International Journal of Research
Available at
https://edupediapublications.org/journals
p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

PHOTOVOLTAIC SYSTEM CONNECTED ISOLATED THREE PORT BIDIRECTIONAL DC-DC CONVERTER WITH ENERGY STORAGE

[1,2]B.SANDHYARANI
Roll No: 14AT1D0708
E-Mail bsandhya205@Gmail.Com
[1,2]R.SHEBA RANI
Assistant Professor
Email: shebaranieee@gpcet.ac.in
[1]Department : Electrical Power Systems
[2]G.Pullaiah College Of Engineering And Technology

ABSTRACT:

This project proposes a new isolated multiple input bidirectional DC-DC converter with power management. The proposed converter uses less number of switches with soft switching option for the main switch, which can be realized by using an inductor-capacitor- inductor (LCL) resonant circuit and hence zero current switching (ZCS) can be achieved. It can manage the power with PV panel, rechargeable battery, and load.

The PV system is connected to unidirectional port and the battery is connected to bidirectional port. Isolated multi port converter which contains transformer, and it is used for high voltage regulation ratio. The operating principle of battery, charging and discharging is explained by using different modes. The main objective is to regulate the output DC link voltage to a constant value and also to manage the power for the sources. MATLAB/ SIMULINK is used for design and simulation of the proposed system.

I INTRODUCTION

To coordinate multiple dc energy wellsprings of various sorts to a power lattice, multiple free dc–d converter are normally used to venture up the time-variation low-level source voltages to a consistent abnormal state voltage that is required by a network tie inverter. Contrasting with that arrangement, a multiport dc–dc converter is best, attributable to the benefits of utilizing less parts, bring down cost, higher power thickness, and higher efficiency. The multiport converter topologies can be characterized into two classes: non isolated and isolated topologies. Non isolated multiport converters are normally utilized as a part of the applications where a low voltage control proportion is required. Conversely, in the applications requiring a high voltage direction proportion, isolated converters, which contain a transformer, are favored. The currently utilized isolated multiport topologies include the isolated full-connect converter, which utilizes four controllable power switches for each source; the isolated half-connect converter, which utilizes two switches for each source; and the isolated Single - switch converter, which just uses one switch for each source. In some down to earth applications, energy stockpiling, for example, batteries, is usually used to deal with the intermittence of sunlight based and wind energy sources. This requires no less than one port of the multiport converter is bidirectional. The previously mentioned topologies are for the most part unidirectional and can't fulfill such applications.

A few bidirectional topologies, for example, full-extension, and half-connect topologies, have been proposed. These two topologies use many switches with muddled drive and control circuits. As of late, a three-port topology has been proposed by adding one center branch to the conventional half-connect converter. It utilizes less controllable power switches than the half-connect topology and can accomplish zero-voltage switching for all principle switches. In any case, the voltage of the essential source ought to be kept up at a high incentive to charge the battery, and the battery is both accused and released of in a switching period. Such a high-frequency charge/release negatively affects the battery lifetime.

This paper proposes another isolated three-port bidirectional dc–dc converter. It contains an inductor–capacitor–inductor (LCL) – thunderous circuit to accomplish zero-current switching (ZCS) for the principle switch. Contrasted and the converter in utilizing five controllable switches, the proposed converter just utilize three switches; also, when utilizing the same sustainable power source to charge a battery, the ostensible voltage of the battery associated with the proposed converter can be higher than that associated with the converter in. The proposed converter is connected for concurrent power administration of a photovoltaic (PV) system with a battery in this paper. The PV system and the battery are associated with the unidirectional port and the bidirectional port of the converter, individually. A greatest power point tracking (MPPT) calculation is intended for the PV board to create the most extreme power when sun based radiation is accessible. A charge and release controller is intended to control the battery to either ingest the surplus power created by the PV board or supply the lacking power required by the load. Reenactment and trial comes about are given to approve the proposed converter.

II PHOTOVOLTAIC SYSTEMS

Energy is the ability to do work. A lot of energy is expected to maintain modern development and agriculture generation.

CLASSIFICATION OF ENERGY

It is broadly classified into

1. **Conventional energy:** It is by and by for long length of time and entrenched innovation is accessible to tap and utilize them. e.g. Coal, oil, flammable gas, hydro power, atomic power and so on.

2. **Non-conventional energy:** source can be utilized with advantage for power era and in addition different applications in a substantial number of areas and circumstances. These energy sources can't be effectively put away and utilized advantageously. e.g. Sun powered, wind, tidal and geothermal and so forth.Based upon nature, energy sources are classified as

3.Renewable energy sources are limitless and are recharged by nature itself. Sunlight based, wind, tidal, hydro and biomass are couple of illustrations.

4. Non-renewable energy : sources are expendable inside a clear time frame depending upon its use. Non-enewable energy sources (coal, oil, gas) and atomic fills are few examples.

III. SOLAR ENERGY

The surface of the earth gets around 1014 kW from sun as sun powered energy which is roughly five requests of extent more prominent than that currently being expended from all assets. It is apparent that sun will keep going for a long time. There are two clear obstructions to saddling sun oriented energy. Right off the bat it is not always accessible on earth.

In this way some type of capacity is expected to support sun oriented energy during that time and amid blustery season. Also the sun oriented energy is diffused. In spite of the fact that the aggregate sum of energy is colossal, the gathering and preservation of sunlight based energy into valuable structures must be completed over an expansive zone which involves extensive capital speculations.

IV. TOPOLOGY AND OPERATING PRINCIPLE OF THE PROPOSED CONVERTER

A. Topology of the Proposed Converter

The circuit diagram of the proposed converter is shown in Fig. 1, which consists of a low-voltage-side (LVS) circuit and a high-voltage-side (HVS) circuit connected by a high-frequency transformer. The LVS consists of two ports, an energy storage capacitor Cs, the primary winding of the transformer, and an LCL-resonant circuit consisting of two inductors Lr and Lp and a capacitor Cr, where Lp includes the added inductance Lp1 and the leakage inductance of the transformer Lp. The HVS consists of the secondary winding of the transformer and a full-bridge rectifier implemented with the diodes Ds1 to Ds4. The transformer's turn ratio is defined as: n = Np/Ns, where Np and Ns represent the numbers of turns of the primary and secondary windings, respectively. Among the switches, S1 is called the main switch because it not only controls the power generated by the source connected to Port 1 (P1) but also changes the direction of the current flowing through the transformer. In this paper, the two ports on the LVS are connected to a PV panel and a battery. To simplify the analysis, the proposed converter is analyzed by two separate converters: one is a single-switch LCL-resonant converter, and the other is the Battery-related buck and boost converter consisting of L2, S2, and S3.

V. POWERMANAGEMENT OF THE PROPOSED CONTROLLER

According to the availability of the solar power, there are three working scenarios of the converter.

A) Scenario1 (p_1>pout): The available solar power is more than the load deman. The PV converter works in the MPPT mode; the battery is charged so that the dc-link voltage is controlled at a constant value.

B) Scenario2 ($0<p_1<p_{out}$): There is solar radiation, but the solar power is not sufficient to supply the load. The PV panel is controlled in the MPPT mode by the MPPT algorithm described later. On the other hand, the deficient power is supplied by the battery, which is discharged by the boost converter, so that the dc-link voltage can be maintained at a constant value.

C) Scenario3 (p_1=0): There is no solar power available and, thus, the battery is discharged to supply the load, as shown in. The active switches are S_1 and S_3.

Proper controllers are designed to manage the power of the system in different scenarios. Fig. 1 shows the overall system with controllers, which include a MPPT controller for the PV panel and charge and discharge controllers for the batter

II. BLOCK DIAGRAM OF THE PROPOSED SYSTEM WITH CONTROLLERS

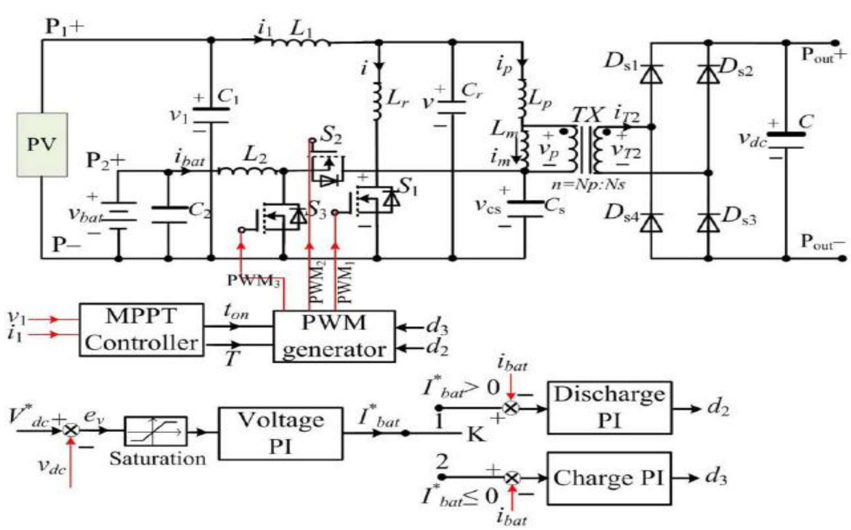

Fig.1 Block Diagram of the System With Controllers

MPPT Controller for PV Panel

The proposed converter is applied for MPPT control of a PV panel using the perturbation and observation (P&O) MPPT algorithm to maximize the PV panel's output efficiency. Fig.2 shows the flowchart of the MPPT algorithm. A ratio r_c is defined to specify the relative power change (RPC) of the PV panel between two consecutive sampling steps. Where, $r_c = \frac{|P_1(k) - P_1(k-1)|}{P_1(k-1)}$

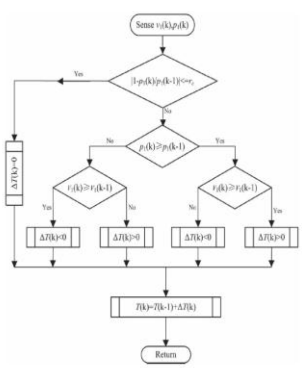

Fig. 2 Flowchart of MPPT Algorithm

II SIMULATION RESULTS AND DISCUSSIONS

(a) WITHOUT CONTROLLER

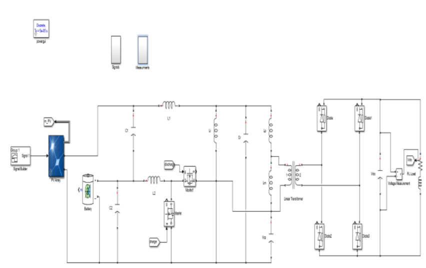

Fig.3 Simulation Diagram of the Proposed System without Controller

A five switch series connected solar module is taken as our source along with battery, which is connected to parallel to the Solar panel. Two capacitors of 1000 micro farad are placed one in parallel with battery and another one with Solar Panel. Two Mosfets are placed in circuit as shown in fig.3. Two mosfets are used for the charging and discharging of the battery according to requirement.

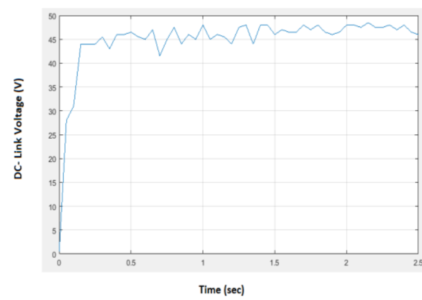

Fig.4 DC- Link Voltage Response Without Controllers

Fig.4 shows that the total input which is generated by both solar panel and battery. It is observed that the output is always less than 50 v dc. When solar power is low, then battery power is added to get constant input

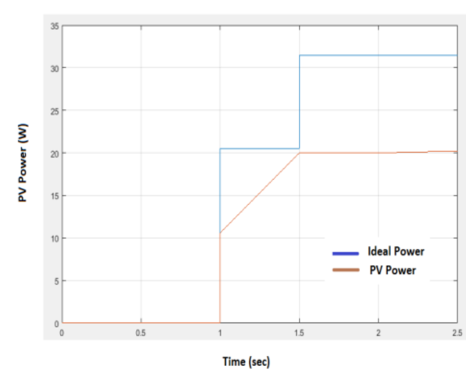

Fig.5 PV Power Response With Out Controller

During initial condition the solar radiation is zero and there is no power generated by the PV Panel as shown in Fig.5. At t=1s the generated solar power is 11W which is less than the load demand of 25W. From t=1s to t=1.5 s the power raises to 20W. At t=1.5 s it is maintained as constant value i.e., 20W which is less than the load demand of 25W.

VIII. PROPOSED CONVERTER WITH MPPT CONTROLLER

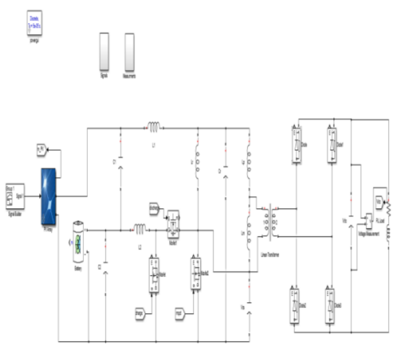

Fig.6 Simulation Diagram of the Proposed System

A five switch series connected solar module is taken as our source along with battery, which is connected to parallel to the Solar panel. Two capacitors of 1000 micro farad are placed one in parallel with battery and another one with Solar Panel. Three Mosfets are placed in circuit as shown in Fig.6. One mosfet is used for MPPT control of solar power and other two are used for the charging and discharging of the battery according to requirement.

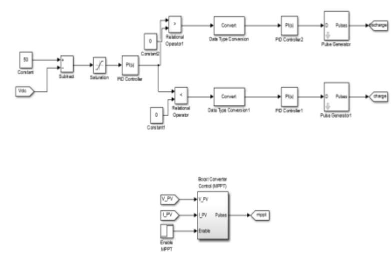

Fig.7 Signals Block of the Circuit Diagram

Charging and discharging of the battery is shown in Fig.7. A constant value of 50V is taken as referral value for comparison of DC voltage from input. If the generated solar power is more than the required load value than the battery is charged and when the generated solar power is less than required load value then the battery is discharged along with the solar power.

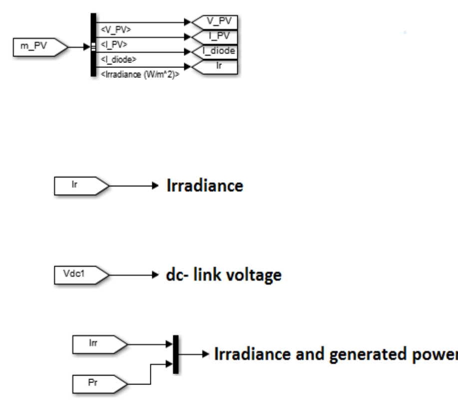

Fig.8 Measurements Block of the Circuit Diagram

Fig.8 shows that the measurements block which is used to measure the dc- link voltage and power for the corresponding solar irradiance.

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

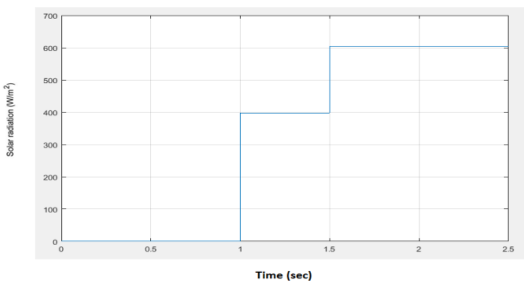

Fig.9 Profile of Solar Radiation

To test the dynamic characteristic of the controllers, the solar radiation is step changed to examine the responses of the dc link voltage and output power of the PV panel. Fig 9 shows that the profile of solar irradiance. From t=0s to t=1s the solar irradiance is zero, and from t=1s tot= 1.5s the irradiance is 400 W/m^2 and from t=1.5 s to t=2.5 s the solar irradiance is 600W/m^2.

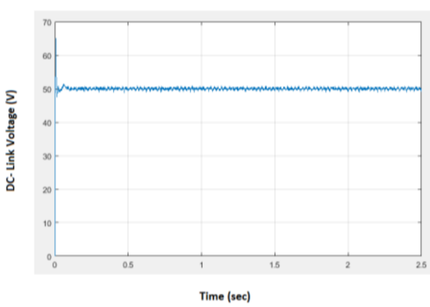

Fig.10 DC-Link Voltage Response

Fig 9. shows that the initial solar radiation is zero and all of the power is supplied by discharging the battery. This indicates that the converter works in scenario 1. Fig 10.shows that the dc- link voltage quickly reaches to its reference value of 50V and maintained at constant.

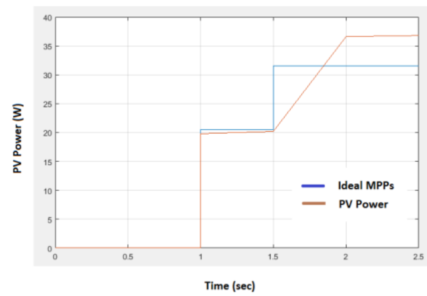

Fig.11 PV Power Response

Fig.9 shows that the initial solar radiation is zero and there is no power generated by the PV panel, as shown in Fig.11. This indicates that the converter works in Scenario 1 and all of the power is supplied by discharging the battery. Scenario 1 does not terminate until the solar radiation changes from zero to 400 W/m2 at the first second. After that, the maximum power generated by the PV panel is 20 W, which is less than the load demand of 25 W. Thus, the battery still works in the discharge mode to provide the deficient power required by the load, and the variation of the dc-link voltage is negligible during the transition. From t=1s to t= 1.5 s, the converter works in Scenario 2. The PV panel generates the maximum power, as indicated in Fig.7. At t= 1.5 s, the solar radiation is changed from 400 W/m^2 to 600 W/m^2, which corresponds to 32-W maximum power. Then, the battery stops discharging and starts to absorb the surplus power generated by the PV panel.

IX. CONCLUSION

This paper has proposed a new isolated three-port bidirectional dc–dc converter, which uses the minimum number of switches. The proposed converter has been used for simultaneous power management of multiple energy sources, i.e., a PV panel and a battery, in this paper. Simulation results have shown that the converter is not only capable of MPPT for the PV panel when there is solar radiation but also can control the charge/discharge of the battery to maintain the dc-link voltage at a constant value.

RESULTS:

	WITH MPPT CONTROLLER	WITHOUT MPPT CONTROLLER
DC- Link Voltage (V)	50	45
Power (W)	32	20

REFERENCES

[1] Jianwu zeng and Liyan Qu, 'An isolated three-port bidirectional DC-DC converter for photo voltaic systems with energy storage' IEEE Trans. Power Electron.

[2] C. Onwuchekwa and A. Kwasinski, "A modified-time-sharing switching technique for multiple-input DC-DC converters," IEEE Trans. Power Electron., vol. 27, no. 11, pp. 4492–4502, Nov. 2012.

[3] A. Khaligh, J. Cao, and Y. Lee, "A multiple-input DC-DC converter topology," IEEE Trans. Power Electron., vol. 24, no. 4, pp. 862–868, Mar. 2009.

[4] J. Lee, B. Min, D. Yoo, R. Kim, and J. Yoo, "A new topology for PV DC/DC converter with high efficiency under wide load range," in Proc. Eur. Conf. Power Electron. Appl., Sep. 2007, pp. 1–6.

[5] C. Lohmeier, J. Zeng, W. Qiao, L. Qu, and J. Hudgins, "A currentsensorless MPPT quasi-double-boost converter for PV systems," in Proc. IEEE Energy Convers. Congr. Expo., Sep. 2011, pp. 1069–1075.

[6] K. Sayed, M. Abdel-Salam, A. Ahmed, and M. Ahmed, "New high voltage gain dual-boost DC-DC converter for photovoltaic power system," Elect. Power Compon. Syst., vol. 40, no. 7, pp. 711–728, Apr. 2012.

[7] Y. Chen, Y. Liu, and F. Wu, "Multi-input DC/DC converter based on the multi winding transformer for renewable energy applications," IEEE Trans. Ind. Appl., vol. 38, no. 4, pp. 1096–1104, Jul./Aug. 2002.

[8] Y. Jang and M. Jovanovic, "Isolated boost converter," IEEE Trans. Power Electron., vol. 22, no. 4, pp. 1514–1521, Jul. 2007.

[9] E. Yang, Y. Jiang, G. Hua, and F. Lee, "Isolated boost circuit for power factor correction," in Proc. IEEE Appl. Power Electron. Conf. Expo., Mar. 1993, pp. 196–203.

[10] Y. Lembeye, V. Bang, G. Lefevre, and J. Ferrieux, "Novel half-bridge inductive DC-DC isolated converters for fuel cell applications," IEEE Trans. Energy Convers., vol. 24, no. 1, pp. 203–210, Mar. 2009.

[11] J. Zeng, W. Qiao, L. Qu, and Y. Jiao, "An isolated multiport dc-dc converter for simultaneous power management of multiple different renewable energy sources," IEEE J. Emerging Sel. Topics Power Electron., vol. 2, no. 1, pp. 70–78, Mar. 2014.

[12] H. Tao, A. Kotsopoulos, J. Duarte, and M. Hendrix, "Family of multiport bidirectional DC-DC converters," Proc. Inst. Elect. Eng.—Elect. Power Appl., vol. 153, no. 3, pp. 451–458, May 2006.

[13] C. Zhao, S. Round, and J. Kolar, "An isolated three-port bidirectional DC-DC converter with decoupled power flow management," IEEE Trans. Power Electron., vol. 23, no. 5, pp. 2443–2453, Sep. 2008.

[14] J. Duarte, M. Hendrix, and M. Simoes, "Three-port bidirectional converter for hybrid fuel cell systems," IEEE Trans. Power Electron., vol. 22, no. 2, pp. 480–487, Mar. 2007.

[15] G. Su and F. Peng, "A low cost, triple-voltage bus DC-DC converter for automotive applications," in Proc. IEEE Appl. Power Electron. Conf. Expo., Mar. 2005, pp. 1015–1021.

[16] D. Liu and H. Li, "A ZVS bi-directional DC-DC converter for multiple energy storage elements," IEEE Trans. Power Electron., vol. 21, no. 5, pp. 1513–1517, Sep. 2006.

[17] H. Al-Atrash, F. Tian, and I. Batarseh, "Tri-modal half-bridge converter topology for three-port interface," IEEE Trans. Power Electron., vol. 22, no. 1, pp. 341–345, Jan. 2007.

[18] Z. Qian, O. Abdel-Rahman, and I. Batarseh, "An integrated four-port DC/DC converter for renewable energy application," IEEE Trans. Power Electron., vol. 25, no. 7, pp. 1877–1887, Jul. 2010.

[19] J. Zeng,W. Qiao, and L. Qu, "A single-switch LCL-resonant isolated DCDC converter," in Proc. IEEE Energy Convers. Congr. Expo., Sep. 2013, pp. 5496–5502.

[20] B. Lu, W. Liu, Y. Liang, F. C. Lee, and J. Van Wyk, "Optimal design methodology for LLC resonant converter," in Proc. IEEE Appl. Power Electron. Conf. Expo., Mar. 2006, pp. 1–6.

[21] J. Zeng, W. Qiao, and L. Qu, "LCL-resonant single-switch isolated DC-DC converter," IET Power Electron., vol. 8, no. 7, pp. 1209–1216, Jul. 2015.

[22] C. Hua, J. Lin, and C. Shen, "Implementation of a DSP-controlled photovoltaic system with peak power tracking," IEEE Trans. Ind. Electron., vol. 45, no. 1, pp. 99–107, Feb. 1998.

[23] B. York, W. Yu, and J. Lai, "Hybrid-frequency modulation for PWMintegrated resonant converters," IEEE Trans. Power Electron., vol. 28, no. 2, pp. 985–994, Feb. 2013.

[24] National Renewable Energy Laboratory Baseline Measurement System. [Online]. Available: http://www.nrel.gov/midc/apps/go2urlpl?site=BMS&page=day.pl?BMS 3452.