# PERFORMANCE COMPARISON OF SIX SWITCH BASED INVERTER VS FOUR SWITCH BASED INVERTER FED BLDC MOTOR DRIVE IN AUTOMOTIVE APPLICATION

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## Abstract:

In recent days BLDC motors frequently used in automotive industries mainly exhaust gas treatment system and other applications. In exhaust gas treatment system BLDC motors mainly used for pumping and purging application for Adblue. In this paper compares the performance of six switch based inverter vs four switch based inverter fed BLDC motor drives in exhaust gas treatment system. Artificial intelligent based six switch inverter fed BLDC motor drive performance compare with SVPWM based four switch inverter fed BLDC motor drive. The simulation results are presented to verify the stability of the different drive system.

Key wards: BLDC motor drive, Exhaust gas treatment system, Fuzzy logic, SVPWM.

## Introduction:

The use of Brushless DC (BLDC) motors is continuously increasing. The reason is obvious: BLDC motors are having a good weight/size to power ration, have excellent acceleration performance, requires little or no maintenance and generates less acoustic and electrical noise than universal (brushed) DC motors. In a Universal DC motor, brushes control the commutation by physically connecting the coils at the correct moment. In BLDC motors the commutation is controlled by electronics. The electronics can either have position sensor inputs that provide information about when to commutate or use the Back Electromotive Force generated in the coils. Position sensors are most often used in applications where the starting torque varies greatly or where a high initial torque is required. Position sensors are also often used in applications where the motor is used for positioning. Sensor less BLDC control is often used when the initial torque does not vary much and where position control is not in focus, e.g. in fans

Three phase voltage source inverter has six power semiconductor switches in three legs with pair of switches in each phase. In order to develop the power inverter circuits with reduced cost and less switching losses, Four switch inverters are the best choice and preferred over three phase inverter. It consists of only four power switches with two legs third leg consist of power capacitors .In this paper briefly discussed about performance evaluation of fuzzy based six switch inverter vs SVPWM based four switch inverter based BLDC motor drive.

**ANALYSIS OF BLDC DRIVE SYSTEM**

In this chapter discussed about Fuzzy based six switch inverter fed BLDC motor drive and SVPWM based four switch inverter fed BLDC motor drive.

**Fuzzy based six switch fed BLDC drive**

Fuzzy logic is a powerful problem solving methodology with a myriad of applications in embedded control and information processing. Fuzzy logic resembles human decision making with its ability to work from approximate data and find precise solutions.

Membership Function (MF) specifies the degree to which a given input belongs to a set. Here, seven membership function have been used to explore best dynamic responses, namely Negative Big (NB), Negative Medium (NM), Negative Small (NS), Zero (ZO), Positive Small (PS), Positive Medium (PM) and Positive Big

(PB). Fuzzy rules are conditional statement that specifies the relationship among fuzzy variables. These rules help us to describe the control action in quantitative terms and have been obtained by examining the output response to corresponding inputs to the fuzzy controller.

The degree of membership function used for fuzzification is shown in Fig.1 and Fig.2 and membership function for defuzzzification is shown in Fig.3.
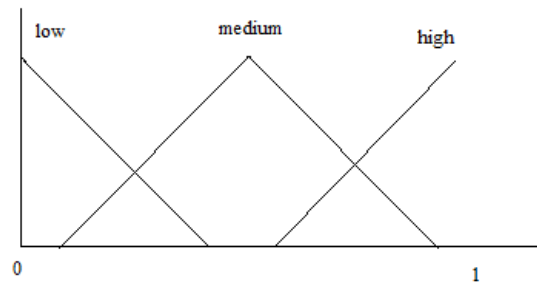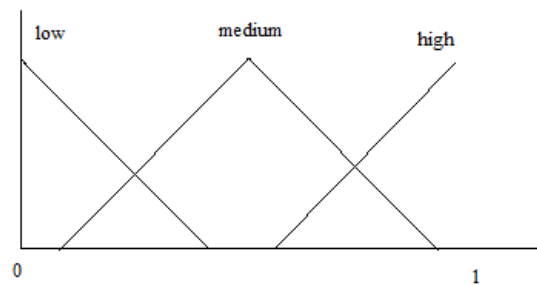


**Figure.1.Membership function for input 1**
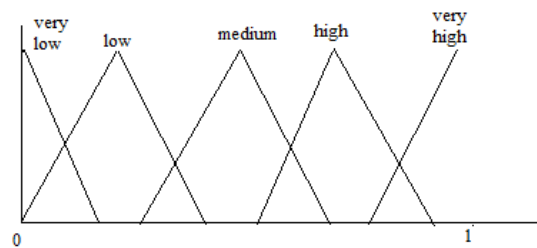


**Figure.2.Membership function for input 2**



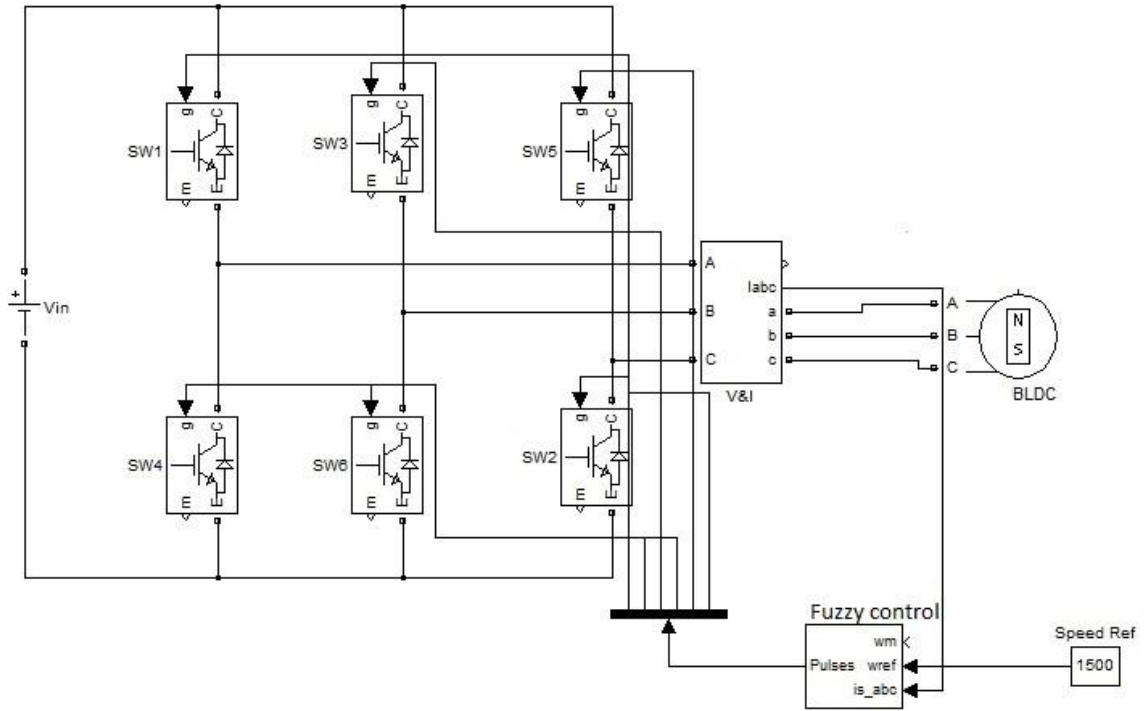**Figure.3.Membership function for output**

**Figure.4.Functional Block diagram for Fuzzy based BLDC motor drive**

**SVPWM based four switch inverter fed BLDC drive**

According to the scheme in fig.5 the switching status is represented by binary variables SI to S4, which are set to "1" when the switch is closed and "0" when open. In addition the switches in one inverter branch are controlled complementary (1 on, 1 off), therefore:

$$`S1 + S2 = 1$$
$$S3 + S4 = 1 \qquad (1)$$

Phase to common point voltage depends on the turning off signal for the switch:

$$V_{ao} = (2S1 - 1) * \frac{V_{dc}}{2} \ ; V_{b0} = (2S3 - 1) * \frac{V_{dc}}{2} ; V_{c0} = 0 \qquad (2)$$
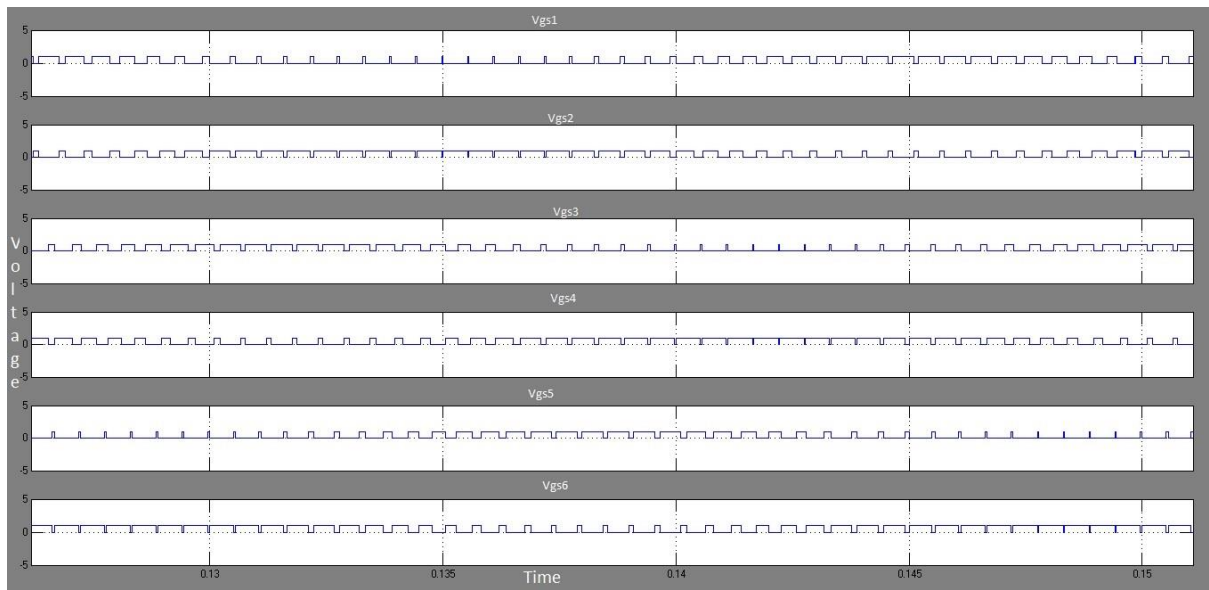
Combinations of switSchting-S4 result in 4 general space vectors v1 – v4  (Table 1), components of αβ of the voltage vectors are gained from abc voltages by using Clark's transformation:

$$\begin{bmatrix} V_\alpha \\ V_\beta \end{bmatrix} = \frac{2}{3} \begin{bmatrix} 1 & -\dfrac{1}{2} & -\dfrac{1}{2} \\ 0 & \dfrac{\sqrt{3}}{2} & -\dfrac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \qquad (3)$$
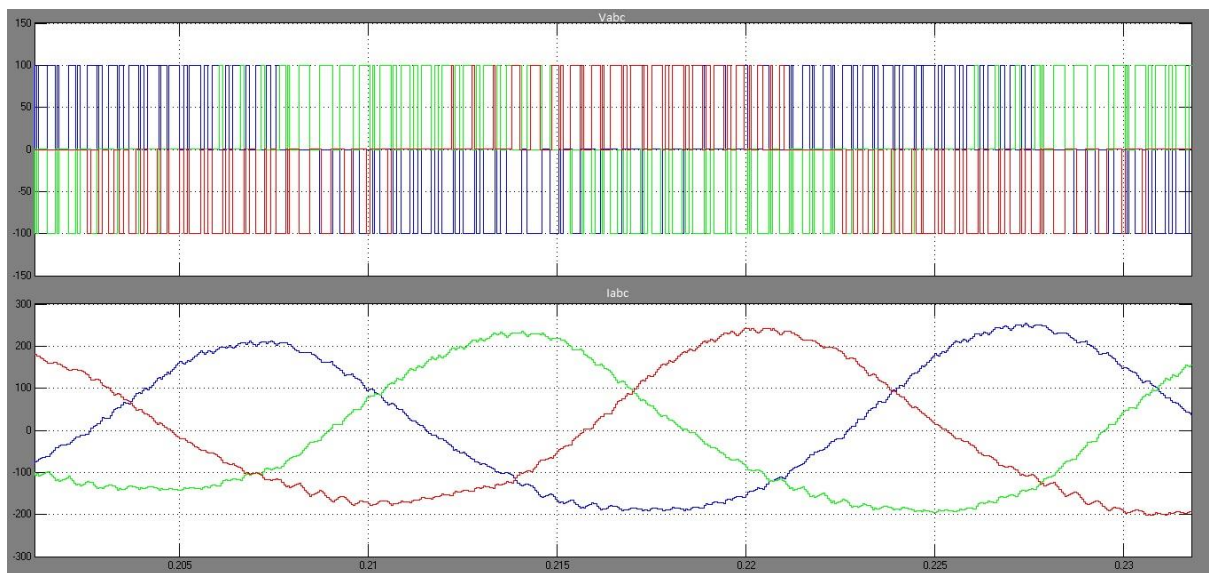
where $V_a$, $V_b$, $V_c$, : phase voltages on the load (Y connection), defined by:

$$V_a = \frac{1}{3}(2V_{a0} - V_{bo}); \ V_b = \frac{1}{3}(2V_{b0} - V_{a0}); \ V_c = -\frac{1}{3}(V_{a0} + V_{b0}) \qquad (4)$$

In order to form the required voltage space vector V $_{ref}$ we can use 3 or 4 vectors in one sampling interval Ts. The constant value 0 (zero) vectors can be formed by dividing to (duration of zero vector) among 2 opposite vectors ( $\vec{v1}$ , $\vec{v3}$ ) or ( $\vec{v2}$ , $\vec{v4}$ ).



**Figure 5 Voltage space vectors in the αβ plan**



**Figure 6 Functional Block diagram for SVPWM based BLDC motor drive**

**Simulation results**

In this chapter discussed about performance comparison of different drive control technology.

**Fuzzy based BLDC drive**

**X-Axis: Time Y-Axis: Voltage**
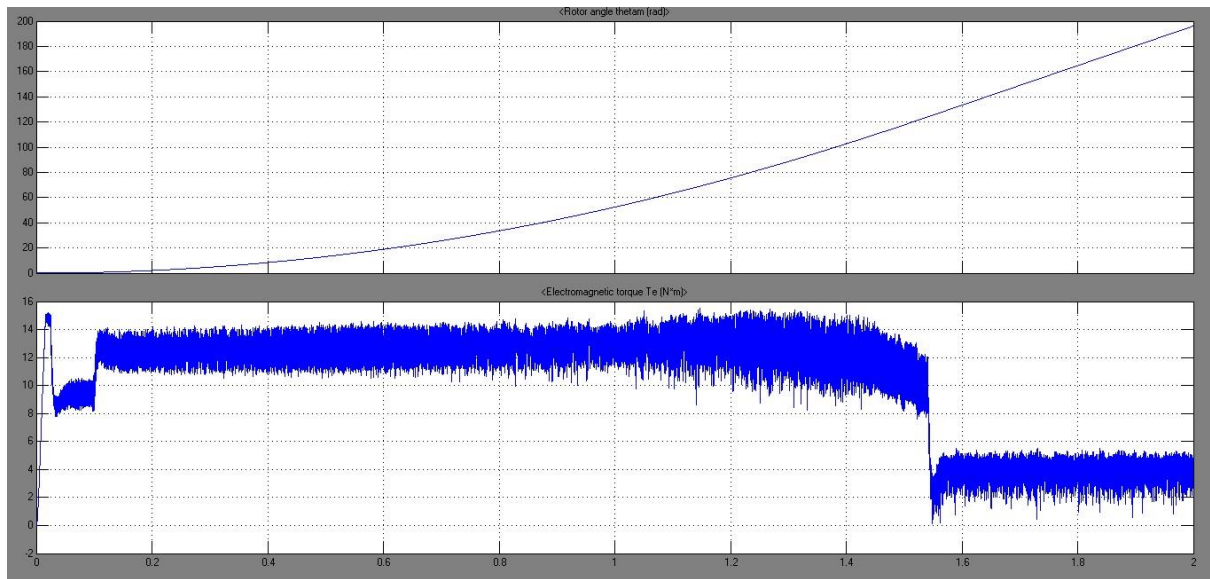**Figure 7 Gate signals for Fuzzy based BLDC motor drive**



**X-Axis: Time Y-Axis: Phase current and Phase Voltage**
**Figure 8 Phase current and voltage signals for Fuzzy based BLDC motor drive**
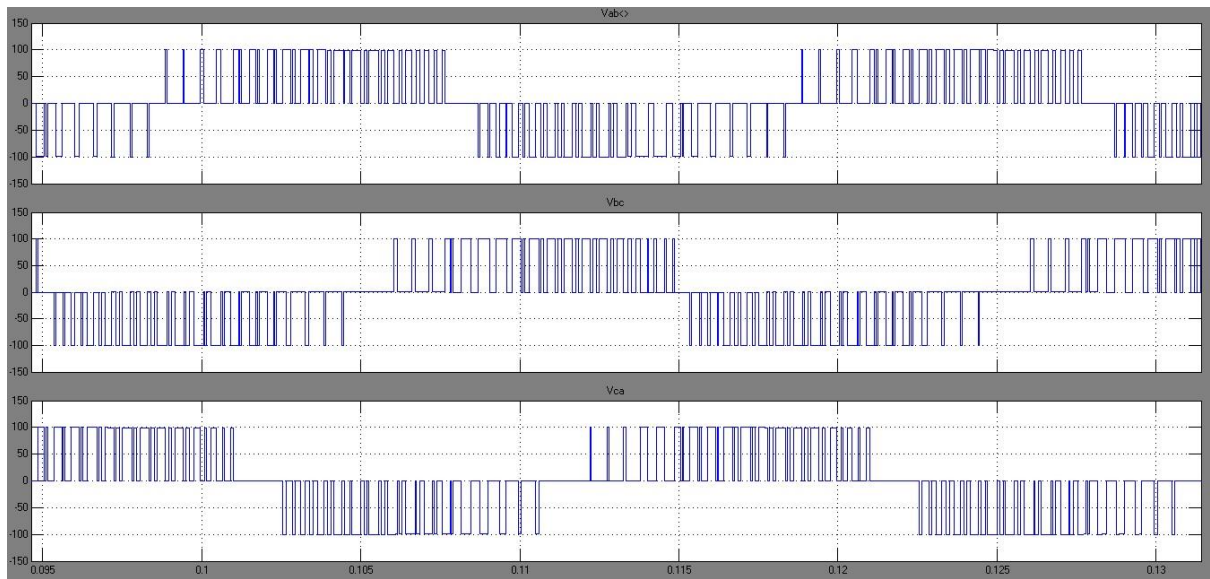
**X-Axis: Time Y-Axis: Phase Voltages**
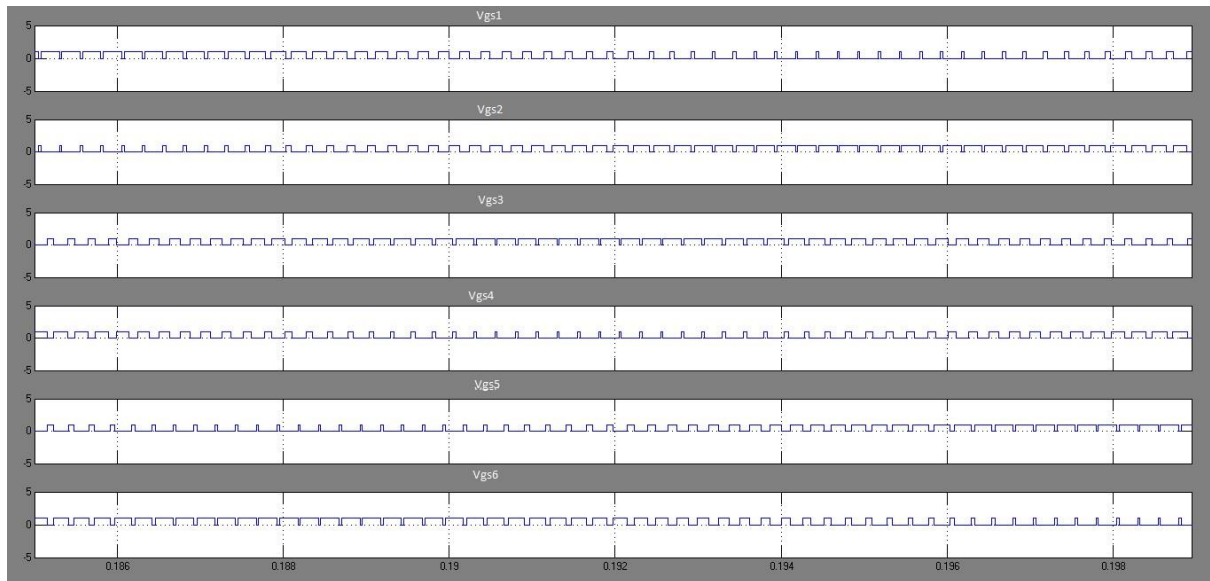**Figure 9 Phase voltage signals for Fuzzy based BLDC motor drive**
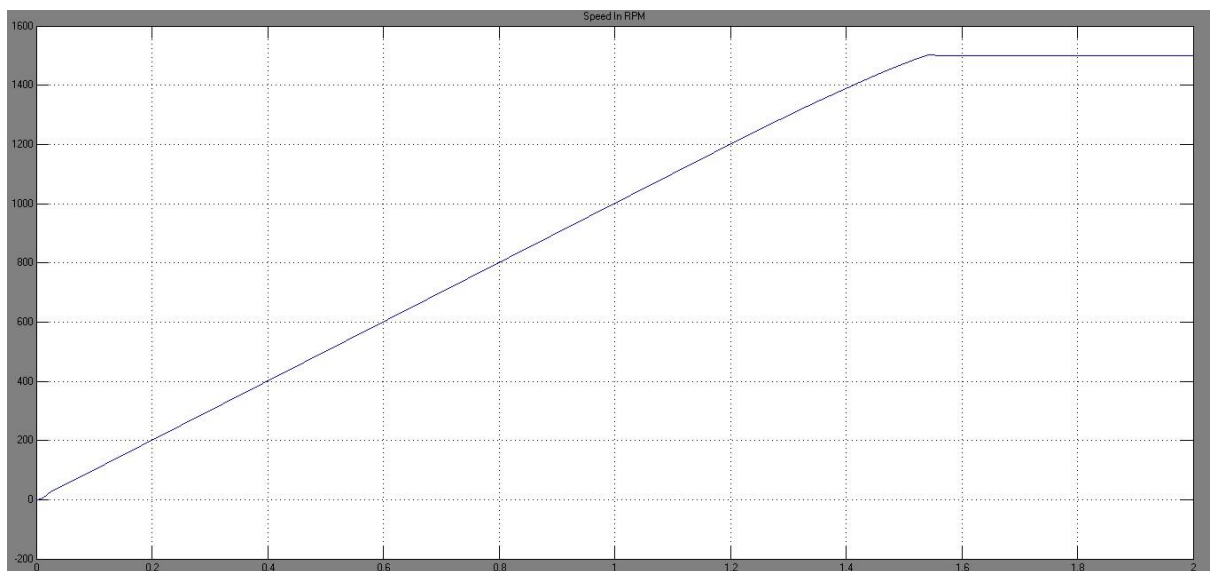


**X-Axis: Time Y-Axis: Speed**
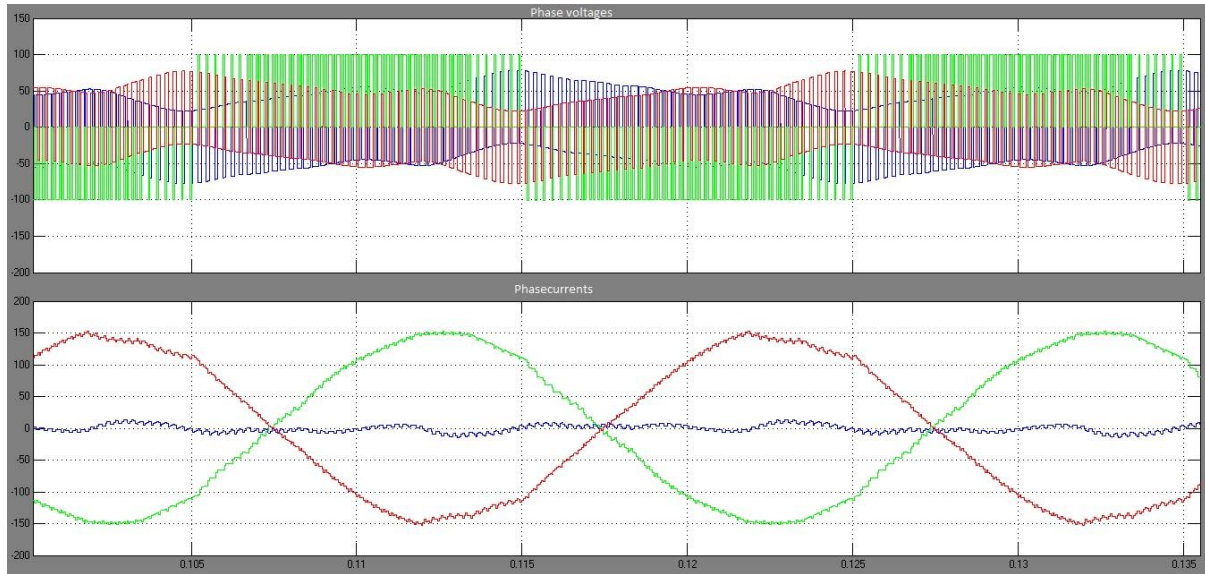**Figure 10 Speed Waveform for Fuzzy based BLDC motor drive**

**X-Axis: Time Y-Axis: Torque Speed**
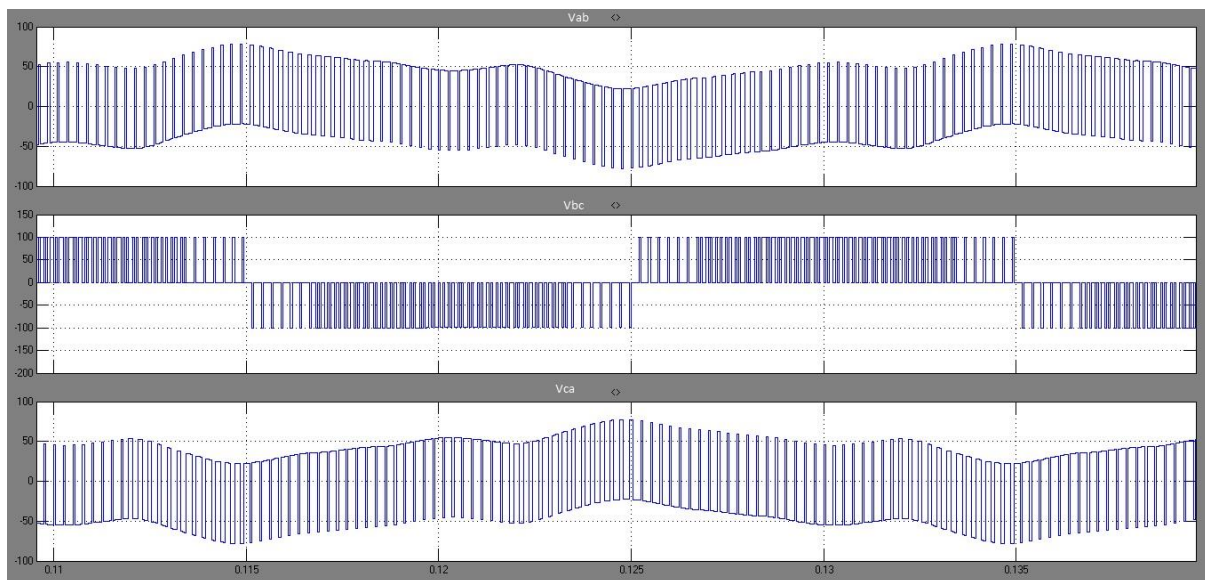**Figure 11 Torque Speed Waveform for Fuzzy based BLDC motor drive**
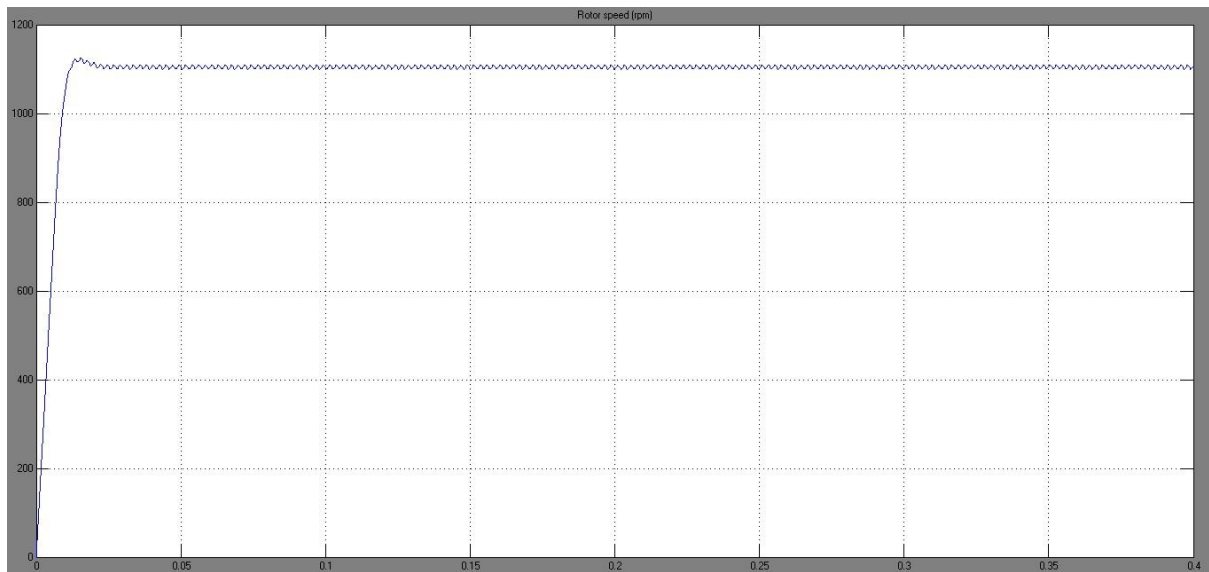
SVPWM based BLDC drive results



**X-Axis: Time Y-Axis: Voltage**
**Figure 12 Gate signals for SVPWM based BLDC motor drive**
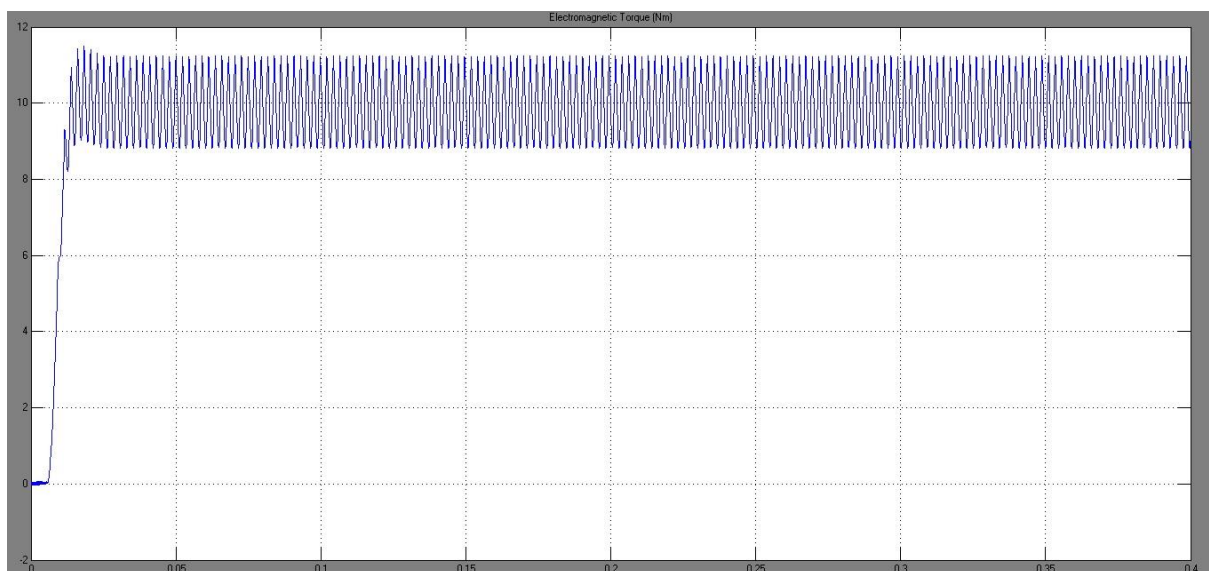
**X-Axis: Time Y-Axis: Phase current and Phase Voltage**
**Figure 13 Phase current and voltage signals for SVPWM based BLDC motor drive**



**X-Axis: Time Y-Axis: Phase Voltages**
**Figure 14 Phase voltage signals for SVPWM based BLDC motor drive**

**X-Axis: Time Y-Axis: Speed**
**Figure 15 Speed Waveform for SVPWM based BLDC motor drive**



**X-Axis: Time Y-Axis: Torque**
**Figure 16 Torque Waveform for SVPWM based BLDC motor drive**

## Conclusion

In this paper present   Fuzzy based six switch three phase inverter and Novel SVPWM based four switch three phase inverter based BLDC drive performance. Simulation results were analysed and compared with Fuzzy and SVPWM based BLDC drive performance. Both methods have their own drawbacks.

**REFERENCE**
[1] F. Blaabjerg, D. O. Neacsu and J. K. Pedersen, "Adaptive SVM to Compensate Dc-Link Voltage Ripple for Four-Switch, Three-Phase Voltage Source Inverter", IEEE Trans. on Power Electronics, Vol. 14, No. 4, July 1999, pp.743-751.
[2] C. B. Jacobina, M. B. R. Correa, E R. C da Silva and A. M. N. Lima, "Induction Motor Drive System for Low Power Applications", IEEE IAS Annual Meeting Conf. Record 1997, New Orleans, Louisiana, USA p.605-612.
[3] R. J. Cruise, C. F. Landy and M. D. McCulloch, "Evaluation of a Reduced Topology Phase-Converter Operating a Three-phase Induction Motor", IEEE/IEMDC Conf. Record 1999, Seattle, USA, pp.466-468

[4] S. Takijawa, M. Tabata, T. Tanigawa, S. Igarashi and K. Kuroki "High Efficiency Drive Techniques for the Brushless DC Motor Using a Four Switch, Three-Phase Inverter" Proceedings of IPEC 2000, Japan, pp.1692-1697.

[5] J. S. Larsen, K. Jespersen, M. R. Pedersen, F. Blaabjerg and J. K. Pedersen, "Control of a Complete Digital Based Component-Minimized Single-Phase to Three-Phase AC/DC/AC Converter, IEEE/IECON 1998, Aachen, Germany, pp. 618-625.

[6] M. N. Uddin, and M. A. Rahman, "Fuzzy Logic Based Speed Control of an IPM Synchronous Motor Drive" International Journal of Advanced Computational Intelligence, Vol. 4, No. 3, Dec. 2000, pp. 212-219.

[7] M. N. Uddin, T. S. Radwan, G. H. George and M. A. Rahman, "Performance of Current Controllers for VSI-Fed IPMSM Drive" IEEE Transactions on Industry Applications, vol.36, no. 6, November/ December 2000, pp. 1531-1538.

[8] T. M. Jahns, G. B. Kliman, and T. W. Neumann, "Interior Permanent Magnet Synchronous Motors for Adjustable-Speed Drives", IEEE Transactions on Industry Applications, vol.IA-22, July/August 1986, pp. 738-747.

[9] M. Azizur Rahman, Mahinda Vilathgamuwa, M. Nasir Uddin, and K. J. Tseng, "Nonlinear Control of Interior Permanent Magnet Synchronous Motor", IEEE Trans.on Ind. Applications, Vol. 30, No. 2, March/April 2003, pp. 408-416.

[10] Matlab, Simulink User Guide, The Math Works Inc.,2003.

[11] dSPACE, DSP Manual Guide, Paderborn, Germany,1999