

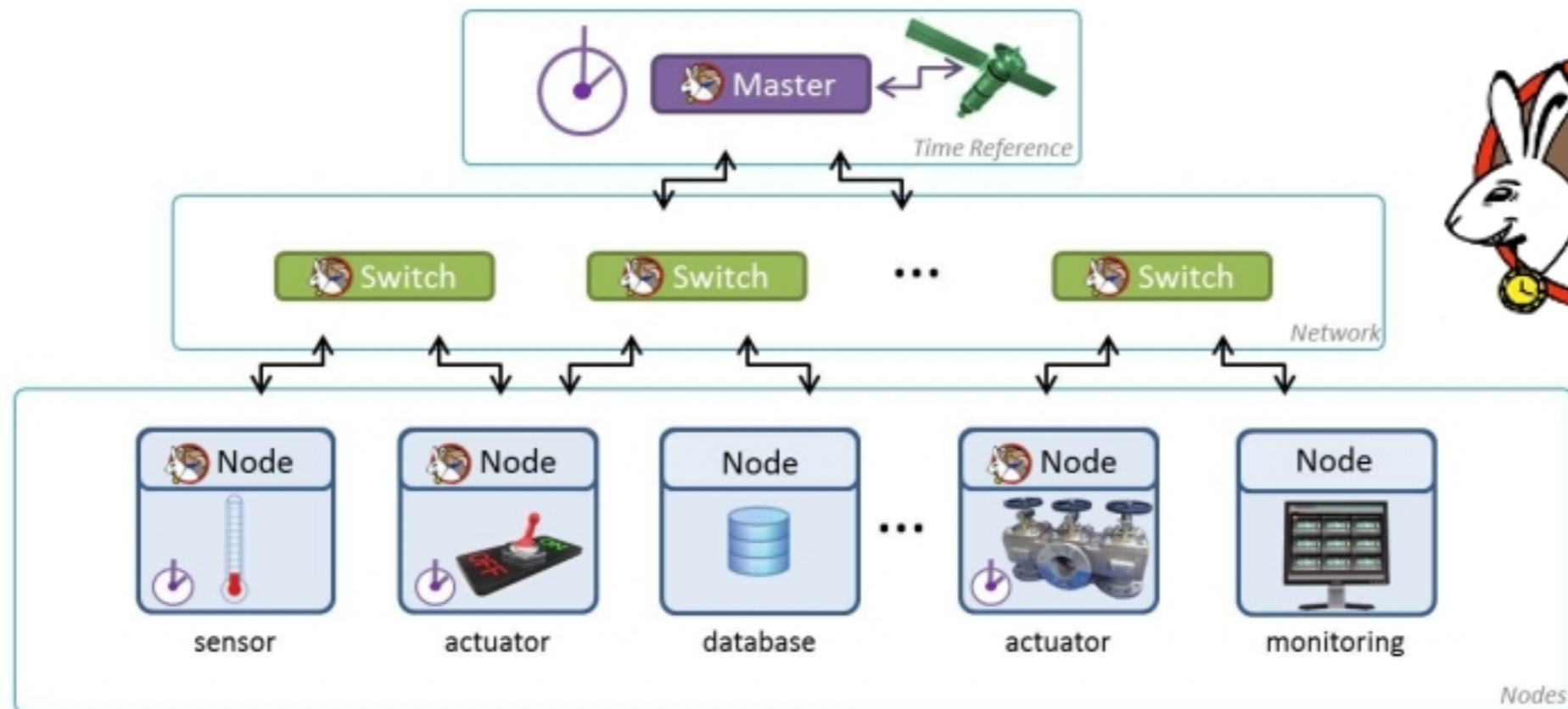
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**A TDC device**

# A network with absolute timestamps

## The White Rabbit network (CERN, GSI, ...)

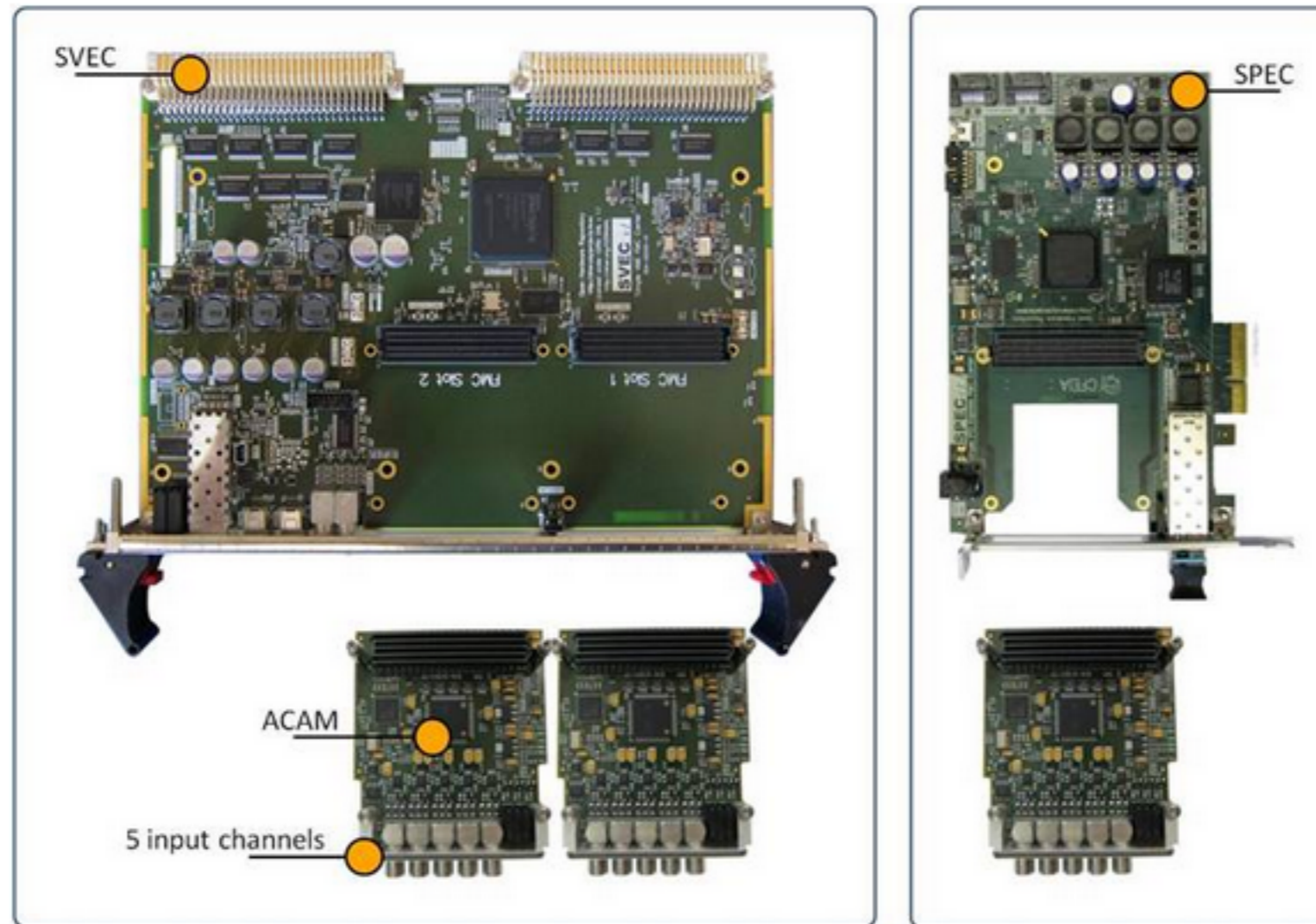
- It distributes absolute time with WR-PTP, from Cesium+GPS
- It supports a wide set of devices



# A real TDC device

## FMC Time to Digital Converter | FMC TDC 1ns 5cha

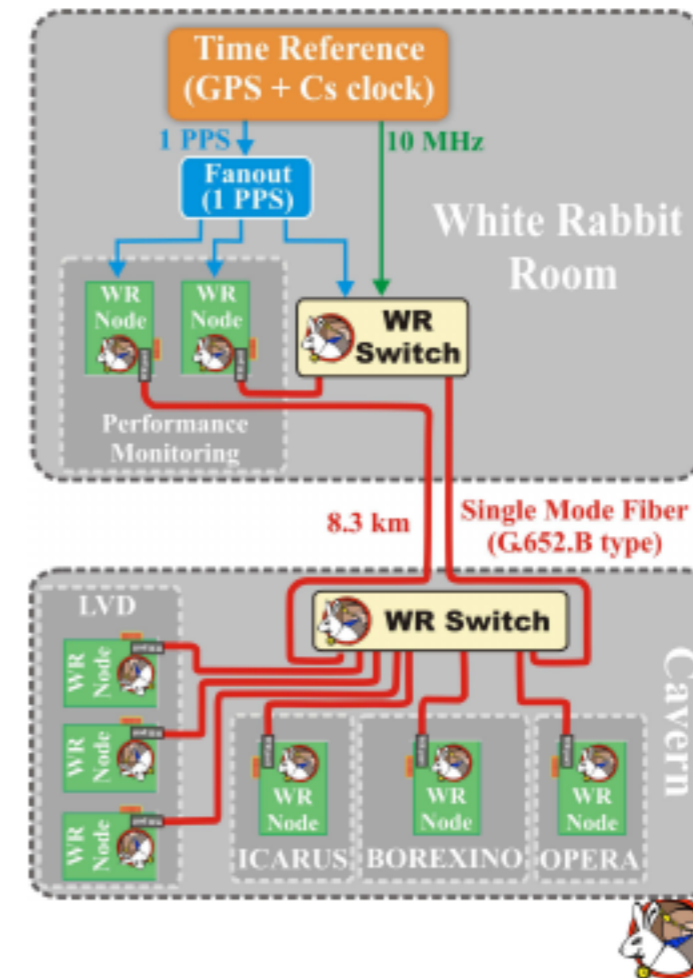
The FMC TDC 1ns 5cha Time to Digital Converter mezzanine board houses 5 input channels. It can calculate time differences between pulses arriving to the channels with a precision of  $\pm 700$  ps. It can be carried by any of the carrier boards: [SPEC](#) or [SVEC](#). It is implemented using a dedicated time-to-digital converter chip from the European company [ACAM](#).



# Real-world use of TDC, within WR

## WR installation

- Grandmaster WR Switch
- 8 km of fiber between switches
- Boundary Clock WR Switch
- WR Node – includes Time-to-Digital Converter (TDC):
  - 55 ps precision (std. dev)
  - 300 ps accuracy
- Performance monitoring



# My own fun project (designed using kicad)

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## GPS-disciplined

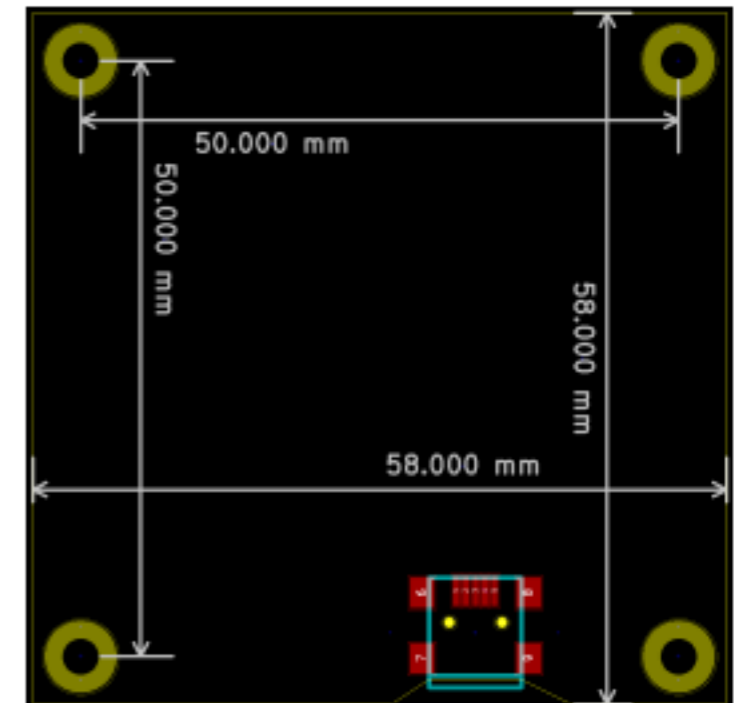
- I take 1pps input from GPS

## Based on a 32-bit microcontroller

- Internal flash and RAM, no external components
- Large enough to be soldered in-house

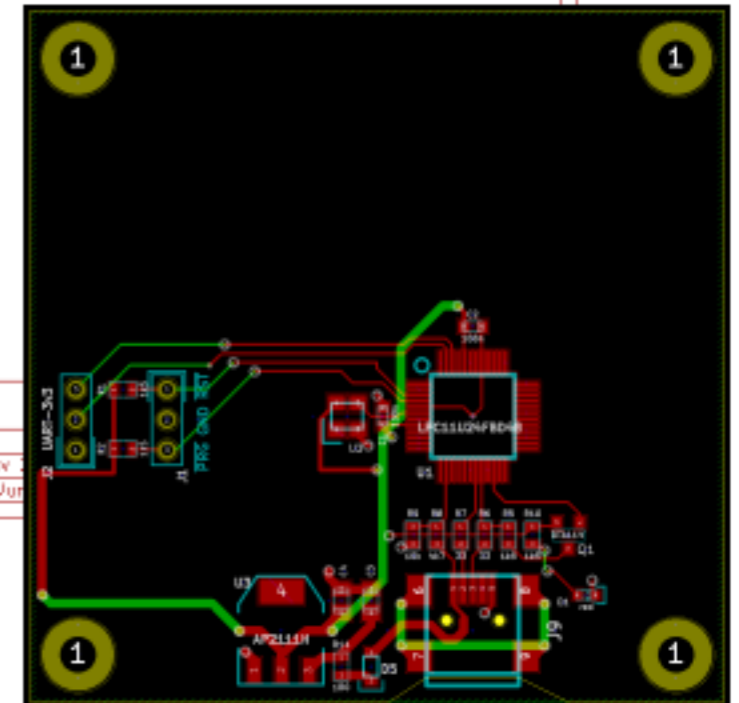
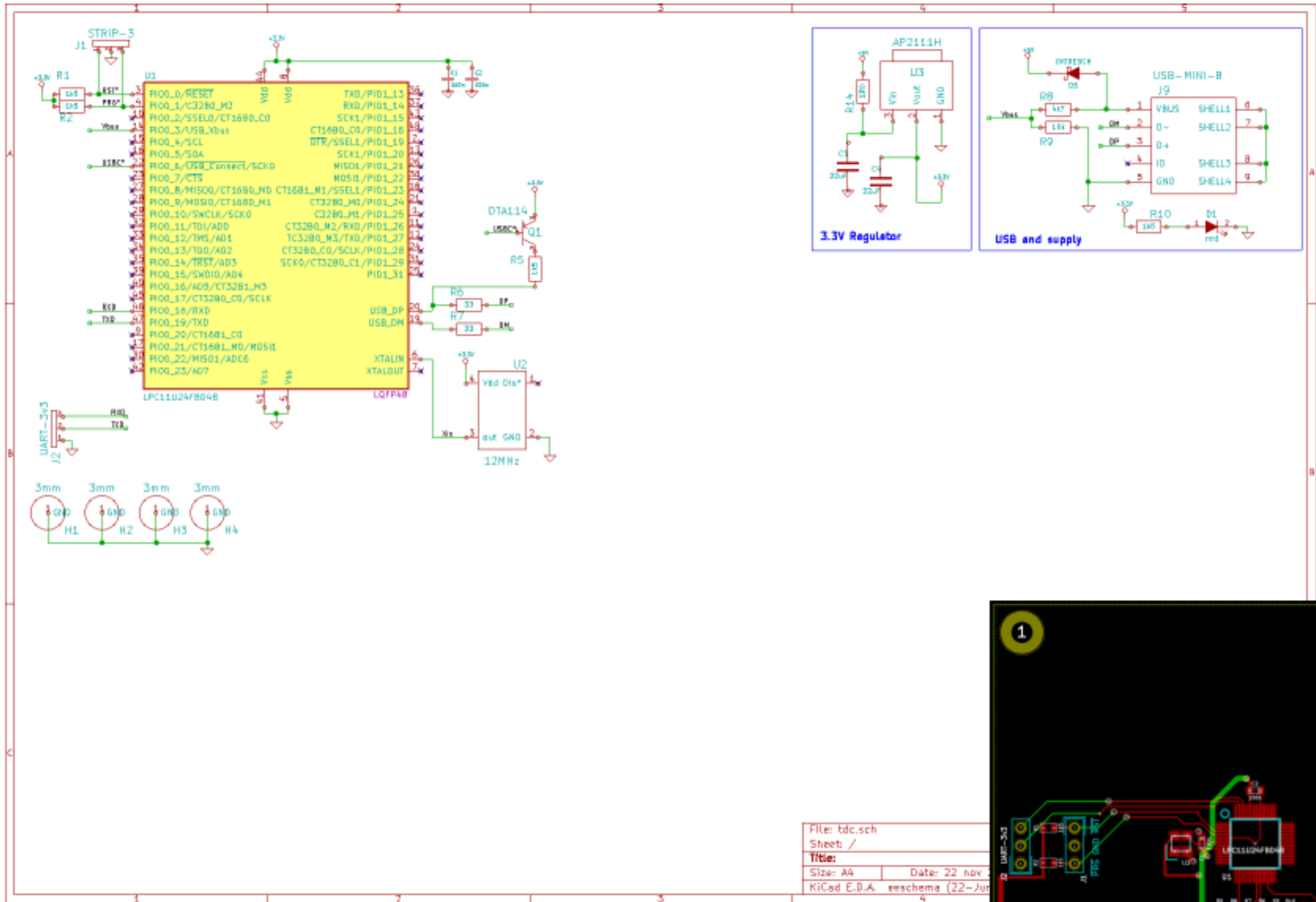
## USB or UART connected

- It reports to a host, needed anyways

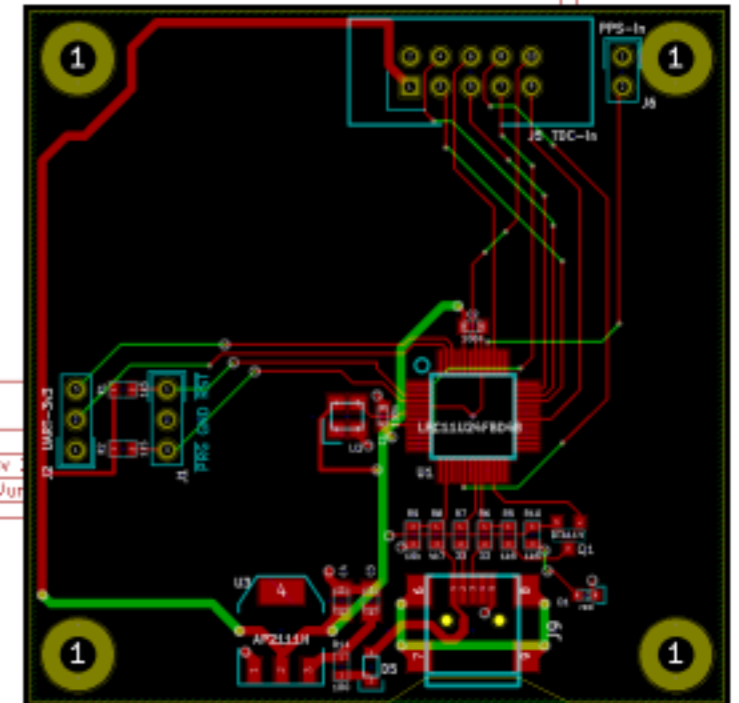
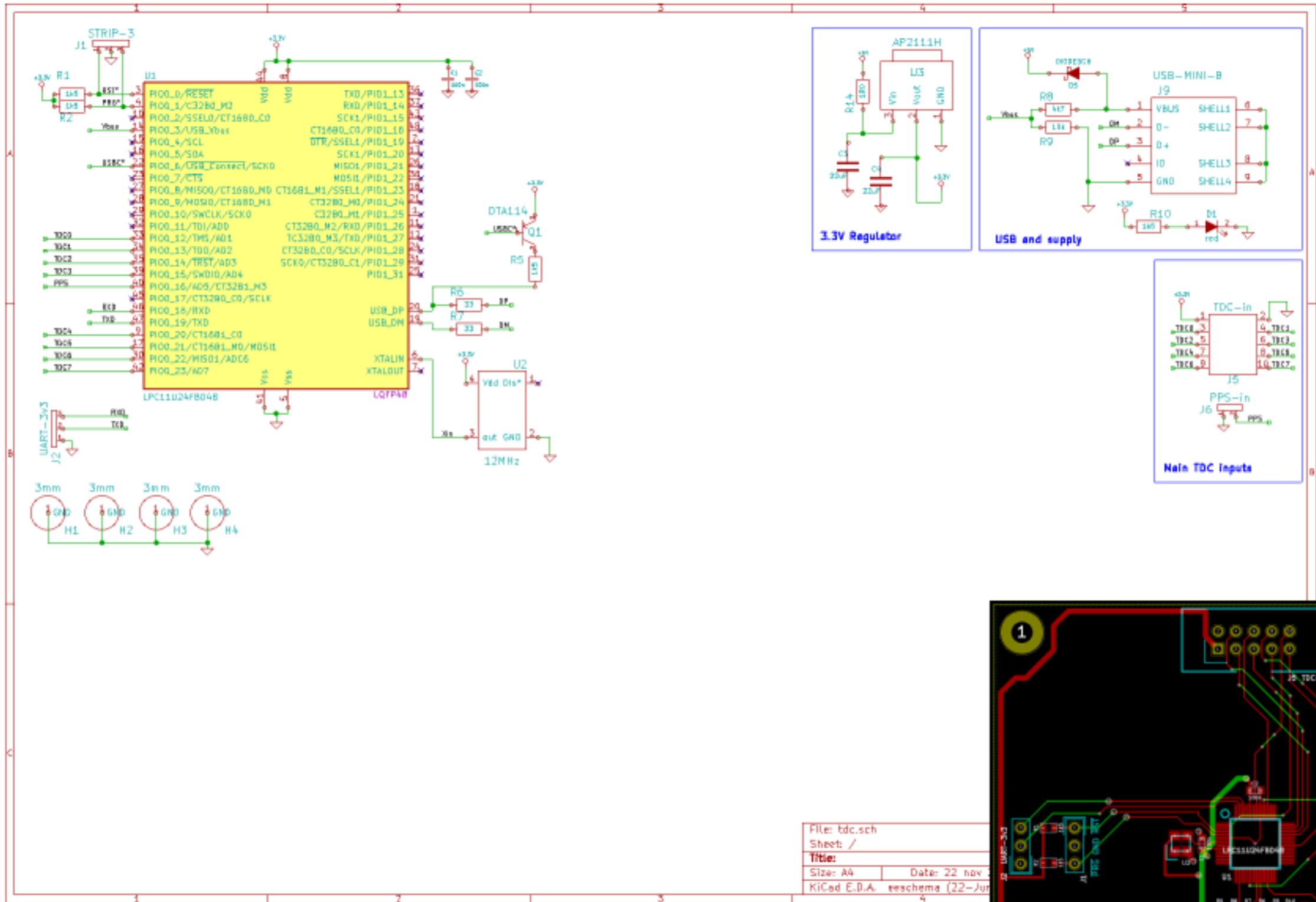




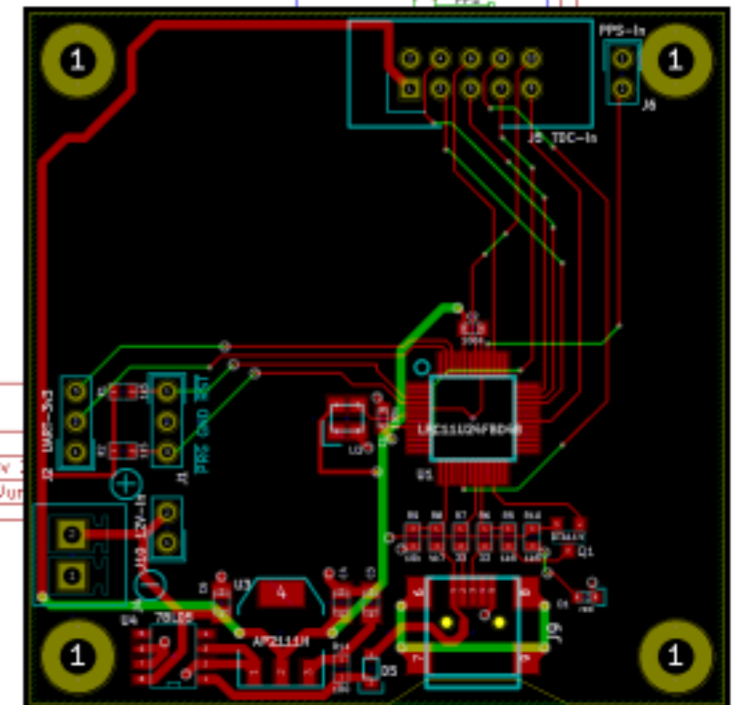
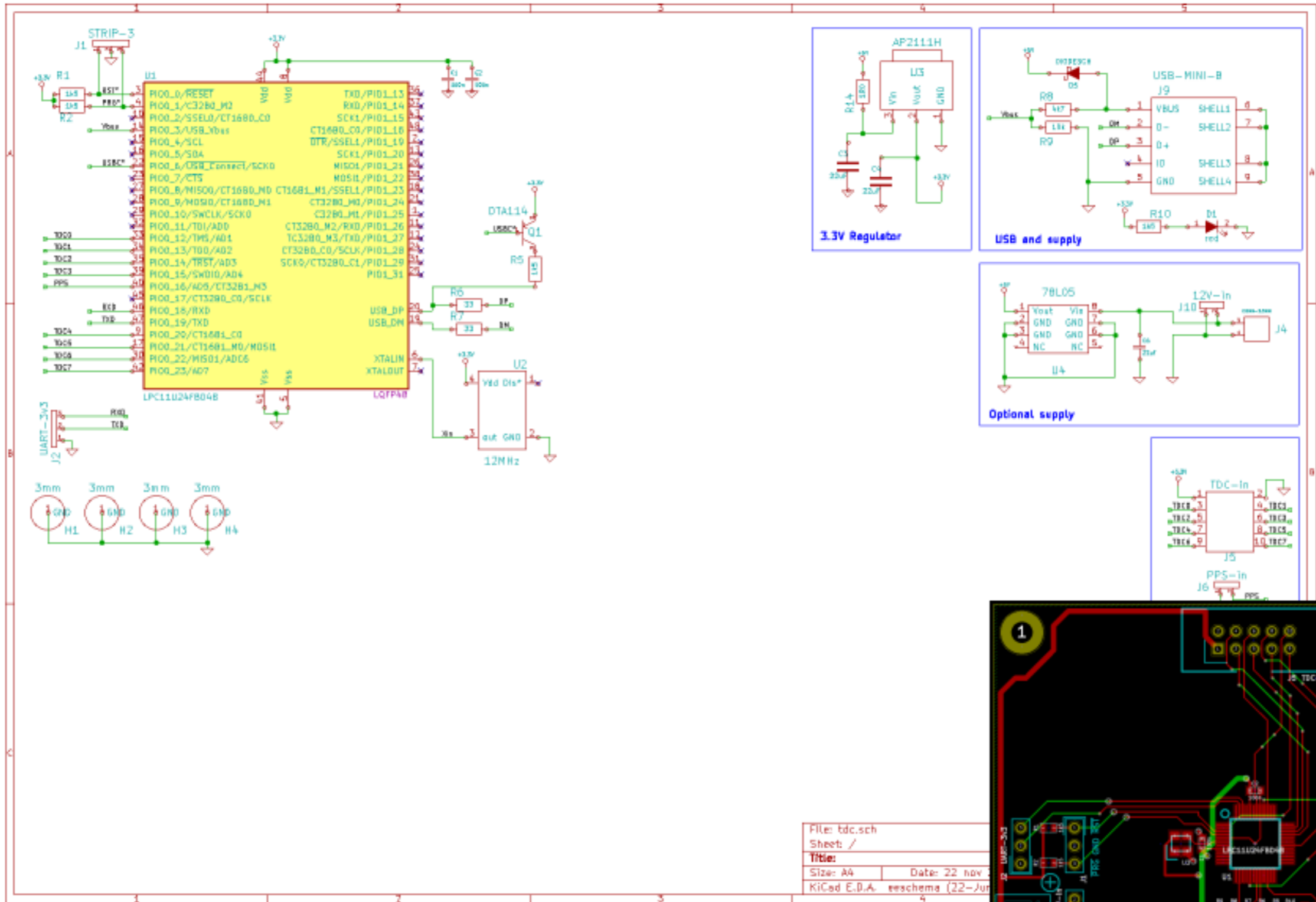
# Microcontroller and USB power/data



# TDC and PPS connectors

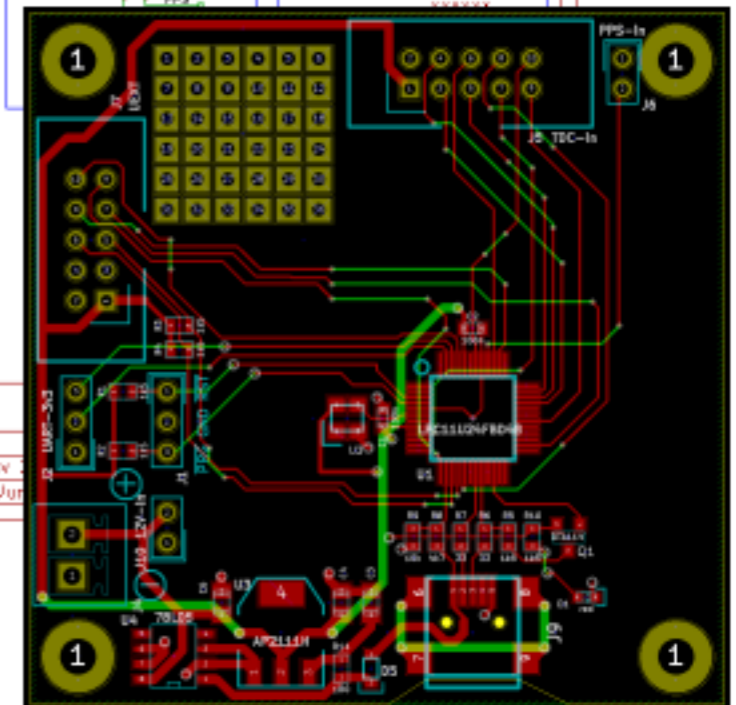
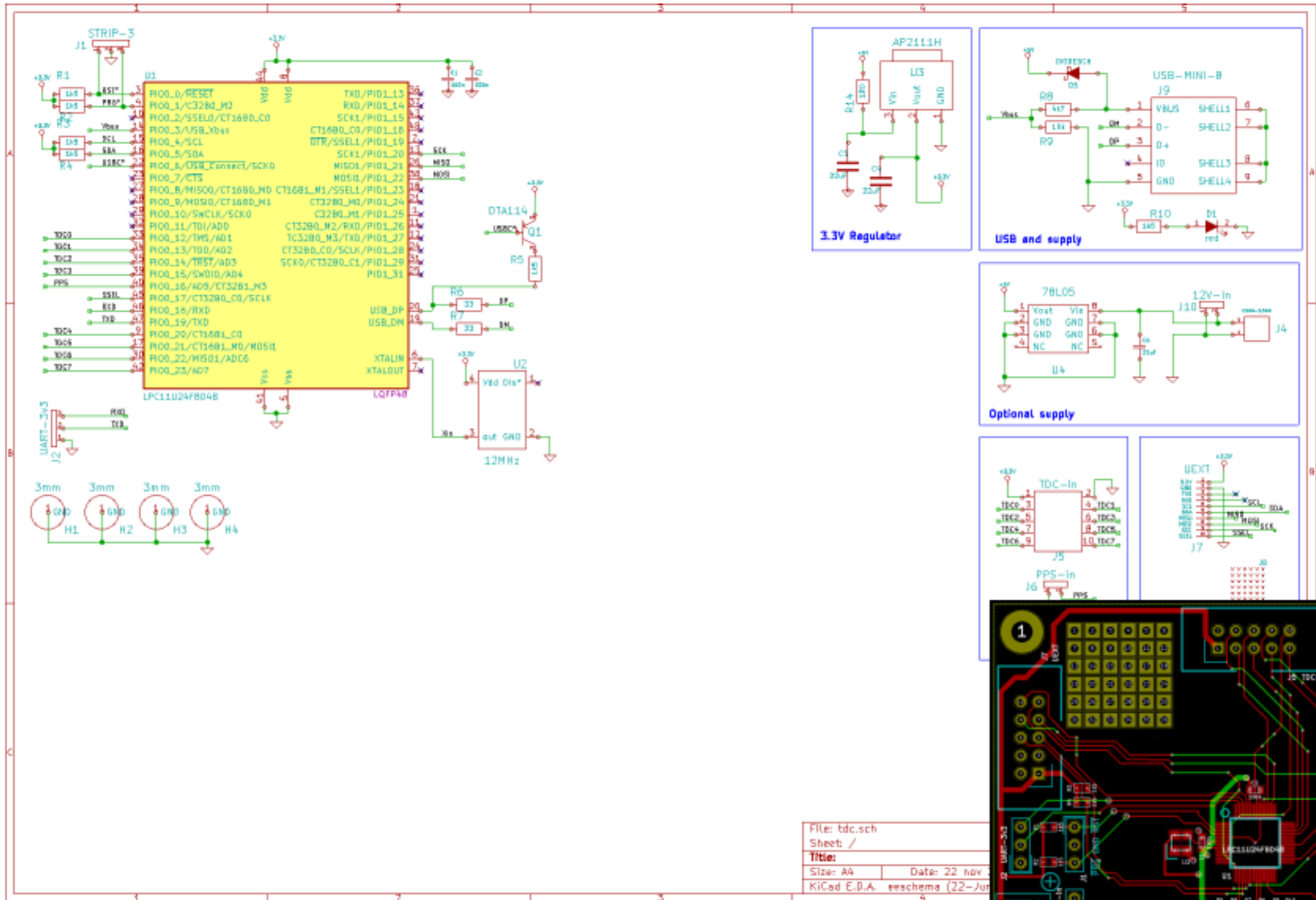


# 12V power supply

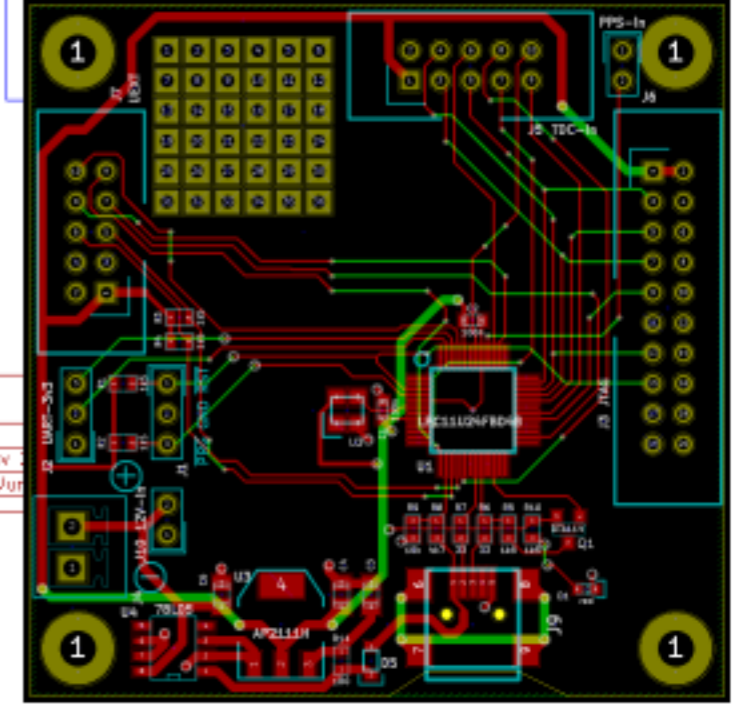
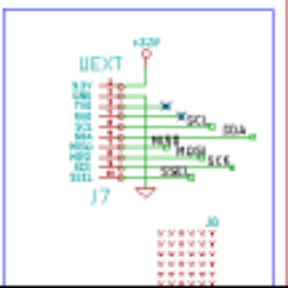
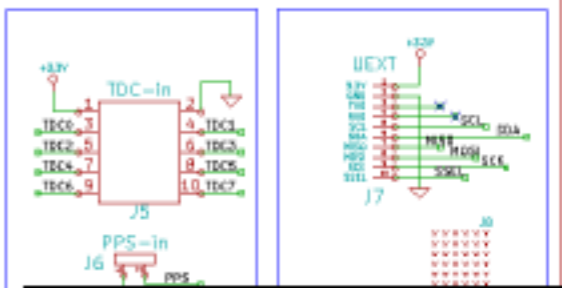
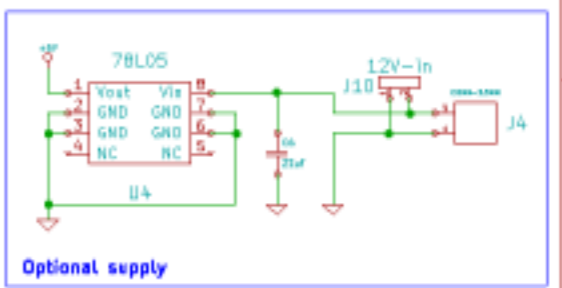
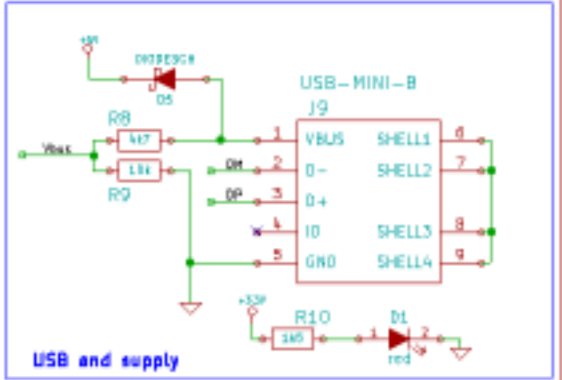
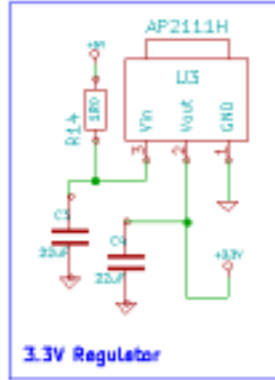
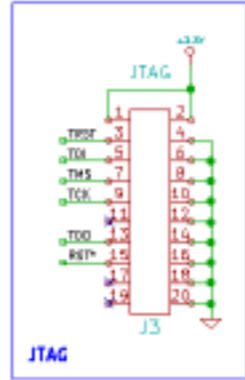
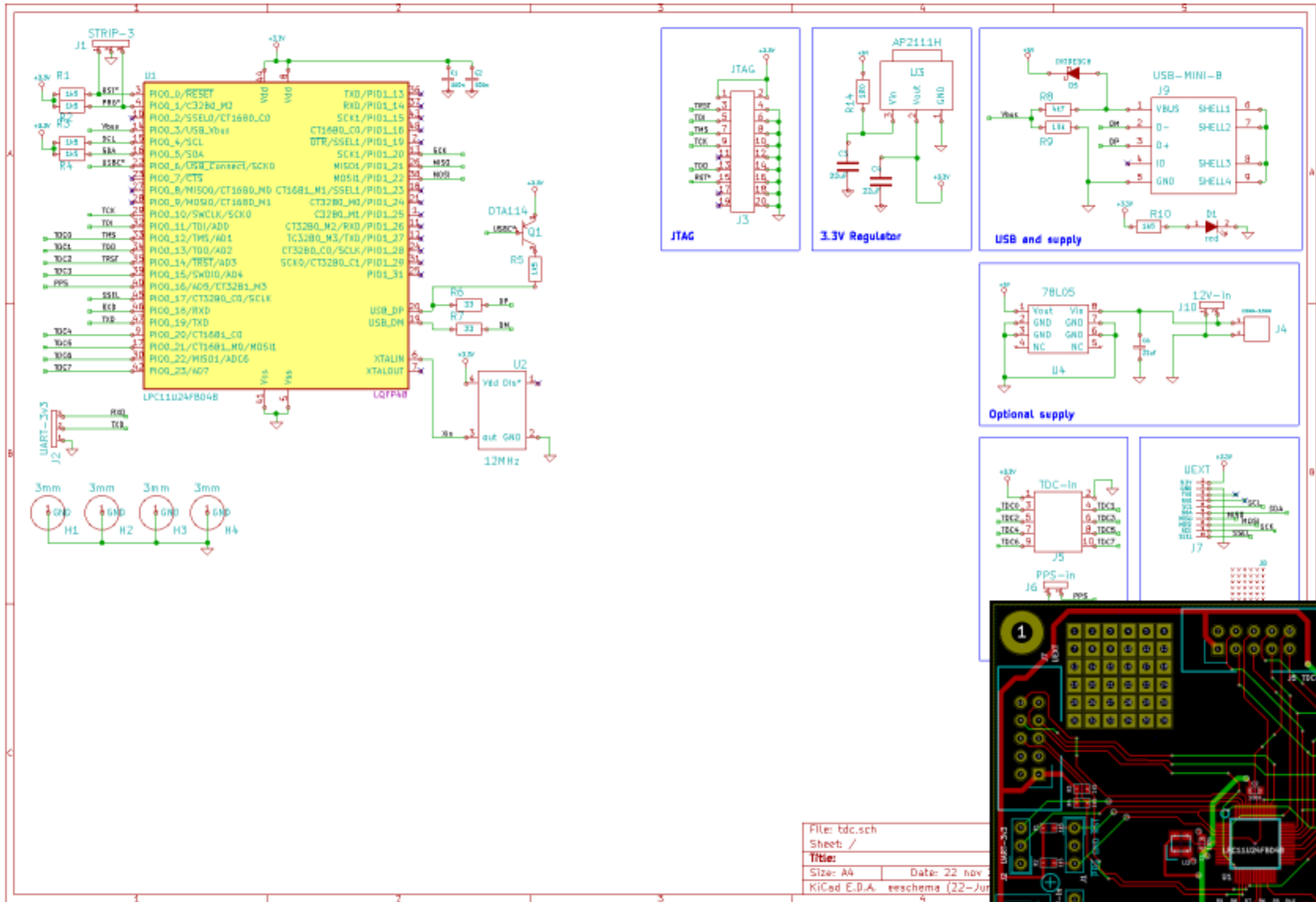




# UEXT and some breadboard space

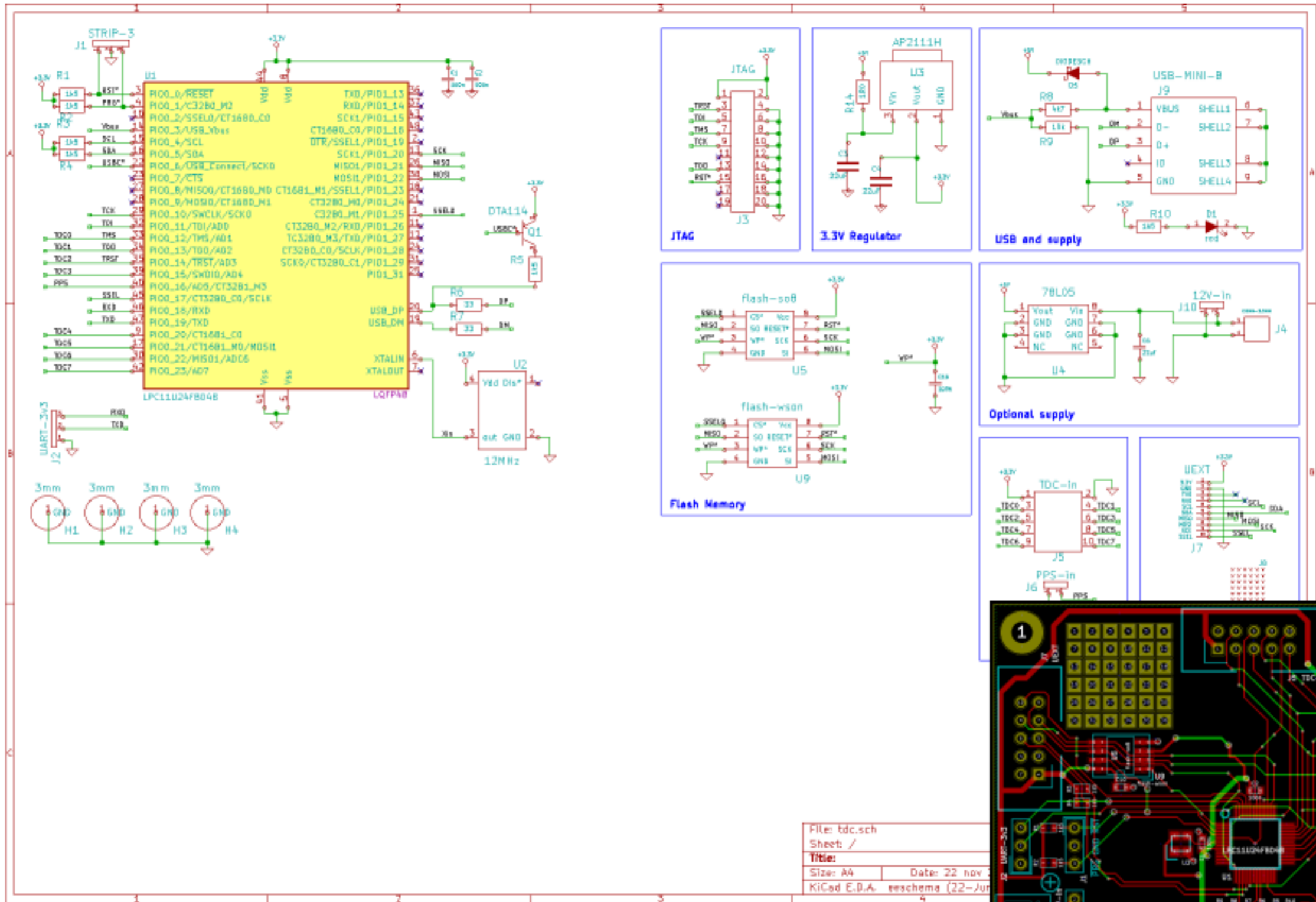


# JTAG connector

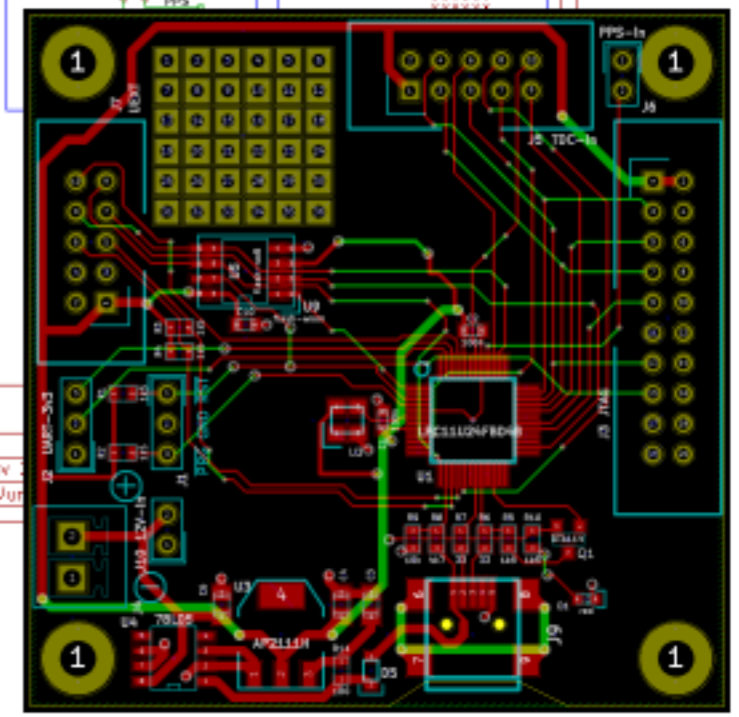


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 Sheet: /  
 Title:  
 Size: A4 Date: 22 nov 2012  
 KiCad E.D.A. eeschema (22-Jun-2012)

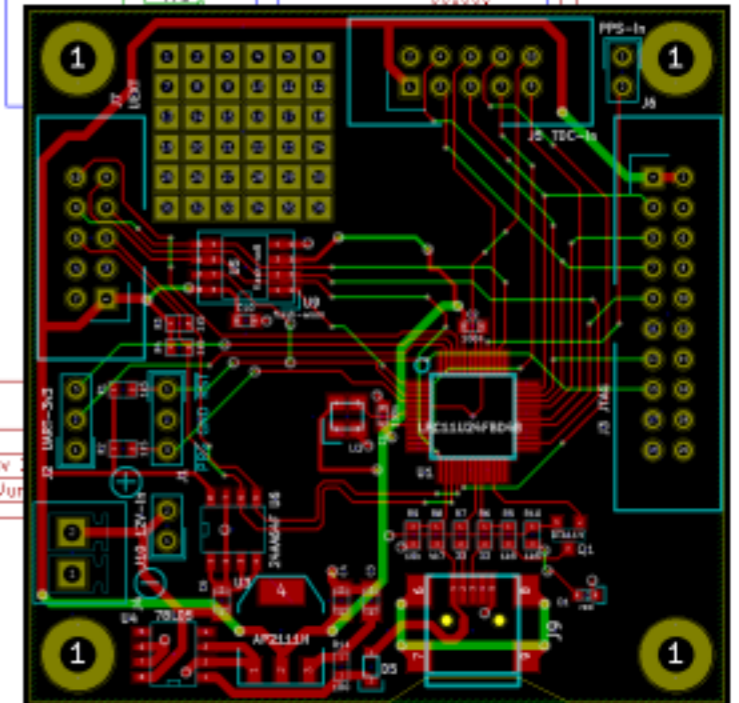
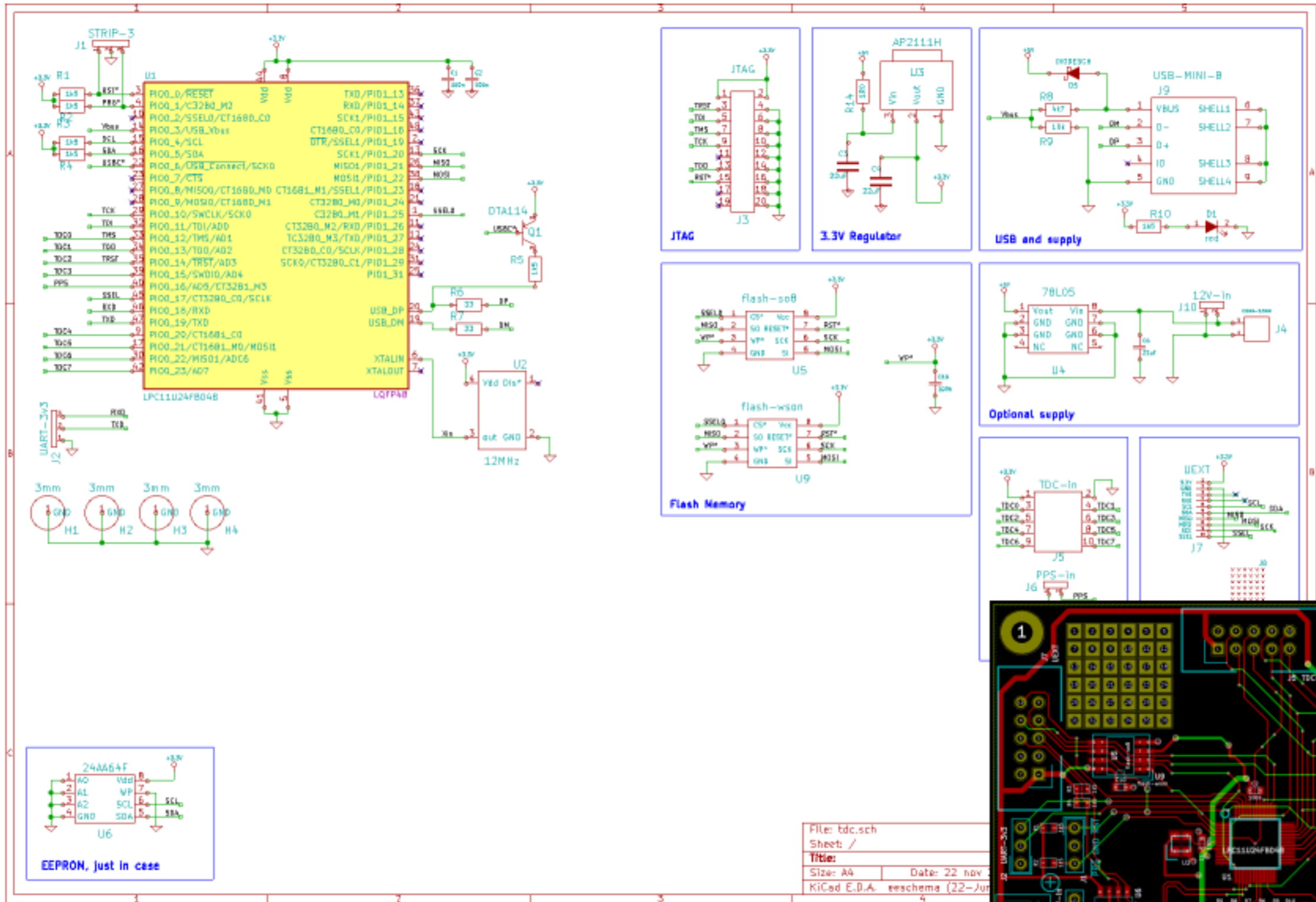
# Flash memory, on the SPI bus



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 KiCad E.D.A. eeschema (22-Jun-2011)

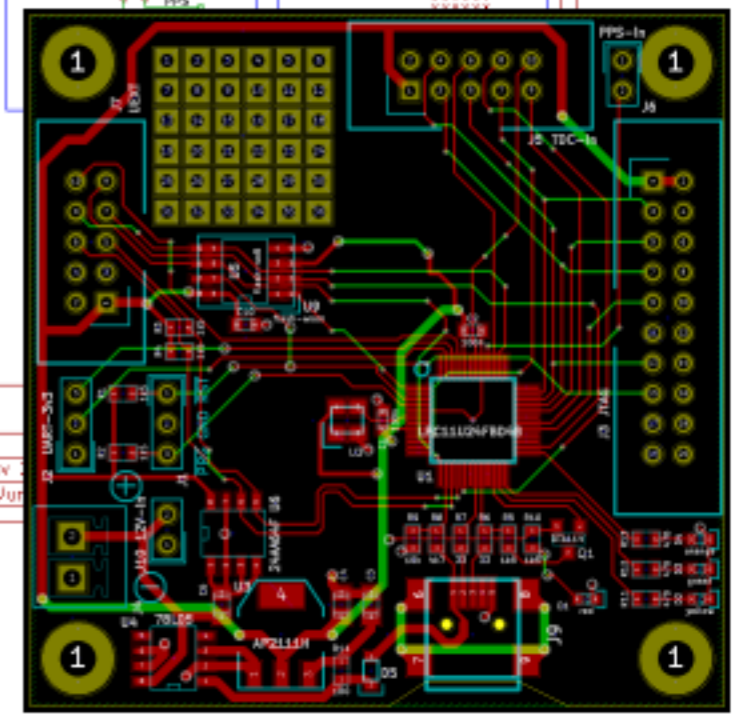
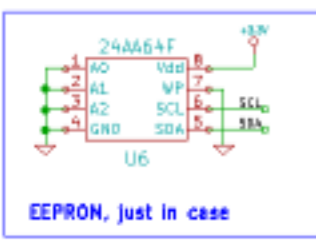
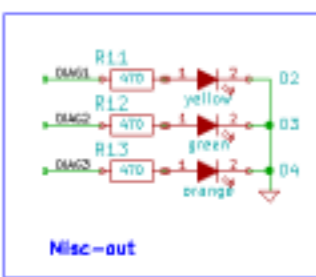
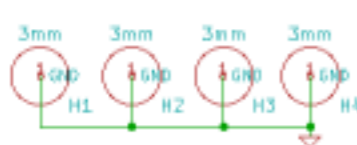
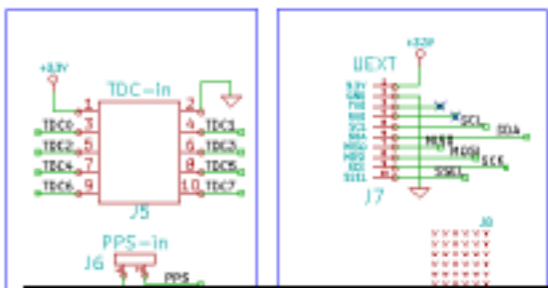
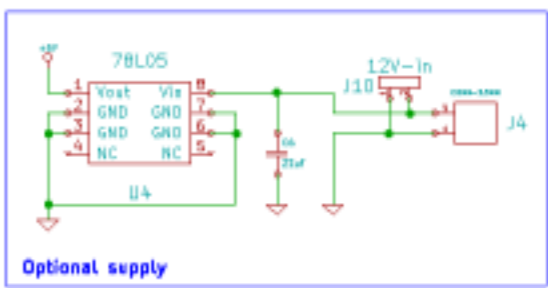
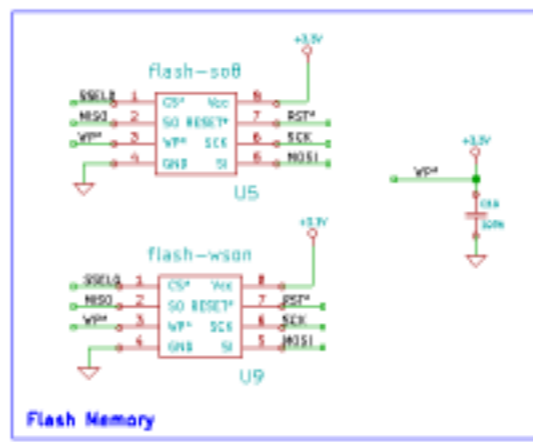
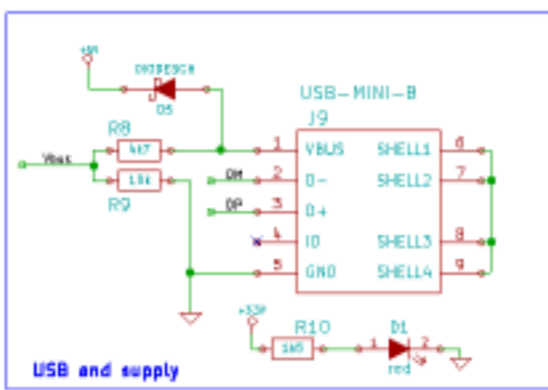
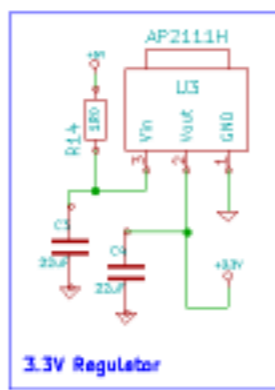
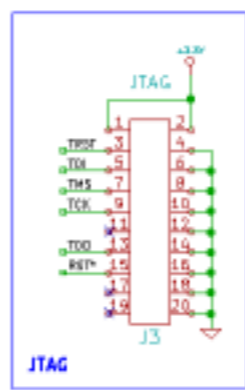
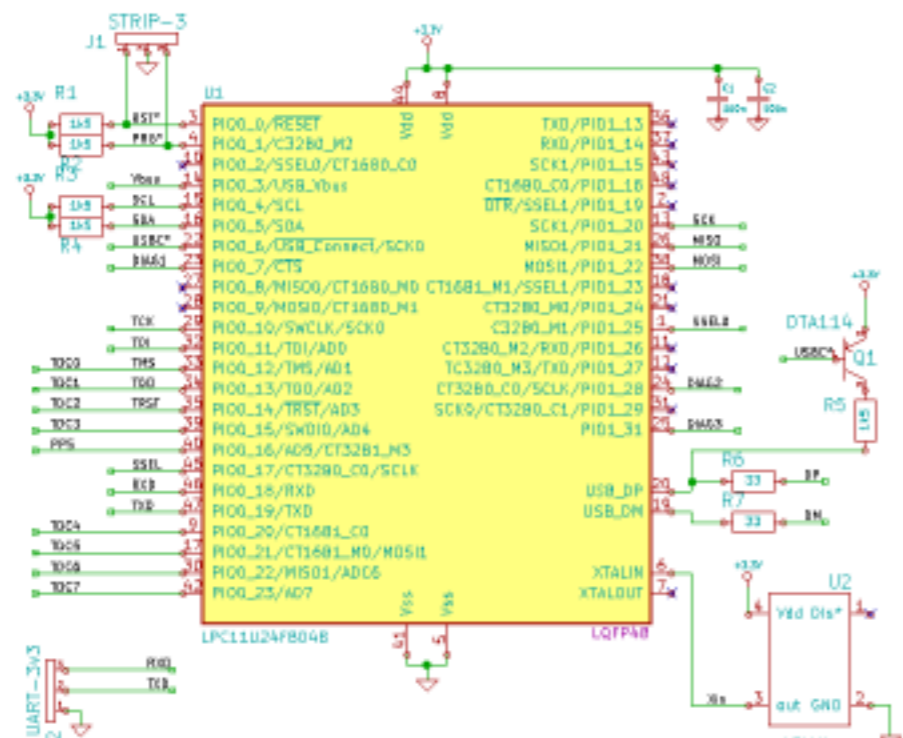
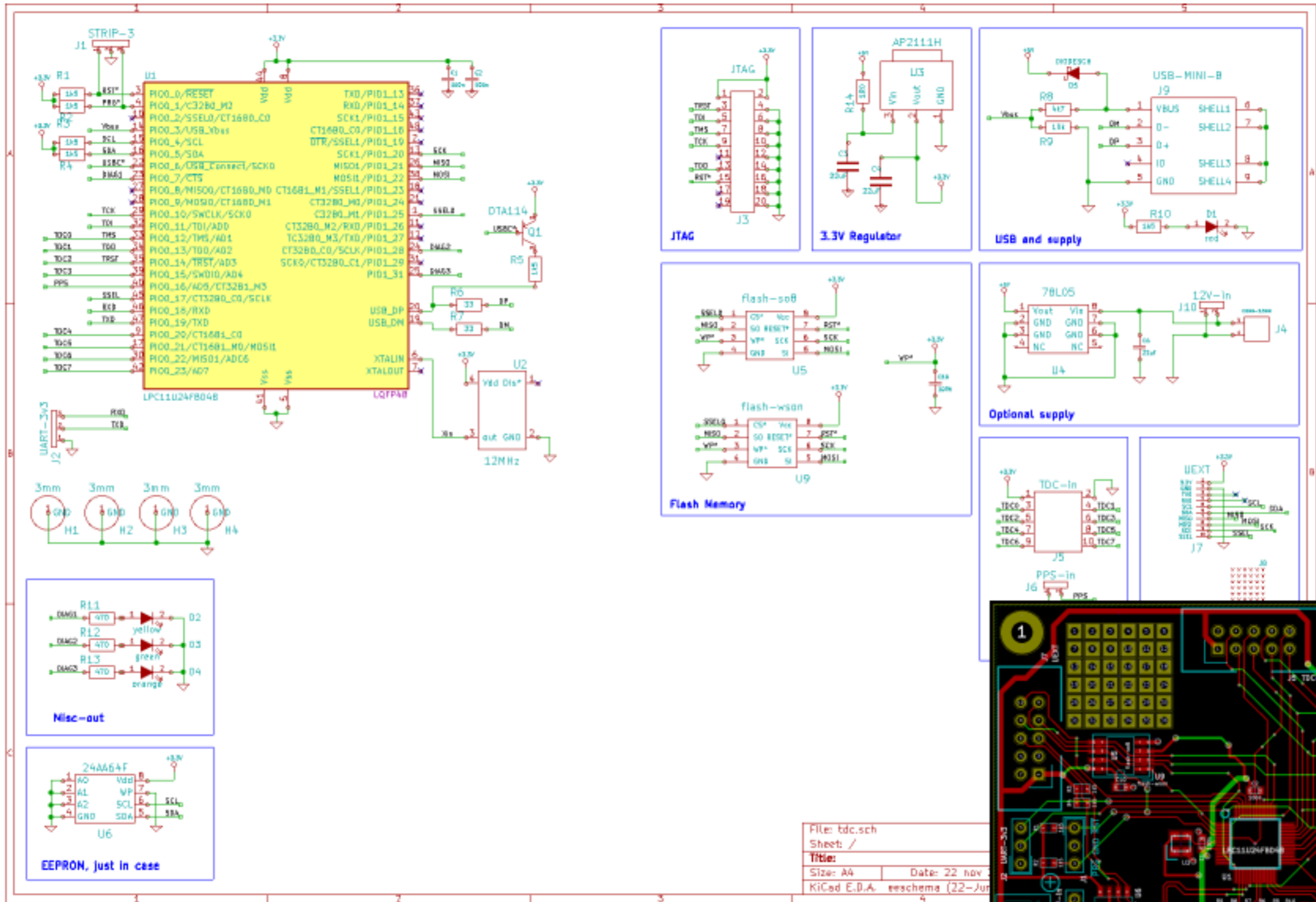


# EEPROM, on the I2C bus



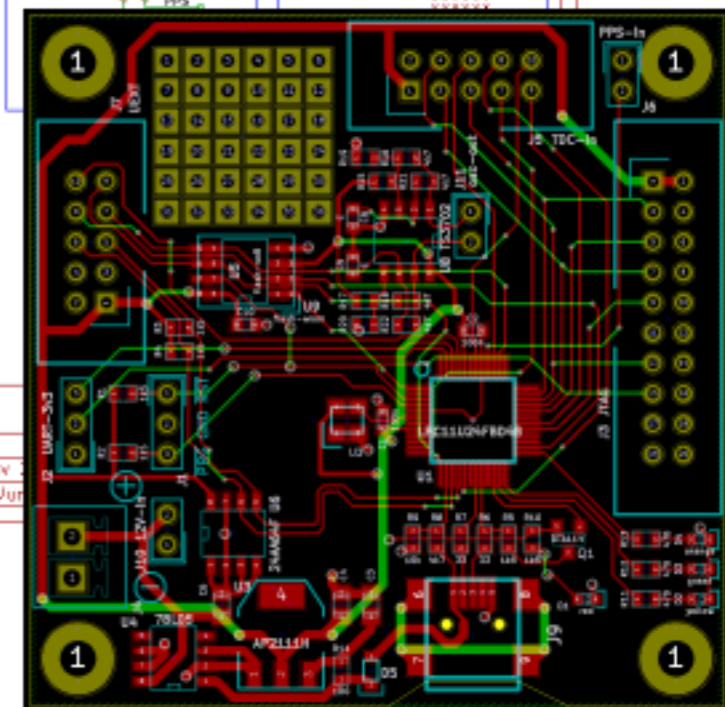
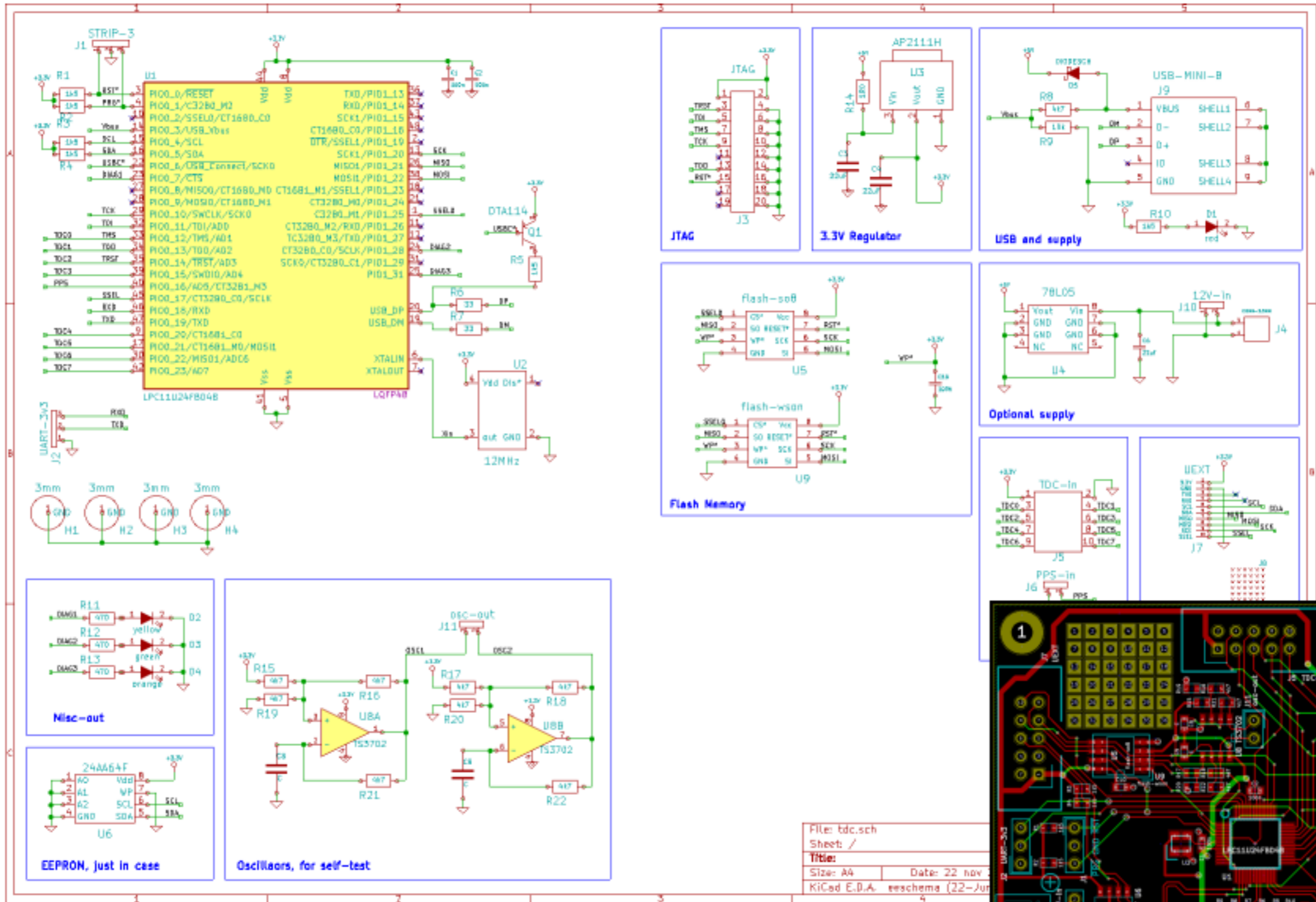


# Diagnostic leds

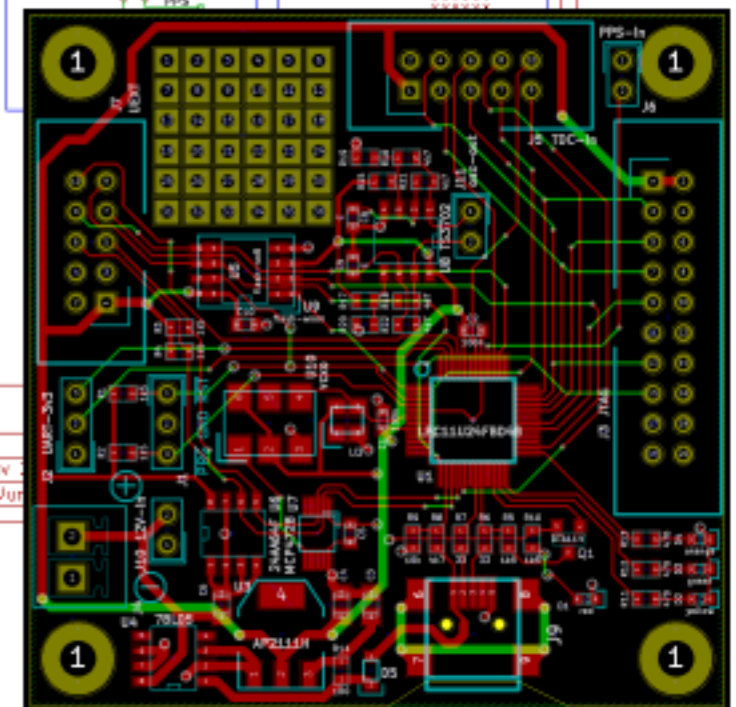
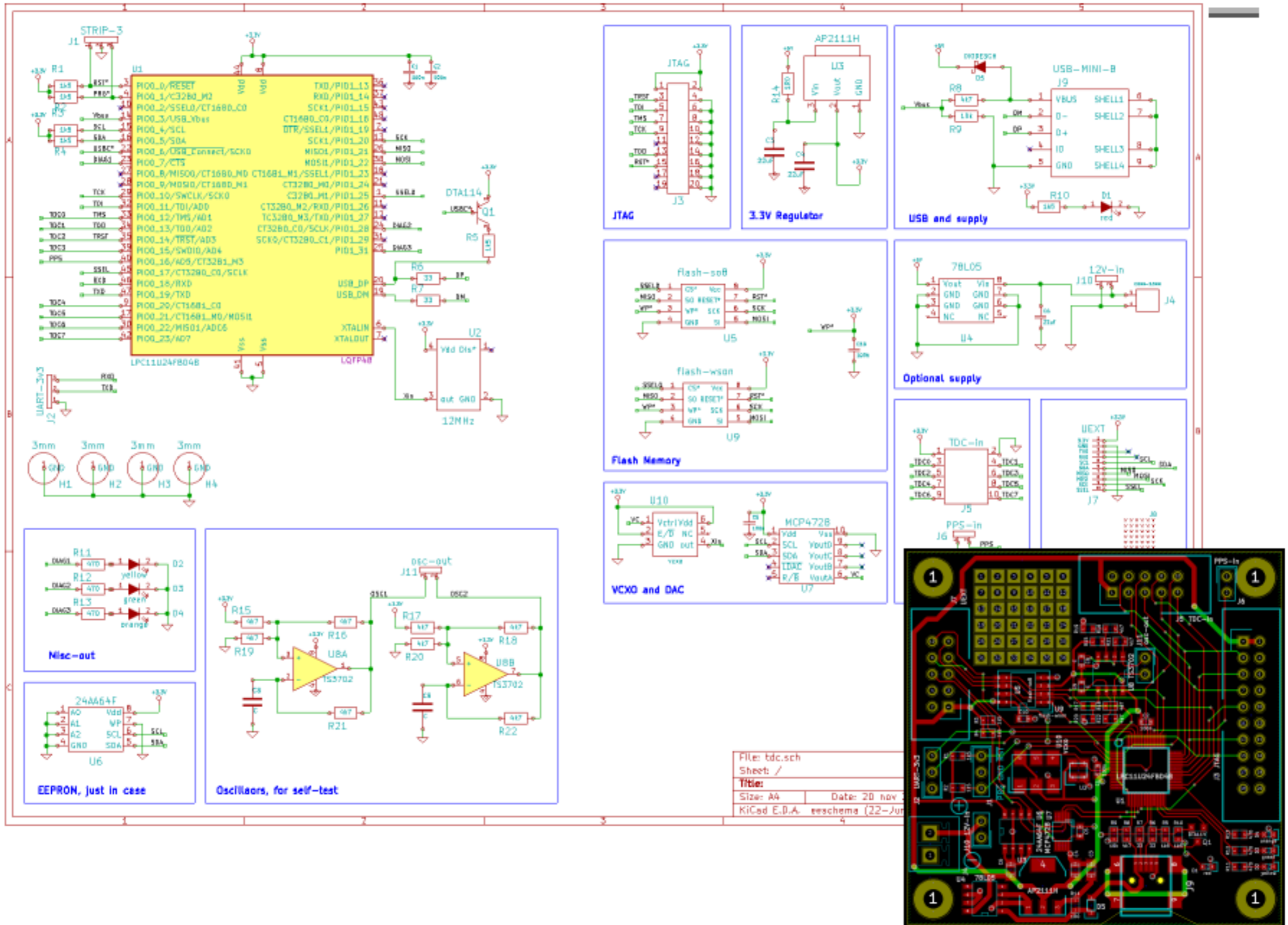




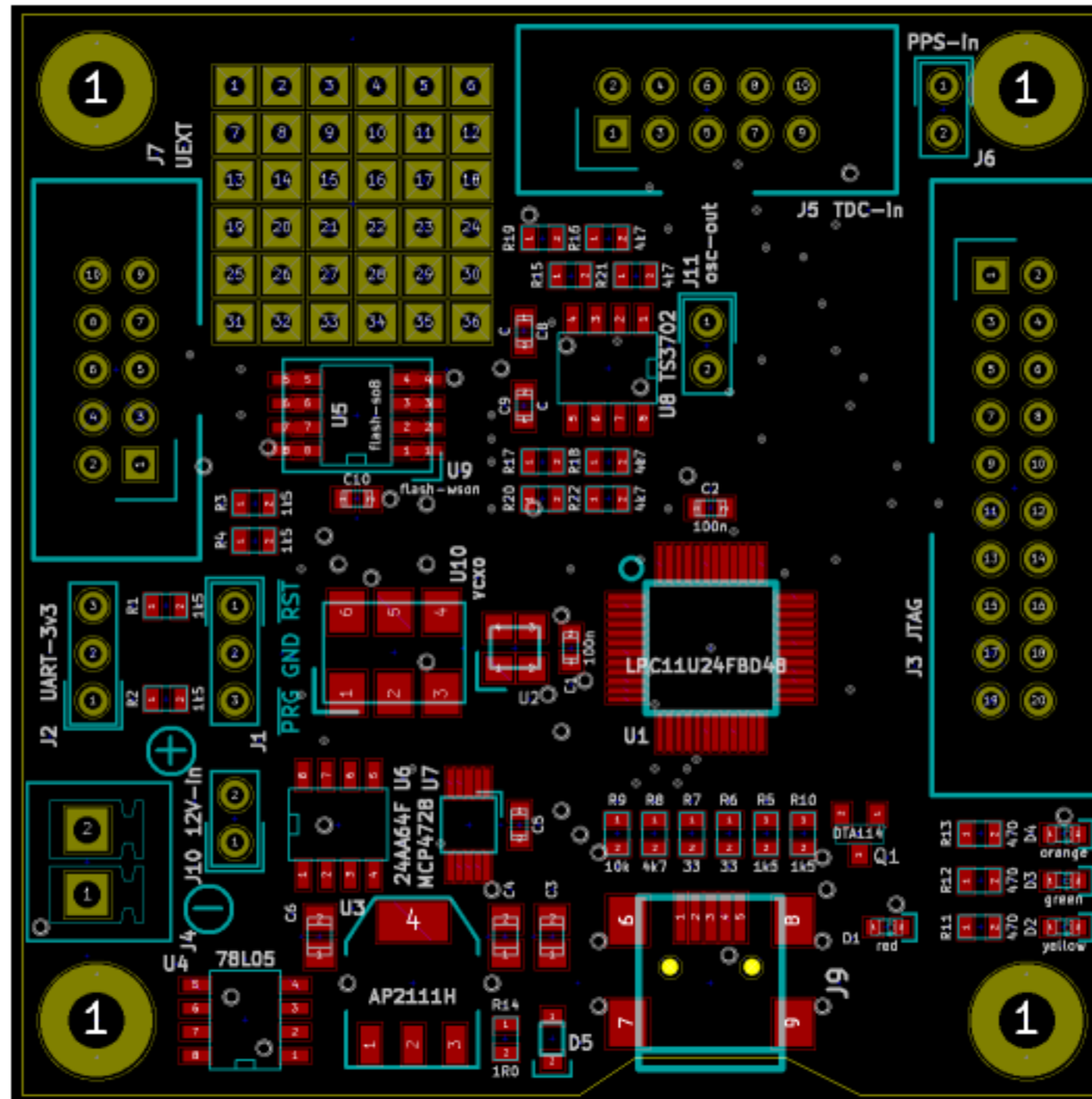
# Oscillators, for self-test



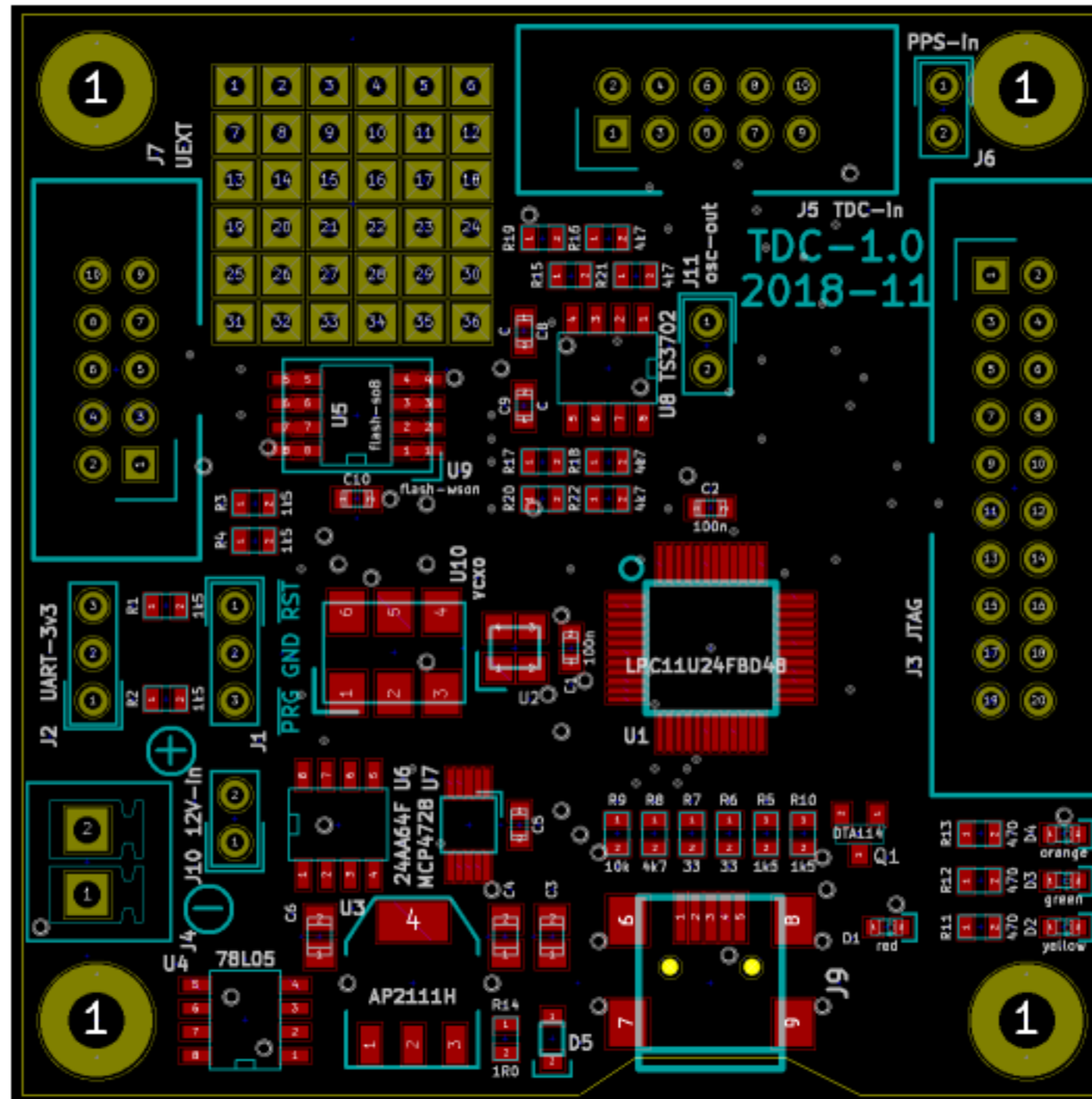
# VCXO, to be able to simulate an atomic clock



# This is the PCB. What is still missing?



# The name and time tag

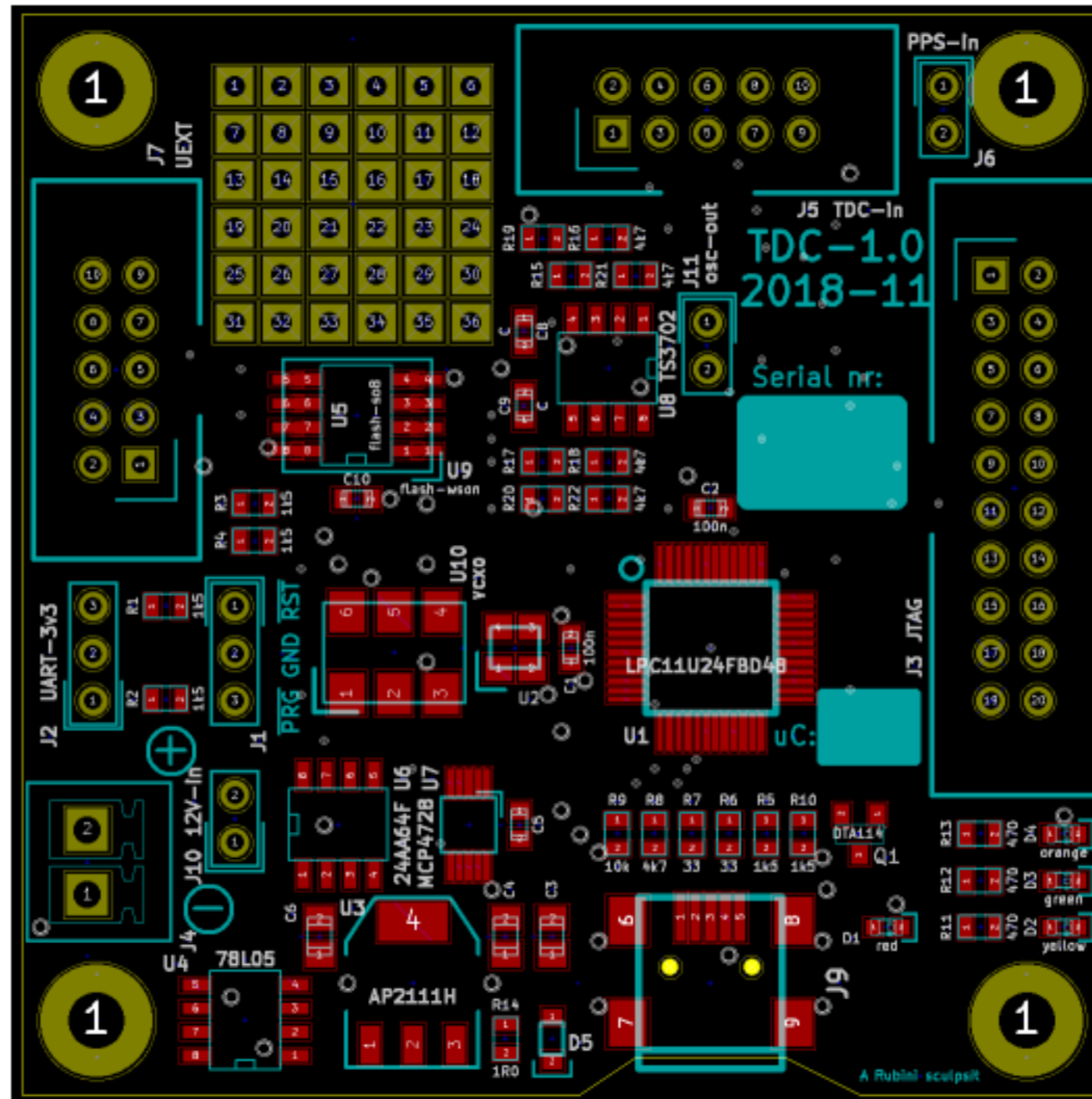








# The signature



# Things to keep in mind when doing hw

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## Use "nice" numbers for mechanics

- Place holes on a regular grid, make the board fit enclosures

## Place all pin-strip holes on a 100mil grid

## Add options: you'll never repent

- You can also test new components in otherwise-empty areas

## Add diagnostics

- Leds, storage, whatever

## Provide for self-test

- Why requesting external hardware?

