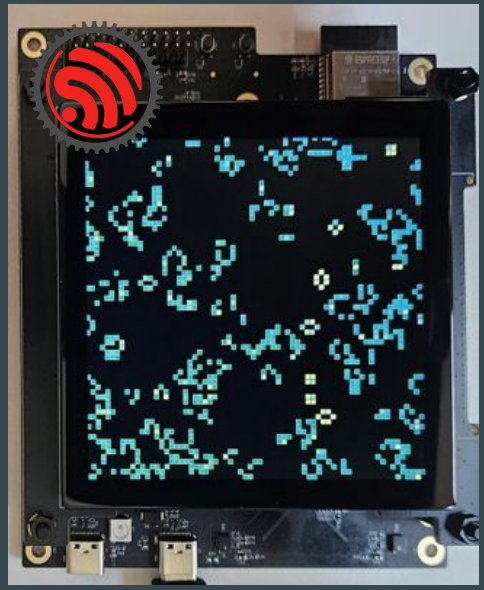
ESP32 Ecosystem



2025-04-29
FI MUNI - Brno

Juraj Michálek, Sudeep Mohanty, Eren Terzioğlu
Espressif Systems

NuttX RTOS

Espressif team

Juraj Michálek

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

Sudeep Mohanty

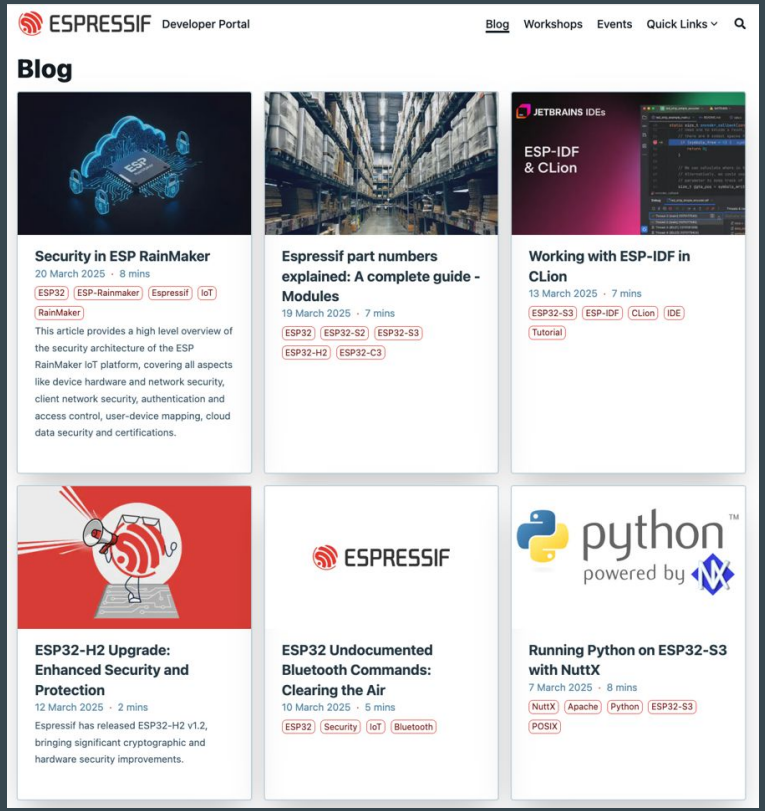
- ESP32 and Low Power core

Eren Terzioğlu

- NuttX

Developer Portal

developer.espressif.com

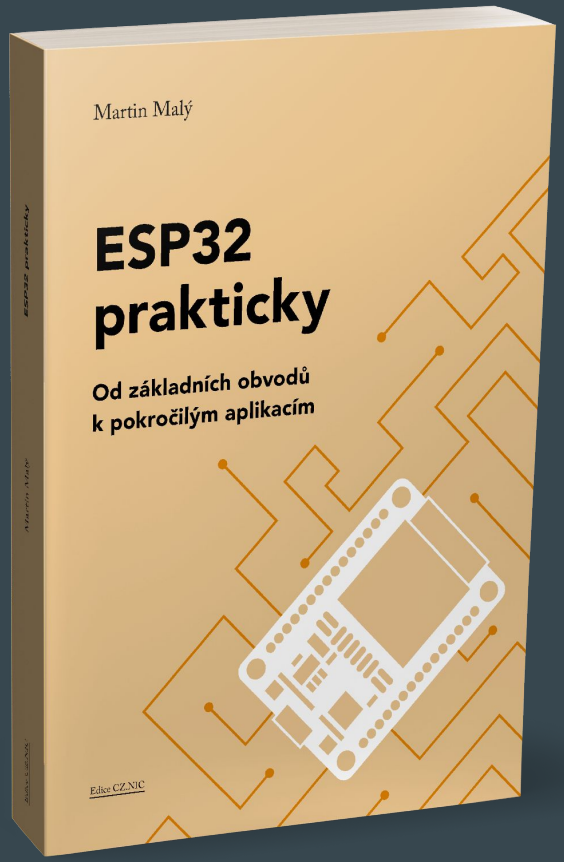


GitHub: https://github.com/espressif/developer-portal/

ESP32 prakticky

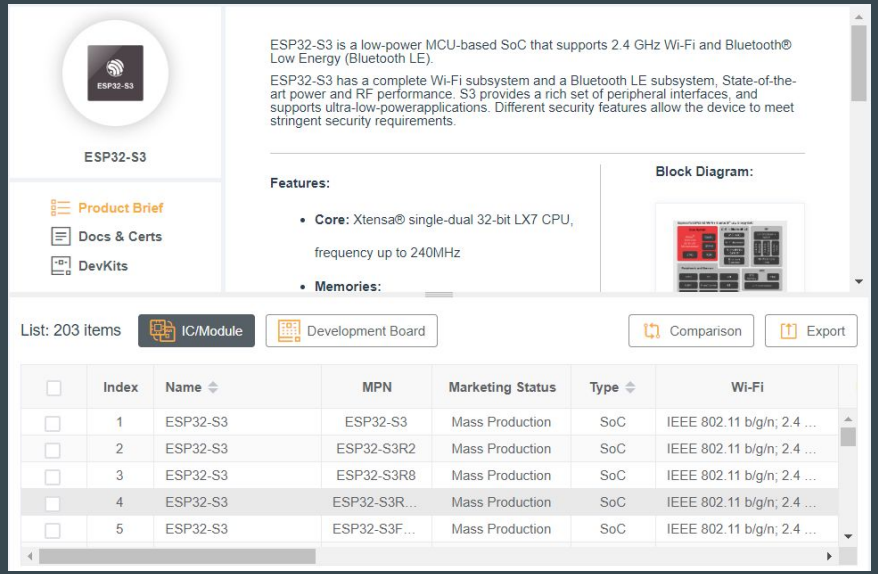
https://espx.cz

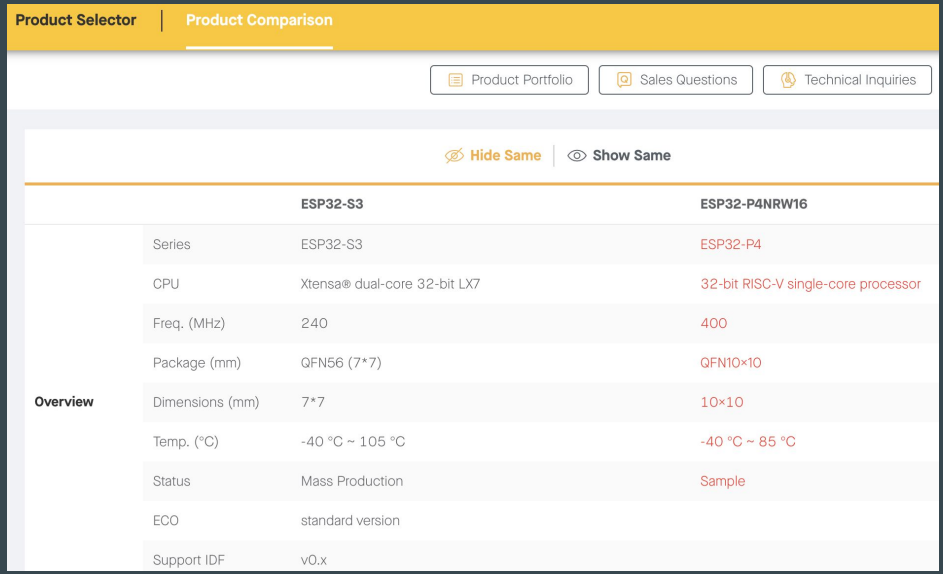
https://github.com/espx-cz



ESP Product Selector + Product Comparison

https://products.espressif.com/





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)

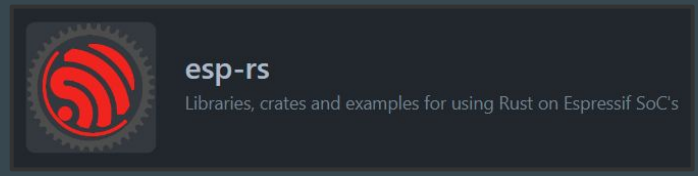
- https://developer.espressif.com/tags/nuttx/

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



Languages and frameworks

Compiled:

- Embedded Swift - Do iOS Amsterdam - https://youtu.be/HFnAvDZtW4A?si=D8sOGMxoOS8BLiso
- 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/

FlowCode

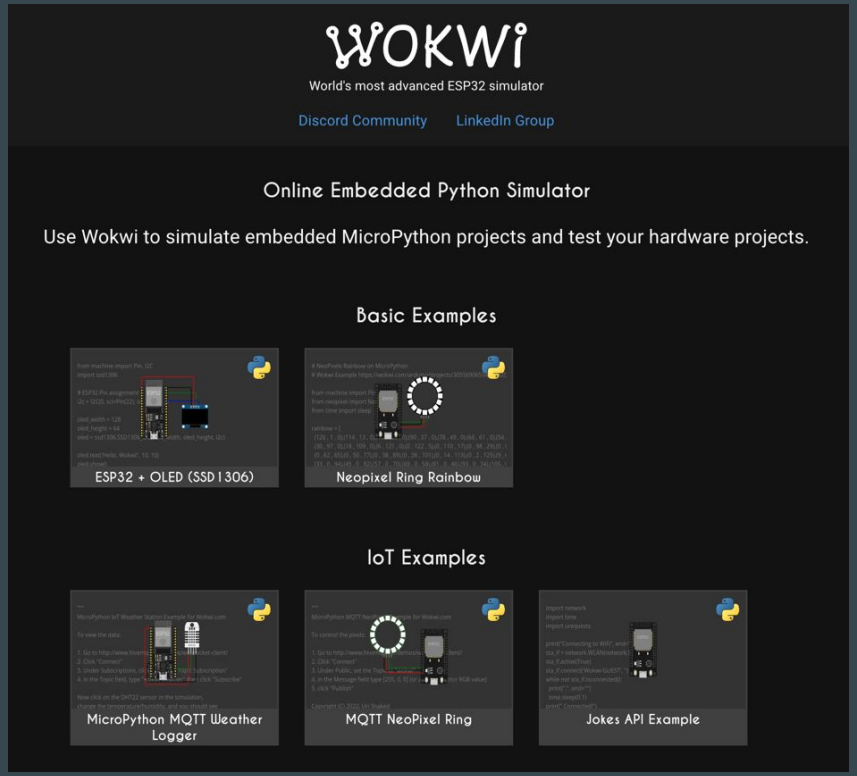
- https://developer.espressif.com/workshops/flowcode/

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

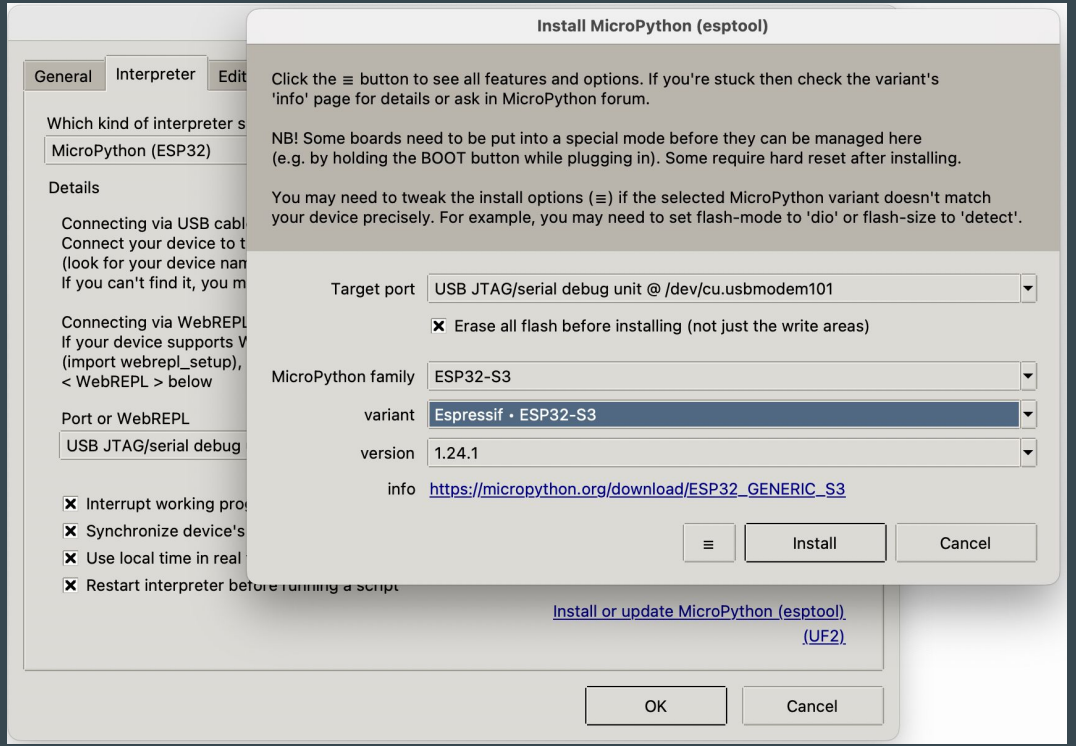


Thonny

Python IDE for beginners

https://thonny.org/

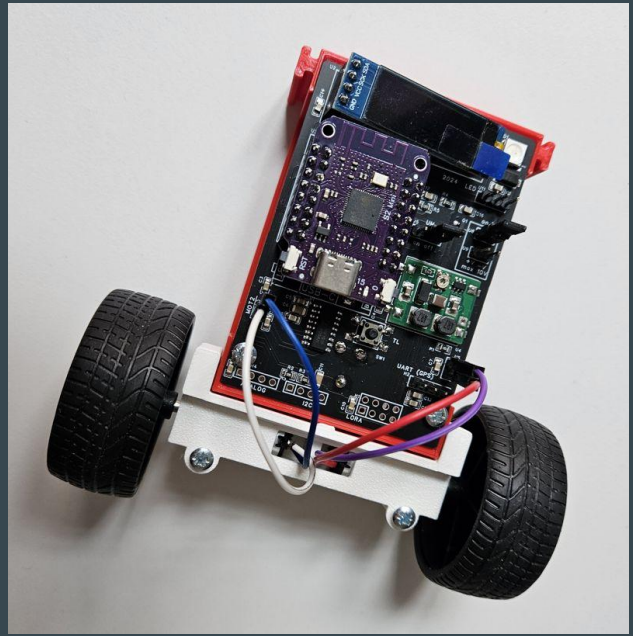
Flash MicroPython directly from IDE



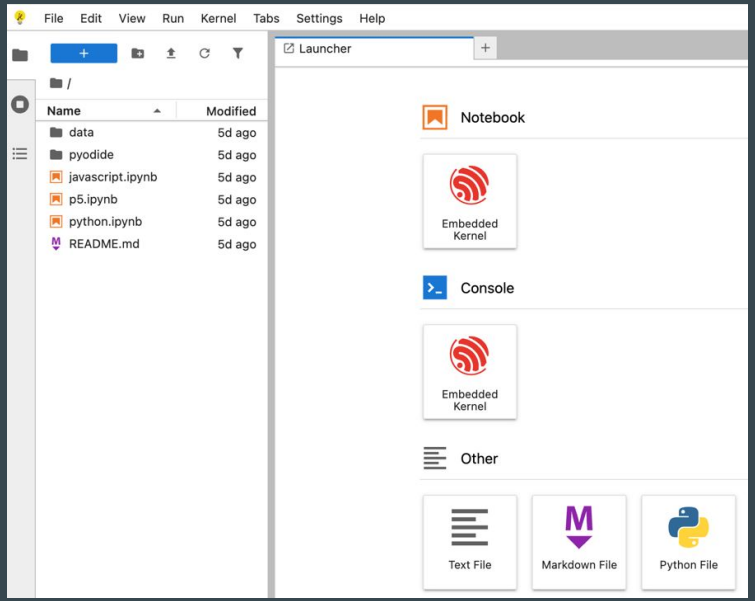
Racing Car in MicroPython

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

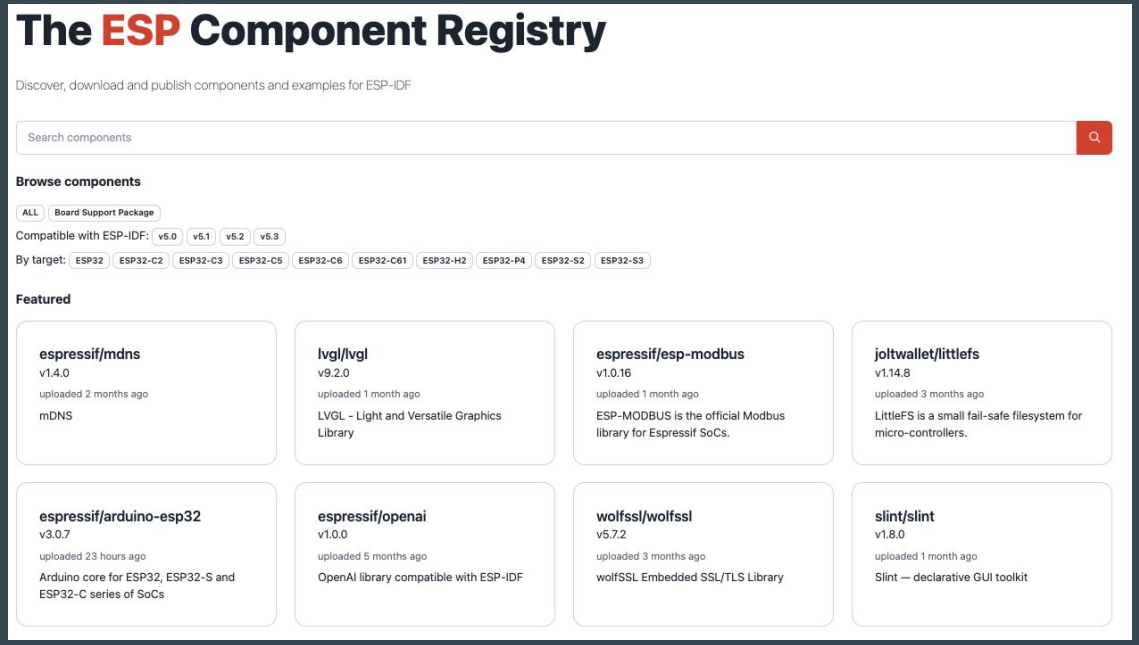
https://github.com/georgik/esp32-conways-game-of-life-python

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



https://components.espressif.com/

Example: 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

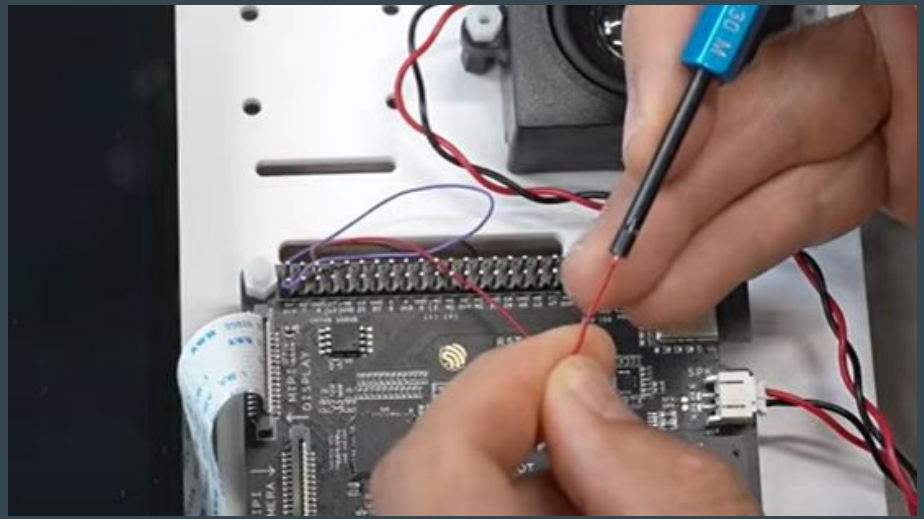
How to “unbrick” ESP32

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

Embedded Wizard

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

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
GUI toolkit

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

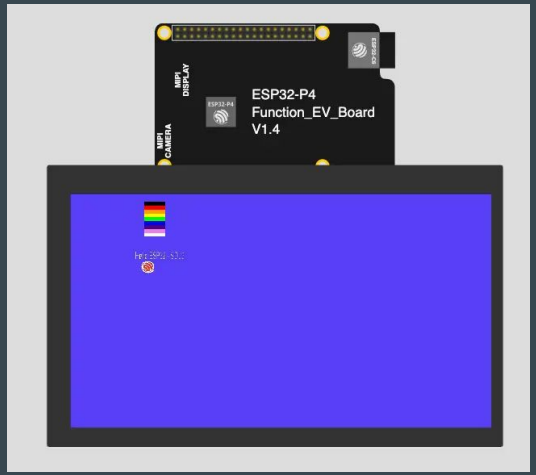
https://github.com/georgik/esp32-sdl3-example

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

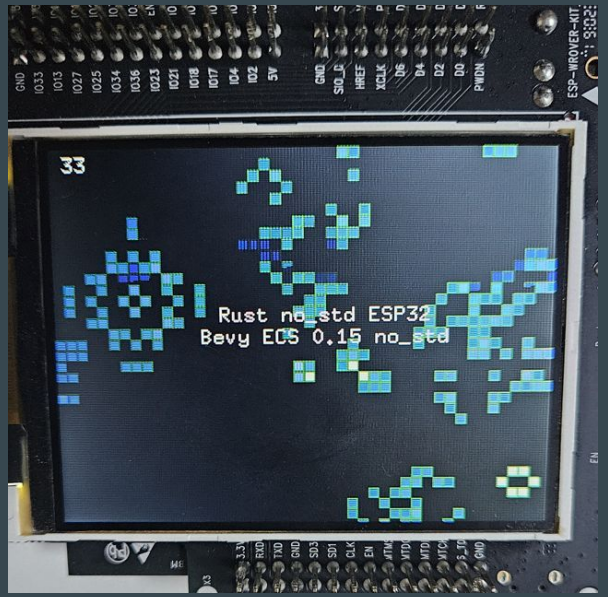
Game is using Bevy ECS no_std.

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

Bevy ECS (Entity Component System)

One of biggest open source Rust projects

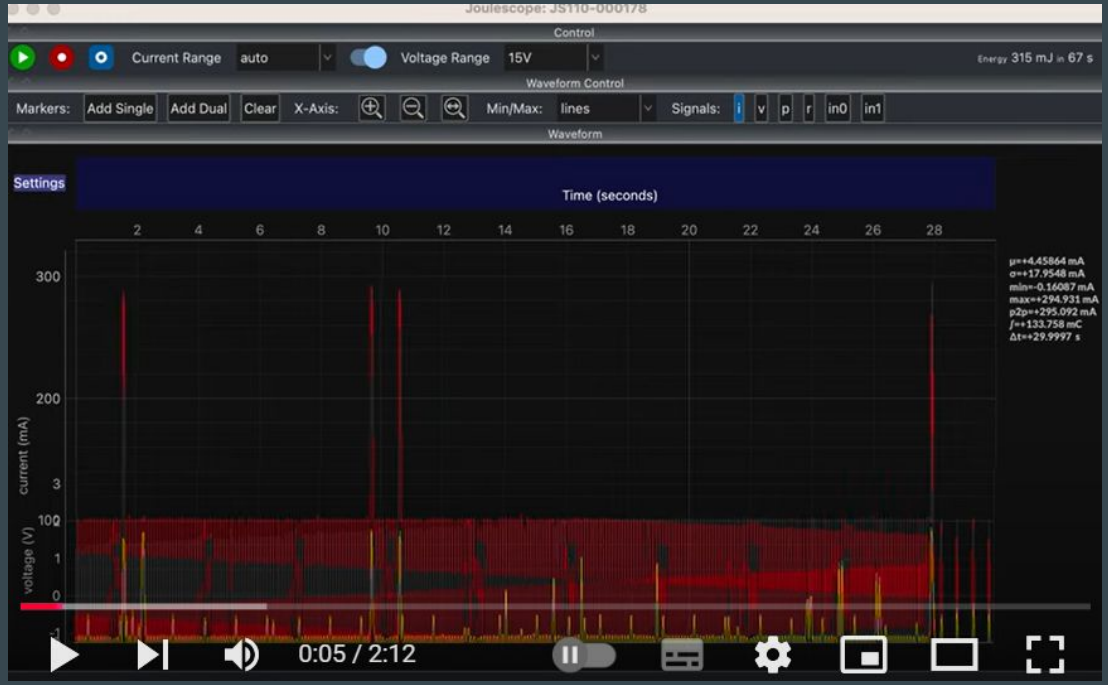
- https://bevyengine.org/



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 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

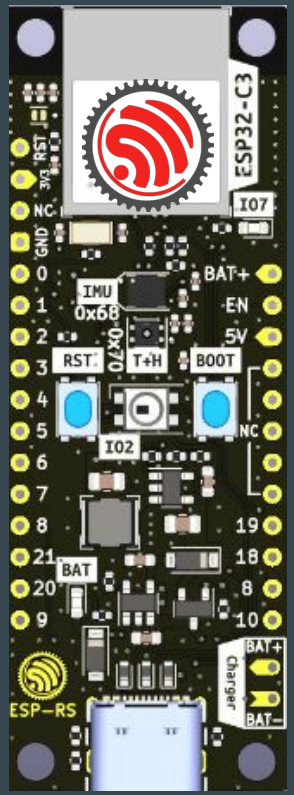
Designing Open Hardware - esp-rust-board

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

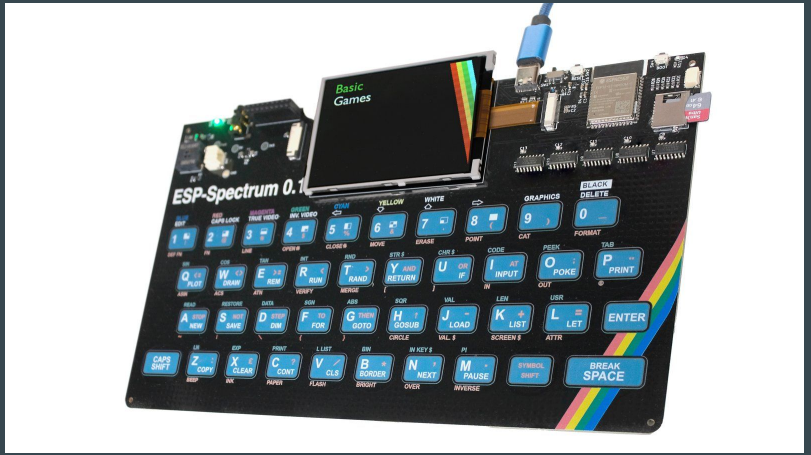
Powered by MicroPython

https://flow3r.garden/

ESP32 Rainbow

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

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

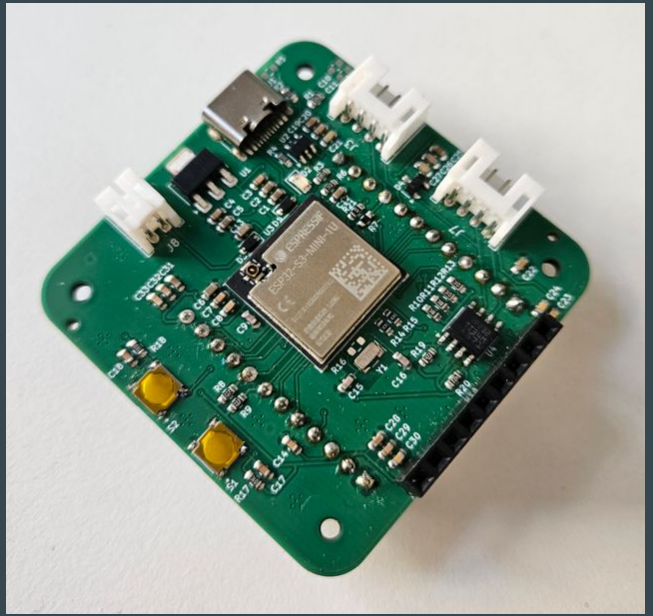


FRI STACK

M5Stack compatible Open Hardware stack

Developed by Technical Cybernetics UNIZA

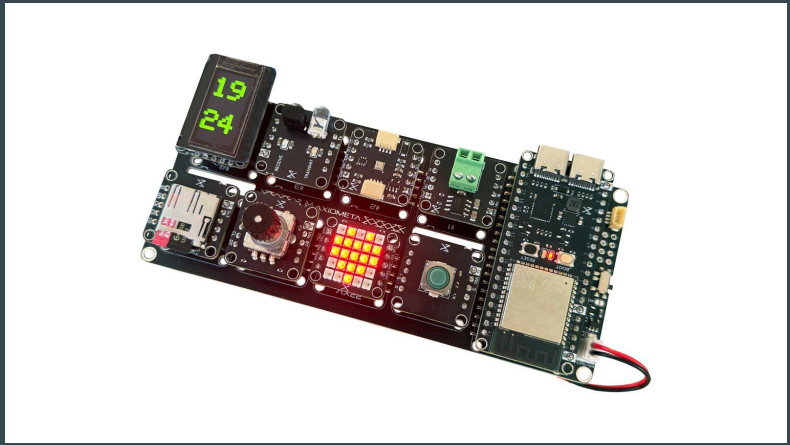
- https://github.com/andsim04/FRI_STACK_HARDWARE

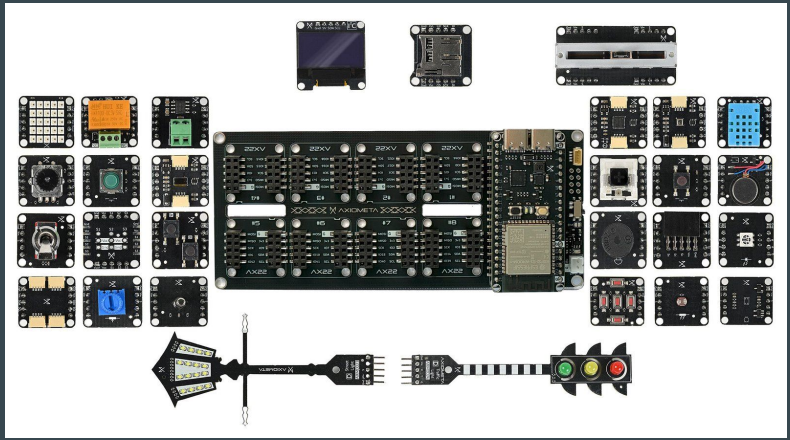


Axiometa - Genesis IoT Discovery Lab

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

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