Wrocław University of Science and Technology

Microcontrollers Project

Name:Chiemelie Nzelibe *Student ID:257283*

Completion Date:14/02/2023

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Introduction:

The project objective was to get us familiar with making schematics and finding parts on our own and connecting them to achieve a working microcontroller. The goal for the project was to design a 2-layer pcb with a surface area of less than $20cm^2$ using the components provided by the professor which are as follows.

Component	Parameters
MCU	STM8 in TSSOP 20
Clock	External crystal SMT
Power	Battery double AAA cell -(VCC2.1v)
Input1	Temperature sensor based on pt1000 with usable range -50 to +200c
Input2	1-axis accelerometer on I2C
Output	LCD2*16char display

Programming through UART

MCU

For this task as I was to use stm8 in tssop 20 package, a microcontroller that fits the description was found on mouser and was readily available for order. The component found is the STM8L101F2P3. This is an Mcu which has a supply voltage range of 1.65volts to 3.6volts which satisfies the supply voltage from the battery. Some important parameter of MCU are:

Low power consumption

Up to 8 bytes of Flash Program including up to 2 kbytes of data EEPROM

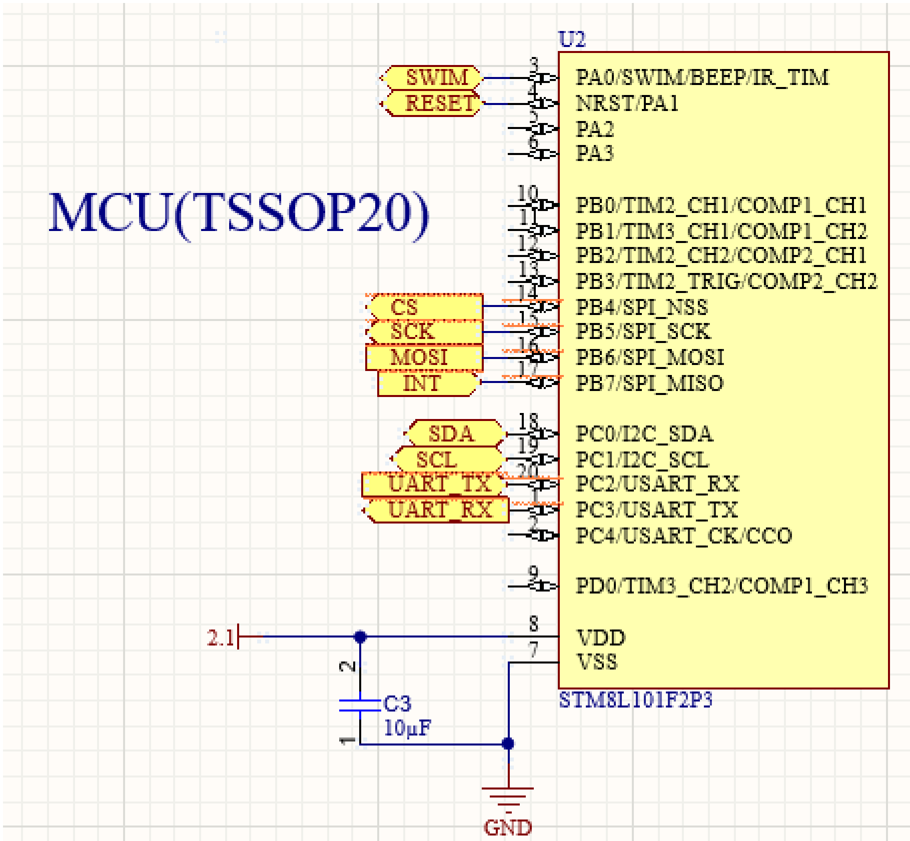
Internal 16MHz RC with fast wakeup time(4us)

Ultra low power POR/PDR

Nested interrupt controller with software priority control

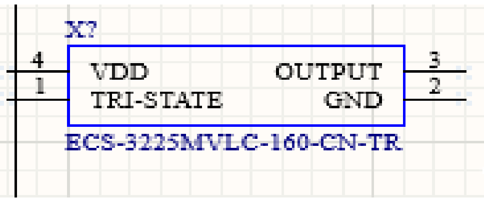
Up to 29 external interrupt vectors

Up to 30 I/Os, all mappable on external interrupt vectors



Clock

For the clock I was to use an external crystal SMT, this was easy to find in mouser website the problem was with the mcu there was no available mcu that used an external crystal SMT with provided requirements just the internal clock so i've improvised and used just the internal clock which has 16MHz RC with fast wakeup time. Here is a schematic of the external clock which was not used but was found and was readily available . The component found was known as the ECS-3225MVLC-160-CN-TR.



Power

For this section, a battery double AAA cell was required to produce a vcc of 2.1volts. An AAA battery has 1.5volts so for this voltage regulators were used to step down the voltage and also to step up the voltage for other parts other than the mcu that required a higher voltage the regulator used to step up the voltage is known as LTC3429 this a boost converter which requires an input voltage of 1-3.5 volts which can be satisfied from the 3 volts of our double AAA battery(Formula used to achieve the 5 volts can be found in data sheet but would be stated here for reference). First a value for R2-255kohms was chosen then the resistor for R1 was calculated in order to achieve the 5 volts the R1 values was not standard as it was 781585.36 so a standard value was chosen from resistor e24 series which gave a value of 768k ohms

$V_{OUT}=1.23V*[1+R1/R2)]$

For the buck converter(stepdown) the LT1110 was used, this can also be used as a boost converter but I've decided to use it as the only buck converter for a variety of parts. Has a supply voltage range of 1 to 30 volts so i've used the 5 volts from the boost converter to supply voltage to this part in order to determine the output a formula was also given in the datasheet which will be shown below

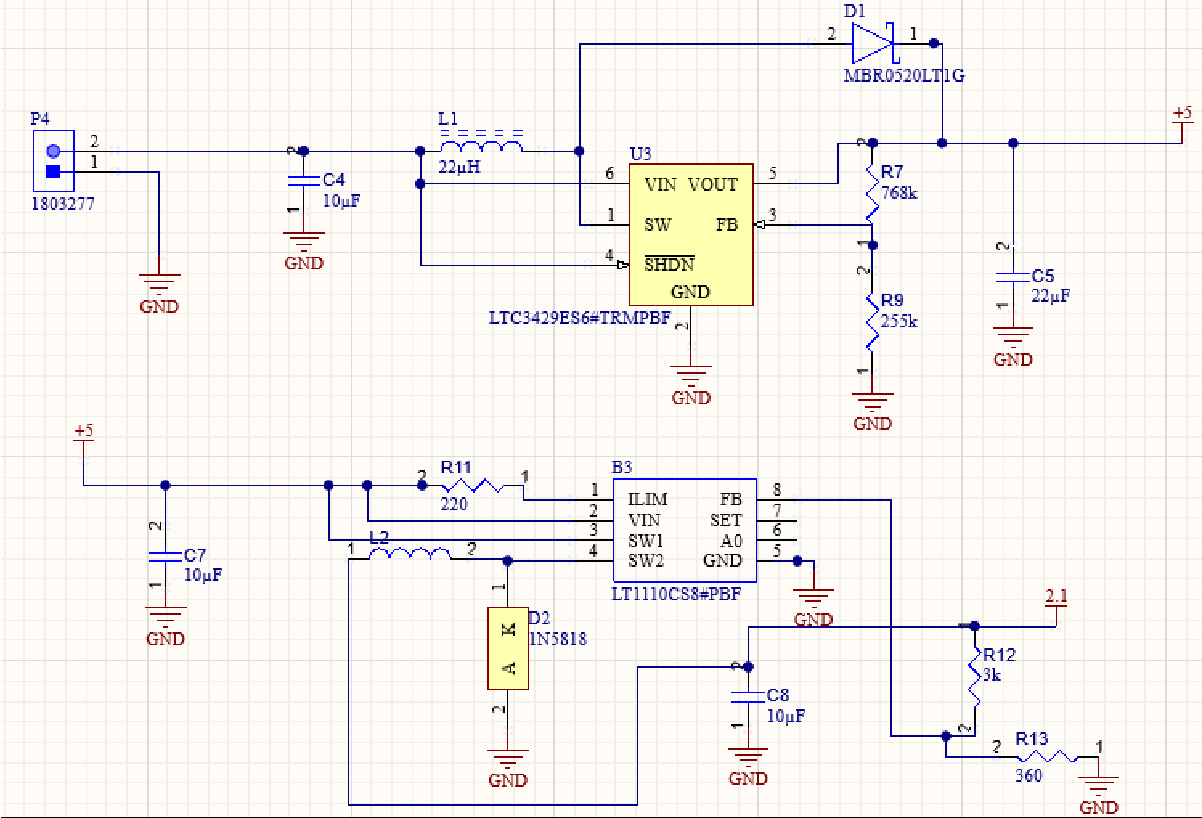
$V_{OUT}=[1+R2/R1](220\ mv)$

With this we were able to attain 2.1volts using resistor R1 as 360 ohms and R2 as 3k ohms. These are standard resistor values from e24 series which were gotten after calculation of resistors.

NOTE: In order to get 5 volts with the first component and lower than 3.3volts with the second component a schottky diode had to be used in each of the converters, they will be seen in the schematic.

The components were ready available on mouser for order .

POWER SUPPLY



Input1(Analog input)

For this part a temperature sensor based on pt1000 was required with a usable range of -50 to +200c the part found for this was known as PTFM102B1A0 with a usable range of -50 to +600c. Change of resistance was measured using voltage divider will be seen in schematic mcu has no built in adc therefore and analog to digital converter was also needed in order to connect the analog input to the mcu the analog to digital component used is known as ADS7816UB which has reference voltage range of 100 mv to 5v so the 2.1volts was used for ref and 5 volts on vcc
PT1000 resistance characteristics based on temperature

Calculation Formulas

The calculation formulas of this Pt-RTD are defined in DIN EN 60751 as following:

For T ≥ 0 °C: $R_{(T)} = R_{(0)} \cdot (1 + a \cdot T + b \cdot T^2)$

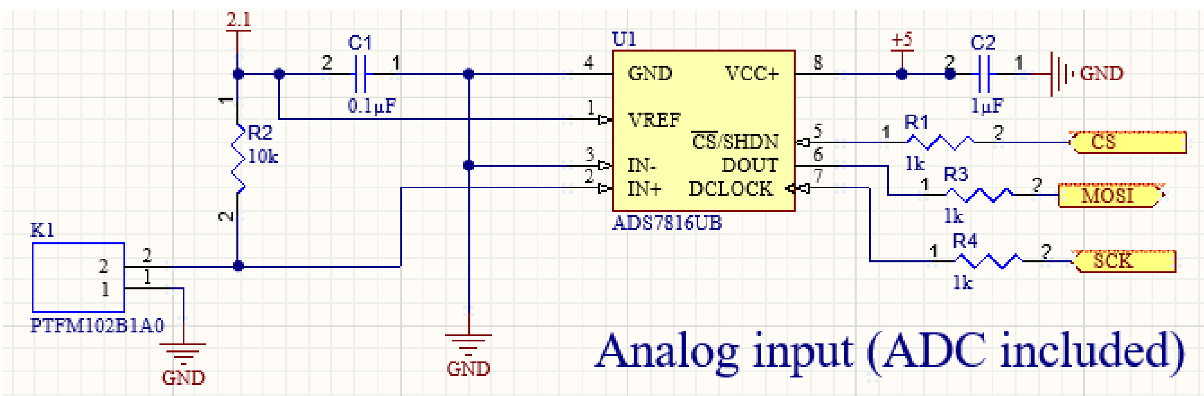
For T < 0 °C: $R_{(T)} = R_{(0)} \cdot [1 + a \cdot T + b \cdot T^2 + c \cdot (T - 100°C) \cdot T^3]$

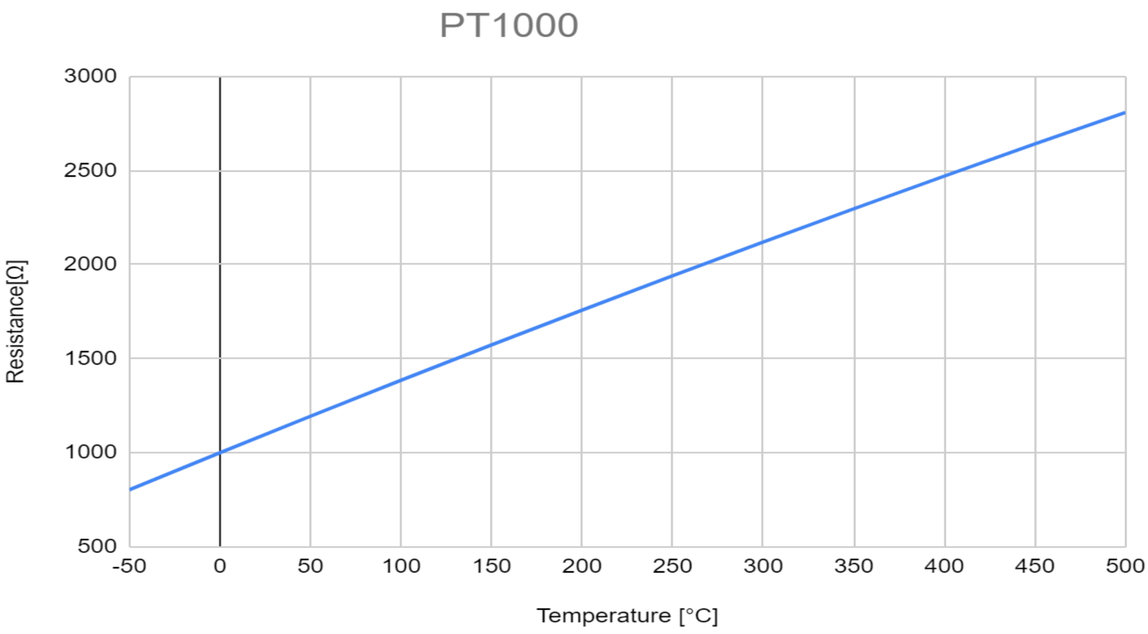
Coefficients:

a = 3.9083E-03
b = -5.775E-07
c = -4.183E-12

Tolerances:

Class F 0.1 (T = AA):	± (0.10+0.0017*|T/°C|) °C	(-30…+200 °C)
Class F 0.15 (A)	± (0.15+0.002*|T/°C|) °C	(-30…+300 °C)
Class F 0.3 (B):	± (0.30+0.005*|T/°C|) °C	(-50…+600 °C)
Class F 0.6 (C):	± (0.60+0.06*|T/°C|) °C	(-50…+600 °C)





Input2(Digital Input)

For this section we were to find a 1 axis accelerometer on I2C but after extensive research on all three websites no 1 axis accelerometer was found so i decided to improvise with a 2 axis accelerometer on I2C instead which was readily available for order on mouser the 2 axis accelerometer used is MXC6255XU which had a supply voltage range of 2.5 - 5.5volts therefore the the 5 volts from boost converter was used to supply voltage to the digital input

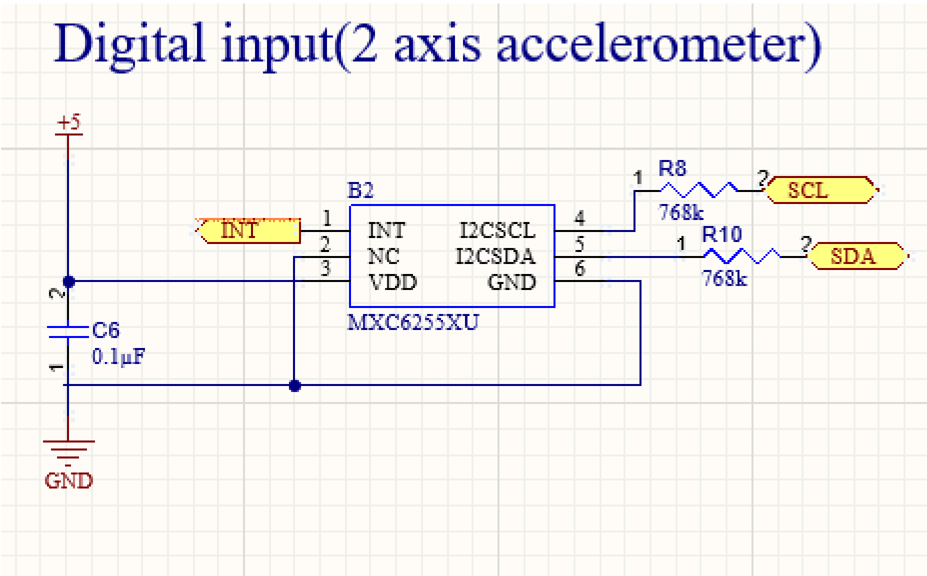
Some feature include:

Fully integrated Thermal Accelerometer

X/Y Axis, 8bit, Acceleration A/D output(+-2g)

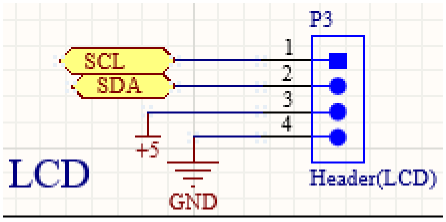
Absolut 0G offset less than +/- 50mg

Shake detection with interrupt etc...

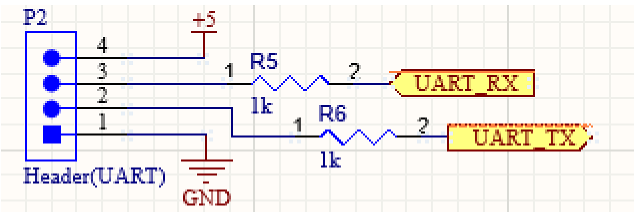


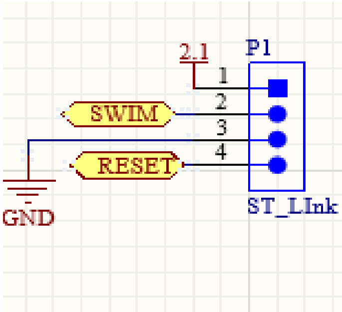
Output

For the output an LCD 2*16 char display was required. Which was connected via I2C which needed just 4 pins for connection LCD which was already soldered to the I2C converter was chosen for this. LCD with HD44780 chosen/used .

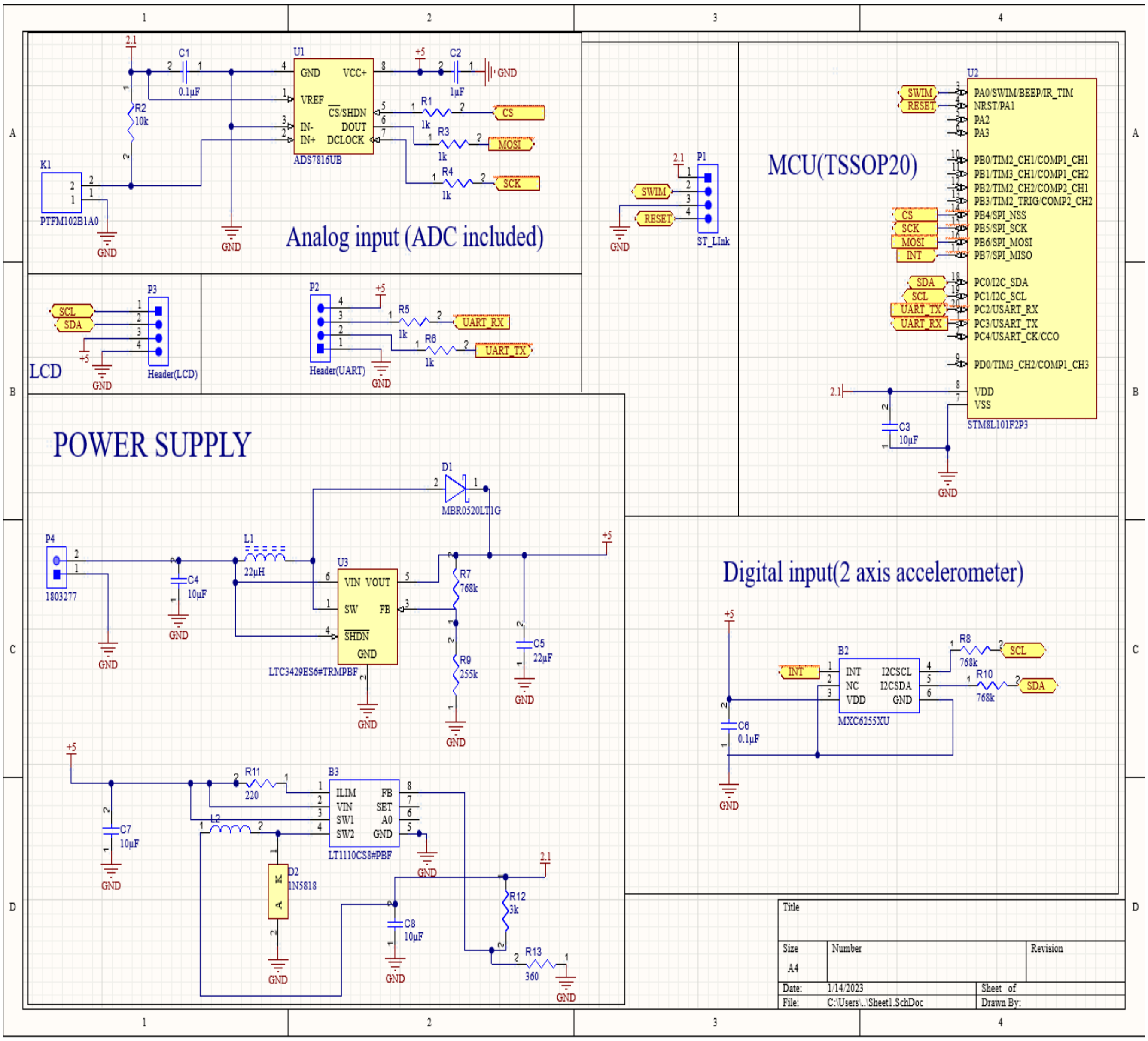


RESET/PROGRAMMING(UART)





Schematic



Analog input (ADC included)
LCD
POWER SUPPLY
MCU(TSSOP20)
Digital input(2 axis accelerometer)
ADS7816UB
STM8L101F2P3
MXC6255XU
LTC3429ES6#TRMPBF
LT1110CS8#PBF
MBR0520LT1G
1N5818
Header(LCD)
Header(UART)
ST_LInk
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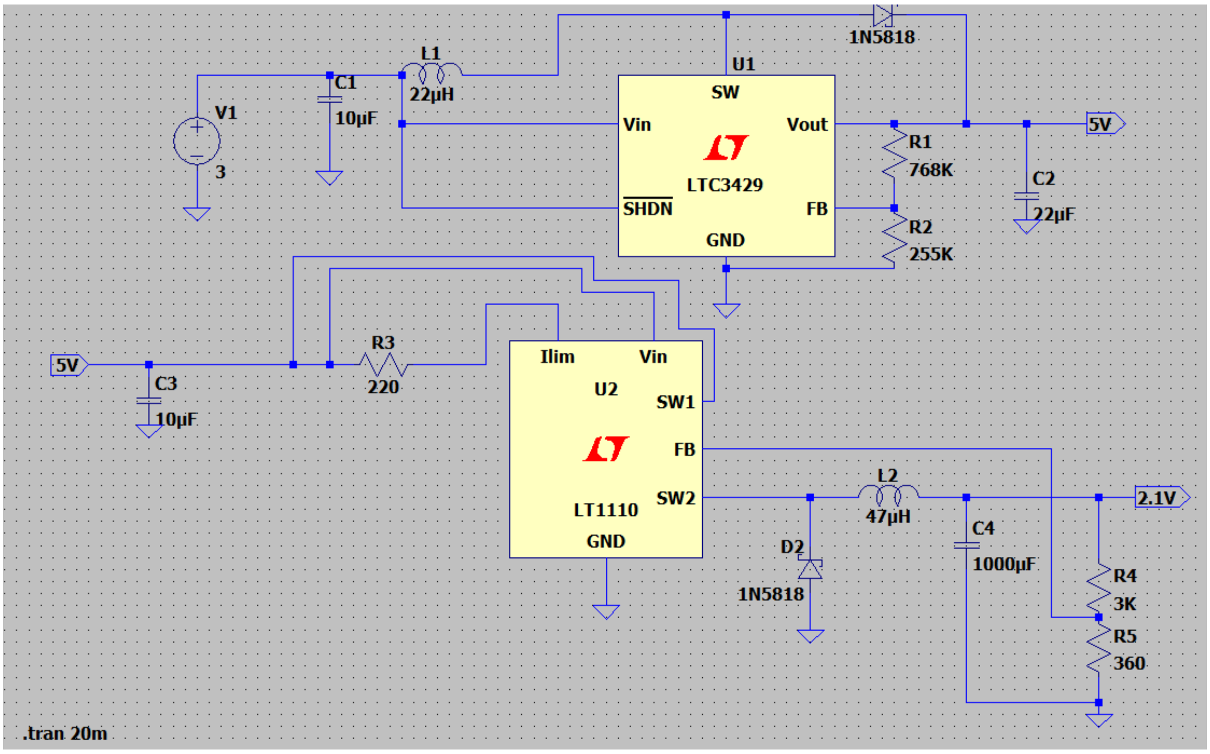
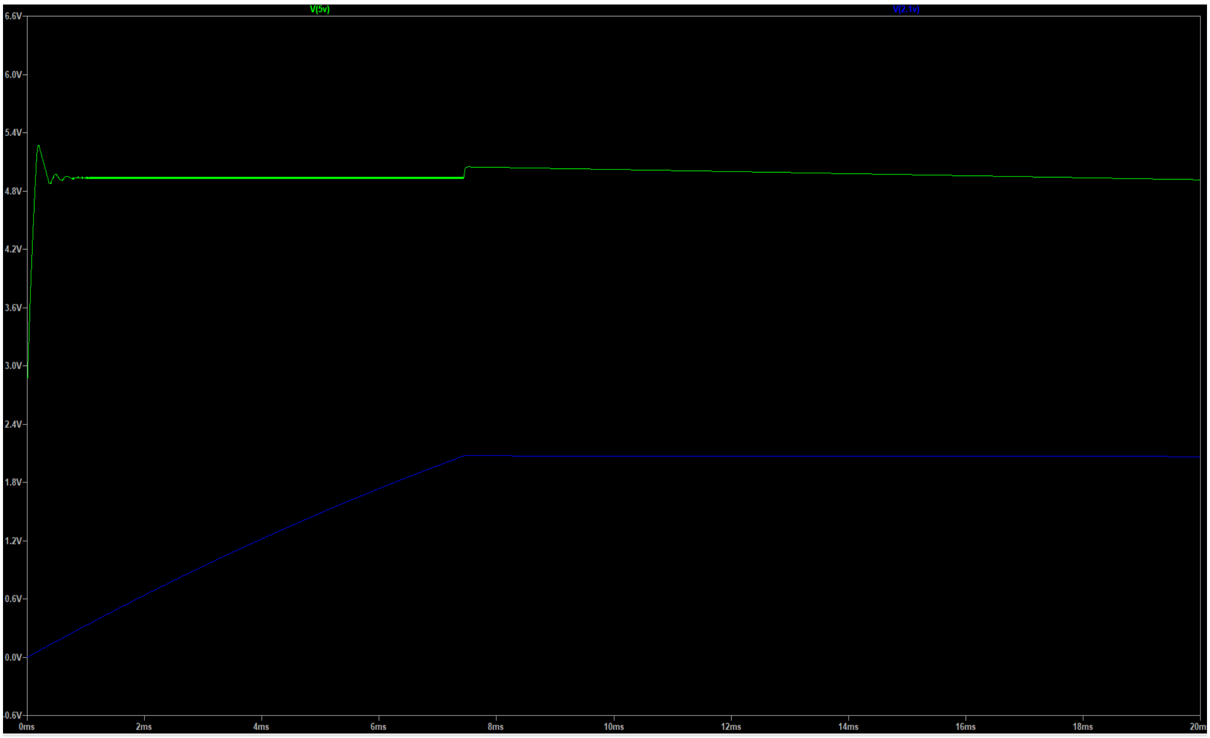
LTSPICE SIMULATION

In this part we simulated the power supply section in order to check if the initial calculation was correct. We used the models used in the altium to simulate in order to get accurate results.

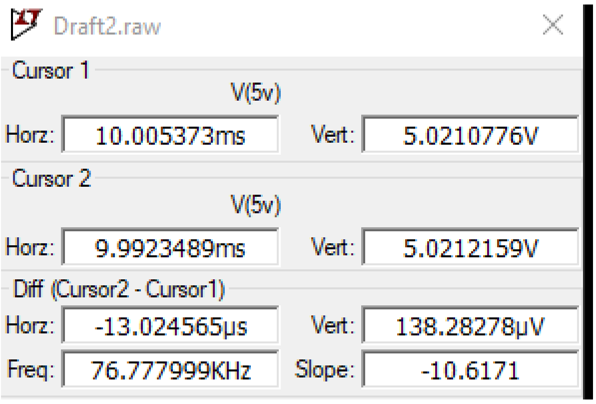


Power supply model

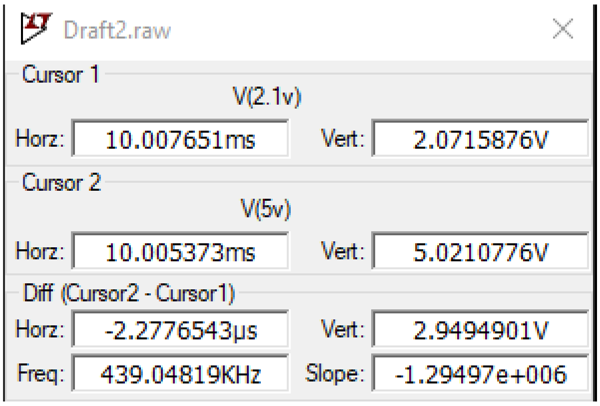
The simulation can be seen below:



From the simulation we can see that for the boost converter we get around 5.02volts at 10ms which is 0.02more than the value needed but works for us as it is less than 1% error(0.4%). Around 0.016 fluctuation

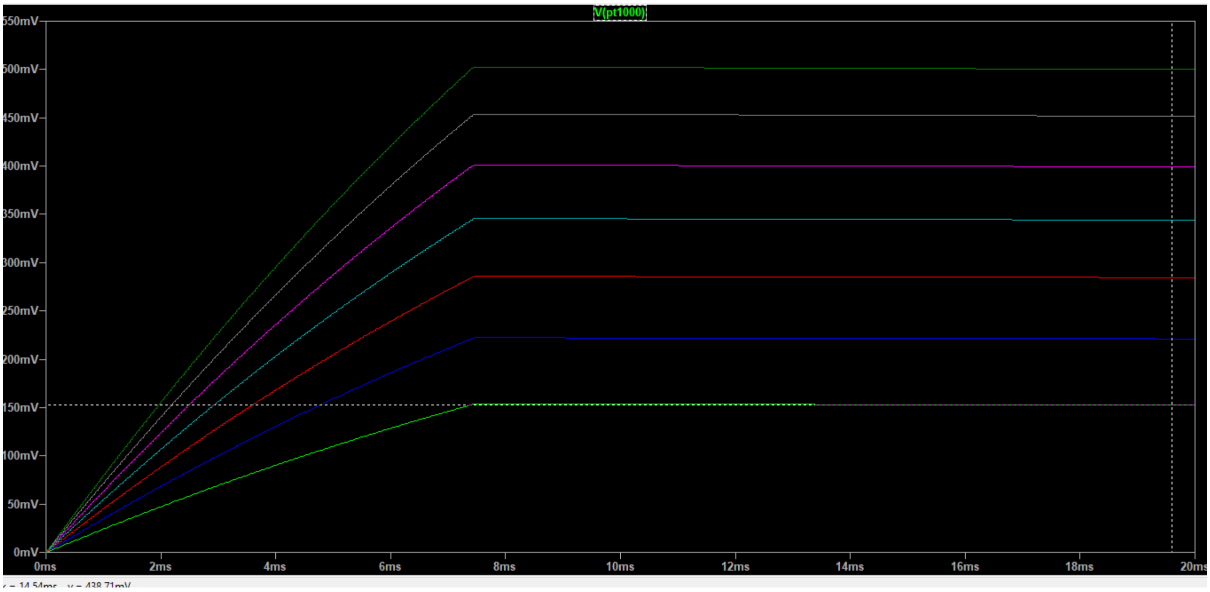


While for the buck converter we get around 2.07volts at 10ms which is 0.03 less than the value meant to be obtained but also works as it's a small error also less than 1% around 0.016 fluctuation



Overall we can say the power supply is a success as we achieved all the right values meant to be obtained

The diagram below show the readings of the voltages for the resistances at temperature from -50 to around 600C incremented by 400 :

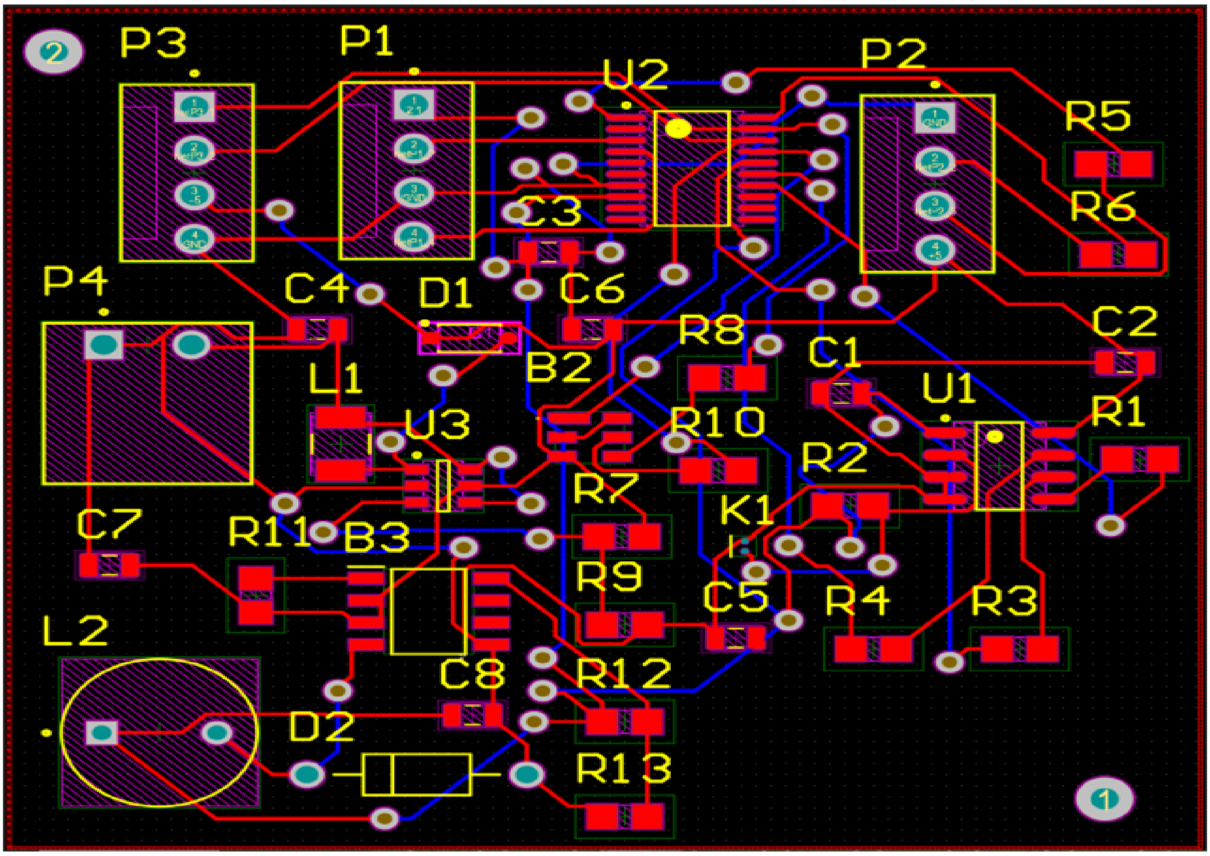


Where we can see that at 800 ohms which is -50deg celsius we have 153mv And at the maximum 3.2k ohms we have 500mv and so on for other values. Therefore ADC is applicable for use.

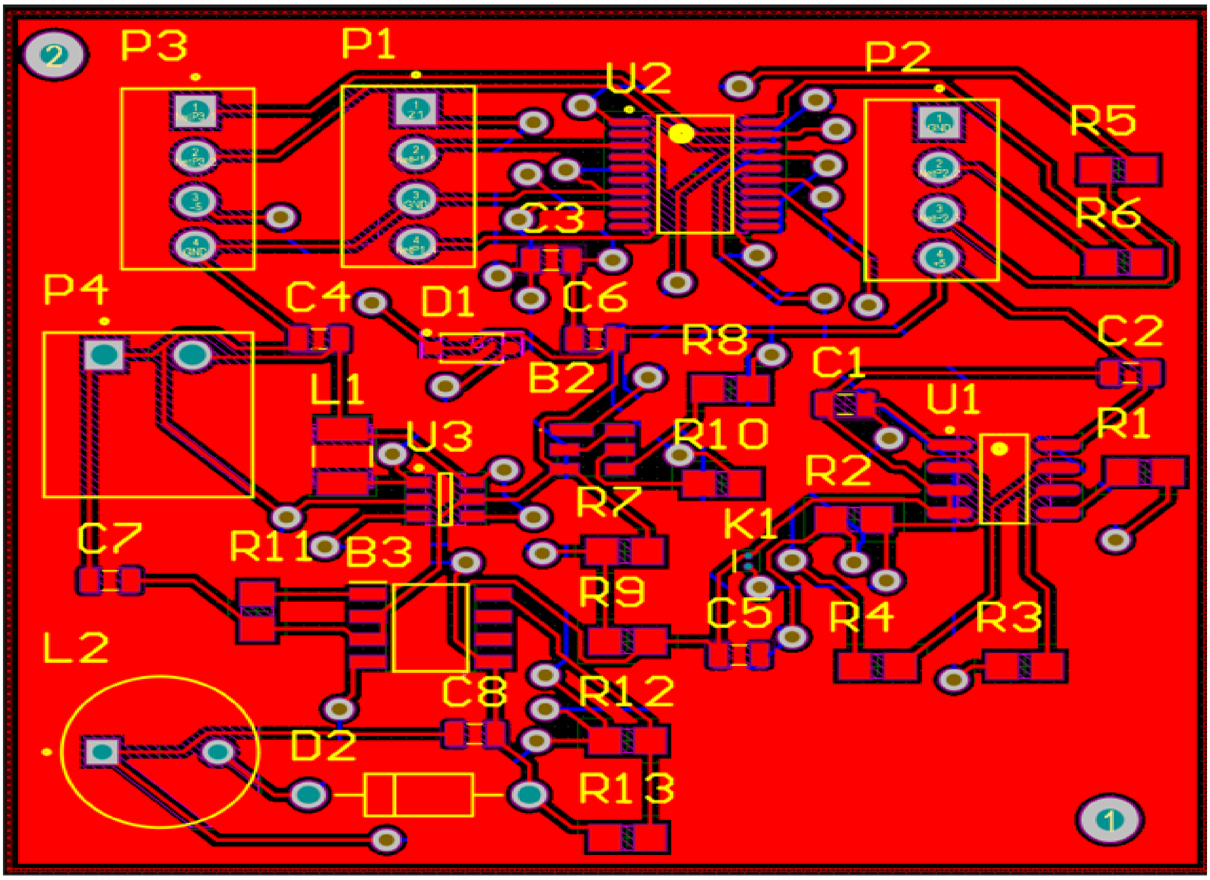
PCB Section

This section we show the final result of the schematic, which is the double sided pcb and its 3d version. The following listed can be seen below:

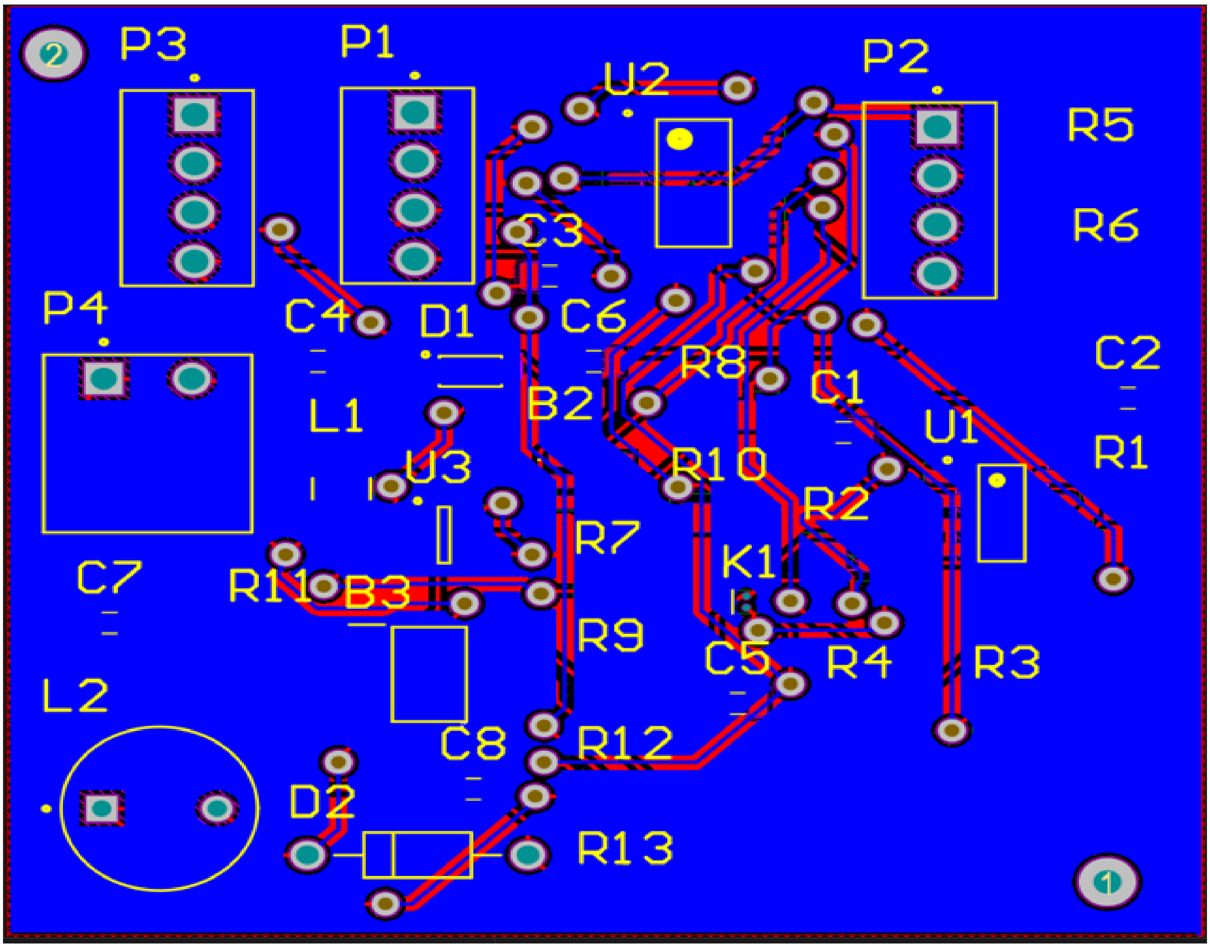
PCB with no polygon pour:



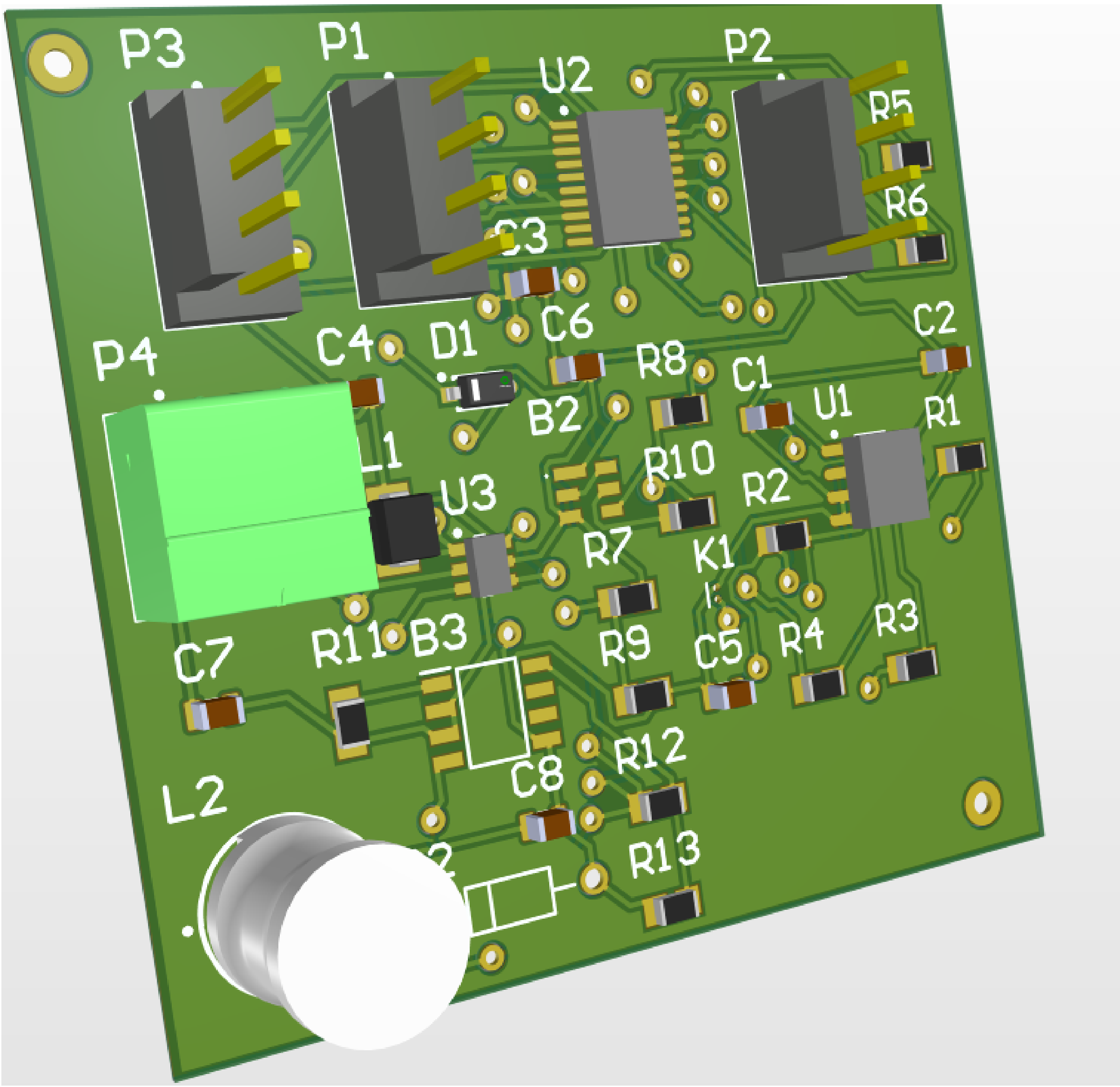
PCB with top layer polygon pour:



PCB with bottom layer polygon pour:



3d model of pcb



Conclusion

In general the completion of this project was very useful and enabled me to gain knowledge about designing pcb's especially when it comes to the connection of schematics, it was also good for building knowledge when it came to reading datasheets which helps in the design of the of the pcb schematics e.g supply voltage of particular component connection pins etc. The project was completed towards the middle of January as I was trying to understand everything in detail, therefore, there was no chance to order the physical version of the pcb. The project was successful to me and the results seem very plausible(very good project for getting started with pcb design).