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Application of Matlab/Simulink in Hybrid Stepper Motor Modeling

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ABSTRACT- Development of digital electronics and microprocessor systems has led to development of electrical motors capable to be digitally controlled. These motors are widely known as stepper motors and the enable transformation of pulsed electrical excitation into mechanical energy. Matlab/Simulink is used as a simulation tool for hybrid stepper motor enabling motor transient characteristics of current, voltage, torque and speed to be obtained. Different operating motor regimes are simulated as no-load and rated load operation. Adequate conclusions regarding motor performance characteristics are derived.

INTRODUCTION:

Introduction to Stepper Motors

Stepper motors are very important in robotics, process control and instrumentation. They enable precise control of motor angular position, speed and direction of motor rotation. They are capable of discrete precise movements i.e. movements in precise steps so they are named as 'stepper motors'. Stepper motors are transforming electrical energy (excitation) into mechanical movement. They are constructed as rotating or translating motors. Although stepper motor are known for a long time, they have achieved their wide popularity in the last thirty years due to development of electronics which enables construction of cheap and reliable control circuits capable to satisfy complex requirements regarding motor torque, speed and angular displacement. In order their transient performance characteristic to be analyzed Matlab/Simulink is chosen as simulation tool and motor characteristics are analyzed under different operating regimes: no-load, rated load and over load. Advantages of stepper motors are: low costs, small dimensions, possibility to transform the pulses from digital inputs into angular movement-step, number of steps is equal to the number of control pulses. The above

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mentioned advantages have lead to their wide application in control systems and robotics and have made them irreplaceable moving force of industrial processes.

Hybrid Stepper Motor-Construction and Principle of Operation

Hybrid stepper motors have magnetic core which is excited by combination of electrical windings and permanent magnet. Electrical windings are placed on stator while rotor is made of permanent magnets (Fig. 1). Number of poles at stator are usually eight and each pole has two to sex teethes. Per pair of poles are placed two excitation windings for example one winding for pole 1,3,5 and 7 and another for pole 2,4,6 and 8 [1].

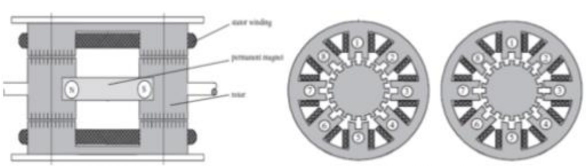

Fig 1: Construction of hybrid stepper motor

ELECTRIC MOTORS

INTRODUCTION

This section describes the main features of the electric motors.

WHERE MOTORS ARE USED

An electric motor is an electromechanical device that converts electrical energy to mechanical energy. This mechanical energy is used for, for example, rotating a pump impeller, fan or blower, driving a compressor, lifting materials etc. Electric motors are used at home (mixer, drill, and fan) and in industry. Electric motors are sometimes called the "workhorses" of industry because it is estimated that motors use about 70% of the total electrical load in industry.

HOW A MOTOR WORKS

The general working mechanism is the same for all motors (Figure):

- An electric current in a magnetic field will experience a force.
- If the current carrying wire is bent into a loop, then the two sides of the loop, which are at right angle to the magnetic field, will experience forces in opposite directions.
- The pair of forces creates a turning torque to rotate the coil.
- Practical motors have several loops on an armature to provide a more uniform torque and the magnetic field is

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produced by electromagnet arrangement called the field coils.

In understanding a motor it is important to understand what a motor load means. Load refers to the torque output and corresponding speed required. Loads can generally be categorized into three groups (BEE India, 2004):

- Constant torque loads are those for which the output power requirement may vary with the speed of operation but the torque does not vary. Conveyors, rotary kilns, and constant-displacement pumps are typical examples of constant torque loads.
- Variable torque loads are those for which the torque required varies with the speed of operation. Centrifugal pumps and fans are typical examples of variable torque loads (torque varies as the square of the speed).
- Constant power loads are those for which the torque requirements typically change inversely with speed. Machine tools are a typical example of a constant power load.

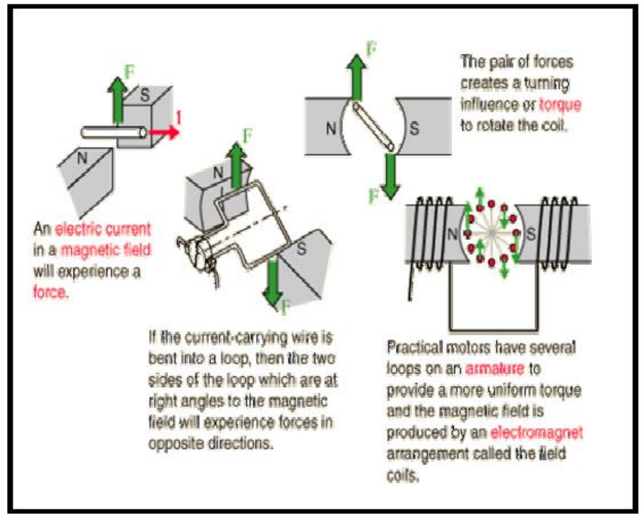

Figure 2.1: Basic Principle of how Electric Motors Work

TYPES OF ELECTRIC MOTORS

This section describes the two main types of electric motors: DC and motors.

Figure shows the most common electric motors. These are categorized based on the input supply, construction, and operation mechanism, and are further explained below.

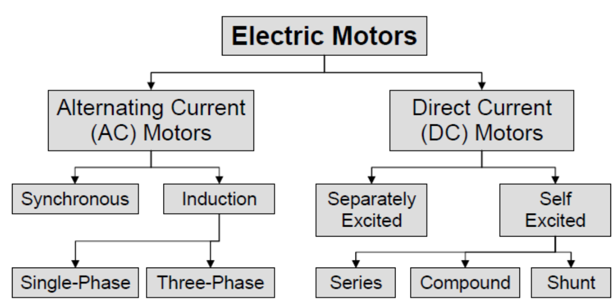

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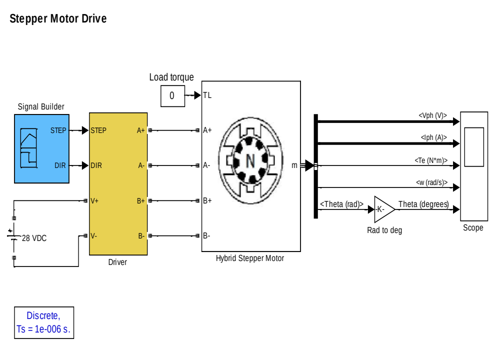
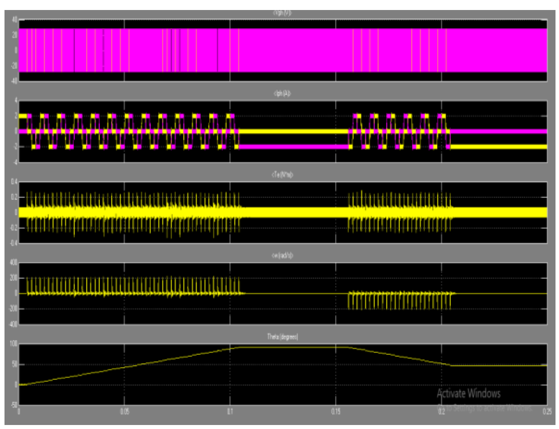
Figure 2.2: Classification of the Main Types of Electric Motors

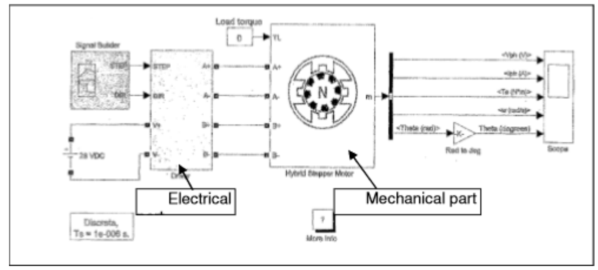
Simulink Model of Hybrid Stepper Motor





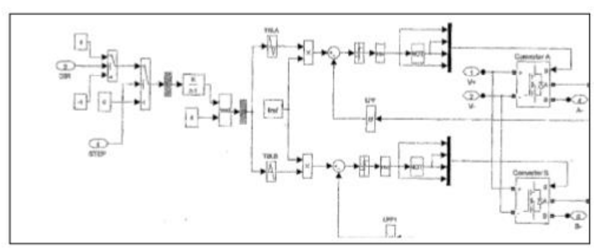
Hybrid stepper motor is operating due to electronically commutated magnetic field which enables rotor movement. All excitation windings are placed at stator while motor rotor is constructed of permanent magnet or soft magnetic material.

In Fig. is presented block diagram of motor simulation model constructed of three basic locks: controller, driver and motor.



Simulink model from Simulink demo library is presented in Fig.3 and it is consisted of two sections: electrical and mechanical [4]. According to Simulik model motor input parameters are: phase voltage (A+, A-, B+ and B-) and mechanical load –TL

Output parameters from motor model are: phase current-Iph, electromagnetic torque-Te, and rotor speed-w and rotor position-theta. Electrical part or motor control circuit is consisted of three functions entities: control block, hystersis comparator and MOSFET PWM converter



Motor movement is controlled by two signals: STEP and DIR which are output signals from block Signal Builder. Positive value (value of ‘1’) of signal STEP enables motor rotation while value ‘0’ stops the rotation. DIR signal controls the direction of

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motor rotation. Positive value (value of '1') enables rotation in one direction while value of '0' reverses the direction of rotation. Converter bridges "A' and "B' are H bridges consisted of four MOSFET transistors. Bridges are supplied by 28 V DC and their outputs supply the motor windings with excitation current and enable the motor movement.

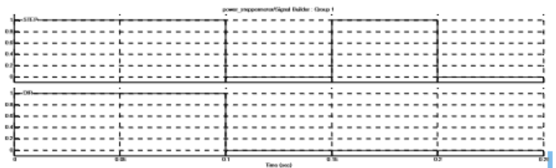
Fig. 5 Output signals from Signal builder block

. Simulation results After all motor parameters are input in motor model simulation is run. Time for simulation execution in is defined to be 0,25 seconds according to the signals from Signal Builder block and set time in Simulink model. First simulation is run at no-load operation or motor is running without any load. From the simulation results presented in Fig. 6 it can be concluded that motor is moving in one direction for 0,1 seconds (STEP=1 and DIR=1), stops in period from 0,1 to 1,5 s (STEP=0, DIR=0) 0,05 seconds is rotating in opposite direction (STEP=1, DIR=0) and again it stops for 0,05 seconds (STEP=0 and DIR=0). Motor transient performance characteristics are presented in Fig. 6 for no load operation.

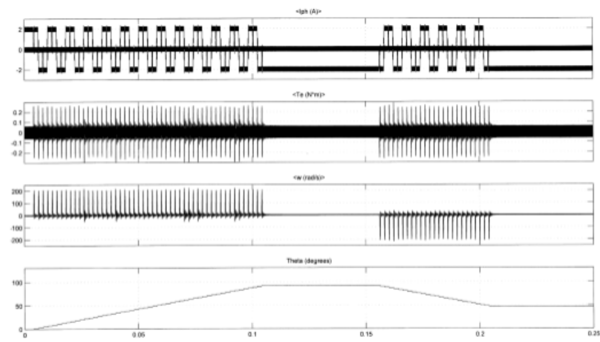
Fig. 6 Motor transient performance characteristics at no-load

CONCLUSION

Different simulation software packages during recent years have proved itself as a useful tool in analyses of electro engineering problems. Simulink with its extensive block libraries enables wide possibilities for electrical machines simulation. In this paper is analyzed simulation of hybrid stepper motor transient performance characteristics under different operating regimes: no-load, rated load and overload. Simulation results proved that motor is running in forward and backward direction according to the applied signals from PWM inverters to the excitation windings and only in case when applied load is smaller than motor electromagnetic torque. In case when external load is bigger than motor electromagnetic torque no rotor movement is achieved and motor speed is rapidly going to zero very shortly after motor start. Application of simulation packages has considerably improved electrical machines analysis replacing the expensive laboratory equipment and enabling performing of different experiments easy and with no cost.

REFERENCES

[1] D.P. Atherton, G.W. Irwin, "Stepping Motors a guide to theory and practice", 4th Edition, The institute of Enginering and Technology, 2007.

[2] Q.B. Al-Sabbagh, A.S. Mahdi, " Pulse width modulation for high performance hybrid stepper motor, Journal of Engineering, Nr. 4, Vol.16, December 2010, p.p. 6028-6047

[3] W.H. Yeadon, A.W. Yeadon "Handbook of small electric motors", McGraw Hill,2003

[4] Matlab/Simulink , User's Manual, Mathworks 2007