OnMCU

Embedded Rust on RP2350: From Zero to Blink (and Beyond)

30-minute hands-on mini-workshop

Agenda

Learning Outcomes

1. Getting Rust onto a chip is dead simple.
2. Embedded Rust feels like real Rust.
3. You can move forward without losing your mind.

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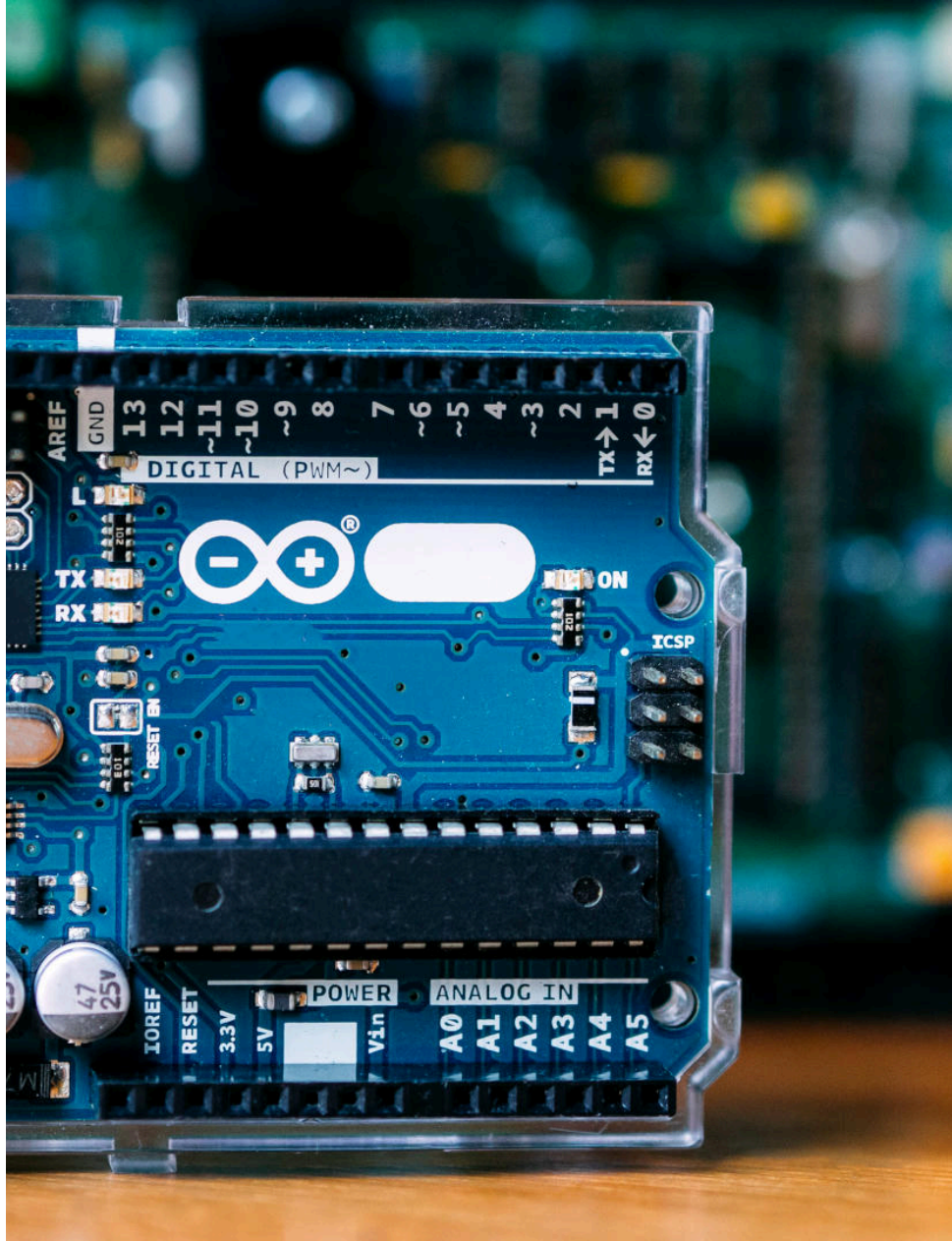
Slides available at yrust.de/rust-rp2350

Who this is for

Prerequisites and assumed knowledge

- You are **comfortable using *Rust***
- You have a *Rust* **toolchain** set up on your machine
- We assume **no prior experience** with embedded development



Learning Outcome 1

Flashing Rust is easier than brewing coffee ☕

How to flash: What we'll learn

- What **toolchain** you need (rustup + target + picotool/UF2)
- **Compile and flash** an RP2350 in only 3 steps (no 2-hour setup nightmare)
- Convert `.elf → .uf2`, drag-and-drop and you are running **Rust on the bare metal**
- **Demo:** blinking an LED

Setting up your Rust toolchain

1. Make sure Rust is installed via rustup.rs

   ```
   curl --proto '=https' --tlsv1.2 -sSf https://sh.rustup.rs | sh
   ```

2. Make sure the toolchain is up-to-date

   ```
   rustup update
   ```

3. Install the `thumbv8m.main-none-eabihf` target

   ```
   rustup target add thumbv8m.main-none-eabihf
   ```

RP2350 MCU Flashing Methods

Method 1: Online Conversion

Prerequisites: None

1. Go to elf2uf2.yrust.de[1]
2. Upload and convert your `.elf` file to `.uf2`
3. Put RP2350 into boot mode:
   - Hold **BOOTSEL** button
   - Power on
   - Release **BOOTSEL**
4. Drag & drop the `.uf2` file to the mounted drive
5. Device will automatically reset and run

Method 2: Bootloader and picotool

Prerequisites: picotool installed

1. Put RP2350 into boot mode:
   - Hold **BOOTSEL** button
   - Power on
   - Release **BOOTSEL**
2. Flash directly with picotool:

```
picotool load -u -v -x -t elf your_file.elf
```

3. Device will automatically reset and run

Method 3: Debug Probe

Prerequisites: Debugger + probe-rs installed

1. Connect debugger or second Pico to target RP2350
2. Flash and run with probe-rs:

```
probe-rs run --chip RP235x --protocol swd
your_file.elf
```

3. Device will be programmed and starts running automatically

Additional Notes

To erase the flash, you can use `picotool erase` or drag & drop the flash nuke utility: flash_nuke.uf2 (direct download, 96 kB)

[1]Our online tool elf2uf2.yrust.de simply executes `picotool uf2 convert your_file.elf your_file.uf2` - it's equivalent to having picotool installed locally but runs in the browser.

The Hello World of Firmware: Blinking an LED

```rust
// Set up GPIO (General Purpose Input/Output) pins
let sio = Sio::new(dp.SIO); // Single-cycle I/O block
let pins = hal::gpio::Pins::new(dp.IO_BANK0, dp.PADS_BANK0, sio.gpio_bank0, &mut dp.RESETS);

// Configure GPIO pin 25 as an output pin (this is where the onboard LED is connected)
let mut led = pins.gpio25.into_push_pull_output();

// Main program loop - runs forever
loop {
    led.set_high().ok(); // Turn the LED on (ignore any errors with .ok())
    delay.delay_ms(500); // Wait for 500 milliseconds (half a second)
    led.set_low().ok();  // Turn the LED off
    delay.delay_ms(500); // Wait for another 500 milliseconds
    // Loop continues, creating a blinking pattern: on 500ms, off 500ms, repeat
}
```

Repository available at github.com/systemscape/pico2-blink.

We have pre-built UF2-images in the repo so you can flash even if building fails.

Takeaway: ***You can put Rust on real hardware faster than you expect.***

Learning Outcome 2

Embedded Rust feels like Rust — not like C. 🤮

Rust stays idiomatic: What we'll learn

- What is a HAL and why does `embedded-hal` make Rust so **special**
- The borrow checker, traits and async patterns – they all **just work.**
- **Example:** Drivers and GPIOs

Embedded-HAL

```rust
// Embedded-HAL defines SpiDevice
pub trait SpiDevice {
    fn read(&mut self, buf: &mut [u8]);
    fn write(&mut self, buf &[u8]);
}

// MCU HAL creates SpiDevice
impl SpiDevice for McuSpi {
    fn read(&mut self, buf: &mut [u8]) {
        // HAL abstracts away register access
        pac::spi_control_register::write(0x01);
    }
}

// Driver consumes SpiDevice
impl<T: SpiDevice> Driver<T> {
    pub fn new(spi_device: T) -> Self { ...}
    pub fn foo(&mut self) { self.spi_device.read(); self.spi_device.write(); }
}
```

Embedded-HAL

- App logic can use **different drivers**
- App logic can use **different HALs**
- Only **requirement:** everyone implements `embedded-hal` traits

→ Using a **different HAL** lets you use a **different chip** (even different CPU architecture!)

Generic Async Code? In `#[no_std]`?

```rust
#[embassy_executor::main]
async fn main(spawner: Spawner) {
    let p = embassy_rp::init(Default::default());
    let led = Output::new(p.PIN_25, Level::Low);
    spawner.spawn(blink(led)).unwrap(); // Returns immediately
}
// One of many embassy tasks
#[embassy_executor::task]
async fn blink(led: Output<'static>) {
    generic_blink(led, embassy_time::Delay {}).await;
}
// `led` and `delay` must implement embedded-hal traits
async fn generic_blink(mut led: impl OutputPin, mut delay: impl DelayNs) {
    loop {
        led.set_high().unwrap();
        delay.delay_ms(500).await; // No busy waiting!
        led.set_low().unwrap();
        delay.delay_ms(500).await;
    }
}
```

Takeaway:

You don’t need to “unlearn” Rust to do embedded.

Learning Outcome 3

Scale without pain: async & tooling to keep you sane 📈

You can move forward without losing your mind: What we'll learn

- Async and `embassy` make concurrency predictable and power-friendly.
- Tooling (`cargo`, `probe-rs`, `defmt`) reduces trial-and-error time.
- Going forward: Further learning resources
- **OnMCU** for CI/CD and real project workflows

Takeaway:

Developing embedded systems has never been easier and more fun!

Contact

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www.onmcu.com

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