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Simulation of Cuk Converter Fed PMBLDC Motor Drive

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Abstract

PMBLDC have been widely accepted for high efficiency, good dynamic response, reliability and very low maintenance. The BLDC motor is highly superior electrical drive compared to other motors. The drive system is proposed with a cuk converter topology .This paper shows the results of speed controller such as fuzzy and conventional proportional integral controller. The conventional PI controller has simple control structures that are used in the industry and the controller has more conditions of disturbances on load, nonlinearity, and on parameters variations are difficult. The voltage source inverter system of 120° mode is controlled by Brushless DC motor using PI and FLC is simulated. The fuzzy controller shows the performance of the brushless dc motor drive, when compared to proportionality integral controller conventional method the performance of fuzzy is observed better. The various performance of the PMBLDCM system is investigated by using MATLAB/SIMULINK software. The overview performance of simulation results that conventional PI controller and fuzzy controller it verifies the fuzzy controller has better performance using MATLAB/SIMULINK software are discussed in this paper.

Keywords: Permanent Magnet Brushless DC motor (PMBLDCM), Proportional Integral (PI) controller, Fuzzy Logic Controller (FLC)

Introduction

This paper deals with Ac single phase mains fed to the diode bridge rectifier with a PMBLDC motor drive. To operate a 3phase voltage source inverter electronic commutation is required.Here, the torque is proportional back electromotive force (EMF) to its phase current has developed for PMBLDCM, which is proportional to the speed.However, the electronic commutation is used to control the VSI.The BLDC motors are categorized in horsepower because of reduction in cost and number of

phases .Major advantage is two hall position sensors are sufficient for two-phase motors.

The role of the commutation is done by inverter while operating with single phase or polyphase motors. Instead of brushes arrangement the electronic commutation is used so that it eliminates the problems in brush and commutation. The control scheme of the four switches BLDC motor drive and operations are theoretically analyzed in [3].

In the control approach, I and fuzzy logic controller are designed and simulated to produce the desired speed –torque characteristics.BLDC are recommended for low and medium power drives because of high efficiency, good dynamic response, reliability and low maintenance [1,2].Therefore, controlling of PI is simple, reliability and adjustment is easy for the speed control[6,7].The fuzzy controller has well defined conditions in controlling the speed of BLDC motor drive. The fuzzy controller gives the better dynamic performance as well as error reduction[4]. The overview of PMBLDCM drives has been presented and PMBLDCM drives are suitable for many applications. The controller topology approach depends on reliability; complexity and accuracy [5].most of the controllers are modeled.Fig.1 shows the overview of BLDC motor drive block. The basis of inverter modeling is discussed below. The MATLAB simulation results of controllers of PI and fuzzy are done by gate control method PI fed through gate controlling BLDC motor drive and Fuzzy controller is fed to the BLDC motor drive are discussed in this paper.

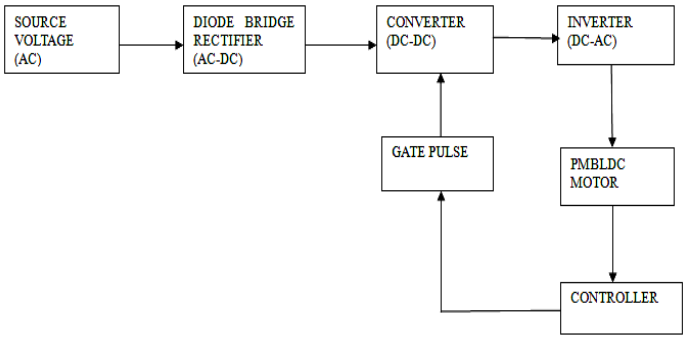

Figure 1: Basic Block Diagram of PMBLDC motor drive

Block Diagram Description

A) Cuk Converter

The inverting of output is termed as Cuk converter. The schematic diagram of cuk converter can be seen in Fig.2.The buck boost operation is similar to Cuk converter and the voltage of output is smaller or larger and the polarity gets inverted. Unlike the other converters, the inductor which is associated with energy transfer but in case of cuk converter it depending upon the capacitor. The operation of converter is that capacitor C_1 transferring of energy to the L_2 inductor and it passes to the capacitor C_2

when switch is in ON mode. On OFF mode of switching the input source charges the capacitor C through the inductor L_1.A Cuk converter consists of a pair of inductors, pair of capacitors, a switch and a diode. For transferring energy the capacitor C_1 is used and it is alternatively connected to the input and to the output of the converter via the commutation of the transistor and the diode.

The current sources can be converted into input and output of voltage sources through two inductors L_1 and L_2 respectively. The current can be maintained constantly by using an inductor, because it resulting to high loss of energy so that the voltage source is connected directly to capacitor and the current can be limited by resistance. The cuk converter can operates in continuous or discontinuous current mode but other converters can operate in both modes.However, during commutation cycle the voltage across the capacitor drops to zero the Cuk converters, it can also operate in discontinuous voltage mode.

Cuk Converter Design

The designing of cuk converter for a PMBLDCMD .Fig.2 shows the schematic diagram of Cuk converter connected to R-load.

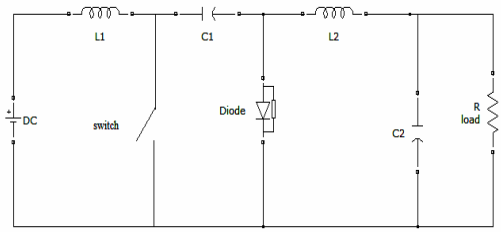

Figure 2: Schematic of Cuk converter

The output voltage of V_o Cuk converter is given in[1].The operating frequency of the switch is 25KHZ.The output voltage equation of Cuk converter is given as

$$Vo = \frac{DVin}{(1-D)} \quad (1)$$

Where,

'D' represents duty cycle,

'V_{in}' represents input voltage,

'V_o' represents output voltage

For transferring the energy converter uses a L1and C_1, from that their equations can be stated as in (2) & (3)

$$L_1 = (1-D)^2 R/(2Df_s) \quad (2)$$

$$C_1 = DV_o/f_s \Delta V_c R \quad (3)$$

The inductor L_2 and capacitor C_2 are ripple filters and the equations are given below. The dc link of the cuk converter has ripple-free voltage and the ripple filter is designed.

$$L_2 = (1 - D)R/(2f_s) \quad (4)$$

$$C_2 = (1 - D)V_o/(8L_o f_s^2 \Delta V_{co} \quad (5)$$

B) Three Phase Inverter

The three phase inverter modeling, for BLDC motor 120° conduction mode is modeled. The MOSFET gating is given at every 60° interval and the MOSFET conducts for each 120 degrees. Here, the switch is used as MOSFET and it has high switching frequency. To driving the motor at low voltage and high current condition are the features of MOSFET.Fig.3 shows Inverter modeling

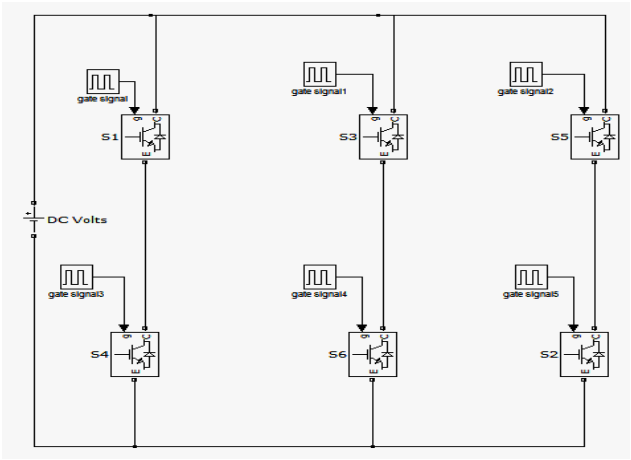

Figure 3: Inverter modeling

C) Voltage Source Inverter Fed Pmbldc Motor Drive

The simulink of Cuk converter fed PMBLDC motor drive in open loop is shown in Fig.4.TheCuk converter with the voltage source inverter of 120^0 mode is used to drive PMBLDC motor. The voltage source inverter of 120^0 mode is used because for conduction the hall sensors use two switches. PMBLDCmotor is an Ac motor and it supplies dc source.

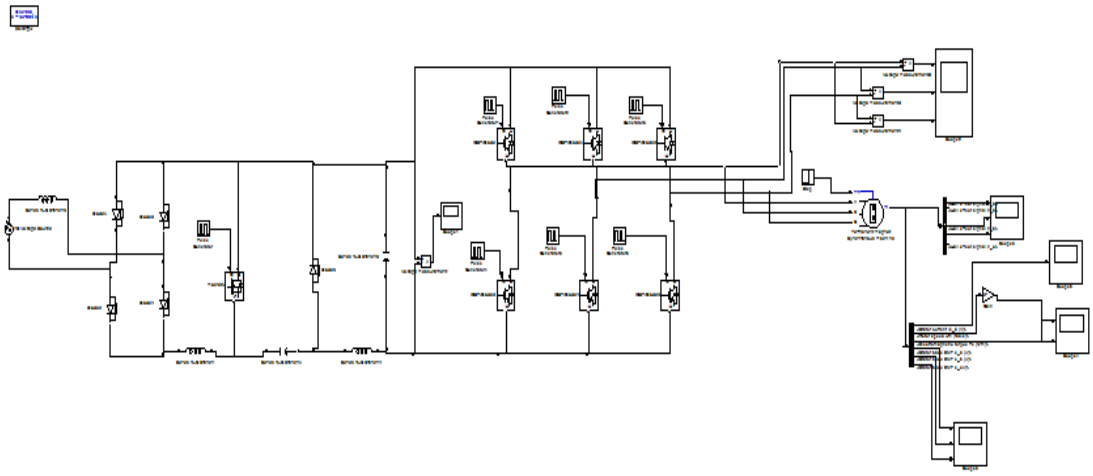

Figure 4: Cuk converter VSI fed PMBLDC motor drive

The dc input voltage as 230 v is given to the converter. The Speed of the PMBLDC motor, it settles at 700rpm.The Stator Current, the Electromagnetic Torque and the electromotive force is a trapezoidal back Electromotive Force (emf) in Fig.5 are shown.

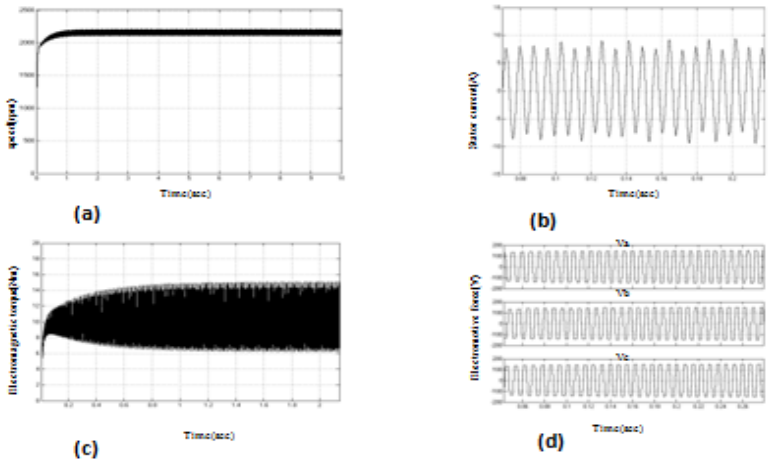

Figure 5: PMBLDC motor performance (a) Speed(rpm) (b) Stator current(Amps) (c) Electromagnetic torque(Nm) (d)Electromotive force(V)

Closed Loop Operation of Pmbldc Motor Drive

The schematic of BLDC motor drive in closed loop is done by two controllers are done by MATLAB software and the controllers are listed below.Such as

- Case (i) PI controller
- Case(ii) Fuzzy logic controller

Case (i) PI controller

The MATLAB schematic of BLDC motor drive in closed loop is investigated in PI controller and their motor performance are analyzed shown in Fig.6.

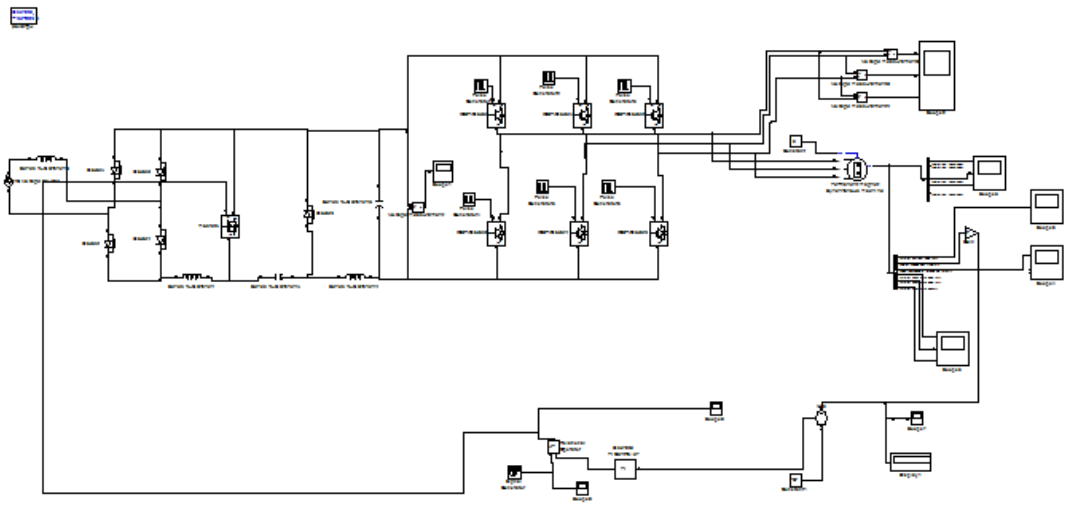

Figure 6: Closed loop of BLDC motor drive using PI controller

By tuning the PI, the measuring error is calculated by the difference of reference and speed of the motor. The K_p and K_i are tuned using trial and error method because the BLDC motor is a non-linear load.Table.1 shows the settling time of speed and torque.

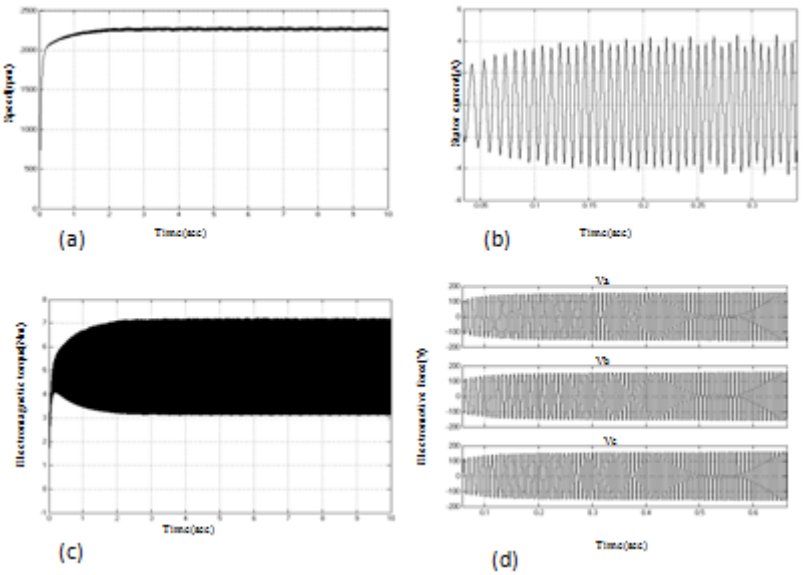

Figure 7: PMBLDC motor performance (a) Speed(rpm) (b) Stator current(Amps) (c) Electromagnetic torque(Nm) (d)Electromotive force(V)

The dc input voltage as 230 v is given to the converter. The Speed of the PMBLDC motor settles at 2400rpm.The Stator Current, the Electromagnetic Torque and the electromotive force is a trapezoidal back Electromotive Force (emf) are shown in Fig.7.

Table 1: PI controller

CONTROLLER	**K_P**	**K_i**	**Settling Time(t_s)**	
			speed	**Torque**
PI	0.001	0.00001	1.6	1.1

The settling time of PI controller for speed and torque is large. The proposed technique of fuzzy logic controller is used to overcome the PI controller technique.

Case (ii) Fuzzy Logic Controller (FLC)

The basic scheme consists of three blocks for fuzzy logic controller such as fuzzification, inference system and defuzzification. Mamdani inference is used as the fuzzy inference method. The Fuzzy logic block diagram is shown in Fig.8.It has two input errors and a output. The term fuzzification means the input of FLC that is input variable converted into basis of linguistic values. The IF-THEN rules constitutes the inference system and the term conversion of linguistic values into input variables are termed as defuzzification.

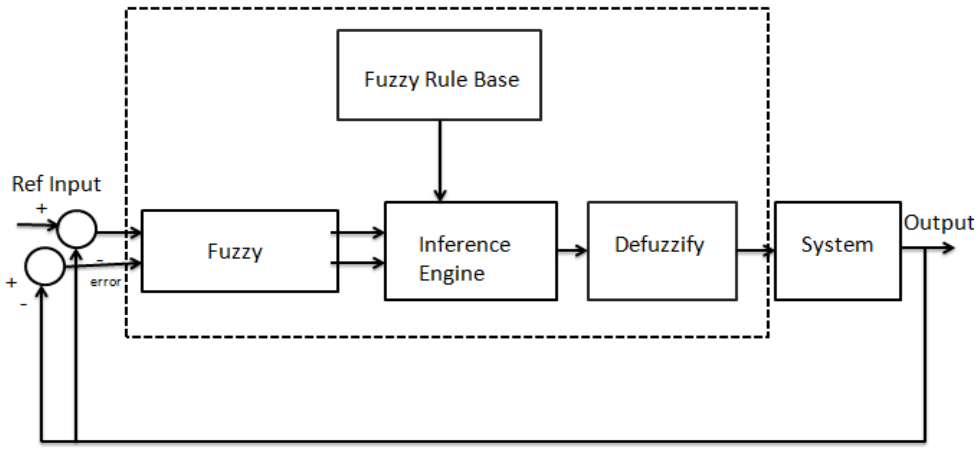

Figure 8: Basic block of fuzzy logic controller

The rule based table has 25 rules constructed for fuzzy controller and gives the change of the output in terms of two inputs. The change of error (ΔE) and (E) error are inputs. The inference can be written as "IF A and B THEN C", such that the rule

can be formed using fuzzy table. The rule tables are designed from Negative to Positive range of values.

The FLC of proposed closed loop fed from PMBLDC motor drive in Fig.9 are shown and the BLDC drive performance such as speed, stator current, electromotive force and electromagnetic torque are simulated and shown below.

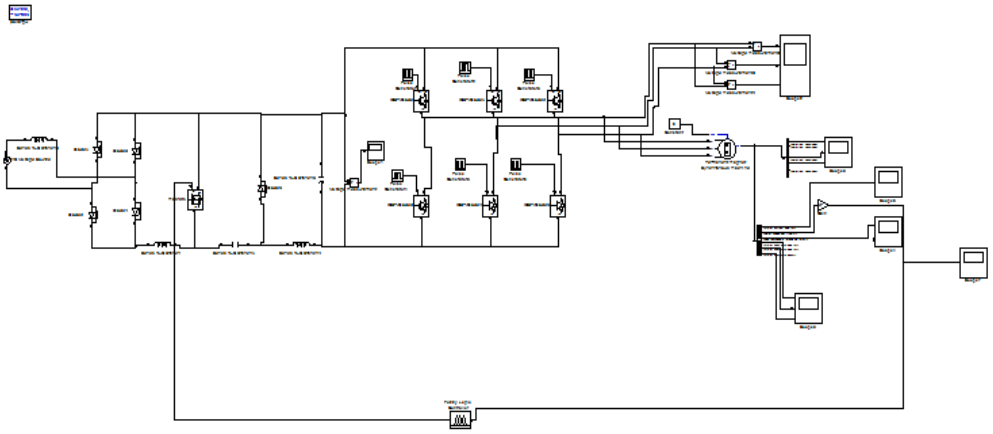

Figure 9: Schematic of PMBLDC Motor In Closed Loop Using FLC

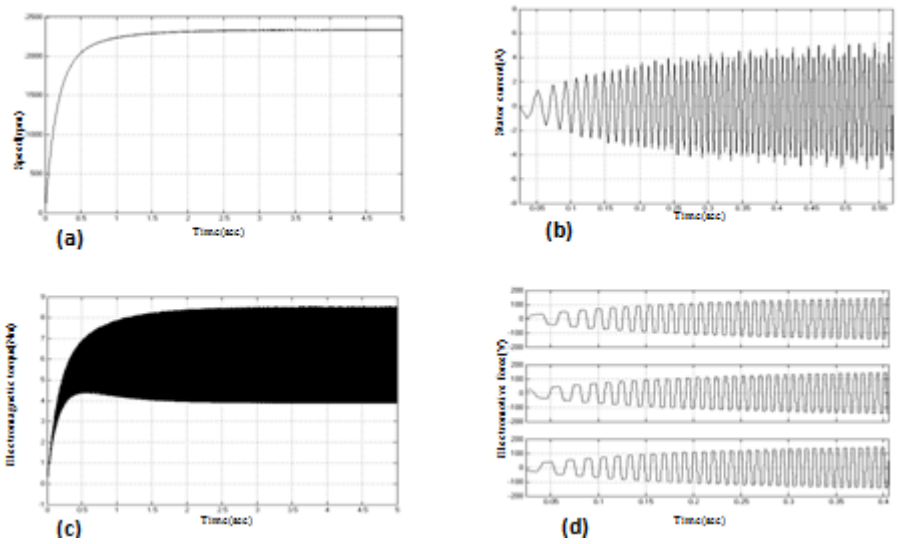

Figure 10: PMBLDC motor performance (a) Speed of the motor (rpm) (b) Stator current (A) (c) Electromagnetic torque (Nm) (d) Electromotive force (v)

The dc input voltage as 230 v is given to the converter. The Speed of the PMBLDC motor settles at 2500rpm.The Stator Current, the Electromagnetic Torque and the electromotive force is a trapezoidal back Electromotive Force (emf) are shown in Fig.10.

Table.3 Comparitive table

CONTROLLER	PARAMETER	SPEED	TORQUE
PI	Settling time(t_s)	1.6	1.1
FUZZY LOGIC CONTROLLER(FLC)		1.0	0.75

Table.3 shows the simulation result comparisons of settling time for speed, torque are analyzed for BLDC drive using the controllers. The proposed Fuzzy Controller is investigated from that the settling time is better for fuzzy controller when it is compared with conventional PI controller.

Conclusion

This project deals with the Cuk converter fed PMBLDC motor drive for conventional PI controller and FLC has been presented in this paper. It is found that the motor speed is controlled in both manners using controllers and torque values are obtained ,respectively the settling time are investigated such that for PI controller and FLC the performance comparisons are done by simulation. Hence the results show, the FLC has better settling time than the conventional PI controller is observed from the MATLAB/SIMULINK software.

References

[1]. MUHAMMAD H.RASHID, "Power Electronics Handbook", second edition., Elsevier,2007.

[2]. Vashist Bist, Bhim Singh "An adjustable-speed PFC bridgeless buck-boost converter BLDC motor drive" IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, vol. 61, no. 6, June 2014

[3]. Byoung-kukLee,Tae-Hyung kim,Ehsani.M"On the feasibility of four switch three phase BLDC motor drive for low cost commercial applications"IEEE TRANSACTIONS ON POWER ELECTRONICS,vol.18, issue 1,January 2003

[4]. Kamnarn, U., Chunkag, V.,"Analysis and design of modular three phase Ac-to-Dc converter using Cuk rectifier module with nearly unity power factor and fast dynamic response"IEEE TRANSACTIONS ON POWER ELECTRONICS ,vol.24,issue 8,August 2009

[5]. I. Janpana , R. Chaisricharoenb, P. Boonyananta,"Control of the Brushless DC Motor in Combine Mode" ELSEVIER 2012

[6]. B.Swamikonda, P.Srinivasulu, G.Jayakrishna, "Design of cuk converter based PMBLDC motor drive"International journal of advances in

engineering and applies science(IJAEAS) vol-1 Iss-2,April-2014 pg.97-101

[7]. S. Assly Steffy, B.Mangaiyarkarasi, S.Sherin Jasper, K.Priyanka, K.Soorya, "Analysis and Simulation of speed control of PMBLDC motor by PI controller", International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 2, February 2014

[8]. J. F. Gieras and M. Wing, Permanent Magnet Motor Technology-Design and Application, Marcel Dekker Inc., New York, 2002.

[9]. C. L. Xia, Permanent Magnet Brushless DC Motor Drives and Controls, Wiley Press, Beijing, 2012.

[10]. B. Mahesh kumar, G.Ravi and R. Chakrabarti "Sensorless speed control of Brushless DC motor with Fuzzy based Estimation" Iranian journal of electrical & computer Engg.vol.8 No.2 Summer-fall 2009.