Open Loop Control of Multi Input Converter for Wind/Solar/Battery

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ABSTRACT

The multi-input dc/dc boost converter is proposed in this paper. The proposed converter uses two sources such as wind, photovoltaic(PV) and battery as a storage element for hybridizing alternative energy sources. This converter draws the power from two different sources depending upon climatic condition and deliver it to the dc load individually or simultaneously. The system is applicable for DC loads which requires 350V and 8A. Supplying the output load, charging or discharging the battery can be made by the PV and the wind power sources individually or simultaneously. The output voltage regulation and power flow control can be achieved by controlling the duty ratio of the four switches. This converter structure uses only four power switches that are independently controlled with four different duty ratios for controlling the whole operation of the converter. Depending on utilization state of the battery, three different power operation modes are defined for the converter either charging or discharging action to be taken place. Simulation has been carried out by using MATLAB SIMULINK software.

Keywords

dc–dc boost converter, photovoltaic/wind/battery hybrid power system

1. INTRODUCTION

Now a day's renewable energy play an important role in the electricity generation. Because of its pollution free ,noiseless, flexibility, little maintenance and robustness. Since one form of renewable energy source is from sun, due to sun irradiation level and ambient temperature and unpredictable shadows, this form of energy should be supplemented by other alternative energy sources to provide the power supply continuously. So wind energy as a promising supplementary power sources due to the merits of cleaness, high efficiency and reliability. So there should be a common interference to be provided to connect both in a common place to provide the power supply to the load continuously. So the use of the multi input boost converter plays a big role in the hybridization of alternative power sources from the natural means. But the main aim of the hybridisation of the renewable energy sources is to provide continous supply to the load without any interruption. But the real world problems, it may not be met. So there is a need for the bidirectional storage element which is nothing but a battery. Batteries are usually considered as the storage mechanism for smoothing output power at any instant and to meet out the peak power demand. By combining such energy sources such as PV/wind/battery hybrid power system, the peak power demand can be managed for the up going power cut problems. This may provide the big support to the government by which people can able to manage the power cut problems for the upcoming years. Thereby fuel usage may be reduced to meet the power demand. The usage of the battery, by which it has the bidirectional power flow capability is the key feature of the multiple input converter. Also input power sources should have the possibility of supplying the load, individually or simultaneously. These are all the important points for modeling of the multiple input boost converter. The many hybrid power system, multiple input converters have been proposed in the literature up to now. The traditional methods use the ac-coupled system. But they replace the complex circuit topology in a single power structure. The MIC introduced in[3] and [4] in which the concept of pulsating voltage source cells are used for driving the MIC. This type of MIC is used to hybridize PV and wind power source in a simple unified structure. But the drawback is the use of number of converter stage increase the power switches and leads to complexity. Another MIC proposed in[5] has the only one power source is allowed to transfer energy to the load at a time and other power source in some other time. So they proposed the converter topology by which best topology is selected for the MIC for hybridizing the buck and buck-boost topology which is given importance and has the limitation that more than four switches used in the circuit becomes unfeasible for the operation. So they provide the better result by using MIC in the different structures. H.Tao et al presented in[6] multiport converters using dc link and the magnetic coupling using half bridge boost converter. The key features of this type of converter is the compact and low cost. The same MIC with two half bridge boost converter[7] is proposed later. Without the use of the transformer for coupling, only passive elements with high value of inductor is used for boosting the input source voltage to meet the load demand which is provided by single source or two source is made possible. But the completion of the circuits is done only when the bidirectional storage element nothing but battery is inserted into the circuit topology. The existing MIC converters uses the two sources such as PV and fuel cell whereas, battery act as the bidirectional storage port. By using this MIC, the PV and fuel cell able to supply power to load indiviudualy or simultaneously. Since PV is uncommon in the night times, the battery backup will come into act at that time. Fuel cell depends upon the hydrogen as the input, but the initial cost of the fuel cell is high. Also for the entire life time, it requires hydrogen as the input, but the initial cost of the fuel cell is high.

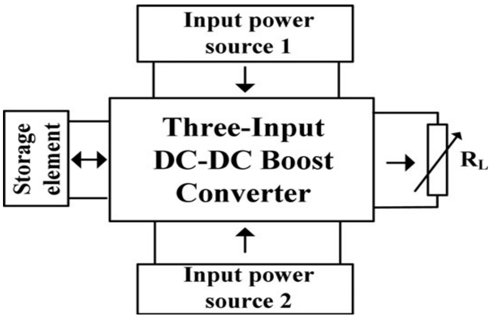

Figure.1. Proposed system overview

Also for the entire life time, it requires hydrogen as fuel. So they lead to high cost for power production. So in the proposed system which is shown in figure1, fuel cell is replaced by the wind energy. Though initial cost of installation is high, one time investment is required but it does not depend on fuel. As an interesting application of the proposed converter, the input ports are mainly considered to interface a PV source and wind, and a battery as the storage element. In this application, achieving the maximum power of the PV source, setting power of the wind energy, charging or discharging the battery, and also regulating the output voltage are realized by utilizing the converter duty ratios.

This paper is organized as follows. The simulation and experimental verifications are explained in Section 2. Section 3 concludes this paper.

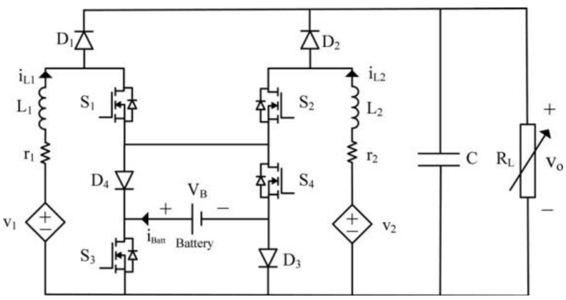

Figure. 2. Circuit topology of the proposed system

2. SIMULATION AND EXPERIMENTAL VERIFICATIONS

The maximum generation capacity of solar panel is 2.5KW.The load requires the current of 8.5A and whereas the voltage required for the load is 350V.The maximum Ah rating of the battery used is 8Ah. Since the output load requires 8Ah of current, the battery Ah rating is considered to be 8A of current is produced for one hour. The wind turbine is used to generate the power from the wind. The startup wind speed that is standstill to start is 2.2m/s. It will not produce power at that mode but starts rotating. The cut in wind speed is 4.6 to 6m/s. It is the speed at which machine starts to produce power. It may be 5% to 7% of the capacity of wind turbine and generator. When the velocity of the wind is 12-14m/s wind turbine produces peak power of its capacity cutout wind speed is 24-28m/s that is at which machine stop itself from generating power. By using this output voltage applied to boost converter. The structure of three input dc-dc boost converter is represented in the figure.2. From the figure.2, it is clearly known that there are two input power source V1 and V2. There is a battery which act as a storage element. The main area applicable this type of converter is for hybrid power system. Therefore we hybridize PV and wind source. If one of the source is from PV, then its character depends upon the solar radiation, light intensity and temperature. So PV act as the first source V1 and its current is given by iL1. It consist of two inductors L1 and L2 which is used to draw the smooth current from the input sources. There are four switches S1,S2,S3 and S4. These are the main components and control for this converter. So the power flow can be controlled in the system by controlling the four switches. Here R_L is the load resistance which is a DC load. In this structure, switches and diode works complementary manner. Note that if switch S3 and S4 are turned on, then their corresponding diode D3 and D4 are reverse biased by the voltage of the battery and it remain in blocked condition. In contrary, if the diodes D3 and D4 conducts then their switches S3 and S4 are turned to off, these process of the converter works to be in continous current mode. By adjusting the input power to a certain current ripple, so that output power can be maintained to a desired value. Based on the usage of the battery, three power operating modes of the battery are designed. So that the working of the converter designed to operate in three mode based on the battery usage. Assumption is made that all switch has the saw tooth waveform and duty ratio, d4 is less than d1 and d2 in the charging condition of the battery or discharging condition of the battery.

2.1. First Power Operation Mode (Supplying The Load With Sources V1 And V2 Without Battery Existence)

In this mode two power sources V1 and V2 are supplying power to the load without any work of battery. So the battery is not charging or discharging action takes place. To work in this mode, the switches are turned on based on the switching state. This is done by turning on the switch S1 and S2 such that other two switches S3 and S4 are turned off. The duty ratio of switch S1 and S2 is set as 0.79 and 0.71. So they may take the two path in order to avoid the working of the battery so to stop the working of battery, the duty ratio of switch d3 is set to zero and switches duty ratio d4 is set to one. Therefore different switching states of the converter is obtained in one switching period. Then consider only two such V1 and V2 are supplying power to the load. Now battery remains idle state. So the battery is not used in this mode of operation. The output voltage required for the load is 350V and 7.14A . After setting the duty ratio for the switches, depending upon the solar radiation the voltage generated from the solar panel is 45.1V and 6.4A where as the voltage and current produced by wind turbine is 7A and 52V. The sun radiation in this stage is 700w/m^2 and their corresponding voltage and current is shown in the figure.3 and figure.4 respectively.

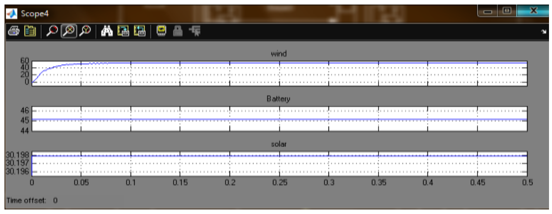

Figure. 3. Input voltage from wind, solar and battery

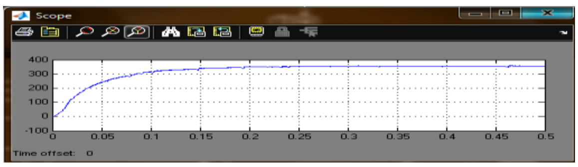

Figure. 4. Output load voltage for first operating mode

The discharging of battery takes place since the radiation of the sun is very low. Since there is a need of the continous power supply to the load this discharging of battery is very important. When switch S2 and S4 are turned on simultaneously, then current iL1 and iL2 are conducted through the path Switch S4, battery and S3. So that they are in discharging state of the battery. This discharging operation of the battery takes place until switches S1 or S2 are conducting. Therefore power of the battery depends on the duty ratio d1 and d2 and also the current iL1 and iL2. By using the two input sources they can be made to operate in this mode effectively. The sun radiation in this stage is

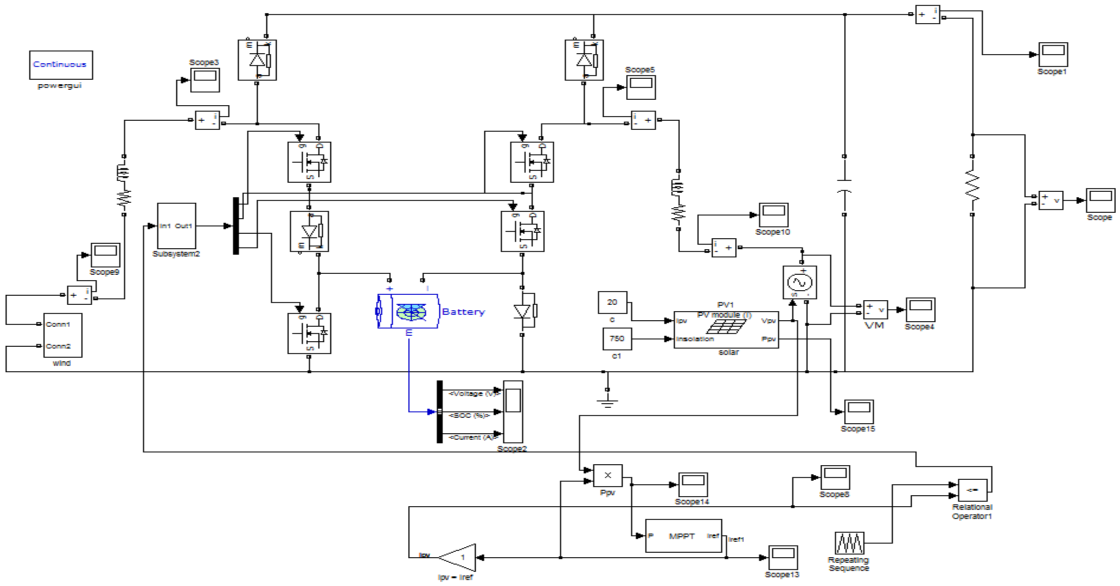

Figure. 5. Simulation Diagram

2.2. Second Power Operation Mode (Supplying The Load With Sources V1 And V2 And The Battery)

In this operating mode, along with the two source V1 and V2, battery also takes part in their working for supplying load. So this state is considered to be the discharging state of the battery. When switch S2 and S4 are turned on simultaneously, then current iL1 and iL2 are conducted through the path Switch S4, battery and S3. The maximum discharging power of the battery takes place with proper current and voltage values. So the discharging state of the battery mainly depends on the two switches S3 and S4, so that they can be decided by their duty ratio of d3 and d4. By designing this state, duty ratio d3 and d4 are kept in mind in order to regulate the working of discharging state. The duty ratio of S1 and S2 is 0.73 and 0.78. The other values of the duty ratio are 0.45 and one. After setting the duty ratio for the switches, depending upon the solar radiation the voltage generated from the solar this stage is 320W/m^2. The working of the battery takes place until switches S1 or S2 are conducting. Therefore power of the battery depends on the duty ratio d1 and d2 and also the current iL1 and iL2. By discharging the two input sources in the proper way the maximum discharging power of the battery takes place with proper current and voltage values and its output voltages are shown in figure.7 and 8. The design of the wind generator is explained in this figure.9

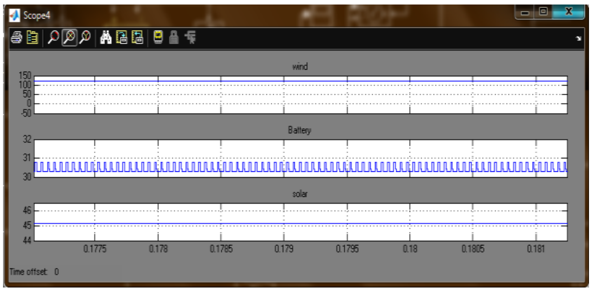

Figure. 6. Input voltage from wind, solar and battery

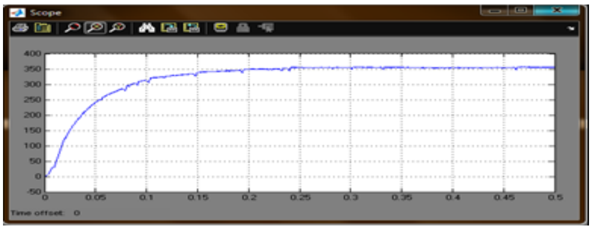

Figure. 7. Output load voltage for second operating mode

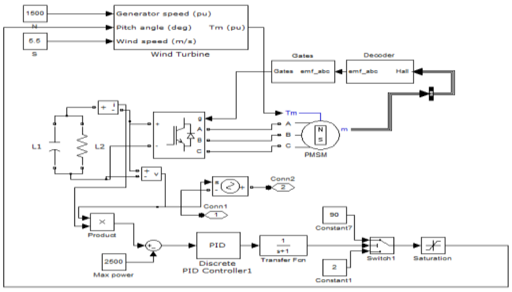

Figure. 8. Wind subsystem

2.3. Third Power Operation Mode (Supplying The Load With Sources V1 And V2 And The Battery)

In this operation mode, two input power sources V1 and V2 are responsible for supplying the load also battery is in charging is considered in this mode. So this state is considered to be in charging state. By considering the converter topology, the switches S3 and S4 are turned off, while the switches S1 and S2 are on. The current iL1 and iL2 are conducted by the path of diode D4, the battery and diode D3, but the battery is charged through the conducted switches. The charging action takes place when switches S1 and S2 are conducting. The maximum charging power of the battery depends on the duty ratios d1 and d2. Therefore, in order to acquire a desired maximum charge power of the battery, the input power sources should be designed in proper current and voltage values. By designing this state, duty ratio d3 and d4 are kept in mind in order to regulate the working of charging state.

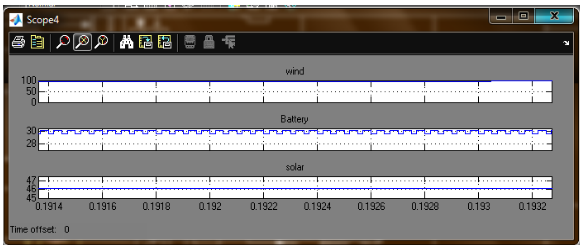

Figure. 10. Input voltage from wind, solar and battery

By setting the duty ratio for the switches, depending upon the solar radiation the voltage generated from the solar panel is 48V and 8.2A where as the voltage and current produced by wind turbine is 8A and 51V. The sun radiation in this stage is 1000W/m^2. Therefore battery remains in charging the battery from solar panel which is shown in figure.10 and figure 11.

Figure. 11. Output load voltage for third operating mode

3. CONCLUSION

A three-input dc–dc boost converter with unified structure for hybrid power systems is proposed in this paper. The proposed converter is applied to hybridize a PV, wind and a battery. The proposed converter has the merits of making use of low-voltage batteries, working in stable operating points in addition to the advantages of bidirectional power flow at the storage port, simple structure, and low-power components. The voltage generated from solar and wind is 45V and 55V which is given to boost converter which is boosted to 360V.By this way of hybridizing the multiple input sources using boost converter load voltage is obtained satisfactorily.

4. REFERENCES

[1] W. Jiang and B. Fahimi, "Active current sharing and source management in fuel cell-battery hybrid power system," *IEEE Trans. Ind. Electron.*,vol. 57, no. 2, pp. 752–761,Mar. 2008.

[2] R. J. Wai, Ch. Y. Lin, J. J. Liaw, and Y. R. Chang, "Newly designed ZVS multi-input converter," *IEEE Trans. Ind. Electron.*, vol. 58, no. 2, pp. 555–566, Feb. 2011.

[3] J. L. Duarte, M. Hendrix, and M. G. Simoes, "Three-port bidirectional converter for hybrid fuel cell systems," *IEEE Trans. Power Electron.*, vol. 22, no. 2, pp. 480–487,Mar. 2006.

[4] N. Kato, K. Kurozumi, N. Susuld, and S. Muroyama, "Hybrid powersupply system composed of photovoltaic and fuel-cell systems," in *Proc. Int. Telecommun. Energy Conf.*, 2001, pp. 631–635, Dec 2001.

[5] K. Rajashekara, "Hybrid fuel-cell strategies for clean power generation," *IEEE Trans. Ind. Appl.*, vol. 41, no. 3, pp. 682–689, May/June2005.

[6] P. Thounthong, 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.

[7] O. C. Onara,M. Uzunoglu, andM. S. Alam, "Modeling, controlandsimulationofanautonomouswindturbine/photovoltaic/fuelcell/ultracapacitorhybridpower system," *J. Power Sources.*, vol. 185, no. 2, pp. 1273–1283, Apr. 2008