



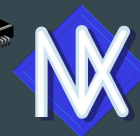
ESP32 Ecosystem

2025-04-29

FI MUNI - Brno



Juraj Michálek, Sudeep Mohanty, Eren Terzioğlu
Espressif Systems



NuttX RTOS

Espressif team

Juraj Michálek

- ESP32 Ecosystem
- Wokwi, MicroPython, Jupyter notebook with ESP32
- Rust, Open hardware, Demos

Sudeep Mohanty

- ESP32 and Low Power core

Eren Terzioğlu

- NuttX



Developer Portal

developer.espressif.com

GitHub: <https://github.com/espressif/developer-portal/>

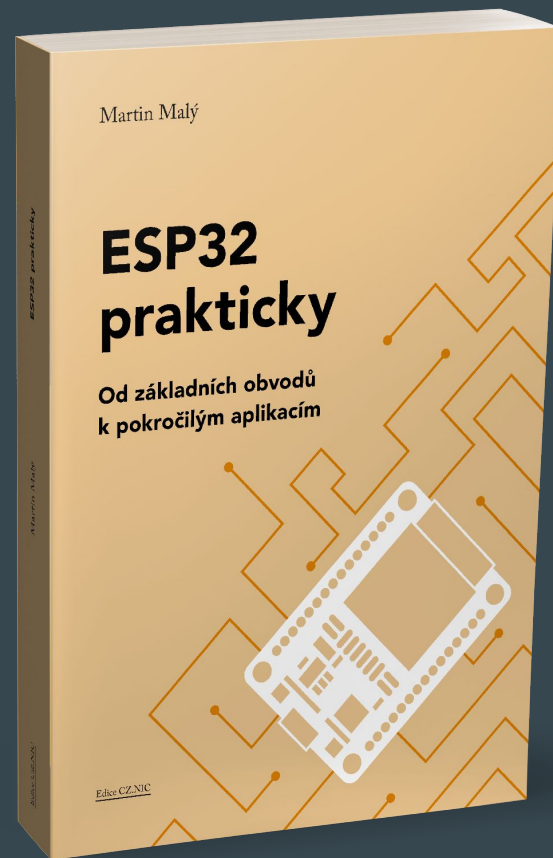
The screenshot shows the Espressif Developer Portal Blog page. At the top, there is a navigation bar with the Espressif logo, the text "ESPRESSIF Developer Portal", and links for "Blog", "Workshops", "Events", "Quick Links", and a search icon. The main content area is titled "Blog" and features a grid of six blog posts. Each post includes a featured image, a title, a date and duration, a list of tags, and a short introductory paragraph.

- Security in ESP RainMaker**
20 March 2025 · 8 mins
Tags: ESP32, ESP-Rainmaker, Espressif, IoT
This article provides a high level overview of the security architecture of the ESP RainMaker IoT platform, covering all aspects like device hardware and network security, client network security, authentication and access control, user-device mapping, cloud data security and certifications.
- Espressif part numbers explained: A complete guide - Modules**
19 March 2025 · 7 mins
Tags: ESP32, ESP32-S2, ESP32-S3, ESP32-H2, ESP32-C3
- Working with ESP-IDF in CLion**
13 March 2025 · 7 mins
Tags: ESP32-S3, ESP-IDF, CLion, IDE, Tutorial
- ESP32-H2 Upgrade: Enhanced Security and Protection**
12 March 2025 · 2 mins
Espressif has released ESP32-H2 v1.2, bringing significant cryptographic and hardware security improvements.
- ESP32 Undocumented Bluetooth Commands: Clearing the Air**
10 March 2025 · 5 mins
Tags: ESP32, Security, IoT, Bluetooth
- Running Python on ESP32-S3 with NuttX**
7 March 2025 · 8 mins
Tags: NuttX, Apache, Python, ESP32-S3, POSIX

ESP32 prakticky


<https://espx.cz>

<https://github.com/espx-cz>



ESP Product Selector + Product Comparison

<https://products.espressif.com/>



ESP32-S3


ESP32-S3 is a low-power MCU-based SoC that supports 2.4 GHz Wi-Fi and Bluetooth® Low Energy (Bluetooth LE).

ESP32-S3 has a complete Wi-Fi subsystem and a Bluetooth LE subsystem. State-of-the-art power and RF performance. S3 provides a rich set of peripheral interfaces, and supports ultra-low-power applications. Different security features allow the device to meet stringent security requirements.

Features:

- **Core:** Xtensa® single-dual 32-bit LX7 CPU, frequency up to 240MHz
- **Memories:**

Block Diagram:



Product Brief
Docs & Certs
DevKits

List: 203 items IC/Module Development Board Comparison Export

<input type="checkbox"/>	Index	Name	MPN	Marketing Status	Type	Wi-Fi
<input type="checkbox"/>	1	ESP32-S3	ESP32-S3	Mass Production	SoC	IEEE 802.11 b/g/n; 2.4 ...
<input type="checkbox"/>	2	ESP32-S3	ESP32-S3R2	Mass Production	SoC	IEEE 802.11 b/g/n; 2.4 ...
<input type="checkbox"/>	3	ESP32-S3	ESP32-S3R8	Mass Production	SoC	IEEE 802.11 b/g/n; 2.4 ...
<input type="checkbox"/>	4	ESP32-S3	ESP32-S3R...	Mass Production	SoC	IEEE 802.11 b/g/n; 2.4 ...
<input type="checkbox"/>	5	ESP32-S3	ESP32-S3F...	Mass Production	SoC	IEEE 802.11 b/g/n; 2.4 ...

Product Selector | **Product Comparison**

[Product Portfolio](#) [Sales Questions](#) [Technical Inquiries](#)

[Hide Same](#) | [Show Same](#)

	ESP32-S3	ESP32-P4NRW16
Series	ESP32-S3	ESP32-P4
CPU	Xtensa® dual-core 32-bit LX7	32-bit RISC-V single-core processor
Freq. (MHz)	240	400
Package (mm)	QFN56 (7*7)	QFN10*10
Dimensions (mm)	7*7	10*10
Temp. (°C)	-40 °C ~ 105 °C	-40 °C ~ 85 °C
Status	Mass Production	Sample
ECO	standard version	
Support IDF	v0.x	

OSes and integration



ESP-IDF (OS based on FreeRTOS) - <https://github.com/espressif/esp-idf>

Rust no_std - <https://github.com/esp-rs/esp-hal> - official support

Rust std - <https://github.com/esp-rs/esp-idf-hal> - community support



Zephyr - <https://zephyrproject.org/>

- <https://developer.espressif.com/tags/zephyr/>
- <https://wokwi.com/projects/325751453458104914>



NuttX - <https://nuttx.apache.org/> (as app, Linux-like OS)

- <https://developer.espressif.com/tags/nuttx/>

SVD files: <https://github.com/espressif/svd>

Programming languages

Active support by Espressif teams

- **C/C++**
 - most common choice - <https://github.com/espressif/esp-idf>
- **Rust**
 - recommended for new design evaluation - <https://github.com/esp-rs>
 - security and memory guaranties of Rust
 - multi-target Xtensa, RISC-V, plus WASM, desktops or mobile
- **Arduino - Maker choice**
 - Arduino IDE 2.x
 - note: check the license for production



esp-rs

Libraries, crates and examples for using Rust on Espressif SoC's

Languages and frameworks

Compiled:

- Embedded Swift - Do iOS Amsterdam - <https://youtu.be/HFnAvDZtW4A?si=D8s0GMxo0S8BLiso>
- Zig

VM based:

- CircuitPython and MicroPython - Python-like language
- Toit
- Nanoframework - C# language
- Mongoose OS
- Lua
- downside: bigger VM
- upside: more robust, comes with OTA and monitoring

IDE

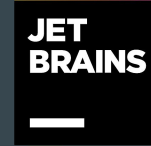
Supported by Espressif:

- VS Code with Espressif Extension - <https://developer.espressif.com/tags/vscode/>
- Espressif IDE - <https://developer.espressif.com/tags/espressif-ide/>



Supported by JetBrains:

- CLion - <https://developer.espressif.com/blog/clion/>



Supported by TARA Systems

- Embedded Wizard - <https://www.embedded-wizard.de/>



Embedded
Wizard

GUI Solutions by TARA Systems

FlowCode

- <https://developer.espressif.com/workshops/flowcode/>



FLOWCODE

wokwi.com/micropython

Contribute: <https://github.com/wokwi>

EDC24: [Flash Less, Do More: The Magic of Virtual Hardware](#)

Hint: Hit pause to see state of GPIOs

WOKWI
World's most advanced ESP32 simulator

[Discord Community](#) [LinkedIn Group](#)

Online Embedded Python Simulator

Use Wokwi to simulate embedded MicroPython projects and test your hardware projects.

Basic Examples

- ESP32 + OLED (SSD1306)
- Neopixel Ring Rainbow

IoT Examples

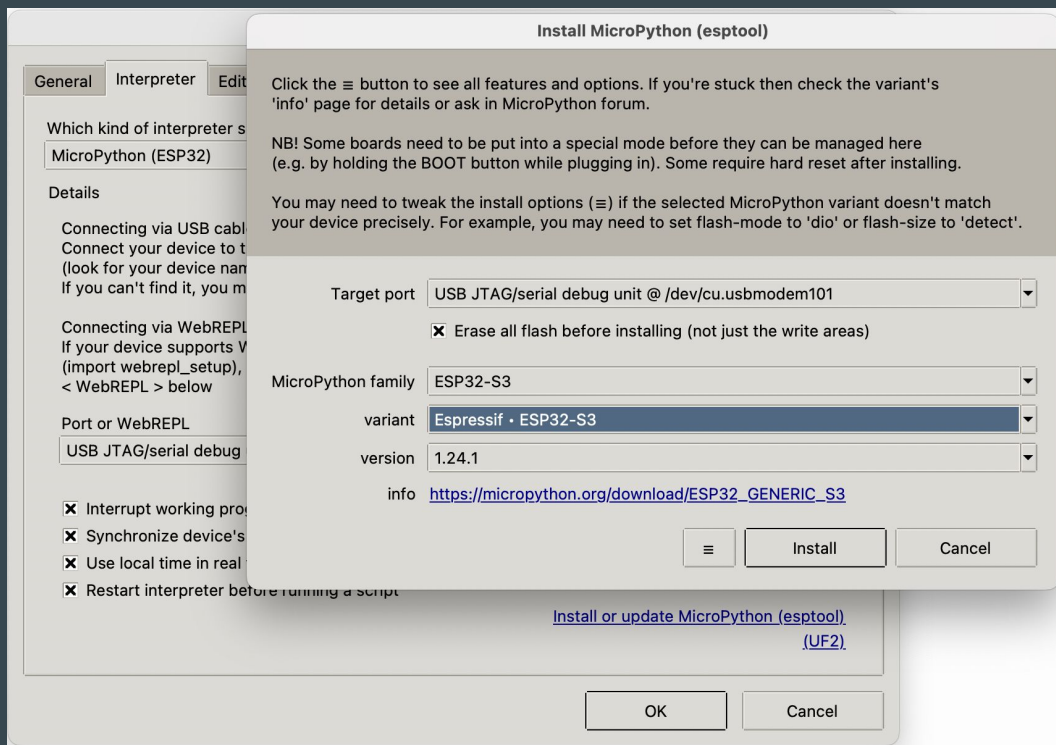
- MicroPython MQTT Weather Station
- MQTT NeoPixel Ring
- Jokes API Example

Thonny

Python IDE for beginners

<https://thonny.org/>

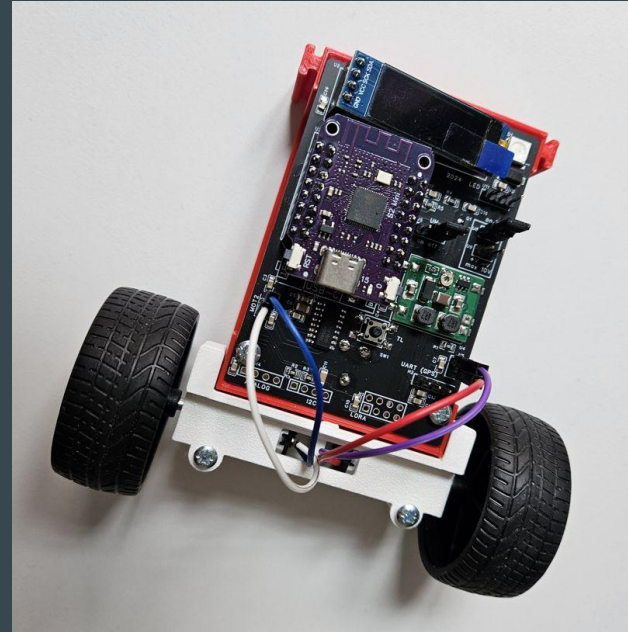
Flash MicroPython directly from IDE



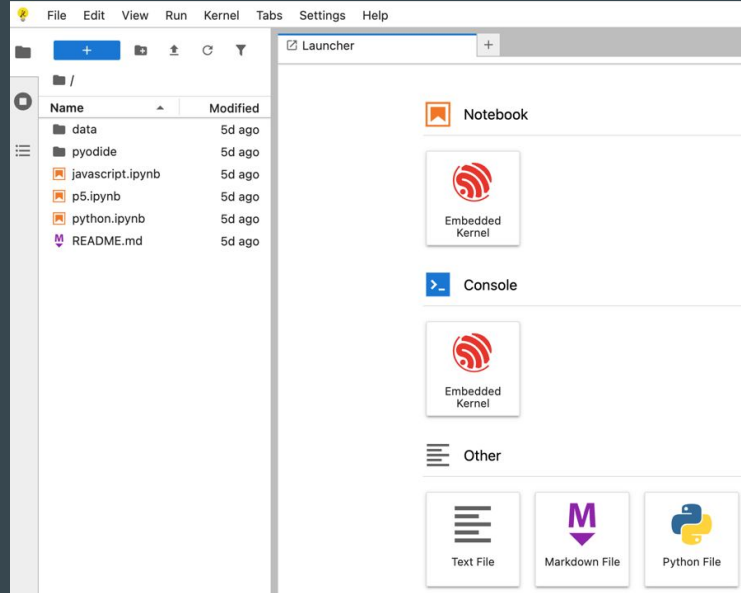
Racing Car in MicroPython

ESP32-S2 - WiFi controller car

Developed by [Technical Cybernetics UNIZA](#)



Jupyter Lite - MicroPython - ESP32



<https://espressif.github.io/jupyter-lite-micropython/lab/index.html>

Expanding HW with esp-box

ESP32-S3-BOX-3

<https://www.espressif.com/en/news/ESP32-S3-BOX-3>

Open source

<https://github.com/espressif/esp-box>

Cool example:

https://github.com/espressif/esp-box/tree/master/examples/esp_joystick/joystick_controller



MicroPython - Conway's Game of Life

<https://github.com/georgik/esp32-conways-game-of-life-python>

Using MicroPython custom build with SDL3 API



Custom build of MicroPython

Let's add some more functionality to MicroPython

- MicroPython - <https://github.com/micropython/micropython>
- Board Support Package (BSP) - <https://components.espressif.com/components?q=tags:bsp>
- SDL3 (port for ESP-IDF) - <https://components.espressif.com/components/georgik/sdl>
- ESP-IDF v5.3 - <https://github.com/espressif/esp-idf>

The **ESP** Component Registry

Discover, download and publish components and examples for ESP-IDF



Browse components

ALL Board Support Package

Compatible with ESP-IDF: v5.0 v5.1 v5.2 v5.3

By target: ESP32 ESP32-C2 ESP32-C3 ESP32-C5 ESP32-C6 ESP32-C61 ESP32-H2 ESP32-P4 ESP32-S2 ESP32-S3

Featured

espressif/mdns

v1.4.0

uploaded 2 months ago

mDNS

lvgl/lvgl

v9.2.0

uploaded 1 month ago

LVGL - Light and Versatile Graphics Library

espressif/esp-modbus

v1.0.16

uploaded 1 month ago

ESP-MODBUS is the official Modbus library for Espressif SoCs.

joltwallet/littlefs

v1.14.8

uploaded 3 months ago

LittleFS is a small fail-safe filesystem for micro-controllers.

espressif/arduino-esp32

v3.0.7

uploaded 23 hours ago

Arduino core for ESP32, ESP32-S and ESP32-C series of SoCs

espressif/openai

v1.0.0

uploaded 5 months ago

OpenAI library compatible with ESP-IDF

wolfssl/wolfssl

v5.7.2

uploaded 3 months ago

wolfSSL Embedded SSL/TLS Library

slint/slint

v1.8.0

uploaded 1 month ago

Slint — declarative GUI toolkit

<https://components.espressif.com/>

Example: [https://components.espressif.com/components/espressif/i2c bus/](https://components.espressif.com/components/espressif/i2c_bus/)

MicroPython - custom build

```
# ESP-IDF v5.3
```

```
./export.sh
```

```
# MicroPython repo + recursive submodules
```

```
cd ports/esp32
```

```
make BOARD=ESP32_GENERIC_S3 BOARD_VARIANT=SPIRAM_OCT
```

```
idf.py -B build-ESP32_GENERIC_S3_SPIRAM_OCT build flash monitor
```

MicroPython - custom build

User Linux or macOS

Windows

- build on Windows suffers from build issues, reasonable alternative WSL2
- E.g. using Fedora Remix for WSL
- build of ESP-IDF app in WSL is way faster than build directly on Windows

Exposing Rust to Python REPL

<https://github.com/georgik/micropython/commits/experimenta/nmea/>

Rust no_std code - as ESP-IDF component (library)

Bridge code - similar like exposing API from C

Sample code:

- https://github.com/georgik/esp32-conways-game-of-life-python/blob/main/rust-no_std-nmea/nmea.py

NMEA altitude: 61.70

Data:

- **Latitude: 53°21.6801' N**

- **Longitude: -7°29.6628' W**

Tips

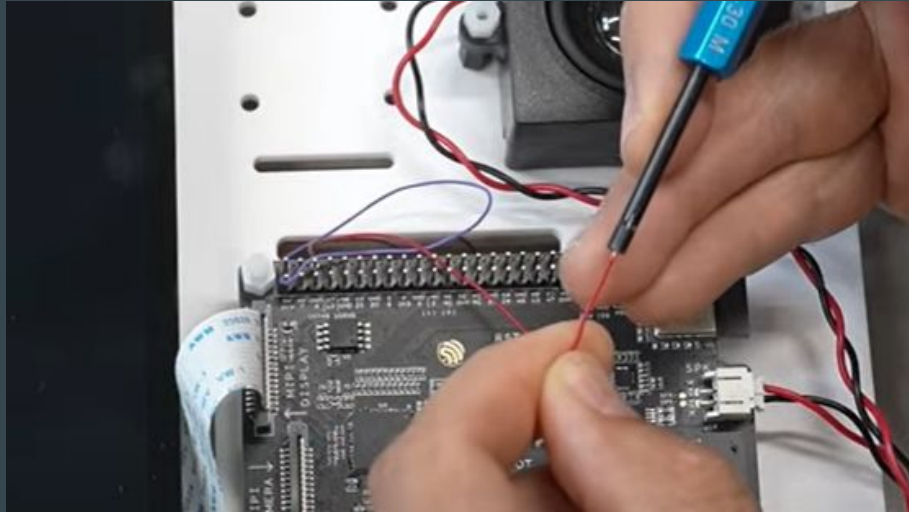
How to “unbrick” ESP32

Many people incorrectly thinks that ESP32 is bricked, in many cases the custom firmware just does not receive UART or USB signals.

Solution: hold BOOT button and press RESET to switch to boot mode

After flashing, just press RESET to return to normal mode.

Wire Wrap Tool



[Espressif DevCon 2024 - Tips and Tricks](#)

Graphical libraries for ESP32



Embedded Wizard



FlowCode



LVGL



Simple Direct Layer



Slint

Architecture

Layers:

Application + UI

Graphical library

ESP-BSP (Board Support Package)

ESP-IDF



GUI Solutions by TARA Systems

Embedded Wizard

Quick prototyping

Free for small, medium projects

Supports ESP32, WASM or Desktop

[Articles at Developer Portal](#)





FlowCode

- <http://flowcode.co.uk>
- [https://www.flowcode.co.uk/wiki/index.php?title=ESP32 Toolchain](https://www.flowcode.co.uk/wiki/index.php?title=ESP32_Toolchain)

Workshop: Flowcode - M5 Stack Dial Workshop

- <https://developer.espressif.com/workshops/flowcode/>



LVGL

Most common solution for ESP32

<https://lvgl.io/>

- <https://developer.espressif.com/blog/switch-between-firmware-binaries/>



Slint

Quick prototyping

Free and commercial version

Rust, C++





SDL

Layers:

Application

UI in C

SDL3

ESP-BSP (noglib)

ESP-IDF

Component:

<https://components.espressif.com/components/georgik/sdl/>

Examples:

- <https://github.com/georgik/esp32-sdl3-example>
- <https://github.com/georgik/OpenTyrian>
- <https://github.com/georgik/esp32-weather-display>
- <https://github.com/georgik/esp32-sdl3-swift-example>



SDL3 + E-paper from Laskakit

- <https://github.com/georgik/esp32-weather-display>
- <https://www.laskakit.cz/lilygo-ttgo-t5-4-7--e-paper-esp32-wifi-modul/>



Example: ESP32 + SDL3 components

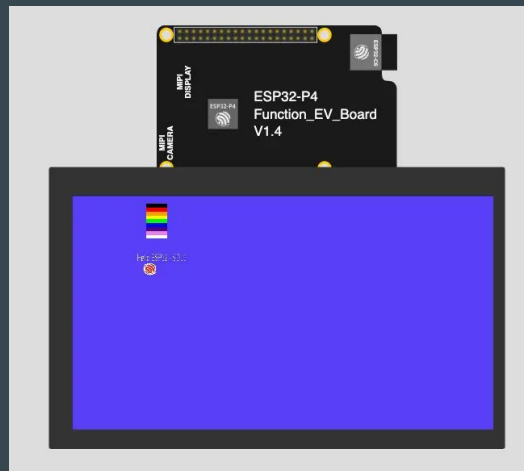
<https://github.com/georgik/esp32-sdl3-example>

[main/idf component.yml](#)

Wrapping components:

<https://github.com/georgik/esp-idf-component-SDL>

<https://github.com/georgik/esp-idf-component-lua>



Rust Bare Metal - Embedded Graphics



Source: <https://github.com/georgik/esp32-spooky-maze-game>

Idea: sharing business logic in Rust between
multiple targets

Game is using Bevy ECS no_std.



<https://github.com/espressif/esp-box>

Bevy ECS (Entity Component System)

One of biggest open source Rust projects

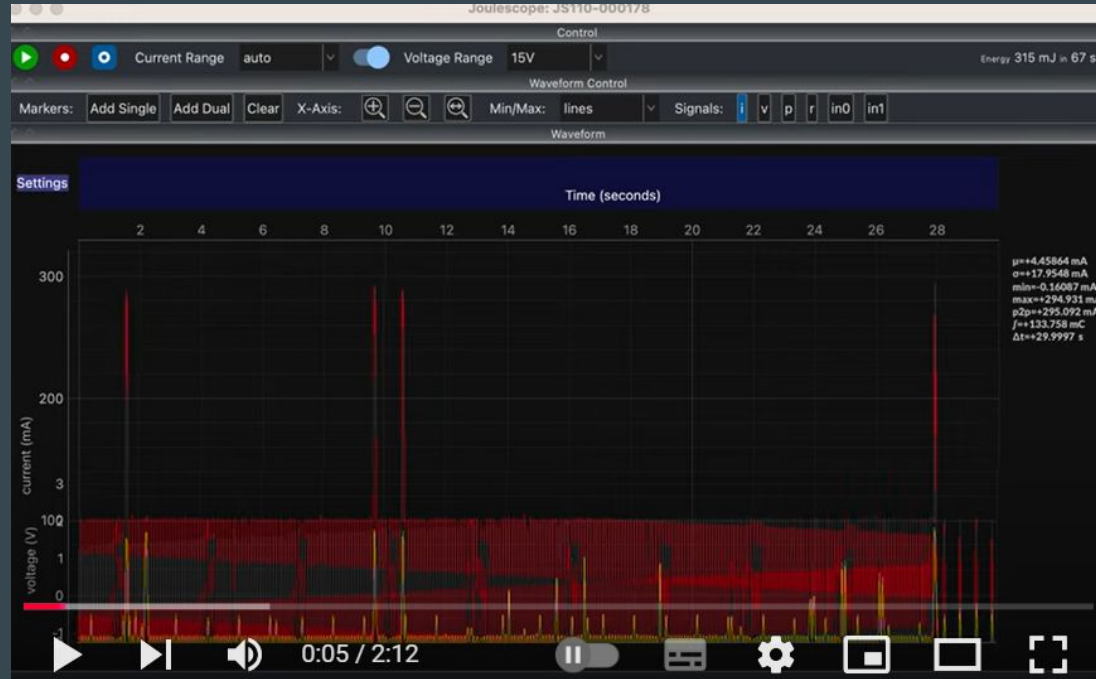
- <https://bevyengine.org/>

Rust no_std + Bevy ECS

- <https://developer.espressif.com/blog/2025/04/bevy-ecs-on-esp32-with-rust-no-std/>
- <https://github.com/georgik/esp32-spooky-maze-game>



ESP32-C6 TWT



<https://www.youtube.com/watch?v=FA1jqZLig4s>

Demo: Digital Twins

Example of combining real and virtual world.

ESP32-C6 observing state of virtual lamp and syncing the state to real Neopixel.

- Access Point + DHCP + NAT on [M5Stack AtomS3](https://github.com/georgik/esp32-dhcp-server) using ESP-IDF
 - <https://github.com/georgik/esp32-dhcp-server>
- Valence Server for PC using Rust std
 - <https://github.com/georgik/valence-client>
- Valence Embedded Client using Rust no_std
 - <https://github.com/georgik/esp32-craft>

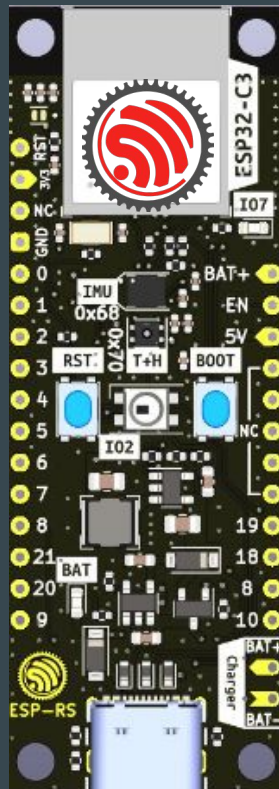
Designing Open Hardware - esp-rust-board

KiCad templates

<https://github.com/esp-rs/esp-rust-board>

ESP32-C3-DevKit-RUST-1 (available at Mouser, AliExpress)

<https://www.espressif.com/en/products/devkits>



flow3r

Powered by MicroPython

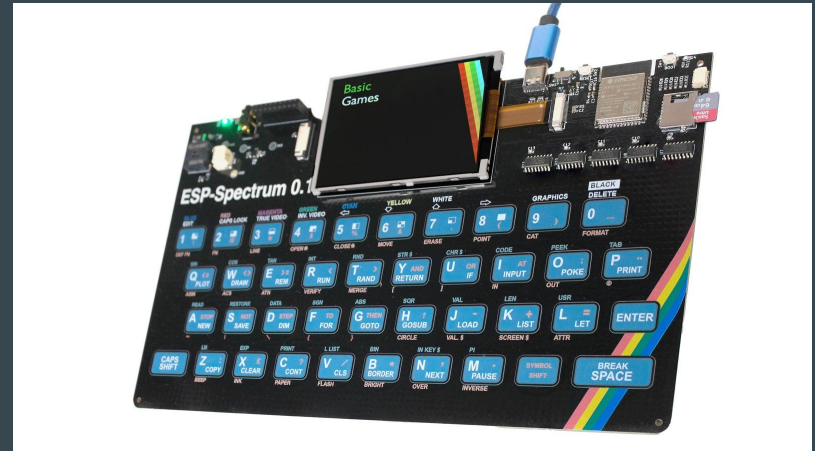
<https://flow3r.garden/>



ESP32 Rainbow

Crowd Supply: <https://www.crowdsupply.com/atomic14/esp32-rainbow>

GitHub: <https://github.com/atomic14/esp32-zxspectrum>

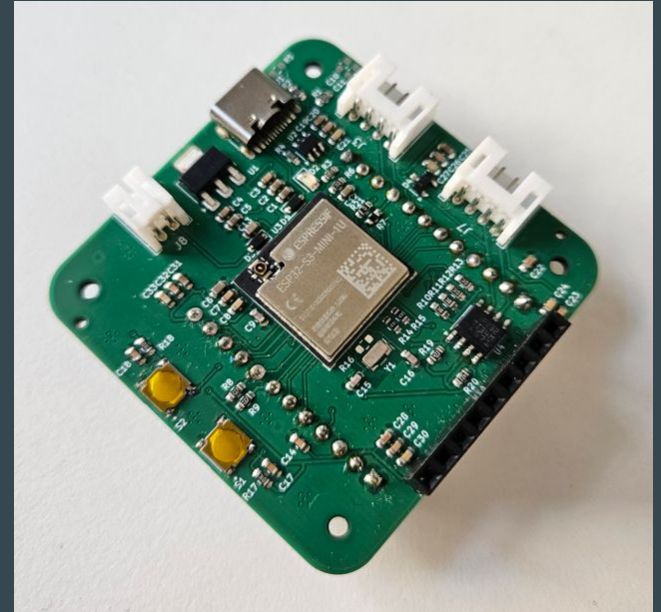


FRI STACK

M5Stack compatible Open Hardware stack

Developed by Technical Cybernetics UNZA

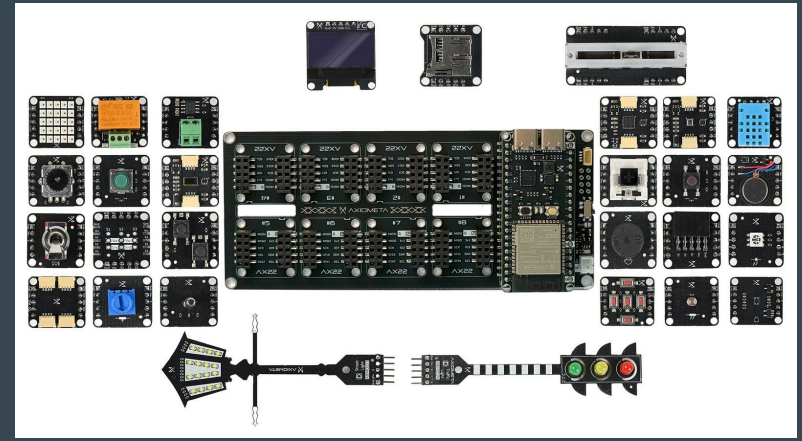
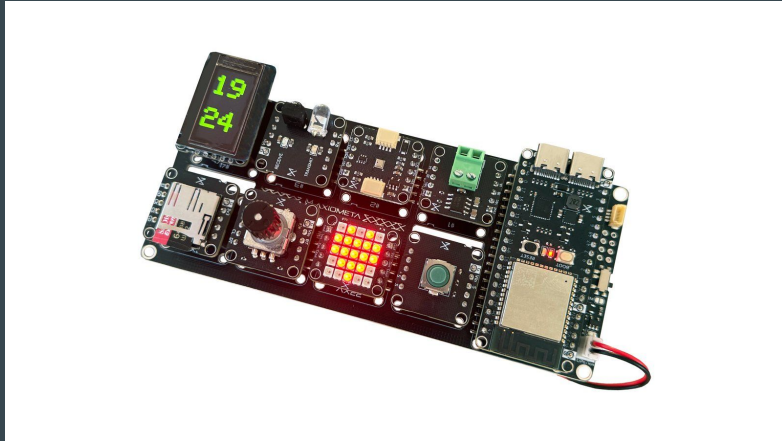
- https://github.com/andsim04/FRI_STACK_HARDWARE



Axiometa - Genesis IoT Discovery Lab

Crowd Supply - <https://www.crowdsupply.com/axiometa/genesis-iot-discovery-lab>

CERN-OHL-S-2.0 license; GitHub: <https://github.com/axiometa/Genesis>



Espressif in Brno

Vlněna Office Park

Espressif Systems (Czech) s.r.o.

Přízova 3, 602 00 Brno

Czechia, Europe



Espressif Developer Conference 2022-2024 - recording



<https://www.youtube.com/@EspressifSystems>

<https://devcon.espressif.com/>

Embedded World 2026

Meet us in Nuremberg, Germany



embeddedworld

Exhibition&Conference

Old games ported to ESP32-P4

OpenTyrian - <https://github.com/georgik/OpenTyrian/>

Doom / FreeDoom - <https://github.com/espressif/esp32-doom>

Quake 1 / LibreQuake - <https://github.com/espressif/esp32-quake>

