Position and Speed Control of Permanent Magnet Motors, State Space Approach

Seyed Zeinolabedin Moussavi, Aliakbar Rahmani

***Abstract*— Present paper is analyzing the permanent magnet dc motor (PMDC) through state space variables so that command speed without consequence resulted from voltage and power and load fluctuations can be obtained. For this purpose, we should write equations of permanent magnetic motor and then by applying these equations and known methods of control, try for making desirable behavior of these motors, and by using MATLAB software in coding, analyzing real behavior of motor could be possible, and regarding to these results, planning for future of a system in front of short circuit and load fluctuation could be possible. We are trying to reduce dangers resulted from mistakes in experiments.**

***Keywords*- permanent magnetic motor, modern control, efficiency, permanent magnetic motors, control, permanent magnet motor, sensorless, torque fluctuation.**

I. INTRODUCTION

One the most considerable advantages of electrical machines is the ability of speed control. Machines with control speed is widely used in industry, that outstanding examples including: cutting machine for metals, electrical lift, machine for electrical transportation ,printing machines, coal mine and other industries, for example, electrical speed in machine for cutting metal should be coordinated by metal kind, quality of cutting kind , and size of particle.in all mentioned machinery , electrical machines should be equipped with speed control in order to present desirable conditions and best quality .speed control is vital important in industry.[1]

The Greek philosopher by name of Thales ,observed one magnetic material that was natural magnetic ore. This material called magnet because was found in Magnesia on the Minor Asia. This discovery was main factor for improving electric engineering in field of different kinds of electric motors. First permanent magnetic application was in electric machine structure that was related to J.Henry(1831), H.PIxii(1833), W. Ritchie 1833), F. Watkins (1835), T.Davenport(1837) and M.H.Jacobi(1839) work. permanent magnetic used for making magnetic field. These primary magnet was steel that because of lack of required ability ,it changed energy in low rate. This problem, was main reason for replacing magent with copper coil and core of soft iron and permanent magnet deleted in machine structure. In 1931, with making alinko (iron alloy , nicol, kebalt , aluminum) in japan,using permanent magnet in electric machine structure was suggested.[2-3]

II. DIVISION KINDS OF PERMANET MACHINE

At first, permanent magnet used in stator of DC machine. permanent magnet replaced by field coil that this resulted in weight and volume drop in DC machine and deletion of copper wasting of field coil. This new machine named permanent magnetic direct current (PMDC). in commutator machines such as usual DC machines, this matter was applied. commutator and sweeper was main problem in DC machines. these components that limit speed of DC machine and commutation would be done hardly with them and in this case machine would be maintained carefully.for solving this problem, commutator with stator should be replaced. In PMAC machines, commutation is done electrically in coils, thus for defining time of commutation, sensor used for recognizing mode for finding location of rotor. thus instead of deleting sweeper and commutator, sensor and control syste should be used for controlling commutation. Another profit for this deletion is deleting radio wave interfernce. [4-5-6]

III. MATHEMATICAL MODELS IS IN PHYSICAL SYSTEMS

Most dynamic systems such as mechanical, electrical systems could be described by differential equations. Differntial equations could be attained by dominant physical rules on special system ,for example, Newton law are about mechanical system and Kirchhoff law about electrical systems[7-8].for this purpose, you should consider permanent magnetic motors fig(1).Regarding to above-mentioned matter, Newton law could be applied for mechanical part of rotors and Kirchhoff law could be applied in electrical part.

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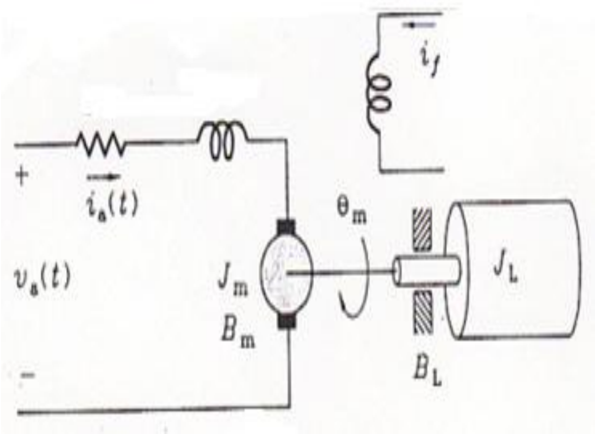


Fig(1): permanent magnet motor

$$V_a(t)=R.I_a+L\frac{di_a}{dt}+V_b(t) \quad (1)$$

$$V_b(t)= K\frac{d\theta}{dt} \quad (2)$$

$$T_e=K_t.I_a \quad (3)$$

$$T_m=T_e=J\frac{d\theta^2}{dt^2}+B\frac{d\theta}{dt} \quad (4)$$

$$V_a(s)=(LS+R)I_a(S)+KS\theta(s) \quad (5)$$

$$K_tI_a(s)=(Js^2+BS)\theta(s) \quad (6)$$

$$I_a(s)=\frac{(JS^2+BS)\theta(S)}{K_t} \quad (7)$$

Replace equation (7) in equation(5) ,and in simulations, rotor angle isn't suitable, because with passing time factor, it's increase appear, and angular speed is used instead of rotor angle and then we can obtain equation (8).

$$\frac{\omega(s)}{V(s)}=\frac{K_t}{JLS^2+(BL+JR)S+(BR+K_tK} \quad (8)$$

IV. PLANNING PRINNCIPLES IN CONTROL SYSTEM

For planing a control system, you should consider following matters:

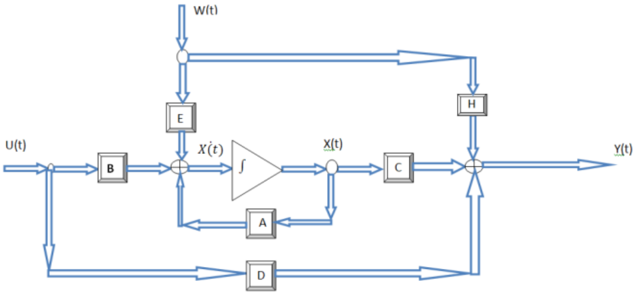
- ever control system should be stable.
- system should have proportional resistance beside absolute resistance, in other word it should be reasonable.
- control system should decrease error rate in reasonable rate.
- controller should consider every effective factor in output variables.
- you should transform control system to mathematical model.

In analyzing and designing modern control system, mode variables in proportion of classic control is considered as new method, because in this method ,most focus is on optimum control. Main character of mode variables method is it's ability for modelling time-factor system, one variant, and multi -variant system. transformation subordinate is defined with linear time in invariant systems. But mode variants including dynamic of system, that aren't appeared in input and output model. In this respect, mode model is called internal description.[9-10] In one invariant system with linear time, dynamic equations of system is written in following form.

$$\dot{X}(t)=AX(t)+BU(t)+EW(t)$$

$$Y(t)=CX(t)+DU(t)+HW(t) \quad (9)$$

Dynamic equation(9) could be drawn in figure(2).This diagram is applicable in simulation of all systems.



Fig(2):diagram simulation systems

V. SPEED CONTROLOF PERMANENT MAGNENT MOTOR

It is one common motive in speed control and permanent magnetic situation that have speed and location of radar motion. In figure (1) , permanent magnetic motor is controlled by armature current. we are planning speed and situation control regarding to transformation subordinate.

motor values be in following form:

$R=1$, $L=0.5$, $K_t=K=0.01$, $B_m+B_l=0.1$, $J_m+J_l=0.01$

We consider dominant conditions of system.

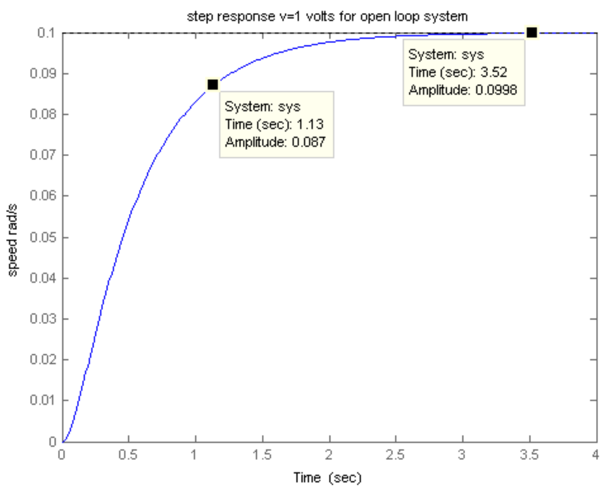
-we should consider error of steady state in one percent because PMM rotating in fixed speed.

-time for achieving speed should be considerd less than 2 seconds.(settling time)

-maximum value for speed change should be considered 5% ,because speed more than usual speed, would damage equipment.(over shoot)

Subordinate for system transformation is equation (8),and open ring system response would be attained by writing order in m-file.

As shown in figure (3) ,time for settling is 3 second and system error is 0.9,and this value is more than predicted values, thus this system should be analyzed accirding to state space. compare these two value with each other.



Fig(3): response open loop

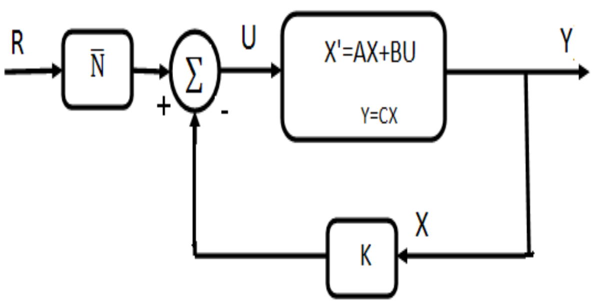
VI. MODEL FOR PERMANENT MAGNETIC MOTOR MODE SPACE

relations from (1) to (7) could be transformed to State Space, that is transformed to equation (10).

$$\begin{cases} \theta = X_1 \\ \dfrac{d\theta}{dt} = X_2 = \dot{X}_1 \\ I_a = X_3 \\ \dfrac{di_a}{dt} = \dot{X}_3 \end{cases} \Longrightarrow \begin{pmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 \\ 0 & \frac{-B}{J} & \frac{-Kt}{J} \\ 0 & \frac{-K}{L} & \frac{-R}{L} \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \\ X_3 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ \frac{1}{L} \end{pmatrix} U(t)$$

$$\begin{pmatrix} \theta \\ I_a \end{pmatrix} = \begin{pmatrix} 1 & 0 & 1 \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \\ X_3 \end{pmatrix} \qquad (10).$$

As it is shown in figure (3), setting time is 3 second, and this value is more than defined value in problem, thus it is required for planning steat controller throught polarization method. In this method ,visibility and contollability is investigated for this matter ,m-file of order are written .For reducing enduring mode error, one fixed reference should be added to the beginning of that. figure(4) and this value could be attained from transformation equation. factor **N** is called rating factor, and for attainig desirable output, reference output should be equal to reference input.



Fig(4):mode space by rating factor

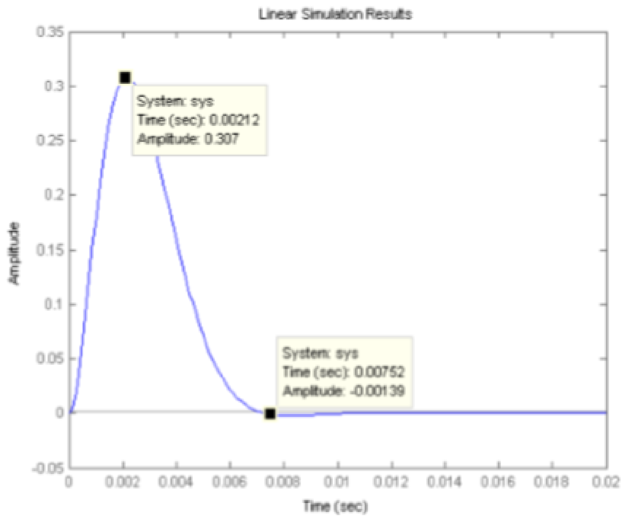
$$U = R\bar{N} - KX$$

$$\dot{X} = AX + BU \Rightarrow \dot{X} = AX + B(R\bar{N} - KX)$$

$$\dot{X} = (A - BK)X + BR\bar{N}$$

$$\frac{\theta(S)}{V(S)} = \frac{K_t}{(JS^2 + BS)(LS + R) + K_t KS} \qquad (11)$$

After defining transformation function(11),figure (4),required orders are written in m-file ,and results are shown in figure(5).



Fig(5):modeling state space permanent magnetic motor

VII. CONCLUSION

Regarding to classic control results(Transfer function) and modern control (state variables) ,it is shown that classic control is related to input and output, in other word it is related to external description of system and there isn't any internal description for it. in controlling pole placement desing method, in case of Controllable system and Observable system, system poles could be located in every points of plan S, state variables are indicator for interior description of system that resulted in error and settling time and if we want to decrease settling time, polarities should be drawn to left side. if poles imaginary part and we want to reduce change rate, imaginary part should be considered smaller than Real part.

FUTURE WORKS

We are going to present suggestive model for permanent magnetic Synchronous motor, that this model in analyzing three phase short connection in termination of motor, showing system transitory faster than any other model.

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