

PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module Data Sheet

PIC32WM-BW1



Introduction

The PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module is a fully integrated wireless solution with dual-core implementation tailored for advanced Internet of Things (IoT) solutions that bridges the gap between end node/sensor devices and the cloud. This Module supports IEEE® 802.11b/g/n, Bluetooth Low Energy 6.0, providing a comprehensive connectivity solution for IoT device manufacturers. With dedicated Wi-Fi and Bluetooth Low Energy cores, this dual-core design delivers consistent responsiveness, lower latency, and more memory headroom for advanced IoT features. It achieves industry-leading Radio Frequency (RF) performance and includes robust security features, making it the ideal choice for smart home, consumer and industrial IoT applications.

The following are the key features of the PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module:

- **Wi-Fi and Bluetooth Low Energy Combo Support:** Integrates Wi-Fi (IEEE 802.11 b/g/n), Bluetooth Low Energy 6.0 support in a single module.
- **High-Performance Two-Chip Architecture:** Features a 64 MHz ARM® Cortex® -M4 MCU with 1 MB Flash, 128 KB RAM, Bluetooth Low Energy 6.0 and independent Wi-Fi network controller, enabling simultaneous reception and improved performance.
- **Enhanced RF Performance:** Equipped with dedicated U.FL antennas for Wi-Fi and Bluetooth Low Energy reducing crosstalk and enhancing signal quality.
- **Security:** Includes an ECC608 Trust&Go secure element for each cloud connection. Supports secure boot and secure Over-The-Air (OTA) updates.
- **Regulatory Certified:** Fully RF certified, ensuring compliance with global standards.
- **Rich Set of MCU Peripherals:** Supports a wide range of advanced MCU peripherals, including Pulse-Width Modulation (PWM), Analog-to-Digital Converter (ADC), Serial Peripheral Interface (SPI), Inter-Integrated Circuit (I2C), Quad Serial Peripheral Interface (QSPI), Universal Asynchronous Receiver-Transmitter (UART) and Serial Wire Debug (SWD).

The PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module builds on the proven technologies of the Microchip's WINCS021C Wi-Fi network controller and the PIC32CX1012BZ25048 MCU, combining them into a single, easy-to-integrate solution. It offers reliable connectivity and dual-core performance for rugged industrial applications. The Module also supports Packet Traffic Arbitration (PTA)/coexistence for both radios, ensuring seamless operation in complex environments and no simultaneous transmission on both radios in the application.

With its robust design, regulatory certifications, and comprehensive feature set, the PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module is the ideal choice for IoT device manufacturers looking to add high-performance wireless connectivity to their products.

For a comprehensive list of features and technical specifications, refer to the [PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module Features](#).

PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module Features

Wi-Fi®

- IEEE® 802.11 b/g/n, Single Stream (1x1) 20 MHz Bandwidth WLAN Link
 - Compatible with Wi-Fi® 6/7 Access Points/Routers at 2.4 GHz
- Integrated Power Amplifier (PA), Low Noise Amplifier (LNA) and Transmitter/Receiver (TX/RX) Switch
- Up to 20.5 dBm Transmit Power in 802.11b Mode
- 2.4 GHz (2400-2483.5 MHz) ISM Band
- Infrastructure Basic Service Set (BSS) Station (STA) and Soft-AP Mode with up to Eight STAs
- WPA3, WPA2 and WEP Modes
- Transmission Control Protocol/Internet Protocol (TCP/IP)-Based Connectivity Protocols Along with SSL and MQTT Capabilities
- Hardware Accelerators for Wi-Fi® and TLS Security to Improve Connection Time
- Hardware-Based IEEE 802.15.2 Compliant Three-Wire Packet Traffic Arbitration (PTA) Interface for Wi-Fi/Bluetooth® Coexistence
- On-Chip Network Stack to Offload MCU
 - Network features – TCP, UDP, DHCP, ARP, HTTP, MQTT, IPv6, TLS 1.2 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) mode
 - Fast host wake-up from Sleep mode by a pin or the host Input/Output (I/O) transaction
 - Optional low-power secondary oscillator (RTCC oscillator) 32.768 kHz for real-time clock and calendar applications
- Immutable Secure Boot with Hardware Root of Trust
- Supports Host Assisted OTA Firmware Update

Bluetooth®

- Bluetooth® Low Energy 6.0 Certified⁽¹⁾
- Up to +12 dBm Programmable Transmit Output Power
- Typical Receiver Power Sensitivity:
 - Bluetooth Low Energy at 1 Mbps: -97 dBm
 - Bluetooth Low Energy at 2 Mbps: -94 dBm
 - Bluetooth Low Energy at 125 Kbps: -104 dBm
 - Bluetooth Low Energy at 500 Kbps: -101 dBm
 - Digital RSSI indicator (-50 dBm to -90 dBm)

- Bluetooth Supported Features:
 - 2M uncoded PHY
 - Long range (Coded PHY)
 - Channel selection algorithm #2
 - Advertising extensions, offloads CPU with hardware-based scheduler
 - High duty cycle non-connectable advertising
 - Data length extensions
 - Secure connections
 - Privacy upgrades (with hardware white-list support)
- ECDH P256 Hardware Engine for Link Key Generation when Bluetooth Pairing
- AES128 Hardware Module for Real-Time Bluetooth Payload Data Encryption
- Pre-programmed MAC Address
- Bluetooth Qualification Test Facility (BQTF) Certification
- Bluetooth Low Energy Profiles:
 - Bluetooth Low Energy peripheral and central roles
 - Bluetooth Low Energy APIs for application layer to implement standard or customize GATT based profiles/services
 - Microchip transparent UART Service
 - Battery service
 - Device information service
 - Custom service
 - Multi-link and multi-role
- Bluetooth Low Energy Services:
 - Provisioning
 - OTA update - Device Firmware Upgrade (DFU)
 - Advertisement/Beacon
 - Personalized configuration
 - Alert notification service
- Connectivity Standards
 - Bluetooth v6.0
 - ETSI EN 300 328 and EN 300 440 Class 2
 - FCC CFR47 Part 15 and ARIB STD-T66

Note:

1. Requires BLE SDK v1.5 or later

Wi-Fi® and Bluetooth® Low Energy Coexistence

- Hardware Based Three-Wire PTA for Wi-Fi® and Bluetooth® Coexistence
- Integrated 2.4 GHz Ultra-low Power RF Transceiver shared among Bluetooth, Link (MAC) Controllers and Proprietary Modulation Schemes

Core: 64 MHz ARM® Cortex®-M4

- 3.35 Coremark®/MHz
- 4 KB Combined Instruction Cache and Data Cache
- Eight-Zone Memory Protection Unit (MPU)
- Thumb®-2 Instruction Set
- Digital Signal Processing Application-Specific Extension (ASE) Rev 2
- Nested Vector Interrupt Controller (NVIC)
- Embedded Trace Module (ETM) with Instruction Trace Stream
- Core Sight Embedded Trace Buffer (ETB)
- Trace Port Interface Unit (TPIU)
- IEEE® 754-Compliant Floating Point Unit (FPU)

Memories

- 1 MB On-Chip Self-Programmable Flash with:
 - Error Correction Code (ECC)
 - Prefetch module to speed up Flash accesses
 - 20-years of data retention support
- 32 KB NVR Flash (Eight Sectors)
 - Private/public boot code and data
 - NV calibration data
- 128 KB Multi-Port Programmable QoS SRAM Main Memory
 - 64 KB of ECC RAM option
- Up to 4 KB of Tightly Coupled Memory (TCM)
- Up to 8 KB Backup SRAM
- Single 32-bit Backup Register

System

- Power-on Reset (POR) and Brown-Out Detect (BOD)
- Internal and External Clock Options
- External Interrupt Controller (EIC)
- Up to Four External Interrupts
- One Non-Maskable Interrupt
- Run, Idle, Dream, Sleep, Deep Sleep and Extreme Deep Sleep Modes
- Sleep Walking Peripherals
- 2-pin Serial Wire Debug (SWD) Programming, Test and Debugging Interface

High Performance Peripherals

- 16-Channel Direct Memory Access Controller (DMAC)
 - Built-in CRC with memory CRC generation/monitor hardware support

System Peripherals

- 32-Channel Event System
 - All channels can be connected to any event generator
 - All channels provide a pure asynchronous path
 - Twelve channels support synchronous and re-synchronous

- Four Serial Communication Interfaces (SERCOM), Each Configurable to Operate as:
 - USART with full-duplex and single-wire half-duplex configuration
 - ISO7816
 - I2C up to 1 MHz (three SERCOMs support I2C)
 - LIN Commander/Responder
 - RS485
 - SPI inter-byte space
- Four 16-bit Timers/Counters (TC), Each Configurable as:
 - 16-bit TC with two compare/capture channels
 - 8-bit TC with two compare/capture channels
 - 32-bit TC with two compare/capture channels
- Two 24-bit Timer/Counters for Control (TCC) with Extended Functions:
 - Up to six compare channels with optional complementary output
 - Generation of synchronized Pulse Width Modulation (PWM) pattern across port pins
 - Deterministic fault protection, fast decay and configurable dead-time between complementary output
 - Dithering that increases resolution with up to 5 bits and reduces quantization error
- One 16-bit Timer/Counters for Control (TCC) with Extended Functions:
 - Up to two compare channels with optional complementary output
- 32-bit Real Time Counter (RTCC) with Clock/Calendar Function
- Up to one Wake-up Pin with Tamper Detection and Debouncing Filter
- Watchdog Timer (WDT) with Window Mode
- Deadman Timer (DMT)
- CRC-32 Generator
- Frequency Meter (FREQM)
- One Configurable Custom Logic (CCL)
- One Analog Comparator (AC) with Window Compare function
- One Temperature Sensor (Die Temperature)

Advanced Analog

- 12-bit Analog-to-Digital Converter (ADC) Successive Approximation Register (SAR) Module:
 - Up to eight analog channels
 - Up to two MSPS conversion rate
 - Multiple trigger sources
 - Supports die temperature sensor built into RF-analog (not an external ambient temperature sensor)
 - Two Analog Comparator (AC) with window compare function or single analog comparator
 - One dedicated AC and second AC is shared with PMU controller

Input/Output (I/O)

- Flexible Peripheral Pin Select (PPS) Support
- High-Current Sink/Source on Most I/O Pins
- Configurable Open-Drain Output on Digital I/O Pins
- Up to 22 Programmable I/O Pins

Oscillators

- 16 MHz, ± 20 PPM Crystal/Resonator Oscillator or External Clock (POSC) for 2.4 GHz RF Transceiver
- Shared System Phase-Locked Loop (PLL) with Bluetooth® RF Data Converter PLL
- 32.768 kHz Ultra-low Power Internal Oscillator
- Higher Accuracy 32.768 kHz, ± 250 ppm Clock Options
 - POSC derived 32 kHz clock
 - 32.768 kHz crystal/resonator oscillator (SOSC)
 - External 32.768 kHz clock source
- 8 MHz Internal RC Oscillator (FRC)

ECC608 on Module

- Provides Robust Hardware-Based Security for IoT Applications
- Facilitates Secure Cloud Authentication using Trust&Go Configuration
- Supports Secure Key Storage and Cryptographic Operations

Antennas

- Dual U.FL Connectors for Dual External Antennas (separate Wi-Fi® and Bluetooth® Low Energy Antennas) improving Crosstalk and RF Performance

Security – Bluetooth® Low Energy

- Advanced Encryption Standard (AES) Engine with Support for 128/192/256-bit Cryptographic Key
- One AES with 256-bit Key Length and up to 2 MB/s Data Rate
 - Five confidential modes of operation
 - Electronic Code Book (ECB)
 - Cipher Block Chaining (CBC)
 - Cipher Feedback (CFB)
 - Output Feedback (OFB)
 - Counter (CTR)
 - Supports counter with Cipher Block Chaining Message Authentication Code (CBC-MAC) mode
 - Galois Counter Mode (GCM)
- True Random Number Generator (TRNG)
- Public Key Cryptography Controller (PUKCC) and Associated Classical Public Key Cryptography Library (PUKCL)
 - Rivest-Shamir-Adleman (RSA) and Digital Signature (DSA) algorithm
 - Elliptic Curves Cryptography (ECC), Elliptic Curve Cryptography Galois Field (ECC GF) (2n) and ECCGF (p)
- Integrity Check Module (ICM) Based on Secure Hash Algorithm (SHA1, SHA224 and SHA256), Direct Memory Access (DMA) Assisted
- Secure Boot Capable and Secure OTA Update

Security – Wi-Fi®

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

Clock Management

- Integrated 16 MHz (PIC32CX-BZ2 IC) and 40 MHz (WINCS02IC) POSCs

Package

- 58-Pin LGA Package with Shield CAN
- Size: 29 mm x 18 mm x 3 mm

Operating Conditions

- 3.0–3.6V Operating Range (Typical value is 3.3V)
- -40 °C to +85 °C

Certifications

- PIC32WM-BW1 Module Certified to FCC, ISER, and CE Radio Regulations (RED-DA Compliant)
- Bluetooth® SIG and Wi-Fi Alliance® Compliant
- RoHS and REACH Compliant

Acronyms and Abbreviations

For complete list of acronyms and abbreviations, refer to the [Appendix D: Acronyms and Abbreviations](#).

Market Segments and Example Applications

- **Smart Home and Consumer IoT:** Connected appliances and home automation devices with local Bluetooth® Low Energy control and cloud Wi-Fi® connectivity
 - Smart plugs, switches, lighting controllers
 - Thermostats, HVAC systems
 - Door locks, video doorbells
 - Appliance modules
- **Industrial IoT (IIoT):** Wireless sensor networks and monitoring systems in industrial environments
 - Temperature, vibration, and pressure sensors
 - Equipment monitoring hubs and gateways
- **Health and Wearables:** Medical monitoring and health devices with dual connectivity options
 - Medical monitoring hubs
 - Glucose/heart rate stations
- **Security and Access Control:** Connected security systems with local Bluetooth Low Energy authentication and cloud logging
 - Connected keypads, RFID controllers
 - Wireless alarm panels

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1. Ordering Information

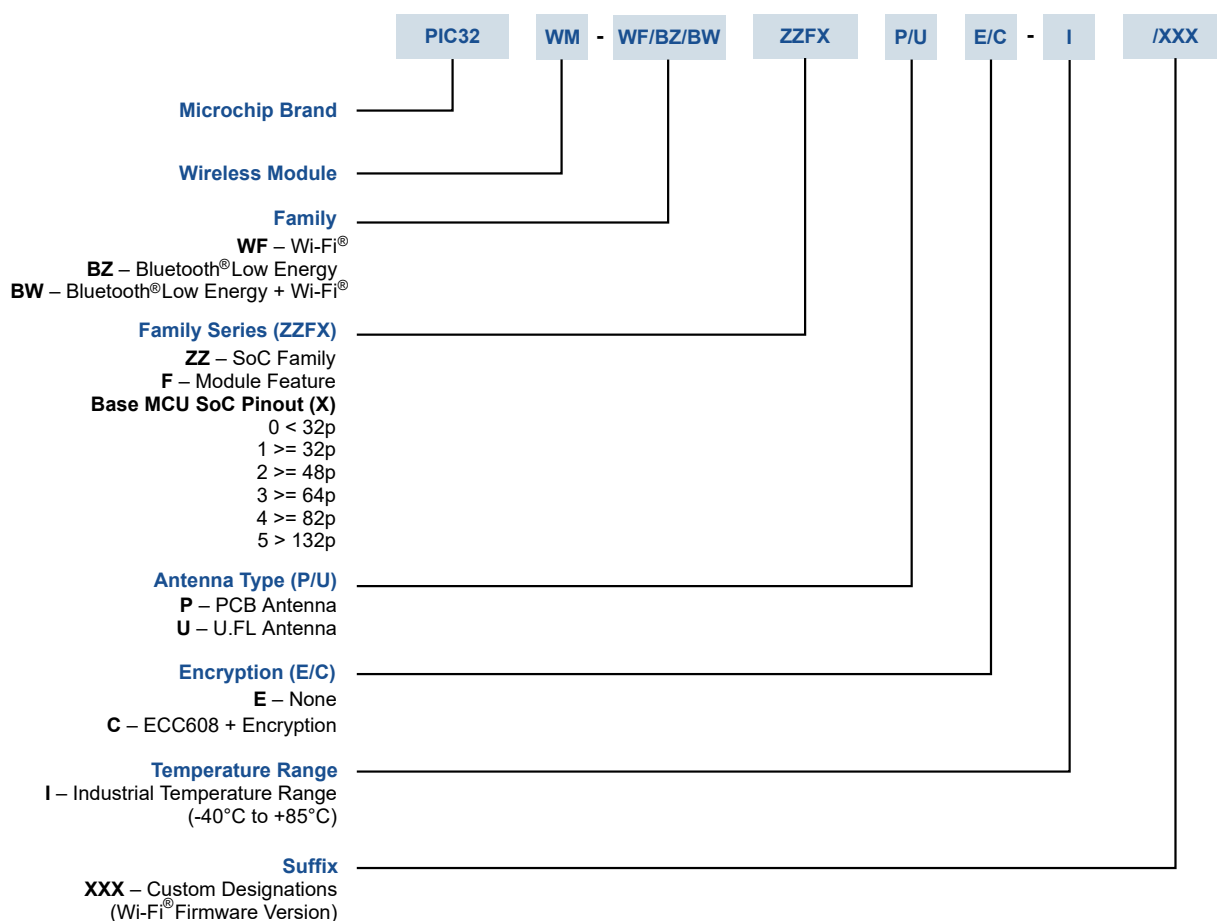
This chapter provides the ordering information of the PIC32WM-BW1002UC Wi-Fi® and Bluetooth® Low Energy Combo MCU Module.

Table 1-1. PIC32WM-BW1 Module Ordering Details

Module Name	Description	Ordering Code
PIC32WM-BW1	Two U.FL antennas without Trust&GO	PIC32WM-BW1002UE-I/300
	Two U.FL antennas with Trust&GO	PIC32WM-BW1002UC-I/300

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

Figure 1-1. PIC32WM-BW1 Ordering Information



2. PIC32WM-BW1 Module Description

The PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module is designed as a multi-protocol solution that integrates Microchip's PIC32CX1012BZ25048 wireless MCU and WINCS02IC 802.11b/g/n-compliant network controller into a single module, providing an end-to-end solution from sensor to cloud.

The PIC32CX1012BZ25048 is a versatile ARM® Cortex®-M4F multi-protocol MCU with integrated Bluetooth Low Energy 6.0, Thread 1.3.0, and supports IEEE® 802.15.4 mesh protocols as well as multi-protocol operations.

Note: This module supports only Wi-Fi and Bluetooth Low Energy; it does not support IEEE 802.15.4, Thread, or related protocols.

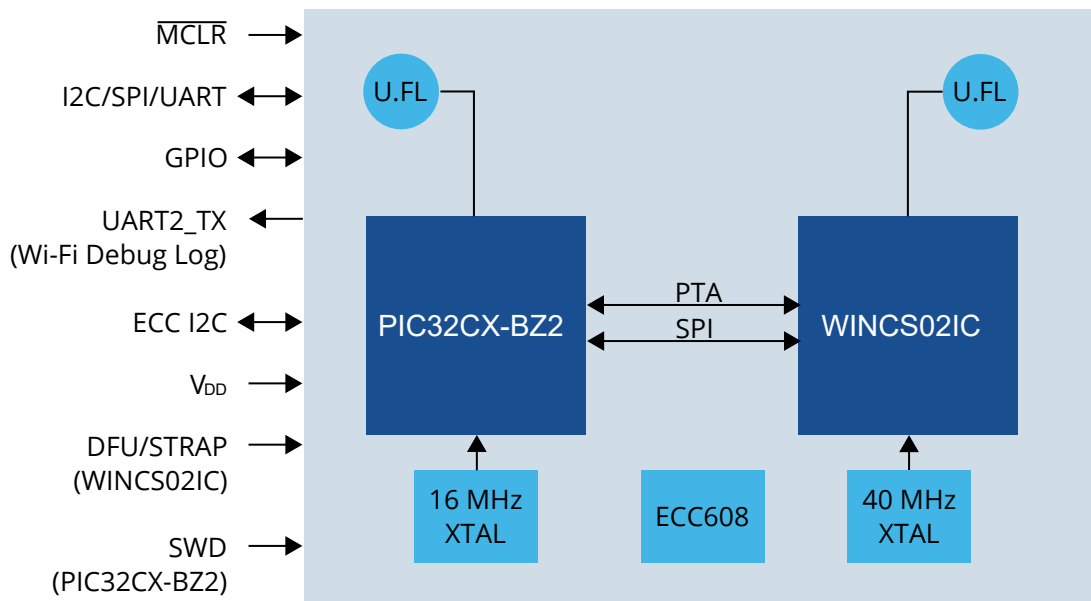
The PIC32CX1012BZ25048 device is powered by a 64 MHz ARM Cortex-M4F and is equipped with features such as OTA, hardware arbitration for multi-protocol wireless, a hardware-based security accelerator, and a rich set of peripherals.

The WINCS02IC is a single-chip 2.4 GHz and IEEE® 802.11b/g/n-compliant solution with an integrated High-Power Amplifier (HPA), Low-Noise Amplifier (LNA), and Radio Frequency (RF) switches for TX/RX control. It functions as a Network Controller IC with a hardware-based security accelerator.

2.1. PIC32WM-BW1 Module Block Diagram

The following figure illustrates the PIC32WM-BW1 Module block diagram and various supported peripherals.

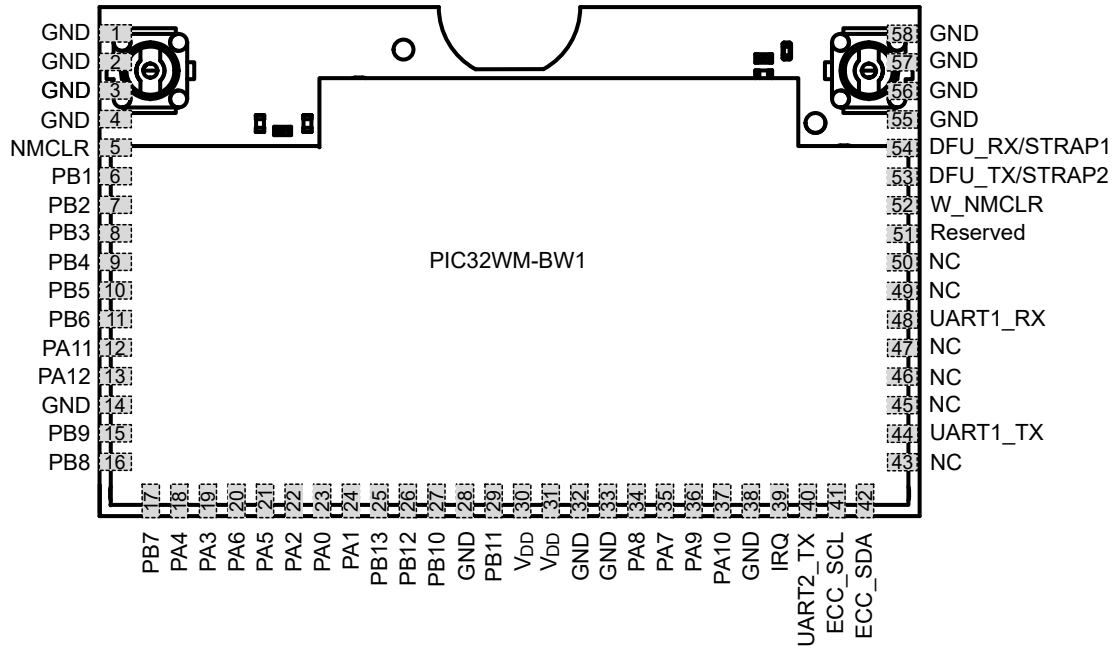
Figure 2-1. PIC32WM-BW1 Module Block Diagram



2.2. Pinout Diagram

This section provides the pin diagram of the PIC32WM-BW1 Module.

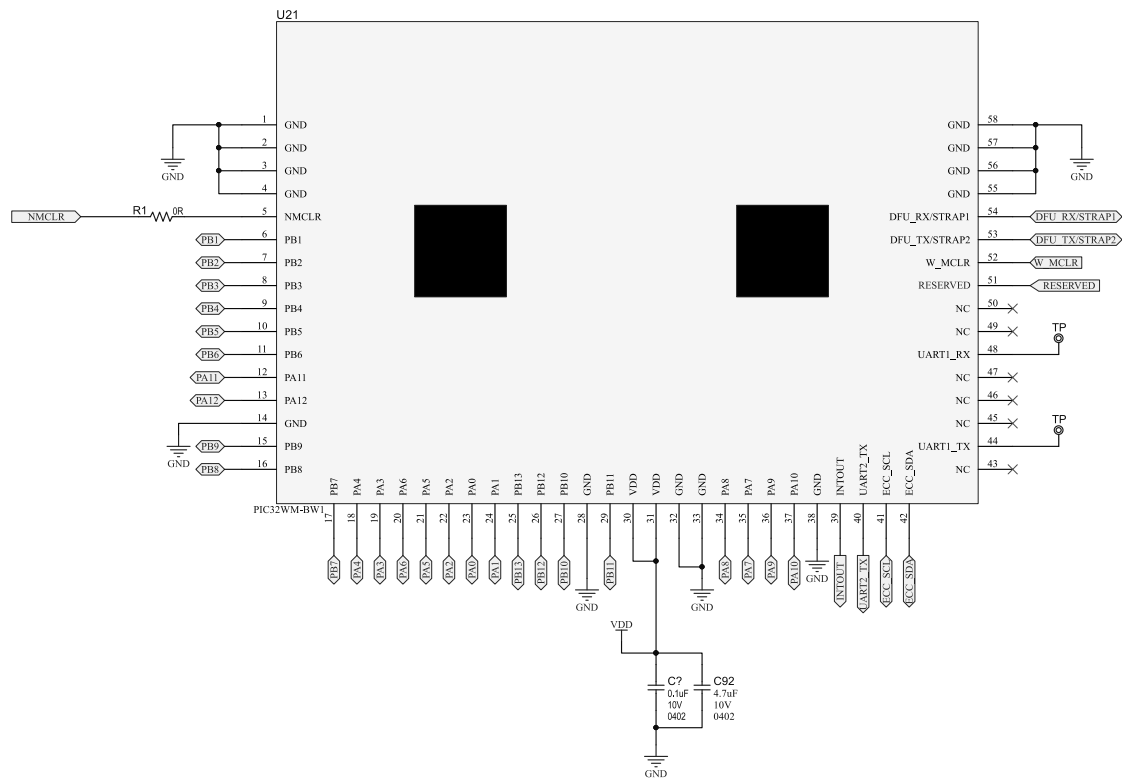
Figure 2-2. PIC32WM-BW1 Module Pinout Diagram



2.3. Basic Connection Requirement

The PIC32WM-BW1 Module requires attention to a minimal set of device pin connections before proceeding with development.

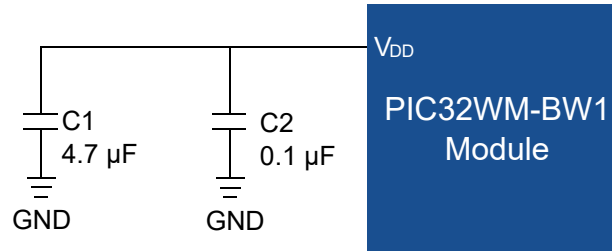
Figure 2-3. PIC32WM-BW1 Module Basic Connection and Interface Diagram



2.3.1. Power Pins

The recommendation is to add a bulk and a decoupling capacitor at the input supply pin 30/31 (V_{DD}) and GND of the PIC32WM-BW1 Module.

Figure 2-4. PIC32WM-BW1 Recommended Module Power Supply Connections



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

Pulling the $\overline{\text{NMCLR}}$ pin low generates a device Reset of the MCU. Pulling the W_NMCLR pin low generates a device reset of the Wi-Fi[®] attach device.

The Module has sufficient filtering (0.1 μF) and pull-up (10k) on the Reset line. In a typical application, no extra filtering is required on this pin.

Note: The W_NMCLR pin exposed on the PIC32WM-BW1 Module must only be asserted by the PIC32CX-BZ2 MCU to trigger a Reset, followed by WINCS02 initialization.

2.3.3. SWD Lines

For SWD programming and debugging purposes, use the CM4_SWCLK, CM4_SWDIO and CM4_SWO pins. The recommendation is to use the CM4_SWCLK and CM4_SWDIO pins for the PIC32WM-BW1 Module for SWD as the default configuration (CM4_SWO can be optional).

Keep the trace length between the SWD pins of the PIC32WM-BW1 Module and the SWD header as short as possible. If the SWD connector is expected to experience an ESD event, a series resistor is recommended with the value in the range of a few tens of Ω s, not to exceed 100 Ω .

Note: Provide an option for adding an external pull-up on SWD lines.

2.3.4. Device Firmware Update (DFU) over UART

The WINCS02IC is a secured part, and all traditional programming interfaces are disabled. These modules can only execute the firmwares which are authorized by Microchip's signer. As all the programming interfaces are disabled, the WINCS02IC enables a special mode called the DFU mode to perform the firmware update. WINCS02IC provides fail-safe device firmware upgrade by having two image slots in the Flash map. The WINCS02IC on this PIC32WM-BW1 Wi-Fi[®] and Bluetooth[®] Low Energy Combo MCU Module shipped from Microchip use the image2 partition to store the default firmware.

For more details about the released standard WINCS02 firmware packages, go to [WINCS02PE](#).

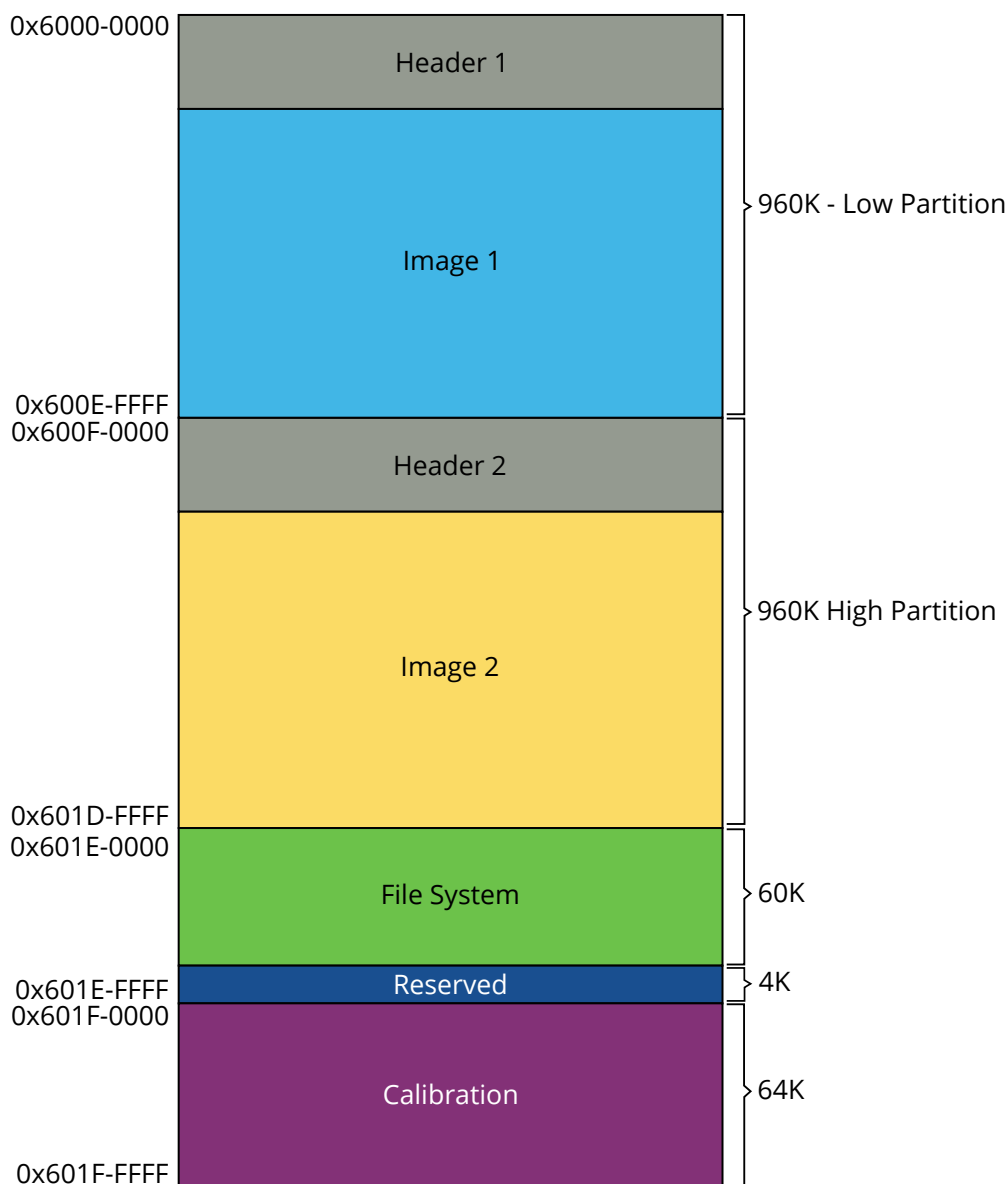
The WINCS02 firmware release package includes the following binary images:

- **All-in-One/Combined Image** – Two firmware images (header1/image1 and header2/image2) + file system
- **OTA Image** – A single firmware image (header/image) up to 960 KB
- **File-System** – File system for storing certificates and key files up to 60 KB

Figure 2-5. WINCS02 Binary Images

Name	Date modified	Type	Size
flfs_image.bin	9/27/2024 10:28 AM	BIN File	16 KB
wincs02.bootable.bin	9/27/2024 10:28 AM	BIN File	1,936 KB
wincs02_dfu_ota.bootable.bin	9/27/2024 10:28 AM	BIN File	513 KB

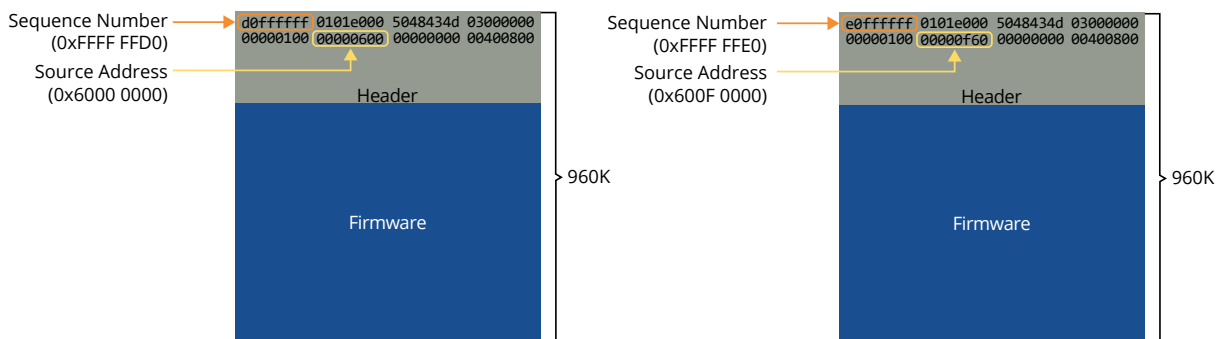
Figure 2-6. Flash Map



These firmware images contain a 4-bytes sequence number in the header, which the boot ROM uses to determine which image to boot on every power-up. The boot ROM always chooses the firmware image with the lowest sequence number among the two partitions, but if both images have the same sequence number, it boots the one in the higher memory address (0x600F0000) or from image2 partition.

The sequence number with all zeros and all 0xFFs are reserved (invalid) sequence numbers. During the DFU programming, the boot ROM validates the firmware and checks the authenticity by verifying the signature. If the firmware is not authentic (in other words, not signed by Microchip), the boot ROM invalidates the image by setting the sequence number to zero and thereby rejects these firmware image.

Figure 2-7. Firmware Header



To implement a fail-safe mechanism, the image1 partition can be used for upgrading to a new firmware image, while the image2 partition serves as the default or backup firmware. In case of failure or issues with the new firmware, the device can revert to the default firmware in the high partition by erasing the low partition of the Flash memory.

2.3.4.1. DFU Utility

The DFU utility is a Python-based tool that supports erase and write operations on the WINCS02IC Flash memory. It also enables modification of image sequence number and source address in the header section. For more details on the DFU utility, go to [WINCS02PE](#) (rnmf-utilities-vx.x.x\dfu).

Figure 2-8. DFU Utility Path

This PC > Windows (C:) > rnmf_utilities_v > dfu			
Name	Date modified	Type	Size
dfu.py	12/6/2023 6:27 PM	Python File	16 KB
do_dfu.py	12/6/2023 6:27 PM	Python File	6 KB
README.md	12/6/2023 6:27 PM	Markdown Source File	1 KB
requirements.txt	12/6/2023 6:27 PM	TXT File	1 KB

To use the DFU utility, the user needs to meet certain hardware and software requirements. The following are the hardware and software requirements:

Hardware

The following are the hardware requirements:

- PIC32WM-BW1 Curiosity Board or PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module
- FTDI cable ([TTL-232R-3V3](#))

Software

The following are the operating system requirements:

- For Windows: [FTDI D2XX Direct Driver for Windows](#).
- For Linux (Ubuntu): The Linux operating system loads the Virtual COM Port (VCP) driver (by default), during the process the script takes care of loading the appropriate driver D2XX/VCP.
Note: sudo permissions are required to run the script.
- For more details about the D2XX driver installation, refer to the *AN_220 FTDI Drivers Installation Guide for Linux* ([FT_000723](#)).

```
$ tar zxvf libftd2xx-x86_64-1.4.27.tgz
$ sudo cp -r release/build/lib* /usr/local/lib
$ cd /usr/local/lib/
$ sudo ln -s libftd2xx.so.1.4.27 libftd2xx.so
$ sudo chmod 0755 libftd2xx.so.1.4.27
$ sudo ldconfig /usr/local/lib/
```

Python 3

- ftd2xx==1.3.2
- pyserial==3.5

Hardware Setup for DFU

The PIC32WM-BW1 Curiosity Board/PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module exposes the following pins to perform DFU. To perform the DFU on the PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module, the user needs to set up the hardware as follows:

Table 2-1. PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module Pin Descriptions for DFU

PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module	Pin	Description	Pin# on FTDI Header (J8) from PIC32WM-BW1 Curiosity Board
W_MCLR	52	Master Clear Reset (MCLR)	J8.2
DFU_Rx/Strap1/W_PB0	54	DFU pattern clock/UART Rx	J8.4
DFU_Tx/Strap2/W_PB1	53	DFU pattern data/UART Tx	J8.5
GND	32 or 33	GND	J8.1

Note: While performing the DFU, the PIC32WM-BW1 Curiosity Board/PIC32WM-BW1 Wi-Fi® and Bluetooth® Low Energy Combo MCU Module must be powered ON.

DFU Setup

The DFU utility simplifies the dependencies installation by providing a requirement file with all the necessary Python modules. Before running the DFU utility, navigate to `rnwf_utilities_vX.X.X\dfu`, and install all the requirements using the following Python command.

```
>python -m pip install -r requirements.txt
```

The following is the DFU utility command syntax:

```
> python do_dfu.py [-h] [-b BIN_FILES BIN_FILES | -e ERASE [ERASE ...]] [-s SEQ_NUM] [-p PORT] [-v]
```

options:

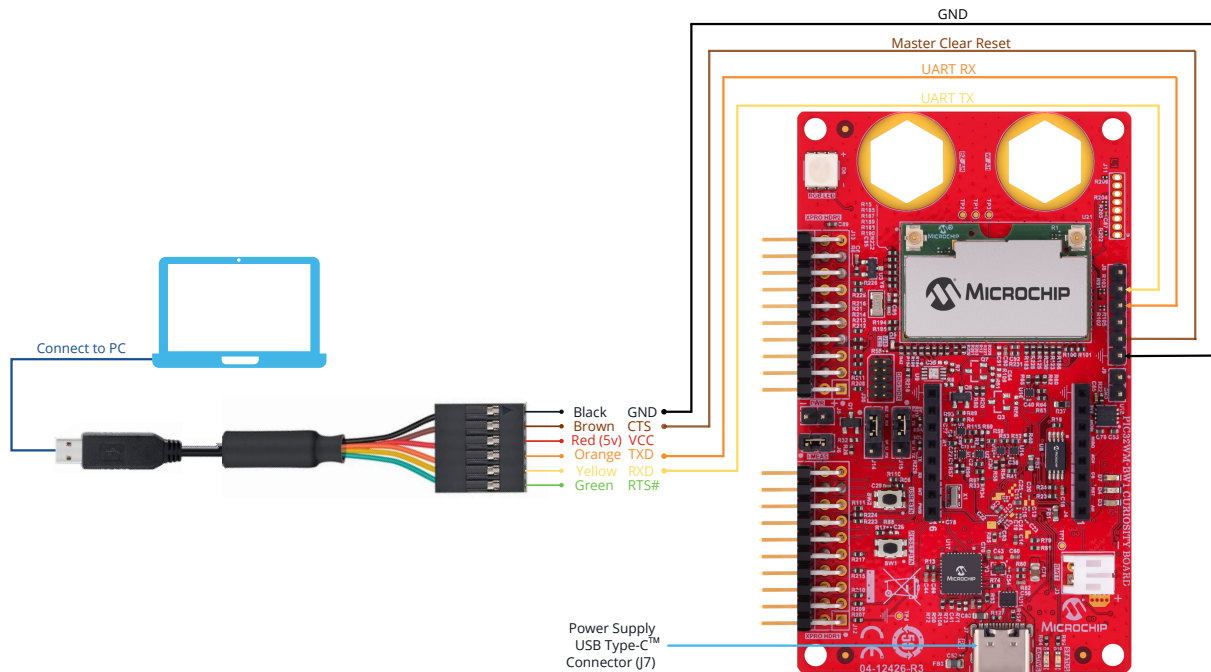
-h, --help show this help message and exit

-b BIN_FILES BIN_FILES

Write option: Erase and write binary file to hexadecimal starting

```
address or section (low,
                    high, file-system).
-e ERASE [ERASE ...] Erase option: Provide either the hexadecimal starting address and
whole number of 4096 byte
                    pages to erase, or just the section to erase (low, high, file-system).
-s SEQ_NUM          Modifies image sequence number. Example format: -s 0xffeeddccc
-p PORT, -port PORT User specific serial number of the FTDIport, else autodetect
mechanism will be used.
-v, -verbose
```

Figure 2-9. PIC32WM-BW1 Curiosity Board DFU Setup



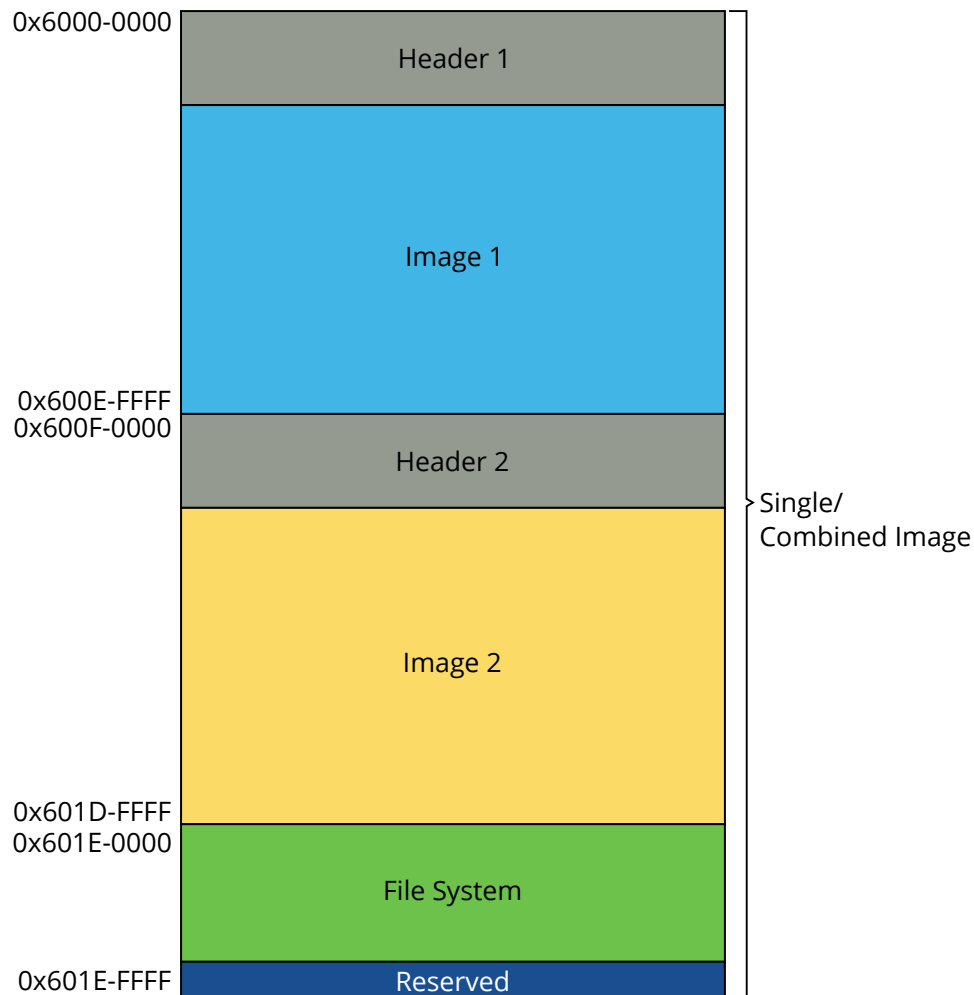
The following section provides command examples for flashing and erasing the different image partitions.

Update Single/Combined Image

The single image update flashes both image1 and image2 partitions along with the file system (certificate store). The user can specify the partition as low or by its starting address (0x60000000).

```
python do_dfu.py -b test_binaries/wincs02.bootable.bin 0x60000000
```

Figure 2-10. Update Single/Combined Image



Update Over-The-Air (OTA) Image

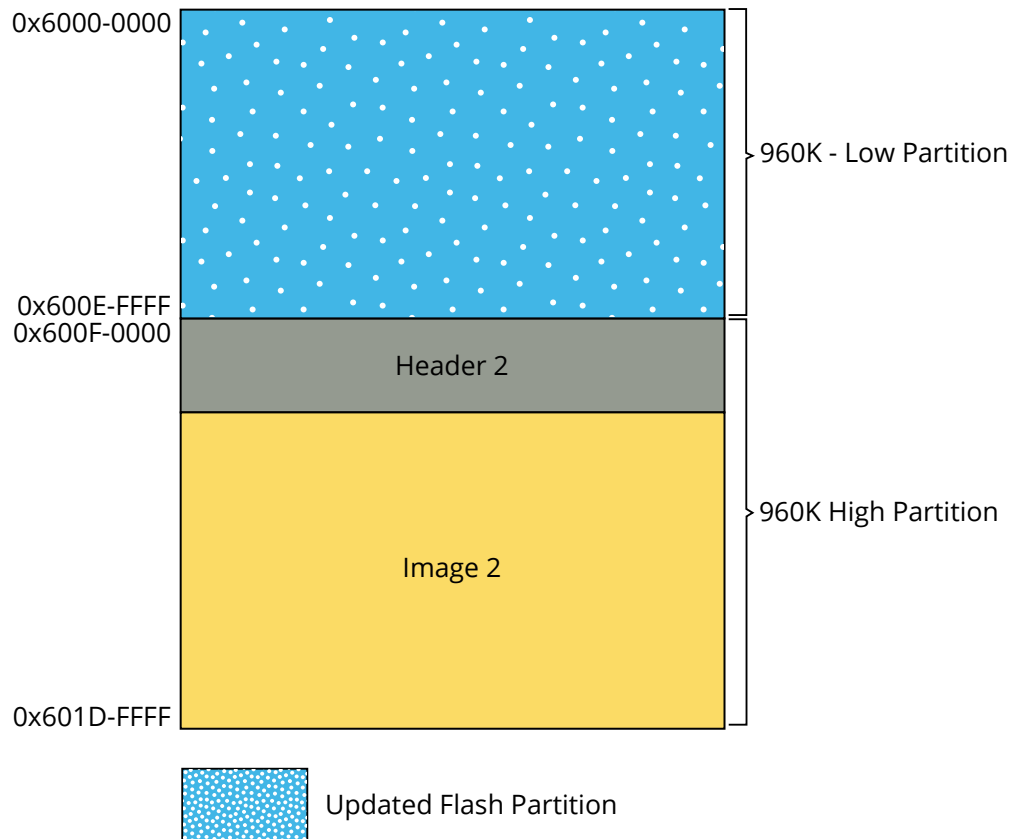
The OTA image only includes the header and the firmware image and does not include the filesystem. The OTA image can be updated in the image1 (low) partition or image2 (high) partition.

```
python do_dfu.py -b test_binaries/wincs02_dfu_ota.bootable.bin low
```

To update the sequence number of the given firmware image, use the `-s` option as follows:

```
do_dfu.py -b test_binaries/wincs02_dfu_ota.bootable.bin low -s 0xffffffffc0
```

Figure 2-11. Update OTA Image

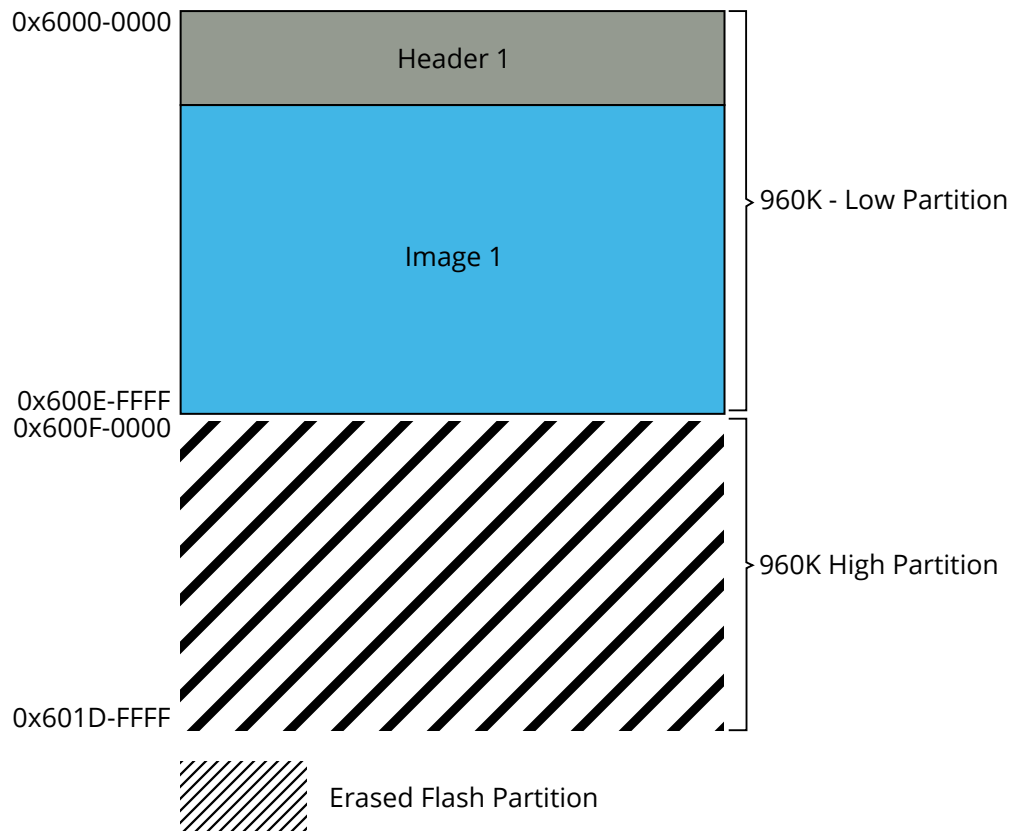


Erase Partition

The DFU utility is flexible to erase only the given partition of the Flash map. Use the `-e` option to erase either low (image1) or high (image2). The erase option is useful to switch the bootable image from other partitions of the Flash map.

```
python do_dfu.py -e high
```

Figure 2-12. Erase Partition



2.3.5. Unused I/O Pins

It is recommended that unused I/O pins must not be left floating as inputs. They can be configured as inputs and pulled up, or alternatively, depending on the application, they can be pulled down.

2.3.6. GPIO Pins/PPS Functions

Most of the PIC32WM-BW1 Module pins can be configured as GPIOs pins or for PPS functionality. To find the functionality supported by each of these GPIOs, refer to Chapter 6: I/O Ports and Peripheral Pin Select (PPS) of the *PIC32CX-BZ2 and WBZ45 Family Data Sheet* ([DS70005504](#)). It is recommended that a series resistor be added on the host board for all critical, high frequency pins and clocks for EMI considerations. The value of the series resistor depends on the actual pin configuration. These resistors must be placed close to the Module. For more details, refer to the [Figure 2-14](#).

Notes:

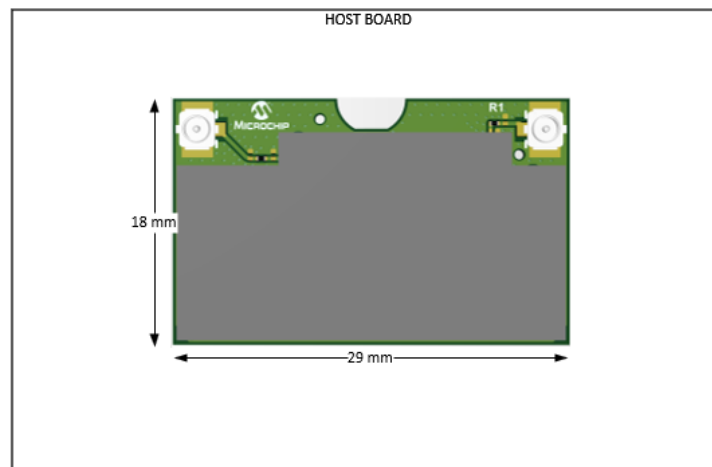
1. The PIC32WM-BW1 Module pins PB10, PB11, PB12, PB13 are used on-board to interface with WINCS02 device over SPI and hence can not be configured as GPIO or any other function.
2. The PIC32WM-BW1 Module pins PA13, PA14, PB0 are used on-board for 3-wire PTA interface with WINCS02 device, hence can not be configured as GPIO or any other function.
3. The PIC32WM-BW1 Module pin PB1 is used to reset WINCS02 device, and connected to pin W_MCLR on the PIC32WM-BW1 Curiosity Board (EV60G68A). therefore, it is recommended to connect PB1 to W_MCLR on the host board to avoid changes in the software implementation.
4. The PIC32WM-BW1 Module pin PB4 (INT0) is used as wake-up source from low power modes, and INT0 functionality on PB4 can not be remapped using PPS. It is recommended to connect pin PB4 to pin INTOUT to allow WINCS02 device to wake-up PIC32CX-BZ2 device from its sleep state, as implemented on the PIC32WM-BW1 Curiosity Board (EV60G68A).

5. The PIC32WM-BW1 Module pins PA7 and PA8 are connected to on-module ECC608 (loop-back) chip on the PIC32WM-BW1 Curiosity Board (EV60G68A).

2.4. PIC32WM-BW1 Module Placement Guidelines

- The PIC32WM-BW1 Module can be placed anywhere on the host-board as shown in the following figure.
- Exposed GND pads on the bottom of the PIC32WM-BW1 Module must be soldered to the host board.
- A low-impedance ground plane for the PIC32WM-BW1 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.
- A PCB cutout or a copper keep out is required under the RF test point.
- Copper keep out areas are required on the top layer under voltage test points.
- Alternatively, the entire region, except the exposed ground paddle, can be solder-masked.

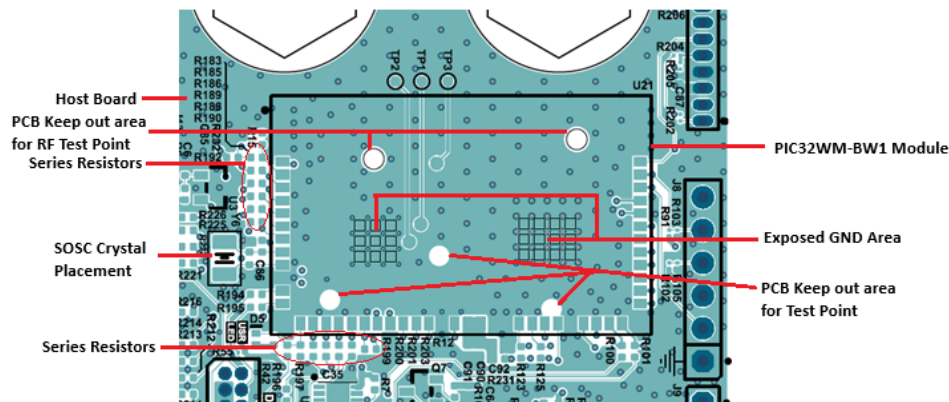
Figure 2-13. PIC32WM-BW1002UC Module Placement (Top View)



2.5. PIC32WM-BW1 Module Routing Guidelines

- Use the multi-layer host board for routing signals on the inner layer and the bottom layer.
- The top layer (underneath the Module) of the host board must be ground with as many GND vias as possible as 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 PIC32WM-BW1 Module.
- For a better GND connection to the PIC32WM-BW1 Module, solder the exposed GND pads of the Module on the host board.
- For the Module GND pad, use a GND via of a minimum 10 mil (hole diameter) for good ground to all the layers and thermal conduction path.
- Having a series resistor on the host board for all reserved pins and digital interface pins is recommended. These resistors must be placed close to the PIC32WM-BW1 Module. The following figure illustrates the placement of the series resistor.
- The RTCC Oscillator (32.768 kHz) on the host board must be placed close to the PIC32WM-BW1 Module and follow the shortest trace routing length with no vias. The following figure illustrates the example of host board on top layer.

Figure 2-14. Host Board on Top Layer



2.6. PIC32WM-BW1 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. The product designer must consider the following guidelines for optimal RF performance:

- Position the PIC32WM-BW1 Module 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, V_{DD} rails are sufficiently large for handling peak TX current consumption.

Note: The PIC32WM-BW1 Module includes RF shielding on top of the board as a standard feature.

2.7. PIC32WM-BW1 Module Antenna Considerations

2.7.1. 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.
- If dipole antenna being used, 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 keep out 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 PIC32WM-BW1 Module.

The following figure illustrates an indication on how to route the antenna cable depending on the location of the antenna with respect to the PIC32WM-BW1 PCB. There are two possible options for the optimum routing of the cable.

Figure 2-15. Antenna Placement Guidelines

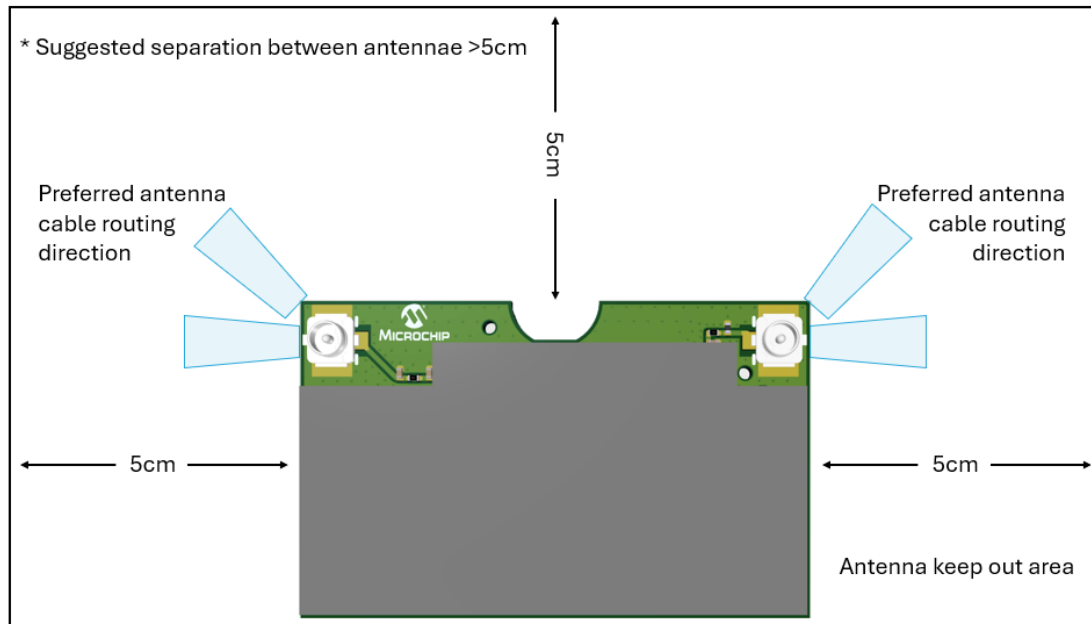


Table 2-2. List of External Antennae

Serial Number	Part Number	Vendor	Gain at 2.4G	Antenna Type
1	ANT-2.4-LPW-125	Linx Technologies	2.8	Dipole
2	RFA-02-L2H1	Aristotle	2	Dipole
3	RFA-02-C2H1-D034	Aristotle	2	Dipole
4	RFA-02-D3	Aristotle	2	Dipole
5	RFDPA870910IMAB308	Walsin	2.04	Dipole
6	W1049B030	Pulse	2.85	Dipole
7	RFDPA870920IMLB301	Walsin	1.84	Dipole
8	RFDPA870920IMAB302	Walsin	1.82	Dipole
9	RFDPA870920IMAB305	Walsin	1.82	Dipole
10	RFDPA870915IMAB306	Walsin	1.82	Dipole
11	YF0026AA	Quectel	2.1	Flex PCB
12	FXP70.07.0053A	TAOGLAS	1.1	Flex PCB
13	RFA-02-P05-D034	Aristotle	2	PCB
14	RFA-02-P33-D034	Aristotle	2	PCB

Note: All the dipole antennae in the above list have similar cutoff frequency.

2.8. PIC32WM-BW1 Module Reflow Profile Information

The PIC32WM-BW1 Module was assembled using the IPC/JEDEC J-STD-020 standard lead-free reflow profile. The PIC32WM-BW1 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. PIC32WM-BW1 Module Assembly Considerations

The PIC32WM-BW1 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. Use the solutions such as IPA and similar solvents to clean this module. The user must never use cleaning solutions containing 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. Pinout and Signal Descriptions

The following table provides details on signal names classified by the peripherals along with the device pinout for the PIC32WM-BW1 Module.

Table 3-1. Pinout and Signal Descriptions List

Pin Number	Module Pin Name	Pin Type	Description	Peripherals								
				AC	ADC	EIC ⁽⁴⁾	GPIO ^(1, 2)	QSPI	RTCC	SERCOM	OSC	DEBUG
1-4	GND	P	Ground	—	—	—	—	—	—	—	—	—
5	NMCLR	I	PIC32CX-BZ2 IC Reset	—	—	—	—	—	—	—	—	—
6	PB1 ⁽⁹⁾	I/O	PIC32CX-BZ2 Port B Digital I/O	AC_AIN3	AN5	—	RB1	—	—	—	—	—
7	PB2	I/O	PIC32CX-BZ2 Port B Digital I/O	AC_AIN0	AN6	—	RB2	—	—	—	—	—
8	PB3	I/O	PIC32CX-BZ2 Port B Digital I/O	AC_AIN1	AN7	—	RB3	—	—	—	—	—
9	PB4	I/O	PIC32CX-BZ2 Port B Digital I/O	—	AN0	INT0 ⁽⁶⁾	RB4	—	—	—	—	TRACEDATA3
10	PB5	I/O	PIC32CX-BZ2 Port B Digital I/O	—	AN1	—	RB5	—	—	—	—	TRACEDATA0
11	PB6	I/O	PIC32CX-BZ2 Port B Digital I/O	—	ANN0, AN2	—	RB6	—	—	—	—	TRACEDATA1
12	PA11	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA11 ⁽⁵⁾	—	—	—	SOSCI	—
13	PA12	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA12 ⁽⁵⁾	—	—	—	SOSCO	—
14	GND	P	Ground	—	—	—	—	—	—	—	—	—
15	PB9	I/O	PIC32CX-BZ2 Port B Digital I/O	—	—	—	RB9	—	—	—	—	CM4_SWDIO
16	PB8	I/O	PIC32CX-BZ2 Port B Digital I/O	—	—	—	RB8	—	—	—	—	CM4_SWCLK
17	PB7	I/O	PIC32CX-BZ2 Port B Digital I/O	LVDIN	AN3	—	RB7	—	—	—	—	TRACEDATA2, CM4_SWO
18	PA4	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA4	—	RTC_OUT	SERCOM0_PAD3	—	—
19	PA3	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA3	—	RTC_IN0	SERCOM0_PAD2	SCLKI	—
20	PA6	I/O	PIC32CX-BZ2 Port A Digital I/O	AC_CMP1_ALT	—	—	RA6	—	—	SERCOM0_PAD1	—	—
21	PA5	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA5	—	—	SERCOM0_PAD0	—	—
22	PA2	I/O	PIC32CX-BZ2 Port A Digital I/O	AC_CMP0	—	—	RA2	—	RTC_IN1	—	—	—
23	PA0	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA0	QSPI_DATA2	RTC_IN3	—	—	—
24	PA1	I/O	PIC32CX-BZ2 Port A Digital I/O	AC_CMP1	—	—	RA1	QSPI_DATA3	RTC_IN2	—	—	—
25	PB13	I/O	QSPI_DATA1	—	—	—	—	QSPI_DATA1 ⁽⁸⁾	RTC_EVENT	—	—	—

Table 3-1. Pinout and Signal Descriptions List (continued)

Pin Number	Module Pin Name	Pin Type	Description	Peripherals								
				AC	ADC	EIC ⁽⁴⁾	GPIO ^(1, 2)	QSPI	RTCC	SERCOM	OSC	DEBUG
26	PB12	I/O	QSPI_DATA0	—	—	—	—	QSPI_DATA0 ⁽⁸⁾	—	—	—	—
27	PB10	I/O	QSPI_CS	—	—	—	—	QSPI_CS ⁽⁸⁾	—	—	—	—
28	GND	P	Ground	—	—	—	—	—	—	—	—	—
29	PB11	I/O	QSPI_CLK	—	—	—	—	QSPI_SCK ⁽⁸⁾	—	—	—	—
30	V _{DD} _IN_1	P	Power supply input (3.0-3.6V)	—	—	—	—	—	—	—	—	—
31	V _{DD} _IN_2	P	Power supply input (3.0-3.6V)	—	—	—	—	—	—	—	—	—
32, 33	GND	P	Ground	—	—	—	—	—	—	—	—	—
34	PA8	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA8	—	—	SERCOM1_PAD1	—	—
35	PA7	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA7	—	—	SERCOM1_PAD0	—	TRACECLK
36	PA9	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA9	—	RTC_IN0_ALT	SERCOM1_PAD2	—	—
37	PA10	I/O	PIC32CX-BZ2 Port A Digital I/O	—	—	—	RA10	—	RTC_OUT_ALT	SERCOM1_PAD3	—	—
38	GND	P	Ground	—	—	—	—	—	—	—	—	—
39	IRQ ⁽¹¹⁾	I/O	Interrupt request (active-low) from the WINCS02 IC to wake-up the host (PIC32CX-BZ2) from its Sleep state	—	—	—	—	—	—	—	—	—
40	UART2_TX	I/O	UART2 transmit signal for firmware log from WINCS02IC	—	—	—	—	—	—	—	—	—
41	ECC_SCL	I/O	Serial clock input for crypto authentication device on module, NC pin for UE variant	—	—	—	—	—	—	—	—	—
42	ECC_SDA	I/O	Serial data for crypto authentication device on module, NC pin for UE variant	—	—	—	—	—	—	—	—	—
43	NC	I/O	—	—	—	—	—	—	—	—	—	—
44	UART1_TX	I/O	Used for external antenna calibration. Connect this signal to a test point or a pin header.	—	—	—	—	—	—	—	—	—
45-47	NC	I/O	—	—	—	—	—	—	—	—	—	—

Table 3-1. Pinout and Signal Descriptions List (continued)

Pin Number	Module Pin Name	Pin Type	Description	Peripherals								
				AC	ADC	EIC ⁽⁴⁾	GPIO ^(1, 2)	QSPI	RTCC	SERCOM	OSC	DEBUG
48	UART1_RX	I/O	Used for external antenna calibration. Connect this signal to a test point or a pin header.	—	—	—	—	—	—	—	—	—
49	NC	P	—	—	—	—	—	—	—	—	—	—
50	NC	I/O	—	—	—	—	—	—	—	—	—	—
51	Reserved ⁽¹⁰⁾	I/O	Reserved pin. Connect to an I/O pin (tri-stated) of a host device or to an external switch for future use	—	—	—	—	—	—	—	—	—
52	W_NMCLR	I	WINCS02IC MCLR Reset	—	—	—	—	—	—	—	—	—
53	DFU_TX/ STRAP2	I/O	For WINCS02 device firmware update receive pin. The recommendation is to connect to a pull-down resistor of 100K.	—	—	—	—	—	—	—	—	—
54	DFU_RX/ STRAP1	I/O	For WINCS02 device firmware update receive pin. The recommendation is to connect to a pull-down resistor of 100K.	—	—	—	—	—	—	—	—	—
55-58	GND	P	Ground	—	—	—	—	—	—	—	—	—
59, 60	EP GND	P	Thermal ground paddle for connection on host board	—	—	—	—	—	—	—	—	—

Table 3-1. Pinout and Signal Descriptions List (continued)

Pin Number	Module Pin Name	Pin Type	Description	Peripherals								
				AC	ADC	EIC ⁽⁴⁾	GPIO ^(1, 2)	QSPI	RTCC	SERCOM	OSC	DEBUG

Notes:

1. All GPIOs (RAn and RBn) can be used by remappable peripherals via PPS.
2. All GPIOs (RAn and RBn) can be used as I/O Change Notification (IOCA_n and IOCB_n) except RA11 and RA12. For more details, refer to *Port A Register Map for RA11 and RA12* in the *PIC32CX-BZ2 and WBZ45 Family Data Sheet* (DS70005504).
3. The metal paddle at the bottom of the device must be connected to system ground.
4. These peripherals have signals that are only available via the PPS remappable pins.
5. This pin can be used as Input only pin if not using SOSC and setting up CFGCON2.SOSCSEL = 0.
6. INT0 can be used as a wake-up source from Deep Sleep or Extreme Deep Sleep Low Power modes, as well as an ADC trigger source. The INT0 can be configured using Configuration Control Register 0 (CFGCON0). INT0 functionality on PB4 cannot be remapped using PPS. The software SDK and operational stacks provided by Microchip handles the operation of INT0 as a wake-up source in Deep Sleep Low Power Mode.
7. These I/O pins are 5.5V tolerant: NMCLR, PA0, PA1, PA2, PA4, PA5, PA6, PA7, PA8, PA9, PA10, PB10, PB11, PB12, PB13. All other I/O pins are 3.3V tolerant.
8. The PIC32CX-BZ2 device's QSPI is configured as SPI to interface with the WINCS02 on the Module PCB.
9. Pin 6 PB1 is used to reset WINCS02 device by driving the pin 52 W_MCLR pin on the PIC32WM-BW1 Curiosity Board (EV60G68A). It is recommended to connect PB1 to W_MCLR on the host-board to avoid changes in software implementation.
10. Do not leave this pin unconnected. Follow the directions in the Pin Description column for future upgrades.
11. Pin 39 IRQ is connected to Pin 9 PB4 on the PIC32WM-BW1 Curiosity Board (EV60G68A). It is recommended to connect IRQ to PB4 on the host-board to avoid changes in software implementation.

4. Electrical Characteristics

This chapter provides the electrical specifications and the characteristics of the PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module across the operating temperature range of the product.

Note: Only electrical specifications and characteristics that are specific to the PIC32WM-BW1 Module are listed in the chapter. For additional specifications, refer to the *PIC32CX-BZ2 and WBZ45 Family Data Sheet (DS70005504)* and *WINCS02IC and WINCS02 Family Data Sheet (DS70005577)*.

4.1. Absolute Maximum Ratings

Exposure to these maximum rating conditions for extended periods may 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 4-1. Absolute Maximum Ratings

Parameter	Value
Ambient temperature under bias	-40 °C to +85 °C
Storage temperature	-40 °C to +125 °C
Voltage on V _{DD} with respect to GND	-0.3V to (V _{DD} + 0.3V)
Voltage on any pin(s), with respect to GND	-0.3V to (V _{DD} + 0.3V)
Maximum current out of GND pins	200 mA
Maximum current into V _{DD} pin(s)	200 mA
Human Body Model (HBM) per JESD22-A114	±2000V
Notes:	
1. Stresses above those listed under “Absolute Maximum Ratings” may 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.	

4.2. Recommended Operating Conditions

Table 4-2. Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Unit
Power supply input voltage	V _{DD}	3.0	3.3	3.6	V
Operating Temperature	TA	-40	25	85	°C
	TJ	-40	—	105	°C

4.3. DC Characteristics

4.3.1. Wi-Fi Current Consumption

Table 4-3. Wi-Fi[®] Current Consumption DC Electrical Specifications

DC Characteristics ⁽¹⁾⁽²⁾				Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0\text{-}3.6\text{V}$ (Unless Otherwise Stated)				
				Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ for Industrial				
Param. No.	Symbol	Device States	Code Rate	Output Power (Typ.) (dBm)	Current (Typ.) (mA) ⁽²⁾	Max.	Units	Conditions
IWF_TX	I_{DD}	On_Transmit	802.11b 1 Mbps ⁽⁴⁾	19	304	—	mA	$V_{DD} = V_{DDIO} = 3.3\text{V}$
			802.11b 1 Mbps ⁽⁴⁾	13	270	—		
			802.11b 11 Mbps ⁽³⁾	20	311	—		
			802.11g 6 Mbps ⁽⁴⁾	19	310	—		
			802.11g 54 Mbps ⁽³⁾	17	274	—		
			802.11n MCS0 ⁽⁴⁾	18	300	—		
			802.11n MCS7 ⁽³⁾	17	273	—		
			802.11n MCS7 ⁽⁴⁾	11	252	—		
IWF_RX	I_{DD}	On_Receive	802.11b 1 Mbps ⁽⁴⁾	—	92	—		
			802.11n MCS7 ⁽³⁾	—	98	—		

Notes:

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

4.3.2. PIC32CX1012BZ25048 MCU Current Consumption

Table 4-4. PIC32CX1012BZ25048 MCU Current Consumption

DC Characteristics				Standard Operating Conditions: $V_{DD} = 3.0\text{--}3.6\text{V}$ (Unless Otherwise Stated)			
				Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ for Industrial Temperature			
Param. No.	Symbol	Characteristics	Clock/Freq	Typ.	Max	Unit	Conditions
APWR_1	$I_{DD_ACTIVE}^{(1,2)}$	MCU I_{DD} in active mode with PMU in LDO mode	PLL 64 MHz	105	291	$\mu\text{A}/\text{MHz}$	$V_{DD} = 3.3\text{V}$
			PLL 48 MHz	89	274		
APWR_13		MCU I_{DD} in active mode with PMU in Buck mode	PLL 64 MHz	70	209		
			PLL 48 MHz	62	197		
IPWR_1	$I_{DD_IDLE}^{(3)}$	MCU I_{DD} in IDLE mode w/LDO mode selected	PLL 64 MHz	54	184	$\mu\text{A}/\text{MHz}$	$V_{DD} = 3.3\text{V}$
			PLL 48 MHz	68	249		
IPWR_3		MCU I_{DD} in IDLE mode w/BUCK mode selected	PLL 64 MHz	77	258		
			PLL 48 MHz	49	178		
SPWR_1	$I_{DD_SLEEP}^{(4)}$	MCU I_{DD} in Sleep mode w/LDO mode selected	—	0.58	10.6	mA	XTAL OFF
SPWR_5			—	0.88	10.1	mA	XTAL ON
SPWR_29		MCU I_{DD} in Sleep mode w/BUCK mode selected	—	0.67	10.7	mA	XTAL ON
SPWR_33			—	0.49	11.0	mA	XTAL OFF
BPWR_1	$I_{DD_BACKUP}^{(5)}$	MCU I_{DD} in Deep Sleep mode powered from $V_{DDIO} 3.3\text{V}$	—	1.5	7.1	μA	No Back-up RAM retained
BPWR_9			—	1.7	11.7	μA	8 KB Back-up RAM retained
OPWR_1	$I_{DD_OFF}^{(6)}$	MCU I_{DD} in OFF mode powered from $V_{DDIO} 3.3\text{V}$	—	0.36	3.99	μA	In OFF mode ⁽⁷⁾ , the device is entirely powered-off.

Table 4-4. PIC32CX1012BZ25048 MCU Current Consumption (continued)

DC Characteristics				Standard Operating Conditions: $V_{DD} = 3.0\text{--}3.6\text{V}$ (Unless Otherwise Stated)			
				Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ for Industrial Temperature			
Param. No.	Symbol	Characteristics	Clock/Freq	Typ.	Max	Unit	Conditions
Note: 1. The test conditions are as follows: - All GPIO are input and pulled up. - RF System ON with default settings but not doing RF transmission. - All Peripherals disabled with PMD bits. - All PB clocks are divided by 16. - LPRC is set as LPCLK. - SOSC is disabled. - PMU 1 MHz clock is derived from FRC. FRC is divided by 8. - Cache is enabled and configured wait time as 0xF. - WCM memories configured in Retention + NAP mode. - DSU is disconnected. 2. MCU running while(1) loop with 50 NOP instructions. 3. The test conditions are as follows: - All GPIO are input and pulled up. - All Peripherals disabled with PMD bits. - All PB clocks are divided by 16. - LPRC is set as LPCLK. - SOSC is disabled. - PMU 1 MHz clock is derived from FRC. FRC is divided by 8. - Cache is enabled and configured to wait time as 0xF. - WCM memories configured in Retention + NAP mode. - DSU is disconnected. - RF system OFF. - Entry to the Sleep mode is disabled and WFI instruction is executed. - On exit by External interrupt, verified RCON status to ensure system was in the IDLE mode.							

Table 4-4. PIC32CX1012BZ25048 MCU Current Consumption (continued)

DC Characteristics				Standard Operating Conditions: $V_{DD} = 3.0-3.6V$ (Unless Otherwise Stated)			
				Operating Temperature: $-40^{\circ}C \leq T_A \leq +85^{\circ}C$ for Industrial Temperature			
Param. No.	Symbol	Characteristics	Clock/Freq	Typ.	Max	Unit	Conditions
4. The test conditions SLEEP mode are as follows: - All GPIO are input and pulled up. - All peripherals disabled with PMD bits. - All PB clocks are divided by 16. - LPRC is set as LPCLK. - SOSC is disabled. - CLDO is configured at lowest possible voltage (VREG Trim = 0x07). - PMU is configured to the Buck PSM mode on the Sleep Mode Entry. - Cache is enabled and configured wait time as 0xF. - WCM memories configured in Retention + NAP mode. - DSU is disconnected. - RF system is in low power configuration. - Entry to the Sleep mode is enabled and WFI instruction is executed. - On exit by External interrupt, verified RCON status to ensure system was in Sleep mode. - In XTAL ON mode - PMU Buck clock is derived from POSC 16 MHz and scaled to 1 MHz. FRC is OFF. - In XTAL OFF mode - PMU is clocked from FRC and XTAL 16 MHz clock is disabled and clock configuration in CRU changed to FRC. 5. The test conditions for Deep sleep mode are as follows: - All GPIO are input and pulled up. - All peripherals disabled with PMD bits. - All PB clocks are divided by 16. - LPRC is set as LPCLK. - SOSC and POSC is disabled. - CLDO configured at lowest possible voltage (VREG Trim = 0x07). - DSU is disconnected. - RF system is in low power configuration. - DSWDT is enabled and configured for wake-up. - Deep sleep entry is configured and WFI instruction is executed. 8 KB RAM WCM memory ON using WCMCFG.WCM1CFG[2:0]=1; WCMCFG.WCM2CFG[2:0]=1 for powered ON, RET + NAP mode. 8 KB RAM WCM memory OFF using WCMCFG.WCM1CFG[2:0]=0; WCMCFG.WCM2CFG[2:0]=0 for powered OFF.							

Table 4-4. PIC32CX1012BZ25048 MCU Current Consumption (continued)

DC Characteristics				Standard Operating Conditions: $V_{DD} = 3.0\text{--}3.6\text{V}$ (Unless Otherwise Stated)			
				Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ for Industrial Temperature			
Param. No.	Symbol	Characteristics	Clock/Freq	Typ.	Max	Unit	Conditions
6. The test conditions for OFF MODE are as follows:							
- All GPIO are input and pulled up. - All peripherals disabled with PMD bits. - DSU is disconnected. - RF system is in low power configuration. - DSWDT is disabled. - RTCC and POSC is disabled. - Deep sleep entry is configured and WFI instruction is executed.							
7. Exit OFF mode by pulling the RESET pin low or by performing a power reset.							
8. Typical value measured at 25 °C and 3.3V							
9. These parameters are characterized but not tested in manufacturing.							

4.3.3. Wi-Fi® and Bluetooth® Low Energy Co-operation Current Consumption

The PIC32CX-BZ2 and WINCS02IC on the PIC32WM-BW1 Module share the same power supply path, following is the measured current consumption from the Module V_{DD} pin.

- Current consumption measurements correspond to Wi-Fi® and Bluetooth® Low Energy operating in co-operation with PTA
- The internal RF test firmware configures Wi-Fi and Bluetooth Low Energy SoCs into specific operating mode for measurement.

Table 4-5. Current Consumption on Wi-Fi® Continuous Transmission with Bluetooth® Low Energy in the Idle Mode

Param. No.	Symbol	Device Status	Code Rate	Output Power (Typ.) (dBm)	Current (Typ.)(mA)	Max.	Units	Conditions
IWF_TX	I _{DD}	Wi-Fi® transmit with Bluetooth® Low Energy in Idle mode	802.11b 1 Mbps	19	310	—	mA	CPU Frequency: 64 MHz $V_{DD}=V_{DDIO} = 3.3\text{V}$
			802.11b 1 Mbps	13	290	—		
			802.11b 11 Mbps	20	321	—		
			802.11g 6 Mbps	19	319	—		
			802.11g 54 Mbps	17	283	—		
			802.11n MCS0	18	312	—		
			802.11n MCS7	17	292	—		
			802.11n MCS7	11	277	—		

Table 4-6. Current Consumption on Bluetooth® Low Energy 1M Continuous Transmission with Wi-Fi® in Receiving Mode

Param. No.	Symbol	Device Status	Bluetooth® Low Energy Output Power (Typ.)(dBm)	Wi-Fi® RX Code Rate	Current (Typ.)(mA)	Max.	Units	Conditions
IBLETX1	IDDTXMPA	Bluetooth® Low Energy with MPA transmitting in DC-DC mode 1 Mbps	12 dBm	802.11b 1 Mbps	139	—	mA	CPU Frequency: 64 MHz V _{DD} =V _{DDIO} =3.3V
IBLETX1	IDDTXMPA	Bluetooth® Low Energy with MPA transmitting in DC-DC mode 1 Mbps	12 dBm	802.11n MCS7	140	—		
IBLETX7	IDDTXLPA	Bluetooth® Low Energy with LPA transmitting in DC-DC mode 1 Mbps	4 dBm	802.11b 1 Mbps	117	—		
IBLETX7	IDDTXLPA	Bluetooth® Low Energy with LPA transmitting in DC-DC mode 1 Mbps	4 dBm	802.11n MCS7	119	—		

Table 4-7. Current Consumption on Bluetooth® Low Energy and Wi-Fi® in Receiving Mode

Param. No.	Symbol	Device Status	Wi-Fi RX Code Rate	Current (Typ.)(mA)	Max.	Units	Conditions
IBWRX1	IDDRXBW	Bluetooth® Low Energy 1 Mbps with RX signal level -80 dBmin DC-DC mode	802.11b 1 Mbps	111	—	mA	CPU Frequency: 64 MHz V _{DD} =V _{DDIO} =3.3V
IBWRX1	IDDRXBW	Bluetooth® Low Energy 1 Mbps with RX signal level -80 dBmin DC-DC mode	802.11n MCS7	117	—		

4.4. SOSC XTAL Electrical Specifications

Table 4-8. XOSC32 AC Electrical Specifications

AC Characteristics			Standard Operating Conditions: V _{DDIO} = V _{DDANA} 1.9V to 3.6V (unless otherwise stated) Operating Temperature: -40 °C ≤ T _A ≤ +85 °C for Industrial Temperature				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions ⁽¹⁾
XOSC32_1	F _{OSC_XOSC32}	XOSC32 oscillator crystal frequency	—	32.79	—	kHz	XIN32, XOUT32 secondary oscillator
XOSC32_3	C _{XIN32}	XOSC32 XIN32 parasitic pin capacitance	—	2.4	—	pF	2.4 pF on the Module
XOSC32_5	C _{XOUT32}	XOSC32 XOUT32 parasitic pin capacitance	—	2.4	—	pF	2.4 pF on the Module
XOSC32_11	C _{LOAD_X32} ⁽³⁾	32.768 kHz crystal load capacitance	—	11	—	pF	—
XOSC32_13	ESR_X32	32.768 kHz crystal ESR	—	75	100	KΩ	—
XOSC32_15	TOSC32	TOSC32 = 1/FOSC_XOSC32	—	30.5	—	μs	See parameter XOSC32_1 for FOSC_XOSC32 value

Table 4-8. XOSC32 AC Electrical Specifications (continued)

AC Characteristics			Standard Operating Conditions: $V_{DDIO} = V_{DDANA}$ 1.9V to 3.6V (unless otherwise stated) Operating Temperature: $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for Industrial Temperature				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions ⁽¹⁾
XOSC32_17	XOSC32_ST ⁽²⁾	XOSC32 crystal start-up time	—	1024	—	TOSC	Crystal stabilization time only not oscillator ready

Notes:

- $V_{DDIO} = V_{DDANA} = 3.3\text{V}$.
- This is for guidance only. A major component of crystal start-up time is based on the second party crystal MFG parasitic that is outside the scope of this specification. If this is a major concern, the customer might need to characterize this based on their design choices.
- The test conditions for crystal load capacitor calculation are as follows:
 - Standard PCB trace capacitance = 1.5 pF per 12.5 mm (0.5 inches) (in other words, PCB STD TRACE W = 0.175 mm, H = 36 μm , T = 113 μm)
 - Xtal PCB capacitance typical; therefore, ≈ 2.5 pF for a tight PCB xtal layout
 - For CXIN and CXOUT within 4 pF of each other, assume $\text{CXTAL_EFF} = ((\text{CXIN} / 2))$
 - Note:** Averaging CXIN and CXOUT will affect the final calculated CLOAD value by less than the tolerance of the capacitor selection.

Equation 1:

$\text{MFG CLOAD Spec} = \{([CXIN + C1] * [CXOUT + C2]) / [CXIN + C1 + C2 + CXOUT]\} + \text{estimated oscillator PCB stray capacitance}$

Assuming $C1 = C2$ and $\text{CXin} \approx \text{CXout}$, the formula can be further simplified and restated to solve for C1 and C2 by:

Equation 4-1. Equation 2 (In other words: Simplified Equation 1)

$C1 = C2 = ((2 * \text{MFG CLOAD Spec}) - \text{CXTAL_EFF} - (2 * \text{PCB capacitance}))$

Example:

- XTAL Mfg CLOAD Data Sheet Spec = 12 pF
- PCB XTAL trace Capacitance = 2.5 pF
- CXIN pin = 6.5 pF, CXOUT pin = 4.5 pF therefore $\text{CXTAL_EFF} = ((\text{CXIN} / 2))$

$\text{CXTAL_EFF} = ((6.5 + 4.5)/2) = 5.5$ pF

$C1 = C2 = ((2 * \text{MFG Cload spec}) - \text{CXTAL_EFF} - (2 * \text{PCB capacitance}))$

$C1 = C2 = (24 - 5.5 - (2 * 2.5))$

$C1 = C2 = (24 - 5.5 - 5)$

$C1 = C2 = 13.5$ pF (Always rounded down)

$C1 = C2 = 13$ pF (in other words, for hypothetical example crystal external load capacitors)

User $C1 = C2 = 13$ pF $\leq \text{CLOAD_X32 (max.) spec}$

- User selectable in OSC32KCTRL.STARTUP.
- These parameters are characterized but not tested in manufacturing.

4.5. RF Characteristics

This section provides detailed information on the RF characteristics of the WLAN and Bluetooth Low Energy modules.

4.5.1. PIC32WM-BW1 WLAN Radio Specifications

Table 4-9. PIC32WM-BW1 WLAN 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

4.5.1.1. PIC32WM-BW1 WLAN Receiver Performance

Table 4-10. PIC32WM-BW1 Receiver Performance Characteristics⁽¹⁾

RF Characteristics			Standard Operating Conditions: V _{DD} = V _{DDIO} = 3.0-3.6V (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	—	-94	—	
		5.5 Mbps CCK	—	-92	—	
		11 Mbps CCK ⁽⁶⁾	—	-89	—	
WF_RX_3	Sensitivity 802.11g	6 Mbps OFDM	—	-91	—	dBm
		9 Mbps OFDM	—	-91	—	
		12 Mbps OFDM	—	-88	—	
		18 Mbps OFDM	—	-86	—	
		24 Mbps OFDM	—	-83	—	
		36 Mbps OFDM	—	-80	—	
		48 Mbps OFDM	—	-76	—	
		54 Mbps OFDM ⁽⁶⁾	—	-74	—	
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	—	-78	—	
		MCS 5	—	-74	—	
		MCS 6	—	-72	—	
		MCS 7 ⁽⁶⁾	—	-70	—	
WF_RX_5	Maximum receive signal level	1, 2 Mbps DSSS	-3	—	—	dBm
		5.5, 11 Mbps CCK	-3	—	—	
		6 Mbps OFDM	-3	—	—	
		54 Mbps OFDM	-7.2	—	—	
		MCS 0	-3	—	—	
		MCS 7	-7	—	—	

Table 4-10. PIC32WM-BW1 Receiver Performance Characteristics⁽¹⁾ (continued)

RF Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0\text{-}3.6\text{V}$ (Unless Otherwise Stated) Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ for Industrial			
Param. No.	Characteristics	Description ⁽⁵⁾	Min.	Typ	Max.	Units
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, ISCED) requirements when the Module is installed in the final host product. 5. This parameter is characterized but not tested in manufacturing. 6. This parameter is characterized and tested in manufacturing.						

4.5.1.2. PIC32WM-BW1 WLAN Transmitter Performance

Table 4-11. PIC32WM-BW1 Transmitter Performance Characteristics

RF Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0\text{-}3.6\text{V}$ (Unless Otherwise Stated) Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ 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	—	

Table 4-11. PIC32WM-BW1 Transmitter Performance Characteristics (continued)

RF Characteristics			Standard Operating Conditions: $V_{DD} = V_{DDIO} = 3.0\text{-}3.6\text{V}$ (Unless Otherwise Stated) Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ for Industrial			
Param. No.	Characteristics	Description ⁽⁸⁾	Min.	Typ ⁽³⁾	Max.	Units
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)	Second	—	42	74 ⁽⁷⁾	dBuV/m
		Third	—	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.

4.5.2. Bluetooth Low Energy RF Characteristics

Table 4-12. PIC32WM-BW1 Bluetooth® Low Energy RF Characteristics

AC Characteristics			Standard Operating Conditions: V _{DDIO} = V _{DDANA} 1.9-3.6V (Unless Otherwise Stated) Operating Temperature: -40 °C ≤ T _A ≤ +85 °C for Industrial Temp				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions
BTG1	FREQ	Frequency range of operation	2402	—	2480	MHz	—
BTTX1	TXPWR:MPA	Bluetooth® transmit power MPA	—	12	—	dBm	—
BTTX2	TXPWR:LPA	Bluetooth transmit power LPA	—	3.95	—	dBm	—
BTX3	TXIB:1 MBPS	In-band emission for FTX ±2 MHz	—	-32	—	dBm	—
		In-band emission for FTX ±(3+N) MHz	—	-45	—	dBm	—
BTX4	TXIB:2 MBPS	In-band emission for FTX ±4 MHz	—	-43	—	dBm	—
		In-band emission for FTX ±5 MHz	—	-48	—	dBm	—
		In-band emission for FTX ±(6+N) MHz	—	-51	—	dBm	—
BTRX1	RXSENSE	Receiver sensitivity at 1 Mbps	—	-97	—	dBm	—
		Receiver sensitivity at 2 Mbps	—	-94	—	dBm	—
		Receiver sensitivity at S = 8	—	-104	—	dBm	—
		Receiver sensitivity at S = 2	—	-101	—	dBm	—
BTRX2	MAXINSIG	Maximum input signal level at 1 Mbps	—	0	—	dBm	—
		Maximum input signal level at 2 Mbps	—	0	—	dBm	
		Maximum input signal level at S = 2	—	0	—	dBm	
		Maximum input signal level at S = 8	—	0	—	dBm	
BTRX3 ⁽³⁾	CI1M:COCH	C/I Co channel rejection	—	8	—	dB	—
	CI1M: ±1 MHz	C/I adjacent channel rejection	—	1	—	dB	—
	CI1M: ±2 MHz	C/I adjacent channel rejection	—	-30	—	dB	—
	CI1M:ADJ(3+n)	C/I alternate channel rejection	—	-48	—	dB	—
	CI1M:IMG	C/I image frequency rejection	—	-24	—	dB	—
	CI1M:IMG ±1 MHz	C/I adjacent channel to image freq rejection	—	-31	—	dB	—

Table 4-12. PIC32WM-BW1 Bluetooth® Low Energy RF Characteristics (continued)

AC Characteristics			Standard Operating Conditions: V _{DDIO} = V _{DDANA} 1.9-3.6V (Unless Otherwise Stated) Operating Temperature: -40 °C ≤ T _A ≤ +85 °C for Industrial Temp				
Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions
BTRX4 ⁽³⁾	CIS2:COCH	C/I Co channel rejection	—	6	—	dB	—
	CIS2: ±1 MHz	C/I adjacent channel rejection	—	-6	—	dB	—
	CIS2: ±2 MHz	C/I adjacent channel rejection	—	-38	—	dB	—
	CIS2:ADJ(3+n)	C/I alternate channel rejection	—	-50	—	dB	—
	CIS2:IMG	C/I image frequency rejection	—	-27	—	dB	—
	CIS2:IMG ±1 MHz	C/I adjacent channel to image freq rejection	—	-37	—	dB	—
BTRX5 ⁽³⁾	CIS8:COCH	C/I Co channel rejection	—	7	—	dB	—
	CIS8: ±1 MHz	C/I adjacent channel rejection	—	-7	—	dB	—
	CIS8: ±2 MHz	C/I adjacent channel rejection	—	-38	—	dB	—
	CIS8:ADJ(3+n)	C/I alternate channel rejection	—	-48	—	dB	—
	CIS8:IMG	C/I image frequency rejection	—	-27	—	dB	—
	CIS2:IMG ±1 MHz	C/I adjacent channel to image freq rejection	—	-41	—	dB	—
BTRX6 ⁽³⁾	CI2M:COCH	C/I Co channel rejection	—	8	—	dB	—
	CI2M: ±2 MHz	C/I adjacent channel rejection	—	1	—	dB	—
	CI2M: ±4 MHz	C/I adjacent channel rejection	—	-29	—	dB	—
	CI2M:ADJ(6+2n)	C/I alternate channel rejection	—	-42	—	dB	—
	CI2M:IMG	C/I image frequency rejection	—	-23	—	dB	—
	CI2M:IMG ±2 MHz	C/I adjacent channel to image freq rejection	—	-28	—	dB	—
BTRX7 ⁽³⁾	BLOCK1M:<2 GHz	Blocking performance from 30-2 GHz	—	-10	—	dBm	—
	BLOCK1M:2 GHz<SIG<2399 MHz	Blocking performance from 2003-2399 MHz	—	-21	—	dBm	—
	BLOCK1M:2484 MHz<SIG<2977 MHz	Blocking performance between 2484-2997 MHz	—	-15	—	dBm	—
	BLOCK1M:3 GHz<SIG<12.75 GHz	Blocking performance between 3-12.5 GHz	—	-10	—	dBm	—
BTRX8 ⁽³⁾	BLE1M:INTERMOD	Inter modulation performance for BLEM	—	-36	—	dBm	—
	BLE2M:INTERMOD	Inter modulation performance for BLEM	—	-28.5	—	dBm	—

Table 4-12. PIC32WM-BW1 Bluetooth® Low Energy RF Characteristics (continued)

AC Characteristics			Standard Operating Conditions: $V_{DDIO} = V_{DDANA}$ 1.9-3.6V (Unless Otherwise Stated) Operating Temperature: $-40\text{ }^{\circ}\text{C} \leq T_A \leq +85\text{ }^{\circ}\text{C}$ for Industrial Temp				
--------------------	--	--	--	--	--	--	--

Param. No.	Symbol	Characteristics	Min.	Typ.	Max.	Units	Conditions
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Notes:

1. Measured at 25°C averaged across all voltages and channels.
2. Measured on a board with the reference schematic.
3. All measurement across voltage based on the SIG specifications.
4. PDU length = 37, channels = 2402/2426/2440/2480 MHz.

5. Packaging Information

This chapter provides the information on package markings, dimension and footprint of the PIC32WM-BW1 Module.

5.1. PIC32WM-BW1 Module Packaging Marking

Figure 5-1. PIC32WM-BW1 Module Package Marking



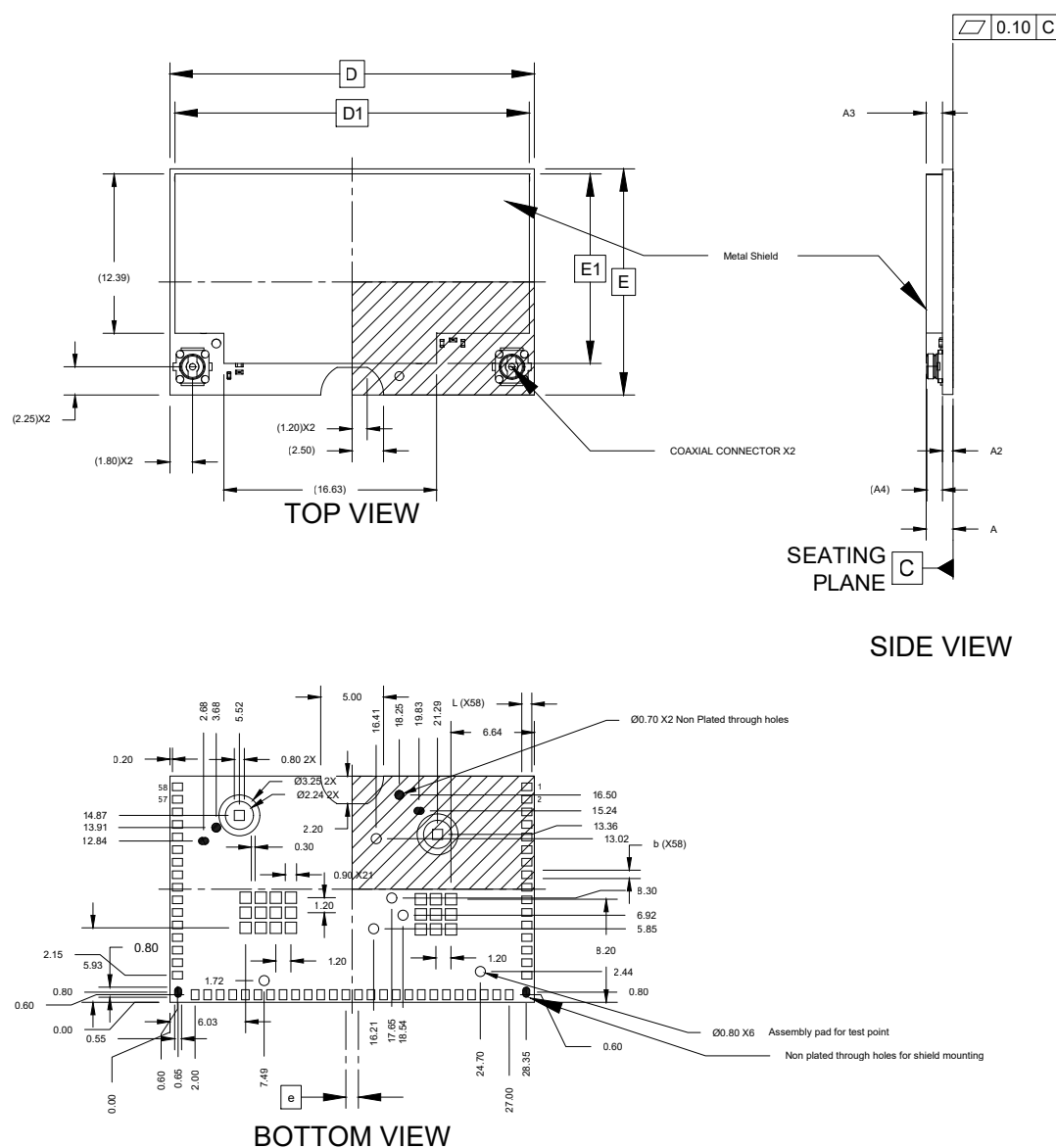
Legend:

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

5.2. PIC32WM-BW1 Module Packaging Information

58-Lead Module (7XW) - 29x18x3.0mm - [MODULE] with Metal Shield and Coaxial Connectors

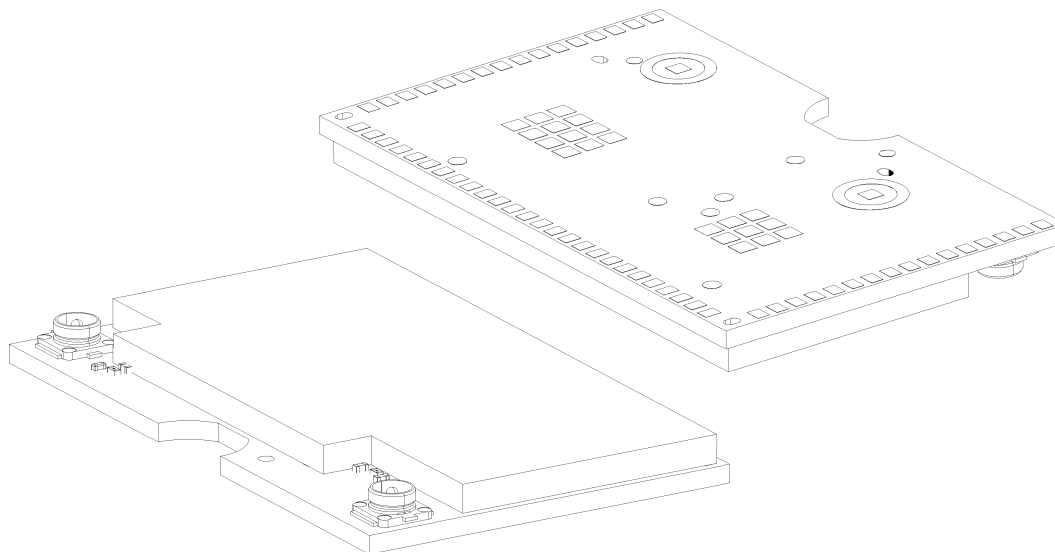
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-00654 Rev A Sheet 1 of 2

58-Lead Module (7XW) - 29x18x3.0mm - [MODULE] with Metal Shield and Coaxial Connectors

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	58		
Pitch	e	1.00 BSC		
Overall Height	A	2.80	3.00	3.10
PCB Thickness	A2	0.90	1.00	1.10
Shield Height	A3	1.92	2.00	2.08
Coaxial Connector Height	A4	2.00 REF		
Overall Length	D	29.00 BSC		
Overall Width	E	18.00 BSC		
Shield Length	D1	27.90 BSC		
Shield Length	E1	14.79 BSC		
Terminal Width	b	0.50	0.60	0.70
Terminal Length	L	0.70	0.80	0.90

Notes:

1. All Dimensions are in Millimeters.

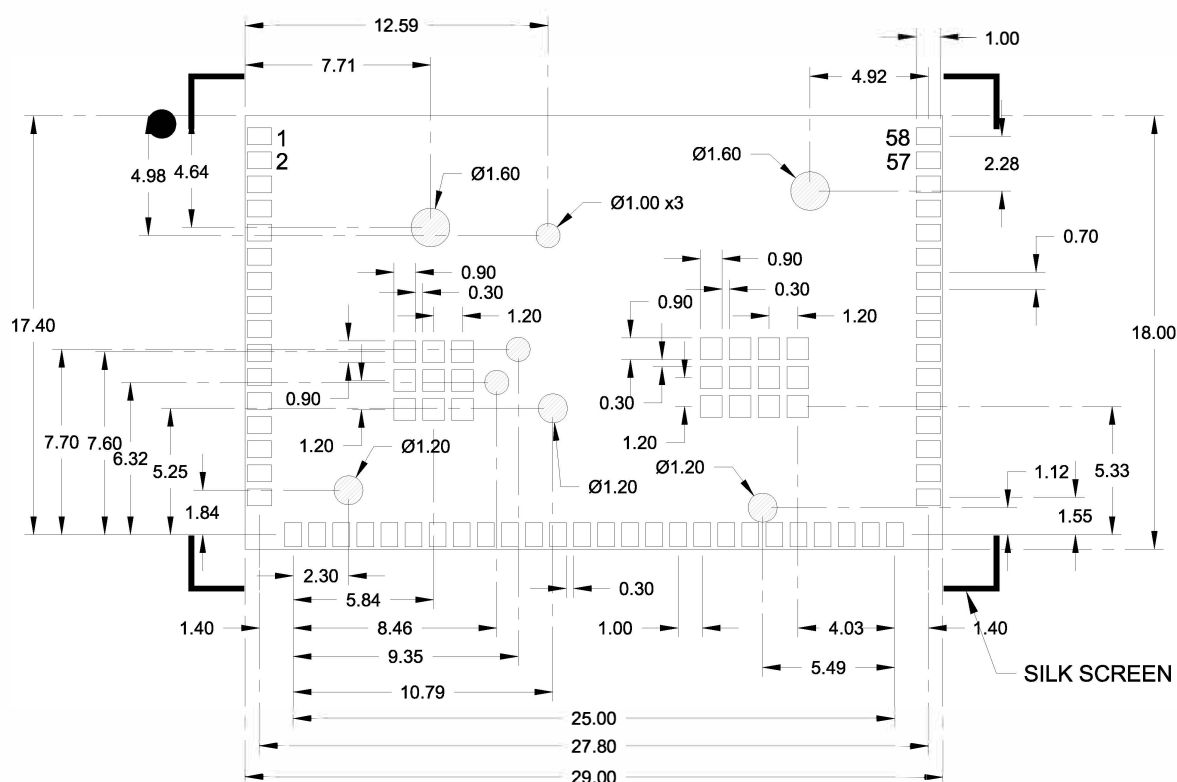
BSC: Basic Dimension. The theoretically exact value is shown without tolerances.

REF: Reference Dimension, usually without tolerance, is for information purposes only.

Microchip Technology Drawing C04-00654 Rev A Sheet 2 of 2

58-Lead Module (7XW) - 29x18x3.0mm - [MODULE] with Metal Shield and Coaxial Connectors

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 this area free from all metal, including ground fill.
3. The gray shaded circles represent the keep-out areas and must be free from routes and exposed copper. Ground fill with solder mask may be placed here.

Microchip Technology Drawing C04-02654 Rev A

6. Appendix A: Regulatory Approval

The PIC32WM-BW1 Module has received regulatory approval for the following countries:

- Bluetooth Special Interest Group (SIG) DN Q339266
- United States/FCC ID: 2ADHKBW1002
- Canada/ISED:
 - IC: 20266-BW1002
 - HVIN: PIC32WM-BW1002UC, PIC32WM-BW1002UE
 - PMN: PIC32WM-BW1 Wi-Fi[®] and Bluetooth[®] Low Energy Combo MCU Module
- Europe/CE
- Great Britain/UKCA

6.1. United States

The PIC32WM-BW1002UC/PIC32WM-BW1002UE 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).

6.1.1. Labeling and User Information Requirements

The PIC32WM-BW1002UC/PIC32WM-BW1002UE 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:

Contains Transmitter Module FCC ID: 2ADHKBW1002

or

Contains FCC ID: 2ADHKBW1002

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.

6.1.2. 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.

PIC32WM-BW1002UC/PIC32WM-BW1002UE: These modules are approved for installation into mobile and/or host platforms having a minimum separation distance of 20 cm from the user.

6.1.3. 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.

6.2. Canada

The PIC32WM-BW1002UC/PIC32WM-BW1002UE 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.

6.2.1. 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 PIC32WM-BW1002UC/PIC32WM-BW1002UE Module

Contains IC: 20266-BW1002

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-BW1002 has 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-BW1002 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.

6.2.2. RF Exposure

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

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

PIC32WM-BW1002UC/PIC32WM-BW1002UE: The devices operate at an output power level that is within the ISED SAR test exemption limits at any user distance greater than 20 cm.

Exposition aux RF

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

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

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

6.2.3. Helpful Web Sites

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

6.3. Europe

The PIC32WM-BW1002UC/PIC32WM-BW1002UE Module 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 PIC32WM-BW1002UC/PIC32WM-BW1002UE Module been tested to RED 2014/53/EU Essential Requirements mentioned in the following European Compliance table.

Table 6-1. 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
Cybersecurity	EN 18031-1	3.3

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.

6.3.1. Labeling and User Information Requirements

The label on the final product that contains the PIC32WM-BW1002UC/PIC32WM-BW1002UE Module must follow CE marking requirements.

6.3.2. 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.

6.3.2.1. Simplified EU Declaration of Conformity

Hereby, Microchip Technology Inc. declares that the radio equipment type PIC32WM-BW1002UC/PIC32WM-BW1002UE is 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/.

6.3.3. Helpful Websites

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

Additional helpful web sites are:

- Radio Equipment Directive (2014/53/EU):
https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/red_en
- European Conference of Postal and Telecommunications Administrations (CEPT):
<http://www.cept.org>
- European Telecommunications Standards Institute (ETSI):
<http://www.etsi.org>
- The Radio Equipment Directive Compliance Association (REDCA):
<http://www.redca.eu/>

6.4. UKCA (UK Conformity Assessed)

The PIC32WM-BW1002UC/PIC32WM-BW1002UE Module is a UK conformity assessed radio module that meets all the essential requirements according to CE RED requirements.

6.4.1. Labeling Requirements for Module and User's Requirements

The label on the final product that contains the PIC32WM-BW1002UC/PIC32WM-BW1002UE 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>.

6.4.2. UKCA Declaration of Conformity

Hereby, Microchip Technology Inc. declares that the radio equipment type the PIC32WM-BW1002UC/PIC32WM-BW1002UE Module 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/pic32wm-bw1002.

6.4.3. Approved Antennas

The testing of the PIC32WM-BW1 Wi-Fi and Bluetooth Low Energy Combo MCU Module was performed with the antennas listed in [Table 2-2](#).

6.4.4. 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.

6.5. Other Regulatory Information

For information about other countries' jurisdictions not covered here, refer to the "Regulatory Approval Documentation Package" available on the respective module product pages. This package provides a complete list of countries and references to worldwide documentation.

7. Appendix B: PIC32CX-BZ2 Additional Information

For additional information on the PIC32CX-BZ2 SoC, refer to the *PIC32CX-BZ2 and WBZ45 Family Data Sheet* ([DS70005504](#)).

8. Appendix C: WINCS02 Additional Information

For additional information on the WINCS02IC Wi-Fi[®] Network Controller, refer to the *WINCS02IC and WINCS02 Family Data Sheet* ([DS70005577](#)).

9. Appendix D: Acronyms and Abbreviations

Table 9-1. Acronyms and Abbreviations

Acronyms and Abbreviations	Descriptions
AC	Analog Comparator
ADC	Analog-to-Digital Converter
AES	Advanced Encryption Standard
AHB	Advanced High-performance Bus
BOD	Brown-Out Detect
BSS	Basic Service Set
BQTF	Bluetooth Qualification Test Facility
CBC	Cipher Block Chaining
CBC-MAC	Cipher Block Chaining Message Authentication Code
CCL	Configurable Custom Logic
CFB	Cipher Feedback
CRC	Cyclic Redundancy Check
CTR	Counter
DMT	Deadman Timer
DMAC	Direct Memory Access Controller
DSA	Digital Signature
ECB	Electronic Code Book
ECC	Error Correction Code
ECC	Elliptic Curves Cryptography
ECC GF	Elliptic Curve Cryptography Galois Field
EIC	External Interrupt Controller
ETB	Embedded Trace Buffer
ETM	Embedded Trace Module
FREQM	Frequency Meter
GCM	Galois Counter Mode
xIP	Execute-In-Place
FPU	Floating Point Unit
ICM	Integrity Check Module
I/O	Input/Output
IoT	Internet of Things
I2C	Inter-Integrated Circuit
LNA	Low Noise Amplifier
MAC	Medium Access Control
MCU	Microcontroller Unit
MPU	Memory Protection Unit
NVIC	Nested Vector Interrupt Controller
OFB	Output Feedback
OTA	Over-The-Air
PA	Power Amplifier
PLL	Phase-Locked Loop
POR	Power-On Reset
PPS	Peripheral Pin Select

Table 9-1. Acronyms and Abbreviations (continued)

Acronyms and Abbreviations	Descriptions
PSDU	Physical Layer Service Data Unit
PTA	Packet Traffic Arbitration
PUKCC	Public Key Cryptography Controller
PUKCL	Public Key Cryptography Library
PWM	Pulse Width Modulation
QSPI	Quad I/O Serial Peripheral Interface
RF	Radio Frequency
RTCC	Real Time Counter
RSA	Rivest-Shamir-Adleman
RX	Receiver
SERCOM	Serial Communication Interfaces
SFD	Start Frame Delimiter
STA	Station
SAR	Successive Approximation Register
SPI	Serial Peripheral Interface
SWD	Serial Wire Debug
T/C	Timers/Counters
TCM	Tightly Coupled Memory
TCP/IP	Transmission Control Protocol/Internet Protocol
TPIU	Trace Port Interface Unit
TRNG	True Random Number Generator
TX	Transmitter
UART	Universal Asynchronous Receiver-Transmitter
WDT	Watchdog Timer
XDS	Extreme Deep Sleep

10. 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 10-1. Document Revision History

Revision	Date	Section	Description
A	10/2025	Document	Initial Revision

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