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Model Of Multiple Input Boost Converter For Renewable Energy System Using Matlab/Simulink

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Abstract— The Multi input dc–dc boost converter is used for hybridizing alternative energy sources such as photovoltaic(PV),fuel-cell(FC) for generation and battery for storage purpose is designed and simulated with a minimum number of switches and also easy control circuit. The system is applicable for DC loads. Control strategy has been considered to achieve permanent power supply to the load via the photovoltaic/battery or the fuel cell based on the power available from the sun. Supplying the output load, charging or discharging the battery can be made by the PV and the FC power sources individually or simultaneously. 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. MATLAB SIMULINK has been used for the simulation work. A sensitivity analysis is conducted with a load level of 100W based on the availability of solar radiation.

Index Terms— Fuel Cell (FC), Multiple input Converter (MIC), Photovoltaic (PV).

1 Introduction

With increasing concern of global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solutions to preserve the earth for the future generations. Other than hydro power, wind and photovoltaic energy holds the most potential to meet our energy demands. The common inherent drawback of wind and photovoltaic systems are their intermittent natures that make them unreliable. So, the number of applications which need more than one power source is increasing. Distributed generating systems or micro-grid systems normally use more than one power source or more than one kind of energy source. Also, to increase the utilization of renewable energy sources, diversified energy source combination is recommended. For example, a wind-photovoltaic generating system, a combination of a wind generator and photovoltaic array, can give a greater degree of freedom when choosing the install location. The combination of more power sources and diversified power sources makes it possible to obtain higher availability in a power system. A parallel connection of converters has been used to integrate more than one energy source in a power system

The converter used for this type of applications is divided into multiple converter and multiple input converter.Multiple input converter has the following disadvantages,more number of switches,complex contol circuit,high cost.Multiple input converter is a device that is used to integrate more than one source. A multiple-input converter (MIC) can generally have the following advantages compare to a combination of several individual converters. They are cost reduction, compactness, more expandability and greater manageability.Three port bidirectional converter advantages is magnetically coupled, multiple-port topology aiming at UPS applications [1]. The main drawback is it cannot handle wide variety of voltage range input. Also, there is a need for improving transients, dynamic character and peak power capacity[1].Multi-input converter for grid connected PV /Wind[2-6] has to control the multi-input inverter properly, the central control unit, DSP, need to sense the input voltages, input currents, dc bus voltage, output voltage and output current continuously. Therefore extra sensor is needed to realize these protection functions which is costly.Newly designed ZVS multi input converter has high switching losses and more number of switches[7].

In order to overcome the drawbacks of above said converters , Farzam Nejabatkhah[8] has proposed a converter in which it has the following advantages,only four switches and simple control circuit.

The paper is organized in the following sequence; proposed converter working is described in section1,the simulation results are described in section3.

2 Converter Operation

The converter structure shows that when switches $S3$ and $S4$ are turned ON, their corresponding diodes$D3$ and$D4$ are reverse biased by the battery voltage and then blocked. On the other hand, turn-OFF state of these switches makes diodes $D3$ and $D4$ able to conduct input currents iL 1 and iL 2. In hybrid power system applications, the input power sources should be exploited in continuous current mode (CCM). For example, in the PV or FC systems, an important goal is to reach an acceptable current ripple in order to set their output power on desired value. Therefore, the current ripple of the input sources should be minimized to make an exact power balance among the input powers and the load. Therefore, in this paper, steady state and dynamic behavior of the converter have been investigated in CCM In general, depending on utilization state of the battery, three power operation modes are defined to the proposed converter. These modes of operation are investigated with the assumptions of utilizing the same saw tooth carrier waveform for all the switches, and $d3$, $d4$

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<min ($d1$,$d2$) in battery charge or discharge mode. Although exceeding duty ratios $d3$ and $d4$ from $d1$ or $d2$ does not cause converter malfunction, it results in setting the battery power on the possible maximum values. In order to simplify the investigations, it is assumed that duty ratio $d1$ is less than duty ratio $d2$. Further, with the assumption of ideal switches, the steady-state equations are obtained in each operation mode.

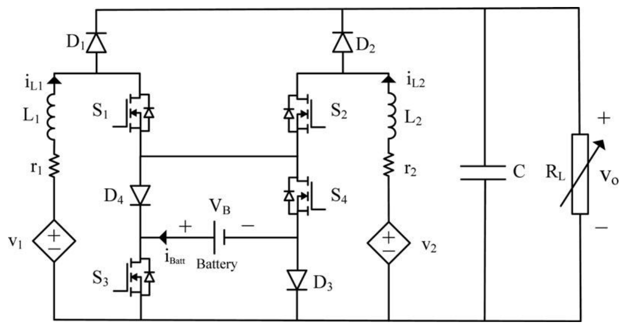

Fig. 2.1Muli input Converter Farzam Nejabatkhah [8]

3 SIMULATION RESULTS

Multiple input boost converter is modelled using the blocks of MATLAB Simulink and the results are presented in this section.

3.1 First Simulation Stage

In this stage, the requirement of load power *PL* is 100W while the maximum available PVpower is 140W and the maximum available FC power is 150W.Thesun irradiation level is G = 750W/m^2. There is no need to charge the battery. First, second, third and fourth duty ratios are set as d1=0.7, d2=0.75,d3=0 and d4=1. By setting $d3 = 0$ and $d4 = 1$, which result the battery power to be set on zero value. The FC current is regulated by d1, which shows iL1 =0.85A. The PVcurrent is regulated by d2, which shows iL2 =0.45A. The results are shown in the figure3.1, 3.2,3.3,3.4,3.5 and figure3.6.The required load voltage is maintained for its entire operating time.

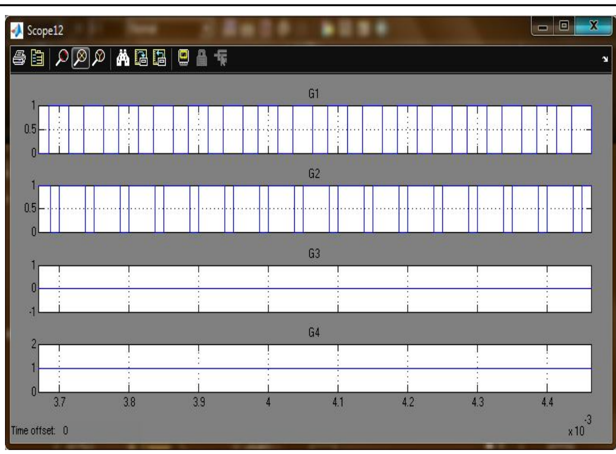

Fig. 3.1 Gate Pulse For Four Switches G1,G2,G3 And G4 Vs time

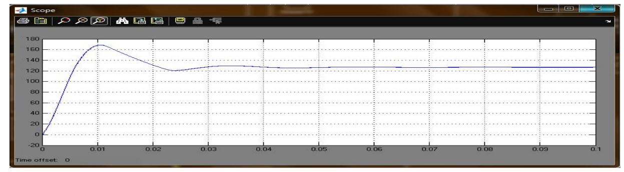

Fig. 3.2 Output Voltage Vs Time At Load Side For First Operating Mode

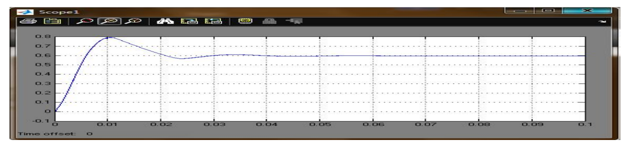

Fig. 3.3 Output Current Vs Time At Load Side For First Operating Mode

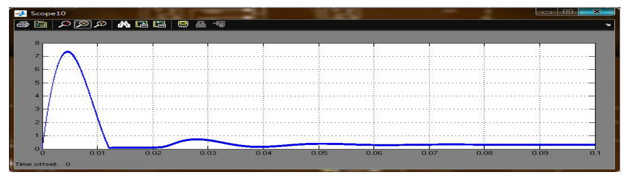

Fig. 3.4 Solar Panel Output Current Vs Time For First Operating Mode

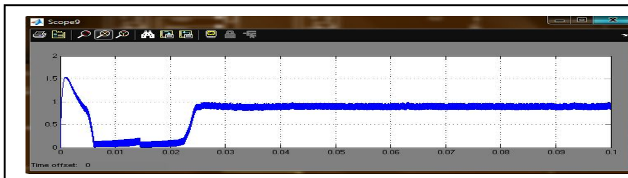

Fig. 3.5 Fuel Cell Current Vs Time Output For First Operating Mode

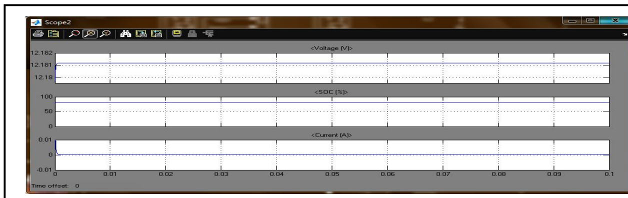

Fig. 3.6 Battery Output Voltage , Current Value Vs Time For First Operating Mode

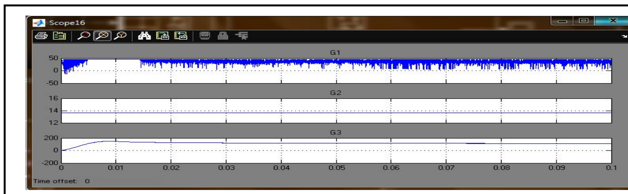

Fig. 3.7 Comparison Of Voltages Of Solarcell, Fuelcell And Load Vs Time

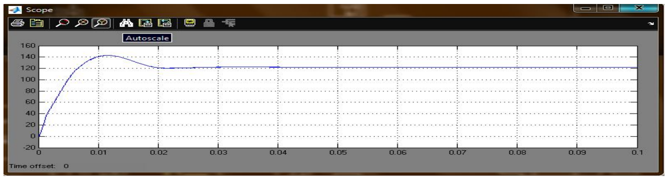

Fig. 3.8 Load Output Voltage Vs Time For Second Operating Mode

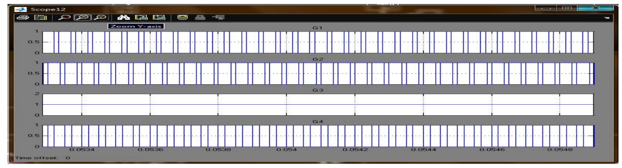

Fig. 3.9 Gate Pulse For Four Switches G1,G2,G3 And G4 Vs Time

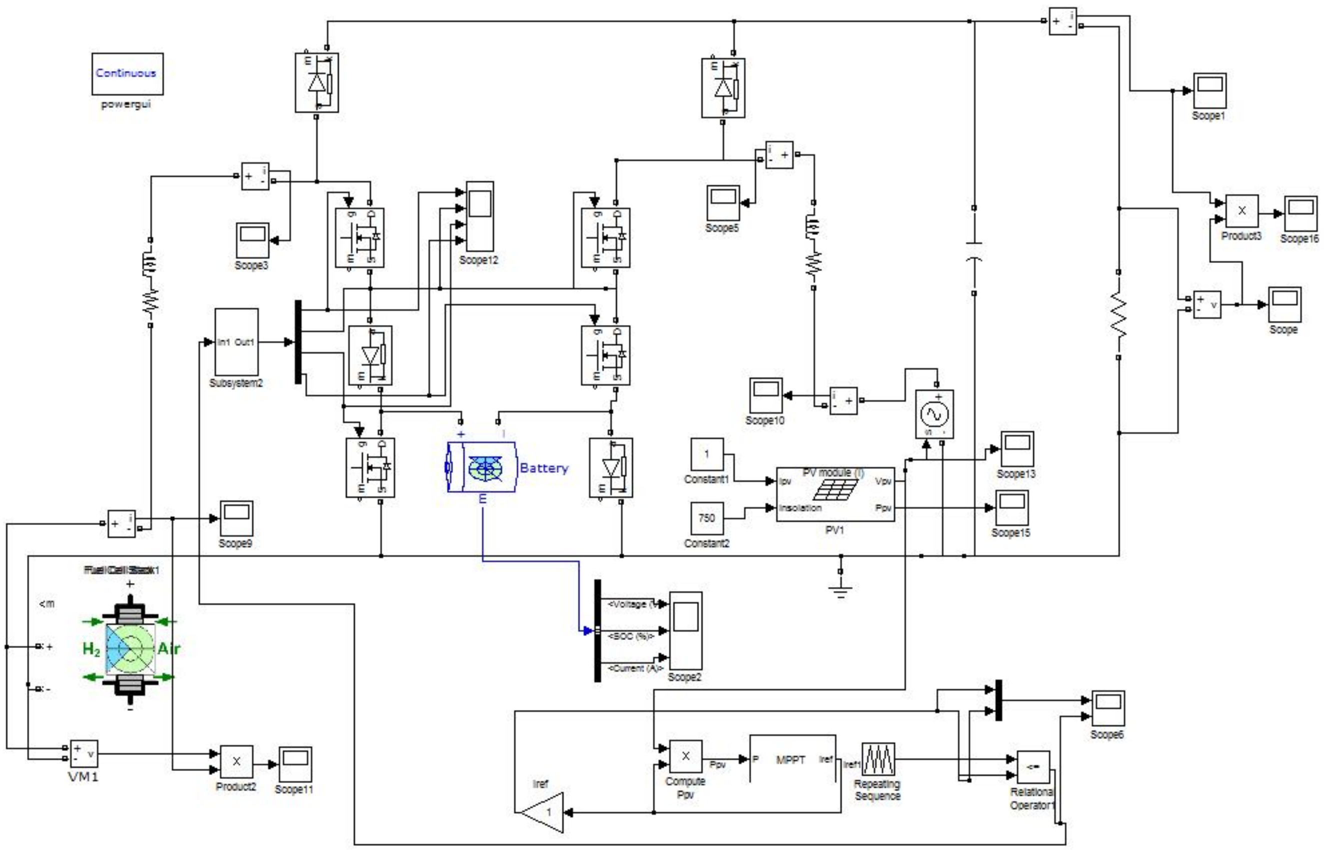

Fig. 3.10 Simulation Diagram

3.2 Second Simulation Stage

In this stage, the sun irradiation level increase to *G* =1000W/m2, while the load power remains constant at *PL* = 100W. In addition, in this stage, the battery charging is assumed to be performed, so the third operation mode is chosen for the converter. In this condition, battery remains in charging due to increase in sun irradiation level. As shown in Figure, the battery has been charged. The FC current is regulated on *iL*1 = 8.85 to 0.9A with duty ratio *d* = 0.73, while the maximum power of the PV source is tracked with regulating the PV current at *iL*2 =0.3A and adjusting the first duty ratio at *d*1 = 0.79. Moreover, controlling the third and fourth duty ratios at *d*3 = 0.45 and *d*4 = 0, respectively, results in providing the charging power of the battery in addition to regulating the output voltage which are-shown in figure3.8,3.9,3.10,3.11,3.12 and 3.13.

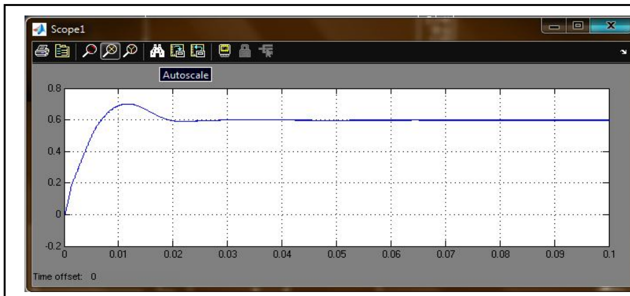

Fig. 3.11 Load current Vs Time for second operating mode

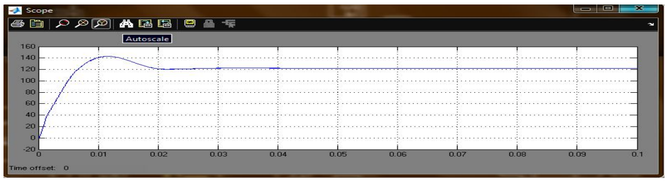

Fig. 3.12 Solar Panel Current Vs Time For Second Operating Mode

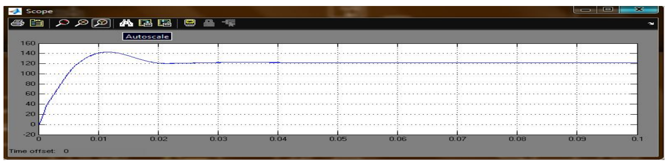

Fig. 3.13 Fuel Cell Current Vs Time For Second Operating Mode

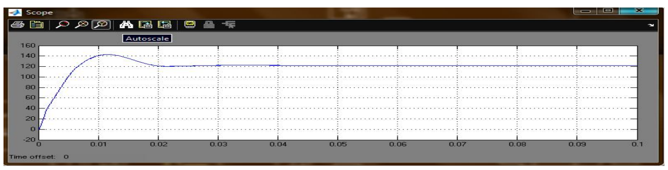

Fig. 3.14 Battery Charging Voltage,Current, SOC VsTime

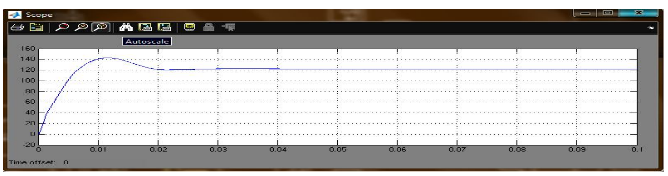

Fig. 3.15 Comparison Of Voltages Of Solarcell, Fuelcell And Load Vs Time

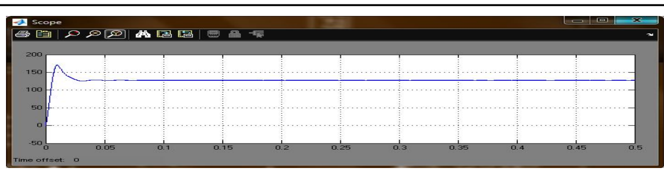

Fig. 3.16 Load Voltage Vs Time For Third Operating Mode

3.3 Third Simulation Stage

This stage occurs in a condition that solar power decreased to certain value in which the load requires PL =100W and the PV power is simultaneously decreased due to sun irradiation level of G = 500 W/m2. From the maximum deliverable power of the PV, it is obviously understood that the PV is not able to completely supply the power deficiency thus the remained power should be supplied by the battery. Therefore, the second operation mode is chosen. The PV is accomplished by regulating its current at $iL2$ =0.24A and adjusting the first duty ratio at $d2$ = 0.73, while the maximum power of the FC is delivered at $iL2$ =1.25 with adjusting the second duty ratio at $d2$ = 0.71. The controlling the third and fourth duty ratios at $d3$ = 1 and $d4$ = 0.4 results in discharging the battery which are shown in figure 3.15.,3.16,3.17.

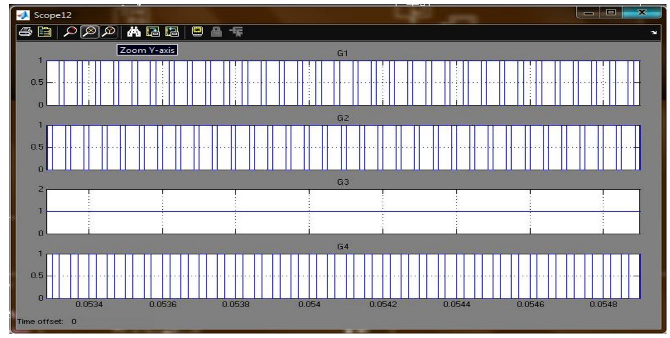

Fig. 3.17 Gate Pulse For Four Switches G1,G2,G3 And G4 Vs Time

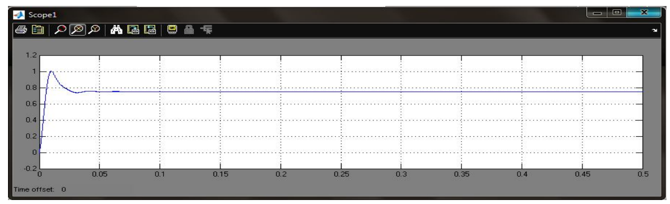

Fig. 3.18 Load Current Vs Time For Third Operating Mode

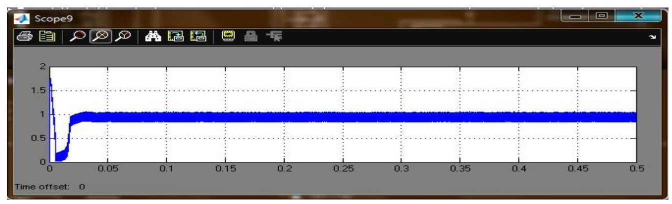

Fig. 3.19 Fuel Cell Output Current Vs Time For Third Operating

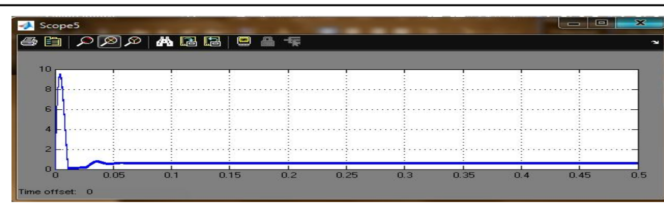

Fig. 3.20 Solar Panel Output Current Vs Time For Third Operating

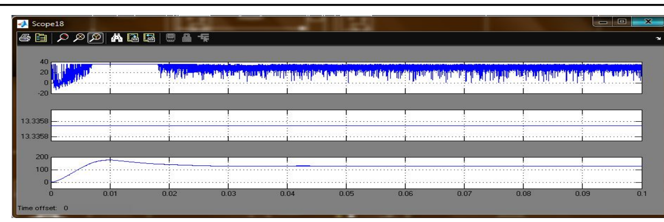

Fig. 3.21a Comparison Of Voltages Of Solar Cell, Fuelcell And Load

From the results of three operating mode,the converter maintains a constant output irrespective of change in solar radiation,fuel cell availability.In the matlab,the control signals are given to the four switches according to the selection of inputs.

4 CONCLUSION

In this Paper multiple input boost converter for solar/fuel cell has been analyzed. A practical case with a constant output load of 100W developed in MATLAB [Simulink].Simulation platform has been presented and the results confirm the adequate performance of whole design. With the merits of flexibility, the proposed multiple input converter shows excellent performance and potential for various applications including communication systems, satellite, radar systems.In future the same converter can be used to integrate wind and other type of renewable energy sources

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