Novelty Journals

ISSN 2394-9678

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 3, Issue 2, pp: (17-23), Month: May - August 2016, Available at: www.noveltyjournals.com

Design and Analysis of Three Port SEPIC/Zeta converter for PV Applications

M. Dhivya[1], Mrs.P. Shanmugapriya[2]

[1]PG Scholar, [2]Assistant Professor, EEE Department, Sri Sai Ram Engineering College, Tambaram, Chennai

***Abstract*: Renewable Energy plays a pre-eminent role in the development of the country. Renewable energy sources are being used all over the world. Much of the world's required energy can be supplied by the use of solar power since it is available in abundant and most importantly cleanest form of energy. The stand-alone PV systems have been implemented to meet the power requirements at these remote areas which are far away from the generating stations. DC-DC converters are well effectively used in renewable energy because they provide maximum output with high efficiency. This paper proposes about the most efficient topology of two converters SEPIC and Zeta where they have a most prominent advantage that the output voltage of these two converters are not reversed. Corresponding simulation results are implemented and verified using MATLAB and hardware prototype is implemented where maximum efficiency and step-up ratio is obtained.**

Keywords: Renewable Energy, DC-DC converters, SEPIC and Zeta Converters.

1. INTRODUCTION

In the human life span, solar energy which is one among the renewable energy resource has replenished itself. In order to overcome and satisfy the demand for power generated from the conventional, fossil fuels, the renewable energy resources are becoming popular. According to researches it is said that the overall global demand for energy is being satisfied by the renewable resources. PV systems are very modular because it is the smallest package which produces useful power. Stand-alone systems also known as remote area power supply (RAPS) are widely used in the various domestic applications. DC-DC converters are widely used in the renewable energy power generation because it regulates the output voltage also improves efficiency. Various researches has been carried out on converter topologies like novel DC-DC topology which has only two ports but requires large storage elements s being overcome by non-isolated bidirectional converter topology which improves power efficiency but it requires backup batteries and also it provides decreased power efficiency and density. An ITPC topology used widely in multiples applications requires a better galvanic isolation and flexible voltage conversion ratio. A combination of new three port DC-DC converter and ITPC topology has been implemented which provides control strategy, flexible power flow despite its complex in system control, decrease in efficiency. It also requires energy storage backup to handle the power mismatch between the load and source.

2. PROPOSED SYSTEM

In this proposed topology a combination of SEPIC and Zeta converter is being implemented where it has the similar characteristics that its output voltage is said to be greater or equal or less than the applied voltage source. They has a specialty that its output voltage is non- inverting. They can operate as both boost and buck converter. The closed loop is said to be highly stable and provides higher efficiency and step-up ratio. SEPIC provides the continuous current at the input and Zeta provides continuous current at output. The zeta converter is actually a fourth order dc-dc converter which similar as that of SEPIC converter. The figure 1 shows the proposed SEPIC and Zeta converter circuit with the integration of full bridge and bi-directional converters. Thus by merging the two bi-directional converters in parallel and two full bridge converter three port bi-directional SEPIC and Zeta converter is obtained. It consists of diodes D1-D4, inductors L1-L4 and capacitors of C1, C2 and Cb. The isolation transformer is used in order to isolate the PV panel and battery from the load. The blocking capacitor Cb is connected with four switches S1-S4. By connecting inductors L1 and L4, S1 and S2 and capacitor Cb Sepic converter is designed. Similarly Zeta is designed by connecting capacitor C2, inductor L2 and L3, switches S3 and S4. The only difference between these two converter is that the way they are connected.

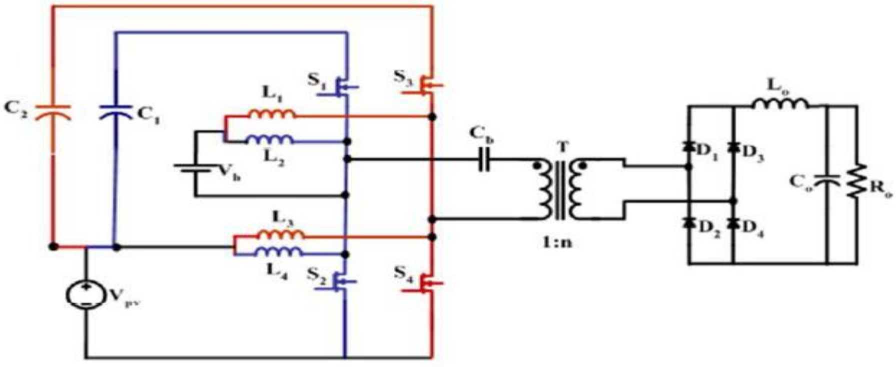

Figure 1. SEPIC&Zeta converter topology

3. MODES OF OPERATION

In a stand-alone system, by the three ways of power flow power mismatch can be improved. The power can be from PV to load, PV to battery and battery to load. The proposed converter consists of three ports in it and so that two ports can be independently controlled and the power balance is maintained by the other port. So based upon the flow of power between these ports there exists the three modes of operation, they are output mode, dual input mode and single input mode.

4. OPERATION OF THE CIRCUIT

In order to control the power exchange between battery and PV the switches S1, S2, S3, S4 are adopted as two control variables. The output voltage of the converter is obtained as,

$$V_o = \frac{V_{pv} \cdot D}{(1\text{-}D)} \qquad (1)$$

The operation of the circuit is carried out at different steps. They are discussed below.

4.1 Step 1

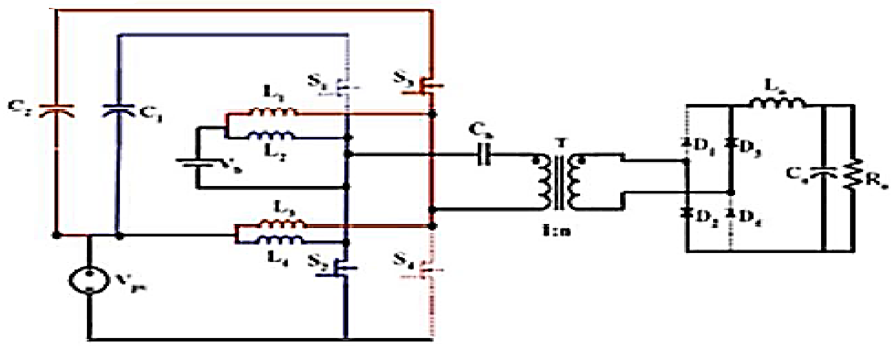

Figure 2. Step 1

In this step, S2 and S2 are turned in and the other switches are turned off. So L4 charges and L1, L2, L3 starts discharging. The diodes D1-D4 gets the freewheeling inductor current IL0, due to this current it short circuits the secondary of the transformer.

4.2 Step 2

The switches remain same as that of the step 1 except that diodes D1-D4 are reverse biased.

4.3 Step 3

The switches S1 and S3 are turned off and switches S4 and S2 are turned on as shown in figure 3. The inductors L1 and L2 discharges and other two inductors starts charging.

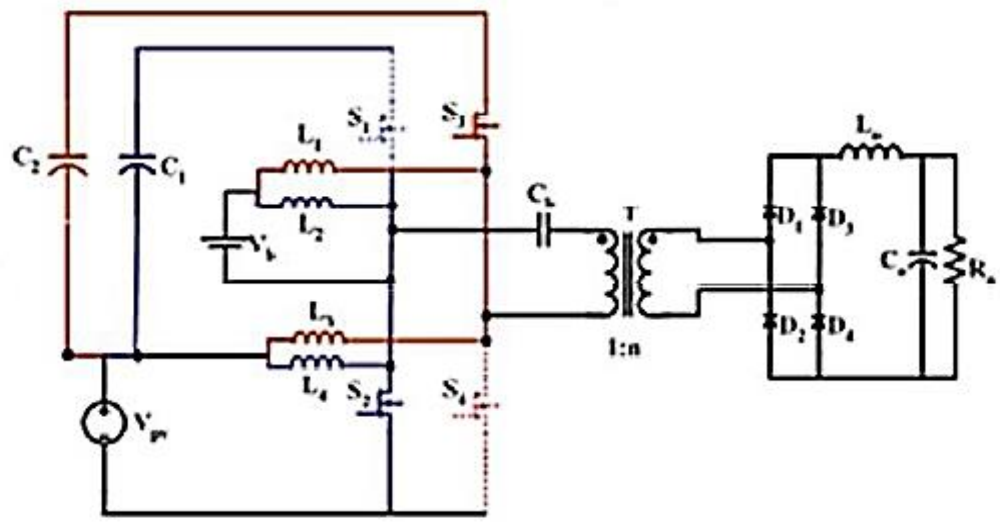

Figure 3. Step 3

4.4 Step 4

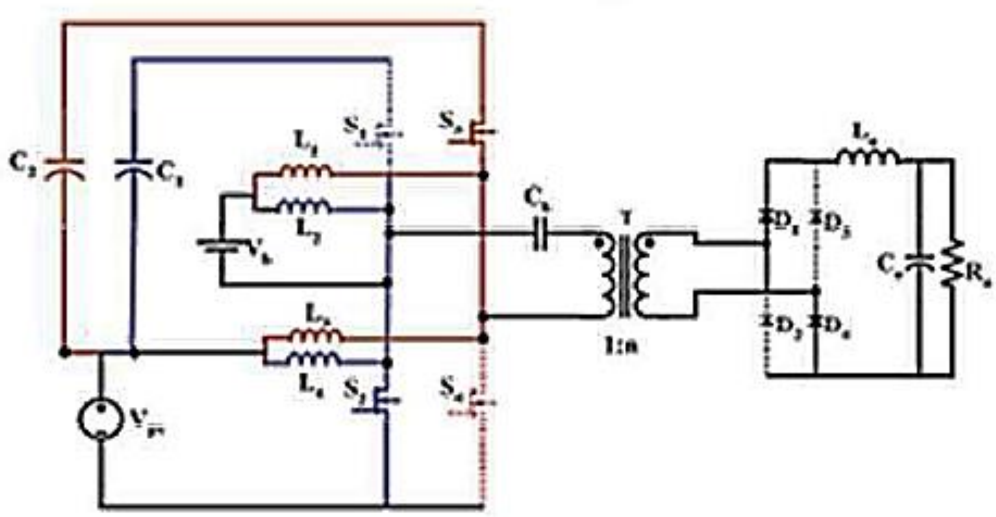

Figure 4. Step 4

Here S3 and S2 are at on state and other switches S1 and S4 are at off state. The inductors L1, L2, L3 charges whereas L4 discharges. The diodes D1-D4 gets freewheeling current.

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 3, Issue 2, pp: (17-23), Month: May - August 2016, Available at: www.noveltyjournals.com

4.5 Step 5

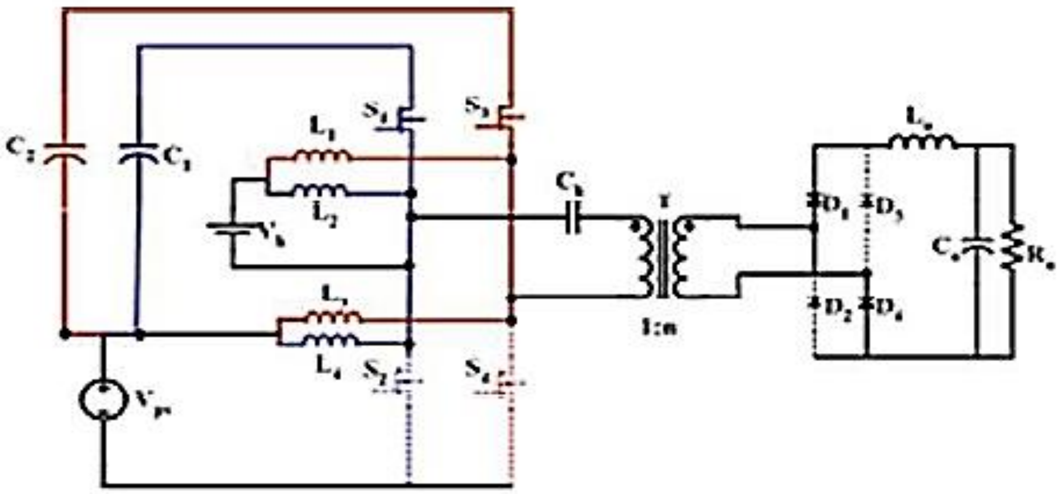

Figure 5. Step 5

This is the complementry of the mode 3 as shown in figure 5. The primary of the transformer is applied with the positive voltage. The current passes through D1 and D4 diodes.

5. SIMULATION AND RESULTS

The figures indicates the simulation effects of three port bidirectional SEPIC&ZETA converter. Figure 6 suggests the general simulation diagram and the fig 8 and 9 suggests the PV and output voltages of the converter. Figure 7 shows the PWM era for the switches used in the circuit. Input voltage used inside the converter is 70v and PV voltage of 40v is used and the maximum output voltage is 350V. MPPT controller is applied within the converter circuit to boom the efficiency in the system. PI controller is used to improve the MPPT controller component. Excessive step-up operation is completed with excessive output efficiency. The obtained output current is with 0.538A. Two of the three ports are regulated and the segment attitude is used to regulate the output voltage. The power output of 188W is obtained with increase in step-up ratio of 8.75.

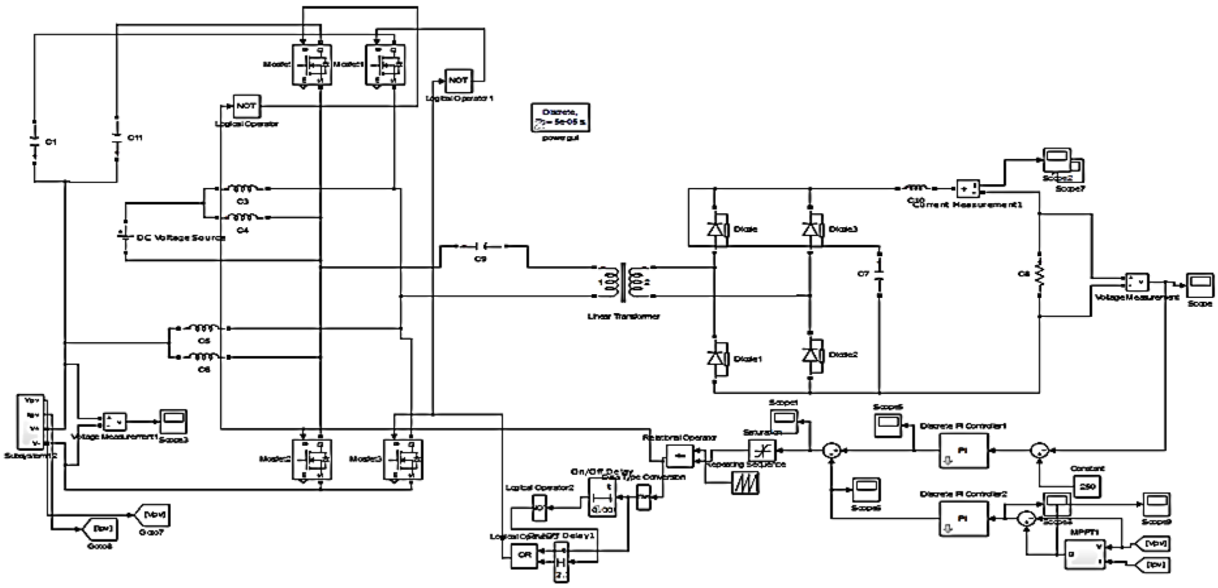

Figure 6. Overall Simulation Diagram

International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 3, Issue 2, pp: (17-23), Month: May - August 2016, Available at: www.noveltyjournals.com

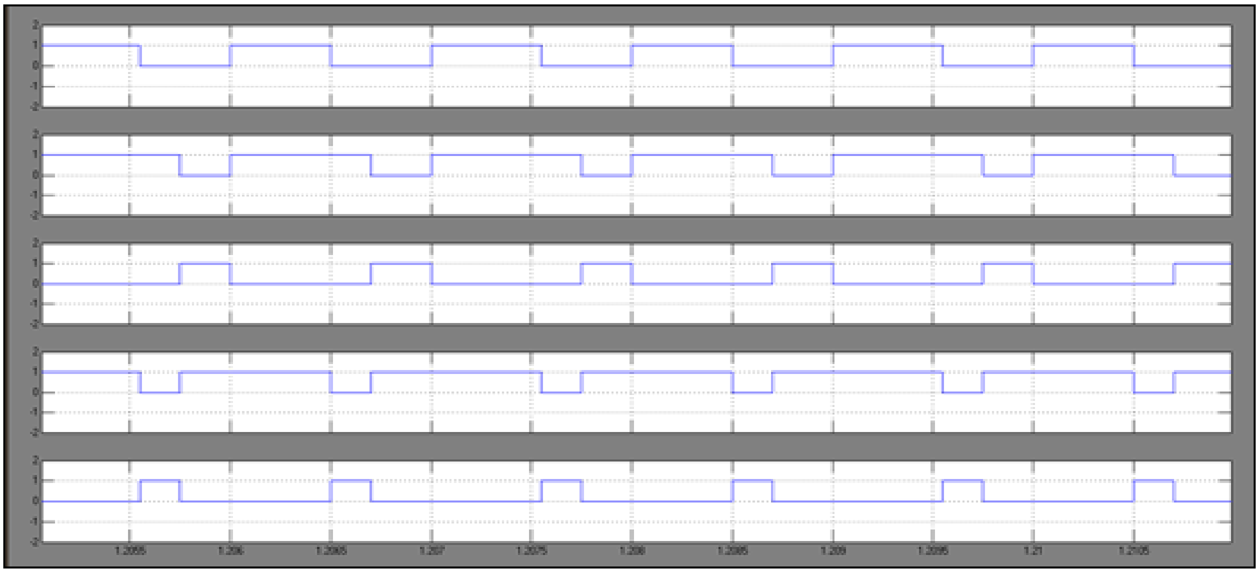

Figure 7. Pulse Generation

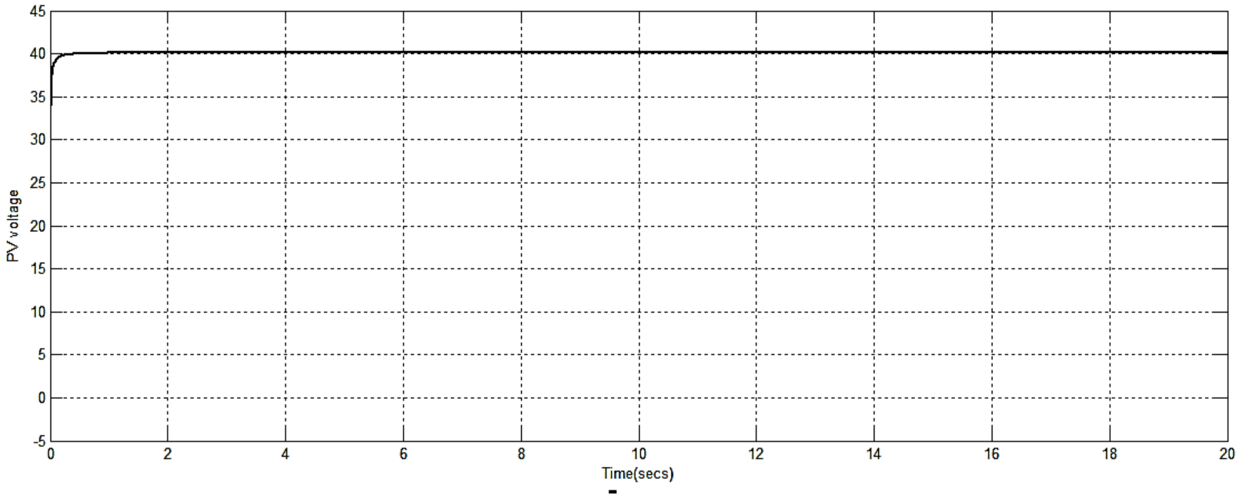

Figure 8. PV voltage

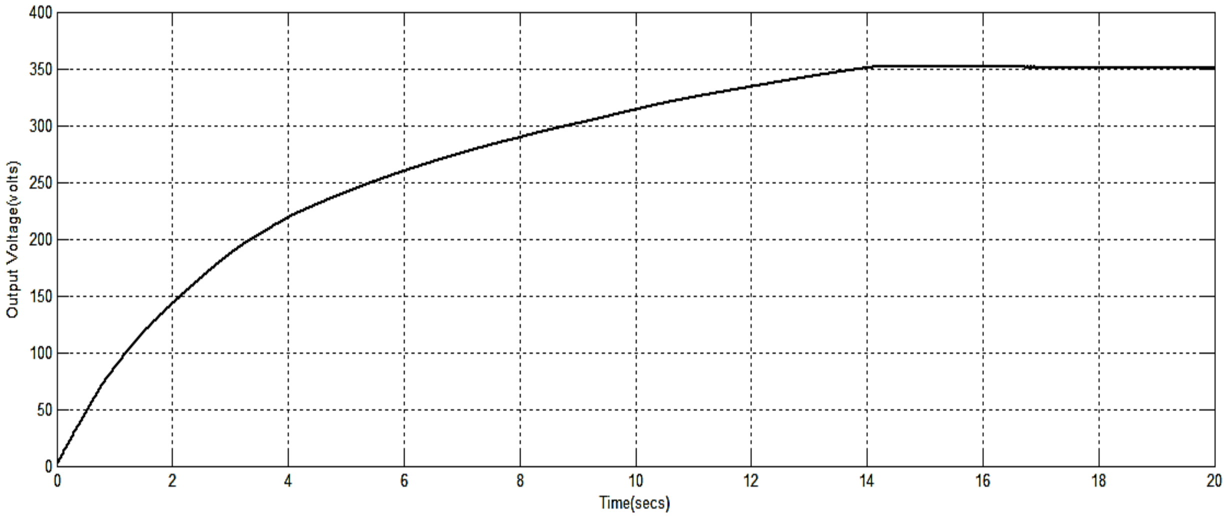

Figure 9. Output Voltage

Novelty Journals
ISSN 2394-9678
International Journal of Novel Research in Electrical and Mechanical Engineering
Vol. 3, Issue 2, pp: (17-23), Month: May - August 2016, Available at: www.noveltyjournals.com

6. HARDWARE PROTOTYPE

The corresponding hardware prototype has been implemented with the battery charging application. The hardware prototype consists of driver circuit which has opto-couplers, buffer IC-CD 4050 and a transistor 2n-2222. The Role of the driver circuit is Amplification and isolation. Transistors are used to amplify the pulses and optocoupler IC is used to provide isolation between main circuit and controller circuit. 12V supply is individually used to operate the transistors and optocoupler. The prototype also consists of controller board. By using controller board PWM pulses are generated. PIC controller is used to generate the pulses. 5V DC supply is given to the PIC controller board. Generated PWM will be below 5V. To operate the MOSFET need to give 9-12V pulses. Driver circuit is used here to increase the pulses amplitude. The microcontroller used is of PIC 16F877A which is one of the most advanced microcontroller widely used for various applications since it is affordable, high quality and ease of availability. The hardware prototype with battery charging application is shown below in figures 10 and 11. The figure 12 shows the voltage charging of the battery by using this setup.

Figure 10. Hardware Prototype

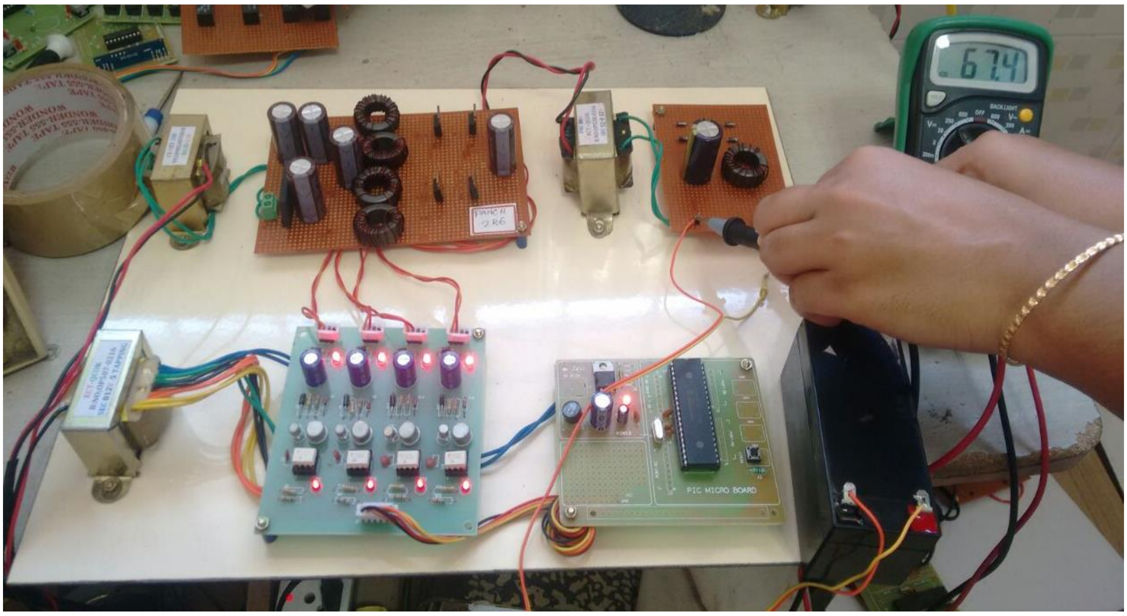

Figure 11. Measured Output voltage

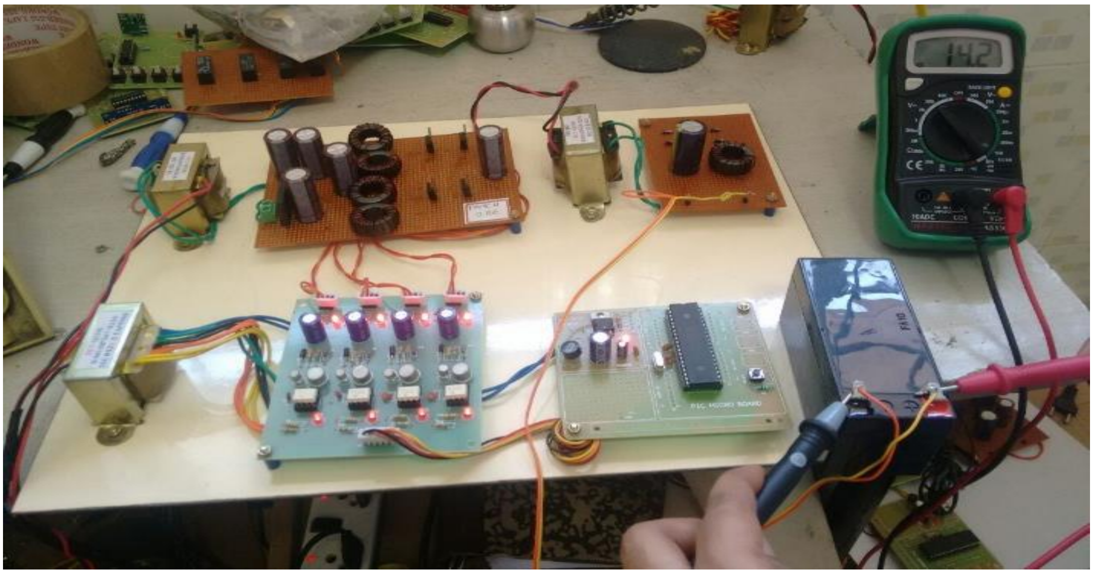

Figure 12. Prototype Measuring the Voltage Charged In The Battery

7. CONCLUSION

Thus the SEPIC & Zeta converter for stand-alone PV system is designed and analysed. These three-ports are interfaced to the solar PV system, battery and the load. This converter balances the power mismatch between different ports. The equivalent circuit at different steps are also analyzed. The system remains stable for various loads current and the input voltage. The corresponding simulation for closed loop system is presented and the corresponding hardware prototype is presented and their outputs are also shown. Increase in step-up ratio improves the capability of the power conversion systems. With this converter, the increase in step-up ratio and efficiency is improved. The system is also made simple, light and cost effective. In future the ZVS can also be achieved for the system.

REFERENCES

[1] Hongfei Wukai sun, Runruo Chen, Haibing Hu and Yan Xing, “ Full bridge three-port converters with wide input voltage range for renewable power system,” IEEEE Trans. Power Electronics, vol. 27,no. 9, pp.3965-3974, Sep. 2012.

[2] Y. Hu, Y. Deng, J. Long, X. Lu, and X. He, “A three-port high step-up DCDC converter for PV system,” presented at the ECCE-Asia, Melbourne, Australia, 2013.

[3] W. Xiao, A. Elnosh, V. Khadkikar, and H. Zeineldin, “Overview of maximum power point tracking technologies for photovoltaic power systems,” in Proc. IEEE 37th Annu. Conf. IEEE Ind. Electron. Soc., 2011, pp. 3900–3905.

[4] Zhijun Qian, Osama Abdel-Rahman and Issa Batarseh, “An integrated four-port dc/dc converter for renewable energy applications,” IEEE Trans. on Power Electronics, vol. 25, no. 7, pp. 1877-1887, July2010.

[5] Yihua Hu, Weidong Xiao, Wenping Cao,,Bing Ji, and D. John Morrow,“Three-Port DC–DC Converter for Stand-Alone Photovoltaic Systems,” IEEE Transactions On Power Electronics, Vol. 30, No. 6, June 2015.