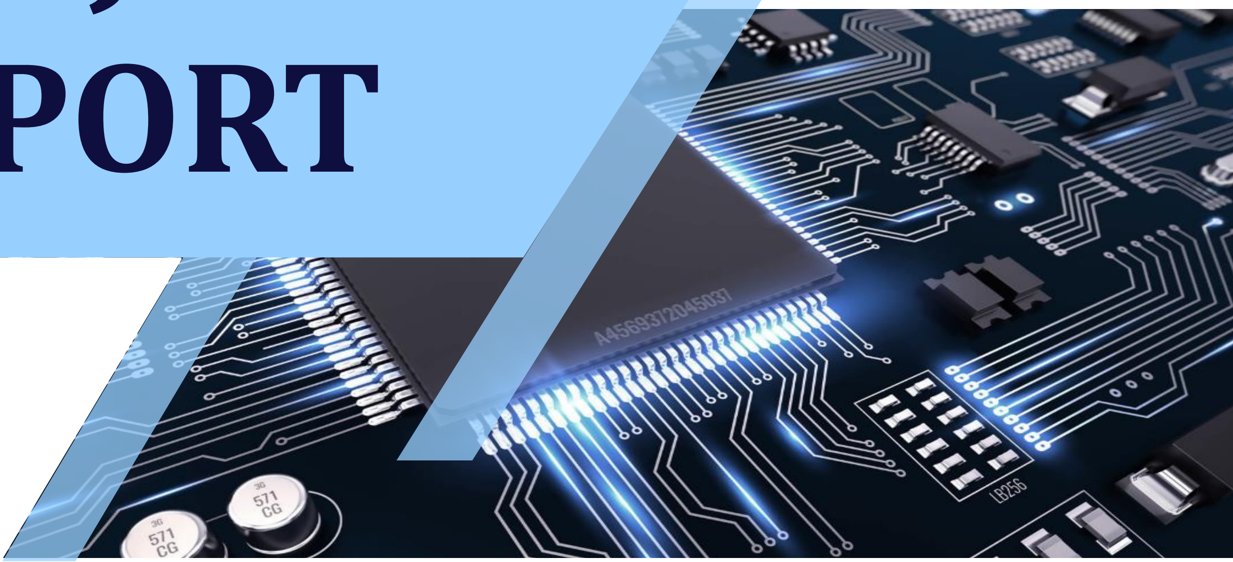
BANGLADESH UNIVERSITY OF ENGINNERING AND TECHNOLOGY

PROJECT REPORT



NAME OF THE PROJECT:

LIQUID LEVEL DETECTOR & AUTOMATED REFILLING CIRCUIT USING OPERATIONAL AMPLIFIER

COURSE NO : EEE 208S
COURSE TITLE : ELECTRONIC CIRCUIT II LABORATORY
DEPARTMENT : EEE

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GROUP NO : 08
SECTION : B2

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INTRODUCTION

Introduction

In various industrial, commercial, and residential applications, monitoring and controlling liquid levels is a critical task. Whether it's managing water levels in a reservoir, monitoring the fuel levels in a tank, or maintaining the right fluid levels in a chemical process, the ability to accurately measure liquid levels is indispensable. To address this need, engineers and hobbyists alike have developed innovative solutions, one of which is the Liquid Level Detector using Operational Amplifiers (Op-Amps) project.

This project is designed to offer a reliable and cost-effective solution for liquid level detection. It utilizes the principles of analog electronics and employs operational amplifiers, versatile devices known for their excellent amplification properties, to create a precise and responsive liquid level sensing system. By converting changes in liquid levels into electrical signals, this project enables real-time monitoring and control of various liquid-based processes.

Objectives

The objectives of the Project are as follows:

1. **Accurate Liquid Level Sensing:** Develop a system capable of accurately and reliably detecting changes in liquid levels, ensuring precise monitoring and control.

2. **Cost-Effective Solution**: Design a cost-effective solution that can be implemented in various applications, making it accessible to a wide range of users, including engineers and industries with budget constraints.

3. **Customizability**: Create a modular and adaptable system that can be customized to accommodate different types of liquids, container shapes, and environmental conditions, enhancing its versatility.

4. **Safety and Reliability**: Prioritize safety and reliability in the design to ensure that the system performs consistently and is suitable for critical applications.

5. **Potential for Expansion**: Design the system with the potential for expansion or integration into larger control systems, allowing for scalability and broader applications.

OPERATING MODULE

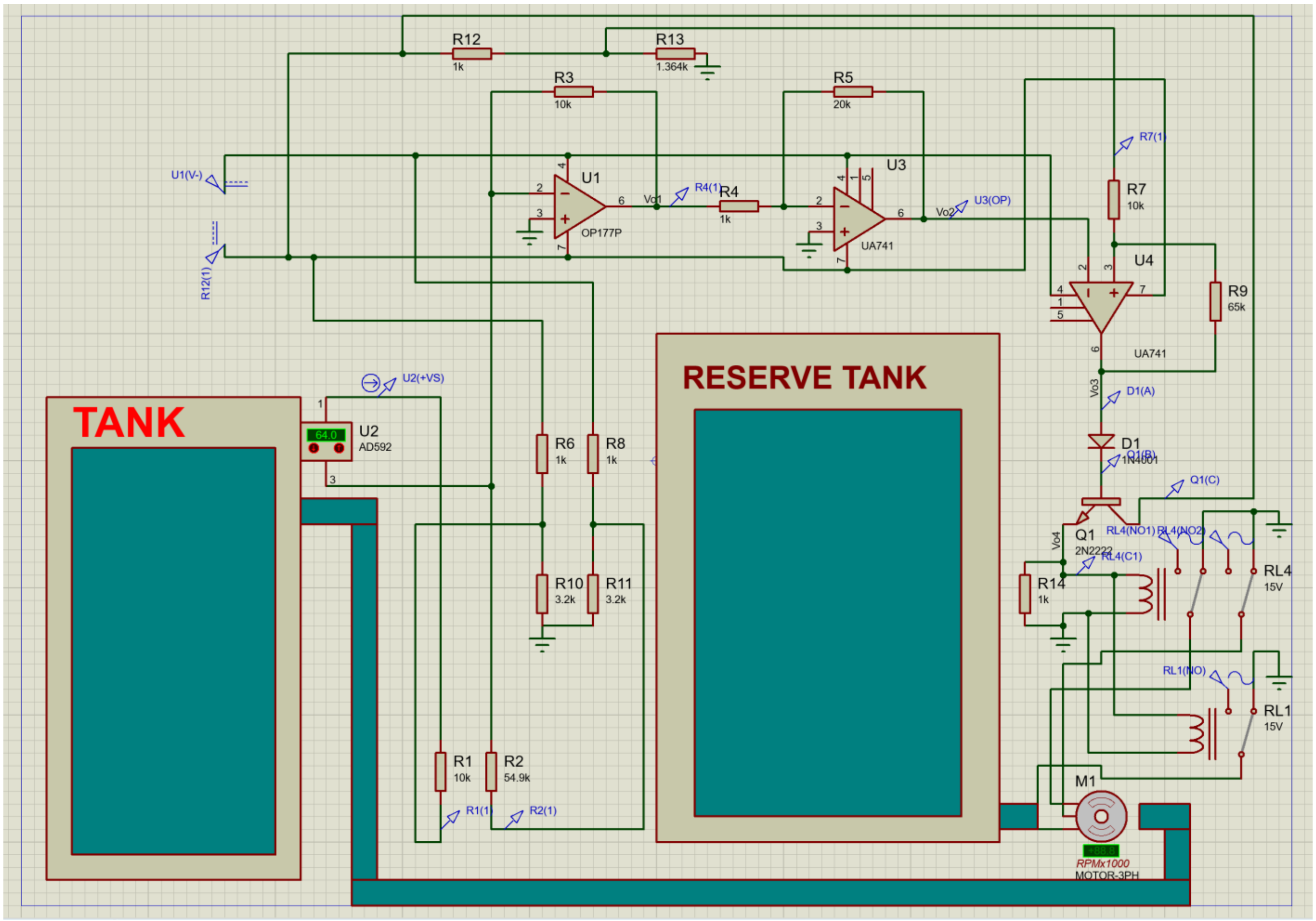
Simulation Software

Proteus 8

Parts/Module Used

1. Op- Amp (UA741, OP177P)
2. Resistor
3. N-p-n Transistor (2N2222)
4. Relay
5. Temperature Transducer (AD592)
6. Diode (1N4001)
7. Three Phase Induction Motor
8. Power Source

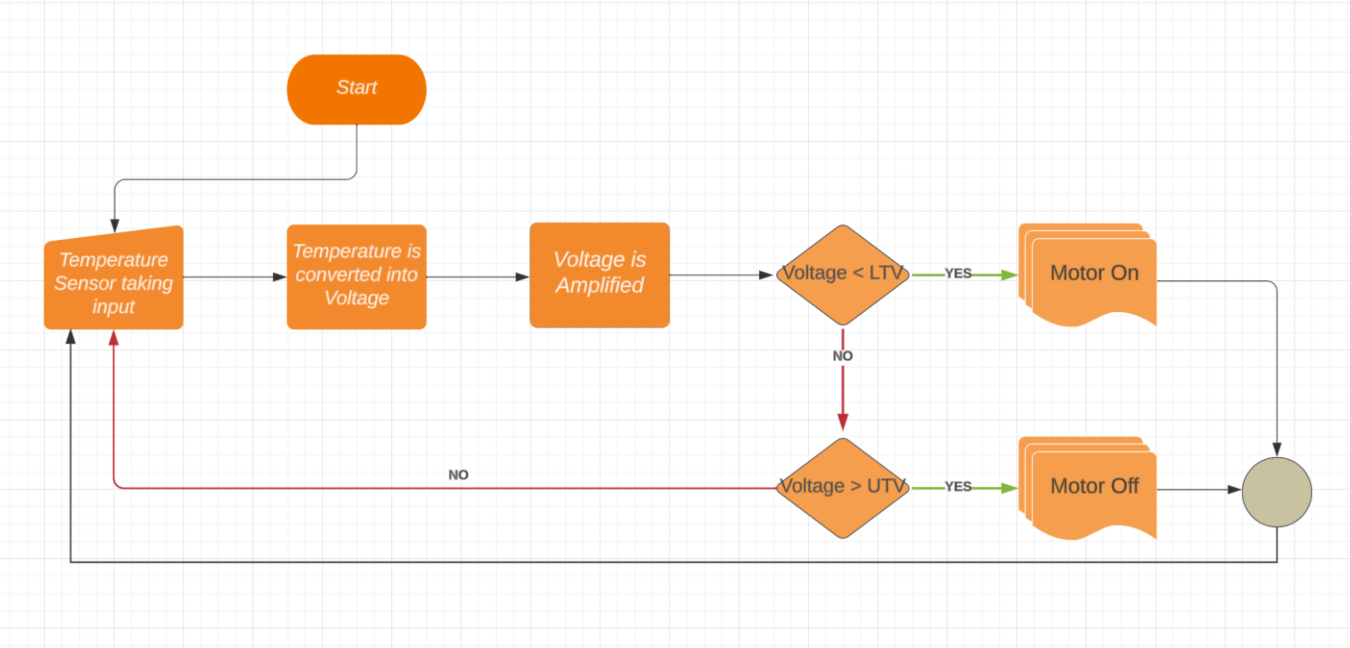
Circuit Diagram



OPERATION

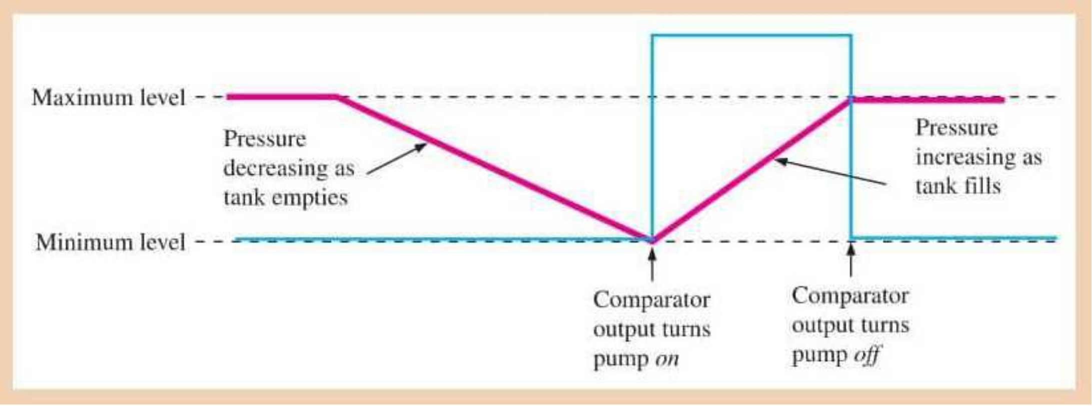
Description of Operation

To detect the level of the liquid in the tank we used a pressure sensor (Here, a temperature sensor is used in place of the pressure sensor because of the limitation of the Proteus 8) which will determine the level of the liquid. By using a pressure transducer (Here temperature transducer AD592 is used) and a Operational amplifier Op-177p we will convert the pressure into voltage. Basically, transducer will produce an current flow through R_1. As a result, a voltage will generate at the end of the op-amp. The voltage that is generated is very low. 0.01V increases per degree increase of the temperature. As the generated voltage is very low, that's why it is easier to get affected by noise. So, we used an amplifier circuit using op-amp UA741 to amplify the circuit. As it is amplified that's why it does not get affected by noise. Then voltage is passed to an inverting voltage level detector circuit with hysteresis by using a upper terminal voltage and a lower terminal voltage and using op-amp UA741. It gives a positive saturation voltage when it crosses lower terminal voltage and negative saturation voltage when it passes higher terminal voltage. A 2N2222 n-p-n transistor is used as a switch so that when the saturation voltage is positive it will be in active mode and the motor will start and when the saturation voltage is negative the transistor will be in cut-off mode. So, the motor will stop. A 1N4001 diode is used in series in between op-amp and n-p-n transistor so that overflow of voltage cannot damage the transistor. The flow chart of the project is as follows:



OPERATION

As the liquid level within the tank decreases, the pressure in the tube also decreases. This pressure reduction translates into a proportional drop in voltage output from the pressure sensor. The circuit processes this voltage decrease to activate the comparator, causing it to enter its HIGH state and turn on the pump when a predefined minimum level is reached. Conversely, as the liquid level rises during pump operation, it leads to a proportional increase in pressure. When the maximum level is attained, the circuit triggers the comparator to switch to its LOW state, thereby turning off the pump. This entire process is illustrated in following figure:



Sample Calculation

For U1, $V_{o1} = -(9.82mV \times T°C)$ **[**Voltage is recorded in R4(1) probe of the simulation**]**

For U3, $V_{o2} = -\frac{R_5}{R_4} \times V_{o1}$ **[**Voltage is recorded in U3(OP) probe of the simulation**]**

For U4, $V_{LT} = 7.29423\ V$ $\ ,V_{UT} = 12.6816\ V\ ,V_{ctr} = \frac{V_{UT}+V_{LT}}{2} = 9.98785\ V$

$$V_H = V_{UT} - V_{LT} = 5.3874\ V\ ,\ \ V_{+sat} = 20\ V\ \ ,V_{-sat} = -20\ V$$

$$n = \frac{V_{+sat-(V_{-sat})}}{V_H} - 1 = 6.43 \quad ,\ \ V_{ref}\big(V(R7)\big) = \frac{n+1}{n} \times V_{ctr} = 11.54117V$$

$R_7 = 10k\ , R_9 = nR_7 = 64.3k$(taken as 65K), V_{BE}=2.27V

[V_{sat} can be seen in probe D1(A), V_{ref} can be seen in probe R7(1)**]**

We have predetermined that we will get temperature reading $\mathbf{37°C}$ when the tank reaches its lower level and $\mathbf{64°C}$ when the tank reaches its upper level.

CALCULATION

So, **for 37° C**,

$$V_{o1} = -(9.82\,mV \times 37) = -0.363593\,V$$
$$V_{o2} = -\frac{20K}{1K} \times -0.3635 = 7.2942\,V$$

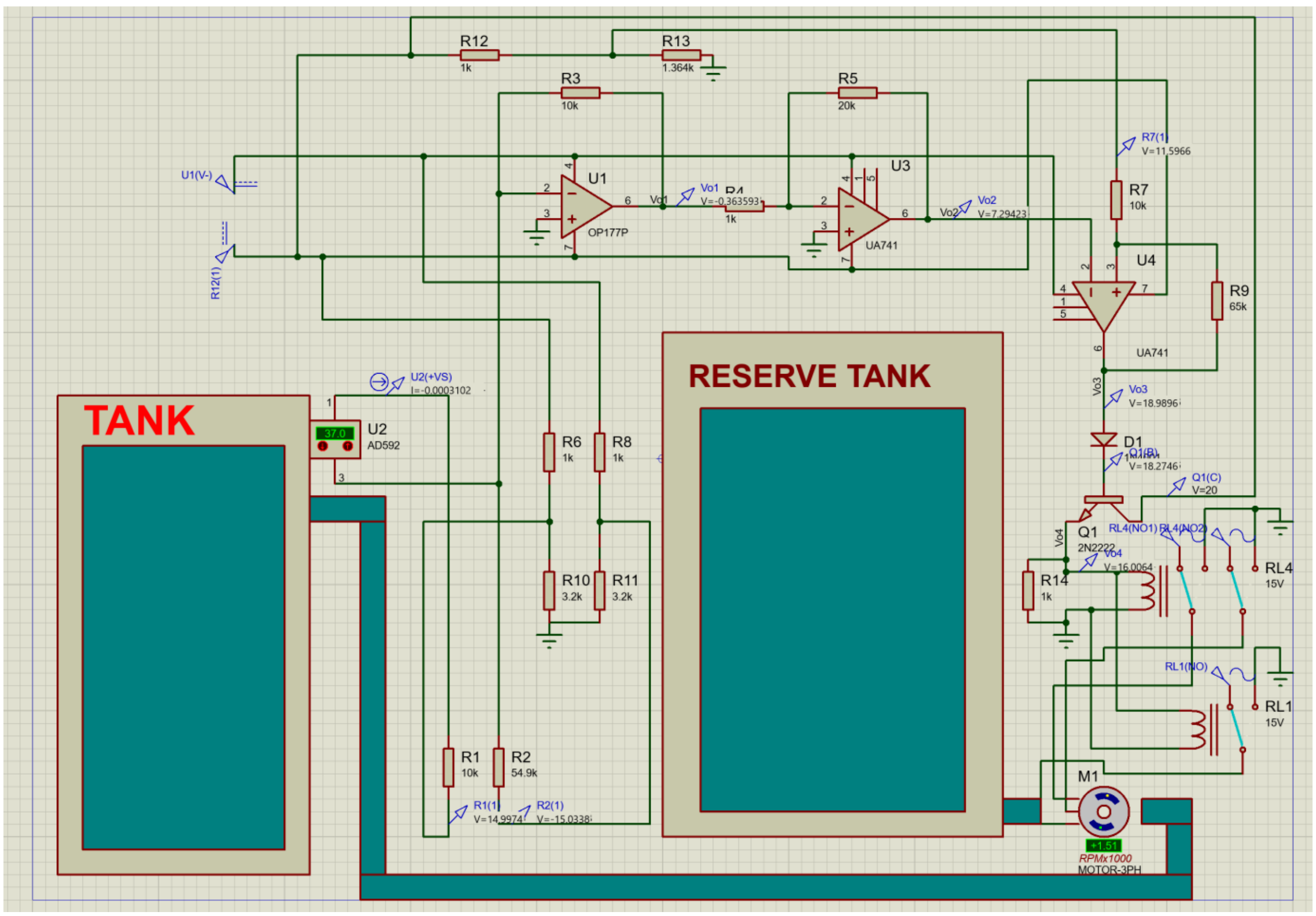
V_{o2} has crossed the lower threshold voltage, so $V_{o3} = V_{sat} = 18.9896$

As V_{o3} is positive so it will have a forward bias in the diode and the transistor.

$$V_{o4} = V_{o3} - 2.27V = 16.0064\,V$$

As $V_{o4} > 15V\,(Relay\ thresold\ voltage)$

The switch will be **closed** with the three-phase connection and the induction motor will **start**.



So, **for 64° C,**

$$V_{o1} = -(9.82\,mV \times 64) = -0.633016\,V$$
$$V_{o2} = -\frac{20K}{1K} \times -0.633016 = 12.6816\,V$$

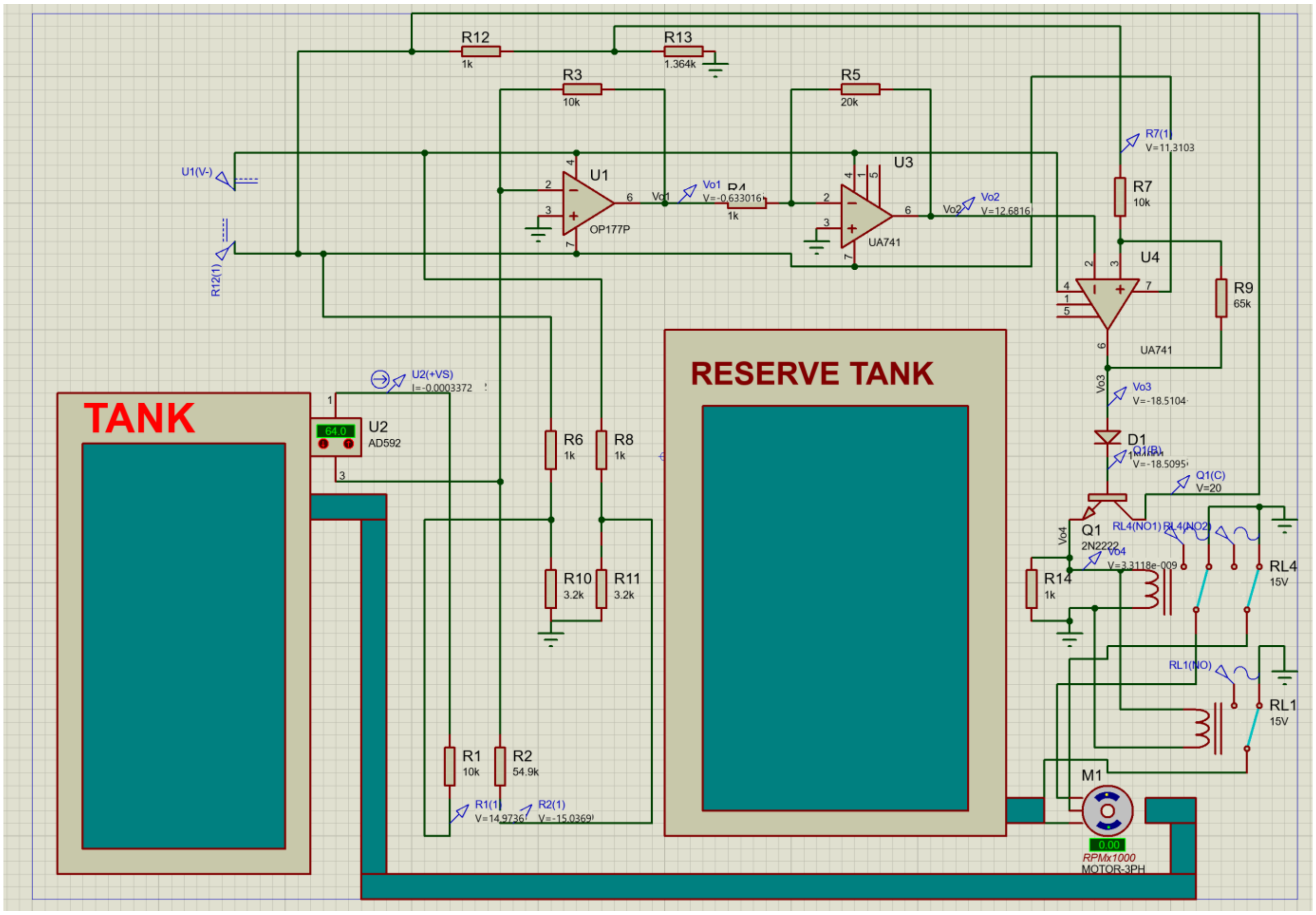
V_{o2} has crossed the upper threshold voltage, so $V_{o3} = -V_{sat} = -18.9896\,V$

As V_{o3} is negative so it will have a reverse bias in the diode and the transistor.

$$V_{o4} = 0V$$

As $V_{o4} < 15V\,(Relay\ thresold\ voltage)$

The switch will be **open** with the three-phase connection and the induction motor will **stop**.



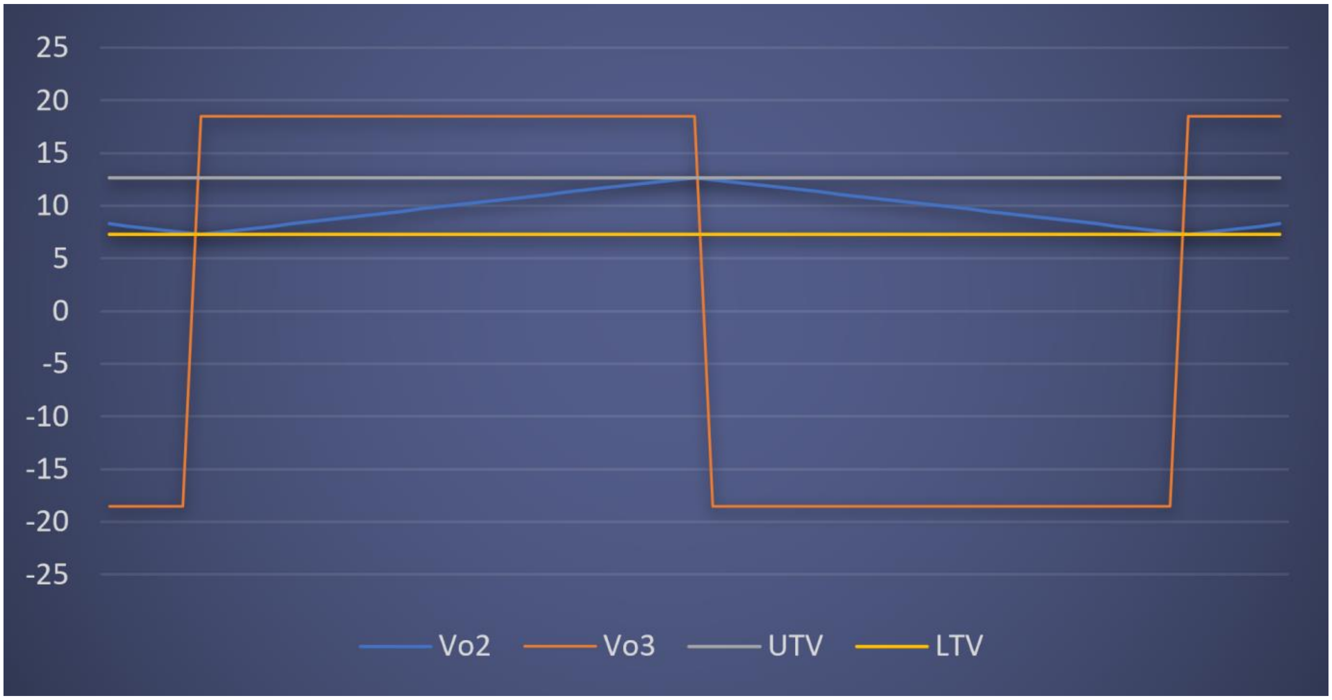
DATA TABLE

Data Table

Temp	V_{o2}	V_{o3}	Temp	V_{o2}	V_{o3}	Temp	V_{o2}	V_{o3}
42	8.29	-18.5	53	10.49	18.5	54	10.69	-18.5
41	8.09	-18.5	54	10.69	18.5	53	10.49	-18.5
40	7.89	-18.5	55	10.89	18.5	52	10.29	-18.5
39	7.69	-18.5	56	11.09	18.5	51	10.09	-18.5
38	7.49	-18.5	57	11.29	18.5	50	9.89	-18.5
37	7.28	18.5	58	11.49	18.5	49	9.69	-18.5
38	7.49	18.5	59	11.69	18.5	48	9.49	-18.5
39	7.69	18.5	60	11.89	18.5	47	9.29	-18.5
40	7.89	18.5	61	12.09	18.5	46	9.09	-18.5
41	8.09	18.5	62	12.29	18.5	45	8.89	-18.5
42	8.29	18.5	63	12.49	18.5	44	8.69	-18.5
43	8.49	18.5	64	12.69	18.5	43	8.49	-18.5
44	8.69	18.5	63	12.49	-18.5	42	8.29	-18.5
45	8.89	18.5	62	12.29	-18.5	41	8.09	-18.5
46	9.09	18.5	61	12.09	-18.5	40	7.89	-18.5
47	9.29	18.5	60	11.89	-18.5	39	7.69	-18.5
48	9.49	18.5	59	11.69	-18.5	38	7.49	-18.5
49	9.69	18.5	58	11.49	-18.5	37	7.28	18.5
50	9.89	18.5	57	11.29	-18.5	38	7.49	18.5
51	10.09	18.5	56	11.09	-18.5	39	7.69	18.5
52	10.29	18.5	55	10.89	-18.5	40	7.89	18.5

LIMITATION & DIRECTIONS

Waveform



Project Limitations

In our project we were supposed to measure the liquid level through a pressure transducer, but we designed the circuit with a temperature transducer because of the limitation of the library of the software. Also, we could not animate the level of liquid because of the software limitations.

Future Directions

The future directions of a liquid level detector can involve various advancements and improvements depending on the specific goals and application requirements. Here are some potential directions to consider:

1. **Enhanced Sensing Technology**:

In this project we designed it with a temperature transducer, but in the future we have the potential to do it with a pressure transducer.

APPLICATIONS

2. **Wireless Connectivity**:

We have the potential to implement wireless communication protocols such as Bluetooth, Wi-Fi to enable remote monitoring and control of liquid levels. This can be particularly useful for industrial applications.

3. **Energy Efficiency**:

We can develop power-efficient designs for the project by shortening the use of power supply.

4. **Customization and Scalability**:

We can create modular and scalable systems that allow users to customize the detector for different liquids, container sizes, and environmental conditions.

5. **Cost Reduction**:

We can investigate ways to reduce the cost of manufacturing and deployment, making the liquid level detector more accessible to a wider range of applications.

6. **Safety Features**:

In this project, as it was software based we did not design much of the safety features which we can add in the future such as fail-safes and redundancy to prevent accidents or damage in case of sensor malfunction.

Applications of our Project

Here are some applications of our project:

1. **Industrial Tank Monitoring**:

Liquid level detectors are commonly used in industrial settings to monitor the levels of liquids in tanks and vessels, such as in chemical plants, oil refineries, and water treatment facilities.

2. **Wastewater Management**:

Monitoring liquid levels in wastewater treatment plants is crucial to control the flow of sewage and ensure that treatment processes function effectively.

APPLICATIONS

3. **Fuel Tank Monitoring**:
Liquid level detectors can be employed in fuel tanks, both for industrial machinery and vehicles, to prevent overflows and optimize fuel consumption.

4. **Pharmaceutical and Biotech**:
Liquid level detection is essential in pharmaceutical and biotechnology processes for precise control of reagent levels, ensuring the quality of pharmaceutical products and bioprocesses.

5. **Water Management**:
Municipal water management systems rely on liquid level detectors in reservoirs, water towers, and distribution systems to maintain water supply and quality.

6. **Chemical Industry**:
In chemical manufacturing, accurate liquid level monitoring is critical for safety and for maintaining the desired chemical reactions.

7. **Oil and Gas Industry**:
Liquid level detectors are used in oil and gas storage tanks, pipelines, and drilling operations to ensure the safe handling and transport of hydrocarbons.

8. **Pool and Spa Management**:
Liquid level detectors are utilized in swimming pools and spas to maintain water levels and prevent overflow.

9. **Automotive Applications**:
Liquid level detectors are used in vehicles to monitor coolant levels, brake fluid levels, and fuel levels.

10. **Boat and Marine Applications**:
Liquid level detectors help boaters and ship operators monitor fuel, water, and sewage tank levels, ensuring safe and efficient maritime operations.

11. **Fire Suppression Systems**:
In fire sprinkler systems, liquid level detectors are employed to monitor water levels in storage tanks and ensure an adequate supply in case of a fire.

DISCUSSION

Discussion

In this project, we have developed a liquid level detector and automated refilling circuit designed to maintain a liquid level within a range in a tank. Our approach involved the use of basic Operational Amplifier Circuits, including an instrumentation amplifier circuit, a temperature to voltage converter circuit using temperature transducer, and a voltage level detector circuit with hysteresis.

During our project demonstration, we successfully showcased the circuit's ability to uphold a constant liquid level. Whenever the level dropped below the reference point, the circuit activated the pump to replenish the tank, and when the level exceeded the reference, the circuit deactivated the pump.

In the circuit we also showcased the animation of motor starting and stopping with the change of the readings of the temperature sensor. Moreover, we tried to design the circuit keeping in mind the real-life scenario. We used an induction motor which is used in pumps to refill liquid. We tried to minimize the cost as my as we can. We used only two power supplies and used the basic principles of voltage division to supply the amount of voltage where it is needed. In the circuit we used the voltage amplifier so that it can be protected from the noises of the industries and gives more accurate result. We used diodes and shunts keeping in mind about the safety of the modules of the circuit.

In our project we were supposed to make the circuit with pressure transducer but unfortunately there is no library of pressure transducer. So, we used the temperature transducer instead.

Lastly, we are highly satisfied with the outcome of our work, and we can confidently state that our project functions effectively.