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Modeling and Simulation of Multi Input Boost Converter for Renewable Energy Applications

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Abstract

In this paper a Multi Input DC-DC boost Converter (MIC) is proposed for renewable energy applications. This converter will give a regulated output voltage to the load. Input sources to the converter include Photovoltaic (PV) cell, Fuel cell, Wind source etc. This converter can deliver power to the load either simultaneously or individually based on the battery utilization. The complete MIC reduces size of the system as well as cost due to the less number of components. The performances of the proposed converter system are analyzed and simulated using PSIM software.

Key Words: *Multi Input Converter, PV cell, Boost converter, PSIM software*

1. Introduction

The invention of electricity is one of the greatest of its wonders. Indeed, we cannot even dream of living in absence of electricity in modern world. The economic growth of a country greatly depends on Electric Energy. Increasing demand of electricity and decaying nature of non-renewable energy needs alternate energy resources. Even more importantly, renewable energy produces little or no waste products such as carbon dioxide or other chemical pollutants, so has minimal impact on the environment. Renewable energy also has the advantage of allowing decentralized distribution of energy particularly for meeting rural energy needs. Out of all the renewable energy, solar energy becomes more popular because of its simple structure. Many researchers and scientists contribute towards the development of solar energy in order to increase the conversion efficiency, extracting maximum power. The converter used in solar energy systems plays significant role in energy conversion. These converters are classified in to two types viz multiple converter and multi input converter. A MIC [1] has the following advantages compared to a combination of several individual converters like cost reduction, compactness and more expandability. MICs are being used in aerospace, electric and hybrid vehicles, sustainable energy sources and micro grid applications.

In a power system the combination of more power sources make it possible to obtain higher availability. A parallel connection of converters has been used to integrate more than one input energy sources in a power system. The Multi-input DC–DC Converter proposed in [2] has the capability of operating in different Converter topologies (Buck, Boost, and Buck–Boost) in addition to its Bidirectional operation and positive output voltage without any additional transformer.

2. Boost Converter Topology

A DC-DC converter is an electronic switching device that converts fixed voltage to a variable voltage at the output side. Output voltage is generally fluctuating and this could be regulated by changing on time of the switch, pulse width and switching frequency. The fundamental for a boost converter consists of an inductor, diode, capacitor and switch. The DC input to a boost converter can be from many sources as well as batteries, such as rectified AC from the mains supply, or DC from solar panels, fuel cells, dynamos and DC generators.

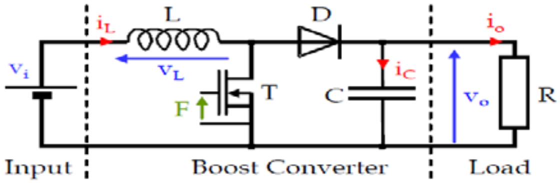

Fig. 1 Boost converter

The output voltage control is obtained by changing the control parameter duty cycle. It is nothing but the ratio of on time to total switching time of converter.

$$\text{Duty cycle } D = \frac{T_{on}}{T}$$

Where

V_i = Input voltage V_o = Output voltage

T_{on} = Switch on time T = Total time

3. Proposed DC-DC Converter

A multi input converter combines several input power sources whose voltage levels and/or power capacity are different and to get regulated output voltage for the load from them. This converter can control power flow between sources with each other and load. A single Multi-Input DC-DC Converter [3] replaces several numbers of parallel connected single converters. Source 1 to Source N can be composed of any kind of energy source combinations, such as wind turbines, PV modules, Fuel Cell and Source N could be a storage unit, such as a battery, ultra capacitor, flywheel or superconducting magnetic energy storage system.

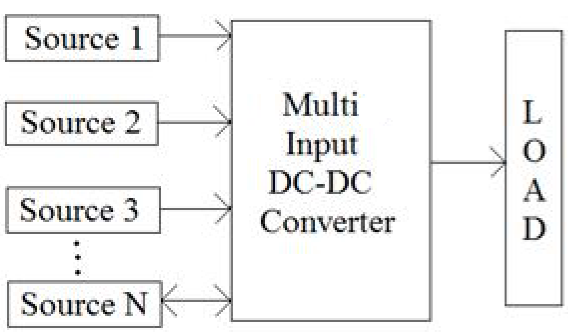

Fig. 2 Multi Input DC-DC Converter

3.1 Modeling of Boost Converter

The modeling of power electronic circuit needs the application of Kirchhoff's laws. Also the electrical and semiconductor devices are represented as ideal components. It is the process of model each individual component connected to the converter. In boost converter, inductor stores the input energy when switch in ON. With a switching period of T and for a continuous conduction, the equations are,

During switch ON

$$\begin{cases} \dfrac{di_L}{dt} = \dfrac{1}{L}(V_{in}) \\ \dfrac{dv_o}{dt} = \dfrac{1}{C}(-\dfrac{v_o}{R}) \end{cases}, \quad 0 < t < dT, \quad Q:ON$$

During switch OFF

$$\begin{cases} \dfrac{di_L}{dt} = \dfrac{1}{L}(V_{in} - v_o) \\ \dfrac{dv_o}{dt} = \dfrac{1}{C}(i_L - \dfrac{v_o}{R}) \end{cases}, \quad dT < t < T, \quad Q:OFF$$

3.2 Modeling of Proposed Converter

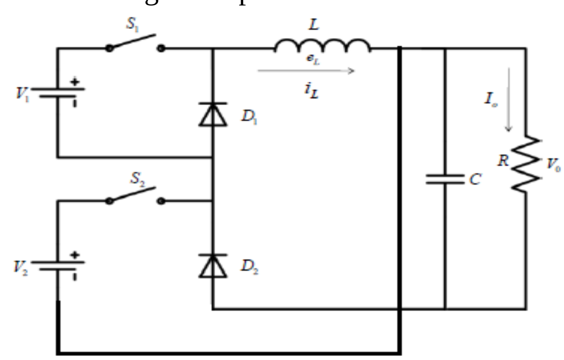

Fig. 3 Circuit of Two input Converter

Figure 3 shows the two input DC-DC converter. The operating principle of the system is described below. It has four operating states

State I: (S_1- ON, S_2- OFF)

In this state switch S_1 is ON, the input source V_1 supplies power to the load through the inductor L.

State II: (S_1-OFF, S_2-ON)

In this state switch S_2 is ON, the input source V_2 supplies power to the load.

State III: (S_1-OFF, S_2-OFF)

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In this state both the switches are OFF, the load receives power from the inductor and capacitor due to the stored energy.

State IV: (S_1-ON, S_2-ON)

In this state both the switches are ON simultaneously, and supplies power to the load also charging the inductor. The output voltage V_o is given by the following equation,

$$V_o = \frac{D_1}{1-D_2} V_1 + \frac{D_2}{1-D_2} V_2$$

4. MIC Input Sources

The input sources for Multi Input Converter are considered as Solar and Wind energy systems.

4.1 Solar Cell design

A solar cell basically is a p-n semiconductor junction. When exposed to light, a dc current is generated. The generated current varies linearly with the solar irradiance. The standard equivalent circuit of the PV cell is shown in Fig. 4.

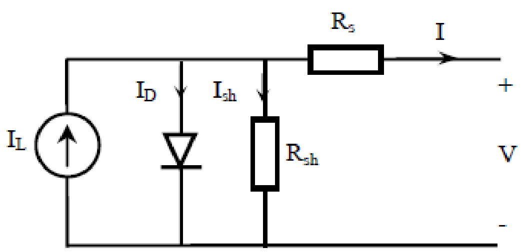

Fig. 4 Equivalent Circuit of Solar cell

The basic equation that describes the (I-V) characteristics of the PV model is given by the following equation:

$$I = I_L - I_o\left(e^{\frac{q(V+IR_s)}{kT}} - 1\right) - \frac{V + IR_s}{R_{sh}}$$

In this paper a solar cell physical model is used and the following are the cell parameters with the I-V, P-V curves.

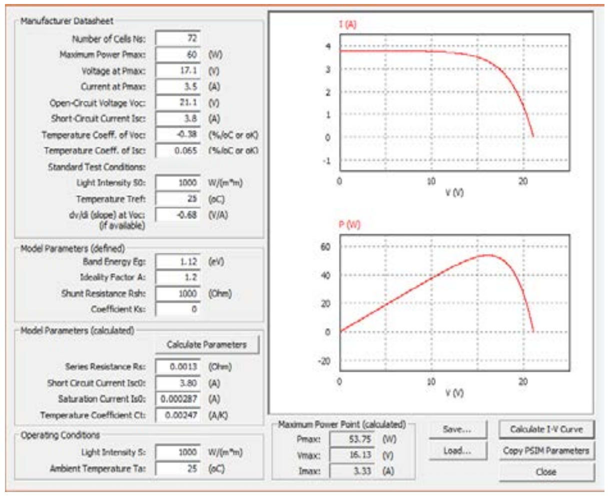

Fig. 5 I-V and P-V curves of Solar cell

4.2 Wind Energy

In wind energy system, power comes from the kinetic energy of the system thus it can be expressed as the kinetic power available in the stream of air multiplied by a C_P factor called power coefficient. C_P mainly depends on the relation between the average speed of the air across the area covered by the wind wheel and its angular speed and geometric characteristics of the turbine. The power extracted by the wind turbine has the following expression

$$P_{ww} = c_P P_{\text{wind}} = c_P \frac{1}{2} \rho A v_w^3,$$

Where P_{wind} is kinetic power of the air stream that crosses the turbine rotor area, ρ is the air density assumed to be constant, A is the surface covered by the turbine and V_w is the average wind speed. The following are the parameters of wind turbine and the curve of the power coefficient versus the tip speed ratio of the wind turbine.

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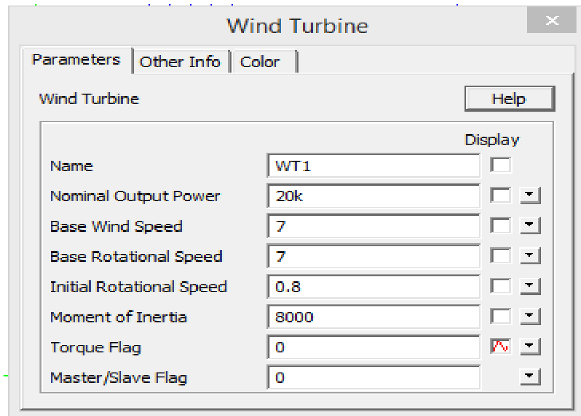

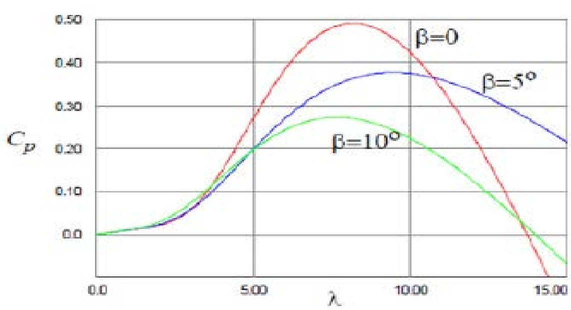

Fig. 6 Power Co-efficient curves

5. Simulation

The MIC is simulated using PSIM. PSIM is simulation software specifically designed for power electronics and motor drives. With fast simulation and friendly user interface, PSIM provides a powerful simulation environment for power electronics, analog and digital control, magnetics, and motor drive system studies. Powersim develops and markets leading simulation and design tools for research and product development in power supplies, motor drives and power conversion and control systems. Fig.7 shows the complete simulation diagram using PSIM.

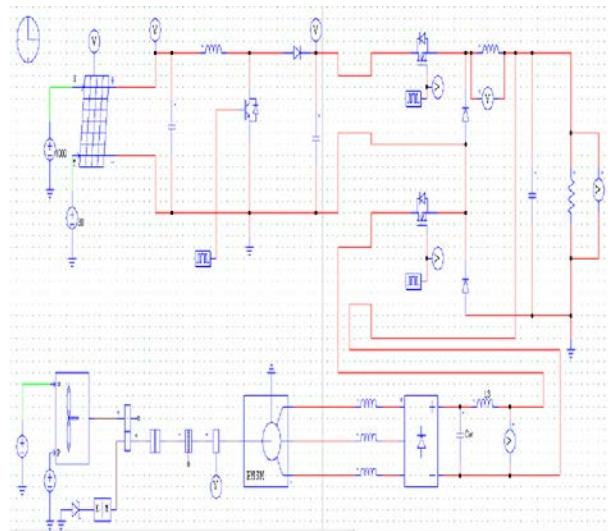

Fig. 7 Simulation Diagram

The following results were obtained from the simulation. The output of solar cell is given to the boost converter in order to obtain a voltage of 150V.

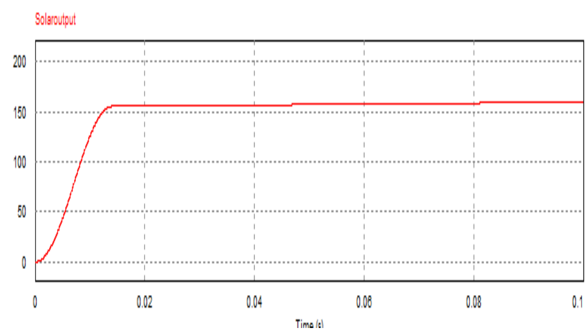

Fig. 8 Solar Output (150V)

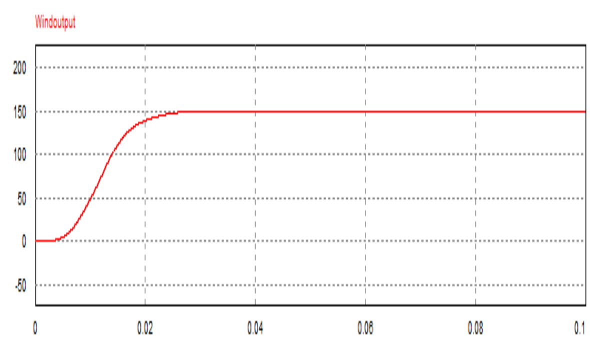

Fig. 9 Wind Output (150V)

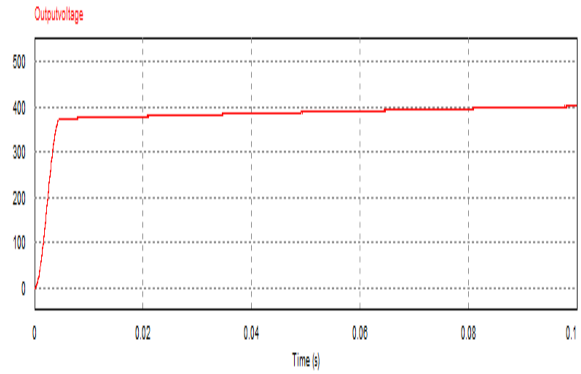

Fig. 10 MIC Output Voltage (400V)

6. Conclusion

The proposed Multi Input Converter is simulated in this paper. The input to the MIC can act individually or simultaneously. Based on the input the converter produces output. 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 has many advantages such as bidirectional power flow, low power components, simple structure, no need of transformer, low weight and also delivers constant and stepped up dc voltage to the load.

References

[1] Li, Z., Onar, O., Khaligh, A and Schaltz, E, 2009,'Design and Control of a Multiple Input DC/DC Converter for Battery/Ultracapacitor Based Electric Vehicle Power System', proceedings on twenty-fourth conference on Applied Power Electronics And Exposition, pp. 591-596.

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

[3] Wai, R.J., Lin, C.Y., Liaw, J.J and Chang, Y.R, 2011,'Newly designed ZVS multi-input converter', IEEE Transactions on Industrial Electronics, Vol. 58, No. 2, pp. 555–566.

[4] Chen, Y.M., Liu, Y.C., Hung, S.C and Cheng, C.S, 2007,'Multiinputinverter for grid-connected hybrid PV/Wind power system', IEEE Transactions on Power Electronics, Vol. 22, No. 3, pp. 1070–1077.

[5] Matsuo, H., Lin, W., Kurokawa, F., Shigemizu, T and Watanabe, N, 2004,'Characteristics of the multiple-input DC–DC converter', IEEE Transactions on Industrial Electronics, Vol. 51, No. 3, pp. 625–631.

[6] Ou, T.C., Lin, W.M and Huang, C.H, 2009,'A Multi-Input Power Converter for Hybrid Renewable Energy Generation System', In Proceedings of IEEE Conference on Sustainable Alternative Energy, pp. 1-7.

[7] Solero, L., Lidozzi, A and Pomilio, J.A, 2005,'Design of multiple-input power converter for hybrid vehicles', IEEE Transactions on Power Electronics, Vol. 20, No. 5, pp. 1007– 1016.

[8] Yan, L., Xinbo, R., Dongsheng, Y., Fuxin, L and Tse, C.K, 2010,'Synthesis of multiple-input DC/DC converters', IEEE Transactions on Power Electronics, Vol. 25, No. 9, pp. 2372– 2385.

[9] Kwasinski R.(2010) 'Identification of feasible topologies for multiple input DC–DC converters', IEEE Transactions on Power Electronics, vol. 24, no. 3, pp. 856– 861.

[10] Duarte J. L, Hendrix M. and Simoes M. G.(2009) 'Three-port bidirectional converter for hybrid fuel cell systems',IEEE Transactions on Power Electronics ,vol. 22, no. 2, pp. 480–487.

[11] 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

[12] M. H. Rashid, Power Electronics: Circuits, Devices and Applications, 3rd edition, Pearson, 2004

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