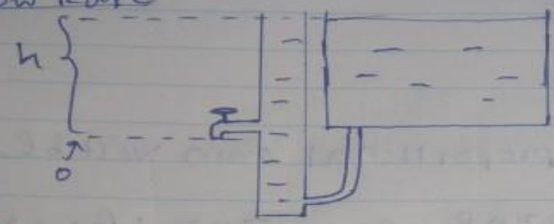
Laboratory Practice- II

Hot Water Dispenser

Group 10

Calculations

Flow Rate



* We assumed that the maximum flow rate will be required is, $20 cm^3/s$ and the area of the ~~out~~ Tap will be $1 cm^2$, so,

$$Q = AV$$

$$V = \frac{Q}{A} = \frac{20 cm^3/s}{1 cm^2} = 20 cm/s$$

• By using Bernoulli equation

$$P_{at} + \rho g h + 0 = P_{at} + 0 + \frac{1}{2}\rho V^2$$

$$gh = \frac{1}{2}V^2 \qquad g = 9.81 m/s^2 = 981 cm/s^2$$

$$h = \frac{V^2}{2g} = \frac{20 \times 20 \, cm^2/s^2}{2 \times 981 \, cm/s^2} = 0.2 cm.$$

* According to the calculation it needs to use a ~~flower~~ controlling equipment tap as such.

POWER CONSUMPTION.

Maximum flow rate = 10ml/s.

Heating temperature range = 40° - 60°C.

Maximum power neaded to heat the water.

$$\dot{Q} = \dot{m} \, C_p \, \Delta T$$

$C_p \to 4200 \text{ J/kg°C}$

$$= \rho_W \cdot VA \; C_p \, (\Delta T)$$

$\Delta T \to$ max = 60 - 25

$\rho_W \to 1000 \text{ kg m}^{-3}$.

$VA \to$ 10ml/s. $10 \times 10^{-6} \text{ m}^3/\text{s}$.

$$\dot{Q} = 1000 \times 10 \times 10^{-6} \times 4200 \times 35°$$

$$= 1.47 \times 10^{9} \times 10^{-6}.$$

$$\dot{Q}_{1max} = 1.47 \text{ kW}.$$

Maximum power needed to heat the water at this flow rate.

Assuming that we choose a Kenthal Al coil with $\sigma = 5.6703 \times 10^{-8} \text{ W/m}^2 K^4$ (Boltzman constant)

$\varepsilon = 0.7$ (Emissitivity of material)

Thermal conductivity = 11 W/mK

and maximum power of 2KW.

$$\dot{Q}_{1max} \le 2\text{KW} \checkmark$$

$$\dot{Q}_{2max} = \sigma \varepsilon A_s (T_{out}^4 - T_m^4)$$

$$= 0.7 \times 5.6703 \times 10^{-8} \times ((333.15)^4 - (298.15)^4) \times 11^4 \times \frac{585 \times 5 \times 10^{-6}}{4}$$

$$= 1.876 \text{ KW}$$

Maximum power radiated by the coil when heated to 60°C

$$\dot{Q}_{1\,max} < \dot{Q}_{2\,max}$$

PID controller

gain calculation

- In the circuit, proportional gain will be

when, $C = 0.22\mu F$. $R_i = 4.7k\Omega$, $R_f = 4.7k\Omega$

$K_p = R_f/R_i$
$K_d = R_f C$, where R_f is the feedback resistor

$K_I = 1/C.R_i$ where R_i is the input resistor

by using above mention values
$K_p = 1$
$K_d = 1.034 \times 10^{-3}$
$K_i = 967.1$

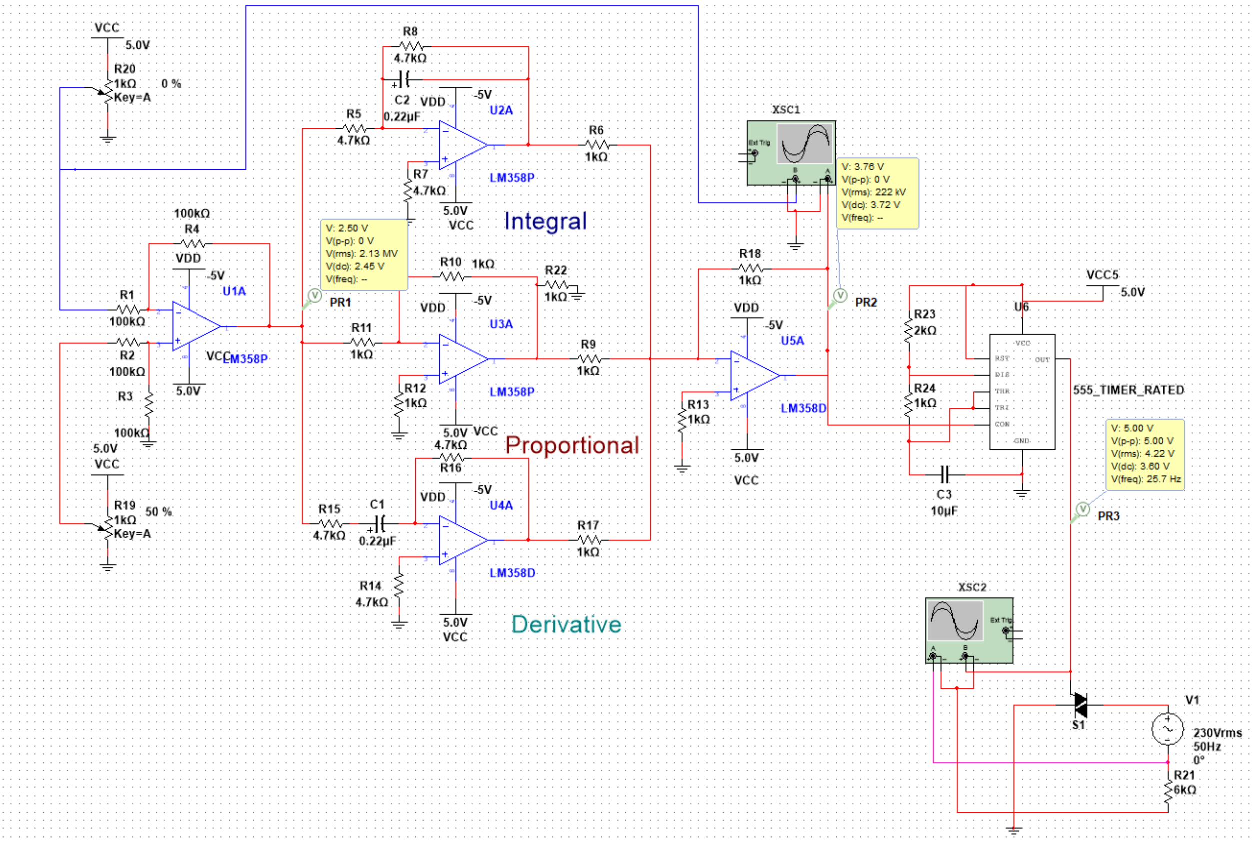
- It can be adjust in tuning ~~pa~~ time in bread board prototyping.

PWM generator

- voltage controlled PWM will be implemented by using 555 timer IC.
- DC part will be isolated from AC circuit by using optocoupler and Triac will be used for ~~the~~ control the Heating element

Multisim Simulations

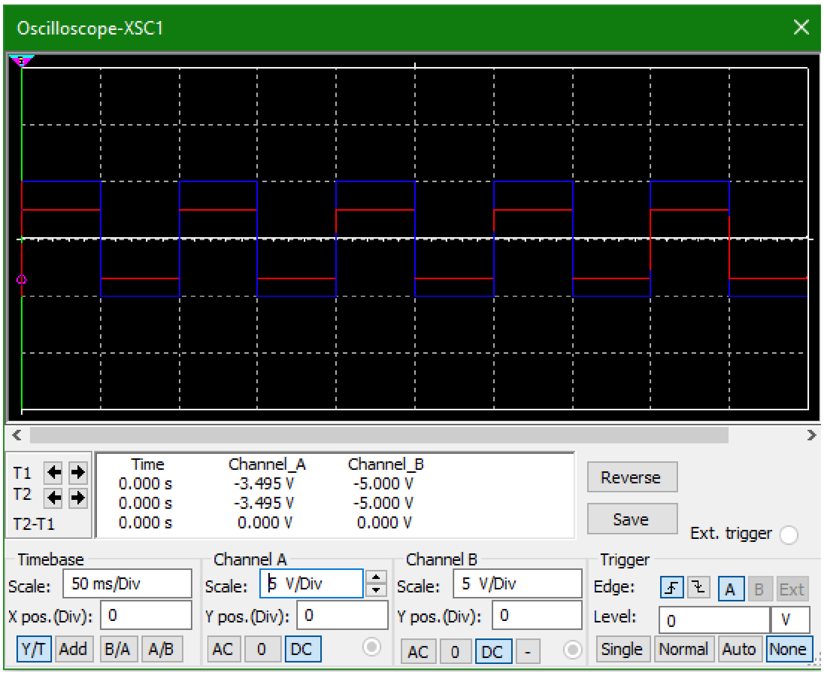
1) PID controller and PWM generator



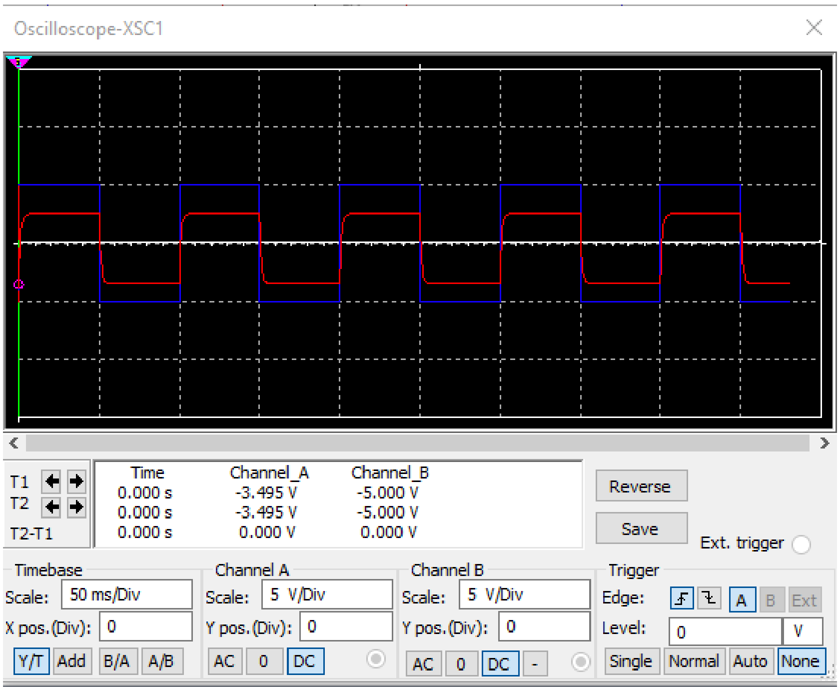
A temperature probe is used to measure water's temperature and output of it will be given as an input voltage in place of variable resister R19. R20 variable resister will be calibrated with temperatures that we want to heat the water. The difference of these voltages will be calculated through the 1st op amp and that will be used as the error function e(t). Then integral, proportional and derivative of e(t) is obtained. These 3 outputs are summed up through the last op amp and the output will be given to PWM signal generator. The output signal will be used to heat the heater and the temperature of water will be measured again. This process will go on as a loop till the error becomes 0.

Graphs

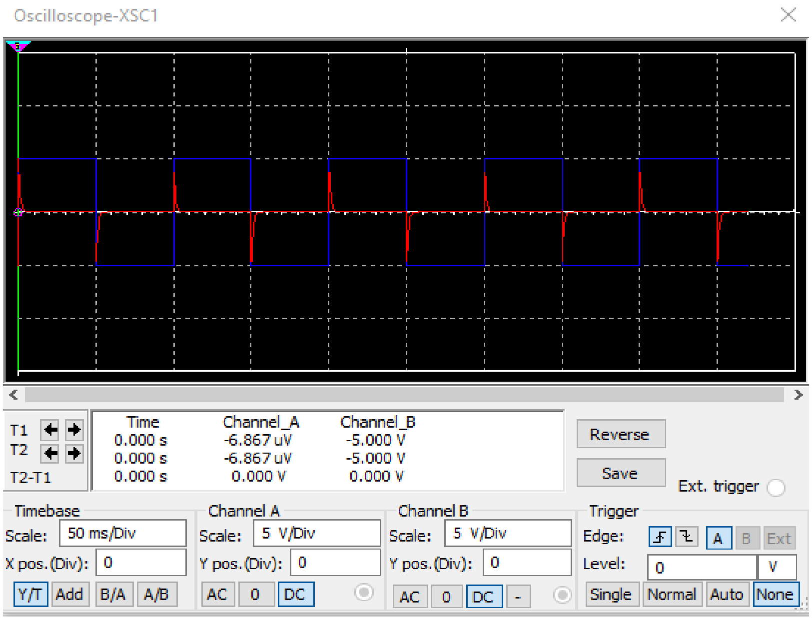
Input vs Proportional Output



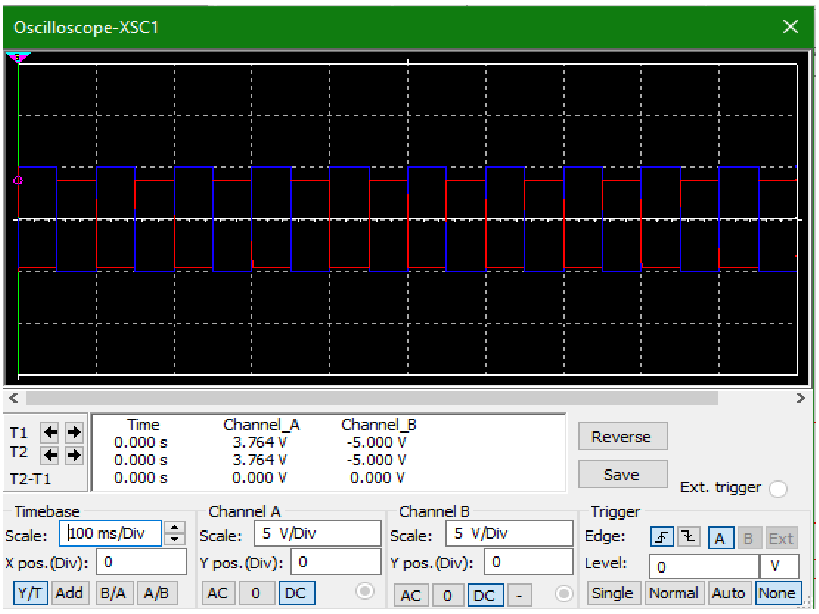
Input vs Integral Output



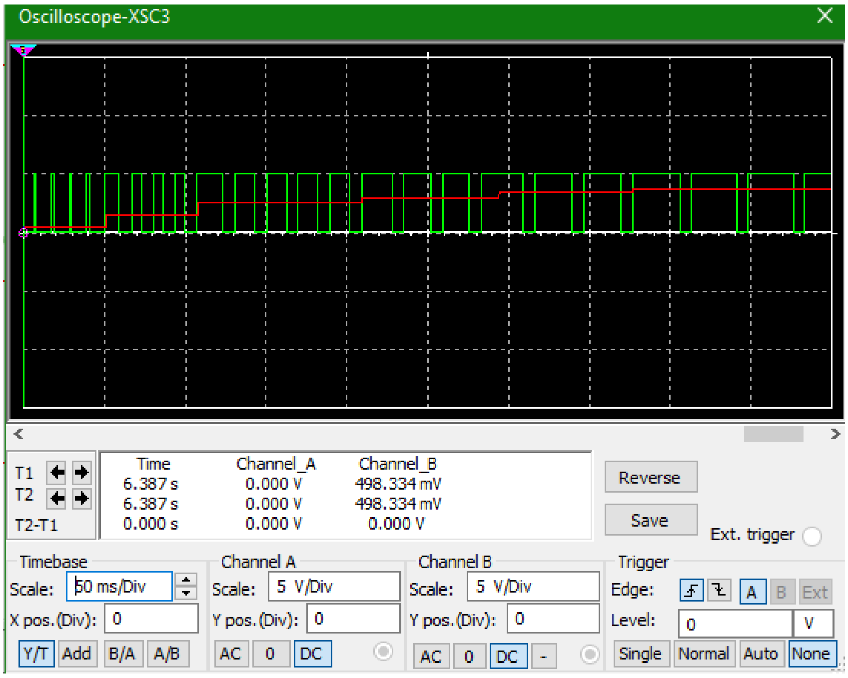
Input vs Derivative Output



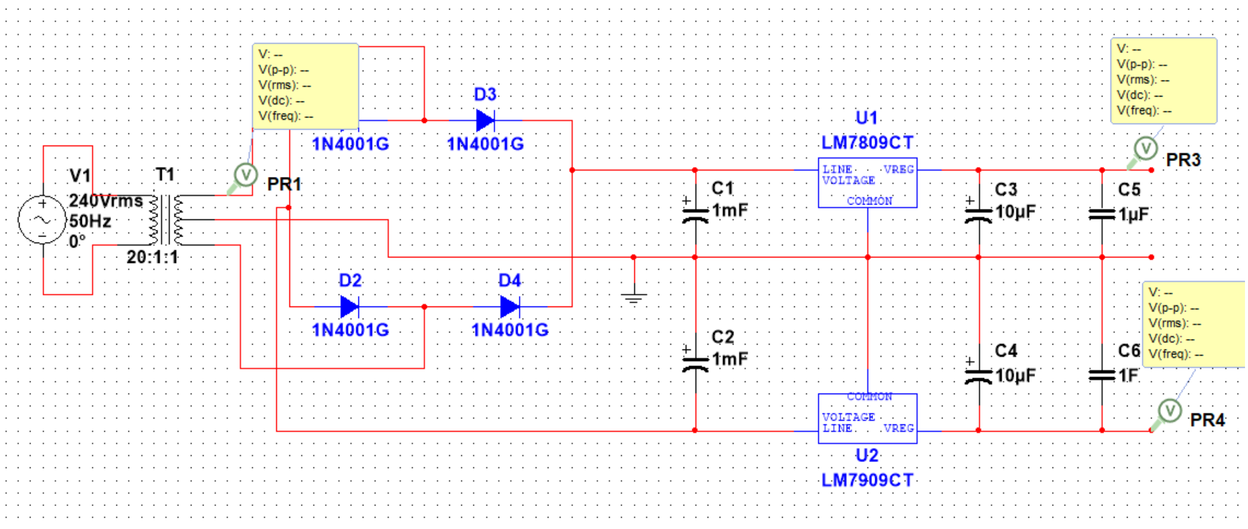
Input vs PID Output



PID_OUTPUT vs PWM_SIGNAL



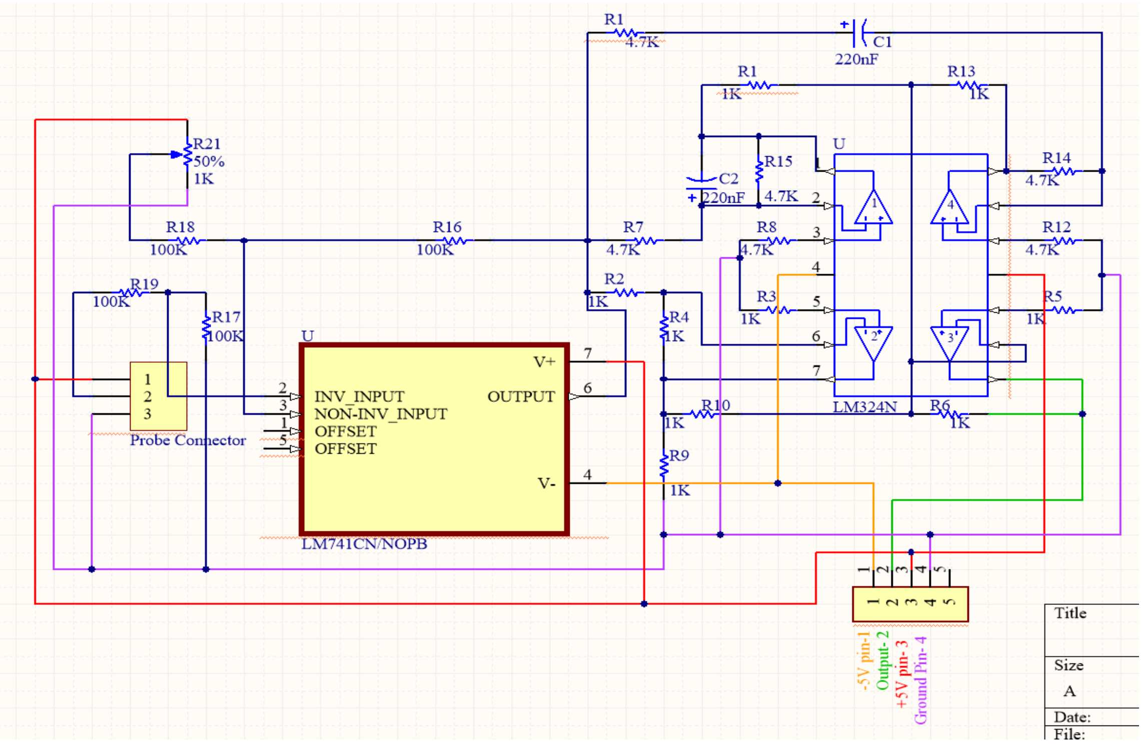
2) Power supply



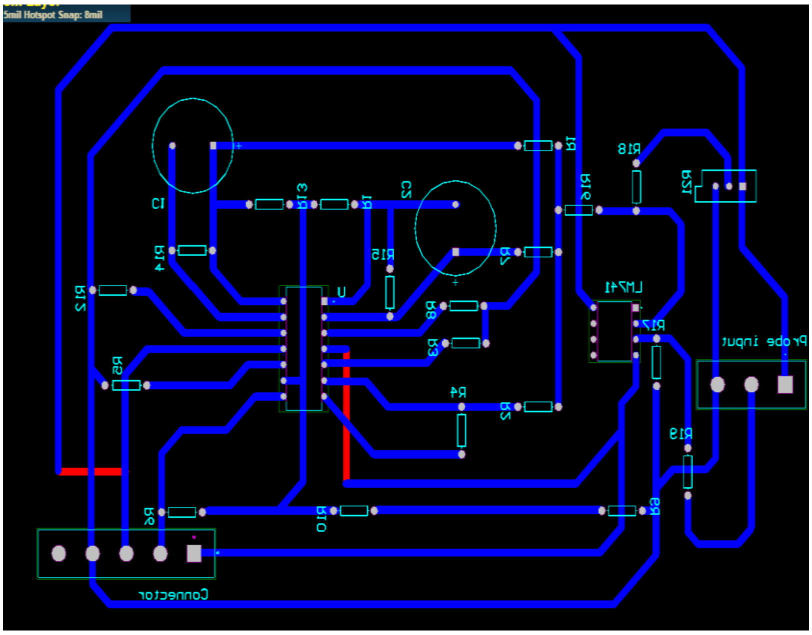
Altium Designs

PID controlling part

1) Schematic Design

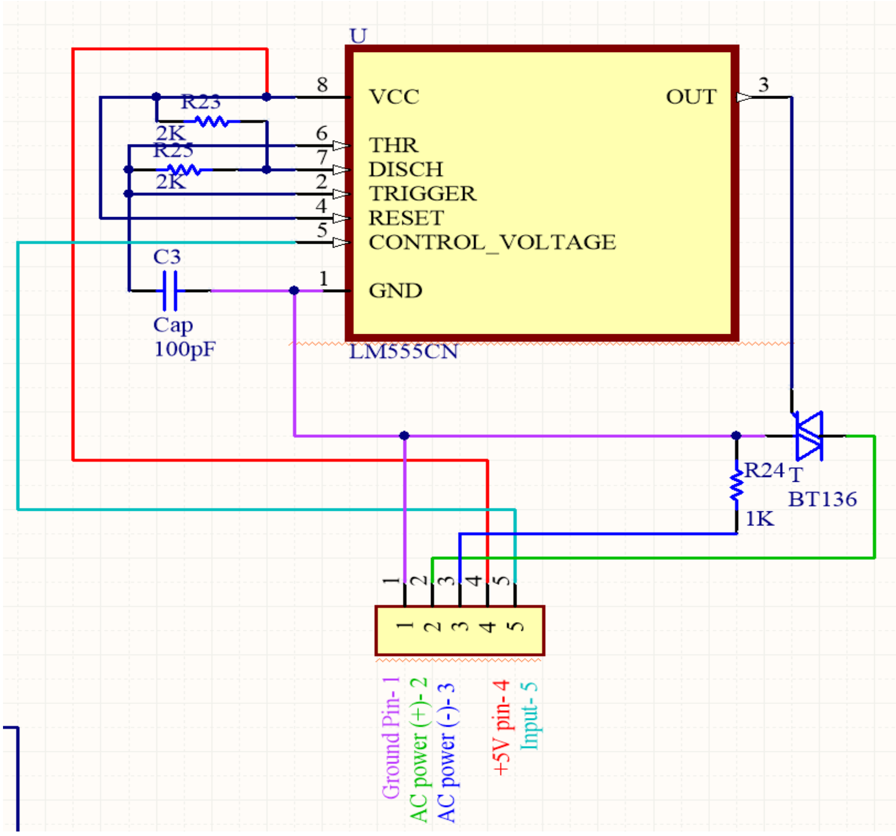


2) Design (Mirrored layout is designed)

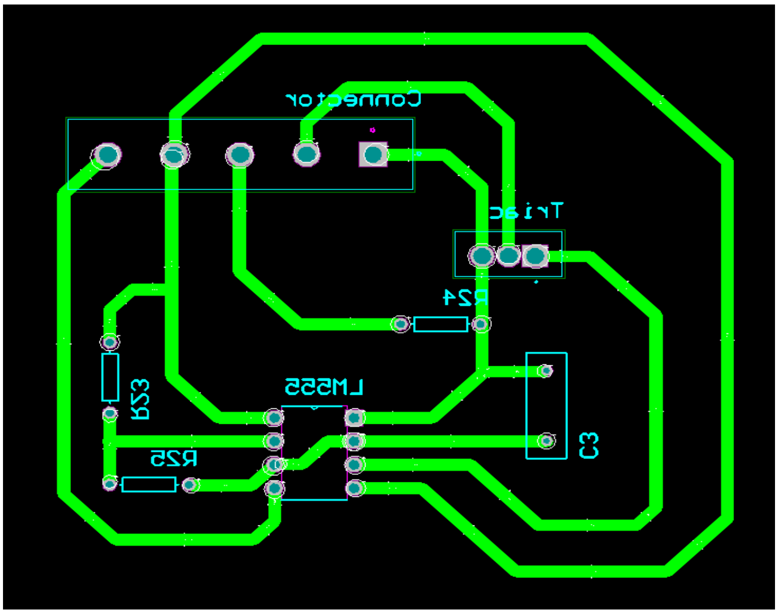


PWM signal generator

1) Schematic design

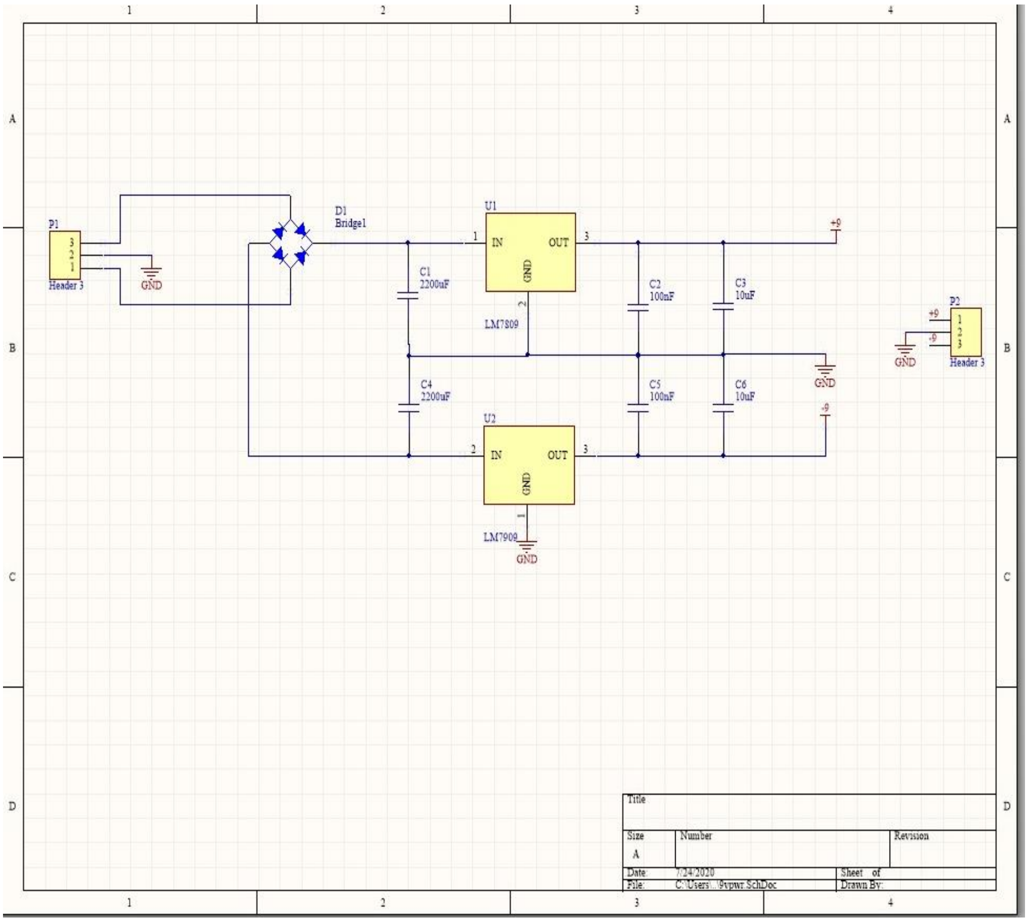


2) PCB design (Mirrored layout is designed)

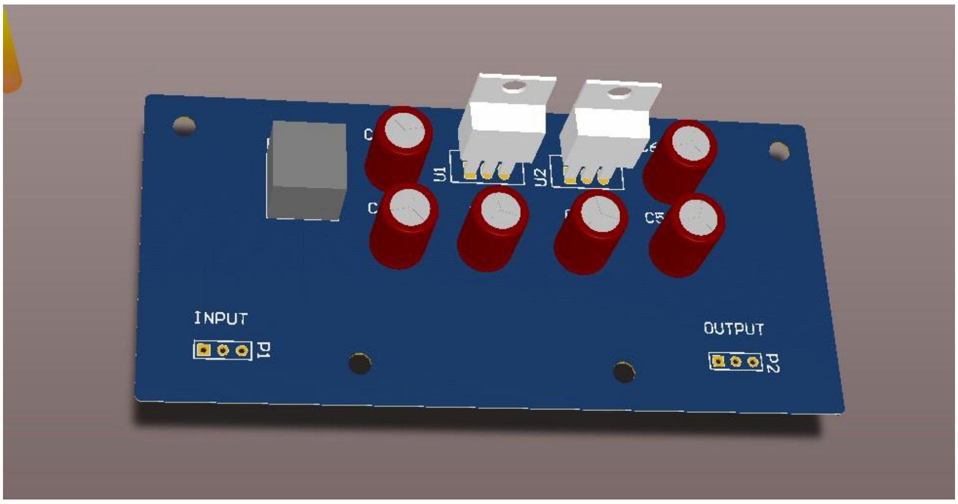


POWER_Supply

1) Schematic Design

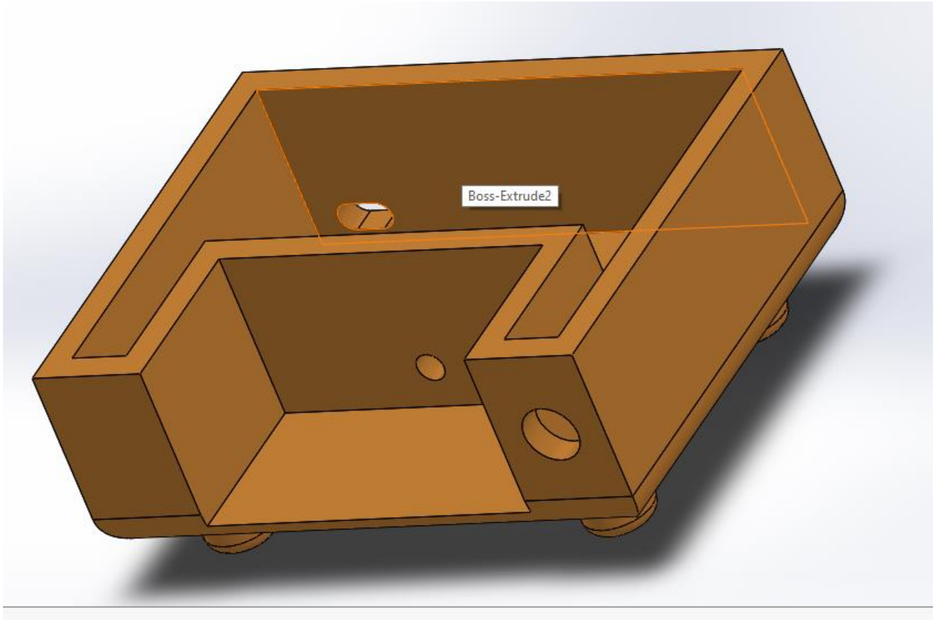


2) PCB Design

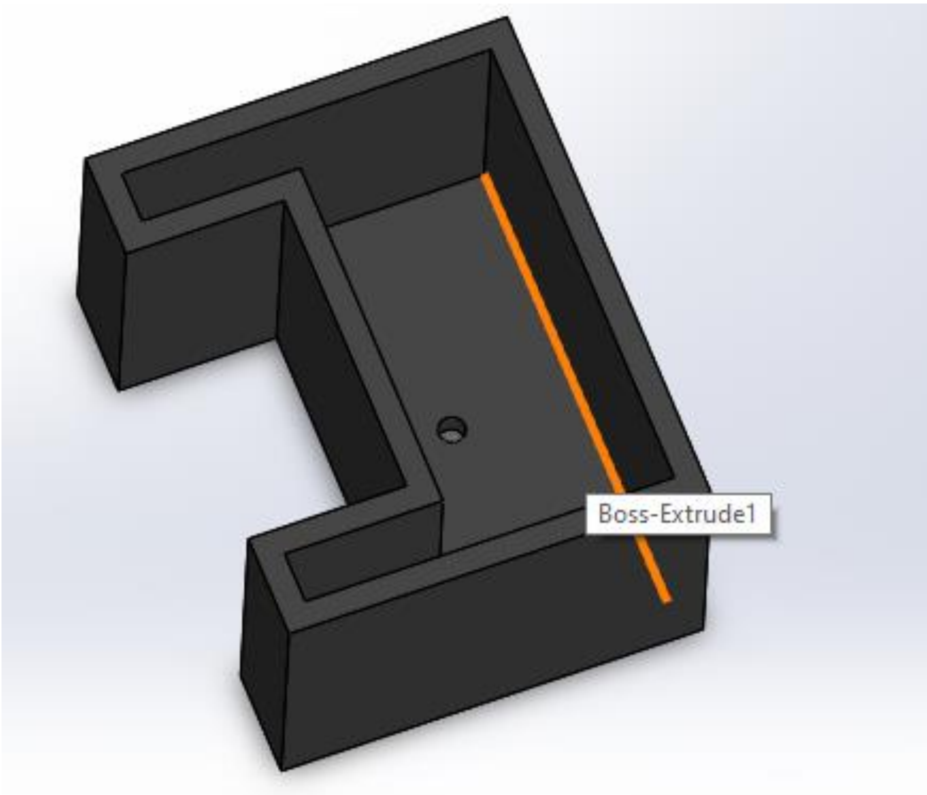


<u>Solid Work Design</u>

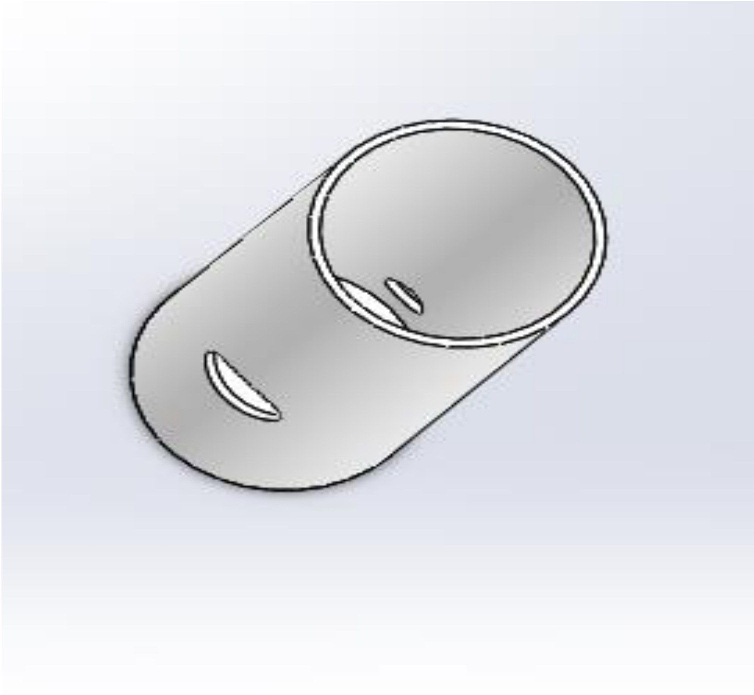
1) Base



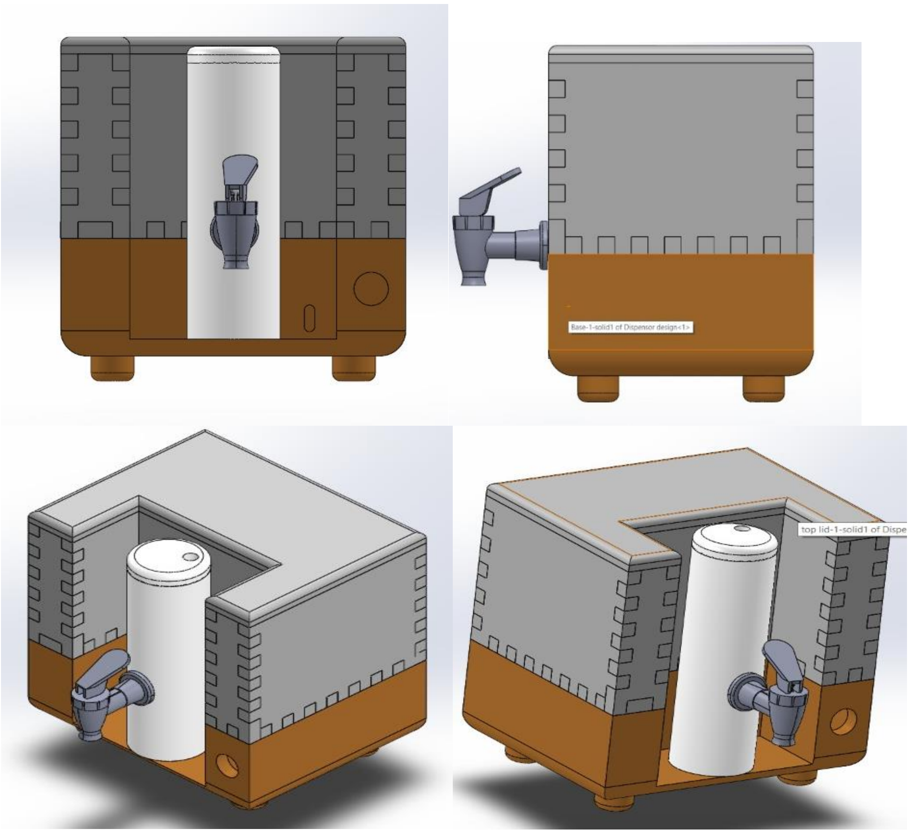
2) Water Container



3) Heating Chamber



4) Overall Design



The overall design is designed by considering robustness of the design. The cost will be reasonable because of the proper material selection. The base is going to be made from wood and the water container is designed for acrylic. Temperature of the water is varying between 40-60C. So, PVC is chosen for heating chamber. Temperature probe will be used for temperature measurements.

Task Delegation

COSTA A.M.J.V.	Power Supply circuit design and simulations. Power supply PCB design.
RASANJI R.V.	Controller circuit PCB design. Heating element calculations.
JAYAMUNI N.P.	Solidworks designs. Calculations related to design.
SIRITHUNGA M.R.A.	Controller circuit (PID, PWM) calculations. Control circuit design and simulations. Solidworks Designs.