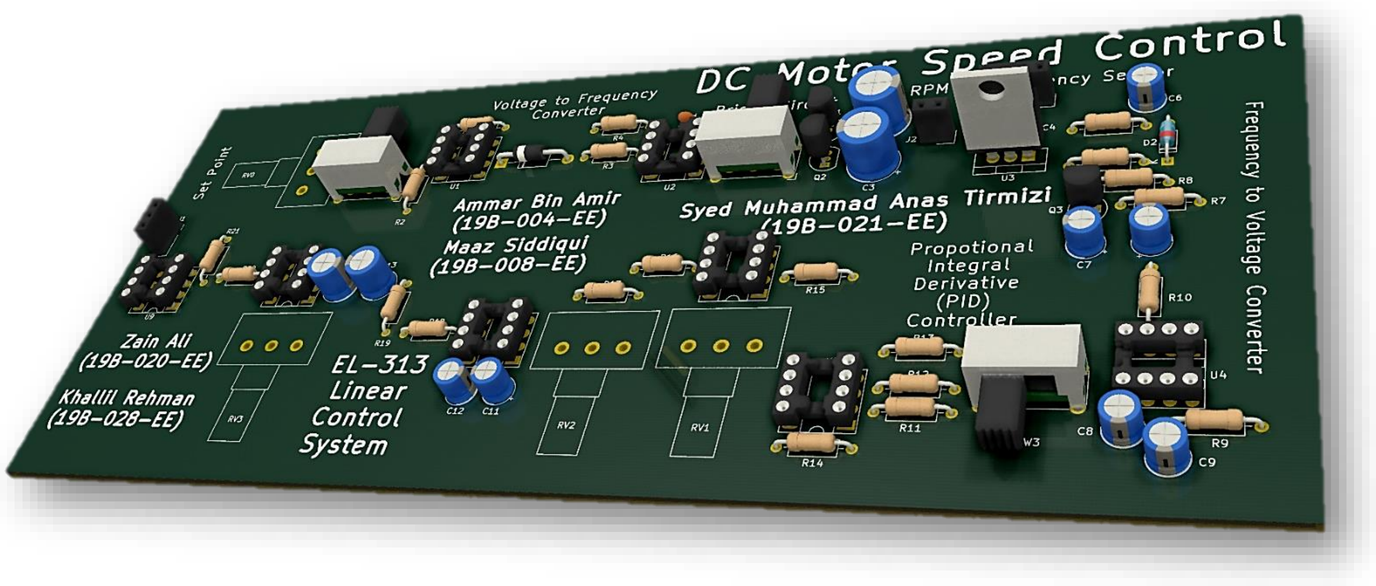

DC MOTOR SPEED CONTROL

EL-313 Linear Control System

Usman Institute of Technology

FALL-2022

Table of Contents

Table of Tables

Table of Figures

I. Abstract

The function of speed control in DC motors is very essential in the achievement of desirable outputs. DC motors are designed for use in industrial and commercial applications. Proportional-Integral-Derivative (PID) controller are considered for controlling the speed of dc motor by giving the step input signal. The response of the motor is investigated using a first order system model of the motor.

An implementation of the controller utilizing OP-AMPs is provided, along with an explanation of the speed control using PID control modes. Designers examine how the controller reacts to changes in load. The system is simulated using KICAD/SIMULINK software. The system responses under PID controllers are also analyzed and discussed in term of their performances.

II. Introduction

It was mainly about P, P-I, P-D and P-I-D controllers, their digital versus continuous time realizations and their characteristics including sampling period effects on the response of digital ones.

A speed control system's goal is to keep the motor's speed constant under a variety of circumstances. The DC motor is a nonlinear device in practice, and speed variations are caused by disturbances, changes in load demand, etc.

The PID controller algorithm, a common controller in industries, has been implemented. The block diagram of a DC motor speed control system. The motor speed is sensed by an optical switch and converted to feedback voltage. It is compared with the reference signal (i.e., desired speed) by the error detector. The PID controller acts on the error signal and generates appropriate control voltage. The PWM generator block than varies the duty cycle of the voltage supplied to the motor to control its speed.

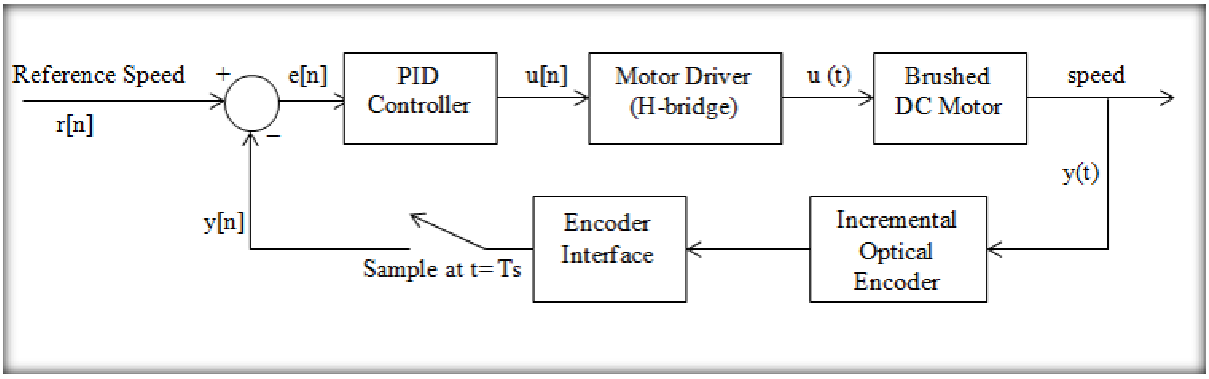

Figure 1: Block Diagram of DC Motor Speed Control

III. Literature Review

For the implementation of the DC motor speed control system, the concepts of motor and PID controller should be understood.

A. DC Motor Specifications

The speed control system was implemented for a Permanent Magnet DC Motor (PMDC). The PMDC consists of rotor or armature and a stator, which is a permanent magnet. There are two ways of speed control for a DC motor.

i. Field Control

In this method, the field current or current through stator is varied to control the speed of the motor.

ii. Armature Control

In this method, the armature voltage is varied to control the speed of the motor.

For the PMDC, a constant field is generated by a permanent magnet and hence we decided to implement Armature control. To control the armature voltage, we are generating a Pulse-Width Modulated (PWM) waveform to control the average voltage applied to the motor.

B. PID Controller

The combination of proportional, integral and derivative control action is called PID control action. PID controllers are commonly used to regulate the time-domain behavior of many different types of dynamic plants. These controllers are extremely popular because they can usually provide good closed-loop response characteristics.

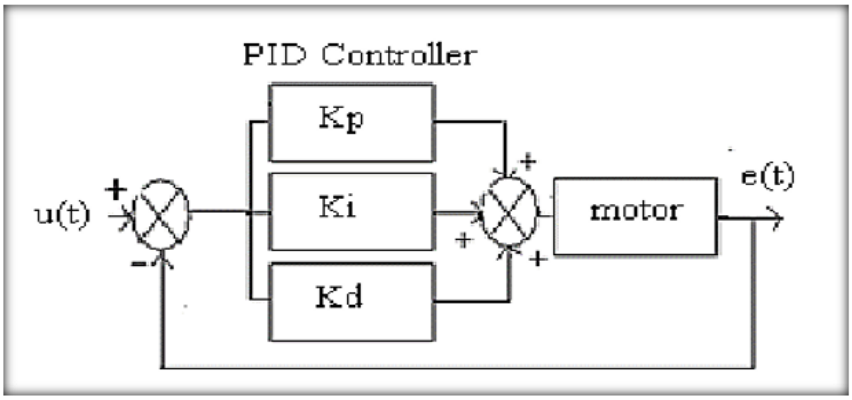

Figure 2: Block Diagram of PID Controller

Table 1: Parameters of PID Controller

Parameter	Rise Time	Overshoot	Setting Time	Steady-state Error	Stability
Kp	Decrease	Increase	Small change	Decrease	Degrade
Ki	Decrease	Increase	Increase	Eliminate	Degrade
Kd	Minor change	Decrease	Decrease	No effect in theory	Improve if Kd small

IV. Proposed System Description

The actual speed of the motor is sensed by the feedback control loop and compares this speed with the preset reference speed in order to determine the required motor's reference armature current. The simulation of proposed system model has been accomplished.

The PID controller is very popular and common in process control industry. In the PID (proportional-integral-derivative) closed control loop controller, the three controllers P, I and D all have different tuning adjustments which interact all together that's why its tuning is time consuming and challenging task. The effects of all three individual controllers (P-I-D) summed together to produce the output value of the system. Tuning of PID controller is the major task of this device in order to proper functioning of the PID controller under the given circumstance of the control system.

The variable stand for the error signal used to track the reference signal. The variable is the difference between the desired reference input set point value and the actual output. This error signal is sent to the PID controller and then controller evaluates the derivative and the integral of the error signal. The output signal of the controller becomes equal to the proportional gain (K_P) times the magnitude of the error plus the integral gain (K_I) times the integral of the error plus the derivative gain (K_D) times the derivative of the error.

V. Important Observations

Accurate performance of a motor is desired feature for any industrial application. As the age of motor increases its performance also deceases with aging, so it is desired to evaluate the performance of motor from time to time for efficient operation The conventional method for calculating output performance indices is quite time consuming.

The PID based approach algorithm worked satisfactory for the test system. Following are the observations:

1) The solution time for proposed PID approach is only a fraction of time taken by conventional algorithm.
2) A proportional controller K_p will have the effect of reducing the rise time and reduce but never eliminate the steady state error.
3) An internal controller K_i will have the effect of eliminate the steady state error, but it may make the transient response worse.

4) A derivative controller K_d will have the effect of increasing the stability of the system and reducing the overshoot and improve the transient response.
5) The output performance obtained by normalized value in PID is very close and near to accuracy.

VI. Schematic

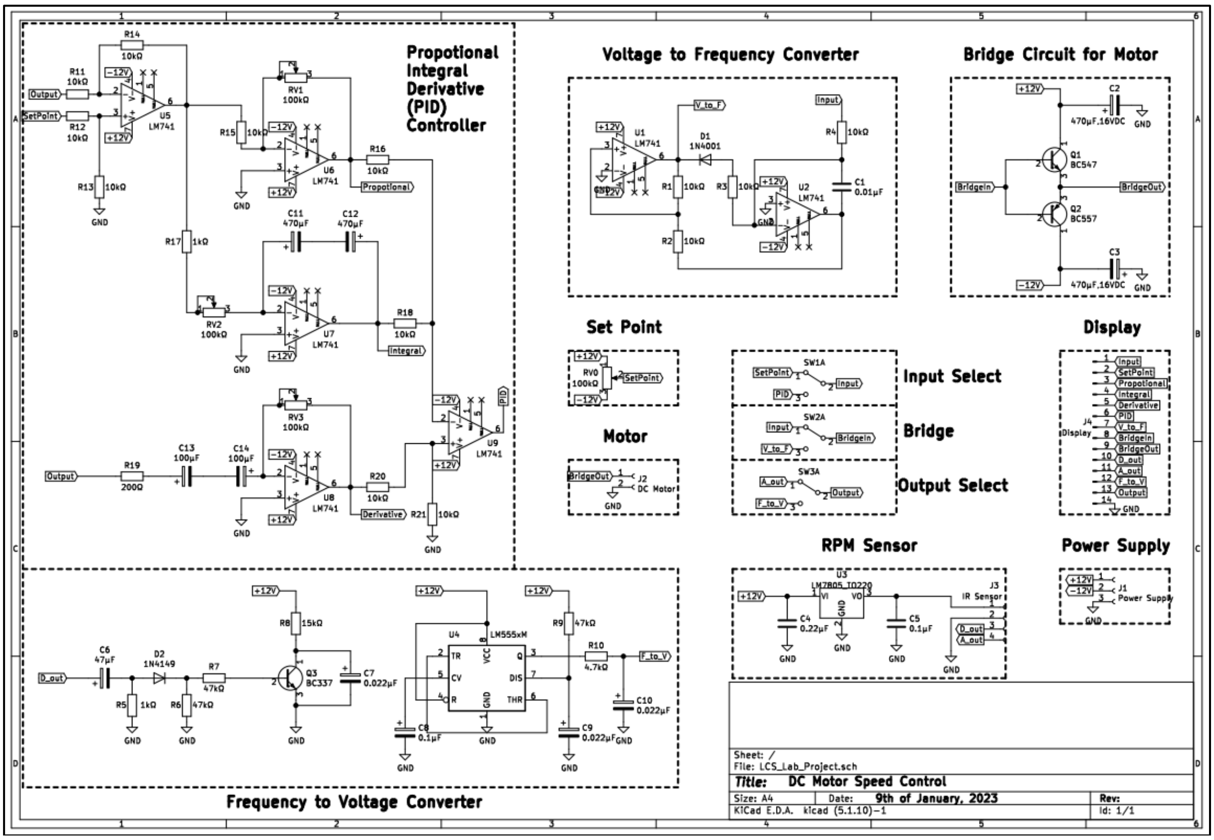

Figure 3: Schematic of DC Motor Speed Control

VII. Simulation

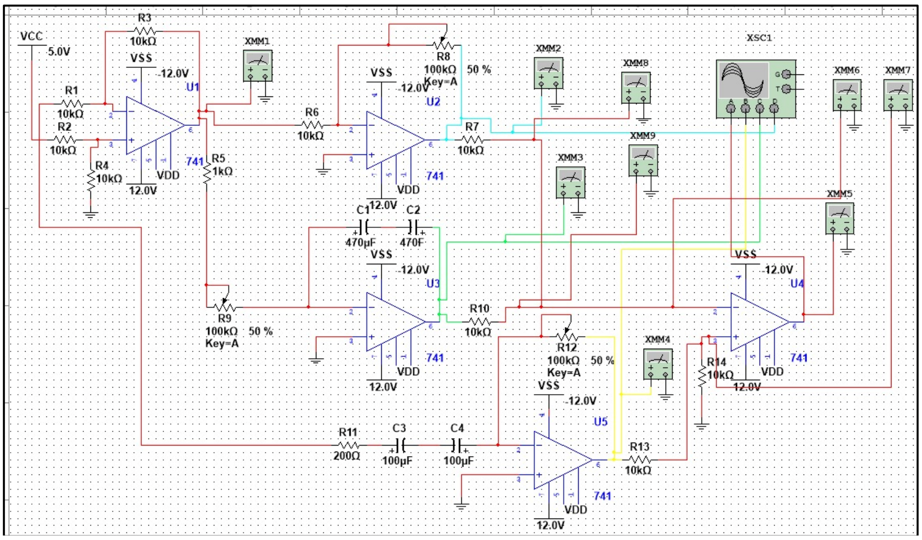

Figure 4: Circuit of PID Controller

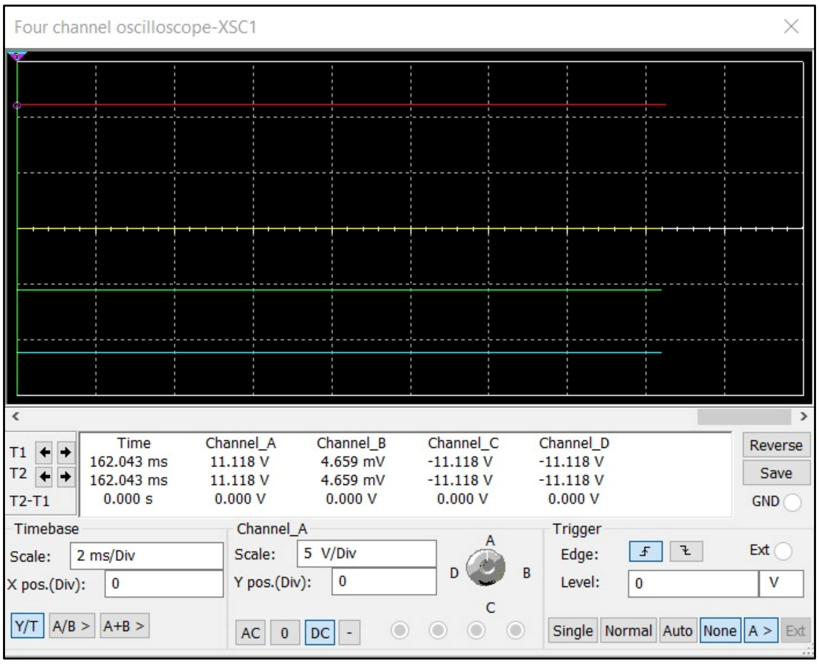

Figure 5: Waveforms of PID Controller

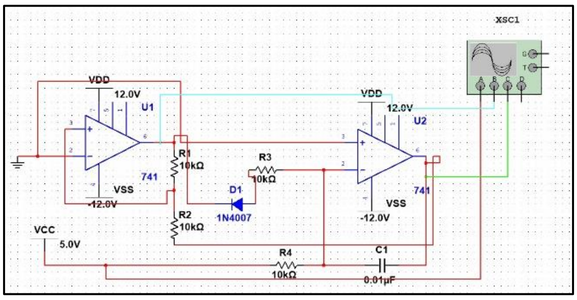

Figure 6: Circuit of Voltage to Frequency Converter

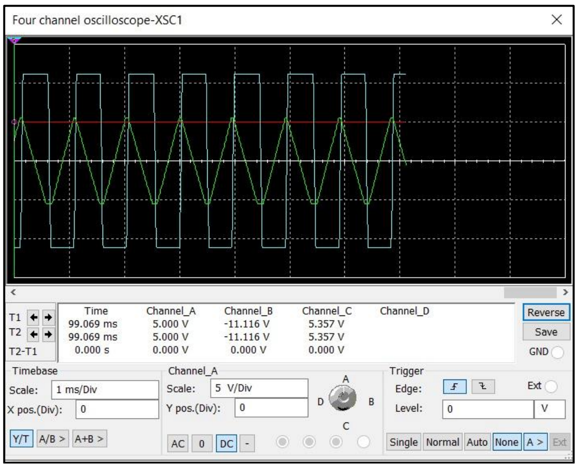

Figure 7: Waveforms of Voltage to Frequency Converter

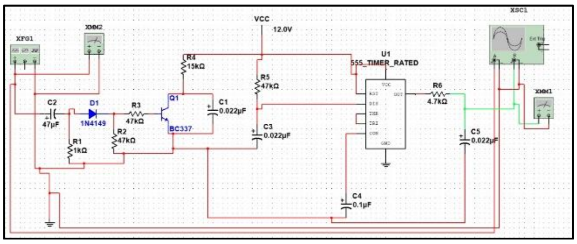

Figure 8: Circuit of Frequency to Voltage Converter

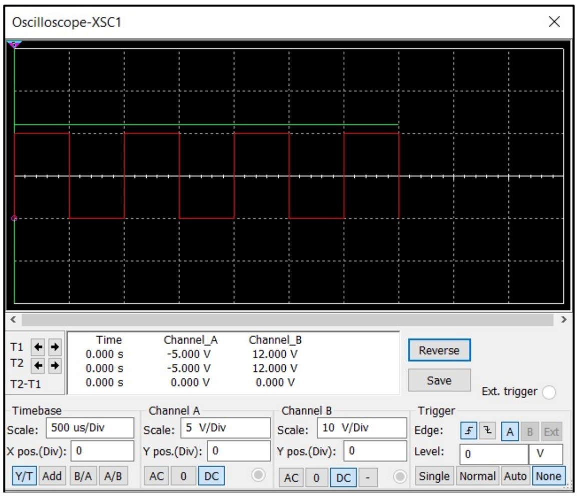

Figure 9: Waveforms of Frequency to Voltage Converter

VIII. Hardware

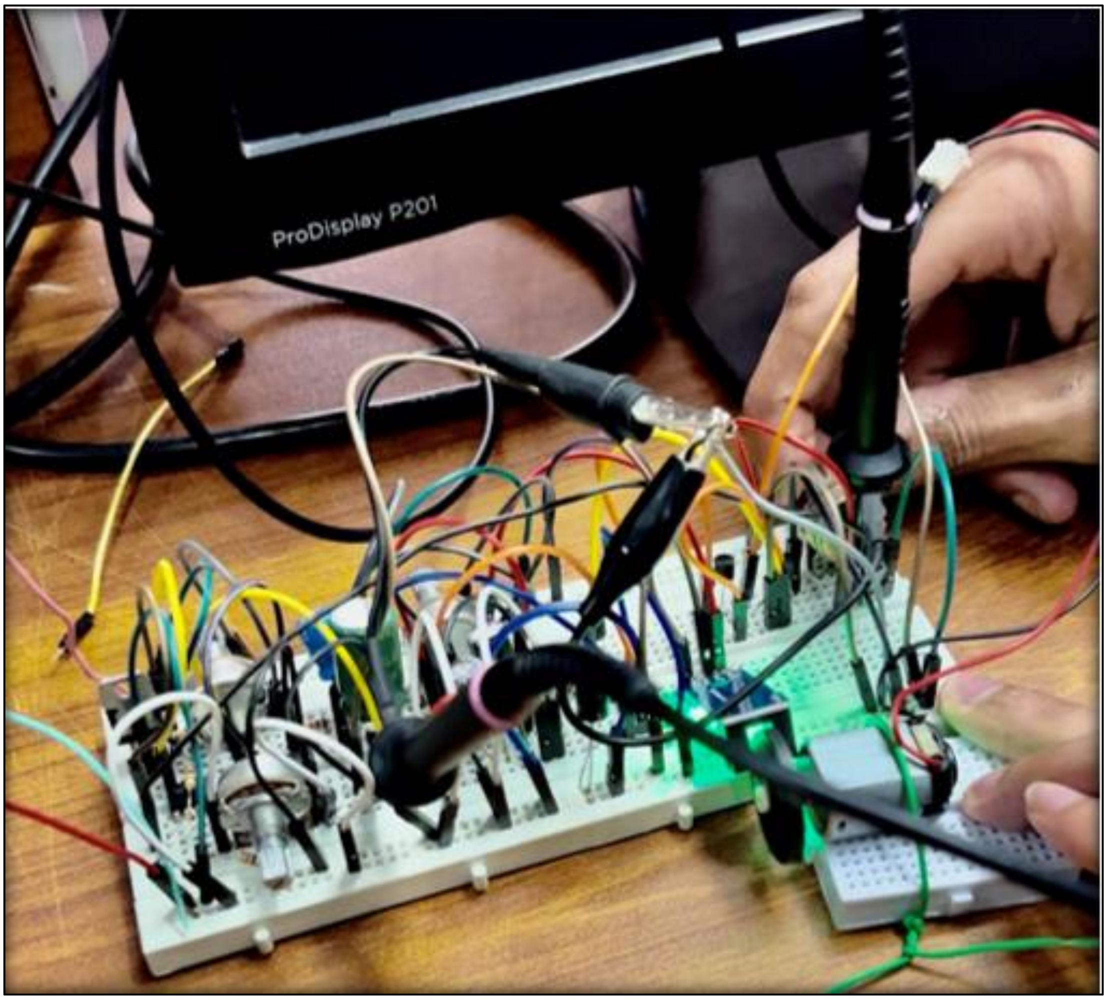

Figure 10: Circuit of DC Motor Speed Control

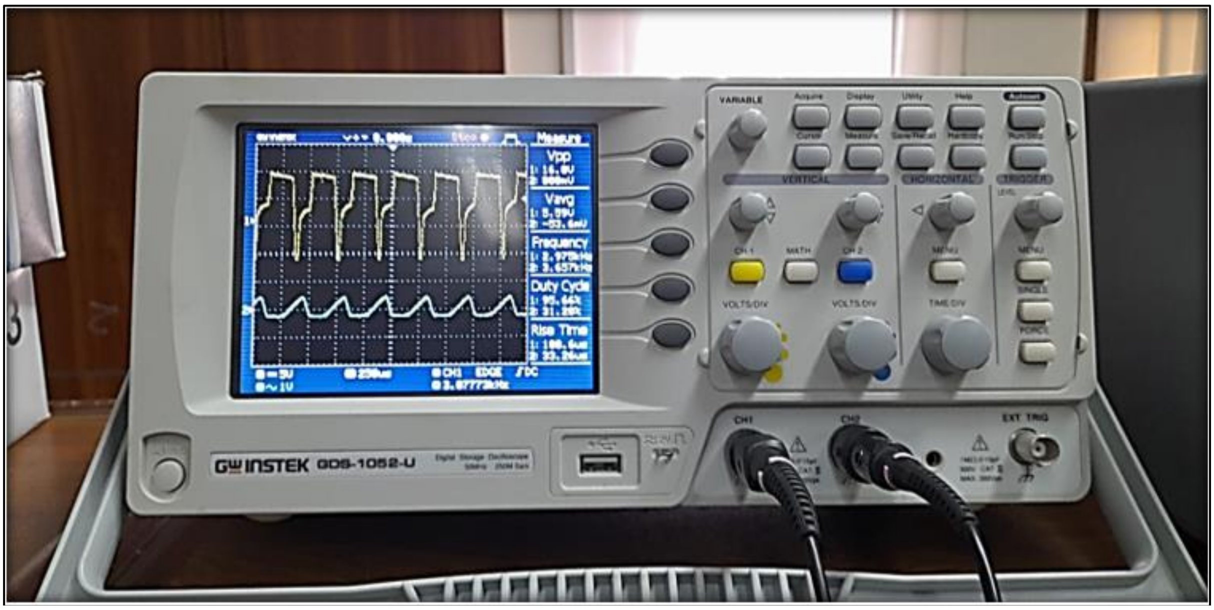

Figure 11: Waveforms of DC Motor Speed Control

IX. Tentative Output

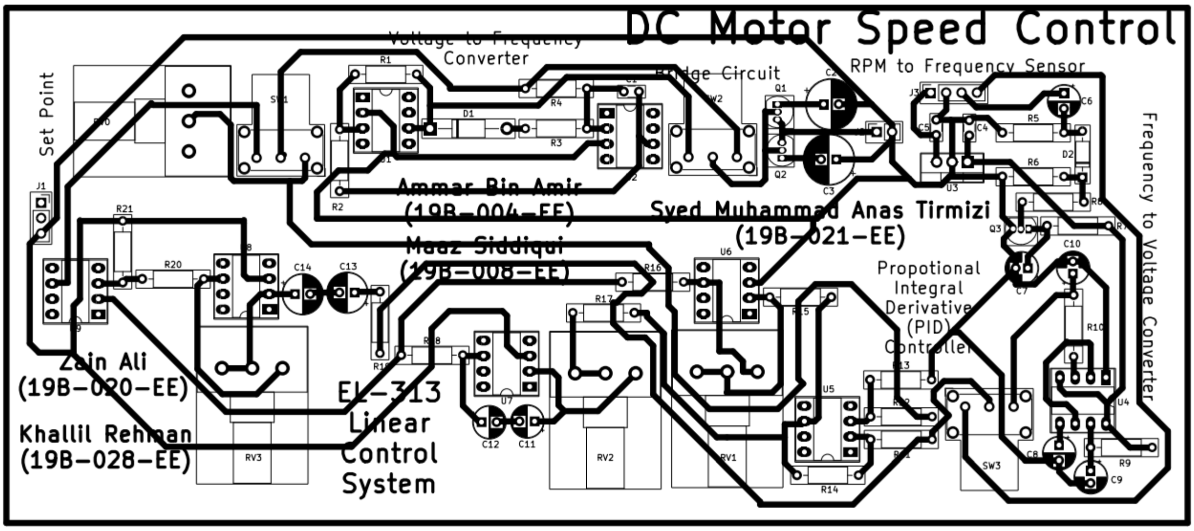

Figure 12: 2D Layout of PCB

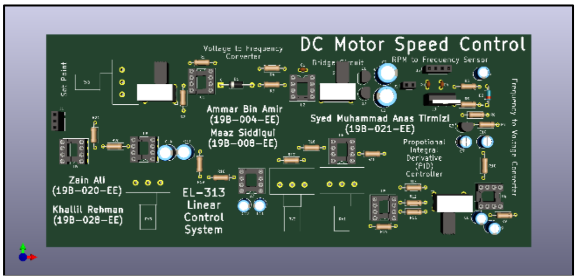

Figure 13: Front 3D Layout of DC Motor Speed Control

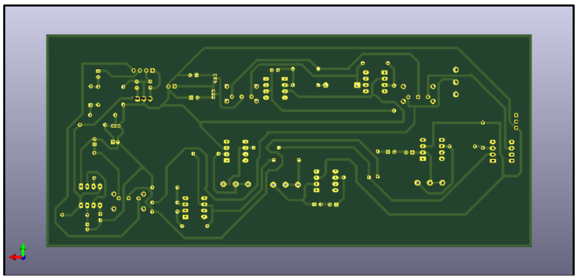

Figure 14: Back 3D Layout of DC Motor Speed Control

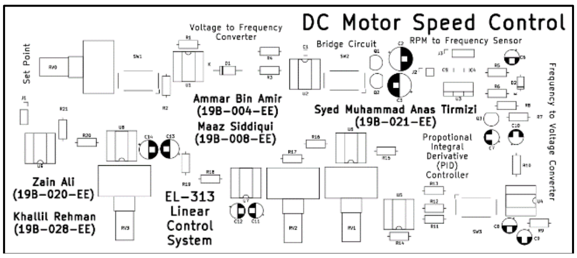

Figure 15: Front Silk Screen Layer of PCB

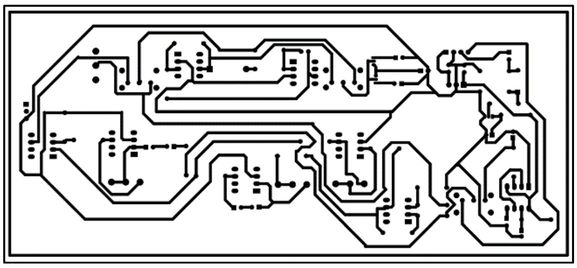

Figure 16: Back Cu Layer of PCB

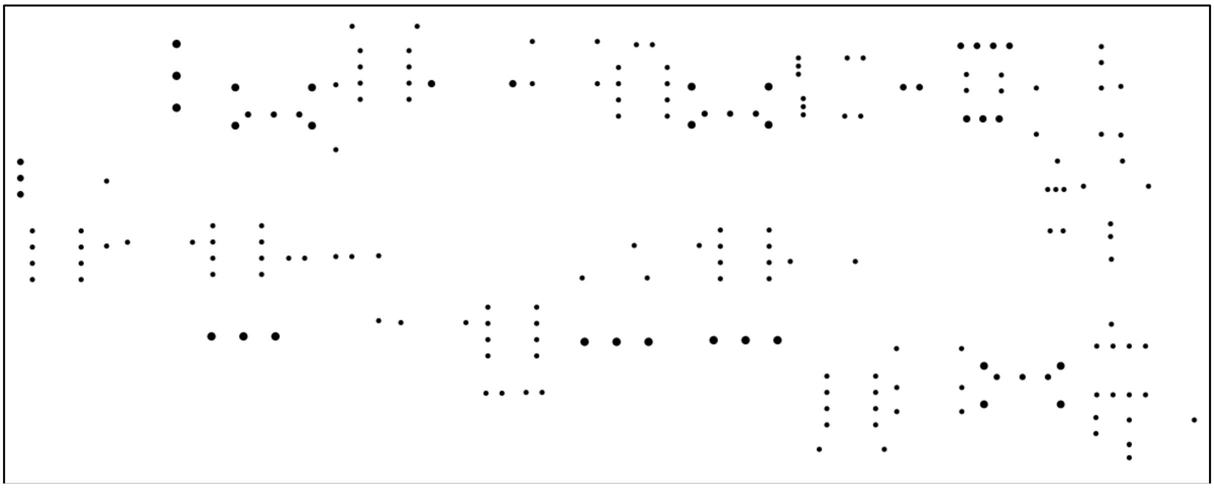

Figure 17: Drill Layer of PCB

X. Problem Faced and Solution

To reduce this offset, we modified the circuit to bring back the triangular wave output to the zero reference level. The modified circuit schematic. The circuit uses the feedback mechanism with the comparator (LM 339) and integrator circuit to correct the DC offset error and brings back the triangular wave output to zero reference level. Because of this error correction we are able to generate the PWM pulses from 0% to 100% duty cycle after comparing this triangular wave with the controlled output from PID controller.

I. Testing Results

The DC motor control system was tested with PI and PID controllers. The output waveforms of the PWM generator for two different reference voltage (corresponding to desired speed) and under full load and no-load condition are shown in this section. The DC motor is loaded by magnetic breaking to study the controller performance under load conditions.

II. Conclusion and Future Work

P-I-D control and its variations are commonly used in the industry. They have so many applications. Control engineers usually prefer P-I controllers to control first order plants. On the other hand, P-I-D control is vastly used to control two or higher order plants. In almost all cases fast transient response and zero steady state error is desired for a closed loop system.

However, some improvements can be made in the control aspects of the proposed system design. In this experiment, the PID controller is well performed for the motor speed control under the loaded condition while the speed is kept constant. The ultimate parameter values of PID controller were setup by Manual Tuning method. An Adaptive approach of PID controller may be used in the prospective development in order of effectively speed control of the motor with reference to input speed under the effect of load.

III. References

https://www.elprocus.com/the-working-of-a-pid-controller
https://ctms.engin.umich.edu/CTMS/index.php?example=Introduction&section=ControlPID
https://www.omega.co.uk/prodinfo/pid-controllers.html
https://en.wikipedia.org/wiki/PID_controller