VIETNAM NATIONAL UNIVERSITY HO CHI MINH CITY
HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY
FACULTY OF COMPUTER SCIENCE AND ENGINEERING

EEC REPORT PROJECT

Class: CC01

Instructor: Nguyễn Thiên Ân

Student	ID
Nguyễn Đăng Duy	2252116

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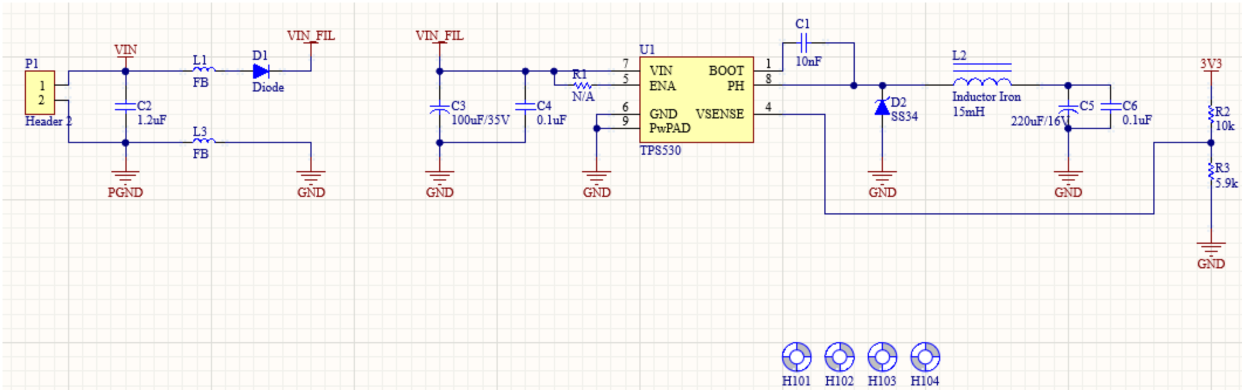
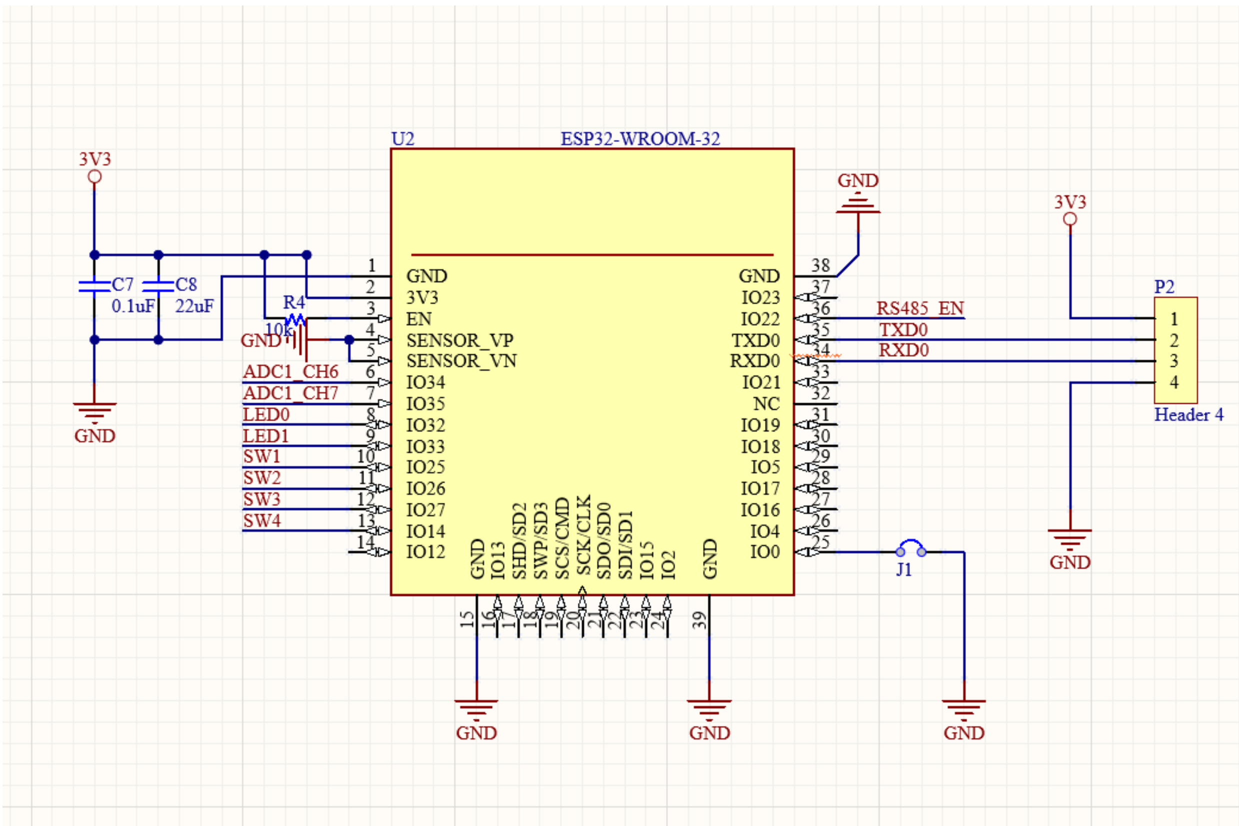
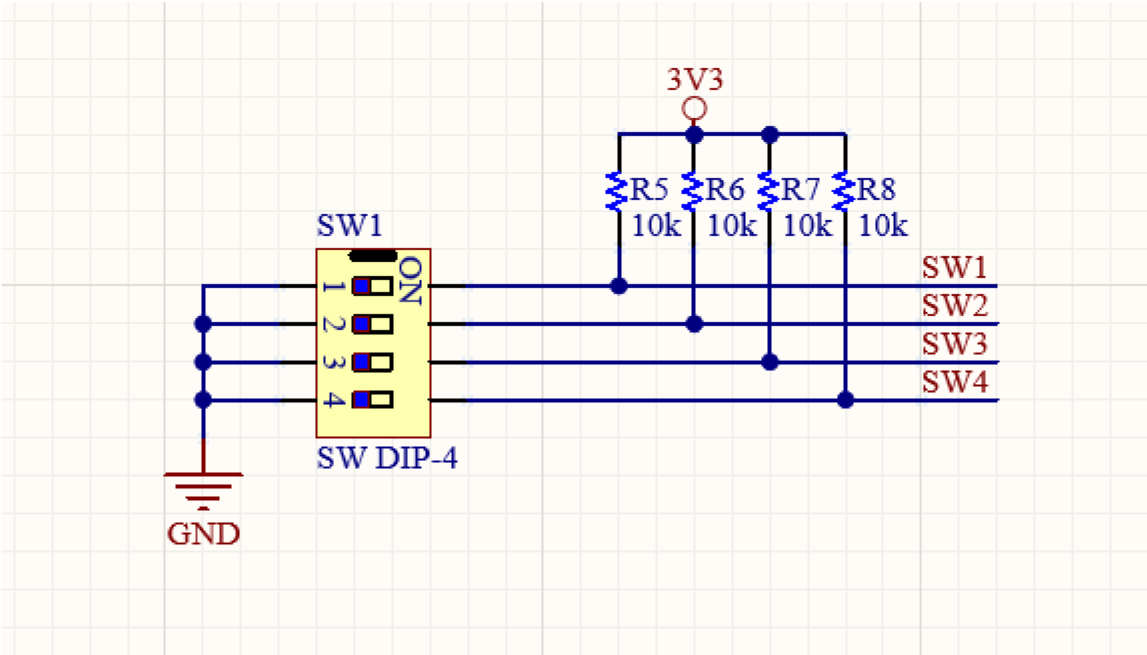


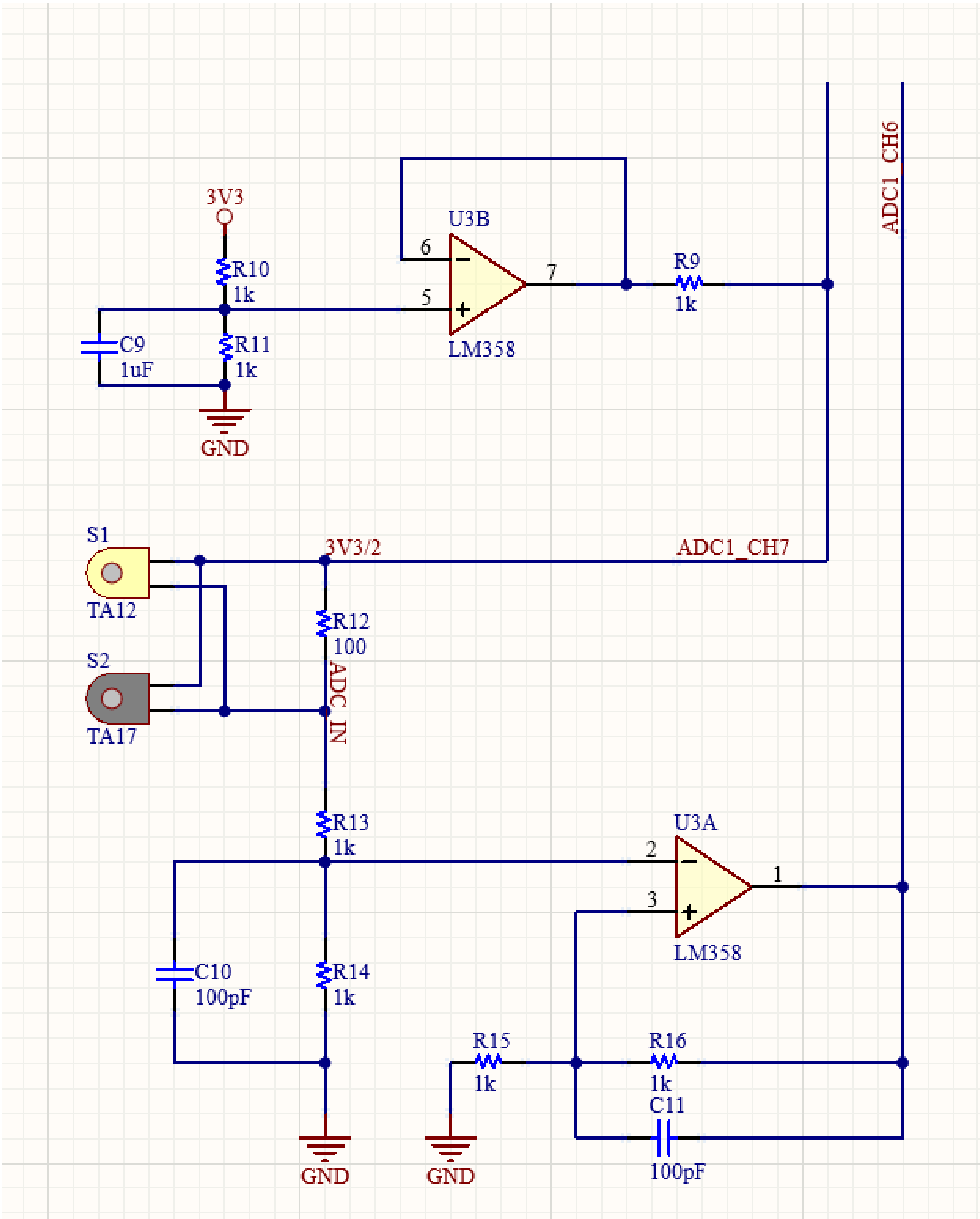
b. ESP32-WROOM32



c. Slide Switch for the MCU



d. Current Sensor using TA12 and TA17



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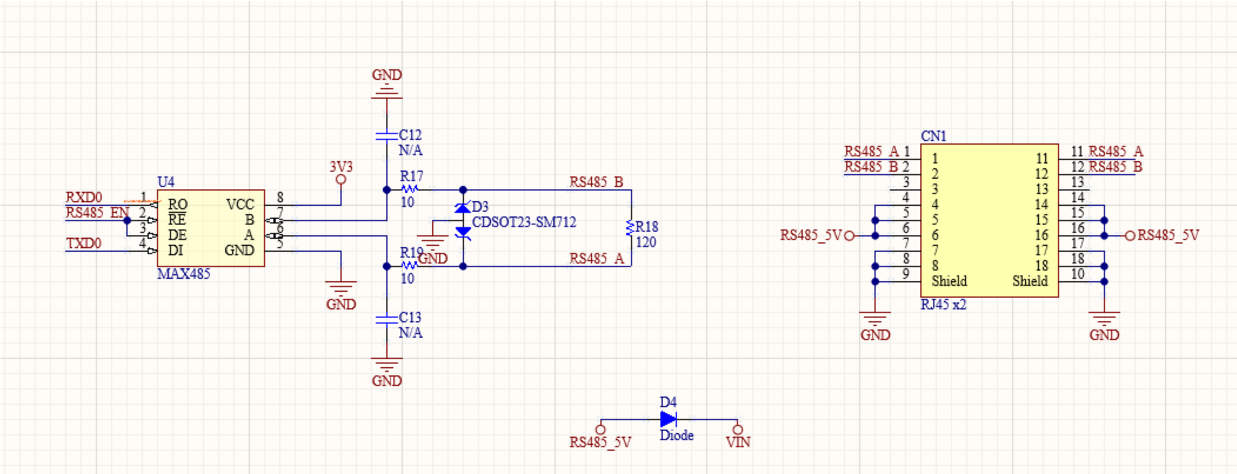
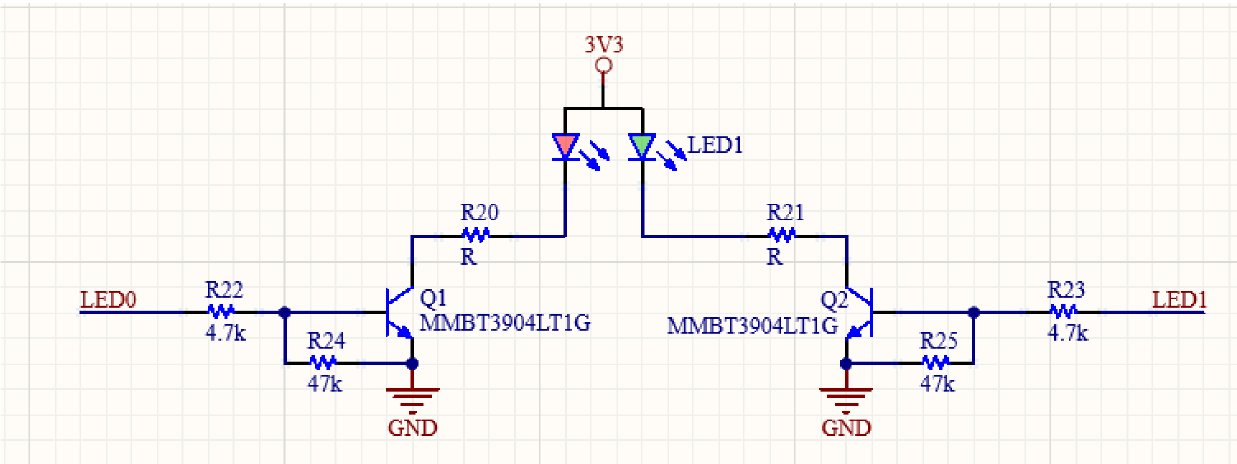
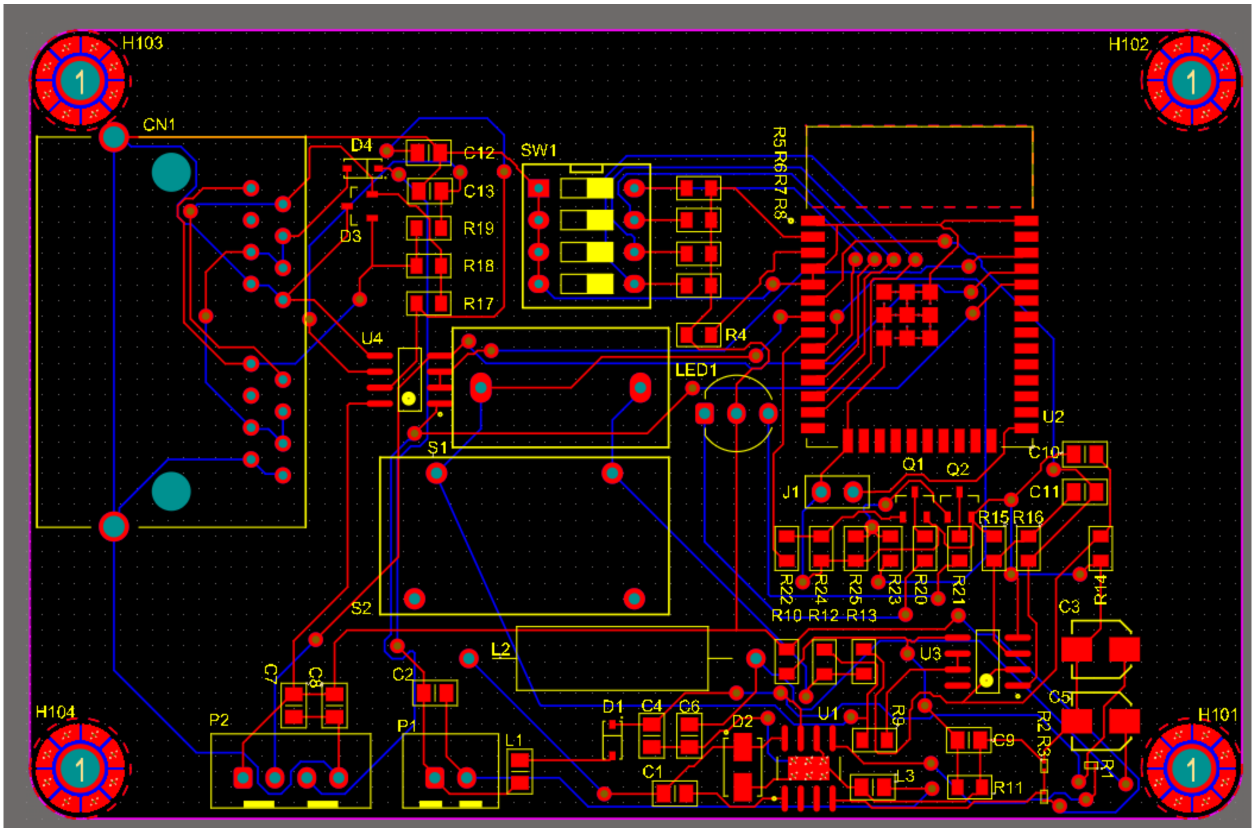
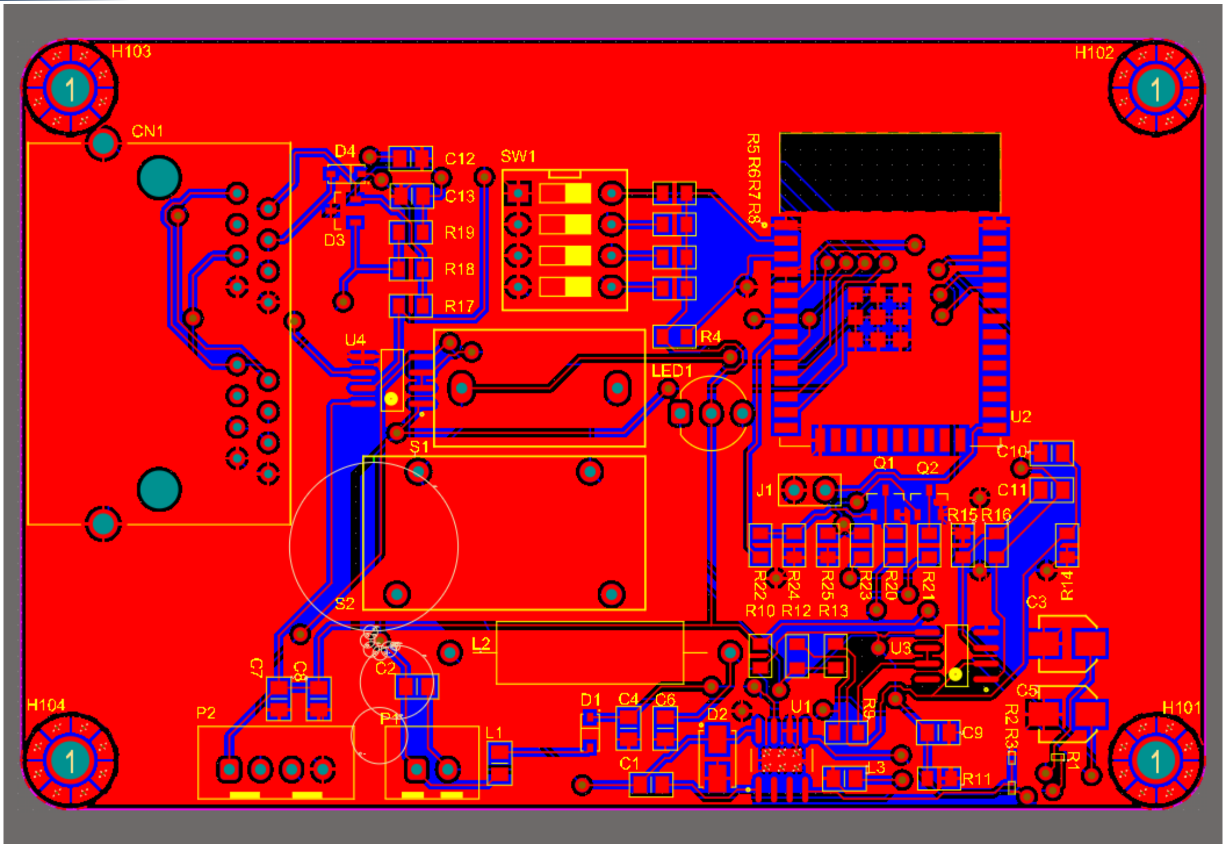


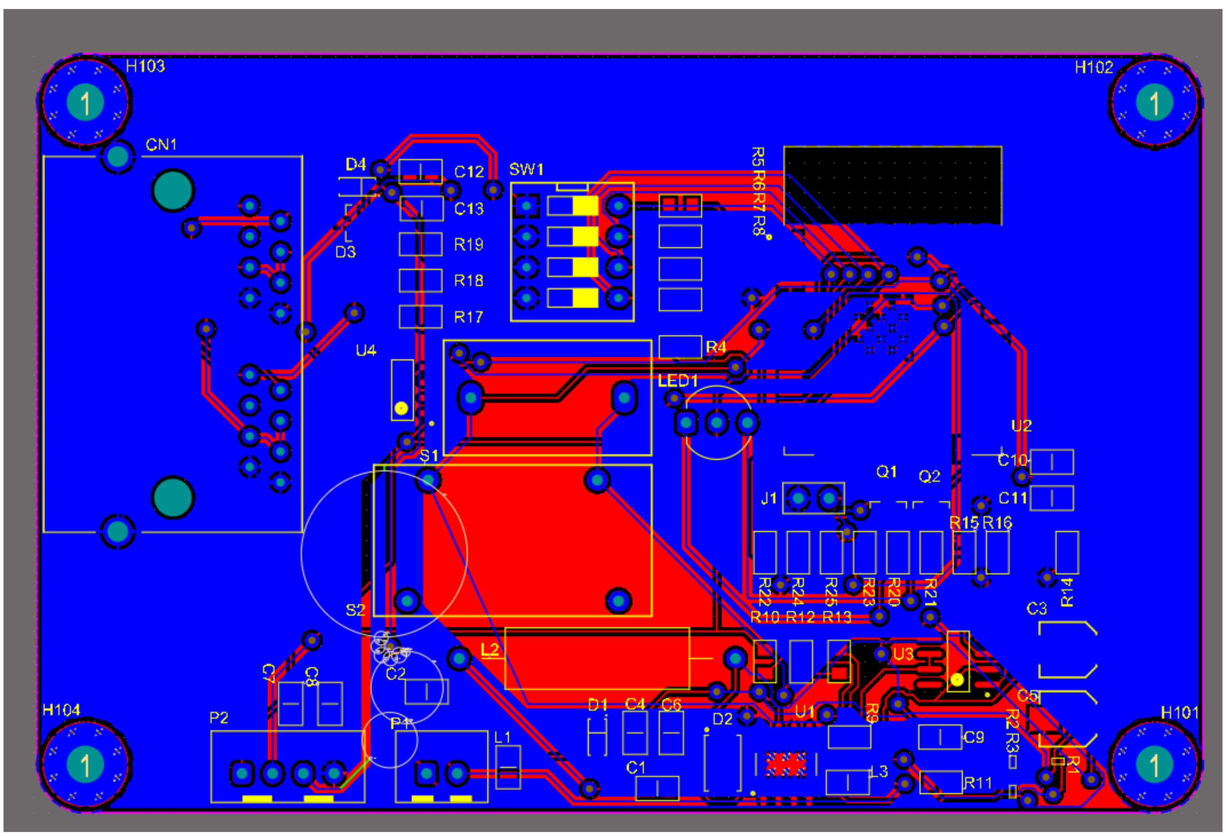
f. High Current LED



2. PCB Layout




H103
H102
CN1
D4
C12
SW1
C13
D3
R19
R18
R17
R5 R6R7 R8
U4
R4
LED1
U2
S1
C10
Q1
Q2
J1
C11
R15 R16
R22
R24
R25
R23
R20
R21
R14
R10 R12 R13
C3
S2
L2
U3
C7
C8
C2
H104
P2
P1
L1
D1
C4
C6
D2
U1
R9
C5
C9
R2 R3
R1
H101
C1
L3
R11


H103
H102
CN1
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C12
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U4
R4
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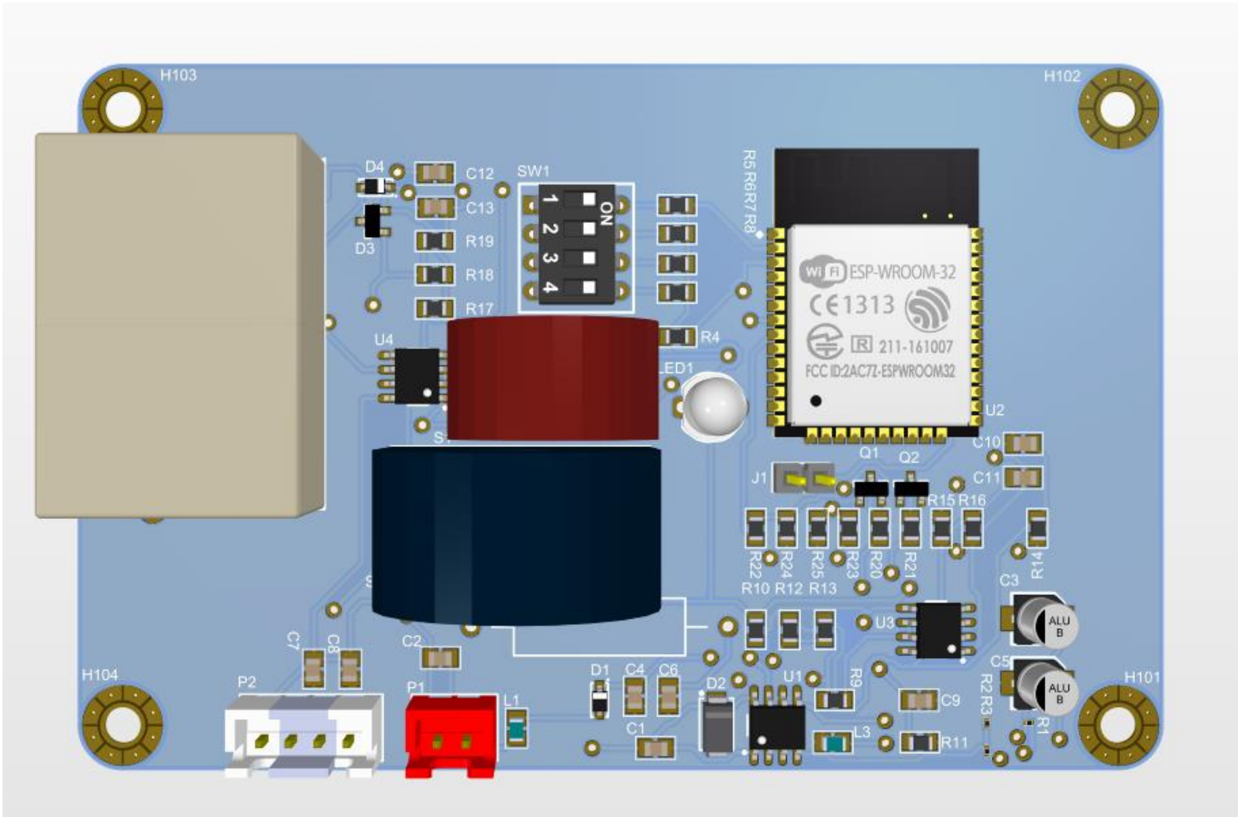
R22
R24
R25
R23
R20
R21
R14
R10 R12 R13
C3
S2
L2
U3
C7
C8
C2
C5
H104
P2
P1
L1
D1
C4
C6
D2
U1
R9
C9
R2 R3
R1
H101
C1
L3
R11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H102
H104
H101
D4
C12
C13
R19
R18
R17
D3
SW1
ON
1
2
3
4
R5 R6 R7 R8
R4
U4
LED1
ESP-WROOM-32
CE1313
211-161007
FCC ID:2AC7Z-ESPWROOM32
U2
C10
C11
Q1
Q2
J1
R15 R16
R22 R24 R25 R23 R20 R21
R10 R12 R13
R14
C3
U3
ALU B
C5
P2
P1
C7
C8
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C4
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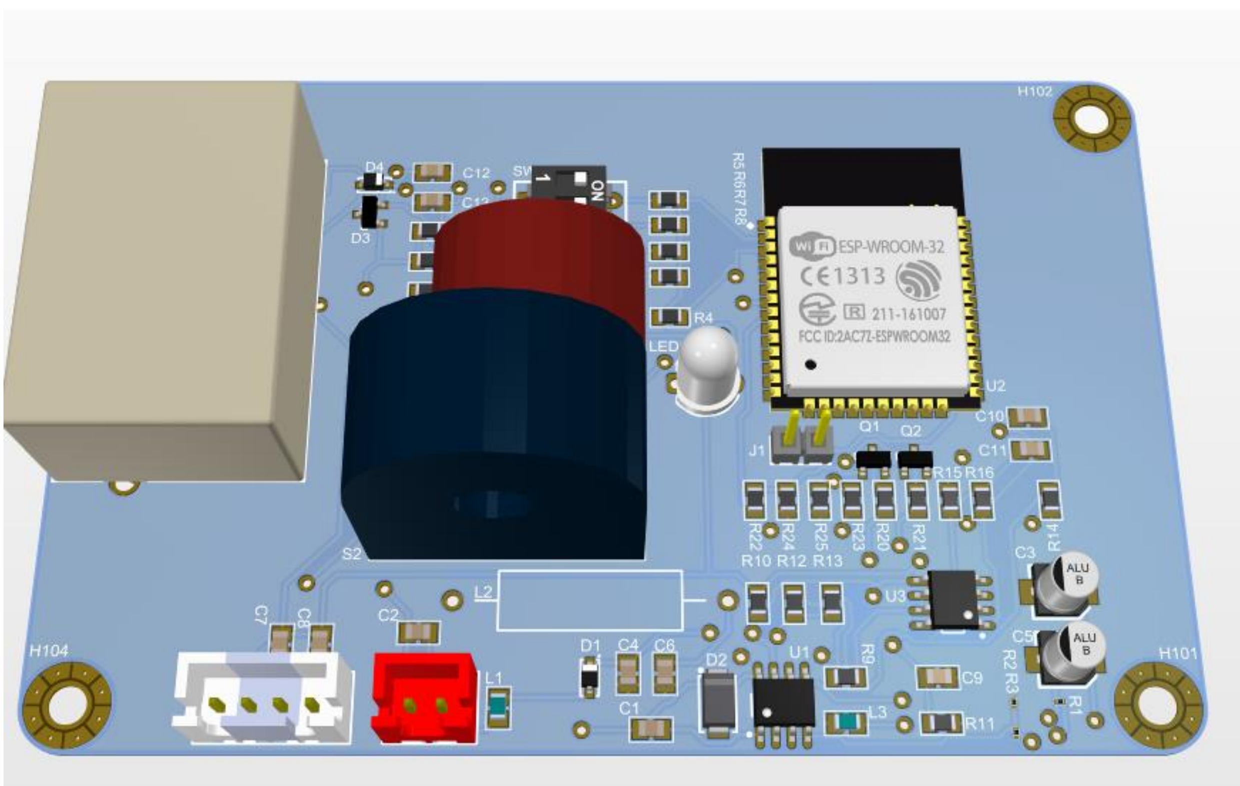
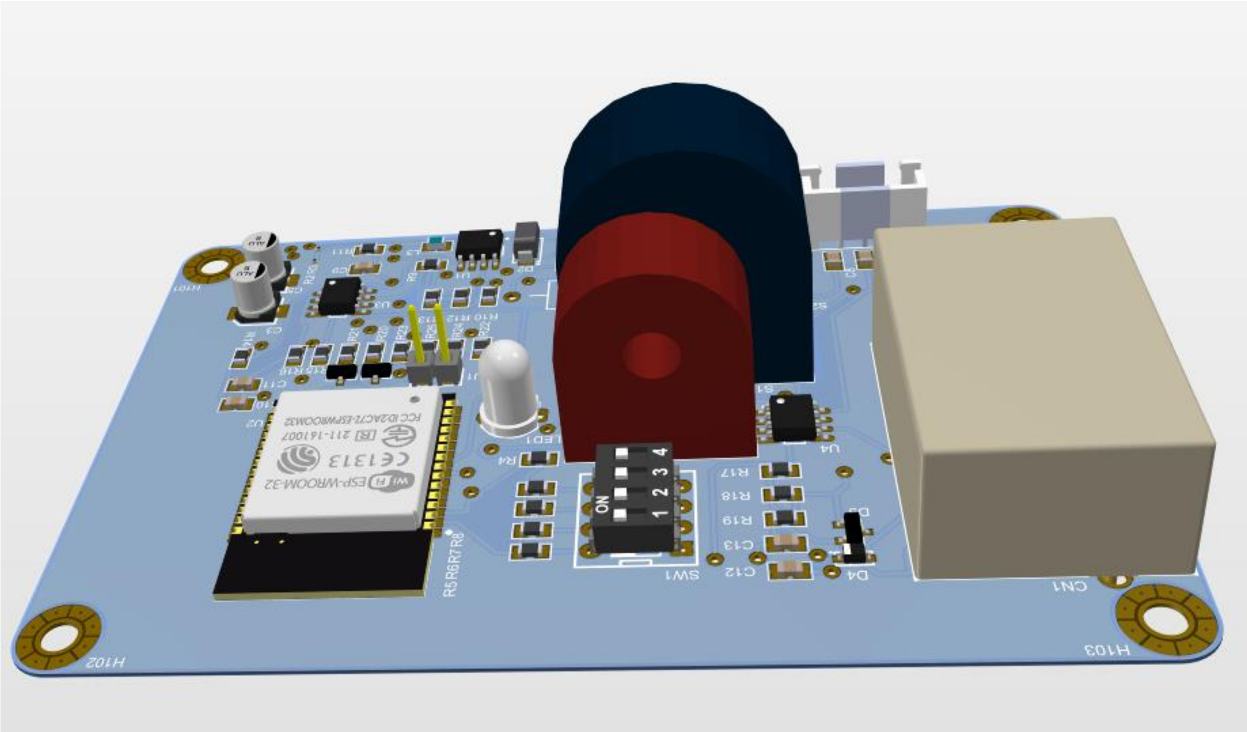
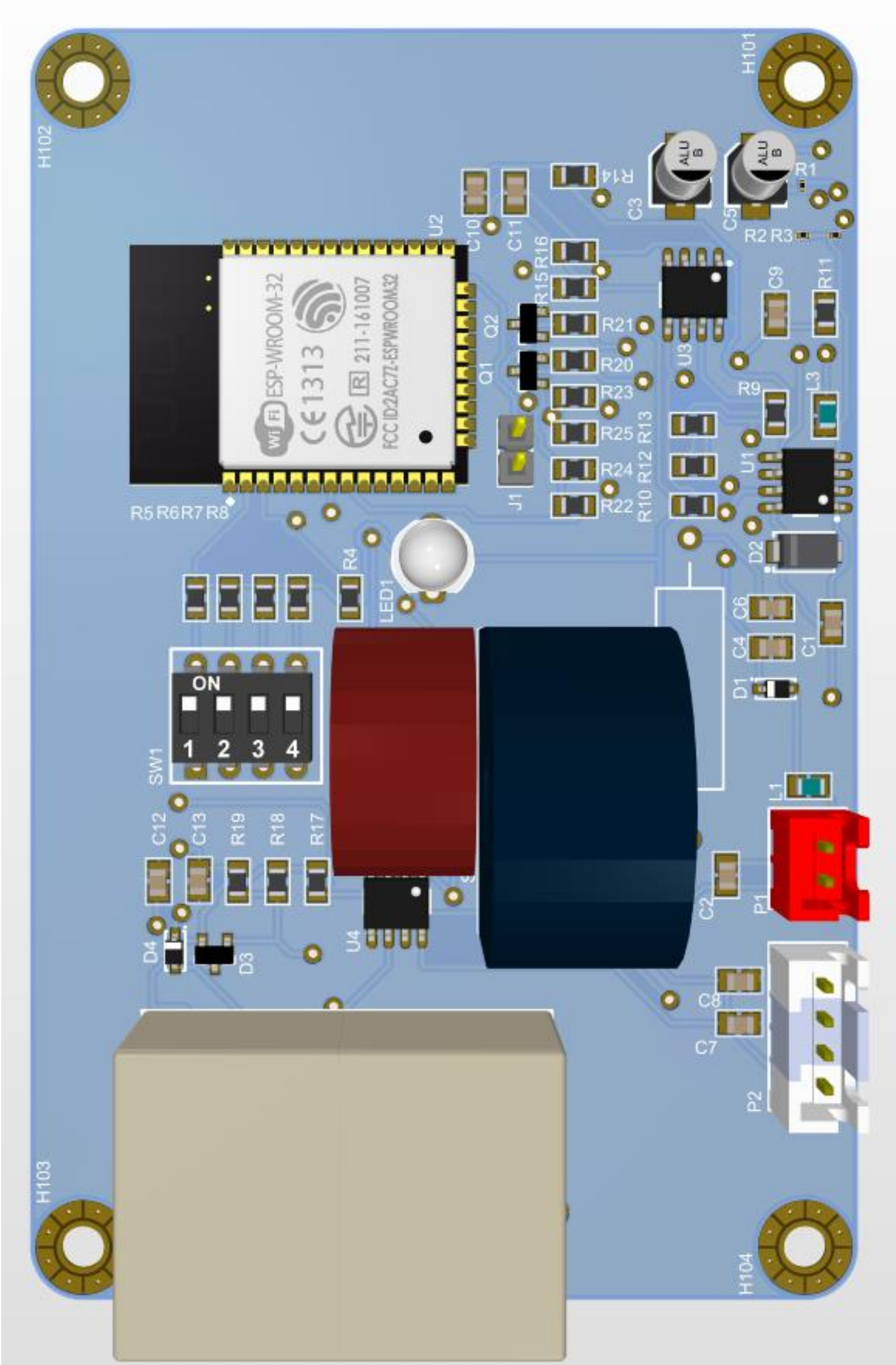
D2
U1
R9
C9
L3
R11
R2 R3
R1


H102
H104
H101
D4
C12
D3
ON
R5 R6 R7 R8
R4
ESP-WROOM-32
CE1313
211-161007
FCC ID:2AC7Z-ESPWROOM32
U2
C10
C11
Q1
Q2
J1
R15 R16
R10 R12 R13
R14
C3
U3
ALU B
C5
S2
L2
C7
C8
C2
L1
D1
C4
C6
C1
D2
U1
R9
C9
L3
R11
R2 R3
R1




H101
H102
H103
H104
U2
ESP-WROOM-32
C10
C11
C3
C5
R1
R2 R3
R14
R15 R16
R21
R20
R23
R25
R24
R22
R10 R12 R13
Q1
Q2
J1
U3
C9
R11
R9
L3
U1
D2
R5 R6 R7 R8
R4
LED1
C6
C4
C1
D1
ON
1 2 3 4
SW1
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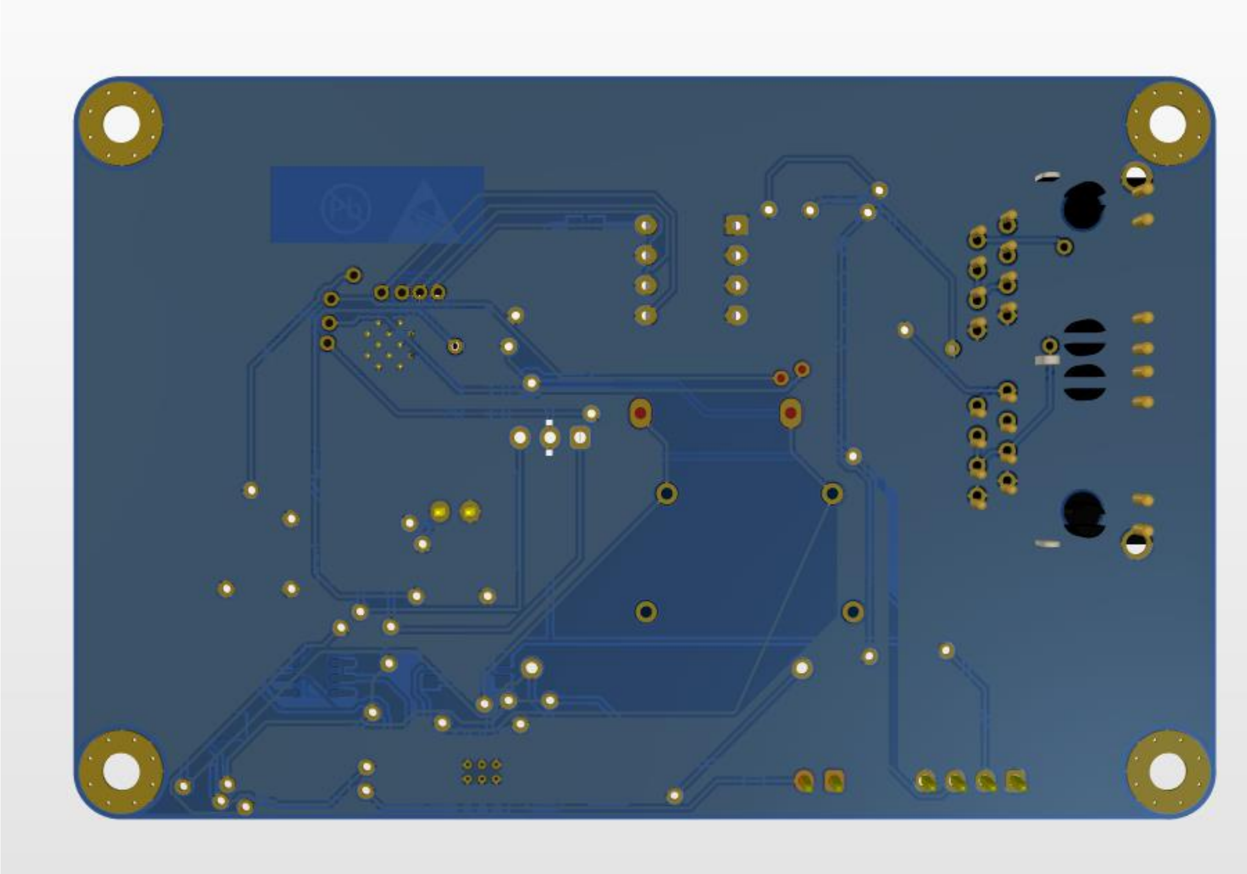
R17
C2
P1
U4
D4
D3
C8
C7
P2



3. Answering the question

[1] Research on the Internet and list 5 different current sensors that you can find. Along with each current sensor, please (1) give a reference source, (2) maximum current that the sensor can measure, and (3) how to obtain its values (e.g, using ADC, UART, I2C or SPI and so on).

These are 5 different current sensor that can be found in the market:

- **ACS712 Current Sensor:**

Reference Source: Allegro MicroSystems datasheet

Maximum Current: Typically available in 5A, 20A, and 30A versions.

How to Obtain Values: Analog output, usually interfaced with an ADC (Analog-to-Digital Converter).

- **LEM HAIS 200-P Current Transducer:**

Reference Source: LEM datasheet

Maximum Current: Up to 200A

How to Obtain Values: Typically provides a voltage or current output proportional to the measured current.

- **INA219 High-Side DC Current Sensor:**

Reference Source: Texas Instruments datasheet

Maximum Current: Up to 3.2A

How to Obtain Values: I2C interface, with built-in 12-bit ADC.

- **Allegro ACS758 Hall Effect-Based Linear Current Sensor:**

Reference Source: Allegro MicroSystems datasheet

Maximum Current: Ranges available up to 200A.

How to Obtain Values: Analog output, usually interfaced with an ADC.

- **LEM IT 205-S Current Transducer:**

Reference Source: LEM datasheet

Maximum Current: Up to 600A

How to Obtain Values: Provides a proportional current or voltage output.

[2] In Figure 1.4, what is the voltage of SW1 when slide switch 1 is ON? and is OFF?

In Figure 1.4, this circuit is called a pull-up resistor. Pull-up resistors are resistors which are used to ensure that a wire is pulled to a high logical level in the absence of an input signal. So, when the Switch 1 is at ON mode, the SW1 wire would be at low logical signal (approx. 0) and vice versa, when the Switch 1 is at OFF mode, the SW1 will have the high logical signal (3.3V).

[3] In Figure 1.5, what is the voltage of ADC1_CH7? of ADC1_CH6?

At the ADC1_CH7, the first op-amp is a voltage follower, so $V_{in} = V_{out}$.

Using the voltage divider, we can calculate the V_{in} at U3B op-amp:

$$V_{in} = \frac{R_{11}}{R_{10} + R_{11}} \times 3.3\ (V) = \frac{1}{1+1} \times 3.3 = 1.65\ (V)$$

$$V_{in(U3B)} = V_{ADC1(CH7)} = 1.65\ (V)$$

We can apply the voltage divider to calculate the V_{in} at the U3A op-amp:

$$V_{in(U3A)} = V_{ADCin} \times \frac{R_{14}}{R_9 + R_{11} + R_{14}} = 1.65 \times \frac{1}{0.1 + 1 + 1} \approx 0.786(V)$$

While at the U3A op-amp, this is a voltage follower with gain op-amp, so the $V_{out(U3A)}$ should be calculated using this formula:

$$V_{out(U3A)} = \left(1 + \frac{R_{16}}{R_{15}}\right). V_{in(U3A)} = \left(1 + \frac{1}{1}\right) \times 0.786 = 1.572(V)$$

$$V_{ADC1(CH6)} = V_{out(U3A)} = 1.572\ (V)$$

[4] In Figure 1.5, we apply a low pass filter to the signal ADC_IN. What is the cutoff frequency of this low pass filter? If we want to set a cutoff frequency is about 10kHz, what should we change in the circuit of U3A?

The cut-off frequency when applying the low pass filter:

$$f = \frac{1}{2\pi RC} = \frac{1}{2\pi \times 1(k\Omega) \times 0.1\ (nF)} \approx 1.59\ (MHz)$$

While the capacitor is not easy to replace and change because of its price, we can change the resistor by adding another resistor next to R16 in the figure or replace the R16 resistor with a higher value resistor accordingly.

At 10kHz cut-off frequency:

$$R = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 10(kHz) \times 0.1(nF)} \approx 0.1591\ (M\Omega) = 159.1\ (k\Omega)$$

So, we can add another $158\ (k\Omega)$ resistor, or we can change the R16 resistor to a higher value resistor at approx. $159.1\ (k\Omega)$.

[5] How much do the currents go through each LED in Figure 1.7? What should we do if we want to control a 100mW LED?

This LED is a complete diode which includes a rheostat at 330R and a diode, so the LED0 and LED1 should be similar and have the same value. Therefore, we just have to calculate 1 value of LED0 or LED1.

In this case, LED0 is used to calculate the value.

We can calculate the value of I_C, which will be the current through LED0. We will calculate the value of I_B and then, we will calculate the I_C:

$$I_B = \frac{3.3 - 0.7(V)}{4.7(k\Omega)} - \frac{0.7\ (V)}{47(k\Omega)} \approx 0.538\ (mA)$$

$$I_C = \beta . I_B = 100 \times 0.538 = 53.8\ (mA)$$

To control the 100mW LED, we will assume that Q1 transistor is saturated, the $V_{CE(Sat)}$ and β should have the value at:

$$V_{CE(Sat)} = 0.65\ (V)$$

$$\beta = 100$$

$$V_{BE} = 0.7(V)$$

We will calculate the voltage at LED0:

$$V_{LED} = 3.3 - 0.65 - 0.7 = 1.95(V)$$

Next, in order to calculate $I_{C(sat)}$, we will need the resistance value of the rheostat:

$$P = \frac{U^2}{R_{LED0}} \rightarrow R_{LED0} = \frac{U^2}{P} = \frac{(1.95\ (V))^2}{0.1(W)} = 38.025(\Omega)$$

$$\rightarrow R = \frac{38.025}{330} \approx 0.1152(\Omega)$$

$$I_{C(Sat)} = \frac{V_{LED}}{R_{LED0}} = \frac{1.95}{38.025} \approx 0.051(A) = 51.282(mA) < 53.8\ (mA)$$

In conclusion, the currents go through each LED is at $53.8mA$, while when controlling a 100mW LED, we need to adjust the value of the rheostat at $R = 0.1152\Omega$, the transistor will be in saturated mode, so the current go through the LED should be equal to the $I_{C(Sat)}$ $(51.282mA)$.

[6] What is the main purpose of D2 in Figure 1.6?

Operating as a reverse-voltage clamp and EMI filter, D2 safeguards the MAX3485. During low RS-485 EN, D2 forward-biases, diverting current from the SVO pin to ground, preventing negative voltage excursions that could harm the transceiver. Additionally, D2's impedance characteristics attenuate high-frequency EMI noise, ensuring clean signal transmission.