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Power Quality Improvement and Sensor-less Control of BLDC Motor

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Abstract : In this paper the control of brushless motors is achieved by grounding a new practice called time based dependence comparator with better standard of power at supply ends. The proposed converter configuration operates in intermittent conduction mode which helps the attainment of power factor close to unity at supply ends. Energy conservation is achieved by supervising the motor speed through commutation process. Using this technique the compound variations of output due to disturbances or undulation are avoided and the phase delay is recompensed. Fuzzy logic improves the robustness with enhancement in the consistent performance of the system. Moreover the bridgeless configurations offer reduced switching losses due to the absence of partial single phase rectifier. The proposed system is validated using MATLAB 2013 and with a experiment model. Thus the harmonics are suppressed and the compatible limits of international standards like IEC 61000-3-2 and IEEE-519 standards are achieved.

Keywords : Intermittent conduction mode, power quality, voltage source inverter (VSI).

1. INTRODUCTION

Brushless direct current machines are being popularly used in low power appliances due to its medium construction complexity, no brush wears and their defensive attribute to electromagnetic interference (EMI) problems. As the name indicates they do not use brushes for commutation. A brushless DC motor is an AC machine with windings on the stator and the rotor is mounted using permanent magnets. Typically three hall transducers are used to detect the alignment of rotor and to control the speed by commutation process [2]. Hall transducers are used with the aim of gaining instant noiseless torque. However, the position sensors have several disadvantages such as noise immunity, reliability and machine size.

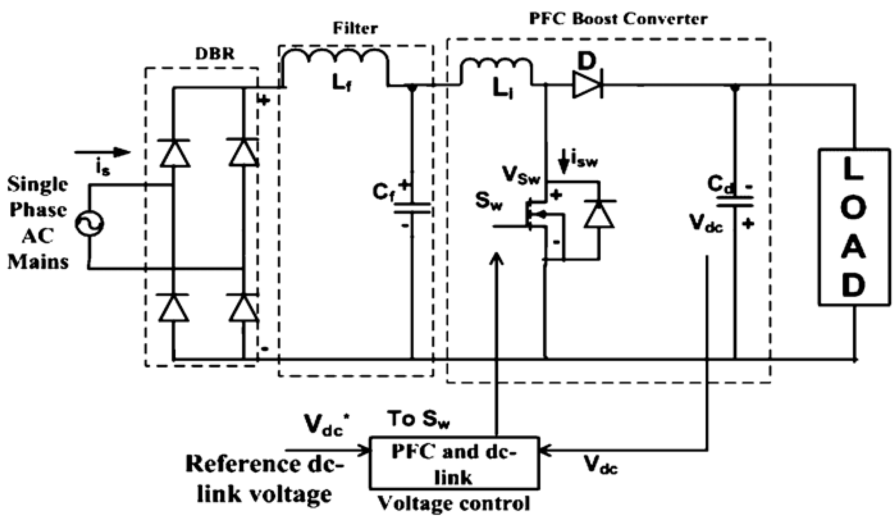

Fig. 1. Conventional PFC circuit

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To overcome these disadvantages many sensorless algorithms has been proposed. The most very frequently used algorithm is back-EMF estimation method which is also called as terminal voltage estimation method. Using this method, accurate rotor position is estimated at very low amplitude. Therefore, the technique generally used is "align and go" method to process the system [5] and [6].

Other sensorless control techniques like third harmonic back-EMF and phase locked loop (PLL) are suggested which leads to error accumulation and attenuation problems which in turn causes commutation delay. Moreover, the researchers have suggested the zero point crossing method of control in which the commutation of switches is calculated by sampling the voltage using current and position sensors.

Some drawbacks of the above literature survey are overcomed in this paper by grounding a new practice called as time based dependence comparator which provides high starting torque.

Power quality improvement is required to reduce the harmonic level and to reduce the load disturbances. A low power factor draws peaky and rich harmonic current from the supply, which in turn cause losses and dielectric stresses. From this point, a conventional system with DBR and a LC circuit fed dc-dc converter perform unsatisfactorily. Thus, technologies are improved to develop systems that maximize the power supply efficiency thereby improving the quality of power. Figure 1 shows the conventional system with PFC step up converter. [4]

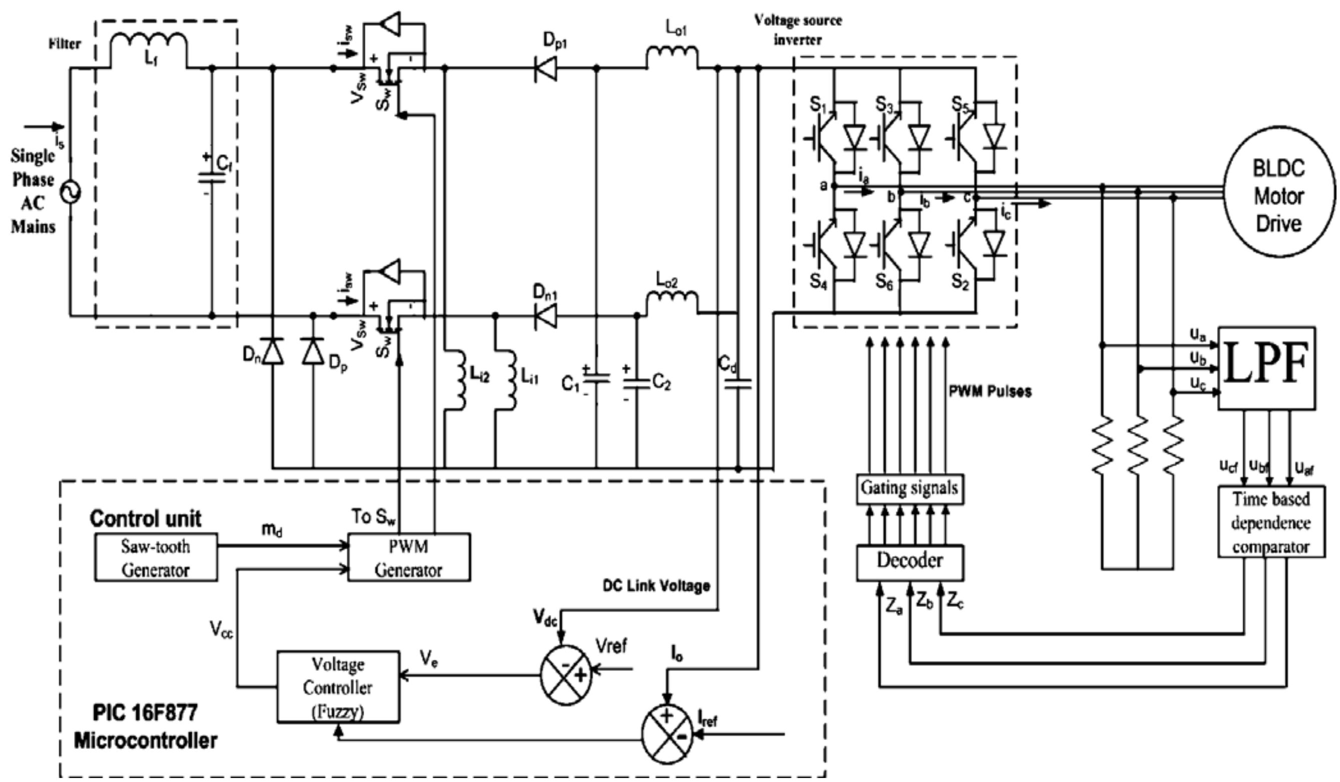

Fig. 2. Proposed PFC system with sensorless speed control of BLDC

Many topologies of PFC have been reported in the literature surveys. The most popular configuration is a PFC step up converter. A stable output voltage is maintained at intermediate capacitor between the inverter-converter systems for controlling the speed. Conventional scheme of PFC includes a current multiplier approach which includes voltage and current sensors. The front end SEPIC and Cuk regulator has been developed which makes the system more expensive. Bridgeless SEPIC regulator of PFC has been proposed at higher cost due to larger inductance.

Bridgeless configurations have been proposed due to their improved efficiency and reduced conduction losses. Partial absence of diode bridge rectifier reduces the turn on losses. The luo regulator has an essential attribute of boosting the voltage. This paper presents a speed sensorless control of BLDCM fed through BL-Luo converter with the improvement of power quality.

2. PROPOSED PFC-BASED BLDC MOTOR DRIVE

The proposed design of converter feeding the drive is shown in figure 2. The proposed configuration of converter operates in intermittent conduction mode which helps the circuit by attaining the standard of power at supply ends. The drive is controlled via through a sensorless system which uses a new comparator technique. Low Pass Filter is used to attenuate the noises and losses.

The proposed comparator provides the proper commutation pulses to the inverter and the presence of LPFs compensates the phase lag of back EMF which produces significant pulsating torques which in turn causes load disturbances. Finally, an experimental model of the proposed system is developed and compared with simulated results over a wide speed range.

3. PRINCIPLE OF OPERATION OF CONVERTER AND SENSORLESS SPEED CONTROL OF BLDC

The circuit operation of the proposed PFC BL-Luo regulator is classified into two divisions in which the switches operates for both units of input voltages.

The block diagram of the sensorless technique for BLDCM is shown in figure 3. The potential difference which is sensed is fed into the LPFs thereby attenuating the ripples or noises and due to the presence of this comparator proper commutation of switches or inverter is achieved. Thus it is used to improve both the performance and reliability of sensorless BLDC motor.

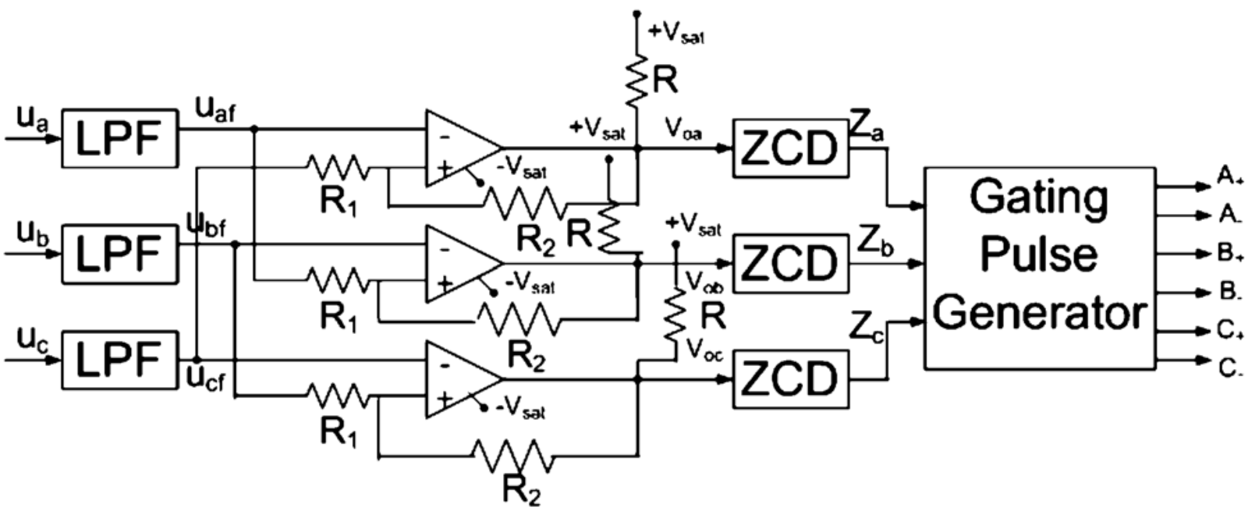

Fig. 3. Block diagram of time based dependence comparator.

4. SUPERVISION OF PROPOSED CONVERTER

A. Control of proposed BL-Luo regulator

Comparison of intermediate capacitors voltage and current with the reference is done, to generate the required switching pulses for the switches to maintain the required voltage at the intermediate capacitor. Conventional controllers are widely used in for closed loop operations. However, this computing technique used achieves a dynamic part in monitoring of non- linear systems and in engineering applications. Fuzzy logic is a problem solving methodology which can be implemented in system ranging from simple, small and larger systems.

In this project FLC is introduced to improve the robustness and suppresses the chattering of the load. Furthermore, fuzzy logic controllers are robust because they can cover an extensive variety of working circumstances and it can provide outputs based on indefinite, unclear and noisy information.

The PWM pulses are fed to the proposed converter to maintain the drive speed. The output voltage produced is matched with a non sinusoidal signal to produce the required signals which are given to the switch Sw.

B. Supervision of BLDCM

As the back EMF of the motor at stable condition is too diminutive; estimation of accurate position of rotor is complex. So, the start up requires a specific procedure in this sensorless technique.

Generally, in BLDC motors any two windings are energized by using the different six voltage vectors V_1-V_6. In the conventional alignment method maximum initial torque cannot be obtained. Since huge current is intended to flow through the stator windings it might get damaged. Thus conventional start up technique cannot be used as it degrades the performance of the BLDCM.

Figure 4 shows the initial rotor position alignment V_i. A rotor position alignment method is used to achieve maximum torque by exciting all the stator windings. At this point the excitation starts using the beginning voltage vector V_i (1, 0, 0). Now the rotor will be positioned with respect to V_1 and V_2 and V_3 is orthogonal to V_i maximum starting torque is obtained.

With the increase in frequency, the speed of the drive gets increased and phase angle is calculated by integrating the speed of rotor and the width of the gate pulses with respect to reference voltage magnitude. Back EMF is sensed to provide the status of the rotor alignment and then the drive is switched to sensorless control system.

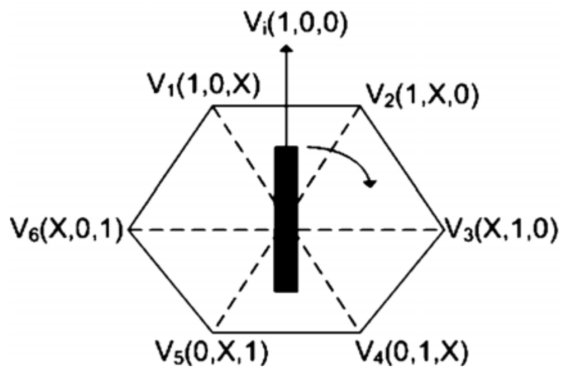

Fig. 4. Initial rotor position alignment

5. SIMULATION OF PROPOSED SYSTEM

A. Implementation of proposed fuzzy based BL-Luo converter

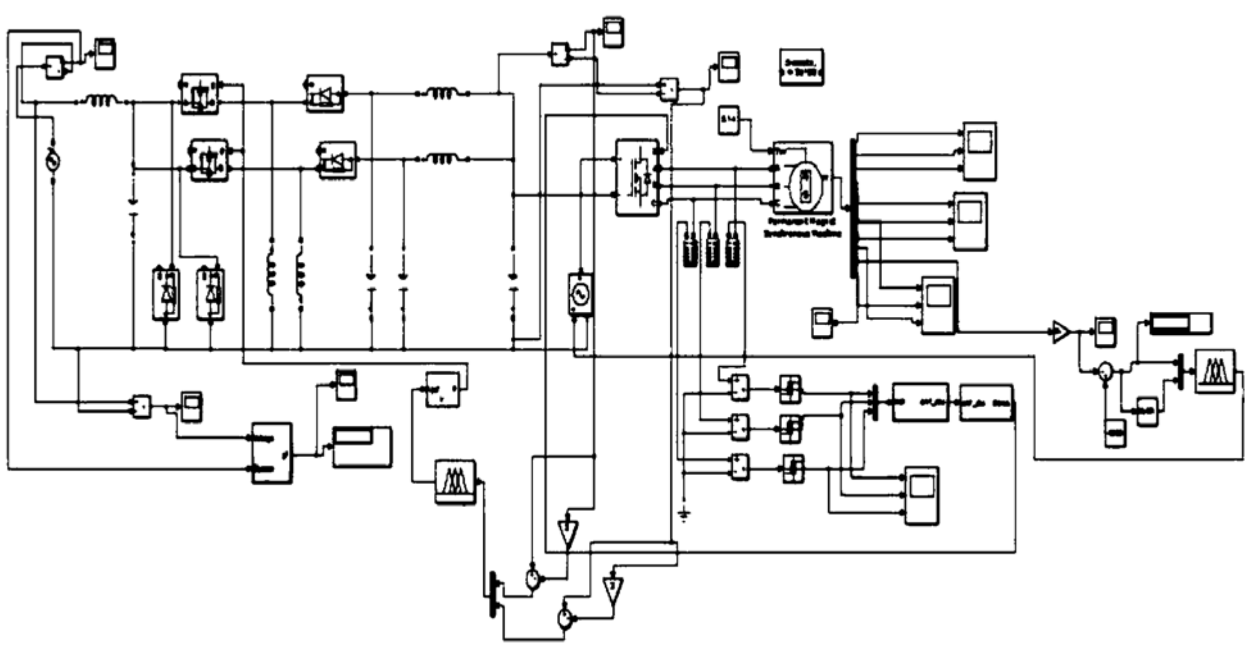

Fig. 5(*a*) Simulation of the developed system

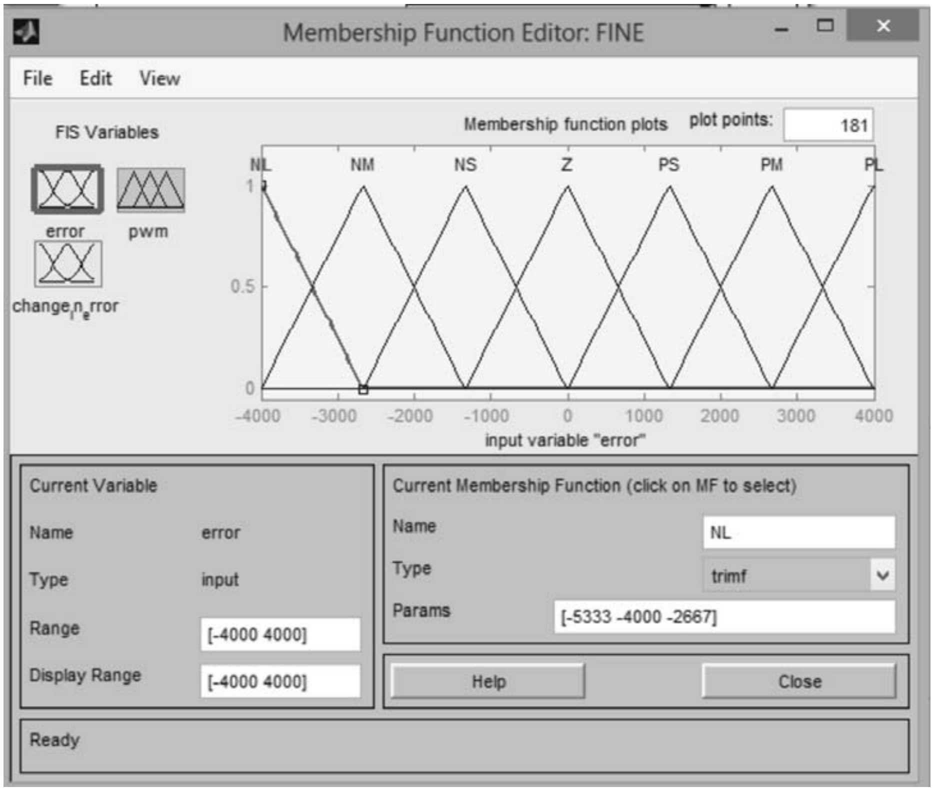

Fig. 5(*b*) Input 1 to fuzzy for BLDC control

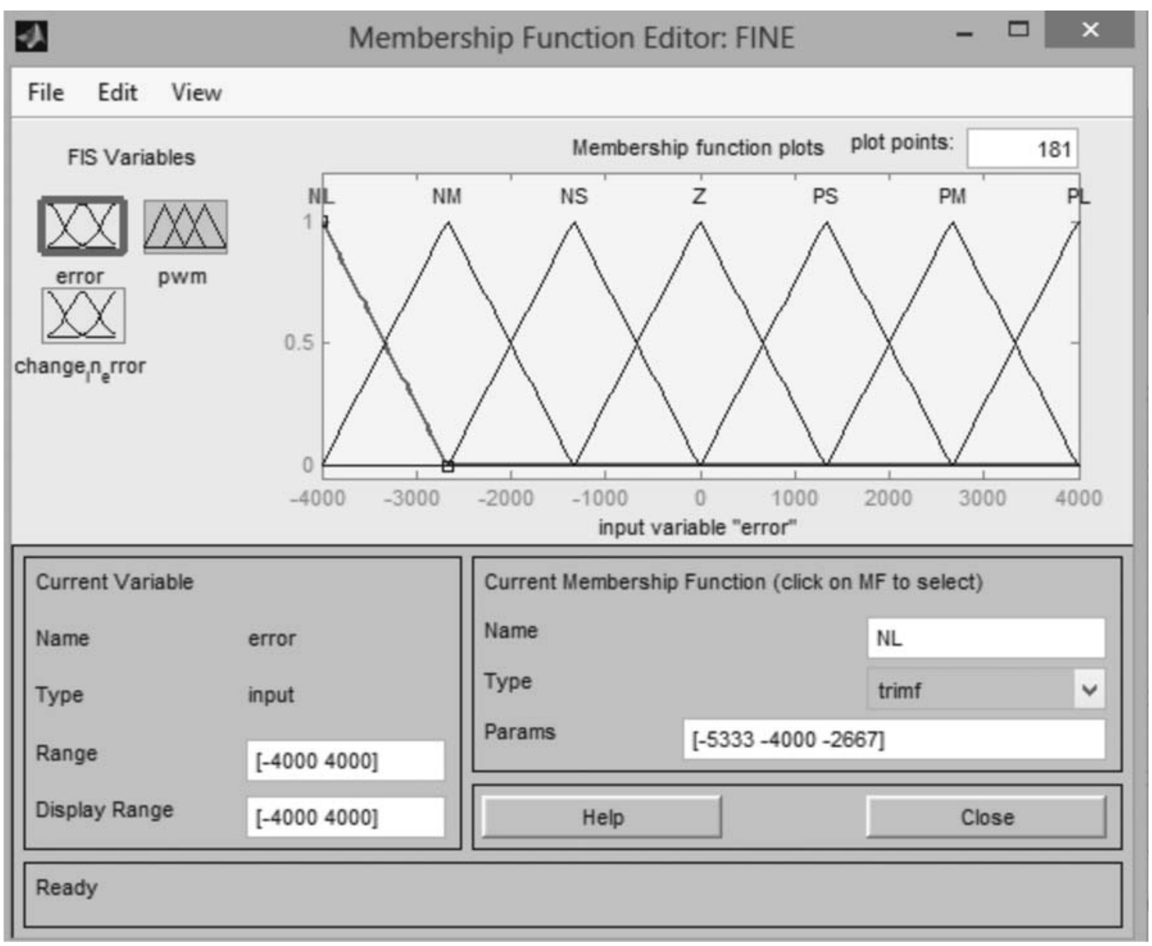

Fig. 5(*c*) Input 2 to fuzzy for BLDC control

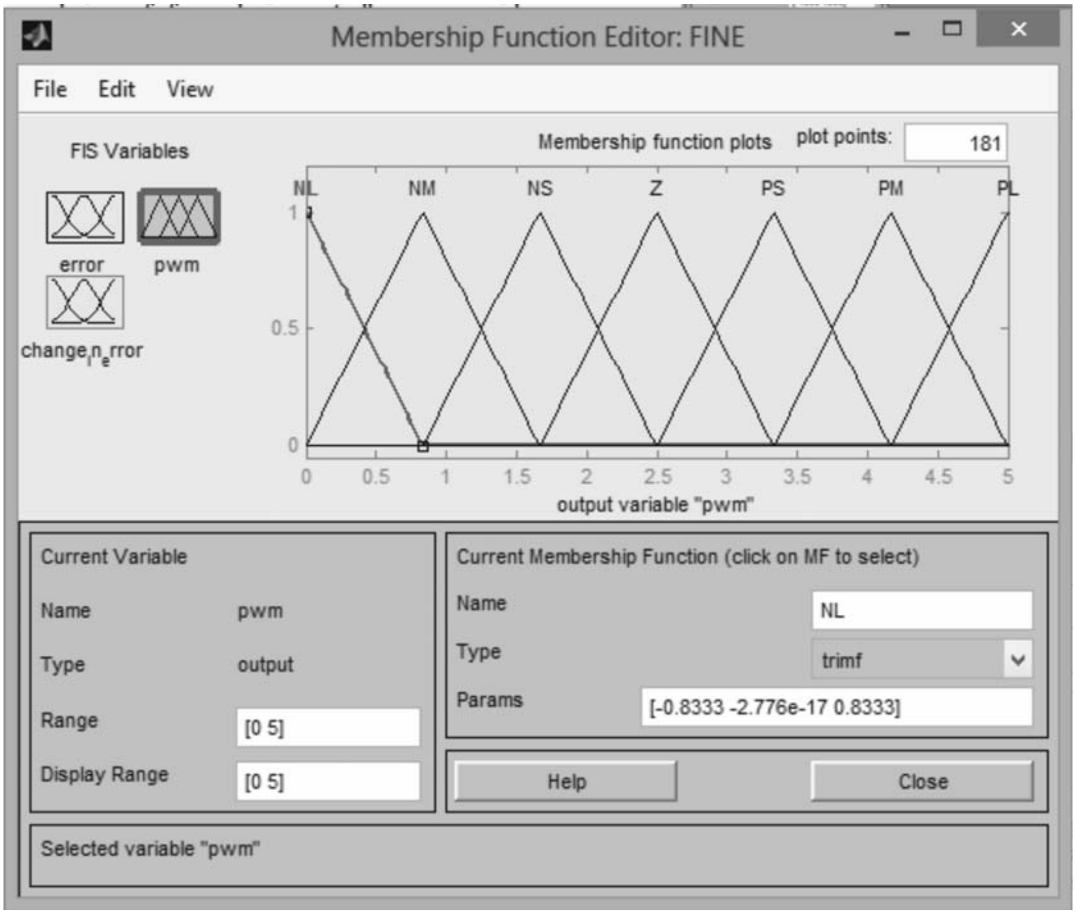

Fig. 5(*d*) Output from fuzzy controller

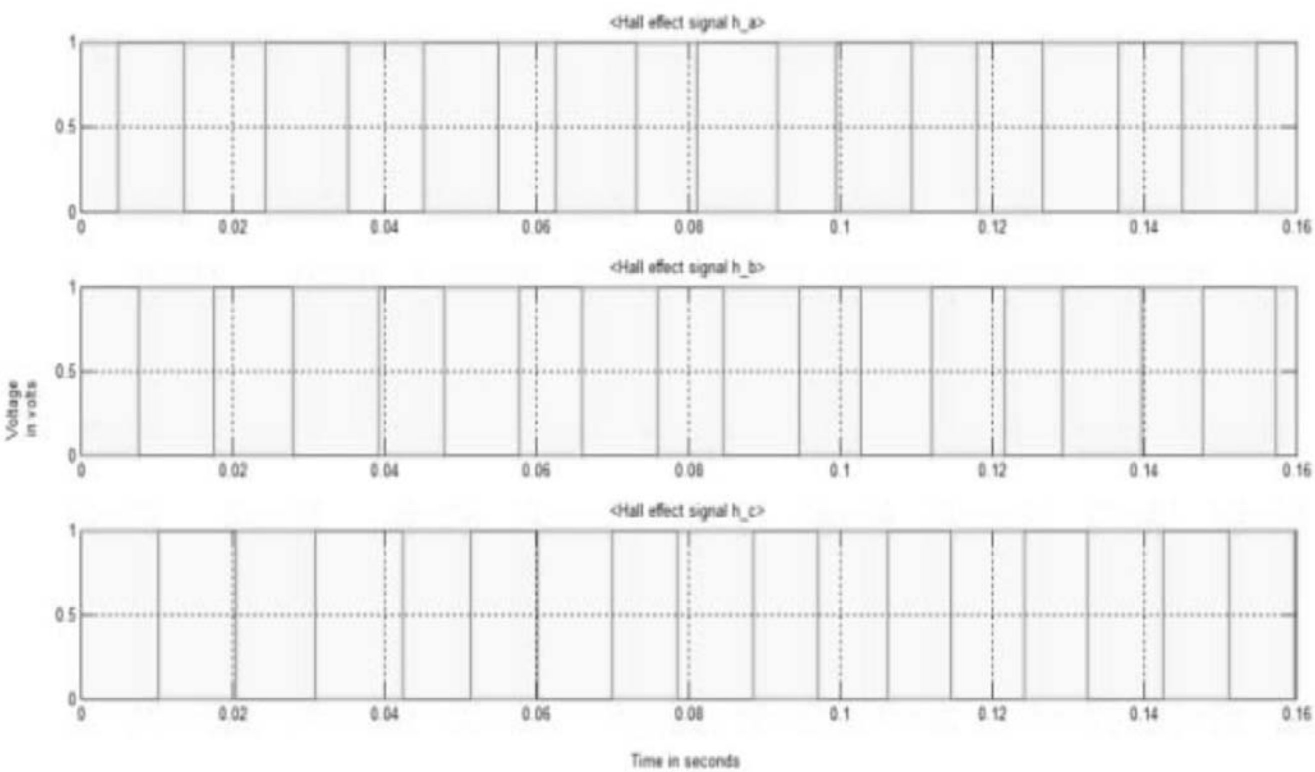

Fig. 5(*e*) Hall signals

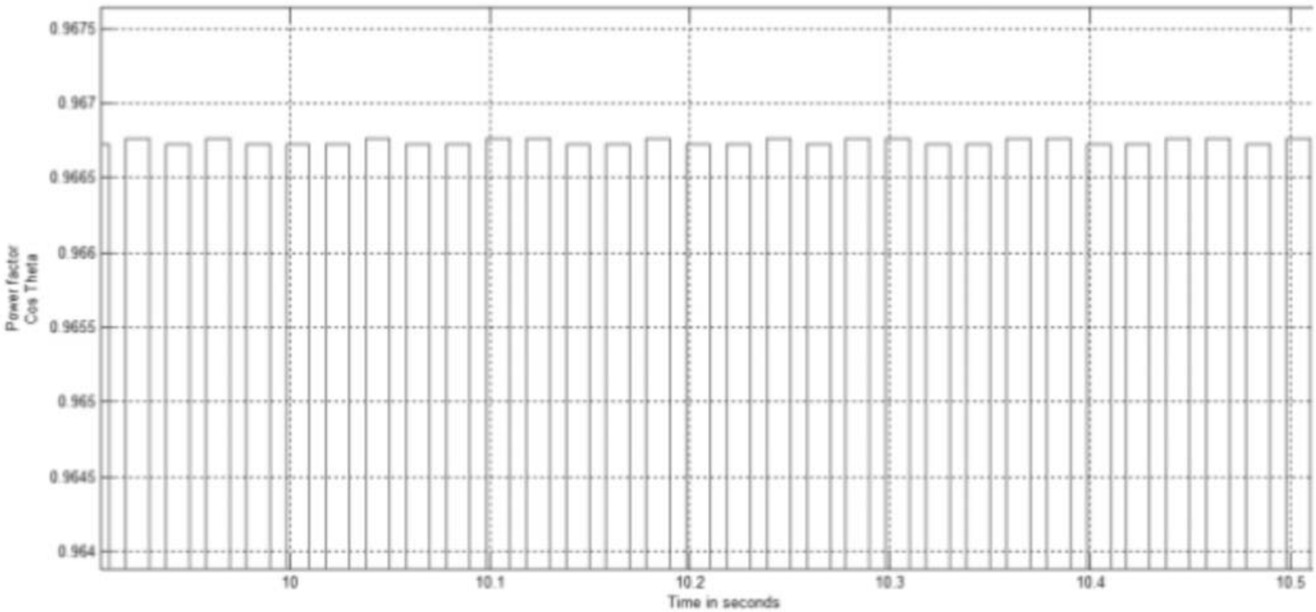

Fig. 5. (*f*) Measurement of power factor

Figure 5(*f*) indices that, the value of PF obtained is under the acceptable IEEE and IEC 61000-3-2 standards.

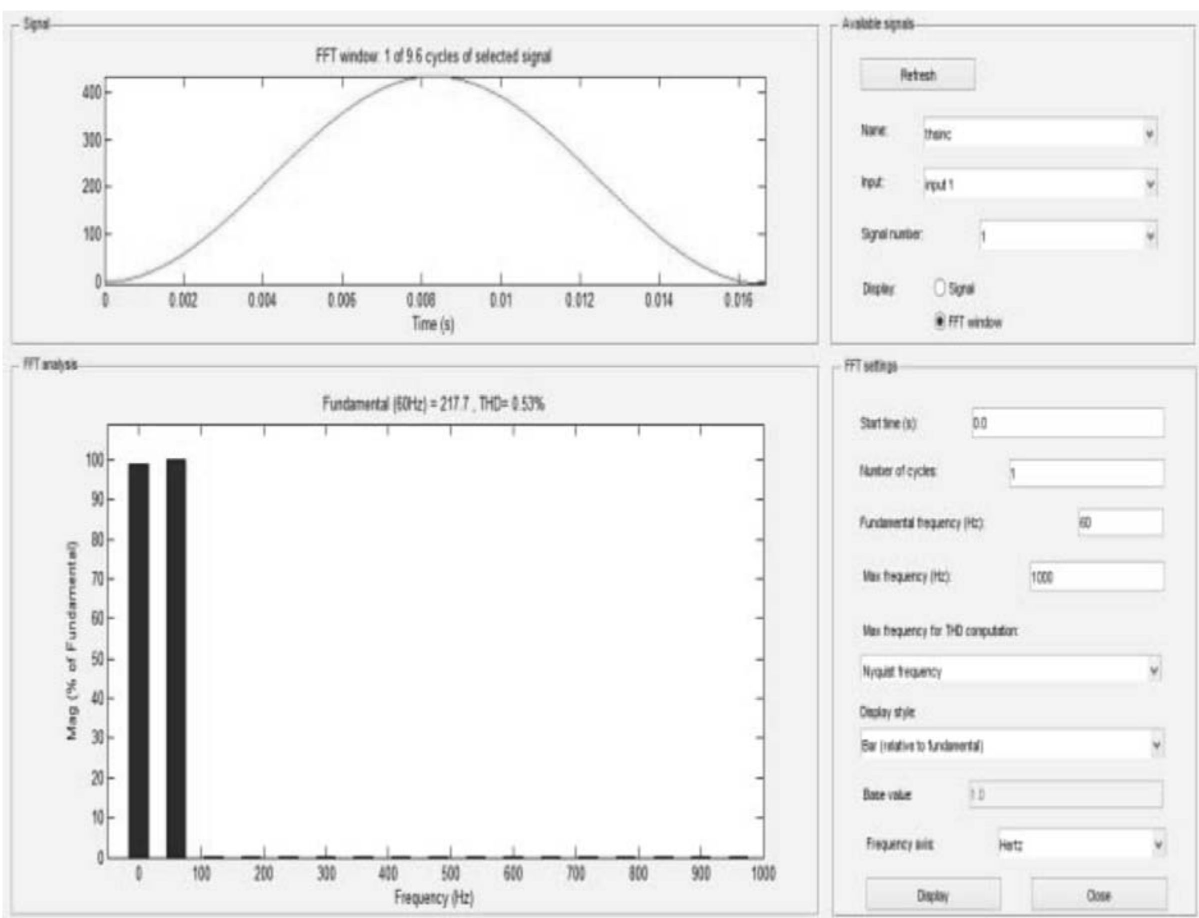

Fig. 5 (*g*) FFT Analysis of source current for THD

Figure 5(*g*) indices that the harmonic distortion of supply is minimized (0.53 %) compared to conventional system and it is within the IEC 61000-3-2 and IEEE 519 standard. Moreover using the intelligent controller we can obtain better THD and improved PF with reduced switching losses.

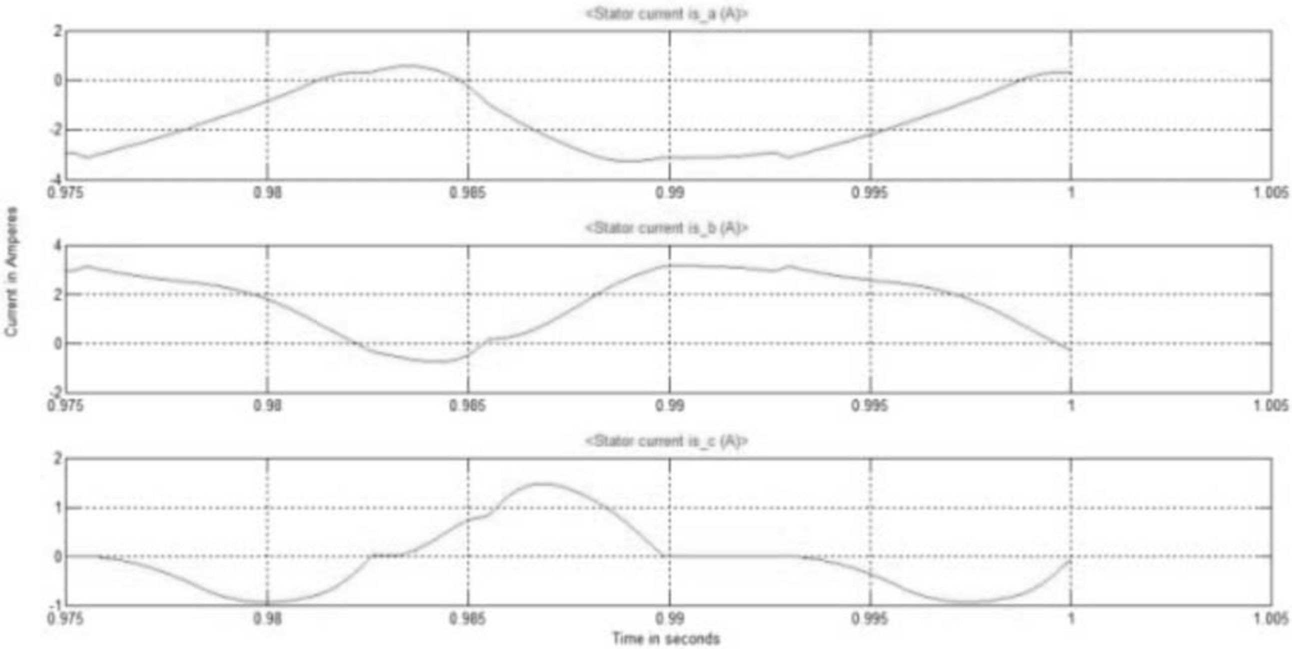

Fig. 5 (*h*) Stator current's (ABC)

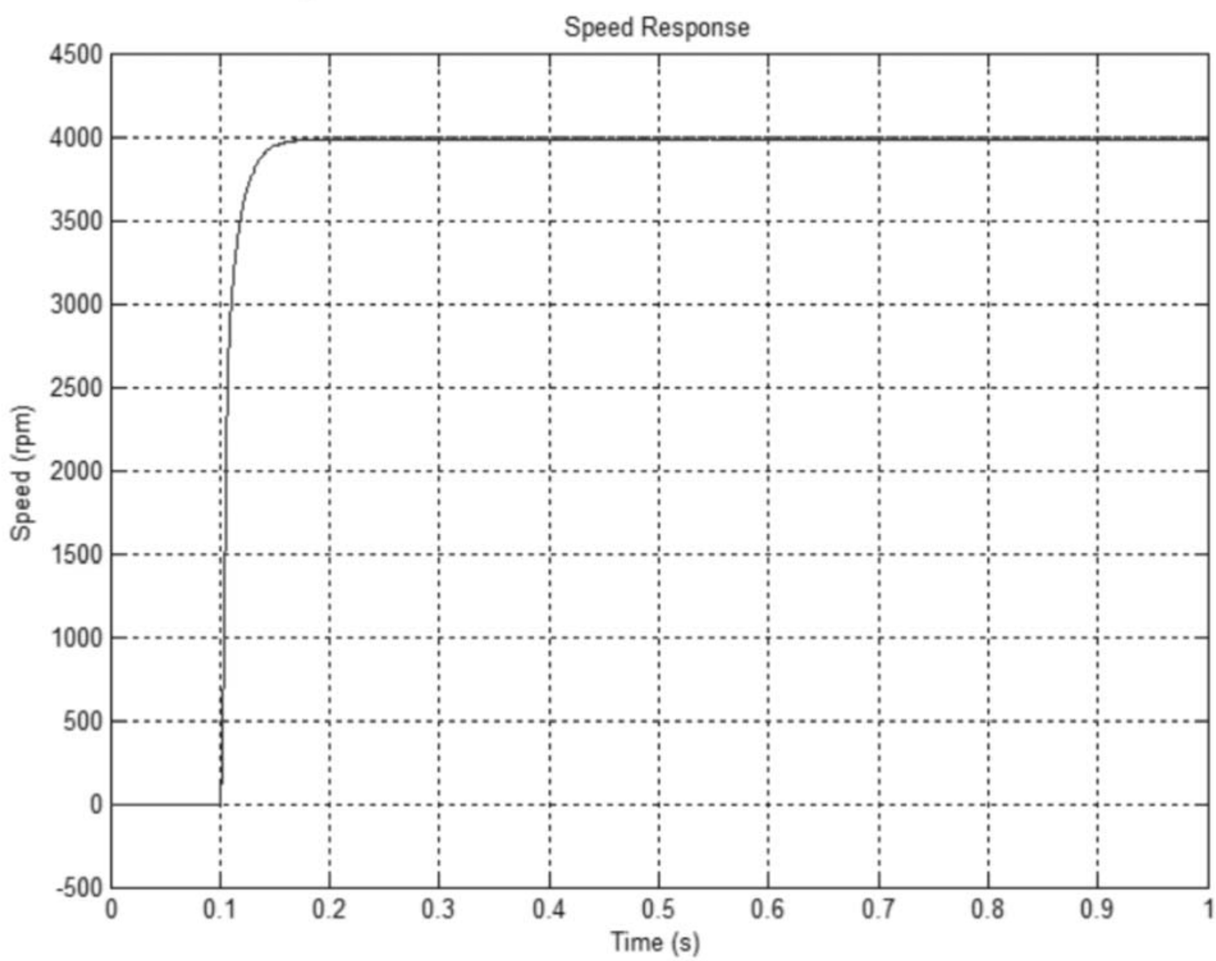

Fig. 5 (*i*) Speed response of BLDC motor (At 4000 RPM)

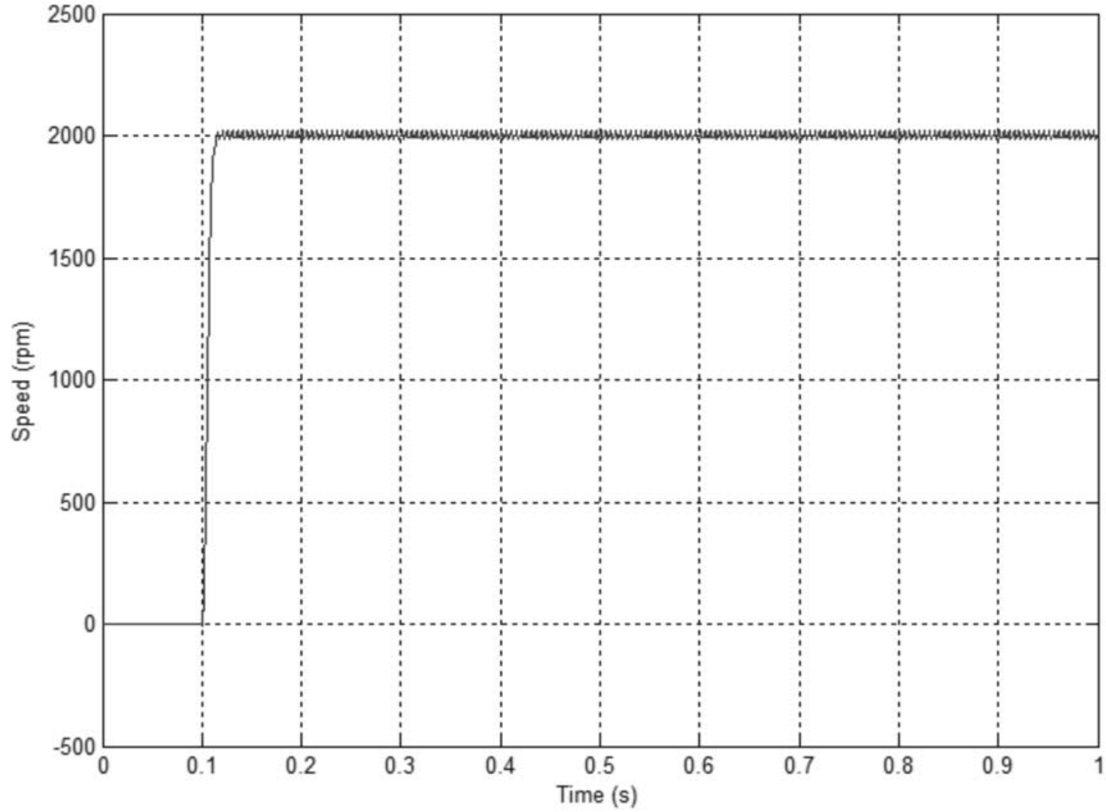

Fig. 5 (*j*) Speed response of BLDC motor (At 2000 RPM)

6. HARDWARE RESULTS AND DISCUSSION

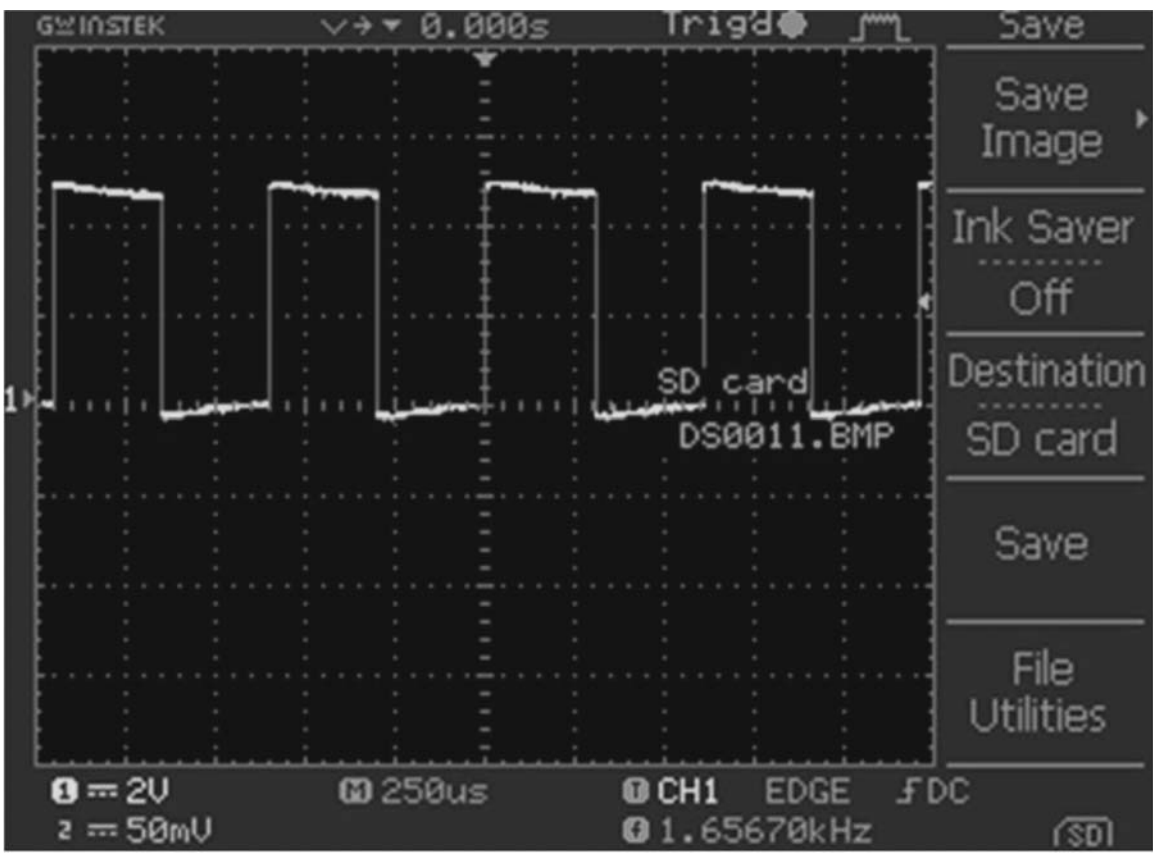

Fig. 6(*a*) PWM pulses fed to MOSFET's

Figure 6(*a*) shows the PWM pulses fed to the MOSFET. It is produced by comparing reference voltage and current with a high frequency non sinusoidal signal.

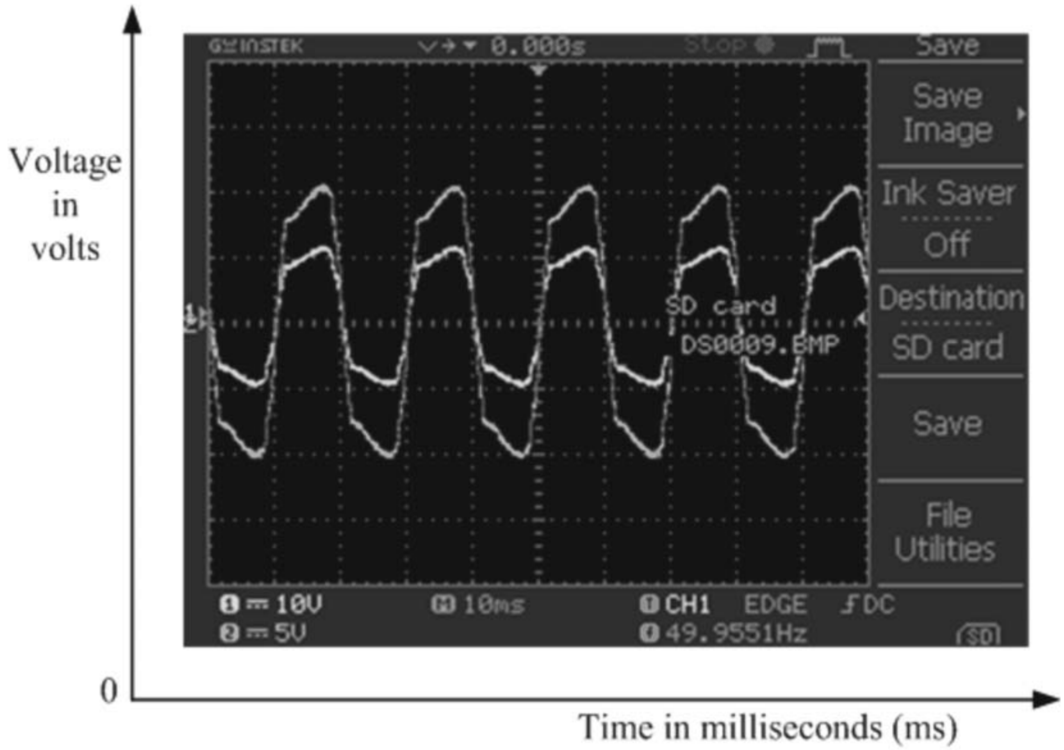

Fig. 6(*b*) Power factor measurement.

From the figure 6(*b*) we can conclude that both the input voltage and current are synchronized with each other.

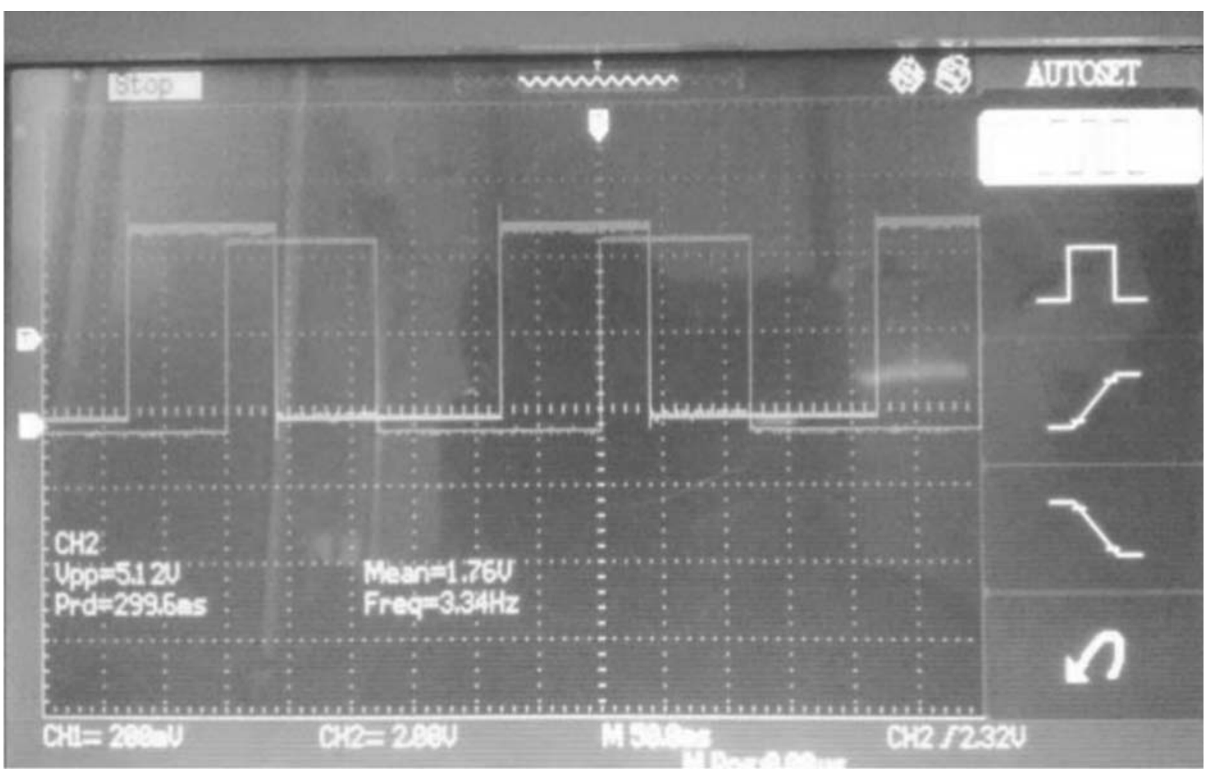

Fig. 6(*c*) Virtual hall signals

7. ANALYSIS OF THE PROPOSED SYSTEM WITH CONVENTIONAL SYSTEM

A. Comparison based on power quality and power factor

Due to the partial elimination of DBR the power factor and total harmonic distortion obtained are better and the switching losses are reduced compared to conventional system. Thus, the quality of power derived in the proposed system is under the international standards.

B. Comparison of control of BLDCM

The sensorless control technique improves the progress of and reduces the overall cost of the drive. The time based dependence comparator is used to reimburse and also avert the changes in the output voltages.

C. Comparison on basis of economy and intricate

Table I shows an analysis of the developed system with the existing system. Since the system requires a mere simple technique to control, a processor with reduced cost can be applied. Increased efficiency with reduced switching losses makes the proposed system applicable for low-power applications.

Table 1. Comparison Between Conventional and Proposed System

Attributes	*Conventional system (Without PFC)*	*Conventionalsystem (with PFC)*	*Proposed system*
Losses (DBR + PFC)	High	Medium	Low
Efficiency	Medium (Upto 75%)	Low (Upto 80%)	High (> 80%)
Cost	Medium	High	Low

8. CONCLUSION

The fuzzy logic based PFC and speed control is robust and efficient compared to conventional control techniques. Using this PFC-converter configuration, the international standards can be achieved. Also sensorless speed control has been proposed to achieve significant improvement in commutation phase lag. The results indicate that the system with sensorless control is of low cost compared to sensored control with improved dynamic response.

9. REFERENCES

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