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Performance of Multi Port Bi Directional Converter for Energy Management System

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Abstract: ***The focal intention of this work is to provide incessant power delivery to the load by finding out the accessible supply sources optimistically among the four sources namely solar, wind, battery and diesel generator. Depends up on the availability the sources can be connected in order to have a sustainable power system. Due to the abnormalities of energy sources Solar and Wind, energy storage units are required in order to provide the sustainable constant voltage to the load without any interruption. The five port convert is used to interface the Solar, Wind, Battery, Diesel Generator sources and the load. The circuit topologies of different boost converters are discussed in [1]. The five-port converter can make sense of bidirectional flow of energy between the source, storage medium and load. Also ensure the DC bus maintaining stable voltage [2].***

Keywords**: *Diesel Generator Sources, Energy Bidirectional Flow Energy Storage Components, Five Port Converter, Renewable Energy Sources.***

I. INTRODUCTION

Usually the solar energy is affected by the weather condition, like sun light intensity, temperature, dust elements which are exists in the normal atmosphere and other external factors similarly the wind also generally depends on the wind speed which is changes very often. Hence an energy storage system is essential in order to maintain the continuous supply source to the load by storing the energy when it is excessively available. Therefore the bidirectional flow power would be there among the storage system and the load [3]. Fig. 1 shows the battery as the energy storage device. The structure includes two-stage DC-DC converters between the renewable sources solar, wind and the storage compartment. The first stage of the system is boost converter which can be used to maintain maximum power by (MPPT) control. The last stage of the system is used to maintained energy bidirectional flow. More over to maintain the stability of DC bus [4]. This converter will reduces number of circuit components, system size, cost by sharing switch devices, weight, and other components.

A five port dc-dc converter interfacing with solar energy, wind source, diesel power generation and energy storage medium is developed. Fig.2 shows structure of five port converter [5].

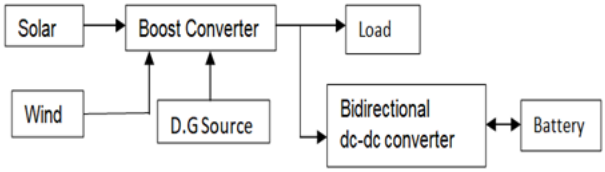

Fig.1 Structure of renewable energy storage system

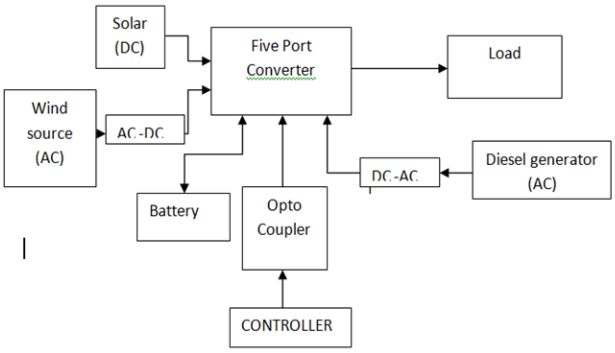

Fig. 2 System structure of five port dc-dc converter

II. FIVE-PORT CONVERTER

The topology of the five port converter is shown in Fig.3. The five ports are used as solar port, wind energy port, diesel generator port, battery port and the last as load port. The four-parallel topologies of the enhanced converter are shown in Fig.4. It has four input ports, Solar energy port (Vs), Wind energy port (Vw), Battery port (Vb), Diesel Generator source port (Vd), and one output, load port (Load).

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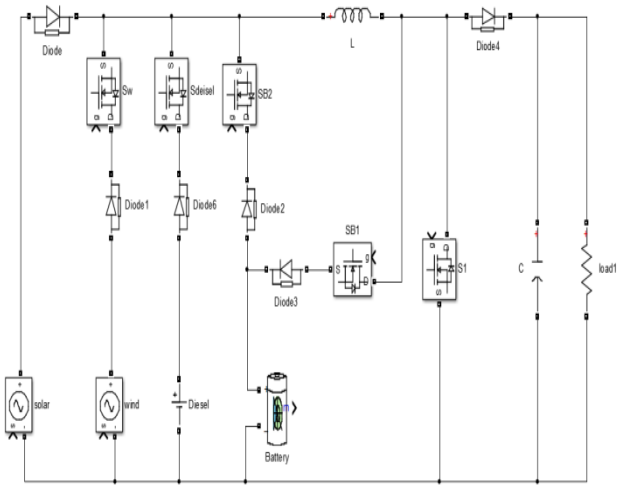

Fig. 3 Five-port converter topology

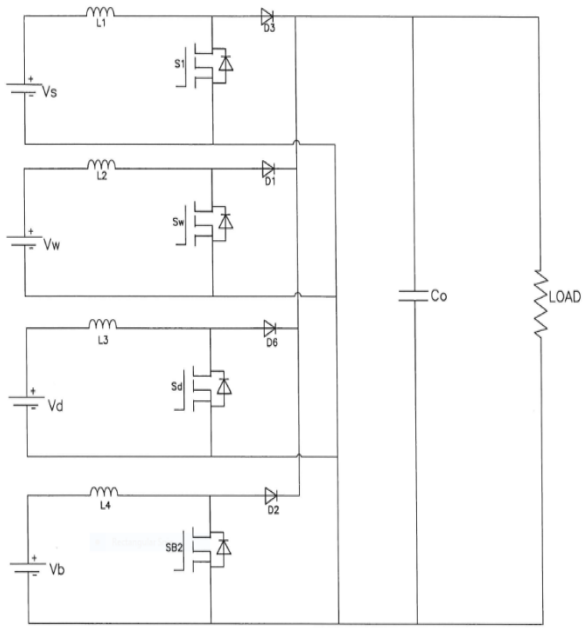

Fig.4 Four parallel Boost converter

According to the availability given sources and relationship between the output power of Solar, Wind, Diesel Generator and the requirement of load, five port converter decides the operating modes in three stages [6].They are Renewable High mode, Renewable Low Mode and NO Renewable Mode.
Five ports of the converter are used as follows
Port 1: Input from the solar source
Port-2: Input supply source from the Wind
Port - 3: Input Supply from the Diesel Generator
Port-4: Battery charging and discharging (Bidirectional)
Port-5: Connected to the Load.

1. Renewable Energy High Mode

When the output power of Renewable energy sources i.e. Solar and Wind is more than requisite amount of the load, the solar power port and wind power ports are connected to battery as shown in the Fig. 5

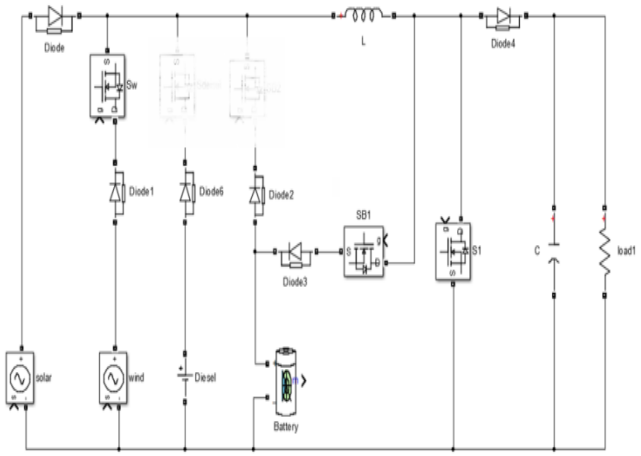

Fig. 5 Renewable Energy High Mode (Mode-3)

The Power switches SB 2, S-Diesel is always in off state. Power switches S1, SW, SB1 adjusts the charging to sustain DC voltage stable [6]. Fig. 6 shows switching waveforms.

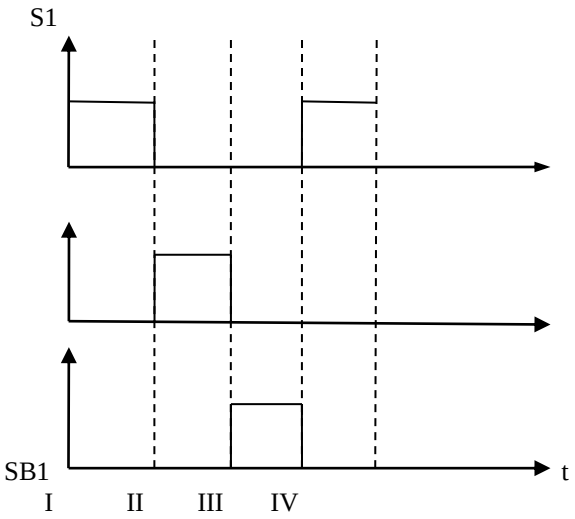

Fig. 6 Each switch operating waveforms in Renewable Energy High Mode (Mode-3)

2. Renewable Energy Low Mode

When the output power of Renewable energy sources i.e. Solar and Wind power is less than load, the Solar power port and Wind power ports provides energy for the load, meanwhile the battery provide energy to the load by discharging [7] as shown in Fig.7.

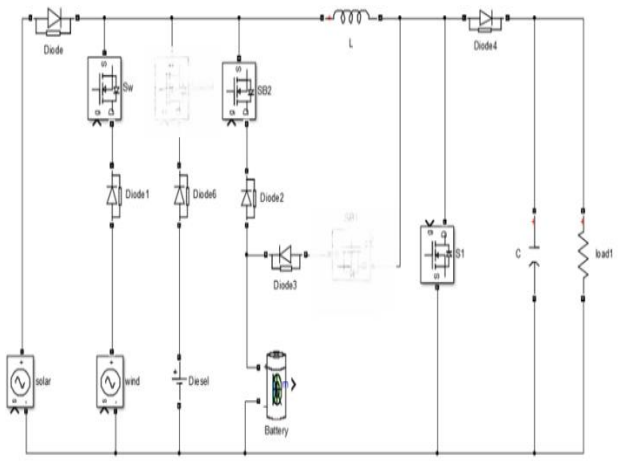

Fig. 7 Each switch operating waveforms in Renewable Energy Low Mode (Mode-2)

The Power switches SB1, S-Diesel is always off state. Power switches S1, SW, SB2 keep exploit to fiddle with the battery discharging and maintain DC voltage constant[8]. Each switch operating waveforms in Fig. 8.

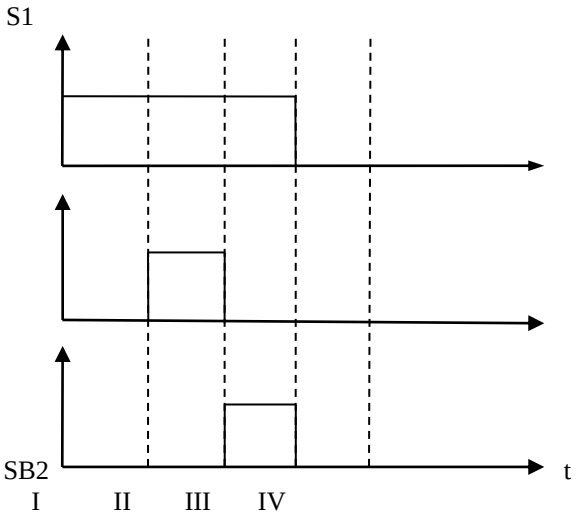

Fig. 8 Each switch operating waveforms in Renewable Energy Low Mode (Mode-2)

3. No Renewable energy Mode

When the output power of Renewable energy is almost zero and the battery state of charging 'SOC' is less than 20%. The Diesel Generator (DG) port provides power to the load as shown in the Fig. No.9. The power switch SW, SB1, SB2 always keeps off state, the power switch S-Diesel keep action and retain DC voltage invariable [9]. Every switch operating waveforms are revealed in Fig. 10

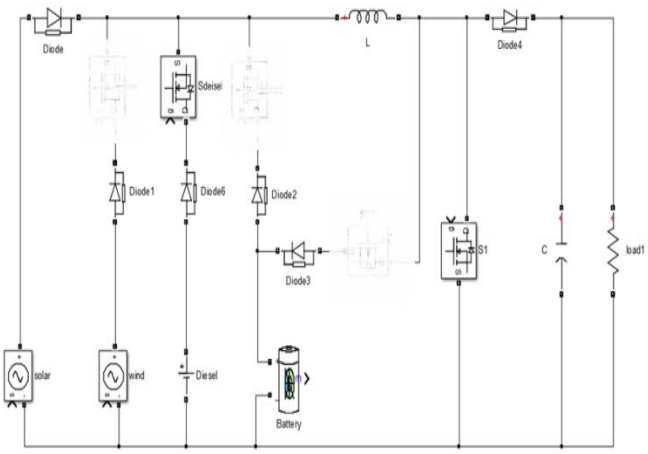

Fig. No. 9 Each switch operating waveforms in No Renewable Energy Mode (Mode-1)

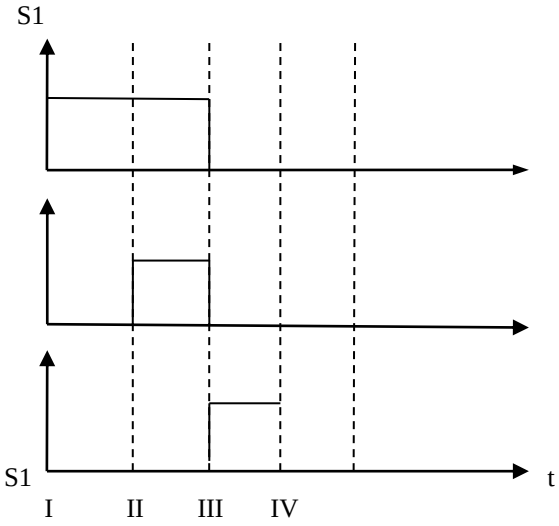

Fig. No. 10 Each switch operating waveforms in No Renewable Energy Mode (Mode-1)

III. OPERATION OF SWITCHES

The different modes of operations are discussed below.

Mode of operation	*Switches in ON state*	*Switches in OFF state*
Renewable energy High	*S1, SW, SB1*	*SB2, S-Diesel*
Renewable low energy	*S1, SW, SB2*	*SB1, S-Diesel*
No Renewable energy	*S1, S-Diesel*	*SW, SB1, SB2*

IV. SYSTEM CONTROL STRATEGY

Solar energy and wind energy are rarely exaggerated by assorted external calamities like sun light intensity, the hotness and wind speed, etc.

It causes the output voltage and fluctuations in power. The proposed five-port converter guaranteed the system constancies at all conditions [10]. The closed loop control system is shown in Fig. 11 the fluctuations in the external factors influence and will cause the output voltage (power) of the solar and wind source ports contains frequency fluctuations. These voltage fluctuations frequencies of the system need to be separated [11].

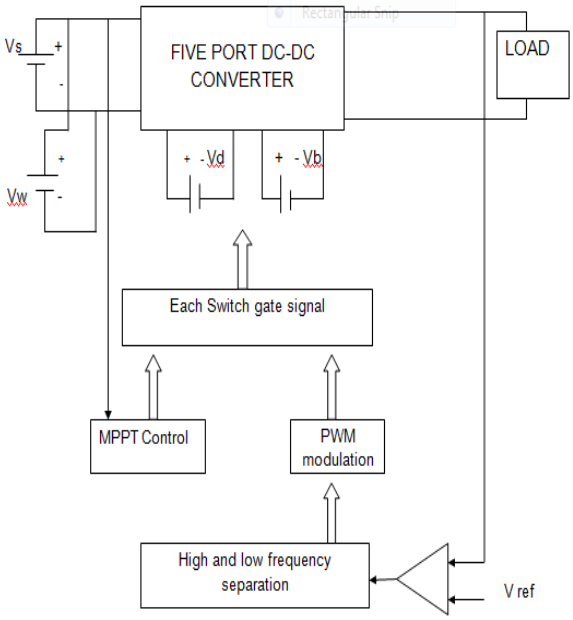

Fig.11 The closed loop control system

In this proposed work the perturbation and observation technique realize MPPT control. Fig.11 shows the realization of MPPT control [12]. The switches Sw, Sd and S1, are controls the Wind, Diesel generator and MPPT respectively. SB1 is used for Battery Charging and SB2 is used for discharging the battery to achieve the output voltage stable in different mode of operations.

V. OPERATION FLOW CHART

The Fig.12 shows the operational flow chart of the proposed five port dc-dc converter, the structure consist of 2 Nos. of voltage sensing units. 1No. for to sense the input sources of the five port converter such as Solar, Wind, Diesel generator and Battery and another for to sense the output voltage(Uo)and give feedback to the microcontroller which compare with the reference voltage(Vref).

If the renewable sources solar and wind sources combined output voltage is greater than the 16V, set the power switches S1, SW and also set the SB1 for charging the battery. If it is less than 16V and the battery SOC (state of charge) is more than 20%, the power switch SB2 will be set to discharge the battery to supply the energy to the load along the renewable sources. Otherwise set the Sd switch ON (diesel Generator source) to meet the load requirement, by which sustainable and reliable output voltage is ensured [13].

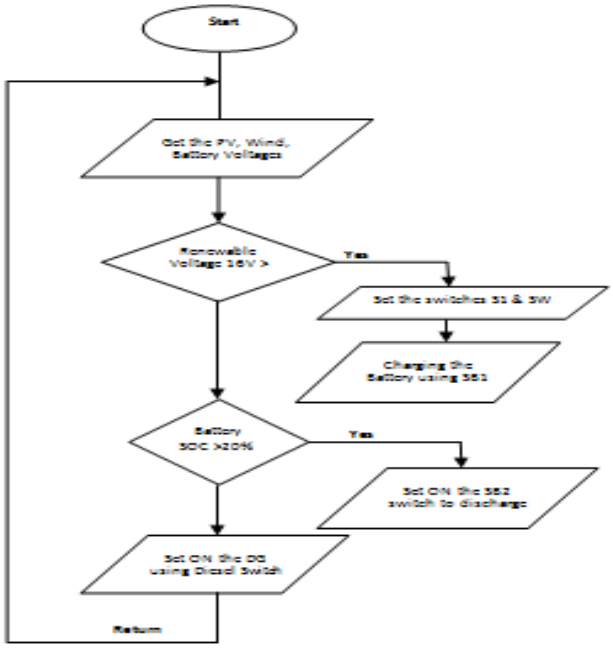

Fig. 12 Operation flow chart of five port converter

VI. SIMULATION RESULTS

In this work, five-port converter is connected to renewable sources such as Solar and wind, the energy storage medium like battery and the non renewable source like Diesel generator source, the entire frame work display is worked in MATLAB. The input voltages are taken from solar, wind, Diesel generator source and battery, the each port waveform of the system in Renewable energy High, Renewable energy Low and NO Renewable energy modes are revealed from Fig.14 to Fig.22 correspondingly.

Vs is the Solar output voltage

Vw ,Vb and Vd represents the wind, battery and Diesel generator source port voltages

Vout is the output voltage of the load port

I-s is the Solar current

I-w is the wind current

I-b is the battery current

I-d is the battery current

IL is load current.

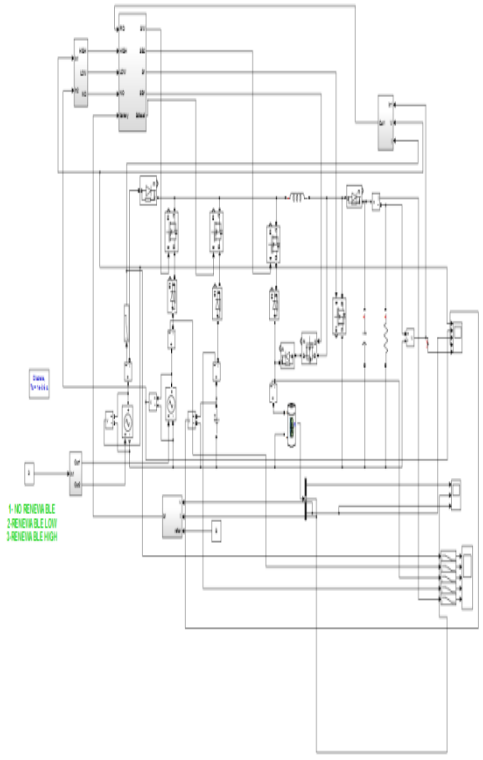

Fig. 13 Simulation diagram

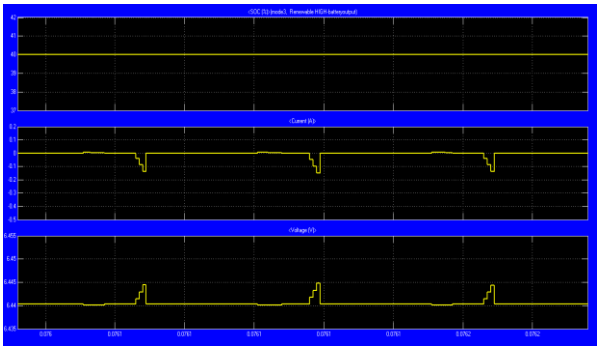

Fig. 16 Mode3Battery output waveforms(Renewable high)

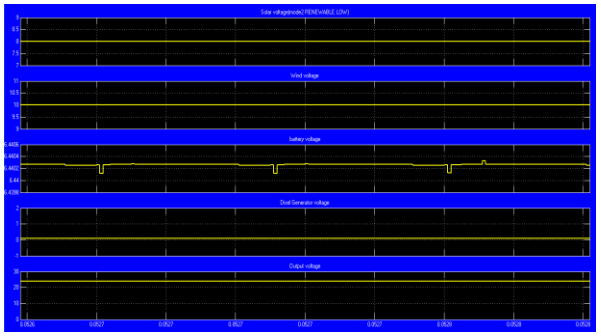

Fig. 17 Mode2voltage output waveforms(Renewable low)

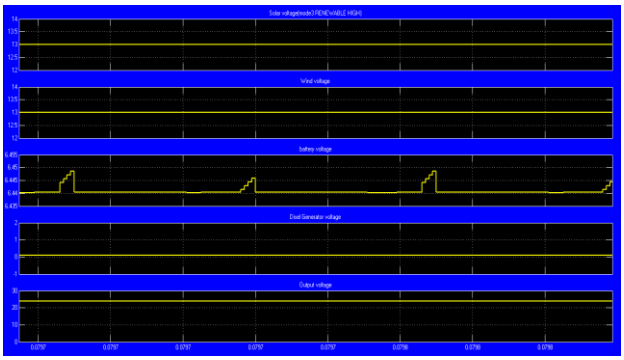

Fig. 14 Mode 3 voltage output waveforms (Renewable high)

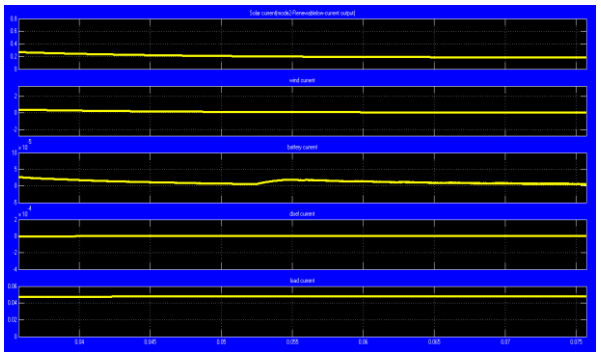

Fig. 18 Mode 2currentoutput waveforms (Renewable low)

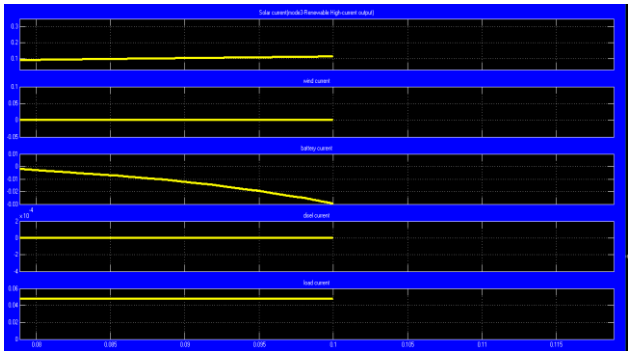

Fig. 15 Mode3currentoutput waveforms (Renewable high)

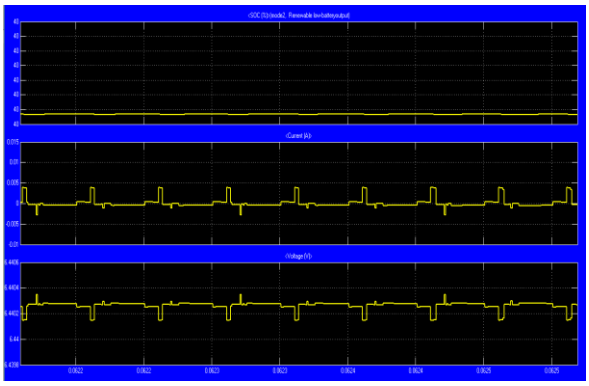

Fig. 19 Mode2Battery output waveforms (Renewable low)

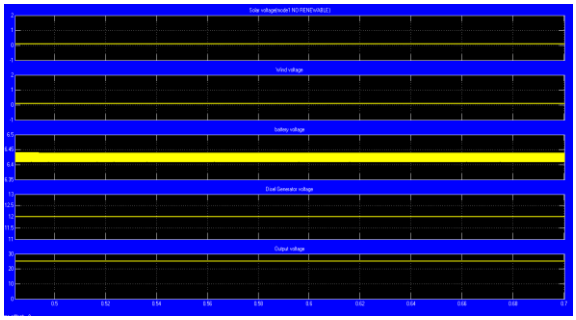

Fig. 20 Mode1voltage output waveforms (No Renewable

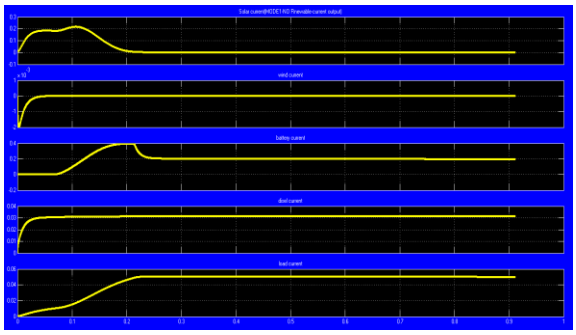

Fig. 21 Mode1current output waveforms (No Renewable)

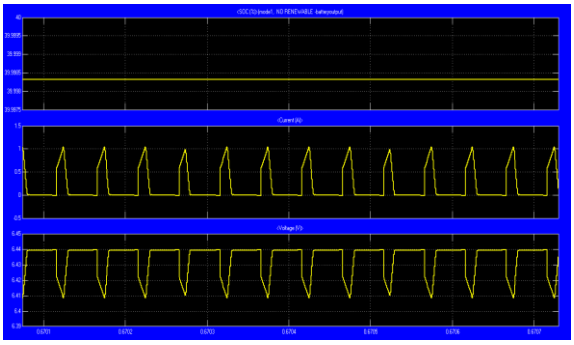

Fig. 22 Mode1Battery output waveforms (No Renewable)

VII. CONCLUSION

The five-port converter ensures as compact in size. The constancy of the system is also well maintained and organized effectively. The converter can be realistically allocating the power sources and the storage medium according to the inevitability of load. This can be established in all the modes for complex loads and verified by the simulation results.

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