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CLOSED LOOP CONTROL OF DC MOTOR USING FIRING ANGLE

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ABSTRACT
In this paper ,we describes the analytical and experimental studies on a variable speed of DC motor driven by single phase controlled bridge rectified power supply using SCRs. The armature voltage is supplied by controlled bridge rectifier. A controller design is provided which improves the performance of the speed control without using any kind of starter for starting purpose which is normally used in our laboratory also I^2R losses are almost reduces which developed in rheostat operation. The speed control of DC motor is very crucial in application where precise and protection is required. For precise control we need to use a controller that has high accuracy. In this paper we present a converter based closed loop speed control by varying firing angle for DC motor using microcontroller Arduino Uno ATmega328p .Feedback speed monitoring is based on IR transmitter and receiver. Hence sensing and calculation part of process is handled by Arduino Uno board.

KEYWORDS: Arduino Uno ATmega328-PU, DC motor, feedback, speed control, sensors.

1. INTRODUCTION

DC motor is an electromechanical device which converts the DC electrical energy into mechanical energy. The first commercially successful DC motor was invented by Zenobe Gramme in 1873. Due to its high reliability and wide operating range from a fraction watt too many kilowatts, it is used in various fields such as automobiles, heavy engineering, aerospace, robotics, biomedical engineering etc.There are two methods widely used to control the speed of DC motor:

i) FIELD CONTROL: It can be obtained by varying the field current. This can be archived by varying the field voltage.

ii) VOLTAGE CONTROL: It can be obtained by varying armature terminal voltage.

Up to the rated(base) speed(the speed corresponding to rated operation condition, rated armaturevoltage, rated armature current and rated field current), the armature and field current are kept constant to maintain the torque at its rated value. Beyond the base speed, the speed control is achieved by varying the field current. Within this range, the motor power is maintained constant and torque is reduced with the increase in rotational speed. In this paper instead of this type of speed control of DC motor we are using fully controlled rectifier. In this fully controlled rectifier the firing angle is controlled by Arduino Uno ATmega328P-PU kit. By adjusting the firing angle of thyrister we can get the required speed, the fee is used with the help of PWM technique, if the load changes or supply voltages changes. It is further displayed on an electronic LCD display interfaced to microcontroller powered by regulated power supply. Therefore, losses are reduced and efficiency increases. The converter converts AC voltage into DC voltage which is then applied to the armature of DC shunt motor. As we know, speed of a motor is given by,

$N=\frac{V-IaRa}{\emptyset}*(\frac{A}{ZP})$…… (1)

Where, N= Speed of motor in rpm

Φ= Flux in Wb/m^2

A= No of Parallel path

Z= No of conductor

P= No of poles

Therefore, the value of armature voltage can be varying firing angle of the thyrister, If we increase the thyrister firing angle, its conduction period is reduced and hence armature voltage is reduced which, in turn decreases the motor speed. If conduction period is increased which increase the mean value of the voltage applied across the motor armature. Consequently motor speed is increased. When the load on motor is increased, motor tends to slow down. Hence, Eb(Back EMF) is reduced. Then adjusting the firing angle increase the speed of motor. Therefore load regulation is maintained by this project. Also we maintain the line regulations; if the supply AC voltage changes within the limit we again adjusting the firing angle maintain the speed of motor is constant.

2. BLOCK DIAGRAM

$$V_a = R_a I_a + E_a$$

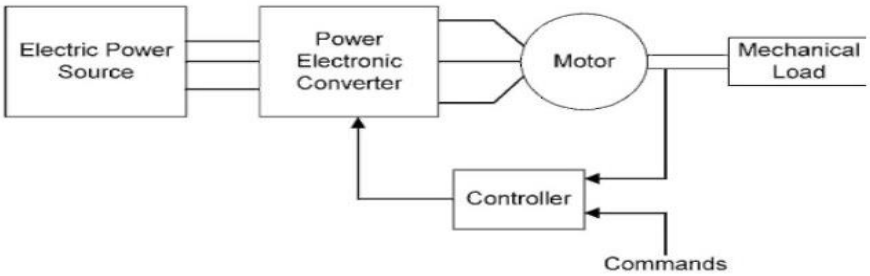


Fig.2.1 Block Diagram

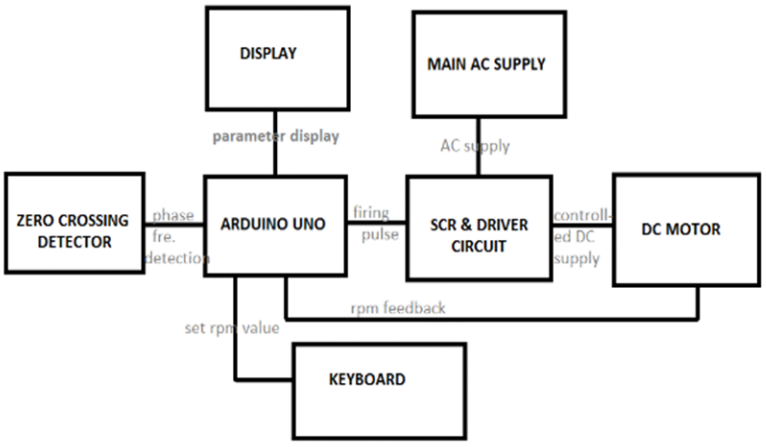


Fig. 2.2 Block Diagram

3. BLOCK DIAGRAM DESCRIPTION

3.1. CONVERTER CIRCUIT: Single phase AC supply is given to the converter circuit .In converter circuit full controlled converter is used to control gate pulse by using Arduino Uno which converts AC into DC. This is useful to control the speed of DC motor. The advantage of fully controlled converter creates less ripple and output is smooth.

3.2. ARDUINO UNO: It is used for building electronic project. It consists of both physical program circuit board and piece of software. In the motor feedback is given to the microcontroller of Arduino UNO. This decides the firing angle of controlled converter and we get required speed. Also connect the display and keyboard.

3.3. KEYBOARD: In keyboard we use a simple switch which is used to set the speed. This command is given to the microcontroller then microcontroller varies the firing angle of converter. By varying this firing angle we get desired speed.

3.4. MICROCONTROLLER: Specially designed for performing single task, is a computer-on-a-chip usually comprise of input and output ports, RAM, ROM, and also CPU. Due to simplicity in design and pocket friendly prices, microcontroller is widely adopted for various field. In addition to this, microcontrollers are commonly built using CMOS technology resulting optimum performance with least consumption of power. Due to performing only single dedicated task is fast more reliable.

3.5. LCD: Liquid Display Crystal is electronic device for displaying text or characters. It display the firing angle and speed of the motor.

We are using 14 pins LCD and description as follows:
Pin 7 to Pin 14- These 8 pins are used for the transfer data.
Pin 4- This is RS i.e. register select pin.
Pin 5- This is R/W i.e. Read/Write pin.
Pin 6- This is enable pin.
Pin 2- This pin is VDD that is power supply pin.
Pin 1- This pin is VSS that is ground pin.
Pin 3- This is short pin.

4. POWER CIRCUIT

4.1. ZERO CROSSING DETECTOR

The figure consists of Power Interrupt, Arduino Uno, and Display. In which AC supply is given to primary of center tapped transformer and secondary output is 9-0-9V. +9V/-9V is given to rectifier bridge. In bridge rectifier 4 diodes D1, D2, D3and D4 are connected in bridge configuration. During positive half cycle only D1 and D4 will conduct and its output is given to 7805 regulator. This regulator is used to get regulated +5 V DC voltage. Capacitor C1 is used for filtering purpose. During negative half cycle diode D2 and D3 are conducted and its rectified output is given to 7905 regulator. Therefore we get -5V DC voltage output. Capacitor C2 is used is for filtering purpose. This +5V/-5V output is used for 741 Op-Amp. This connected in parallel with the secondary of center tapped transformer. At non-inverting terminal of Op-Amp (pin- 3) positive 9V IS connected and negative terminal connected to the inverting terminal of Op-Amp (pin- 2). This Op-Amp is used to generate square wave having magnitude+5V/-5V. Only +5V is used for input of Arduino Uno at A0 pin, for this we use negative clipper circuit. We are using diode as clipper. In this when we apply -5V to the cathode terminal of clipper then diode becomes forward biased and the -5V will grounded. Also +5V voltage is given to 2N2222 transistor operation. Capacitor C1 is used for filtering purpose and freewheeling diode D1 used ground the circulating current. Output of Q1 is taken from collector terminal which is square wave. This square wave is given to another transistor Q3. Q3 is used to phase shift of square wave of Q1. This shifted square wave is given to microcontroller as input at pin- 3 and output of transistor Q2 given to a pin- 2

Purpose of giving this input to microcontroller is to decide input voltage whether positive or negative. At the rising edge of waveform negative half cycle is present & at falling edge positive half cycle is present. The main task is to convey this message to the microcontroller which is obtained through ZCD. According to that it will vary firing the angle of thyrister. After getting the input as user interface & ZCD thyrister are fired according to positive & negative cycle. For examplethyrister 2&3 are fired forpositive half cycle and thyristors 1&4 are fired for negative half cycle.

In this two push buttons are used to vary the firing angle according to user requirement. One push button is used for increasing the firing angle & another one is for decreasing the firing angle, remaining two push buttons are used to enter in the menu & exit from the menu. Suppose we apply alpha=90 then microcontroller sense it as 5msec. similarly alpha=180 and alpha=360 microcontroller sense it as 10msec &

20msec respectively. 16*2 display is used. The pin 11,12,13,14 of display are connected to pin 8,9,10,11 of Arduino Uno respectively. Controlled firing angle is taken from pin 4 & 5 of Arduino Uno which is given to digital oscilloscope.

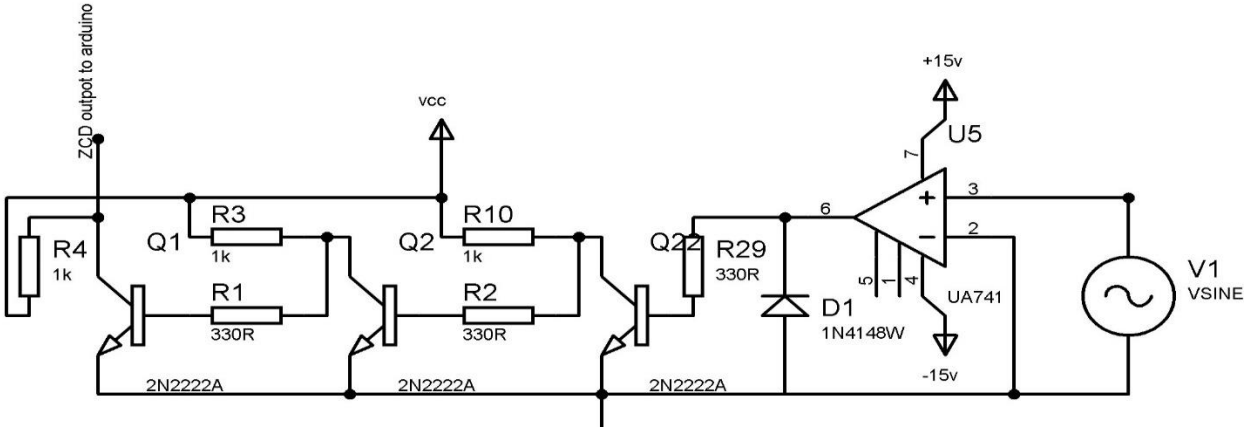


Fig.4.1 ZCD Circuit

4.2. OPTO-COUPLER

Opto-Coupler is used for isolation purpose. It isolate power circuit & drive circuit of IR2110. Two outputs from opto-coupler are HIN and LIN given to IR2110 drive circuit. It convey the signal of microcontroller optically to the SCR through opto-coupler.

4.3. DRIVE CIRCUIT

It is common practice to use VDD=+5V. When VDD=+5V, the logic 1 input threshold is slightly higher than 3V. Thus when VDD=+5V, the IR2110 can be used to drive the loads when input 1 is more than 3 point something volts. This means that it can be used for almost all circuits.

HIN & LIN are the logic inputs. A high signal to HIN means that you want to drive the high side SCR, meaning a high output is provided on HO.

A low signal to HIN means that you want to turn of the high side SCR, meaning a low output is provided on high output. The output to high output high or low is not with respect to ground, but with respect to VS. VCC, VB&VS is used to provide floating supply to drive the SCR. VS is the high side floating supply return. When high, the level onHO is equal to the level on VB, with respect to VS. When low, the level on HO is equal to VS, with respect to VS, effectively zero.

A high signal to LIN means that you want to drive low side SCR, meaning a high output is provided on LO. A low signal to LIN means that you want turn off the low side SCR, meaning a low output is provided on low output. The output on LO is with respect to ground. When high, the level on LO is equal to the level of VCC, with respect to VSS, effectively ground. When low, the level on LO is equal to the level on VSS, with respect to VSS, effectively zero.

SD is used as shutdown control. When this pin is low, IR2110 is enabled shutdown function is disabled. When this pin is high, the outputs are turned off, disabling the IR2110 drive

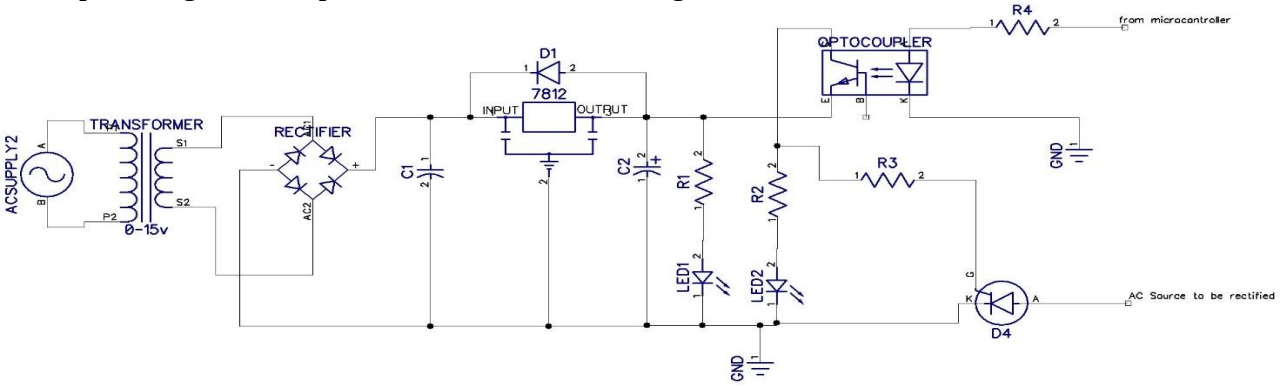


Fig.4.3 Drive Circuit

Table for IR2110 Pin/Lead Definition

Symbols	Description
VDD	Logic Supply
HIN	Logic input for high side gate drive output (HO), in phase
SD	Logic input for shutdown
LIN	Logic input drive for low side gate output (LO), in phase
VSS	Logic ground
VB	High side floating supply
HO	High side gate output
VS	High side floating supply return
VCC	Low side supply
LO	Low side gate output
COM	Low side Return

5. EXPERIMENTAL SET UP

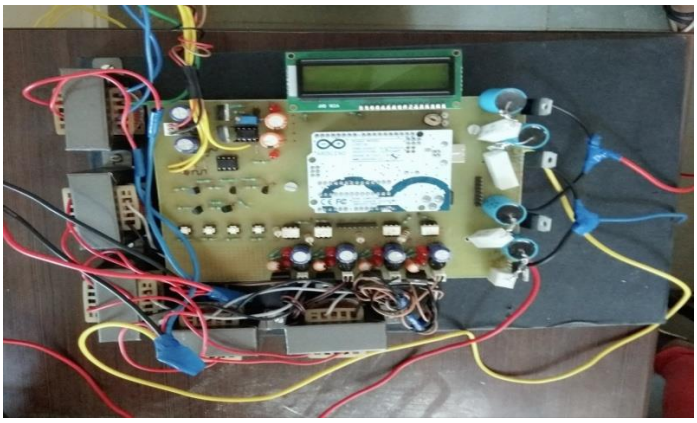


Fig.5.1 Experimental Setup

6. RESULTS

6.1 OBSERVATIONAL RESULT

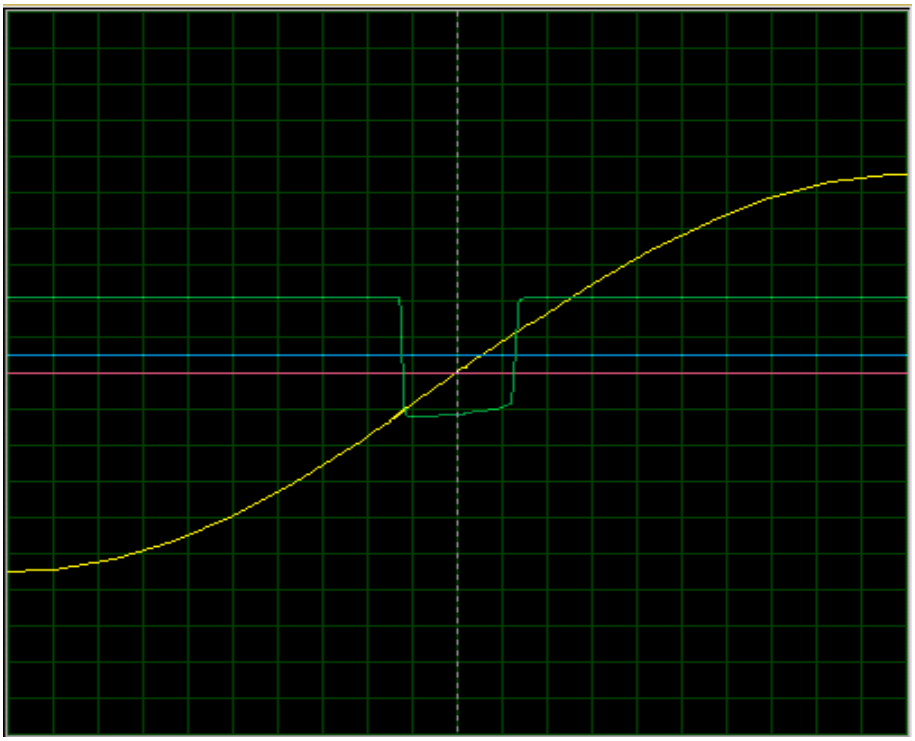
Fig.5.2 Observation result

5.2PRACTICAL OBSERVATIONS

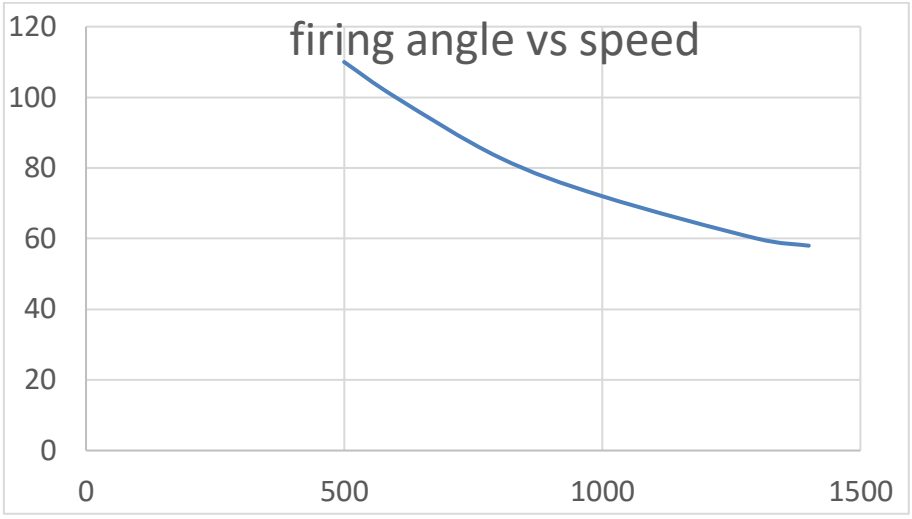
Table.1

Sr. No	Set Speed	Actual Speed	Firing Angle	Armature Voltages
1	720	710	80	100
2	900	920	65	123
3	1000	1005	58	137
4	1200	1195	35	164
5	1330	1325	28	182
6	1420	1415	17	194

5.3 WAVEFORMS



5.2.1 Output of Zero Crossing Detector



5.2.2. Graph of Firing Angle v/s Speed

7. CONCLUSION

In the given paper possibilities of use of variable firing angle of thyrister in speed control of DC motor were discussed. Possible topologies were analyzed and it was found that the speed control of DC motor is easily controllable with minimum losses. It was calculated that we also possible the line regulation and load regulation. However, from the economical point of view in this technique rheostat is replaced by converter circuit.

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II. Sandhya Kumar Electronics and telecom department Vidyalankar polytechnic Sandhya.kumar@vpt.edu.in and Dr. Anjali Deshpande Senior Member, IEEE Vidyalankar institute of technology Anjali.deshpande@vit.edu.in:DSP BASED CLOSE- LOOP SPEED CONTROL SYSTEM FOR DC MOTOR USING DUAL CONVERTER.

III. Abhishek Khanna Electrical and Electronics Department Amity University, Uttar Pradesh Noida, India abhishekkhanna1994@outlook.com Priya Ranjan Electrical and Electronics Department Amity University, Uttar Pradesh Noida, India abhishekkhanna1994@outlook.com :SOLAR -POWERED ANDROID BASED SPEED CONTROL OF DC MOTOR VIA SECURE BLUTOOTH.