# TRANSIENT ANALYSIS OF A. D. C. MOTOR FED FROM STATIC CONVERTER

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**Abstract**

Separately excited D.C. motors are widely uses for precision control of position, Speed and torque output. One of the common mode is to use fixed field excitation and variable armature voltage which fed from 3- phase bridge fully controlled convertor. Computer program for the system analysis been carried out to study the behavior of the motor during the transient periods. Good agreement has been obtained between experimental and computed results for transient conditions.

## 1- Introduction

Recently fully controlled converters have found wide applications in speed controlled of D. C. motor drives, especially when precise speed control is required (1,2). The low forward voltage drop of the thyristor provides an efficient rectifier when used with standard low voltage supply for the control of D. C. machines, as a replacement for the conventional ward-leonard system (3).

A computer program is used here for armature voltage control model of the motor which fed from a closed loop 3- phase fully controlled bridge convertor, to study the transient behavior of the motor during various conditions.

## 2- System Equatioms

The basic circuit the converter-motor is shown in fig. 1. At constant field current the motor torque and back e.m.f. are given by :

$T_m$=Km . Ia (N.m) ..........................................................................(1)

$E_b$ = Km .w (volts) .........................................................................(2)

$V_a$= $(3\sqrt{6}/\pi)$ Vph. Cos ( $\propto$) Converter output voltage.

The converter output voltage Va, the moter back e.m.f $E_b$ and the motor current $I_a$ are related by the following expression :

$$Va = E_b + I_a . R_a \frac{d(L_a . I_a)}{dt}$$

Or

$$\frac{dI_a}{d_t} = \frac{1}{l_a} (Va - Km . W - I_a . R_a) \quad (3)$$

$$\frac{d_w}{d_t} = \frac{T_m - TL}{J_m + JL} \quad (4)$$

$$W = d\,\theta / d_t \quad (5)$$

Equations (3 through 5) are first – order differential equations, which can be solved by runge – kutta numerical technique. Fig.( 2 )shows the model of system as needed for control problems and transient performance.

## 3- Computer Program

A simplified flowchart of the computer program is shown in fig.( 3). The fourth order Runge – Kutta numerical integration procedure is used for solution of system differential equations (3 through 5) with appropriate step length (step = 0.05 sec.) is chosen. A reference voltage $V_r$ is used for a closed loop system, which varies in steps (each a step $=\frac{3}{20\pi}$) from zero to fourteen for varying the delay angle of the thyristors ($\propto$) from $\frac{\pi}{2}$ to approximate zero ($\propto = \frac{\pi}{2} - \frac{\pi}{30} . Vr$) which depends on the design of the thyristor unit (CA 6000) (2). The program has a validity for studying the normal operating conditions such as sudden application of load torque and regenerative braking including steady - state as wel1 as transient conditions. Also, abnormal operating conditions such as sudden reversing polarity of armature voltage can be studied using the same program.

## 4-Results

Experimental results were taken on a small laboratory d.c. motor with the following parameters :

$K_m$=1.45 , $L_a$ = 0.0.86 H , $R_a$ = 4.3 Ω

$J_m = J_1$ = 0.017 $K_g$ . $m^2$ , $R_f$ = 370 Ω $V_f$ =210 volt

$V_{ph}$ =220 $/\sqrt{3}\ volts$ , Rated Power = 1.2 KW.

Fig. 4(a , b ) Shows the X- Y plotter photographs for practical starting –up condition of the armature voltage and current.

The computer results during starting - up conditions are shown in fig. ( 5). The agreement between the practical and theoretical traces are very clear from these figures. Fig.(6) shows the computer trace for regenerative braking of the motor. Fig. (7) shows the computer trace for a sudden reversing polarity of the armature voltage, which additive with motor back e. m. f. and a very large current is likely to flow in the common circuit to which power is contributed by the A.C. mains and motor together. The motor brakes due to plugging, but this operation is not convenient for SCR converters.

## 5-Conclusion

An accurate and efficient method of analyzing armature voltage control d. c. motor system using digital computer has been presented. With this method, it is easy to study the various operating conditions during transient and steady – state periods.

## References

[1]M. S. Berde . Thyristor engineering , Khanna Publ . p p. 356 -367,1982.

[2] Instruction Mannual of thyristor unit CA 6000 presented by TERCO A. B, SWEDEN, 1981.

[3] Schofield J.R.G. Smith G. A. and Whitmore M. G., The application of thyristor to the control of D. C. machines, I E E Conf. Publ. 17 power applications of controllable semiconductor devices 1965, pp. 219 - 229,1965.

[4] M. V. Deshpande, Electric motors applications and control , A.H. wheeler CO., private limited, pp. 141-144,1985.

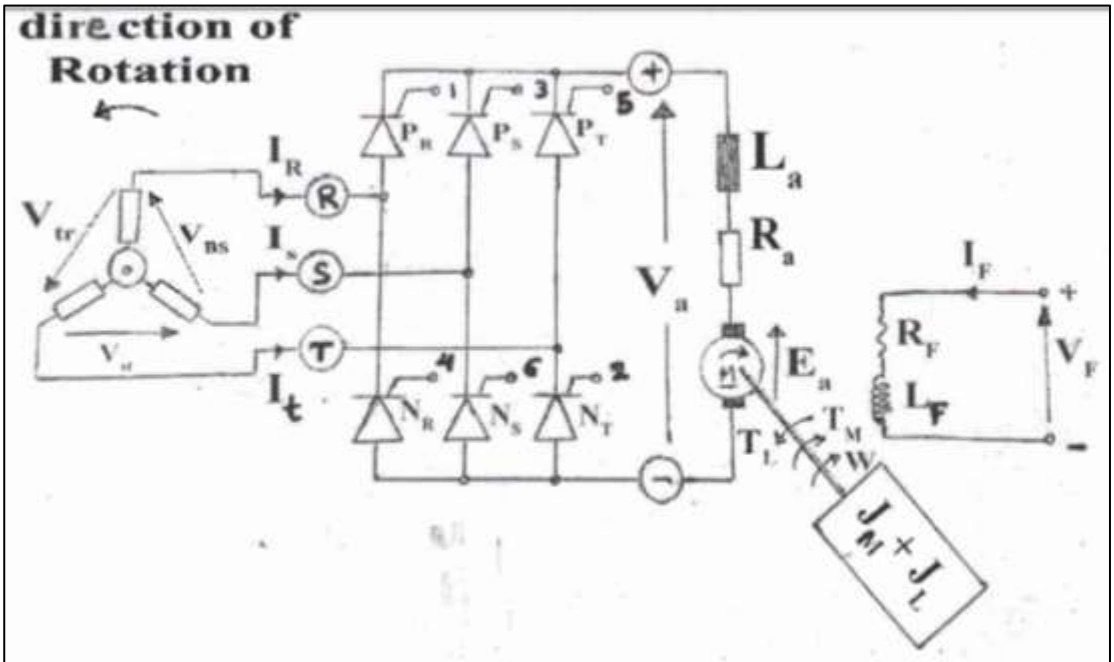


figure (1) Basic configuration of converter-motor system

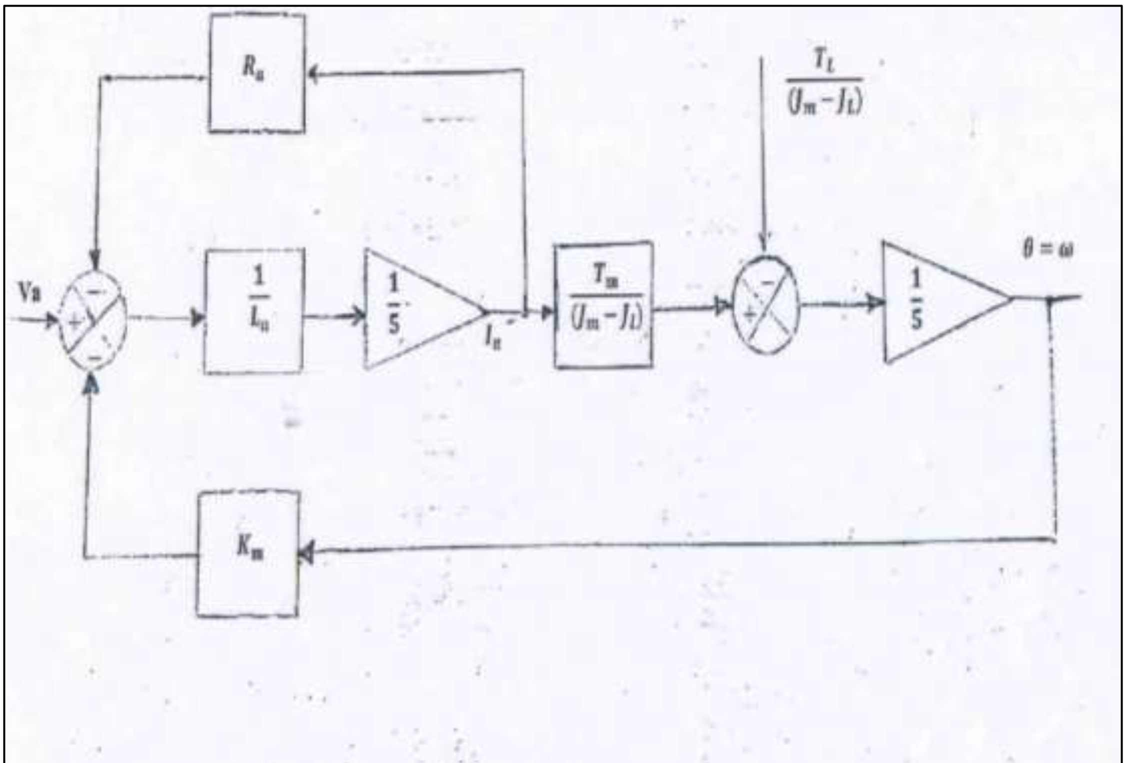


Fig. (2) A model for armature controlled D.C. motor

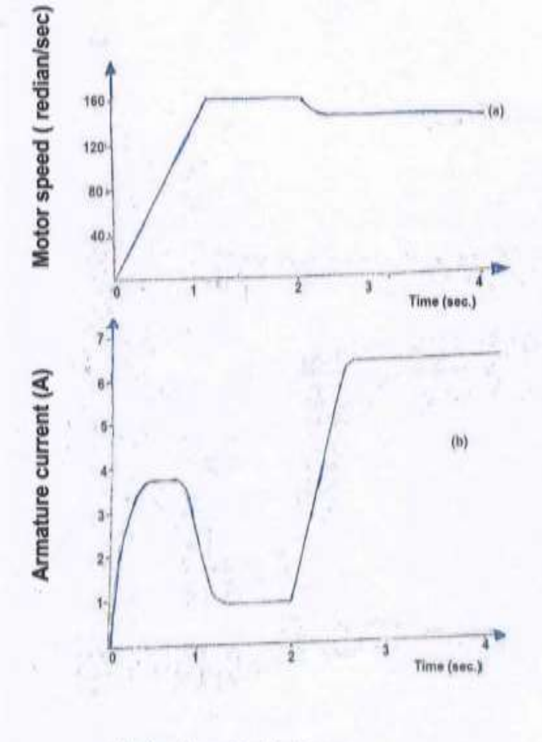


Fig. (4 - a, b ) practical strating -up condition and load of 5 Nm suddenly applied at t=2.00 sec.

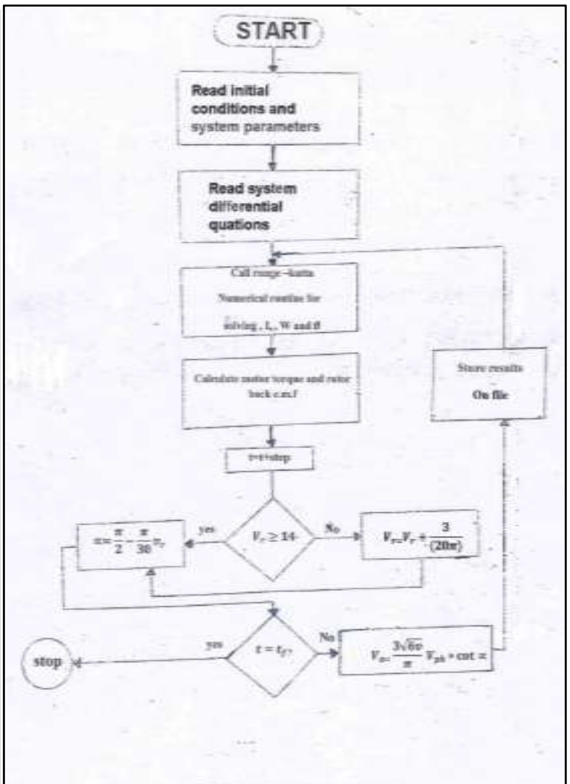


Fig.(3) Flowchart of computer program

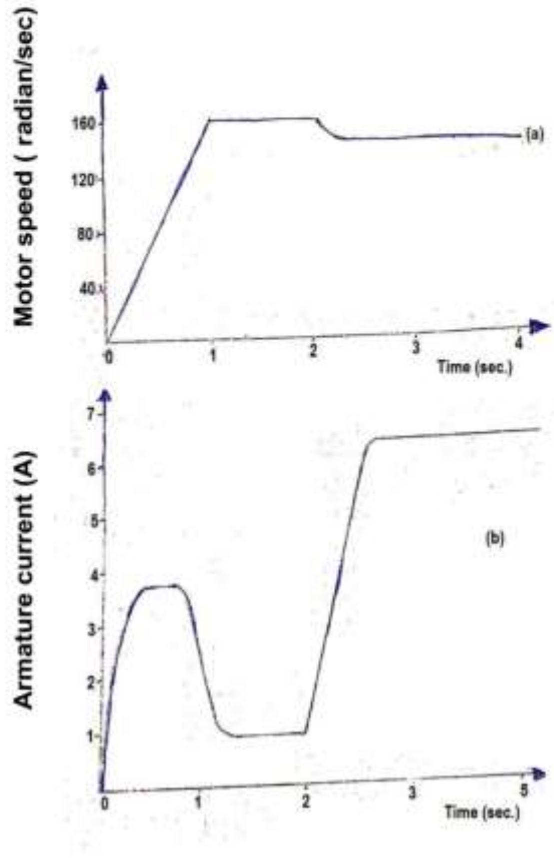


Fig. (5- a, b ) practical results for statring - up condition and load of 5 Nm suddenly applied at t=2.00 sec.

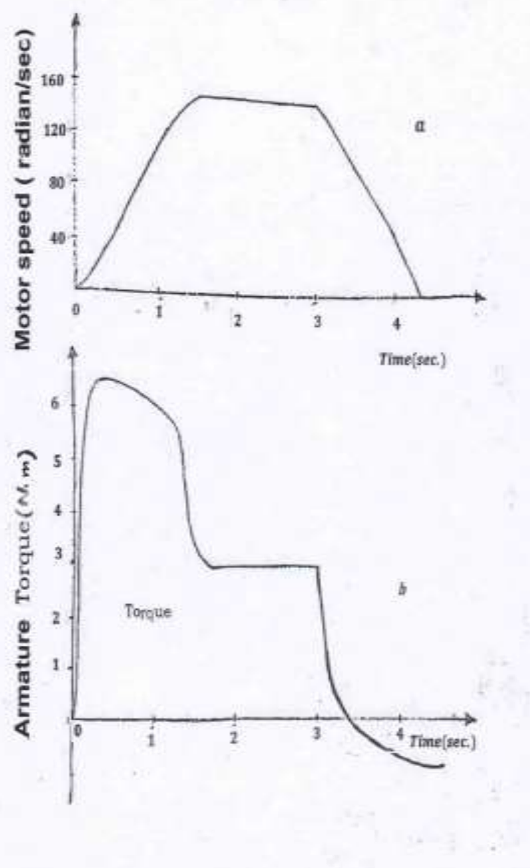


Fig .(6-a,b) computer result for regenerative braking at t=3 sec. and a load of 5 N.m. suddenly applied at t=3 sec.

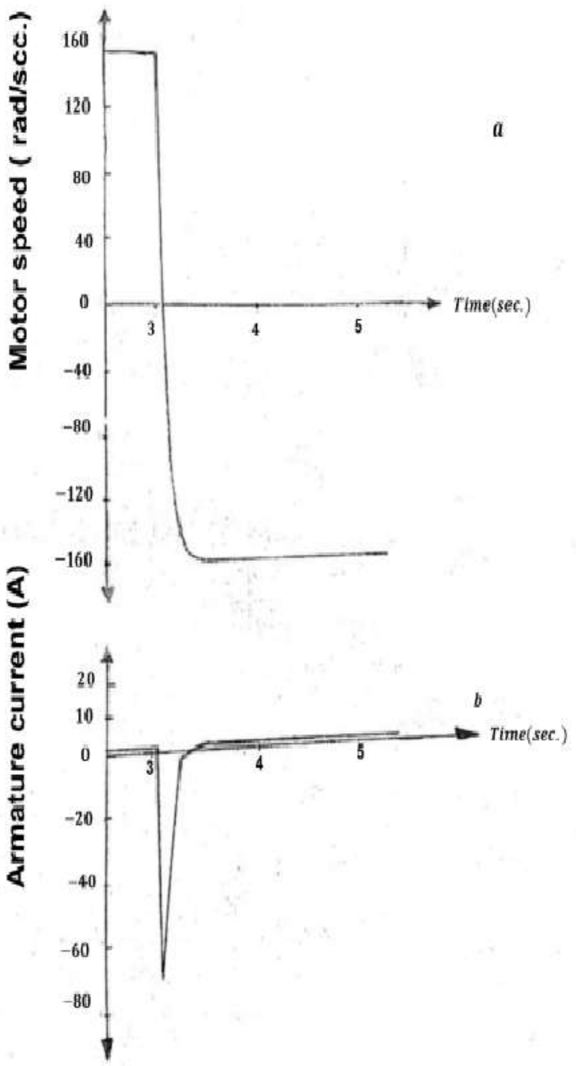


Fig .(7-a,b) computer result for sudden reversing ploarity at no load of and at t=3 sec.