

Simulation Model of Buck Converter Closed System Using PMBLDC Drive

Ajay Mishra¹, Arti Bhandakkar² (associate professor)^{1,2} SRIT, JABALPUR, M.P

ABSTRACT

The PMBLDC motor is 3 phases, 4 poles, Y connected; trapezoidal back-EMF type of BLDC motor for automotive industry application is modeled and simulated in MATLAB / SIMULINK. A *MATLAB* program is developed to simulate the overall motor drive system. A closed loop speed control strategy is developed and simulated. The drive system is proposed with a buck converter topology. In this model the buck converter is used as a step-down DC voltage. A single neuron PI controller is used to control the speed. According to simulation and experimental results, the proposed strategy shows good self adapted track ability, also the structure of the drive is simplified. A detailed discussion about the simulation of the proposed drive system is presented.

Key words:-PMBLDC, EMF, buck converter, hall effect, inverter.

I. Introduction

BLDC motors are very popular in a wide array of applications. Permanent magnet brushless (PMBL) motors can be considered a kind of three phase synchronous motor; they are well driven by dc voltage having permanent magnets on the rotor, replacing the mechanical commutator and brush gear. The commutation in a PMBLDCM is accomplished by solid state switches of a three-phase voltage-source inverter (VSI).[1]Commutation is accomplished by electronic switches, which supply current to the motor windings in synchronization with the rotor position. A PMBLDCM has the developed torque proportional to its phase current and its back electromotive force (EMF), which is proportional to the speed.[1] A BLDC motor needs quasi square current waveforms, which are synchronized with the back-EMF to generate constant output torque and have 120 conduction and 60 non conducting regions BLDC motor has trapezoidal emf and quasi rectangular current waveforms. In the BLDC motor, the torque ripple is decided by the back emf and current waveforms, and their non-ideal effects generate a pulsating torque. The reduction of the torque ripple is important from a speed and position control point of view. The rotor position is sensed by a Hall Effect sensor or a slotted optical disk, providing three square Waves with phase shift of 120°. These signals are decoded by a combinatorial logic to provide the firing signals for 120° conduction on each of the three phases. The conventional three phase full wave inverter has the demerit of current ripple during commutation, thus the torque ripple of BLDCM is high.[2]

II. Brushless dc motor introduction

The first earliest evidence of a brushless DC motor was in 1962 when T.G. Wilson and P.H. Trickey wrote about a DC brushless motor in a paper. It was subsequently developed as a high torque, high response drive for special applications such as tape and disk drives for computers, robotics and positioning systems, and in aircraft, where brush wear was intolerable due to low humidity. This motor could not be used for industrial purposes for a power requirement greater than 5hp.

The increasing popularity of brushless permanent magnet motors in recent years is due to the drop in prices of the high energy magnets and electronic devices. The brushless permanent magnet motors perform better and have higher efficiency than the machines with electromagnetic excitation. Fig. 1 shows a permanent magnet brushless DC motor. The rotor is a permanent magnet; the sensors used are hall elements.

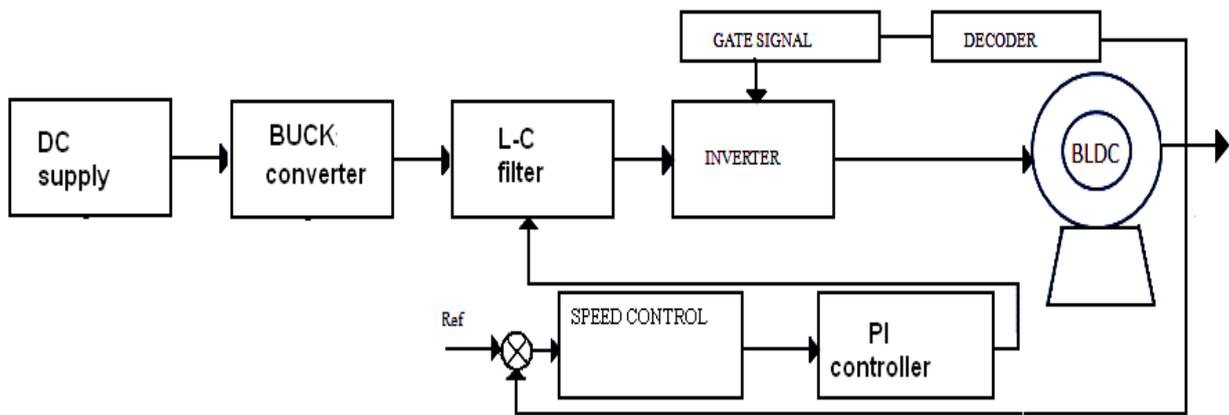
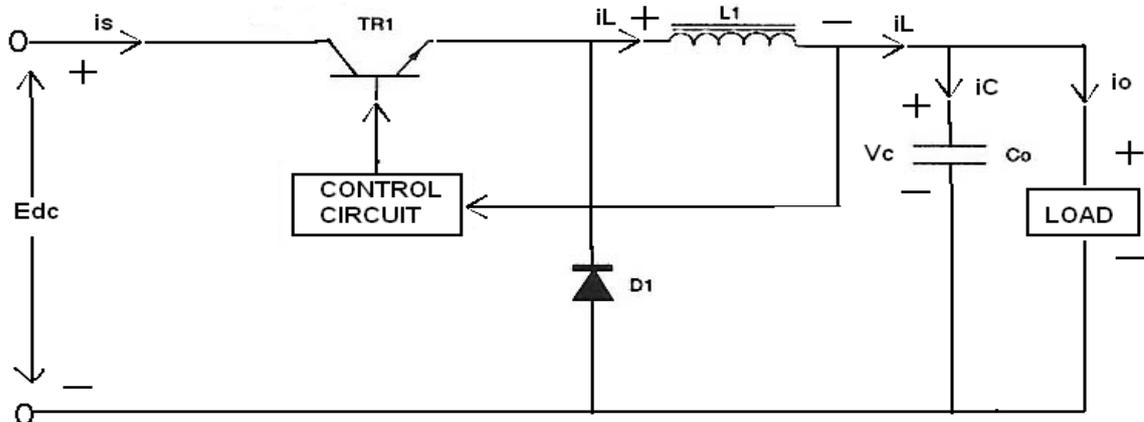


Fig.(1):-block diagram of pmblcdc motor closed loop controlled buck converter system.

III. BUCK (STEP DOWN) CONVERTER

A step down (BUCK) converter produces a lower average output voltage E_o than the d.c. input voltage E_{dc} . By varying the Duty-ratio T_{on} / T of the transistor, the average output voltage can be controlled. The associated voltage and current

waveform for the continuous current flow in the inductor. Transistor T1 is switch on at time $t=0$. The supply current which rise, flow through the path filter inductor. Filter capacitor and load resistance. Therefore, the inductor stored energy during the T_{on} period.



Fig(2):- A step down(BUCK) converter.

During the interval when the transistor is on, the diode becomes reverse biased and the input provides energy to the load as well as to the inductor. Now, at instant $t= T_{on}$, transistor T1 is switched off. During the interval when the transistor is off, the inductor current flows through L,C load and freewheeling diode Df and hence diode Df conducts. The output voltage fluctuations are very much diminished, using a low pass filter, consisting of an inductor and a capacitor.

IV. MATLAB SIMULATION AND RESULT

Closed loop system is simulated using Matlab Simulink. The Simulink model of closed loop controlled buck converter inverter fed PMBLDC drive which shown in Fig.3. Here 48V DC is stepped down to 24V DC using a buck converter. The output of buck converter is filtered using pi-filter. The output of the pi-filter is applied to the three phase inverter, the inverter produces three phase voltage required by the PMBLDC motor.

s.no.	Parameter	Rating
1	Input voltage	48 V DC
2	Buck output voltage	24 V DC
3	Pulse width to Buck MOSFET	0.5 duty cycle (50%)
4	Toff	50%
5	Pulse width (33%) to Inverter MOSFET	120° mode of operation.

A decoder is a circuit that changes a code into a set of signals. It is called a decoder because it does the reverse of encoding, but we will begin our study of encoders and decoders with decoders because they are simpler to design. A common type of decoder is the line decoder which takes an n-digit binary number and decodes it into 2n data lines. The simplest is the 1-to-2 line decoder. The truth table is A is the address and D is the data line.

The gate circuit is used to triggering gate pulse for commutation in to the inverter. The above truth table shown the EMFs signal are enter in the gate circuit and the signal are compared to the grater then to zero or less then to zero. This signal is throwing to the inverter and inverter is conducting. If the signal is zero the inverter is not conducting and if the signal is one the inverter is conducting.

The comparator circuit is used to controls the pulse width applied signal for conducting the buck MOSFET. In this circuit the two signals are enter. One signal are come for the pi controller and other signal are come for the repeating signal, both the signals are to difference and the signal are gave to the relay. The relay is used as a sensing device and the relay is sense the signal. If the signal is zero the relay is off and if the signal is one the relay is on the mosfet is conduct.

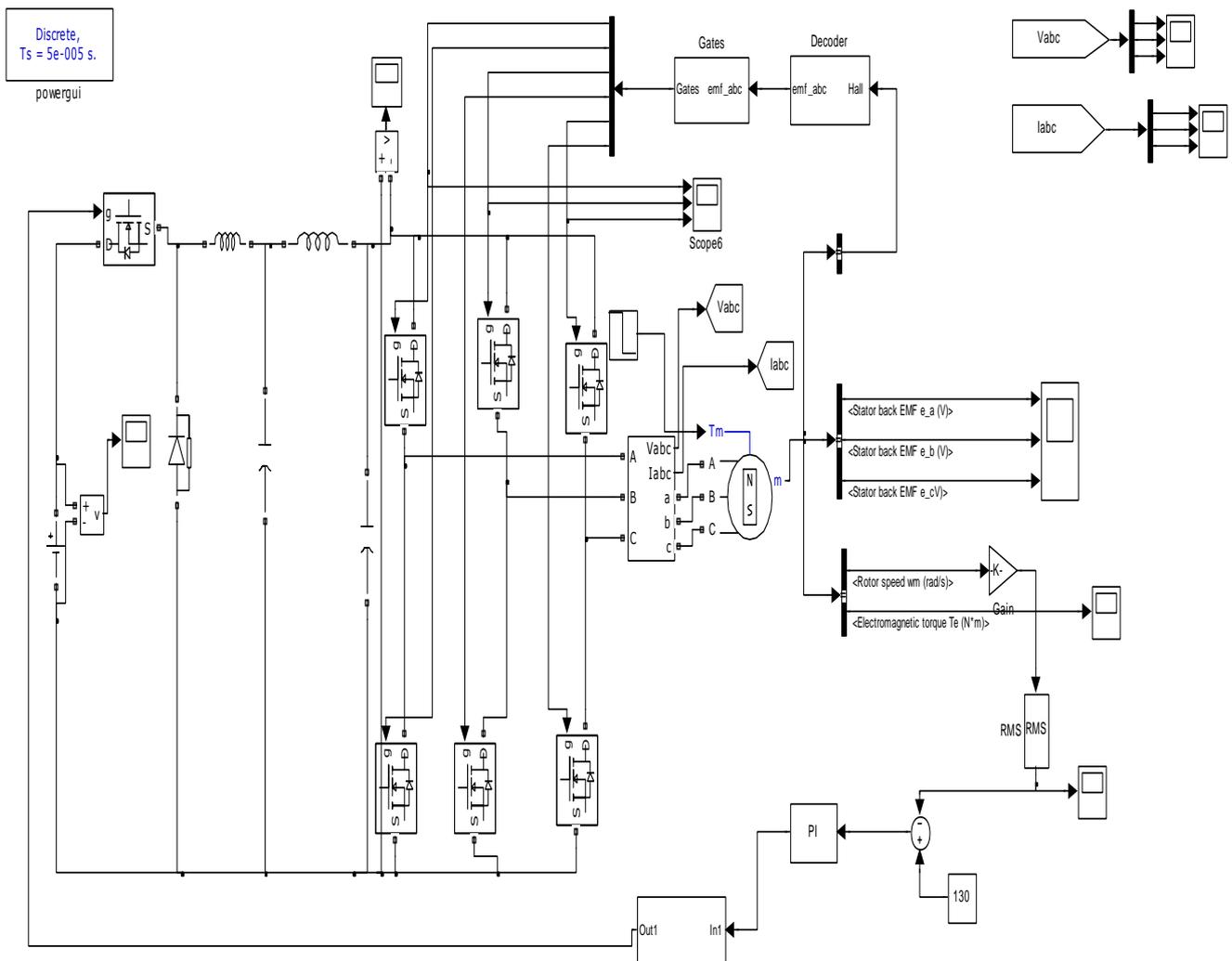


Fig.3:-The Simulink diagram of closed loop controlled buck converter inverter fed PMBLDC drive.

Ha	Hb	Hc	Ha'	Hb'	Hc'	Ha* Hc'	Hb* Hc'	Hc* Ha'	Ha'* Hb	Hb'* Hc	Hc'* Ha	Emf a	Emf b	Emf c
0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
0	0	1	1	1	0	0	0	1	0	1	0	0	-1	+1
0	1	0	1	0	1	0	1	0	1	0	0	-1	+1	0
0	1	1	1	0	0	0	0	1	1	0	0	-1	0	+1
1	0	0	0	1	1	1	0	0	0	0	1	+1	0	-1
1	0	1	0	1	0	1	0	0	0	1	0	+1	-1	0
1	1	0	0	0	1	0	1	0	0	0	1	0	+1	-1
1	1	1	0	0	0	0	0	0	0	0	0	0	0	0

V. Simulation Result

The result is show the drive system with the buck converter topology that is reduced the switching losses. The system is work at low voltage that the power losses are low. The switching are through into

the inverter at 120 degree mode and the output voltage of the inverter is displayed by 120 degree each other. Same the output current of the inverter is very 0.5 to -0.5. The output of the rotor speed is 1360 rpm or 160red/sec. the electromagnetic torque is 1.2 N-m.

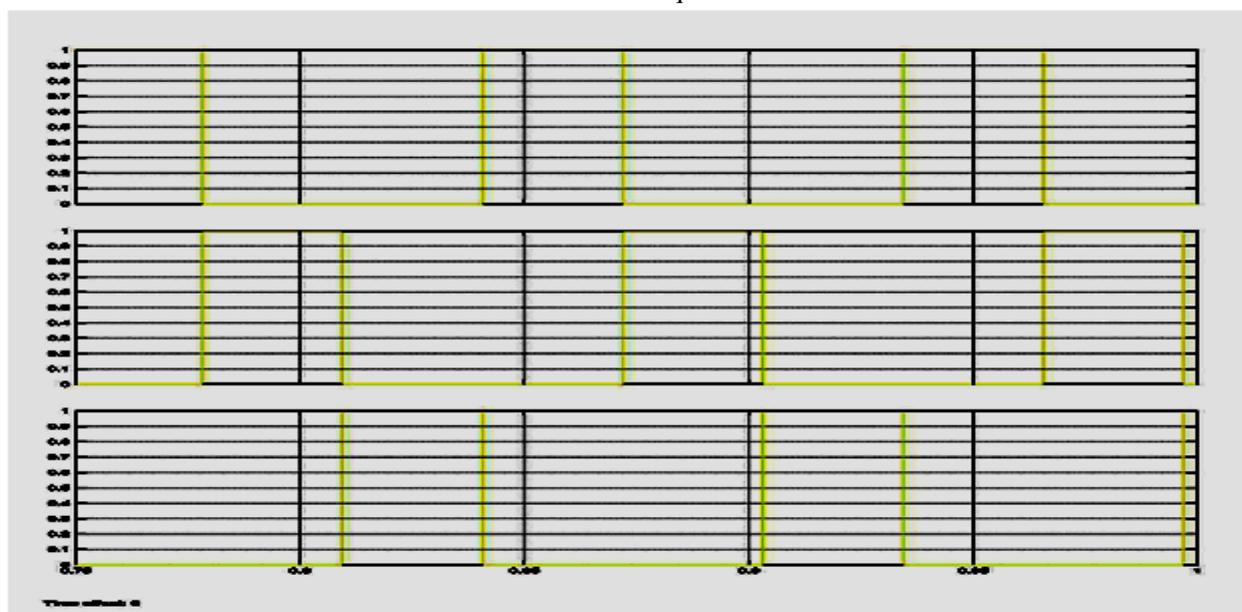


Fig4:-The triggering pulse.

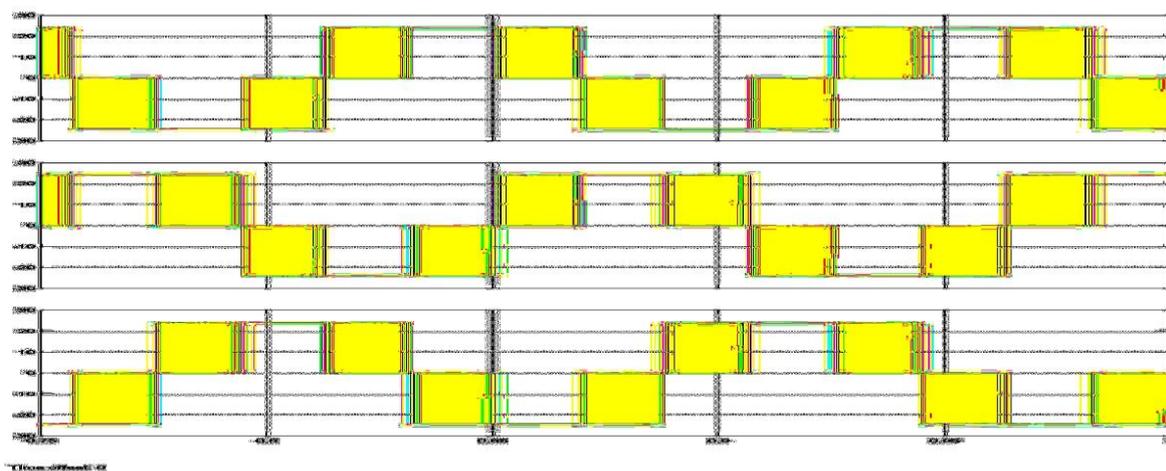


Fig5:-phase voltage of inverter.

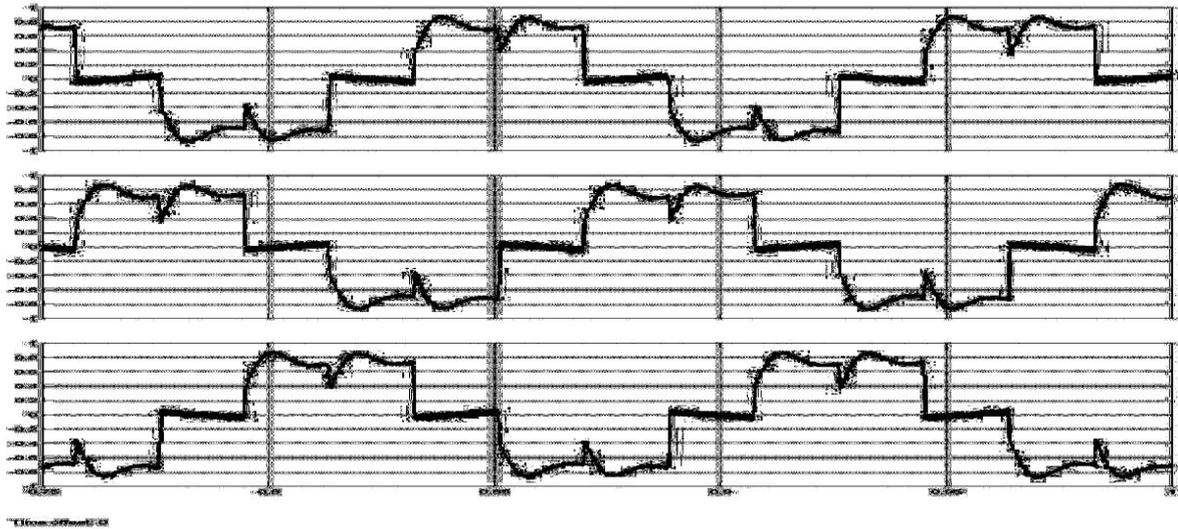
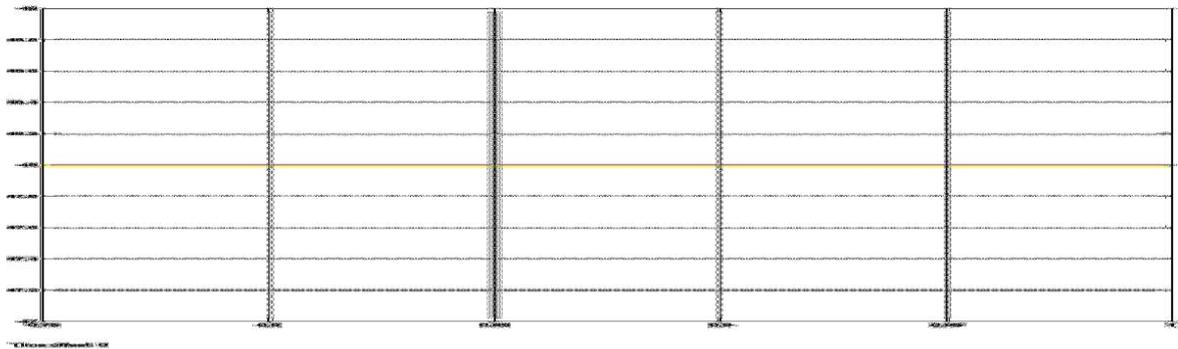


Fig6:-output current of inverter.



Fig(7):-input DC voltage.

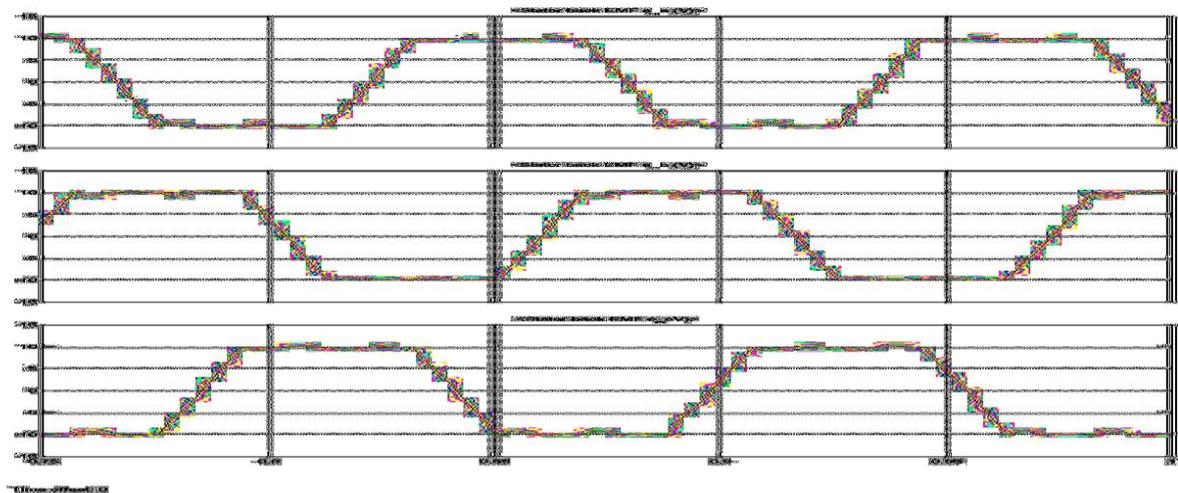


Fig:-8:-Back EMF waveform

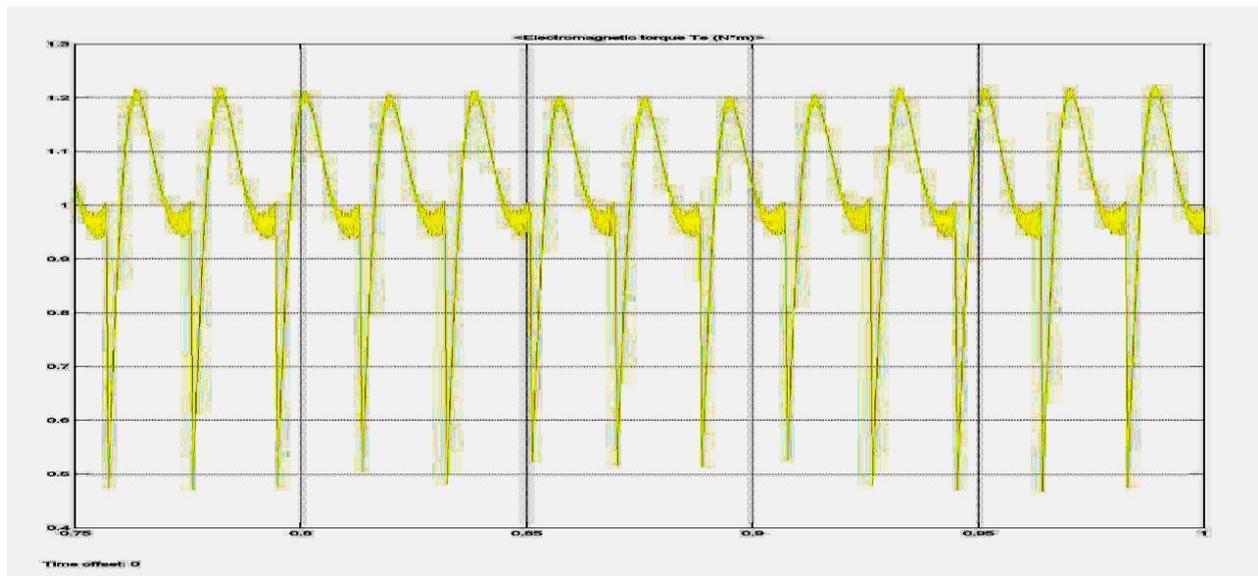


Fig:-9:-Electromagnetic torque waveform.

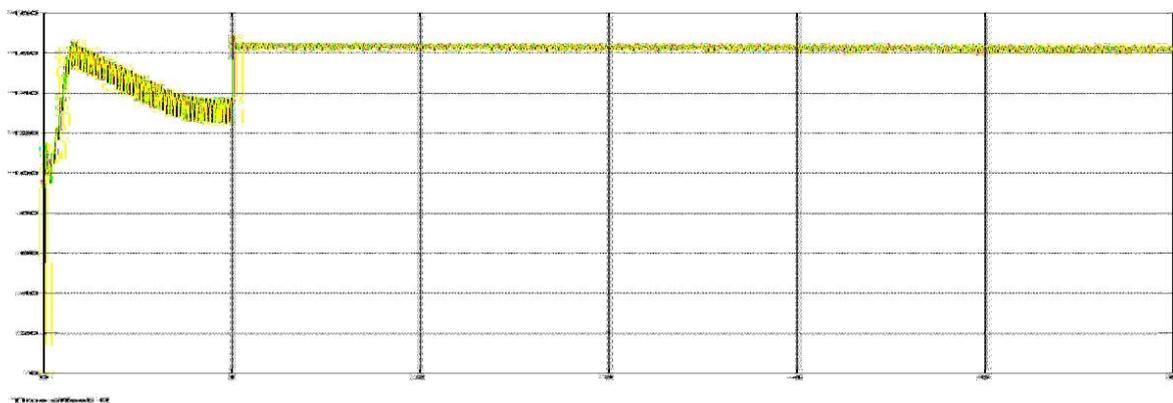
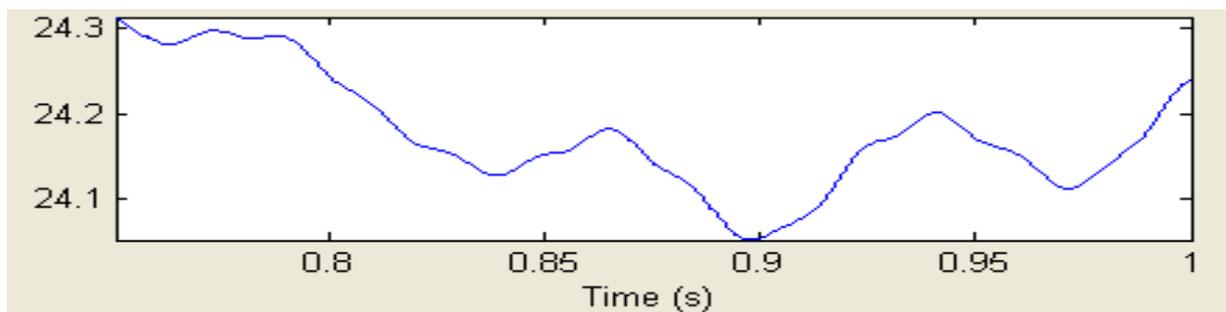


Fig:-10:-Rotor speed waveform.



Fig(11):-output of the buck converter

VI. CONCLUSION

Buck converter is proposed to reduce the input voltage to the required value. Pi-filter is proposed at the output of the buck converter to reduce the ripple. We can adjust its speed in the between the range 0 to 2600 rpm according to our application requirement. We can apply a maximum torque load of 1.2 N-m to this drive. All switches work under soft-switching condition, so their power losses are small. Torque ripple of motor is reduced significantly. The back EMF is a result of the movement of the PM rotor,

thereby, dependent on rotor position and proportional to rotor velocity. The machine voltage and current waveforms reflect the rotor-position dependence of the inductance and back EMF. Therefore, the voltage and current waveforms can be analyzed to extract the back EMF or inductance (or a combination of the two), from which the rotor position can be estimated in the position sensor less schemes.

REFERENCES

- [1] S. Prakash, Modelling and Simulation of Closed Loop Controlled Buck Converter Fed Pmbldc Drive System, 2011
- [2] Jibin M Varghese, Jaya B and Justin Baby “PI tuning control of Four Switch Three Phase Brushless DC Motor” IPCSIT vol.21 (2011)
- [3] T.S. Low,K.J. Tseng,T.H. Lee K.W. Lim, K.S. Lock “Strategy for the instantaneous torque control of permanent-magnet brushless DC drives” IEE PROCEEDINGS, Vol. 137, Pt. B, No. 6, NOVEMBER 1990
- [4] Ahmed Rubaai ,Raj C. Yalamanchili, “Dynamic study of an electronically brushless dc machine via computer simulation” IEFEE Transactions on Energy Conversion, Vol. 7, No.1, March 1992
- [5] Tilak Gopalarathnam, Hamid A. Toliyat “A New Topology for Unipolar Brushless DC Motor Drive with High Power Factor” IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 18, NO. 6, NOVEMBER 2003