

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Design & Implementation Digital Liquid Level Control System Using Microcontroller



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Design & Implementation
Digital liquid level control system using microcontroller

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Remarks by Advisor

Advisor

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Dedication

**TO
Our Parents
For Their Sacrifices
And
Worthy Teachers
For Their Diligence
And
Encouragement.**

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Acknowledgement

In the name of the **ALMIGHTY ALLAH**, the most Gracious and the ever merciful. Praise is to Allah the lord of the universe and prayers be upon his final **HOLY PROPHET MUHAMMAD** (PEACE BE UPON HIM), the cause of creation of this universe, who is forever a source of guidance and knowledge for humanity. Thanks to Him for giving us the source of power, guidance and strength to finish final year project of Electrical Engineering.

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Thanking you

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Abstract

“**Digital Liquid Level Control System**” as cleared by its name that this project is digitally controlled through the digital microcontrollers such as PIC16F877A. The aim of this project is to maintain the fluid level in the tanks by using the techniques of microcontroller. Instead of analogue control the digital control is carried out through the microcontrollers by developing their algorithms and using the feed-back by the appropriate sensors.

Coupled-tanks model which resembles the model of the chemical or mixing process plant is used to evaluate the performance of digital liquid level control system under various conditions. Simulation work is carried out using MATLAB® and Proteus to control the modeled nonlinear coupled tanks using the microcontroller algorithm. It is also utilized to show that the controller can produce the appropriate control signals to the coupled tank system’s control devices to control the liquid level in the presence of plant nonlinearity, disturbance and measurement noise. Basically in this project there are three main fields of work, mathematical work related to this project, simulation work and hardware developing of the project. Initially the mathematical work will be completed then simulation and at the end the hardware will be implemented. At the end the results will be compared of the simulated work with the real developed hardware.

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List of Symbols

Ho	Normal operational level
Qi	Input Flow
Qo	Output Flow
g	Gravitational Force Constant
A	Area of Tank
ρ	Specific Gravity of Fluid
R	Resistance of Valve/pipe
H	Derivative of Height
h1	Small Variation In Height of Tank 1
h2	Small Variation In Height of Tank 2

List of Abbreviations

U-Controller	Microcontroller
PWM	Pulse Width Modulation
BJT	Bipolar Junction Transistor
DC	Direct Current
Act.	Valve Actuating Valve
TF	Transfer Function
ZPK	Zero Pole Gain
PI	Proportional Integrator
PID	Proportional plus integral plus Derivative
Res	Resistance
C	Capacitor

[Chapter 01]

Project Basics and Description

This project is based on the knowledge of control systems and automating systems which can be accomplished at industrial level.

This chapter will cover following aspects:

- What is control system?
- Introduction to Liquid Level Control System
- When and Why coupled tanks?
- Natural existence of this project
- Application in Industries

1.1. What is control system?

Control engineering is based on feedback theory and linear system analysis and it integrates the concepts of network theory and communication theory. Therefore control engineering is not limited to any engineering discipline. The control system can be defined as

“Control system is the connection of the subsystem and process in such a way to get desire output with desire performance when applying a specific input”.



Figure 1- 1 Control System

1.1.1. Components of Control system

There are the following components of control system

- Process
- Control actuator
- Sensor/measuring device
- Controller/compensator/filter
- Plant

1.1.2. Configuration of Control System

There are following configuration of control system

- Open loop control system
- Close loop control system

1.1.2.1. Open Loop Control System: Brief Introduction

In open loop control system there is not any connection between input and output via measuring devices or sensor for feedback as shown in the figure below,

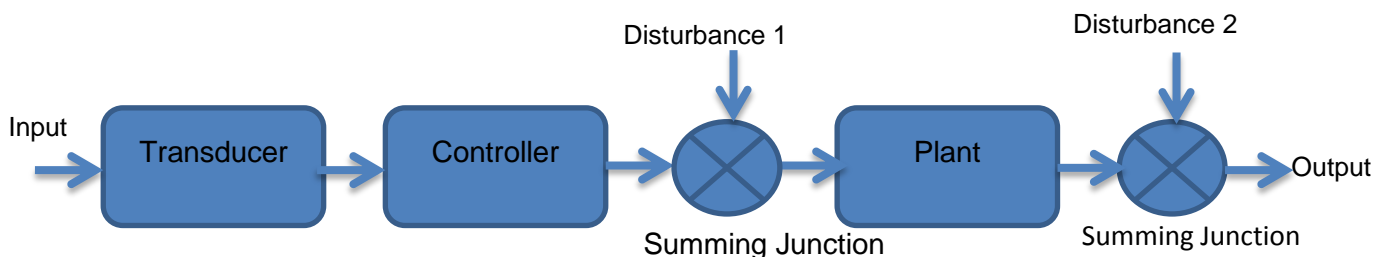


Figure 1- 2 Open Loop Control System

[Ref 1]

This system starts with a subsystem named as “Transducer” which converts the input signal into convenient form for the controller and then controller drives a process or plant. Normally there is some noise for signal at each stage which is shown in figure by

a summing junction. A big disadvantage of open loop system is that we cannot overcome the disturbances.

1.1.2.2. Close Loop Control System: Brief Introduction

In close loop system there is a connection between output and input via measuring device or sensor. In this configuration we can reduce the error by using the feedback of sensor

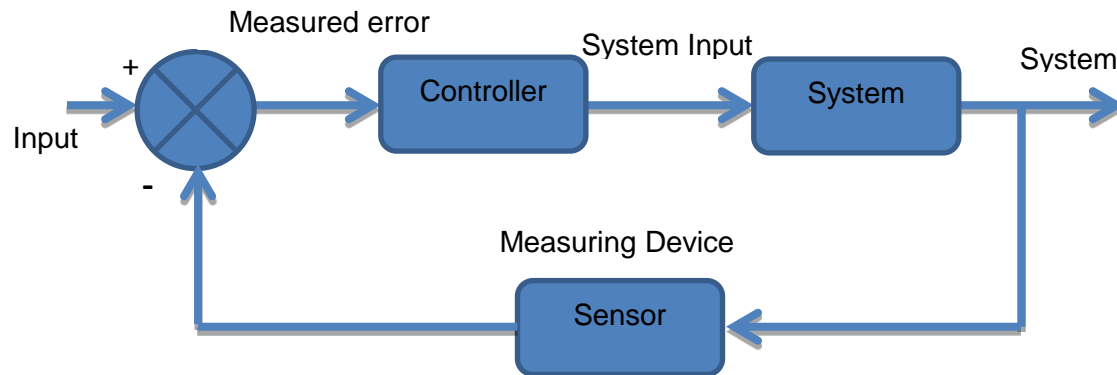


Figure 1- 3 Closed Loop Control System

This is the required configuration which is used in this project for controlling the steady state error

1.2. Introduction to Liquid Level Control System:

Liquid is an incompressible fluid which is not significantly affected by temperature. We are confining our direction towards the liquid system for reason

- Space
- Complexity

For example, in chemical industry liquid are stored which are then mixed in a specific amount to allow chemical reaction. A major problem with liquid system is to control the specific amount for reaction otherwise there will be some other resultant which is unwanted. For this purpose we use liquid level control system which is described below. The liquid level control system is an example of the close loop control system also known as feedback control system

1.2.1. History of Liquid Level Control system

The Greeks began engineering feedback systems around 300 B.C. A water clock invented by Ktesibios operated by having water trickle into a measuring container at a constant rate. The level of water in the measuring container could be used to tell time. For water to trickle at a constant rate, the supply tank had to be kept at a constant level. This was accomplished using a float valve similar to the water-level control in today's flush toilets. Soon after Ktesibios, the idea of liquid-level control was applied to an oil lamp by Philon of Byzantium. The lamp consisted of two oil containers configured vertically. The lower pan was open at the top and was the fuel supply for the flame. The closed upper bowl was the fuel reservoir for the pan below. The containers were interconnected by two capillary tubes and another tube, called a vertical riser, which was inserted into the oil in the lower pan just below the surface. As the oil burned, the base of the vertical riser was exposed to air, which forced oil in the reservoir above to flow through the capillary tubes and into the pan. The transfer of fuel from the upper reservoir to the pan stopped when the previous oil level in the pan was reestablished, thus blocking the air from entering the vertical riser. Hence, the system kept the liquid level in the lower container constant.

1.3. Couple Tank Control System:

“Two or more than two tanks are connected in series or in parallel to reduce space instead of a bigger tank but at the same time trading with complexity of the system and then task according to this, is to regulate the tanks fluid level”.

The Coupled Tank Model is a control system which deals with common problems associated with controlling fluid flows and levels between two tanks. Such models are designed and implemented in various industries, for example, the petro-chemical, paper making and water treatment industries which greatly rely on control mechanisms to regulate large volumes and flows of liquid.

1.3.1. Selected Coupled Tank Control System

Here is the modeling of project which is based on coupled tank system and feedback system. In this system the basic model of coupled tanks containing two tanks is selected because the further extension is same as for two coupled tank system as well as for hundreds of tanks coupled.

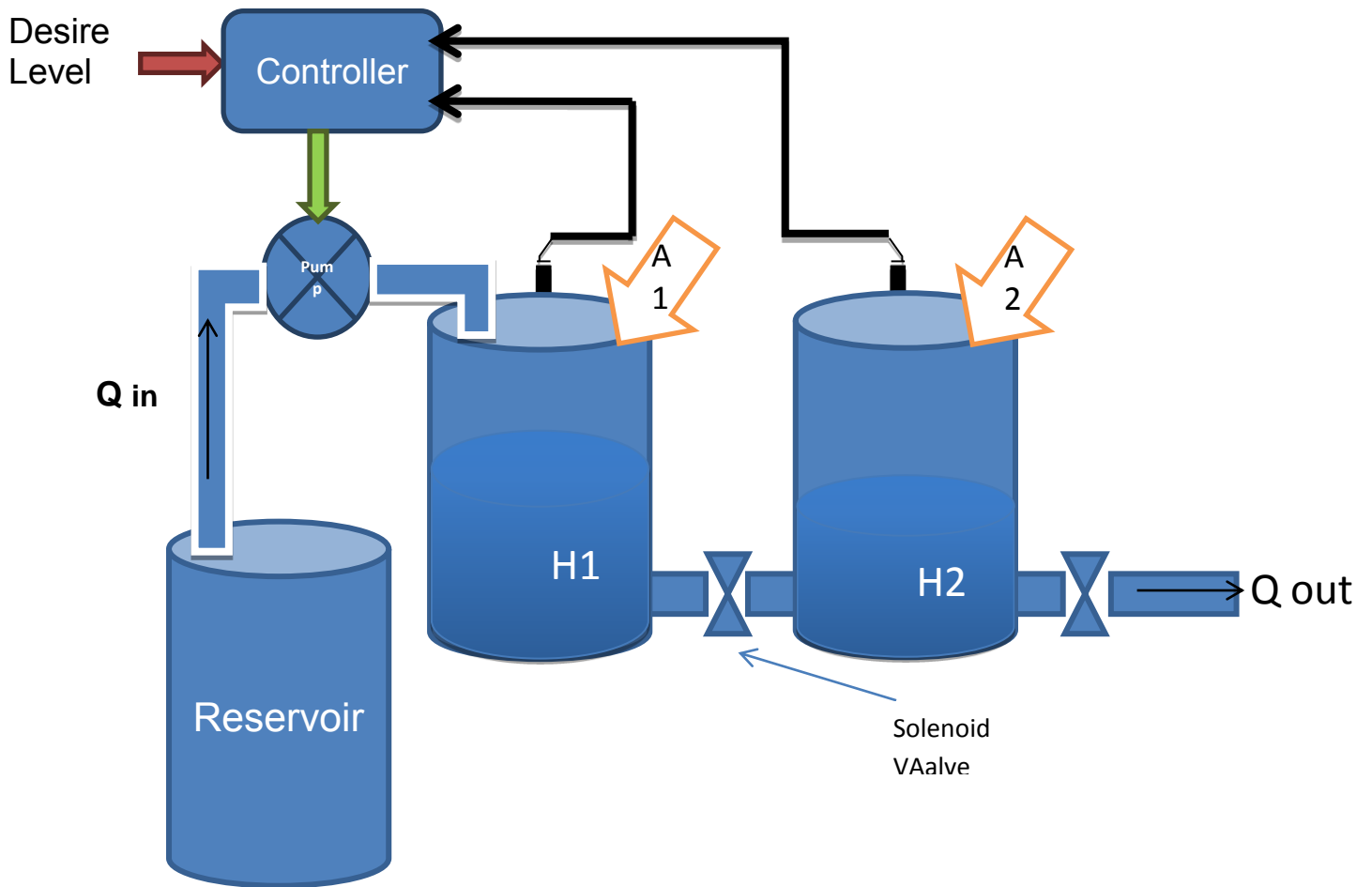


Figure 1- 4 Selected Coupled Tank System

- H1- Height of Tank 1
- H2- Height of Tank 2
- A1- Area of Tank 1
- A2- Area of Tank 2
- Qin- Input Flow into Tank
- Qout- Output Flow of the Tank 2

The task is to maintain the levels of the tanks using feedback system by the help of liquid level floating sensor. In our system the area of both tank are same.

1.4. Why and when coupled Tanks

1.4.1. Coupled tanks: Why

The coupled tanks system are used in industry instead of using a Huge tank because it is obviously more secure in case of any erosion or chemical breakdown. To make a continuous flow of process we prefer coupled tanks. There is another advantage that we may be enhancing capacity of liquid storage any time.

1.4.2. Coupled tanks: When

The industrial application of liquid level control is tremendous especially in chemical process industries. Level and flow controls in tanks are at the heart of all chemical engineering systems. But chemical engineering systems are also at the heart of our economies. Vital industries where liquid and flow control are essential include petro chemical industries, paper making industries and water treatment industries

1.4.3. Coupled tanks: Limitations and solutions

The control of liquid level in tanks and flow between tanks is a basic problem in the process industries. The process industries require liquids to be pumped, stored in tanks, then pump to another tank. Many times the liquids will be processed by chemical or mixing treatment in the tanks, but always the level of liquid in the tanks must be controlled, and the flow of the tank must be regulated. This is the basically task of project which is to be solved by using efficient controlling of level for this purpose. The microcontroller, sensor, actuating valve and pump are used, and the level of the tanks is to be regulated at a desired level by using the pump control

1.4.4. Natural existence of this Project

Our lives are governed by level and flow control systems. For example, medical physiology involves many fluid bio-control systems. Bio-systems in our body are there to control the rate that blood flows around our body. Other bio-systems control the pressure and levels of moisture and chemicals in our body. Tank level control systems are everywhere. All of our process industries, the human body and fluid handling systems depend upon tank level control systems. It is essential for control systems engineers to understand how tank control systems work and how the level control problem is solved.

1.5. Problem Statement

To control the levels of the coupled tanks at desired level with random output flow from the outlet valve, by the help of the input flow of pump and actuating valve.

1.6. Objective

Here are the basic parts of project

- Design Mathematical model for coupled tank system
- Simulation in MATLAB®
- Simulation on Proteus
- Implement a controller to the coupled tanks

Control systems analysis and design focuses on three primary objectives:

- a. Producing the desired transient response
- b. Reducing steady-state errors
- c. Achieving stability.

[Chapter 02]

Basic Concepts: Previous Knowledge

In this chapter the basic concepts are reviewed according to previous lectured knowledge. This previous knowledge is categorized according to the following classification,

- Instrumentation & Measurement
- Power Electronics
- Embedded Systems
- Engineering Mathematics

2.1. Instrumentation and Measurement:

“Instrumentation is defined as the art and science of measurement and control of process variables within a production, or manufacturing area”

Instruments can be subdivided into separate classes according to several criteria. These sub classifications are useful in broadly establishing several attributes of particular instruments such as accuracy, cost, and general applicability to different applications.

- Active and passive instruments
- Null Type and deflection type
- Analogue and digital instruments
- Indicating instruments and instruments with a signal output

2.1.1. Active and Passive Instruments:

Instruments are divided into active or passive.

The instrument output is entirely produced by the quantity being measured without an external power source is known as **passive instruments**.

The instruments which produce output quantity being measured by the help of external power source are known as the **active instruments**.

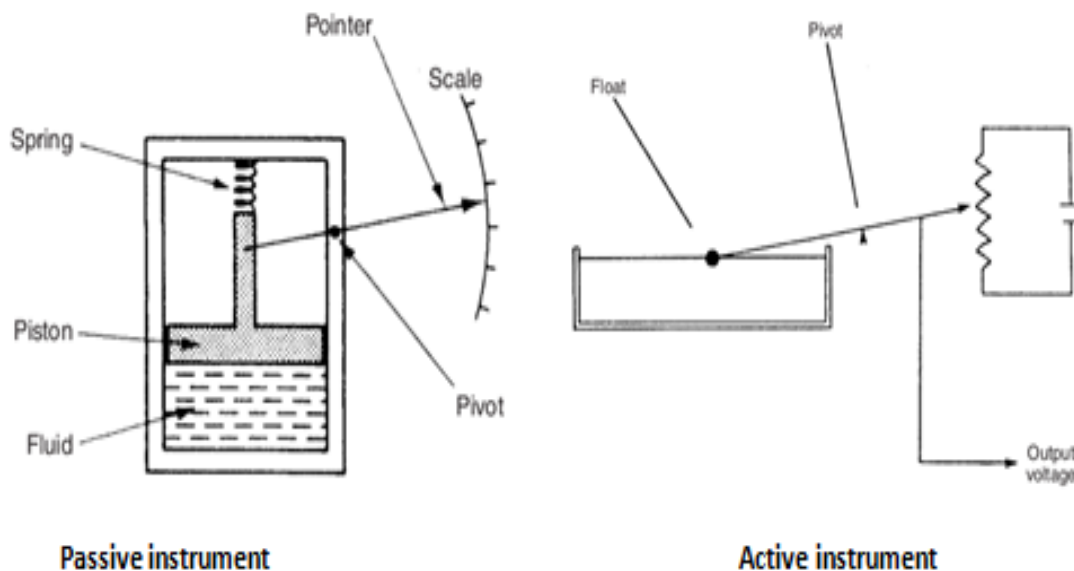


Figure 2- 1 Active and Passive Instruments

[Ref 6]

2.1.2. Null Type and Deflection Type

Deflection type: instrument, where the value of the quantity being measured is displayed in terms of the amount of movement of a pointer.

In a **Null type Instrument**, the quantity to be measured produces an effect that is compared with an already calibrated effect of another system

2.1.3. Analogue and Digital Instruments

An analogue instrument gives an output that varies continuously as the quantity being measured changes.

The output can have an infinite number of values within the range that the instrument is designed to measure.

A digital instrument has an output that varies in discrete steps and so can only have a finite number of values.

2.1.4. Indicating Instruments and Instruments with a Signal Output

The final way in which Instruments can be divided is between those that merely give an audio or visual indication of the magnitude of the physical quantity measured Instrument that gives an output in the form of a measurement signal whose magnitude is proportional to the measured quantity. [Ref 6]

2.2. Power Electronics

Power electronics is the application of solid-state electronics for the control and conversion of electric power.

2.2.1. PWM Pulse Width Modulation

Pulse width modulation: A modulation technique that generates variable-width pulses to represent the amplitude of an analog input signal. Like its fixed-width pulse density modulation (PDM) cousin, the output switching transistor is on more of the time for a high-amplitude signal and off more of the time for a low-amplitude signal. It is known as Pulse duration modulation (PDM).

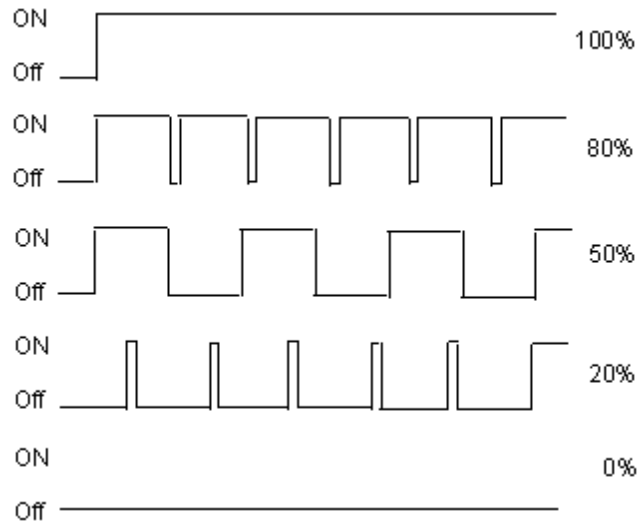


Figure 2- 2 PWM

Pulse-width modulation (PWM), or pulse-duration modulation (PDM), is a commonly used technique for controlling power to inertial electrical devices, made practical by modern electronic power switches. The average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast pace. The longer the switch is on compared to the off periods, the higher the power supplied to the load is.

The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM also works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle. [Ref 6]

2.2.1.1. Application of pulse width modulation

PWM is widely used in the common "switch-mode" power supplies that convert AC power to DC for computers and other electronic devices. It is also used to control the speed of a DC motor and the brightness of a bulb. For example, if the line were closed for 1ms, opened for 1ms and continuously repeated, the target would receive an average of 50% of the voltage and run at half speed or half brightness. If the line were closed for 1ms and open for 3ms, the target would receive an average of 25%.

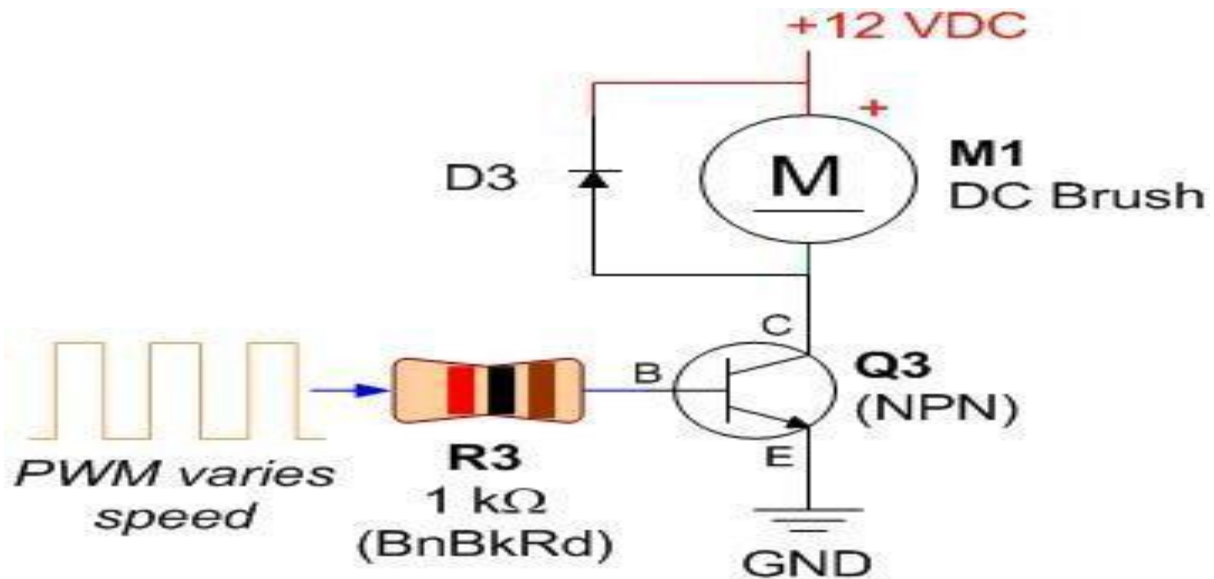
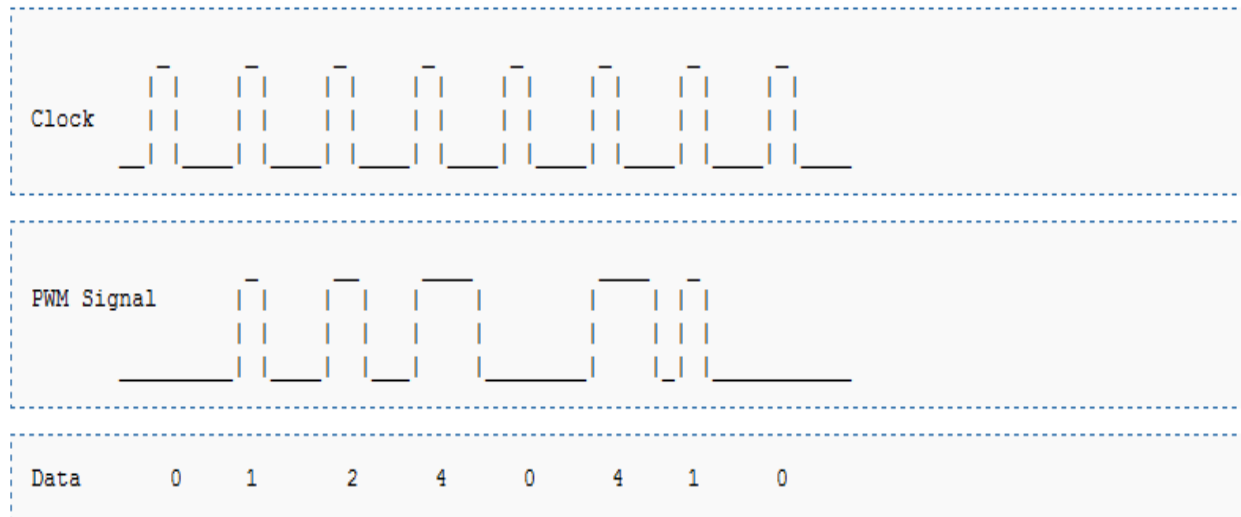


Figure 2- 3 Application of PWM

In telecommunications, the widths of the pulses correspond to specific data values encoded at one end and decoded at the other. Pulses of various lengths (the information itself) will be sent at regular intervals (the carrier frequency of the modulation)



2.2.2. How we can get pulse width modulation:

The PWM signals can be generated in a number of ways. There are several methods:

1. Analogue method
2. Digital method

2.2.2.1. Analogue Method

The diagram below shows how comparing a ramp waveform with a DC level produces the PWM waveform that we require. The higher the DC level is, the wider the PWM pulses are. The DC level is the 'demand signal'. The DC signal can range between the minimum and maximum voltages of the triangle wave.

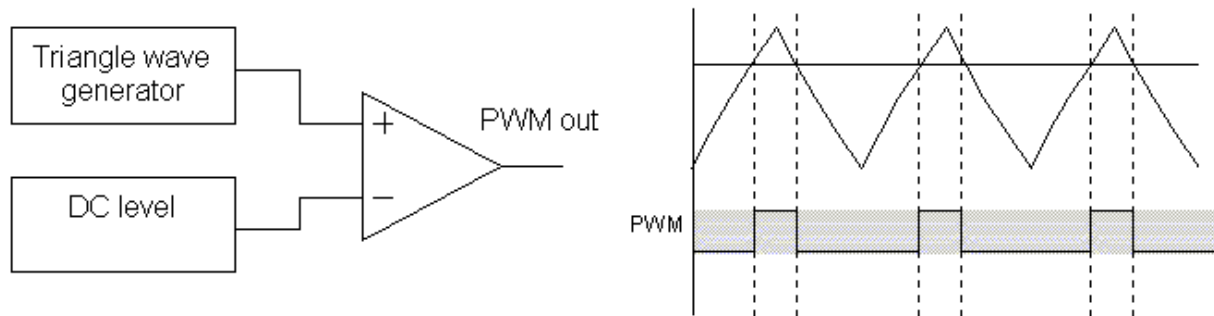


Figure 2- 4 Analogue Method to get PWM

2.2.2.2. Digital Method

In this method microcontroller is used and by the help of coding the pulse width modulation is generated, in microcontroller coding by the help of timer, delay or interrupts the PWM of different Duty cycle can be generate. The main advantage of this generation type is that microcontroller can be automatically set to judge the state of the measuring device and send the required PWM to output port intelligently.

Here is a simple diagram to show the basic PWM controlled DC motor which is controlled by the help of microcontroller.

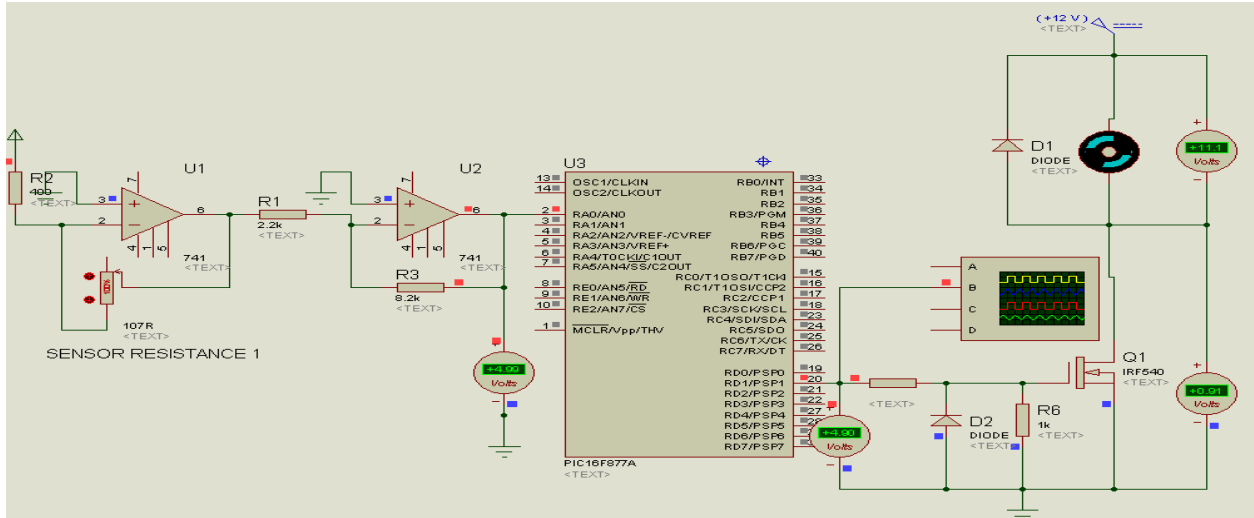


Figure 2- 5 Digital Method to get PWM

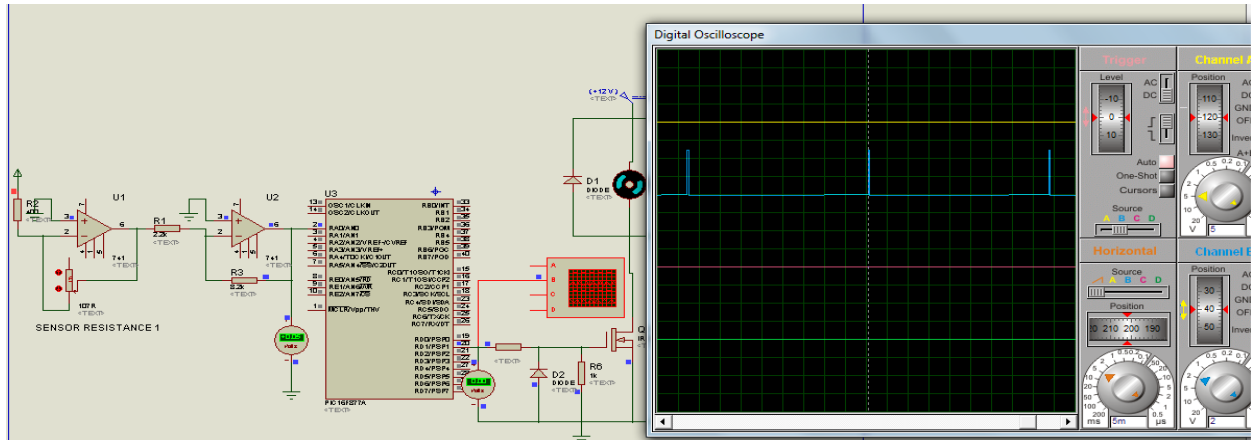


Figure 2- 6 PWM Signal Output, Duty Cycle 5%

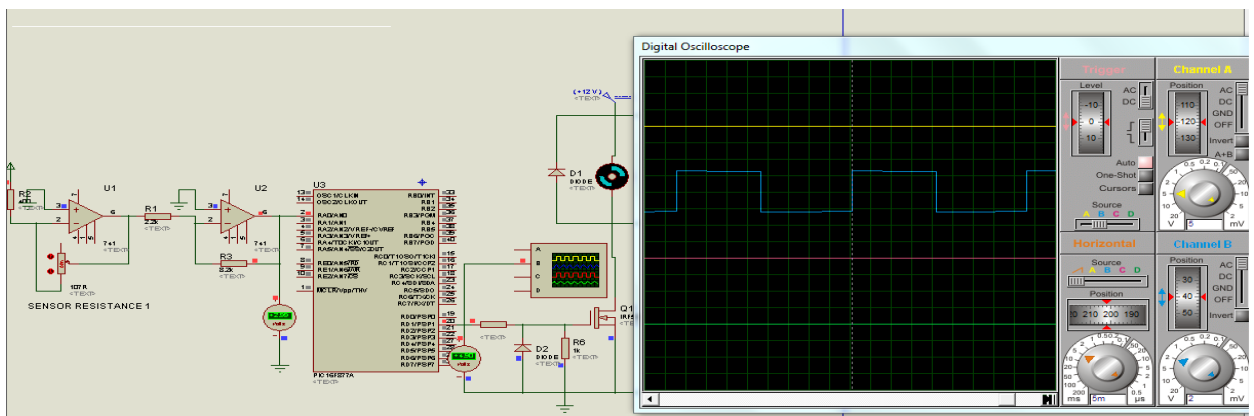


Figure 2- 7 Duty Cycle 50%

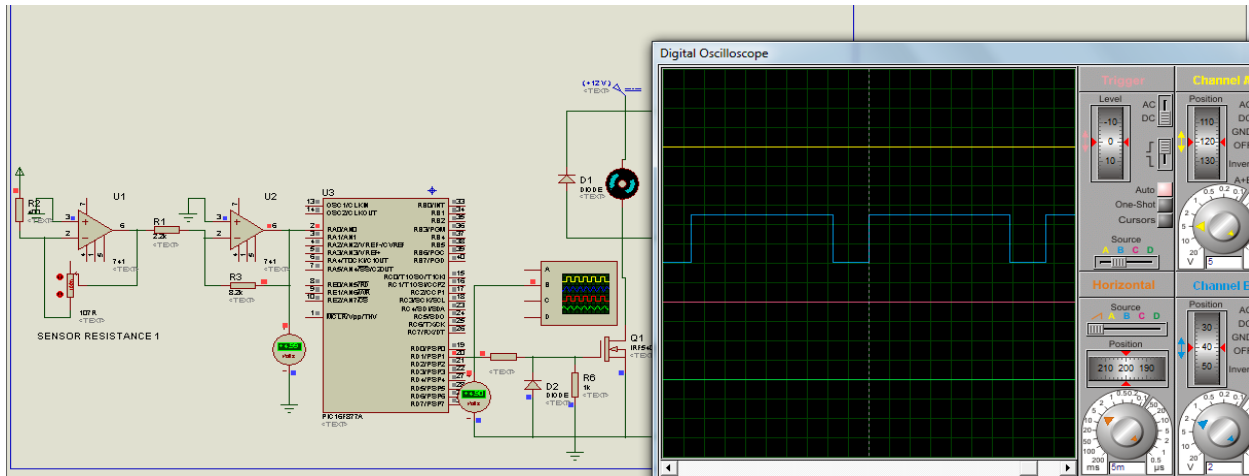


Figure 2- 8 Duty Cycle 98%

2.2.3. DC Motor

A DC motor is an electric motor that runs on direct current (DC). Motor basically convert electrical energy to mechanical energy which may be used for different purpose.



Figure 2- 9 DC Motor

DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Modern DC motors are nearly always operated in conjunction with power electronic devices.

Most of the dc motors are brushless motor which is also called permanent Magnet DC motor because it contains the permanent magnet inside. We also used 12V permanent dc motor because of high efficiency and less maintenance cost.

2.2.3.1. Working Principal

The working principle is very simple because of its Magnetic Structure. it contain the permanent magnetic halved into 2 piece .also contain two wires one is positive and other is negative by connecting it to battery the magnetic field generate and rotational torque produce which rotate the shaft of the motor. Direction of Rotation can be controlled by swapping the terminals. In simple the speed can be control by the help of voltage control, speed increase as the voltage increase and speed decrease as the voltage decrease. [Ref 7]

2.2.4. Solenoid Valve

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold.

Solenoid Valve have coil types and this depend upon project demand

- DC 12V Coil
- DC 24V Coil
- AC 220V Coil

Here we use DC12V solenoid valve



Figure 2- 10 Solenoid Valve

2.2.5. Rectification

A rectifier is an electrical device that converts alternating current (AC) to direct current (DC), which flows in only one direction. The process is known as rectification. A diode bridge is an arrangement of four diodes in a bridge circuit configuration that provides the same polarity of output for either polarity of input. When used in its most common application, for conversion of an alternating current (AC) input into a direct current (DC) output, it is known as a bridge rectifier. A bridge rectifier provides full-wave rectification from a two wire AC input, resulting in lower cost and weight as compared to a rectifier with a 3-wire input from a transformer with a center-tapped secondary winding.

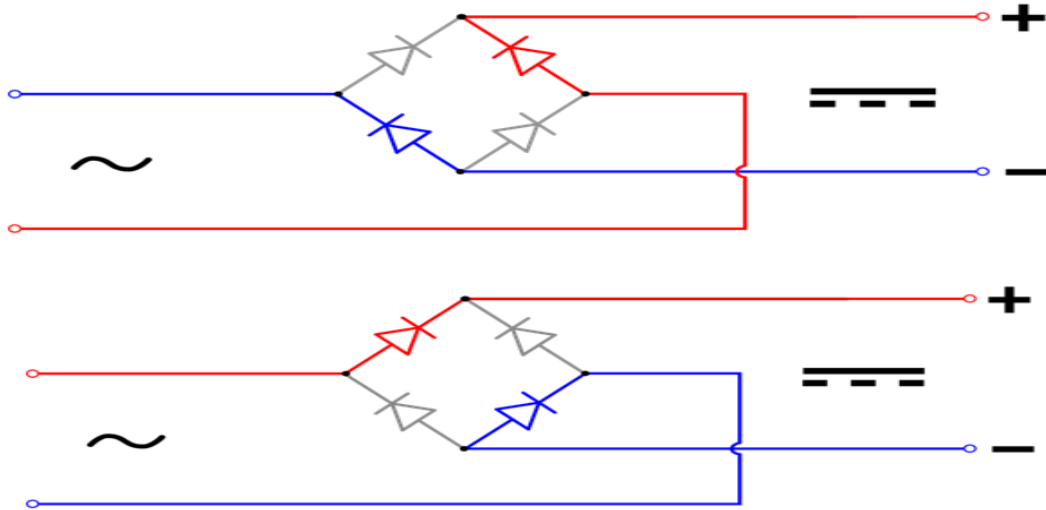


Figure 2- 11 Rectification

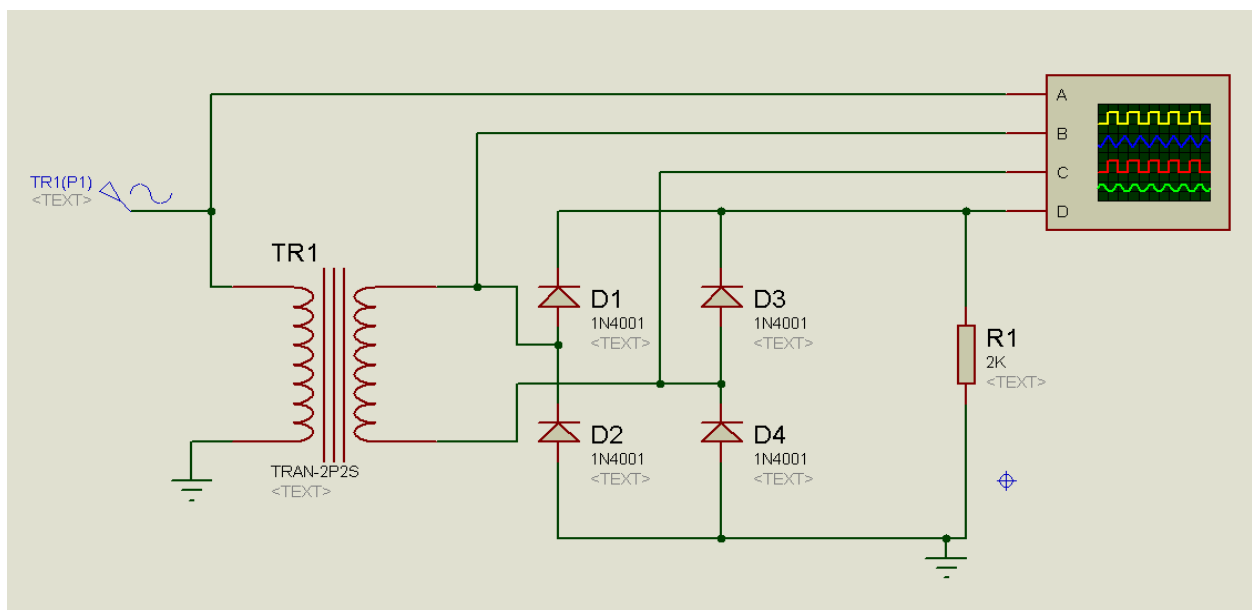


Figure 2- 12 Rectification Proteus Circuit

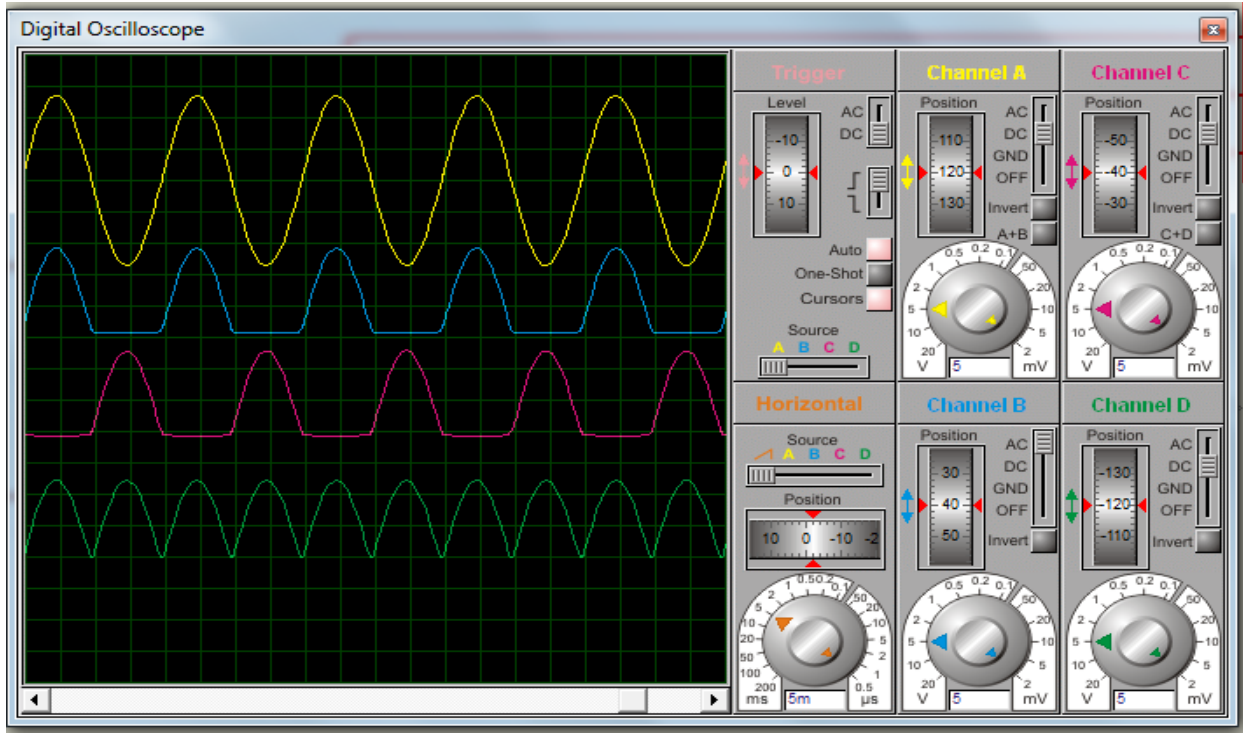


Figure 2- 13 Rectification Output with Pulsating DC

For many applications, especially with single phase AC where the full-wave bridge serves to convert an AC input into a DC output, the addition of a capacitor may be desired because the bridge alone supplies an output of pulsed DC. The function of this capacitor, known as a reservoir capacitor (or smoothing capacitor) is to lessen the variation in (or 'smooth') the rectified AC output voltage waveform from the bridge. There is still some variation, known as "ripple". One explanation of 'smoothing' is that the capacitor provides a low impedance path to the AC component of the output, reducing the AC voltage across, and AC current through, the resistive load. In less technical terms, any drop in the output voltage and current of the bridge tends to be canceled by loss of charge in the capacitor. This charge flows out as additional current through the load. Thus the change of load current and voltage is reduced relative to what would occur without the capacitor. Increases of voltage correspondingly store excess charge in the capacitor, thus moderating the change in output voltage / current. [Ref 8]

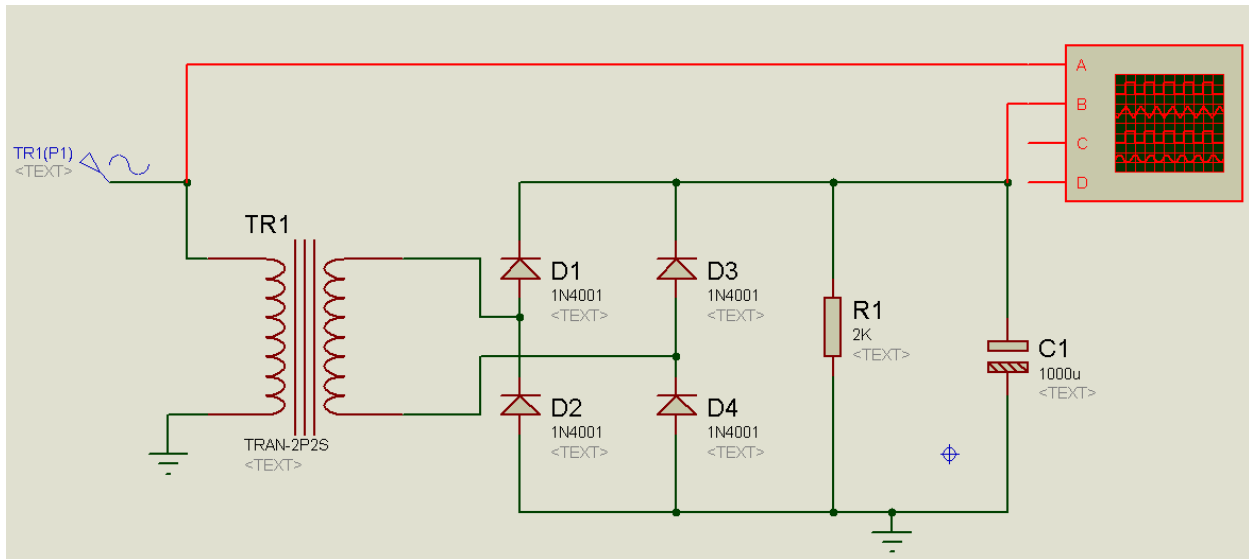


Figure 2- 14 Rectification Proteus Circuit without Pulsating DC

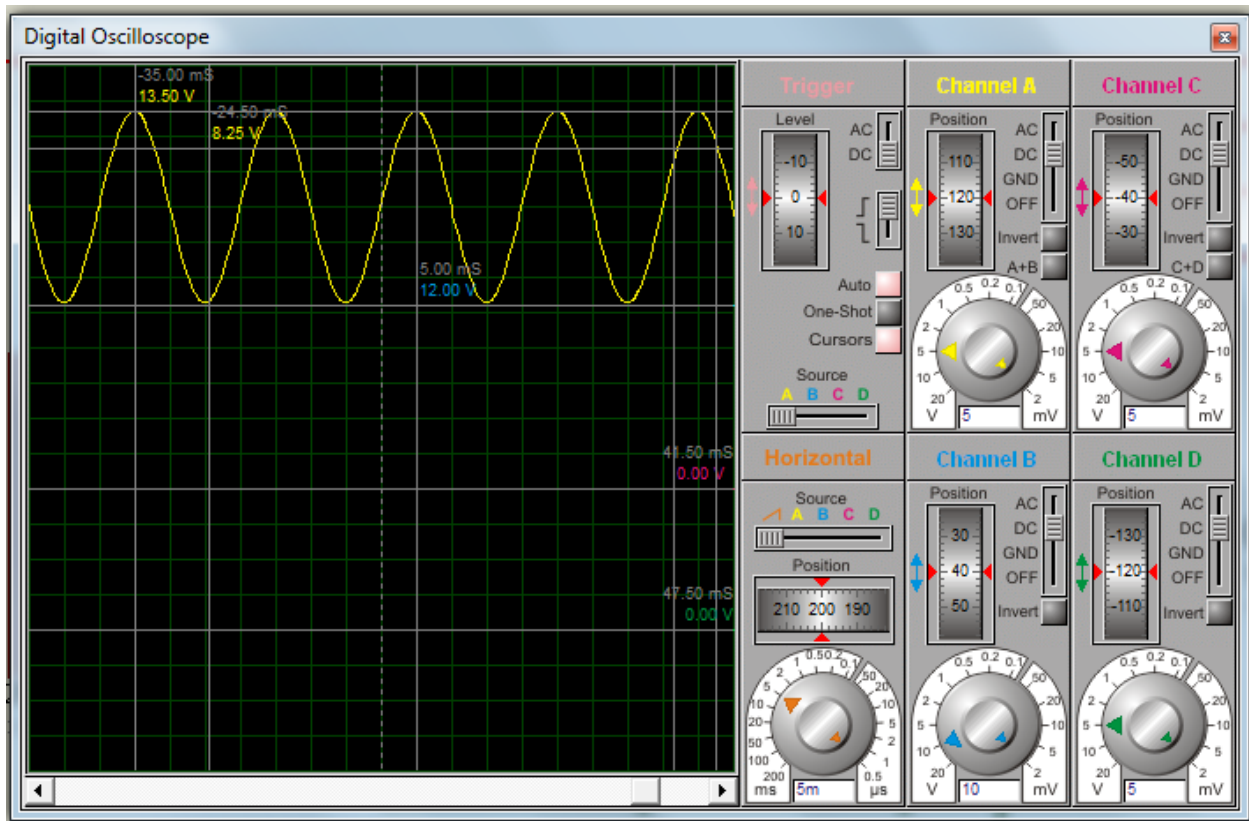


Figure 2- 15 Rectification Output without Pulsating DC

2.2.6. BJT Theory

The transistor is a three-layer semiconductor device consisting of either two N- and one P-type layers of material or two P- and one N-type layers of material. The former is called an NPN transistor, while the latter is called a PNP transistor. Both are shown in fig with the proper dc biasing.

$$I_e = I_c + I_b$$

The output or collector set of characteristics has three basic regions of interest, as indicated in Fig listed

- Active region
- Cutoff region
- Saturation region

In the **active region** the collector-base junction is reverse-biased, while the base emitter junction is forward-biased.

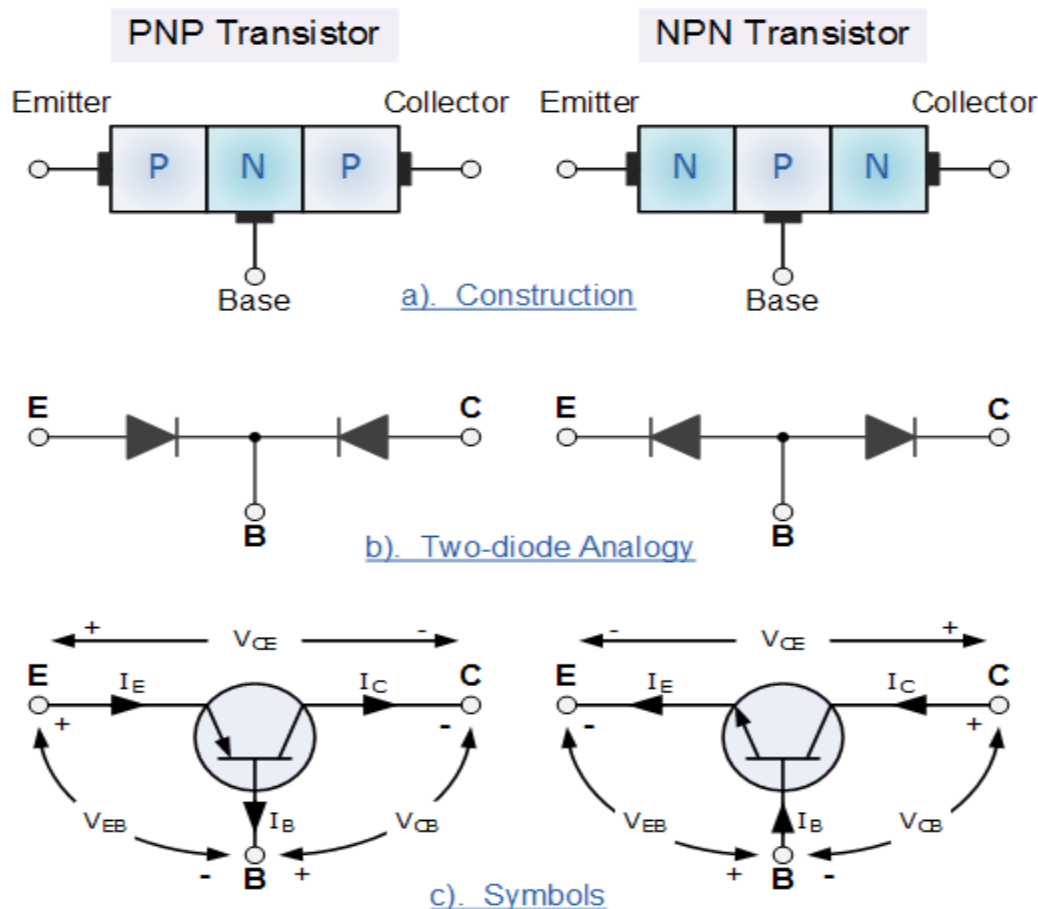


Figure 2- 16 BJT Operation and Symbol

[Ref 9]

Voltage wise differentiation

$E < B < C$ Forward Reverse-active

$E < B > C$ Reverse Cut-off

$E > B < C$ Forward Saturation

$E > B > C$ Reverse Forward-active

In the **cutoff region** the collector-base and base-emitter junctions of a transistor are both reverse biased, in the **saturation region** the collector-base and base-emitter junctions are forward-biased.

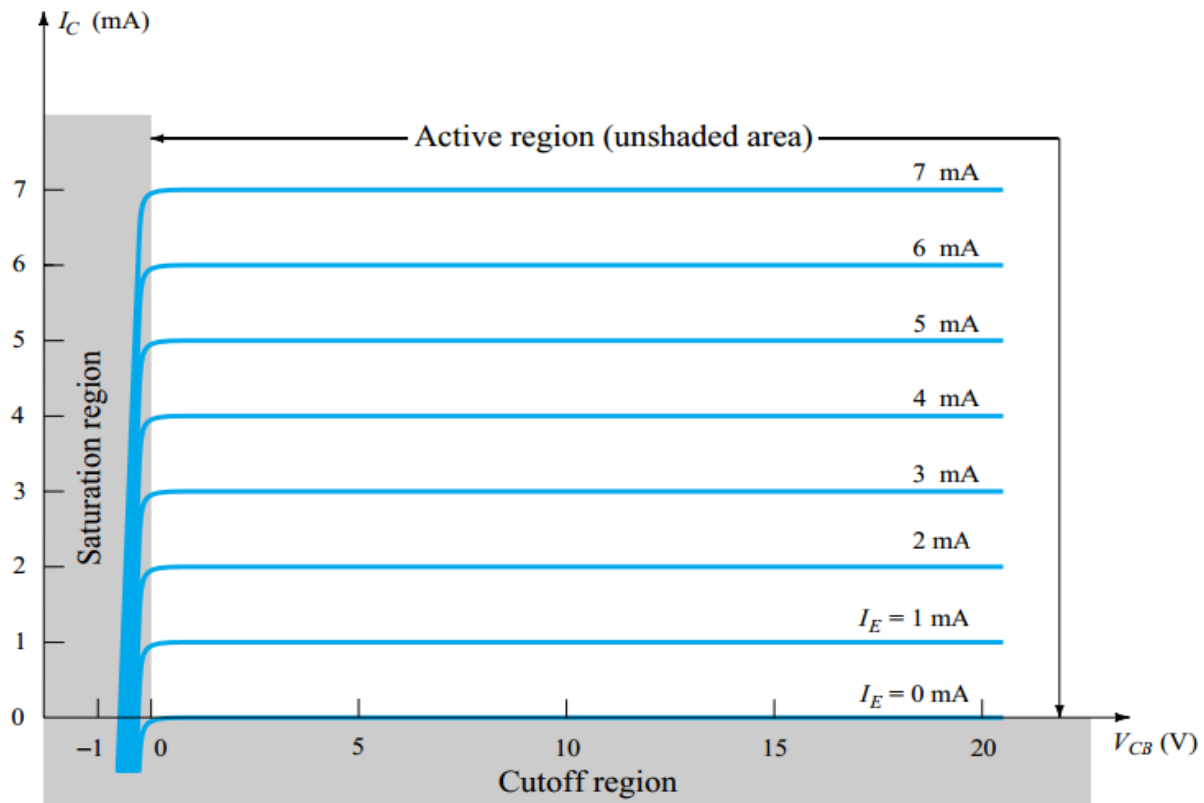


Figure 2- 17 BJT Regions

Because a transistor's collector current is proportionally limited by its base current, it can be used as a sort of current-controlled switch. A relatively small flow of electrons sent through the base of the transistor has the ability to exert control over a much larger flow of electrons through the collector

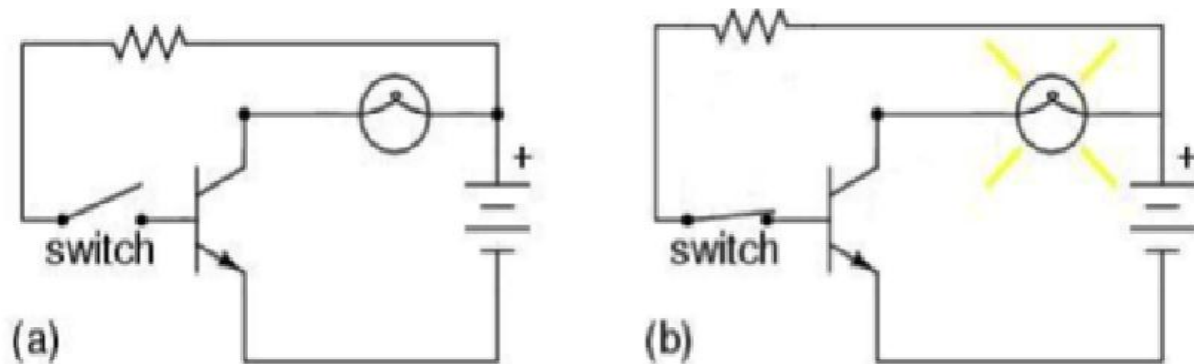


Figure 2- 18 Transistor Application as Switch-1

This is just the basic overview how to use transistor as switch, means when excess amount of current flow through the base then the transistor will turn on and vice versa. We can replace manual switch with controller bit, solar controlled switch, etc

2.3. Embedded Systems

An embedded system is a computer system designed for specific control functions within a larger system, often with real-time computing constraints.

2.3.1. Embedded System Basics:

The basic difference between the microprocessor and microcontroller is listed below
General purpose microprocessors contains

- No RAM
- No ROM
- No I/O ports

Now also put a glance at the differences between embedded devices and PC. An embedded product uses a microprocessor (or microcontroller) to do one task and one task only. There is only one application software that is typically burned into ROM.

A PC, in contrast with the embedded system, can be used for any number of applications. It has RAM memory and an operating system that loads a variety of applications into RAM and lets the CPU run them.

A PC contains or is connected to various embedded products each one peripheral has a microcontroller inside it that performs only one task.

2.3.1.1. PIC16F877A

This project is being implemented with the help of microcontroller PIC16F877A, the basic purpose of the controller are following

- Controlling ADC
- Handling ADC Signal
- Generating PWM Signal
- Controlling Actuating Valve
- Decision for desire level

2.3.1.2. PIC16F877A Overview

This powerful yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40 pin package. The PIC16F877A features 256 bytes of EEPROM data memory, self-programming, an ICD, 2 Comparators, 14 channels of 10-bit Analog-to-Digital (A/D) converter, 1 capture/compare/PWM and 1 Enhanced capture/compare/PWM functions, a synchronous serial port that can be configured as either 3-wire Serial Peripheral Interface the 2-wire Inter-Integrated Circuit (I²C™) bus and an Enhanced Universal Asynchronous Receiver Transmitter (EUSART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances or consumer applications

2.3.1.3. Pin Configuration

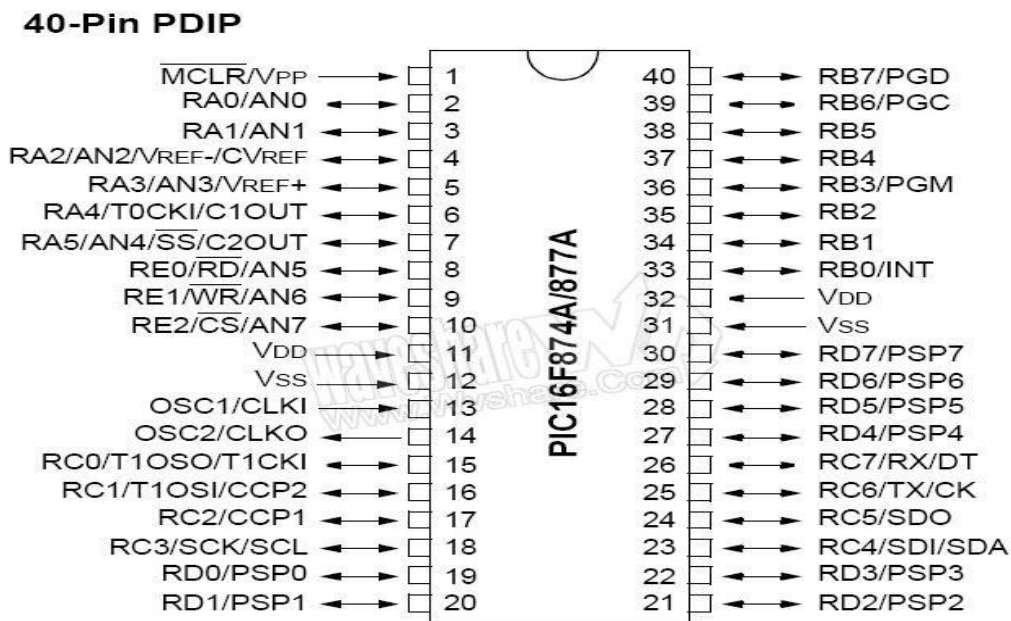


Figure 2- 19 Configuration of PIC16F877A

As seen in Fig, above, the most pins are multi-functional. For example, designator RA3/AN3/Vref+/C1IN+ for the fifth pin specifies the following functions:

- RA3 Port A third digital input/output
- AN0 to AN7 analog input pin
- Vref+ Positive voltage reference
- C1IN+ Comparator C1 positive input

This small trick is often used because it makes the microcontroller package more compact without affecting its functionality. These various pin functions cannot be used simultaneously, but can be changed at any point during operation.

Table 1 Pin Description

Name	Number (DIP 40)	Function	Description
RE3/MCLR/Vpp	1	RE3	General purpose input Port E
		MCLR	Reset pin. Low logic level on this pin resets microcontroller.
		Vpp	Programming voltage
RA0/AN0/ULPWU/C12IN0-	2	RA0	General purpose I/O port A
		AN0	A/D Channel 0 input
		ULPWU	Stand-by mode deactivation input
RA1/AN1/C12IN1-	3	C12IN0-	Comparator C1 or C2 negative input
		RA1	General purpose I/O port A
		AN1	A/D Channel 1
RA2/AN2/Vref-/CVref/C2IN+	4	C12IN1-	Comparator C1 or C2 negative input
		RA2	General purpose I/O port A
		AN2	A/D Channel 2
		Vref-	A/D Negative Voltage Reference input
RA3/AN3/Vref+/C1IN+	5	CVref	Comparator Voltage Reference Output
		C2IN+	Comparator C2 Positive Input
		RA3	General purpose I/O port A
		AN3	A/D Channel 3
RA4/T0CKI/C1OUT	6	Vref+	A/D Positive Voltage Reference Input
		C1IN+	Comparator C1 Positive Input
		RA4	General purpose I/O port A
RA5/AN4/SS/C2OUT	7	T0CKI	Timer T0 Clock Input
		C1OUT	Comparator C1 Output
		RA5	General purpose I/O port A
		AN4	A/D Channel 4
RE0/AN5	8	SS	SPI module Input (<i>Slave Select</i>)
		C2OUT	Comparator C2 Output
RE1/AN6	9	RE0	General purpose I/O port E
		AN5	A/D Channel 5
RE2/AN7	10	RE1	General purpose I/O port E
		AN6	A/D Channel 6
Vdd	11	RE2	General purpose I/O port E
		AN7	A/D Channel 7
Vss	12	+	Positive supply
		-	Ground (GND)

Name	Number (DIP 40)	Function	Description
RA7/OSC1/CLKIN	13	RA7	General purpose I/O port A
		OSC1	Crystal Oscillator Input
		CLKIN	External Clock Input
RA6/OSC2/CLKOUT	14	OSC2	Crystal Oscillator Output
		CLKO	Fosc/4 Output
		RA6	General purpose I/O port A
RC0/T1OSO/T1CKI	15	RC0	General purpose I/O port C
		T1OSO	Timer T1 Oscillator Output
		T1CKI	Timer T1 Clock Input
RC1/T1OSO/T1CKI	16	RC1	General purpose I/O port C
		T1OSI	Timer T1 Oscillator Input
		CCP2	CCP1 and PWM1 module I/O
RC2/P1A/CCP1	17	RC2	General purpose I/O port C
		P1A	PWM Module Output
		CCP1	CCP1 and PWM1 module I/O
RC3/SCK/SCL	18	RC3	General purpose I/O port C
		SCK	MSSP module Clock I/O in SPI mode
		SCL	MSSP module Clock I/O in I ² C mode
RD0	19	RD0	General purpose I/O port D
RD1	20	RD1	General purpose I/O port D
RD2	21	RD2	General purpose I/O port D
RD3	22	RD3	General purpose I/O port D
RC4/SDI/SDA	23	RC4	General purpose I/O port A
		SDI	MSSP module <i>Data</i> input in SPI mode
		SDA	MSSP module <i>Data</i> I/O in I ² C mode
RC5/SDO	24	RC5	General purpose I/O port C
		SDO	MSSP module <i>Data</i> output in SPI mode
RC6/TX/CK	25	RC6	General purpose I/O port C
		TX	USART Asynchronous Output
		CK	USART Synchronous Clock
RC7/RX/DT	26	RC7	General purpose I/O port C
		RX	USART Asynchronous Input
		DT	USART Synchronous Data

Name	Number (DIP 40)	Function	Description
RD4	27	RD4	General purpose I/O port D
RD5/P1B	28	RD5	General purpose I/O port D
		P1B	PWM Output
RD6/P1C	29	RD6	General purpose I/O port D
		P1C	PWM Output
RD7/P1D	30	RD7	General purpose I/O port D
		P1D	PWM Output
Vss	31	-	Ground (GND)
Vdd	32	+	Positive Supply
RB0/AN12/INT	33	RB0	General purpose I/O port B
		AN12	A/D Channel 12
		INT	External Interrupt
RB1/AN10/C12INT3-	34	RB1	General purpose I/O port B
		AN10	A/D Channel 10
		C12INT3-	Comparator C1 or C2 Negative Input
RB2/AN8	35	RB2	General purpose I/O port B
		AN8	A/D Channel 8
RB3/AN9/PGM/C12IN2-	36	RB3	General purpose I/O port B
		AN9	A/D Channel 9
		PGM	Programming enable pin
		C12IN2-	Comparator C1 or C2 Negative Input
RB4/AN11	37	RB4	General purpose I/O port B
		AN11	A/D Channel 11
RB5/AN13/T1G	38	RB5	General purpose I/O port B
		AN13	A/D Channel 13
		T1G	Timer T1 External Input
RB6/ICSPCLK	39	RB6	General purpose I/O port B
		ICSPCLK	Serial programming Clock
RB7/ICSPDAT	40	RB7	General purpose I/O port B
		ICSPDAT	Programming enable pin

In case of this project the working of the ADC connecting with microcontroller is as under

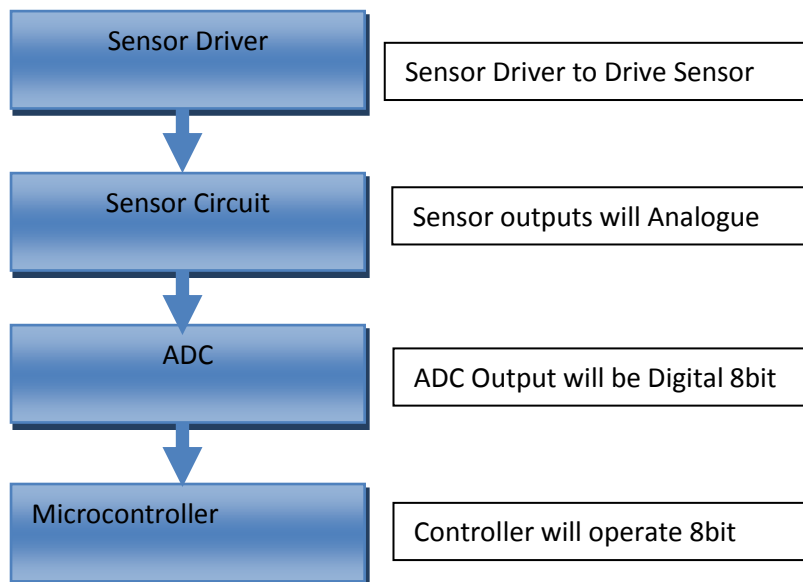


Figure 2- 20 ADC Operation

[Chapter 03]

Mathematical Work

Mathematical modeling of digital liquid level control system is the main part of this chapter. In this chapter following aspect of modeling will be discussed

- Modeling of single tank system
- Mathematical modeling for coupled tank
- State space of liquid level control system
- Output form of Modeling

3.1. Modeling the Single Tank System

It is important to understand the mathematics of how the coupled tanks system behaves. This is system modeling and it is a very important part of control systems analysis. To begin look at a single tank system in figure

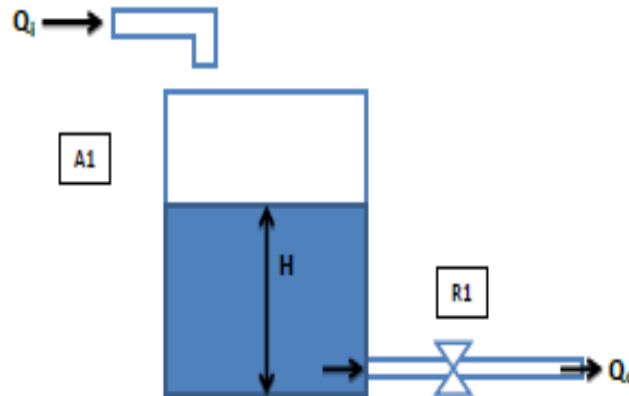


Figure 3- 1 Modeling of Single Tank System

The system model is determined by relating the flow Q_i into the tank to the flow Q_o leaving through the valve at the tank bottom. Using a balance of flows equation on the tank, it is possible to write:

$$Q_i - Q_o = A \frac{dH}{dt} \quad (1)$$

Where, A is the cross-sectional area of the tank, and H is the height of the fluid in the tank. If the valve is assumed to behave like an idea sharp edged hole, then the flow through the valve will be related to the fluid level in the tank, H , by the expression,

$$H = H^o + h$$

3.2. Mathematical Modeling for coupled tanks:

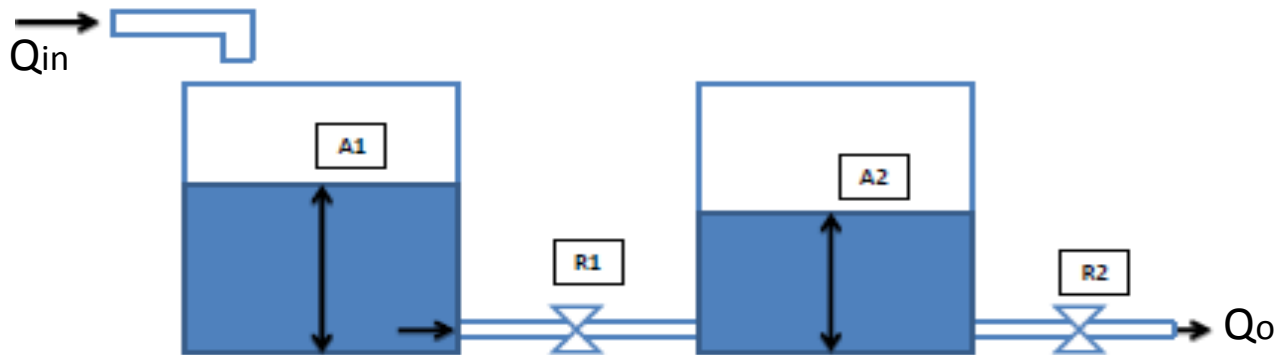


Figure 3- 2 Mathematical Modeling for Coupled Tank

For tank 1 rate of change of height named as h_1 can be taken as

$$Q_i - Q = A_1 \frac{dh_1}{dt}$$

Basically the product of flow and resistance is

$$\ast QR = \rho gh$$

Variation in height $h_1 - h_2$

Putting the value of Q in above equations we have

$$Q_i - \frac{\rho g(h_1 - h_2)}{R_1} = A_1 \frac{dh_1}{dt}$$

$$\frac{dh_1}{dt} = \frac{Q_i}{A_1} - h_1 \left\{ \frac{\rho g}{A_1 R_1} \right\} + h_2 \left\{ \frac{\rho g}{A_1 R_1} \right\}$$

Similarly for tank2

$$Q - Q_o = A_2 \frac{dh_2}{dt}$$

Putting the value of Q in above equations we have

$$\frac{\rho g(h_1 - h_2)}{R_1} - Q_o = A_2 \frac{dh_2}{dt}$$

$$\frac{dh_2}{dt} = h_1 \left\{ \frac{\rho g}{A_2 R_1} \right\} - h_2 \left\{ \frac{\rho g}{A_2 R_1} + \frac{\rho g}{A_2 R_2} \right\}$$

Now

$$\frac{dh_1}{dt} = \frac{Q_i}{A_1} - h_1 \left\{ \frac{\rho g}{A_1 R_1} \right\} + h_2 \left\{ \frac{\rho g}{A_1 R_1} \right\}$$

$$\frac{dh_2}{dt} = h_1 \left\{ \frac{\rho g}{A_2 R_1} \right\} - h_2 \left\{ \frac{\rho g}{A_2 R_1} + \frac{\rho g}{A_2 R_2} \right\}$$

Representing the above equations in “**State Space**”,

$$\begin{bmatrix} \dot{h}_1 \\ \dot{h}_2 \end{bmatrix} = \begin{bmatrix} -\frac{\rho g}{A_1 R_1} & \frac{\rho g}{A_1 R_1} \\ \frac{\rho g}{A_2 R_1} & -\left\{ \frac{\rho g}{A_2 R_1} + \frac{\rho g}{A_2 R_2} \right\} \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} \frac{1}{A_1} \\ 0 \end{bmatrix} Q_i$$

Output equation

$$Q_o = [1 \ 1] \begin{bmatrix} h_1 \\ h_2 \end{bmatrix}$$

Where

$$\begin{aligned}\rho &= 1000 \text{ kg/m}^3 & A_1 &= A_2 = 0.016129 \text{ m}^2 \\ R_1 &= R_2 = 1 & g &= 9.82 \text{ m/s}^2\end{aligned}$$

After putting values the obtained "State Space representation" is:

$$\begin{bmatrix} \dot{h}_1 \\ \dot{h}_2 \end{bmatrix} = \begin{bmatrix} -607601.22 & 607601.22 \\ 607601.22 & -1215202.43 \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} 62 \\ 0 \end{bmatrix} Q_i$$

Output equation,

$$Q_o = [1 \ 1] \begin{bmatrix} h_1 \\ h_2 \end{bmatrix}$$

[Chapter 04]

Simulation Using MATLAB ®

This chapter contains the simulation of mathematical work in MATLAB® covered in previous chapter and classified as given below

- State-Space Representation of the System
- Developing Transfer Function of the System using MATLAB ®
- Step Response of the Uncompensated System using MATLAB ®
- Developing PI Compensated Transfer Function using MATLAB ®
- Step Response of the Uncompensated System using MATLAB ®
- Step Response of the Compensated System using MATLAB ®
- Root Locus of the Compensated System

4.1. Mathematical Modeling using MATLAB®

The equations obtained in the previous chapter are

$$\begin{bmatrix} \dot{h}_1 \\ \dot{h}_2 \end{bmatrix} = \begin{bmatrix} -607601.22 & 607601.22 \\ 607601.22 & -1215202.43 \end{bmatrix} \begin{bmatrix} h_1 \\ h_2 \end{bmatrix} + \begin{bmatrix} 62 \\ 0 \end{bmatrix} Q_i$$

$$Q_i = [1 \ 1] \begin{bmatrix} h_1 \\ h_2 \end{bmatrix}$$

4.1.1. Editor MATLAB®

```
clear all % Clearing All Variables
clc % Clearing Command Window
A = [-607601.22 607601.22; 607601.22 -1215202.43]; % Matrix A
B = [62; 0]; % Matrix B
C = [1 1]; % Matrix C
D = [0]; % Matrix D
[num den] = ss2tf(A,B,C,D); % State Space 2 Numerator Denominator
display('-- Uncompensated T.F --') % Display
Sys=tf(num,den) % Numerator & Denominator into T.F
display('-- Uncompensated Z.P.K --') % Display
Y=zpk(Sys) % Zero_Pole_Gain Form
display('-- Uncompensated feedback --') % Display
Sys_feedback_old=feedback(Sys,1) % Feedback of System
ltiview('step',Sys_feedback_old); % Drawing the step response of
transfer function
rlocus(Sys); % RootLocus
ltiview('bode',Sys); % BodePlot of transfer function

% --- Compensator --- %
num_new=poly(1e4*[-1.823e006 -0.01]); % Adding Zero
den_new=poly([0 -1.591e006 -2.321e005]); % Adding Pole at origin
display('-- Compensated T.F --') % Display
Sys_new=tf(num_new,den_new) % Transfer function
display('-- Compensated Z.P.K --') % Display
Y_new=zpk(Sys_new) % Zero/pole/Gain Notation
display('-- Compensated feedback --') % Display
Sys_feedback=feedback(Sys_new,1) % feedback of System
Y=zpk(Sys_feedback)
ltiview('step',Sys_feedback); % Step response of transfer function
rlocus(Sys_new); % RootLocus
ltiview('bode',Sys_new); % BodePlot of transfer function
```

4.1.2. Command Window MATLAB®

-- Uncompensated T.F --

Transfer function:

$$62 s + 1.13e008$$

$$\frac{62 s + 1.13e008}{s^2 + 1.823e006 s + 3.692e011}$$

-- Uncompensated Z.P.K --

Zero/pole/gain:

$$62 (s+1.823e006)$$

$$\frac{62 (s+1.823e006)}{(s+1.591e006) (s+2.321e005)}$$

-- Uncompensated feedback --

Transfer function:

$$62 s + 1.13e008$$

$$\frac{62 s + 1.13e008}{s^2 + 1.823e006 s + 3.693e011}$$

-- Compensated T.F --

Transfer function:

$$s^2 + 1.823e010 s + 1.823e012$$

$$\frac{s^2 + 1.823e010 s + 1.823e012}{s^3 + 1.823e006 s^2 + 3.693e011 s}$$

-- Compensated Z.P.K --

Zero/pole/gain:

$$(s+1.823e010) (s+100)$$

$$\frac{(s+1.823e010) (s+100)}{s (s+1.591e006) (s+2.321e005)}$$

-- Compensated feedback --

Transfer function:

$$s^2 + 1.823e010 s + 1.823e012$$

$$\frac{s^2 + 1.823e010 s + 1.823e012}{s^3 + 1.823e006 s^2 + 3.875e011 s + 1.823e012}$$

Zero/pole/gain:

$$\frac{(s+1.823e010)(s+100)}{(s+1.577e006)(s+2.456e005)(s+4.705)}$$

4.1.3. Result of Unit Step Response

Table 2 Compensated vs Uncompensated

Uncompensated	Compensated
Tr: 9.51e-6(sec)	Tr: 0.467(sec)
Ts: 1.69e-5(sec)	Ts: 0.821(sec)
Pole: -1.591e6,-2.321e5	Pole: -4.705,-2.456e5,-1.5e6
Peak Amplitude: 3.006e-4	Peak Amplitude: 1

4.1.4. Output Windows

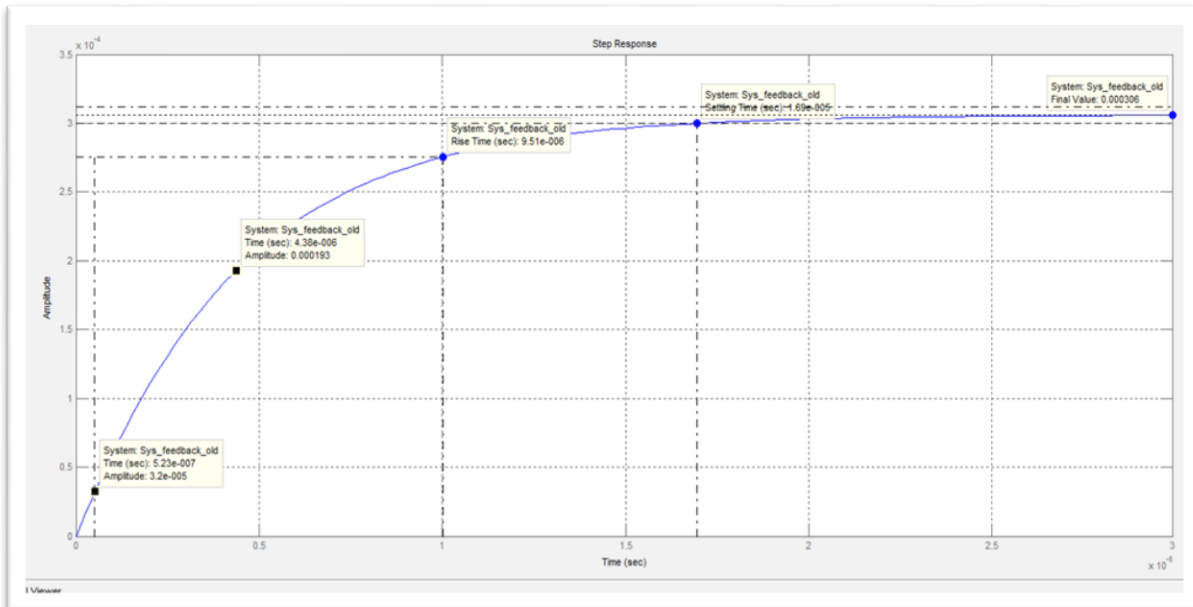


Figure 4- 1 Uncompensated System Step Response

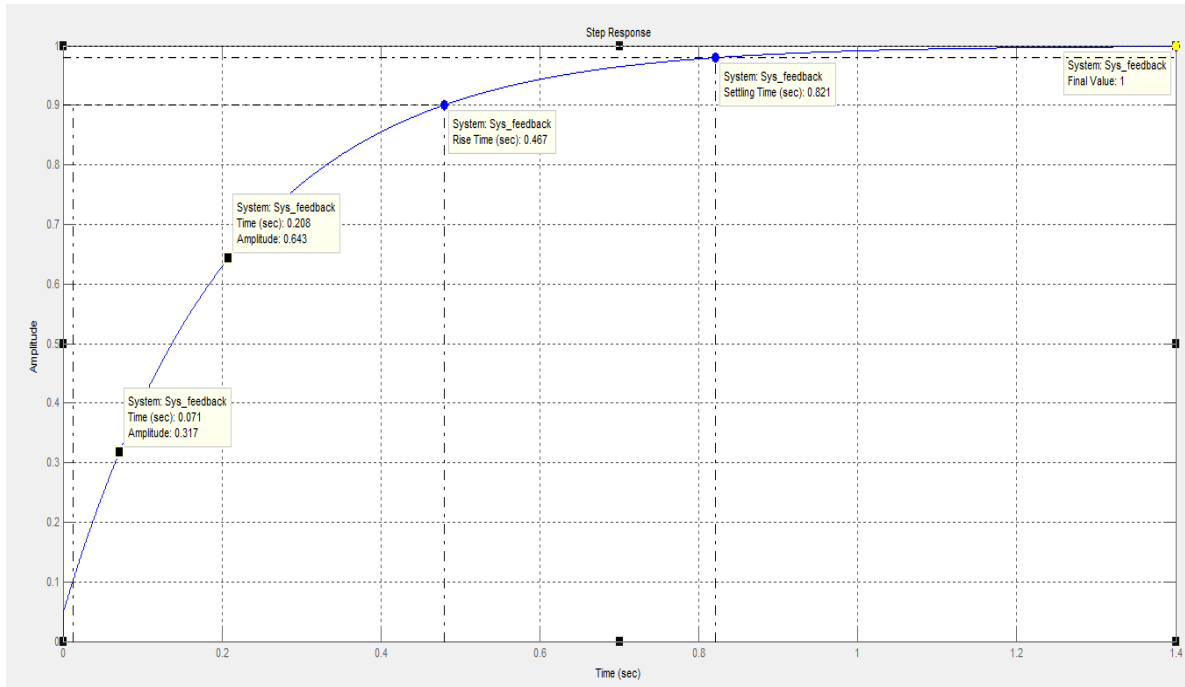


Figure 4- 2 Compensated System Step Response

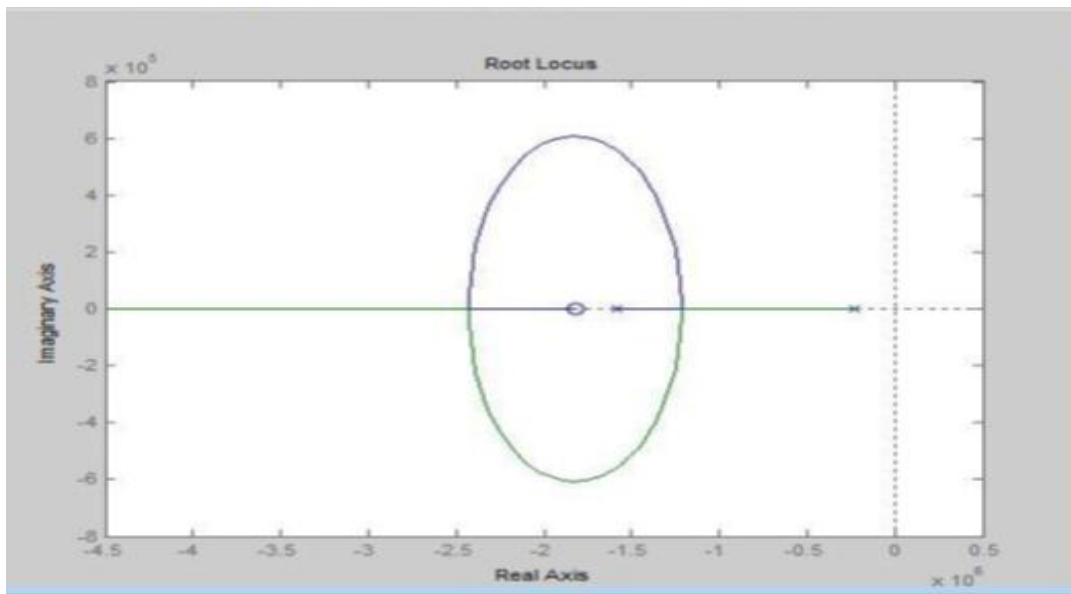


Figure 4- 3 Root Locus of The System

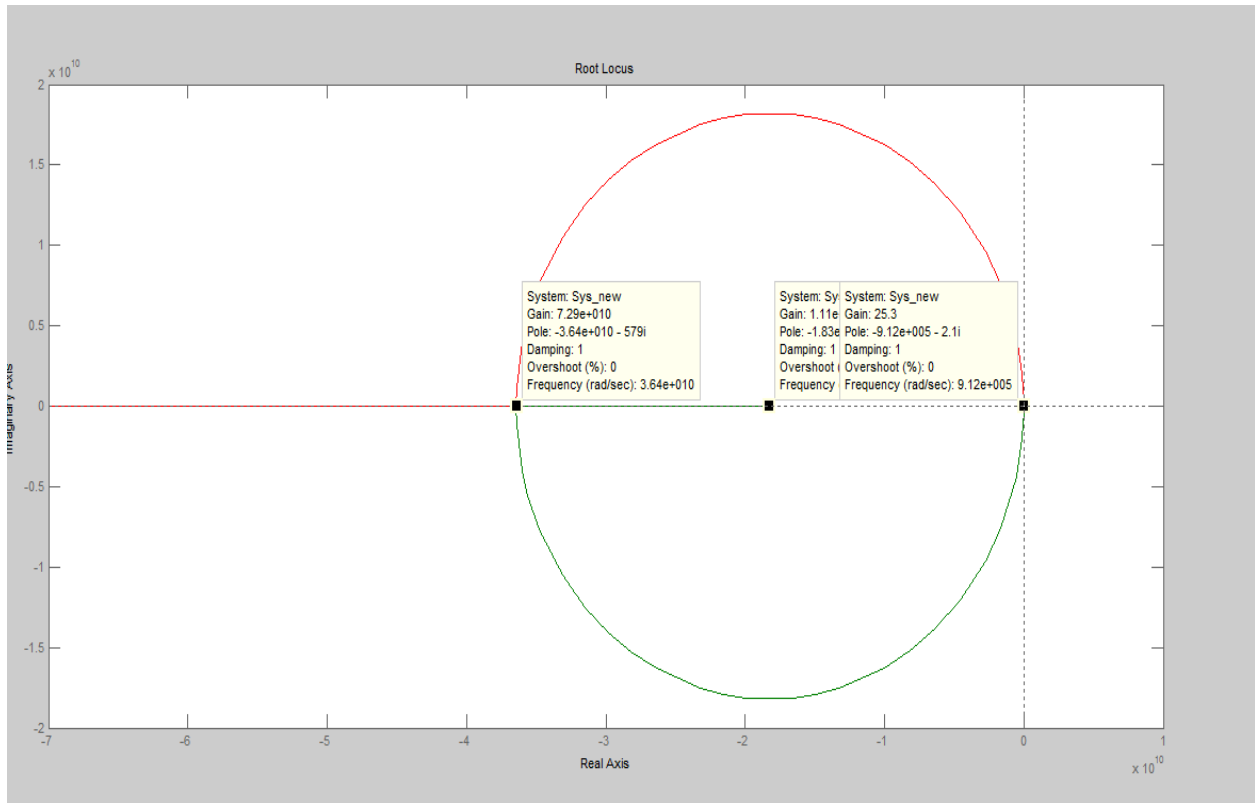


Figure 4- 4 Root Locus for Compensated System

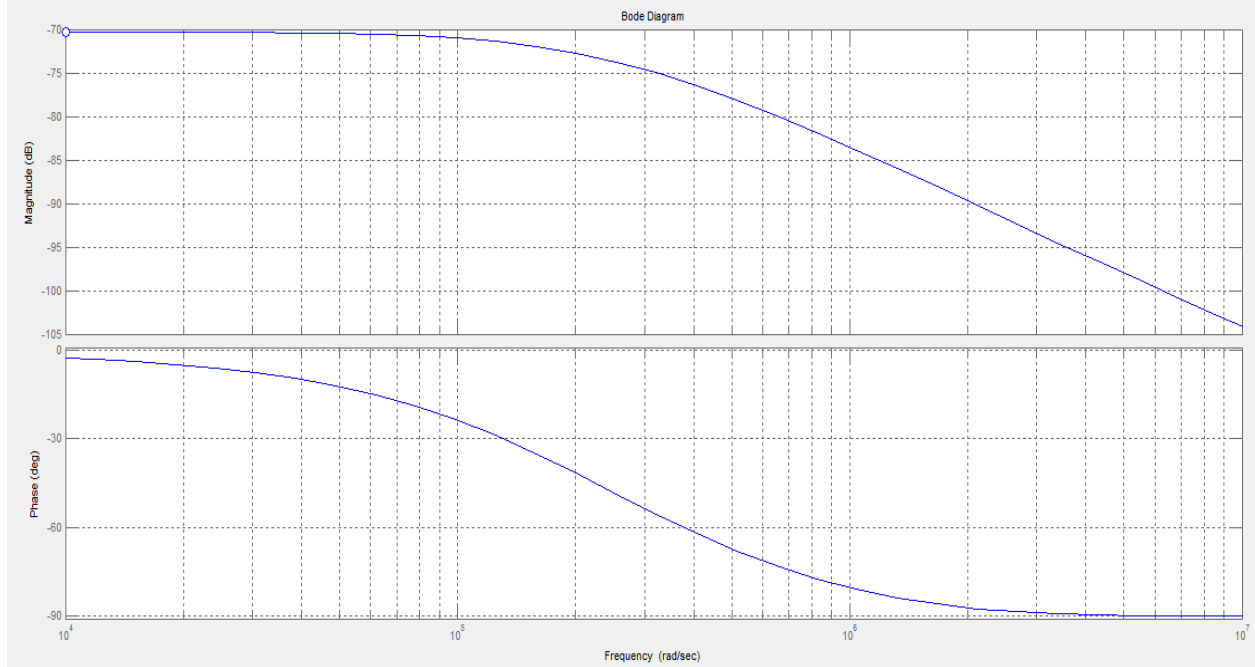


Figure 4- 5 Uncompensated Bode Plot

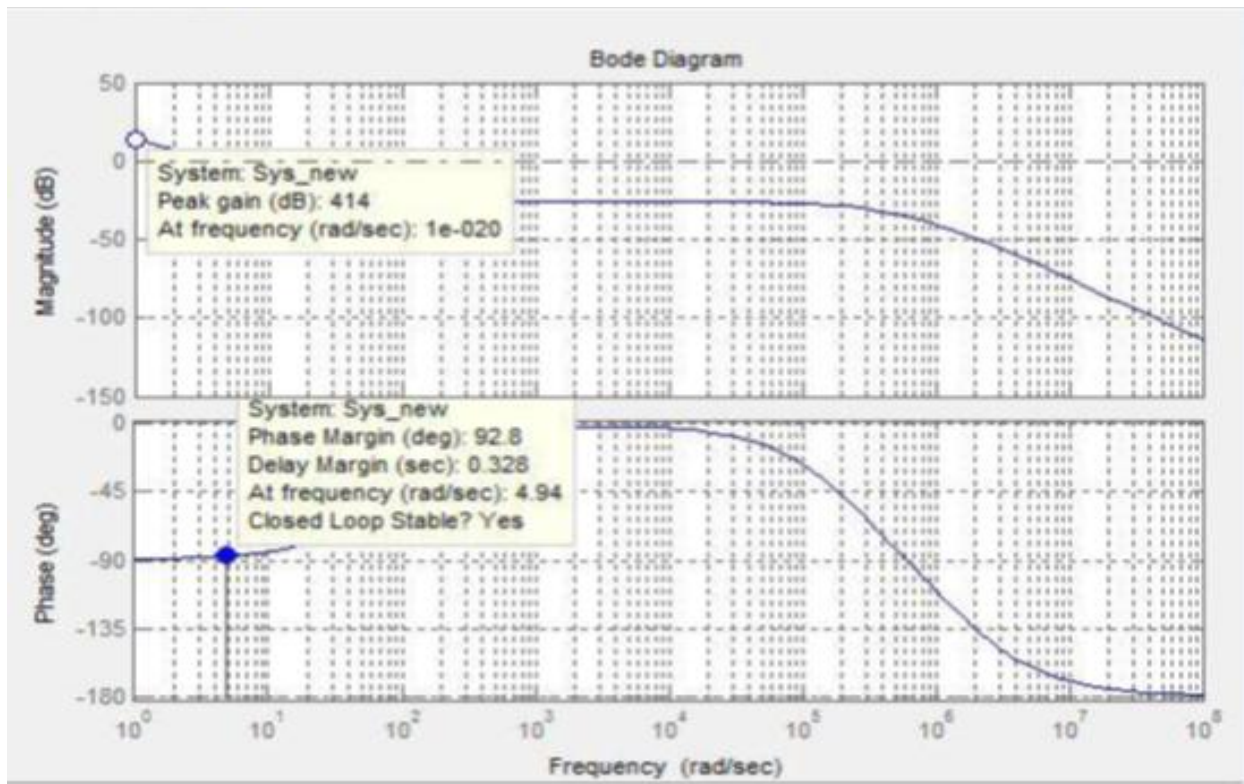


Figure 4- 6 Compensated Bode Plot

[Chapter 05]

Hardware Implementation

This chapter belongs to the hardware implementation and has the brief introduction to electrical components and circuits. This can be classified as following

- Components used
- Sensor circuit / Sensor Driver
- Motor Circuit / Motor Driver
- Solenoid valve Circuit
- LCD circuit diagram

5.1. Electrical Components

There are detail and configuration of components which is used in this project and their working is illustrated by the help of Software simulation

5.1.1. Floating Sensor

The basic idea is to change voltage with the change in the liquid level. For this purpose the potentiometer which will do change in resistance with change in level of water. In fig below the air ballooned material which will float on the surface of water and the level will change due to change in the fluid height and this ballooned floating material is connected in such a way that will cause change in resistance upon change in its position.



Figure 5- 1 Floating Sensor

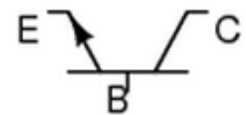
5.1.2. PIC16F877A Microcontroller

The controller being used in this project which is to do following

- Sensor1 read
- Sensor 2 read
- Pump Control
- Actuating Valve Control
- Sensor Reading Display on LCD

5.1.3. Bipolar Junction Transistor (BJT)

The bipolar junction transistor (BJT) was named because its operation involves conduction by two carriers: electrons and holes in the same crystal. The bipolar junction transistor shown in Figure is an NPN three layer semiconductor sandwich with an emitter and collector at the ends, and a base in between. It is as if a third layer were added to a two layer diode. If this were the only requirement, we would have no more than a pair of back-to-back diodes. In fact, it is far easier to build a pair of back-to-back diodes. The key to the fabrication of a bipolar junction transistor is to make the middle layer, the base, as thin as possible



without shorting the outside layers, the emitter and collector. An example of BJT in project can be illustrated as following

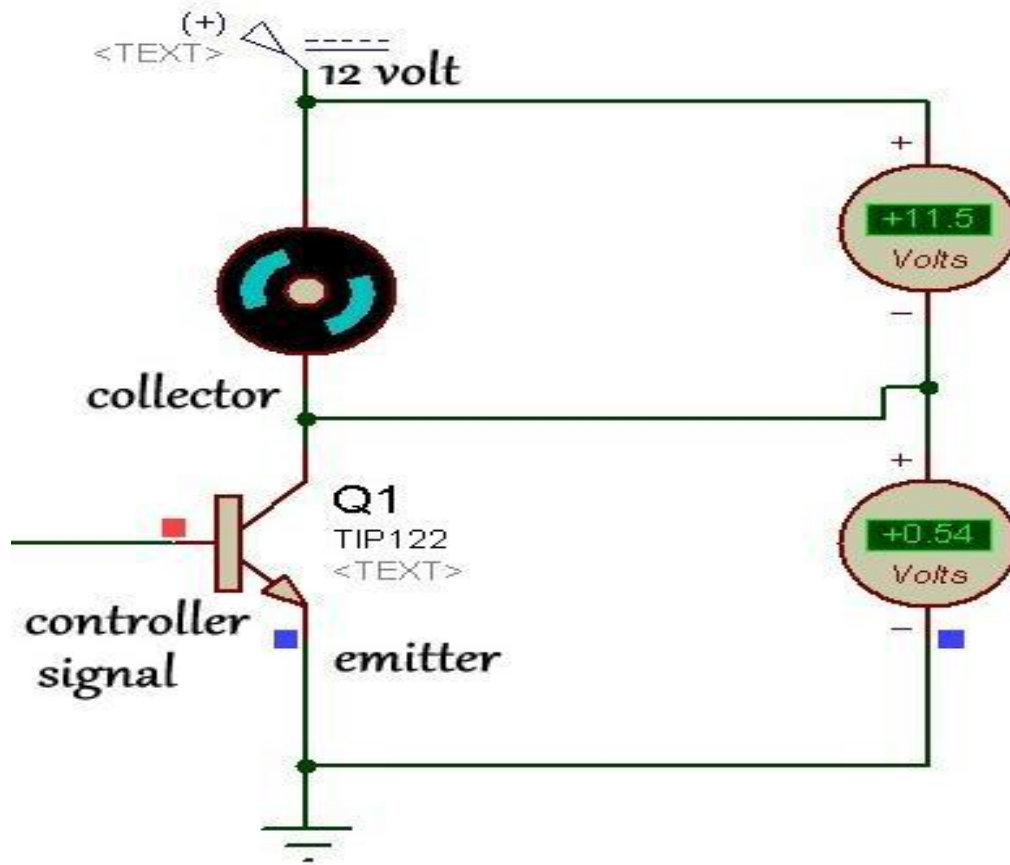


Figure 5- 2 BJT Application

5.2. Sensor Circuit / Sensor Driver

This circuit will convert the sensing quantity into convenient electrical form which is easily can be used to sensing the required sensor change in accordance with change in level.

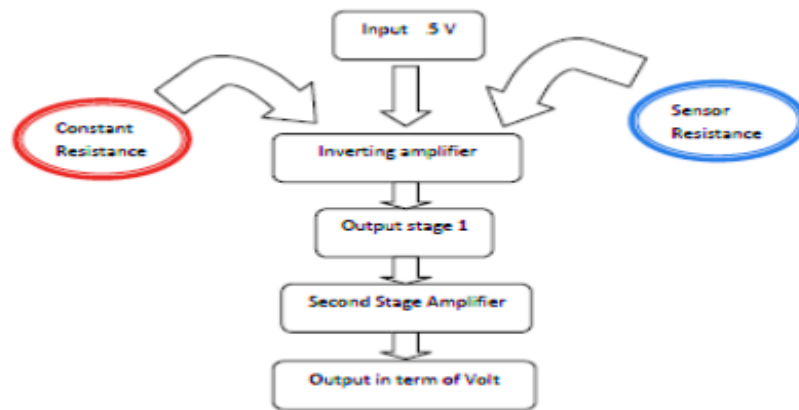


Figure 5- 3 Sensor Circuit Operation

Table 3 Resistance Verses Output Voltage Sensor 1&2

Input(%)	Sensor Resistance 1 (Ω)	Controller Output sensor 1 (V)	Sensor Resistance 2 (Ω)	Controller Output sensor 2 (V)
4	4.28	0.20	1.84	0.20
6	6.42	0.30	2.76	0.30
8	8.56	0.40	3.68	0.40
10	10.7	0.50	4.60	0.51
12	12.84	0.60	5.52	0.61
14	14.98	0.70	6.44	0.71
16	17.12	0.80	7.36	0.81
18	19.26	0.90	8.28	0.91
20	21.4	1.00	9.20	1.01
22	23.54	1.10	10.12	1.11
24	25.68	1.20	11.04	1.21
26	27.82	1.30	11.96	1.31
28	29.96	1.40	12.88	1.41
30	32.1	1.50	13.80	1.51
32	34.24	1.60	14.72	1.61
34	36.38	1.70	15.64	1.71
36	38.52	1.80	16.56	1.82
38	4.66	1.90	17.48	1.92
40	42.8	2.00	18.40	2.02
42	44.94	2.09	19.32	2.12
44	47.08	2.19	20.24	2.22
46	49.22	2.29	21.16	2.32
48	51.36	2.39	22.08	2.42
50	53.5	2.49	23.00	2.52

Input(%)	Sensor Resistance 1 (Ω)	Controller Output sensor 1 (V)	Sensor Resistance 2 (Ω)	Controller Output sensor 2 (V)
52	55.64	2.59	23.92	2.62
54	57.78	2.69	24.84	2.72
56	59.92	2.79	25.76	2.82
58	62.06	2.89	26.88	2.92
60	64.2	2.99	27.60	3.02
62	66.34	3.09	28.52	3.12
64	68.48	3.19	29.44	3.23
66	70.62	3.29	30.36	3.33
68	72.76	3.39	31.28	3.43
70	74.9	3.49	32.20	3.53
72	77.04	3.59	33.12	3.63
74	79.18	3.69	34.04	3.73
76	81.32	3.79	34.96	3.83
78	83.46	3.89	35.88	3.93
80	85.6	3.99	36.80	4.03
82	87.74	4.09	37.72	4.13
84	89.88	4.19	38.64	4.23
86	92.02	4.29	39.56	4.34
88	94.16	4.39	40.48	4.41
90	96.30	4.49	41.40	4.53
92	98.44	4.59	42.32	4.63
94	100.58	4.69	43.24	4.73
96	102.72	4.79	44.16	4.84
98	104.86	4.89	45.08	4.94
100	107	4.99	46.00	4.98

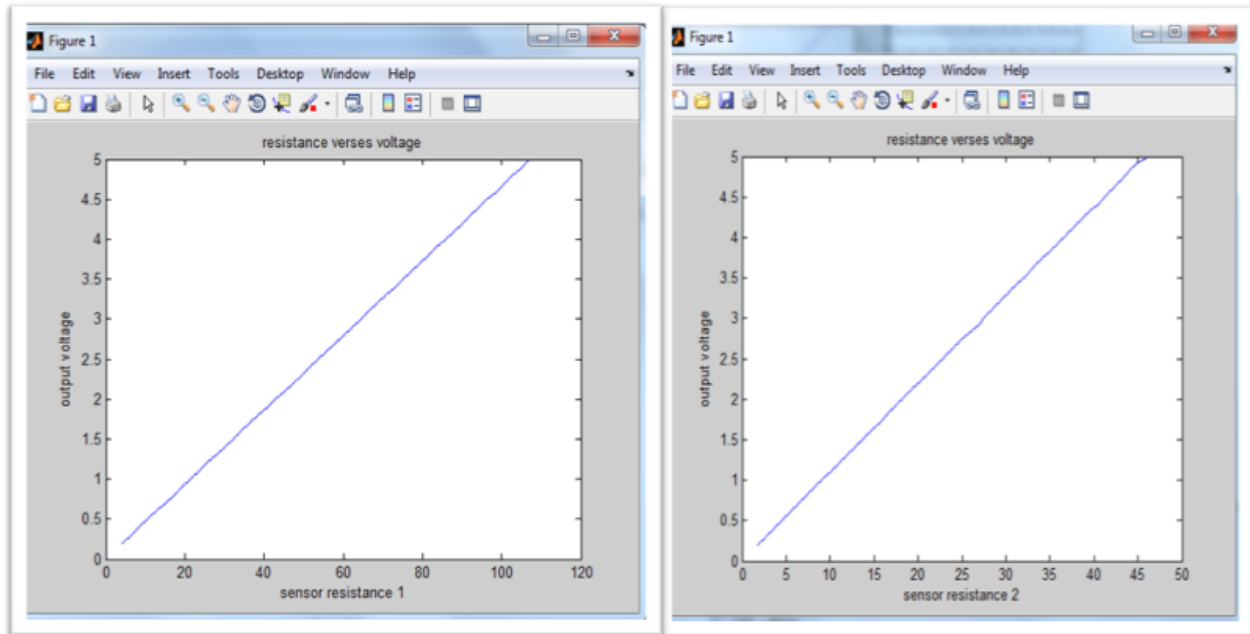


Figure 5- 4 Relationship between Sensor Resistance and Controller Voltage

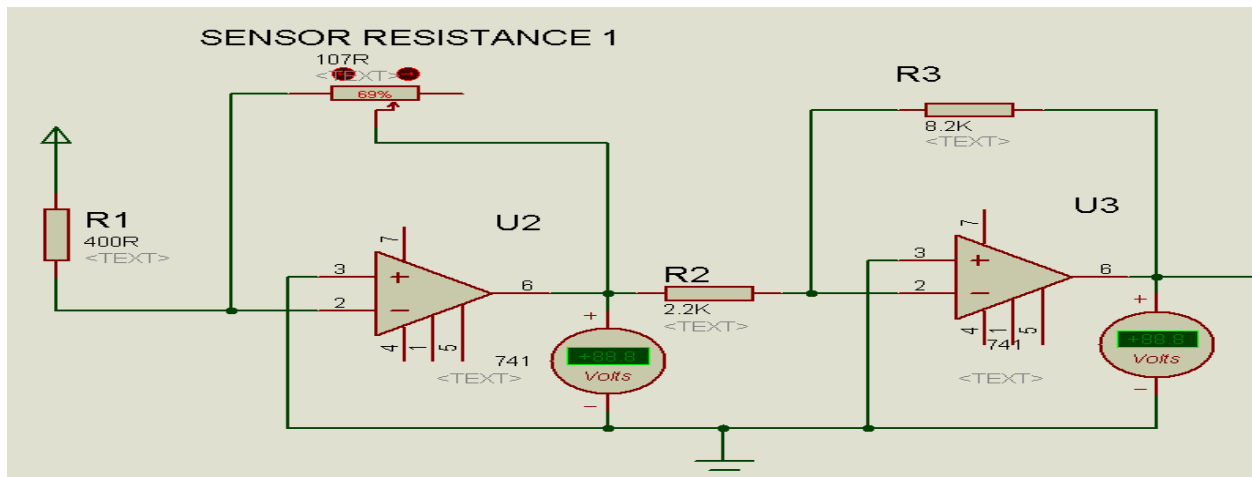


Figure 5- 5 Sensor Circuit

5.3. Motor Circuit / Motor Driver

This circuit will operate the motor in accordance with the signal received by the controller to control the speed of motor with respect to current level. Fluid is pumped into the tanks via a 12V DC Shower Pump. Pulse Width Modulation (PWM) is used to change the speed of the pump. The supply voltage to the pump is turned on and off at a very high frequency via an electronic speed controller inside the instrumentation control box. The microcontroller determines the speed of the pump. Adjusting the duty cycle of the PWM effectively changes the average voltage seen by the pump.

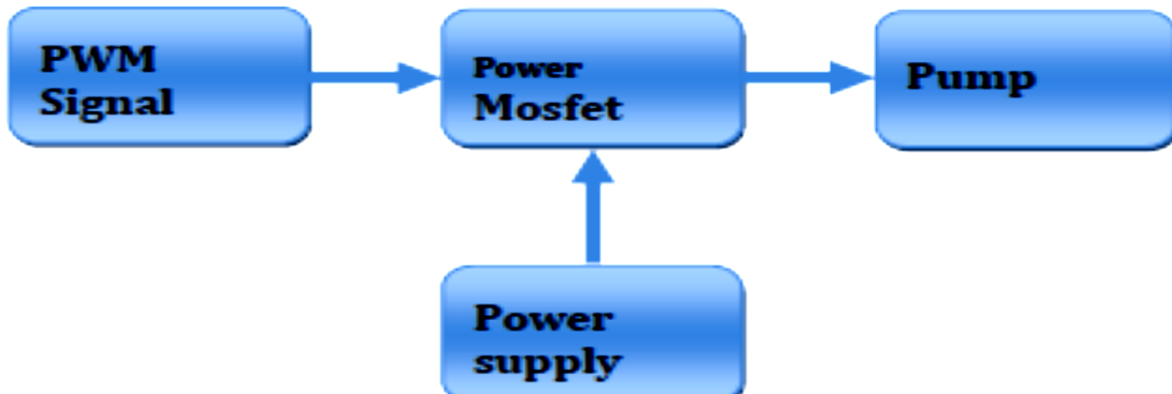


Figure 5- 6 Motor Control Circuit Operation

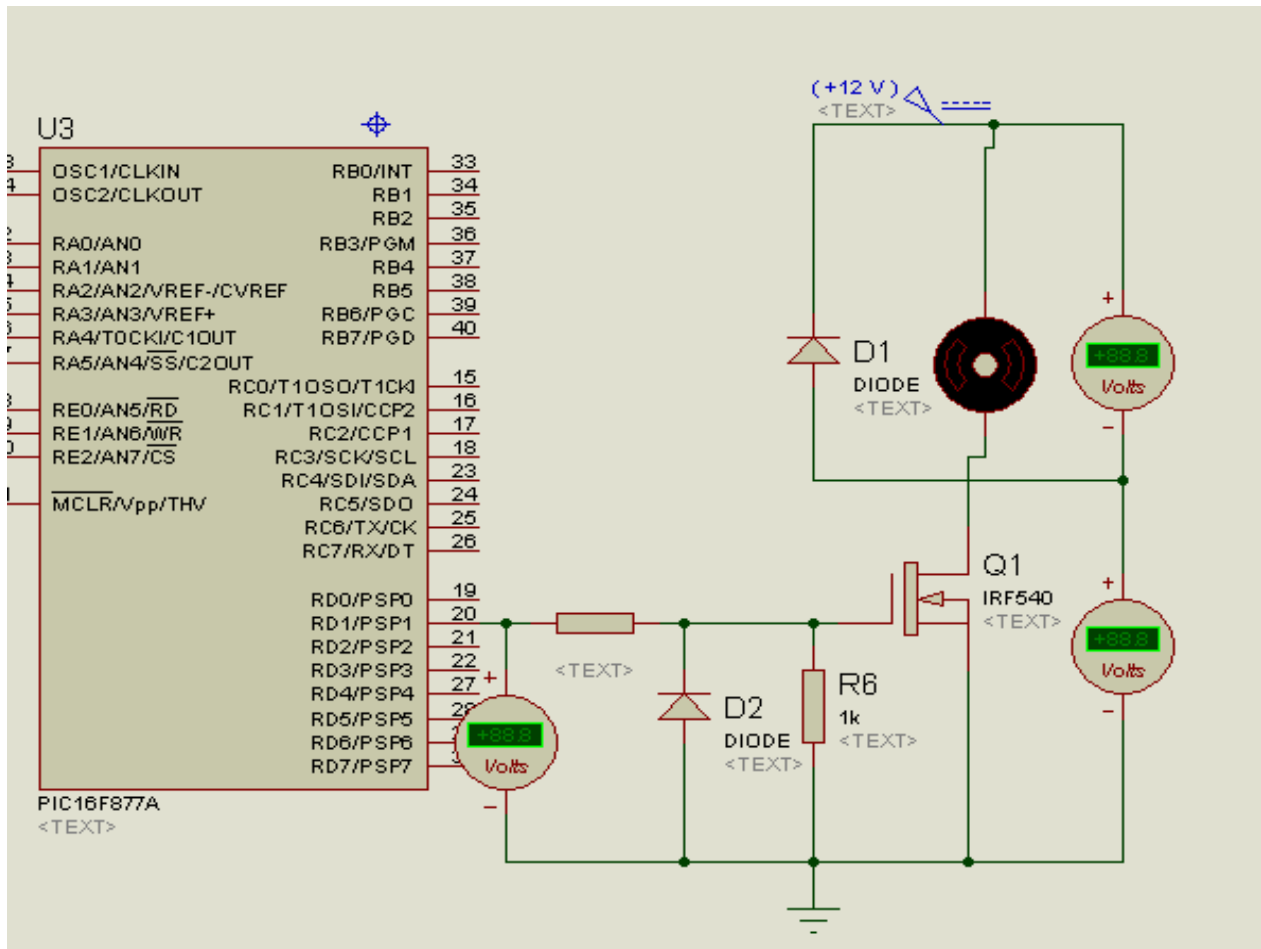


Figure 5- 7 Motor Pump Driver Circuit

Note: C5200 transistor is more powerful driver instead of IRF 640

5.4. Final Circuit

Now the final connections of the circuit are being implemented on the PCB here is the concept of connection/interfacing between the individual circuits of following.

- Motor circuit
- Sensor circuit
- ADC circuit (built in microcontroller)
- Microcontroller circuit

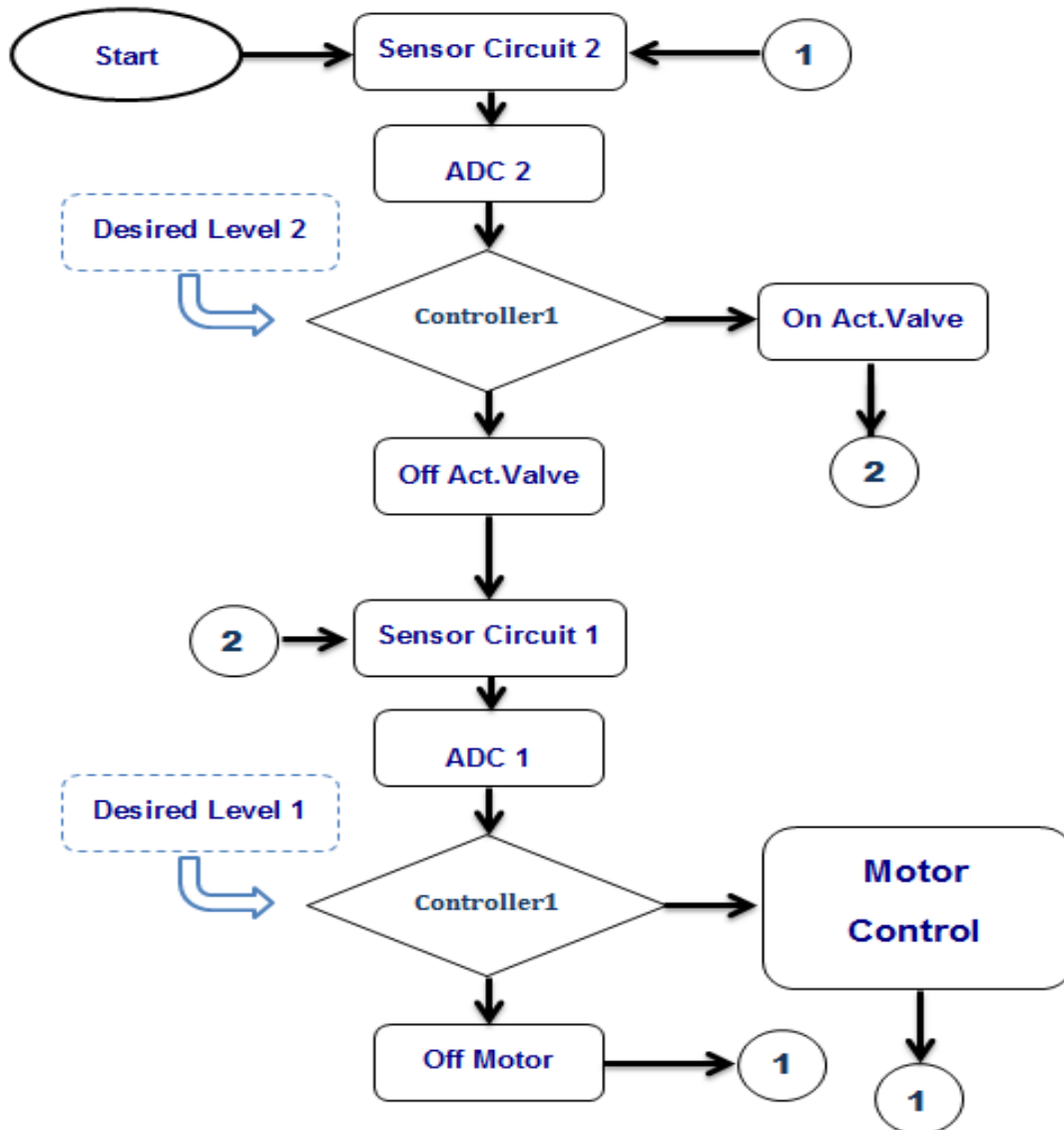


Figure 5- 8 Final Circuit Flowchart

And the Block "Motor Control" is explained by the following block

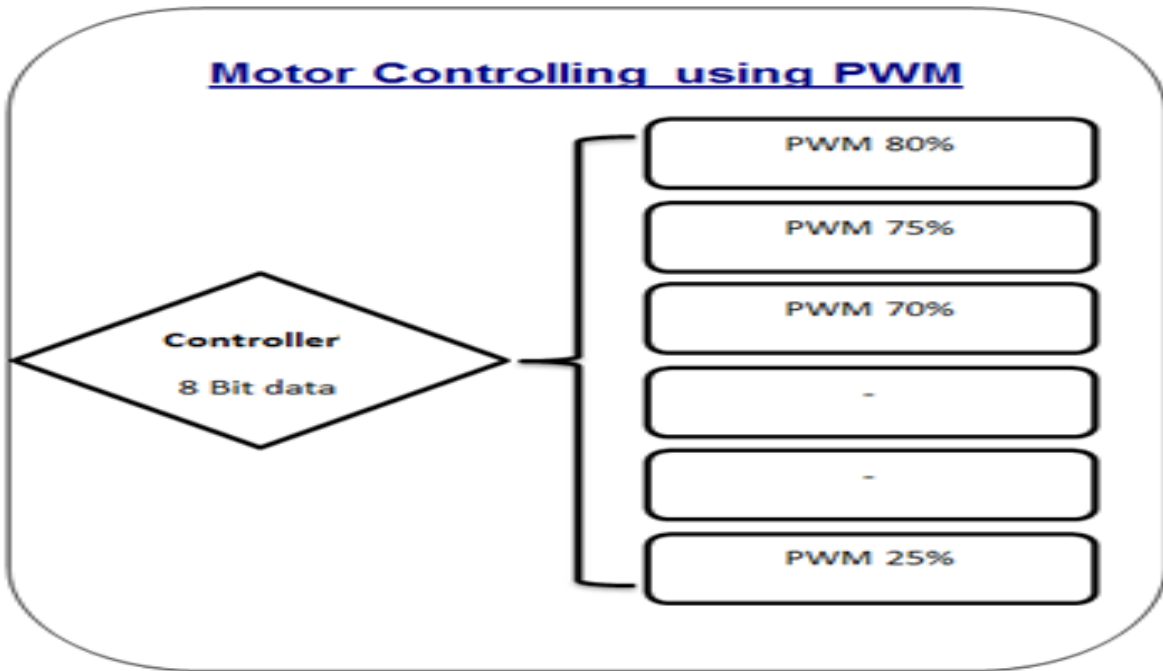


Figure 5- 9 Motor Controlling Block

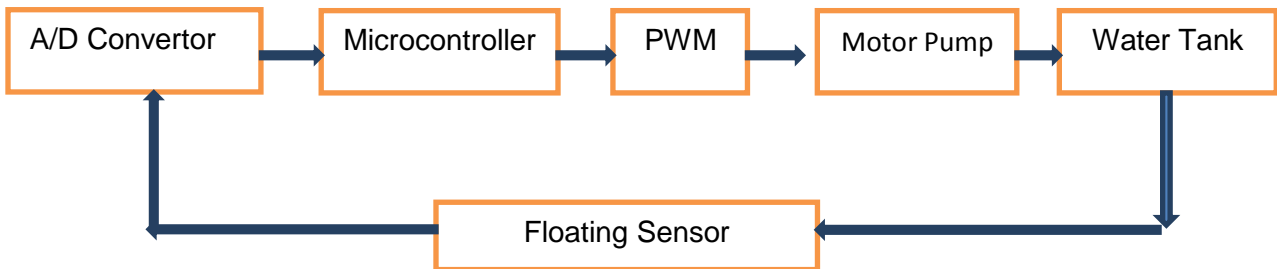


Figure 5- 10 Block Diagram of PWM

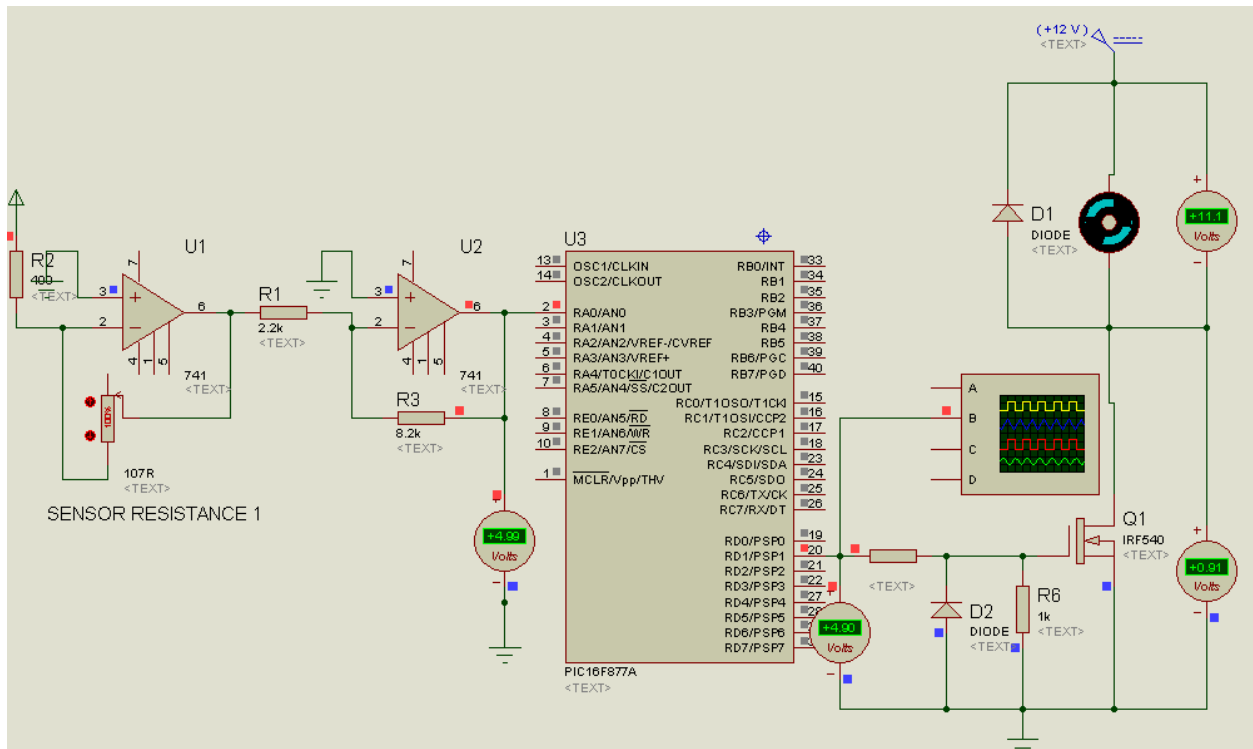


Figure 5- 11 Proteus Diagram of PWM

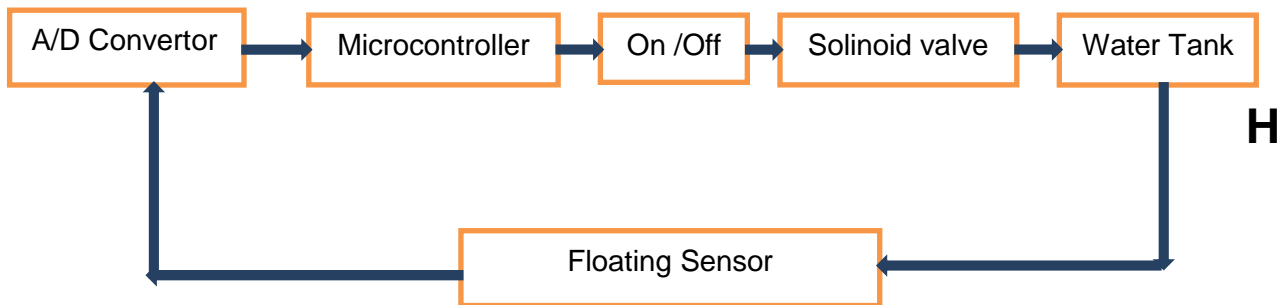


Figure 5- 12 Block Diagram of Solinoid Valve

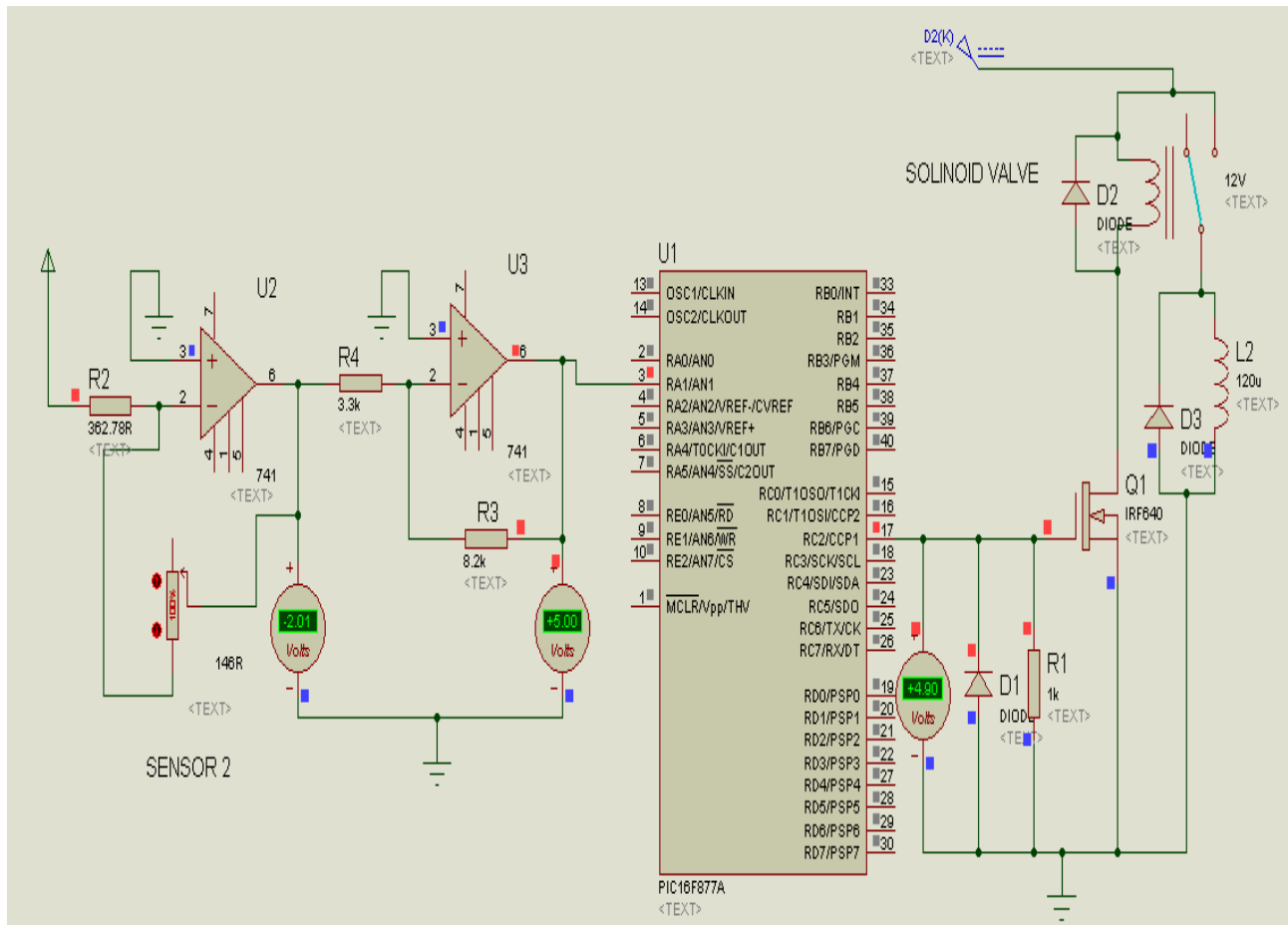


Figure 5- 13 Proteus Schematic Diagram of Solinoid Valve

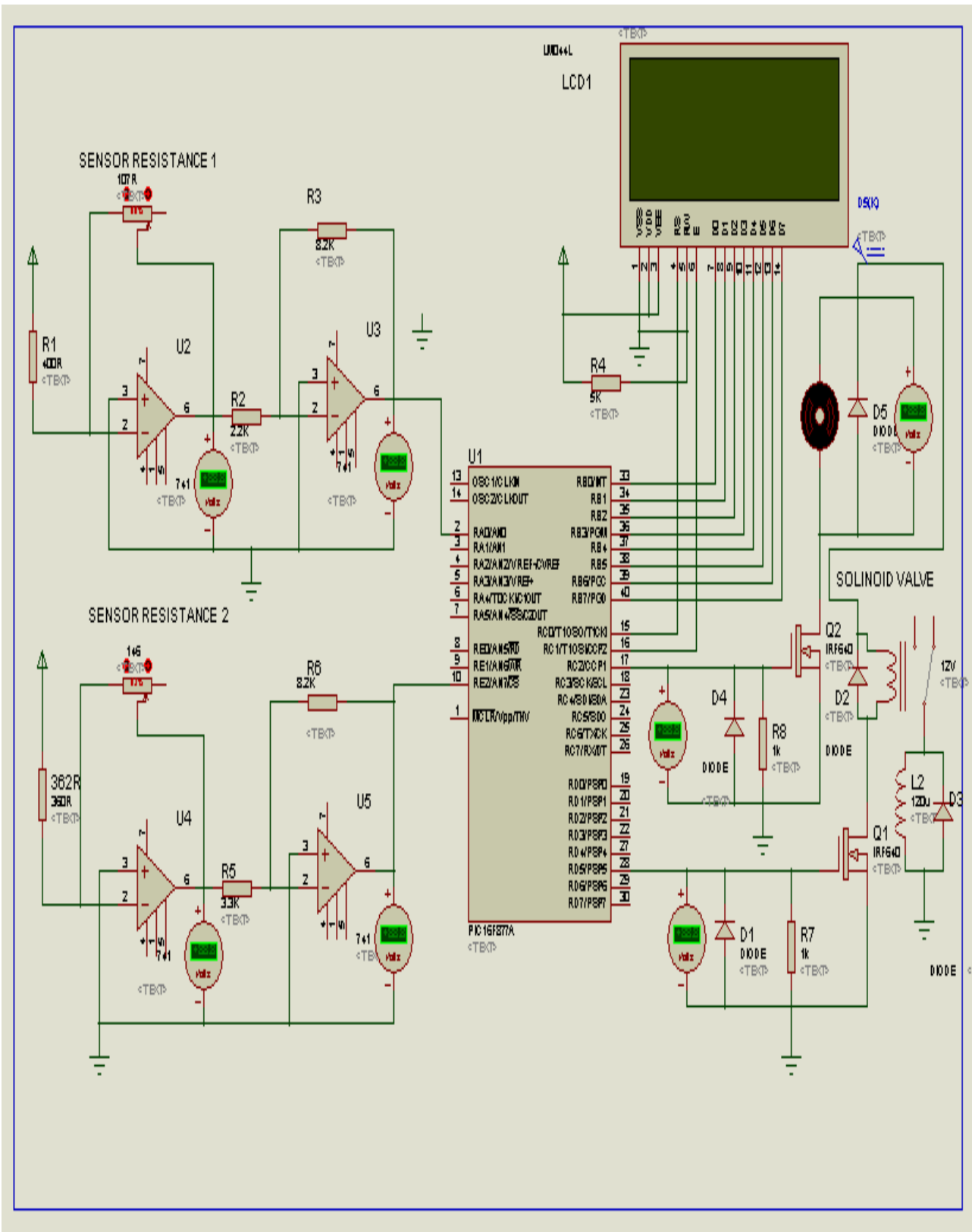


Figure 5- 14 Complete Proteus Schematic Diagram with LCD

5.5. ALGORITHM TO CODING CONVERSION

5.5.1. Code PIC16F877A Microcontroller

```
////////////////////////////////////
#include    <16F877a.h>
#device    adc=10
#use       delay (clock=20000000)
#fusesBROWNOUT, HS, NOWDT, NOLVP
#define     sw      pin_c2
#define     s       pin_d2

//////////////////////////////////// variables //////////////////////////////////////

unsigned int32    count,count1,on_time,off_time;
unsigned int32    adc_value,adc_value1;
void    pwm_on ();
void    pwm_off ();
////////////////////////////////////
void main()
{
    SETUP_ADC_PORTS(ALL_ANALOG);
    setup_adc(ADC_CLOCK_DIV_64);
    while(1)
    {

        set_adc_channel(7);

        delay_us(5);

        adc_value1=0;

        for(count1=0; count1<5; count1++)
        {
            adc_value1 = adc_value1 + read_adc();
            delay_us(10);
        }

        adc_value1 = adc_value1/5;
        if(adc_value1>=410)
        {
            output_high(s);
        }
        if (adc_value1<410)
        { output_low(s);
        }

        set_adc_channel(0);
        delay_us(5);
    }
}
```

```
adc_value=0;
  for(count=0; count<5; count++)
  {
    adc_value = adc_value + read_adc();
    delay_us(10);
  }

  adc_value = adc_value/5;

on_time = adc_value;

pwm_on(); pwm_off();

}

}
```

//

```
void pwm_on()
{
  for(count=0; count<on_time;count++)
  output_high(sw);
  delay_us(1);
}
```

```
void pwm_off()
{
  off_time=1000-on_time;
  for (count=0; count<off_time; count++)
  {
  output_low(sw);
  delay_us(1);
  }

}
```

//

LCD Code

```
/////////////////////////////////////////////////////////////////
#include <16F877a.h>
#define device adc=10
#define use delay (clock=4000000)

#define fuses BROWNOUT, HS, NOWDT, NOLVP

#define lcd_rs pin_c0
#define lcd_enpin_c1

///////////////////////////////////////////////////////////////// variables ///////////////////////////////////////////////////////////////////

unsigned int32 adc_value;
unsigned int8 digit1, digit2, digit3, digit4;
unsigned int8 count;

///////////////////////////////////////////////////////////////// functions ///////////////////////////////////////////////////////////////////

void lcd_ini (void);
void lcd_data (unsigned char);
void lcd_cmd (unsigned char);
void lcd_clear(void);
void lcd_line1(unsigned char);
void lcd_line2(unsigned char);
void lcd_line3(unsigned char);
void lcd_line4(unsigned char);
void bcd (void);

/////////////////////////////////////////////////////////////////

void main()
{
    lcd_ini();
    SETUP_ADC_PORTS(ALL_ANALOG);
    setup_adc(ADC_CLOCK_DIV_64);
    while(1)
    {
```

```

    set_adc_channel(0);
    delay_us(100);

    //////////////////////////////////////

    adc_value=0;

    for(count=0; count<50; count++)
    {
        adc_value = adc_value + read_adc();
        delay_us(500);
    }
    adc_value = adc_value*100/1023;

    //////////////////////////////////////

    bcd();

    lcd_line1(0);
    lcd_data("PEACE ENGINEER GROUP ADC");
    lcd_data(' ');
    lcd_data('=');

    lcd_data(digit4+0x30);
    lcd_data('.');
    lcd_data(digit3+0x30);
    lcd_data(digit2+0x30);
    lcd_data(digit1+0x30);
    lcd_data(" VOLTS");

    }

}

    //////////////////////////////////////

    //////////////////////////////////////

void bcd (void)
{
    digit4 = (adc_value/1000);
    digit3 = (adc_value/100 ) % 10;
    digit2 = (adc_value/10 ) % 10;
    digit1 = (adc_value ) % 10;
}

```

```

}

////////////////////////////////////////////////////////////////

void lcd_ini (void)
{
    delay_ms(300);
    lcd_cmd(0b00111000); // function set
    lcd_cmd(0b00001100); // display controll
    lcd_clear();
}

////////////////////////////////////////////////////////////////

void lcd_cmd (unsigned char i)
{
    output_low (lcd_rs); // its a command
    output_b(i);
    output_high(lcd_en);
    delay_us(100);
    output_low (lcd_en);
}

////////////////////////////////////////////////////////////////

void lcd_data(unsigned char i)
{
    output_high(lcd_rs); // its a data
    output_c(i);
    output_high(lcd_en);
    delay_us(100);
    output_low (lcd_en);
}

////////////////////////////////////////////////////////////////

////////////////////////////////////////////////////////////////

void lcd_clear (void)
{
    lcd_cmd(0x01);
    delay_ms(5);
}

////////////////////////////////////////////////////////////////

void lcd_line1 (unsigned char j)
{
    lcd_cmd(0x80+j);
}

```

```
}  
  
void lcd_line2 (unsigned char j)  
{  
    lcd_cmd(0xc0+j);  
}  
  
void lcd_line3 (unsigned char j)  
{  
    lcd_cmd(0x90+j);  
}  
  
void lcd_line4 (unsigned char j)  
{  
    lcd_cmd(0xd0+j);  
}
```

//////////////////// END PROGRAM //////////////////////

[Chapter 06]

Frame Designing

Mechanical designing is the main part of this chapter and this designing is classified into sections mentioned below.

- Material
- Structure Material
- Structure Idea
- Mind Sketch
- Paper Sketch
- Design in AutoCAD”
- Practical Design of the Project
- Final View of the Project

6.1. Project Frame Designing:-

The frame of this project is processed in different steps which are described one by one.

- ✓ Mind Sketch
- ✓ Paper Sketch
- ✓ Design in AutoCAD
- ✓ Practical Design of the Project
- ✓ Final View of the Project

6.1.1. Mind Sketch:

First of all the different ideas were discussed about the frame and design of the project among the project members and our respected advisor. After that a rough design was built in the mind. And then was decided to make the sketch on a paper.

6.1.1.1. Paper Sketch:

The sketch was prepared on the blank paper. Different calculations were performed for the better design. Following is the pencil sketch,

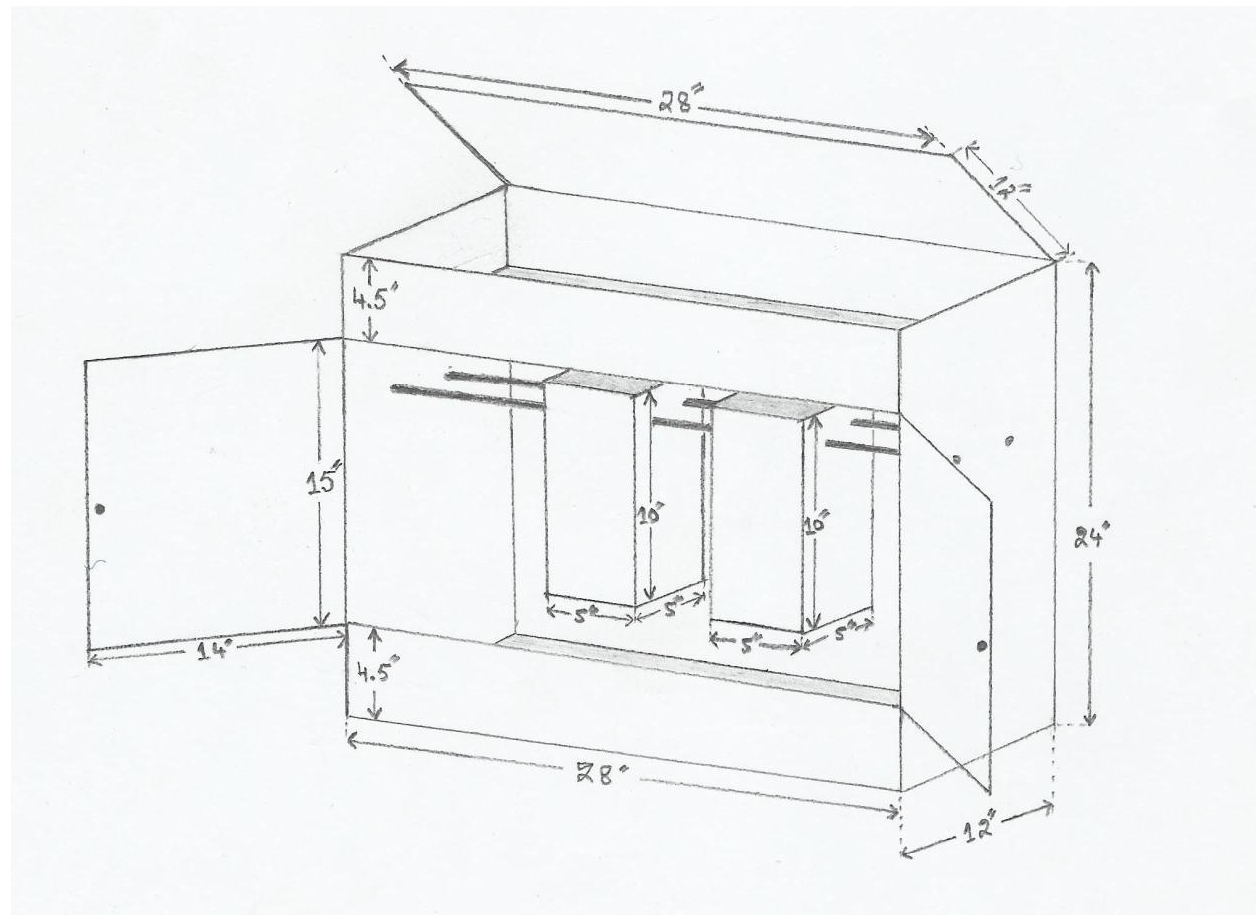


Figure 6- 1 Mind Sketch of Coupled Tank System

6.1.2. Design in AutoCAD:

After that the design is prepared in the software “AutoCAD”. According to the calculations decided the design was sketched. Actually, this sketch had to be used for real designing of the project. Here is given below the sketch prepared in the “AutoCAD”.

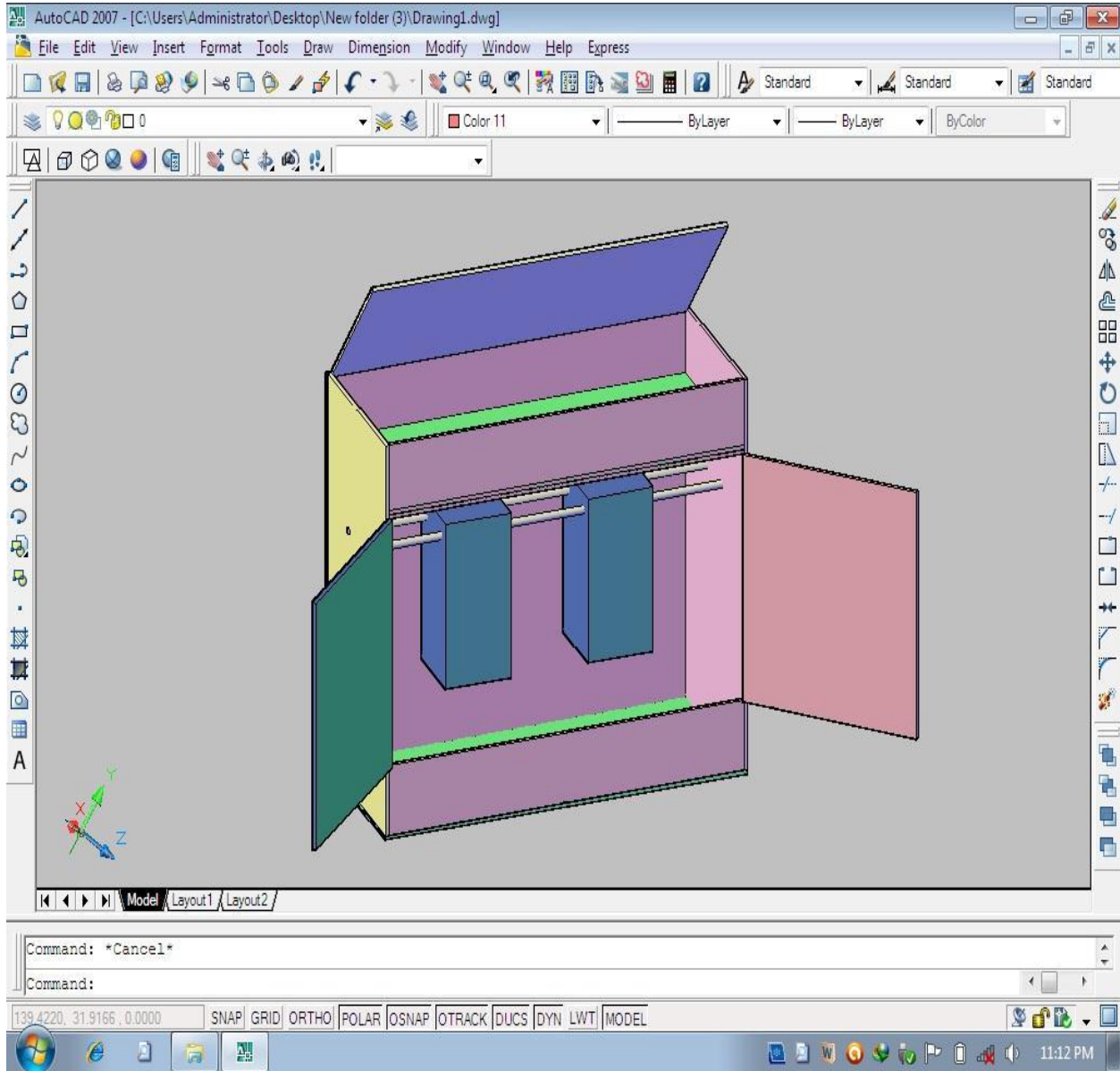


Figure 6- 2 Auto CAD Design of Coupled Tank System

6.1.3. Practical Design of the Project

The final design of the project was prepared from the market. The design and assembling was done by the highly skilled person as per the directions and calculations given. The practical view of the project is given below in the picture,

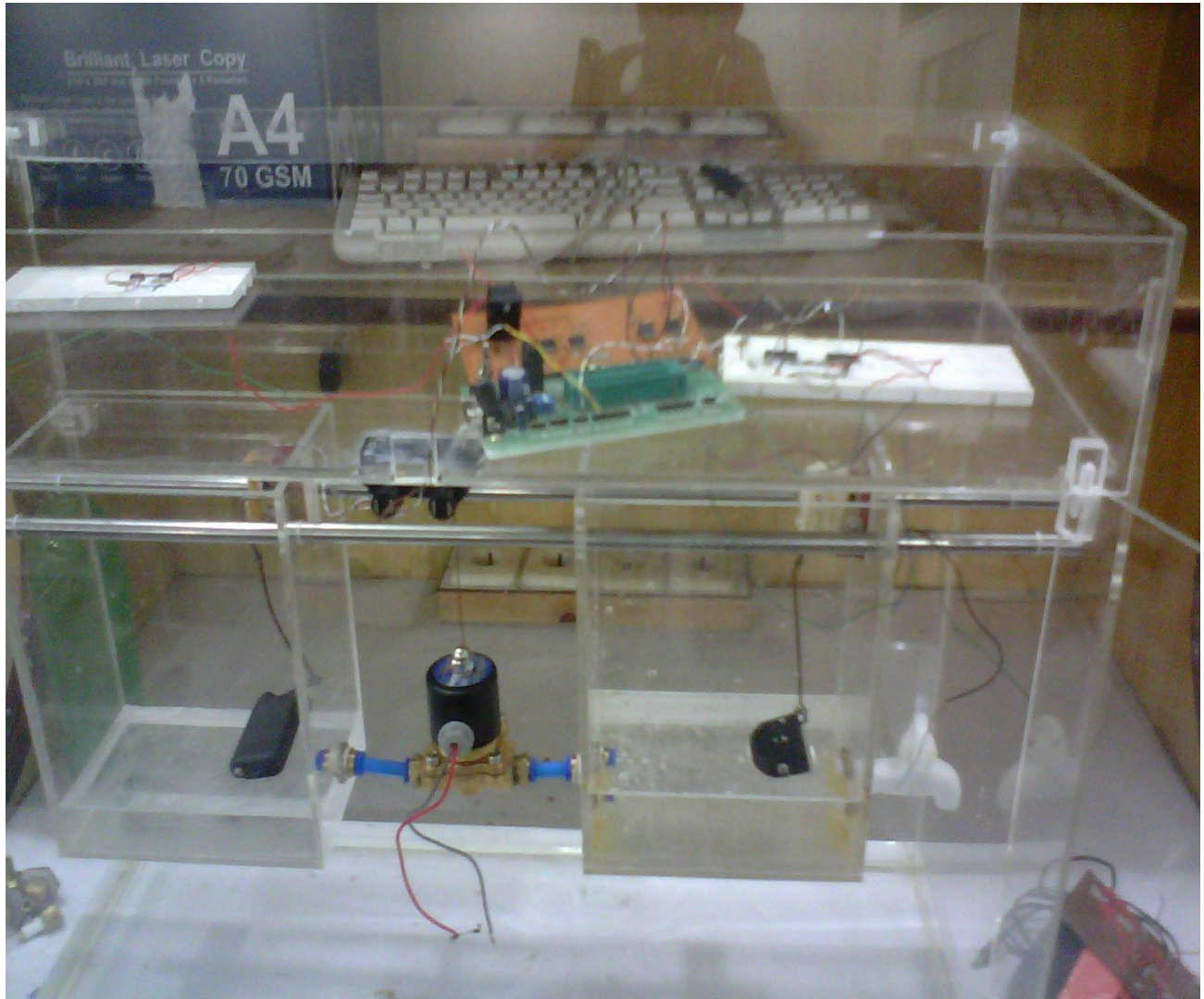


Figure 6- 3 Practical Design

6.2. Mechanical Components

6.2.1. Connector

Connector is used to make connection between the tanks and manual valve or the actuating solenoid valve.



Figure 6- 4 Connector

6.2.2. Manual Valve

This is manual valve to control the output flow of the tanks.



Figure 6- 5 Manual Valve

6.2.3. Steel Rods

These steel rods are used to support tanks at suitable height from the reservoir



Figure 6- 6 Steel Supporting Rod

6.2.4. Actuating Solenoid Valve

The actuating valve is used to control the level of 2nd tank and this is normally closed valve and the reason behind this that in case of electric breakdown there should no flow between tanks.



Figure 6- 7 Actuating Solenoid Valve

6.2.5. Lock

The lock is use to protect the circuit



Figure 6- 8: Lock

6.2.6. Stopper

The purpose of this is clear from its name that used for stopping liquid and the main purpose of using stopper is that the extenuation of coupled tanks can be done at any time.



Figure 6- 9 Stopper

6.2.7. Tanks

This is tank fig as shown below it has dimensions of 5x8x10 inch (length x width x height) and made up by the 6mm fiber plastic sheet

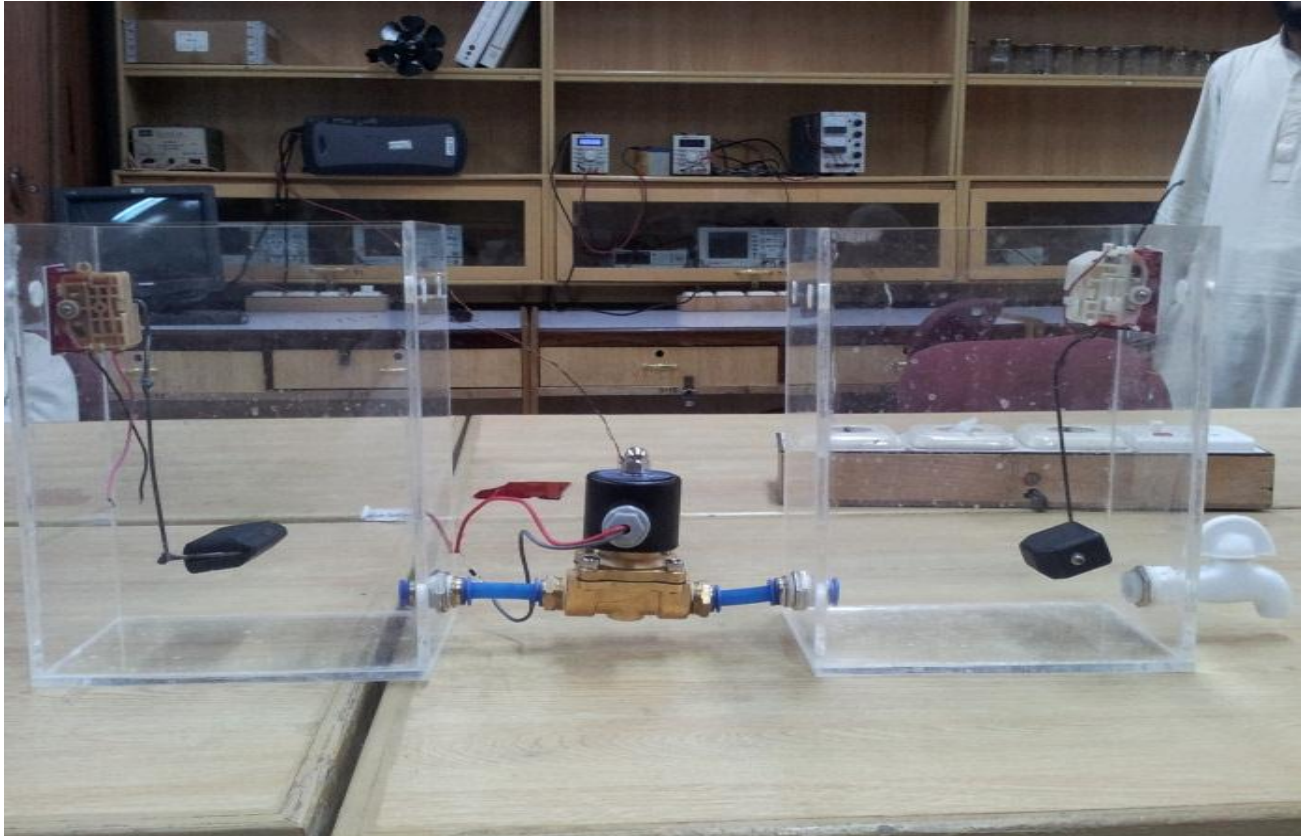


Figure 6- 10 Coupled Tank

6.2.8. Pipe

This pipe is connecting tank 1 and tank 2 diameter of this pipe is 8mm and also connected to pump to intake liquid from reservoir and outlet connector to exhaust water from tank.



Figure 6- 11 Pipe

[Chapter 07]

Results, Conclusion and Future Recommendations

In this chapter following sections will be discussed which are listed below.

- Results
- Conclusions
- Limitations
- Future Recommendations

7.1. Results

The coupled tanks system are used in industry instead of using a Huge tank because it is obviously more secure in case of any erosion or chemical breakdown. To make a continuous flow of process we prefer coupled tanks. There is another advantage that we may be enhancing capacity of liquid storage any time. The task of this project was to maintain the level of coupled tanks system and this should had to be independent to the output flow from the outlet valve.

- Level is maintained using the PID algorithm through the digital controller
- Steady state error is minimized
- The system time response for stability is very small

7.2. Conclusions

By the end of this project there are still a lot of improvements to be done, particularly the performance and testing. Many problems were encountered during the time of the project, particularly involving the PID algorithm implementation using digital controller. Much time was spent learning, fixing and debugging the system. Unconvincingly, we have somewhat shown that an adaptive controller can be designed for the Coupled Tank level System. There will be clearly more work to be done for further advancements.

7.3. Limitations

- Here is the main limitation of this project is that there is compulsory to use sensor for each tank which is mechanically and electrically not suitable for industrial purpose because of the handling of each sensor with controller which will increase the cost.
- Mathematically modeling of the system in which more than two tanks are used will make system complex and its mathematical modeling will also be complex.
- If a single motor pump for more than two tanks is used then the flow of fluid from one tank to another will consume more time and hence system time response for leveling will become bad.
- The sensors used in this project are not précised due to which the system precision is affected.

7.4. Future recommendations

The sensors used in this project were like variable resistance (potentiometer) due to which there was a dead zone and in this dead zone sensor was unable to change the resistance value although the level of fluid was changing at the same time. So for this purpose the recommendation is to use a continuous variable resistor, infrared sensor or capacitive level sensor in order to get the linear change in resistance or capacitance value respectively with the linear change in the height of fluid.

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