Journal of Applied Science and Engineering Methodologies
Volume 3, No.2, (2017): Page.465-470
www.jasem.in

Parameter Identification in BLDC Motor using Optimization Technique

P.Danusuya[1], K.Balamuruga[2] and R.Mahalakshmi[3]

[1]UG Scholar, [2]Assistant Professor and [3]Professor
[1,2,3]Department of Electrical and Electronics Engineering,
[1, 2] Sri Ramakrishna Engineering College & Technology, Coimbatore, India
[3]Kumaraguru College of Technology, Coimbatore, India
danusuya.1303015@srec.ac.in[1], kb.sreceee@gmail.com[2], mahacbe45@yahoo.com[3]

***Abstract*: *Brushless DC (BLDC) motor widely utilized in industrial automation, aerospace, and military appliances. The accurate model and efficiency parameter depending upon its analysis and design of the BLDC motor. The parameter identification is derived by practical mathematical model via optimisation techniques. The two optimization methods for parameter identification in BLDC, i.e. Deep neural network (DNN) and BAT algorithm are employed. The DNN and BAT optimisation technique can provide optimal BLDC model parameters. The speed, temperature, current and voltage of BLDC motor are measured using concern sensors with Arduino controller and analysed.*

***Keywords*: *Arduino, BAT algorithm, BLDC, current, DNN, speed, temperature and voltage*.

I. Introduction

The fundamental concept of parameter estimation is to determine optimal values of parameters for a numerical model that predicts dependent variable outputs of a function, process or phenomenon based on observations of independent variable inputs. For a given data observation, independent variable inputs are grouped into an input vector and dependent variable outputs are grouped into an output vector [1]. Corresponding input and output vectors for a given data observation are called a training pair.

In general, training pairs from data observations are pooled to estimate model parameters. Mathematical modelling via parameter estimation is one of the ways that leads to deeper understanding of the system's characteristics. These parameters often describe the stability and control behaviour of the system [2]-[3]. Estimation of these parameters from input-output data (signals) of the system is thus an important step in the analysis of the dynamic system.

In this paper, modelling and speed control of BLDC motor is presented. Then parameter estimation for BLDC motor is done. The engineering optimization techniques are used for estimation of motor parameters. The primitive strategy of parameter estimation might be to measure optimal values of parameters for a numerical model which expects reliant variable results of a process or occurrence determined by observations of independent variable inputs [4].

For a certain data observation, independent variable inputs are classified into an input vector and dependent variable outputs are classified into an output vector [4]. Deep Neural network and BAT optimization algorithm methods are implemented for the estimation of parameters of the BLDC motor. The Mathematical model of the BLDC motor consisting of the electrical and mechanical system is realized in the second chapter, to be followed by the Parameter estimation in the third chapter. The Parameter estimation, as quoted earlier comprises of the recent methodologies viz DNN based PID controllers and BAT algorithm.

The fourth and fifth chapter comprises of Experimental results and conclusion respectively [5]-[6].

II Mathematical model of BLDC motor

The electrical and mechanical system of the BLDC motor can be realized in the form of mathematical model. The mathematical model of BLDC motor is:

A. Speed and Torque control

The speed and torque equations of the motor are:

$$W = (1/J)\int (T_e - T_1)\, dt$$

$$T_e = T_a + T_b + T_c$$

$$T_a = (e_a I_a)/W$$

$$T_b = (e_b I_b)/W$$

$$T_c = (e_c I_c)/W$$

Where W is speed of motor.
Te is electromagnetic torque.
Tl is load torque.
ea, eb ,ec are back emfs of three phases.
Ia, Ib, Ic are three phase currents.
J is moment of inertia.

B. Three Phase Currents

The equations for the three phase currents are:

$$I_a = I_1 - I_3$$

$$I_b = I_2 - I_1$$

$$I_c = I_3 - I_2$$

C. *Back EMF equation*

The back emf equation for the motor is

$$E = K_e W f(\theta_r)$$

Where,

Ke is Back emf constant

III. Parameter estimation

Parameter estimation refers to the process of obtaining the parameters of a system to a specific input, given the knowledge of the model representing the system. Thus, in this process, the knowledge of the mathematical model and its parameters is of prime importance. The problem of parameter estimation belongs to the class of 'inverse problems' in which the knowledge of the dynamical system is derived from the input output data of the system. The overview of the speed control of BLDC motor using a Deep Neural Network based (DNN) Proportional plus Integral plus Derivative (PID) controllers shown in the Figure 1.

The conventional feedback controllers find wide applications in the process industry. One of the earliest controllers that were used for control was the Proportional-Integral-Derivative (PID) controller. PID controller has proved to be remarkably effective in controlling a wide range of processes. The use of PID controller does not require an exact process model and hence, it is effective in controlling industrial processes whose models are difficult to derive. Moreover, PID controllers are based on linear control theory and are much easier to understand and implement. However, in spite of these advantages of the PID controllers, they possess several disadvantages as well.

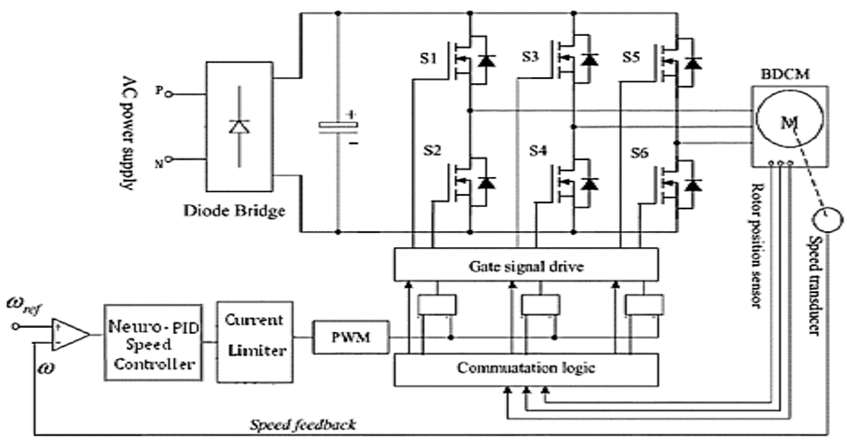

Fig.1 DNN based PID control of BLDC motor

If the operating points of the process or the plant parameters are changed due to disturbances etc., such fixed-gain feedback controllers need to be returned to obtain the new optimal settings. For the processes with variable time delays, varying plant parameters, large non-linearity and considerable process noise, the PID controller does not give optimal performance. For the control of such highly complex and non-linear systems the PID controllers fail miserably because of their limitations. Recently, work has been started toward the development of Deep Neural Network (DNN) based PID controllers called Neuro-PID intelligent controllers. A lot of research is going on applications of Neuro-PID in process control and have been successfully implemented. The most widely applied neuro control scheme is the direct inverse model neuro-control approach. In this approach neural network is trained to learn the inverse of the plant either offline or online. Once trained, it can then be configured to control the plant. The BAT algorithm parameter estimation methods which are used for the estimation of parameters is shown in figure 2.

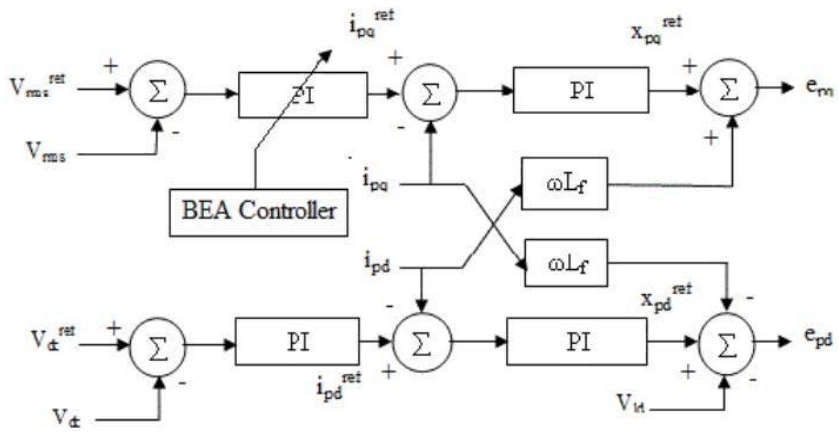

Fig. 2 Parameter estimation using BAT algorithm

The parameter estimation with sensor interfacing using microcontroller block diagram is shown in figure 3.

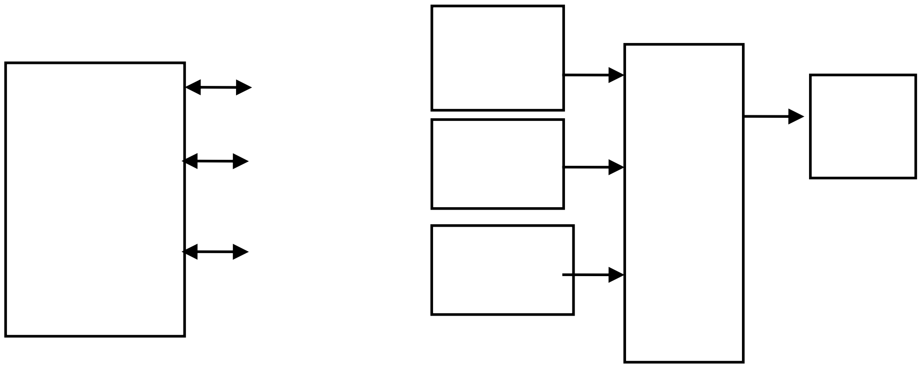

Fig. 3 Parameter Estimation using Sensor Interfacing

IV Experimental result

The schematic diagram for the DNN optimization is shown in figure 4.

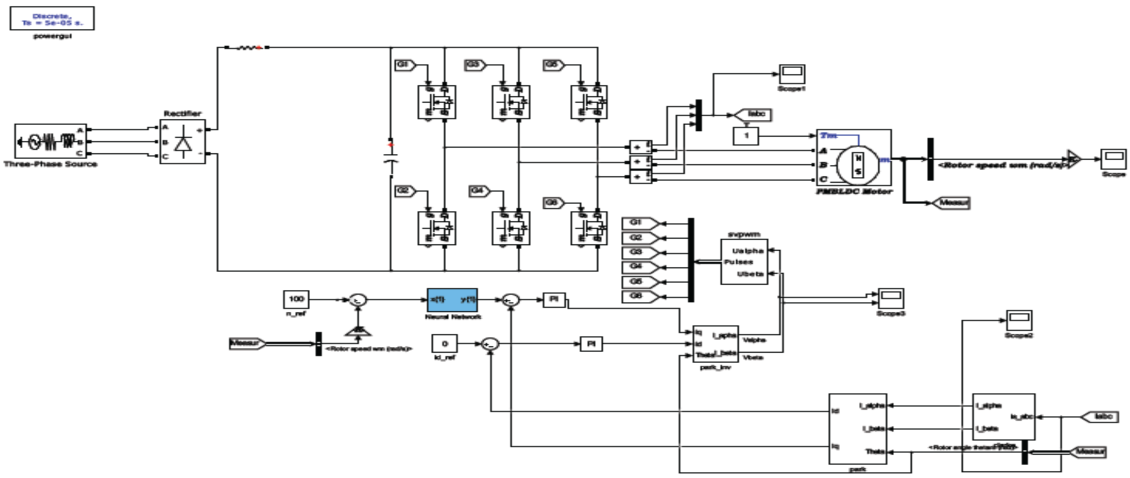

Fig. 4 Schematic diagram for DNN optimization

The schematic diagram for the BAT optimization algorithm are shown in figure 5.

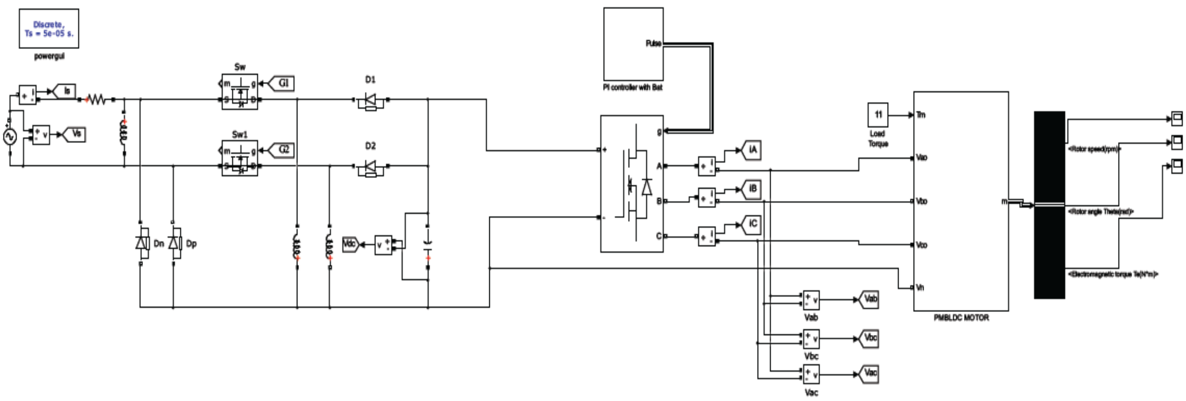

Fig. 5 Schematic diagram for BAT optimization

The BLDC motor is modelled as shown in the figure and simulated in MATLAB/SIMULINK with the assumed parameters which are determined using trial and error method. Then, the algorithm of the Deep Neural Network and BAT Echo optimization method are coded and executed to estimate the parameters of the BLDC motor with the inputs as voltages, currents, electric torque, load torque, change in currents and speed with respect to time. The DNN and BAT based estimation of speed are shown in following figure 6 and 7.

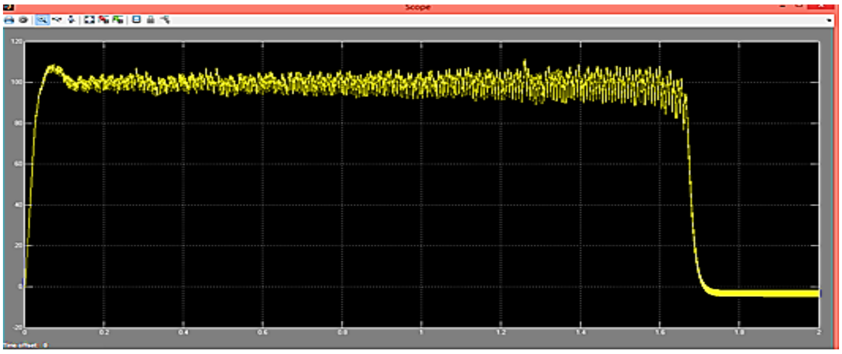
Fig. 6 Speed obtained for DNN

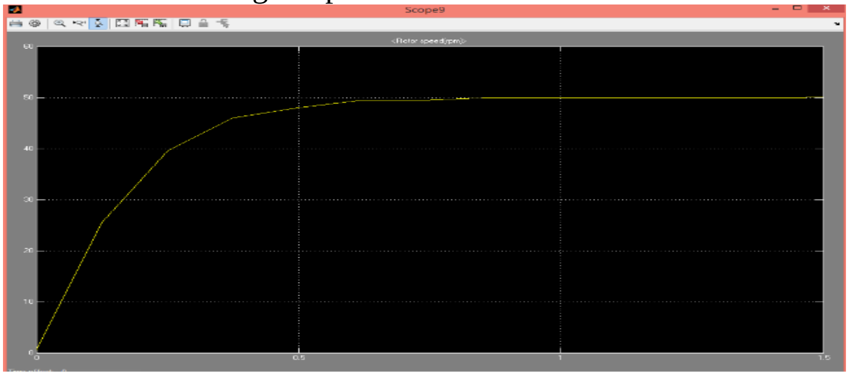
Fig. 7 Speed obtained for BAT algorithm

The hardware configuration with bldc motor with speed sensor, current sensor, voltage sensor and IR temeperature sensor is shown in figure 8 as follows.

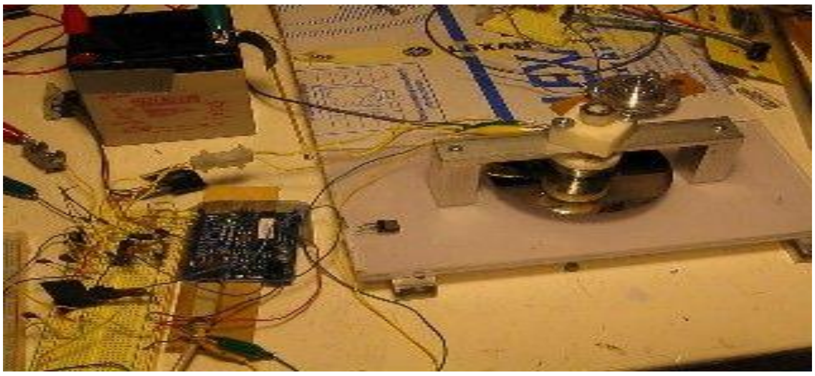
Fig. 8 Hardware results

V Conclusion

In this paper, the parameter identification methods are implemented to the BLDC motor model to estimate the parameters of the motor. With these estimated parameters, speed of the BLDC motor can be controlled with less settling time and with reduced ripples as shown in the results. Therefore, speed control of the BLDC motor with the estimated parameters is more efficient than with the parameters determined with trial and error method.

Parameter estimation algorithms also give the parameters in less time with more accuracy as compared to the conventional methods.

REFERENCES

[1] Tingna Shi, Yuntao Guo, Peng Song, and Changliang Xia, A New Approach of Minimizing Commutation Torque Ripple for Brushless DC Motor Based on DC-DC Converter, *IEEE Trans. Ind. Electron., 57 (10),* 2010, 3483-3490.

[2] Sathyan A., Milivojevic N., Lee Y-J., Krishnamurthy M., and EmadiA., An FPGA-based novel digital PWM control scheme for BLDC motor drives, *IEEE Trans. Ind. Electron., 56 (8)*, 2009, 3040-3049.

[3] Kanimozhi.G and Sreedevi.VT., Modeling and Control of Bridgeless Interleaved PFC boost converter, *Transylvanian Review., 24 (11)*, 2016, 2915-2924.

[4] Majoros WH, Advanced Methods for Parameter Estimation, Online supplement to: Methods for Computational Gene *Prediction*, Cambridge University Press, 2007.

[5] Liu Y., Zhu Z. Q., and Howe D., Commutation torque ripple minimization in direct-torque-controlled PM brushless dc drives, *IEEE Trans. Ind. Electron. 43 (4),* 1012-1021.

[6] Rodriguez F., and Emadi A., A novel digital control technique for brushless dc motor drives, *IEEE Trans. Ind. Electron., 54 (5)*, 2365-2373.

About Authors:

Ms.P.Danusuya doing her B.E. Degree in Electrical and Electronics Engineering from Sri Ramakrishna Engineering College, Coimbatore. She is currently doing research in the field of BLDC motor optimization techniques.

Mr.K.Balamurugan received his B.E. Degree in Electrical and Electronics Engineering from Muthayammal Engineering College, Rasipuram in 2004 and M.E. Degree from Kumaraguru College of Technology, Coimbatore in 2006. He is currently doing research in the field of Torque ripple reduction of BLDC motor. He is currently Assistant Professor in the Department of Electrical and Electronics Engineering, Sri Ramakrishna Engineering College, Coimbatore.

Dr.R.Mahalakshmi received her B.E. Degree in Electrical and Electronics Engineering from Madurai Kamaraj University, M.E. Degree from Thiagarajar College of Engineering and Ph.D from JNTU AP. Currently concentrating on the broad area of Power quality issues related with renewable energy sources. Most recent work is linking and combining different renewable energy sources to create a hybrid environment and to study their behaviour under various loading conditions. She is currently Professor in the Department of Electrical and Electronics Engineering, Kumaraguru College of Technology, Coimbatore.