Speed Control of BLDC Motor using Open Loop, PID Controller and Neural Network

P. S. Vikhe, B. S. Shukla, C. B. Kadu, V. V. Mandhare

Abstract: ***The low cost of manufacturing having higher performance is main goal of upcoming and present applications. However, its possible to achive these aims using brushless DC motors (BLDC), due to its use in many applications. The applications such as sppining, drilling, elevators, lathes, etc can be exicuted using BLDC motor and can replace conventional DC brush motor. The effective vechiel control required for applications of variable speed can be achived using BLDC motors. This paper presents speed control of BLDC motor for open loop using PID and neural network techniques and their comparative study. From the simulation study it is observed that neural network gives better performance compaiered to other technique.***

Keywords: Artificial Neural Network, PID, Open Loop, Control of Speed

I. INTRODUCTION

The BLDC is synchronous and DC electricity driven power motor, having electronic control communication mechanism and not using mechanical control mechanism as in brushes. Therefore, relation of Revolution per Minute (RPM) and voltage, torque and current is linear for these motors. The BLDC motor is classified in two sub-types namely, stepper and reluctance motor respectively. In stepper motor is having more poles compare to stator. However, compare to brushed DC and BLDC motor BLDC is much effective. As, more electric power is converted to mechanical power using BLDC motor compare to brushed motor for equivalent input power. This is possible only due to friction less working of BLDC. The improved effectiveness is higher for no and low-load region performance curve. Thus, BLDC motor under high load and brushed motor with high quality are compared in terms of efficiency. The precise control of speed required can be easily achieved using BLDC motor [1, 11].

To achieve desired rate for motor working control of speed it is essential in BLDC motor. Thus, in BLDC motor speed can be controlled using applied current or voltage. As input varies speed of BLDC also varies linearly. The large literature is provides to control the speed of BLDC motor. The linear voltage regulator concept is incorporated based on power transistor to control the voltage of motor. This aspect may fail for the motors having higher rating. Pulse width Modulation (PWM) with microcontroller is used to control the higher rating motors that provide control and starting functions [12].

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II. LITERATURE SURVEY

A. Rizal et al. [1] proposed consolidating novel model reference versatile control (MRAC) and neural system (NN) to accomplish high following accuracy for servo frameworks. Broke down impact of non-direct and dubious factors on the execution of the plant. The neural system is utilized to repay the impacts brought about by non-linearity and vulnerability in this manner the blunder between the speed circle and the reference model can be decreased. To clarify adequacy of the proposed control conspire, tests were conveyed in a 3-hub pilot test program. Tests results show that the proposed control plan can decrease the plant's affectability to parameter variety and unsettling influence and improve the following execution successfully.

P. Singh and A.K. Pandey [2] introduced neural system based model reference versatile control approach (MRAC) for ship directing frameworks. For the nonlinearities of ship directing framework, exhibitions of conventional versatile control calculations are not acceptable. The introduced MRAC framework uses RBF neural system to rough the obscure nonlinearities so as to get a high versatile control execution. Creator likewise talked about solidness of the framework with Lyapunov steadiness hypothesis. Reenactment additionally demonstrates the adequacy and superior of the proposed calculation.

G. Prasad and N. S. Ramya [3] presented neural system control are contrasted and the relating fluffy PI controller and ordinary PI controller. Neural system improves speed reaction and furthermore decreases torque swells. By utilizing this controller, its yield dependent on a lot of guidelines to keep up fantastic control execution even within the sight of parameter variety and drive non-linearity. This basic plan has altogether improved the execution of the BLDC framework while in the meantime keeping up the basic control structure of the BLDC. Matlab/Simulink programming was utilized to reenact the proposed plan.

In this author put forward a control technique of RBF neural system PID in light of the fact that regular PID controller is hard to meet the execution necessities of BLDC motor

Author examined its execution both tentatively and by reproduction when the framework is exposed to step change in reference speed and unexpected burden unsettling influence.

Different control framework parameters for the two controllers have been estimated, broke down and thought about. The examination demonstrates obviously that the proposed controller gives better exhibitions.

T. Fu and X. Wang [4] discussed about drive of dc brushless engine framework for two different speed controllers in particular controller based on technique firefly and PI, utilizing resounding post inverter. He utilizes fluffy rationale based delicate exchanging full shaft inverter utilizing transformer, which can create dc connect voltage scores amid hacking. Consequently all switches work in zero voltage exchanging condition [4].

S. Sivakotiah and J. Rekha [5] introduced dynamic conduct framework of drive for two controllers exhibited and analyzed for operation of speed. In this fluffy rationale provides better control action and powerful reaction for framework. The back emf stator current, torque and speed waveform was contemplated related with PI control of BLDC drive engine.

U. Ansari et al. [6] provided data about displaying and control of BLDC engine utilizing the PID control with hereditary calculation. He clarifies the upsides of 3 phases BLDC motor control utilizing Genetic algorithm (GA) and PID approach. The creator clarifies the correlation between response of 3 phases BLDC motor utilizing Genetic and PID algorithm based on Ziegler.

Y. Fang et al. [7] introduced Model Reference Versatile Sliding Mode Control (MRASMC) utilizing radical premise work RBF neural system (NN) for controlling single-stage dynamic power channel (APF). The creator further used The RBF NN to estimated nonlinear capacity and takes out the demonstrating blunder. It is inferred that AC model reference versatile current control doesn't just certifications comprehensively solidness of APF framework yet additionally create the repaying current to follow the consonant current precisely.

H. Chaoui et al. [8] introduced a control methodology dependent on fake neural systems (ANN) for a situating framework with an adaptable transmission component, considering coulomb grinding for two engines with burden, utilizing learning variable rate to adjust change of parameter for union quicken.

J. Cheng et al. [9] exhibited a MRAC framework which uses RBF neural system to surmised the obscure nonlinearities so as to get a high versatile control execution. In light of the Lyapunov solidness hypothesis, the refreshing law for the RBF neural system and down to earth strength are dissected, which considers the neural system learning mistake. Numerical recreation was done to demonstrate the handy practicality and execution of the proposed neural system based versatile control calculation.

A. Azmi et al. [10] demonstrated NMRAC ready for follow adjustments in set display reaction for proof over, steady time of set point demonstrate were varied from 200s to 550s. Thus, NMRAC indicated great execution for temperature control as reference.

III. PROPOSED SYSTEM

The uses of BLDC motor have been increased due to commercial and home appliances application in present days. Thus, it is significantly essential to use BLDC motor for control of speed. This involves applied phase voltage change to control the speed. Thus, PWM concept based on sensor approach is used to achieve the task. Brushless DC motors (BLDCM) are the synchronous type of motors whose field winding is of permanent magnets. These are the motors which don't have the brushes or the commutators for passing of current or commutation. That is why these types of motors are also called electronically commutated motors. They are not operated directly instead they are operated through an inverter which switches the phases of BLDCM ON/OFF based on the position of the rotor. The switches in the inverter can work for 1200 conduction mode or 1800 conduction mode. Different types of controlling methods for BLDC motor are discussed in subsequent sections.

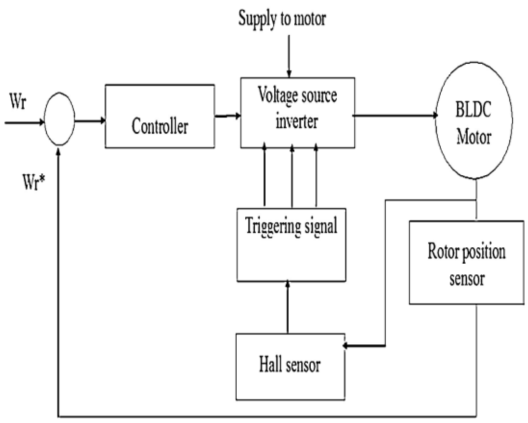

Fig.1. Schematic diagram of BLDC motor drive.

OPEN LOOP CONTROL

The linear response is obtained for speed and related input voltage for the constant load on the motor for the provided operating range. If regulated voltage is applied along with constant load torque, this leads motor to operate in open loop configuration for overall speed range. The duty cycle of PWM is linear with reference to applied excitation voltage. An open loop controller can be made via linking PWM duty cycle to a table of motor pace values saved, due to time of commutation of each drive segment.

ANN based PID Controller

Traditional feedback controllers, PID or linear quadratic, requires correct mathematical representation elaborating dynamics of the plant under study. This can be a most important limiting element for systems having varying unknown parameters. The system model can be determine for the control approach, for unspecified conditions like disturbances, drifts, noise and saturation may be unimaginable to model with desirable accuracy. The normal electrical drives functions, these unknown stipulations procedure nonlinearities may also be suppressed, resulting in unacceptable efficiency tracking. Excessive accuracy is just not more commonly vital. The traditional PID controllers, situated on control theory of linearity have less complexity in understanding and implement. However, endure the hazards when working features of the plant parameters are converted as a result of disturbances. Thus, process with time delays variable, having fluctuating plant parameters, higher nonlinearities and giant process noise, PID controller doesn't provide top-quality performance.

The controller with fixed feedback gain will receive new superior settings. For time delays variable process, plant varying parameters, higher non-linearities and giant process noise, PID controller will not provide optimal efficiency.
BLDCM were used as varying speed drives for wide array of functions, due to higher effectiveness, its compact form, reliability, low maintenance and silent operation. These drives are commonly used in industries, as they are robust having higher torque to weight ratio. Due to availability of low cost embedded processor with less power requirement now days control approach based on sensor less are widespread used. Thus, avoiding use of position and speed transducers increase the robustness and reduce the cost. The High Performance Drives (HPD) applications can be achieved due to higher ratio of torque to volume, for, applications like robotics, dynamic actuators and guided manipulators. The accurate moment of rotor for given period time can be obtained. The various industries namely food, chemical, process automobile, etc., have this essential requirement. However, it can be obtained even for inertia, parameters and system loads. Thus, to achieve this adaptive, accurate, simple to implement and robust strategy for speed control must be used [12].

IV. RESULTS

Fig. 2 shows the simulation for speed control of BLDC motor. In this having set point 5000 RPM open loop gives approximately 4200 RPM after transient. The response is stable but is sensitive to other parameters like torque, disturbance, etc illustrated in Fig. 3.
Fig. 4 demonstrate BLDC motor speed control of using PID were, set point is 5000 RPM for open loop it gives approximately 4850 RPM after transient. The response is stable.

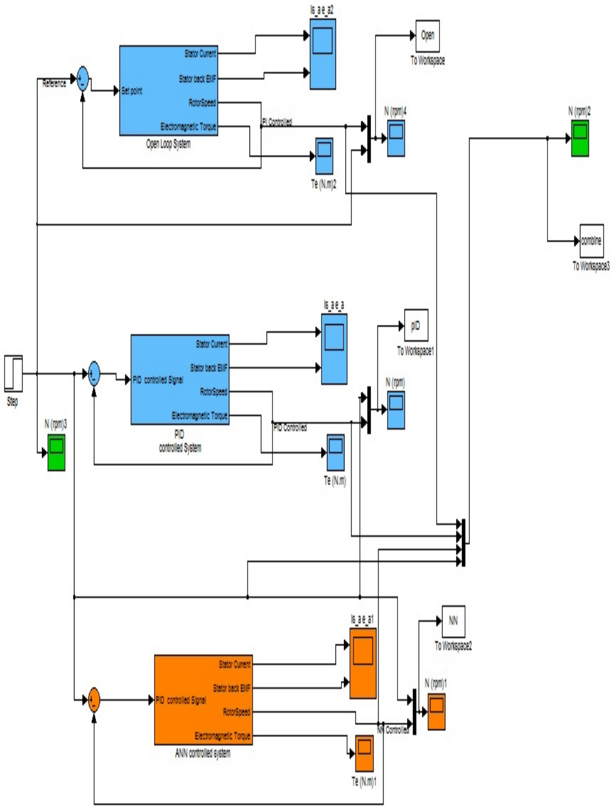

Fig.2. Simulink block for speed control of BLDC motor.

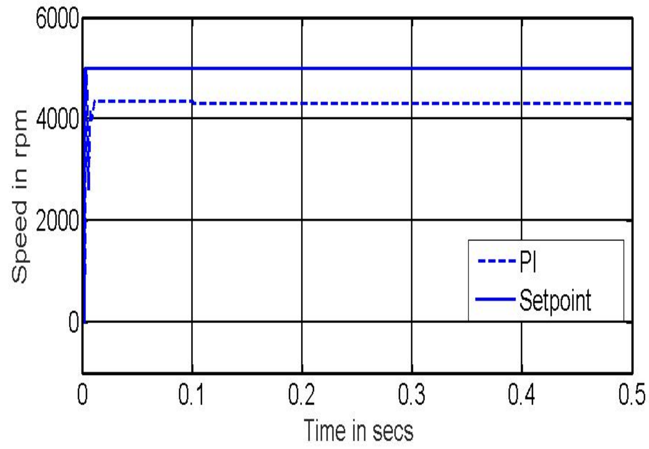

Fig.3. BLDC motor with open loop action.

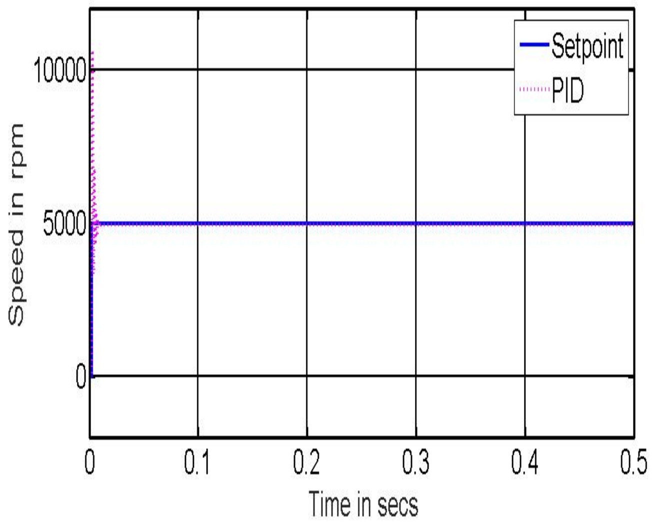

Fig.4. Speed control of BLDC motor with PID control action.

Once motor started it is not in control and speed changes suddenly and varies rapidly, at t = 0.001 sec it achieves 11000 RPM.

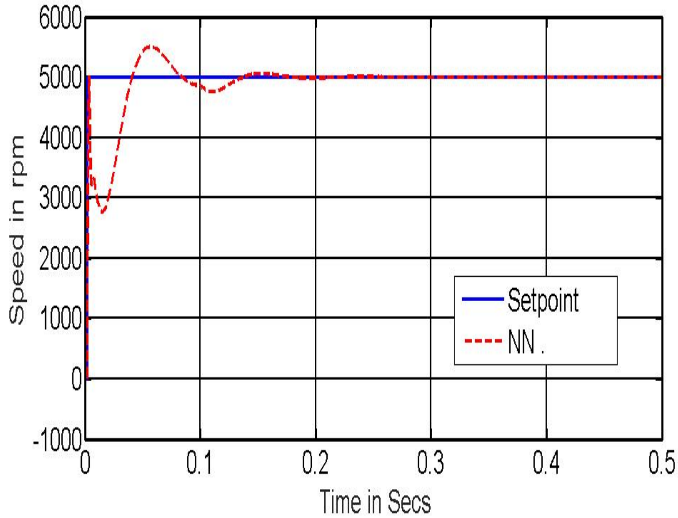

Fig.5. Speed control of BLDC motor with PID control action with Neural Network

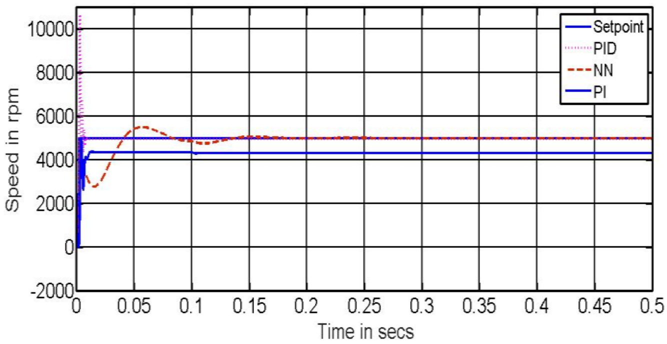

Fig.6. Combined response speed control of BLDC motor.

To improve this initial response of PID control action, PID is tuned with Neural Network. Result of tuning with neural network depicted in Fig. 5 clearly indicates exact desired speed achieved. However, combine response is represented in Fig. 6. The initial unstability is improved by tuning PID with Neural Network.

V. CONCLUSION

A BLDC motor controller model has been developed in the Matlab Simulink. The optimization tool present in Matlab simulink was used for designing of system. The speed has been varied (E.g. 1000, 2000 RPM) and comparison were carried for BLDC motor with open loop technique, PID controller, PID controller with ANN. However, performance index based on overshoot, rise and settling time were calculated and compared. The simulation results obtained based on optimization system design using combination of PID and ANN provides improved performance response compare to traditional PID controller for nonlinear dynamic environment. The obtained results for the proposed approach compare to conventional method, highlights proposed method is effective.

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