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Simulation of Multi Input DC-DC Boost Coverter for Hybrid Power System

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ABSTRACT

A multi input DC-DC boost converter is proposed in this paper. The converter constitutes three input ports and an output port, of the three input ports two are unidirectional ports and one is bidirectional port. The two unidirectional ports are PV system and a wind system whereas the battery is the storage element i. e. the bidirectional port. Different modes of operation are defined based on the availability of the power from the two unidirectional input ports. For this converter four different switches are used, the output voltage and the power flow is regulated by varying the duty ratio of the four switches. The simulation has been performed and desired output is obtained using MATLAB SIMULINK software.

Keywords: DC-DC boost converter, hybrid power system

INTRODUCTION

With increasing environmental concerns and the depleting natural resources the focus is shifting on the renewable sources so that they can meet the growing demand for energy to some extent. Photovoltaic (PV) energy system are becoming are becoming quite popular because of its cleanliness, high efficiency and least maintenance required. There are a few shortcomings of the PV energy as it is dependent on the Solar irradiation which keeps varying throughout the day hence this form of energy must be well supplemented by the alternative forms of energy like wind energy and it is to an extent is reliable. Now we need to integrate the two sources of energy to supply power to the load continuously for this multi input boost converter is utilized to hybridize the two systems. But in practical systems the above mentioned sources may fail to supply to the load, hence a bidirectional storage element, battery is used to maintain continuity in the power flow. By combining the energy sources PV, wind and battery a hybrid power system is proposed to meet the peak power demand and efficient answer to the power cut problems. The use of the battery in the system makes it dynamic as the battery can be charged, discharged or kept at standby mode as per availability and the power requirement of the system. All these factors are important in the designing of the converter. Various converters are proposed in the literature survey until now. The major drawback of these traditional converters are that they have a complex circuit topology, difficult integrating methods, large number of components which increases the losses and hence less efficient. In the recent years the multi input converters has come up as efficient solution to the problems stated for the traditional converters. An effective way of designing an MIC is proposed in the paper [1] where the concept of pulsating voltage source cell and pulsating current source cell are utilized to design a converter where various constraints in designing a converter is discussed. The above mentioned concept is utilized in [2] to design a MIC to hybridize the PV and the wind energy system. Another MIC proposed in [3] allows one of the source to transfer energy to load at a time and the others at some time later. In [4] the MIC designed uses the concept of DC link and magnetic coupling using half bridge boost converter the key feature of thisconverter is its

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compact nature and low cost. In [5] MIC is based on the flux additivity in a multi winding transformer is proposed the drawback of this system is no bidirectional operation of the converter is possible. The MIC discussed in [6] is a DC-DC Boost converter useful for combining several energy sources with different power capacity and voltage levels. In the paper [7] a three input DC-DC converter combine PV/FC/battery in a simple integrated circuit is designed, power management algorithm is used to achieve maximum power point tracking of the PV sources and set the FC in its optimaloperation range. In this paper a three input DC DCboost converter is discussed for hybrid power system fig 1. Shows the block diagram for the converter discussed in this paper. The converter has two unidirectional ports which supplies the power to the load. The battery isthebidirectional element in of the mode it supplies the load along with the two input sources and in the other operating mode it is charged i. e. the input sources supplies the battery to charge along with the load. The converter is a current source type at both the input ports as the inductors are the charge storing elements in the proposed circuit and hence it is able to step up the input voltage. The power flow in the discussed circuit is controlled using the duty ratio of the switches , these duty ratios also regulate the output voltage at the load.

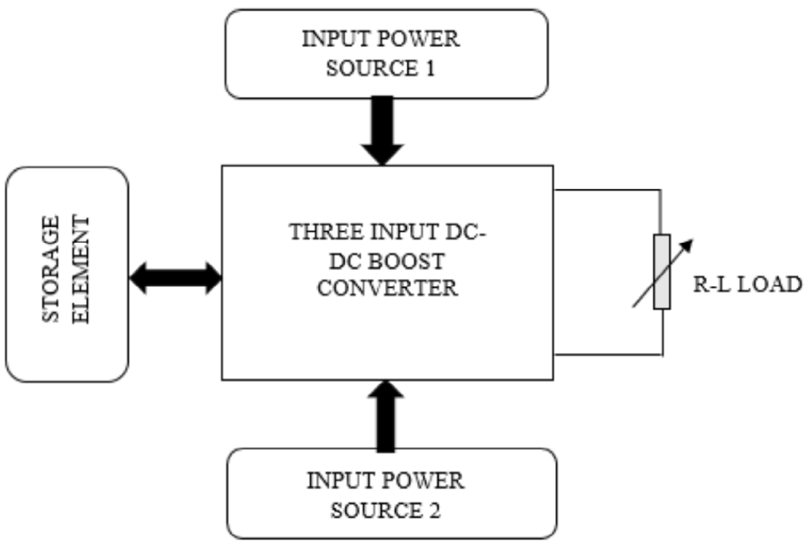

Figure 1: System Overview

CONVERTER TOPOLOGY

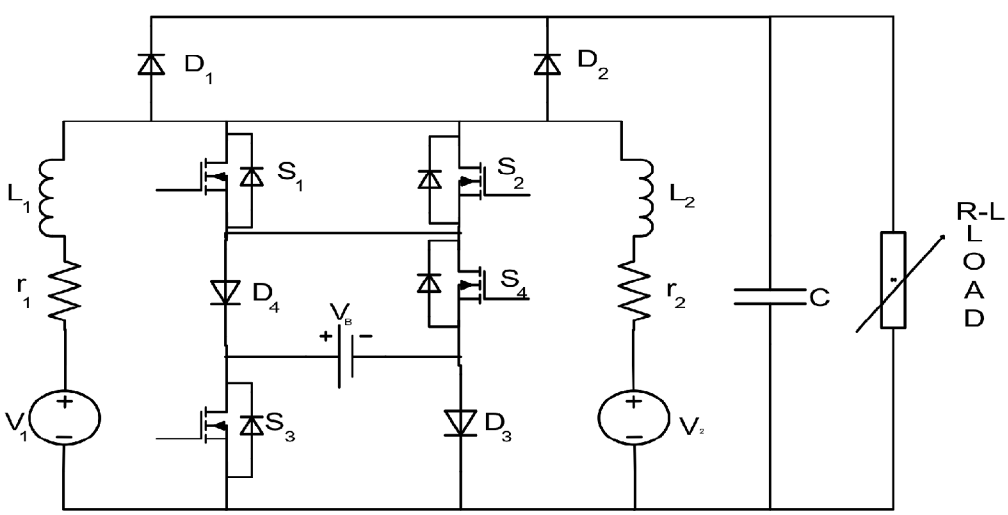

Figure 2: Circuit topology

The topology of the four port DC-DC boost converter is shown in fig. 2. In the above shown converter is configured with three input ports and an output port. Three input constitutes of two unidirectional input ports and a bidirectional port which is used as storage element. The two unidirectional ports are the two dependent voltage sources V_1 and V_2 which depends on the respective input sources i. e. PV and wind. for an instance power provided by V_1 depends on the PV source i. e. it will vary with the varying solar irradiation, temperature. The circuit has two inductors to store the charge, this stored energy is supplied to the load. The two inductors in the given circuit function as two current type sources. here four diodes D_1, D_2, D_3, D_4 where D_1 and D_2 conduct in a complementary manner with the two switches S_1, S_2 as in a conventional boost converter circuit. Whereas the D_3 and D_4 are reversed biased by battery voltage when the switches S_3 and S_4 are ON and turning OFF these switches causes the Diode to conduct current i_{L1} and i_{L2}. The four switches play an important role in regulating the power flow in the circuit, by varying the duty ratio d_1, d_2, d_3, d_4 of the switches we can regulate the output voltage. The load used for the converter is an R_L load.

OPERATION MODE

The proposed converter is operated in three different modes. The modes of the converter has been defined according to the availability of power from the input sources i. e. V_1 and V_2. The converter operates in a battery standby mode where the battery is nonfunctional, in a battery discharge mode and a battery charging mode. In each mode of operation a different set of switching signal have been given by varying duty ratios d_1, d_2, d_3, d_4 the four power switches S_1, S_2, S_3, S_4.

MODE 1 (only V_1 and V_2 supplying the load)

This is the basic mode of operation of the proposed converter the two input sources V_1 and V_2 are supplying the load while the battery is in a standby mode i. e. neither charging nor discharging. As seen in the converter topology there is two paths for the current to flow S_4-D_3 and S_3-D_4, for this mode the former path S4-D_3 is chosen. Hence, the switch S3 is off for this mode and the switch S_4 is ON for the entire mode 1. This mode of operation is split into three different switching states as:

Switching state 1: At T= 0, Switch S_1 and S_2 are turned ON, the two inductors L_1 and L_2 gets charged with the voltages V_1 and V_2 as shown in fig (a).

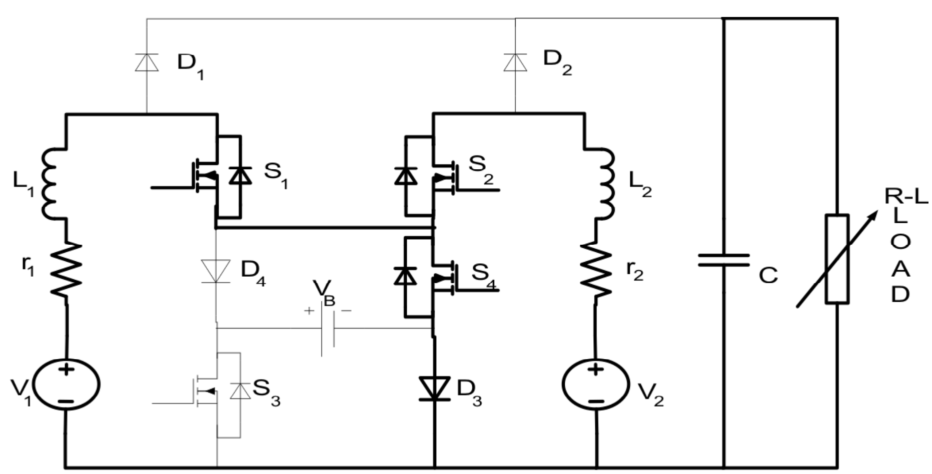

Figure 3(a): First operation mode: Switching state 1

Switching state 2: At T=d_1T, switch S_2 goes OFF While S_1 is still ON. Hence L_1 continues to be charged while L_2 gets discharged to the Load through diodes D_1 and D_2 as shown in fig 3(b).

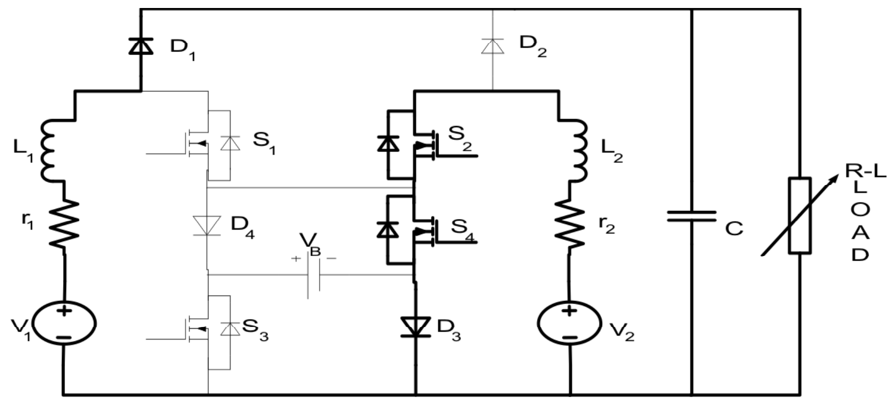

Figure 3(b): First Operation Mode: Switching State 2

Switching state 3: At T=d_2T, both switches S_1 and S_2 are OFF. Hence, L_1 and L_2 gets discharged to the load through diodes $D_1$and D_2 as shown in fig 3(c).

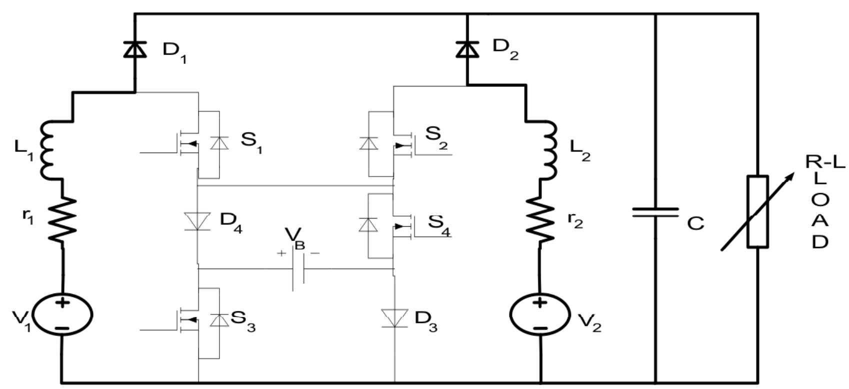

Figure 3(c): First Operation Mode: Switching State 3

MODE 2 (V_1 and V_2 supply load with battery discharge)

In this operating mode the two input sources V_1 and V_2 along with the battery discharging supplies the load. As seen in the circuit topology this mode of operation takes place only when the switches S_1 and S_2 are ON, the duty ratio provided for S_1 and $S_2$are 0. 73 and 0. 78. In this mode the switch S_3 and S_4 are ON which provides a path for the current to flow through the path S_4, battery, S_3 which causes the battery to discharge. The duty ratio provided for S_3 and S_4 are of 0. 45 and 1 respectively. As shown in the Fig 4(a-d) there are four different switching states as:

Switching state 1: At T = 0, all switches S_1, S_2, S_3, S_4 are turned ON. Hence, the inductors L_1 and $L_2$are charged with voltages V_1+V_b and V_2 +V_b as shown in fig 4(a).

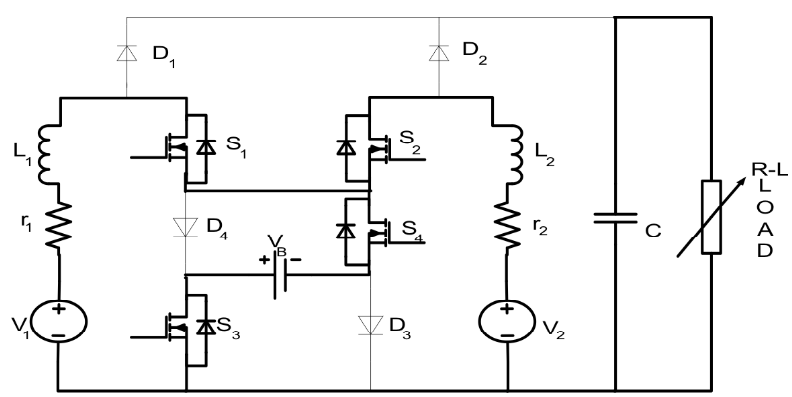

Figure 4(a): Second Operation Mode: Switching State 1

Switching state 2: At T = d_4T, S_4 is turned OFF while S_1 and S_2 are ON and it keeps charging the inductors L_1 and L_2 with voltages V_1 and V_2 as shown in fig 4(b).

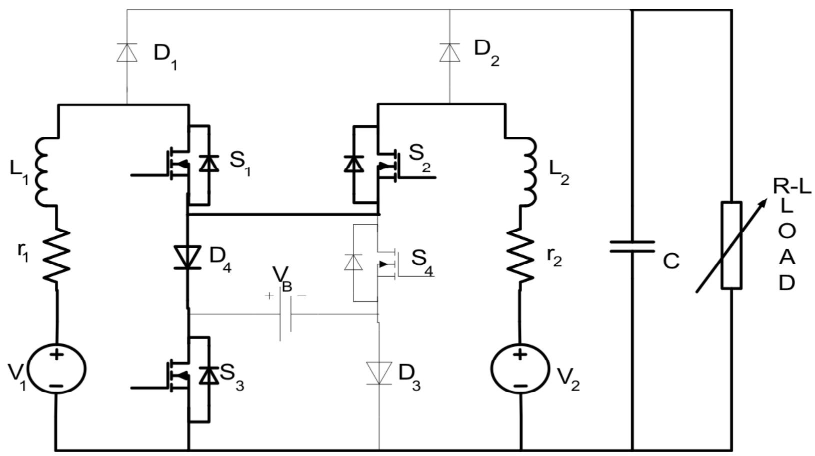

Figure 4(b): Second Operation Mode: Switching State 2

Switching state 3: At T = d_1T, switch S_2 is turned off while S_1 is still ON. Hence, L_1 is charged from V_1 whereas L_2 discharges to the load as shown in fig 4(c).

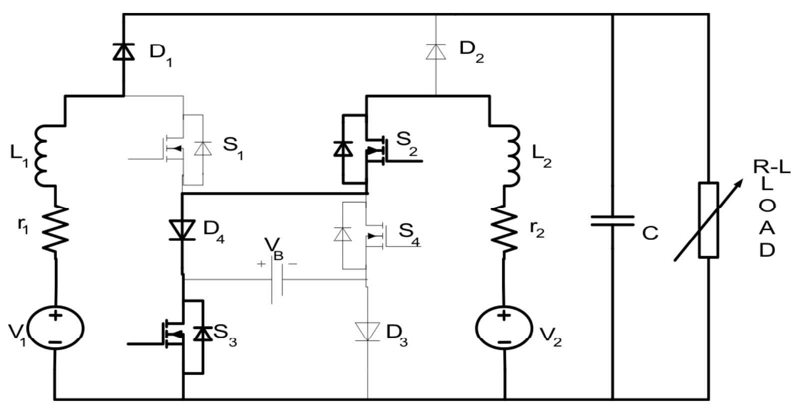

Figure 4(c): Second Operation Mode: Switching State 3

Switching state 4: At T= d_2T, both the switches S_1 and S_2 are Turned OFF. Hence, both the inductors L_1 and L_2 discharges to the load as shown in Fig 4(d).

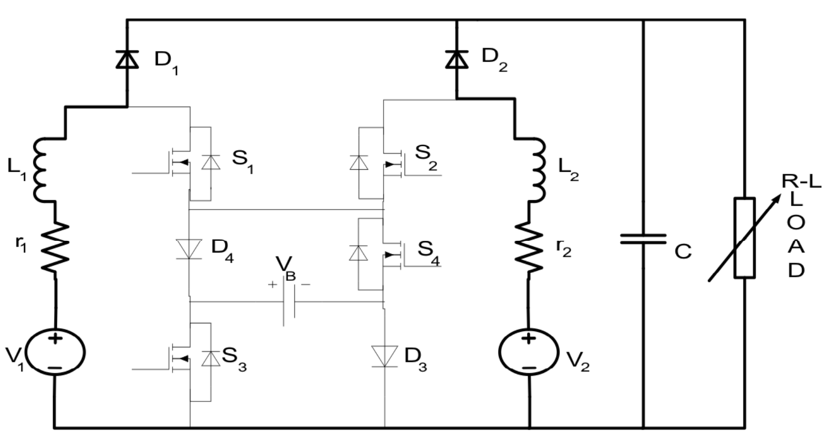

Figure 4(d): Second Operation Mode: Switching State 4

MODE 3 (V_1 and V_2 supply load with battery charging)

In this operating mode, the two input sources V_1 and V_2 supply the load and also provides power to the battery to charge this in the battery charging mode. The circuit topology shows the converter operates in this mode only when the switches S1 and S_2 are conducting. The switches S_3 and S_4 are turned off as the current path is through diode D_4, battery, D_3. Therefore, the battery is charged. In this paper, to regulate the charging power of the battery switch S_3 is controlled as when S_3 is ON the charging of the battery is not possible. As shown this mode has four switching states:

Switching state 1: At T = 0, Switches S_1, S_2, S_3 are turned ON, therefore, the inductors L_1 and L_2 are charged with voltages V_1 and V_2.

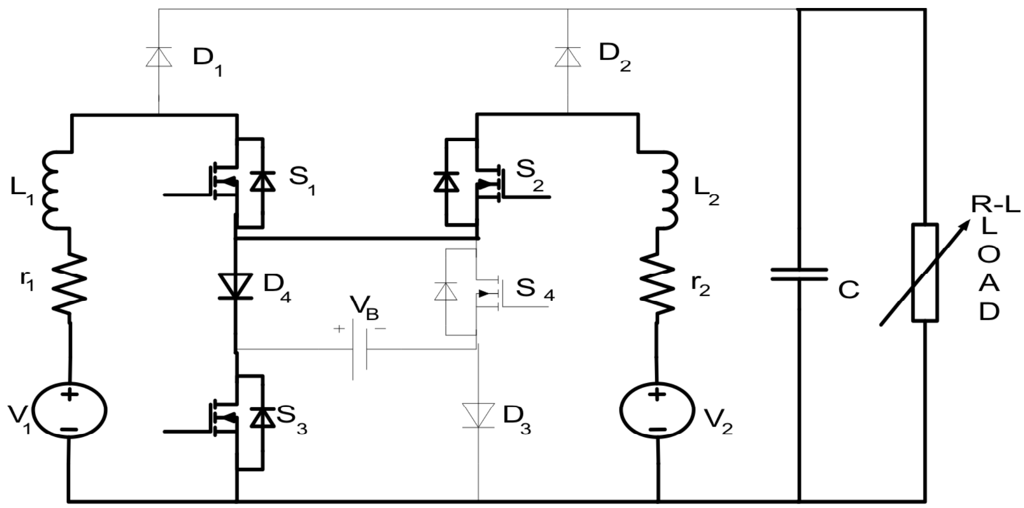

Figure 5(a): Third Operation Mode: Switching State 1

Switching state 2: At T =d_3T, Switches S_3 is turned OFF whereas S_1 and S_2 are ON, hence the inductors L_1 and L_2 are charged with V_1-V_b and V_2-V_b as Shown in fig 5 (b).

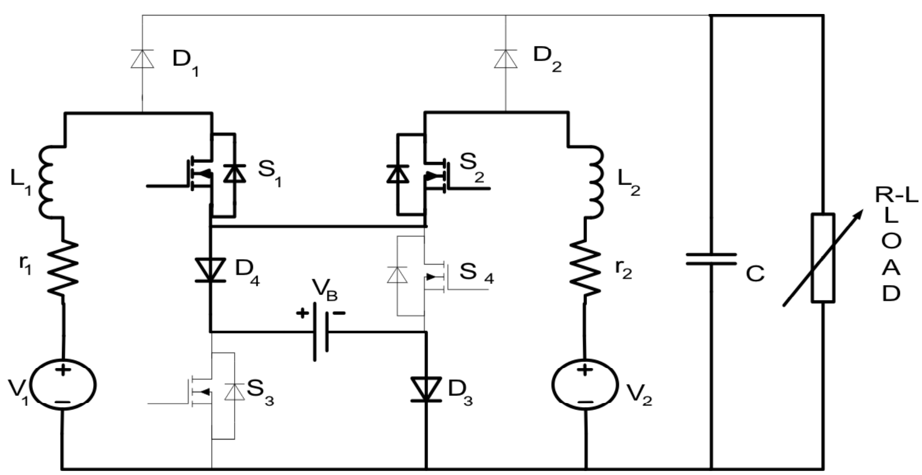

Figure 5(b): Third Operation Mode: Switching State 2

Switching State 3: At T=d_1T, switch S_2 is turned OFF hence the inductor L_1 is charged with voltage V_1-V_b while the inductor L_2 is discharged to the Load.

Switching State 4: At T=d_2T, switch S_1 is turned OFF. Hence, the inductor L_1 and L_2 both gets discharged to the load.

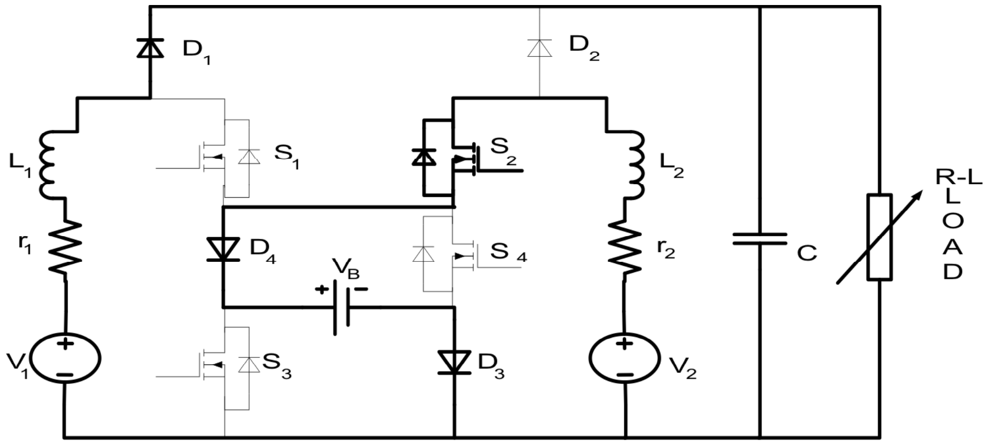

Figure 5(c): Third Operation Mode: Switching State 3

DETERMINATION OF MODES

The mode of operation is determined by the availability of the power from the input sources i. e. PV and wind system, the output voltage value and the battery charging necessity. The proper determination of the mode of operation is as:

MODE 1: This operation is triggered when the there is sufficient power available from the input sources PV and wind and no charging or discharging of the battery is required to supply the load.

MODE 2: This operating mode is triggered when there is a deficiency of power from the input sources. Therefore the battery discharges and supplies the load to maintain a constant output voltage.

MODE 3: This operating mode is triggered when the power of the battery is below a certain value, and there is a surplus of the energy from the input sources after supplying the load.

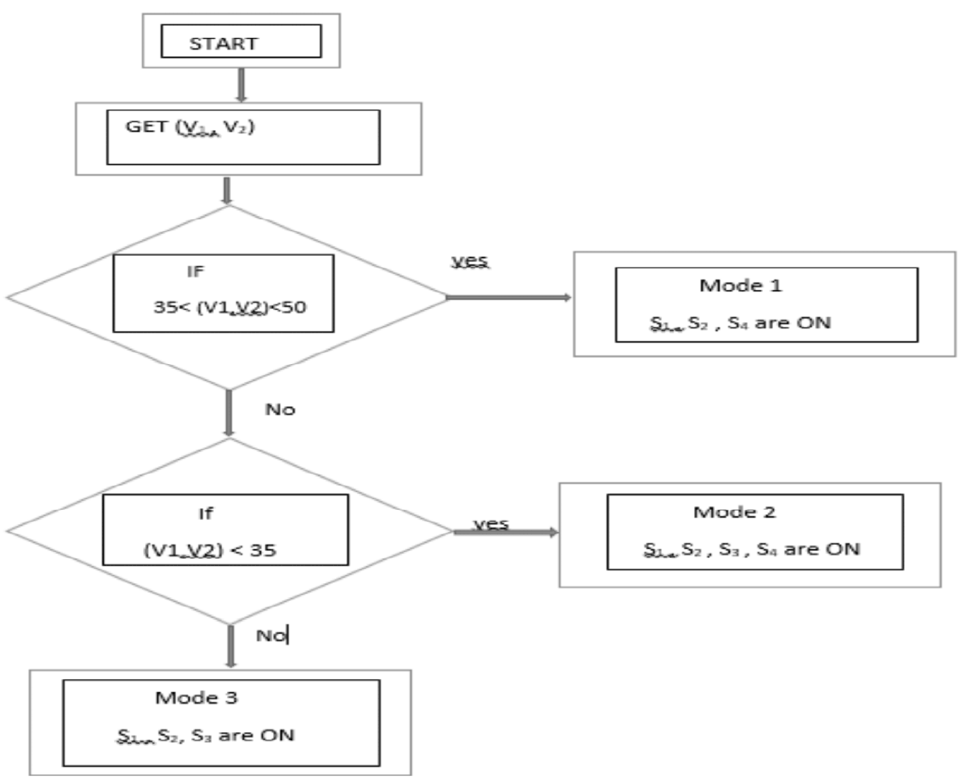

Figure 6: Determination of modes

SIMULATION

To verify the performance of the proposed converter the open loop simulation is done in all thethree modes independently and then integration of all the three modes have been done using the logic gates. An R-L load is being supplied an output voltage of V_O = 170 v and an output current of I_o = 3. 5 A. the simulation parameters are $r_1 = r_2$= 0. 1&Ω, L_1=L_2= 4mH, C = 200mF, fs=10 KHz. In this paper logic gates are used to decide the mode of operation. For the simulation, the V1 and V2 are assumed to be the PV and Wind systems for simplicity. There are four switches S_1, S_2, S_3, and S_4 these are the main component to control ofthe converter. Theswitching signal for each mode has been provided to the switches. In the simulation the mode of operation has been decided by the voltage provided by the input sources V_1 and V_2 and accordingly switching pattern is provided. The corresponding simulation results are shown.

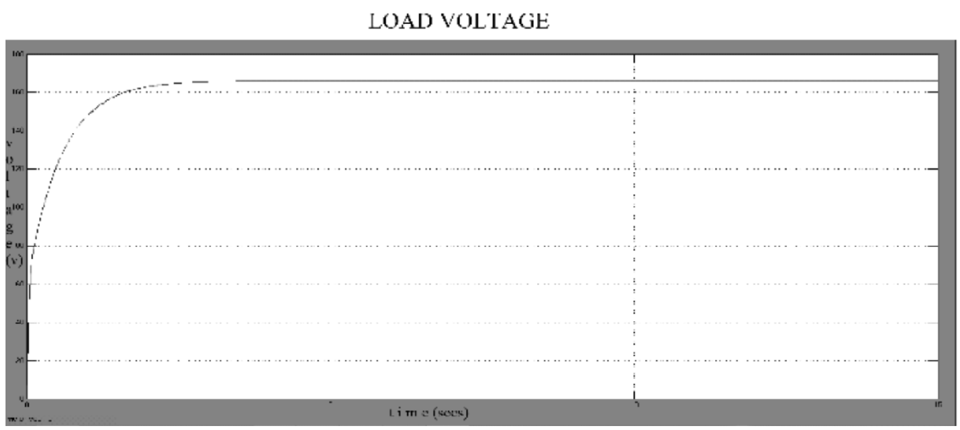

Figure 7: Output Load Voltage

Figure 8: Battery SOC for MODE 1

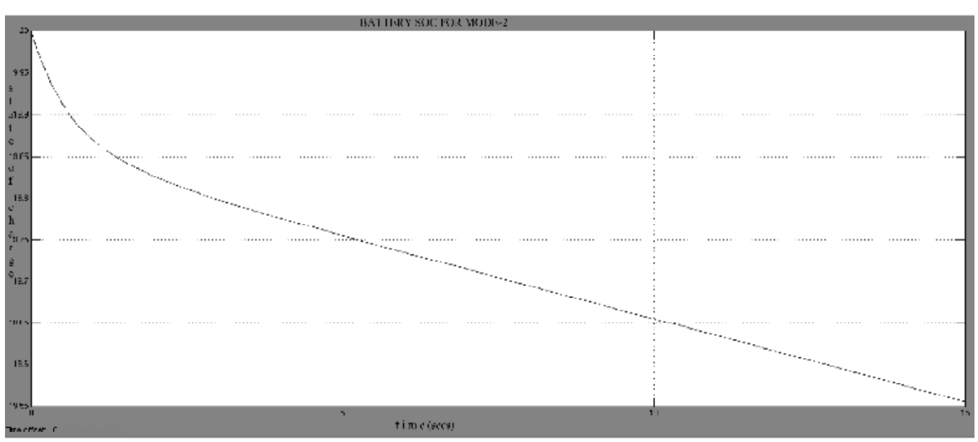

Figure 9: Battery SOC for MODE 2

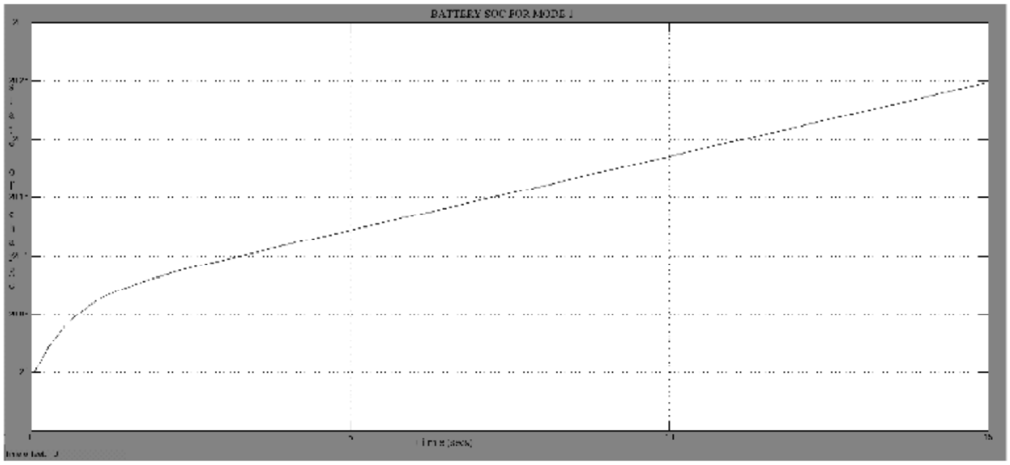

Figure 10: Battery SOC for MODE 3

CONCLUSION

This paper describes renewable energy hybrid Wind-PV with battery energy storage system. Four independent duty ratios of the converter facilitate power ûow among input sources and the load. A complete description of the hybrid system has been presented along with its detailed simulation results. The simulation results showed satisfactory performance of the hybrid system. The proposed system is a good alternative for the multiple-source hybrid power systems and hasmany advantages such as bidirectional power flow at the storage port,simple structure, low power components, centralized control, and no need of transformer, low weight and high level of boosting. On addition, the structure utilizes from power switches with four different duty ratios.

REFERENCES

[1] Y. Ch. Liu and Y. M. Chen, "A systematic approach to synthesizing multi-input DC–DC converters," *IEEE Trans. Power Electron*., vol. 24, no. 1, pp. 116–127, Jan. 2009.

[2] Y. M. Chen, Y. Ch. Liu, S. C. Hung, and C. S. Cheng, "Multi-input inverter for grid-connected hybrid PV/Wind power system," *IEEE Trans. Power Electron.* , vol. 22, no. 3, pp. 1070–1077, May 2007.

[3] K. Rajashekara, "Hybrid fuel-cell strategies for clean power generation,"*IEEE Trans. Ind. Appl.* , vol. 41, no. 3, pp, 682-689, May/ June 2005.

[4] P. Thounttthong, S. Rael, and B. Davat, "Control Strategy of fuel cell and supercapacitor association for a distributed generation system," *IEEE Trans. Ind. Electron.* , vol. 56, no. 6, pp, 3225-3233, Dec. 2007.

[5] Y. M. Chen, Y. Ch. Liu, and F. Y. Wu, "Multi-input DC/DC converter based on the multi-winding transformer for renewable energy applications," *IEEE Trans. Ind. Electron.* , vol. 38, no. 4, pp. 1096–1103, Jul. /Aug. 2002.

[6] L. Solero, A. Lidozzi, and J. A. Pomilio, "Design of multiple-input power converter for hybrid vehicles," IEEE Trans. Power Electron., vol. 20, no. 5, pp. 1007–1016, Sep. 2005.

[7] S. H. Hosseini, S. Danyali, F. Nejabatkhah, and S. A. K. Mozafari Niapour, "Multi-input DC boost converter for grid connected hybrid PV/FC/battery power system," in Proc. IEEE Elect. Power Energy Conf., 2010, pp. 1–6.