Contents

Short:

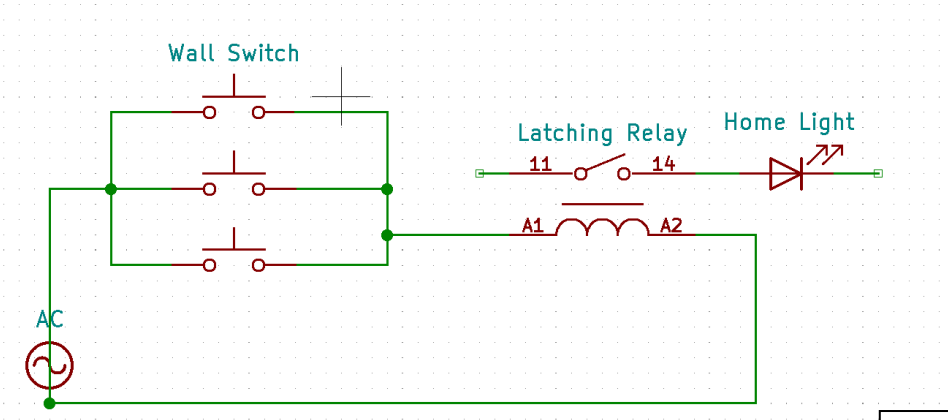
This is my first ever electronics project, and these are my main concerns regarding my PCB design sorted by priority:

1) Is this PCB safe to operate with Mains voltage? Any risks you can see?
2) The board is sensing mains (**Part 3** of this document), I added a fuse to the return because it would take too much space to add a fuse for every channel. Is this enough?
3) Are there any other protections that you would add?
4) Is the USB-to-serial correct?
5) Are .250mil traces enough for the USB part?

Full project link: https://github.com/crgarcia12/electronics-homeassistant-lightscontroll/tree/main/PCB/schematics-v16-espinside/main-project

Context:

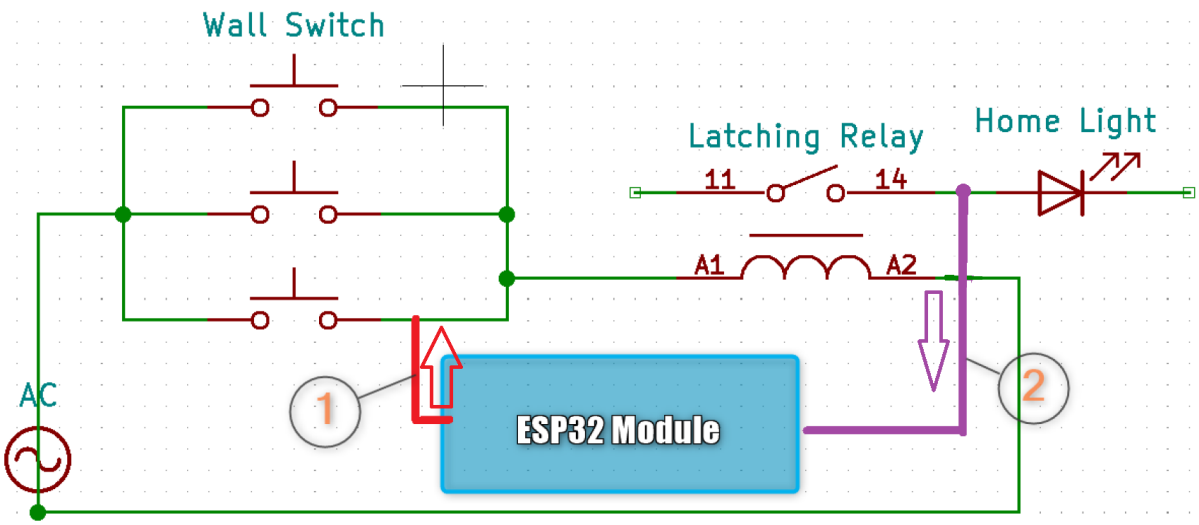
Most modern houses in Switzerland uses latching relays stored in the central panel turn on/off lights from different switches:



Example DIN latching relay (Datasheet)

I want to control and monitor those lights with an ESP32, for that I will build a DIN rail module that:

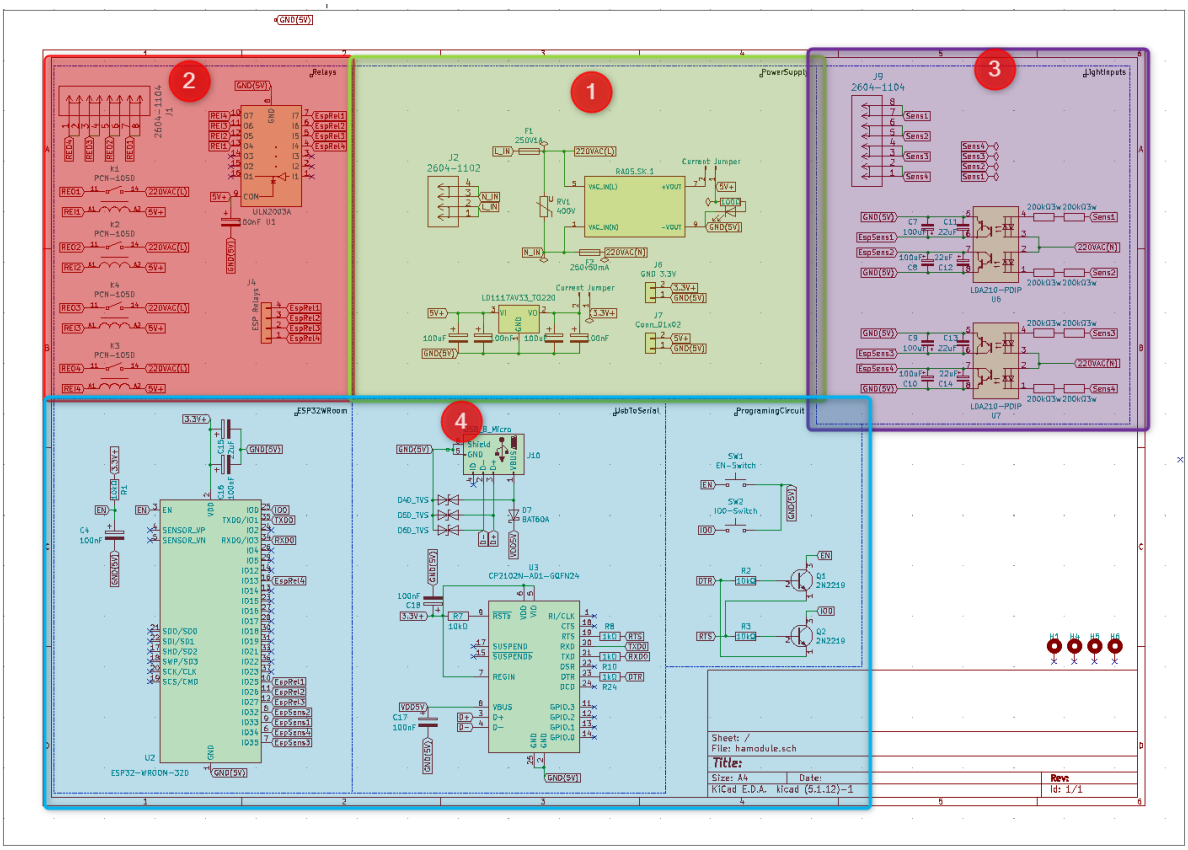
1. Act as a switch, controlling the latching relays (Nr 1 in the image)
2. Sense the output of the relays, to check if the lights are ON or OFF (Nr 2 in the image)



The module can handle four “channels”, so it can control 4 latching relays and sense 4 relays outputs.

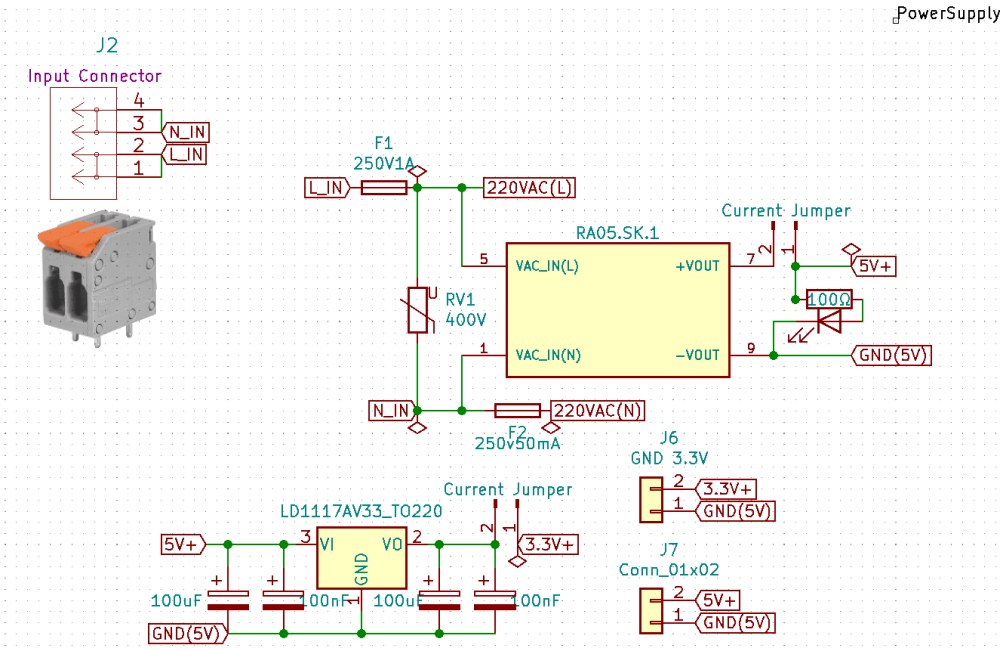
The schematics can be split in 4:

1) Power Supply
2) Act as a switch (relays controlled by ESP32) (Nr 1 in the previous image)
3) Sense the relay output (Nr 2 in the previous image)
4) ESP32 + USB

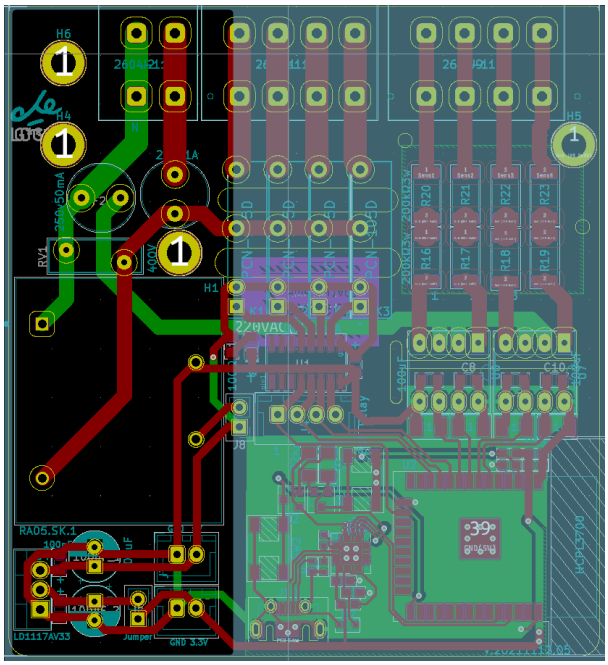

2
Relays
1
PowerSupply
3
LightInputs
4
ESP32WRoom
UsbToSerial
ProgramingCircuit
Sheets: /
File: hamadule.sch
Title:
Size: A4
Date:
KiCad E.D.A. kicad (5.1.12)-1
Rev:
Id: 1/1

Part 1: Power Supply

The board 3.3v and 5v, and it needs to be powered with mains. RAC05SK is an AC/DC PowerSupply module

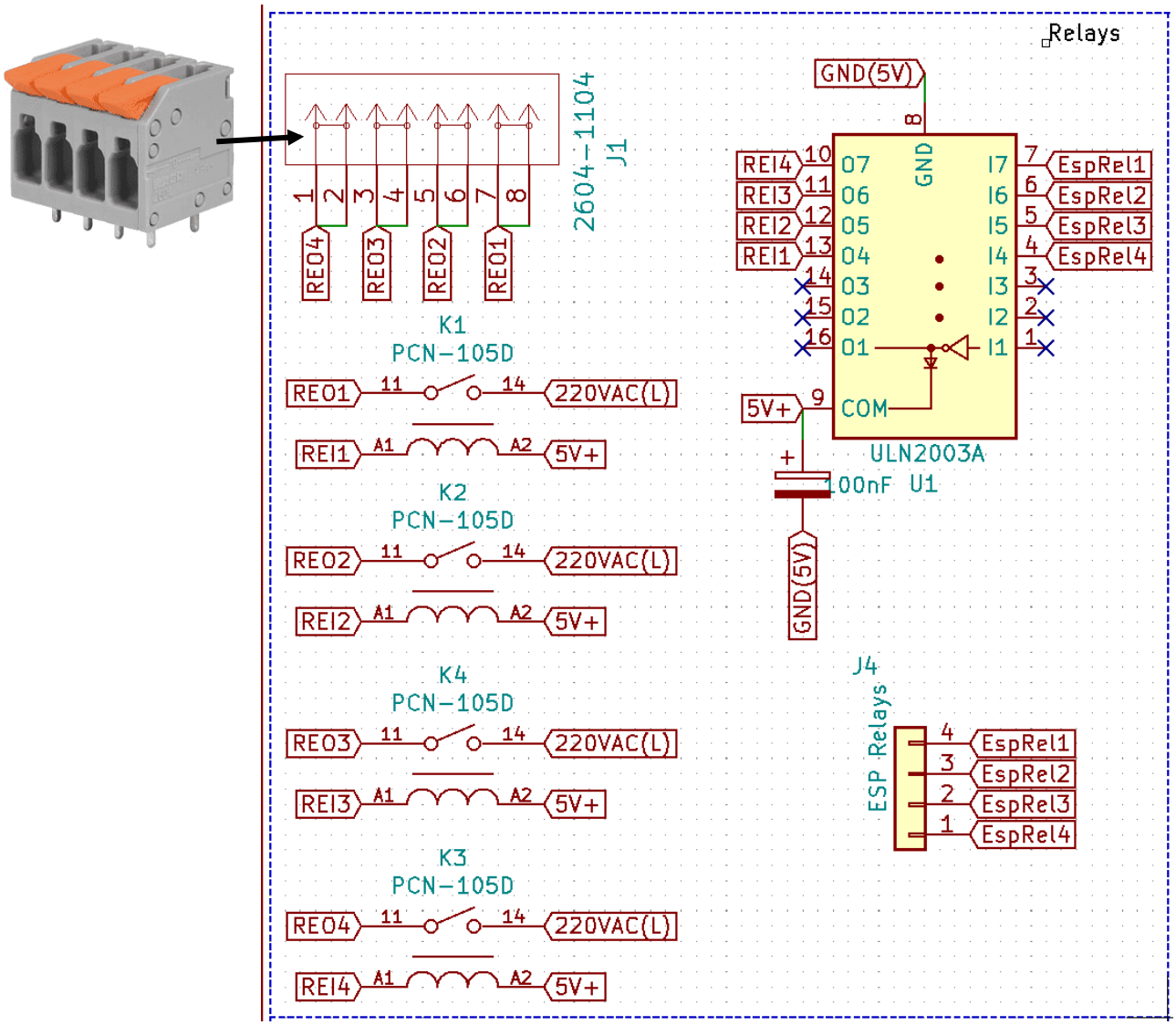


RAC05-05SK datasheet: https://recom-power.com/pdf/Powerline_AC-DC/RAC05-K.pdf

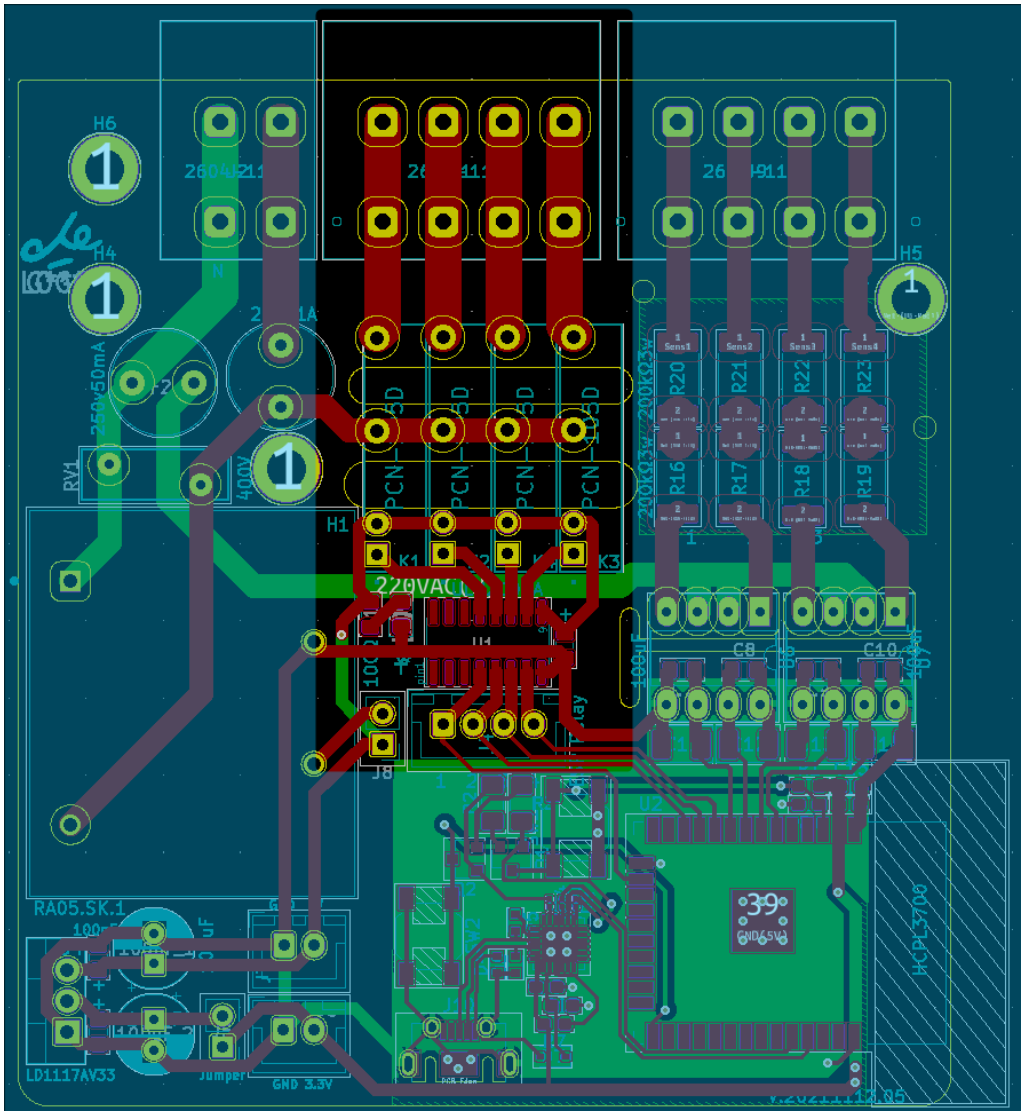


Part 2: Act as a switch

To act as a switch, the module needs to send a short (~50ms) 220V pulse to the input of the latching relays. For that the board will use 4 x 3A relays, and a controller ULN2003A



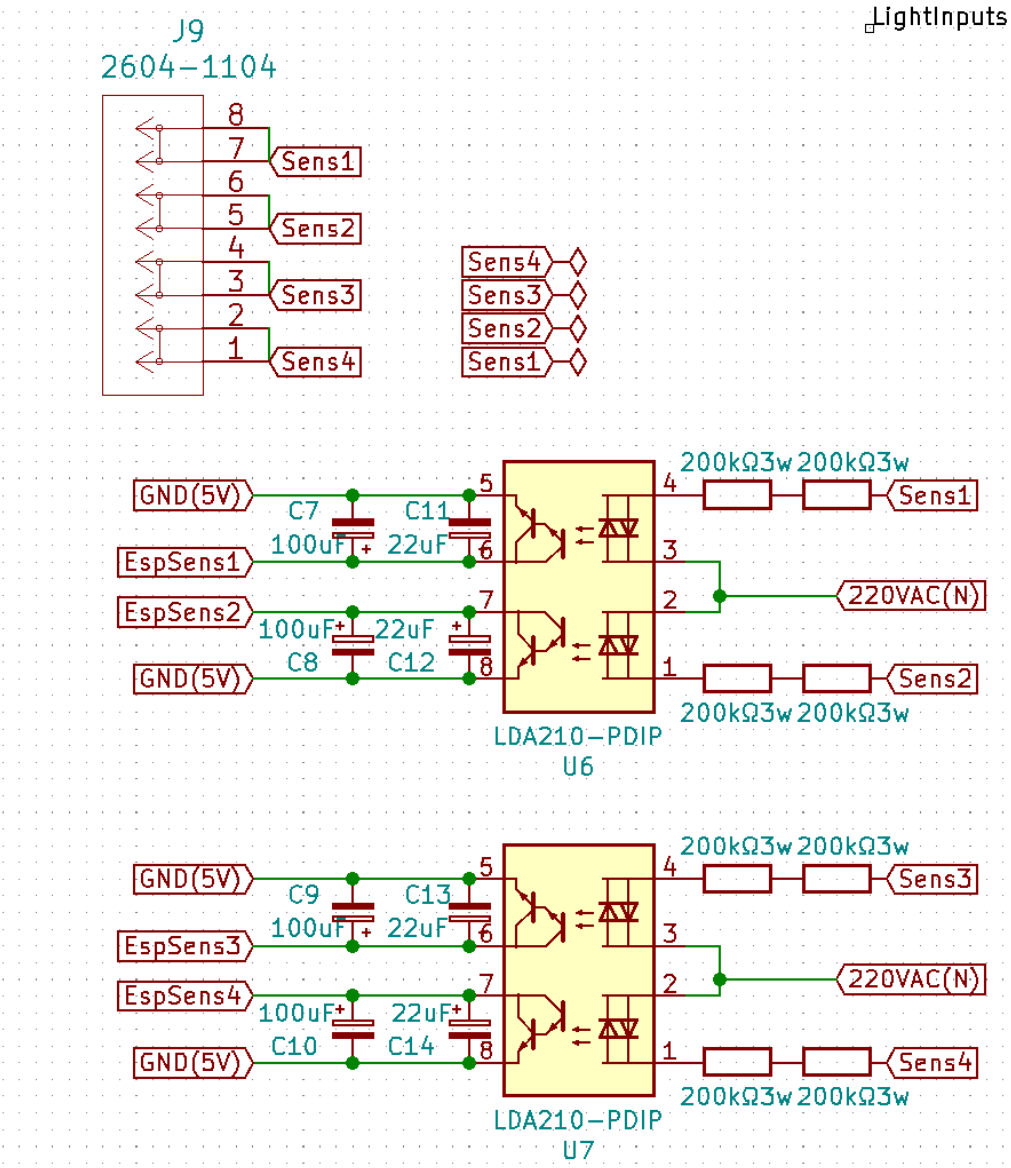
Relay datasheet: https://www.distrelec.ch/Web/Downloads/_t/ds/PCN_eng_tds.pdf
ULN2003A datasheet: https://www.st.com/resource/en/datasheet/uln2001.pdf


H6
H4
H5
H1
RV1
250V50mA
400V
K1
K3
220VAC
R20
R21
R22
R23
R16
R17
R18
R19
200KΩ3W
C8
C10
100uF
J8
U2
RA05.SK.1
LD1117AV33
Jumper
GND 3.3V
HC4_3700

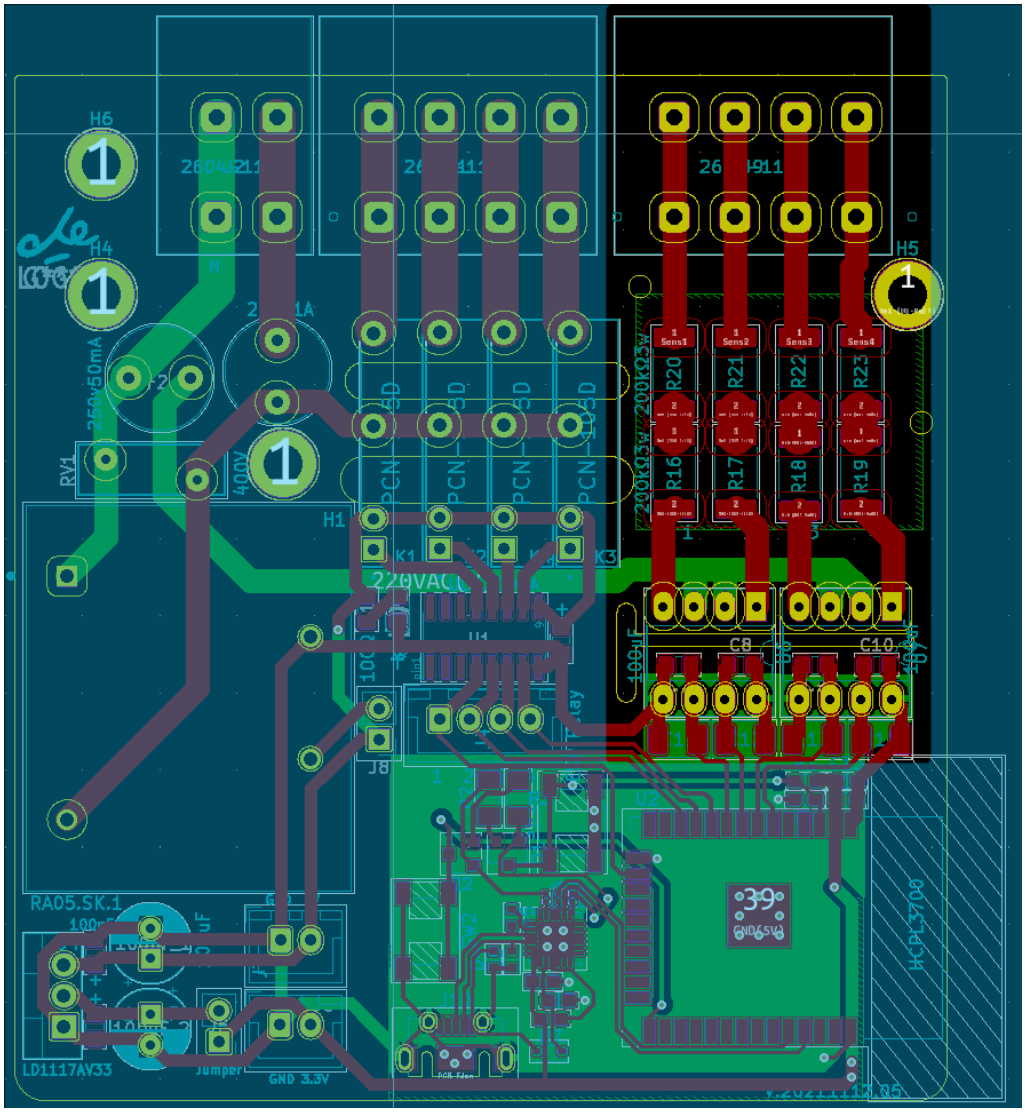
Part 3: Sense the relay output

Since the lights can be operated manually, the ESP32 needs to know if the house lights are ON or OFF all the time. For that I am planning to sense the output of the latching relay with some resistors and optocouplers:

Note: All EspSensX will have internal pull-up enabled



LDA210 optocoupler: https://www.ixysic.com/home/pdfs.nsf/www/LDA210.pdf/$file/LDA210.pdf



I also tried to calculate what would be the optimal resistors value in order they don't heat up. Considering that the ESP32 pullup resistors are 45k and the optocoupler minimum CTR is 300%:

$$I_{ce} = \frac{V_{ce}}{R_{ce}} = \frac{3.3\ V}{45\ k\Omega} = 0.073\ mA$$

$$CTR = \frac{I_{ce}}{I_f} \Longrightarrow I_f = \frac{0.073\ mA}{300\ \%} = 0.024\ mA$$

$$R_f = \frac{V_f}{I_f} = \frac{230V - 1.2V}{0.024\ mA} = 9.5\ M\Omega$$

That sounds way too little current, so I decided to go with 400k instead that gives me 0.57 mA and 13W

$$I_f = \frac{V_f}{R_f} = \frac{230V - 1.2V}{400\,k\Omega} = 0.57\,mA$$

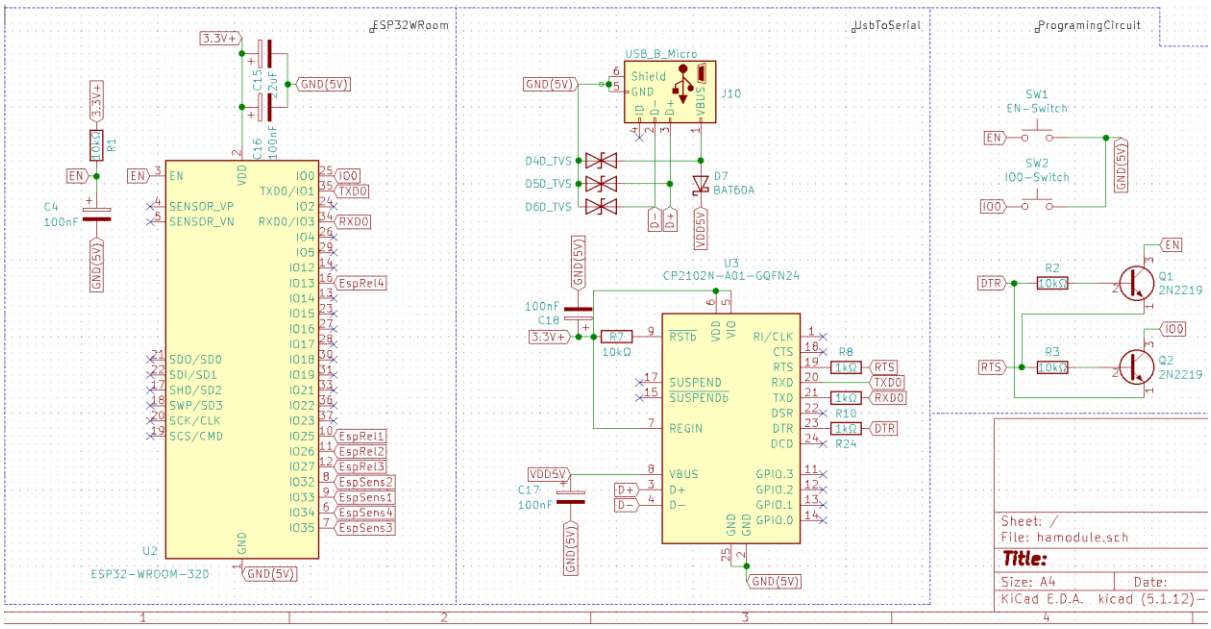
$$P_f = V_f * I_f = (230V - 1.2V) * 0.57\,mA = 0.13W$$

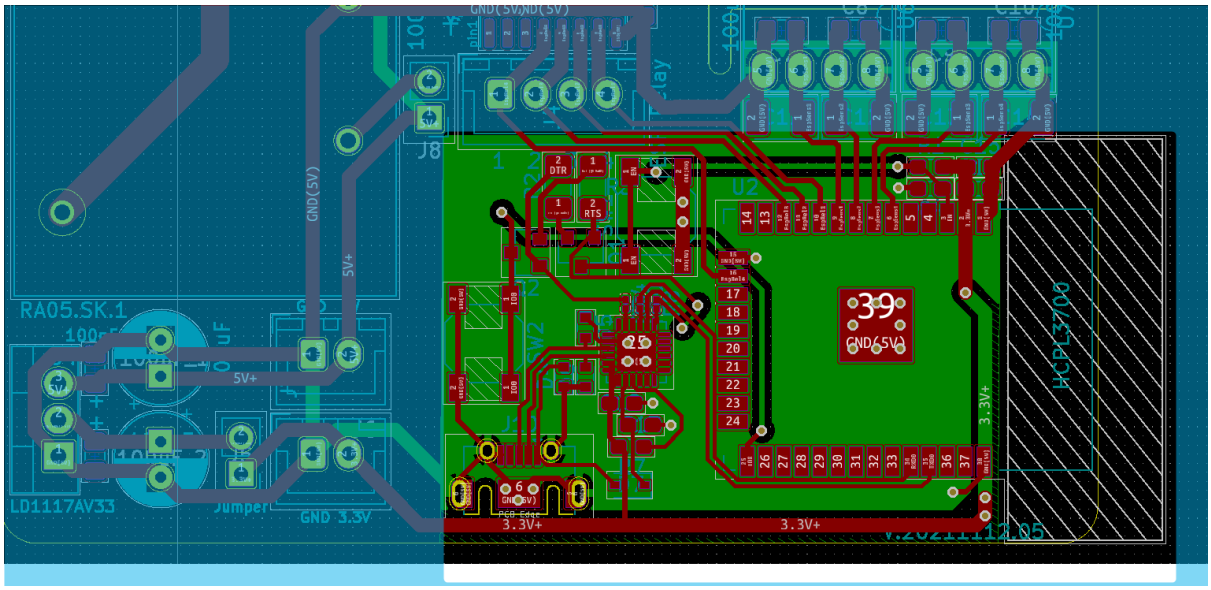
Part 4: ESP32 and USB

Most of the USB part I just copied, I don't fully understand every detail, and I am not sure if this will actually work because I did not manage to route it nicely.

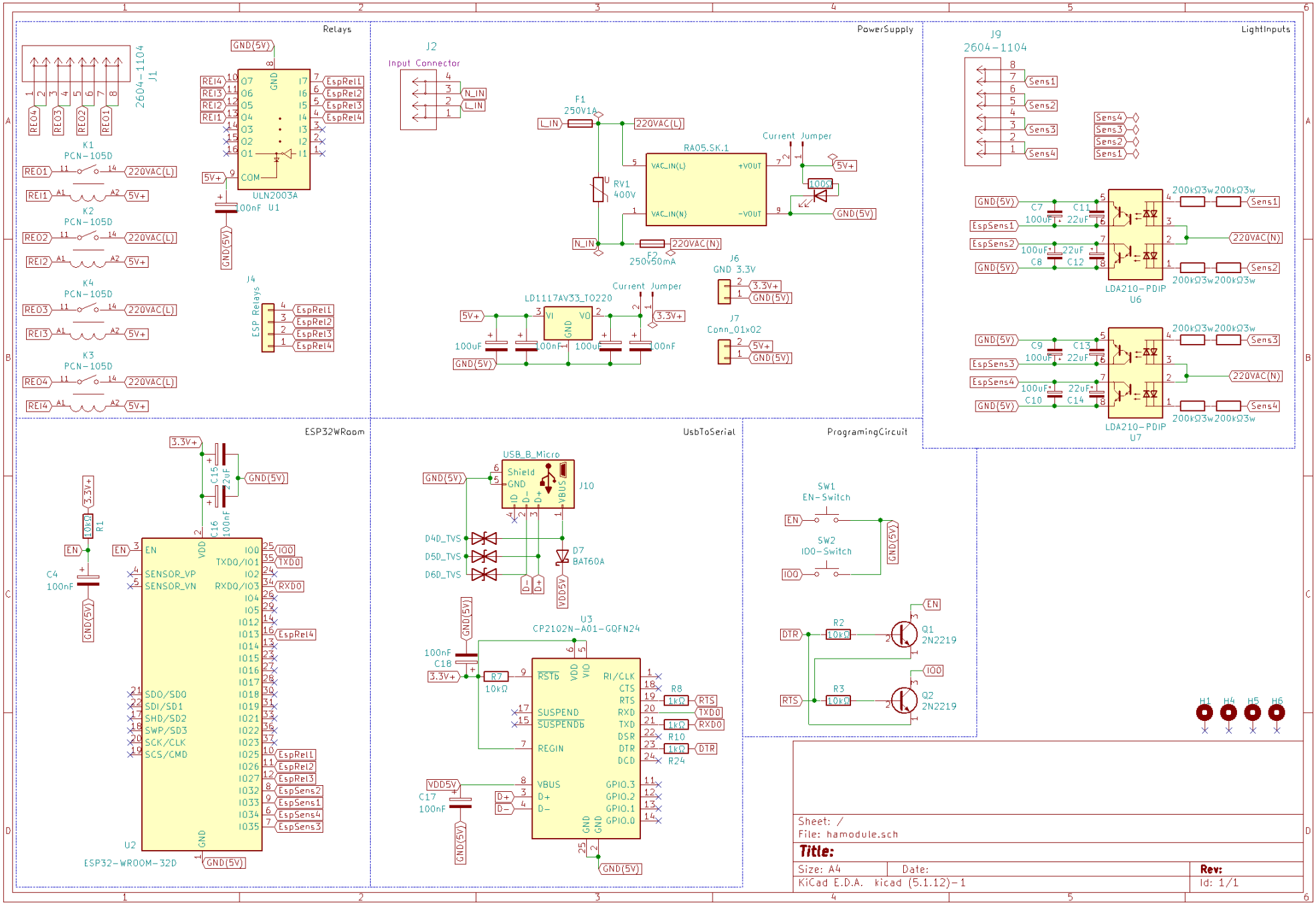
Some questions:

- What is going to happen when the 3.3v from the PS and from the CP2102 chip collide?
- Are the tracks big enough?
- Would you split this into another stacked board instead?





Schematics


Relays
PowerSupply
LightInputs
ESP32WRoom
UsbToSerial
ProgramingCircuit
2604-1104
ULN2003A
Input Connector
RA05.SK.1
LD1117AV33_TO220
LDA210-PDIP
USB_B_Micro
CP2102N-A01-GQFN24
ESP32-WROOM-32D
EN-Switch
IO0-Switch
BAT60A
2N2219
Sheet: /
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Title:
Size: A4
Date:
Rev:
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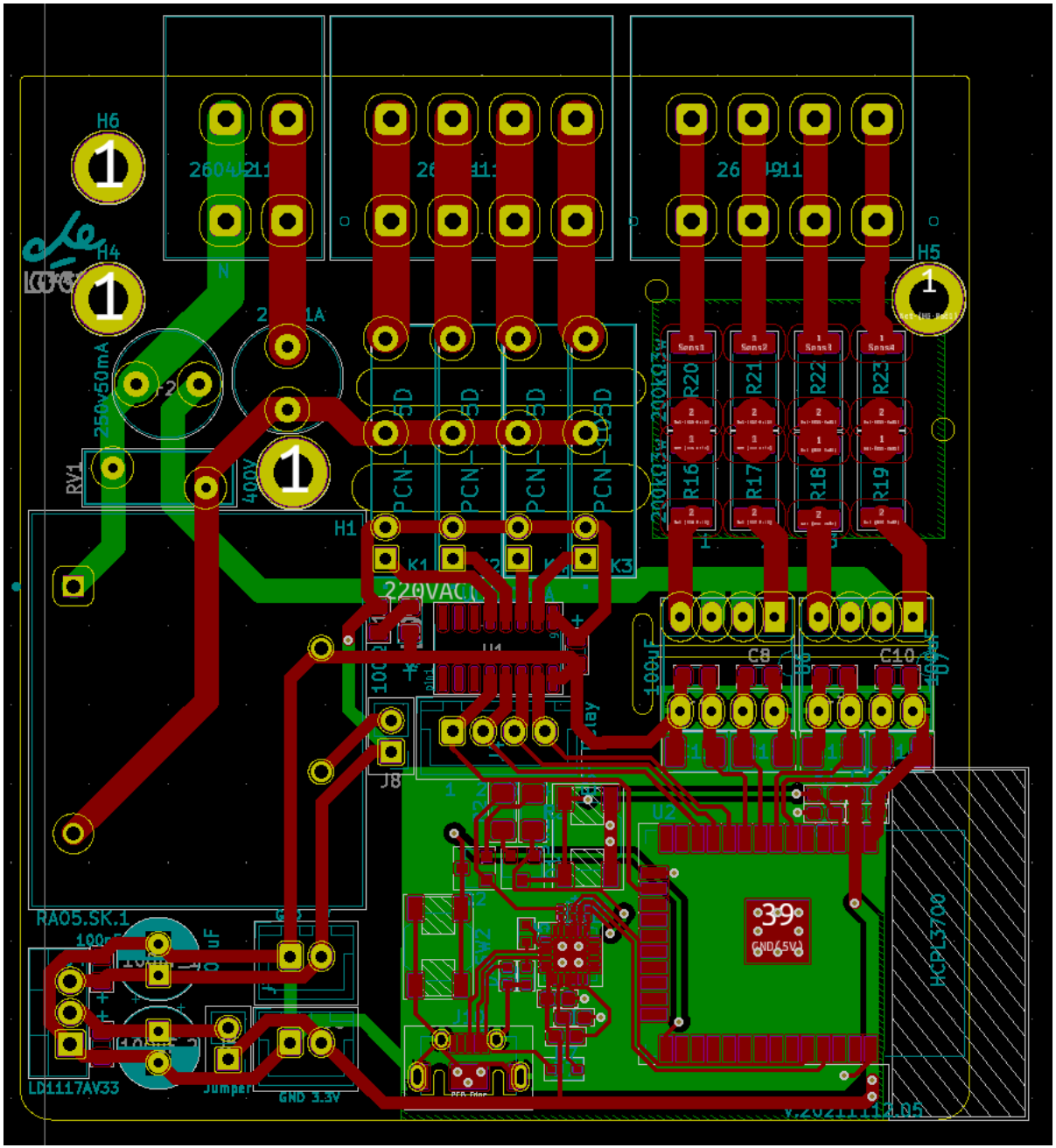
Id: 1/1

PCB Layout


H6
H4
H5
H1
N
L
RV1
250v50mA
400V
220VAC
K1
K2
K3
J8
U4
U2
C8
C10
100uF
R20
R21
R22
R23
R16
R17
R18
R19
200KΩ3W
PCN_SD
Sens1
Sens2
Sens3
Sens4
RA05.SK.1
LD1117AV33
Jumper
GND 3.3V
HCPL3700
GND(5V)