International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2015): 6.391

Multiport Converter for Micro Grid Application

Sheeja Raphel[1], Surya Natarajan[2]

[1]PG Student [PEPS], Dept. of EEE, Fisat, Angamaly, Kerala, India

[2]Assistant Professor, Dept. of EEE, FISAT, Angamaly, Kerala, India

Abstract: ***Nowadays, renewable energy has shared more and more proportions of power demands globally. A new dual source converter is introduced to interface solar PV and fuel cell (FC) sources to a low-voltage dc microgrid. This non-isolated converter topology is efficient, compact and has fewer circuit components with only one inductor compared to the conventional non-isolated dc-dc converters. This topology is suitable for a low-voltage bipolar type dc-microgrid system, where power from both the sources is fed to the bipolar bus of a bipolar type dc microgrid system. This converter is a unidirectional converter with only a single inductor and is well-suited for hybridizing PV source along with FC, UC and Wind sources. Here, a hybrid combination of PV and FC sources are considered. The outputs of this converter are interfaced to a 48 V bipolar type (with_24V) dc microgrid system, where the voltage at the 48V bus is regulated by other sources in the dc micro grid and the voltage at the 24V bus is controlled by the converter along with the other sources in the dc microgrid.***

Keywords: DIDO converter, PV, FC, DC grid, Bipolar grid

1. Introduction

In the future, there will be widespread use of low power renewable energy sources (RES) in residential applications in order to meet the growing energy demands and to reduce the emission of greenhouse gases. These low power dc output type RES (like solar PV, low power wind turbines, fuel cell (FC) etc.), feed power efficiently when interfaced to a low-voltage dc microgrid system compared to a conventional AC grid. The Micro-grid concept has provided a new paradigm for future distribution power systems. Micro-Grid is a small-scale grid that is de- signed to provide power for local communities. A Micro-Grid is an aggregation of multiple distributed generators (DGs) such as renewable energy sources, conventional generators, in association with energy storage units which work together as a power supply network. Here a low voltage bipolar type dc microgrid system is considered for residential applications. In a bipolar dc microgrid environment, if separate conventional dc-dc converters are used to interface various elements (energy sources, storage units and loads) to the dc bus; then this would result in high cost, high volume and reduced efficiency. As a solution to this problem, multiport dc-dc converters are introduced. A new DIDO converter is introduced to interface PV and FC sources to a bipolar dc microgrid. Compared to the other similar converters discussed in the literature, this converter has fewer switches and has only one inductor. Hence, this converter is e_cient, compact and economical. The proposed converter is well-suited for a low-voltage bipolar type dc-microgrid system, where power from PV and FC sources is fed to the bipolar bus of a bipolar type dc microgrid system. Hence, by using this converter, efficiency of a bipolar type dc microgrid system can be enhanced.

The remaining sections of this paper are organized as follows. Section II describes the dual source converter.. Section III describes modes of operation. Sections IV gives the overall simulation and result analysis. Finally, section V provides the conclusion.

2. Dual Source Converter for DC Micogrid

Fig. 1, shows the dual input dual output converter which is a unidirectional converter with only a single inductor and is well-suited for hybridizing PV source along with FC, UC and Wind sources. Here a hybrid combination of PV and FC sources are considered.

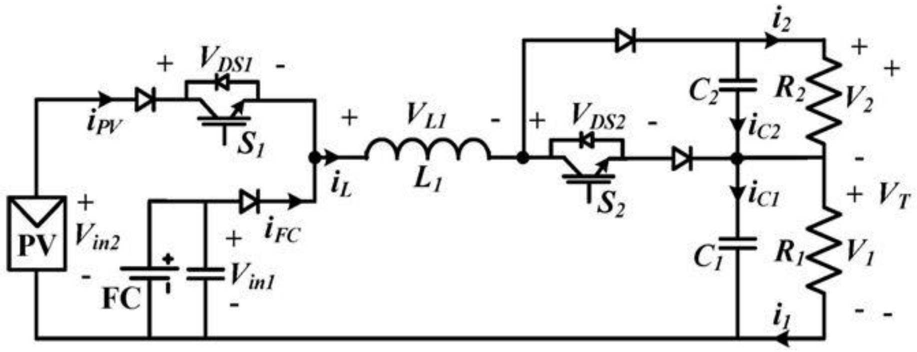

Figure 1: Dual source converter for DC microgrid

Fig. 1, Sl is controlled to control the PV current and S2 is controlled to control the output voltage VT . The outputs of the proposed converter are interfaced to a 48 V bipolar type (with _ 24V) dc microgrid system, where the voltage at the 48V bus is regulated by other sources in the dc micro grid and the voltage at the 24V bus is controlled by the proposed converter along with the other sources in the dc microgrid. It can also operate in the current control mode to ensure that the operating point of the PV source is always at MPP.

3. Photovoltaic Cell and MPPT

Photovoltaic Cell

The renewable energy sources like wind, solar, geothermal and biomass represent an alternative to traditional methods of producing electrical energy. Among them solar source is becoming popular due to its effectiveness nowadays. Solar energy can be converted directly into electricity using photovoltaic panels (PV) through the photovoltaic effect. The photovoltaic effect is the basic physical process through which a solar cell converts sunlight into electricity. A PV panel may consist of a number of solar or photovoltaic cells arranged in series or parallel.

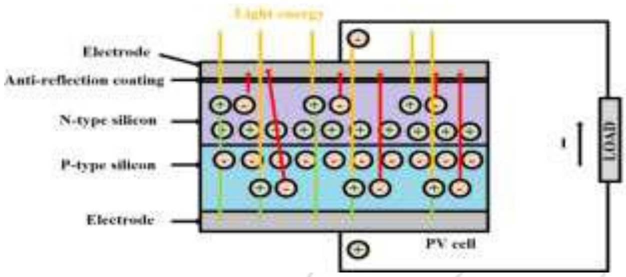

Figure 2: Representation of PV cell working

The PV cell is basically a PN junction diode so when light is incident on it, free charge carriers are created i.e. electron hole pairs are created. From light energy absorbed by them gives the charge carriers the energy to cross the potential barrier. The electrons will start moving towards N type semiconductor layer and holes will be started moving towards P type semiconductor material. Thus by connecting a metal electrode in both ends we can channelize these charges to either side of the load. The fig 2 shows the representation of a PV cell working. The PV cells can be modeled as a current source in parallel with a diode. When there is no light present to generate any current, the PV cell behaves like a diode. As the intensity of incident light increases, current is generated by the PV cell. The current source I_{ph} represents the cell photocurrent. R_{sh} and R_s are the shunt and series resistances of the cell, respectively. R_s represents usually the structural resistance of the device like contact resistance, p-n bodies etc and R_{sh} exists mainly due to leakage current of p-n junction, fabrication methods of PV cell etc. Usually the value of R_{sh} is very large and that of R_s is very small, hence they may be neglected to simplify the analysis. Load is connected across it. I_{pv} represents PV current. The fig 3 shows (a) PV cell modeled as a diode circuit and (b) Simplified equivalent circuit of PV array.

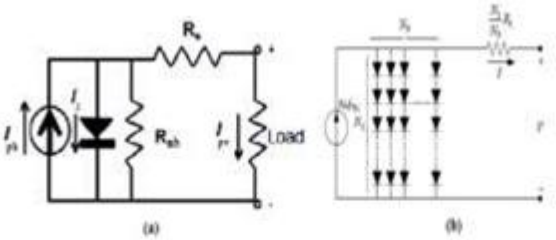

Figure 3: (a) PV cell modeled as a diode circuit (b) Simplified equivalent circuit of PV array

Maxing Power Point Tracking

The power characteristic of the PV is nonlinear and has a particular point for which the power generated by the PV is maximal.This is usually noted MPP (Maximum Power Point). In order to get maximum power of the PV panel several Maximum Power Point Tracking (MPPT) algorithms are used. There are several MPPT algorithms, among them ―Perturb and Observe‖ (P&O) is widely used. The fig 4 shows the flowchart representation of P&O algorithm.

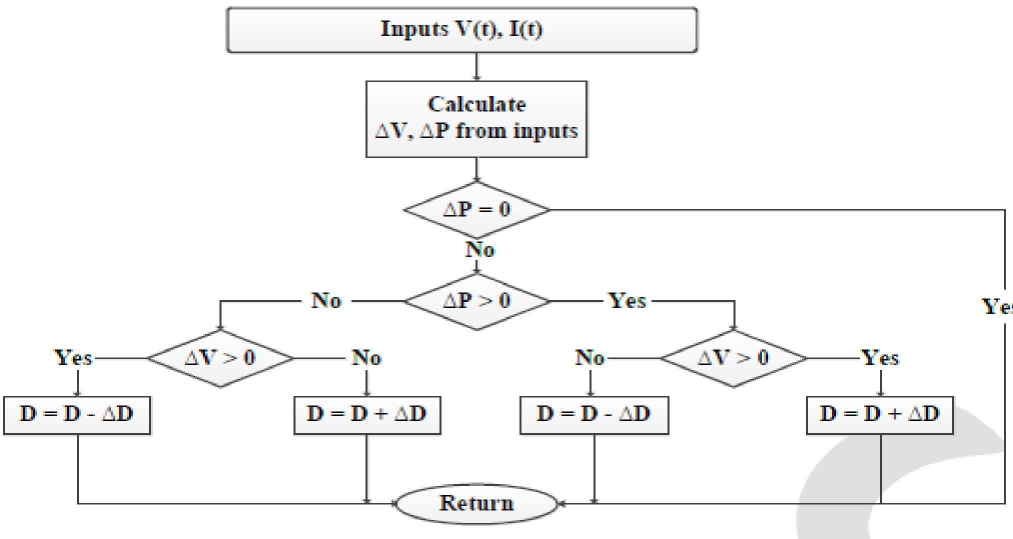

Figure 4: P & O algorithm

4. Modes of Operation

For satisfactory operation of the converter, the duty ratios of the switches can take either of the two conditions, i.e., Dl>D2 or Dl < D2. Where Dl is the duty ratio of the switch Sl and D2 is the duty ratio of the switch S2. Irrespective of the duty cycle condition, the proposed converter operates in three operating modes in one switching period. If Dl < D2, the operating modes would be as shown in Fig. 5.2a, 5.2b and 5.2d. If Dl > D2, the operating modes would be as shown in Fig. 5.2a, 5.2c and 5.2d.

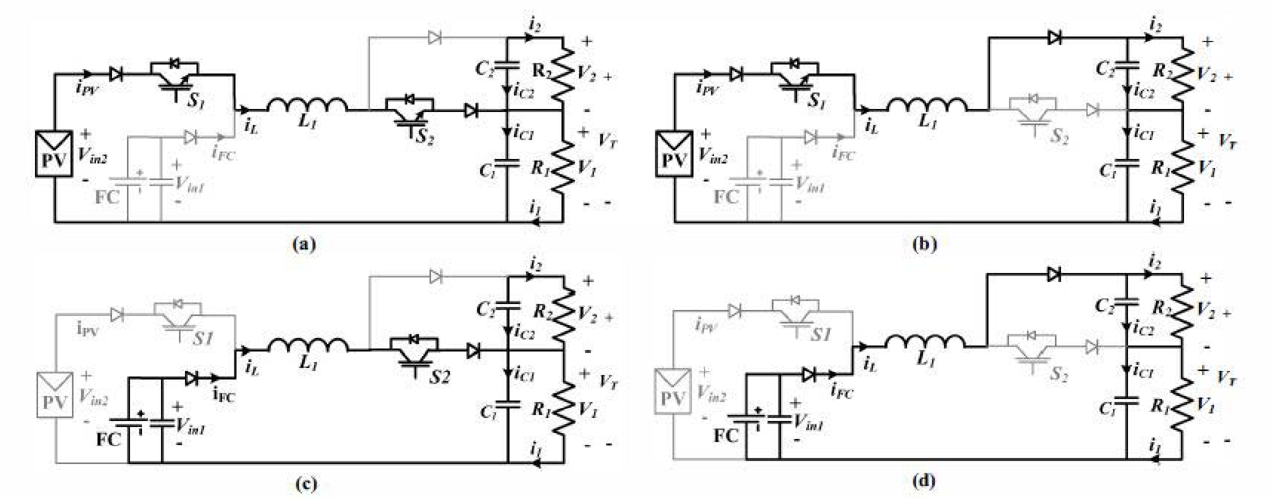

Figure 5: Operating modes of converter

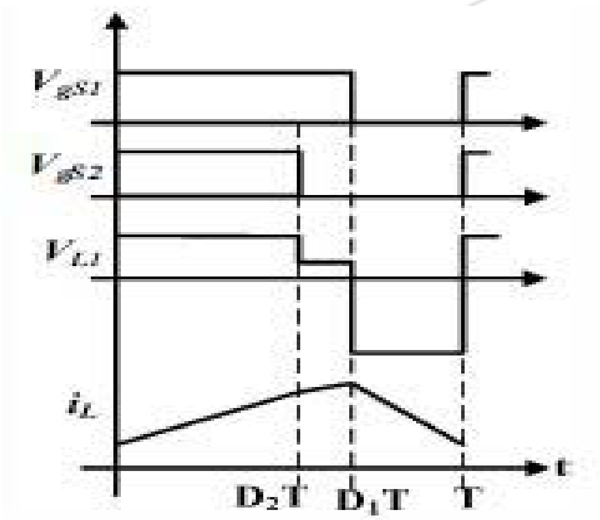

Figure 6: Steady state waveforms

Fig. 6 shows the gating pulses of the proposed converter along with the steady state inductor current and voltage waveforms, when Dl < D2.

5. Simulation and Results

Electrical power systems are combinations of electrical circuits and electromechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically increased efficiency have forced power system designers to use power electronic devices and sophisticated control system concepts that tax traditional analysis tools and techniques. Further complicating the analyst's role is the fact that the system is often so nonlinear that the only way to understand it is through simulation .Land-based power generation from hydroelectric, steam, or other devices is not the only use of power systems. A common attribute of these systems is their use of power electronics and control systems to achieve their performance Sim Power Systems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. Sim Power Systems uses the Simulink environment,allowing you to build a model using simple click and drag procedures. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB® as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. Sim Power Systems and SimMechanics share a special Physical.

Table 1: Paramters Used

Elements	*Values*
INDUCTOR	250 µH
CAPACITOR(C1)	1000µF
CAPACITOR(C2)	1000µF
SWITCHING FREQUENCY	30KHz
INPUT VOLTAGE(Vin1)	24V
INPUT VOLTAGE(Vin2)	73V
OUTPUT VOLTAGE(Vt)	48V

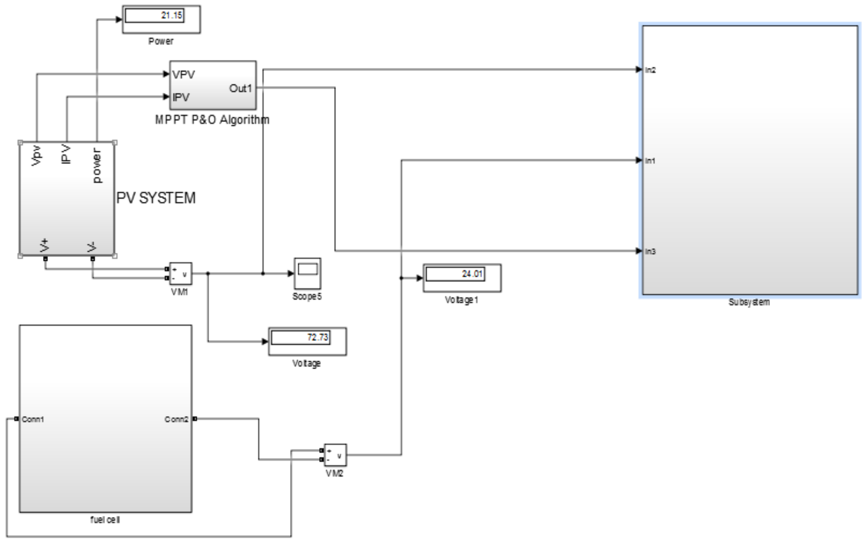

Figure 7: Overall Simulation

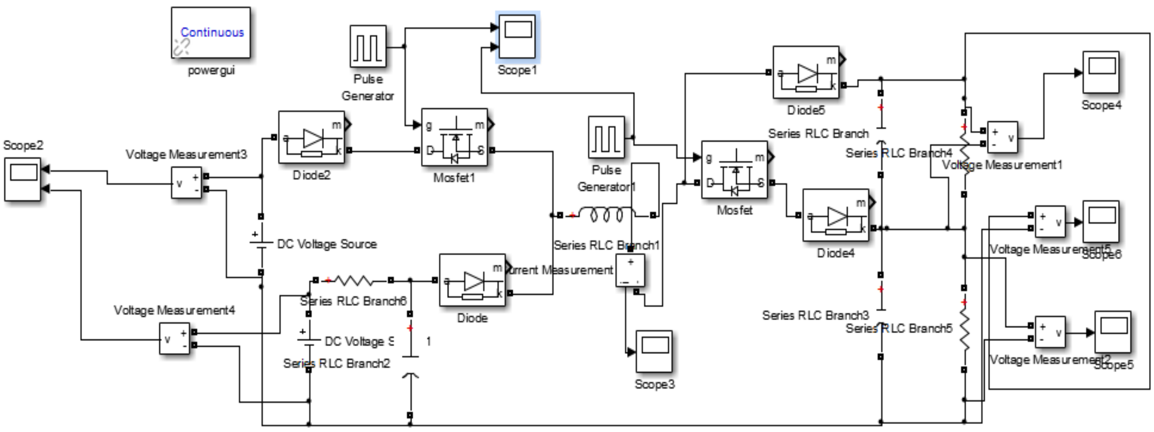

Figure 8: Converter Section

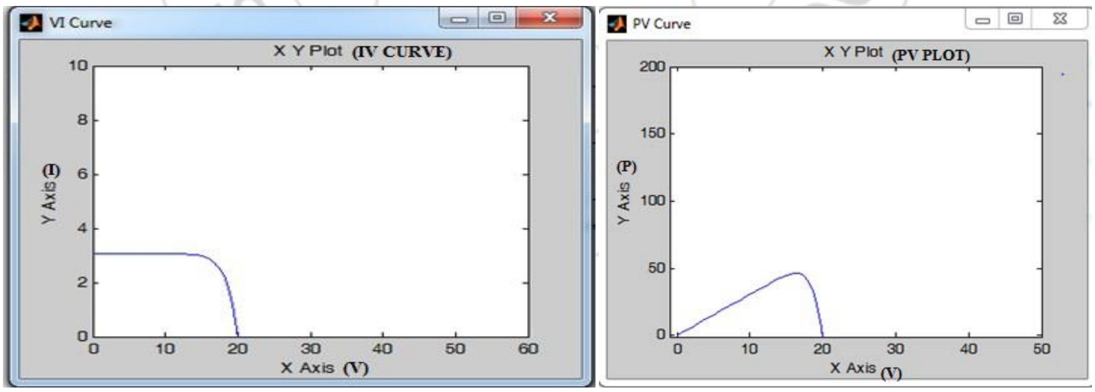

Figure 9: PV IV curve

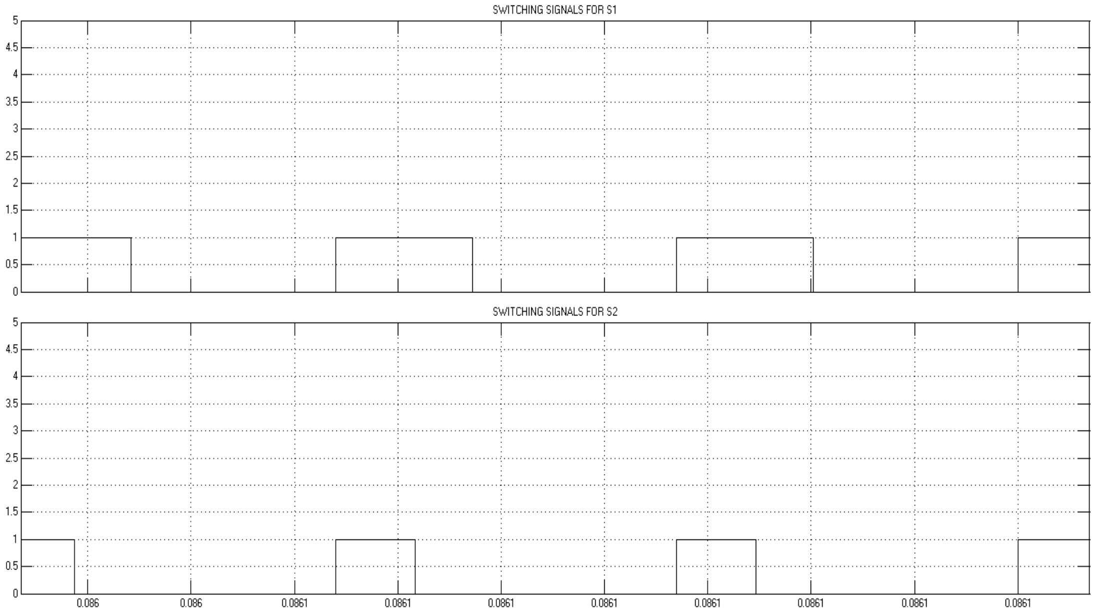

Figure 9: Switching Pulses for S1,S2

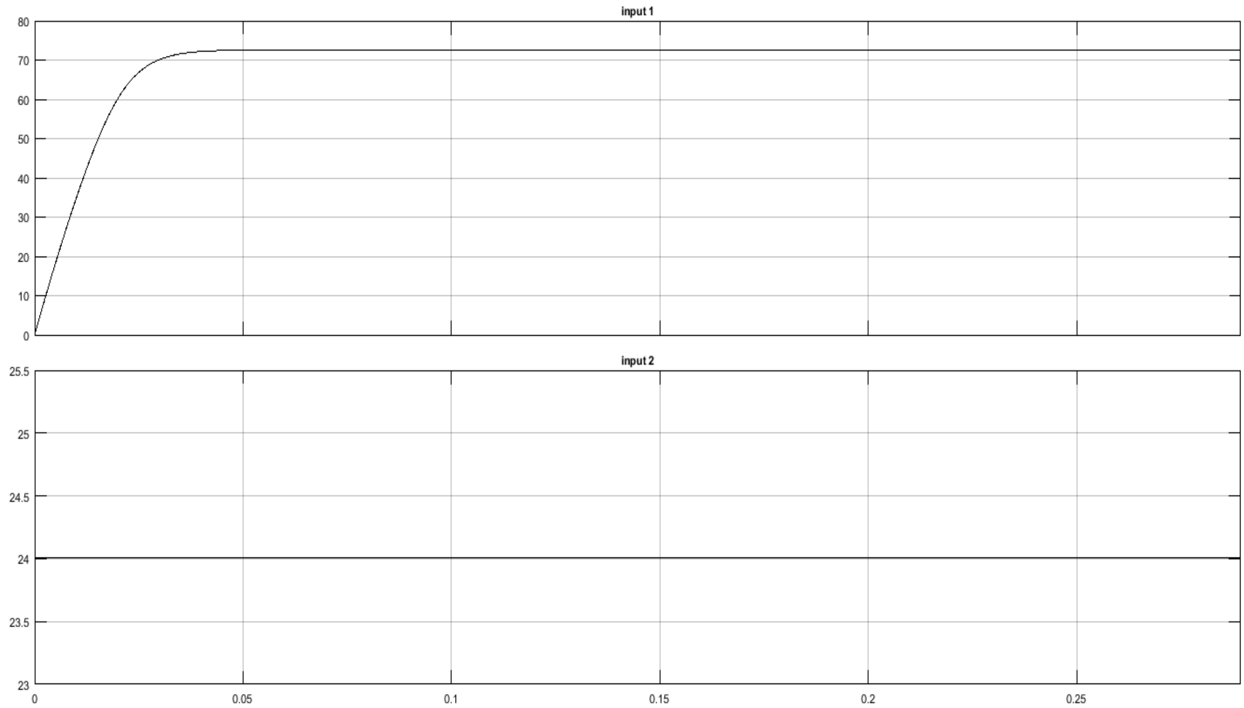

Figure 10: Two input voltages-Vin1, Vin2

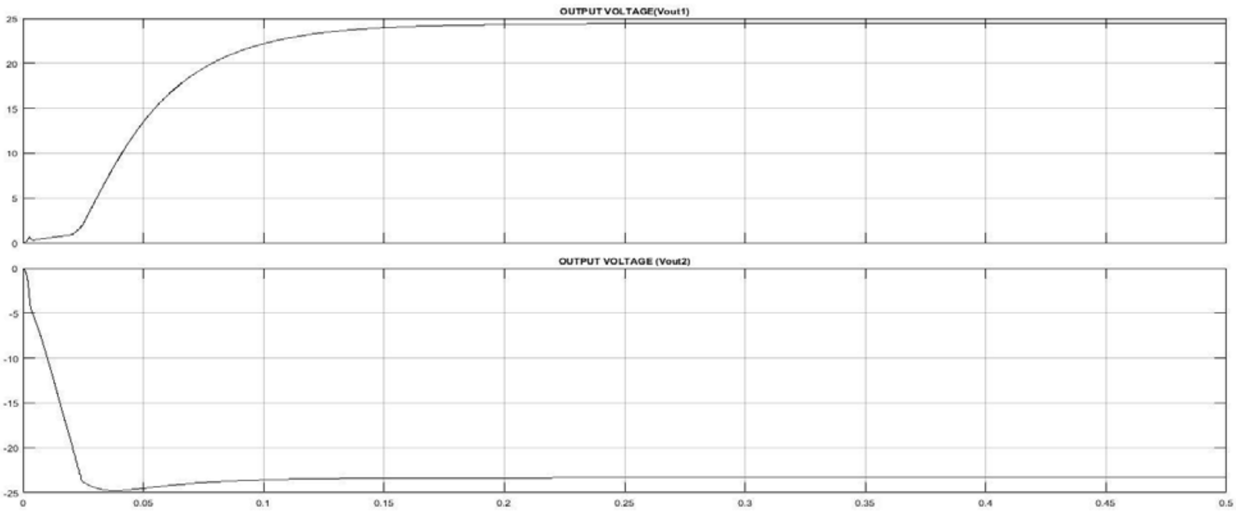

Figure 11: Two output voltages-V1, V2

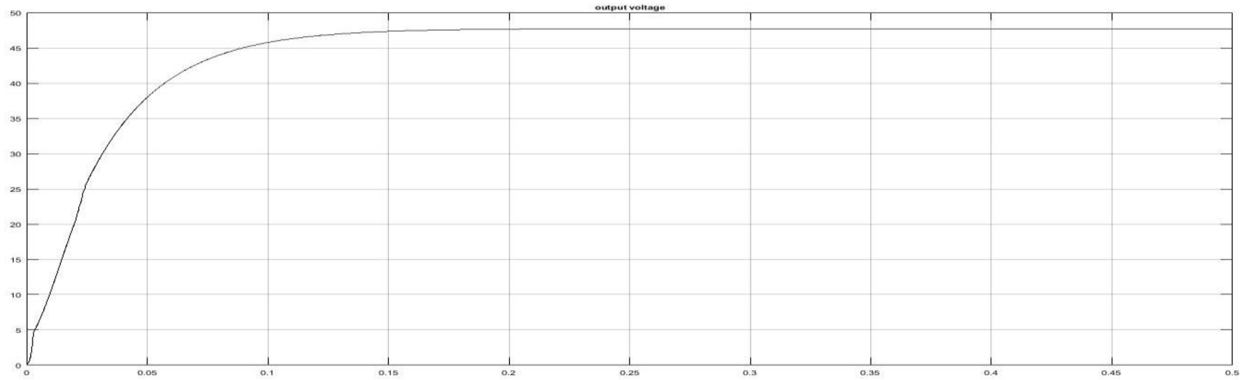

Figure 12: Two output voltages-Vt

6. Conclusion

A new dual source dc-dc converter is introduced, designed and analyzed for hybridizing PV and FC sources connected to a low-voltage bipolar type dc mi- crogrid. This converter uses less number of switches and has only one inductor. Hence, this converter is e_cient, compact and cheap. The proposed converter ensures MPPT operation of the PV source and also regulates one of the pole voltages of the dc bus. Simulation results of the proposed converter are presented.The topology is capable of supporting multiple inputs and shows promise for achieving diversification of multiple energy sources.

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