Getting started with ESP32-C3-DevKitM-1

Software Design for Embedded Systems

Additional course materials

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Contents

1 Development tools installation

This guide will assume the following development environment:

- Espressif IDE with ESP-IDF framework[1]
- Windows operating system[2]
- hardware: ESP32-C3-DevKitM-1 development kit
- programming and debugging: ESP PROG[3]

Device drivers need to be installed (FTDI) in addition to installation of IDE and libraries.

1.1 Espressif IDE Installation (Windows)

Download installer:

https://docs.espressif.com/projects/esp-idf/en/latest/esp32/get-started/index.html#ide

`espressif-ide-setup-espressif-ide-2.6.0-with-esp-idf-4.4.2.exe`

Note: If necessary, uninstall previously installed version and manually delete what is left over in installation folder (e.g. `C:/Espressif`).

1.2 ESP32-C3-DevKitM-1 / ESP PROG FTDI drivers installation

After successfull installation of Espressif IDE, run installation of VCP FTDI drivers:

https://ftdichip.com/drivers/vcp-drivers/

Operating System	Release Date	X86 (32-Bit)	X64 (64-Bit)	Comments
Windows (Desktop)*	2021-07-15	2.12.36.4	2.12.36.4	WHQL Certified. Includes VCP and D2XX. Available as a setup executable Please read the Release Notes and Installation Guides.

[1] Other development enivornments (e.g. VSCode) will be added in future document revisions

[2] Linux guidelines will be added in future document revisions

[3] Although it is possible to program flash of ESP32-C3-DevKitM-1 without ESP PROG via USB cable and bootloader, such approach does not offer debugging capabilities; it is important to use external hardware debuggers such as ESP PROG to provide debugging capabilities; other debuggers (e.g. JLINK) may be covered in future revisions of this document

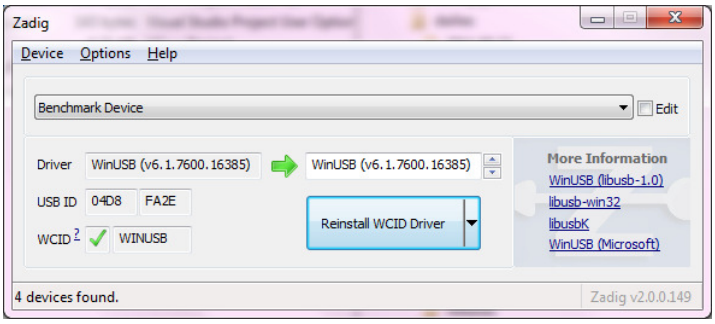
Espressif IDE will install **WinUSB drivers** during the installation process but it is important also to install **original FTDI drivers** used both for ESP32-C3-DevKitM-1 and ESP PROG.

IMPORTANT: Development environment is sensitive to combination which WinUSB / FTDI device drivers versions are used – if the right combination is not set up properly (manually!) hardware debugging will not work! Detailed description how to set up right versions of device drivers (WinUSB vs FTDI) will be described in the following section.

1.3 Setting up correct driver versions for ESP32-C3

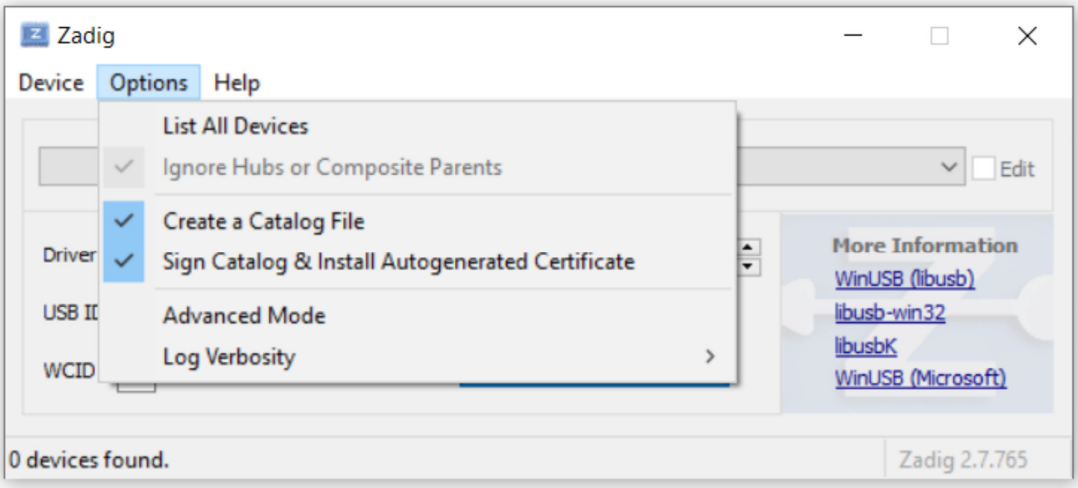
Install USB drivers management Zadig tool from:

https://zadig.akeo.ie/

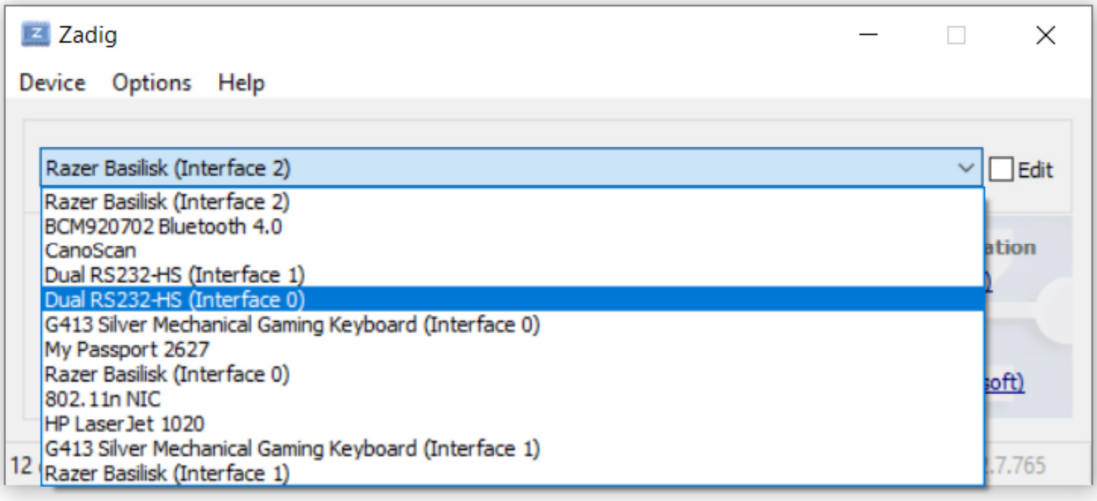


The following steps are very important to enable ESP PROG to work correctly:

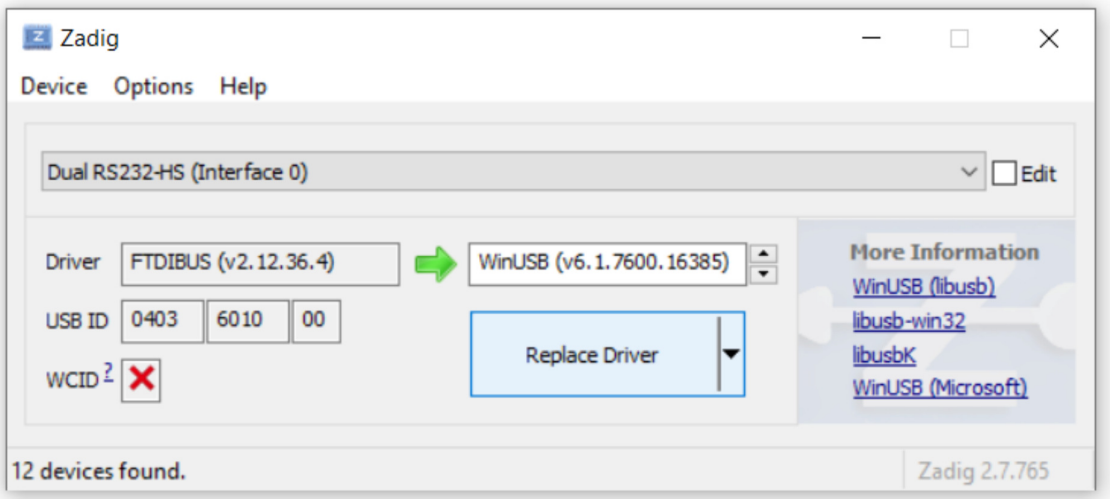
1. Plug ESP PROG into PC and wait for Windows to install FTDI device drivers
2. Run Zadig tool; select *List All Devices*:

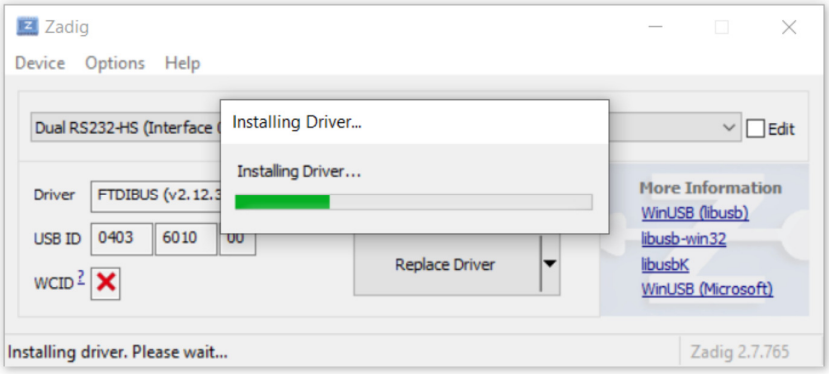


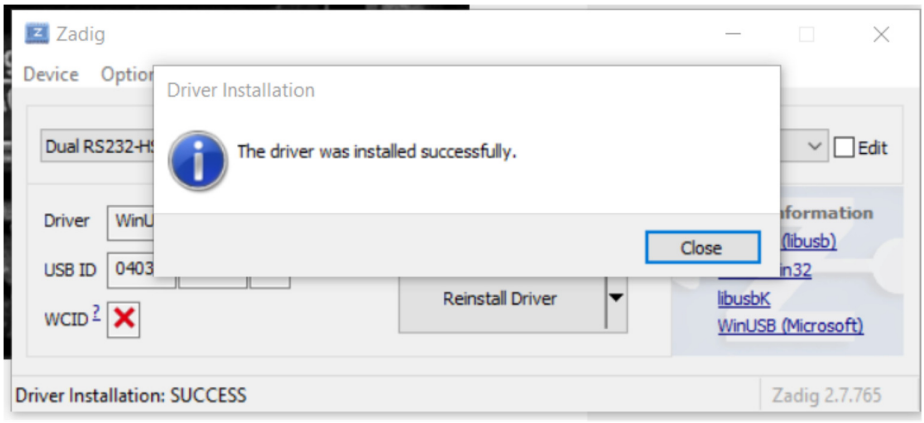
3. Find Dual RS232-HS **interface 0**:



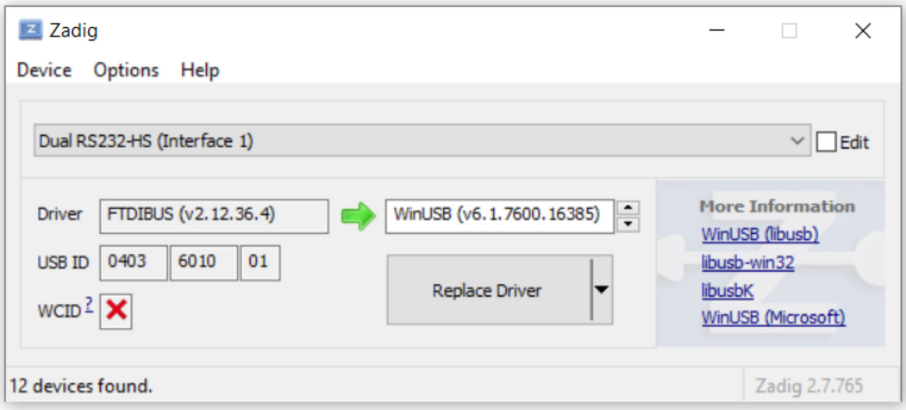
4. Replace **existing FTDI driver** for Dual RS232-HS **interface 0** with **WinUSB driver**:







5. **<u>VERY IMPORTANT</u>**: DO NOT REPLACE **existing FTDI driver** for Dual RS232-HS interface <u>1</u> with **WinUSB driver**:

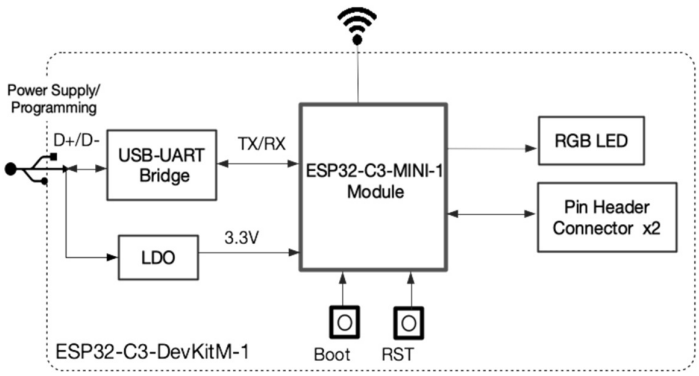


<u>IMPORTANT</u>: Connect ESP PROG before running Zadig, otherwise, drivers (interface 0/1) will not be displayed on a list!

2 Setting up ESP32-C3-DevKitM-1 for debugging via ESP PROG

2.1 Notes about ESP32-C3-DevKitM-1 hardware configuration

Out of the box ESP32-C3-DevKitM-1 IS NOT READY FOR IN-CIRCUIT debugging!



The initial HW setup has the following configuration for programming/debugging:

- USB is connected to ESP32-C3 UART port for with bootloader programming support and diagnostics output console
- USB is connected to the **internal JTAG** debugger BUT please keep in mind:
    - internal JTAG debugger is **not functional** since it **physically shares USB interface with UART**; it is necessary to resolder two 0402 resistors to make hardware change to choose internal JTAG instead of UART for bootloader and diagnostics
    - **external JTAG is not accessibly** via TMS, TCK, TDI, TDI pins because **eFuse** is initally programmed that **only internal JTAG is accessible**
- external JTAG interface via TMS, TCK, TDI, TDI is not accessible because of eFuse factory default settings

This factory default does not allow the use of external JTAG programming/debugging capabilities. One has two choices:

- modify hardware to enable internal JTAG instead of bootloader UART
    - PROBLEMS:
        - UART debug output provided by ESP-IDF is very useful tool for monitoring runtime state and to provide fallback option in case of any problems with JTAG programmer/debugger
        - Windows drivers for internal JTAG support are not stable – it is better to avoid internal JTAG programmer approach altogether for both said reasons!

- leave hardware as is (i.e. no changes to two 0402 resistors) and **burn eFuse** to **disable internal JTAG** to **enable external JTAG**
    - then connect ESP PROG or JLINK via external pins

In the next paragraphs both approaches will be documented in more details although option 1 is not recommended.

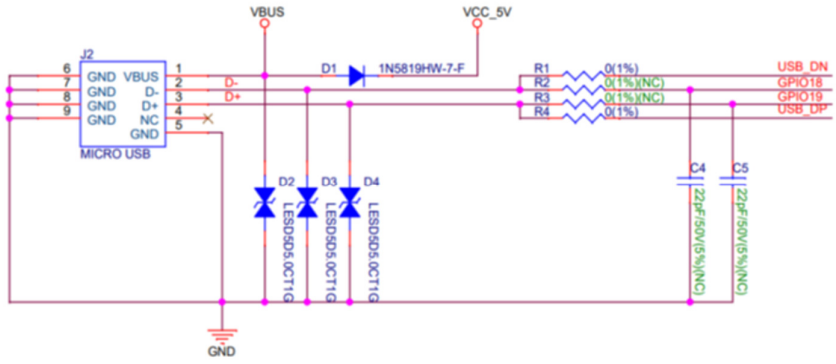
2.2 Enabling internal JTAG support for ESP32-C3-DevKitM-1

ESP32-C3 pins and USB signals:

ESP32-C3 Pin	USB Signal
GPIO18	D-
GPIO19	D+
5V	V_BUS
GND	Ground

If internal JTAG debug is intented to be used, please verify that the ESP32-C3 pins used for USB communication are not connected to some other HW that may disturb the JTAG operation.

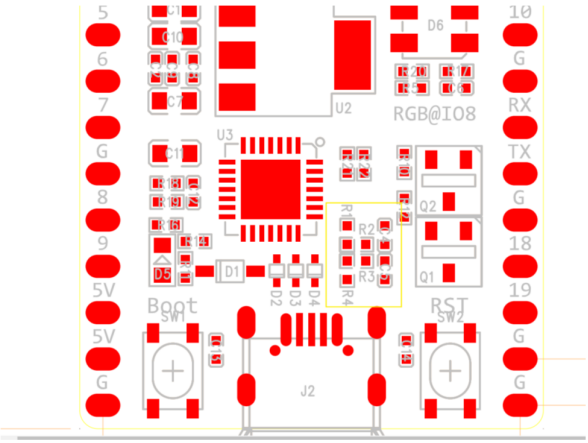
ESP32-C3-DevKitM-1 schematic:



If we want to use internal JTAG, GPIO18 and GPIO19 must be connected to D- and D+. Factory default for ESP32-C3-DevKitM-1 does not allow it – R2 and R3 are N.C.! R1 and R2 are 0R0 meaning that D+ and D- are connected to USB_DN and ESB_DP on a chip. For more information please refer to:

https://dl.espressif.com/dl/schematics/SCH_ESP32-C3-DEVKITC-02_V1_1_20210126A.pdf

https://dl.espressif.com/dl/schematics/PCB_ESP32-C3-DevKitC-02_V1_1_20210121AA.pdf



Note: changing the resistors will enable internal JTAG access, but **disable UART bootloader support**! The operation is reversible but still not ideal solution, suitable approach only in case when external programmers (such as ESP PROG and JLINK) are not available.

Important:

https://docs.espressif.com/projects/esp-idf/en/latest/esp32c3/api-guides/jtag-debugging/index.html

Debugging through the USB interface implemented in ESP32-C3 requires to have a chip with revision 3 or newer. Other debugging options (e.g. with ESP-Prog) are mandatory for chip revision 1 and 2. The easiest way to determine the chip revision is to look for the Chip is ESP32-C3 (revision 3) message near the end of a successful chip flashing done by `idf.py flash`.

```
Serial port COM8
Connecting....
Chip is ESP32-C3 (revision 3)
Features: Wi-Fi
Crystal is 40MHz
```

Another option:

```
C:\Espressif\frameworks\esp-idf-v4.4.2>esptool.py --port COM7 flash_id
esptool.py v3.3.2-dev
Serial port COM7
Connecting....
Detecting chip type... ESP32-C3
Chip is ESP32-C3 (revision 3)
Features: Wi-Fi
Crystal is 40MHz
MAC: 84:f7:03:40:2f:d0
Uploading stub...
Running stub...
Stub running...
Manufacturer: 20
Device: 4016
Detected flash size: 4MB
Hard resetting via RTS pin...
```

2.3 Enabling external JTAG support for ESP32-C3-DevKitM-1

Using external JTAG tool is very easy but the important prerequisite is to **disable internal JTAG on ESP32-C3**. This is done by **burning fuse DIS_USB_JTAG** (changing it from 0 => 1)!

Some useful references:

https://chowdera.com/2022/02/202202040556046742.html

It is helpful first to examine the current state of all fuses. It may be done by issuing the command from CLI (ESP-IDF 4.4 CMD):

```
espefuse.py --port COM7 summary
```

where port is serial port on PC (ESP32 bootloader support comm port). The result:

```
C:\Espressif\frameworks\esp-idf-v4.4.2> espefuse.py --port COM6 summary
Connecting....
Detecting chip type... ESP32-C3
espefuse.py v3.3.2-dev

=== Run "summary" command ===
EFUSE_NAME (Block) Description  = [Meaningful Value] [Readable/Writeable] (Hex Value)
----------------------------------------------------------------------------------------
Config fuses:
DIS_ICACHE (BLOCK0)                           Disables ICache                          =
False R/W (0b0)
...
Usb Config fuses:
DIS_USB_JTAG (BLOCK0)                          Disables USB JTAG. JTAG access via pads is
control = False R/W (0b0)
                                                   led separately
DIS_USB_DEVICE (BLOCK0)                       Disables USB DEVICE                      =
False R/W (0b0)
USB_EXCHG_PINS (BLOCK0)                       Exchanges USB D+ and D- pins             =
False R/W (0b0)
DIS_USB_SERIAL_JTAG_DOWNLOAD_MODE (BLOCK0)        Disables USB-Serial-JTAG download feature in
UART  = False R/W (0b0)
                                                   download boot mode
...
```

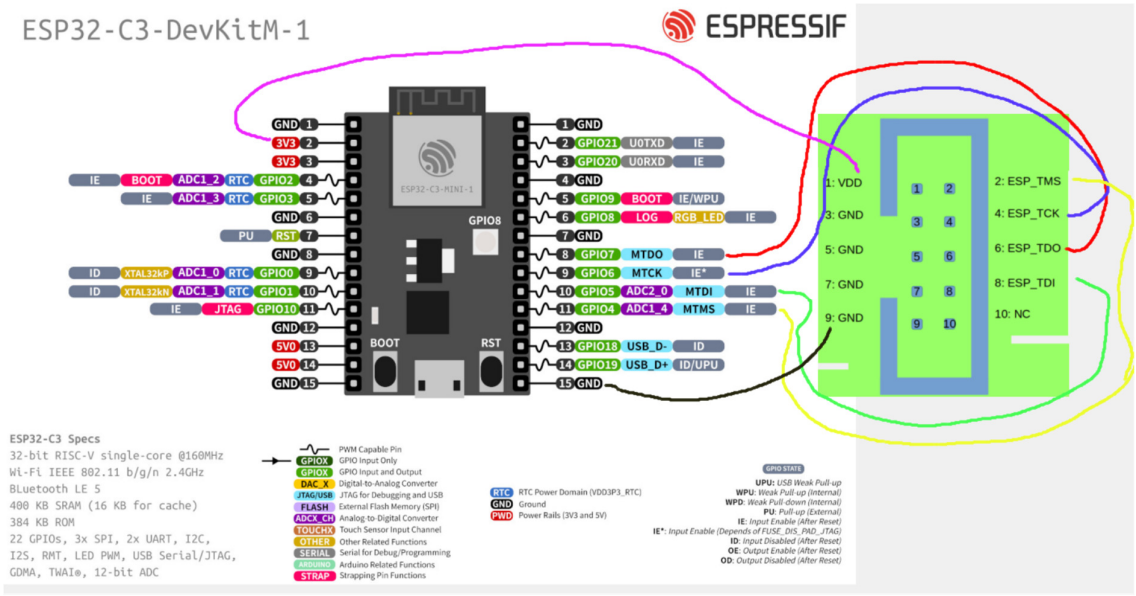
Now we have to burn DIS_USB_JTAG efuse - this is a one-time (irreversible) operation, afterwards JTAG will only be accessible over GPIOs. Built-in USB to Serial part of USB_SERIAL_JTAG peripheral will still work.

https://docs.espressif.com/projects/esp-idf/en/latest/esp32c3/api-guides/jtag-debugging/configure-other-jtag.html

This is what is needed to burn the fuse:

```
espefuse.py --port COM7 burn_efuse DIS_USB_JTAG
```

Now we can use external ESP PROG! Wiring:

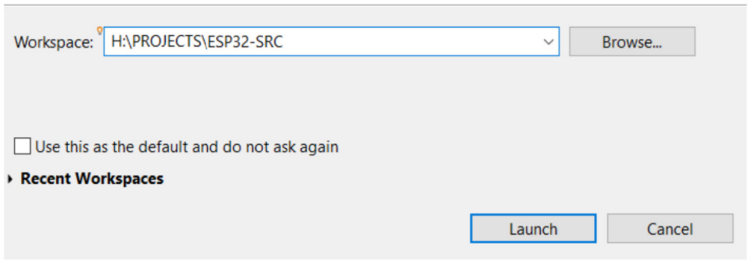


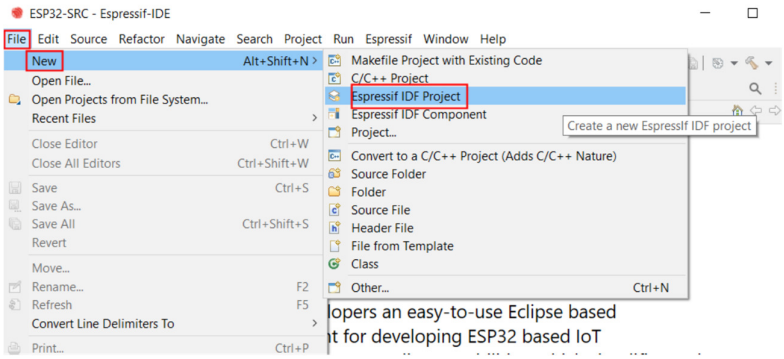
Note: when a physical port on PC to which ESP PROG is connected is changed (i.e. you simply connect USB cable to a different physical port), you need to re-run driver installation procedure!!! This introduces inconveniences in daily work so it is advisable to use one fixed USB port on a PC for ESP PROG connection to minimize the hassle! Each port change where you connect ESP PROG on PC requires another procedure of updating which USB driver you use! (WinUSB vs FTDI!)

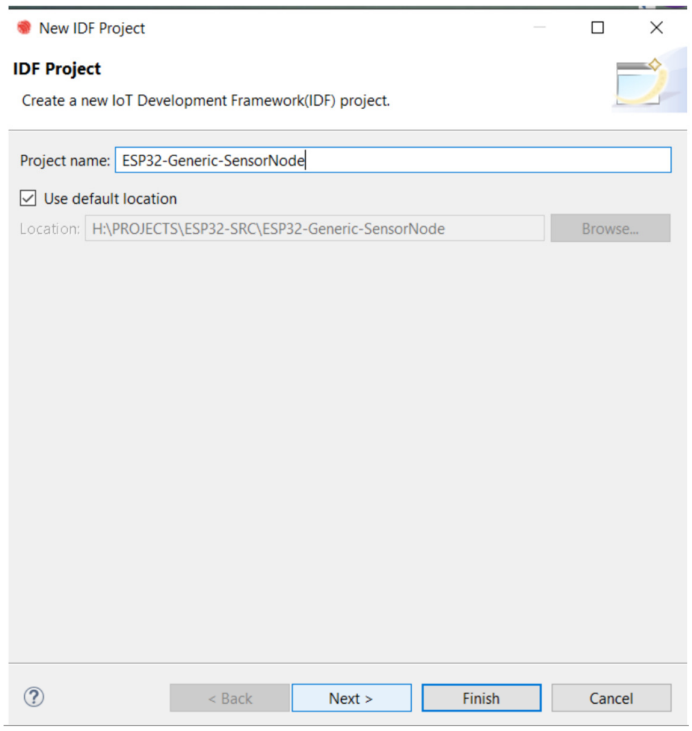
3 Creating project in Espressif IDE

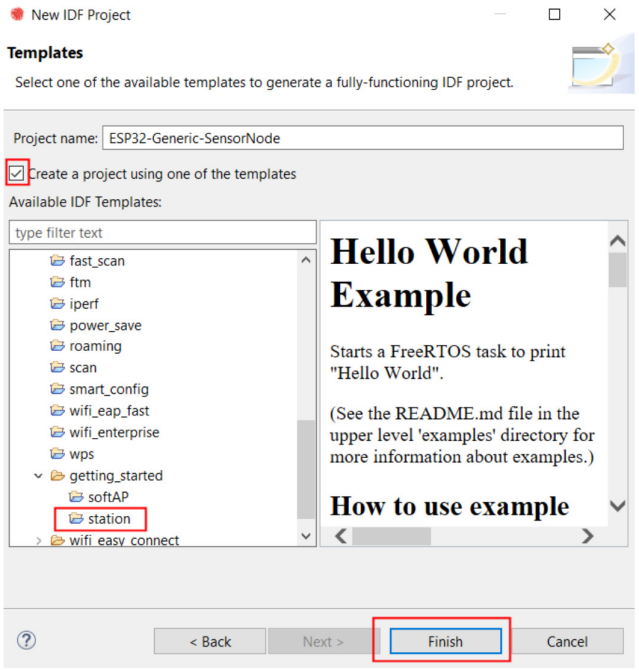
3.1 Starting new project from the scratch

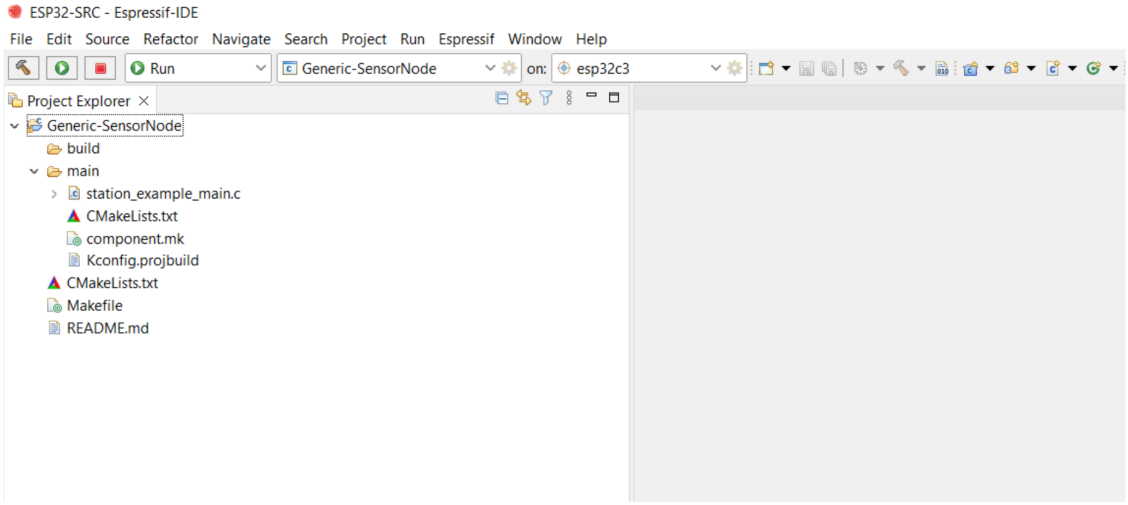
Set workspace folder (even if it does not exist, to start with clean project).









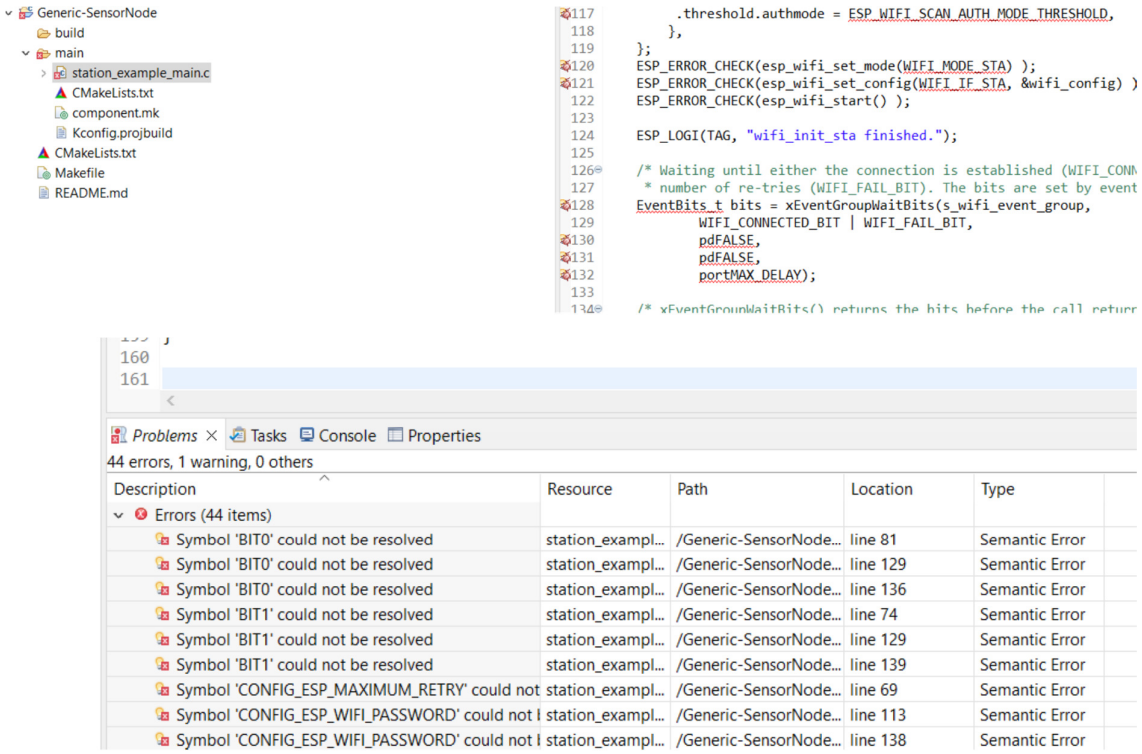


(note: you may rename project by right click on the Project Explorer root)

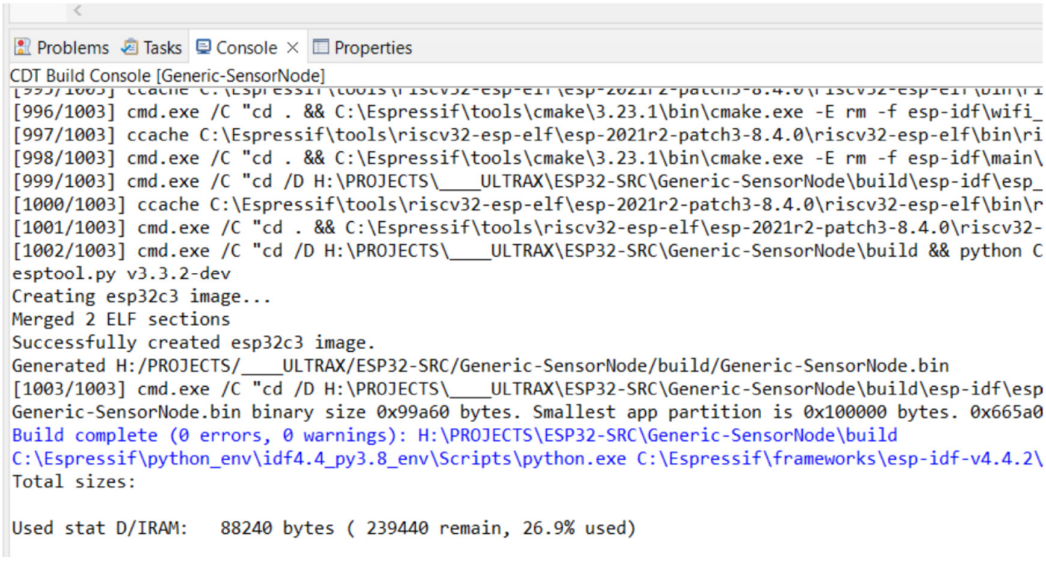
Then call *Project – Build Project*

NOTE: it takes some longer time to build the project for the first time, since all ESP-IDF components (libraries) are built from the source.

Before build some error indicators may be shown:



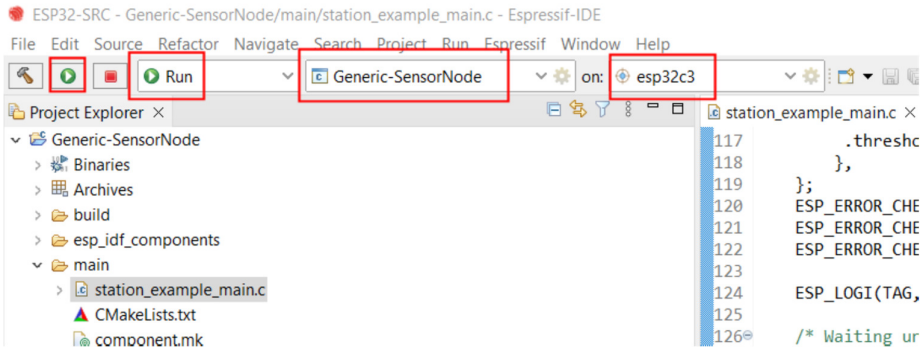
After successful build (it may take several minutes) all red marks should be gone and the result of successful build should be displayed:



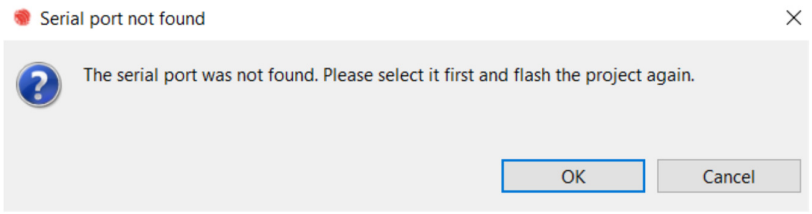
There are to ways to program the target[4]

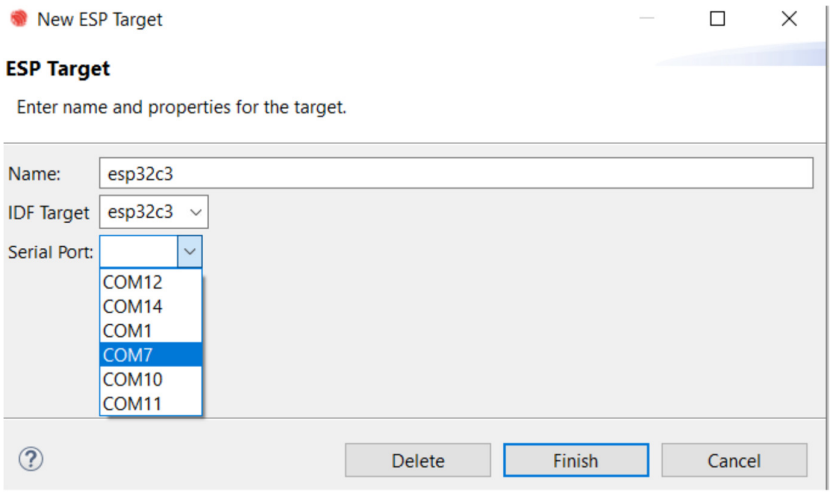
- via serial port (via bootloader, no debugging)
- via JTAG (e.g. ESP PROG)

Let's run the example:



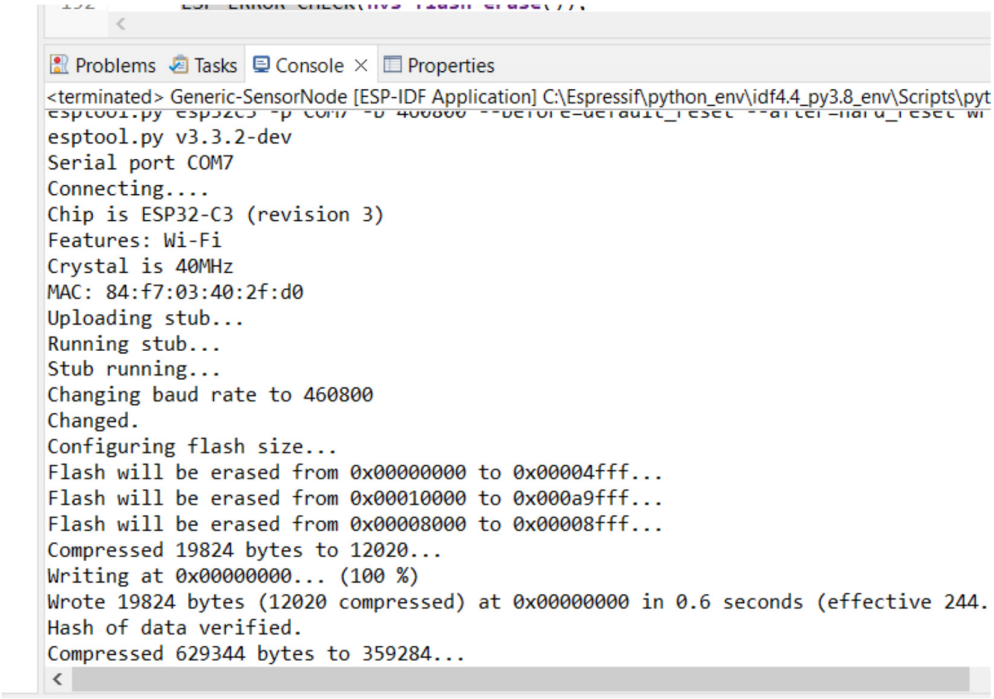
If this is a first run and serial port is not defined:

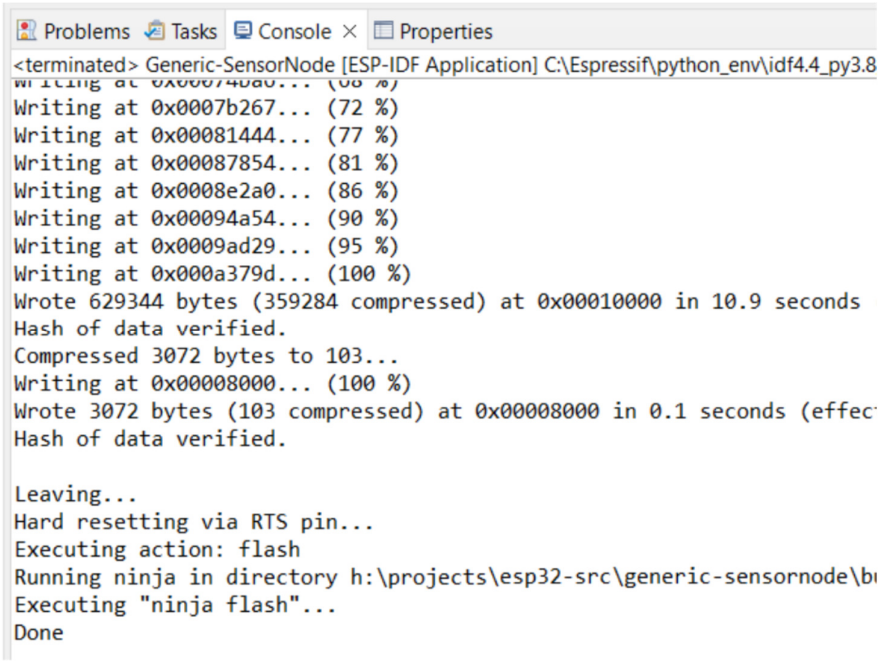




[4] This guide assumes that ESP PROG is used for external debugging.

Run again:

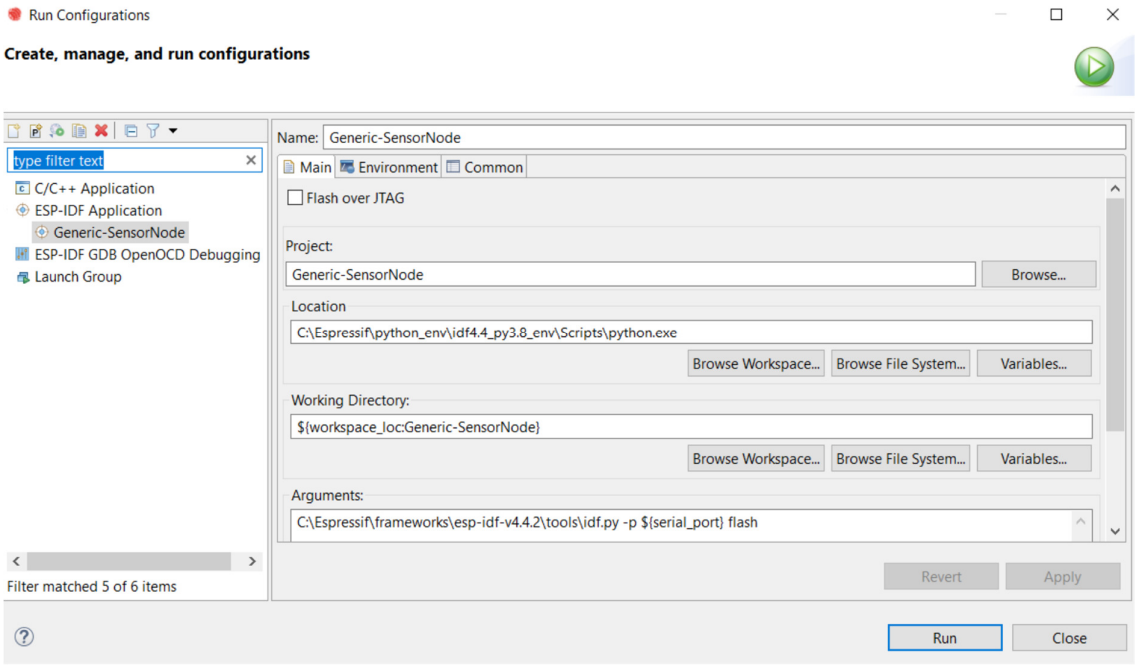




The content of Console output window indicates that target has been programmed.

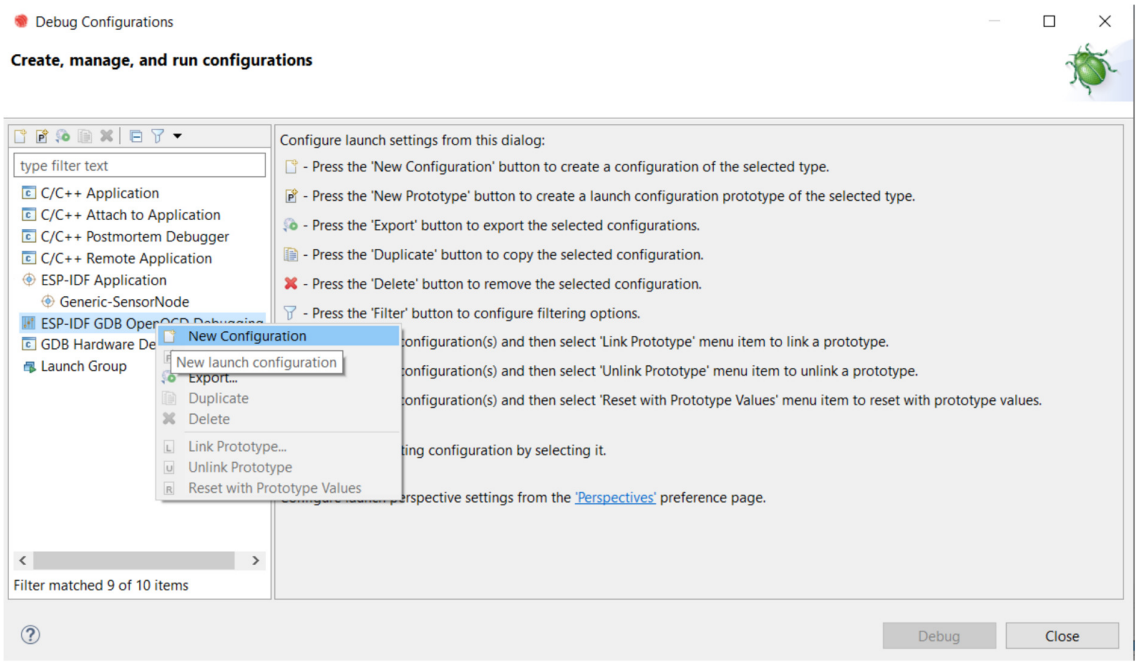
This approach will upload last firmware build but debugging is not possible.

If you click Run-Run Configurations:

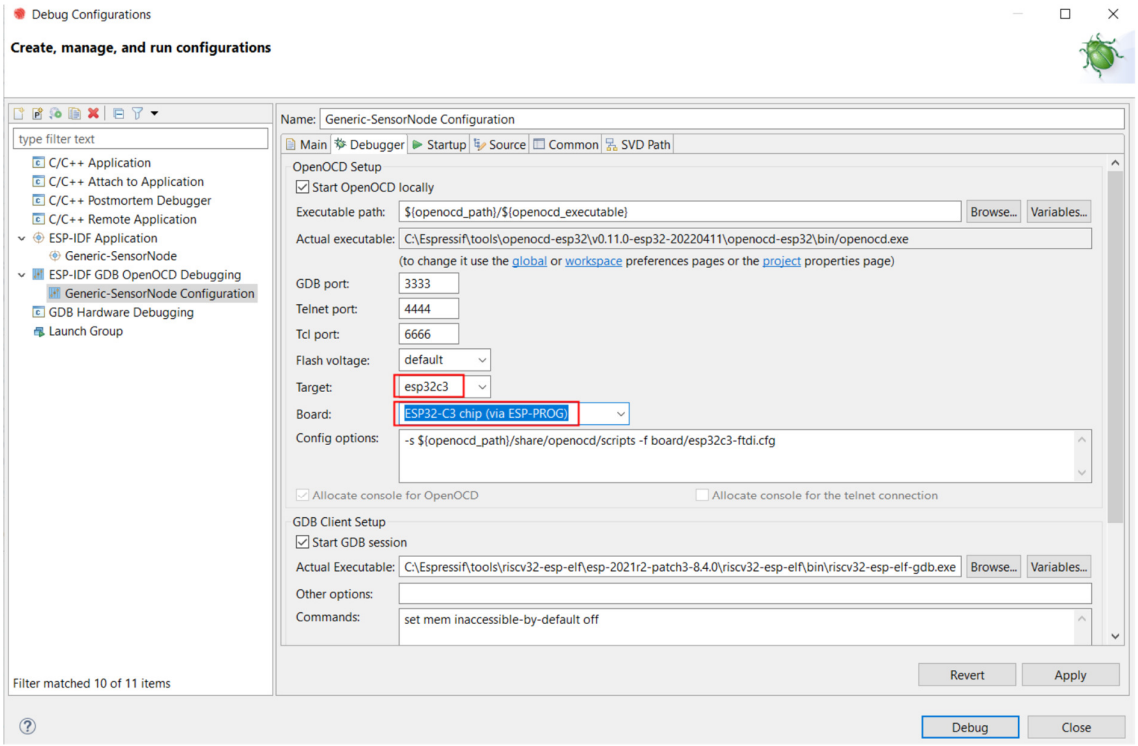


the entry is automatically created in the previous step that connects Run action with *Run Configuration*.

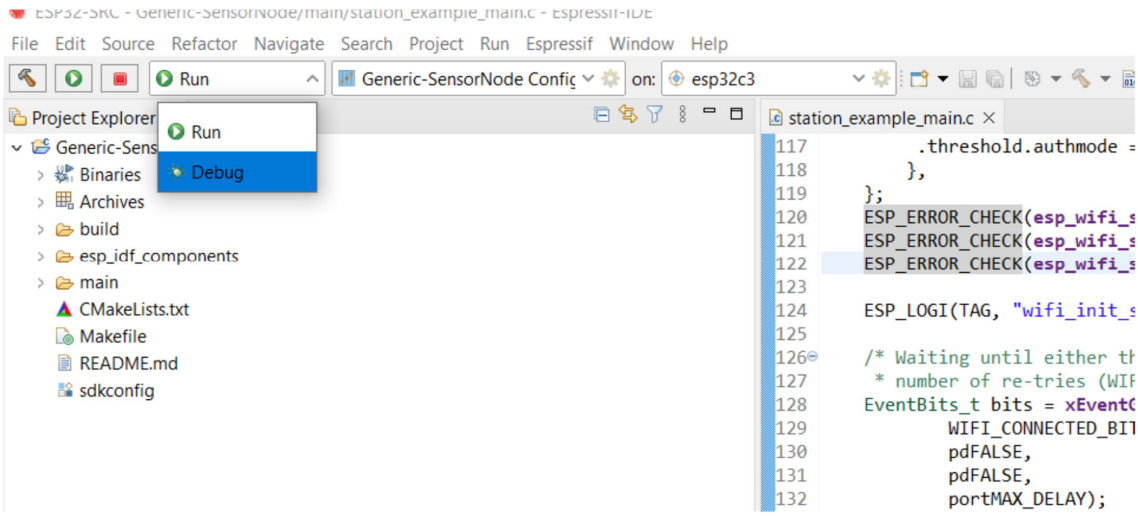
However, we want to have Debug session started over JTAG during development as a faster mean to upload firmware and have capability for in-circuit debugging. To do so, call option *Run-Debug Configurations*. Add new debug configuration:



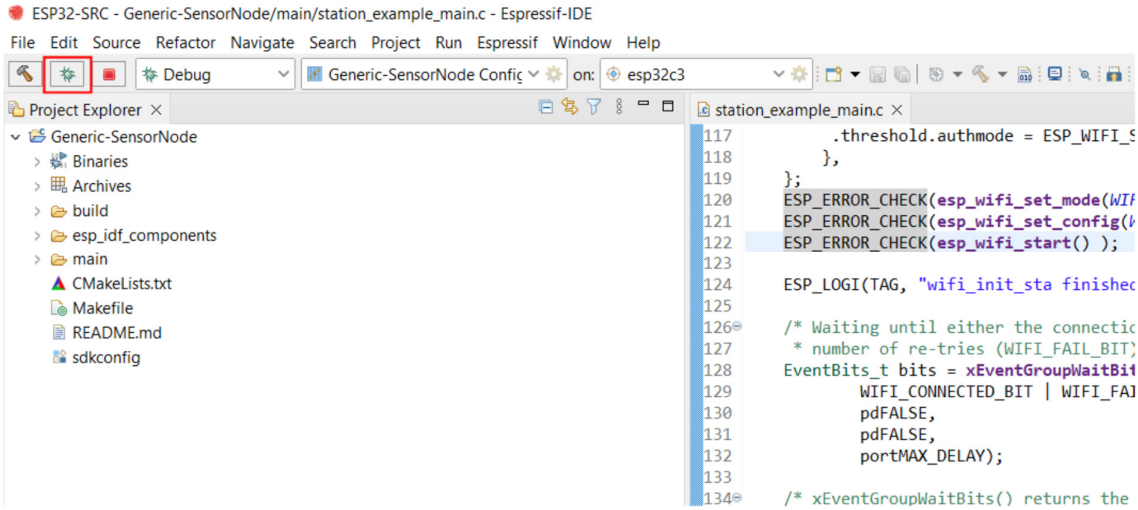
Ensure correct target and debug interface chosen:



Switch to Debug mode:



Start debug session:



Note: if you installed correctly drivers for ESP PROG, you may still experience difficulties with drivers:

If you change physical port where you connect ESP PROG, you need to re-run driver installation procedure!!! Each port change where you connect ESP PROG on PC requires another procedure of updating which USB driver you use! (WinUSB vs FTDI!)

Now you are ready to program and debug you application.