THE DYNAMICAL PERFORMANCE OF CONTROLLED FLYWHEELING DUAL CONVERTER - FED DC MOTOR DRIVES WITH SIMULATANEOUS CONTROL AND FUZZY PI CONTROLLER.

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Abstract - This paper describes the dynamical performance of a four - quadrant criculation current mode control of dc motor drive, using the controlled flywleeling technique, a four - quadrant closed - loop control drive with an inner current control loop and a speed fuzzy PI regulator is designed.

The obtained comouter simulation results of a dc motor drive below and and above the base speed are demonstrated. These result show that compare to a conventional dual - converter - fed dc motor drive with simultaneous control, the overal system performance has been improved and also, agood stabilty and robstness has been achieved.

1 - INTRODUCTION

Phase controlled thyristor converters are used extensively for speed control of dc motor drives. The basic theory of *current circulating control* mode of dual converter - fed dc motor drives widely reported in litertures, [1,2], where both converter are phase controlled. operated

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These system controls are simple, economical and reliable, [1]. However, due to the presence of dc choke, the transient response becomes slow and inaddition, of circulating current, power factor and efficiency are low. the circulation current increases the reactive power and consequently, the power pactor *deteriorates approximately for all firing* angles. To eliminate the above mentioned drawbacks, a new simultaneous gating GTO dual converter - fed dc motor without circulation current was proposed in, [3]. This reference has described the experimental results for a 3 - hp dc motor have good agreement with provides improved overall performance, Atlhough, an excelent and original method has deen proposed *however, is not simple to* implement and not economical especially for high power applications.

This paper employs the controlled flywheeling technique described in [4] to improve the overal perforance of dc drive/system shown in Fig.(1). The conventional Speed contoroller (SCPIC) is usually used in speed control system because of the simplicity and stability.

However, it is not adaptiv to change, in the load torqus, load inertia moment and change in the armature resistance and inductance due to the skin effects and magnetic saturation. Using the (SCPIC), the overshoot and oscillation of the motor speed as well as the oscillation of the motor torque and the long settling time may be observed. To overcome the above problems, the present paper employs a speed fuzzy pi controller (SFPIC) instead of (SCPIC). The guide to a design of this controller is described and the obtained computer simulation results of the whole drive/ system are presented.

2 - CONTROLLED FLYWHEELING

The method of controlled flywheeling reported in, [4] is benefecial improving of the armature riple and torque pulsation. This technique can be implemented in a 3 - phase fully controlled rectifier by eliminating negative excursions of the output voltage in rectification and positive excursions of the output voltage in inversion diverting the current to one of the three freewheeling converter. paths formed by thyristors pairs, T_1T_4, T_3T_6 and T_5T_2 as shown in Fig.(1). For equal loading, they are used alternately in such away that the transfer of the converter current to a freewheeling path is obtained by generating timed additional gate pulses., [1,4].

With reference to [1,4], in a 3-phase controlled rectifier, the controlled flywheeling can be applied only for the firing angle range from 60° to 120° where the instantaneous output voltage has both positive and negative excursions. Therefore, this technique can be applied to dc drive system shown in fig.(1).

3 - SPEED FUZZY PI CONTROLLER

in order to establish the SFPIC, the speed error as well as the change in this error are used as the input varibles. At a sampling point k,e, and e°_r are expressed as follows :

$$e_r(k) = \omega_r(k) - \omega_{ref} \quad (1)$$

$$\Delta e_r(k) = e^{\circ}_r(k) = e_r(k) - e_r(k-1) \quad (2)$$

with $\Delta e(1) = 0$

where ω_{ref} and ω_r are the speed commond and the actual speed of the dc motor. The output variable is the change in armature current commond ΔIa and therefore, the following equation can be obtained.

$$I_a(k) = I_a(k-1) + \Delta I_a(k) \quad (3)$$

with $I_a(0) = 0$

where I_a is armature current commond. The fundamental seven kinds of fuzzy variables are used as follows :

NL : Negative large
NM: Negative medium
NS : Negative small
ZE : Approximately zero
PL: positive large
PM: positive medium
PS: positive small

The control rules for the SFPIC can be described by language using the input variables, E°_r & ΔE°_r and the output nariable ΔI_a The Mamdani's minimum control rule, [5] for the i-th variable therefore is written as : follows

rule i:IF E_r is A_i and E°_r is B_i then ΔI_a is C_i (4)

Using, the typical step response of the speed from O rpm to a set value as introduced in [6] and shown in Fig.(2), the fuzzy control rules then are formulated as given in table 1.

Obviously from this table, the SFPIC is composed of 17 control rules.

Based on equation (4) and the member distribution of fuzzy variables as shown in Fig.(3), then, from knowledge base, the Zadeh - Mamadni compositional rule of inference is applied to obtain the fuzzy output variable C_i, [6].

The value of ΔI_a is then obtained by centere of gravity method used for for defuzzification, [6].

4 - COMPUTER RESULTS

Based on the theory described sofar, a computer program has been developed inorder to simulate the whole drivr/system shown in Fig.(1).

Using this program, the obtained results are demonstrated in Figs.(4.5) From these results the following are summariaed .

5 - CONCLUSIONS

Using the controlled flywheeling technique, a speed fuzzy pl controller has been designed to improve the overal performance of dc drive/ systems.

The computer results show that compare to conventional dual converter - fed dc motor drive with current circulating mode control not only the overal system performance has been considerably improved but also, a good stabilty and robstness has been achieved.

6 - REFERENCES

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Tabel. 1 - Fuzzy rules

E_r \ E	LN	MN	SN	ZE	SP	MP	LP
LN				LN	MN		
MN				MN			
SN				SN			MP
ZE	LN	MN	SN	ZE	SP	MP	LP
SP	MN			SP			
MP				MP			
LP			MP	LP			

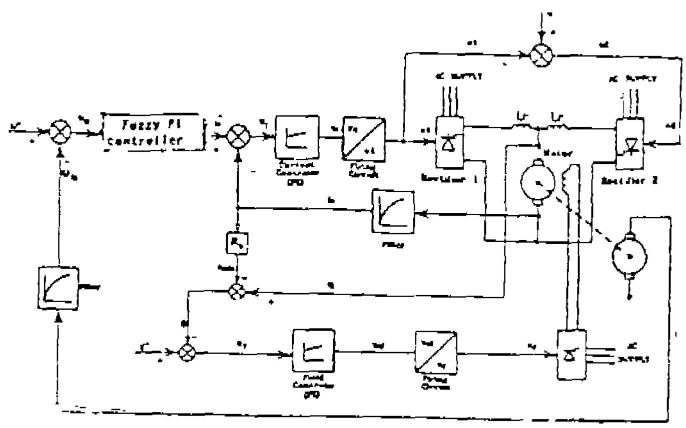


Fig. (1). Black control diagram of dc drive / system

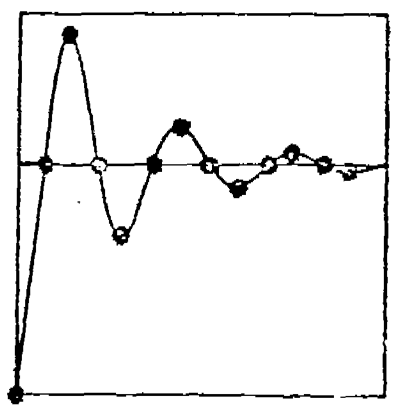


Fig. (2). Typical step response of dc motor speed

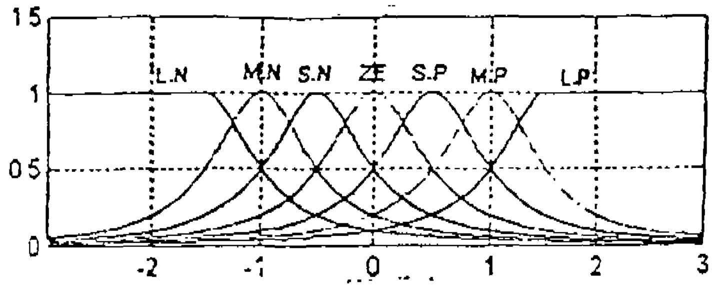
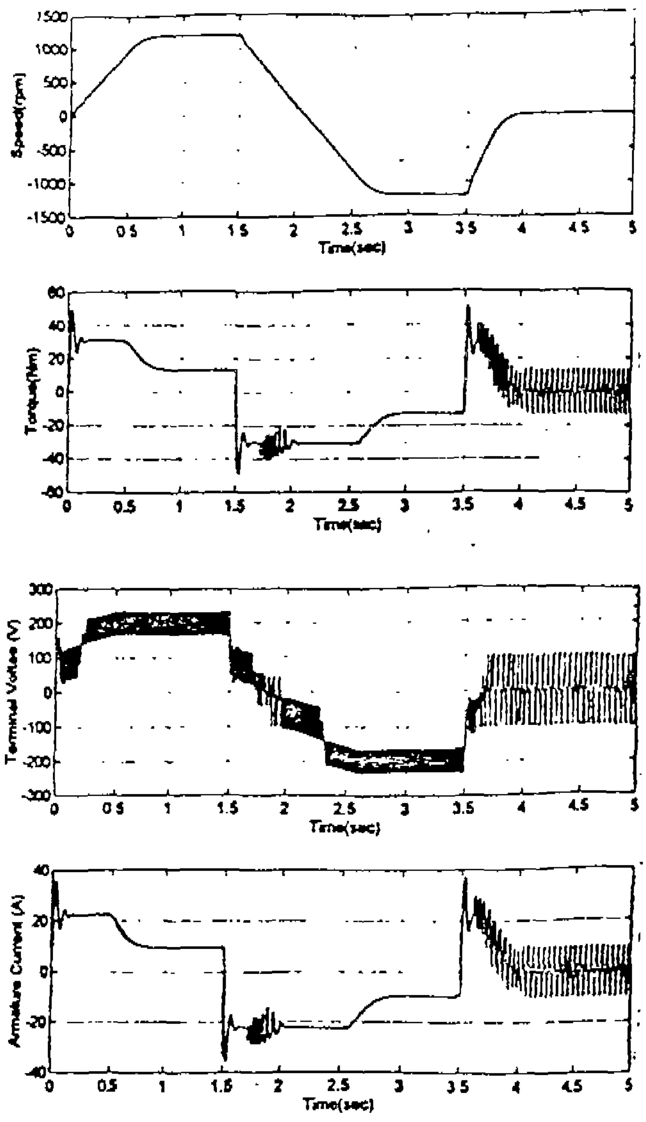


Fig. (3). Fuzzy distribution members



ω^* : 0 ⟶ 1200 ⟶ -1200 ⟶ 0

T_L : 0 ⟶ 15 ⟶ -15 ⟶ 0

Fig. (4). Dynamical performance of dc drive/system

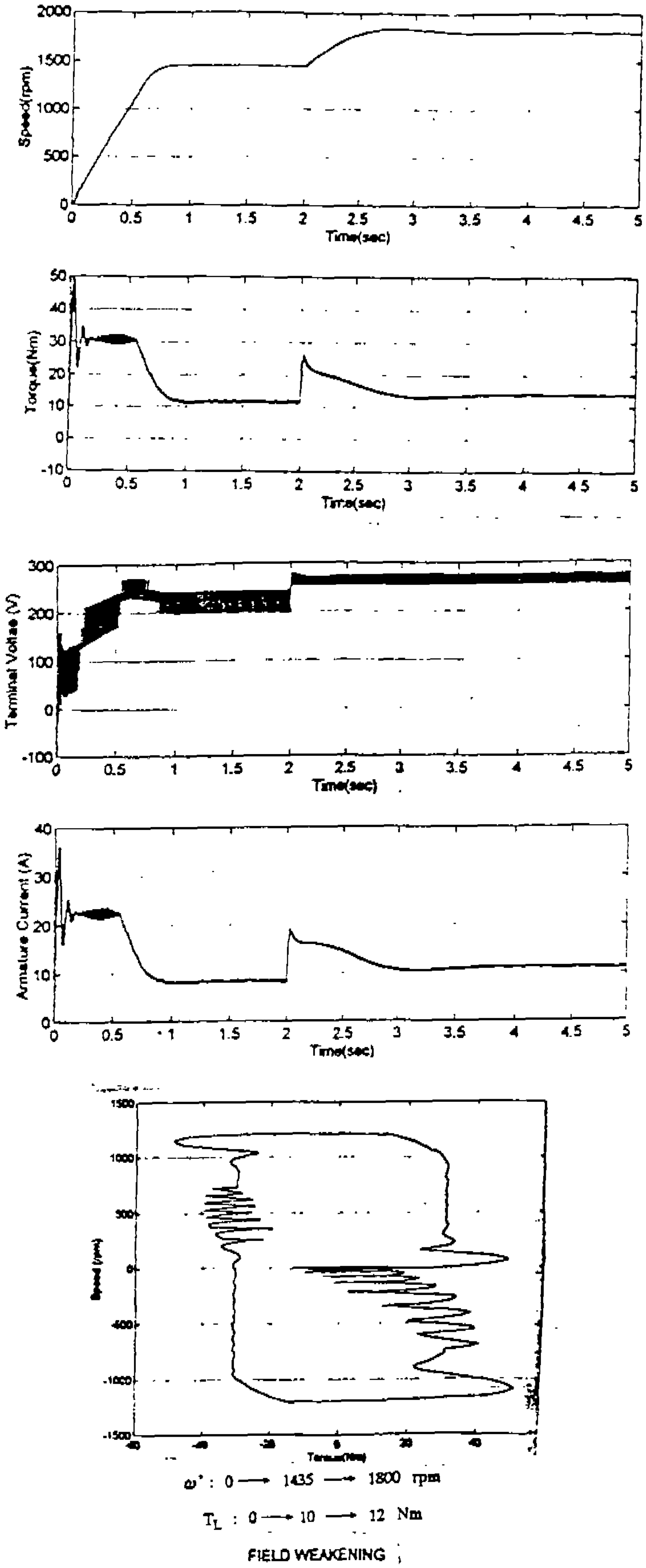
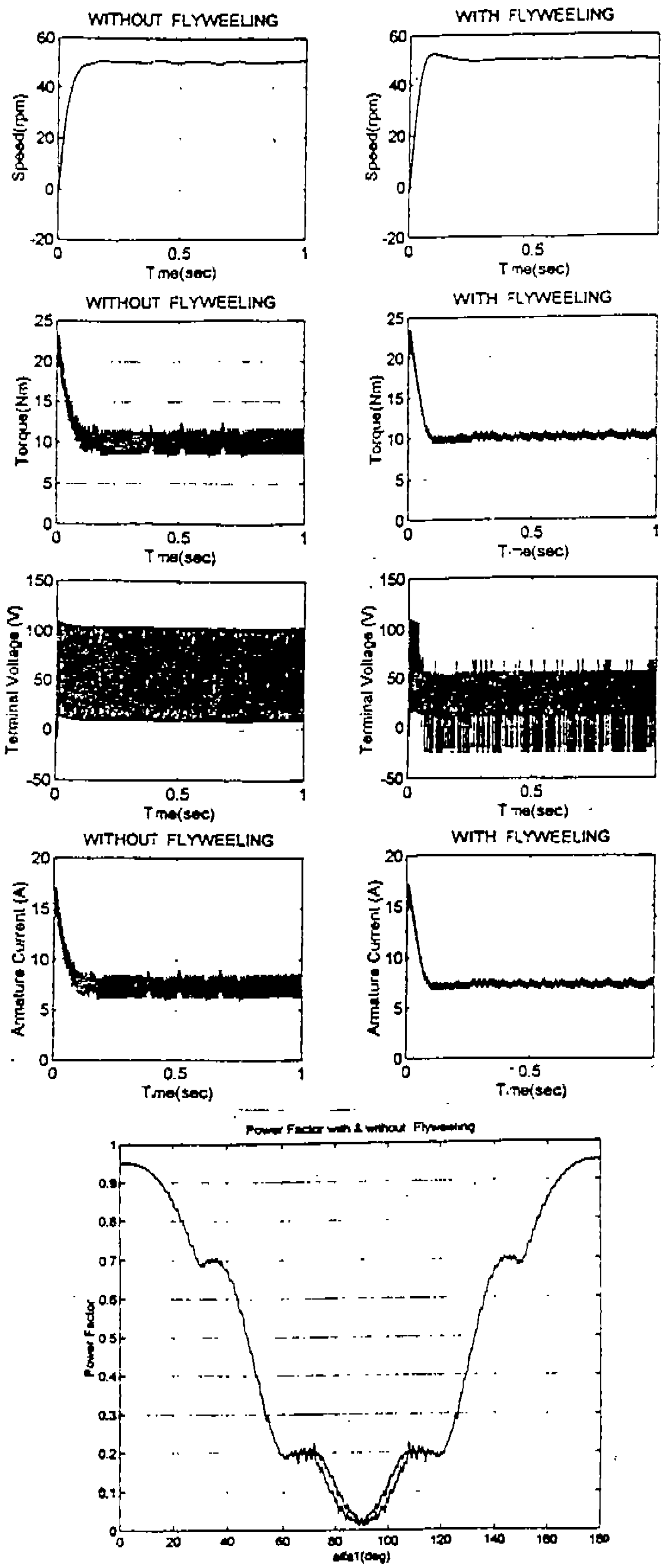


Fig. (5). Dynamical performace above base speed operation



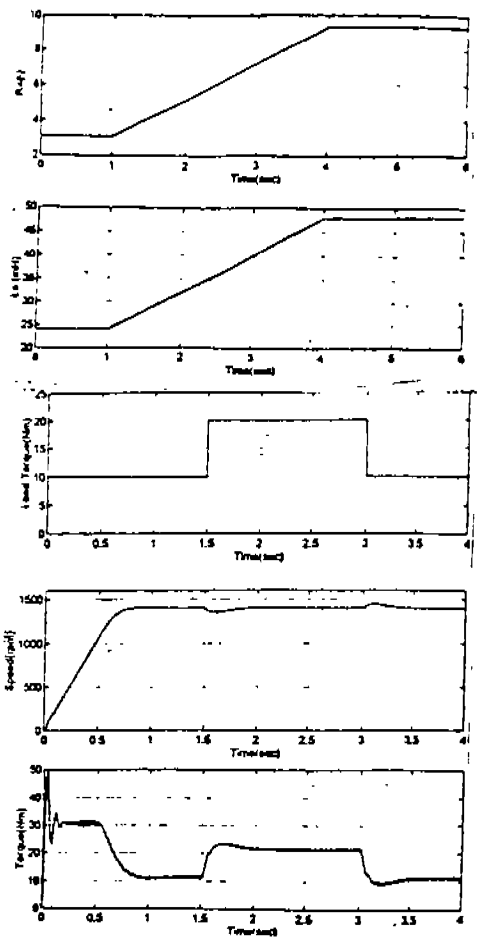


Fig. (6). Dc drive / system response to the change in motor load torque, R_a and L_a

Fig. (7). Comparison of controlled and uncontrolled flyweeling