

DC MOTOR SPEED CONTROL USING MICROCONTROLLER PIC 16F877A

Azizul Rahim Bin Mohd
Department of Power
Faculty of Electrical Engineering
Universiti Teknologi MARA Malaysia
40450 Shah Alam, Selangor, Malaysia.
Email:joeabdal@yahoo.com

Abstract-The main objective of this project is to control the speed of separately-excited DC motor using microcontroller PIC 16F877A. It is a closed - loop real time control system, where rotary encoder is connected to motor shaft to provide feedback signal to controller. The infra red sensor will detect how many pulse of encoder and will send feedback signal to controller. A driver will be connected to drive the motor and speed control is achieved by PWM technique using the microcontroller. Pulse Width Modulation (PWM) technique is used where its signal is generated in microcontroller. The PWM signals send to the motor driver and vary the voltage supply to motor thus its speed. PI controller is implemented into the microcontroller to control the speed of motor. Through this project it can be conclude that digital feedback signal can be use to control the speed of motor.

Keywords-component : PIC microcontroller, DC motor, Encoder

1. INTRODUCTION

Direct current (DC) motor is versatile and extensively used in industry. A wide variety of characteristics can be obtained from various connections to dc motor. Its speed can be controlled over a wide range easily. Large dc motors are used in conveyors, fans, paper mills, textile mills, pumps and so forth. In home appliances, washers, dryers and compressors are good examples. In automotive, fuel pump control, electronic steering control, engine control and electric vehicle control are good examples of these. In aerospace, there are a number of applications, like centrifuges, pumps, robotic arm controls, gyroscope controls and so forth.

11. LITERATURE REVIEW

Power electronics has evolves to modern technology rapidly due to many researches that successfully established. The development of power electronics also involve in microcontroller. In this project, a closed loop circuit was used to control the speed of motor.

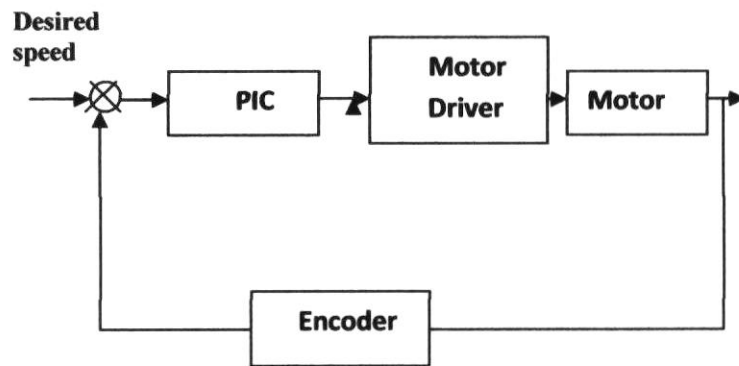


Figure 1:Block Diagram of System

The actual speed of DC motor will be measured by Infra-red sensor combine with rotary encoder and feed back to microcontroller. In microcontroller, it will calculate the error between the desired speed or set point with the actual speed. The error will determine the duty cycle of pulse-width modulation (PWM) in microcontroller. The calculated duty cycle will be send to DC motor driver whether to increase or decrease speed of the motor. The objective of this study is to use digital feedback signal method rather than old method such as analog feedback signal.

PI controller is implemented into PIC using assembly program language. In this project if a load is applied the motor will slows down from the actual value so that a positive error speed is produced. In order to stabilize the output, proportional control is applied by error speed multiply the gain. Hence, the motor speed will stabilize at some speed below the set point. If the gain is set so that any changes in motor speed causes a significant change in drive level and as the effect motor speed will oscillate. However proportional control has only limited use as it can never force the motor to run exactly at the set point speed [1].

The next new improvement is to introduce a correction to the output which will keep adding or subtracting a small amount to the output until the motor reaches the set point, at which point no further changes are made. In fact a similar effect can be had by keeping a running total of the error speed speeds observed for instance, every specific time and multiplying this by another gain before adding the result the proportional correction found above. This new term is called the integral of the error speed. Now we have a scheme where there are two mechanisms trying to correct the motor speed which constitutes a PI (proportional-integral) controller. This controller is a fast-acting correction which will make a change in the output as quickly as the error arises. The integral takes a finite time to act but has the ability to remove all the steady-state speed error. Figure 2 shows the block diagram that a close loop using PI controller and have a encoder feedback.

Three samples of error was taken during each interruption. The samples is added or subtracted and divided by T_i or time to get data in integral controller.

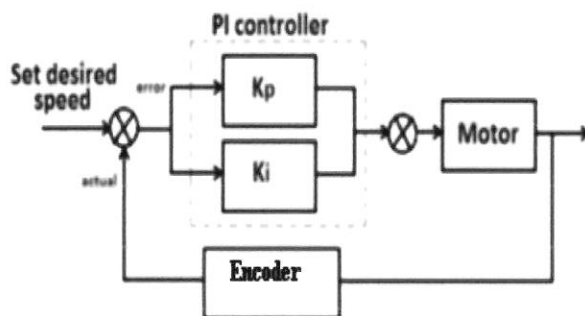


Figure 2:Block Diagram of PI System

A.DC Motor Parameter

Parameters of motor are an important step to know which to determine necessary rating for power switching element. Understanding of these parameters will be useful in designing the circuit.

Table 1 shows the Leybold-Dedactic motor's parameter. All the value in Table 1 below show the rating value of motor parameter.

PARAMETER	RATING VALUE
Model	LEYBOLD-DIDACTIC GMBH
Rated current	2.0A
Base speed	2000rpm
Power rating	0.3kWatt
Voltage	220V

Table 1: Motor parameter

B.PIC Controller

The microcontroller acts like the brain of the DC motor speed control system [2]. The microcontroller chip that has been selected for the purpose of controlling the speed of DC motor is PIC16F877A manufactured by Microchip [3]. This chip is selected based on several reasons:

- It is equipped with sufficient output ports without having to use a decoder or multiplexer
- It is small, portability and low current consumption
- It has PWM inside the chip itself which allow us to vary the duty cycle of DC motor drive.
- It is a very simple microcontroller. Users only need to learn 35 single word instructions in order to program the chip.

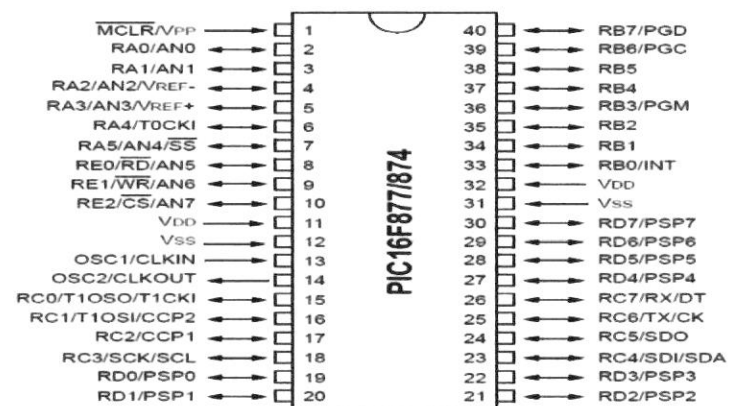


Figure 3:Pin diagram for PIC 16F877A

C. IGBT Driver

Figure 4 show the IGBT driver that was used in this project. The IGBT is suitable for many applications in power electronics. It improves performance and efficiency. The PWM from microcontroller will be send to the IGBT driver [4]. The driver circuit will amplify the PWM voltage to a level that is suitable to ON the IGBT. The driver circuit also act as a protection for microcontroller from high voltage side of driver. The frequency is fix to 1.22090Khz.

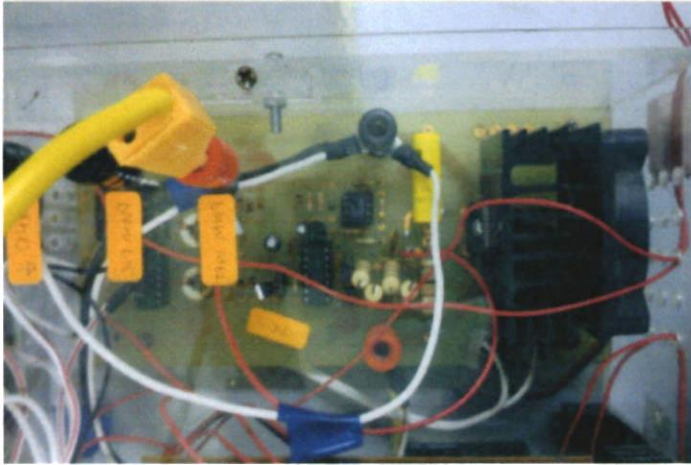


Figure 4: IGBT driver

D. Speed Feedback using rotary encoder

To compute the angular velocity ω , suppose that the count during a sample period T is n pulses. Hence, the average time for one pulse is T/n . If there are N windows on the disk, the average time for one revolution is NT/n . Hence ω (rad/s) = $2\pi n/NT$ [5]. In this project we use RPM in calculation. Figure 5 shows the rotary encoder that was used in this project. The encoder will produce 20 pulses when motor turn for 1 round. The motor speed is given by formula

$$\text{Speed} = \frac{n \cdot 1}{N \cdot T} \text{ round/s}$$

n = no of pulses
 N = number of slots
 T = time to get data

$$\text{Detected speed} = \frac{\text{detected pulse} \cdot 1}{20 \cdot T} \text{ round/s}$$

$$\text{Detected speed} = \frac{\text{detected pulse} \cdot 1}{20 \cdot T} \cdot 60 \text{ round /minute (RPM)}$$

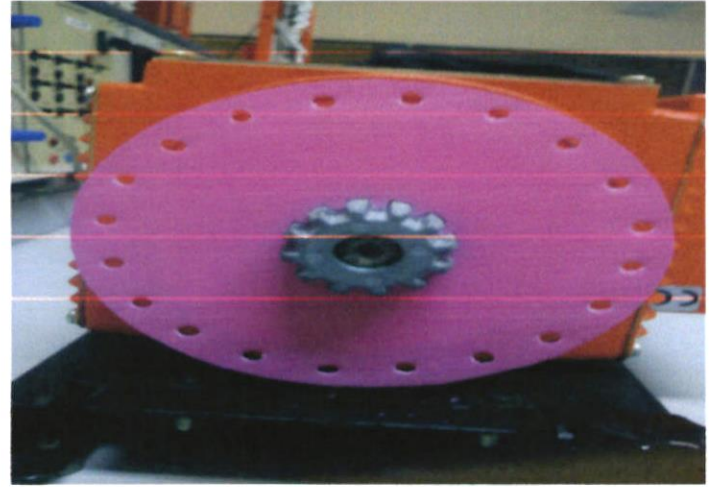


Figure 5: Rotary encoder

E. Infra-Red sensor

Figure 6 shows the schematic and real circuit of Infra-red sensor. Chip LM324 is used to ensure that the output waveform in digital signal (High/Low) is readable by microcontroller, Chip LM324 is function as a comparator. When the V_{out} of Infra-red sensor is greater than $VR1$, the output of LM324 will be High (5V) and when the V_{out} is less than $VR1$, the output of LM324 will be Low (0V). Then, the output signal will be sent to microcontroller as a feedback.

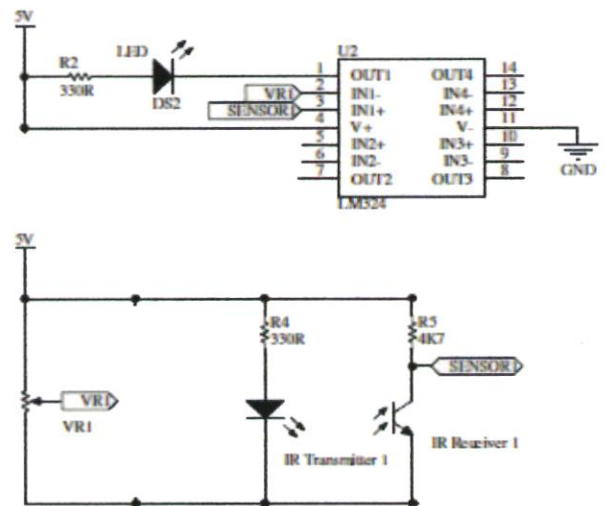


Figure 6: IR sensor

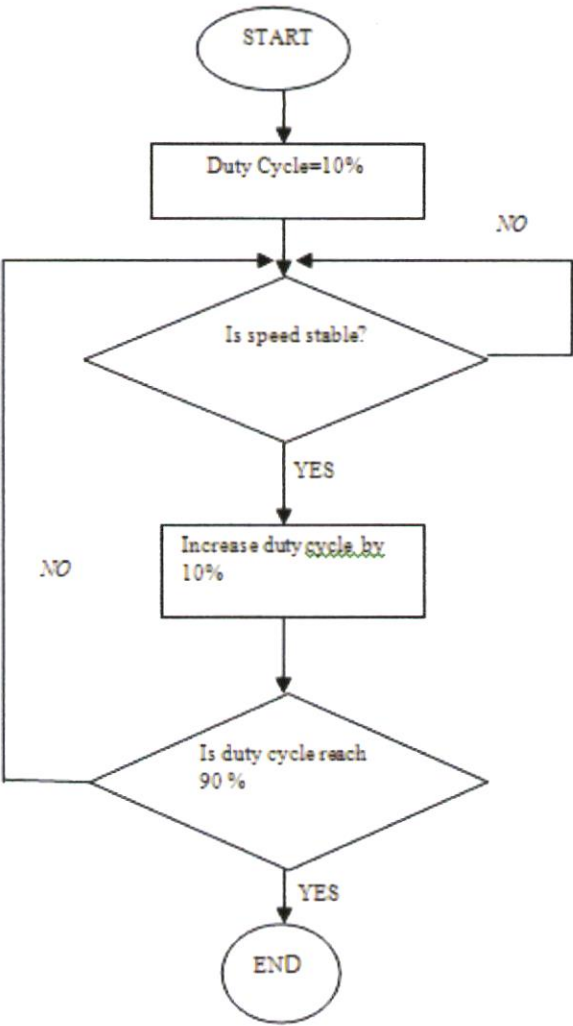


Figure 8:Flowchart program for ramp-up duty cycle

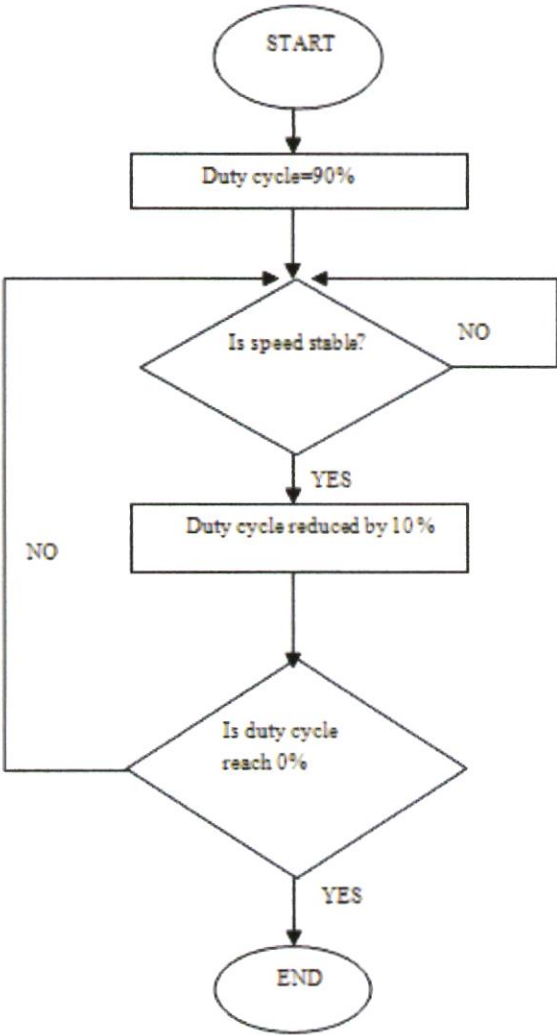


Figure 9:Flowchart program for ramp down duty cycle

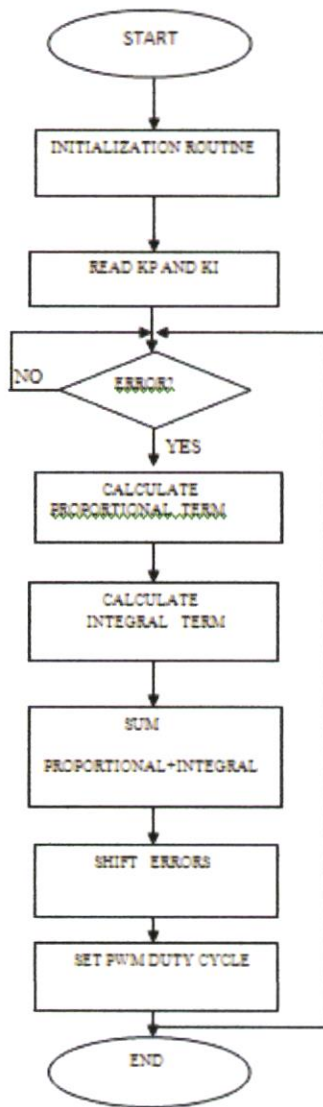


Figure 10:Flowchart program

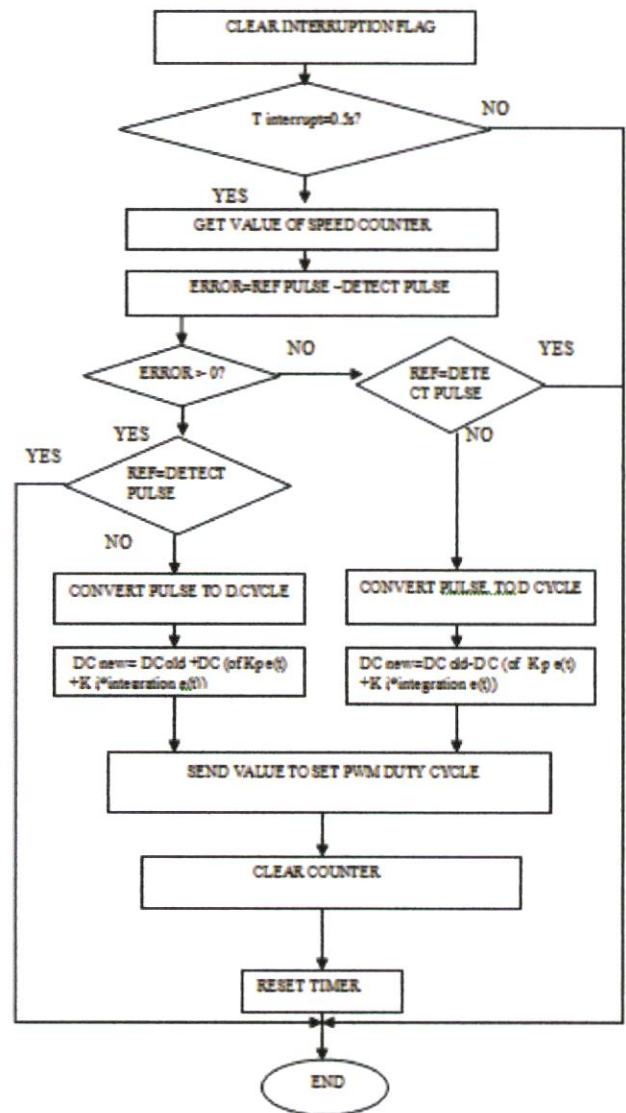


Figure 11:Flowchart of interrupt routine

III. RESULT AND DISCUSSION

In this project, variable resistor was used to substitute motor as a load to ensure that motor driver is functional. The output voltage to motor was recorded from 0.1-0.9 duty cycle. Figure 12 and 13 shows the PWM waveform at 0.1 and 0.9 duty cycle.

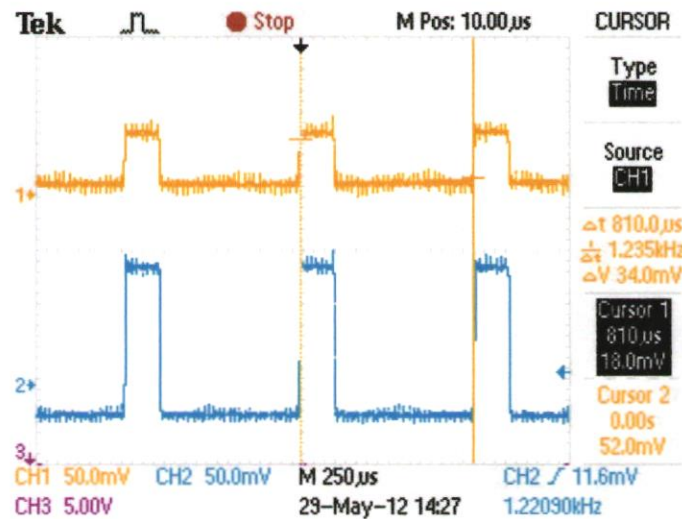


Figure 12: Duty cycle at 0.1

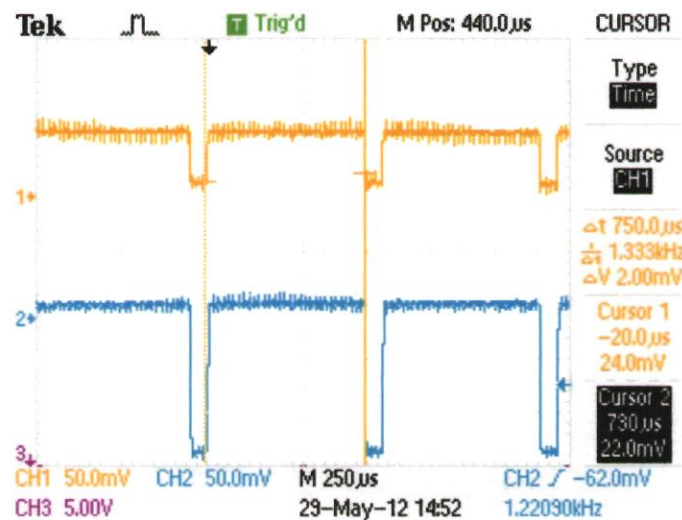


Figure 13: Duty cycle at 0.9

Table 2 and Figure 14 show the result duty cycle and V_{out} when connected to variable resistor. The graph in Figure 14 clearly shows that when duty cycle is increase, the output voltage will also increase meaning that V_o is proportional to duty cycle

Duty Cycle	V_o
0.1	17
0.2	32
0.3	52
0.4	75
0.5	92
0.6	110
0.7	130
0.8	149
0.9	172

Table 2: V_{out} using variable resistor

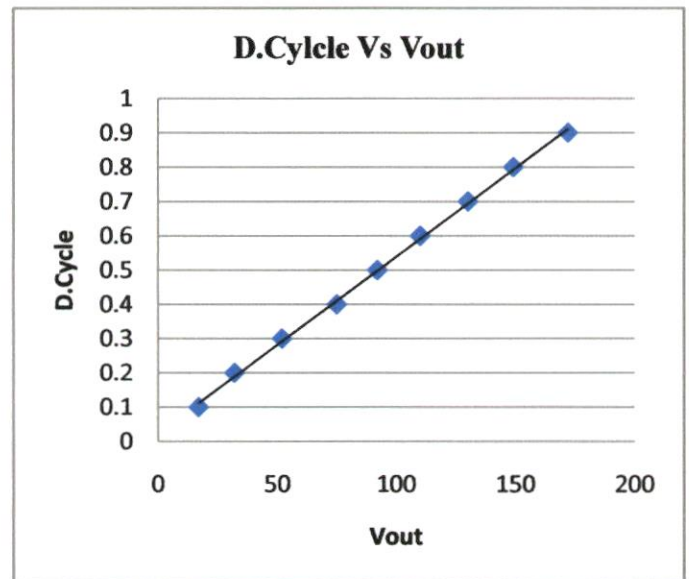


Figure 14: D.Cycle Vs V_{out}

The speed of encoder was compared with the speed that was taken from tachometer. The speed of encoder was taken using formula and monitored through oscilloscope

$$\frac{\text{Freq} * 60}{\text{No. of slots}}$$

[6]

We can see that there appeared some error in encoder speed. Error in encoders can come from quantization error (due to digital word size limitation), assembly error, coupling error, structural limitation, manufacturing tolerances and ambient effect(vibration).[7]

Duty cycle	RPM	Frequency (Hz)	Speed encoder= Freq*60/20
0.1	160.6	55.56	166.6
0.2	369.6	125.0	375.0
0.3	566.9	192.3	576.9
0.4	773.9	256.4	769.2
0.5	974.8	322.6	967.7
0.6	1195.0	400.0	1200.0
0.7	1400.0	465.0	1395.0
0.8	1601.0	535.5	1605.0
0.9	1807.0	600.0	1800.0

Table 4: RPM and Encoder speed

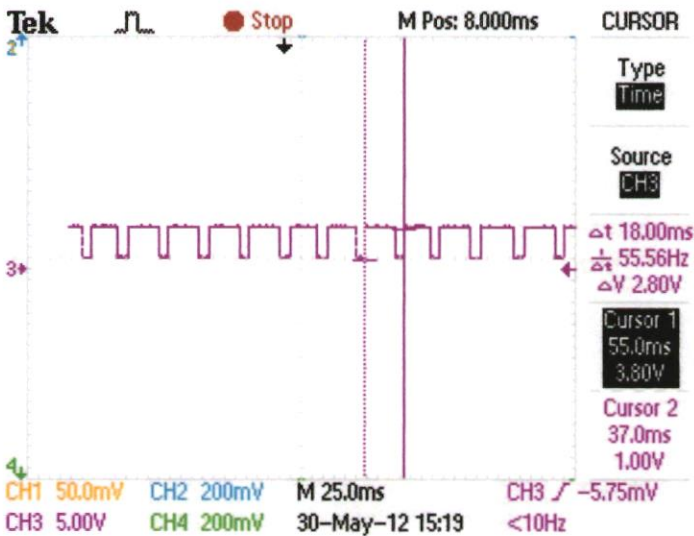


Figure 16: Frequency encoder at 0.1 duty cycle

Users can select their desired duty cycle by select it through switch button. Table 3 and Figure 15 show the result of speed and Vout during selecting duty cycle. The result is relevant when motor was ramp-up and ramp down.

Duty Cycle	Vo	RPM
0.1	20	160.6
0.2	40	369.6
0.3	60	566.9
0.4	80	773.9
0.5	98	974.8
0.6	120	1195.0
0.7	136	1400.0
0.8	155	1601.0
0.9	175	1807.0

Table 3:Vout and RPM at desired duty cycle

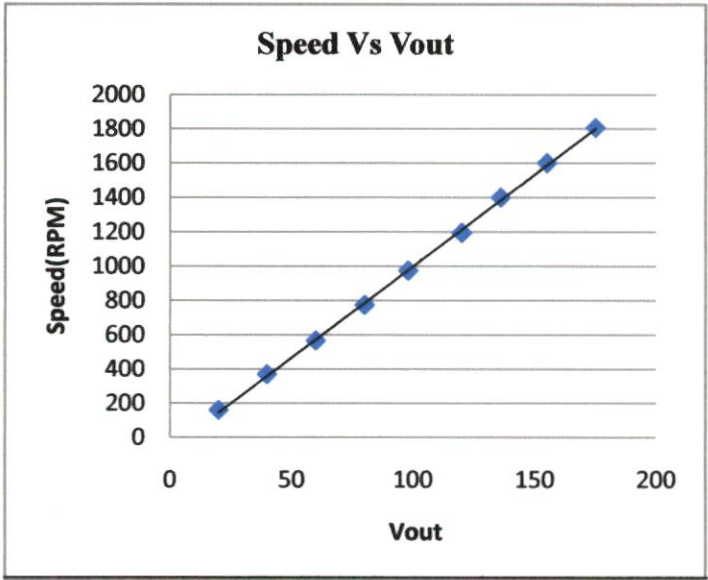


Figure 15: Speed Vs Vout

Figure 17 show the result when motor was running with no load at 0.6 duty cycle. It can be seen that the motor oscillate during the experiment. This was due to the process of subtracting and adding of error in integral controller.

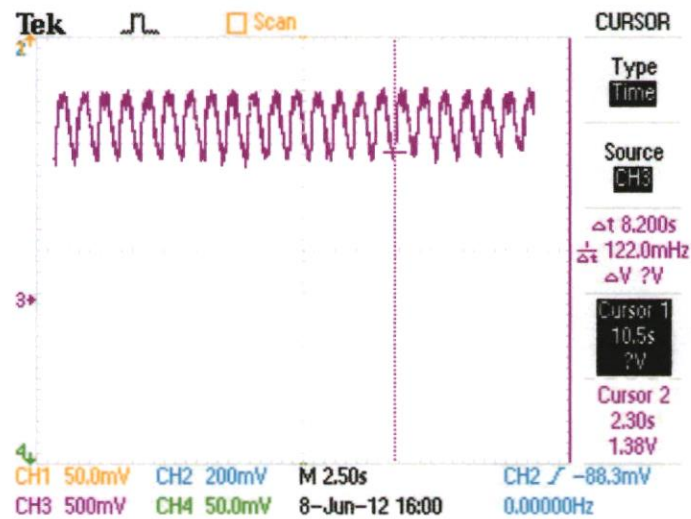


Figure17: Motor speed when desired speed 1195 rpm at no load.

Figure 18 show the result when motor at 1195 rpm was connected to load 4N/M. The motor speed decrease when connected to a load using braking unit. After that the microcontroller will detect the error and send signal to accelerate motor to desired speed.

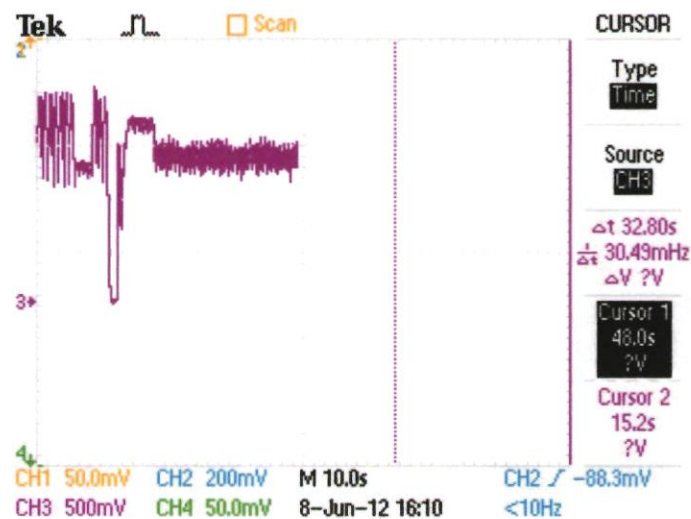


Figure 18: Motor speed when desired speed 1195 rpm With load 4N/m.

IV. CONCLUSION

Science and development have provide a large range of application of DC motor in area such as robotic, electric motor, home electric appliances. All this application required speed controller to perform the task. DC motor have a great speed control capabilities, which mean that torque, speed and direction can be changed to meet new condition.

The goal of this project is to design a DC motor speed control using digital feedback signal. By using low cost encoder and Infra-red circuit we can control the speed of DC motor.

V. FUTURE RECOMMENDATION

It is hoped that DC motor speed control that using PIC microcontroller will offer a new era in the technology that will offer a low-cost, high performance and smaller compartment solution for industrial arena. The author hopes some development in technology in order to achieve more efficient control solution for DC motor using encoder. The author also hopes some research on other type of encoders that can increase the efficiency to control motor speed.

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VII. REFERENCES

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