3.2. Solar System with Closed Loop PID Controller for Grid System

The closed loop simulink model shown in figure 12 comprises of solar model, boost converter, impedance-source inverter (impedance-filter and three-phase inverter), PID controller, RL Load, grid system etc. is aimed for a switching frequency of 5 kHz and the outcomes of the same are presented below.

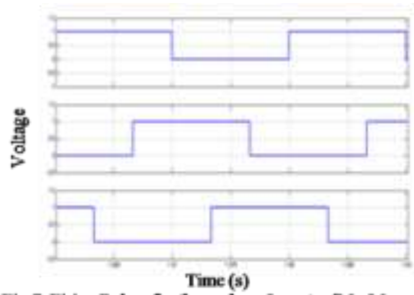

Fig.7. Firing Pulses for three phase Inverter (M_1, M_3 and M_5)

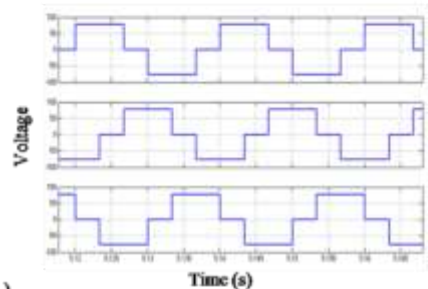

Fig.8. Output Voltage of three phase Inverter

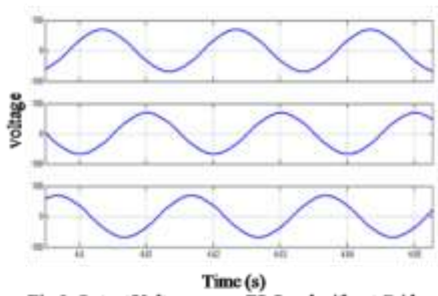

Fig.9. Output Voltage across RL Load without Grid System

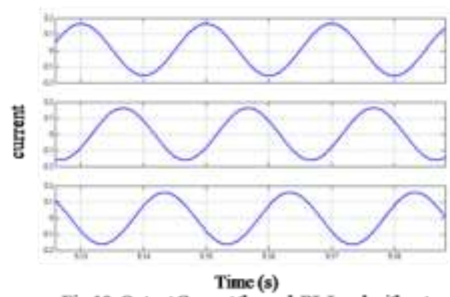

Fig.10. Output Current through RL Load without Grid System

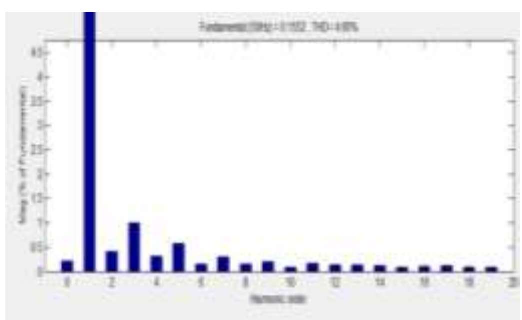

Fig.11. Analysis of Current THD

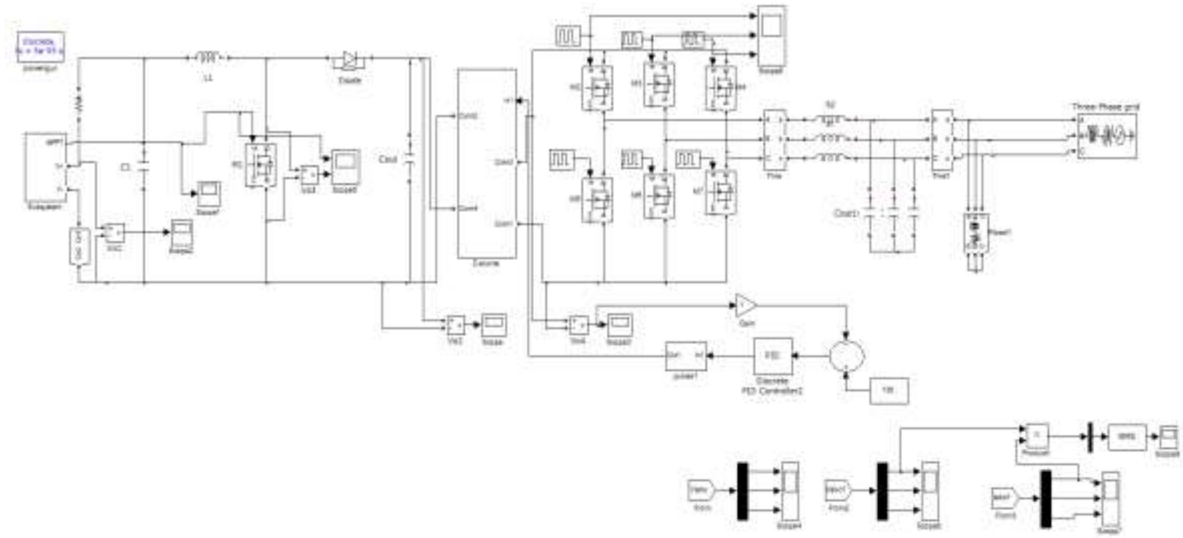

Fig.12. Simulink Model –Solar System with Closed Loop PID Controller for Grid System

The output voltage of 40V from solar panel is given to boost converter where it is boosted to nearly 80 V as shown in figures 13 and 14.

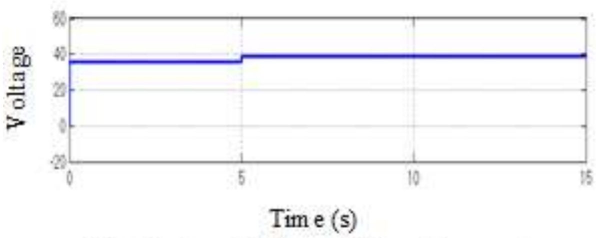

Fig.13. Input Voltage of Boost Converter

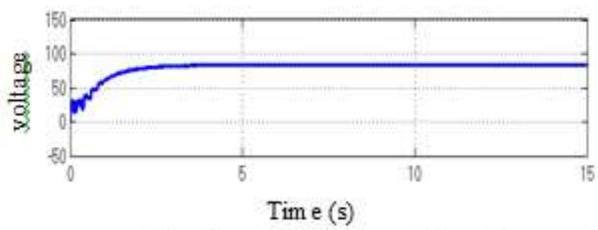

Fig.14. outut Voltage of Boost Converter

The firing pulses for three MOSFET switches viz. M_1, M_3 and M_5 of three-phase inverter, a part of impedance-source inverter is shown in figure 15. The three output voltages displaced by certain degree of three-phase inverter is shown in figure 16. The output voltage across connected grid and output current through connected grid are shown in figures 17 and 18.

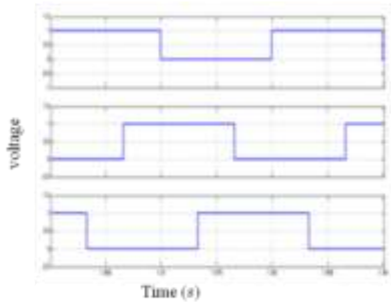

Fig. 15. Firing Pulses for three phase Inverter (M_1, M_3 and M_5)

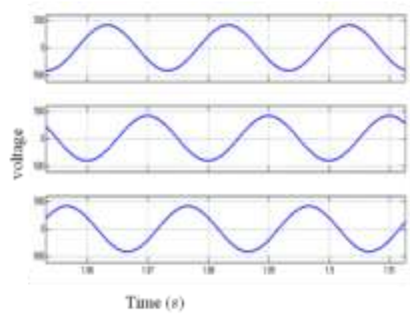

Fig. 17. Output Voltage across Grid System

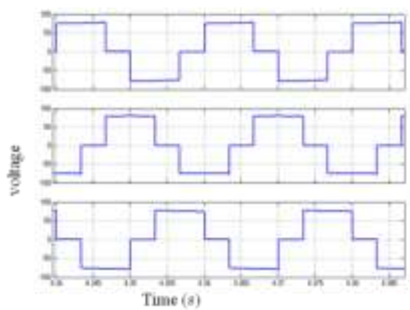

Fig. 16. Output Voltage of three phase Inverter

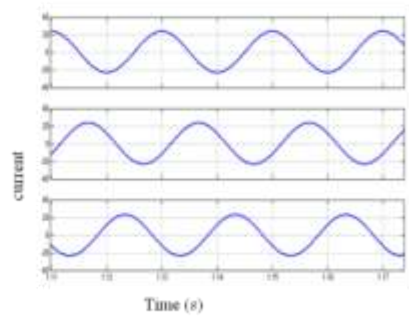

Fig. 18. Output Current through Grid System

The FFT analysis is obtained as in figure 19 for solar system with closed loop PID controller for grid system. The current total harmonic distortion with PID controller is 3.05% which is comparatively less.

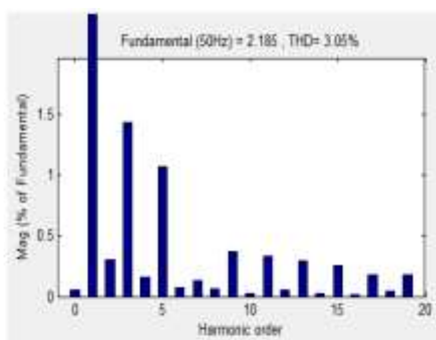

Fig.19. Analysis of Current THD

Different THD levels with RL Load and grid system of solar system are tabulated in table 4.

TABLE IV THD with RL load and grid

Type of Controller	THD for RL-Load without Grid System	THD with Grid System
PID	4.60%	3.05%

4. Experiment Results

The PIC controller PIC16F84A is preferred for this solar energy system for the creation of all control signals to the boost converter and impedance-source inverter. These signals are amplified by driver ICs IR 2110 and IRF 840. The input voltage required both by driver and microcontroller circuits are provided by LM 7812 voltage regulator. The figure 20 is prototype hardware model of impedance-source inverter for solar energy system.

Figure 21 shows the output voltage of solar panel. Switching pulses and output voltage of boost converter are in figures 22. The output voltage across RL load is shown in figure 23.

Fig.20. Prototype Hardware Model –Impedance-source Inverter for Solar Energy System

Fig.22. Output Voltage of Boost Converter

Fig.21. Output Voltage of Solar panel

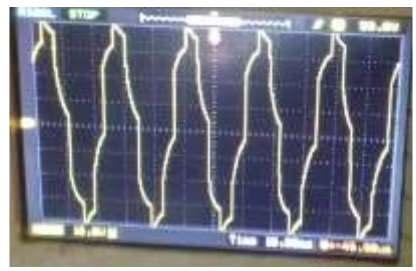

Fig.23. Output Voltage across RL load

5. Conclusions

A solar based impedance-source inverter with PID controllers for both RL load without grid and with grid system are analysed and compared. The accomplishment demonstrates that the performance of the system with grid was better with regard to that of RL load without grid system. Digital simulation and prototype hardware modelling of solar based impedance-source inverter with PID controllers is established and the output obtained under transient and steady state conditions. The future enhancement of this work is to simulate for wind energy system and to realize a hardware model of the system proposed.

6. References

[1] Mukund R. Patel: "Wind and solar power systems design, analysis and operation." Second edn., CRC Taylor and Francis Group, pp.163-168.

[2] R.Gules, J.De Pellegrin Pacheco, H. Leaes Hey and J. Imhoff: "A maximum power point tracking system with parallel connection for PV stand-alone applications", IEEE Trans. (2008), 55, (7), pp. 2674-2683. https://doi.org/10.1109/TIE.2008.924033

[3] Aashoor, F.A.O.; Robinson, F.V.P: "A variable step size perturb and observe algorithm for photovoltaic maximum power point tracking," IEEE (2012) https://doi.org/10.1109/UPEC.2012.6398612

[4] Al-Diab, A.; Sourkounis, C: "Variable step size P&O MPPT algorithm for PV systems," IEEE (2010) https://doi.org/10.1109/OPTIM.2010.5510441

[5] H. Bounechba, A. Bouzid,K.Nabti and H. Benalla: "Comparison of P&O and fuzzy logic in Maximum power Point Tracker for PV system" Technologies and Materials for Renewable Energy, Environment and Sustainability (2014) pp.677-684 .

[6] www.greenrhinoenergy.com

[7] www.bryan.buckley.com

[8] John Marshal: "Single input DC-DC converter for hybrid distributed energy generators with maximum utilization using DSP controller", IJERA (2012) pp. 989-993.

[9] Shuouitao Yang, F Z Feng, Qin Lei, Ryosuke Inoshita and Zhaoming Qian: "Current-fed quasi-Z-source inverter with voltage buck-boost and regeneration capability" IEEE (2010) pp. 882-892.

[10] F Z Peng and Yi Huang: "Z-source inverter for power conditioning and utility interface of renewable energy sources"

[11] Y M Chen and S C Hung:"Multi-input inverter for grid connected hybrid PV/wind power system", IEEE Trans.(2007) pp. 850-856.

[12] Yi Huang, Miaosen Shen and F Z Peng:"Z-source inverter for residential PV systems" IEEE (2006) pp. 1776-1782.

[13] ZhiqiangGao, KeShen, Jianze Wang and Qichao Chen:"An improved control method for inductive load of Z-source inverter" IEEE (2010).

[14] Farzad Sedaghati and Ebrahim Babaei: "Double input Z-source DC-DC converter" IEEE (2011).

[15] Reza Gharakhany, Mustafa Mohamadian and Ali YazdianVarjani: "Reactive power compensation using Z-source based PV system" IEEE (2009).

[16] Fang Zheng Peng: 'Z-Source Inverter', IEEE Transactions on Industry Applications, (2003), 39, (2), pp. 504-510. https://doi.org/10.1109/TIA.2003.808920

[17] B. Justus Rabi, R. Arumugam: 'Harmonics Study and Comparison of Z-Source Inverter with Traditional Inverters', American Journal of Applied Sciences', (2005), 2, (10), pp. 1418-1426 https://doi.org/10.3844/ajassp.2005.1418.1426

[18] S. Kamalakkannan, D.Kirubakaran: 'Comparative Analysis of Grid Connected Photovoltaic based Z-Source Inverter with PI and PID Controllers', Journal of Computational and Theoretical Nano science, 1, (14), pp. 577-584. https://doi.org/10.1166/jctn.2017.6364