A Review Paper on Design And Comparison of Controllers For Speed Control of BLDC Motor

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Abstract- *This study is to find better speed controller for BLDC motor using PI controller and Antiwindup PI controller. The speed control analysis is based on simulation result of these controllers. The speed control system of BLDC motor is designed by studying its mathematical model. The model of these two controller is prepare on Simulink software of MATLAB. The performance result of pi controller and Anti windup PI controller with BLDC motor drive is compared in MATLAB Simulink platform. This analysis include the integral windup or rollover issue arise in PI controller and Antiwindup PI controller eliminate the integral windup arising in BLDC motor. In this paper the design and simulate the BLDC motor drive with PI controller and Antiwindup PI controller and compare the result on speed response on MATLAB Simulink software.*

Keywords- BLDC motor, speed response, PI controller, Anti windup PI controller, MATLAB/SIMULINK.

I. INTRODUCTION

Brushless DC motor (BLDC) is in widely in industries due to its dynamic response, high power factor, noiseless operation, compact size, reliable performance, good efficiency with less maintenance cost. The traditional motor like Induction motor and DC motor, the commutation process is done by brushes, While in Brushless DC motor communication are done by electronically instead of brushes. Induction motor is also used widely in industries but these motor also have drawback such as low staring torque and power factor. On another side BLDC motor is popular because of it high torque and less maintenance they have extra advantage such as high speed range and long operating life.
Conventionally we use PI Controller for speed control of BLDC motor. PI controller is close loop feedback control widely used in industrial control systems. A PI continuously calculates difference between actual output and desired output. As PI is old controller it has issue of integral windup or rollover in BLDC motor. Integral windup or roll over is a process of accumulating the integral component beyond the saturation limits of the system. There will be a significant error if set output suddenly increase or decrease suddenly. This error causes the integral component to accumulate with time to make this error zero results into delayed response, large overshoot and very high settling time.

To overcome with phenomena of integral windup or rollover, Antiwindup pi controller is used. AWPI controller is continuously calculates error value and applies a correction signal based on proportional and integral terms. The controller attempts to minimize error over time by adjusting the control variable.

This paper present the comparision of PI controller and Antiwindup PI controller on the speed control basis on Simulink MATLAB platform.

II. BLDC MOTOR

A BLDC motor is permenant magnet BLDC motor in which commutation is done by electronically. The BLDC motor has 3 main parts that is rotor, stator and hall sensor. Rotor is permenant magnet with north and south direction in it. Speed of rotor is controlled by pulse signal of stator winding. Stator is a stationary part of motor in which carry the rotor .There are three Hall sensors attached to stator to sense the position of rotor and also sense the speed of rotor.

The control system senses the rotor position and the proper switching pattern is supplied by three phase inverter to motor. The combination of signal of hall sensors determine the sequence of commutation.

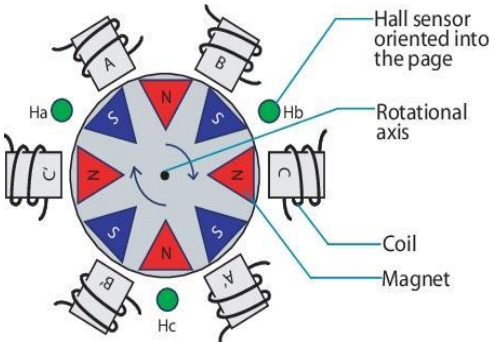

Fig.1. Equivalent Circuit Diagram of 3 Phase BLDC Motor
Dynamic modelling of BLDC motor

Consider equivalent circuit diagram of 3 phase BLDC motor with windings, in cylindrical rotor there is uniform air gap,

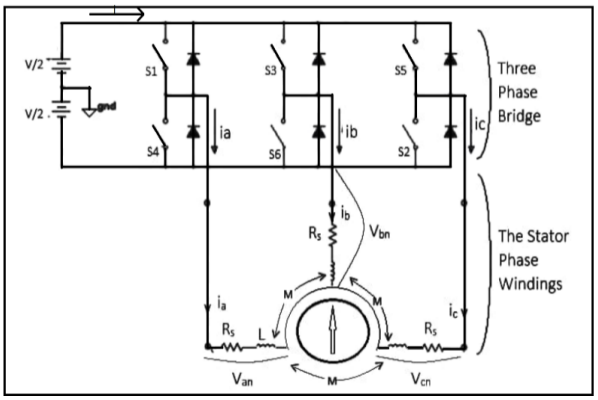

Fig.1.Equivalent Circuit Diagram of BLDC Motor

$$V_{an} = R_s i_a + LS\frac{di_a}{dt} + e_a$$

$$V_{bn} = R_s i_b + LS\frac{di_b}{dt} + e_b$$

$$V_{cn} = R_s i_c + LS\frac{di_c}{dt} + e_c$$

Mechanical power of BLDC motor is

$$P_m = (e_a i_a + e_b i_b + e_c i_c)$$

Torque of BLDC motor is

$$T = \frac{P}{2}(k_a i_a + k_b i_b + k_c i_c)$$

III. PI CONTROLLER

Proportional integral is Conventional PI controller. The output of the PI controller is defined by the following equation:

$$V_c(t) = K_p e(t) + K_i \int_0^t e(t)\, dt$$

Where, $V_c(t)$ is output of the PI controller, k_p is the proportional gain, k_i is the integral gain, and $e(t)$ is the instantaneous error signal.[2] The advantage of adding the integral part of PI controller is to reduce the constant error in the system. However, the integral controller has limitationwhen system goes under saturation and if system stays in under saturation condition integral component of controller start accumulating which result into delayed response This phenomenon is known as windup or rollover and can be eliminate by introducing a limiter to the integral part of the controller before adding its output to the proportional controller.[2] Fig.2 shows the PI controller block diagram:

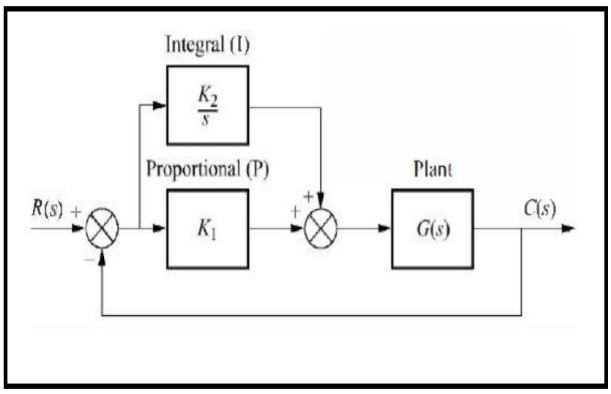

Fig.2. Block Diagram of PI controller

IV. ANTI WINDUP PI CONTROLLER

Every real life system has limitations and every system saturates but in the control system, we never accounted for this limitation till now. We assume that the system is linear and the output will keep rising as we keep increasing the commanded input.

$$u(t) = K_p e(t) + K_i \int_0^t e(t)\, dt$$

The PI Controller has only problem is the phenomenon of windup or roll over, therefore we compare the actual input and the commanded input. If they are the same, the saturation is not in effect. Antiwindup controller calculates the error value of e(t) and it applies a correction signal based on proportional and integral terms. This error causes the integral component to accurate with time to bring the error to zero which result in delayed response, large overshoot and very high settling time. This controller is used to minimize error over time by adjusting the control variable.

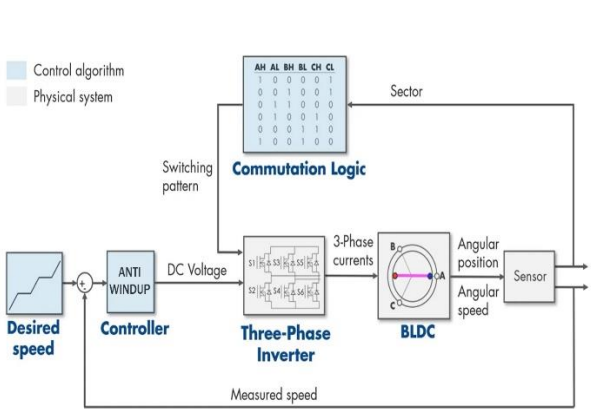

Fig.3. Block Diagram Of Anti Windup controller with BLDC motor Drive

V. METHODOLOGY

In this project, we will obtain mathematical model of BLDC motor. Basis of Mathematical model reference model of BLDC motor will be designed to observe the ideal response of the motor. Then we are going to design a model of BLDC motor which is controlled by Anti-windup controller and We are going to simulate mathematical modeling on Simulink. By the result of Simulink, we will conclude efficient controller for BLDC motor. The simulation results of PID and Anti windup based controller are compared with each other. A simulation result will come to the conclusion and based on that results we will decide best controller for BLDC motor.

VI. CONCLUSION

We can compare these technique for better speed control and load variation for BLDC motor we are designing and simulating mathematical model of BLDC motor with various controllers on MATLAB Software. By changing or controlling input voltage to the motor, we can construct the speed of the motor. We can conclude, by compare Anti-windup controller with conventional PI controller, we can compare the performance of the BLDC motor, hence we can identify the best suitable method.

REFERANCES

[1] Arundhathi Shyam, Febin Daya J L, "A Comparative Study on the Speed Response of BLDC Motor Using Conventional PI Controller, Anti-windup PI Controller and Fuzzy Controller," 2013 International Conference on Control Communication and Computing (ICCC), 2013.

[2] NehaTiwary, A. Rathinam, S. Ajitha, "Design of Hybrid Fuzzy-PI controller for speed control of Brush less DC Motor",
International Conference on Electronics, Communication and Instrumentation (ICECI), 2014.

[3] Archana Mamadapur, Dr.Unde Mahadev G, "Speed Control of BLDC Motor Using Neural Network Controller and PID Controller," in 2nd International Conference on Power and Embedded Drive Control (ICPEDC, 2001.

[4] P.Suganthi , S. Nagapavithra , S. Umamaheswari, "Modeling and Simulation of Closed Loop Speed Control for BLDC Motor," Proc. IEEE Conference on Emerging Devices and Smart Systems (ICEDSS 2017) 3-4 March 2017, Mahendra Engineering College, Tamilnadu, India, 2017.

[5] Greeshma Sarah John, Abhilash T Vijayan, "Anti-Windup PI Controller for Speed Control of Brushless DC Motor," IEEE International Conference on Power, Control, Signals and Instrumentation Engineering, 2017.

[6] Ahmadi, M., Baojahmadi, M., Fallah, S. N., Karami, K., & Soheilirad, M., "PI- controller Adjustment for a Lab Scale CSTH by Using Imperialist Competitive Algorithm," Plant and Soil, vol. 248, no. 1-2, pp. 43–59, 2003.

[7] Bill Argo," Understanding pH management and plant nutrition", Journal of the International Phalaenopsis , vol. 13, 2003.

[8] R. A. Dahlgren, "Biogeochemical processes in soils and ecosystems: from landscape to molecular scale," Journal of Geochemical Exploration, vol. 88, no. 1–3, pp. 186–189, 2006.

[9] G. P. Gillman, "An analytical tool for understanding the properties and behaviour of variable charge soils," Soil Re-search, vol. 45, no. 2, pp. 83–90, 2007.

[10] Bodie V. Pennisi and Paul A. Thomas, "Essential pH Management in Greenhouse Crops pH and Plant Nutrition" Extension Floriculture Specialists, 2015.