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Brushless DC Motor Drive during Speed Regulation with Artificial Neural Network Controller

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ABSTRACT
Brushless DC motor, at this moment is extensively used being many industrial functions due to the different features like high efficiency and dynamic response and high speed range. This paper is proposing a technology named as Artificial Neural Network controller to control the speed of the brushless DC motor. Here the paper contributes an analysis of performance Artificial Neural Network controller. Because it is difficult to handle by the use of conventional PID controller as BLDC drive is a nonlinear. Through PID controller, the speed regulation of BLDC is not efficient and reliable as PID controller cannot operate the large data, results it gives different variation in BLDC motor control. The ANN easily trains the data of large amount by NN toolbox. As ANN controller has the strength to indulge characteristics of control and it is accessible to operate the huge amount of data as like human can store in a mind. The empirical results prove that an ANN controller can better control the act than the PID controller. The modelling, control and the simulation of the BLDCM get done by applying MATLAB/SIMULINK software kit.
Keywords: BLDC motor or BLDCM, ANN Controller, Proportional Integral Derivative (PID) Controller, NN Toolbox.

I. INTRODUCTION

BLDC motor is consistently determined as a Permanent Magnet Synchronous motor along a trapezoidal back EMF waveform shape. The word "Brushless DC motor" is commonly identifies the sequence of machines of AC, position sensor of the rotor, and solid-state inverter that outcomes in a drive system having characteristics of linear torque. BLDC motor is only one type of motor which is attaining demands. BLDC motors in others situations changes conventional dc motors. Against the term, BLDC motors are genuinely a type of permanent magnet synchronous motors. They are directed by DC voltage although the current commutation is executed by the solid state switches. The commutation prompts are tenacious by the rotor position and the position of the rotor is revealed either by position sensors or by Sensor less techniques.

BLDC motors includes many advantages by conventional DC motors like long operating life, dynamic response is high, efficiency is high, speed vs. torque characteristics is improved, operation of noiseless, speed range is high, torque-weight ratio is also high. The rise in the energy cost urges higher appeals of variable speed PM motor drives. Further, new rapid generation of motor drives into the automobile industry, established on the hybrid drives, develops a serious need for great efficient PM motor drives, and this was the origin of importance in the BLDC motors. The BLDC is an electronically controlled commutation system, rather including a mechanical commutation, which is characteristic of brushed motors. Also, the electromagnets do not move the rotation of the permanent magnets and the armature leftover static. The problem earned by this that how to shift the current to a moving armature. According to do this, the brush system/commutator assembly is restored by an intelligent electronic controller, which executes the same power distribution like a brushed DC motor. Because of the BLDC moves without brushes its lifetime used can be raised and operation of maintenance also evade.

II. THE STUDY OF BLDCM DRIVE

The search of BLDC motor is placed on the acceptance for simplification and windings are identical and the self and Mutual inductances are stable. The energetic equations of BLDC motor using assuming point scan be derived as-

$$V_a = RI_a + (L-M)\frac{dia}{dt} + e_a$$

$$V_b = RI_b + (L-M)\frac{dib}{dt} + e_b$$

$$V_c = RI_c + (L-M)\frac{dic}{dt} + e_c$$

Locates, V_a, V_b, V_c = Stator phase voltages
I_a, I_b, I_c = Stator phase currents
e_a , e_b, e_c = Back emf of phases
L = Self inductance
M= Mutual inductance
R= Phase resistor

A controller of speed, the braking chopper, and the intelligent controller models are limited to the Electric Drives library. It is desirable

to practise a simplified version of the drive involving an average-value model of the inverter for rapid simulation. A Brushless DC motor (BLDC) is a DC motor twisted inside out; therefore the field is on the rotor and the armature is on the stator. The BLDC motor is actually a permanent magnet AC motor in which a torque-current tendency mimes the DC motor. Rather of commutating the armature current by using the brushes, commutation of electronic is used. This rejects the problems joined with the brush and the commutator adjustment for pattern, flickering and wearing out of the commutator-brush adjustment, thereby, making a BLDC motor more rugged as compared to a DC motor. BLDC motors have so many similarities to the AC induction motors and the brushed DC motors in terms of the construction and working principles respectively. Same as other motors, BLDC motors also consists of a rotor and a stator.

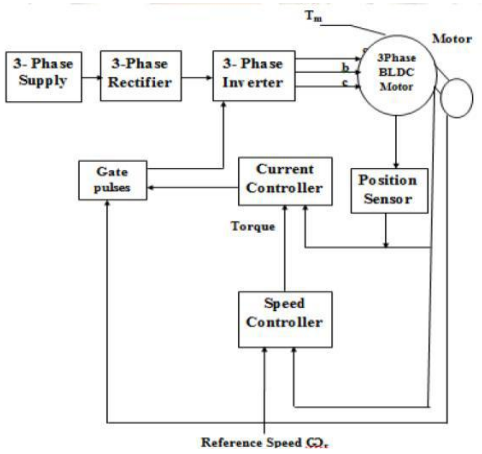

Figure-1 Speed regulation of BLDC motor

III. SPEED CONTROLLER

- **PID Controller**

The PID controller is adapted in the different fields in the engineering payable to its simplicity, powerful, reliability and tuning parameters easily. The honoured method to detect PID parameters is the Ziegler-Nichols rule although sometimes are not that good in the results. Unusually, it can be easily accomplished by using the genetic optimization technique which depends on three various price functions to detect the better PID control parameters. The major obstructions siding PID control technique is rapid change in the firm point and the parameter deviations, it builds the PID control which provides a flat response. This complication can be mitigated by concluding an advanced control technique such as Artificial Neural Network Method (ANN).

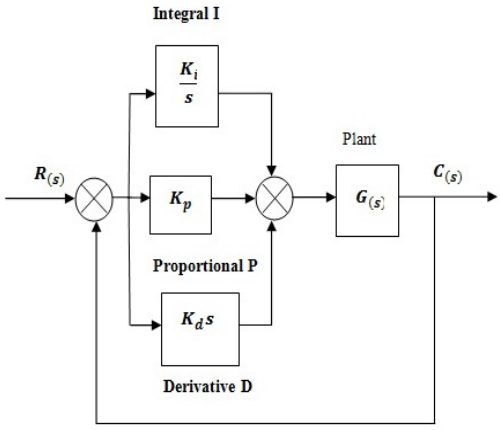

Figure2- PID controller block diagram

- **Artificial Neural Network (ANN) Controller**

An ANN-depend controller for the BLDC motor drive which desires minimal offline training still absolutely and veraciously pursue command speed with the insensitivity to load and parameter deviations. ANNs are the analytical systems comprising of various weighted interconnected operation elements that is neurons. The processing element is an equation, which is usually named as transfer function. This processing element hold signals from other neurons and attaches and disciple them and yields a numerical result. In the regular, processing elements practically correspond to the actual neurons, they are attached via a network and this format establishes neural network. The network of the ANNs comprises three major aspect neurons, the connection giving the input and the output direction, and relation weights indicating the capability of these relations. Often, the architecture of an ANN is prepared and weight values needed to upgrade the certainty of the outputs are tenacious using one of the different numerical algorithms. The ANNs resolve a relationship between the input variables and approximated variables by certaining the weights using past examples. In different words, ANNs are "trained". Formerly these relationships are checked, an ANN can be regulated with a new data and evaluations can be generated.

The attainment of a structure is detected by the calculated signal and error criterion. The error edge is produced by the observation of the output of the structure and the calculated output. A back-propagation algorithm is used to conform the weights in alike a way to decrease the error edge. The structure is trained by imitating these processing bountiful times. The target of training is too able an optimum solution dependent on the attainment measurements. ANNs includes a huge range of functions in actual life problems. They are presently used fortunately in abounding industries.

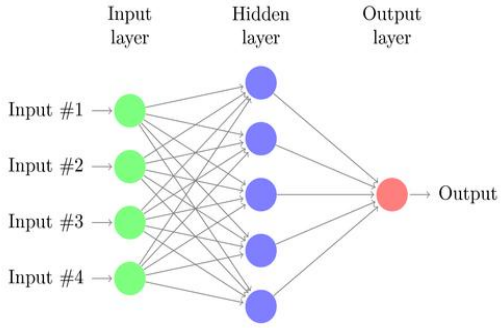

Figure3 - ANN Structure

III. SIMULATION RESULTS

PID controller controls the speed of BLDC motor but not as efficient as Artificial Neural Network can do. So just to make the motor more efficient and reliable, we are using the PID data only for future work. These are too trained for best results. We have replaced PID controller by ANN as PID controller have the parameters of the practical system which changes during operating conditions. Hence, PID controller failed to give desired performance under the nonlinearity, load disturbances, speed regulation of motors. Through this disadvantage of PID controller, the ANN for its demand for non linear controllers is purposed here. Then the inputs (IN1, IN2) and output (OUT) set for PID controller will be observed in the workspace of the MATLAB. Then put emfg algorithm in your current folder so that system can read all the data. The data provided from the PID is till 3614.

The emfg is the back emf propogation algotrithm which is expressed here,

```
Function y=emfg(u)
if (u>-180)&&(u<=-120)
y=[-1;0;1];
elseif(u>-120)&&(u<=-60)
y=[0;-1,1];
elseif(u>-60)&&(u<=0)
y=[1;-1;0];
elseif(u>0)&&(u<=60)
y=[1;0;-1];
elseif(u>60)&&(u<=120)
y=[0;1;-1];
elseif(u>120)&&(u<=180)
y=[-1;1;0]
end
```

After retaining this, we secure a set of variables IN1, IN2 and OUT data. Then in a program window we type,

```
"inpt=[IN1.Data  IN2.Data]
 target=[out.Data]
```

Then new variables will be created with the name "inpt" and "target". And then type in command window 'save data". By which "data.mat' is created in the current folder.

Finally at the end run, ANN MATLAB code nn1.m for this data.mat must be in current folder. The code for nn1.m is as given here,

```
clc
clear all
close all
load data
net=feedforwardnet(50)
net=int (net);
[net,tr]=train(net,inpt',target')
```

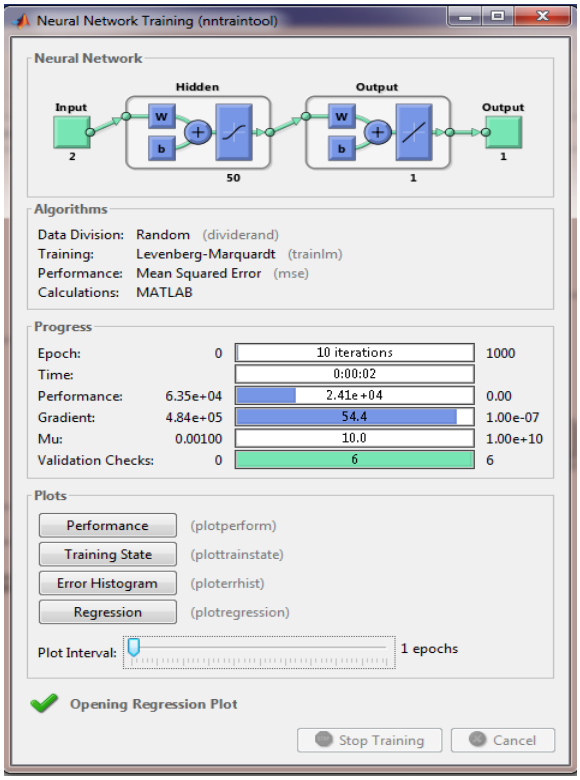

Figure4- NN training toolbox

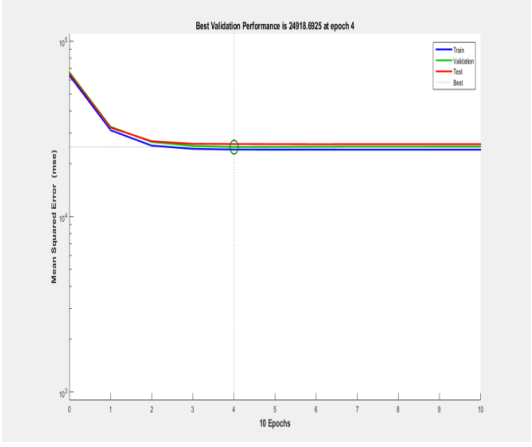

Figure5- Performance Plot

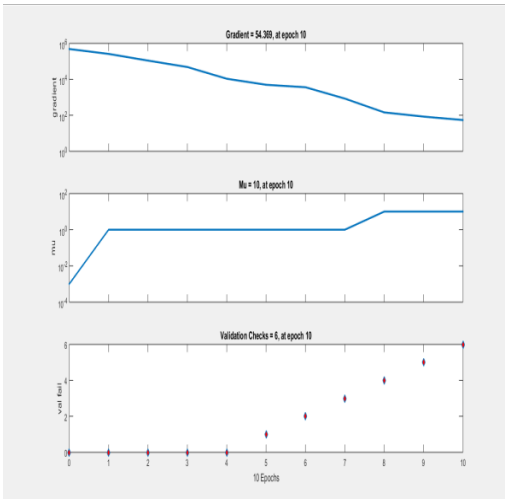

Figure6- Training State Plot

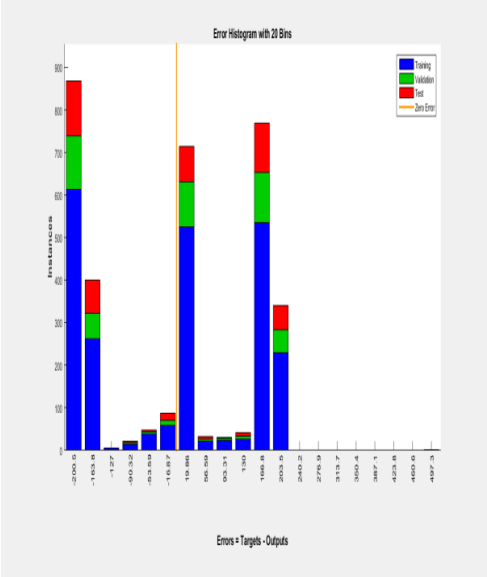

Figure7- Error Histogram Plot

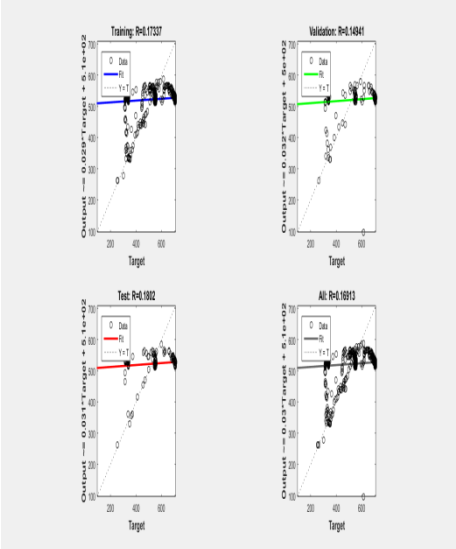

Figure8- Regression Plot

Here, Performance plot shows a plot of training record error values against the number of training epochs, Training state plot plots the training state from a training record returned by train, Error histogram plots a histogram of error values, Regression plot displays the network outputs, with respect to targets for training, validation and test sets. After getting these plots by training the data, we will write in a command window 'gensim (net)'. Then after pressing this command we will get the ANN simulink block which is blue in color.

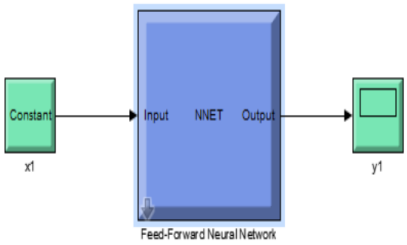

Figure9- Simulink block of ANN

Now placing this blue coloured block to the controller of speed controller by replacing PID by ANN. As in practical MATLAB, the variation in the speed of PID and ANN is seen. The speed variation is given for 1700rpm or 1600rpm. Therefore it is found that ANN works more efficiently than PID for the large number of data. In PID controller if any change occurs, then big variations occur in the result of speed. And once ANN gets trained, it gives efficient results.

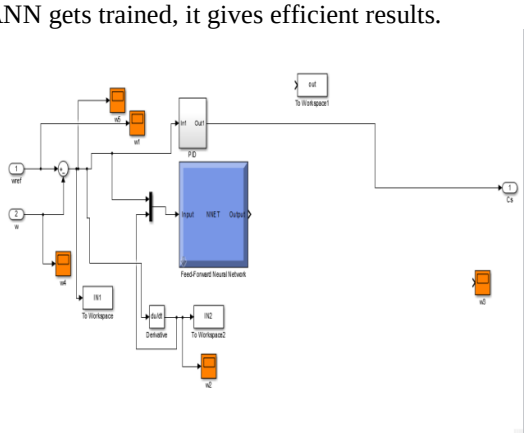

Figure10- Simulation Block of ANN controller for speed regulation

IV. CONCLUSION

An Artificial Neural Network controller (ANN) has been employed for the speed control of BLDC motor drive and analysis of the results of the performance of ANN controller is presented. The modelling and the simulation of the complete drive system are described in this paper. An effectiveness of a model is established by the

performance prediction over the wide range of operating conditions. The performance of the BLDC motor drive with implication to PID controller, ANN controller and experimentally verified with conventional PID controller using MATLAB/SIMULINK software.

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