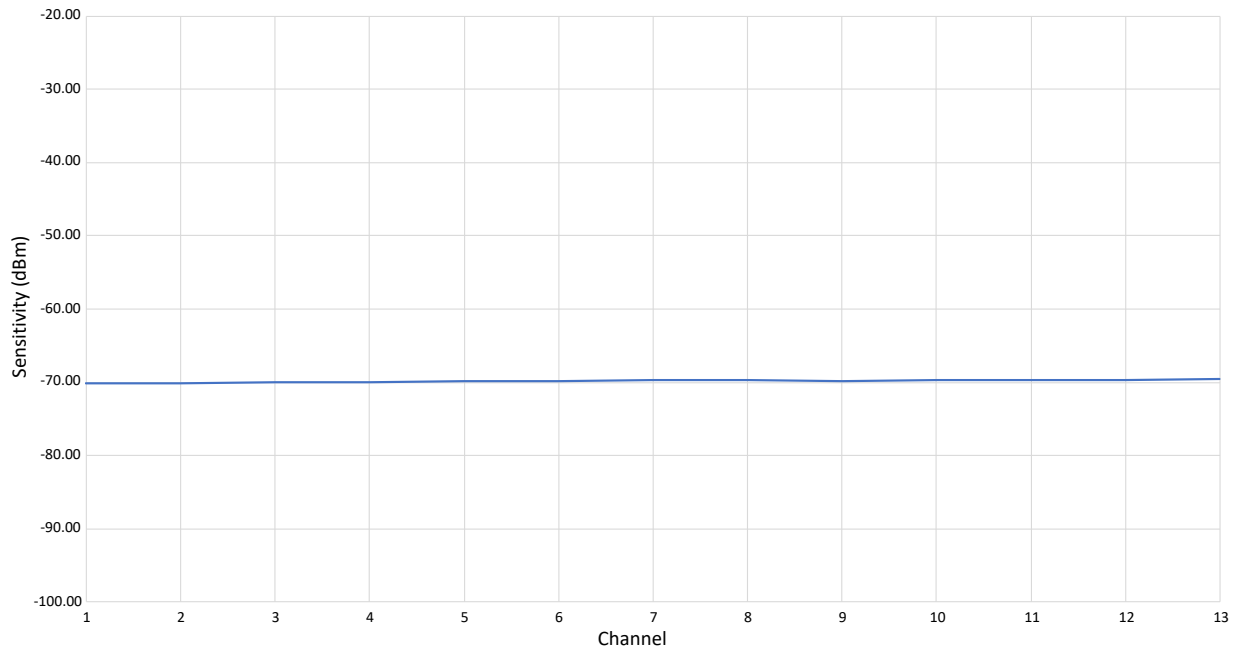


Figure 3-21. Receive Sensitivity vs Voltage, MCS7, Channel 7, 3.3V, 25°C

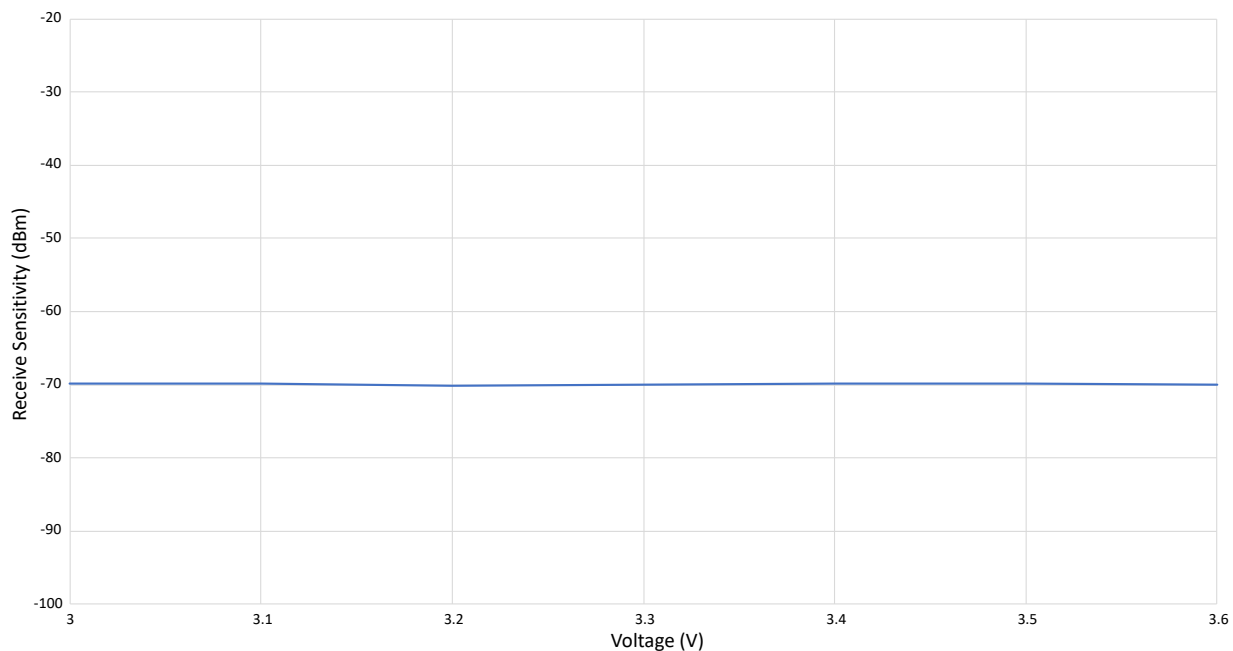
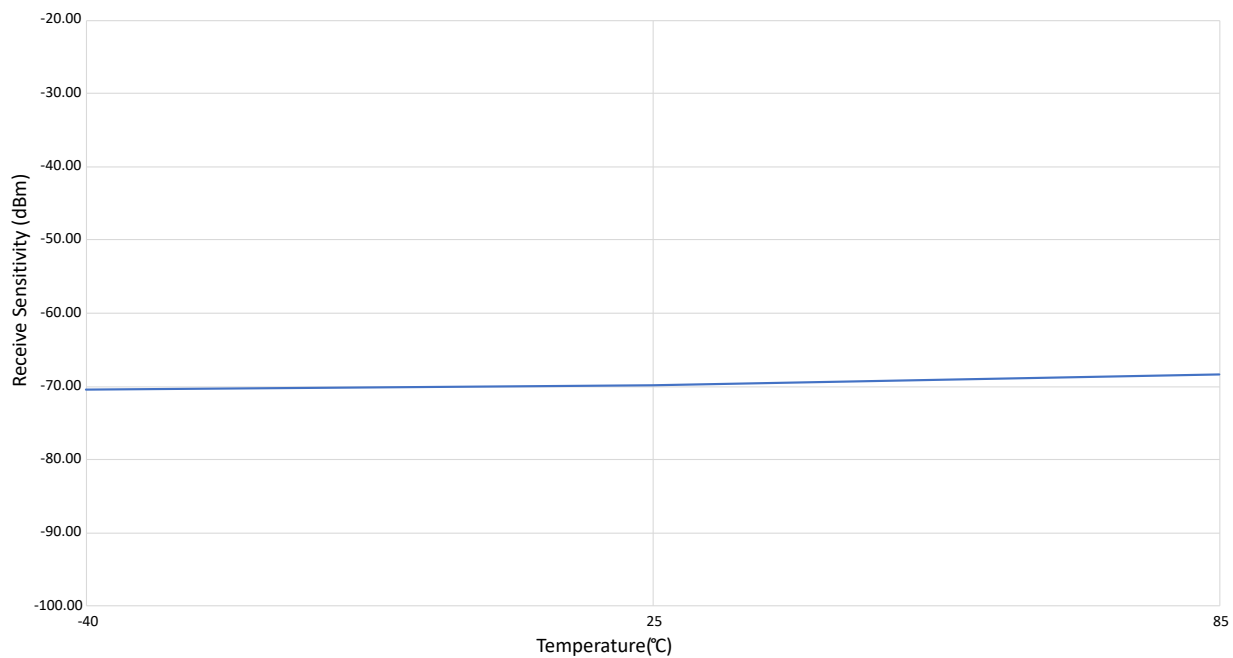


Figure 3-22. Receive Sensitivity vs Temperature, MCS7, Channel 7, 3.3V



4. Packaging Information

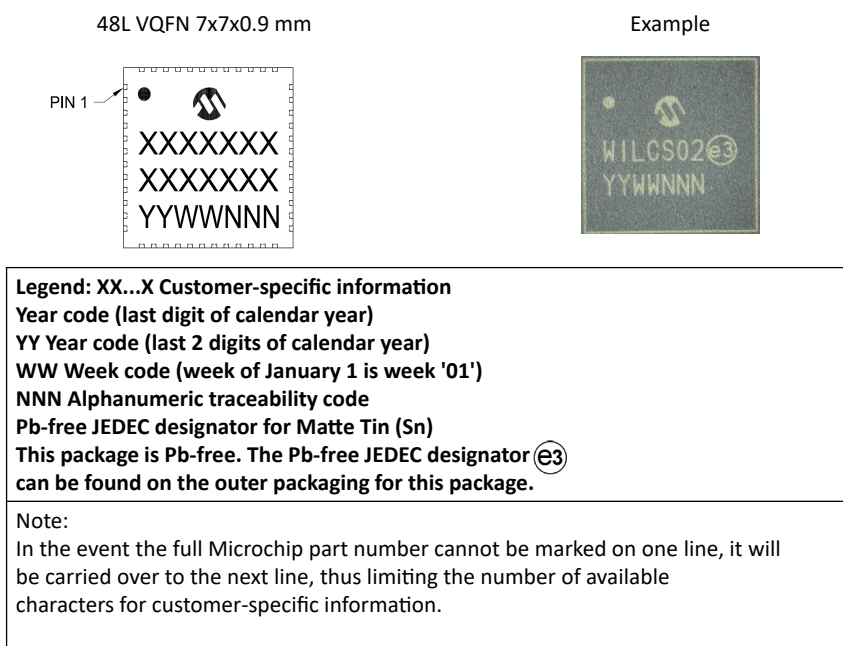
This chapter provides information on package markings, dimension and footprint of the WILCS02IC and the WILCS02 Module.

4.1 WILCS02IC Packaging Information

For the most current package drawings, see the Microchip Packaging Specification available at www.microchip.com/en-us/support/package-drawings.

4.1.1 WILCS02IC Package Marking

Figure 4-1. WILCS02IC Package Marking

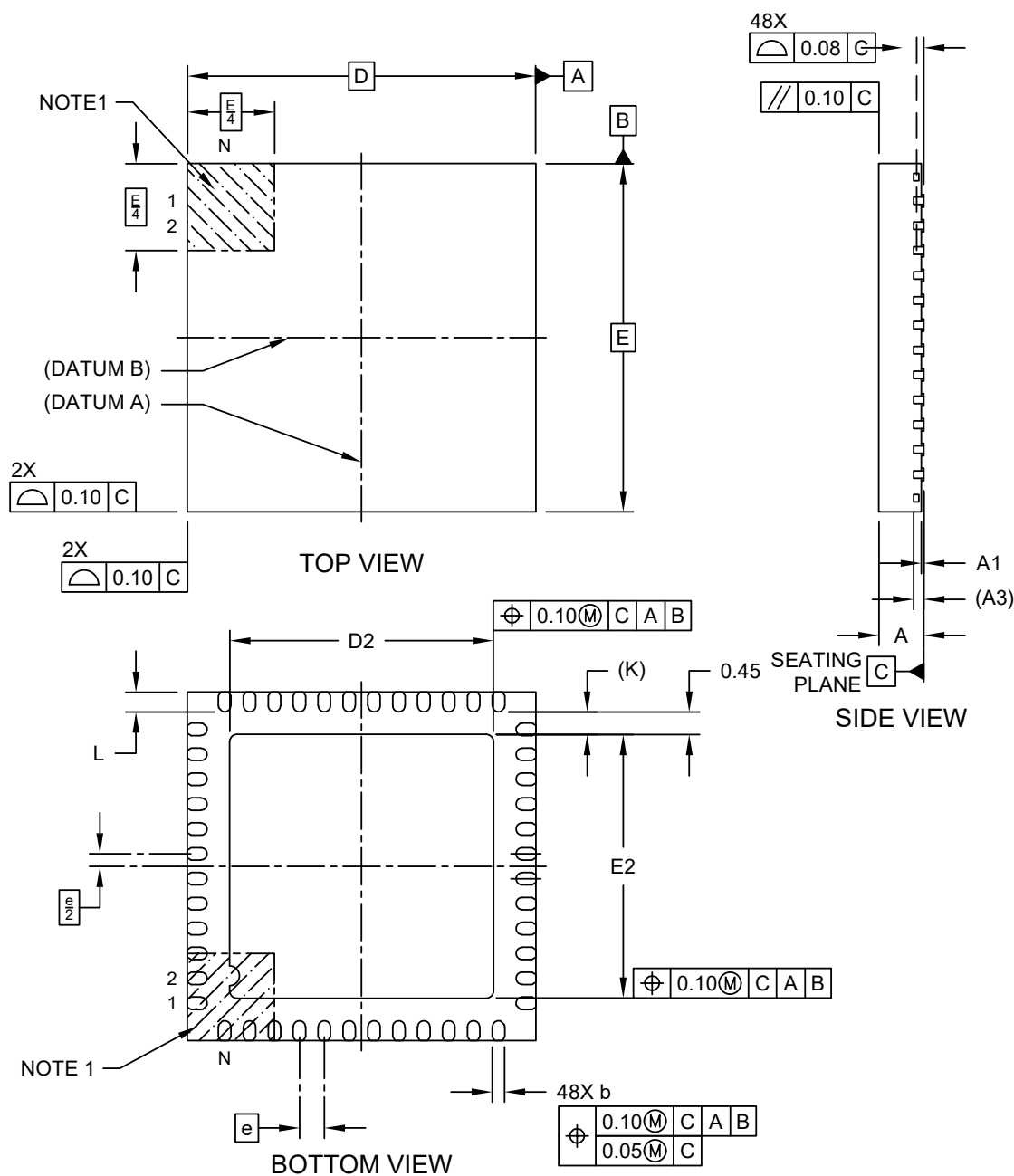


4.1.2 WILCS02IC Packaging Dimension

This section provides the package dimension details of WILCS02IC.

**48-Lead Very Thin Plastic Quad Flat, No Lead Package (ZZX) - 7x7 mm Body [VQFN]
With 5.3 mm Exposed Pad**

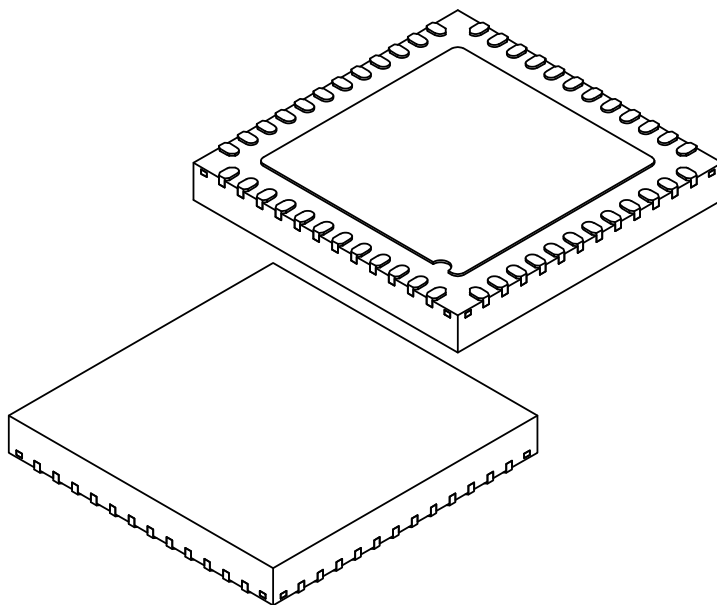
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-535 Rev A Sheet 1 of 2

48-Lead Very Thin Plastic Quad Flat, No Lead Package (ZZX) - 7x7 mm Body [VQFN] With 5.3 mm Exposed Pad

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N	48		
Pitch	e	0.50 BSC		
Overall Height	A	0.80	0.85	0.90
Standoff	A1	0.00	0.035	0.05
Terminal Thickness	A3	0.203 REF		
Overall Length	D	7.00 BSC		
Exposed Pad Length	D2	5.20	5.30	5.40
Overall Width	E	7.00 BSC		
Exposed Pad Width	E2	5.20	5.30	5.40
Terminal Width	b	0.20	0.25	0.30
Terminal Length	L	0.30	0.40	0.50
Terminal-to-Exposed-Pad	K	0.45 REF		

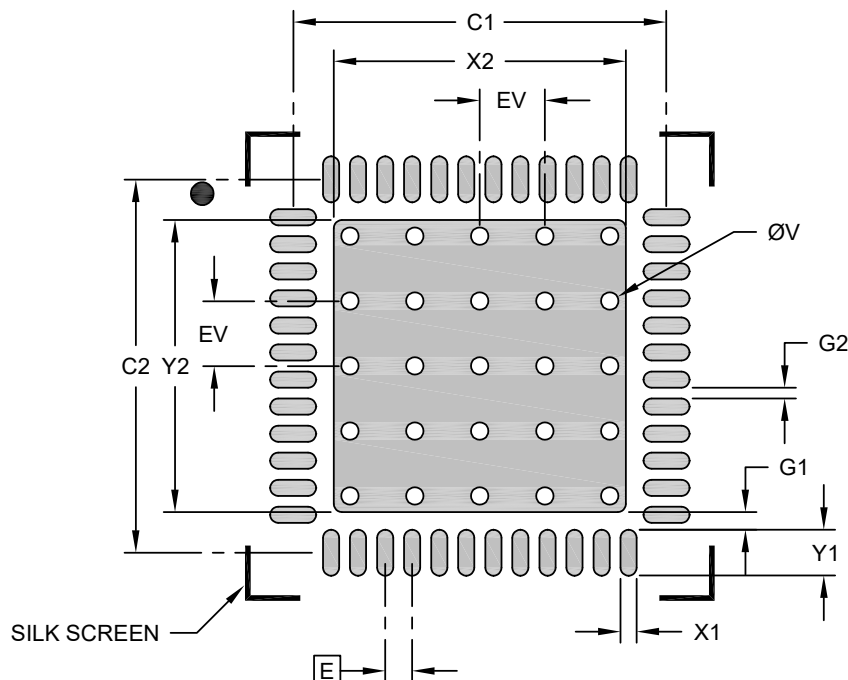
Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package is saw singulated
- Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-535 Rev A Sheet 2 of 2

48-Lead Very Thin Plastic Quad Flat, No Lead Package (ZZX) - 7x7 mm Body [VQFN] With 5.3 mm Exposed Pad

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	0.50 BSC		
Center Pad Width	X2			5.40
Center Pad Length	Y2			5.40
Contact Pad Spacing	C1		6.90	
Contact Pad Spacing	C2		6.90	
Contact Pad Width (X48)	X1			0.30
Contact Pad Length (X48)	Y1			0.85
Contact Pad to Center Pad (X48)	G1	0.33		
Contact Pad to Contact Pad (X44)	G2	0.20		
Thermal Via Diameter	V		0.33	
Thermal Via Pitch	EV		1.20	

Notes:

- Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
- For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-2535 Rev A

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4.2 WILCS02 Module Packaging Information

4.2.1 WILCS02 Module Packaging Marking

Figure 4-2. WILCS02 Module Packaging Marking



Legend:

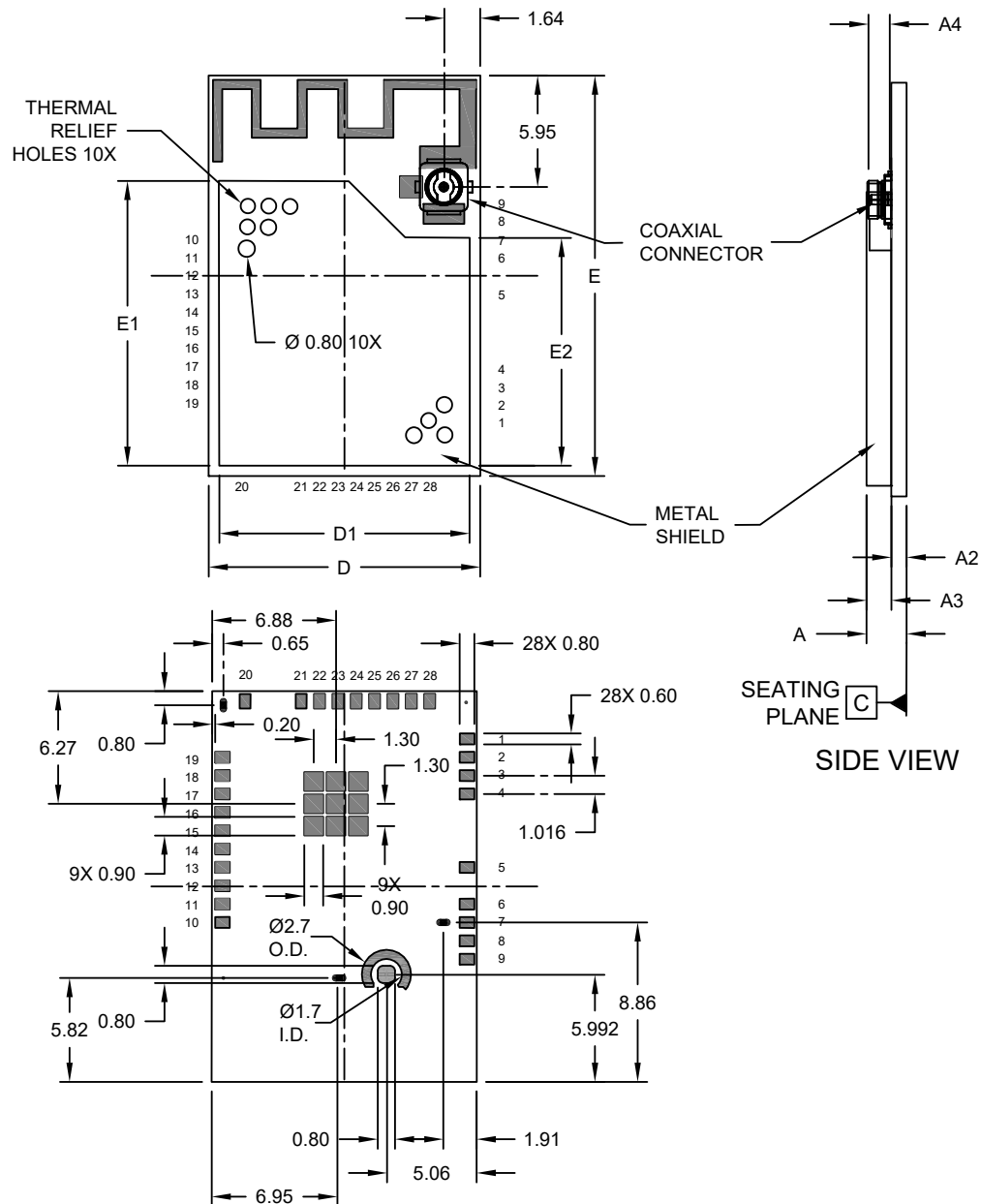
XX....X	Module part number and version and regulatory designator
YY:	Year code (last 2 digits of calendar year)
WW	Week code (week of January 1 is week "01")
NNN	Alphanumeric traceability code

4.2.2 WILCS02 Module Packaging Dimension

This section provides the package dimension details of the WILCS02 Module.

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

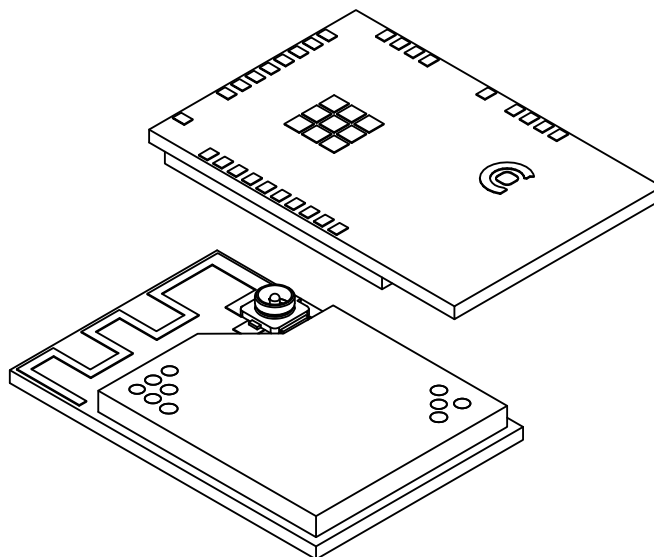
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-21567 Rev C Sheet 1 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>



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N	28		
Overall Height	A	1.90	2.10	2.30
PCB Thickness	A2	0.70	0.80	0.90
Shield Height	A3	1.30 REF		
UFL Connector Height	A4	1.25 REF		
Overall Length	D	14.73 BSC		
Overall Width	E	21.72 BSC		
Shield Length	D1	13.53	13.63	13.73
Shield Width	E1	15.36	15.46	15.56
Terminal Width	b	0.50	0.60	0.70
Terminal Length	L	0.70	0.80	0.90
Shield Width 2	E2	12.30	12.40	12.50

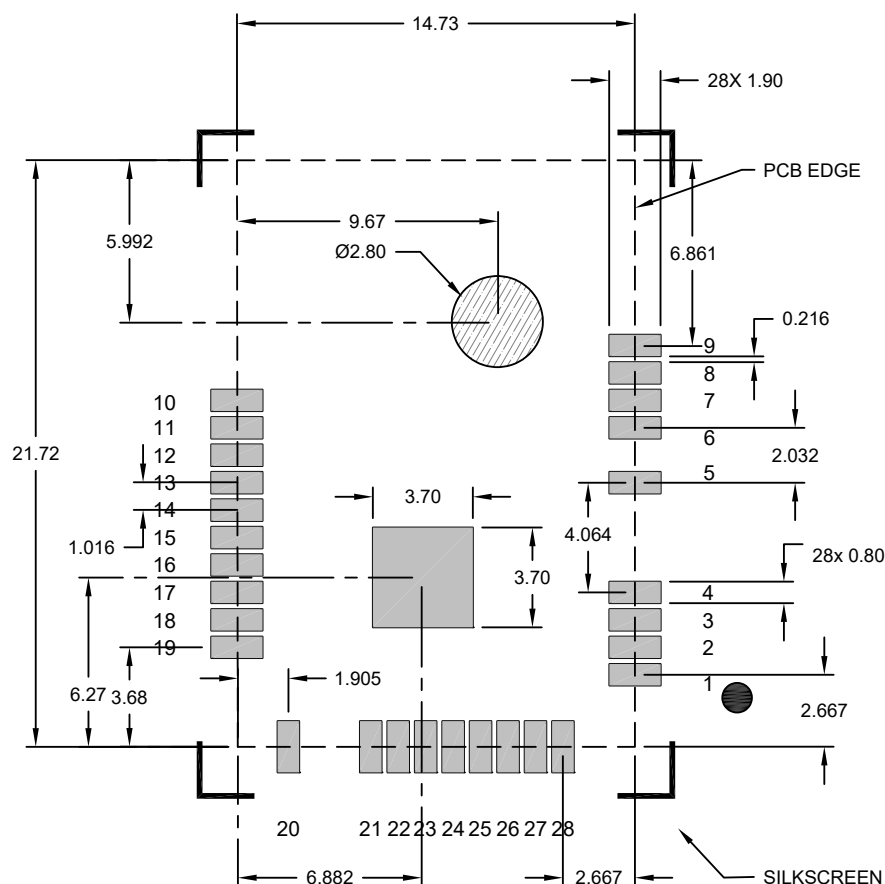
Notes:

1. All dimensions are in millimeters.

Microchip Technology Drawing C04-21567 Rev C 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 C

5. Appendix A: Regulatory Approval

The WILCS02PE module has received regulatory approval for the following countries:

- United States/FCC ID: 2ADHKWIXCS02
- Canada/ISED:
 - IC: 20266-WIXCS02
 - HVIN: WILCS02PE
 - PMN:Wireless MCU Module with IEEE® 802.11 b/g/n
- Europe/CE
- Great Britain/UKCA
- Japan/MIC: 020-240380
- Korea/KCC: R-R-mcp-WIXCS02
- Taiwan/NCC: CCAN24Y11104T0

The WILCS02UE module has received regulatory approval for the following countries:

- United States/FCC ID: 2ADHKWIXCS02U
- Canada/ISED:
 - IC: 20266-WIXCS02U
 - HVIN: WILCS02UE
 - PMN:Wireless MCU Module with IEEE® 802.11 b/g/n
- Europe/CE
- Great Britain/UKCA
- Japan/MIC: 020-240380
- Korea/KCC: R-R-mcp-WIXCS02
- Taiwan/NCC: CCAN24Y11114T3

5.1 United States

The WILCS02PE/WILCS02UE modules have received Federal Communications Commission (FCC) CFR47 Telecommunications, Part 15 Subpart C “Intentional Radiators” single-modular approval in accordance with Part 15.212 Modular Transmitter approval. Single-modular transmitter approval is defined as a complete RF transmission sub-assembly, designed to be incorporated into another device, that must demonstrate compliance with FCC rules and policies independent of any host. A transmitter with a modular grant can be installed in different end-use products (referred to as a host, host product or host device) by the grantee or other equipment manufacturer, then the host product may not require additional testing or equipment authorization for the transmitter function provided by that specific module or limited module device.

The user must comply with all of the instructions provided by the Grantee, which indicate installation and/or operating conditions necessary for compliance.

A host product itself is required to comply with all other applicable FCC equipment authorization regulations, requirements, and equipment functions that are not associated with the transmitter module portion. For example, compliance must be demonstrated: to regulations for other transmitter components within a host product; to requirements for unintentional radiators (Part 15 Subpart B), such as digital devices, computer peripherals, radio receivers, etc.; and to additional authorization requirements for the non-transmitter functions on the transmitter module (i.e., Suppliers Declaration of Conformity (SDoC) or certification) as appropriate (e.g., Bluetooth and Wi-Fi transmitter modules may also contain digital logic functions).

5.1.1 Labeling and User Information Requirements

The WILCS02PE/WILCS02UE modules have been labeled with its own FCC ID number, and if the FCC ID is not visible when the module is installed inside another device, then the outside of the finished product into which the module is installed must display a label referring to the enclosed module. This exterior label must use the following wording:

For the WILCS02PE module	Contains Transmitter Module FCC ID: 2ADHKWIXCS02 or Contains FCC ID: 2ADHKWIXCS02 This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.
For the WILCS02UE module	Contains Transmitter Module FCC ID: 2ADHKWIXCS02U or Contains FCC ID: 2ADHKWIXCS02U This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The user's manual for the finished product must include the following statement:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures: • Reorient or relocate the receiving antenna • Increase the separation between the equipment and receiver • Connect the equipment into an outlet on a circuit different from that to which the receiver is connected • Consult the dealer or an experienced radio/TV technician for help

Additional information on labeling and user information requirements for Part 15 devices can be found in KDB Publication 784748, which is available at the FCC Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB) apps.fcc.gov/oetcf/kdb/index.cfm.

5.1.2 RF Exposure

All transmitters regulated by FCC must comply with RF exposure requirements. KDB 447498 General RF Exposure Guidance provides guidance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to Radio Frequency (RF) fields adopted by the Federal Communications Commission (FCC).

From the FCC Grant: Output power listed is conducted. This grant is valid only when the module is sold to OEM integrators and must be installed by the OEM or OEM integrators. This transmitter is restricted for use with the specific antenna(s) tested in this application for Certification and must not be co-located or operating in conjunction with any other antenna or transmitters within a host device, except in accordance with FCC multi-transmitter product procedures.

WILCS02PE/WILCS02UE: These modules are approved for installation into mobile or/and portable host platforms.

5.1.3 Approved Antenna Types

To maintain modular approval in the United States, only the tested antenna types are used. It is permissible to use different antenna, provided the same antenna type, antenna gain (equal to or

less than), with similar in-band and out-of band characteristics (refer to specification sheet for cutoff frequencies).

For the WILCS02PE, the approval is received using the integral PCB antenna.

For the WILCS02UE, approved antennas are listed in the [WILCS02 Module Approved External Antenna](#).

5.1.4 Helpful Web Sites

- Federal Communications Commission (FCC): www.fcc.gov.
- FCC Office of Engineering and Technology (OET) Laboratory Division Knowledge Database (KDB) apps.fcc.gov/oetcf/kdb/index.cfm.

5.2 Canada

The WILCS02PE/WILCS02UE modules have been certified for use in Canada under Innovation, Science and Economic Development Canada (ISED, formerly Industry Canada) Radio Standards Procedure (RSP) RSP-100, Radio Standards Specification (RSS) RSS-Gen and RSS-247. Modular approval permits the installation of a module in a host device without the need to recertify the device.

5.2.1 Labeling and User Information Requirements

Labeling Requirements (from RSP-100 - Issue 12, Section 5): The host product shall be properly labeled to identify the module within the host device.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host device; otherwise, the host product must be labeled to display the Innovation, Science and Economic Development Canada certification number of the module, preceded by the word "Contains" or similar wording expressing the same meaning, as follows:

For the WILCS02PE module	Contains IC: 20266-WIXCS02
For the WILCS02UE module	Contains IC: 20266-WIXCS02U

User Manual Notice for License-Exempt Radio Apparatus (from Section 8.4 RSS-Gen, Issue 5, February 2021): User manuals for license-exempt radio apparatus shall contain the following or equivalent notice in a conspicuous location in the user manual or alternatively on the device or both:

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

(1) This device may not cause interference;

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

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

1. L'appareil ne doit pas produire de brouillage;

2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Transmitter Antenna (From Section 6.8 RSS-GEN, Issue 5, February 2021): User manuals, for transmitters shall display the following notice in a conspicuous location:

This radio transmitter IC: 20266-WIXCS02 and IC: 20266-WIXCS02U have been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.

Le présent émetteur radio IC: 20266-WIXCS02 and IC: 20266-WIXCS02U a été approuvé par Innovation, Sciences et Développement économique Canada pour fonctionner avec les types d'antenne énumérés cidessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué pour tout type figurant sur la liste, sont strictement interdits pour l'exploitation de l'émetteur.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi) and required impedance for each.

5.2.2 RF Exposure

All transmitters regulated by Innovation, Science and Economic Development Canada (ISED) must comply with RF exposure requirements listed in RSS-102 - Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands).

This transmitter is restricted for use with a specific antenna tested in this application for certification, and must not be co-located or operating in conjunction with any other antenna or transmitters within a host device, except in accordance with Canada multi-transmitter product procedures.

WILCS02PE/WILCS02UE: The device operates at an output power level which is within the ISED SAR test exemption limits at any user distance.

Exposition aux RF

Tous les émetteurs réglementés par Innovation, Sciences et Développement économique Canada (ISDE) doivent se conformer à l'exposition aux RF. exigences énumérées dans RSS-102 - Conformité à l'exposition aux radiofréquences (RF) des appareils de radiocommunication (toutes les bandes de fréquences).

Cet émetteur est limité à une utilisation avec une antenne spécifique testée dans cette application pour la certification, et ne doit pas être colocalisé ou fonctionner conjointement avec une autre antenne ou émetteur au sein d'un appareil hôte, sauf conformément avec les procédures canadiennes relatives aux produits multi-transmetteurs.

Les appareils fonctionnent à un niveau de puissance de sortie qui se situe dans les limites du DAS ISED. tester les limites d'exemption à toute distance d'utilisateur supérieure à 20 cm.

5.2.3 Approved Antenna Types

For the WILCS02PE, approval was received using the integral PCB antenna.

For the WILCS02UE, approved antennas are listed in the [WILCS02 Module Approved External Antenna](#).

5.2.4 Helpful Web Sites

Innovation, Science and Economic Development Canada (ISED): www.ic.gc.ca/.

5.3 Europe

The WILCS02PE/WILCS02UE modules are a Radio Equipment Directive (RED) assessed radio module that is CE marked and has been manufactured and tested with the intention of being integrated into a final product.

The WILCS02PE/WILCS02UE modules have been tested to RED 2014/53/EU Essential Requirements mentioned in the following European Compliance table.

Table 5-1. European Compliance Information

Certification	Standard	Article
Safety	EN 62368	3.1a
Health	EN 62311	
EMC	EN 301 489-1	3.1b
	EN 301 489-17	
Radio	EN 300 328	3.2

The ETSI provides guidance on modular devices in the *“Guide to the application of harmonised standards covering articles 3.1b and 3.2 of the RED 2014/53/EU (RED) to multi-radio and combined radio and non-radio equipment”* document available at http://www.etsi.org/deliver/etsi_eg/203300_203399/20_3367/01.01.01_60/eg_203367v010101p.pdf.

Note: To maintain conformance to the standards listed in the preceding European Compliance table, the module shall be installed in accordance with the installation instructions in this data sheet and shall not be modified. When integrating a radio module into a completed product, the integrator becomes the manufacturer of the final product and is therefore responsible for demonstrating compliance of the final product with the essential requirements against the RED.

5.3.1 Labeling and User Information Requirements

The label on the final product that contains the WILCS02PE/WILCS02UE modules must follow CE marking requirements.

5.3.2 Conformity Assessment

From ETSI Guidance Note EG 203367, section 6.1, when non-radio products are combined with a radio product:

If the manufacturer of the combined equipment installs the radio product in a host non-radio product in equivalent assessment conditions (i.e. host equivalent to the one used for the assessment of the radio product) and according to the installation instructions for the radio product, then no additional assessment of the combined equipment against article 3.2 of the RED is required.

5.3.2.1 Simplified EU Declaration of Conformity

Hereby, Microchip Technology Inc. declares that the radio equipment type WILCS02PE/WILCS02UE modules are in compliance with Directive 2014/53/EU.

The full text of the EU declaration of conformity, for this product, is available at www.microchip.com/design-centers/wireless-connectivity/.

5.3.3 Approved Antenna Types

For the WILCS02PE, approval was received using the integral PCB antenna.

For the WILCS02UE, approved antennas are listed in the [WILCS02 Module Approved External Antenna](#).

5.3.4 Helpful Websites

A document that can be used as a starting point in understanding the use of Short Range Devices (SRD) in Europe is the European Radio Communications Committee (ERC) Recommendation 70-03 E, which can be downloaded from the European Communications Committee (ECC) at: docdb.cept.org/.

Additional helpful web sites are:

- Radio Equipment Directive (2014/53/EU): https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/red_en
- European Conference of Postal and Telecommunications Administrations (CEPT):

<http://www.cept.org>

- European Telecommunications Standards Institute (ETSI):
<http://www.etsi.org>
- The Radio Equipment Directive Compliance Association (REDCA):
<http://www.redca.eu/>

5.4 Japan

The WILCS02PE/WILCS02UE modules have received type certification and is required to be labeled with its own technical conformity mark and certification number as required to conform to the technical standards regulated by the Ministry of Internal Affairs and Communications (MIC) of Japan pursuant to the Radio Act of Japan.

Integration of this module into a final product does not require additional radio certification provided installation instructions are followed and no modifications of the module are allowed. Additional testing may be required:

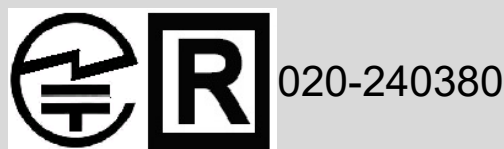
- If the host product is subject to electrical appliance safety (for example, powered from an AC mains), the host product may require Product Safety Electrical Appliance and Material (PSE) testing. The integrator should contact their conformance laboratory to determine if this testing is required
- There is an voluntary Electromagnetic Compatibility (EMC) test for the host product administered by VCCI: www.vcci.jp/vcci_e/index.html

5.4.1 Labeling and User Information Requirements

The label on the final product which contains the WILCS02PE/WILCS02UE module(s) must follow Japan marking requirements. The integrator of the module should refer to the labeling requirements for Japan available at the Ministry of Internal Affairs and Communications (MIC) website.

For the WILCS02PE/WILCS02UE modules, due to a limited module size, the technical conformity logo and ID is displayed in the data sheet and/or packaging and cannot be displayed on the module label. The final product in which this module is being used must have a label referring to the type certified module inside:

WILCS02PE/WILCS02UE module



5.4.2 Helpful Web Sites

- Ministry of Internal Affairs and Communications (MIC): www.tele.soumu.go.jp/e/index.htm.
- Association of Radio Industries and Businesses (ARIB): www.arib.or.jp/english/.

5.5 Korea

The WILCS02PE/WILCS02UE modules have received certification of conformity in accordance with the Radio Waves Act. Integration of this module into a final product does not require additional radio certification provided installation instructions are followed and no modifications of the module are allowed.

5.5.1 Labeling and User Information Requirements

The label on the final product which contains the WILCS02PE/WILCS02UE module(s) must follow KC marking requirements. The integrator of the module should refer to the labeling requirements for Korea available on the Korea Communications Commission (KCC) website.

The WILCS02PE/WILCS02UE modules are labeled with its own KC mark. The final product requires the KC mark and certificate number of the module:

WILCS02PE/WILCS02UE module



R-R-mcp-WIXCS02

5.5.2 Helpful Websites

- Korea Communications Commission (KCC): www.kcc.go.kr.
- National Radio Research Agency (RRA): rra.go.kr.

5.6 Taiwan

The WILCS02PE/WILCS02UE modules have received compliance approval in accordance with the Telecommunications Act. Customers seeking to use the compliance approval in their product should contact Microchip Technology sales or distribution partners to obtain a Letter of Authority.

Integration of this module into a final product does not require additional radio certification provided installation instructions are followed and no modifications of the module are allowed.

5.6.1 Labeling and User Information Requirements

For the WILCS02PE/WILCS02UE modules, due to the limited module size, the NCC mark and ID are displayed in the data sheet only and cannot be displayed on the module label:

WILCS02PE module



CCAN24Y11104T0

WILCS02UE module



CCAN24Y11114T3

The user's manual should contain following warning (for RF device) in traditional Chinese:

根據 NCC LP0002 低功率射頻器材技術規範_章節 3.8.2:

取得審驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。

低功率射頻器材之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。

前述合法通信，指依電信管理法規定作業之無線電通信。

低功率射頻器材須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。

此模組於取得認證後將依規定於模組本體標示審驗合格標籤，並要求平台廠商於平台上標示本產品內含發射器模組

5.6.2 Helpful Web Sites

National Communications Commission (NCC): www.ncc.gov.tw

5.7 UKCA (UK Conformity Assessed)

The WILCS02PE/WILCS02UE Module is a UK conformity assessed radio module that meets all the essential requirements according to CE RED requirements.

5.7.1 Labeling Requirements for Module and User's Requirements

The label on the final product that contains the WILCS02PE/WILCS02UE Module must follow UKCA marking requirements.



The UKCA mark above is printed on the module itself or on the packing label.

Additional details for the label requirement are available at:

<https://www.gov.uk/guidance/using-the-ukca-marking#check-whether-you-need-to-use-the-new-ukca-marking>.

5.7.2 UKCA Declaration of Conformity

Hereby, Microchip Technology Inc. declares that the radio equipment type the WILCS02PE/ WILCS02UE modules are in compliance with the Radio Equipment Regulations 2017. The full text of the UKCA declaration of conformity for this product is available (under *Documents > Certifications*) at: www.microchip.com/en-us/product/WILCS02.

5.7.3 Approved Antennas

The testing of the WILCS02PE/WILCS02UE Module was performed with the antennas listed in [WILCS02 Module Approved External Antenna](#).

5.7.4 Helpful Websites

For more information on the UKCA regulatory approvals, refer to the www.gov.uk/guidance/placing-manufactured-goods-on-the-market-in-great-britain.

5.8 Other Regulatory Information

- For information about other countries' jurisdictions not covered here, refer to the www.microchip.com/design-centers/wireless-connectivity/certifications.
- Should other regulatory jurisdiction certification be required by the customer, or the customer needs to recertify the module for other reasons, contact Microchip for the required utilities and documentation.

6. Appendix B: Acronyms and Abbreviations

Table 6-1. Acronyms and Abbreviations

Acronyms and Abbreviations	Description
ADC	Analog-to-Digital Converter
AES	Advanced Encryption Standard
CBC	Cypher Block Chaining
CDM	Charged Device Model
CFB	Cypher Feedback Mode
CLK	Clock
CMD	Command
CPU	Central Processing Unit
CTR	Counter Mode
DAC	Digital-to-Analog Converter
DC	Direct Current
DFU	Device Firmware Update
DMA	Direct Memory Access
ECB	Electronic Code Book
ECC	Elliptic-Curve Cryptography
ECDH	Elliptic-curve Diffie–Hellman
ECDSA	Elliptic Curve Digital Signature
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
ESD	Electrostatic Discharge
EVM	Error Vector Magnitude
FCC	Federal Communications Commission
GND	Ground
GPIO	General Purpose I/O
HBM	Human Body Model
HPA	High Power Amplifier
I/O	Input Output
IP	Internet Protocol
IRQ	Interrupt Request (active-low)
ISED	Innovation, Science and Economic Development
ISM	International Safety Management Certification
LNA	Low Noise Amplifier
MCLR	Master Clear Input Active Low
MSB	Most Significant Bit
NC	No Connection
NDRNG	Non Deterministic Random Number Generator
NIST	National Institute of Standards and Technology
OEM	Original Equipment Manufacturer
OFB	Output Feedback Mode
OFDM	Orthogonal Frequency Division Multiplexing
PA	Power Amplifier
PCB	Printed Circuit Board

Table 6-1. Acronyms and Abbreviations (continued)

Acronyms and Abbreviations	Description
PMF	Protected Management Frame
PMU	Power Management Unit
POR	Power-on Reset
POSC	Primary Oscillator
PRI0	Priority
PTA	Packet Traffic Arbitration
REACH	Registration, Evaluation, Authorisation and restriction of Chemicals.
RF	Radio Frequency
RoHS	Restriction of Hazardous Substances in Electrical and Electronic Equipment
RP	Reverse Polarity
RSSI	Receive Signal Strength Indication
RTC	Real Time Counter
RTCC	Real Time Clock Calendar
RX	Receive
SDIO	Secure Digital Input Output
SMA	SubMiniature version A Connector
SMD	Surface Mount Device
SPI	Serial Peripheral Interface
SRAM	Static Random Access Memory
STM	Standard Test Method
TDES	Triple Data Encryption Standard
TP	Test Point
TPC	Transmit Power Control
TX	Transmit
UART	Universal Asynchronous Receiver/Transmitter
VQFN	Very Thin Quad Flat No-lead
WLAN	Wireless Local Area Network
WPA	Wi-Fi Protected Access
XDS	Extreme Deep Sleep
XOSC	Crystal Oscillator

7. 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 7-1. Document Revision History

Revision	Date	Section	Description
C	03/2025	WILCS02IC and WILCS02 Module Features	Added compatibility for Wi-Fi® 6/7 2.4 GHz band
		Device Overview	Updated “WILCS02 Module Block Diagram”
		Basic Connection Requirement	Updated “WILCS02 Module Basic Connection and Interface Diagram”
		Pin Details of WILCS02IC, Pin Details of WILCS02 Module	Updated the pin description
		SDIO Controller and SDIO-SPI AC Timing Specifications	Updated the section and figure title
		External Antennas	Updated “WILCS02 Module Approved External Antenna List with Antenna Gain” table
		Appendix A: Regulatory Approval, Japan, Korea, Taiwan	Added regulatory approval details for Japan, Korea and Taiwan
B	09/2024	Document	Updated document title as “WILCS02 Family Data Sheet”
		Introduction	- Removed support for the voltage range of 1.8-3.6V - Editorial updates
		WILCS02IC and WILCS02 Module Features	- Removed hardware based low power modes - Removed 1.8-3.6V operating voltage for IC and Module - Editorial updates
		WILCS02IC Ordering Information	- Added note for Tray packing - Updated Figure 1-1 for packaging Tray/Tape&Reel
		WILCS02 Module Ordering Information	- Updated ordering code in Table 1-2 - Updated Figure 1-2 for packaging Tray/Tape&Reel - Added note for Tray packing
		Device Overview	Updated Figure 2-1
		Pin Details of WILCS02IC	- Updated Figure 2-2 to top view - Updated Table 2-1 - Updated Table 2-1 notes
		Pin Details of WILCS02 Module	- Updated Figure 2-3 - Updated Table 2-2 - Updated Table 2-2 notes
		Basic Connection Requirement	- Updated Figure 2-4 - Removed Configuration Details table
		Power Supply Pin	- Updated Figure 2-5 - Updated content as per the modified Figure 2-5
		Device Firmware Update	Updated Figure 2-7

Table 7-1. Document Revision History (continued)

Revision	Date	Section	Description
		Interface with Host Microcontroller	- Updated Figure 2-8 - Added Figure 2-9
		Master Clear (MCLR) Pin	- Updated Figure 2-6 - Removed note referenced for the previous image
		WILCS02 Module Routing Guidelines	Updated Figure 2-12
		External Antennas	- Updated Table 2-4 - Added a note to refer the calibration guide for post-calibration steps
		WILCS02IC Absolute Maximum Ratings	Updated Table 3-1
		Thermal Specifications	- Updated Thermal Operating Conditions - Updated Recommended Operating Voltages
		I/O Pin DC Electrical Specifications	Updated Table 3-6
		WILCS02IC Wi-Fi Current Consumption	Updated Table 3-7
		External XTAL POSC 40 MHz AC Electrical Specifications	Updated Table 3-8
		SPI Electrical Specifications	- Updated SPI Client CPHA=0 Timing Diagram - Updated SPI Client CPHA=1 Timing Diagram - Updated SPI Client Mode Electrical Specifications
		SDIO Controller and SDIO-SPI AC Timing Specifications	Updated Table 3-9
		Power-on Reset AC Electrical Specifications	Modified the symbol TRST to T(nRST)
		Extreme Deep Sleep (XDS) Current Consumption	Removed this section
		WILCS02IC Receiver and Transmitter Characteristics Graphs	Updated first four plots
		Thermal Specifications	Updated V_{DDIO} voltage range and conditions
		Wi-Fi Current Consumption	Updated Table 3-17
		WILCS02 Module Receiver and Transmitter Characteristics Graphs	Updated the plots
		WILCS02IC Package Marking	Updated Figure 4-1
		WILCS02 Module Packaging Marking	- Added FCC and IC ID details - Updated Figure 4-2
		WILCS02 Module Packaging Dimension	Updated package dimension
		Appendix A: Regulatory Approval	Updated Great Britain/UKCA to the list
		I/O Pin DC Electrical Specifications	Updated Table 3-6
		Appendix A: Regulatory Approval	Added Regulatory Chapter
A	03/2024	Document	Initial Revision

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