

SPEED CONTROL OF DC MOTOR USING COMBINED ARMATURE AND FIELD CONTROL

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ABSTRACT

The aim of this investigation is to describe the principle of DC motor speed control using nonlinear combined control (armature voltage and field current). For the armature control mode, the field current is held constant and an adjustable voltage is applied to the armature. In the field control mode, the armature voltage is held constant and an adjustable voltage is applied to the field. The mathematical model of a separately excited DC motor (SEDM) with independent armature/field control can be obtained by considering the electrical system, electromagnetic interaction and mechanical system. Simulation models of DC motor speed control methods and feedback control system for DC motor drives have been developed using MATLAB/Simulink.

1. INTRODUCTION

DC motors consist of rotor-mounted windings (armature) and stationary windings (field poles). In all DC motors, except permanent magnet brushless motors, current must be conducted to the armature windings by passing current through carbon brushes that slide over a set of copper surfaces called a commutator, which is mounted on the rotor.

The commutator bars are soldered to armature coils. The brush/commutator combination makes a sliding switch that energizes particular portions of the armature, based on the position of the rotor. This process creates north and south magnetic poles on the rotor that are attracted to or repelled by north and south poles on the stator, which are formed by passing direct current through the field windings. It's this magnetic attraction and repulsion that causes the rotor to rotate.

The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage and/or the field current will change the rotor speed.

Today, adjustable frequency drives can provide precise speed control for AC motors, but they do so at the expense of power quality, as the solid-state switching devices in the drives produce a rich harmonic spectrum. The DC motor has no adverse effects on power quality.

The dynamic behavior of the DC machine is mainly determined by the type of the connection between the excitation winding and the armature winding including the commutation and compensation winding:

- **Separately excited DC machine:** excitation and armature winding supplied at separate voltages.
- **Shunt DC machine:** excitation and armature winding are connected in parallel (i.e. fed by the same source).
- **Series-wound machine:** the excitation and the armature winding connected in series; if the stator is laminated, series-wound machines can operate at AC current.
- **Compound machine:** This is a combination of shunt DC machine and series-wound machine (both shunt and series winding are available).

In special cases shunt-, series-, and separate excitation can be combined

There are three methods of controlling the speed of the shunt and separately excited dc motor, armature voltage speed control, field flux speed control and armature resistance speed control (speed may be controlled by changing R_a).

2. VOLTAGE SPEED CONTROL OF A SEPARATELY EXCITED DC MOTOR

The field current, i_f , is constant (and hence the flux density B is constant), and the armature voltage is varied. A constant field current is obtained by separately exciting the field from a fixed dc source. The flux is produced by the field current, therefore, essentially constant. Thus the torque is proportional only to the armature current.

3. FIELD SPEED CONTROL OF A SEPARATELY EXCITED DC MOTOR

We can also control the dc motor, that is vary its speed by varying the field flux. The method of control is generally used when the motor has to run above its rated speed. To understand the operation of field control suppose that the dc motor running at a constant speed. If the field current is reduced by reducing the voltage across the field coil, the flux density will be reduced. This will reduce the back emf instantaneously and will cause armature current to increase resulting in the motor speed increasing. Consequently the back emf will increase and a new equilibrium will be established at a higher speed. With field control one can achieve as high a speed as five times the rated speed.

The armature current, i_a , is kept constant and the flux density B is varied by varying i_f .

4. COMBINED ARMATURE AND FIELD CONTROL OF SEDM

The speed of a separately excited dc motor could be varied from zero to rated speed mainly by varying armature voltage in the constant torque region. Whereas in the constant power region, field flux should be reduced to achieve speed above the rated speed. Torque and limitations in combined armature voltage and field control can be shown in figure 1.

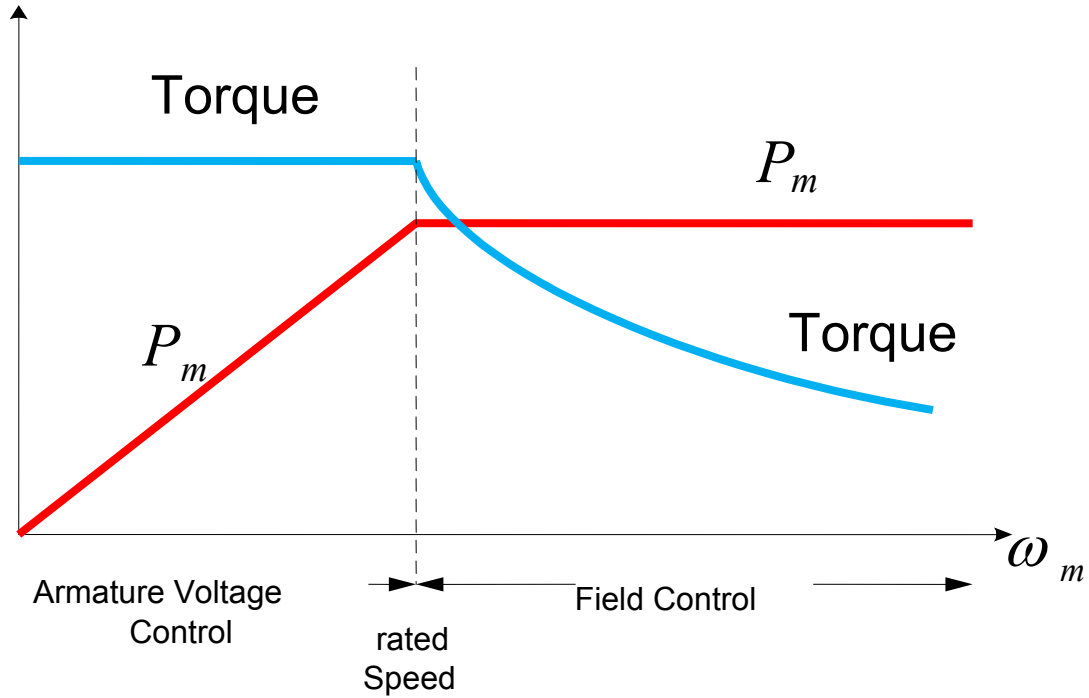


Fig. 1: Combined armature voltage and field current control

5. MODELING AND CONTROL OF SEDM USING MATLAB/SIMULINK

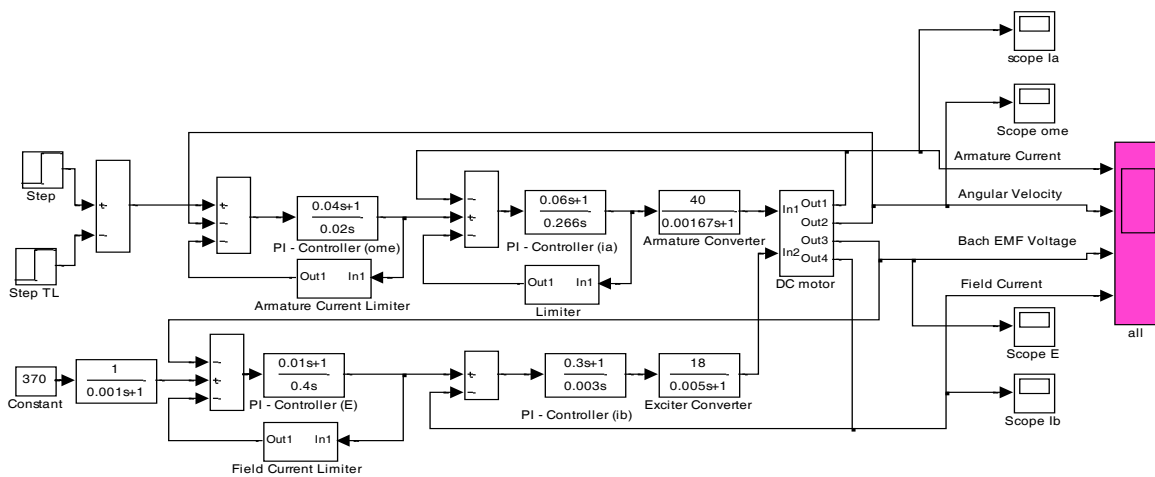
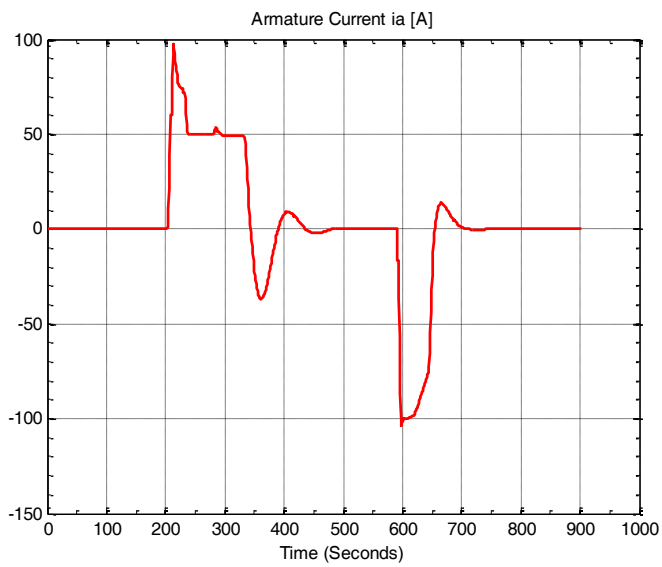
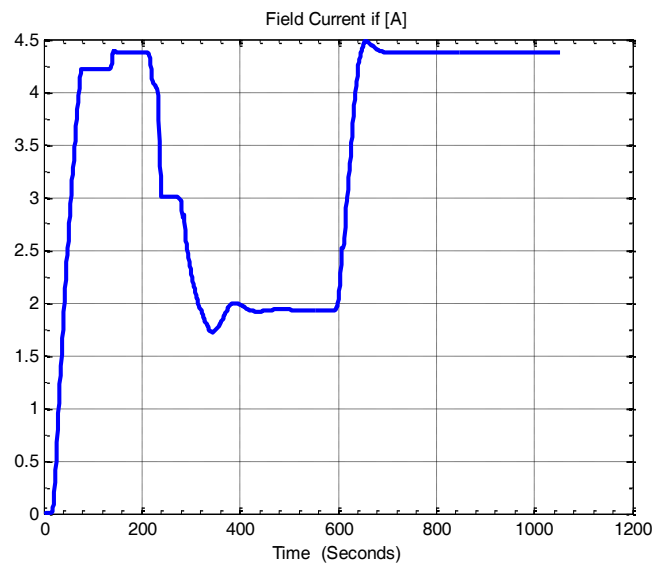


Fig. 2: Block diagram of combined armature voltage and field current control

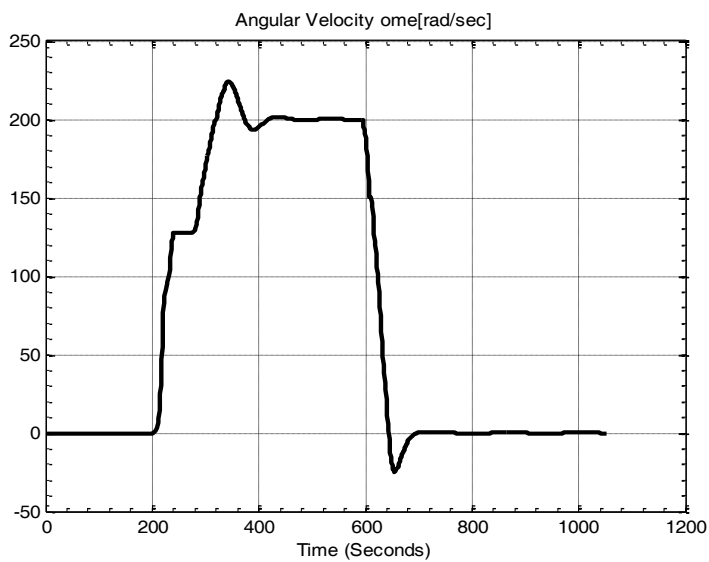


a)

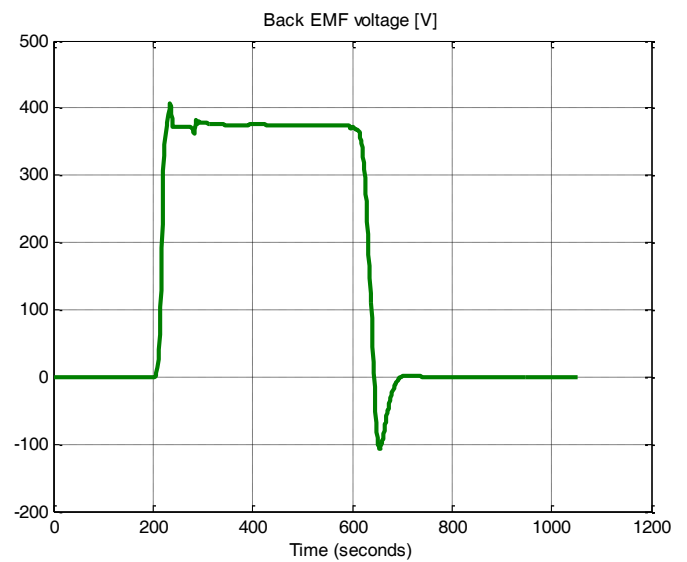


b)

Fig. 3: a) Step response of armature current b) Step response of field current



a)



b)

Fig. 4: a) Angular velocity step response b) Back EMF voltage Step response

6. CONCLUSION

Non-linearity of the combined field and armature control system has been studied and carried out using Matlab/Simulink. A DC motor drive for the armature and associated field winding of the motor includes an armature feedback loop responsive to the current flow in the armature, an input command signal such as a speed control signal, and the actual speed of the armature for providing a control of the current supplied by a DC source means to the armature to thereby provide speed control of the motor. A field feedback loop control is also provided and includes means responsive to the voltage across the armature and to the line voltage supplied to the armature for providing a control of the field intensity to assure that the back EMF of the armature is always less than the available DC voltage supplied to the armature. This dual feedback control provides for a faster response time of the armature throughout its total speed range together with the feature of a constant torque for different speeds.

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