PIC32CX-BZ2

PIC32CX-BZ2 Production User's Guide

Introduction

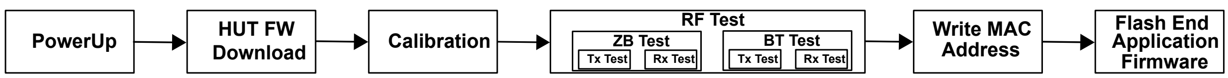
This user guide provides detailed information about PIC32CX-BZ2 production test setup, production tool, calibration and production test to run on the manufacturing line.

The user has to develop their own automated production test script/tool based on MCHPRT3 PIC32CX-BZ2 DLL/CLI for the production testing (or) use the Litepoint (third-party) test suite for the mass production.
Note: To know more about Litepoint test suite for this device, contact Litepoint.

Recommended Production Test Flow

The following figure shows the recommended production test flow.

Figure 1. Recommended Production Test Flow



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1. Quick References

1.1 Hardware Prerequisites

- External Programmer/Debugger - MPLAB® ICD 4 In-Circuit Debugger to Flash HUT firmware
- USB to UART converter (MCP2200 Breakout Board or equivalent)

1.2 Software Requirements

- MPLAB® Integrated Programming Environment (IPE) – To Flash the firmware to the DUT
- Test Tool Package:
  – MCHPRT3 Microchip Radio Testing Tool:
    - MCHPRT3 tool package consists of:
      – PIC32CX-BZ2 HUT Firmware
      – MCHPRT3 GUI
      – MCHPRT3 CLI
      – MCHPRT3 DLL

Note: It is recommended that the MCHPR3 GUI be used for manual testing and the MCHPRT3 CLI/DLL for an automated test.

1.3 Acronyms/Abbreviations

Table 1-1. Acronyms/Abbreviations

Acronyms/Abbreviations	Description
API	Application Programming Interface
CLI	Command Line Interface
DLL	Dynamic Link Library
DUT	Device Under Test
EVM	Error Vector Magnitude
GUI	Graphical User Interface
HUT	Hardware Under Test
IB	Information Block
LPA	Low Power Amplifier
MCHPRT3	Microchip Radio Test Tool 3rd Generation
MPA	Medium Power Amplifier
OTP	One Time Programmable
PCB	Printed Circuit Board
RF	Radio Frequency
RX	Receiver
SMA	Subminiature Type A
SWD	Serial Wire Debug

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Acronyms/Abbreviations	Description
TX	Transmitter
UART	Universal Asynchronous Receiver-Transmitter
USB	Universal Serial Bus
ZB	Zigbee

2. Production Tool

The MCHPRT3 PIC32CX-BZ2 Tool Package has the following contents:

- MCHPRT3 PIC32CX-BZ2.DLL
- MCHPRT3 PIC32CX-BZ2_CLI

2.1 MCHPRT3 PIC32CX-BZ2.DLL

The DLL provides the APIs to control the DUT (PIC32CX-BZ2 device). Refer to the `PIC32CX-BZ2.chm` (compiled HTML help file) on the MCHPRT3 PIC32CX-BZ2 Tool Package for the list of available API details.

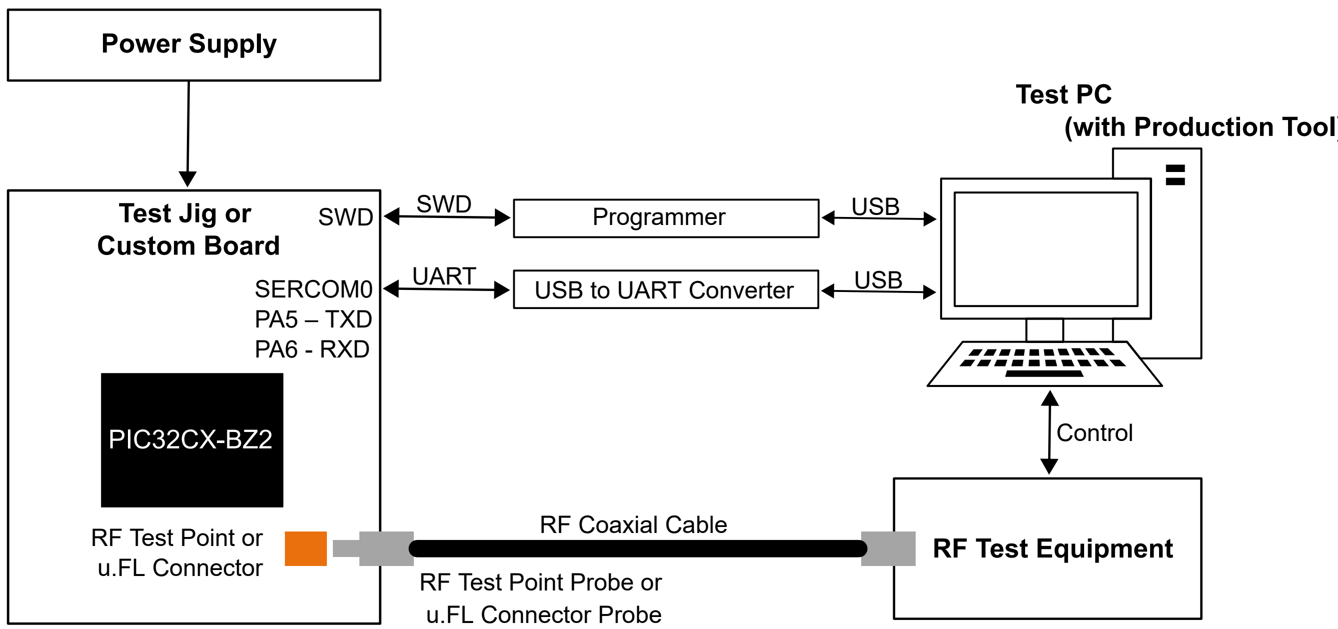
2.2 MCHPRT3 PIC32CX-BZ2_CLI

The CLI provides the list of commands to control the PIC32CX-BZ2 device. `PIC32CX-BZ2 CLI` is built on top of the `PIC32CX-BZ2.DLL`. It is recommended that `PIC32CX-BZ2.DLL` be used to utilize the optimized production test time. To get the list of MCHPRT3 PIC32CX-BZ2 CLI commands, run `MCHPRT3_CLI.exe` on the MCHPRT3 PIC32CX-BZ2 tool package, then enter command PIC32CX-BZ2. Select the command **help** to get the list of commands used to control the PIC32CX-BZ2 device.

3. Production Test Setup

This chapter describes how to set up PIC32CX-BZ2 for production test. The following figure illustrates the production test setup.

Figure 3-1. Production Test Setup



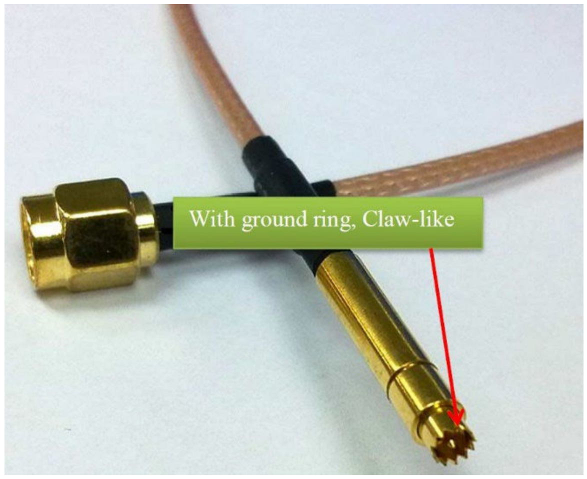
- **Test Jig or Custom Board:**
  PCB designed with the PIC32CX-BZ2 can be directly interfaced to the test PC and RF test equipment. The user can also design their own test jig, which interconnects the DUT to the PC and the RF test equipment. Refer to the *PIC32CX-BZ2 based module - WBZ451/WBZ450 Curiosity Board* for the I/O interface to develop a test jig.

  Note: Refer to the device errata document to check if the specific revision of the device has any operating/programming voltage limitations. Based on that, provide the required options on the test jig or custom board to have the flexibility to change the voltage.
- **Programming and Control Interface:**
  PCB designed with the PIC32CX-BZ2 must have the following interfaces to connect to the PC.
  - SWD (for firmware programming).
  - SERCOM0 (PA5-TXD and PA6-RXD) UART interface to connect the DUT to the test tool on the PC, in order to control the test mode of the device.
- **RF Test Interface:**
  The type of interface to the DUT for RF testing can determine the accuracy and repeatability of the measurements. It is important to pay special attention to the RF test interface to the DUT because of the sensitivity of these signals.

  For example, a product with a 50Ω terminated Subminiature Type A (SMA) or u.FL connector populated on the board can be connected directly to a coaxial cable with a known loss. Repeatability in this scenario is very good.

  Another example is a product with an embedded antenna that is designed with test points for RF and ground that can be connected with an RF probe with a ground ring as shown in the following figure.

Figure 3-2. RF Probe with Ground Ring



The path loss from the RF test point to the cabled connections of the setup needs to be calibrated, and, also, the path loss for the test fixture due to the radiating antenna loading can be calibrated to determine accurate performance. Place a ground metal plate close to the device antenna to detune the antenna and reflect the energy back to the test point to improve the power measurement accuracy in case of a board with an embedded antenna.

The repeatability of this setup is dependent on the board layout. The RF and ground signals must have test points in close proximity to one another. The repeatability is also more dependent on the shielded enclosure in this case because the RF signal is exposed at the test point and radiating through the antenna rather than enclosed within an SMA/ u.FL connector as in the first example.

- **Test Equipment:**
  Bluetooth® Low Energy and Zigbee Tester like Litepoint IQxel
- **Production Test Tool:**
  Use the MCHPRT3 GUI during the initial proto validation. For production, develop the test script based on the MCHPRT3 CLI or DLL.
- **Programmer:**
  ICD4 programmer/debugger to flash the device
- **Power Supply:**
  To provide the required supply to the test jig or a custom board designed with the PIC32CX-BZ2 device

4. Firmware

There two types of firmware for PIC32CX-BZ2 are as follows:

- HUT firmware
- Application firmware

4.1 HUT Firmware for Production Test

- HUT firmware is available inside the MCHPRT3 PIC32CX-BZ2 tool package.
- HUT firmware is mainly to control the PIC32CX-BZ2 device as following:
  - To run the calibration and store the calibration data on Information Block (IB)
  - For RF testing
  - Write MAC address to OTP

4.2 Application Firmware

Normal end-product application firmware that controls various interfaces of the DUT (PIC32CX-BZ2 device)

5. Production Flow

The section describes the production flow that needs to be followed. The user needs to read/write the commands to the DUT in each flow (refer to the *MCHPRT3 User Guide or Litepoint Test Suite User Guide)*.

5.1 Power-Up

Supply power to the DUT.

5.2 HUT Firmware Download

Using MPLAB X IPE, Flash the HUT firmware available on the MCHPRT3 PIC32CX-BZ2 tool package to the DUT.

5.3 Calibration

Refer to the *PIC32CX-BZ2 Calibration User's Guide* for the complete list of calibration and sequence to be followed. Before running any RF tests, the calibration must be completed and commit the Information Block (IB) in the OTP memory.

5.4 RF Test

The following table includes the usual test scenarios that must be performed in the manufacturing line to confirm the RF performance. If the user needs to implement reduced test cases to optimize the test time (or) increase the test cases to do a more detailed testing, the user can perform these based on their interest.

Table 5-1. RF Test

Zigbee/ Bluetooth	TX/RX	Test	Channel	Data Rate
Zigbee Test	TX	TX power	Low, Mid, High	—
		EVM	Low, Mid, High	—
		Center frequency tolerance	Low, Mid, High	—
	RX	Receiver sensitivity	Low, Mid, High	—
Bluetooth Test	TX	TX power	Low, Mid, High	BLE_1M, BLE_2M and BLES8 -125K
		Modulation characteristics	Low, Mid, High	BLE_1M, BLE_2M and BLES8 -125K
		Carrier frequency offset and drift	Low, Mid, High	BLE_1M, BLE_2M and BLES8 -125K
	RX	Receiver sensitivity	Low, Mid, High	BLE_1M, BLE_2M and BLES8 -125K

5.4.1 Zigbee Test

We suggest running the production Zigbee test on low, mid and high channels.

5.4.1.1 Zigbee TX Test

To do the Zigbee transmit test, the DUT (PIC32CX-BZ2 device) needs to be configured as follows:

1. Configure the RF mode to Zigbee TX mode.
2. Select the channel.
3. Select the packet type.

4. Select MPA/LPA mode.
5. Configure the device to transmit in maximum output power level.
6. Select the package delay time.
7. Select the number of transmitting packets.
8. Start to transmit the Zigbee packet.
9. Capture the transmitted Zigbee packet in an RF test equipment and measure the required parameters.
   Note: By default, the HUT firmware runs in MLDO mode.

5.4.1.1.1 TX Power

The expected TX power at the output of the DUT after calibration is as follows:

Table 5-2. DUT Output

Device	MPA Mode	LPA Mode
PIC32CX1012BZ25048	+12 dBm ±0.5 dB	+4 dBm ±0.5 dB

Configure the device in Zigbee TX test mode as listed in 5.4.1.1. Zigbee TX Test and measure the output power using an RF test equipment.

5.4.1.1.2 Error Vector Magnitude (EVM)

EVM is a measure of the difference between a reference waveform, which is the error-free modulated signal, and the actual transmitted waveform. EVM is used to quantify the modulation accuracy of a transmitter. IEEE® Standard 802.15.4 specification requires that an 802.15.4 transmitter shall not have an RMS EVM value worse than 35%.

Configure the device in Zigbee TX test mode as listed in 5.4.1.1. Zigbee TX Test and measure the EVM using an RF test equipment and ensure it is within an expected limit.

5.4.1.1.3 Transmit Center Frequency Tolerance

The transmitted center frequency tolerance shall be ± 40 ppm maximum as per IEEE Standard 802.15.4 specification, which includes variation due to voltage and temperature. Even though IEEE specification allows ± 40 ppm frequency tolerance, the actual tolerance can be made closer to 0 ppm by using the proper crystal and load caps along with the calibration.

Configure the device in Zigbee TX test mode as listed in 5.4.1.1. Zigbee TX Test and measure the transmit center frequency using an RF test equipment and ensure it is within an expected limit.

5.4.1.2 Zigbee RX Test

To do Zigbee receiver test, the DUT (PIC32CX-BZ2 device) needs to be configured as follows:

1. Configure the RF mode to Zigbee RX mode.
2. Select the channel.
3. Select the data rate.
4. Start to receive the Zigbee packet.
5. Configure the RF tester to transmit the Zigbee packets to the DUT with a specific RF power level for the receiver test.
6. Number of received packet would be shown as RX packet.

5.4.1.2.1 Receiver Sensitivity

The 802.15.4 IEEE standard specifies a minimum receiver sensitivity of -85 dBm for 2.4 GHz radios. The PIC32CX-BZ2 device exceeds these standard requirements and provide better receiver sensitivity. Refer to the *PIC32CX-BZ2 Data Sheet* for the receiver sensitivity information. Start the Packet Error Rate (PER) test as described in 5.4.1.2. Zigbee RX Test with the TX power from the RF equipment set to 3 dB higher than the receiver sensitivity level described in the data sheet, and decrease the RF level step by step till the PER > 10%.

The minimum RF level with which it meets the PER limit <10% is referred to as receiver sensitivity.

5.4.2 Bluetooth Test

We suggest to run the production Bluetooth test on low, mid and high channels and on data rates BLE_1M, BLE_2M and BLES8 (125K).

5.4.2.1 Bluetooth TX Test

For the Bluetooth transmit test, the DUT (PIC32CX-BZ2 device) needs to be configured as follows:

1. Configure the RF mode to Bluetooth TX mode.
2. Select the channel.
3. Select the payload.
4. Select the PHY (Data Rate = BLE_1M, BLE_2M and BLES8 -125K).
5. Select MPA/LPA mode.
6. Configure the device to transmit in maximum output power level.
7. Start to transmit the Bluetooth Low Energy packet.
8. Capture the transmitted Bluetooth Low Energy packet in an RF test equipment and measure the required parameters.
   Note: By default, the HUT firmware runs in MLDO mode.

5.4.2.1.1 TX Power

The expected TX power at the output of the DUT after calibration is listed in the following table.

Table 5-3. DUT Output

Device	MPA Mode	LPA Mode
PIC32CX1012BZ25048	+12 dBm ±0.5 dB	+4 dBm ±0.5 dB

Configure the device in Bluetooth TX test mode as listed in 5.4.2.1. Bluetooth TX Test and measure the output power using an RF test equipment.

5.4.2.1.2 Modulation Characteristics

This test verifies that the modulation characteristics of the transmitted signal are correct when the transmitter is operating at a certain data rate.

Refer to the following table to verify the TX modulation characteristics of the device.

Table 5-4. Bluetooth PHY Test Specification

Bluetooth PHY Test Specification	Description
RFPHY/TRM/BV-05-C	Modulation characteristics, uncoded data at 1 Ms/s
RFPHY/TRM/BV-10-C	Modulation characteristics at 2 Ms/s
RFPHY/TRM/BV-13-C	Modulation characteristics, LE Coded (S=8)

5.4.2.2 Carrier Frequency Offset and Drift

The purpose of the carrier frequency drift test is to verify the transmitter center frequency drift within a packet.

Refer to the following table to verify the carrier frequency offset and drift of the device.

Table 5-5. Bluetooth PHY Test Specification

Bluetooth PHY Test Specification	Description
RFPHY/TRM/BV-06-C	Carrier frequency offset and drift, uncoded data at 1 Ms/s
RFPHY/TRM/BV-12-C	Carrier frequency offset and drift at 2 Ms/s
RFPHY/TRM/BV-14-C	Carrier frequency offset and drift, LE Coded (S=8)

5.4.3 Bluetooth RX Test

For the Bluetooth receive test, the DUT (PIC32CX-BZ2 device) needs to be configured as follows:

1. Configure the RF mode to Bluetooth RX mode.
2. Select the channel.

3. Configure the RF tester to transmit the Bluetooth Low Energy packet to the DUT with a specific RF power level for the receiver test.
4. The number of received packets must be shown as an RX packet.

5.4.3.1 Receiver Sensitivity

Sensitivity is the lowest power level that a receiver is expected to operate at the specified Bit Error Rate (BER).

The purpose of the receiver sensitivity test is to verify that the sensitivity of the DUT meets the required limit of -70 dBm or less, while being stimulated by non-ideal signals representing realistic traffic conditions. The receiver sensitivity level is one of the key parameters that affects the maximum range of a radio link.

5.5 Write MAC Address Test

All devices are pre-loaded with a unique Zigbee and Bluetooth MAC address.

The user can either use the pre-loaded MAC address or use their own custom MAC address by writing it into the OTP Information Block. Read back the MAC address to verify if it is written properly.

5.6 Flash Application Firmware

If the user wants to check any other functionality or interfaces on their board, the user can run the related test cases and confirm the functionality/interface using their own test firmware. At the end of the production test, the user can flash their end-product application firmware into the PIC32CX-BZ2 device before shipping out to the field.

6. Document Revision History

Revision	Date	Section	Description
A	08/2022	Document	Initial revision

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