FIRING ANGLE CONTROL OF DUAL CONVERTER USING DSPIC 30F 6012A FOR SPEED CONTROL OF DC MOTOR

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ABSTRACT

DC motors are extensively used in adjustable speed drives and position control applications.so speed control of DC motor is an important function and is carried out in many industrial applications. The speed control of DC motor is very crucial in application where high precision is required. To control the speed of dc motor for different load conditions and disturbances we need to impliment complex control algorithm which requires precise control so for this we need to use a controller that has high accuracy and liniarity. In this paper we showing the relationship between firing angle of converters (positive group and negetive group) of dual converter and the speed achieved by the motor. Firing pulses are geneated to trigger thyristor using processor DSPIC 30F 6012A.PID control algorithm has been used to control motor speed .relationship between firing angle and speed of motor was found to be linear in nature in both the case ie for positive converter group and negetive converter group.

Keywords: ***Dspic 30f 6012a, Dual Converter, Speed Control, Dc Motor, Non-Circulating Current***

I. INTRODUCTION

The electric drive system is used in many industrial applications, robotics and home appliances because of their low cost, less complex control structure and wide range of speed and torque which requires high performance, reliability, and variable speed due to its ease of controllability.The speed control of DC motor is very crucial in application where precision and protection are of essence. There are many methods of speed control of dc motor drive namely field weakening, voltage control, current control and torque methods [1].In DC motor control, Armature voltage control method is widely used in industry to control the speed of DC motor. [2]

Mainly traditional DC drives are used in operation for speed control with forward and reverse operation. The reversal of current and speed through the dc motor is provided by dual converter [3].

II. DUAL CONVERTER AND CONTROL

A single-phase converter operates only in two quadrants and can provide unidirectional torque with reversible rotation. To reverse speed and torque both voltage as well as current should be reversed. This can be achieved with reversing switch along with full converter thyristor switches (separate triggering circuits required). A dual converter provides the easiest way to speed reversal of a dc motor Figure 1 shows the Equivalent Circuit of Dual Converter.[4]

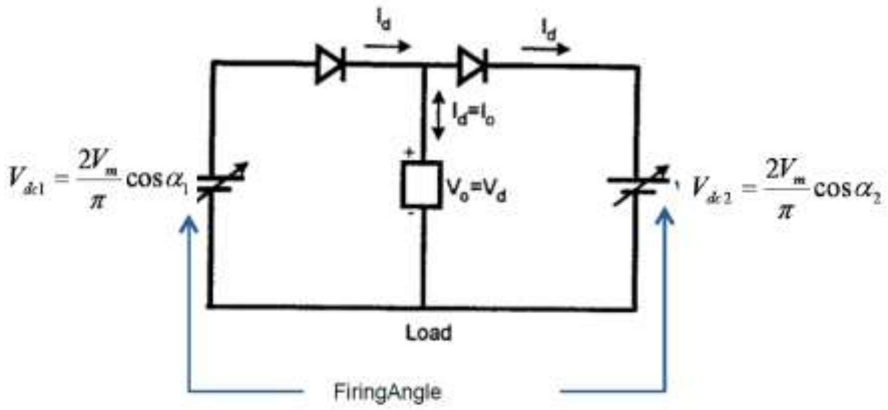


Fig 1: Circuit Diagram of Dual Converter

Dual converter consists of two fully controlled converter (one positive group converter and other negative group converter) connected back-to-back .One converter acts as a rectifier and other converter acts as inverter. In DualConverter both the voltage and current can be reversed at dc terminal. There are two operating modes, Non- circulating current control and Circulating current control. In this work we have used the Non Circulating Current Mode. In this mode of operation, Only one converter is operated at a time. When converter 1 is ON, $0 < \alpha_1 < 90^0$,V_d is

positive and I_d is positive.

Voltage across converter 1 is given by[5]

$$V_1 = \frac{v_m}{\pi}(\cos\alpha_1 - \cos\beta_1)$$

whereα_1*is firing angle*andβ_1 is conduction angle of a thyristor. When converter 2 is ON, $0 < \alpha_2 < 90^0$, V_d is negative

V and I_d is negative. Voltage across converter 2 is

given by

$$V_2 = \frac{v_m}{\pi}(\cos\alpha_2 - \cos\beta_2)$$

whereα_2*is firing angle* and β_2 is conduction angle. The DC motor speed reversal is achieved as follows, For Forward Motoring operation, Converter1works as a rectifier, while pulses to converter 2 are removed. For Braking and speed reversal, Converter 1 is first operated as inverter and when Armature current reduces to zero, 2-10 msec delay is provided to ensure turn off of thyristors in converter, Firing pulses withdrawn and transferred to converter 2. Initially firing angle for converter 2 is high. It is adjusted to brake the motor at maximum allowable current from initial speed to zero speed. Then motor is accelerated to desired speed in reverse direction.

III. BLOCK DIAGRAM

Block Diagram of the control scheme is shown in Figure 2. When we enter the speed using key pad , Initially dsp will give pulses to run motor at 25 rpm, when motor reaches speed of 25 rpm again dsp will generate firing pulses to increase motor speed to 50 rpm i.e. speed of motor will be increased in the steps of 25 rpm and so on ,and within seconds motor will start running at its set speed.

Speed of motor is sensed by optical sensor, which gives an output voltage of +5v when light is blocked, and about 0.5 v when light is allowed to pass through the transparent part of the disc. Optical encoder gives series of pulses with a frequency proportional to the motor speed. The frequency of the output waveform is given by,[6]

This frequency is converted into voltage using frequency to voltage converter. This output of optical sensor is subtracted from the set point to produce error.The error is used in PID algorithm to generate the controller output. This digital output is then converted to analog using digital to analog converter and that analog value after amplification is given to ramp generation circuit, output of ramp generation circuit is saw tooth wave which when given to 555 timer in monostable mode produces series of pulses. A pulse transformer is used to give these pulses to trigger the SCR. The frequency of triggering pulses will change according to increase or decrease in error voltage. If the error is positive that means speed is more than the set speed, then the processer will reduce the digital value which was given to DAC by 25. This causes reduction in DAC output and if error voltage is negative that means speed of motor is less than set speed, in this case DSP will increase the digital value by 25, which increases the DAC output.

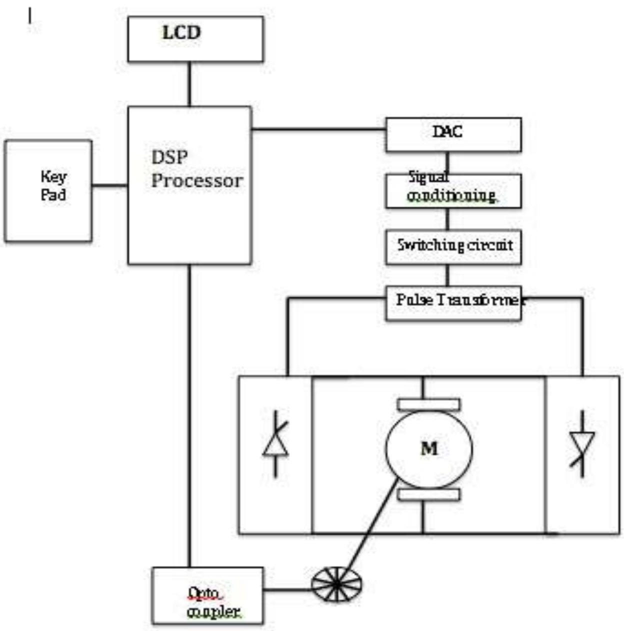


Fig 2 Block Diagram

In this method output is increased by proportional amount to try and restore the speed. However as the motor speed recovers,the error reduces and motor speed is maintained. In this closed loop system Speed of motor is controlled using a PID controller implemented using DSP processor in this work.

Fig 3 Implmentated Circuit Diagram

IV. DSP (DSPIC 30F 6012A)

DSP processor (DSPIC 30F 6012A) is used which consists of 40 bit wide accumulator with CPU speed 30 MIPS, it is 16 bit fixed processor this means it does not directly deals with real no, but uses modified form of integers for all calculations ,44 K byte flash memory for executing user code ,Inter integrated circuit (I^2C) to provide complete hardware support for both slave and master modes and it also allows bidirectional transfer between these two. Universal Asynchronous Receiver transmitter module (UART) for full duplex transmission, Controller area network (CAN) module is a serial interface useful for communicating with other microcontroller device, A to D converter allows conversion of an analog input to 12 bit digital no .

V. FLOW CHART OF CONTROL SCHEME

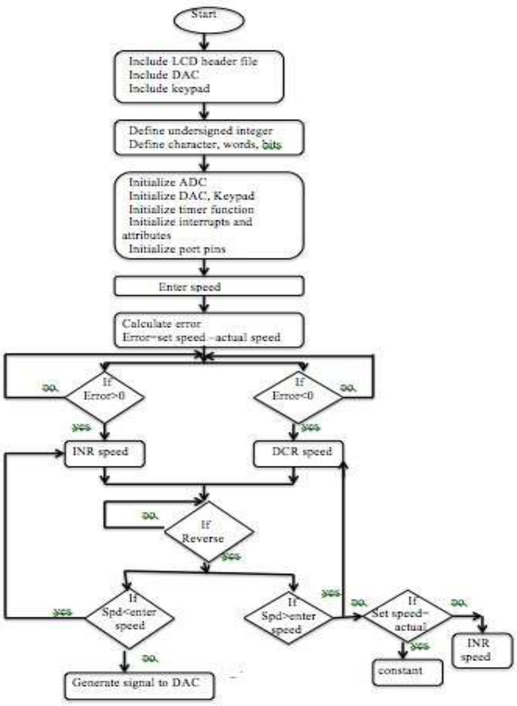


Fig 4: Flow Chart

VI. RESULTS AND CONCLUSION

Experiments were carried out for different speed settings, to find the relationship between voltage and speed and also to observe the effect on firing angle. Then data collection was done at each speed of dc motor Theoretical formula for firing angle calculation is given below.

$V = V_m/\pi\ (\cos\alpha - \cos\beta)$ where

V_m=peak voltage of voltage supply of thyristor

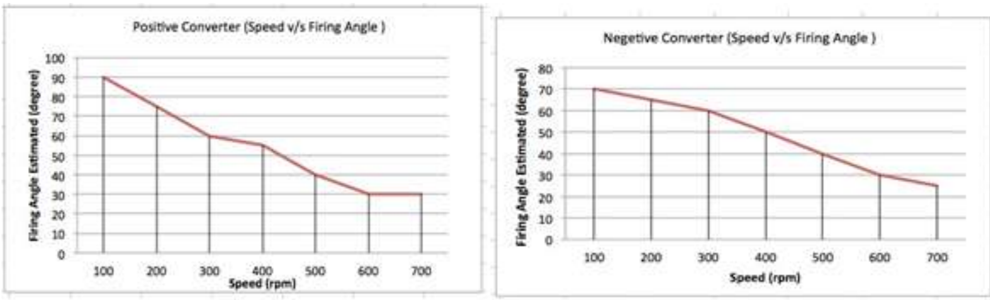
α = firing angle of thyristor

β = conduction angle of thyristor firing angle value was estimated by using waveform fig 8

Table 1: Relationship of Firing Angle and Speed of Motor

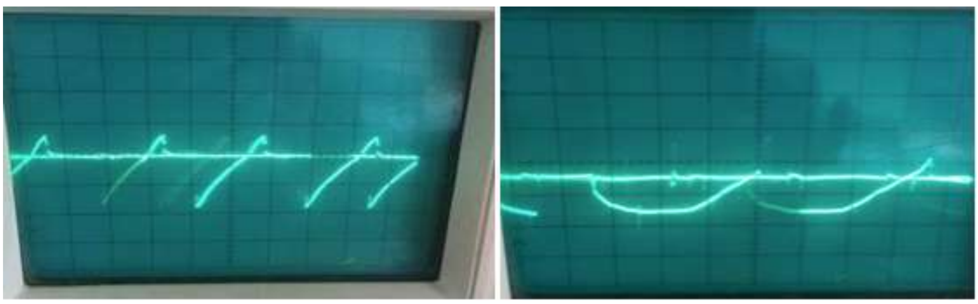
Sr no	Positive converter			Negative converter		
	Speed (rpm)	Voltage(v)	Firing angle (degrees) estimated	Speed (rpm)	Voltage(v)	Firing angle (degrees) estimated
1	100	2.25	90	100	-2.30	70
2	200	3.10	75	200	-3.00	65
3	300	5.11	60	300	-4.90	60
4	400	7.90	55	400	-6.00	50
5	500	9.1	40	500	-8.1	40
6	600	9.7	30	600	-9.2	30
7	700	10.2	30	700	-10.2	25

We measured the firing angle generated by DSP at different speed and observed that change in voltage was linear ,then we plotted the graph (graph 1 and graph 2)and found linear relationship between speed and firing angle for both positive and negetive group of converters.



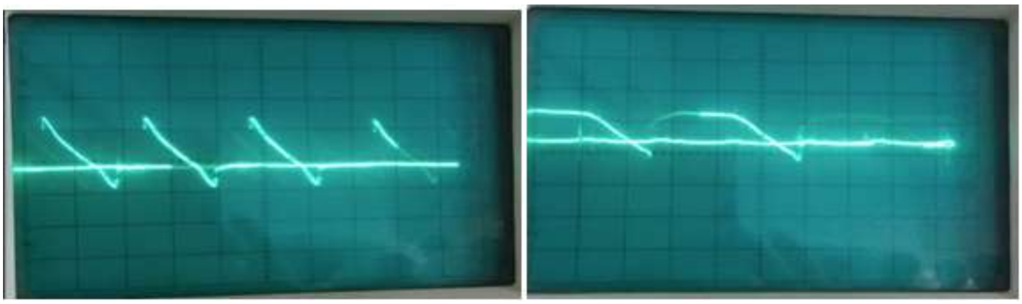
Graph: Showing Relationship Between Speed and Firing Angle Generated by DSP

VII. DC MOTOR SPEED CONTROL WAVEFORMS



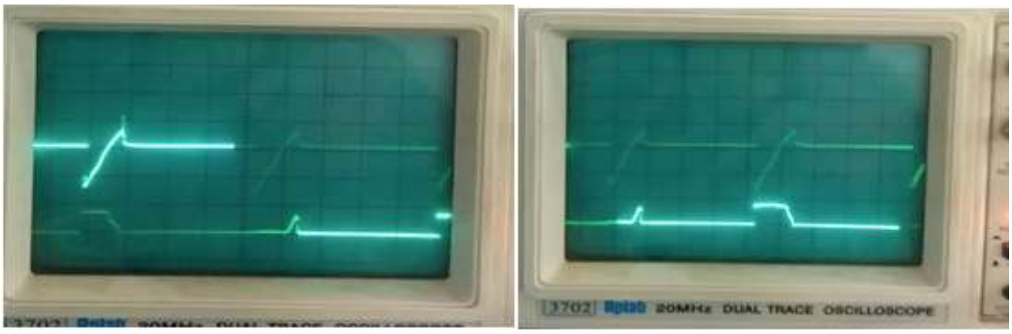
(a)Motor speed 200rpm **(b)Motor speed 700rpm**

Fig 5 (a & b)- Load Voltage Waveform Observed at Negative Converter



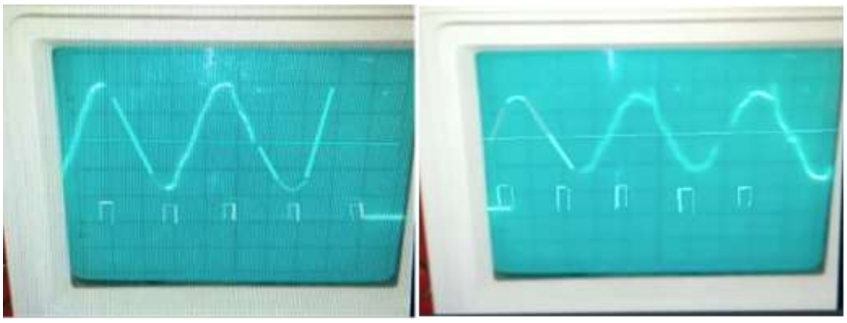
(a)Motor speed 200rpm **(b)Motor speed 700rpm**

Fig 6(a & b) :Load Voltage Waveform Observed at Positive Converter



(a)(scr1&3 Conducting) in Positive Half Cycle **(b)(scr 2&4 Conducting) in Negative Half Cycle**

Fig7(a&b):triggering pulses generated by DSP and observed across for scr (1 & 3 which was conducting in positive half cycle)and scr (2 & 4 which was conducting in negative half cycle) when motor was running at a speed of 200rpm



(a) Motor Speed 200rpm((α = 90 deg) **(b) Motor Speed 700 rpm(α = 30 deg)**

Fig 8 (a & b): Waveform Showing Supply Voltage and Triggering Pulses

waveforms in fig 8 shows the synchronization of supply voltage and triggering pulses and we can see that at low speed firing angle is high (table 2) and at high speed firing angle is less (table 2) and this is to maintain the dc voltage across the load.

VIII. FUTURE SCOPE

In this project we are using optical encoder to sense the speed of DC motor. In future we can connect current sensor in cascade with motor which can sense even very small change in current and will be able to control speed of motor more precisely. Current sensors can increase stability of the system also.

IX. CONCLUSION

The speed control of DC Motor was achieved successfully, Motor was rotated in both the directions .The DSP 30f 6012a was programmed to achieve firing pulses to trigger SCR in dual converter .Performance was fast at low speed also because of DSP processor. Speed of dc motor was observed to be constant at and below the reference speed.Relation ship between motor speed and firing pulses generated by DSP was also found to be Linear.

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