ESP32-C3-WROOM-02U

User Manual

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Espressif Systems
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About This Document

This user manual shows how to get started with the ESP32-C3-WROOM-02U module.

Document Updates

Please always refer to the latest version on https://www.espressif.com/en/support/download/documents.

Revision History

For revision history of this document, please refer to the last page.

Documentation Change Notification

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Certification

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Contents

1 Overview

1.1 Module Overview

ESP32-C3-WROOM-02U is a general-purpose Wi-Fi and Bluetooth LE module. The rich set of peripherals and a small size make this module an ideal choice for smart homes, industrial automation, health care, consumer electronics, etc.

Table 1: ESP32-C3-WROOM-02U Specifications

| Categories	Parameters	Specifications
Wi-Fi	Protocols	802.11 b/g/n (up to 150 Mbps)
	Frequency range	2412 ~ 2462 MHz
Bluetooth®	Protocols	Bluetooth® LE: Bluetooth 5 and Bluetooth mesh
	Radio	Class-1, class-2 and class-3 transmitter
		AFH
	Audio	CVSD and SBC
Hardware	Module interfaces	GPIO, SPI, UART, I2C, I2S, remote control peripheral, LED PWM controller, general DMA controller, TWAI® controller (compatible with ISO 11898-1), temperature sensor, SAR ADC
	Integrated crystal	40 MHz crystal
	Integrated SPI flash	4 MB
	Operating voltage/Power supply	3.0 V ~ 3.6 V
	Operating current	Average: 80 mA
	Minimum current delivered by power supply	500 mA
	Ambient temperature	85 °C version: −40 °C ~ +85 °C;
		105 °C version: −40 °C ~ +105 °C
	Moisture sensitivity level (MSL)	Level 3

1.2   Pin Description
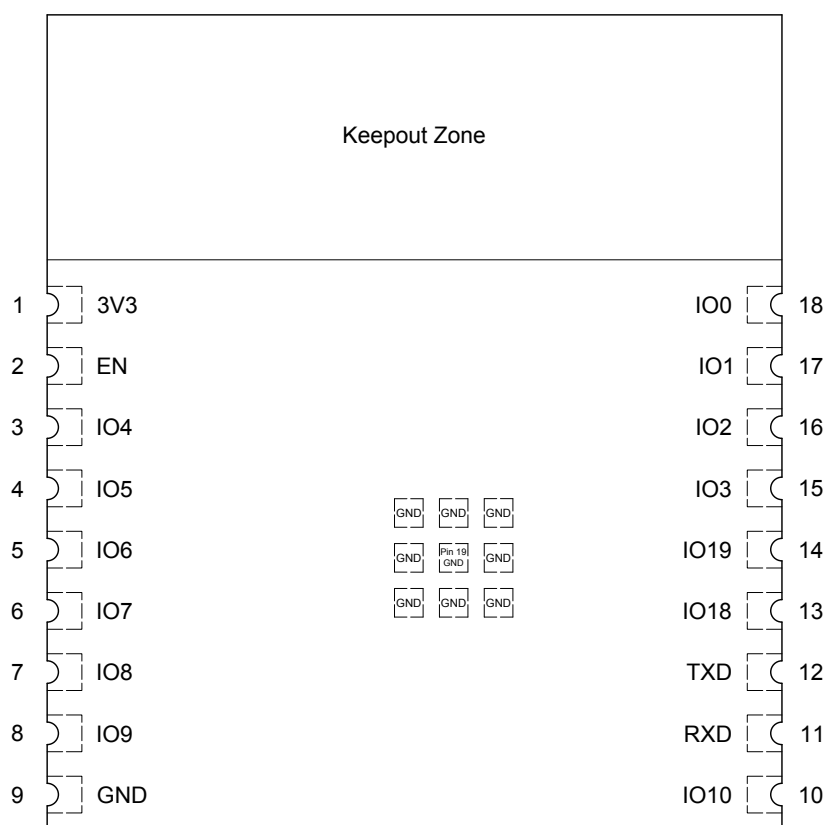
Figure 1: Pin Layout (Top View)

The module has 19 pins. See pin definitions in Table 2.

For peripheral pin configurations, please refer to *ESP32-C3 Series Datasheet* .

Table 2: Pin Definitions

Name	No.	Type	Function
3V3	1	P	Power supply
EN	2	I	High: on, enables the chip. Low: off, the chip powers off. Note: Do not leave the EN pin floating.
IO4	3	I/O/T	GPIO4, MTMS, ADC1_CH4, FSPIHD
IO5	4	I/O/T	GPIO5, MTDI, ADC2_CH0, FSPIWP
IO6	5	I/O/T	GPIO6, MTCK, FSPICLK
IO7	6	I/O/T	GPIO7, MTDO, FSPID
IO8	7	I/O/T	GPIO8
IO9	8	I/O/T	GPIO9
GND	9, 19	P	Ground
IO10	10	I/O/T	GPIO10, FSPICS0
RXD0	11	I/O/T	U0RXD, GPIO20

Cont'd on next page

Table 2 – cont'd from previous page

Name	No.	Type	Function
TXD0	12	I/O/T	U0TXD, GPIO21
IO18	13	—	GPIO18, USB_D-
IO19	14	I/O/T	GPIO19, USB_D+
IO3	15	I/O/T	GPIO3, ADC1_CH3
IO2	16	I/O/T	GPIO2, ADC1_CH2, FSPIQ
IO1	17	I/O/T	GPIO1, ADC1_CH1, XTAL_32K_N (32.768 kHz crystal output)
IO0	18	I/O/T	GPIO0, ADC1_CH0, XTAL_32K_P (32.768 kHz crystal input)

2   Get Started on ESP32-C3-WROOM-02U

2.1   What You Need

To develop applications for ESP32-C3-WROOM-02U module you need:

- 1 x ESP32-C3-WROOM-02U module

- 1 x Espressif RF testing board

- 1 x USB-to-Serial board

- 1 x Micro-USB cable

- 1 x PC running Linux

In this user guide, we take Linux operating system as an example. For more information about the configuration on Windows and macOS, please refer to *ESP-IDF Programming Guide*.

2.2   Hardware Connection

1. Solder the ESP32-C3-WROOM-02U module to the RF testing board as shown in Figure 2.
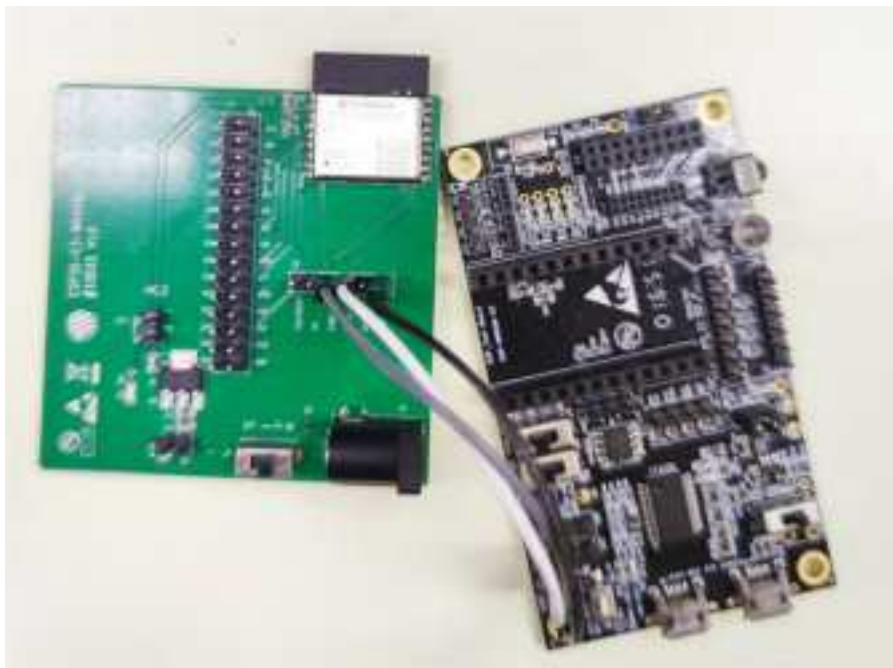

Figure 2: Hardware Connection

2. Connect the RF testing board to the USB-to-Serial board via TXD, RXD, and GND.

3. Connect the USB-to-Serial board to the PC.

4. Connect the RF testing board to the PC or a power adapter to enable 5 V power supply, via the Micro-USB cable.

5. During download, connect IO9 to GND via a jumper, and pull up IO2 and IO8. Then, turn "ON" the testing board.

6. Download firmware into flash. For details, see the sections below.

7. After download, remove the jumper on IO0 and GND, and the jumper wire to pull up IO8.

8. Power up the RF testing board again. ESP32-C3-WROOM-02U will switch to working mode. The chip will read programs from flash upon initialization.

Note:

IO9 is internally logic high. If IO9 is pulled low, and IO2 and IO8 is pulled high, the Boot mode is selected. In other cases, the Download mode is selected. For more information on ESP32-C3-WROOM-02U, please refer to
 ESP32-C3-WROOM-02 & ESP32-C3-WROOM-02U Datasheet .

2.3   Set up Development Environment

The Espressif IoT Development Framework (ESP-IDF for short) is a framework for developing applications based on the Espressif chips. Users can develop applications with ESP chips in Windows/Linux/macOS based on ESP-IDF. Here we take Linux operating system as an example.

2.3.1   Install Prerequisites

To compile with ESP-IDF you need to get the following packages:

- CentOS 7:

```
1      sudo yum install git wget flex bison gperf python cmake ninja-build ccache dfu-
          util
```

- Ubuntu and Debian (one command breaks into two lines):

```
1      sudo apt-get install git wget flex bison gperf python python-pip python-
          setuptools cmake
2      ninja-build ccache libffi-dev libssl-dev dfu-util
```

- Arch:

```
1      sudo pacman -S --needed gcc git make flex bison gperf python-pip cmake ninja
          ccache dfu-util
```

Note:

- This guide uses the directory ~/esp on Linux as an installation folder for ESP-IDF.
- Keep in mind that ESP-IDF does not support spaces in paths.

2.3.2   Get ESP-IDF

To build applications for ESP32-C3-WROOM-02U module, you need the software libraries provided by Espressif in ESP-IDF repository.

To get ESP-IDF, create an installation directory (~/esp) to download ESP-IDF to and clone the repository with 'git clone':

```
1  mkdir -p ~/esp
2  cd ~/esp
3  git clone --recursive https://github.com/espressif/esp-idf.git
```

ESP-IDF will be downloaded into ~/esp/esp-idf. Consult ESP-IDF Versions for information about which ESP-IDF version to use in a given situation.

2.3.3   Set up Tools

Aside from the ESP-IDF, you also need to install the tools used by ESP-IDF, such as the compiler, debugger, Python packages, etc. ESP-IDF provides a script named 'install.sh' to help set up the tools in one go.

```
1  cd ~/esp/esp-idf
2  ./install.sh
```

2.3.4   Set up Environment Variables

The installed tools are not yet added to the PATH environment variable. To make the tools usable from the command line, some environment variables must be set. ESP-IDF provides another script 'export.sh' which does that. In the terminal where you are going to use ESP-IDF, run:

```
1  . $HOME/esp/esp-idf/export.sh
```

Now everything is ready, you can build your first project on ESP32-C3-WROOM-02U module.

2.4   Create Your First Project

2.4.1   Start a Project

Now you are ready to prepare your application for ESP32-C3-WROOM-02U module. You can start with get-started/hello_world project from examples directory in ESP-IDF.

Copy get-started/hello_world to ~/esp directory:

```
1  cd ~/esp
2  cp -r $IDF_PATH/examples/get-started/hello_world .
```

There is a range of example projects in the examples directory in ESP-IDF. You can copy any project in the same way as presented above and run it. It is also possible to build examples in-place, without copying them first.

2.4.2   Connect Your Device

Now connect your ESP32-C3-WROOM-02U module to the computer and check under what serial port the module is visible. Serial ports in Linux start with '/dev/tty' in their names. Run the command below two times, first with the board unplugged, then with plugged in. The port which appears the second time is the one you need:

```
1  ls /dev/tty*
```

> **Note:**
> Keep the port name handy as you will need it in the next steps.

2.4.3   Configure

Navigate to your 'hello_world' directory from Step 2.4.1. Start a Project, set ESP32-C3 as the target and run the project configuration utility 'menuconfig'.

```
1   cd ~/esp/hello_world
2   idf.py set-target esp32c3
3   idf.py menuconfig
```

Setting the target with 'idf.py set-target esp32c3' should be done once, after opening a new project. If the project contains some existing builds and configuration, they will be cleared and initialized. The target may be saved in environment variable to skip this step at all. See Selecting the Target for additional information.

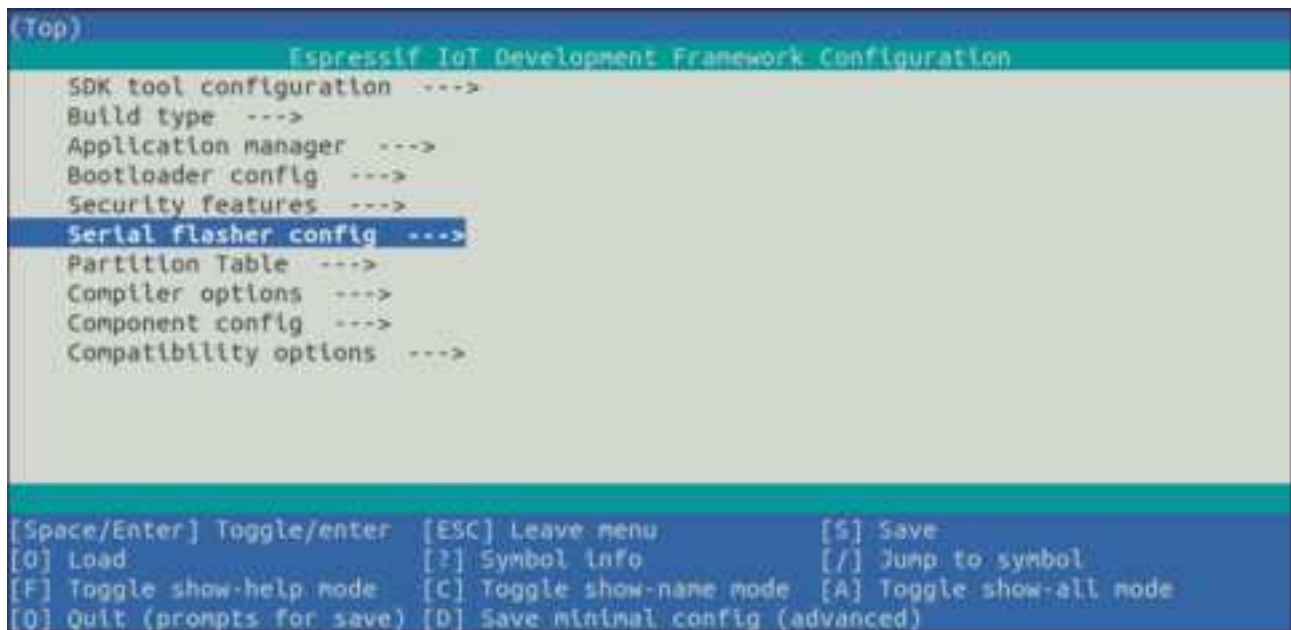If the previous steps have been done correctly, the following menu appears:

Figure 3: Project Configuration - Home Window

The colors of the menu could be different in your terminal. You can change the appearance with the option '--style'. Please run 'idf.py menuconfig --help' for further information.

2.4.4   Build the Project

Build the project by running:

```
1   idf.py build
```

This command will compile the application and all ESP-IDF components, then it will generate the bootloader, partition table, and application binaries.

```
1   $ idf.py build
2   Running cmake in directory /path/to/hello_world/build
3   Executing "cmake -G Ninja --warn-uninitialized /path/to/hello_world"...
4   Warn about uninitialized values.
5   -- Found Git: /usr/bin/git (found version "2.17.0")
6   -- Building empty aws_iot component due to configuration
7   -- Component names: ...
```

```
 8   -- Component paths: ...

 9

10   ... (more lines of build system output)

11

12   [527/527] Generating hello-world.bin

13   esptool.py v2.3.1

14

15   Project build complete. To flash, run this command:

16   ../../../components/esptool_py/esptool/esptool.py -p (PORT) -b 921600 write_flash --flash_
         mode dio

17   --flash_size detect --flash_freq 40m 0x10000 build/hello-world.bin  build 0x1000

18   build/bootloader/bootloader.bin 0x8000 build/partition_table/partition-table.bin

19   or run 'idf.py -p PORT flash'
```

If there are no errors, the build will finish by generating the firmware binary .bin file.

2.4.5   Flash onto the Device

Flash the binaries that you just built onto your ESP32-C3-WROOM-02U module by running:

```
 1   idf.py -p PORT [-b BAUD] flash
```

Replace PORT with your module's serial port name from Step: Connect Your Device.

You can also change the flasher baud rate by replacing BAUD with the baud rate you need. The default baud rate is 460800.

For more information on idf.py arguments, see idf.py.

> **Note:**
> The option 'flash' automatically builds and flashes the project, so running 'idf.py build' is not necessary.

```
 1           ...

 2           esptool.py --chip esp32c3 -p /dev/ttyUSB0 -b 460800 --before=default_reset --after
                =hard_reset write_flash --flash_mode dio --flash_freq 80m --flash_size 2MB 0x
                8000 partition_table/partition-table.bin 0x0 bootloader/bootloader.bin 0x10000
                 hello-world.bin

 3           esptool.py v3.0

 4           Serial port /dev/ttyUSB0

 5           Connecting....

 6           Chip is ESP32-C3

 7           Features: Wi-Fi

 8           Crystal is 40MHz

 9           MAC: 7c:df:a1:40:02:a4

10           Uploading stub...

11           Running stub...

12           Stub running...

13           Changing baud rate to 460800

14           Changed.

15           Configuring flash size...

16           Compressed 3072 bytes to 103...
```

```
17          Writing at 0x00008000... (100 %)
18          Wrote 3072 bytes (103 compressed) at 0x00008000 in 0.0 seconds (effective 4238.1
                kbit/s)...
19          Hash of data verified.
20          Compressed 18960 bytes to 11311...
21          Writing at 0x00000000... (100 %)
22          Wrote 18960 bytes (11311 compressed) at 0x00000000 in 0.3 seconds (effective 584.9
                kbit/s)...
23          Hash of data verified.
24          Compressed 145520 bytes to 71984...
25          Writing at 0x00010000... (20 %)
26          Writing at 0x00014000... (40 %)
27          Writing at 0x00018000... (60 %)
28          Writing at 0x0001c000... (80 %)
29          Writing at 0x00020000... (100 %)
30          Wrote 145520 bytes (71984 compressed) at 0x00010000 in 2.3 seconds (effective
                504.4 kbit/s)...
31          Hash of data verified.
32
33          Leaving...
34          Hard resetting via RTS pin...
35          Done
```

If everything goes well, the "hello_world" application starts running after you remove the jumper on IO0 and GND, and re-power up the testing board.

2.4.6   Monitor

To check if "hello_world" is indeed running, type 'idf.py -p PORT monitor' (Do not forget to replace PORT with your serial port name).

This command launches the IDF Monitor application:

```
1  $ idf.py —p /dev/ttyUSB0 monitor
2  Running idf_monitor in directory [...]/esp/hello_world/build
3  Executing "python [...]/esp—idf/tools/idf_monitor.py —b 115200 [...]/esp/hello_world/build
       /hello—world.elf"...
4  ——— idf_monitor on /dev/ttyUSB0 115200 ———
5  ——— Quit: Ctrl+] | Menu: Ctrl+T | Help: Ctrl+T followed by Ctrl+H ———
6  ets Jun  8 2016 00:22:57
7
8  rst:0x1 (POWERON_RESET),boot:0x13 (SPI_FAST_FLASH_BOOT)
9  ets Jun  8 2016 00:22:57
10 ...
```

After startup and diagnostic logs scroll up, you should see "Hello world!" printed out by the application.

```
1  ...
2  Hello world!
3  Restarting in 10 seconds...
4  This is esp32c3 chip with 1 CPU core, WiFi/BLE
5  Restarting in 9 seconds...
```

```
6  Restarting in 8 seconds...
7  Restarting in 7 seconds...
```

To exit IDF monitor use the shortcut Ctrl+].

That's all what you need to get started with ESP32-C3-WROOM-02U module! Now you are ready to try some other examples in ESP-IDF, or go right to developing your own applications.

3   U.S. FCC Statement

The device complies with KDB 996369 D03 OEM Manual v01. Below are integration instructions for host product manufacturers according to the KDB 996369 D03 OEM Manual v01.

List of Applicable FCC Rules

FCC Part 15 Subpart C 15.247 & 15.209

Specific Operational Use Conditions

The module has WiFi, and BLE functions.

- Operation Frequency:

    - WiFi: 2412 ~ 2462 MHz

    - Bluetooth: 2402 ~ 2480 MHz

- Number of Channel:

    - WiFi: 12

    - Bluetooth: 40

- Modulation:

    - WiFi: DSSS; OFDM

    - Bluetooth: GFSK;

- Type: FPC antenna

- Gain: 2.94 dBi Max

The module can be used for IoT applications with a maximum 2.94 dBi antenna. The host manufacturer installing this module into their product must ensure that the final composit product complies with the FCC requirements by a technical assessment or evaluation to the FCC rules, including the transmitter operation. The host manufacturer has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual.

Limited Module Procedures

Not applicable. The module is a single module and complies with the requirement of FCC Part 15.212.

Trace Antenna Designs

Not applicable. The module has its own antenna, and does not need a host's printed board microstrip trace antenna, etc.

RF Exposure Considerations

The module must be installed in the host equipment such that at least 20cm is maintained between the antenna and users' body; and if RF exposure statement or module layout is changed, then the host product manufacturer

required to take responsibility of the module through a change in FCC ID or new application. The FCC ID of the module cannot be used on the final product. In these circumstances, the host manufacturer will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

Antennas

Antenna specification are as follows:

- Type: FPC antenna
- Gain: 2.94 dBi

This device is intended only for host manufacturers under the following conditions:

- The transmitter module may not be co-located with any other transmitter or antenna.
- The module shall be only used with the external antenna(s) that has been originally tested and certified with this module.
- The antenna must be either permanently attached or employ a 'unique' antenna coupler.

As long as the conditions above are met, further transmitter test will not be required. However, the host manufacturer is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

Label and Compliance Information

Host product manufacturers need to provide a physical or e-label stating "Contains FCC ID: 2AC7Z-ESPC3WROOMU" with their finished product.

Information on test modes and additional testing requirements

- Operation Frequency:
  - WiFi: 2412 ~ 2462 MHz
  - Bluetooth: 2402 ~ 2480 MHz
- Number of Channel:
  - WiFi: 12
  - Bluetooth: 40
- Modulation:
  - WiFi: DSSS; OFDM
  - Bluetooth: GFSK;

Host manufacturer must perform test of radiated and conducted emission and spurious emission, etc., according to the actual test modes for a stand-alone modular transmitter in a host, as well as for multiple simultaneously transmitting modules or other transmitters in a host product. Only when all the test results of test modes comply with FCC requirements, then the end product can be sold legally.

Additional testing, Part 15 Subpart B compliant

The modular transmitter is only FCC authorized for FCC Part 15 Subpart C 15.247 & 15.209 and that the host product manufacturer is responsible for compliance to any other FCC rules that apply to the host not covered by the modular transmitter grant of certification. If the grantee markets their product as being Part 15 Subpart B compliant (when it also contains unintentional-radiator digital circuity), then the grantee shall provide a notice stating that the final host product still requires Part 15 Subpart B compliance testing with the modular transmitter installed.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part15 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 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.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- This device may not cause harmful interference.

- This device must accept any interference received, including interference that may cause undesired operation.

> Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This device and its antenna must not be co-located or operating in conjunction with any other antenna or transmitter. The antennas used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

OEM Integration Instructions

This device is intended only for OEM integrators under the following conditions:

- The transmitter module may not be co-located with any other transmitter or antenna.

- The module shall be only used with the external antenna(s) that has been originally tested and certified with this module.

As long as the conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

Validity of Using the Module Certification

In the event that these conditions cannot be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization for this module in combination with the host equipment is no longer considered valid and the FCC ID of the module cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End Product Labeling

The final end product must be labeled in a visible area with the following:　"Contains Transmitter Module FCC ID: 2AC7Z-ESPC3WROOMU"．

4   Learning Resources

4.1   Must-Read Documents

Please familiarize yourself with the following documents:

- *ESP32-C3 Series Datasheet*

  This is an introduction to the specifications of the ESP32-C3 hardware, including overview, pin definitions, functional description, peripheral interface, electrical characteristics, etc.

- *ESP-IDF Programming Guide*

  Extensive documentation for the ESP-IDF development framework, ranging from hardware guides to API reference.

- *ESP32-C3 Technical Reference Manual*

  Detailed information on how to use the ESP32-C3 memory and peripherals.

4.2   Important Resources

Here are the important ESP32-C3-related resources.

- ESP32 BBS

  Engineer-to-Engineer (E2E) Community for Espressif products where you can post questions, share knowledge, explore ideas, and help solve problems with fellow engineers.

Revision History

Date	Version	Release notes
2024-10-16	v0.1	Preliminary release