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Analysis of Steady State and Dynamic Operating Condition of Chopper Fed Dc Series Motor with Software Tools

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Abstract: *Motion control is necessary phenomenon necessary in large scale in industrial and domestic environment. Hence dc series motor along with chopper is widely used for variable speed demand and sophisticated operation. So, to determine the steady state and dynamic behavior is plays an important role. The visual basic software interpretation is one of easy way which acts as its analyzing tool. The transient response of the chopper fed motor is obtained by considering a small in the duty interval and in the load. Hence operation of four quadrant dc chopper that can be use of many application. The paper describe approximation which permit the derivation of simple but accurate analyzing methods for analysis of dc series motor fed by chopper with pulse width control using visual basic software tool.*

Keywords: *Chopper, DC series Motor, Steady state, Dynamic state, Motion control, Visual basic software.*

I. Introduction

Nowadays, motion control is one of the important needs of domestic and industrial environment. So, the electric dc drive is one of the very useful motion control technique has been used especially for variable control application [1, 2, 3, 4].There are many control strategies had used. They are current limit control, time ratio control and pulse width modulation control [2]. The pulse width modulation is one of the effective method used close loop operation of chopper fed dc series motor [3]. The control using this technique is accomplishes by using control of duty cycle [4]. In this topology, we consider dc series motor in which field configuration is in series armature hence it make more advantageous for overall system working[4]. Since, mathematical model of dc series motor is nonlinear, the proposed method included the effect of it for better control operation [5]. Therefore the smooth four quadrant operation of dc series motor deals with many industrial and domestic applications with low cost than others [1].

The main component of electric drive is power modulator which modulates flow of power from source to motor and imparted speed- torque characteristics required by load [5]. The chopper is work as power modulator which is driven by control unit. Hence control is takes place by using firing circuit also with semiconductor circuit or either microcontroller for sophisticated control [6]. The arduino is nowadays used as microcontroller for various control strategies because of its very much advantageous [7].

So, in this paper, the proposed method of PWM has been used. The dc supply provided to chopper has been chopped and duty cycle controlled by arduino controller. And all configurations of chopper fed dc series motor is interfaces with visual basic software which interpretates the steady state and dynamic conditions.

II. Mathematical Modelling

A. Chopper fed dc series motor

Fig.1 shows basic configuration of chopper fed dc series motor. The basic control parameter duty cycle is presented as δ.

Hence basic motor voltage equation can be written as,

$$v_a = \delta v_s = i_a R_a + L\frac{di_a}{dt} + E_b E_{res} \tag{1}$$

$$R_a = R_{arm} + R_{se}\ L_a = L_{arm} + L_{se} + 2M$$

Where,

i_a - motor current

R_{arm} & R_{se} – Resistance of armature and field winding

L_{arm} & L_{se} - Inductance of armature and field winding

M- Mutual inductance

e_b & e_{res} – back emf and emf due to residual magnetic flux

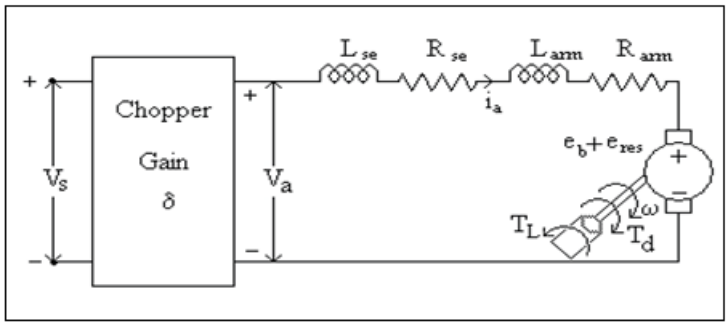

Fig.1 Chopper Controlled DC Series Motor

Torque equation of dc series motor is,

$$T_d = J\frac{d\omega}{dt} + B_\omega + T_L \tag{2}$$

Where,
J is moment of inertia, B is coefficient, T_L is load torque and ω is angular velocity
The transfer function of chopper fed dc series motor is given by,

$$\frac{\Delta\omega(S)}{\Delta\delta(S)} = \frac{2V_s K_{af} I_{a0}}{\{JL_a S^2 + (JR_a + K_{af}\omega_0 J + BL_a)S + [(BR_a + K_{af}\omega_0 B) + (2K_{af} I_{a0})(K_{af} I_{a0} + K_{res})]\}} \tag{3}$$

B. DC-DC Converter
The model equation given by,

$$V_0 = \delta V_s \tag{4}$$

$$\delta = \frac{T_{on}}{T} \tag{5}$$

$$T = T_{on} + T_{off} \tag{6}$$

Where,
V_0- Output voltage
V_s- Input voltage
T_{on}- On time
T_{off}- Off time
T- Total time
δ- Duty cycle

C. Pulse Width Modulation Control
For proper duty cycle δ and angular speed ω, value of motor constant K_v is obtained from magnetization characteristics of motor.

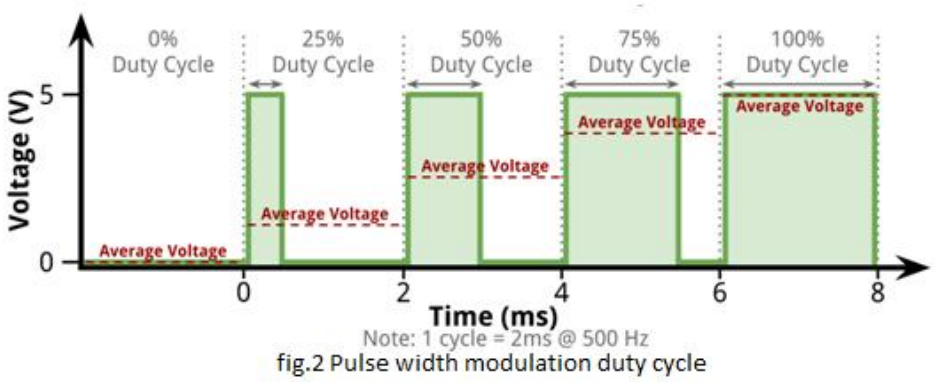

fig.2 Pulse width modulation duty cycle

Then,

$$E = K_v\,\omega_{av}$$

Where, K_v- motor constant

ω_{av}= average speed= $\frac{\delta v - i_{av} R_a}{K_v}$

T_{av}= average torque= $K_v I_{av}$

III. Proposed System

The chopper is now very widely used for the control of dc series motors for traction applications. The advantages of the chopper over the conventional resistance controller are: higher efficiency, flexibility in control, regeneration down to very low speed, light-weight and smaller size. The chopper output voltage can be controlled either by using a current-limit control scheme or by pulse width control. In the current-limit controlled scheme, the current is controlled between certain maximum and minimum values of current-when the current reaches the maximum value the chopper disconnects the supply from the load and reconnects it when the current reaches the minimum value. he major problem in analysis of chopper fed dc series motor arises due to non linear relation between armature induced voltage and armature current. In this method the pulse width modulated input data provided to visual basic software and analyzes system parameters.

A. Interfacing of chopper fed dc series motor

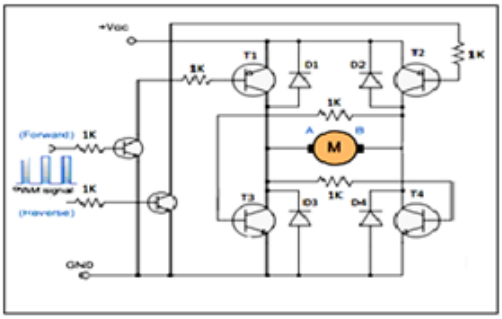

Fig.2 H-bridge & motor interfacing

The DC supply is provided to pair either T1 and T3 or T2 and T4 of 5V to their base. The 12V dc supply is provided to chopper and chopped dc output is given to motor. Therefore, the chopped input is given to motor and losses are reduced on level of fraction but help much in all the setup, so the heating in motor reduces. The free-wheeling diode is connected along with every transistor. For the purpose to limit the current passed through it. The operation of chopper fed dc series motor is work according to different intervals. This different intervals (or modes) in a cycle are duty interval commutation interval and freewheeling interval. The duty interval is more than charging period of capacitance. The commutation interval when voltage increased over limit. Foe successful commutation the freewheeling interval will be always present.

B. Interfacing of circuitry to arduino and visual basic software

As stated above, the PWM output is provided to motor with help of dc-dc converter. The chopper is converting fixed 12V dc supply into chopped dc output and this chopping interval is decided by arduino microcontroller. This decides their duty cycle and duty cycle is control by arduino programming. The current sensor is connected in series with dc series motor and arduino controller. The current is measured by current sensor and send it to arduino.

The visual basic is software we used for interpretation of steady state and dynamic operating condition. The steady state and dynamic condition of drive expressed in terms of speed in rpm and current in ampere. The whole circuitry of chopper, transmitter and receiver and current sensor is connected and one output is provided to visual basic software. Then visual basic is collected whole data and show the change according to load variation.

C. Hardware system

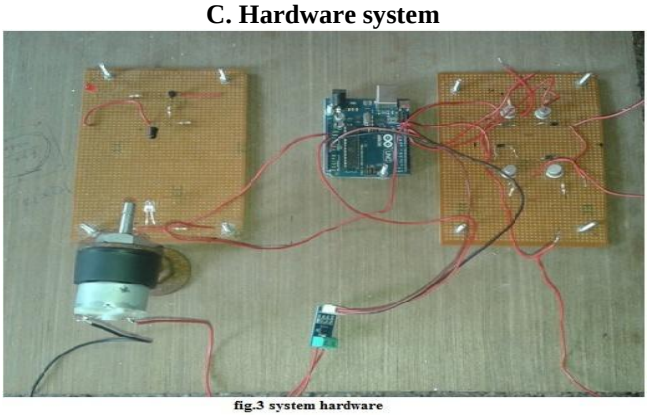

fig.3 system hardware

IV. Results And Discussions

1. Steady state condition:

Here for static condition, IR Circuitry is used. Whenever there is interruption between rotating fan and transmitter-receiver the Ardunio gives speed of the motor. Motor rotates on 5V supply. Thus as the speed decreases the current also get decreased.

Sr.No.	Speed(rpm)	Current(mA)
1	110	520
2	100	490
3	80	400
4	60	350
5	40	320
6	40	315

2. Dynamic Condition:

For Dynamic condition there is need to give 12V supply to the dc motor. Thus the motor speed gets increases and as the speed increases the motor current increases.

Sr.No.	Speed(rpm)	Current(mA)
1	70	410
2	100	430
3	120	460
4	150	490
5	200	511

In this way it is possible to analysis and performance of chopper fed dc series motor under steady state and dynamic operating condition.

V. Conclusion

When the motor is in steady state i.e. off load condition then the current decreases and almost speed remains constant. When we vary the voltage then speed remains constant otherwise it varies normally. When the motor is in dynamic state i.e. on load condition then the current increases and speed also increases. Both speed and current gives the reading according to time for better performance of motor. We should show the graphical representation of current and speed when loaded and not loaded conditions. Hence, finally the speed in rpm and current in ampere is interpreted.

References

[1]. P. D. Damle and G. K. Dubey, "Analysis of Chopper-Fed DC Series Motor," in *IEEE Transactions on Industrial Electronics and Control Instrumentation*, vol. IECI-23, no. 1, pp. 92-97, Feb. 1976.

[2]. G. K. Dubey and W. Shepherd, "Transient Analysis of Chopper-Fed DC Series Motor," in *IEEE Transactions on Industrial Electronics and Control Instrumentation*, vol. IECI-28, no. 2, pp. 146-159, May 1981.

[3]. G. Rajeshkanna, "Modern speed control of separately excited DC Motor by Boost converter fed field control method," *2013 International Conference on Computer Communication and Informatics*, Coimbatore, 2013, pp. 1-7.

[4]. M. Muruganandam and M. Madheswaran, "Performance analysis of fuzzy logic controller based DC-DC converter fed DC series motor," *2009 Chinese Control and Decision Conference*, Guilin, 2009, pp. 1635-1640.

[5]. S. Arof, N. M. Yaakop, J. A. Jalil, P. A. Mawby and H. Arof, "Series motor four quadrants drive DC chopper for low cost, electric car: Part 1: Overall," *2014 IEEE International Conference on Power and Energy (PECon)*, Kuching, 2014, pp. 342-347.

[6]. P. D. Damle and G. K. Dubey, "A Digital Computer Program for Chopper-Fed DC Motors," in *IEEE Transactions on Industrial Electronics and Control Instrumentation*, vol. IECI-22, no. 3, pp. 408-412, Aug. 1975.

[7]. K.B. Naik, S.D. Pandey, ‘‘Analysis and performance of a chopper fed DC series motor during steady-state and dynamic operating conditions’’, Electric Power Systems Research, Volume 17, Issue 2, 1989, Pages 139-147, ISSN 0378-7796, http://dx.doi.org/10.1016/0378-7796(89)90046-1.

[8]. Y. I. Al-Mashhadany, "Modeling and simulation of Adaptive Neuro-Fuzzy controller for Chopper-Fed DC Motor Drive," *2011 IEEE Applied Power Electronics Colloquium (IAPEC)*, Johor Bahru, 2011, pp. 110-115.

[9]. M. H. Rashid, "Transient responses of combined regenerative and rheostatic braking for DC chopper-fed motors," in *IEEE Transactions on Vehicular Technology*, vol. 34, no. 2, pp. 45-54, May 1985.

[10]. R. Parimelalagan and V. Rajagopalan, "Steady-State Investigations of a Chopper-Fed Dc Motor with Separate Excitation," in *IEEE Transactions on Industry and General Applications*, vol. IGA-7, no. 1, pp. 101-108, Jan. 1971.

[11]. H. Satpathi, G. K. Dubey and L. P. Singh, "Performance and Analysis of Chopper-Fed DC Series Motor with Magnetic Saturation, Armature Reaction and Eddy Current Effect," in *IEEE Power Engineering Review*, vol. PER-3, no. 4, pp. 38-39, April 1983.

[12]. K. Kumar, T. Padmavathy, N. Mahitha, V. S. Sowmya and Vinay Kumar T, "Reduction of torque ripple in DC motor drive based on cascading three H-bridge chopper topology," *2016 IEEE Students' Conference on Electrical, Electronics and Computer Science (SCEECS)*, Bhopal, 2016, pp. 1-5.