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Closed loop speed control of dc motor using PID controller

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Abstract: This paper presents simulation and hardware implementation of constant speed dc motor, using Thyristor Bridge, which operates in two quadrants. The firing angle is controlled by PID controller and is given to Thyristor Bridge which intern control the armature voltage of dc motor. Pic microcontroller PIC16F877A is used to implement PID controller. Variable resistor is used to set the speed of motor. This project is done for 0.5Kw motor. Motor gives constant speed for the variation in input voltage.

Keywords: PID controller, fully controlled thruster bridge, PIC 16F877A,

I. INTRODUCTION

Dc motors are used in many industries, where frequent starting, reversing and braking is required. It has special characteristics, which provides precise speed control, regenerative strategy in contest of an active load for energy conversion [1]. In this project speed of the motor is controlled by controlling the armature voltage by fully controlled thyristor bridge. This provides forward motoring and regenerative braking. This is controlled by thyristor bridge and the input voltage is controlled by varying the firing angle. It is the easiest method and efficient method compared to other complicated methods. A constant speed is provided by PID controller. Proportional Integral and derivative control is extensively used due to its simplicity, stability and robustness[2]. In earlier days pid controllers were implemented using opamps. The constant Kp, Ki, Kd values are set by using resistor and capacitor. These are replaced by microcontrollers.Microchip PIC18F family has benefit of integrating large amounts of code in a single IC. All circuit values operations are written in terms of formulae and constants are can easily written in program by just by numerical values. These circuits and PID controller is prepared and tested in MATLAB and the kp, ki and kd values are tuned by trial and error method.

II. BLOCK DIAGRAM

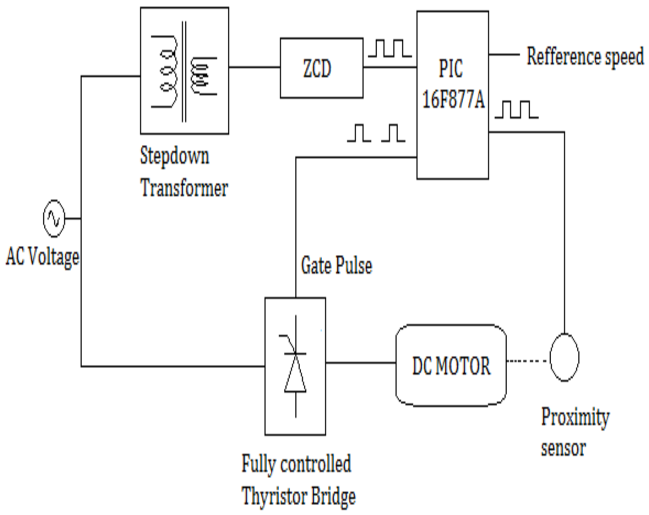

Fig:1 Block Diagram

The proposed speed control of DC motor shown in block diagram fig:1. Single phase ac input is given to step down transformer and also to the thyristor bridge. Using step down transformer the voltage is stepped down to 12v ac which is given to zero crossing detector to initiate pulse.

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A. Zero crossing detector:

Zero crossing detector, will give a pulse when the AC supply crosses zero line. This is used to synchronize both microcontroller and thyristor bridge[5]. The zcd output is given to external interrupt pin of pic Microcontroller.

B. Fully controlled thyristor Bridge:

The fully controlled thyristor bridge will give rectified DC output from AC input. Switching angle of the thyristor is varied to control the rectifier output. The thyristor bridge provides the easiest way to control the speed. In this, project thyristor bridge is used for forward motoring and regenerative braking. Thyristor bridge will operate in rectified mode when the firing angle is varied from 0 to 90. After 90 to 180 circuit will act in inverter mode. This is because of the inductance current that will not be zero when the voltage across the thyristor is zero. This will provide the breaking action to the motor. When firing angle is greater than 90 the average voltage will be negative and current will be positive [1].

Average output voltage of fully controlled thyristor bridge

$V_{dc}=2*V_m/(\prod) *Cos(\alpha)$ ………………………….(1)

Where α is firing angle (0^O to 180^O).

C. Feedback

Feedback is taken from the motor using inductive proximity sensor. Proximity sensor will give a pulse when metal comes near to it and this pulse is calculated for a second, using pic microcontroller that will give number of rotations for a second [6].

D. Pic Microcontroller

PIC stands for Peripheral Interface Controller. PIC processor (PIC 16F877A) is a 8 bit processor with 8kb flash memory is used to executing user code, which also have 200 ns instruction cycle Operating speed. Inter integrated circuit (I2C) is a special feature of PIC family which enables bidirectional transfer between master and slave. Controller area network (CAN) module is a serial interface useful for communicating with other microcontroller device. ADCof 10bit resolution enables to convert analog signal to digital.

III. MOTOR USED

Here the separately exited 0.375kw/ 0.5 hp motor is used for project. The motor parameters like armature resistance and inductance, field resistance and inductance are calculated using LCR meter.

Developed torque (Td) = Power/speed

= 0.375/ (2∏/60)

= 3.5 Nm

The maximum torque can develop by the motor is 3.5Nm.[1]

The motor specifications are shown in block diagram below

Manufacturer	Megha Electric Co.
Rated Voltage	220
Rated current	3.0
Speed	1500
Type	Separately exited
Field voltage	220
Field current	0.21 A
Armature resistance (Ra)	11 Ω
Armature inductance (La)	122.57e-3H
Field resistance (Rf)	166 Ω
Field inductance (Lf)	4.6 H
Moment of inertia(J)	0.002215 kg m^2
Friction constant(B)	0.002953 N

IV. PID CONTROLLER

In PID controller, output of the proportional path is large when error is large. In Integral path it will continuously add the error and multiply with a constant. The output signal of derivative path is contributed by the rate of change of error. The output is small when the rate of change of error is low and it is large when the rate of change of error is high.

The overall pid formulae is

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$$u_k = \overline{u} + K_c e_k + K_I \sum_{i=0}^{k} e_i + K_d (\frac{e_k - e_{k-1}}{T}) \quad \ldots\ldots(2)$$

ek=current instant
ek-1=previous instant
ei=error at ith instant

Proportional Integral and Deferential constants can be find by two methods

1) By Bode plot when transfer function of the plant is available
2) By experimental method when the model of the plant is unknown
3)

W(s)/Vr(s) = {(K2*Kv*If)/(Ra*B)}/ {(s^2(x)+s(y)+($Kv*If)^2$/((Ra*B)+1)} ……………………………….(3)
x= La*J/Ra*B =8.3532e-3
y= La/Ra + J/B =0.7612
W(s)/Vr(s) = 4.5461/ ((0.0083535) s^2+ 0.76125 s +0.02112) ……………………………….(4)

The kp, ki and kd values can also be calculated using trial and error method in MATLAB Simulink
ie kp= 2.9
ki= 5.5
kd= 0.0001
Sampling time = 10 mili sec

V. HARDWARE DEVELOPMENT

Thyristors are fired by pulses and opt couplers provides isolation to controlling circuit and Thyristor bridge. It acts as driver circuit for thyristor. The pic controller output signal is given to transistor. Transistor will act a switch and when pic controller send signal to transistor it will turn on opto coupler it intern drive thyristor.

A. Flow chart of the scheme

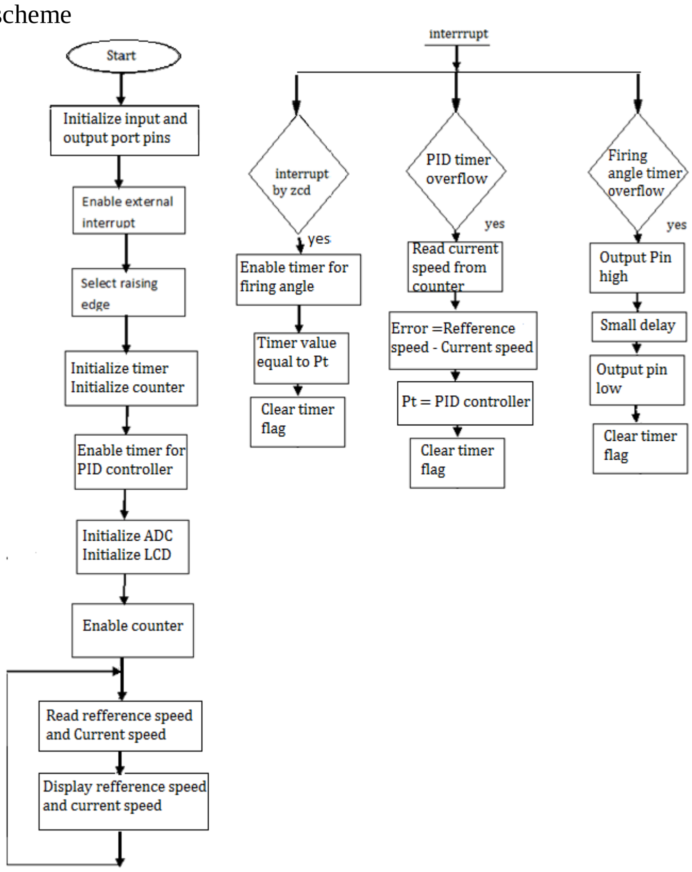

Fig.2 Flow chart for the PIC16f877A program

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B. Working :

For one cycle of AC input zcd will give two pulses. The zcd output is connected to interrupt pinof pic controller. For each consecutive zero cross program will interrupt. After every interrupt a pulse is created for required firing angle using timer. These pulses is given to respective thyristors which conducts for positive half cycle and another pulse is given to the respective thyristors which conducts for negative half cycle. The pulses are given to thyristors through opto couplers and driver circuit. This pulse time duration (firing angle) is depending on pid controller output. These positive half cycle pulse and negative half cycle pulses are taken out from the pic by two output pins. The feedback is taken from proximity sensor which is connected to counter pin. When motor starts rotating proximity sensor will give pulses. These pulses is calculated for a second by using timer in pic. A reference speed is set by using pot, that output is connected to analog pin of pic microcontroller. These values are made proportional to the speed, when pot is varied reference speed also will vary accordingly. The difference between two speeds is the error. This error is reduced using Pid controller, pid controller design is written interms of program and sampling time is adjusted using timer. Pid controller will increase or decrease the firing angle of the thyristor.

VI. EXPERIMENTAL RESULTS

Matlab simulation for the 2-Quadrant operation of DC machine shown in fig. 3. It consists of separately exited dc motor model, Thyristor based full bridge circuit and AC mains. The load for the motor, which is proportional to motor speed. The output voltage and speed is observed for different input ac voltages and for different reference speed. The reference speed is varied by varying the constant block connected to pid block through summer block. The dc motor gives constant speed, when the input voltage is varied. Motor changes speed only when the reference speed is varied. As the ac voltage is increased or decreased the firing angle will change but the speed will be constant, which is observed in output waveforms shown in fig 3a, 3b, 4a and 4c.

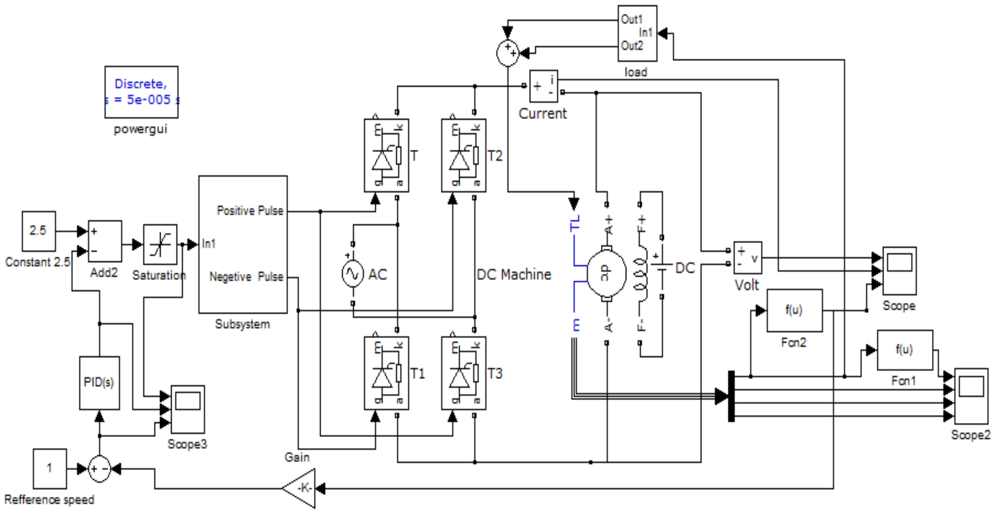

Fig. 3

A. Output waveform

The output voltage waveform fig 3a. shows the supply of 310 voltage(peak) and the refference speed is set for 1000rpm. The motor speed isn shown in fig. 3b.

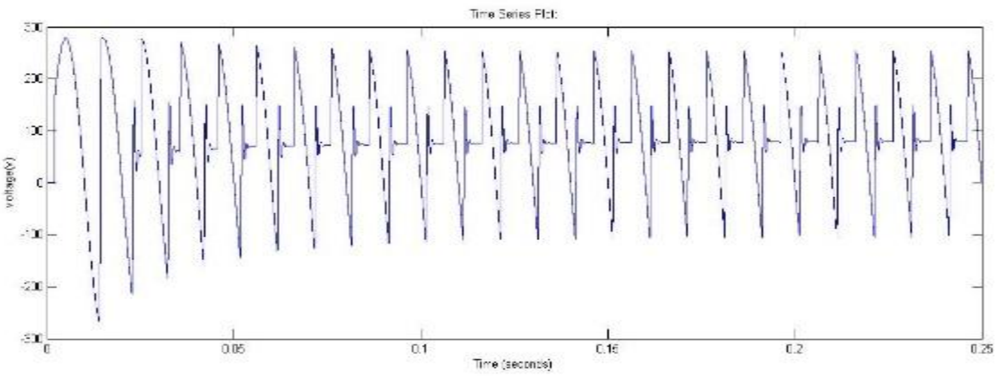

Fig. 3a

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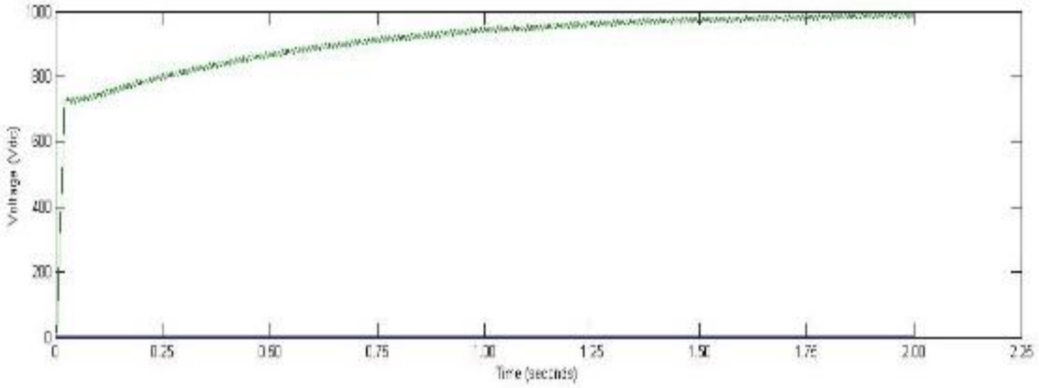

Fig 3b

The output waveform for the supply of 280 voltage and refference speed is 1000rpm
The output voltage waveform fig 4a. shows the supply of 280 voltage(peak) and the refference speed is set for 1000rpm. The motor speed isn shown in fig. 4b.

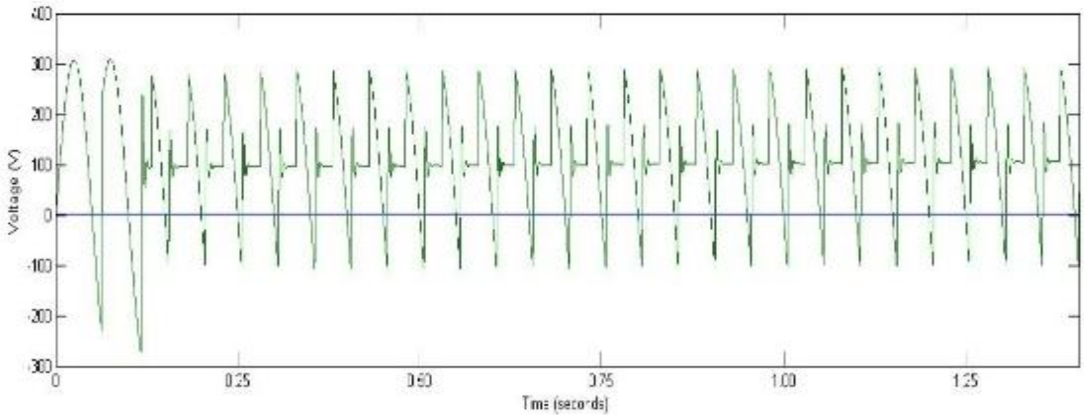

Fig 4a

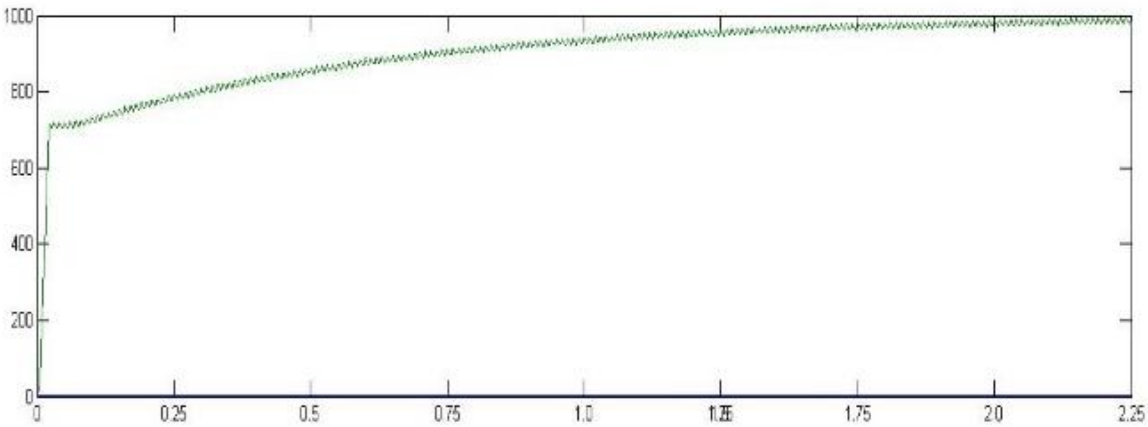

Fig 4b

The designed pid controller hardware is tested with 0.5hp seperately exited dc motor. The motor speed is observed for by adjusting reference speed ie. by varying the pot. Also the voltage across the motor and speed of the motor is observed by varying the input voltage and output load. The load is a belt load with brake drum. Firing angle calculation is done using dual channel power scope. When reference speed is increased the firing angle reduces, voltage and speed of the motor increases. And it is also observed that when output load across the motor is increased the motor gives constant speed. Motor changes its speed only when the reference speed is varied.

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B) Dc motor speed control waveforms

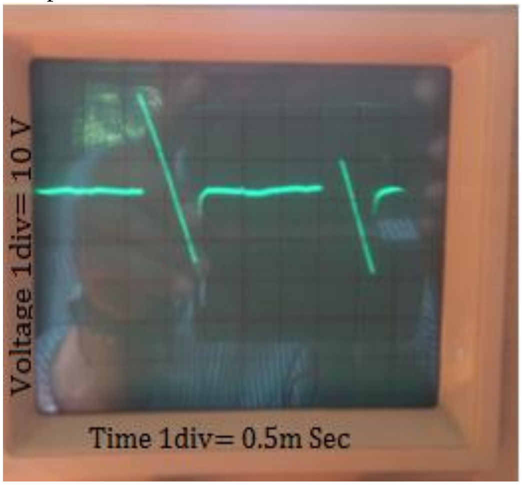

Fig. 5

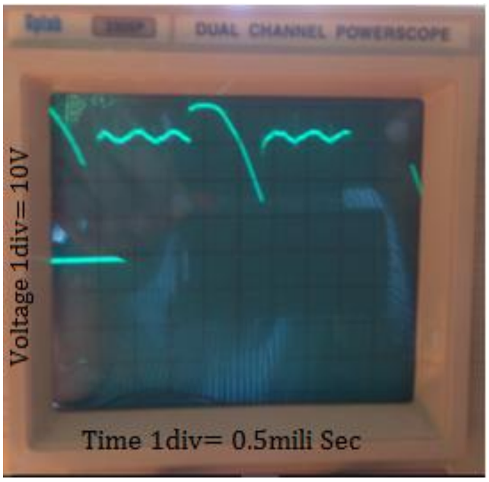

Fig. 6

Fig 5 shows voltage verses time for 50 V Output voltage at Motor speed 200rpmand fig 6. Shows voltage verses time waveform for 136 V Output voltage at Motor speed 800rpm

From above wave forms we observed that voltage appeared across the motor was less when motor was running at a speed of 200rpm. Firing angle was high for a motor running at a speed of 200rpm when compared to the motor at 800 rpm. At high speed we could also notice the effect of back emf.

VII. CONCLUSION

The speed control of DC MOTOR is achieved with hardware implementation successfully. The firing pulses to trigger the thyristor of the two quadrant converter is observed by programming PIC18F877A. Faster response was obtained i.e. rapid change from higher speed to lower speed is obtained within a fraction of seconds.

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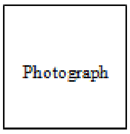
REFERENCE

[1]. Muhammad H. Rashid, 2003 ,Power Electronics: Circuits, Devices, and Applications, 3nd Edition, Prentice Hall, USA Umanand.
[2]. Kumar, Sandhya, and Anjali Deshpande."DSP based close- loop speed control system for DC motor using dual converter", 2014Annual IEEE India Conference (INDICON),
[3]. Sarin, Sereyvatha, Hilwadi Hindersah, and Ary Setijadi rihatmanto. "Fuzzy PID controllers using 8-Bit microcontroller for UBoard speed control", 2012 International Conference on System Engineering and Technology (ICSET), 2012.
[4]. SPEED CONTROL OF A SEPARATELYEXCITED DC MOTOR Monaaf D.A. Al-Falahi1
[5]. Mr. Tushar Jamsutkar1 , Mr. Sagar Gore2 , Mr. Pankaj Patil3 , Prof. Ashok Suryawanshi4 "PLC BASED SYSTEM FOR CONTROLLING AND MONITORING PARAMETERS IN SHIP"
[6]. P. Karpagavalli and A.Ebenezer Jeyakumar, "SIMULATION ANALYSIS ON PROPERTIONAL INTEGRAL AND DERIVATIVE CONTROL OF CLOSED LOOP DC MOTOR DRIVE WITH BIPOLAR VOLTAGE SWITCHING", American Journal of Applied Science 10 (7): 714-723,2013
[7]. Ramyasree P R Dr. R. Sankaran, " Simulation and implimentation of Two- Quadrant Operation of Mains Operated DC Drive System", vol. 1, issue 6, September 2013.
[8]. Sarita Shastri, Pawann Pandey, "A comparative Analysis of Firing angle based speed control Scheme of DC motor".

BIOGRAPHIES



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