Waveshare RP2040-Zero

Waveshare RP2040-Zero Microcontroller Board User Manual

Model: RP2040-Zero | Brand: Waveshare

1. PRODUCT OVERVIEW

The Waveshare RP2040-Zero is a compact, high-performance microcontroller unit (MCU) board designed around the Raspberry Pi RP2040 chip. This board is ideal for a wide range of embedded applications, offering a powerful dual-core Arm Cortex M0+ processor with flexible clock speeds up to 133 MHz. It integrates 264KB of SRAM and 2MB of on-board Flash memory, providing ample resources for complex projects. Its castellated module design allows for direct soldering onto carrier boards, making it suitable for SMD applications. The inclusion of a modern USB-C connector enhances ease of use and connectivity.
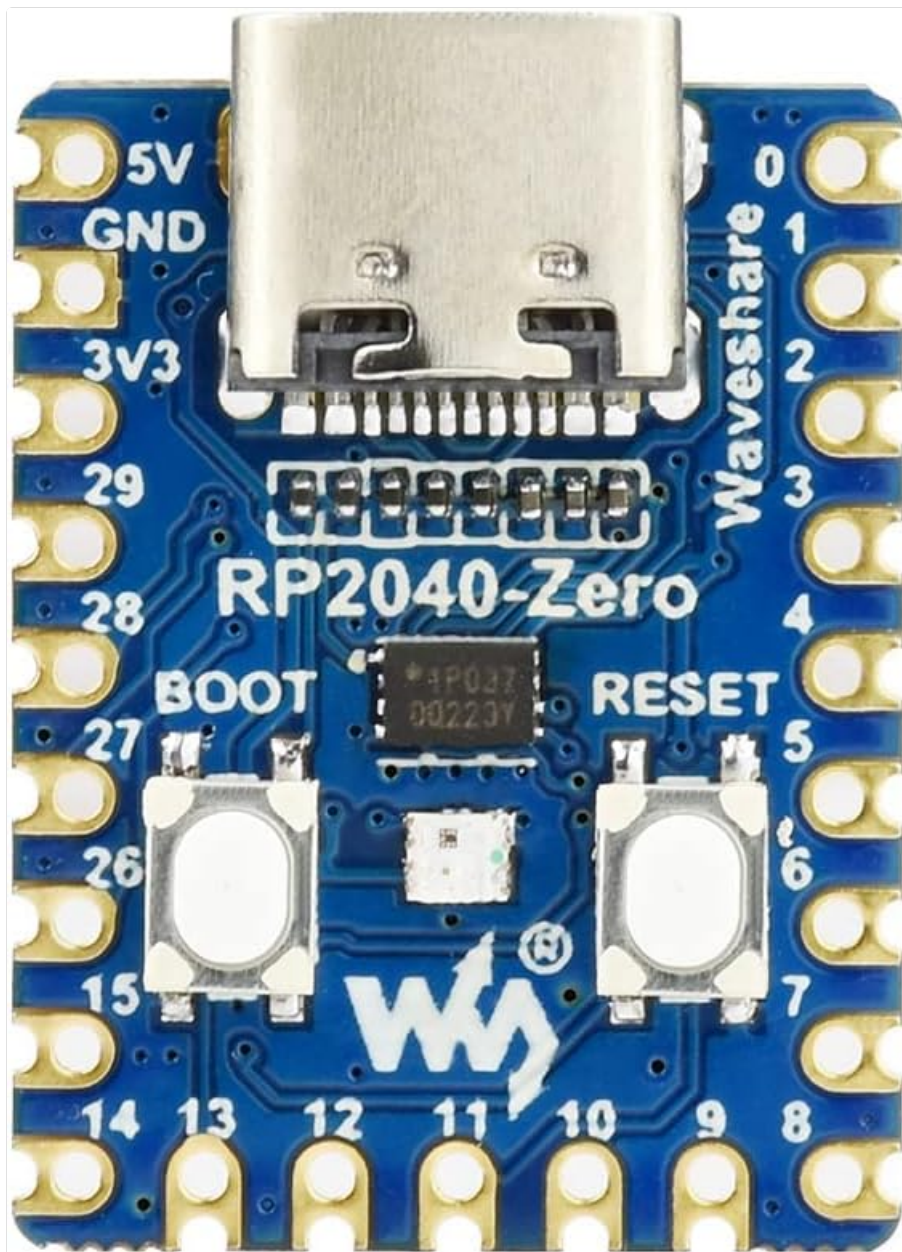
Figure 1: Front view of the Waveshare RP2040-Zero Microcontroller Board.

2. KEY FEATURES

- **RP2040 Microcontroller Chip:** Designed by Raspberry Pi, featuring a dual-core Arm Cortex M0+ processor.

- **Flexible Clock Speed:** Operates up to 133 MHz.

- **Memory:** Equipped with 264KB of SRAM and 2MB of on-board Flash memory.

- **USB-C Connector:** Modern and reversible connector for power and data.

- **Castellated Module:** Enables direct soldering to custom carrier boards for integrated designs.

- **USB 1.1 Support:** Includes both device and host capabilities.

- **Power Modes:** Supports low-power sleep and dormant modes for energy efficiency.

- **Programming:** Features drag-and-drop programming via mass storage over USB.

- **GPIO Pins:** 29 multi-function GPIO pins (20 via edge pinout, others via solder points).

- **Peripherals:** 2 × SPI, 2 × I2C, 2 × UART, 4 × 12-bit ADC, 16 × controllable PWM channels.

- **Internal Components:** Accurate clock and timer on-chip, temperature sensor, accelerated floating-point

libraries.

- **PIO State Machines:** 8 × Programmable I/O (PIO) state machines for custom peripheral support.
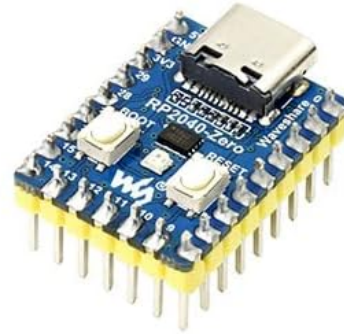
3. SETUP

3.1 Physical Connection

To begin using your Waveshare RP2040-Zero, connect it to your computer using a standard USB-C cable. The board will typically appear as a mass storage device, allowing for easy firmware upload. Ensure the cable is securely connected to both the board's USB-C port and your computer's USB port.

Pinheader Options

without pinheader

with pre-soldered pinheader

C/C++, MicroPython Support

Comprehensive SDK, Dev Resources, Tutorials To Help You Easily Get Started

Pico C/C++ SDK

The Raspberry Pi official C SDK can be used from the command line, or from popular integrated development environments like Visual Studio Code and Eclipse.
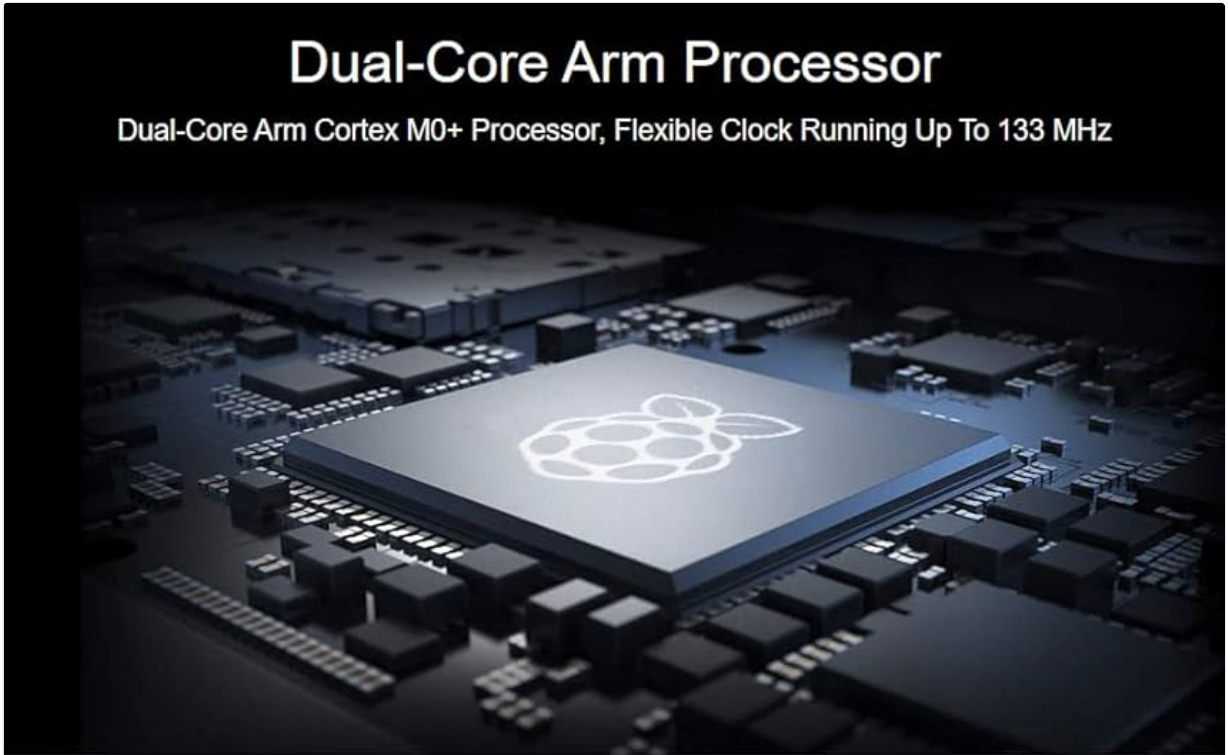
MicroPython

MicroPython is a full implementation of the Python 3 programming language that runs directly on embedded hardware like Raspberry Pi Pico.

Figure 2: The RP2040-Zero board, showing the USB-C port for connection.

3.2 Pinout Diagram

Understanding the pinout is crucial for connecting external components and utilizing the board's full capabilities. The RP2040-Zero provides various GPIO pins, power pins (5V, 3V3, GND), and dedicated peripheral pins (SPI, I2C, UART, ADC, PWM). Refer to the diagram below for a detailed layout.

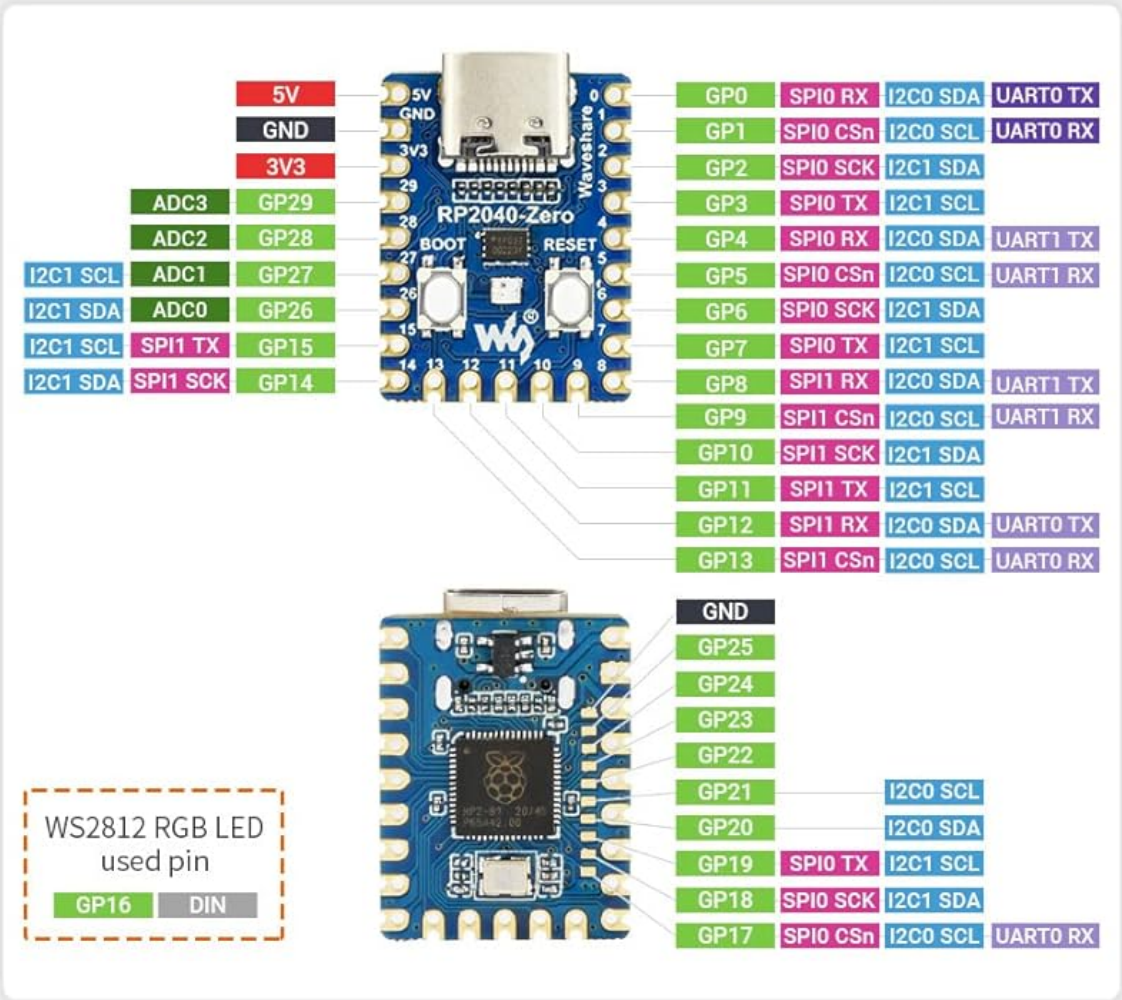| Power | Ground | UART / UART (default) | GPIO, PIO, and PWM |
| ADC | SPI | Debugging | I2C |

Figure 3: Detailed pinout diagram for the Waveshare RP2040-Zero, indicating multi-function GPIOs and power connections.

3.3 Programming Environment

The RP2040-Zero supports multiple programming environments, offering flexibility for developers:

- **Pico C/C++ SDK:** The official C SDK from Raspberry Pi, suitable for command-line development or integration with IDEs like Visual Studio Code and Eclipse.

- **MicroPython:** A full implementation of the Python 3 programming language optimized for embedded hardware like the Raspberry Pi Pico.

- **Arduino IDE:** Compatibility with the Arduino IDE allows for familiar development using Arduino sketches.

Figure 4: Illustration of C/C++ SDK and MicroPython support for the RP2040-Zero.

For a visual introduction to the RP2040-Tiny (a similar board from Waveshare), including its features and programming capabilities, please watch the video below:

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Video 1: Overview of the RP2040 Tiny Kit, demonstrating its features and programming support.

4. OPERATION

4.1 Boot and Reset Buttons

The RP2040-Zero features two tactile buttons: BOOT and RESET. These buttons are essential for controlling the board's state and uploading new firmware.

- **BOOT Button:** Press and hold this button while connecting the USB-C cable to enter USB mass storage mode, which allows you to drag-and-drop firmware files onto the board.
- **RESET Button:** Press this button to restart the microcontroller. This is useful after uploading new code or if the board becomes unresponsive.

What's On Board

1. **USB Type-C connector**
2. **W25Q16JVUXIQ**
   2MB NOR-Flash
3. **BOOT button**
   press it when resetting to enter download mode
4. **RESET button**
5. **WS2812**
   cool RGB LED

6. **ME6217C33M5G**
   low dropout LDO, max current 800MA
7. **RP2040**
   dual-core processor, up to 133MHz operating frequency
8. **RP2040 pins**
   10x solder points, 9 of which are for GPIO

Outline Dimensions

Unit:mm

Figure 5: Labeled components of the RP2040-Zero board, highlighting the BOOT and RESET buttons.

4.2 Drag-and-Drop Programming

One of the most user-friendly features of the RP2040-Zero is its drag-and-drop programming capability. When the board is in bootloader mode (by holding the BOOT button during connection), it appears as a removable drive on your computer. You can then simply drag and drop a compiled firmware file (.uf2 format) onto this drive. The board will automatically flash the new firmware and reboot.

5. MAINTENANCE

To ensure the longevity and optimal performance of your Waveshare RP2040-Zero, follow these general maintenance guidelines:

- **Handle with Care:** Avoid dropping the board or subjecting it to excessive physical stress.
- **Static Protection:** Always handle the board in an anti-static environment or use appropriate grounding measures to prevent electrostatic discharge (ESD) damage.
- **Keep Dry:** Protect the board from moisture and liquids, which can cause short circuits and corrosion.
- **Cleanliness:** Keep the board free from dust and debris. Use a soft, dry brush or compressed air for cleaning if necessary.
- **Proper Storage:** When not in use, store the board in its original packaging or an anti-static bag in a cool, dry place.

6. TROUBLESHOOTING

If you encounter issues with your RP2040-Zero, consider the following troubleshooting steps:

- **Board Not Recognized by Computer:**

  - Ensure the USB-C cable is fully inserted and functional. Try a different cable or USB port.
  - Verify the board is in bootloader mode (hold BOOT button while connecting USB).
  - Check if necessary drivers are installed for your operating system (though often not required for RP2040).

- **Firmware Upload Failure:**

  - Confirm the firmware file is in the correct .uf2 format.
  - Ensure the board is in bootloader mode before dragging the file.
  - Check for sufficient free space on the board's flash memory (if applicable for your specific firmware).

- **Code Not Running as Expected:**

  - Double-check your code for syntax errors or logical flaws.
  - Verify that all external components are correctly wired according to the pinout diagram.
  - Use serial debugging to output messages and identify where the code might be failing.

- **Power Issues:**

  - Ensure your USB power source provides adequate current.
  - Inspect the board for any visible damage or short circuits.

7. TECHNICAL SPECIFICATIONS

Feature	Specification
Processor	Dual-core Arm Cortex M0+
CPU Speed	Up to 133 MHz
SRAM	264 KB
Flash Memory	2 MB
USB Connector	USB-C
USB Standard	USB 1.1 (Device and Host support)
GPIO Pins	29 (20 via edge pinout)
ADC Channels	4 × 12-bit
PWM Channels	16 × controllable
PIO State Machines	8
Operating System Support	FreeRTOS (and others via SDKs)
Dimensions	23mm x 18mm (approx. 0.90 x 0.70 inches)
Item Weight	0.704 ounces

8. SUPPORT AND RESOURCES

For further assistance, detailed documentation, and community support, please refer to the official Waveshare resources:

- **Waveshare Wiki/Documentation:** Visit the Waveshare official website for comprehensive guides, tutorials, and technical specifications specific to the RP2040-Zero.
- **Raspberry Pi Pico Documentation:** As the RP2040-Zero is based on the RP2040 chip, much of the official Raspberry Pi Pico documentation and SDK information is directly applicable.
- **Community Forums:** Engage with the broader Raspberry Pi and embedded systems communities for project ideas, troubleshooting tips, and shared knowledge.
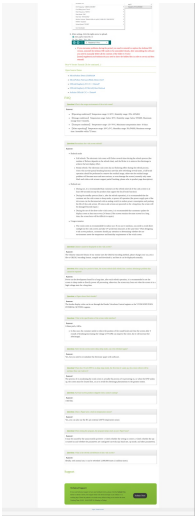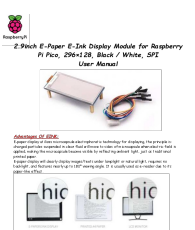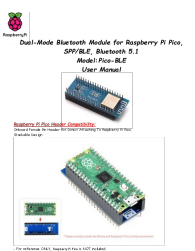
Related Documents - RP2040-Zero

[2.9-inch E-Paper E-Ink Display Module for Raspberry Pi Pico User Manual](#)

This user manual provides details on the 2.9-inch E-Paper E-Ink Display Module for Raspberry Pi Pico. It covers E-Ink technology advantages, compatibility with Raspberry Pi Pico, application examples, and pinout definitions. The module features a 296x128 resolution, Black/White display, and SPI interface.

[Raspberry Pi Pico Dual-Mode Bluetooth Module (Pico-BLE) User Manual](#)

User manual for the Waveshare Pico-BLE, a dual-mode Bluetooth 5.1 module designed for Raspberry Pi Pico, supporting SPP and BLE protocols. Features header compatibility and onboard antenna.

[Waveshare Industrial 8-Channel Relay Module for Raspberry Pi Pico User Manual](#)

User manual for the Waveshare Industrial 8-Channel Relay Module for Raspberry Pi Pico (Pico-Relay-B). Details features, compatibility, enclosure, and pinout for industrial control applications.

[Waveshare Pico Servo Driver: 16-Channel Control for Raspberry Pi Pico](#)

Discover the Waveshare Pico Servo Driver, a 16-channel, 16-bit resolution module designed to expand the capabilities of the Raspberry Pi Pico. This guide details its features, specifications, and setup for controlling multiple servos with precision.

[Waveshare Pico-ResTouch-LCD-3.5: 3.5-inch SPI Touch Display Module for Raspberry Pi Pico](#)

Detailed specifications, features, pinout, and hardware connection guide for the Waveshare Pico-ResTouch-LCD-3.5, a 3.5-inch IPS touch display module with XPT2046 controller and ILI9488 driver for Raspberry Pi Pico.