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Direct Torque Control of Sensorless BLDC Motor Using Artificial Neural Networks

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Abstract*: *Brushless DC motor and permanent magnet synchronous motor are known as electronically commuted motors which does not have brushes. BLDC motor have a higher efficiency compared to brushed motor. Sensored BLDC motors have facing problems on temperature sensitive, higher cost, space.

An Alternative solution is sensor less method. In sensor less methods We want evaluate the speed measuring by Back EMF method. The drawback in BLDC motor is torque pulsation. In BLDC motor we get high torque ripples in order to minimize the ripples we are using direct torque control method. we are using ANN (Artificial Neural Network) instead of PI controller because in ANN is faster time response than pi. We are using ANN for better response and reduce the minor errors automatically. In this paper we are going to reduce the ripple torque using Artificial Neural Network and We implement this method using MATLAB/Simulink software.

Index Terms*: *Sensorless BLDC motor,Artificial Neural Network, Direct Torque Control ,Back EMF.9

I. INTRODUCTION

BLDC (Brushless direct current) motors are one of the motor kinds rapidly grabbing unmistakable quality. BLDC motors are used in endeavors, for instance, Applications, Motorized, Aerospace, Remedial, automation in industries and variable speed drives etc. BLDC motors don't use brushes for pay; rather, they are electronically commutated. BLDC motors have various inclinations over brushed DC motors and enrolment motors. Two or three these are:

- improved torque vs speed qualities
- Highly incredible response
- Highly profitability
- Long working life
- Noiseless movement
- Higher speed ranges

Additionally, the extent of torque passed on to the proportion of the motor is higher, making it accommodate in applications where space and weight are essential parts. In sensoredBLDC[5] we are using hall effect sensors, but we have some drawbacks like

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- temperature sensitive
- higher cost etc.

so to get over the drawbacks we choose the sensor less bldc motor.

In sensor less bldc motor to determine the position of the rotor based on feedback that feedback is called back-EMF[2]-[3].

II. Direct Torque Control

Direct torque control is a method in which we can estimate the torque and flux of the motor individually based on measure voltage of the motor and measure current of the motor[4].

Torque can achieve through the product of motor current and flux linkage. the appraisal torque and flux value will be compared with reference value. if any deviations are there with respective reference value +- tolerance then the transistors of the frequency vary as turn on and off in the same way it continuous, the flux and torque will reach the tolerance very quickly. Direct torque control is one of the forms of hysteresis[1].

III. Artificial neural network

Artificial neural networks are those which are rapidly developing in the world. A considerable number of individuals have thought about them, yet very few truly acknowledge what they are the term 'ANN'[6] is. The term neural networks are from human natural science and here we refer neural networks with artificial neural networks. According to the natural science the human brain consists of the neurons when are all collected together that is called neural network. Our brain consists of billons of neurons connected to each other. The main theme of Ann is replicate the human brain neural network in operation and architecture. According to the human biology until now we all don't know how the human brain neurons work and hence the architecture changes from one type to another.

A. The Neuron

There are 50 to 500 more types of neuron in our human brain. The basic neuron consists of the dendrite, nucleus, axon, myelin sheet, node of Ranvier, axon terminal. Synapse is the bridge between neurons. They are not physically connected connections but very tiny gap between them allows the electrical signal to go from one neuron to another neuron and then the electrical signal goes to the cell body and do some process and sends the signal to the axon. The electrical signal which comes from the axon is again connected to the dendrites with the axon terminal and this procedure repeats continuously

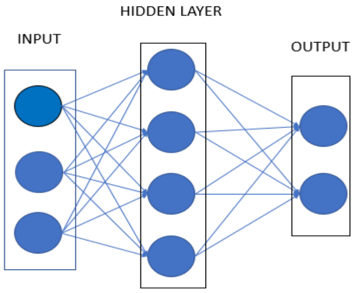

Fig. 1: An architecture of artificial neural network.

As same as human brain neuron, there is also an artificial neuron. As shown in Fig. 1 it is the architecture of artificial neural network. Each artificial neuron has multiple inputs and each input has its weights. Every weight has its significant role and the total value of the artificial neuron is calculated by the sum of all inputs are multiplied by their specific weight.

Each artificial neuron has its own threshold value. If the total threshold value is greater than threshold then artificial neuron gives output as 1 if not it gives output as 0. Then this output is fed into all the artificial neuron which are connected to it.

ANN is a computational system impelled by the Structure Processing Method Learning Ability of a characteristic personality[7]-[8].

B. ***Feed forword back propogation method:***

In ANN we have inputs and outputs for getting outputs there is a hidden layer in between inputs and outputs. If error has occurred in output. To minimize the error the ANN it self gets back propagated from outputs to input. If the ANN didn't get any error and we got required output then this process is called feed forward and vice versa of this method is called feed forward back propagation.

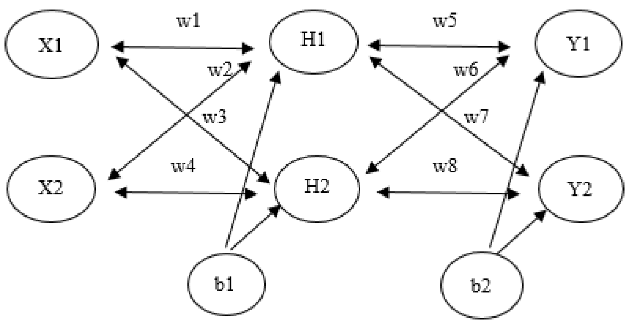

Fig.2 Feed forward back propagation process

Here X1, X2 are the inputs H1, H2 are hidden layers, Y1, Y2 are the outputs. b1, b2 are the bias and w1, w2, w3, w4, w5, w6, w7, w8 are the weights of your inputs.

Calculate H1

$$H1 = X1 * w1 + X2 * w2 + b1$$

$$H_o = \frac{1}{1 + e^{-H1}}$$

Similarly, we can calculate the H2, Y1&Y2.

C. *BLOCK DIAGRAM*

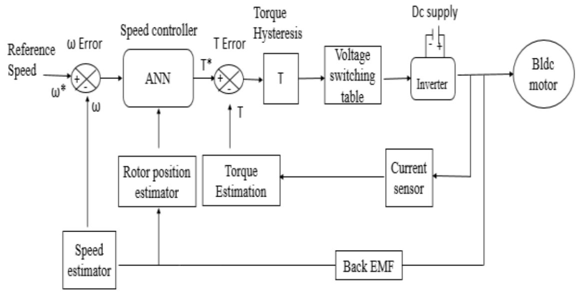

Fig.3: Block diagram of DTC of sensor less bldc motor using ann.

Fig. 3 shows the block diagram of dtc of sensor less bldc motor using ann, Here T=Obtained torque, T*=Reference torque, ω=Actual speed of the motor, ω*=Reference speed, ω Error=Reference speed -Actual speed, T Error =T*-T.

From the fig. 3 the input signal is reference speed (ω*) and we gain the actual speed of the motor where reference speed(ω*) – actual speed (ω) is known as ω Error. To compensate this ω Error it was given to Ann speed controller.

D. *SPEED CONTROL OF ANN*

In ANN we are using Feed Forward Back propagation method to compensate the error and from the speed controller. In ann from the input there exits a weights which are given to the hidden layer. Each and every input of ann have different weight which are connected to hidden layer. Fig. 4 shows the weight of ann here 20 weights are used for the speed control.

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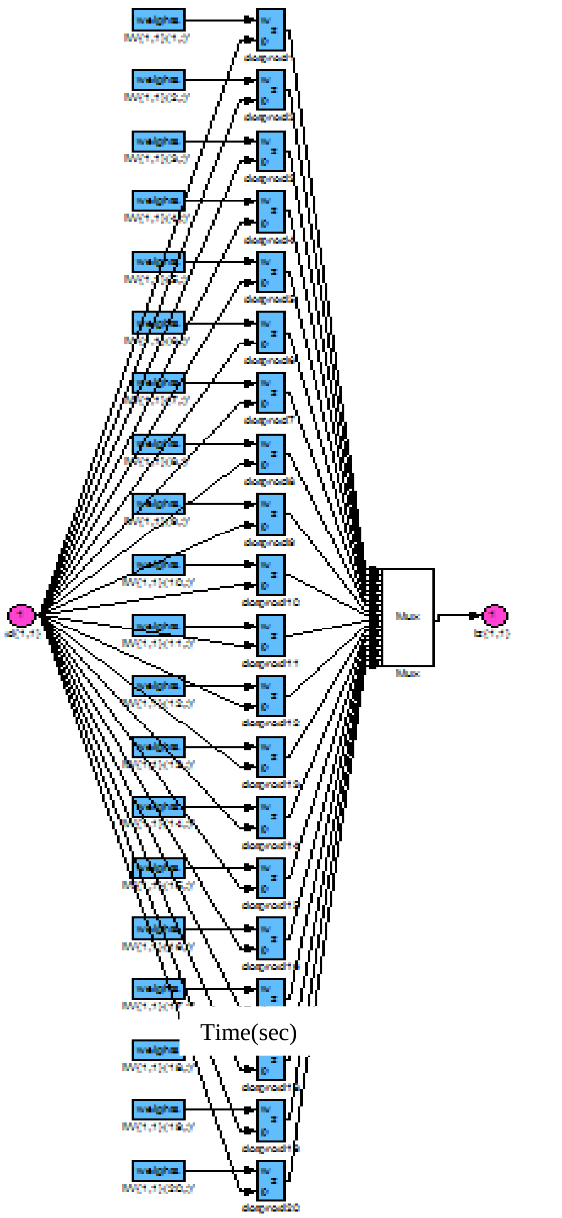


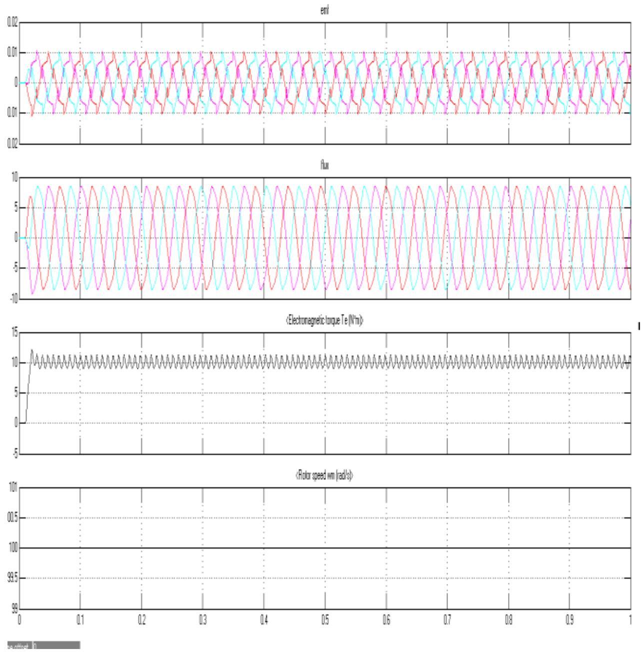
Time(sec)

Fig. 4: weights of ANN

From the speed control we gain the reference torque. actual torque is gain from the motor. the difference between the reference torque and actual torque is known as Torque Error. torque should not be e Time(sec) it so we torque hysteresis. Torque controller will e sector commutation and gives it to the voltage switching table from switching table is to produce pwm pulses from the pwm pulses the inverter will be operated. From inverter bldc motor will be operated.

IV. RESULTS AND ANALYSIS

The proposed DTC of sensor less bldc motor using Ann & under load condition, it simulated. we verified both pi and ann using SIMULINK andthe results are shown below



Time(sec)

Fig. 5: Simulation results of the DTC of sensor less bldc motor using ANN a) induced emf b) Stator flux c) Load torque d) motor speed at 100 rad/sec.

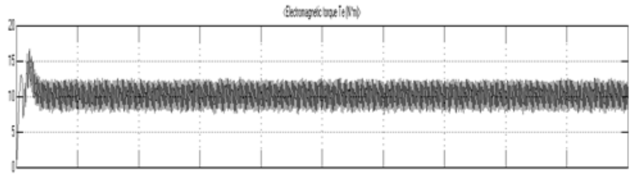


Fig. 6: Torque ripple of DTC of bldc motor using pi controller.

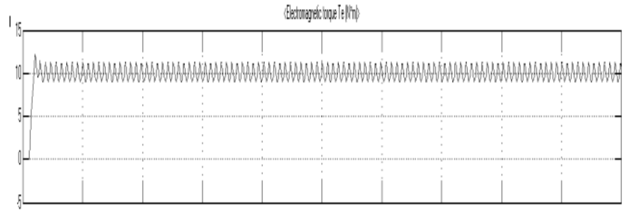


Fig.7: Torque ripple of DTC of bldc motor using ANN.

From the Fig. 6 Shows the Torque ripple of DTC of bldc motor using pi and Fig. 7 Shows the Torque ripple of DTC of bldc motor using ANN. From above shown fig. 6 and 7 results shows the torque ripples and there is much difference between them. when we observe the both the results pi controller having more torque ripples compared to Artificial neural Network and it clearly shows the Ann is best compared to pi and it gives faster response than pi.

V. CONCLUSION

In this paper, a new direct torque control of sensor less of bldc motor using Artificial Neural Network is developed with the help of an optimized Switching table.

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voltage vectors are chosen in such a way that it reduces torque ripple. Here we are gone through Sensor less of bldc motor using Back emf method. ANN was introduced for better performance of the motor.

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