

WINCS02IC and WINCS02 Family Data Sheet

WINCS02IC and WINCS02 Family



Introduction

The WINCS02IC 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 Network Controller IC with a hardware-based security accelerator.

The WINCS02 is a low power consuming 802.11 b/g/n IoT (Internet of Things) module with built-in Wi-Fi® and TCP/IP stacks, specifically optimized for low power IoT applications. The module can be interfaced to a host microcontroller through Serial Peripheral Interface (SPI). The module is interoperable with various vendors 802.11 b/g/n access points. The module has compact form factor of 21.7 mm x 17.3 mm x 2.1 mm.

The WINCS02 module operates at a single supply voltage VDD (3.3V typical), Specific Input/Output (I/O) pins support voltage range of 1.8-3.6V by supplying the V_{DDIO} pin separately.

The WINCS02 module is available with an on-board Printed Circuit Board (PCB) antenna or U.FL connector for an external antenna and with or without integrated Microchip Trust&Go Secure device.

Note: The WINCS02IC must be programmed with the appropriate Network Controller firmware version to meet the specification described in the data sheet.

WINCS02IC and WINCS02 Module Features

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

- Secure Device Firmware Upgrade (DFU)
- Integrated Microchip Trust&Go Secure Device (Optional)

Security

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

Operating Conditions

- **WINCS02IC**
 - Operating Voltage V_{DD} : 3.0-3.6V, V_{DDIO} : 1.8-3.6V (3.3V Typical)
 - Operating Temperature: -40°C to 105°C
- **WINCS02**
 - Operating Voltage V_{DD} : 3.0-3.6V, V_{DDIO} : 1.8-3.6V (3.3V Typical)
 - Operating Temperature: -40°C to 85°C

Module Variants

- PCB Antenna:
 - WINCS02PE
 - WINCS02PC
- U.FL Connector for External Antenna:
 - WINCS02UE
 - WINCS02UC

Package

- **WINCS02IC**
 - 48-Pin QFN
 - Size: 7 mm x 7 mm x 0.9 mm
- **WINCS02**
 - 28-Pin SMD Package with Shield CAN on Top
 - Size: 21.7 mm x 14.7 mm x 2.1 mm

Applications

- Smart Factories/Control Devices
- Security Systems, CCTV
- Smart Homes/Lighting, Smart Locks
- Computing, Wi-Fi Dongles, Protocol Bridging

- Internet of Things (IoT) Sensor Tag
- Remote Control
- Wearable Smart Devices
- Industrial Control

Certifications

- WINCS02 Module is Planned to be Certified to FCC, ISED, UKCA and CE Radio Regulations
- RoHS and REACH Compliant

Notes:

1. For more details about the latest supported features, refer to the *WINCS02 Application Developer's Guide (TBA)*
2. The WINCS02 module does not support the PTA interface and the RTCC oscillator function together. Refer to [2.2. Pin Details of WINCS02 Module](#) for more details.

Table of Contents

Introduction.....	1
WINCS02IC and WINCS02 Module Features.....	1
1. Ordering Information.....	5
1.1. WINCS02IC Ordering Information.....	5
1.2. Module Ordering Information.....	6
2. Device Overview.....	7
2.1. Pin Details of WINCS02IC.....	8
2.2. Pin Details of WINCS02 Module.....	10
2.3. Basic Connection Requirement.....	12
2.4. WINCS02 Module Placement Guidelines.....	14
2.5. WINCS02 Module Routing Guidelines.....	16
2.6. WINCS02 Module RF Considerations.....	17
2.7. WINCS02 Module Antenna Considerations.....	17
2.8. WINCS02 Module Reflow Profile Information.....	23
2.9. WINCS02 Module Assembly Considerations.....	24
3. Electrical Specifications.....	25
3.1. WINCS02IC Electrical Specifications.....	25
3.2. WINCS02 Module Electrical Specifications.....	41
4. Packaging Information.....	51
4.1. WINCS02IC Packaging Information.....	51
4.2. WINCS02 Module Packaging Information.....	55
5. Appendix A: Regulatory Approval.....	59
5.1. United States.....	59
5.2. Canada.....	61
5.3. Europe.....	63
5.4. UKCA (UK Conformity Assessed).....	64
5.5. Other Regulatory Information.....	65
6. Appendix B: Acronyms and Abbreviations.....	66
7. Document Revision History.....	68
Microchip Information.....	69
The Microchip Website.....	69
Product Change Notification Service.....	69
Customer Support.....	69
Microchip Devices Code Protection Feature.....	69
Legal Notice.....	69
Trademarks.....	70
Quality Management System.....	71
Worldwide Sales and Service.....	72

1. Ordering Information

This chapter provides the ordering information of the WINCS02IC and the WINCS02 module.

1.1 WINCS02IC Ordering Information

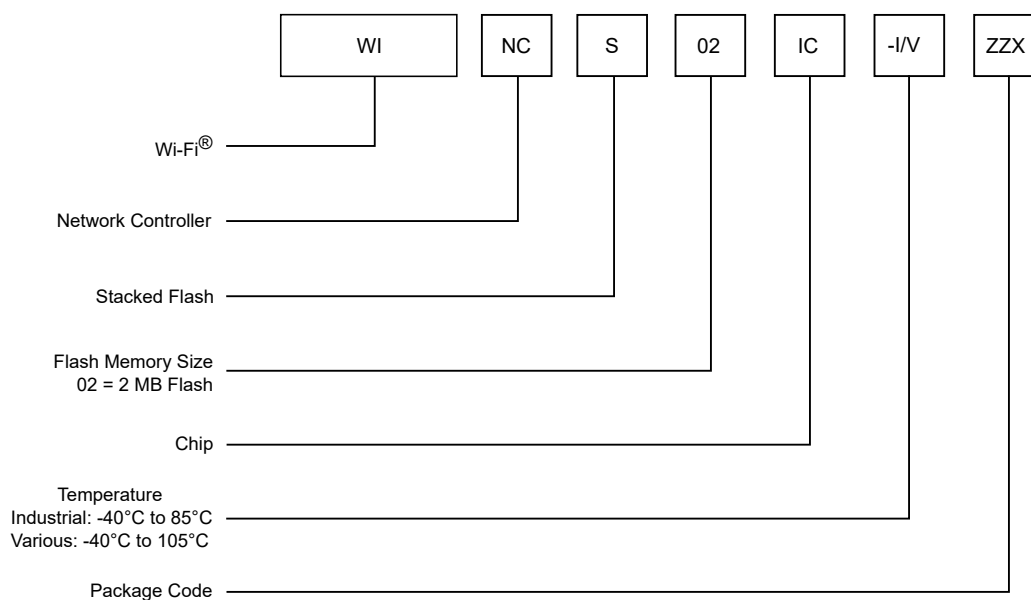
This section provides the ordering information of the WINCS02IC.

Table 1-1. WINCS02IC Ordering Details

SoC Name	Pin and Package	Description	Ordering Code
WINCS02IC	48-pin VQFN (7 mm x 7 mm x 0.9 mm)	32-bit Network Controller IC with WLAN connectivity and hardware based security accelerator with embedded Flash of 2 MB	WINCS02IC-I/ZZX

The following figure illustrates the details of the WINCS02IC ordering information.

Figure 1-1. WINCS02IC Ordering Information



Note: The WINCS02IC must be programmed with the appropriate Network Controller firmware version to meet the specification described in the data sheet.

1.2 Module Ordering Information

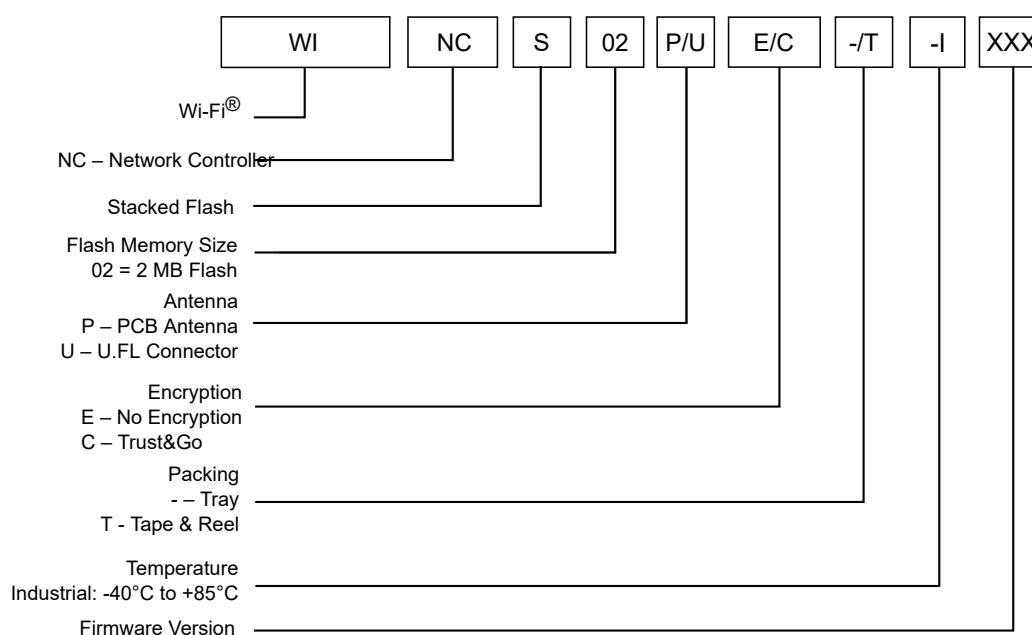
This chapter provides the ordering information of the WINCS02 module.

Table 1-2. WINCS02 Module Ordering Details

Module Name	Description	Ordering Code
WINCS02PE	Wi-Fi® Network Controller Module with PCB Antenna	WINCS02PE-I
WINCS02PC	Wi-Fi Network Controller Module with PCB Antenna and Trust&Go	WINCS02PC-I
WINCS02UE	Wi-Fi Network Controller Module with U.FL connector for external Antenna	WINCS02UE-I
WINCS02UC	Wi-Fi Network Controller Module with U.FL connector for external Antenna and Trust&Go	WINCS02UC-I

The following figure illustrates the details of the WINCS02 module ordering information.

Figure 1-2. WINCS02 Module Ordering Information



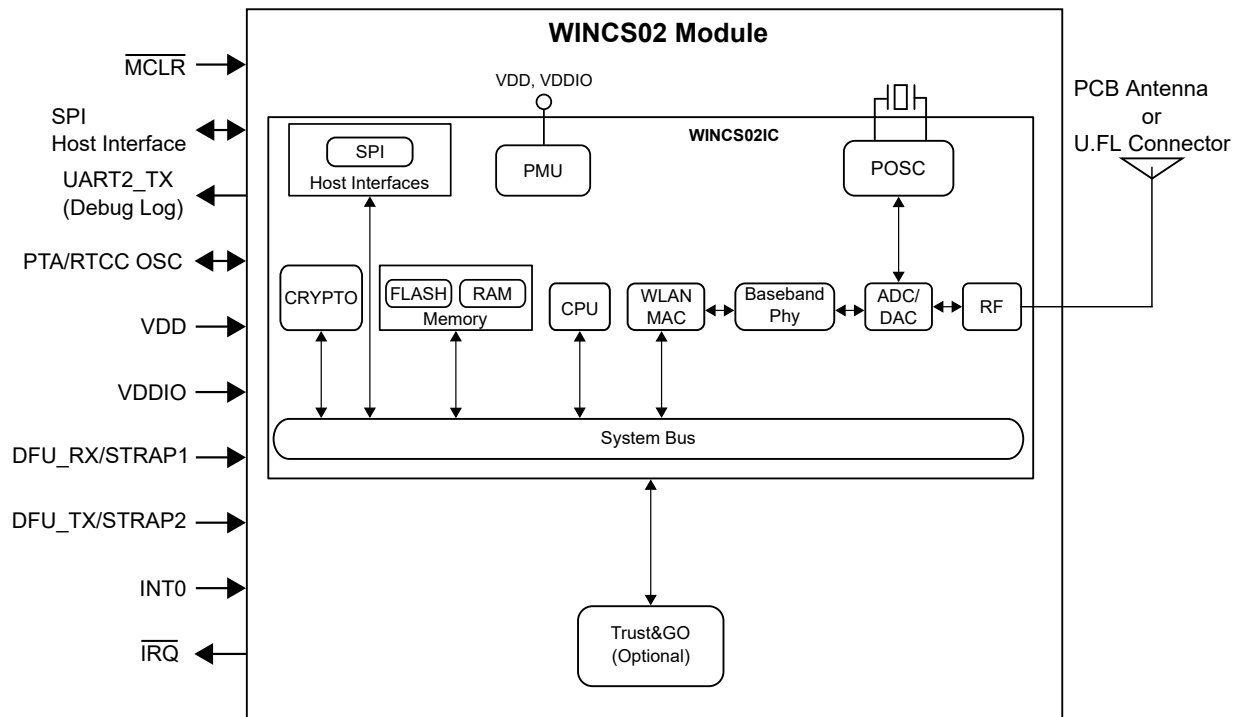
2. Device Overview

The WINCS02IC is a single chip 2.4GHz and IEEE 802.11b/g/n-compliant solution with integrated HPA, LNA and RF switches for TX/RX control. The WINCS02 is a fully RF and Wi-Fi Alliance certified module based on WINCS02IC available with the following antenna variants:

- PCB antenna (WINCS02PE/WINCS02PC)
- U.FL connector (WINCS02UE/WINCS02UC) for external antenna

The following figure illustrates the WINCS02IC and the WINCS02 module block diagram and various peripherals supported by these devices.

Figure 2-1. WINCS02 Module Block Diagram



2.1 Pin Details of WINCS02IC

This section provides details on pin diagrams and the pinout table of WINCS02IC.

Figure 2-2. WINCS02IC Pin Diagram (Bottom View)

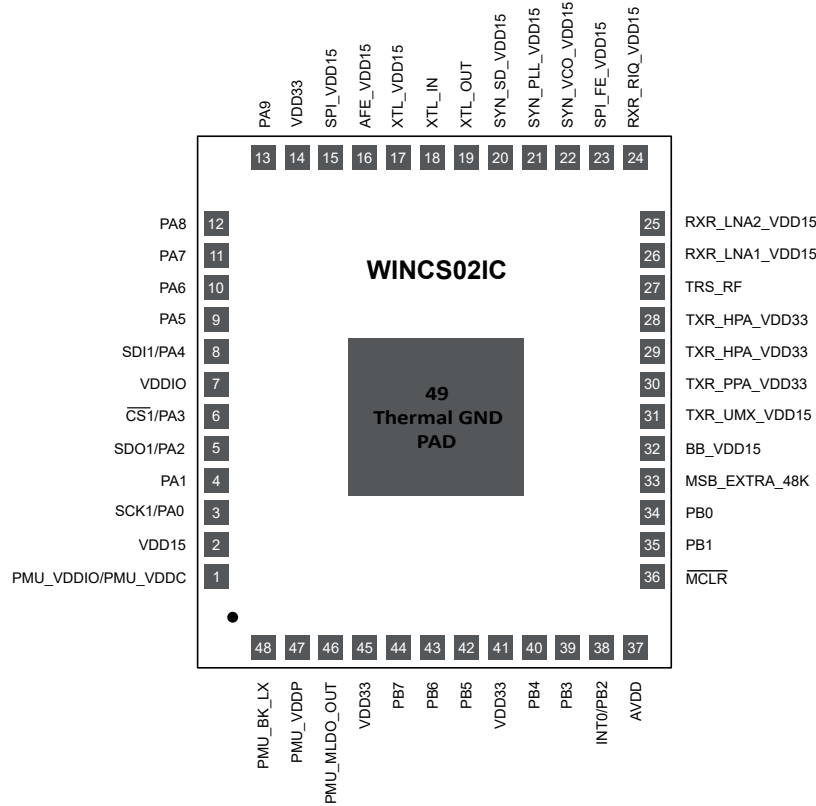


Table 2-1. WINCS02IC Pinout Table

Pin Number	Pin Name	Pin Type	Description
1	PMU_VDDIO/ PMU_VDDC	P	3.3V input supply voltage to PMU
2	VDD15	P	Input supply voltage (1.5V) from PMU
3	SCK1/PA0 ⁽¹⁾	O	SPI1 serial clock
4	PA1 ⁽¹⁾	O	Reserved
5	SDO1/PA2 ⁽¹⁾	O	SPI1 serial data out
6	CS1/PA3 ⁽¹⁾	I	SPI1 chip select
7	VDDIO	P	Input supply voltage for I/O Port A (PA0-PA7)
8	SDI1/PA4 ⁽¹⁾	I	SPI1 serial data in
9	PA5 ⁽¹⁾	I/O	Reserved
10	PA6 ⁽¹⁾	O	Reserved
11	PA7 ⁽¹⁾	I/O	Reserved
12	PA8	I/O	Reserved
13	PA9	I/O	Reserved
14	VDD33	P	Input supply voltage
15	SPI_VDD15	P	RF supply voltage from PMU
16	AFE_VDD15	P	
17	XTL_VDD15	P	
18	XTL_IN	I	
			40 MHz primary oscillator crystal input

.....continued

Pin Number	Pin Name	Pin Type	Description
19	XTL_OUT	O	40 MHz primary oscillator crystal output
20	SYN_SD_VDD15	P	RF supply voltage from PMU 1.5V
21	SYN_PLL_VDD15	P	
22	SYN_VCO_VDD15	P	
23	SPI_FE_VDD15	P	
24	RXR_RIQ_VDD15	P	
25	RXR_LNA2_VDD15	P	
26	RXR_LNA1_VDD15	P	
27	TRS_RF	I/O	RF transmit/receive
28	TXR_HPA_VDD33	P	RF supply voltage 3.3V
29	TXR_HPA_VDD33	P	
30	TXR_PPA_VDD33	P	
31	TXR_UMX_VDD15	P	RF supply voltage from PMU 1.5V
32	BB_VDD15	P	
33	MSB_EXTRA_48K	O	RF PIN, Pull down with 48.7K resistor
34	PB0	I/O	Reserved
35	PB1	I/O	Reserved
36	MCLR	I	Master clear input active low
37	AVDD	P	Analog input supply voltage 3.3V
38	INT0/PB2	I	External interrupt to wake up from deep sleep
39	PB3	I/O	Reserved
40	PB4	I	PTA_WLAN_ACTIVE
41	VDD33	P	Input supply voltage
42	PB5	—	Reserved
43	PB6	—	Reserved
44	PB7	—	Reserved
45	VDD33	P	3.3V input supply voltage
46	PMU_MLDO_OUT ⁽⁴⁾	P	PMU MLDO output voltage (1.5V).
47	PMU_VDDP	P	Input supply to PMU
48	PMU_BK_LX	P	PMU BUCK output. Connection to external LC filter
49	GND	P	Thermal ground PAD

Notes:

1. These pins support lower voltage by supplying the V_{DDIO} pin separately (1.8V – 3.6V).
2. Refer to the reference design package for exact pin mapping and signal connection.
3. The WINCS02 module firmware does not support the GPIO functionality. All the pins are reserved.
4. This is for internal use only. Do not connect any external circuits.

2.2 Pin Details of WINCS02 Module

This section provides details on pin diagrams and pinout table of WINCS02 module.

Figure 2-3. WINCS02 Module Pin Diagram (Bottom View)

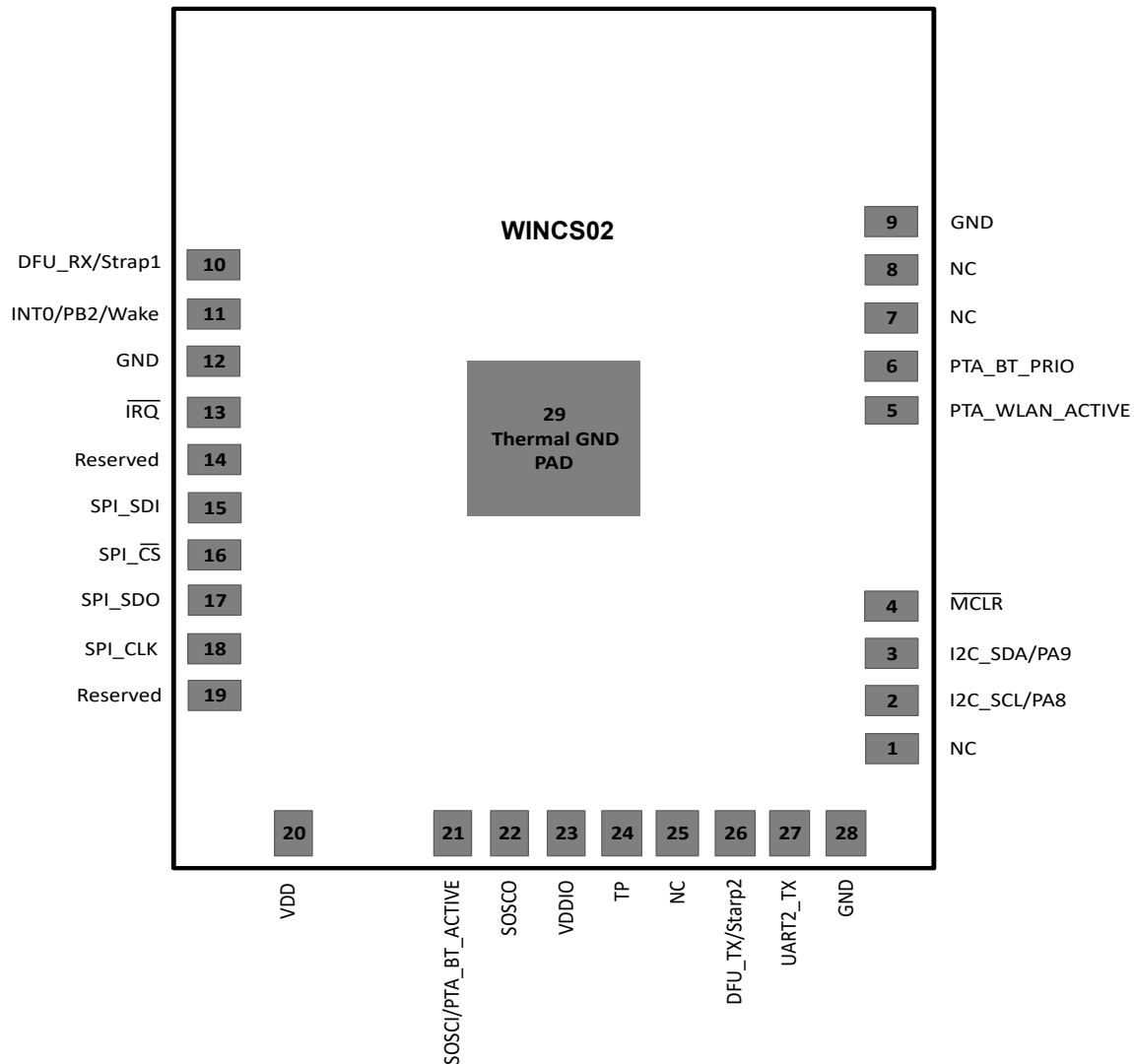


Table 2-2. WINCS02 Module Pinout Table

Pin Number	Pin Name	Pin Type	Pin Description
1	NC	—	No connection
2	I2C_SCL	I	I2C clock connected to Trust&GO device. Recommended to connect external pull-up resistor of 1.2K.
3	I2C_SDA	I/O	I2C data connected to Trust&GO device. Recommended to connect external pull-up resistor of 1.2K.
4	MCLR	I	Master clear reset, active-low
5	PTA_WLAN_ACTIVE	O	PTA interface, WLAN_ACTIVE
6	PTA_BT_PRIO	I/O	PTA interface, BT_PRIORITY
7	PB7	I/O	Reserved
8	NC	—	No connection
9	GND	P	Ground

.....continued

Pin Number	Pin Name	Pin Type	Pin Description
10	DFU_RX/Strap1	I	For device firmware update receive pin. Recommended to connect to a pull-down resistor of 100K.
11	INT0/Wake	—	To wake-up the Wi-Fi® module from its Extreme Deep Sleep (XDS) mode by the host
12	GND	P	Ground
13	IRQ ⁽²⁾	O	Interrupt request (active-low) from the Wi-Fi module to wake-up the host from its Sleep state
14	Reserved	O	Reserved
15	SPI_SDI/PA4 ⁽²⁾	O	Serial Peripheral Data In, Host interface
16	SPI_CSn/PA3 ⁽²⁾	I	Serial Peripheral Chip Select (active-low), Host interface
17	SPI_SDO/PA2 ⁽²⁾	I/O	Serial Peripheral Data Out, Host interface
18	SPI_CLK/PA0 ⁽²⁾	I/O	Serial Peripheral Clock, Host Interface
19	Reserved	I	Reserved
20	VDD	P	VDD power supply (3.0-3.6V)
21	SOSCI/PTA_BT_ACTIVE ⁽¹⁾	I	RTCC oscillator input for 32.768 KHz external crystal/ PTA Interface BT_ACTIVE
22	SOSCO	O	RTCC oscillator output
23	VDDIO	P	I/O power supply (1.8-3.6V)
24	TP	P	Test point: 1.5V ⁽³⁾
25	NC	—	No connection
26	DFU_TX/Strap2	I	For device firmware update receive pin. Recommended to connect to a pull-down resistor of 100K.
27	UART2_TX ⁽²⁾	I/O	UART2 transmit signal for firmware log
28	GND	P	Ground
29	GND Paddle	P	Thermal ground pad

Notes:

1. This pin can be configured either as an oscillator input pin or as PTA BT_ACTIVE. The WINCS02 module does not support both the functionality together.
2. These pins support lower voltage by supplying the V_{DDIO} pin separately (1.8V - 3.6V).
3. Do not connect any signal to source the voltage.

2.3 Basic Connection Requirement

The WINCS02 module requires attention to a minimal set of device pin connections before proceeding with development.

Figure 2-4. WINCS02 Module Basic Connection and Interface Diagram

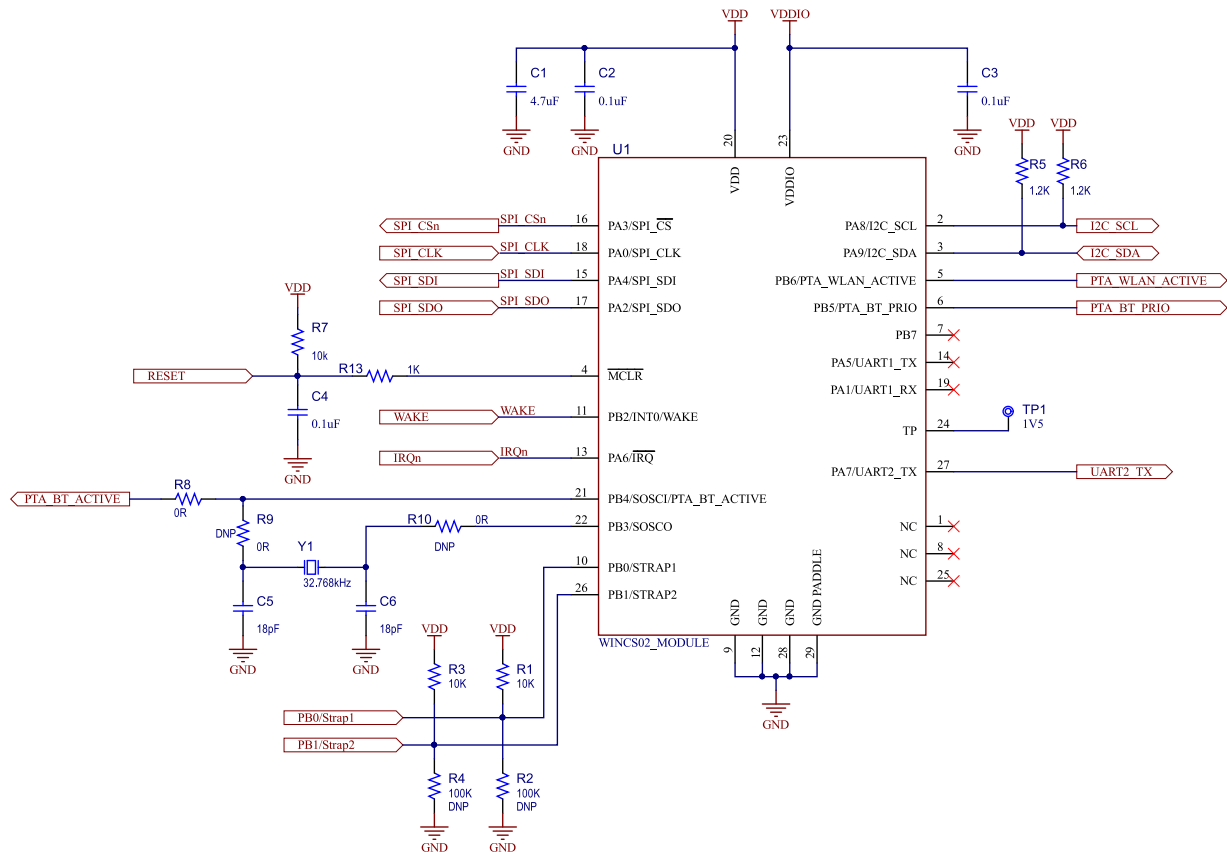


Table 2-3. Configuration Details

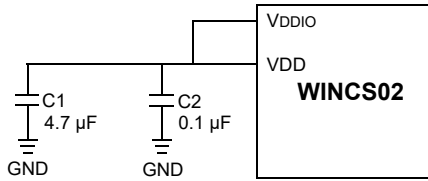
Configuration Details			
Module Pin10/Strap1	Module Pin26/Strap2	Host Interface Selection	Description
1	1	SPI	WINCS02 module with SPI
Note: The mentioned resistance values are only guidelines. For details on the application schematics, refer to the WINCS02 Add On Board User's Guide (TBA).			

2.3.1 Power Supply Pin

It is recommended to add a bulk and a decoupling capacitor at the input supply Pin 20 (VDD), Pin 23 (VDDIO) and GND of the WINCS02 module.

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

Figure 2-5. Recommended Module Power Supply Connections



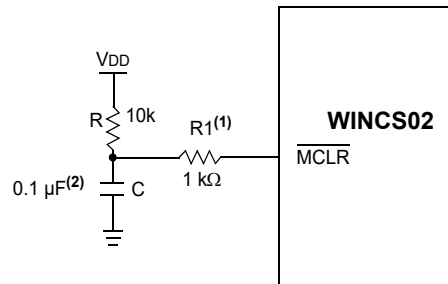
The value of the C1 and C2 capacitors may vary based on the application requirements and source of supply voltage. The C1 and C2 capacitor must be placed close to the pin.

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

The $\overline{\text{MCLR}}$ 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 *Module Basic Connection and Interface Diagram* in the *Basic Connection Requirement* from Related Links.

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



Notes:

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

Related Links

[2.3. Basic Connection Requirement](#)

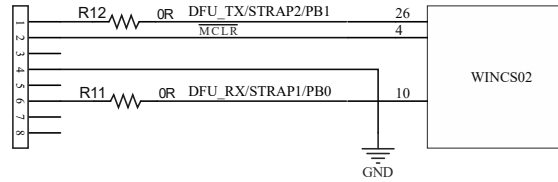
2.3.3 Device Firmware Update

The WINCS02 module is available for purchase with pre-programmed firmware. Microchip periodically releases the firmware to fix reported issues or to implement the latest feature support. There are two ways to perform a regular firmware update:

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

Note: For the serial DFU and OTA programming guidance, refer to the *WINCS02 Module Application Developer's Guide*.

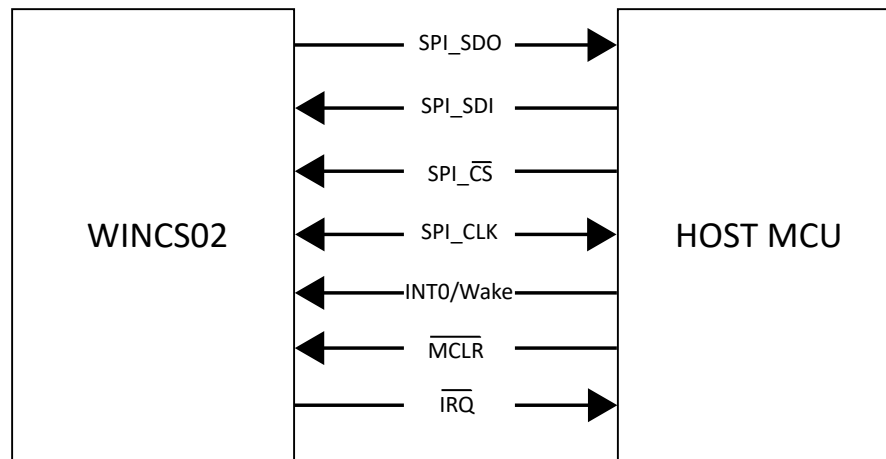
Figure 2-7. Basic Connection Diagram of DFU



2.3.4 Interface with Host Microcontroller

The WINCS02 module can be interfaced with the host microcontroller through the UART_TX and UART_RX data line and optional UART flow control signals UART_RTS and UART_CTS.

Figure 2-8. WINCS02 Module Host Interface Diagram



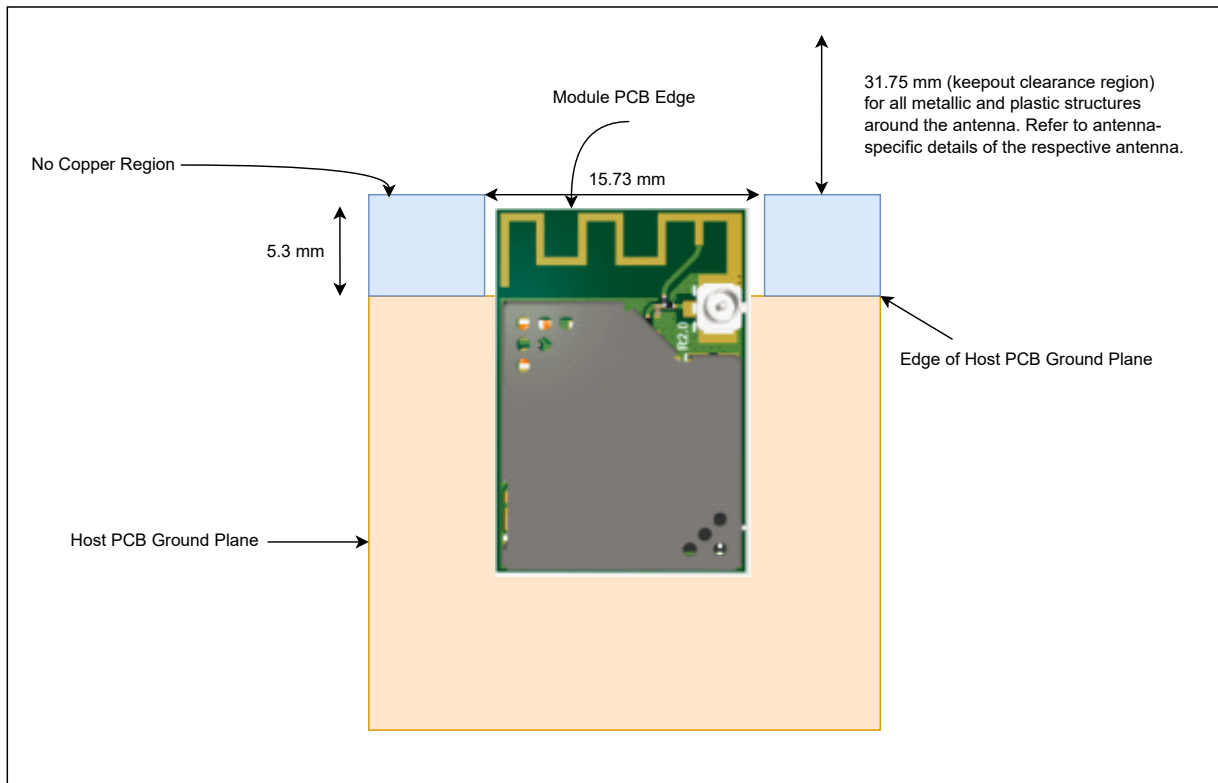
2.4 WINCS02 Module Placement Guidelines

- 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 WINCS02PC/E module is placed at the edge of the host board.
- The WINCS02PC/WINCS02PE module ground outline edge must be aligned with the edge of the host board ground plane as shown in the following figure.
- A low-impedance ground plane for the WINCS02 module ensures the best radio performance (best range and lowest noise). The ground plane can be extended beyond the minimum recommendation as required for the host board EMC and noise reduction.
- For the best performance, keep metal structures and components (such as mechanical spacers, bump-on and so on) at least 31.75 mm away from the PCB trace antenna as illustrated in the following figure.
- The antenna on the WINCS02 module must not be placed in direct contact with or in close proximity to plastic casing or objects. Keep a minimum clearance of 10 mm in all directions around the PCB antenna as shown in the following figure. Keeping metallic and plastic objects close to the antenna can detune the antenna and reduce the performance of the device.
- Exposed GND pads on the bottom of the WINCS02 module must be soldered to the host board (see the *Example of Host Board on Top Layer* figure in the *WINCS02 Module Routing Guidelines* from Related Links).

- A PCB cutout or a copper keepout is required under the RF test point (see *WINCS02 Module Packaging Information* from Related Links).
- Copper keepout areas are required on the top layer under voltage test points (see *WINCS02 Module Packaging Information* from Related Links).
- Alternatively, the entire region, except the exposed ground paddle, can be solder-masked.

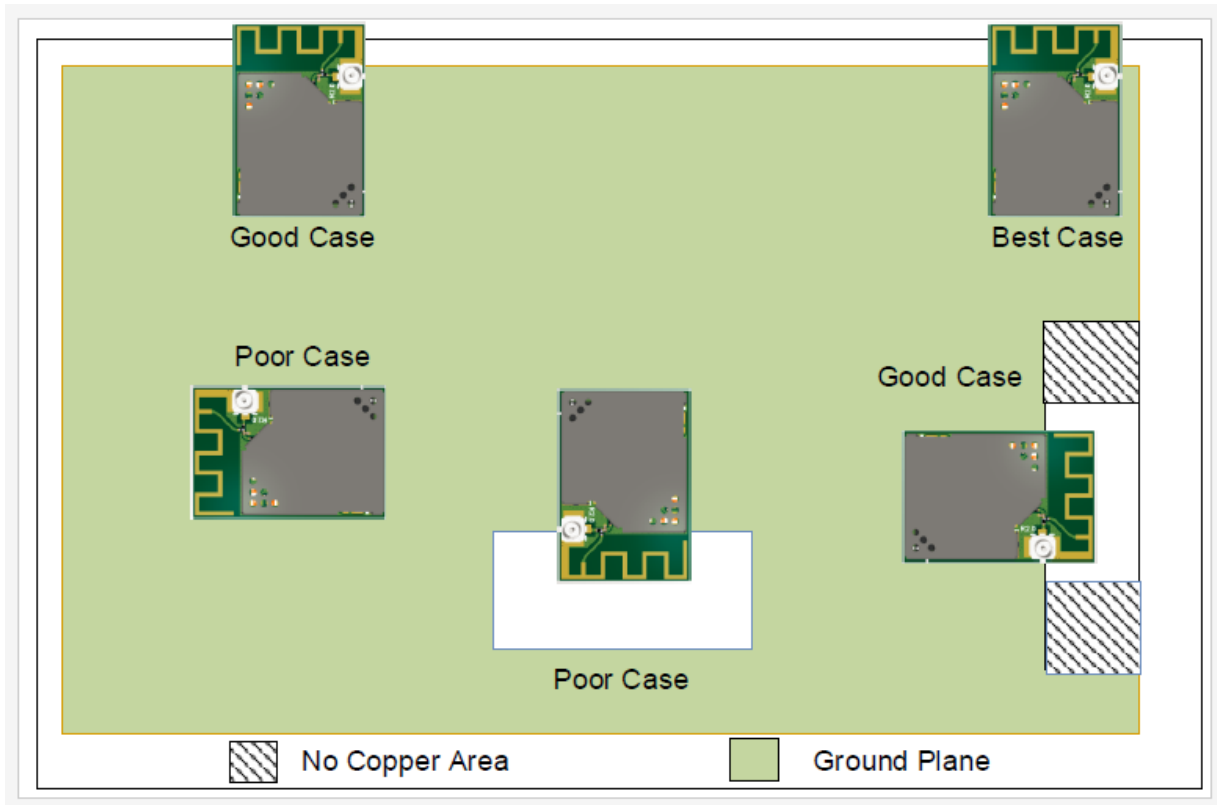
The following figure illustrates the examples of WINCS02 Module placement on a host board with a ground plane. Refer to the following figure for placement-specific guidance.

Figure 2-9. Module Placement Guidelines



The following figure illustrates the examples of the WINCS02 module placement on a host board with a ground plane. Refer to [Figure 2-9](#) for placement-specific guidance.

Figure 2-10. WINCS02 Module Placement



Related Links

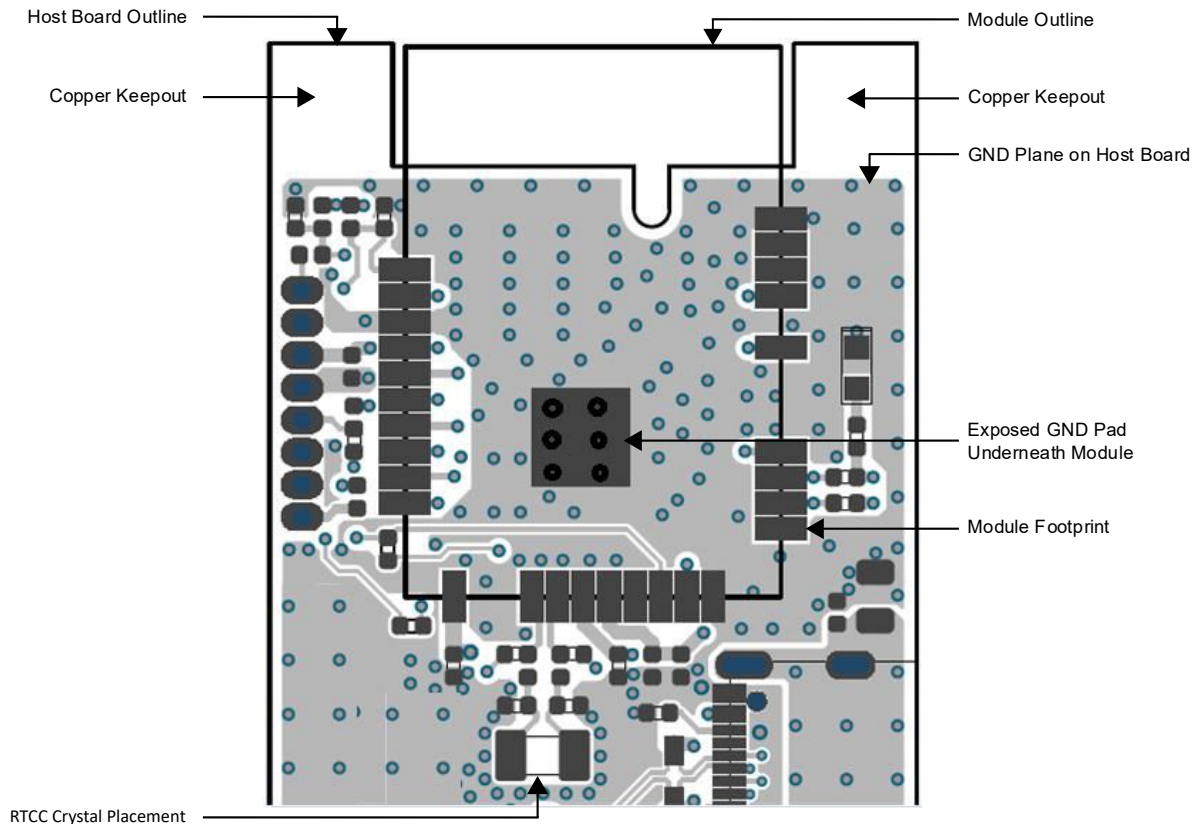
[2.5. WINCS02 Module Routing Guidelines](#)

[4.2. WINCS02 Module Packaging Information](#)

2.5 WINCS02 Module Routing Guidelines

- Use the multi-layer host board for routing signals on the inner layer and the bottom layer.
- The top layer (underneath the module) of the host board must be ground with as many GND vias as possible, shown in the following figure.
- Avoid fan-out of the signals under the module or antenna area. Use a via to fan-out signals to the edge of the WINCS02 module.
- For a better GND connection to the WINCS02 module, solder the exposed GND pads of the WINCS02 module on the host board.
- For the module GND pad, use a GND via of a minimum 10 mil (hole diameter) for good ground to all the layers and thermal conduction path.
- Having a series resistor on the host board for all GPIOs is recommended. These resistors must be placed close to the WINCS02 module. The following figure illustrates the placement of the series resistor.
- The SOSC crystal (32.768 kHz) on the host board must be placed close to the WINCS02 module and follow the shortest trace routing length with no vias (see the following figure).

Figure 2-11. Example of Host Board on Top Layer



2.6 WINCS02 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 WINCS02 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 WINCS02 module includes RF shielding on top of the board as a standard feature.

2.7 WINCS02 Module Antenna Considerations

2.7.1 PCB Antenna

For the WINCS02PE/PC module, the PCB antenna is fabricated on the top copper layer and covered with a solder mask. The layers below the antenna do not have copper trace. It is recommended that the module to 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 WINCS02 module mounted on the WINCS02 Add-On Board.

Table 2-4. PCB Antenna Specification for WINCS02 Module

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

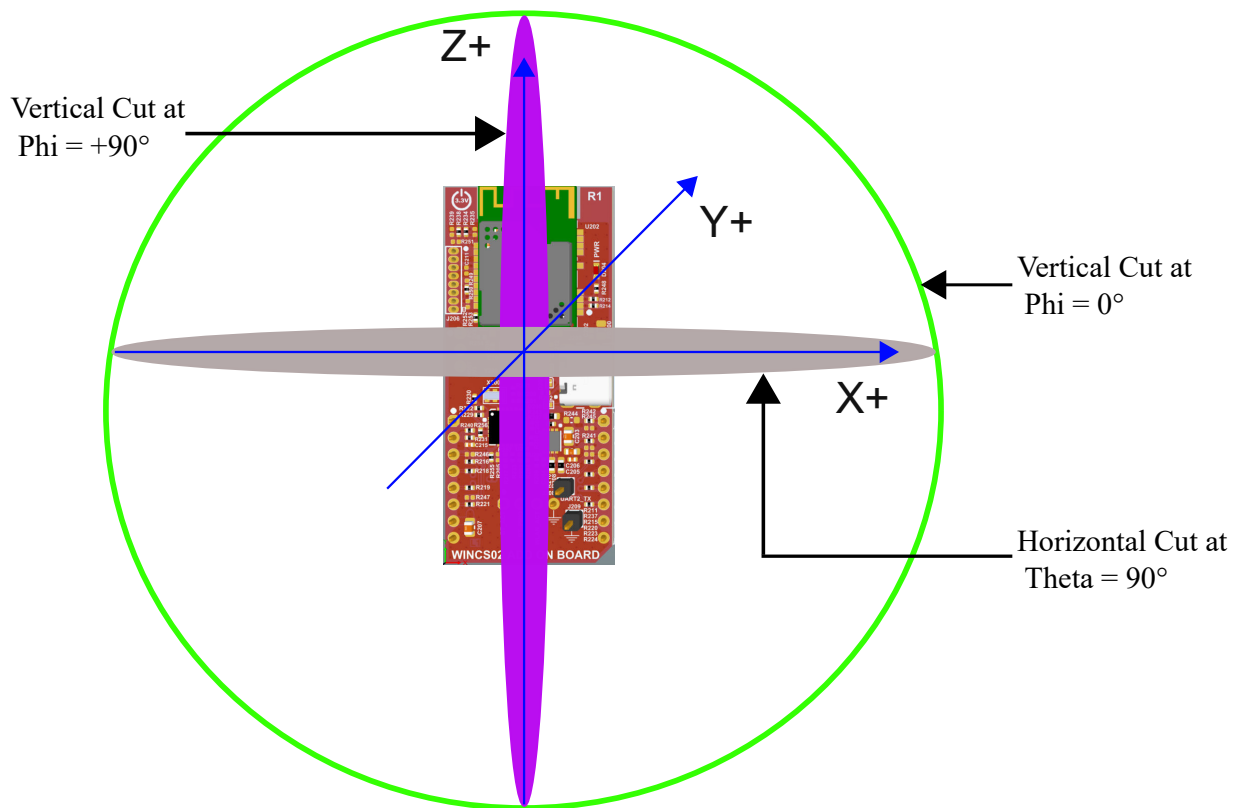
Note:

1. The size of the WINCS02 Add-On Board is 25.4 mm x 57.2 mm. The antenna efficiency will improve with larger ground plane base boards. The same antenna achieved an average efficiency of 69% with a base board size of 85 mm x 40 mm. If the best case routing guidelines are followed on a larger ground plane application board, the efficiency will be better.

PCB Antenna Radiation Pattern

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

Figure 2-12. Module Orientation for Radiation Pattern Measurement



Antenna Radiation Pattern

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

Figure 2-13. Antenna Radiation Pattern when $\Phi = 0^\circ$

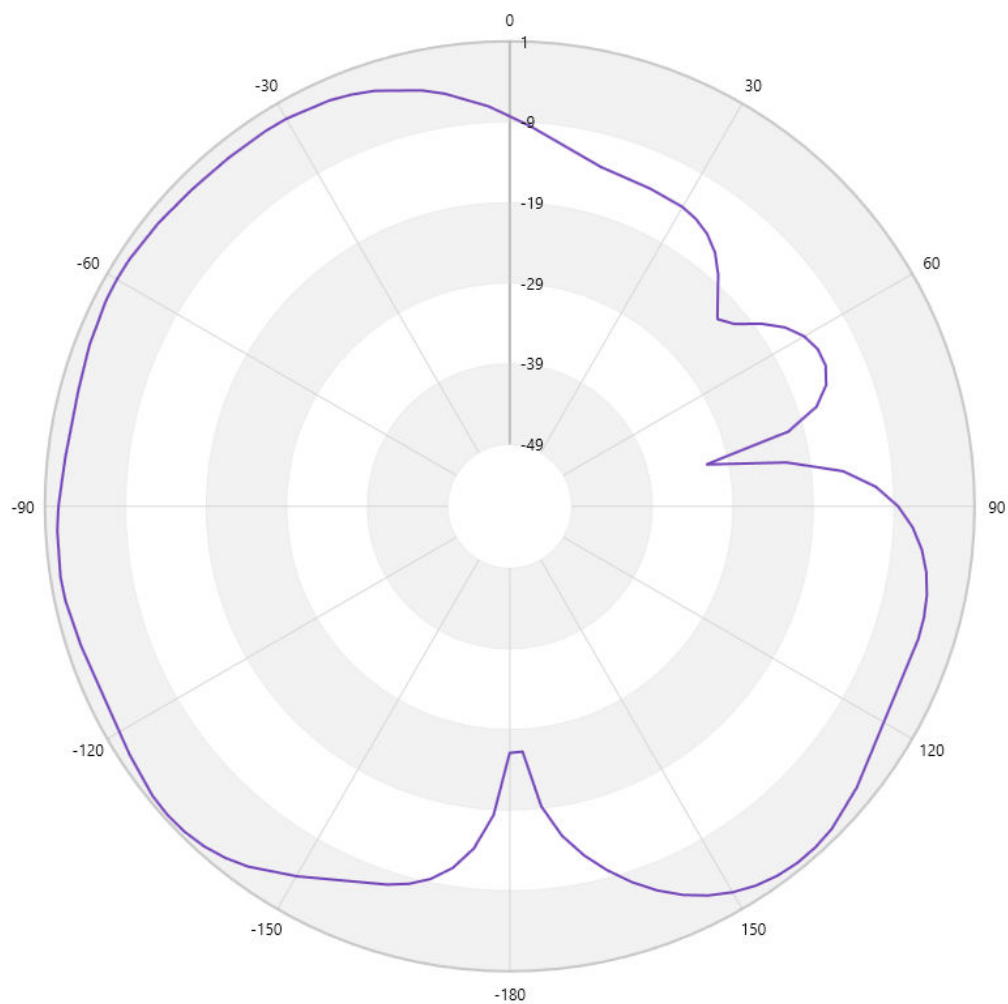
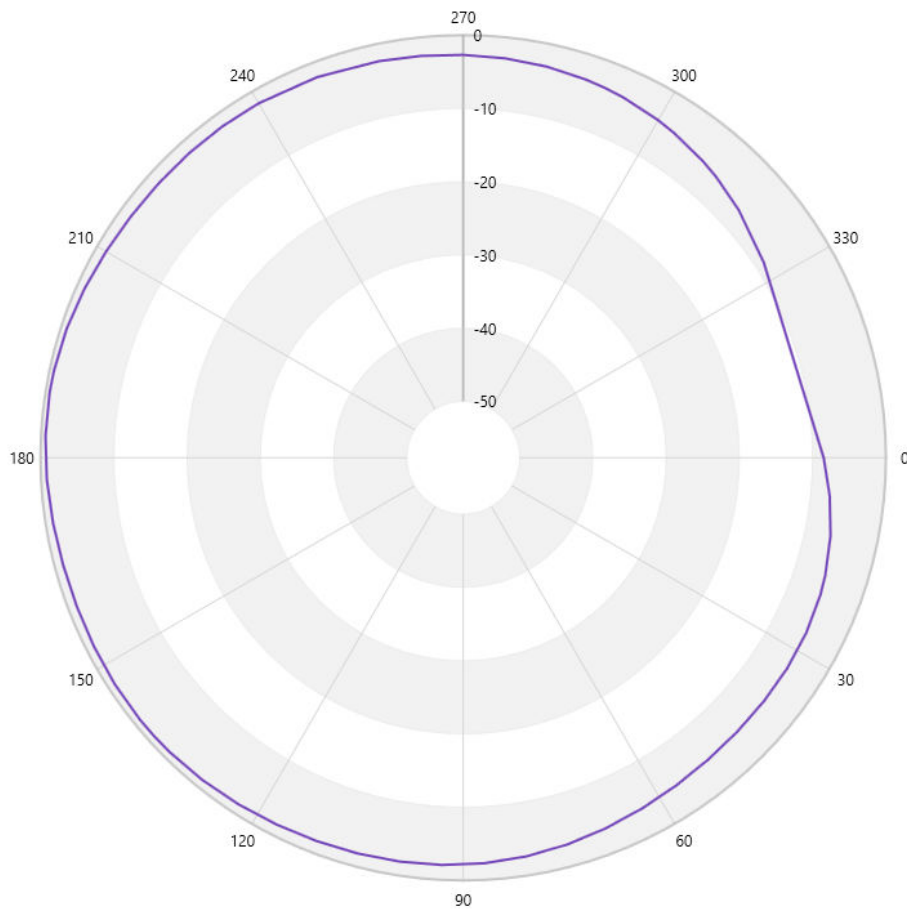


Figure 2-14. Antenna Radiation Pattern when $\Phi = 90^\circ$



Figure 2-15. Antenna Radiation Pattern when Theta = 90°



2.7.2 External Antenna Placement Recommendations

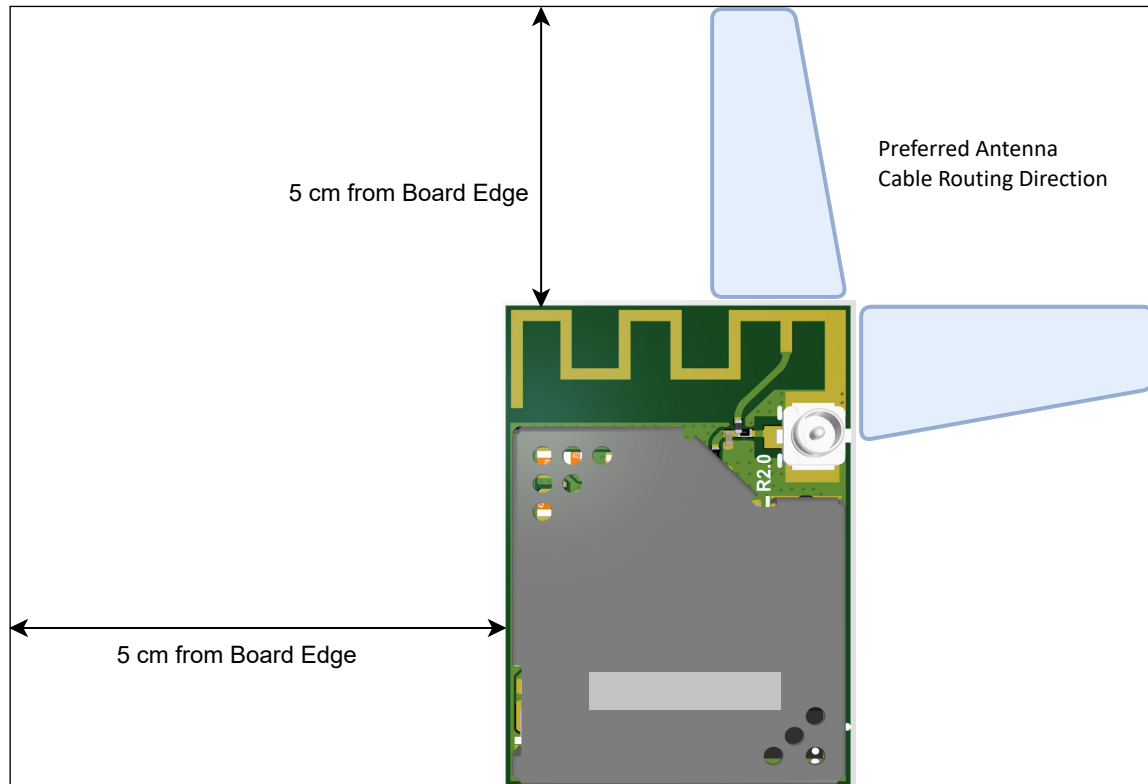
The user must ensure the following for the placement of the antenna and its cable:

- 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 WINCS02 module.

These recommendations are based on an open-air measurement and do not take into account any metal shielding of the customer end product. When a metal enclosure is used, the antenna can be located closer to the WINCS02 module.

The following figure illustrates how the antenna cable must be routed depending on the location of the antenna with respect to the WINCS02 PCB. There are two possible options for the optimum routing of the cable.

Figure 2-16. WINCS02 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 WINCS02/UE/UC modules have an ultra-small surface mount U.FL connector for an external antenna connection. The choice of antenna is limited to the antenna types that the module is tested and approved for.

The WINCS02/UE/UC modules are approved to use with the antennas listed in the following table. It is permissible to use a different antenna, provided it is the same antenna type, has the same antenna gain (equal or less than) and similar in-band and out-of-band characteristics are present (refer to antenna specification sheet for cutoff frequencies).

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

Table 2-5. WINCS02 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 ⁽⁶⁾	Aristotle	2	Dipole	x	x
5	RFA-02-C2H1-D034 ⁽⁶⁾	Alead	2	Dipole	x	x
6	RFA-02-D3 ⁽⁶⁾	Aristotle	2	Dipole	x	x
7	RFDPA870920IMLB301 ⁽⁶⁾	Walsin	1.84	Dipole	x	x
8	RFDPA870920IMAB302 ⁽⁶⁾	Walsin	1.82	Dipole	x	x
9	RFDPA870920IMAB305 ⁽⁶⁾	Walsin	1.82	Dipole	x	x
10	RFDPA870910IMAB308 ⁽⁶⁾	Walsin	2	Dipole	x	x
11	RFA-02-C2M2 ⁽⁶⁾	Aristotle	2	Dipole	x	x
12	RN-SMA-S-RP ⁽⁶⁾	Microchip	0.56	Dipole	x	x
13	W1049B030 ⁽⁶⁾	Pulse	2	Dipole	x	x
14	RN-SMA4-RP ⁽⁶⁾	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, RP (Reverse Polarity)-SMA socket).
3. If an RF coaxial cable is used between the module RF output and the enclosure, a unique (non-standard) antenna connector must be used in the enclosure wall to interface with the antenna.
4. Contact the antenna vendor for detailed antenna specifications to review the suitability to the end product operating environment and to identify alternatives.
5. If any external antenna is used other than the recommended antennas in the list, it may need an extra step of post-calibration on the customer's application board.
6. These antennas need post calibration, refer to the application note for post calibration process.

2.8 WINCS02 Module Reflow Profile Information

The WINCS02 module was assembled using the IPC/JEDEC J-STD-020 standard lead-free reflow profile. The WINCS02 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 WINCS02 Module Assembly Considerations

The WINCS02 module is assembled with an EMI shield to ensure compliance with EMI emission and immunity rules. The EMI shield is made of a tin-plated steel (SPTE) and is not hermetically sealed. Solutions like IPA and similar solvents can be used to clean the WINCS02 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 WINCS02IC and the WINCS02 Module across the operating temperature range of the product.

3.1 WINCS02IC Electrical Specifications

This chapter provides the electrical specifications and the characteristics of the WINCS02IC.

3.1.1 WINCS02IC Absolute Maximum Ratings

The following table provides details about the list of absolute maximum ratings for the WINCS02IC 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 ⁽³⁾	-0.3V to (V _{DD} +0.3V)
Voltage on any pin, with respect to GND (PA0-PA7)	-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 output current sourced/sunk by any Low-Current Mode I/O pin (4x I/O Pin)	15 mA
Maximum output current sourced/sunk by any High-Current Mode I/O pin (8x I/O Pin)	25 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
V-Temp Temperature Devices:					
Operating ambient temperature range	T _A	-40	—	+105	°C
Operating junction temperature range ⁽¹⁾	T _J	-40	—	+125	°C
Power Dissipation:					

.....continued

Rating	Symbol	Min.	Typ	Max.	Unit
Internal chip power dissipation: $P_{INT} = (V_{DDIO} \times (I_{DD} - \sum I_{OH})) + (V_{DDCORE} \times I_{DDCORE}) + (V_{USB3V3} \times I_{DDUSB}) + (V_{DDANA} \times I_{DDANA_IDD}) + (V_{DDREG} \times I_{DDREG})$	P_D	$P_{INT} + P_{I/O}$			W
Maximum allowed power dissipation	$P_{D_{MAX}}$	$(T_J - T_A)/\theta_{JA}$			W
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	1.8	3.3	3.6	V	PA[7:0] I/O pins only, All other I/Os are at V_{DD}
DC_7	GNDDB	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: $-40^\circ C \leq T_A \leq +85^\circ C$ for Industrial $-40^\circ C \leq T_A \leq +105^\circ C$ for V-temp	
Param. No.	Symbol	Characteristics	Max.	Units
FCLK_1	F_{CY}	Frequency of system clock	80	MHz

3.1.4 Power Management Unit DC Electrical Specifications

Table 3-6. Power Management Unit DC Electrical Specifications

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.	Max.	Units	Conditions
REG_45	V_{BUK}	Buck convertor output voltage range	1.425	1.5	1.575	V	With external L-C filter
REG_53	F_{BUK}	Buck switching frequency	—	1	—	MHz	Buck convertor switching frequency
External LC Filter Components							

.....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.	Max.	Units	Conditions
REG_58	L	Inductor value	—	4.7	—	μH	—
REG_59	L_{DCR}	Inductor DCR	—	—	—	—	Lower is better for high load efficiency
REG_60	C	Capacitor value	—	10	—	μF	—
REG_61	C_{ESR}	Capacitor ESR	—	—	0.01	Ω	Lower is better for low ripple
REG_62	C_{ESL}	Capacitor ESL ⁽¹⁾	—	—	5	nH	Lower is better for high frequency ripple
PMU MLDO Mode							
REG_64	V_{MLDO}	MLDO output voltage range	1.425	1.5	1.575	V	—
Note: 1. Measurement depends on the quality of the evaluation board with respect to coupled noise, input bypass capacitor and output capacitor's Effective Series Resistance (ESR). 2. This parameter is characterized but not tested in manufacturing.							

3.1.5 WINCS02IC DC Characteristics

3.1.5.1 I/O Pin DC Electrical Specifications

Table 3-7. 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: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ 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_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
DI_13	I_{IL}	Input pin leakage current	-1	—	+1	μA	—
Note: 1. This parameter is characterized but not tested in manufacturing.							

3.1.5.2 WINCS02IC Wi-Fi Current

Table 3-8. WINCS02IC Wi-Fi Current

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 $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp Temp				
Param. No.	Symbol	Device States	Code Rate	Output Power (Typ.) (dBm)	Current (Typ.) (mA) ⁽³⁾	Max.	Units	Conditions
IWF_TX	I_{DD}	On_Transmit ⁽⁵⁾	802.11b 1 Mbps	19	281	—	mA	$V_{DD} = V_{DDIO} = 3.3V$
			802.11b 1 Mbps	13	254	—		
			802.11b 11 Mbps	20	284	—		
			802.11g 6 Mbps	19	283	—		
			802.11g 54 Mbps	17	253	—		
			802.11n MCS0	18	274	—		
			802.11n MCS7	17	252	—		
			802.11n MCS7	11	237	—		
IWF_RX	I_{DD}	On_Receive	802.11b 1 Mbps	—	88	—		
			802.11n MCS7	—	94	—		

Notes:

- Measured along with RF matching network (assume 50Ω impedance).
- The test conditions for I_{DD} current measurements are as follows:
 - CPU, Flash panel and SRAM data memory are operational
 - CPU is operating at 80 MHz
 - CPU is in Wi-Fi® RF Test mode
 - All peripheral modules are disabled (ON bit = 0) but the associated PMD bit is cleared
 - WDT and FSCM are disabled
 - All I/O pins are configured as inputs and pulled to V_{DD}
 - $\overline{MCLR} = V_{DD}$
- Data in the "Typ." column is at 3.3V, 25°C unless otherwise stated.
- This parameter is characterized but not tested in manufacturing.
- Tested at channel 7 in Fixed mode gain.

3.1.5.3 Extreme Deep Sleep (XDS) Current Consumption

Table 3-9. Extreme Deep Sleep (XDS) Current Consumption

DC Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0V$ to $3.6V$ (unless otherwise stated)			
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp			
Param. No.	Symbol	Characteristics	Typ ⁽¹⁾	Max.	Units	Conditions
XDSPWR_1	I_{DD_XDS} ⁽²⁾	I_{DD} in XDS mode	0.7	—	μA	$V_{DD} = V_{DDIO} = 3.3V$

.....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	Typ ⁽¹⁾	Max.	Units	Conditions
Notes: 1. Typical values at $25^{\circ}C$ only 2. Conditions: – All peripherals inactive – All IO configured as input and pulled down internally						

3.1.6 WINCS02IC AC Characteristics

3.1.6.1 External XTAL POSC 40 MHz AC Electrical Specifications

Table 3-10. 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 ⁽²⁾	Characteristics	Min.	Typ	Max.	Units	Conditions ⁽¹⁾
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
XOSC_11	C _{LOAD}	XOSC crystal FOSC = 40 MHz	—	—	12	pf	—
XOSC_34	g _m	XOSC transconductance GAIN = 0	—	16	—	mA/V	XOSC auto gain control disabled
XOSC_39	XCLK_FST	Primary XIN clock fail safe time-out period	—	2	—	ms	—
Notes: 1. Crystal oscillator requirements: – Crystal load capacitance = 12 pF – ESR = 50Ω – Maximum drive level = 200 μW 2. This parameter is characterized but not tested in manufacturing.							

3.1.6.2 XOSC32 RTCC Oscillator AC Electrical Specifications

Table 3-11. XOSC32 RTCC Oscillator AC Electrical Specifications

AC Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0V$ to $3.6V$ (unless otherwise stated)				
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ 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⁾
XOSC32_1	FOSC_XOSC32	XOSC32 oscillator crystal frequency	—	32.768	—	kHz	SOSCI, SOSCO RTCC oscillator

.....continued

AC Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0V$ to $3.6V$ (unless otherwise stated)				
			Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ 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⁾
XOSC32_15	TOSC32	$TOSC32 = 1/FOSC_XOSC32$	—	—	—	μs	See parameter XOSC32_1 for FOSC_XOSC32 value
XOSC32_21	XCLK32_DC	Ext clock oscillator duty cycle	—	50	—	%	—

Notes:

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

3.1.6.3 SPI Electrical Specifications

Figure 3-1. SPI Client CPHA=0 Timing Diagram

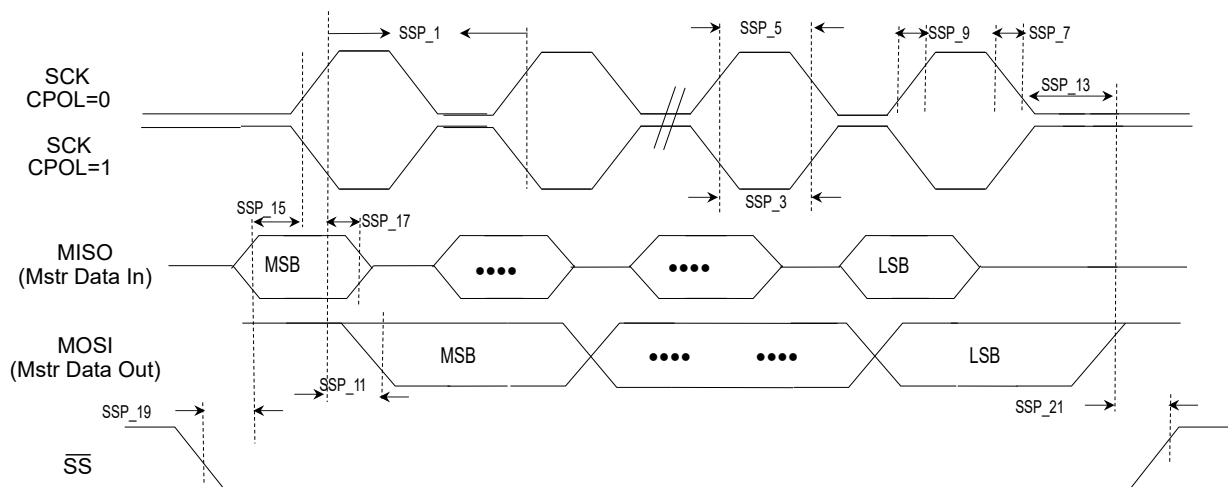


Figure 3-2. SPI Client CPHA=1 Timing Diagram

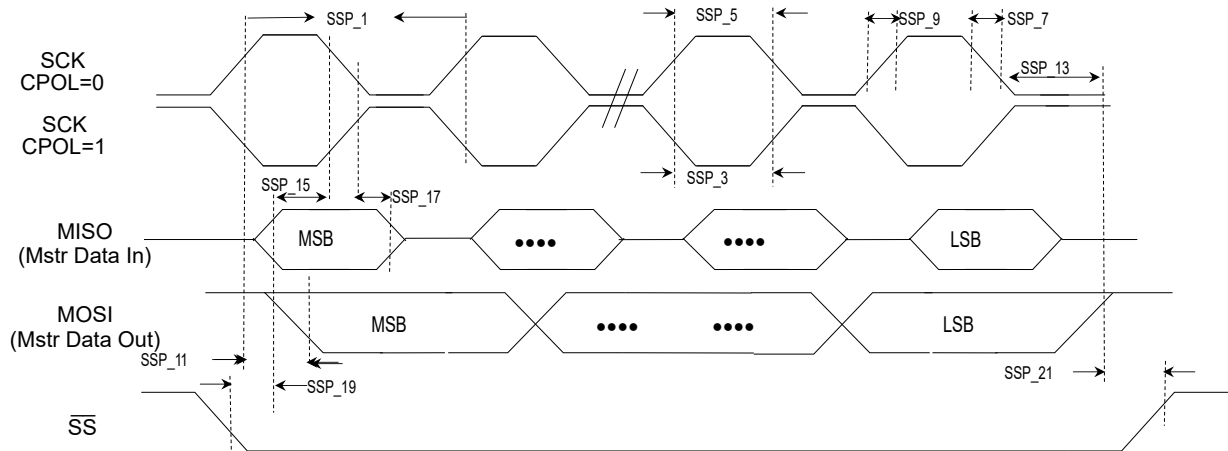


Table 3-12. SPI Client Mode Electrical Specifications

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	Min.	Typ	Max.	Units	Conditions
SSP_1	FSCK	SCK frequency	—	—	40	MHz	SPI1 CLOCK on PA0
SSP_3	TSCL	SCK output low time	—	1/ (2*FSCK)	—	ns	—
SSP_5	TSCH	SCK output high time	—	1/ (2*FSCK)	—	ns	—
SSP_7	TSCF	SCK and MOSI output fall time	—	—	10	ns	—
SSP_9	TSCR	SCK and MOSI output rise time	—	—	10	ns	—
SSP_11	TSOV	MOSI data output valid after SCK	—	—	13	ns	—
SSP_15	TSIS	MISO setup time of data input to SCK	6	—	—	ns	
SSP_17	TSIH	MISO hold time of data input to SCK	1	—	—	ns	
Notes:							
1. Assumes VDDIOx (min) and 15 pF external load on all SPIx pins unless otherwise noted.							
2. CPHA=0							
3. CPHA=1							
4. These parameters are characterized but not tested in manufacturing.							

3.1.6.4 Power on Reset AC Electrical Specifications

Table 3-13. 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: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions
DC_11	VPOR	V_{DD} start voltage to ensure internal POR signal	1.45	—	1.65	V	—
DC_12	SVDD	V_{DD} rise rate to ensure internal POR signal	0.03	—	0.115	V/ms	0-3.0V in 0.1s
DC_13	TRST	External Reset valid active pulse width	3	—	—	us	—

3.1.7 WINCS02IC Radio Specifications

Table 3-14. WINCS02IC 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

3.1.7.1 WINCS02IC Receiver Performance

Table 3-15. WINCS02IC 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 $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp 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	—	
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	—	

.....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 Temp			
Param. No.	Characteristics	Description ⁽⁵⁾	Min.	Typ	Max.	Units
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.
7. Preproduction samples must undergo RF testing using either conducted methods or antennas that exhibit a return loss better than -20 dB. Production samples designed to support VSWR<2.

3.1.7.2 WINCS02IC Transmitter Performance

Table 3-16. WINCS02IC 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 $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp			
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⁾	

.....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 $-40^{\circ}C \leq T_A \leq +105^{\circ}C$ for V-temp			
Param. No.	Characteristics	Description ⁽⁸⁾	Min.	Typ ⁽³⁾	Max.	Units
Notes: 1. Measured at IEEE® 802.11 specification compliant EVM/Spectral mask 2. Measured after RF matching network (assume 50Ω impedance) 3. RF performance is ensured at 3.3V, 25°C, with a 2-3 dB change at boundary conditions. 4. With respect to TX power, different (higher/lower) RF output power settings can be used for specific antennas and/or enclosures, in which case, re-certification can be required. Program the custom gain table to control the transmit power using the MCHPRT3 tool. 5. The availability of some specific channels and/or operational frequency bands are country-dependent and must be programmed in the host product at the factory to match the intended destination. Regulatory bodies prohibit exposing the settings to the end user. This requirement needs to be taken care of via host implementation. 6. The host product manufacturer must ensure that the RF behavior adheres to the certification (for example, FCC, ISCED) 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.						

3.1.7.3 WINCS02IC Receiver and Transmitter Characteristics Graphs

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

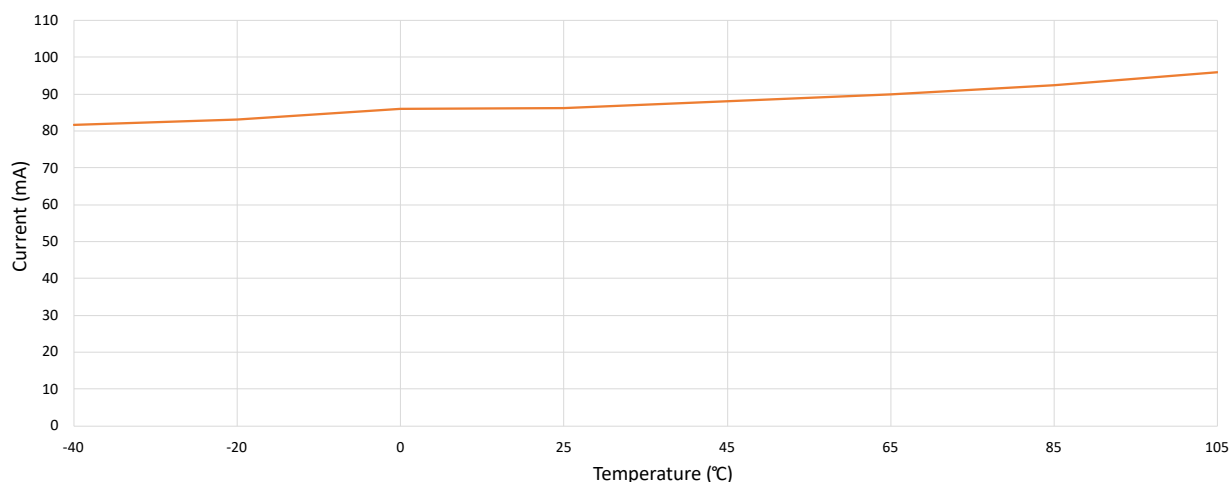


Figure 3-4. Receive Current vs Receive Signal Power, MCS7, Channel 7, 3.3V, 25°C

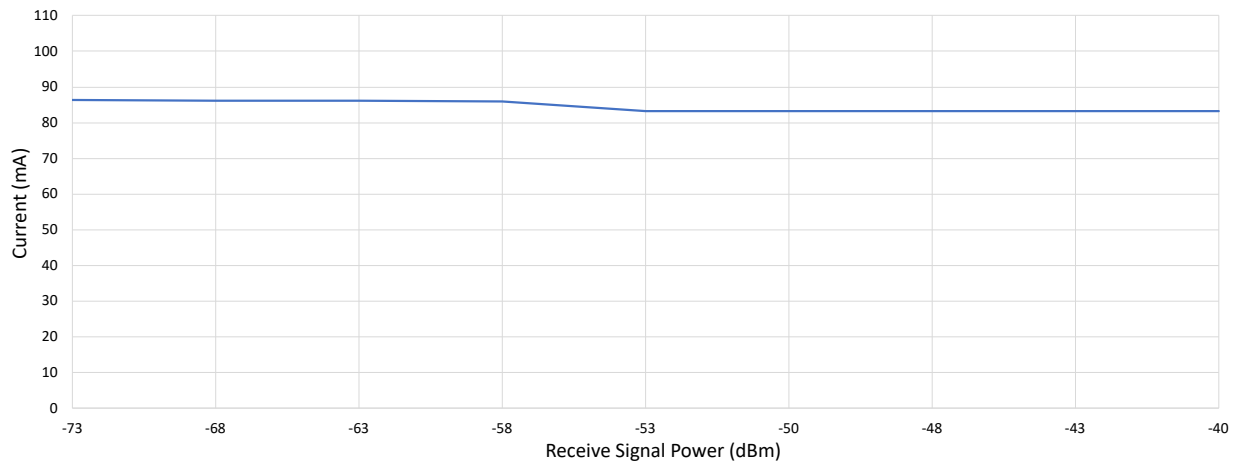


Figure 3-5. Transmit Current vs Temperature, MCS7, Channel 7, 3.3V

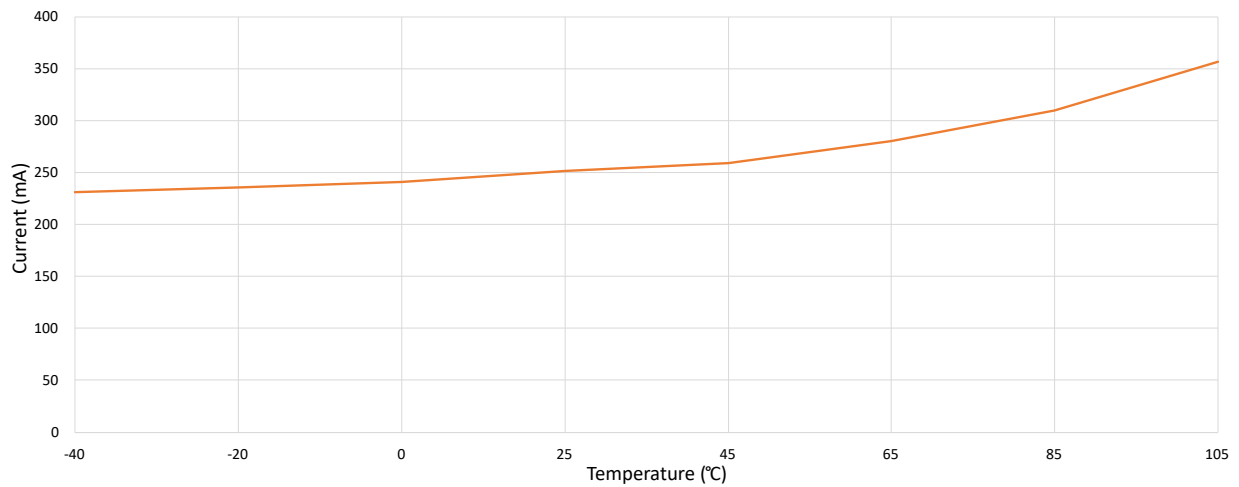


Figure 3-6. Transmit Current vs Transmit Output Power, MCS7, Channel 7, 3.3V, 25°C

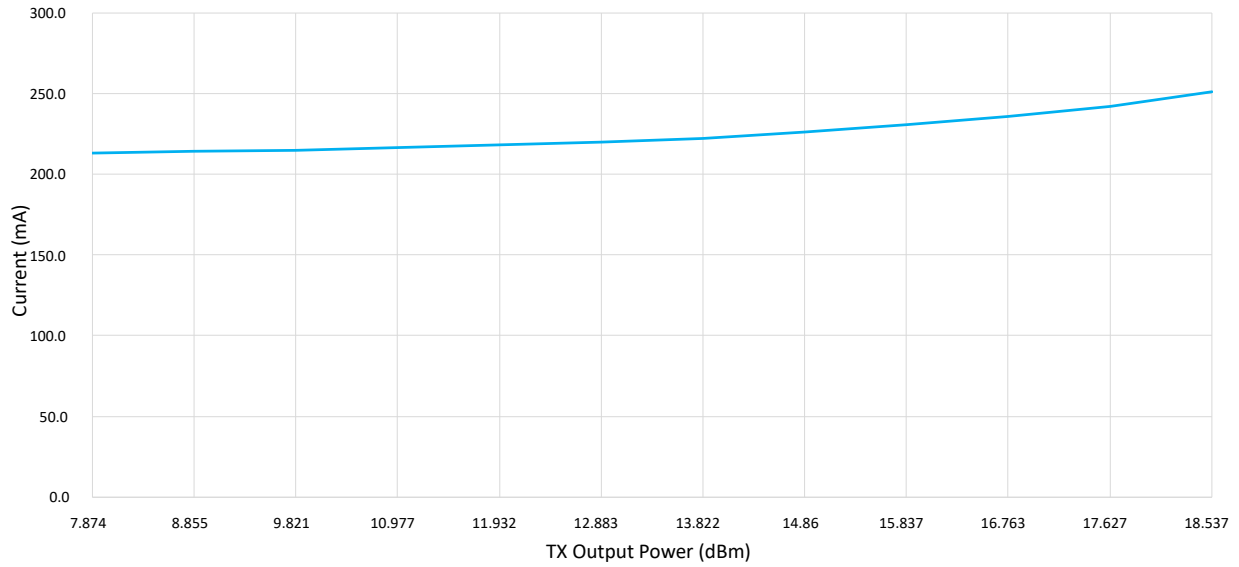


Figure 3-7. Transmit Power vs Voltage, 11b, 1Mbps, Channel 7, 25°C

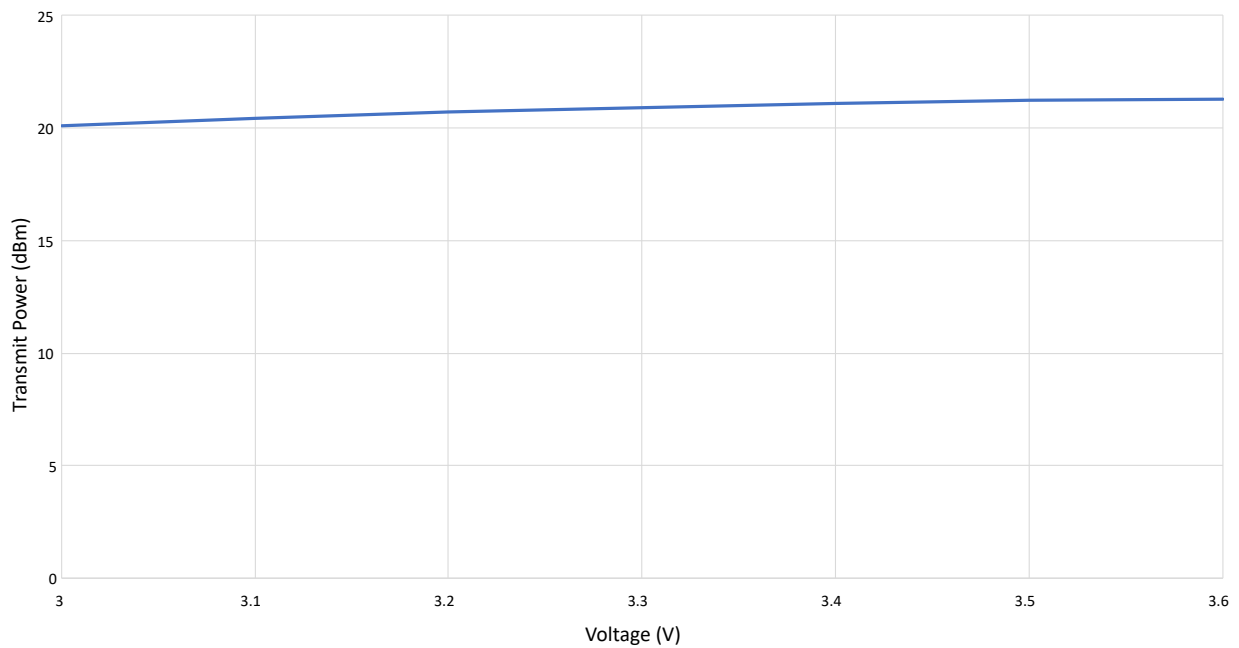


Figure 3-8. Transmit Power vs Temperature, 11b, 1Mbps, Channel 7, 3.3V, 25°C

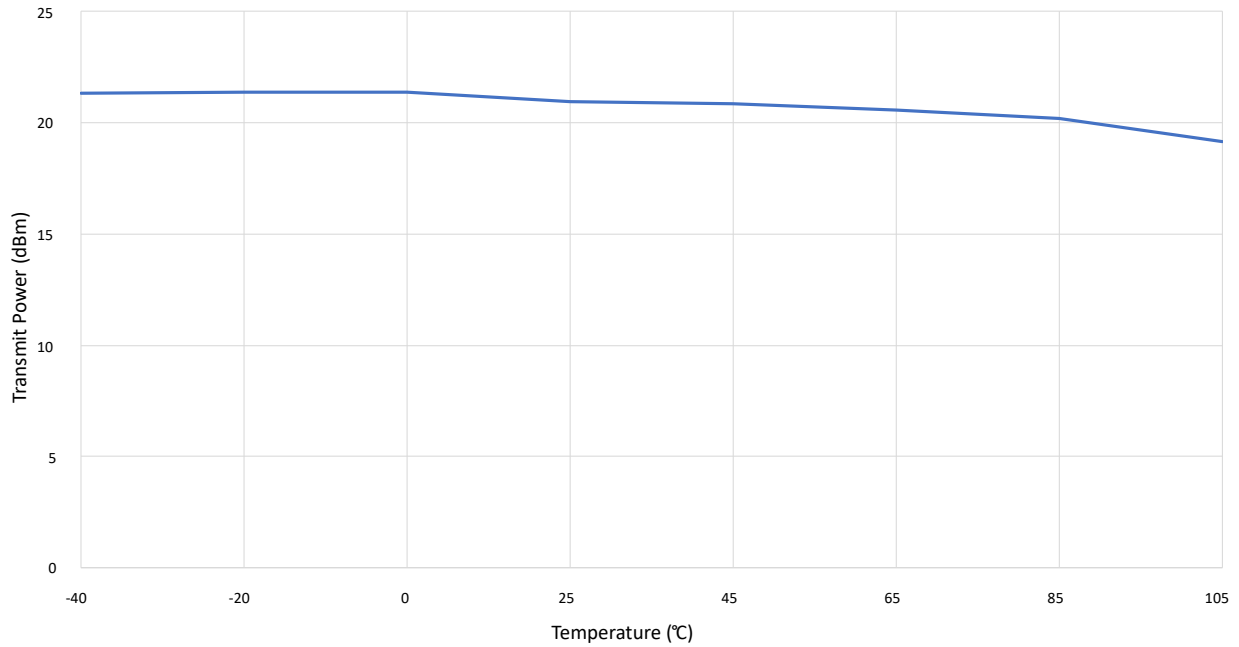


Figure 3-9. Transmit Power vs Channel, 1Mbps, 3.3V, 25°C

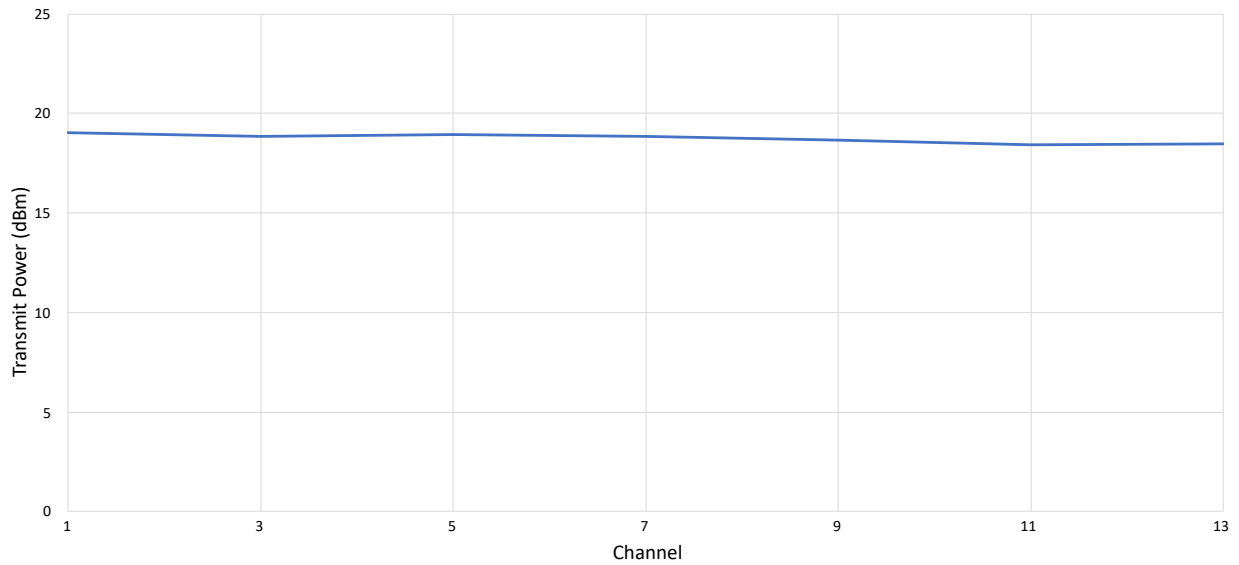


Figure 3-10. RSSI vs Received Signal Power, MCS7, Channel7, 3.3V, 25°C

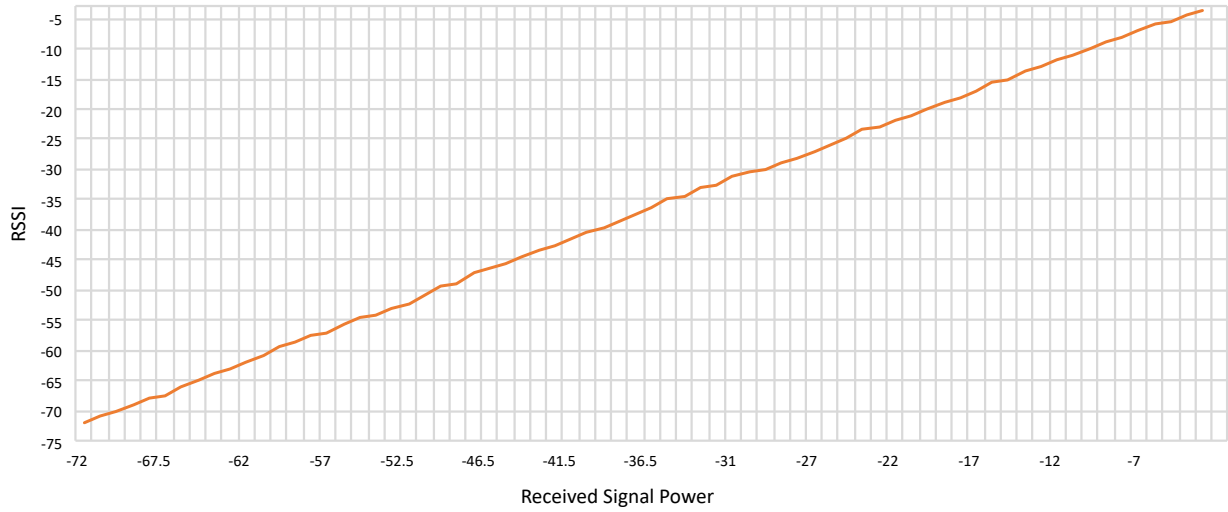


Figure 3-11. RX Sensitivity vs Channel, MCS7, 3.3V, 25°C

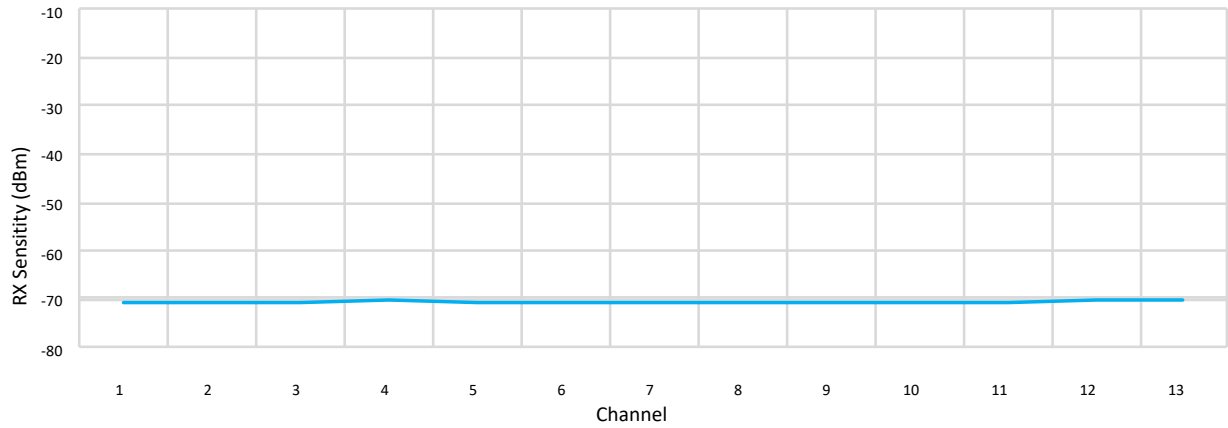
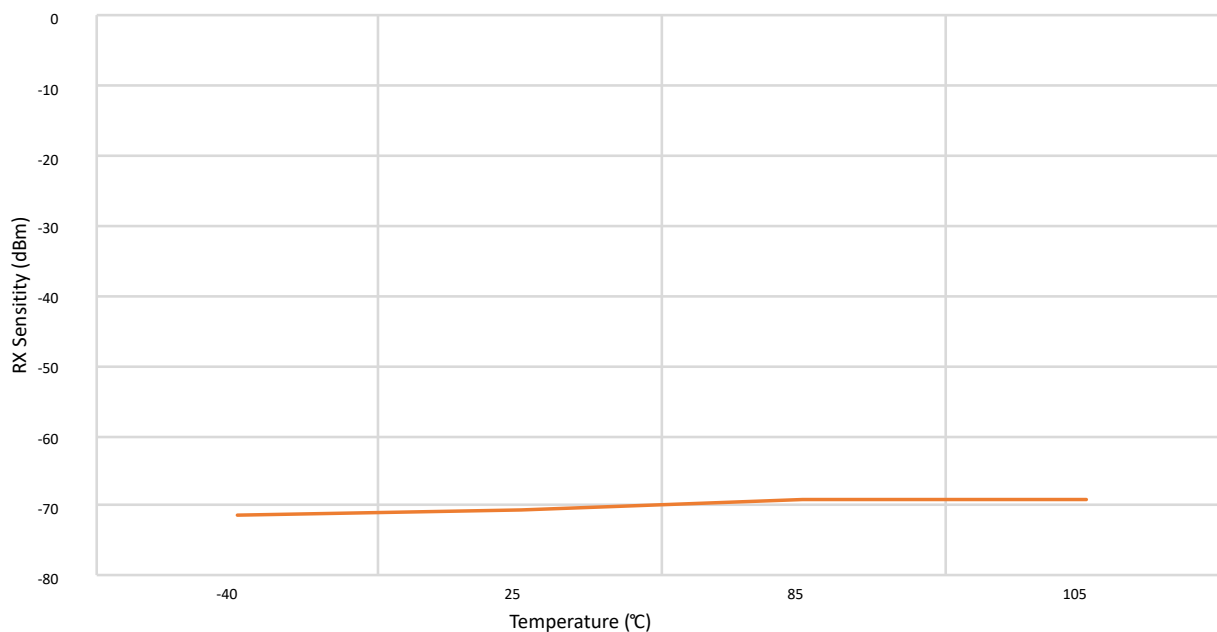


Figure 3-12. RX Sensitivity vs Temperature, MCS7, Channel 7, 3.3V



3.2 WINCS02 Module Electrical Specifications

This chapter provides the electrical specifications and the characteristics of the WINCS02 Module across the operating temperature range of the product.

3.2.1 WINCS02 Module Absolute Maximum Ratings

The following table provides details about the list of absolute maximum ratings for the WINCS02 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 3-17. 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 3-18. 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 3-19. Recommended Operating Voltages

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

3.2.3 WINCS02 Module AC and DC Characteristics

For WINCS02 Module AC and DC Electrical Characteristics, refer to [3.1. WINCS02IC Electrical Specifications](#).

3.2.3.1 Wi-Fi Current Consumption

Table 3-20. 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) ⁽³⁾	Max.	Units	Conditions
IWF_TX	I_{DD}	On_Transmit ⁽⁵⁾	802.11b 1 Mbps	19	295	—	mA	$V_{DD} = V_{DDIO} = 3.3V$
			802.11b 1 Mbps	13	264	—		
			802.11b 11 Mbps	20	299	—		
			802.11g 6 Mbps	19	296	—		
			802.11g 54 Mbps	17	266	—		
			802.11n MCS0	18	288	—		
			802.11n MCS7	17	265	—		
			802.11n MCS7	11	246	—		
IWF_RX	I_{DD}	On_Receive	802.11b 1 Mbps	—	92	—		
			802.11n MCS7	—	98	—		

Notes:

- Measured along with the RF matching network (assume 50Ω impedance)
- The test conditions for I_{DD} current measurements are as follows:
 - CPU, Flash panel and SRAM data memory are operational
 - CPU is operating at 80 MHz
 - CPU is in Wi-Fi RF Test mode
 - All peripheral modules are disabled (ON bit = 0) but the associated PMD bit is cleared
 - WDT and FSCM are disabled
 - All I/O pins are configured as inputs and pulled to V_{DD}
 - $\overline{MC\overline{L}R} = V_{DD}$
- Data in the "Typ." column is at 3.3V, 25°C unless otherwise stated.
- This parameter is characterized, but not tested in manufacturing.
- Tested at channel 7 in Fixed mode gain.

3.2.4 WINCS02 Module Radio Specifications

Table 3-21. WINCS02 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 WINCS02 Module Receiver Performance

Table 3-22. WINCS02 Module Receiver Performance Characteristics⁽¹⁾

RF Characteristics			Standard Operating Conditions: V _{DD} =V _{DDIO} = 3.0V to 3.6V (unless otherwise stated)			
			Operating Temperature: -40°C ≤ T _A ≤ +85°C for Industrial			
Param. No.	Characteristics	Description ⁽⁵⁾	Min.	Typ	Max.	Units
WF_RX_1	Frequency	—	2412	—	2472	MHz
WF_RX_2	Sensitivity 802.11b	1 Mbps DSSS	—	-97	—	dBm
		2 Mbps DSSS	—	-93	—	
		5.5 Mbps DSSS	—	-92	—	
		11 Mbps DSSS ⁽⁶⁾	—	-88	—	
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	—	
WF_RX_5	Maximum receive signal level	MCS 7 ⁽⁶⁾	—	-70	—	dBm
		1, 2 Mbps DSSS	8	—	—	
		5.5, 11 Mbps CCK	8	—	—	
		6 Mbps OFDM	-1.5	—	—	
		54 Mbps OFDM	-8.5	—	—	
		MCS 0	-0.5	—	—	
WF_RX_6	Adjacent channel rejection	MCS 7	-8.5	—	—	dB
		1 Mbps DSSS	43.5	—	—	
		(30 MHz offset)				
		11 Mbps CCK	38.5	—	—	
		(25 MHz offset)				
		6 Mbps OFDM	46.5	—	—	
		(25 MHz offset)				
		54 Mbps OFDM	28.5	—	—	
WF_RX_7	RSSI accuracy	(25 MHz offset)				dB
		MCS 0 – 20 MHz Bandwidth (25 MHz offset)	45.5	—	—	
		MCS 7 – 20 MHz Bandwidth (25 MHz offset)	25.5	—	—	

.....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, 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.						

3.2.4.2 WINCS02 Module Transmitter Performance

Table 3-23. WINCS02 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

.....continued

RF Characteristics			Standard Operating Conditions: V _{DD} =V _{DDIO} = 3.0V to 3.6V (unless otherwise stated) Operating Temperature: -40°C ≤ T _A ≤ +85°C for Industrial			
Param. No.	Characteristics	Description ⁽⁸⁾	Min.	Typ ⁽³⁾	Max.	Units
WF_TX_6	Harmonic output power (Radiated, Regulatory mode)	2nd	—	42	74 ⁽⁷⁾	dBuV/m
		3rd	—	Below noise floor	74 ⁽⁷⁾	
Notes:						
1. Measured at IEEE® 802.11 specification compliant EVM/Spectral mask						
2. Measured after RF matching network (assume 50Ω impedance)						
3. RF performance is ensured at 3.3V, 25°C, with a 2-3 dB change at boundary conditions.						
4. With respect to TX power, different (higher/lower) RF output power settings can be used for specific antennas and/or enclosures, in which case, re-certification can be required. Program the custom gain table to control the transmit power using the MCHPRT3 tool.						
5. The availability of some specific channels and/or operational frequency bands are country-dependent and must be programmed in the host product at the factory to match the intended destination. Regulatory bodies prohibit exposing the settings to the end user. This requirement needs to be taken care of via host implementation.						
6. The host product manufacturer must ensure that the RF behavior adheres to the certification (for example, FCC, 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 WINCS02 Module Receiver and Transmitter Characteristics Graphs

Figure 3-13. Receive Current vs Temperature, MCS7, Channel 7, 3.3V

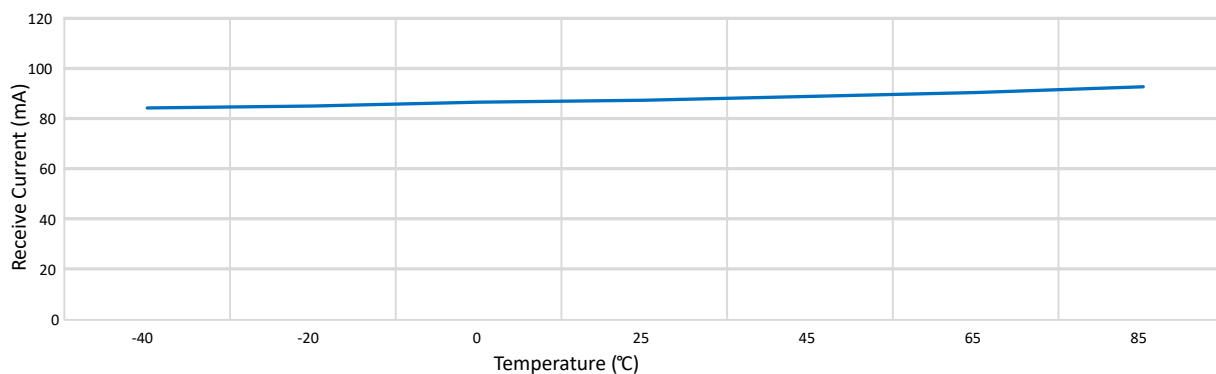


Figure 3-14. Receive Current vs Receive Signal Power, MCS7, Channel 7, 3.3V, 25°C

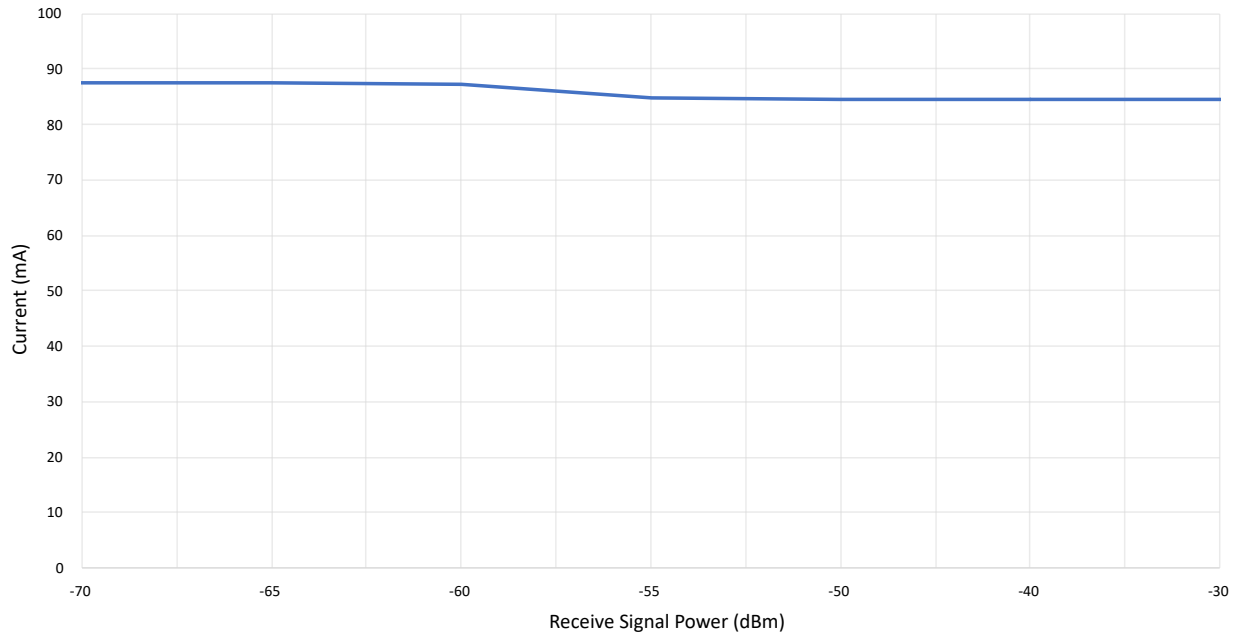


Figure 3-15. Transmit Current vs Temperature, MCS7, Channel 7, 3.3V

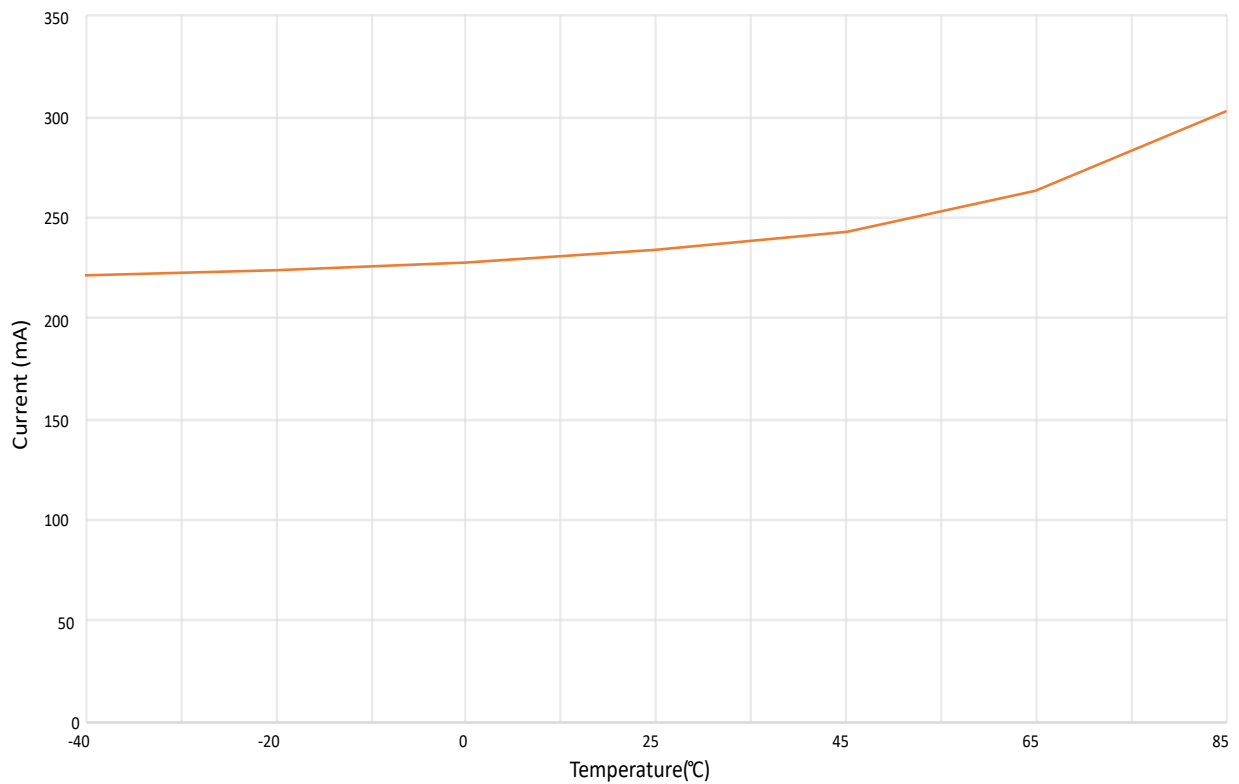


Figure 3-16. Transmit Current vs Transmit Output Power, MCS7, Channel 7, 3.3V, 25°C

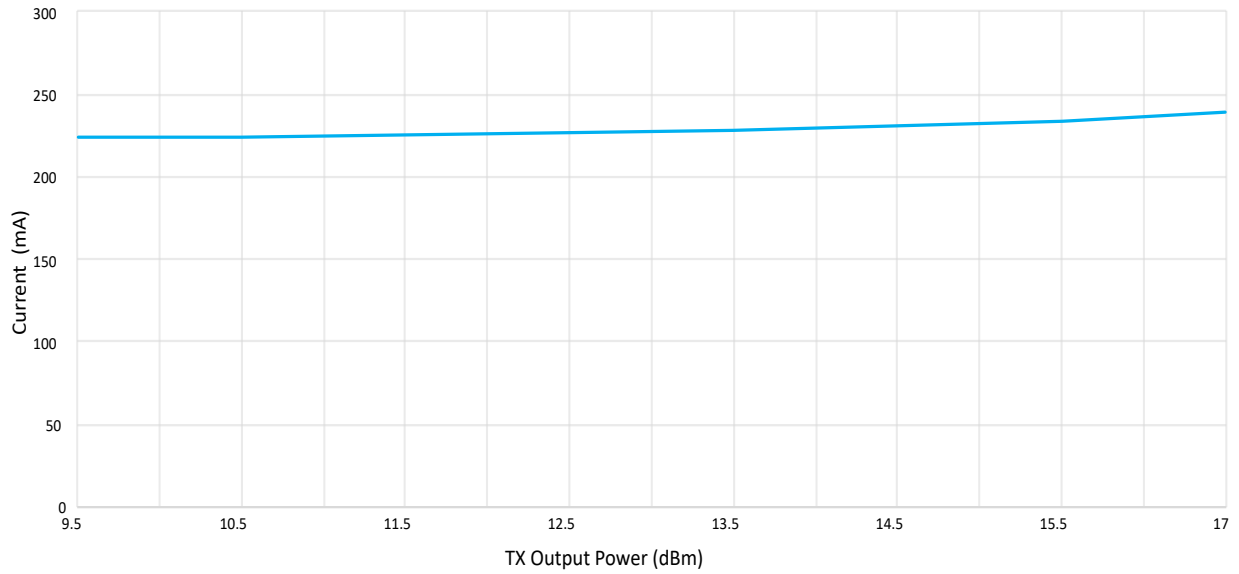


Figure 3-17. Transmit Power vs Voltage, 1M, Channel 7, 3.3V, 25°C

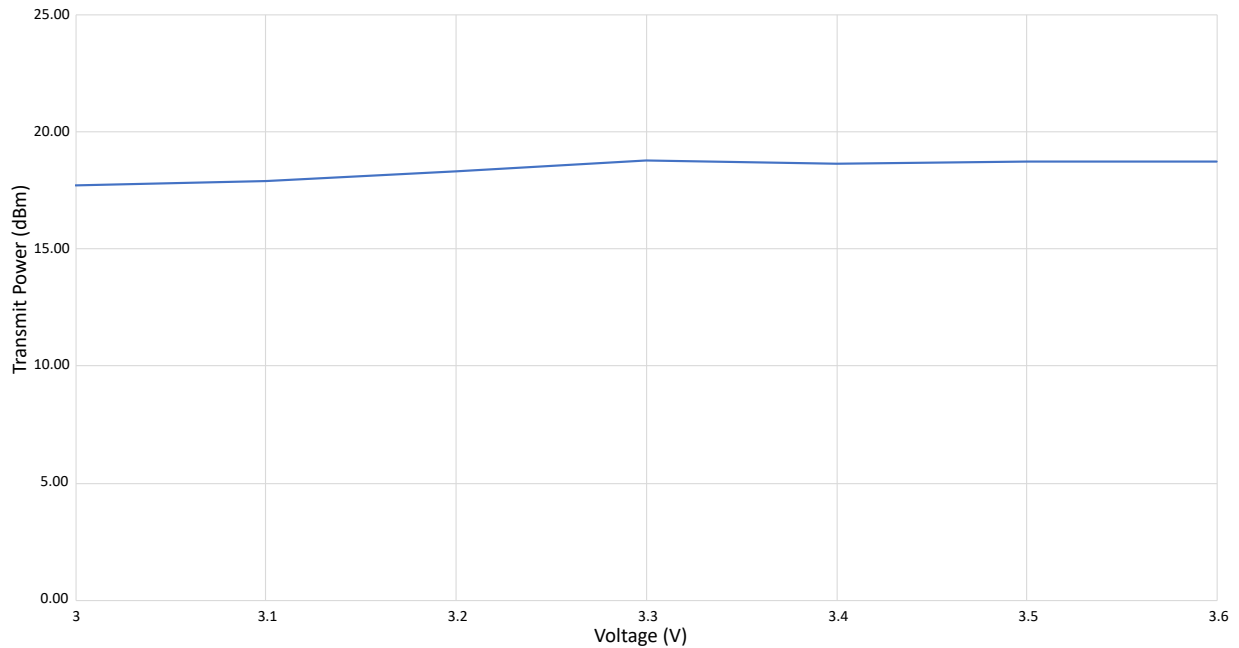


Figure 3-18. Transmit Power vs Temperature, 1M, Channel 7, 3.3V

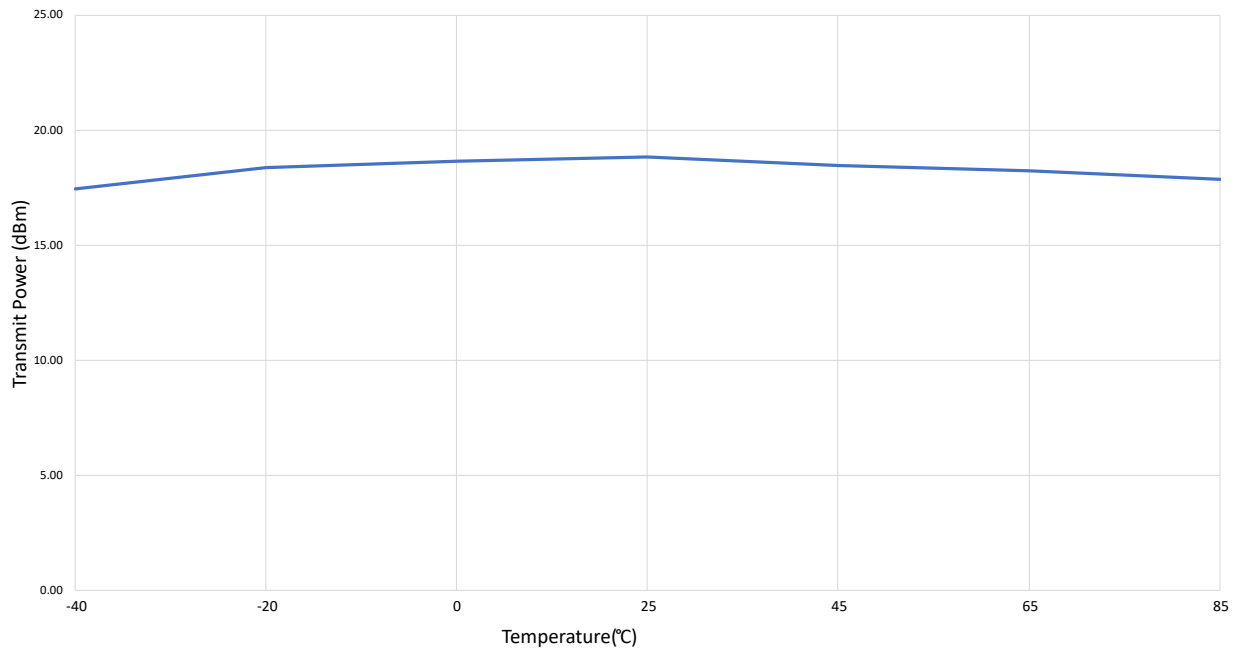


Figure 3-19. Transmit Power vs Channel, 1M, Channel 7, 3.3V, 25°C

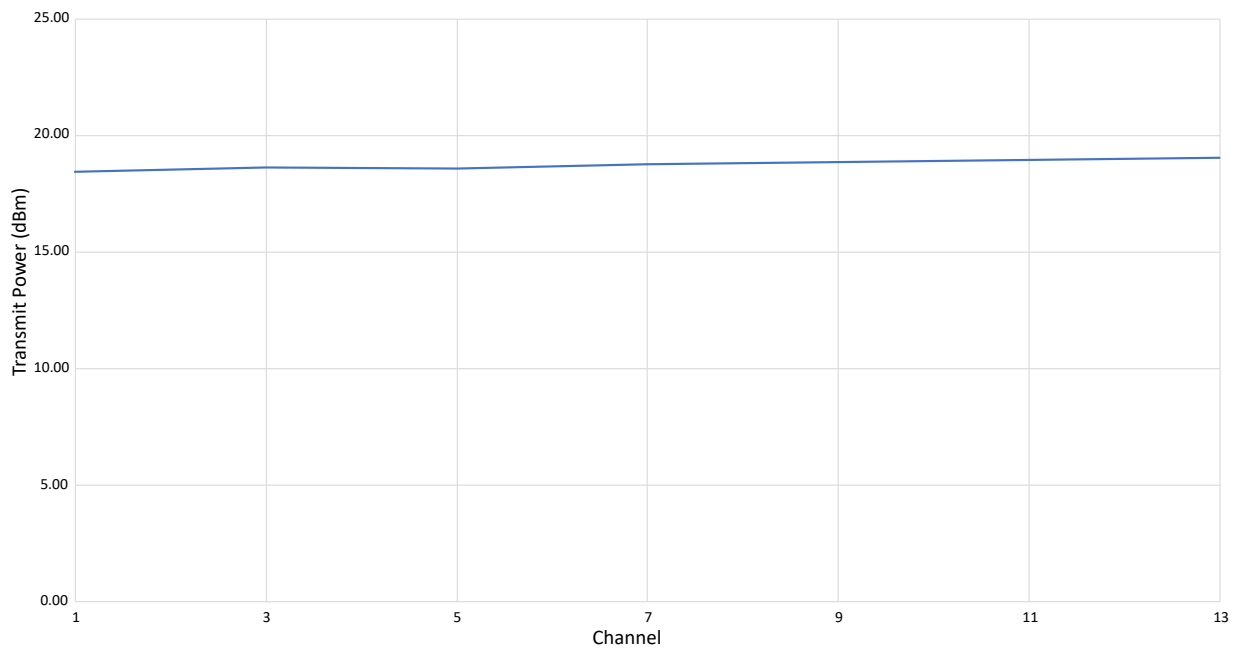


Figure 3-20. RX RSSI vs RX Input Power, MCS7, 3.3V, 25°C

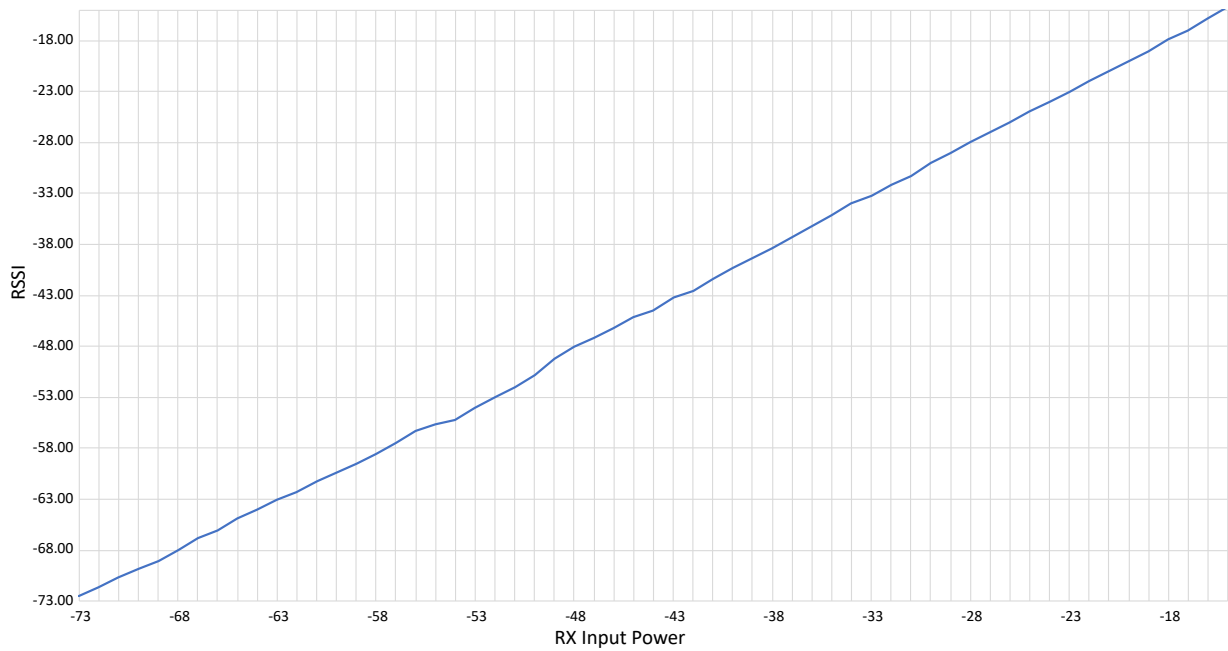


Figure 3-21. RX Sensitivity vs Channel, MCS7, 3.3V, 25°C

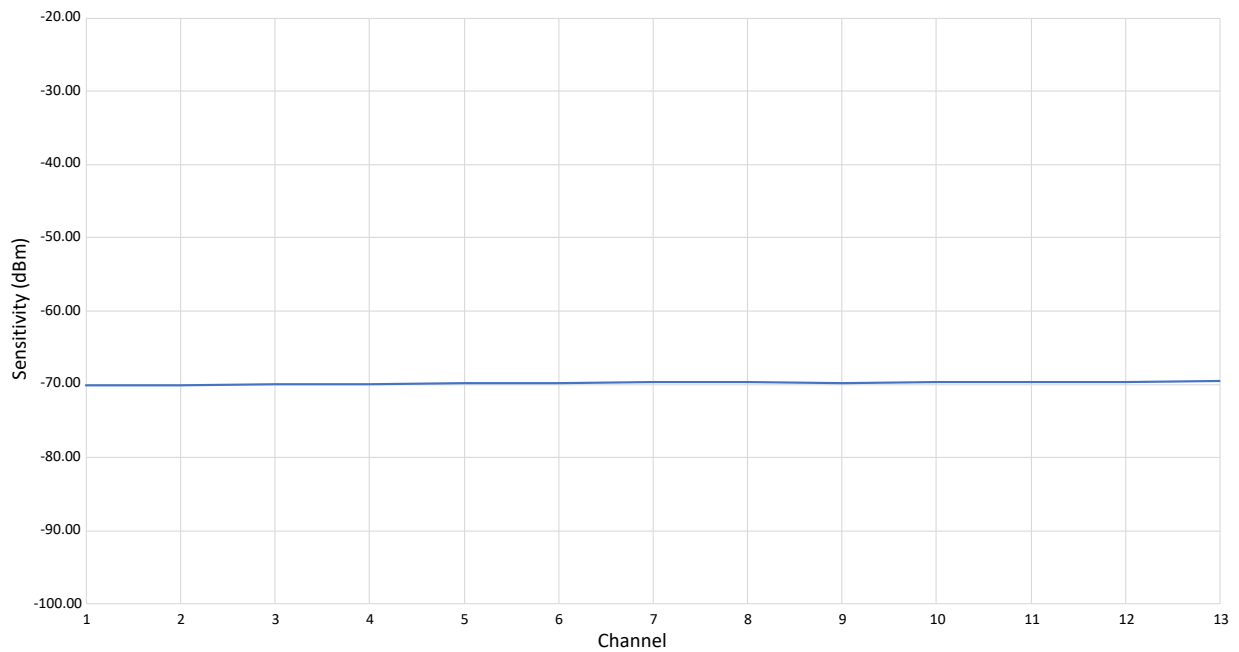


Figure 3-22. Receive Sensitivity vs Voltage, MCS7, Channel 7, 3.3V, 25°C

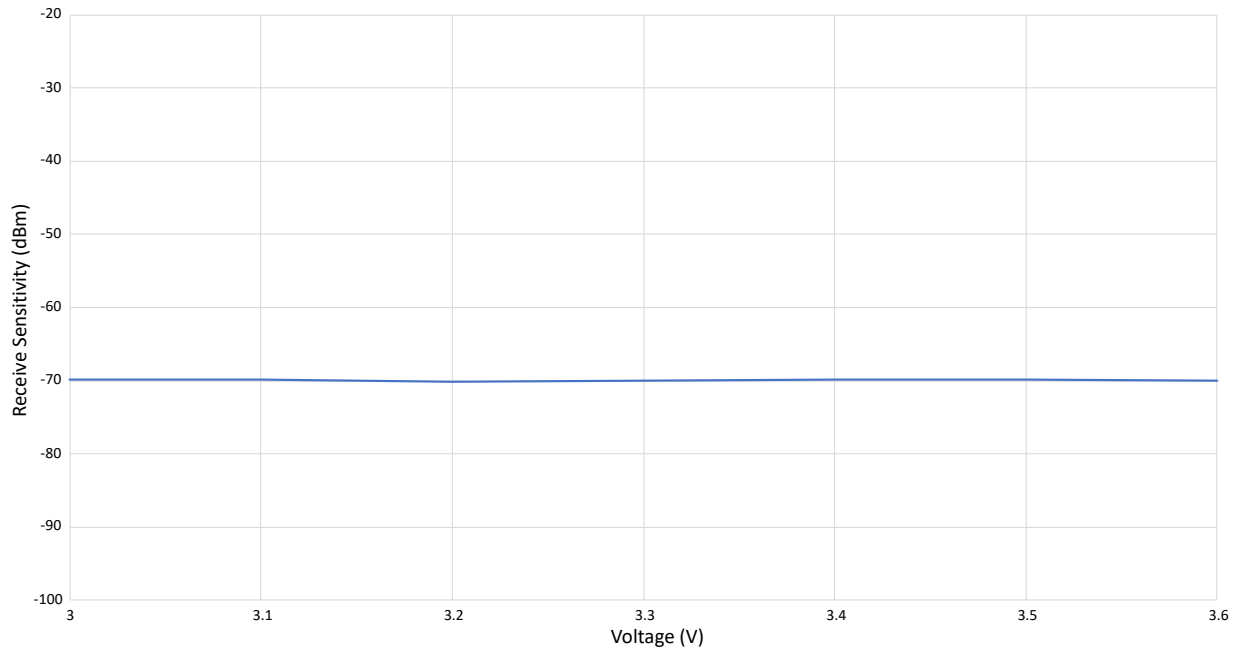
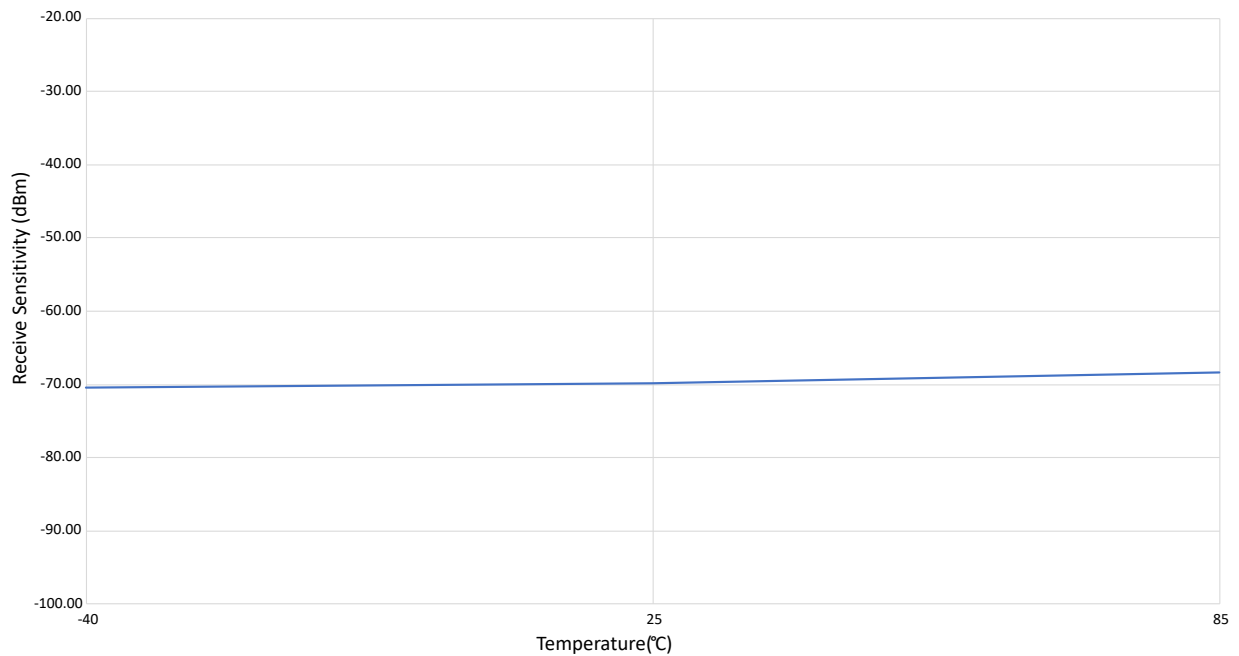


Figure 3-23. Receive Sensitivity vs Temperature, MCS7, Channel 7, 3.3V



4. Packaging Information

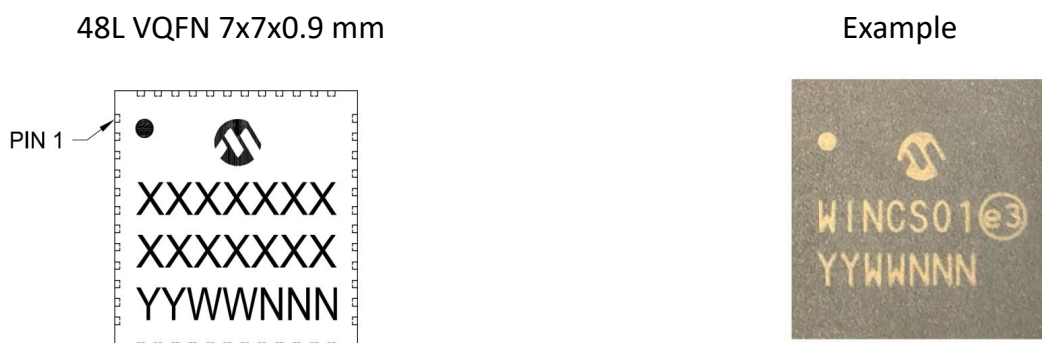
This chapter provides information on package markings, dimension, and footprint of the WINCS02IC and the WINCS02 Module.

4.1 WINCS02IC 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 WINCS02IC Package Marking

Figure 4-1. WINCS02IC Package Marking



Legend: XX...X Customer-specific information

Year code (last digit of calendar year)

YY Year code (last 2 digits of calendar year)

WW Week code (week of January 1 is week '01')

NNN Alphanumeric traceability code

Pb-free JEDEC designator for Matte Tin (Sn)

This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note:

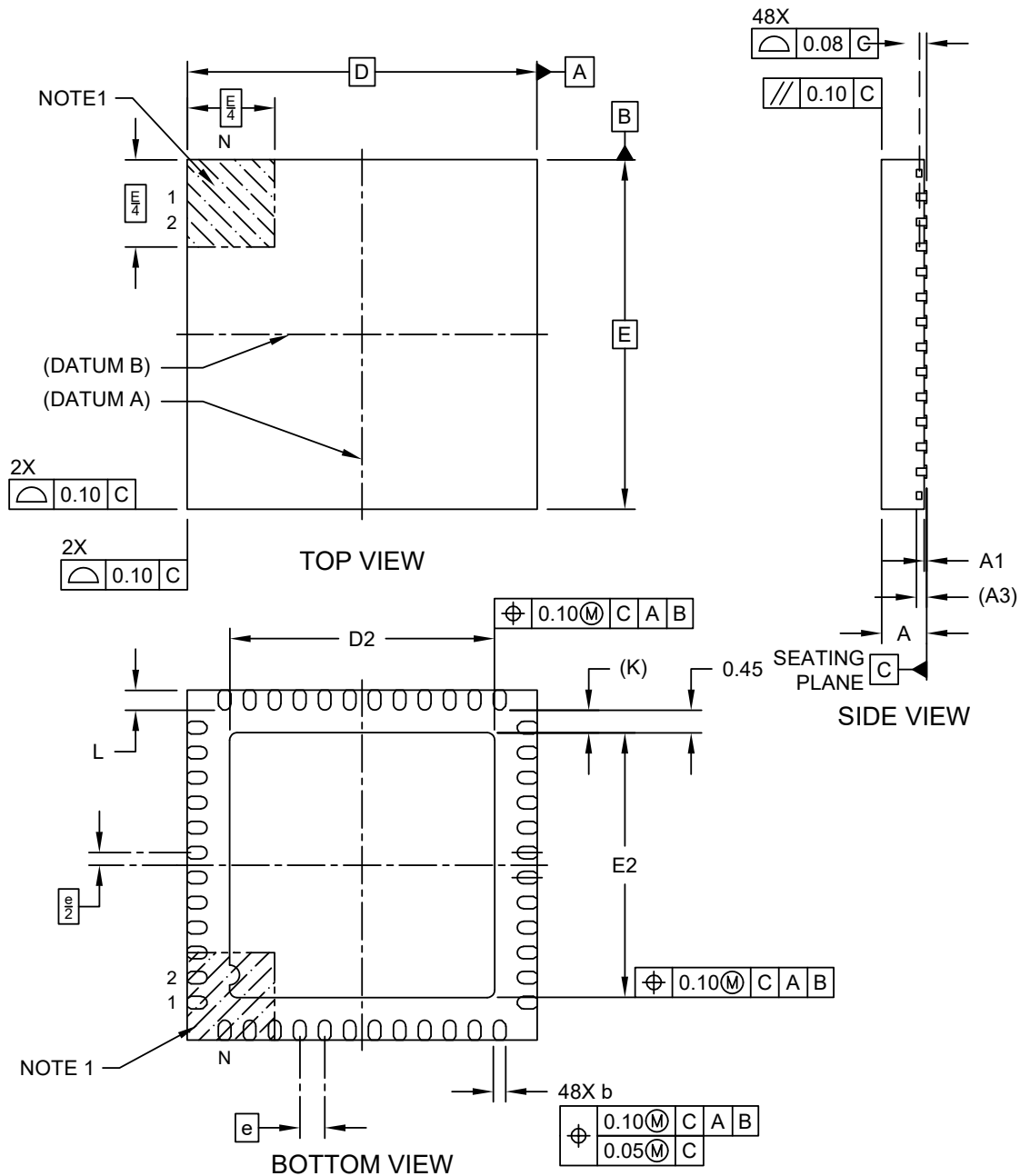
In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

4.1.2 WINCS02IC Packaging Dimension

This section provides the package dimension details of WINCS02IC.

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

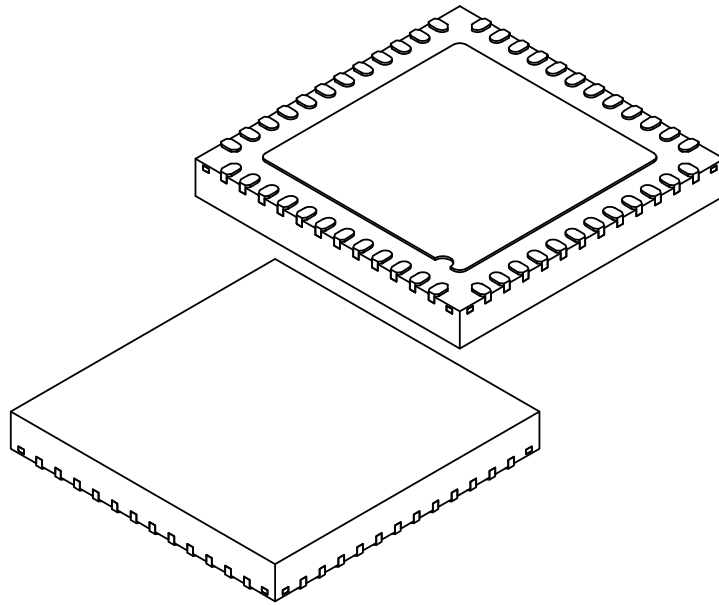
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



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		

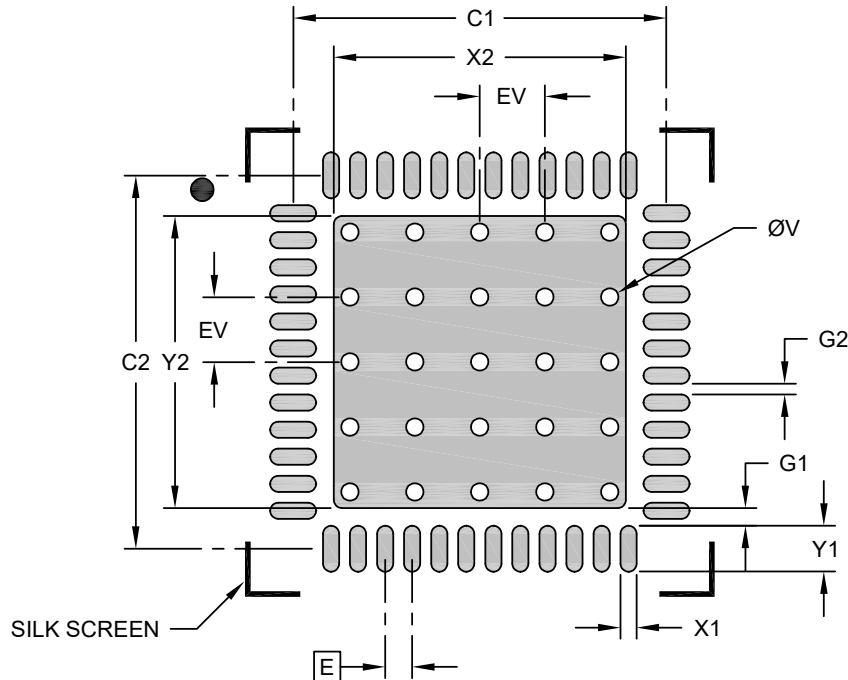
Notes:

- 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

Dimension	Units	MILLIMETERS		
		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

© 2021 Microchip Technology Inc.

4.2 WINCS02 Module Packaging Information

4.2.1 WINCS02 Module Packaging Marking

Figure 4-2. WINCS02 Module Packaging Marking



Legend:

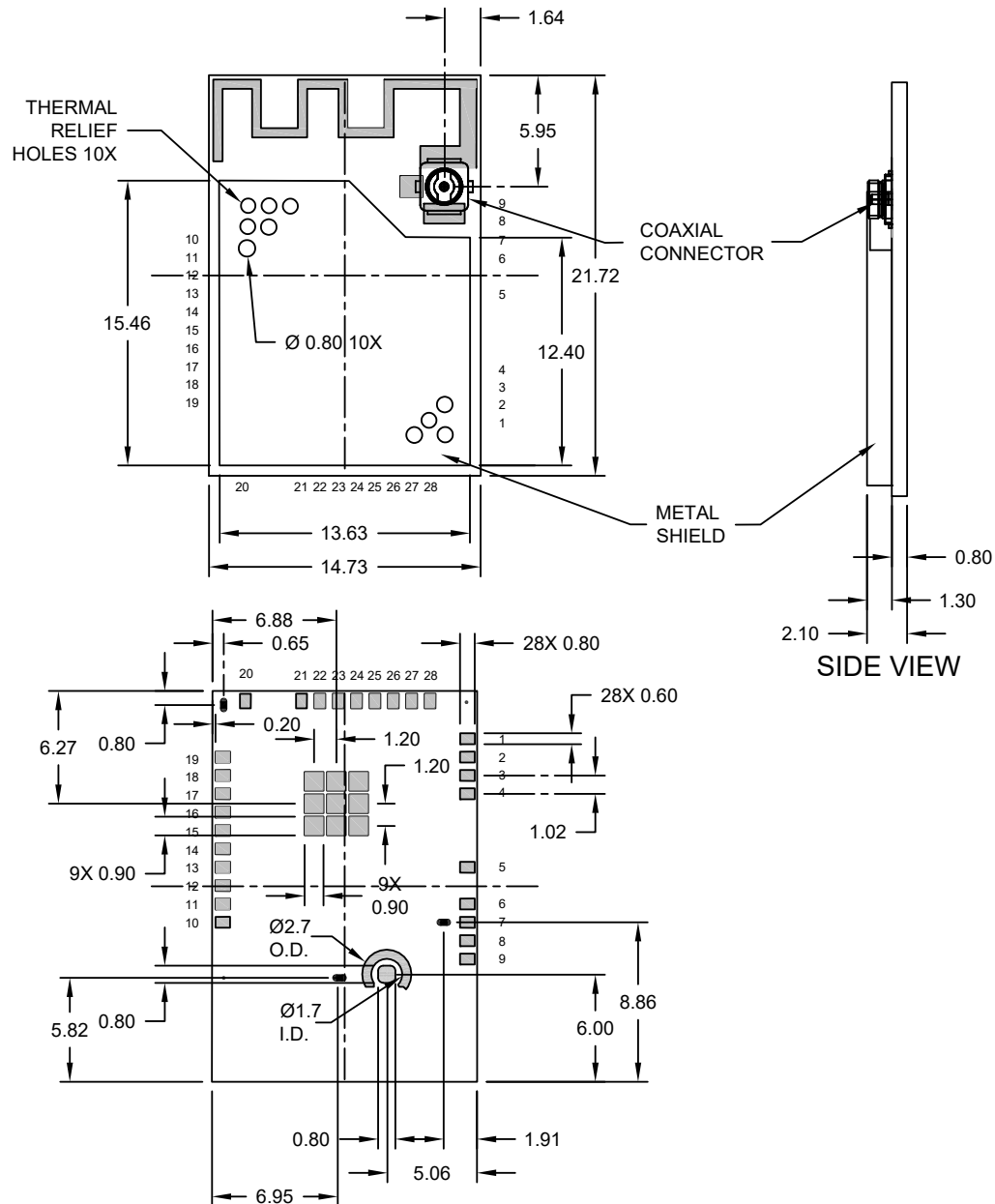
XX....X	Module part number and version and regulatory designator
YY:	Year code (last 2 digits of calendar year)
WW	Week code (week of January 1 is week "01")
NNN	Alphanumeric traceability code

4.2.2 WINCS02 Module Packaging Dimension

This section provides the package dimension details of the WINCS02 module.

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

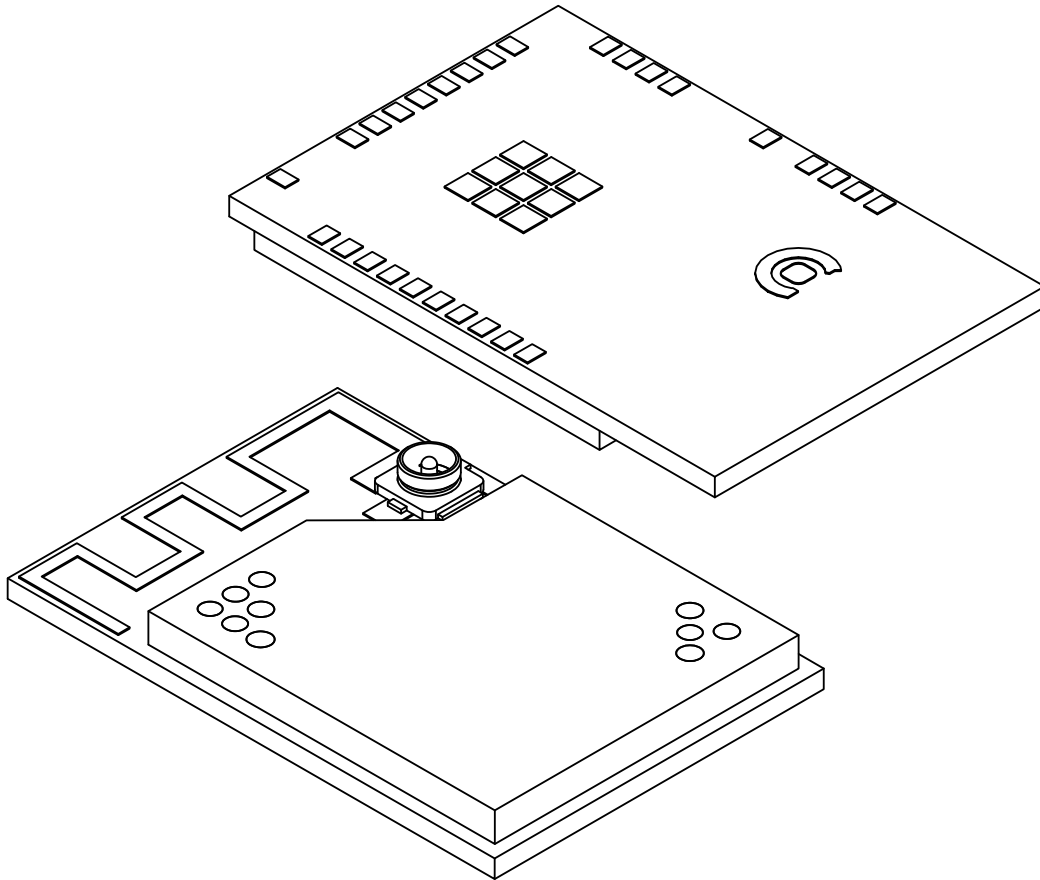
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-21567 Rev B 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>



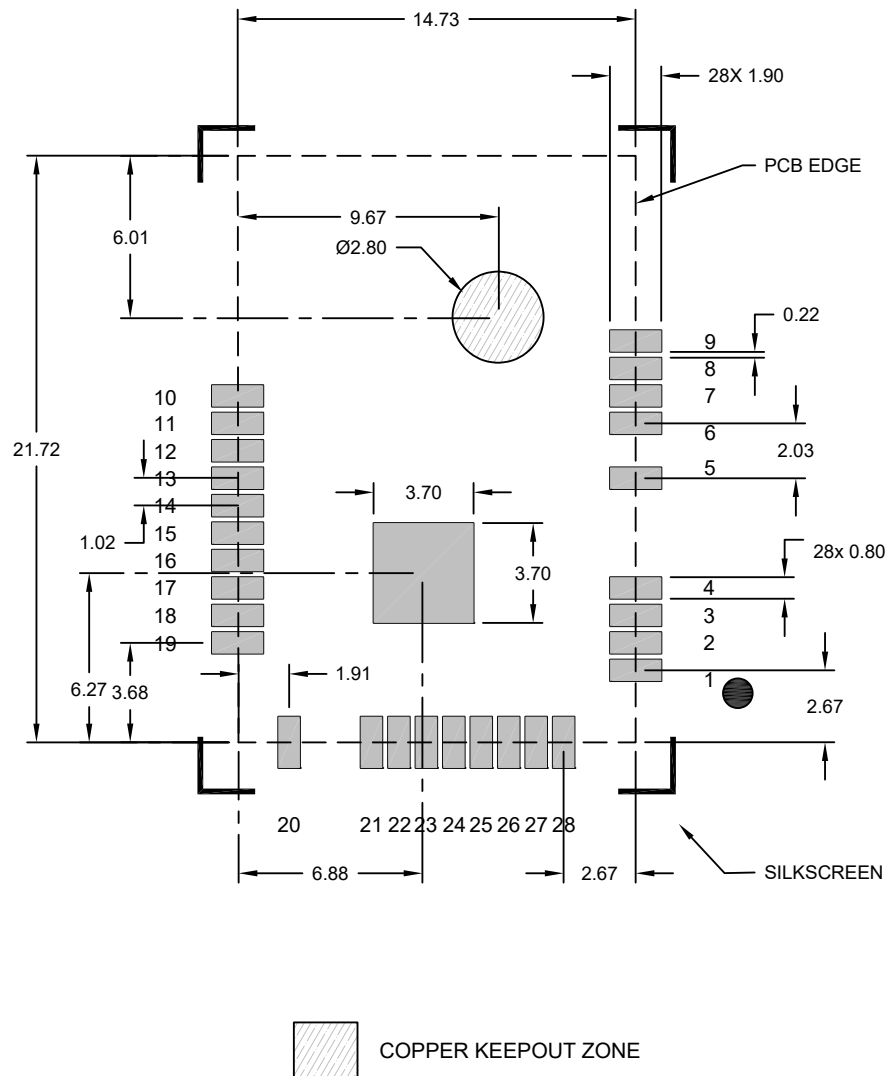
Notes:

1. All dimensions are in Millimeters.

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

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

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



RECOMMENDED LAND PATTERN

Notes:

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

Microchip Technology Drawing C04-23567 Rev B

5. Appendix A: Regulatory Approval

The WINCS02PC module has received regulatory approval for the following countries:

- United States/FCC ID: 2ADHKWIXCS02
- Canada/ISED:
 - IC: 20266-WIXCS02
 - HVIN: WINCS02PC
 - PMN:Wireless MCU Module with IEEE®802.11 b/g/n
- Europe/CE

The WINCS02PE module has received regulatory approval for the following countries:

- United States/FCC ID: 2ADHKWIXCS02
- Canada/ISED:
 - IC: 20266-WIXCS02
 - HVIN: WINCS02PE
 - PMN:Wireless MCU Module with IEEE®802.11 b/g/n
- Europe/CE

The WINCS02UC module has received regulatory approval for the following countries:

- United States/FCC ID: 2ADHKWIXCS02U
- Canada/ISED:
 - IC: 20266-WIXCS02U
 - HVIN: WINCS02UC
 - PMN:Wireless MCU Module with IEEE®802.11 b/g/n
- Europe/CE

The WINCS02UE module has received regulatory approval for the following countries:

- United States/FCC ID: 2ADHKWIXCS02U
- Canada/ISED:
 - IC: 20266-WIXCS02U
 - HVIN: WINCS02UE
 - PMN:Wireless MCU Module with IEEE®802.11 b/g/n
- Europe/CE

5.1 United States

The WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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 WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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 WINCS02PC/PE 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 WINCS02UC/UE 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.

WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE: These modules are approved for installation into mobile or/and host platforms at least 20 cm away from the human body.

5.1.3 Approved Antenna Types

To maintain modular approval in the United States, only the antenna types that have been tested shall be 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 WINCS02PC/PE, the approval is received using the integral PCB antenna.

For the WINCS02UC/UE, approved antennas are listed in the [WINCS02 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 WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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 WINCS02PC/WINCS02PE module	Contains IC: 20266-WIXCS02
For the WINCS02UC/WINCS02UE 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: 20266-20266-WIXCS02 and IC: 20266-20266-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: 20266-20266-WIXCS02 and IC: 20266-20266-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 Radio communication 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.

WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE : The devices operate at an output power level which is within the ISED SAR test exemption limits at any user distance greater than 20 cm.

5.2.3 Exposition aux RF

Tous les émetteurs réglementés par Innovation, Sciences et Développement économique Canada (ISED) 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.

5.2.4 Approved Antenna Types

For the WINCS02PC/PE, the approval is received using the integral PCB antenna.

For the WINCS02UC/UE, approved antennas are listed in the [WINCS02 Module Approved External Antenna](#).

5.2.5 Helpful Web Sites

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

5.3 Europe

The WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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 WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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 WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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 WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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 WINCS02PC/PE, the approval is received using the integral PCB antenna.

For the WINCS02UC/UE, approved antennas are listed in the [WINCS02 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: <http://www.ecodocdb.dk/>.

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 UKCA (UK Conformity Assessed)

The WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE module is a UK conformity assessed radio module that meets all the essential requirements according to CE RED requirements.

5.4.1 Labeling Requirements for Module and User's Requirements

The label on the final product that contains the WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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>.

5.4.2 UKCA Declaration of Conformity

Hereby, Microchip Technology Inc. declares that the radio equipment type the WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE 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/WINCS02.

5.4.3 Approved Antennas

The testing of the WINCS02PC/WINCS02PE/WINCS02UC/WINCS02UE module was performed with the antennas listed in [WINCS02 Module Approved External Antenna](#).

5.4.4 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.

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

.....continued

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

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
A	06/2024	Document	Initial Revision

Microchip Information

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable". Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure

that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, TimeCesium, TimeHub, TimePictra, TimeProvider, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, Clockstudio, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, EyeOpen, GridTime, IdealBridge, IGaT, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, IntelliMOS, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, MarginLink, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mSiC, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, Power MOS IV, Power MOS 7, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SmartHLS, SMART-I.S., storClad, SQL, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, Trusted Time, TSHARC, Turing, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2024, Microchip Technology Incorporated and its subsidiaries. All Rights Reserved.

ISBN:

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: www.microchip.com/support Web Address: www.microchip.com	Australia - Sydney Tel: 61-2-9868-6733 China - Beijing Tel: 86-10-8569-7000 China - Chengdu Tel: 86-28-8665-5511 China - Chongqing Tel: 86-23-8980-9588 China - Dongguan Tel: 86-769-8702-9880 China - Guangzhou Tel: 86-20-8755-8029 China - Hangzhou Tel: 86-571-8792-8115 China - Hong Kong SAR Tel: 852-2943-5100 China - Nanjing Tel: 86-25-8473-2460 China - Qingdao Tel: 86-532-8502-7355 China - Shanghai Tel: 86-21-3326-8000 China - Shenyang Tel: 86-24-2334-2829 China - Shenzhen Tel: 86-755-8864-2200 China - Suzhou Tel: 86-186-6233-1526 China - Wuhan Tel: 86-27-5980-5300 China - Xian Tel: 86-29-8833-7252 China - Xiamen Tel: 86-592-2388138 China - Zhuhai Tel: 86-756-3210040	India - Bangalore Tel: 91-80-3090-4444 India - New Delhi Tel: 91-11-4160-8631 India - Pune Tel: 91-20-4121-0141 Japan - Osaka Tel: 81-6-6152-7160 Japan - Tokyo Tel: 81-3-6880-3770 Korea - Daegu Tel: 82-53-744-4301 Korea - Seoul Tel: 82-2-554-7200 Malaysia - Kuala Lumpur Tel: 60-3-7651-7906 Malaysia - Penang Tel: 60-4-227-8870 Philippines - Manila Tel: 63-2-634-9065 Singapore Tel: 65-6334-8870 Taiwan - Hsin Chu Tel: 886-3-577-8366 Taiwan - Kaohsiung Tel: 886-7-213-7830 Taiwan - Taipei Tel: 886-2-2508-8600 Thailand - Bangkok Tel: 66-2-694-1351 Vietnam - Ho Chi Minh Tel: 84-28-5448-2100	Austria - Wels Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 Denmark - Copenhagen Tel: 45-4485-5910 Fax: 45-4485-2829 Finland - Espoo Tel: 358-9-4520-820 France - Paris Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79 Germany - Garching Tel: 49-8931-9700 Germany - Haan Tel: 49-2129-3766400 Germany - Heilbronn Tel: 49-7131-72400 Germany - Karlsruhe Tel: 49-721-625370 Germany - Munich Tel: 49-89-627-144-0 Fax: 49-89-627-144-44 Germany - Rosenheim Tel: 49-8031-354-560 Israel - Ra'anana Tel: 972-9-744-7705 Italy - Milan Tel: 39-0331-742611 Fax: 39-0331-466781 Italy - Padova Tel: 39-049-7625286 Netherlands - Drunen Tel: 31-416-690399 Fax: 31-416-690340 Norway - Trondheim Tel: 47-72884388 Poland - Warsaw Tel: 48-22-3325737 Romania - Bucharest Tel: 40-21-407-87-50 Spain - Madrid Tel: 34-91-708-08-90 Fax: 34-91-708-08-91 Sweden - Gothenberg Tel: 46-31-704-60-40 Sweden - Stockholm Tel: 46-8-5090-4654 UK - Wokingham Tel: 44-118-921-5800 Fax: 44-118-921-5820