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Speed Generation and Control of DC Motor Using Neural Network Configuration

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ABSTRACT

The mechanical energy generated by a DC rotating machine (motor) is proportional to the armature current and the strength of the magnetic field. Based on the mathematical model of a DC rotating machine, a simplified model using Mat lab/Simulink is presented in this study. The simulation results and analyses of the machine output with loading and unloading condition is discussed in detail. The speed of DC motor is estimated and controlled using the concept of ANN. The Neural Network scheme consists of two parts: one is the neural estimator, which is used to estimate the motor speed and the other is the neural controller, which is used to generate a control signal for a converter. Simulation results are presented to demonstrate the effectiveness and advantage of control system of DC motor with ANNs in comparison with the conventional control scheme.

I. Introduction

In modern electrical machine industry productions, DC rotating machines (motors) are rapidly gaining popularity, due to performance optimization, simple structure and high reliability output torque. The development of high performance motor drives is very important in industrial applications. Generally, a high performance motor drive system must have good dynamic speed command tracking and load regulating response.

D.C motors have long been the primary means of electric traction. D.C motor is considered a SISO system having torque or speed characteristics compatible with most mechanical loads. This makes a D.C motor controllable over a wide range of speeds by proper adjustment of its terminal voltage. Recently, brushless D.C motors , induction motors , and synchronous motors have gained widespread us e in electric traction. However, there is a persistent effort towards making them behave like dc motors through innovative design and control strategies . Hence dc motors are always a good proving ground for advanced control algorithm because the theory is extendable to other types of motors. Many practical control issues (motor control problems):

1) Variable and unpredictable inputs
2) Noise propagation along a series of unit processes
3) Unknown parameters
4) Changes in load dynamics

Under these conditions, the conventional constant gain feedback controller fails to maintain the performance of the system at acceptable levels. The incorporation of feed forward in artificial neural networks is important for several reasons the dynamical properties of the system, and in practice it may imp rove the performance. They are generally present in most non -linear dynamical system and can be used to implement specific structures. Advantages of using ANNs:

1) Learning ability
2) Massive parallelism
3) Fast adaptation
4) Inherent approximation capability
5) High degree of tolerance Speed control techniques in separately excited dc motor:
1) Varying the armature voltage in the constant torque region.
2) In the constant power region, field flux should be reduced to achieve speed above the rated speed.

A. Operation of DC Rotatatig Machine (motors)

DC rotating machine can generates mechanical energy by creating an interaction between a fixed and rotating magnetic field. The fixed field is supplied by high energy permanent magnets. The rotating field is created by passing a DC current through several different windings on the armature (rotating part) and timing which winding is powered through a device called a commutator. Power is supply to the armature by brushes which ride on the commutator. To understand how the machine responds to load, the machine is divided into four major components. These components are the ideal machine, back e m f (electromotive force), resistance and inductance. These parts are really not physically separable, but for modelling purposes this is important and convenient. DC rotating machine (motor) can be turned into a DC rotating machine (generator) simply by turning the shaft. When a machine rotates due to supply voltage, it generates back e m f which opposes the supply voltage. The difference between the supply voltage and the back e m f is the net voltage that the machine actually sees. As the mechanical load on the DC rotating machine is increased, the machine slows down, back e m f is reduced and the net voltage that the machine sees increases. It turns out that the actual machine current is determined by the difference between the supply voltage and the back e m f divided by the resistance. When the machine speed is zero and back e.m.f will therefore be zero. The amount of current generated is controlled by the resistance, and if the resistance is small, the resultant current is much higher than it would be under normal running conditions.

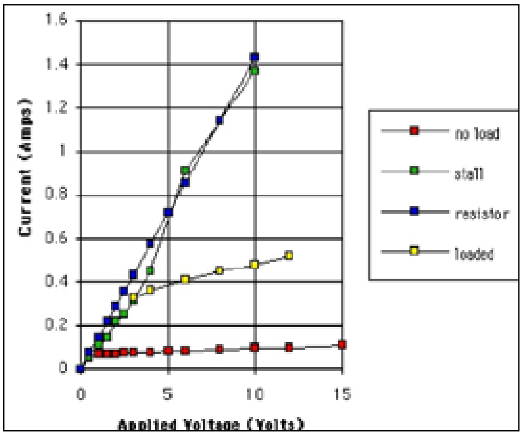


Fig 1 Relationship between Machine Current and voltage

Figure 1 shows, at no load the machine is able to turn fast, allowing the back e.m.f to be almost equal to the supply voltage. As the load increased the slow down and draw more current from the supply voltage. In this case, the graph shows that increasing load causes increasing current.

B. Mathematical Model of a DC Rotating Machine

The use of mathematical models can speed up design processes, and minimize the time wasted on trial and error design methods. Two balanced equations can be developed by considering the electrical and mechanical characteristics of the system. The equivalent electrical circuit of DC rotating machine is illustrated in Figure 2. The circuit has a voltage source VS across the coil of the armature. The armature coil can be described by a resistance R in series with inductance L in series with an induced voltage VB which opposes the voltage source. The induced voltage is generated by the rotation of the electrical coil through the fixed flux lines of the permanent magnets. This voltage is often referred to as the back e.m.f.

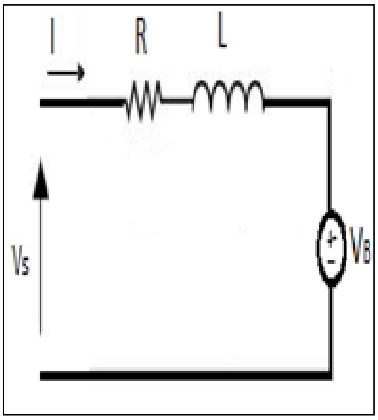


Fig 2 Equivalent Circuit of DC Rotating Machine

According to Ohm's law, the voltage across the resistor R, inductance l and the back e.m.f VB can be represented as

Vs = IR + Ldi/dt + VB

The voltage induced in the machine armature can be calculated for any rotational speed by multiplying the KB

(Voltage Constant) by the rotational speed of the armature

VB =KB W

Vs = IR + Ldi/dt + KB W

By taking the derivative of the current with respect to time. The induced voltage (back e.m.f) opposes the voltage

di/dt = 1/L [VS - RI - KB W]

I = (integral)1/L[VS - RI - KB W]

C. Mat lab Model Of Dc Rotating Machine using ANN :

The separately excited DC motor is described by the following equations:

KFωp (t) = – Ra ia(t) – La[d ia(t)/dt] + Vt (t)...............(1)

KF ia (t) = J [dωp (t)/dt] + Bωp (t) + T L(t)…………..(2)

Where,

ωp (t) - rotor speed (rad/s)

Vt (t) - terminal voltage (V)

ia (t) - armature current (A)

TL (t) - Load torque (Nm)

J - Rotor inertia (Nm2)

KF - torque & back e.m.f constant (NmA -1)

B - Viscous friction coefficient (Nms)

Ra - armature resistance (Ω)

La - armature inductance (H)

From these equations mathematical model of the DC

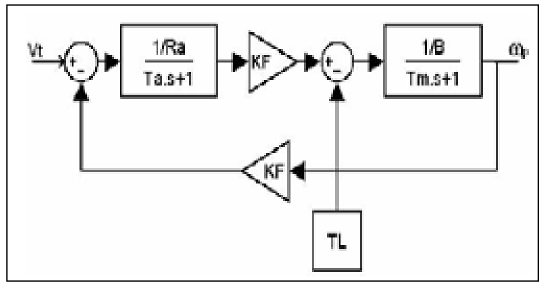
Motor can be created when,

Ta -Time constant of motor armature circuit and

Ta =La/Ra (s)

T m – Mechanical time constant of the motor

T m=J/ B (s)



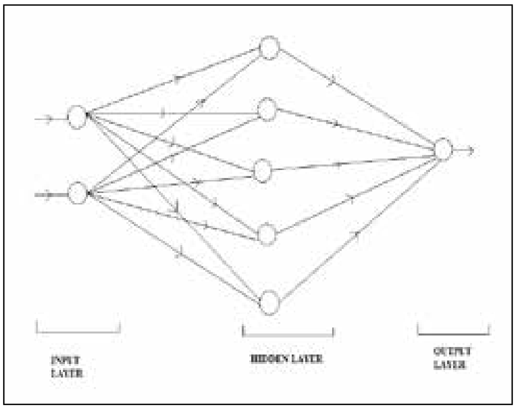
II. conventional dc drivers

Conventional direct current electric machines and alternating current induction and synchronous electric machines have traditionally been the three corners tones serving daily electric motors needs from small household appliances to large industrial plants. Recent technological advances in computing power and motor drive systems have allowed an even further increase in application demands on electric motors . Through the years, even AC power system clearly winning out over DC system, DC motors still continued to be significant fraction in machinery purchased each year. There were several reasons for the continued popularity of DC motors. One was the DC power systems are still common in cars and trucks. Another application for DC motors was a situation in which wide variations in speed in needed. Most DC machines are like AC machines in that they have AC voltages and currents within them, DC machines have a DC output only because a mechanism exists that converts the internal AC voltages to DC voltages at their terminals . The greatest advantage of DC motors may be speed control. Since speed is directly proportional to armature voltage and inversely proportional to the magnetic flu x 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 s o 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

III. THE control system of dc motor using ann

A neural net work is a generalized approach of making the learning algorithm and making a decision for accurate controlling operation in various applications . The approach of neural network basically works on the provided priory's information and makes a suitable decision for a given testing input based on the provided training in formation. This approach is analogous to the human controlling approach where all the past observations are taken as the reference information and are used as a decision variable. To obtain such estimation in current DC motor controlling approach the current DC motor drives are to be improved using such a learning approach. In this paper a dual level neural network approach is designed for DC machine speed controlling. A dual level modeling provides a faster training and converging as compared to a single level neural mode ling. For the realization of a dual level neural modeling, two -neuro architecture namely ANN-control and ANN-train is proposed. The 2 models of the control system of DC motor using

ANNs is built withANNtra in, and ANN control unit where the network are trained to emulate a function: ANN-train to estimate the speed, ANN-control to control terminal voltage.[1,2,3]



IV. the structure and learning of ann

ANNs have been found to be effective systems for learning discriminates for patterns from a body of exa mples [5]. Activation signals of nodes in one layer are trans mitted to the next layer through links which either attenuate or amplify the signal. ANNs are trained to emu late a function by presenting it with a representative set of input/output parts of functional patterns. The back- propagation training technique adjusts the weights in all connecting links and thresholds in the nodes s o that the difference between the actual output and target output are minimized for all given training patterns [1]. In designing and training an ANN to emulate a function, the only fixed parameters are the number of inputs and outputs to the ANN, which are based on the input/output variables of the function. It is also widely accepted that maximum of two hidden layers are sufficient to learn any arbitrary nonlinearity [4]. However, the number of hidden neurons and the values of learning parameters , which are equally critical for satisfactory learning , are not supported by such well established s election criteria. The choice is usually based on experience. The ultimate objective is to find a combination of parameters which gives a total error of required tolerance a reasonable number of training sweeps.[6,7]

Network	ANN 1	ANN 2
Number of input	3	4
Number of output	1	1
Number of hidden layer	1	1
Number of hidden neurons	3	4
Number of training patterns	1215	1215

The ANN1 and ANN2 structure consists of an input layer, output layer and one hidden layer. The input and hidden layers are tensing - sigmoid activation functions, while the output layer is a linear function. Three inputs of ANN are reference speed ωr(k), terminal voltage Vt (k-1) and armature current ia (k-1). And output of A NN1 is an estimated speed ωp* (k). The A NN2 has four inputs : reference s pee d ωr(k), terminal voltage Vt(k-1), armature current ia(k-1) and an estimated speed ωp*(k) fro m ANN-1. The output of ANN is the control signal for converter Alpha.

V. identification of dc motor MODEL: [8,9]

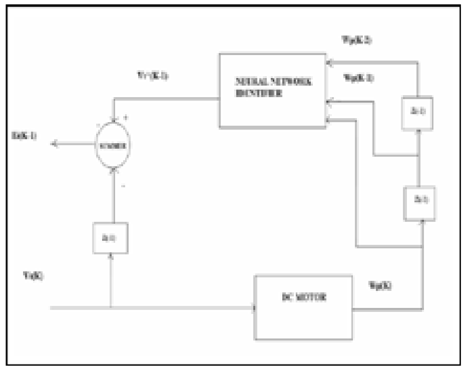
The equation can be manipulated to the form;

Vt(k) = g[W p(k+1), W p(k), W p(k -1)]

Where the function g[.] is given by;

g[W p(k+1), W p(k), W p(k -1)] = { W p(k+1) - α W p(k) - β W p(k-1) - [s ign (W p(k))]
Wp 2(k) - [s ign (W p(k -1))] W p 2(k -1) }/ ;

And is assumed to be unknown. An ANN is trained to emu late the unknown function g[.].
However as W p(k+1) cannot be readily available.



I. output

Specifications of the motor used:- separately excited dc motor with name plate ratings of 1 hp,220V,550 rpm is used in all simulations. Following parameter values are associated with it.

J=0.068 Kgm2

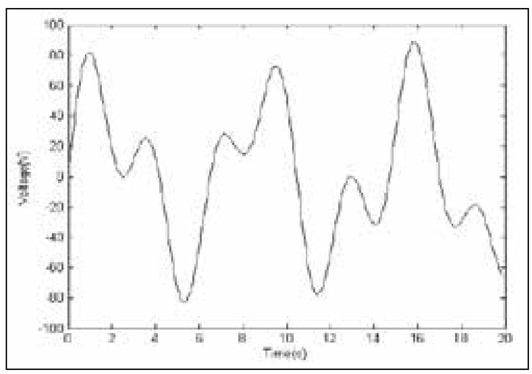
K=3.475 Nm A-1

Ra= 7.56 Ω

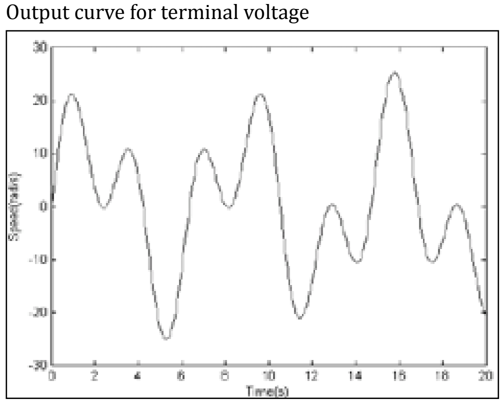
La=0.055 H

D=0.03475 Nms

T=40ms



Output curve for terminal voltage



Output curve for the rotor s peeds

Vi. conclusion

Electric machines are used to generate electrical power from power plants and provide mechanical work in industries. The DC machine is considered to be basic electric machines. The DC motor has been success fully controlled using an A NN. Two ANNs are trained to emulate functions: estimating the speed of

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DC motor and controlling the DC motor, Therefore, ANN can replace speed sensors in the control system models. Using ANN, there is no need to calculate the parameters of the motor when designing the system control. It has shown an appreciable advantage of control system using ANNs above the conventional one, when parameter of the DC motor is variable during the operation of the motors. The satisfied ability of the system control with ANNs is much better than the conventional controller. ANN application can be used in adaptive controls for machines with complicated loads.

REFERENCE

[1] Moleykutty, G. (2008). Speed Control of Separately Excited DC Motor. American Journal of Applied Sciences 5, 227-233. | [2] S.Wee rasoorya and M.A Al-Sharkawi "Identification and control of a DC Motor using b ac k-p rop agation neural networks " IE EE transactions on Energy Conversion, Vo l.6, No.pp663-669, December 1991 | [3] Neural Network Controller" , IEEE Control System Magazine, pp.17- 20,1988. | [4] B. Kosko, Neural Network s and Fuzzy Systems, Pr entice- Ha ll International Inc,1992 | [5] E. Levin, R. Gewirtzman, and G.F.nbar, "Neural Network Architecture for Adaptive System Modeling and Control", Neural Networks , No 4(2) pp185-191,1991. | [6] Parthasarathy, K., & Narendra, K. (March, 1990). Identification and Control of dynamica l systems using neural networks . IEEE Transactions on Neural Network s, volume-1 , 4-27. | [7] J . Santana, J. L. Naredo , F. Sandova l, I. Grout, and O. J . Argueta, Simulation and construction of a speed control for a DC series motor ," Mechatronics , vo l. 12, issues 9-10, Nov. - Dec. 2002, pp. 1145-1156 | [8] Zilkova, J., Timko, J., & Girovsky, P. (2006). Nonlinear Sys tem Control Using Neural Networks .Acta Polytechnica Hungarica, Vol.3; No.485-94. | [9] Liu, Z., Zhuang, X., & Wang, S. (2003). Speed Control of a DC Motor using BP Neural Networks .IEEE Transactions , 832-835. | |