IJCTA, 9(36), 2016, pp. 663-672

Implementation of PMSG Based Power Generation System using Switched Inductor Based Quasi Impedance Source Inverter

S. Sivaganesan* and D. Kirubakaran**

Abstract : PMSG system based quasi switched inductor inverter (Q-SLI) fed three phase induction motor drive is proposed in this paper. The proposed system has better voltage gain and less harmonic compare than quasi impedance source inverter (*qzsi*). The switched inductor network is used to improve the voltage gain. The PWM technique is used to reduce the current harmonic. The output voltage is controlled by controlling the inverter switch. The proposed circuit is simulated using MATLAB simu-link platform. The prototype is developed using PIC16F877A controller. The circuit simulation results are compared with hardware results.

Keywords : Switched impedance network, shoot through, voltage gain and harmonic.

1. INTRODUCTION

Power demand is increased due to lack of power generation and more power consumption. The renewable energy based power generation is recently developed very fast. The power electronic converter is required for energy conversion. Many research works is going to improve the power converter performance [1-3]. The reliability of the variable speed wind energy systems can be improved mainly by using a permanent magnet synchronous generator (PMSG). The low speed of PMSG operation is affects the gearbox setup and required maintenance [4, 5]. Wind energy system generates variable output voltage. This voltage is converted into stable voltage and fed to motor or grid with help of power converter [6-7].

Many research works is going on continuously to improve the impedance source inverter voltage gain and system performance compare than previous version [8-9]. PWM method with shoot through concept is applied for increase the voltage gain and reduces the harmonic of the impedance source inverter [9-11]. Recently quasi z-source inverter has developed for improving the system performance [10]. The switched inductor based quasi impedance source inverter is proposed in this paper. The switched inductor network is included in the quasi source inverter for improving the voltage gain and reduces the current harmonic. The circuit performance is compared and verified using simulation results. The circuit prototype is developed for low voltage and power range. The following section describes the inverter operation, simulation results and hardware implementation results.

2. CIRCUIT DESCRIPTION

The PMSG based power generation system is as shown in fig 1. This circuit consists wind turbine, PMSG, uncontrolled rectifier, switched inductor based quasi impedance source (Sl-Qzi) inverter and load. The PMSG wind generator generates the ac voltage it's given to rectifier for converting ac to dc. This dc supply is fed to Sl-Qzi for converting dc to ac with voltage boosting. The impedance network with inverter produces the constant voltage with fixed frequency output. This ac voltage is given to the motor load or any other load.

---

* Research Scholar, Vels University, Chennai, India.

** Professor, St. Joseph's Institute of Technology, Chennai, India.

A. Switched inductor based quasi impedance source (Sl-Qzi) inverter

The proposed circuit consists of three inductors (L1, L2, and L3), two capacitors (C1 and C2), and four diodes (D1, D2, D3 and D4). The combination of L1–L3–D1–D2–D3 performs the function of the SL module This SL modules are used to store and transfer the energy from the capacitors and dc source to the dc bus under the switching action of the main circuit.

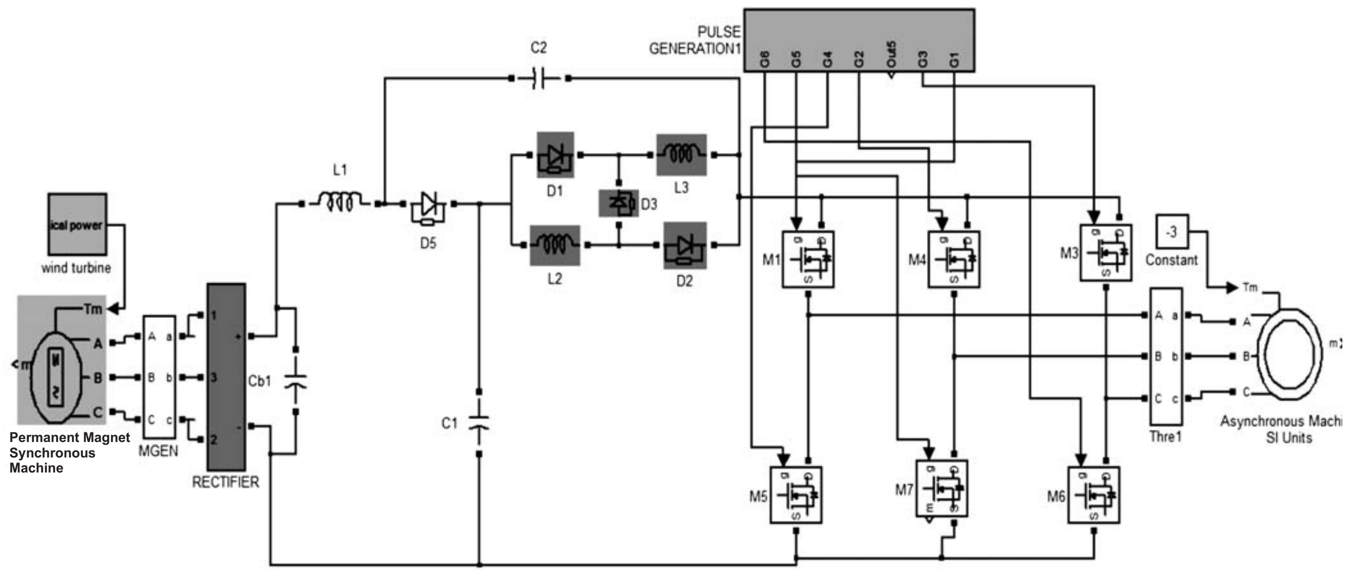

Figure 1: Proposed Circuit Diagram

B. Operating Principles

The operating principles of the proposed impedance network are similar to the classical Z-source impedance network. For the convenience of analysis, the equivalent circuit of the proposed switched impedance network viewed from the dc bus is shown in Fig 2. This circuit has totally eight modes of operation. Two modes relevant to shoot through condition and another six modes are normal inverter operation. Shoot through states is classified into non shoot through and shoot through modes.

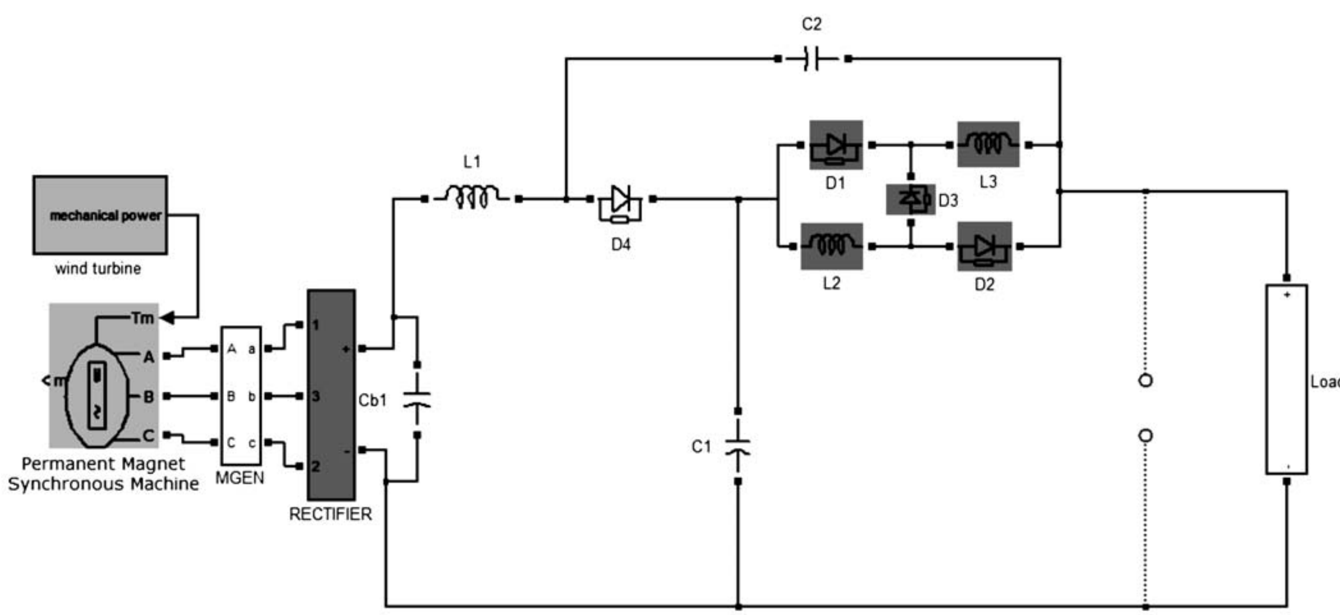

Figure 2 : Switched inductor based quasi impedance source (Sl-Qzi) inverter

Shoot-Through State*:* During this mode, inverter one leg both switch becomes conduction mode, while both D3 and D4 are reverse bias. At the same time the SL module, D1 and D2 are forward bias as a result L3 get charging from dc source through D1. Similarly L2 get charging through D2. The shoot through operation equivalent circuit is as shown in Fig 3. The capacitors C1 transfer their electrostatic energy to magnetic energy stored in the inductors L2 and L3.

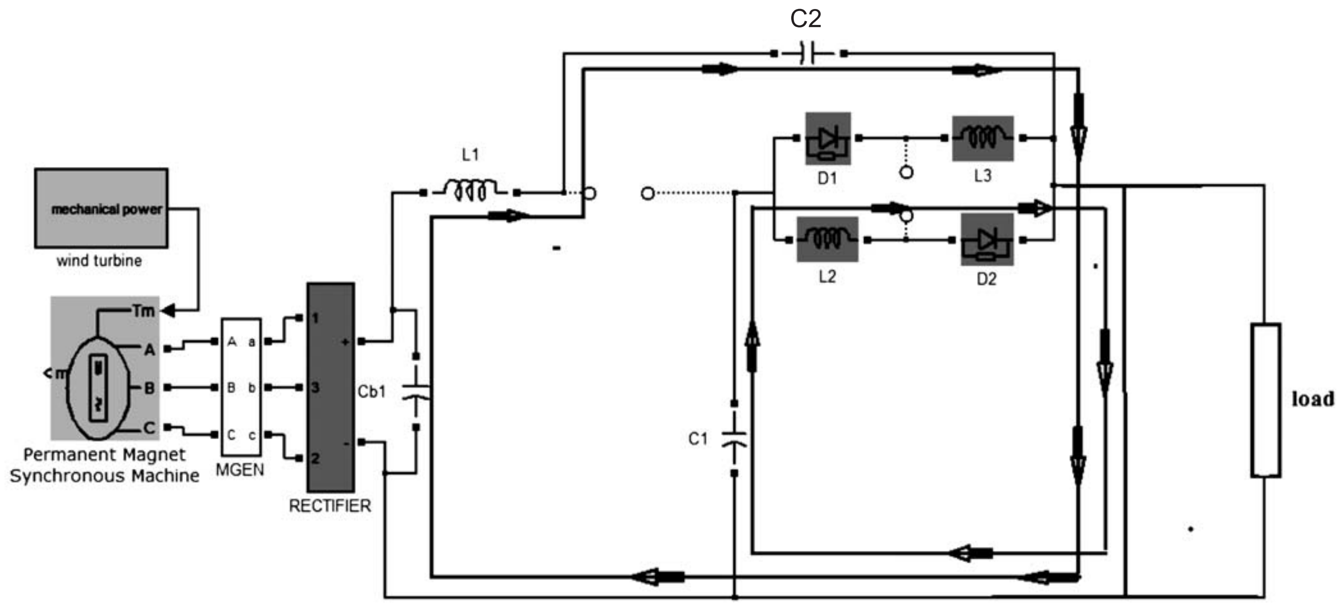

Figure 3: Shoot-Through State

Non-Shoot-Through State : This mode corresponds to the six active states and two zero states of the main circuit and the equivalent circuit is shown in Fig 4. During this active state, inverter one leg top or bottom switch is OFF condition, while both D3 and D4 are ON. At that time SL module, D1 and D2 are becomes reverse bias. L1, L2 and L3 are connected in series, and the stored inductor energy is transferred to the main circuit. The dc power source, as well as the inductors energy is delivered to load as well as charges the capacitors C1 and C2. Thus the dc link voltage is increased with help of inductor and capacitor stored energy.

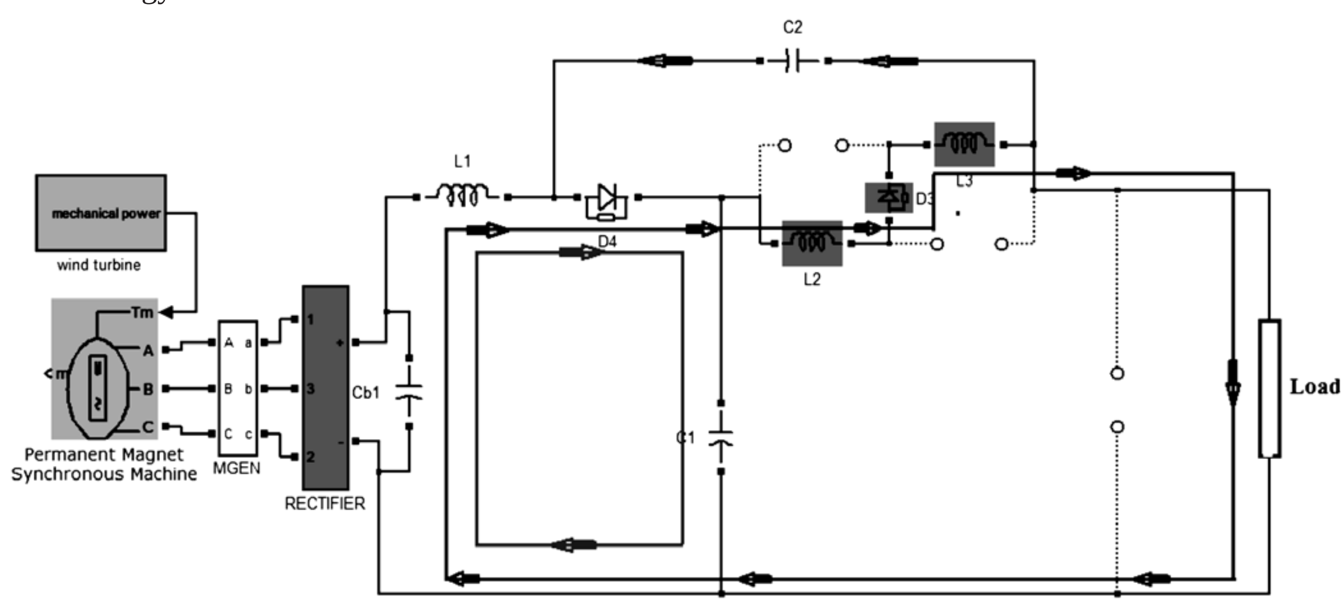

Figure 4: Non- Shoot-Through State

3. SIMULATION RESULT

The proposed switched inductor based quasi impedance source inverter circuit is as shown in figure 5. Figure 6 shows the proposed wind generator output voltage. Figure 7 shows the rectifier output voltage.

Figure 8 shows the switched impedance network output voltage. The dc link voltage is increased from 180V to 360V due to shoot through and impedance network. It is proven that from fig 8. Fig 9 shows the single pulse pattern M3, M6 and shoots through period. Figure 10 shows the inverter output current.

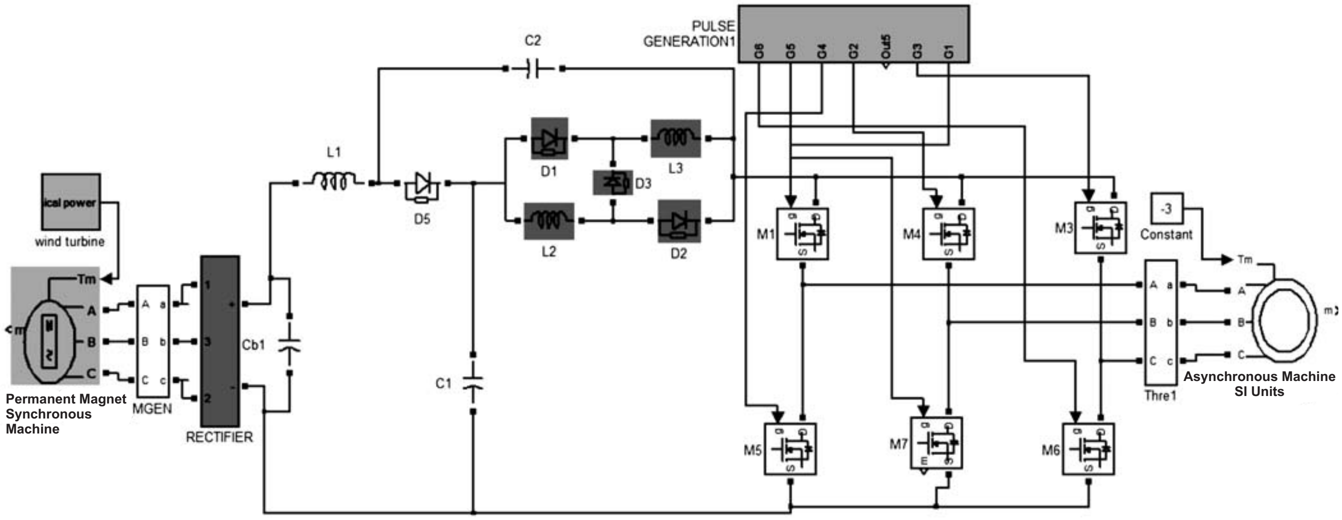

Figure 5: Proposed circuit diagram

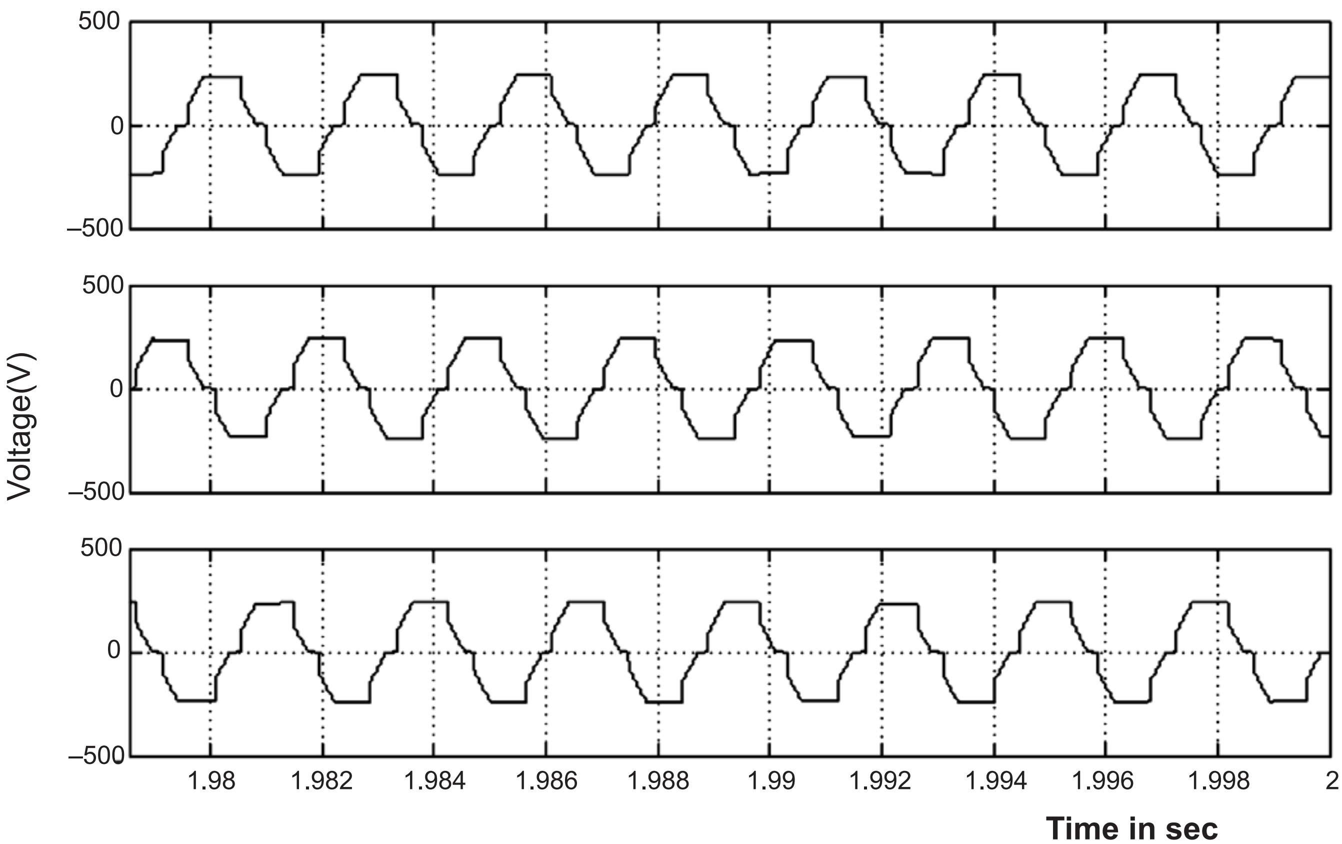

Figure 6: Wind generator output voltages

4. IMPLEMENTATION RESULTS

The prototype is developed for proposed inverter circuit with low voltage and low power rating as shown in fig 12. The proposed circuit control circuit as shown in fig 11. This circuit has power supply section, PIC controller and Driver section. The PIC controller is used for generating triggering pulse to inverter switches. Opto isolator is used for driver. It is used to amplification and isolation purpose. Figure 13 and

14 shows the triggering pulses with shoot through for inverter switches S1 and S4 pair and S3 and S6 pair respectively. Figure 15 shows the rectifier output voltage and fig 16 shows the voltage waveform across impedance network. The impedance network with shoot through operation is used to increase the voltage gain of the system. It is proven that from Fig 15 and 16. Fig 17 shows the inverter line voltage (Vab and Vac)

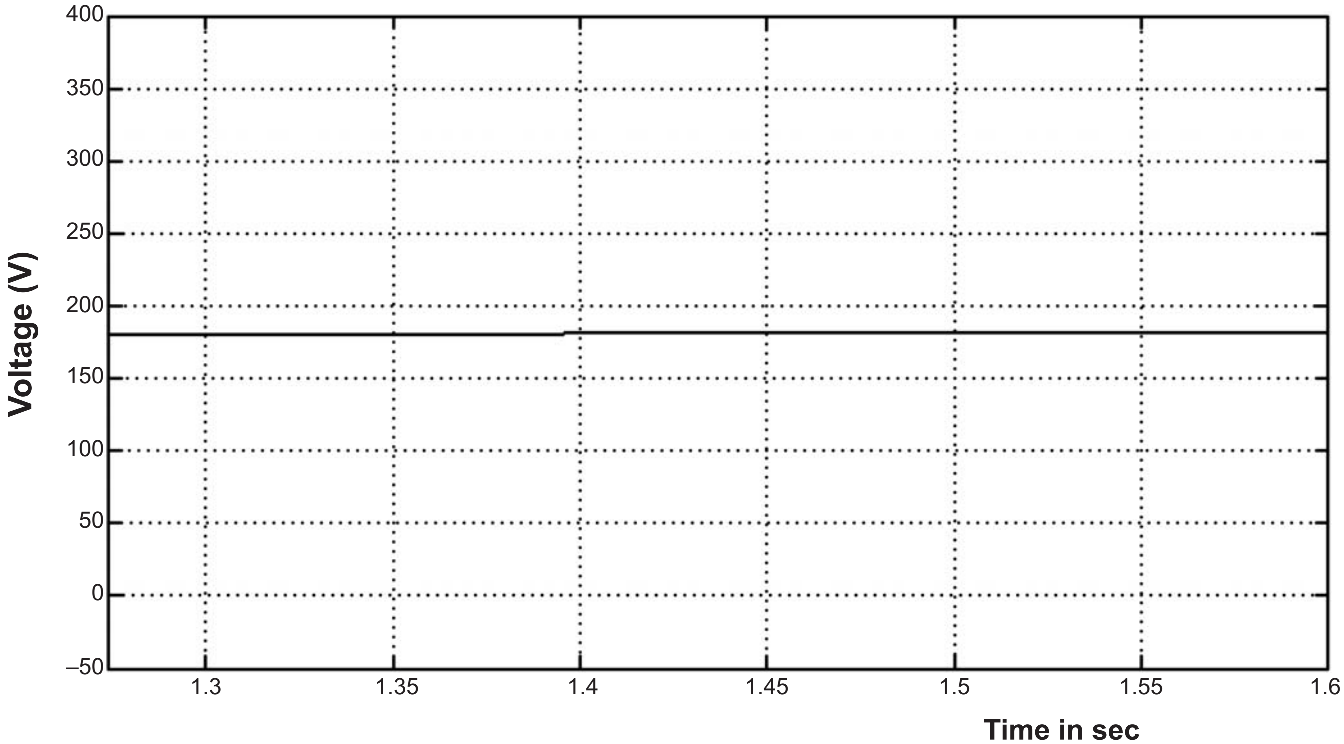

Figure 7: Rectifier output voltage

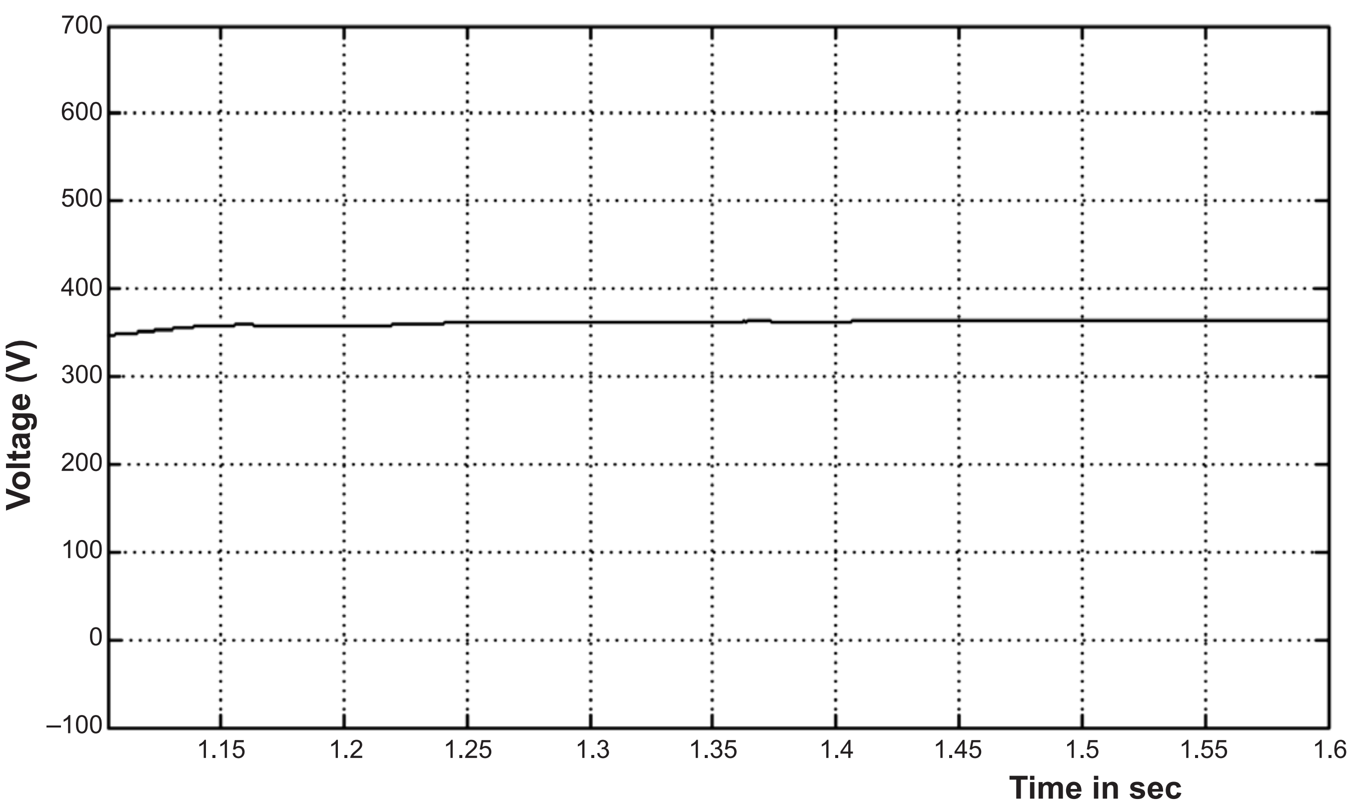

Figure 8: Quasi network output voltage

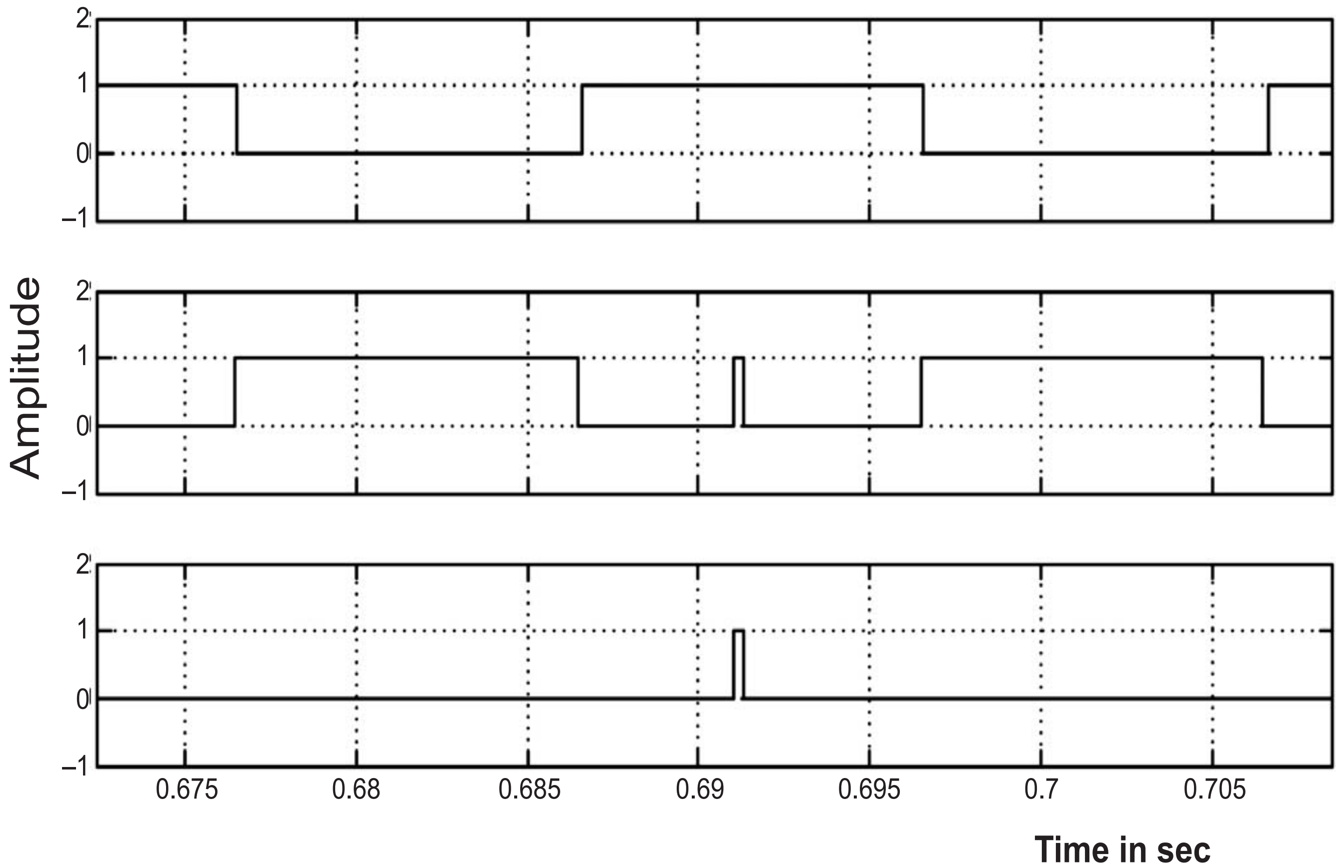

Figure 9: Triggering pulses for M3, M6 and shoot through period

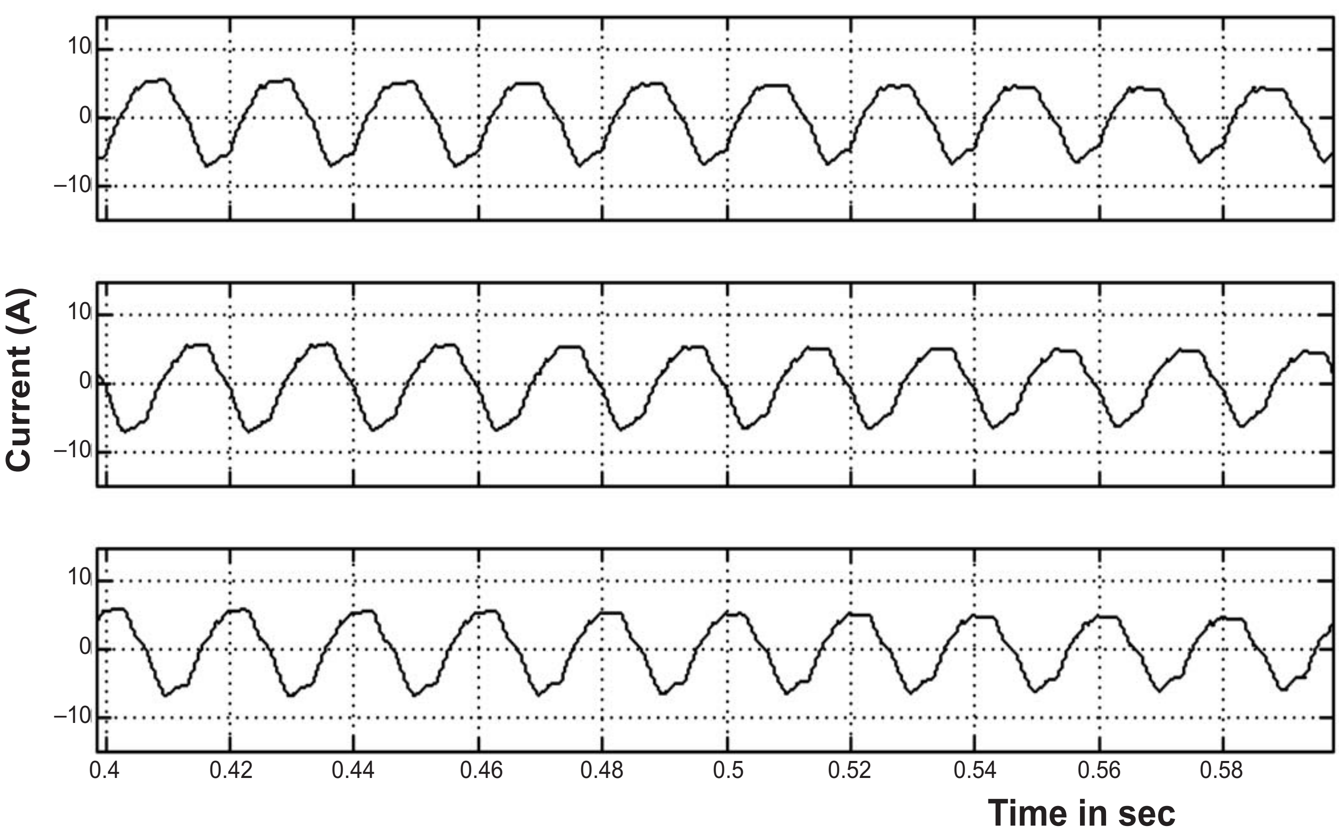

Figure 10: Inverter output current

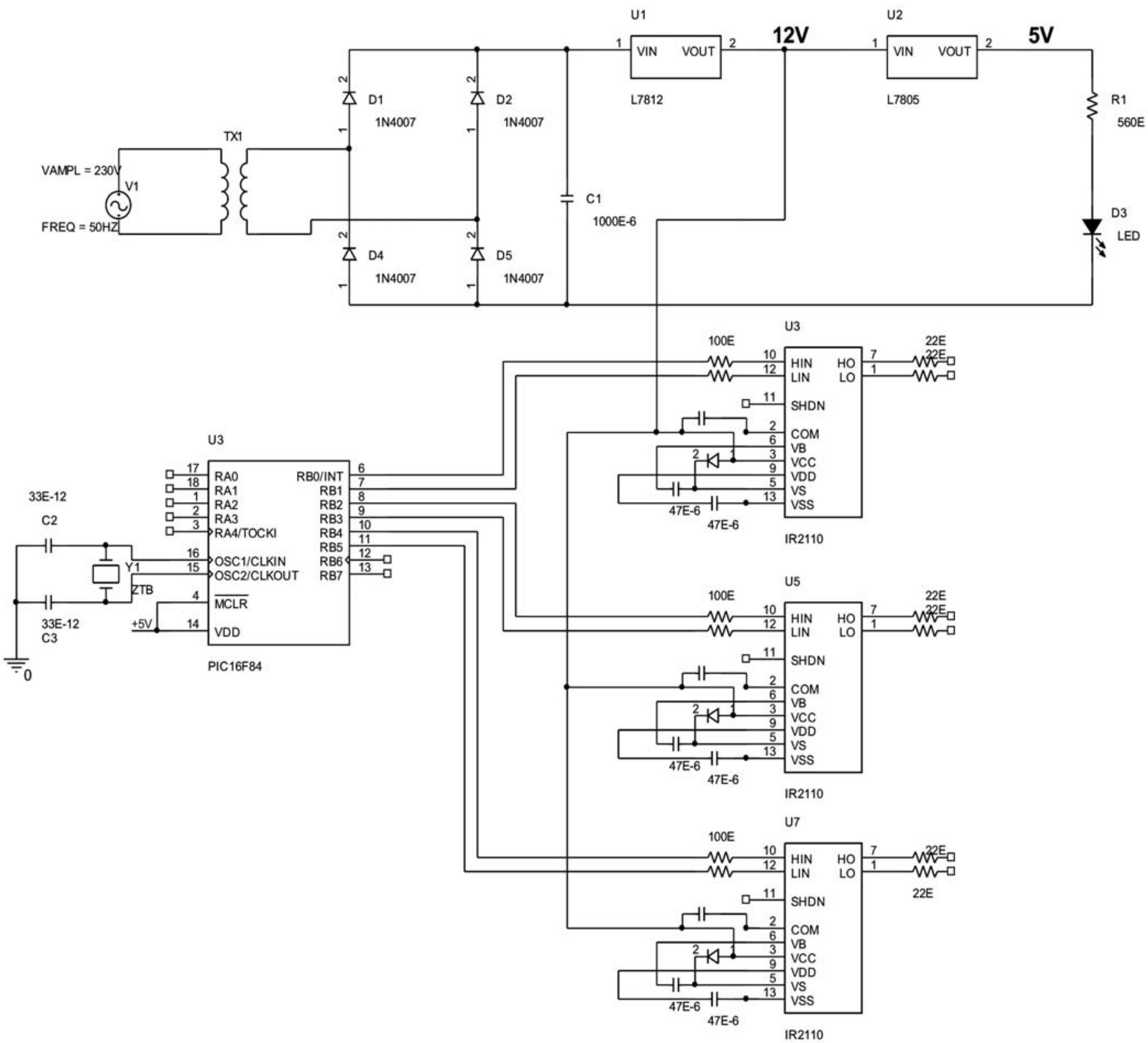

Figure 11: Control circuit diagram

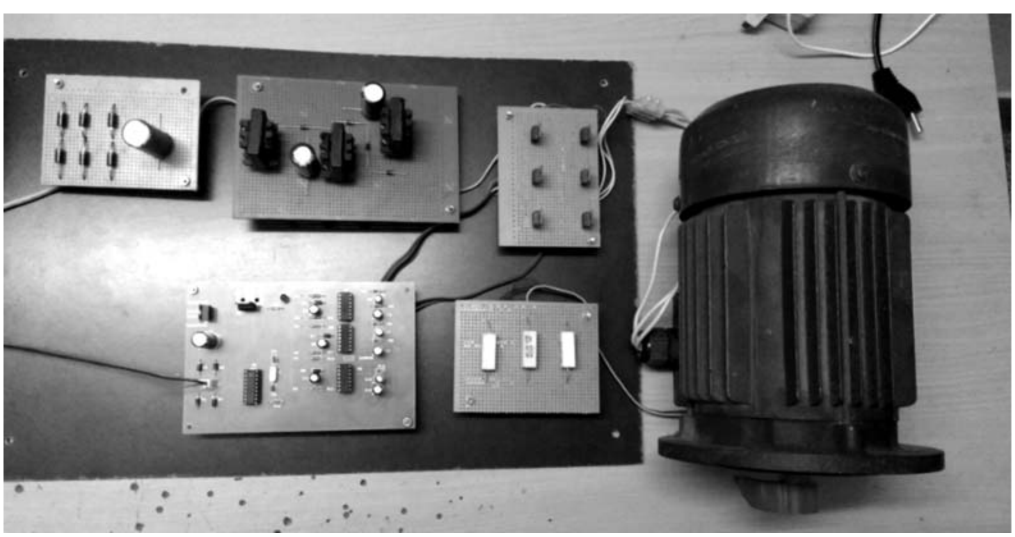

Figure 12: Implementation layout

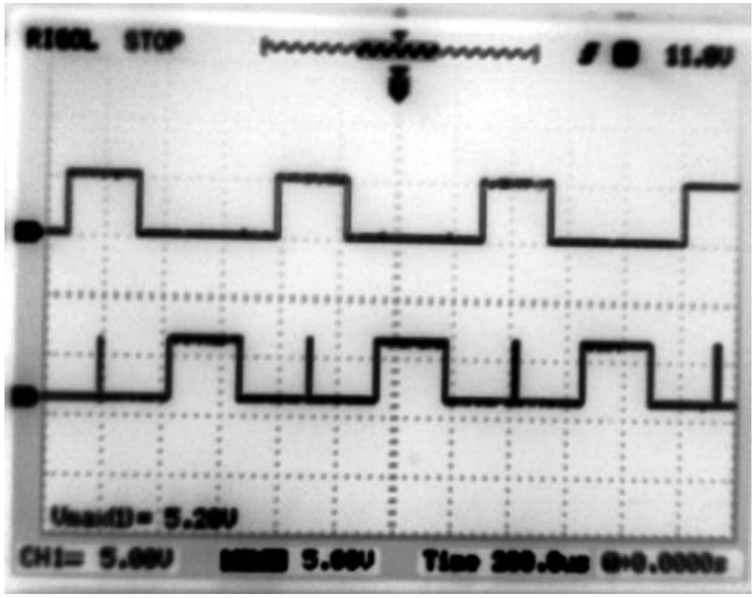

Figure 13: Triggering pulses for inverter switches S1 and S4

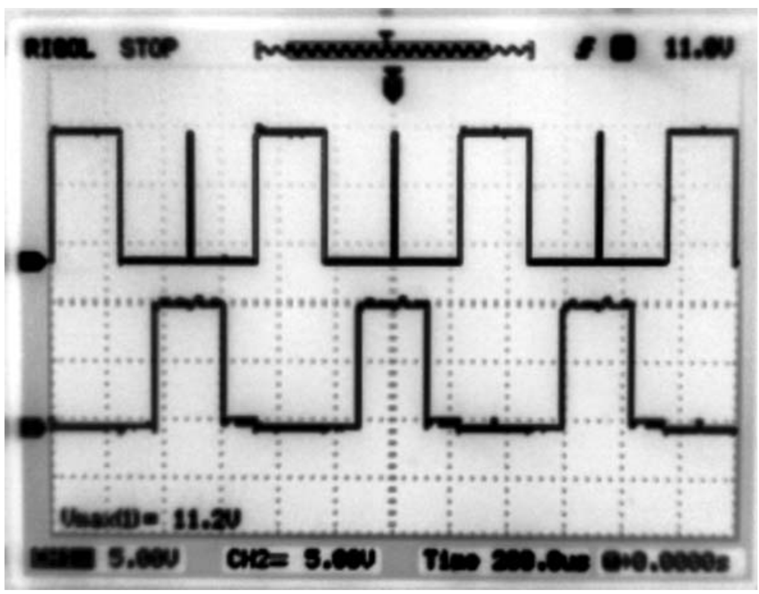

Figure 14: Triggering pulses for inverter switches S3 and S6

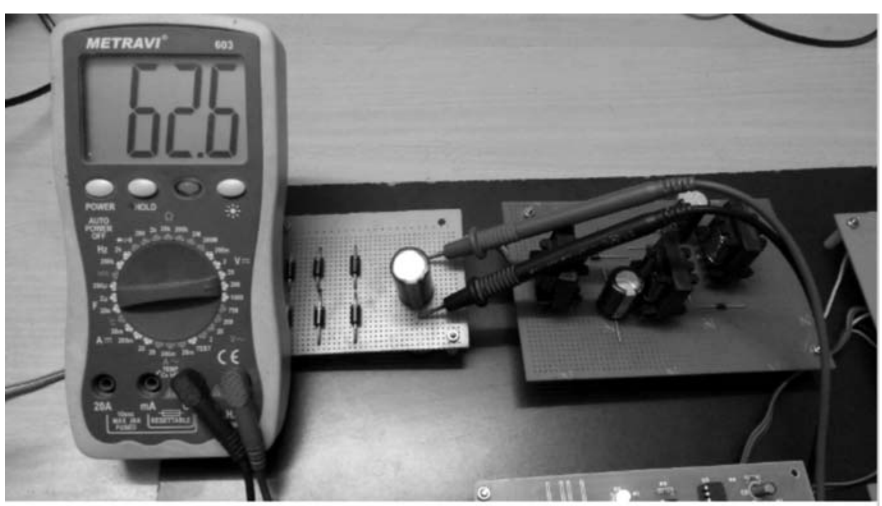

Figure 15: Rectifier output voltage

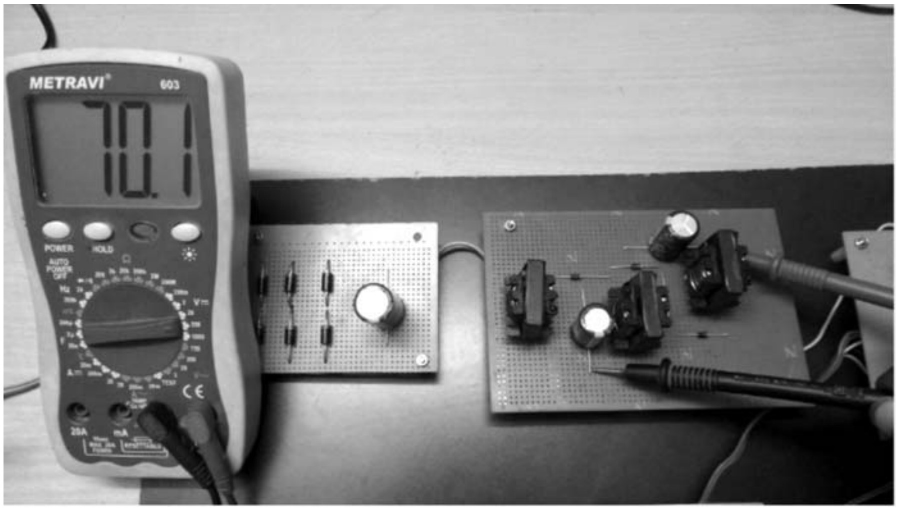

Figure 16: Voltage across impedance network

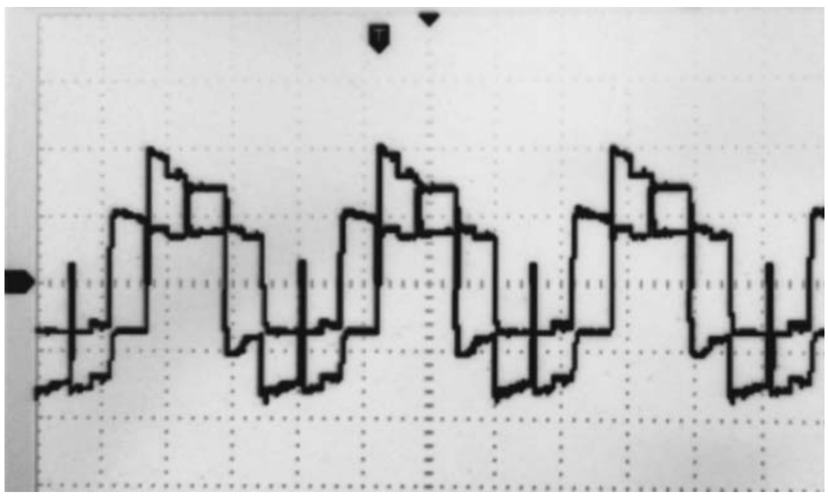

Figure 17: Inverter output voltage

5. CONCLUSION

This paper has presented PMSG based power generation using switched inductor based quasi impedance source inverter with single pulse PWM technique. The circuit is simulated and implemented. The impedance network based inverter is used to convert stable ac output voltage coming from variable wind voltage. During Shoot through state the high current is stored in inductor and capacitor as a result to avoid the short circuit and protect the switching devices. The switched inductor cell is used to store and transfer the energy from source to the load as a result it increase the voltage gain of the inverter. Thus the proposed inverter has high voltage gain. It is proven that from simulation and hardware results.

6. REFERENCES

1. Muller, S.; Deicke, M.; de Doncker, R.W. Doubly fed induction generator system for windturbines. *IEEE Ind. App. Mag.* 2002, *8*, 26–33.
2. Ackerman, T.; Soder, L. An overview of wind energy status 2002.*Renew. Sus. Energy Rev.* 2002, *6*, 67–127.
3. Bleij, J.A.M.; Chung, A.W.K.; Rudell, J.A. Power Smoothing and Performance Improvement of Wind Turbines with Variable Speed. In Proceeding of 17th British Wind Energy AssociationConference, Warwick, UK, 19–21 July 1995; pp. 353–358.
4. Westlake, A.J.G.; Bumby, J.R.; Spooner, E. Damping the power-angle oscillations of a permanent magnet synchronous generator with particular reference to wind turbine applications. *IEE Proc. Elec. Power Appl.* 1996, *143*, 269–280.

5. Polinder, H.; van der Pijl, F.F.A.; de Vilder, G.J.; Tavner, P.J. Compaison of direct-drive andgeared generator concepts for wind turbine. *IEEE Trans. Energy Convers.*2006, *3*, 725–733.
6. Chinchilla, M.; Arnaltes, S.; Burgos, J.C. Control of permanent-magnet generator applied tovariable-speed wind-energy system connected to the grid. *IEEE Trans. Energy Convers.*2006, *21*, 130–135.
7. Thongam, J.S.; Bouchard, P.; Ezzaidi, H.; Ouhrouche, M. Wind Speed Sensor less MaximumPower Point Tracking Control of Variable Speed Wind Energy Conversion Systems. In Proceeding of the IEEE International Conference on Electric Machines and Drives, Miami, FL,USA, 3–6 May 2009; pp. 1832–1837
8. F. Z. Peng, M. Shen, and Z. Qian, "Maximum boost control of the Z-source inverter," *IEEE Trans. Power Electron.*, vol. 20, no. 4, pp. 833–838, Jul. 2005.
9. F. Z. Peng, M. Shen, and K. Holland, "Application of Z-Source inverter for traction drive of fuel cell-battery hybrid electric vehicles," *IEEE Trans. Power Electron.*, vol. 22, no. 3, pp. 1054–1061, May 2007
10. Yuan Li, , Shuai Jiang, "Modeling and Control of Quasi-Z-Source Inverter for Distributed Generation Applications "ieee transactions on industrial electronics, vol. 60, no. 4, April 2013
11. Cluster based Key Management Authentication in Wireless Bio Sensor Network ", ,International Journal of pharma and bio sciences.