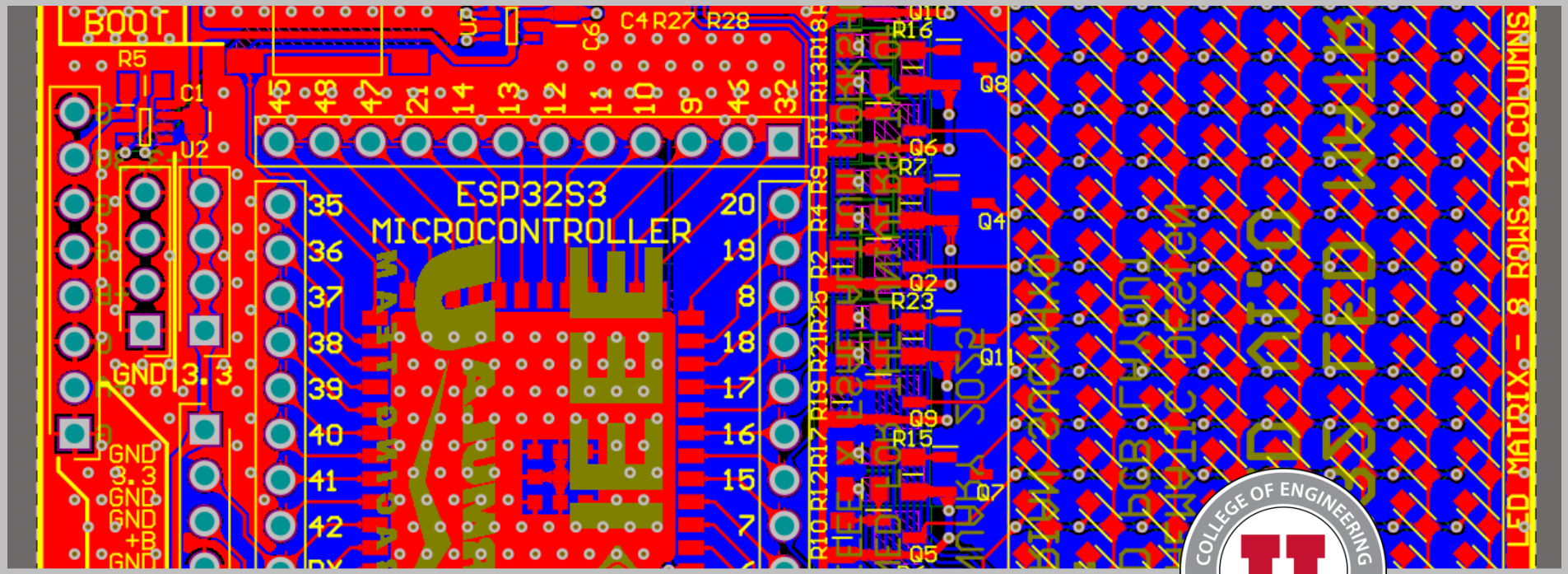
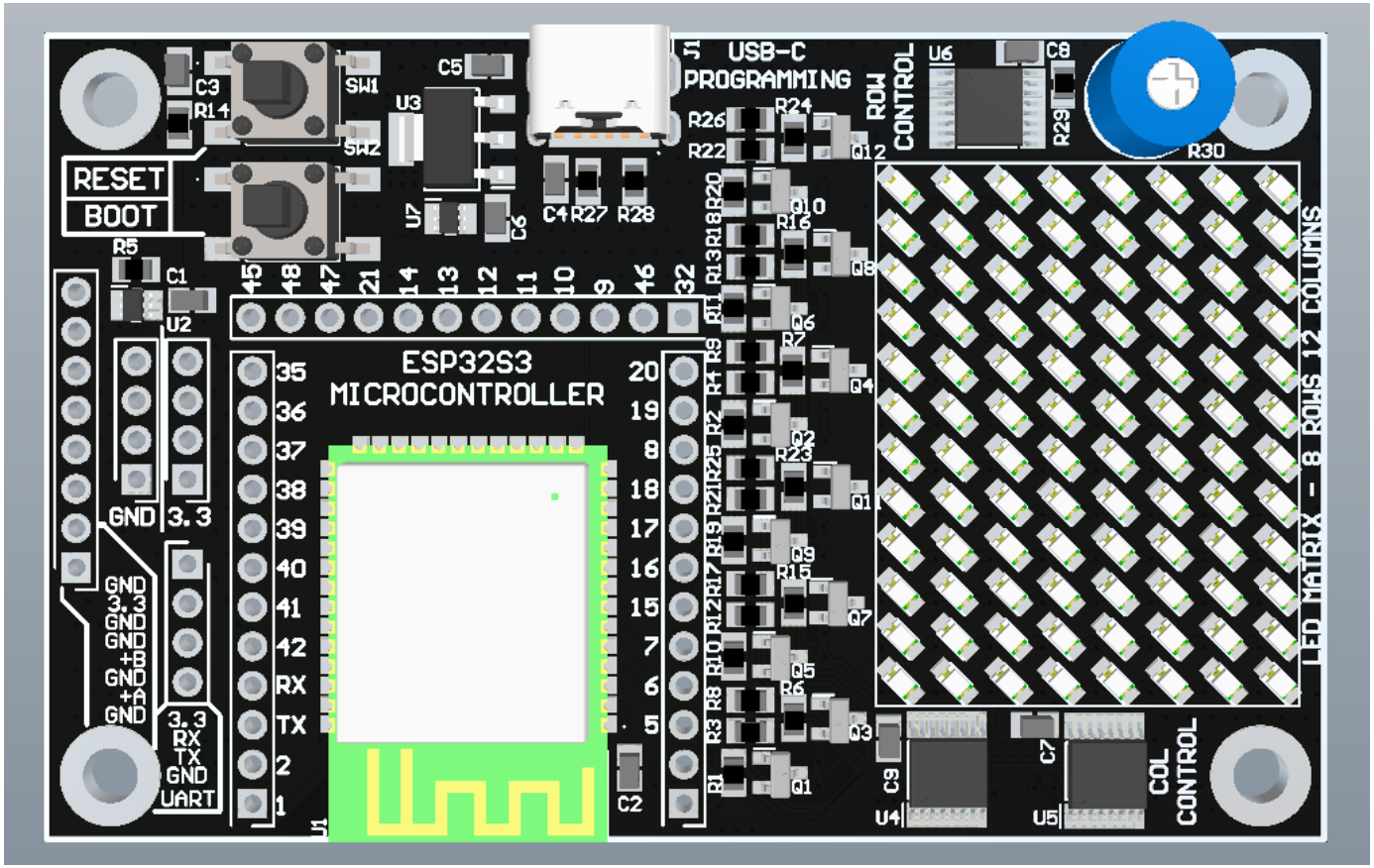
IEEE X FSAE PCB Design Workshop: (Week 03)

Intermediate Printed Circuit Board Design (LED Matrix)



Hosted By: Adrian Sucahyo and Nick Howard

Project Overview



- Features Programmable Microcontroller
- LED Matrix Peripheral

Microcontroller Overview

- LED Matrix based on ESP32S3
  - Simple to design around
  - Beginner friendly
    - (Arduino Framework or esp-idf)
  - More advanced that ATMEGA328p
  - Many additional features
    - WiFi
    - Bluetooth
    - USB OTG

Microcontroller Design Guidelines

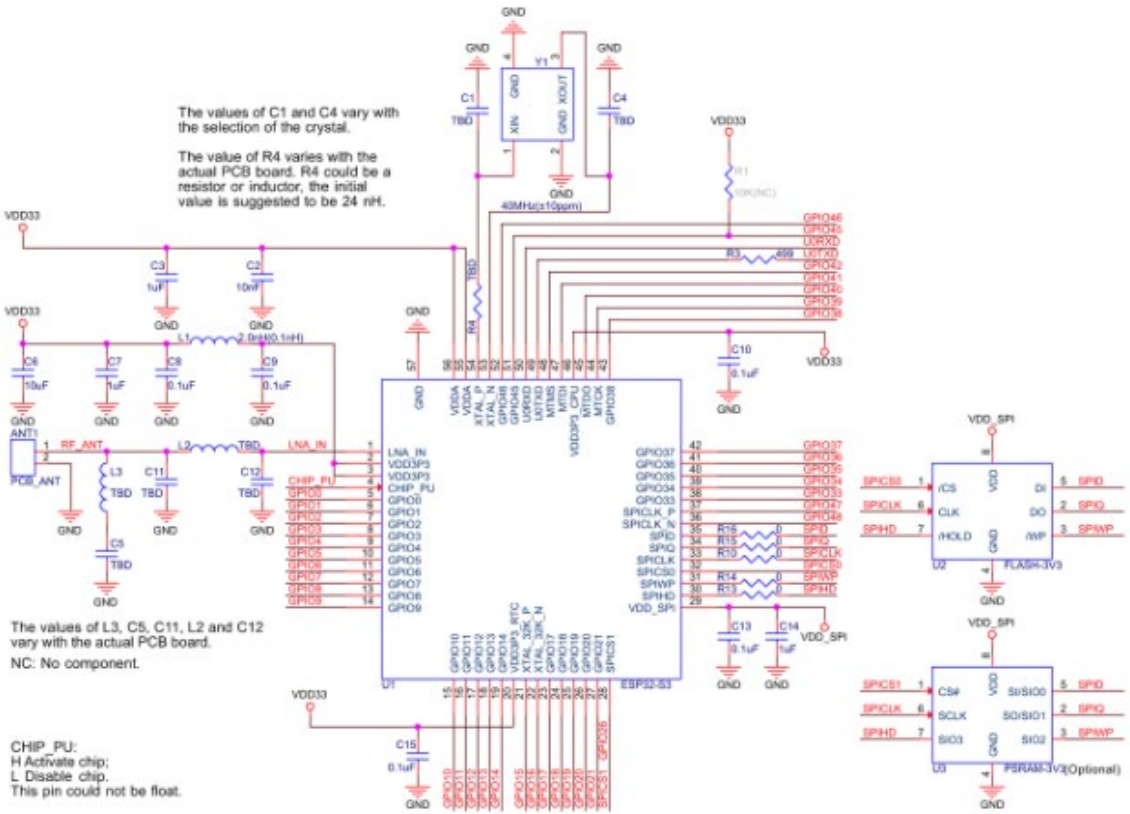
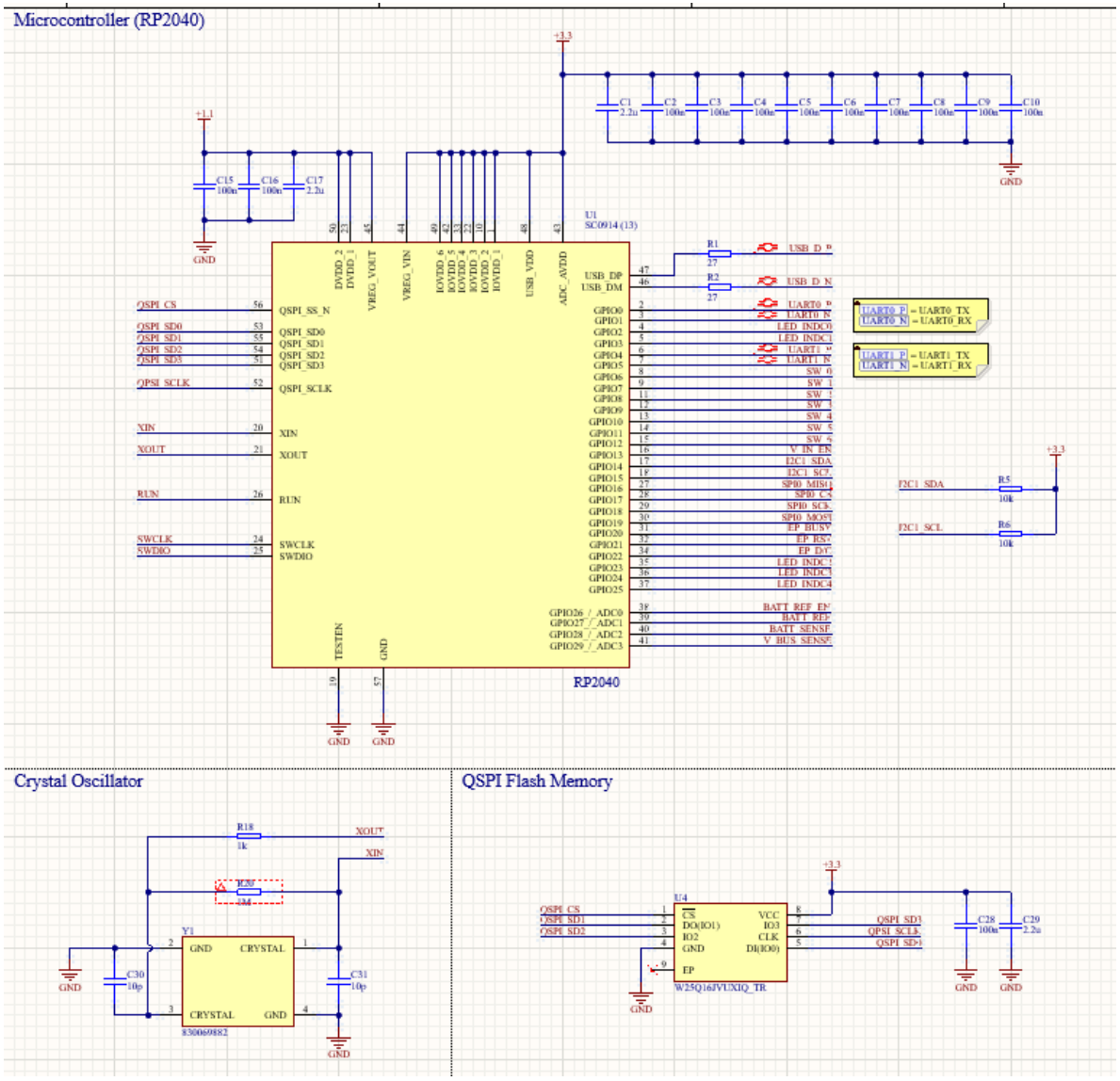


Fig. 1: ESP32-S3 Reference Schematic

https://docs.espressif.com/projects/esp-hardware-design-guidelines/en/latest/esp32s3/esp-hardware-design-guidelines-en-master-esp32s3.pdf

Other Microcontroller Designs (RP2040)



- Many filtering capacitors
- Routing a Clock
- External Flash Storage and Routing

Microcontroller Design Guidelines

- We don’t want to focus on designing an ESP32S3 microcontroller circuit from scratch.
  - Many extra components
  - Sensitive data lines
  - Someone has already designed if for us
- Use the ESP32S3 Module!

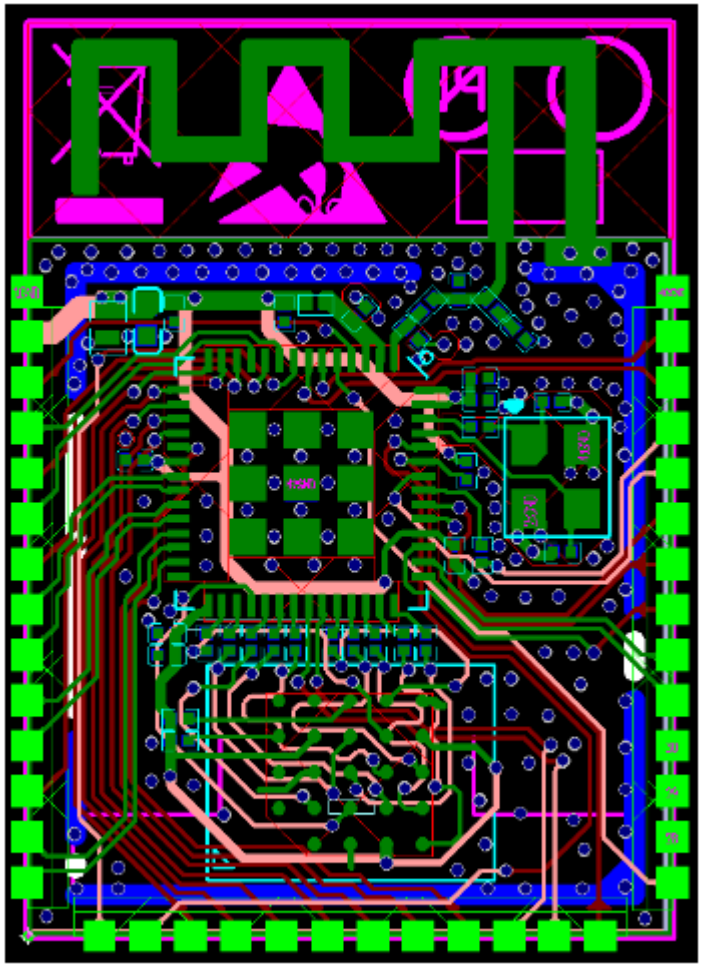
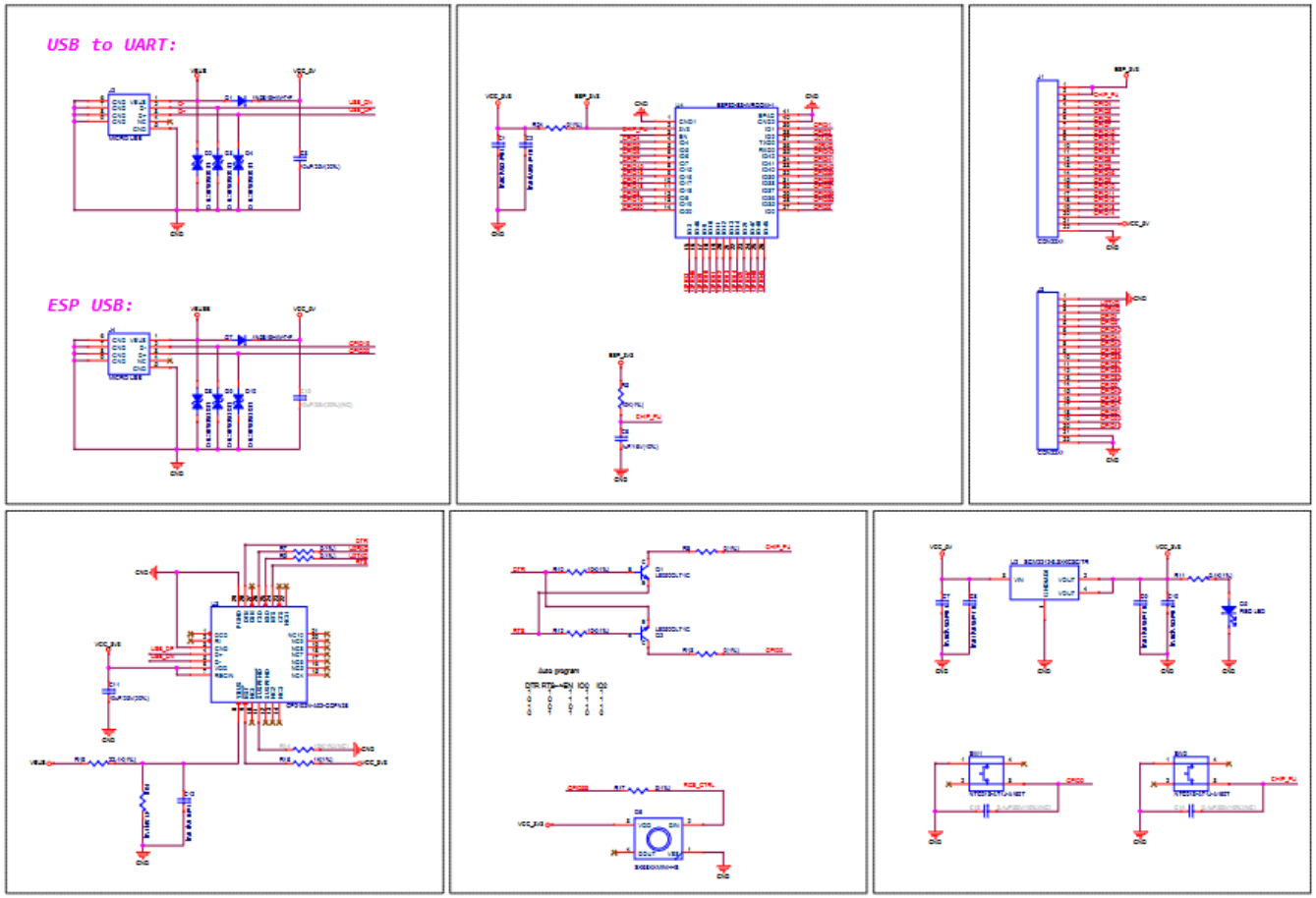


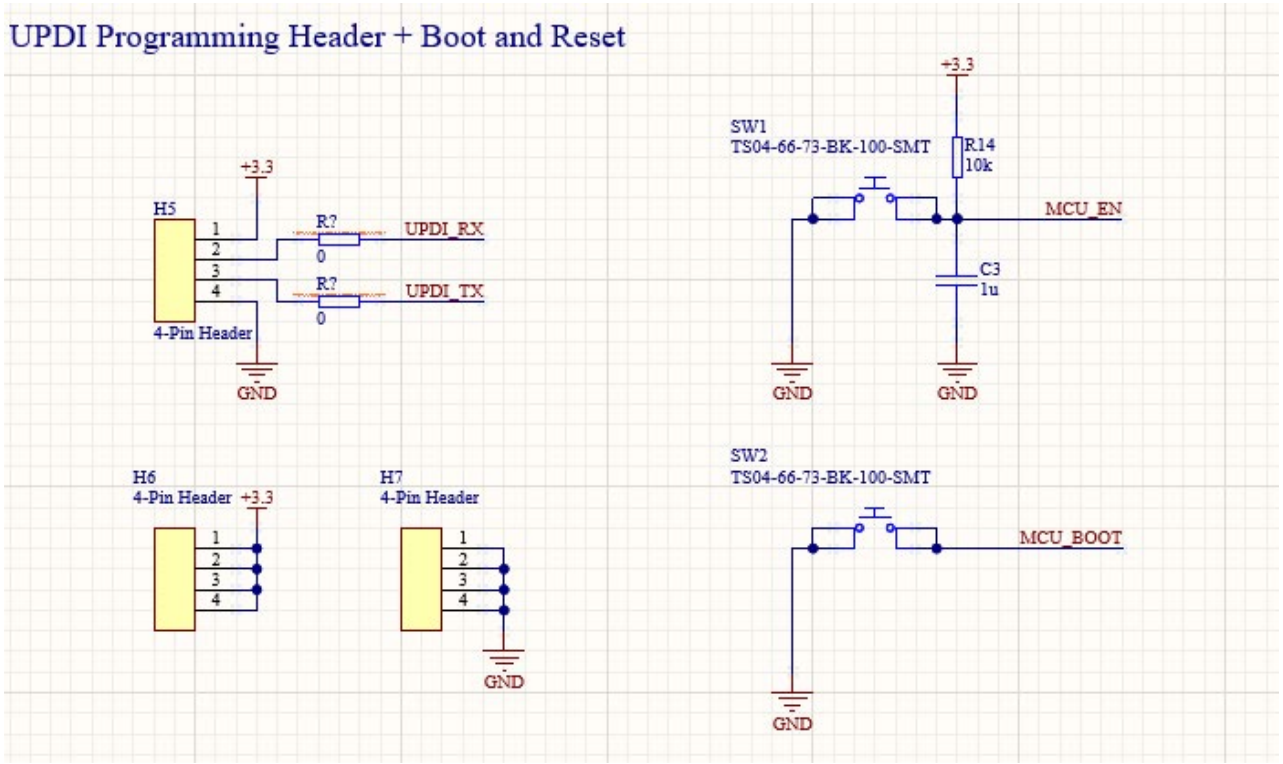
Fig. 1: ESP32-S3 Reference PCB Layout

ESP32S3 DevKit as Reference



https://dl.espressif.com/dl/schematics/SCH_ESP32-S3-DevKitC-1_V1.1_20220413.pdf

ESP32S3 Module Support Circuitry



- MCUs must know when they are being programmed and when they are being run.
- Bootstrapping signals tell the ESP32S3 how to boot

Power Supply Restrictions

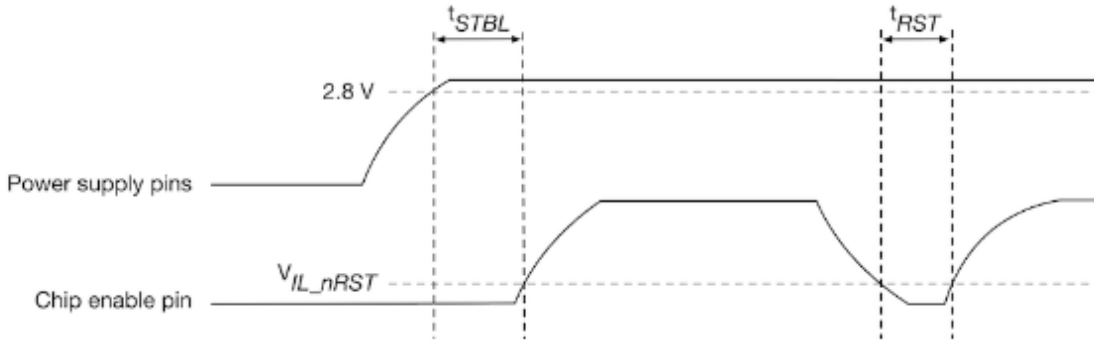
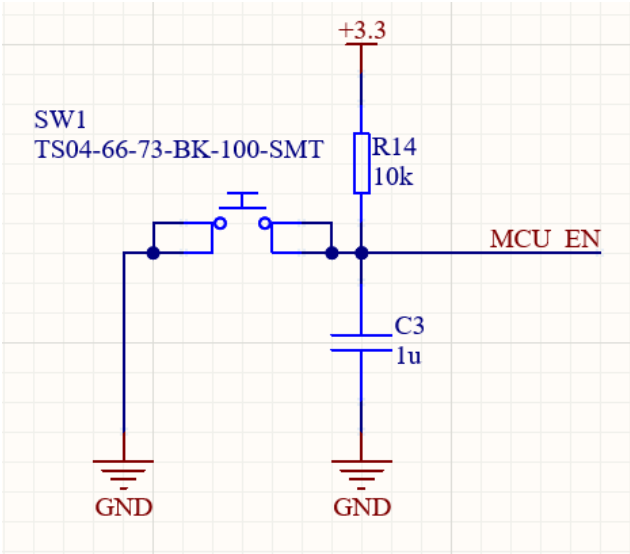


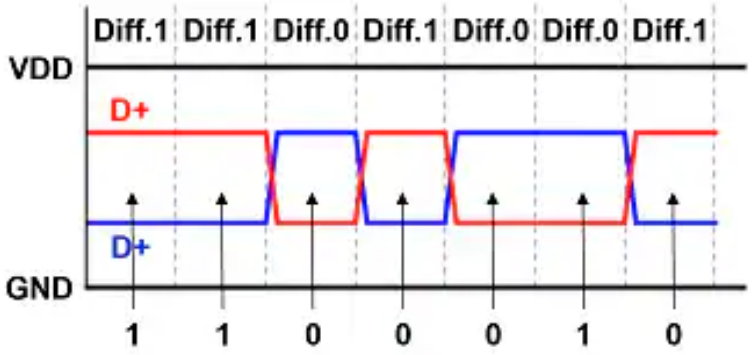
Fig. 6: ESP32-S3 Power-up and Reset Timing



- To ensure the ESP32S3 boots into the correct mode, there are timing restrictions on the power supply voltage rise times (ensure that the line is stable).
- Bootstrapping (EN and BOOT) also need sharp edges.

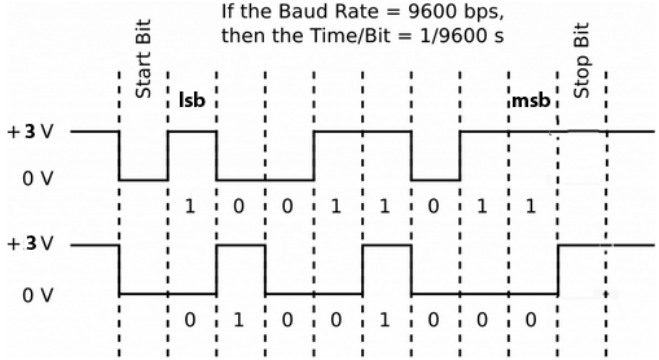
Programming

- ESP32S3 can be programmed over USB and UART
  - USB is a differential signal and needs to have D+ and D- traces length mapped.



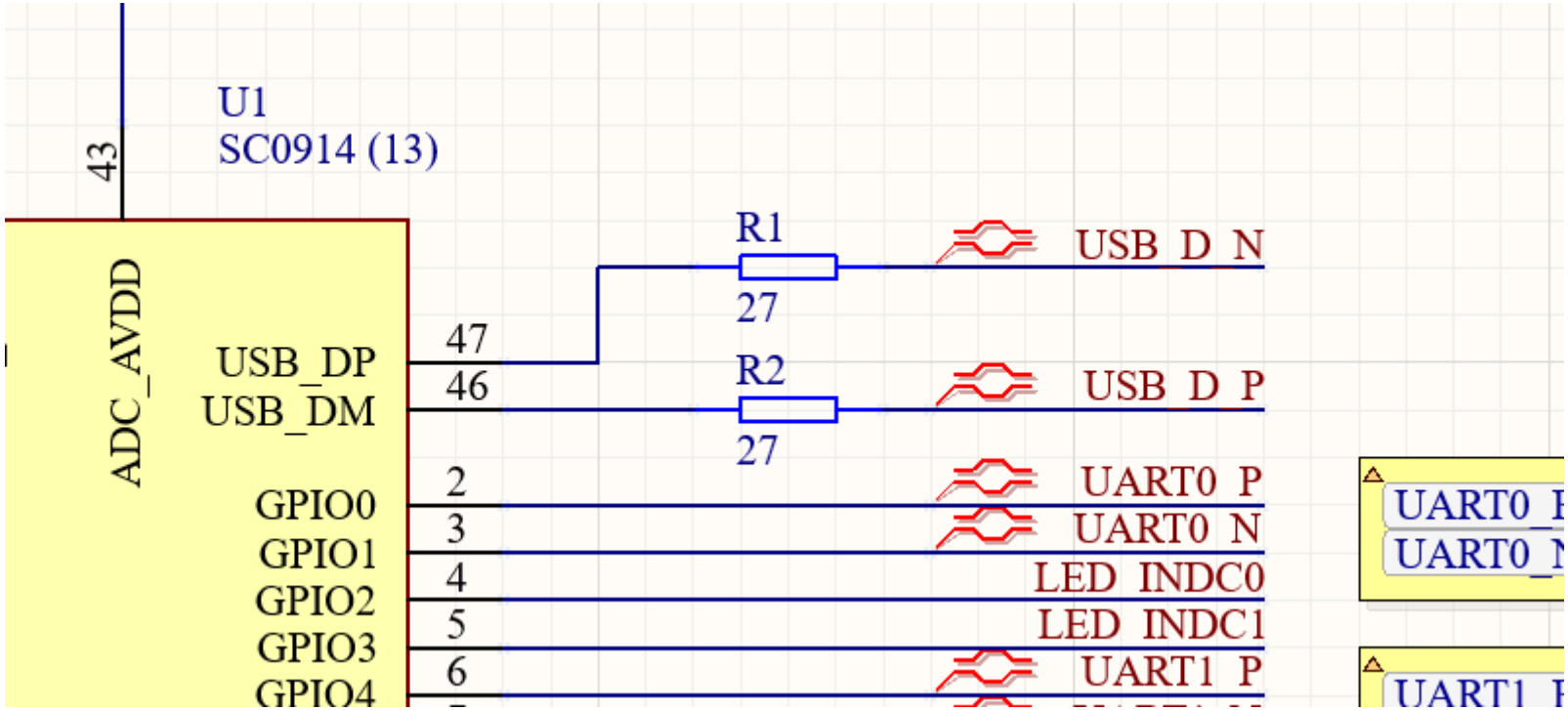
https://toshiba.semicon-storage.com/us/semiconductor/knowledge/e-learning/village/usb-interface-1.html

  - UART uses TX and RX, not differential



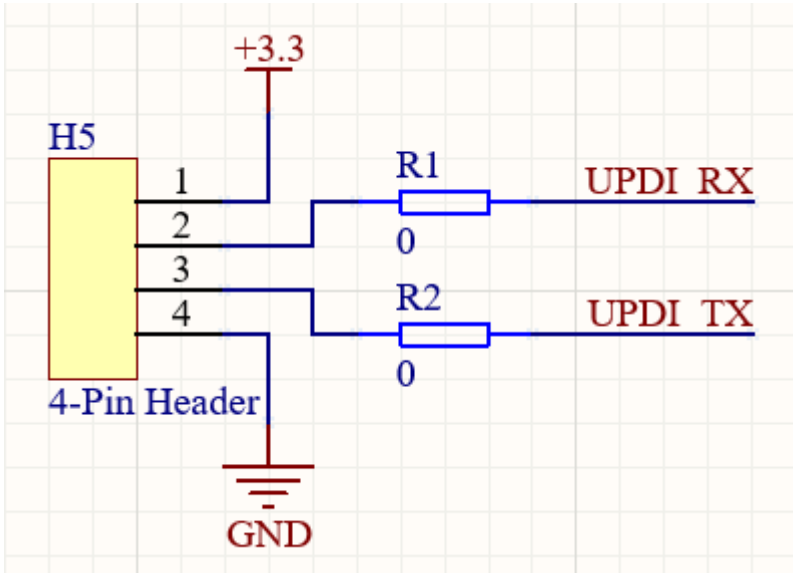
https://people.ece.cornell.edu/land/courses/ece4760/PIC32/index_UART.html

What's the issue?

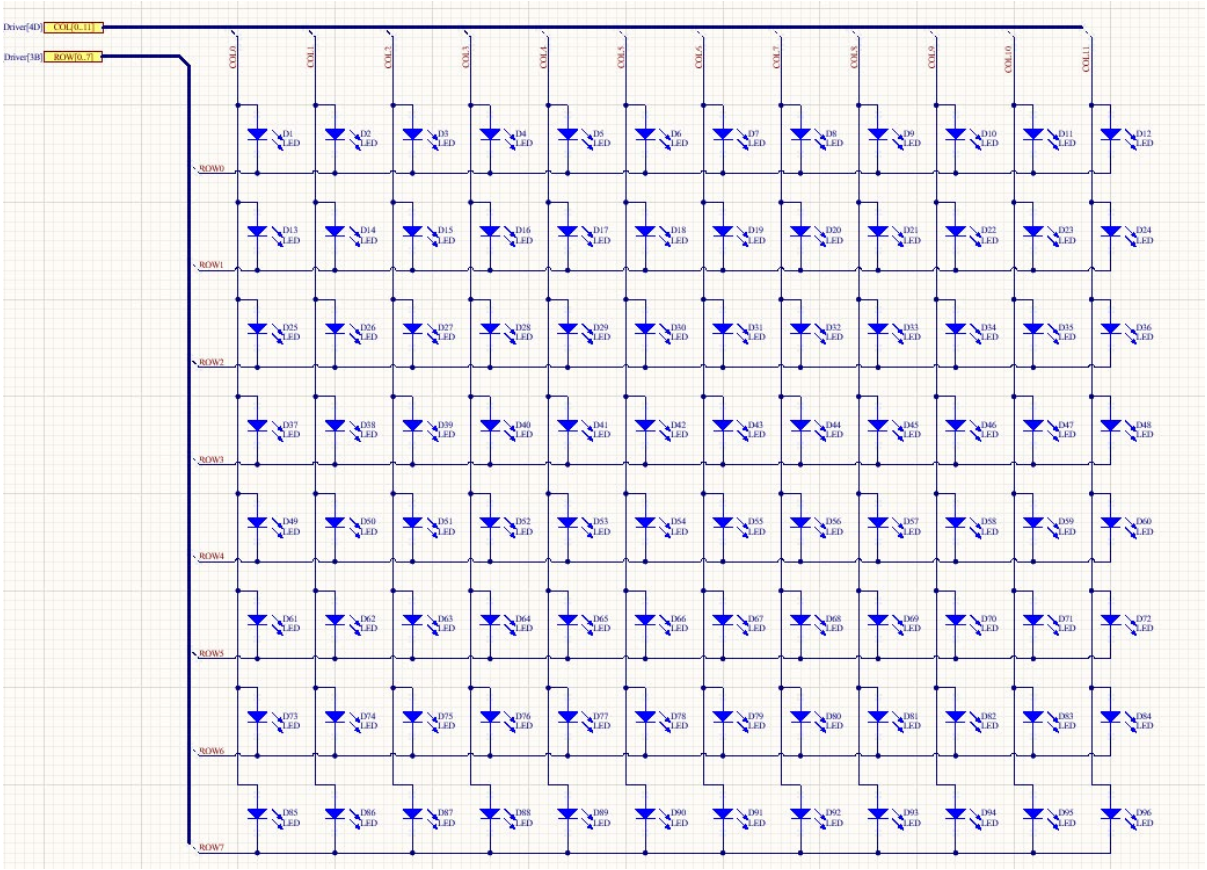


Double Check Your Signals!

- Design in ways to fix errors if you make them!
  - Jumpers are a great way to allow for easier fixes!
  - Can also be used to disconnect signals from their source / destination
- Swapping USART signals is common enough for STM to design in a software swap.

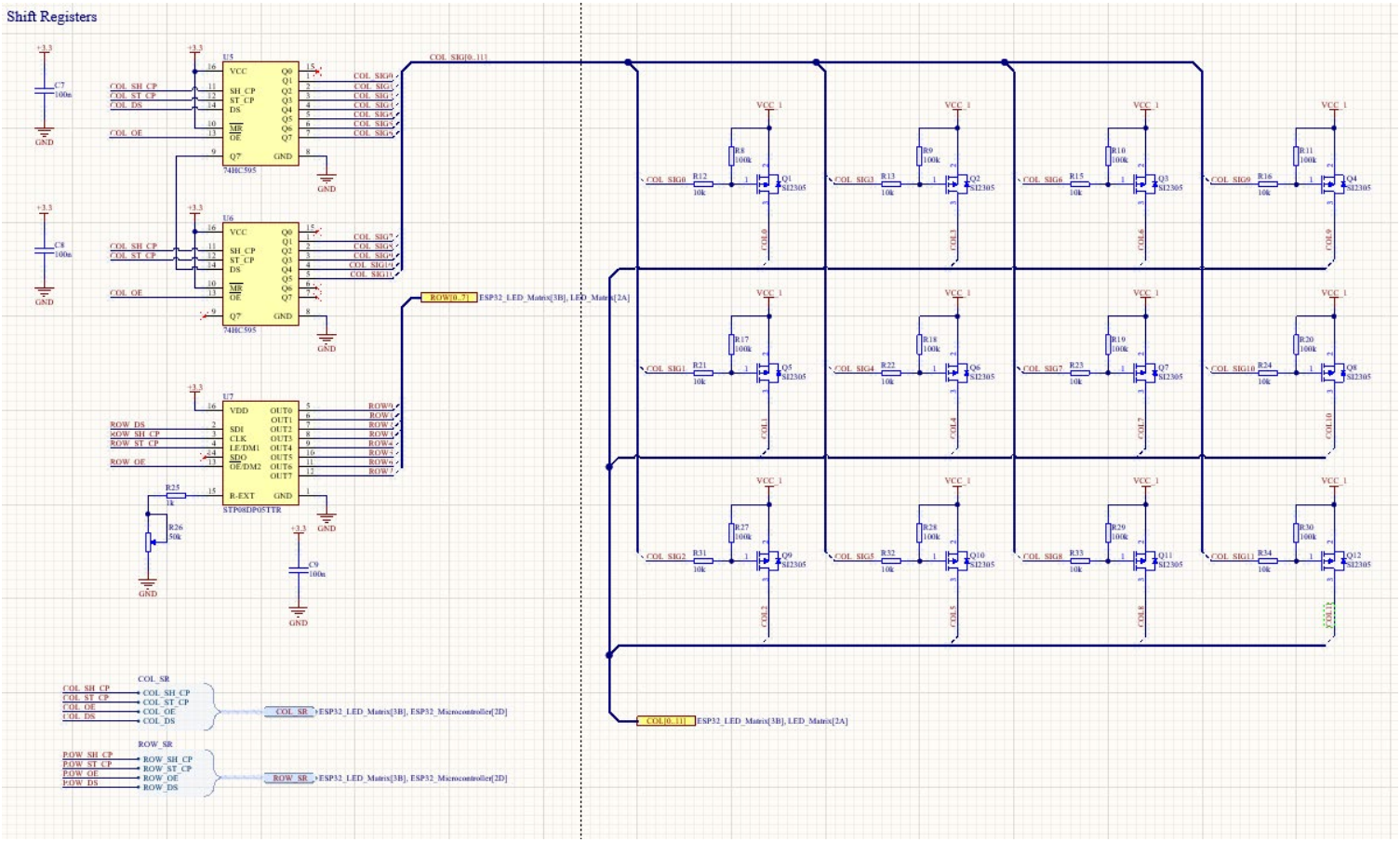


Peripheral: LED Matrix



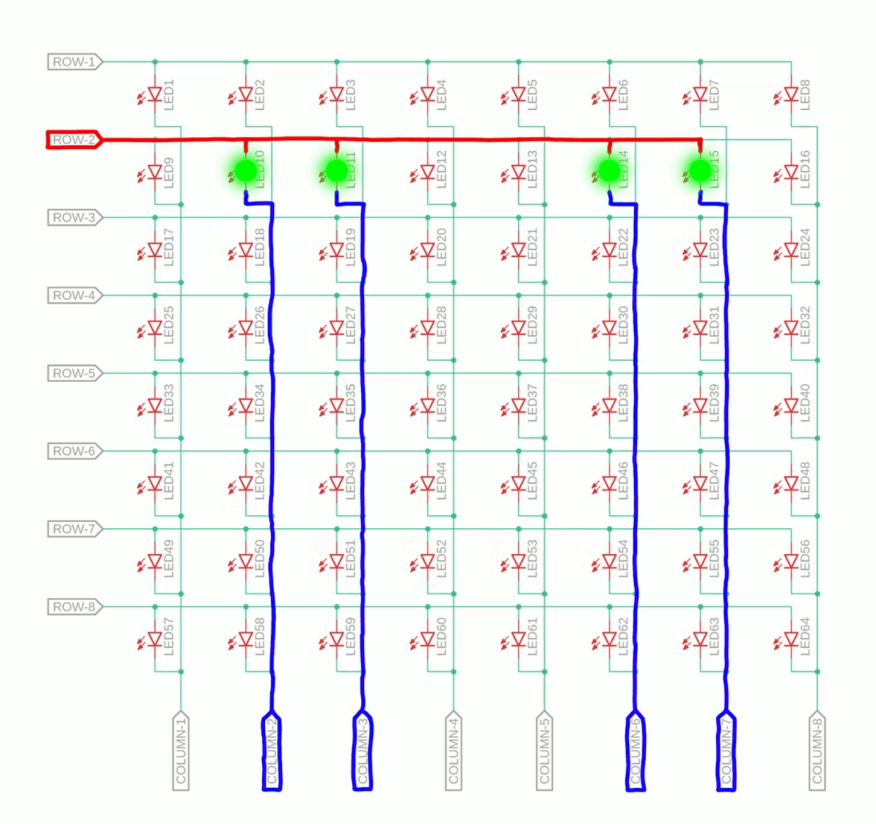
- Common Row and Column Lines with bridged with LEDs
- Allows for “selection” of any particular LED

LED Matrix Driver



- Driver provides the current to power all LEDs
- Uses shift registers to minimize input on GPIO

Multiplexing



- By selecting LEDs fast enough, an “image” can be drawn across the matrix.

https://www.friendlywire.com/tutorials/max7219/

Questions?

Questions?

Other Topics for Today

- Intro to Schematic Symbol Creation
- Intro to Hierarchal Design
- Wiring Harnesses and Busses
- Differential Signals

- Workshop Timeline Updates and Alternate Design Inquiry

Download Today's Project Files

Navigate to the workshop GitHub and download today's files listed under Week03

https://github.com/AdrianSucahyo/IEEE-PCB-Workshop-Resources-2025