Improved Power Quality Flyback Converter fed PMBLDCM Drive

Nadar Thangamalar N[1], Dodiya Siraj Ahemad[2], Janak Sorathiya[3], Sanjay R Bhanderi[4]
[1, 2, 3, 4] Department of Electrical Engineering
[1, 2, 3] SCET.Saij,Kalol
[4] VIMAT Kim

Abstract- *An attempt has been made in the present work to modify the existing state of computation through modeling, identification, tuning and control of PMBLDC motor effectively. The following are the salient objectives set for the present work. The emphasis of this dissertation is on high performance control strategies for speed position control of PMBLDC motor system. High performance control strategies are capable of providing accurate control over speed. Also it optimizes one or more performance indices such as maximum overshoot, integral square error, efficiency and settling time. This in fact, forms the main goal of this thesis. General objective is to simulate mathematical model in MATLAB and implement control of PMBLDC motor and PFC Flyback Convertor using microcontroller and Lab view. To study and develop the control system from PMBLDC Motor mathematical model.*

Matlab/simulink simulates speed and voltage control of PMBLDC Motor using the variable voltage. Experimental investigation of speed control of PMBLDC motor using a voltage controlled PFC Flyback converter.

I. INTRODUCTION

The techniques to improve the efficiency of motor drive by power factor correction play an important role in the energy saving during energy conversion. The ac-dc conversion of electric power is usually required for the BLDC motor drives, nevertheless, it causes many current harmonics and results in the poor power factor at the input ac mains. The use of a (PMBLDCM) in low-power appliances is increasing because of its high efficiency, wide speed range, and low maintenance.

II. MATHEMATICAL REPRESENTATION OF THE BLDC MOTOR.

1. Voltage Equations:

The equation of each armature winding can be represented follows

$$V_a = (L - M) * \frac{di_a}{dt} + i_a * R + E_a \qquad (1\text{-}1)$$

$$V_b = (L - M) * \frac{di_b}{dt} + i_b * R + E_b \qquad (1\text{-}2)$$

$$V_c = (L - M) * \frac{di_c}{dt} + i_c * R + E_c \qquad (1\text{-}3)$$

- The voltages assume one of the values (Vdc/2,-Vdc/2,0).
- They have the same frequency which is dependent on ω_r.
- The voltages are symmetric and are phase shifted by 120 degrees.

1.2 Back EMF Equations:

Back EMF is trapezoidal in shape and is related to a function of the rotor position and can be expressed as:

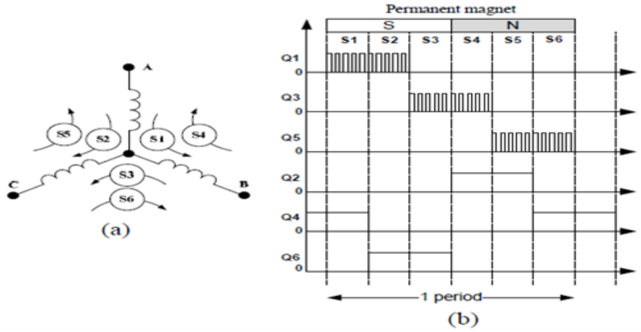


Figure 1-1 Commutation sequence (a) Current flow in each commutation stage (b) Switching scheme

$$E_a = \begin{cases} \left(\dfrac{E}{\pi/6}\right) * \theta & \text{for } 0 < \theta < 30 \\ E & \text{for } 30 < \theta < 150 \\ \left(\dfrac{-E}{\pi/6}\right) * (\theta - 150) + E & \text{for } 150 < \theta < 210 \\ -E & \text{for } 210 < \theta < 330 \\ \left(\dfrac{E}{\pi/6}\right) * (\theta - 330) - E & \text{for } 330 < \theta < 360 \end{cases} \qquad (1\text{-}4)$$

$$E_b = \begin{cases} -E & \text{for } 0 < \theta < 90 \\ \left(\frac{E}{\pi / 6}\right) * (\theta - 90) - E & \text{for } 90 < \theta < 150 \\ -E & \text{for } 150 < \theta < 270 \\ \left(\frac{-E}{\pi / 6}\right) * (\theta - 270) + E & \text{for } 270 < \theta < 330 \\ -E & \text{for } 330 < \theta < 360 \end{cases} \qquad (1\text{-}5)$$

$$E_c = \begin{cases} E & \text{for } 0 < \theta < 30 \\ \left(\frac{-E}{\pi / 6}\right) * (\theta - 30) + E & \text{for } 30 < \theta < 90 \\ -E & \text{for } 90 < \theta < 210 \\ \left(\frac{E}{\pi / 6}\right) * (\theta - 210) - E & \text{for } 210 < \theta < 270 \\ E & \text{for } 270 < \theta < 360 \end{cases} \qquad (1\text{-}6)$$

$$E = K_b * \omega_r (\text{Volts}) \qquad (1\text{-}7)$$

1.3 Rotor Dynamic Equations

$$T_e = J * \frac{dW_r}{dt} + B * W_r + T_l \qquad (1\text{-}8)$$

Where: K_b = Motor Back emf constant (Volts / radians per second)

θ_m = mechanical angle (radians)

J = Inertia constant of the rotor and the load (kgm^2)

B = viscous friction coefficient(Nm/ radians per second)

T_l= load torque in (Nm)

Electromagnetic Torque Developed:

$$T_e = \frac{(E_a * I_a + E_b * E_c I_b + E_c * I_c)}{W_r}$$

The rotor position θ is a function of w_r and is expressed as:

$$\frac{d_\theta}{dt} = P w_r$$

Where P is the number of poles in the rotor.

1.4 Current Equations:

$$i_a = \frac{1}{(L-M)} \int (V_a - I_a * R - E_a)\, dt \qquad (1\text{-}11)$$

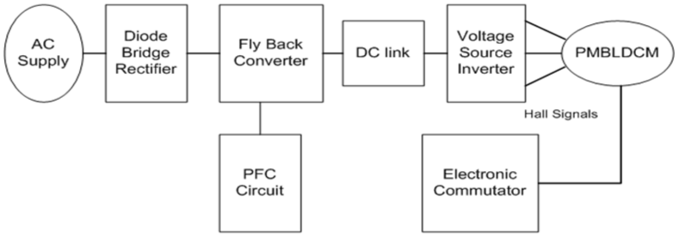
$$i_b = \frac{1}{(L-M)} \int (V_b - I_b * R - E_b)\, dt \qquad (1\text{-}12)$$

$$i_c = \frac{1}{(L-M)} \int (V_c - I_c * R - E_c)\, dt \qquad (1\text{-}13)$$

M = Mutual inductance of each phase of the motor(H)
R = Resistance of each phase of the motor(Ω)
Vi = Voltage of each phase of the motor (V)
Ii = Current of each phase of the motor(Amp)
Ei = Back EMF of each phase of the motor (Volts/radians per sec)

The BLDC motor offers many advantages over other types of motors. BLDC motor requires less copper (metal) than other motor types.The BLDC motors have some drawbacks, though. Rotor position information is required for proper operation, so either Hall sensors or a back-EMF signal with intelligence must be used to obtain this information.In general, the motor requires external power electronics, whereas an AC induction motor achieves constant-speed operation when started from and driven by an AC power supply. The BLDC motor is a 3-phase device. As such, it requires an inverter and thus, a power switch. Its rotor requires magnetic (rare-earth) metal, so it may cost more. Finally, incorrect control of a BLDC motor, especially at high temperatures, can damage its permanent magnet, so careful design of the control electronics is essential.

IV. PROPOSED SYSTEM



Block Diagram of Fly Back Converter Fed PMBLDC Motor Drive

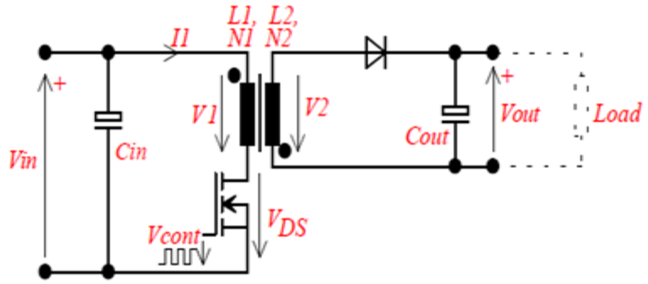
The flyback PFC converter fed PMBLDCM drive with the speed and current control is shown in Figs. The PFC converter controls the DC link voltage as well as performs PFC action by its duty ratio (D) at a constant switching frequency (fs).The flyback converter uses the magnetizing inductance (Lm) of HFT for buck-boost operation as well as for ripple filter in combination with DC link capacitor (Cd). The design of an isolated buck-boost flyback PFC converter is carried out on the basis of PQ constraints at AC mains and allowable ripple in DC-link voltage (Vdc).

V. ADVANTAGES COMPARED TO OTHER CONVERTOR

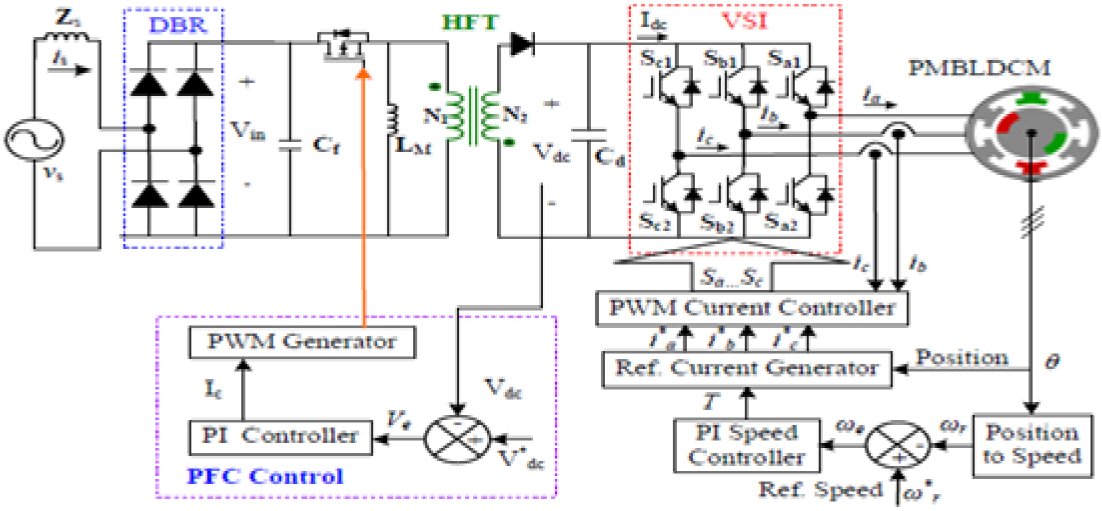
Flyback converters have a remarkably low number of components compared to other converters they also have the advantage that several isolated output voltages can be regulated by one control circuit. High frequency transformer isolation provides voltage adjustment for better control, safety of the motor, compactness, reduction in weight, size and losses; and suitability of the drive to various applications. These topologies are less popular as PFC due to their higher complexity as compared to boost or flyback structures. Like the flyback converter, they draw a sinusoidal input current, when working in DCM, with no need of duty-cycle modulation. In this case the input current can be continuous even in DCM

Fig. shows the basic topology of a fly-back circuit. Input to the circuit may be unregulated dc voltage derived from the utility ac supply after rectification and some filtering. The ripple in dc voltage waveform is generally of low frequency and the overall ripple voltage waveform repeats at twice the ac mains frequency. Since the SMPS circuit is operated at much higher frequency (in the range of 100 kHz) the input voltage, in spite of being unregulated, may be considered to have a constant magnitude during any high frequency cycle. A fast switching device („S‟), like a MOSFET, is used with fast dynamic control over switch **duty ratio** (ratio of ON time to switching time-period) to maintain the desired output voltage.

VI. BASIC TOPOLOGY OF FLY-BACK CONVERTER

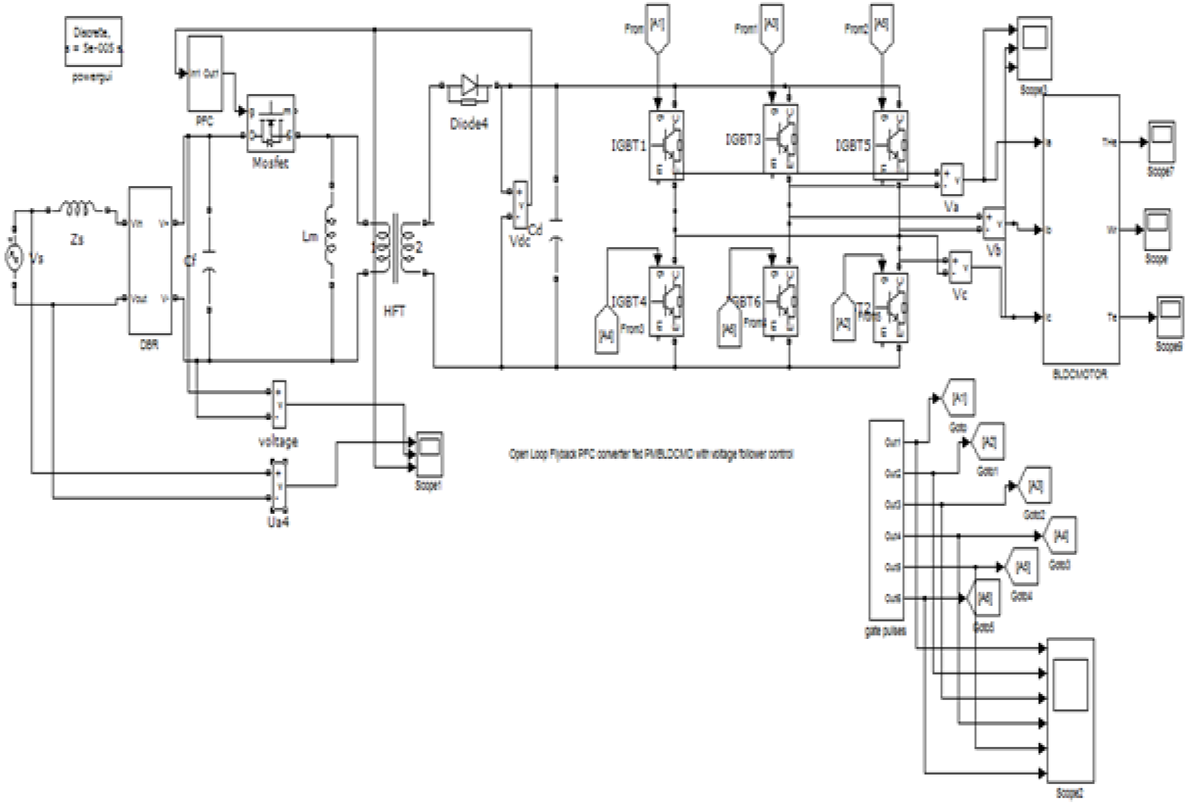


VII. CIRCUIT DIAGRAM AND CONTROL OF PROPOSED DRIVES

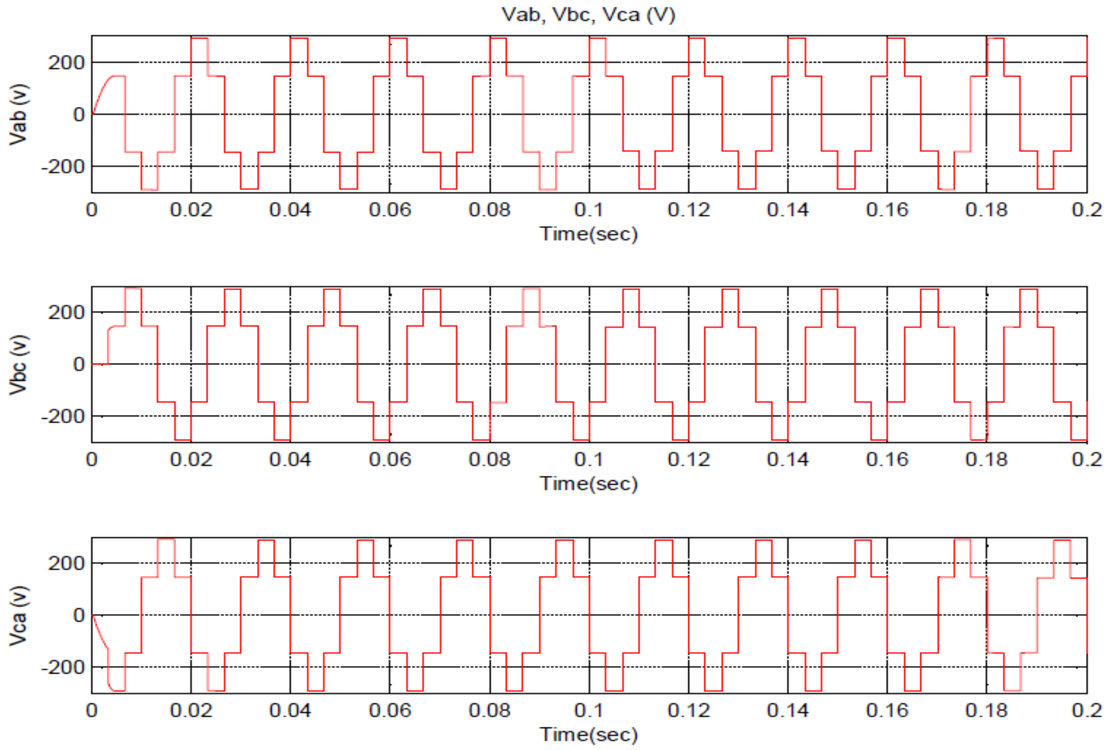


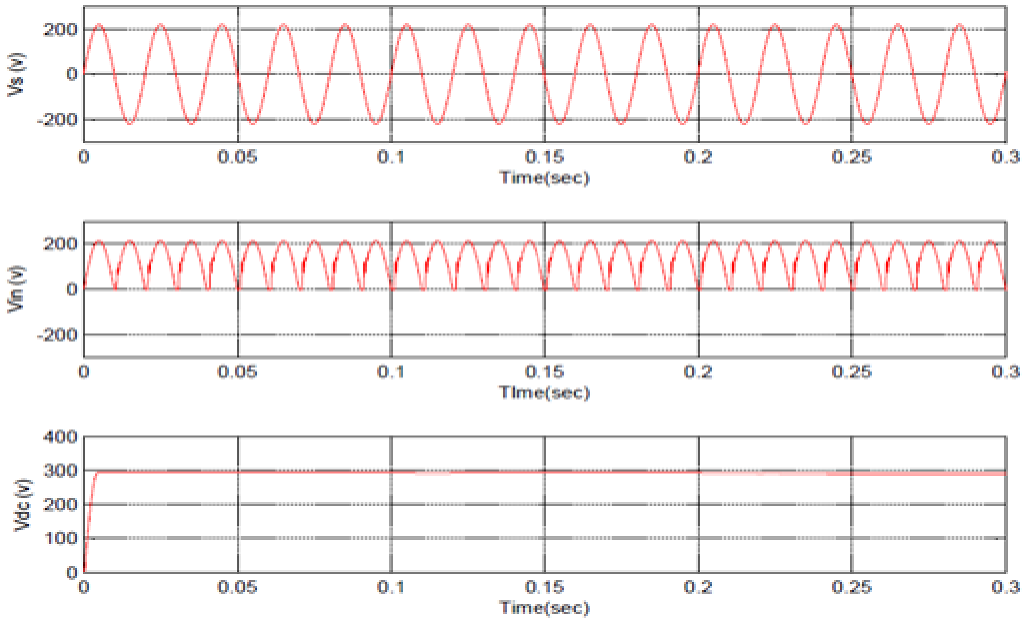
VIII. STIMULATION STUDIES

Open loop simulation of flyback PFC converter fed PMBLDCM drive

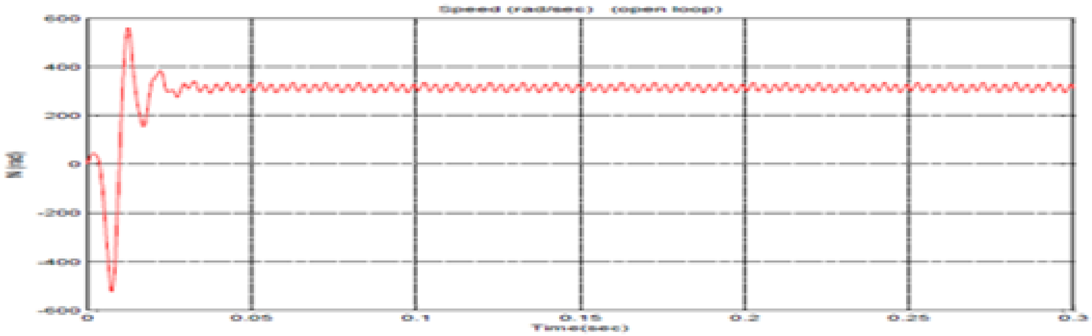


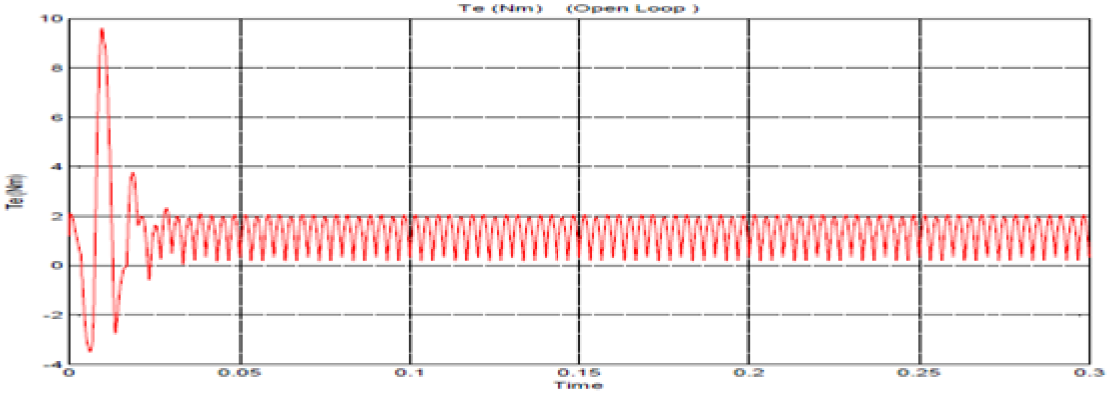
OPEN LOOP RESULTS



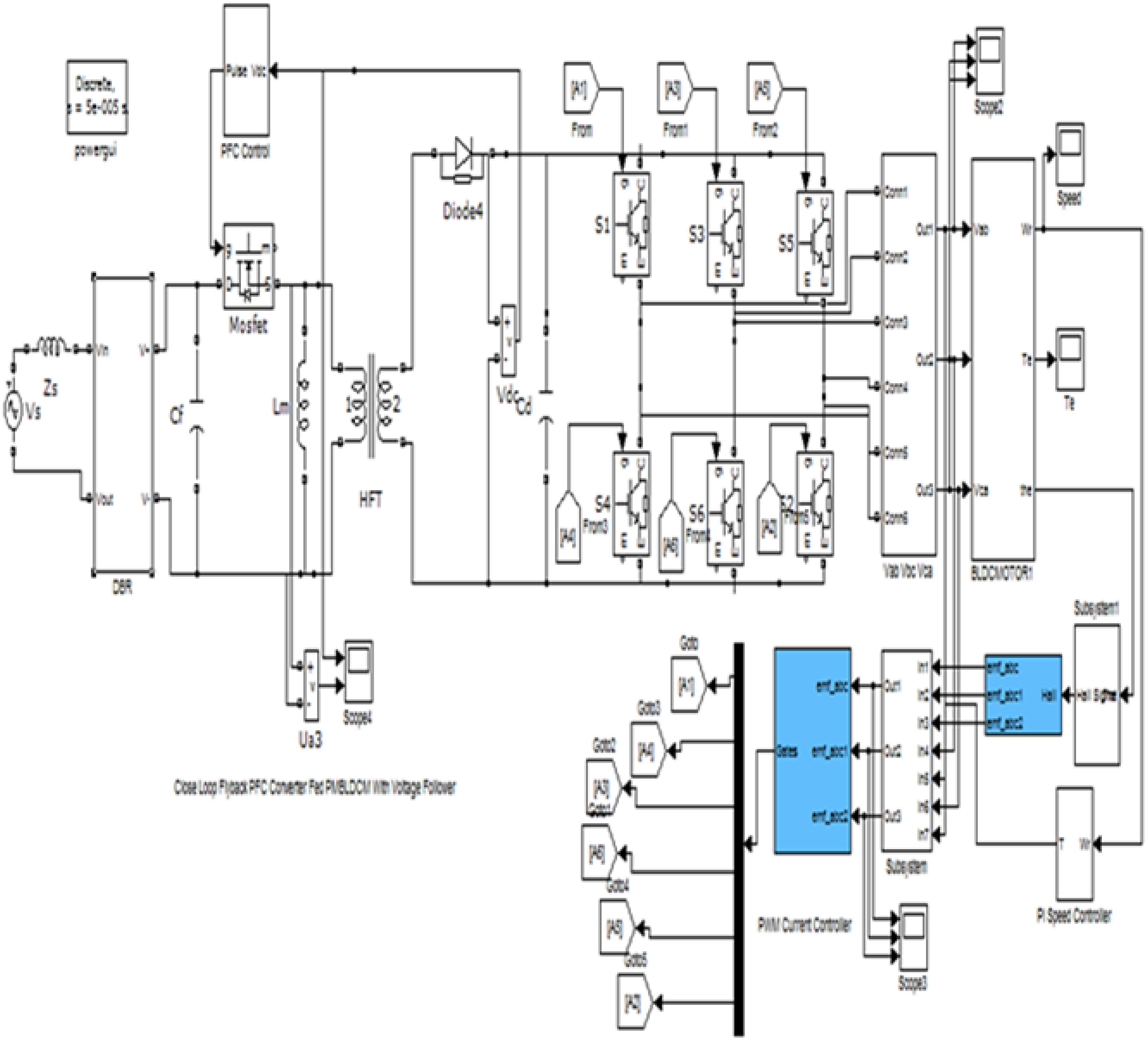


SIMULATION RESULT STUDIES OF SPEED V/S TIME CHARACTERISTICS FOR OPEN LOOP

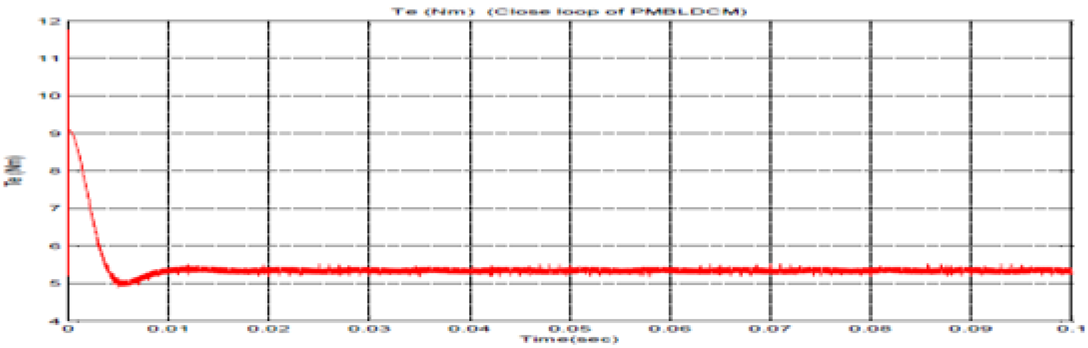


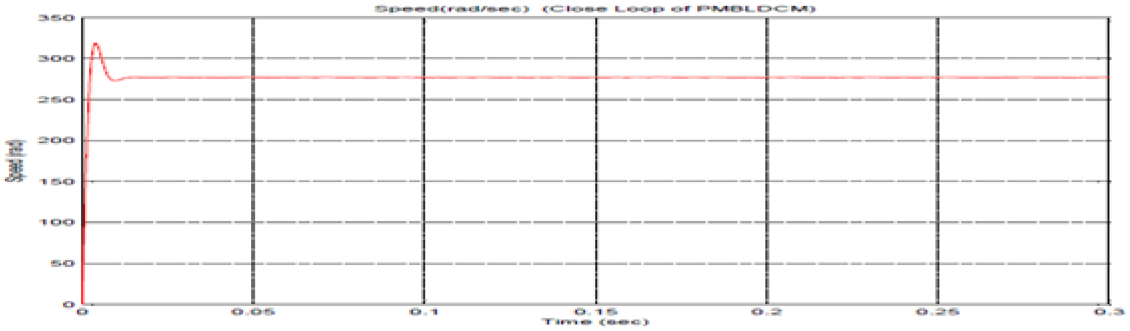


Close Loop Simulation of flyback PFC Converter Fed PMBLDCM drive



CLOSE LOOP RESULTS





RESULTS OBTAINED

Control Scheme	Parameters	Controller Parameters	PF(W/O)	PF(With)
Voltage Follower	Vs (v)=230	KPi= 0.085,KIi = 0.95	0.81	0.96
	Vin (v)=198 Vdc (v)=298	KP w=0.11, KIw=12		

IX. CONCLUSIONS

The design, modeling and simulation of flyback PFC converter fed PMBLDCM drive have been carried out in detail for its operation under speed control and varying input ac voltage. the voltage follower control operated in DCM operation of the PFC converter. However, the voltage follower control has added advantage of reduced sensors for PFC converter. Therefore, the flyback PFC converter fed PMBLDCM based on voltage follower control has potential for low cost and low voltage speed control applications operated from utility AC mains. It is concluded that the proposed concept of single stage PFC with single controller for a flyback PFC converter fed PMBLDCMD shall be a good solution for many applications in low power range.

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