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Hybrid Sensorless Speed Controllers of Brushless DC Motor Using Blending Schemes

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Abstract – Speed control of Brushless DC (BLDC) motor based on conventional control schemes are now most commonly used in industries. Despite the fact that PI controllers maintained the steady state accuracy, these controllers pose difficulties such as load disturbances and parametric variations. FLC offers better speed response at dynamics and cancels disturbance impacts when load torque change.To improve control performance and integrate the benefit of these two controllers, a hybrid controller is included in this comparative study. The performance of the hybrid controller is obtained with two schemes Logical switching based-on error and Smart blending based-on system states. The dynamic characteristics of speed and torque of the drive system are effectively evaluated and compared for different operation modes. Results showed that Smart blending scheme is better in generally for most of the performances. The modeling and simulation of the speed controllers have been done in MATLAB/SIMULINK environment.

Index Terms - BLDC Motor, Sensorless control, PI controller, Fuzzy, Hybrid PI-Fuzzy.

I. INTRODUCTION

Due to natural of high power density, better dynamic response, higher efficiency, low maintenance requisites, no noise operation , high-speed permanent magnet brushless dc motors have been widely studied and used as a part of numerous fields [1].

The BLDC motor drives require position sensors i.e., Hall-effect or absolute encoder for precise execution of current commutation instant. However, establishment of these sensors in the motor poses some problems for the motor-drive system as discussed in [2]. Sensorless operation can significantly improve system reliability and decrease the performance variations caused by discrete sensors.Most existing sensorless strategies of the BLDC motor have low performance at transients or low speed range and infrequently need extra circuit. To handle this issue, the unknown input (back-EMF) is modelled as the additional state of system that can successfully estimate a required back-EMF for BLDC motor drive which has a trapezoidal shape back-EMF [3].

As the speed of the BLDC motor is specifically relative to the applied dc link voltage, hence, the speed control of BLDC motor is achieved by controlling the DC link voltage of the voltage source inverter[4]. So far, over 80% of the controllers are PI controllers as they offer simplicity and easier to understand, It has a good steady state accuracy and great flexibility over load torque variation, but suffers from performance degradation under system disturbances[5].

To overcome the performances issues of PI controller, FLC can be utilized; as it offer better performance while dealing with such kind of uncertaininties. Furthermore, fuzzy logic controllers can be easily designed and implemented knowing the behaviors of the system [6,7].

To ensure great dynamic response for the parameter variation and support steady-state accuracy hybrid controllers are proposed. Benefits of both controller can be achieved utilizing these Controllers [8]-[10]. A switching algorithm between controllers could be enhanced to allow switching of the controllers corresponding to each specific region that each controller is intended for.

Two schemes are proposed in this paper:

- Logical switching based-on error .
- Smart blending (Fuzzy-soft-switching) based-on system states .

This paper is structured as follows. Section II presents the modelling of brushless dc motor. Section III describes the sensorless control technique which used in the drive system. Section IV introduces the different speed controllers as PI, fuzzy Logic and hybrid PI-Fuzzy. Section V presents the results obtained for the different operation modes, as well as, discusses the results before Section VI concludes.

II. MODELING OF BRUSHLESS DC MOTOR

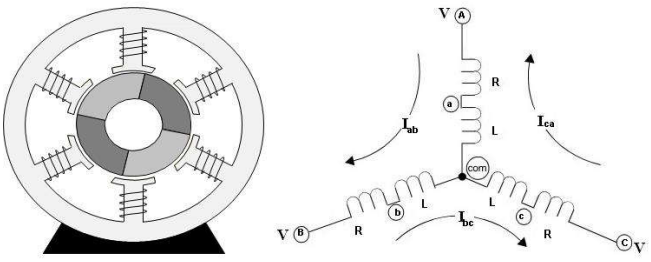

Fig. 1 Equivalent circuit of BLDC motors [13].