Implementation of Different Power Transfer Modes in Modular MIBC for Grid/Hybrid Electric Vehicle Application

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Abstract- The traditional method of power transfer between source and load is direct. In DC-DC converter the power transfer between two or more sources is difficult. In the proposed system the problem can be resolved by using multiple input bi-directional Power converter (MIBC) connected across the dc-link. In this MIBC auxiliary sources are connected in parallel. The auxiliary sources incorporated are battery and ultra capacitor. Multiple sources are interface to provide maximum available energy to grid. The bi directional operation of the converter is introduced in this project. It operates with various power transferring modes of different sources having different voltage levels. With simple circuit change there is a provision to add more number of sources to increase the efficiency and reduce the complexity. The MIBC can be applicable to Grid and hybrid EV in which multiple sources are interfaced.
The simulation of MIBC has validated the different modes of operation and shows the effectiveness of the design using MATLAB/Simulink software.

Index terms- Multiple input dc-dc bidirectional converter, (MIBC), auxiliary sources, hybrid electric vehicle (HEV).

1. INTRODUCTION

Renewable resource play a predominant role to produce the electrical source to fulfill the demand of energy needs without affecting the environment. Unlike non- renewable energy sources renewable energy sources are nature friendly and they will not pollute the environment. Solar and wind are the prime energy sources. Solar is the ultimate energy source which can easily available to produce maximum energy according to needs. From past few decades the utilization of solar energy for our daily needs increasing day by day and so many techniques used to get maximum energy from the irradiance of sun. A single day radiations of solar can generate the energy to fulfill whole world's energy requirement for one year. But because of the lack of technology for storage system it is impossible to utilize the available energy. Energy storage system is necessary to capture the energy generated for future use, batteries and ultra-capacitors are frequently used energy storage devices in all applications because of their high energy and power densities respectively. To power up required power to the load in the absence of main source like solar photo – voltaic (PV) generation they are used as auxiliary sources. For best performance the auxiliary sources are given supply to the load.

When solar radiations fall on the pv cells they produce electrical energy which depends on the many environmental factors like temperature, irradiance, humidity and wind speed. Because of these factors energy produced by solar pv array will not be constant always therefore the maximum power method of technique is used to get the power from sunlight. Maximum power method is an algorithm which works on the V-I characteristics of solar model which are not linear.

In the proposed system the problem can be resolved by using multiple input bi-directional Power converter (MIBC) connected across the dc-link. In this MIBC auxiliary sources are connected in parallel. The auxiliary sources incorporated are battery and ultra capacitor. Multiple sources are interface to provide maximum available energy to grid. The bi directional operation of the converter is introduced in this project. It operates with various power transferring modes of different sources having different voltage levels. With simple circuit change there is a provision to add more number of sources to increase the efficiency and reduce the complexity. The MIBC can be applicable to Grid and hybrid EV in which multiple sources are interfaced.

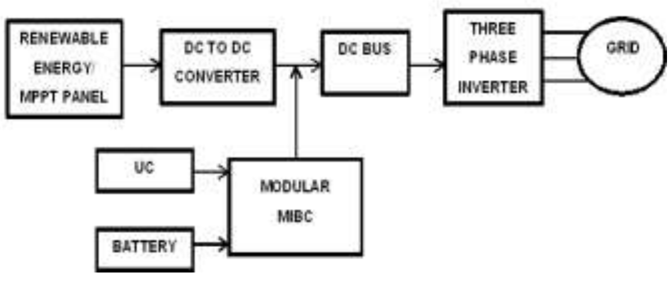


Fig.1. Block diagram of modular MIBC system

The solar PV panel with MPPT control system which produces the electrical energy that is supplied to grid by using the three phase inverter. Block diagram is shown in Fig.1. The energy generated by solar is supplied to dc link. There are three sources interfaced to the converter to operate it in either buck mode or boost mode. The main source is solar and two auxiliary sources are battery and ultra-capacitor. The topology presented in this project consists of a converter operates bi-directionally to charge and discharge of these auxiliary sources shown in Fig.1. During peak power generation the generated voltage is greater at maximum insolation, then energy will be utilized to charge the auxiliary sources. In that condition converter operates in buck mode. These auxiliary sources discharge to dc link, during low power generation by PV modules at less insolation to supply the grid by operating converter in boost mode. The different power transfer modes of operation of MIBC are discussed in the upcoming section.

2.PROBLEM DEFINITION

In pv application to maintain constant dc voltage at DC-link, the conversion devices are preferred in source and load. In addition with that buck- boost converter is used between DC-link and storage devices. They act as auxiliary sources during peak power demand and as load during peak generation, accordingly converter operates in boost or buck mode. Storage capacity is depends on number of auxiliary sources used, normal buck-boost converter have capacity to interface only one auxiliary source for storage and this energy may be insufficient to supply than needed. It requires another converter to interface one more source which requires more space and increased cost; this is the main drawback of this technique. Hence a modified multiple input converter for capability of bidirectional power flow is introduced to minimize the complexity and cost, also to increase the efficiency.

3.OBJECTIVE

Proposed converter used in this project is interfaced with multiple sources like battery and ultra-capacitor. Number of switches used are 6 with wide voltage range, duty ratio controlled with independent power flow. The topology used is buck-boost without isolation.

The main objective is implementation of different operational modes in modular MIBC.

4. METHODOLOGY

In pv application to maintain constant dc voltage at DC-link, the conversion devices are preferred in source and load. In addition with that buck- boost converter is used between DC-link and storage devices. They are act as auxiliary sources during peak power demand and as load during peak generation, accordingly converter operates in boost or buck mode. Storage capacity is depends on number of auxiliary sources used, normal buck-boost converter have capacity to interface only one auxiliary source for storage and this energy may be insufficient to supply than needed. It requires another converter to interface one more source which requires more space and increased cost; this is the main drawback of this technique. Hence a modified multiple input converter for capability of bidirectional power flow is introduced to minimize the complexity and cost, also to increase the efficiency.

This circuit comprises of ultra capacitor voltage VUC and battery voltage and Vbt, these are interfaced with the dc bus voltage Vdc. Two switches which are connected to the auxiliary source voltages. Other input of the converter connects the inverter side of dc bus. The circuit comprises of 3 phase inverter and it can be implemented by using two inductors. If required, additional power transfer sources can be incorporate in the converter. Modular MIBC connecting with the auxiliary sources of ultra capacitor and battery, the remaining parameters are connected to the grid. The generated voltage of inverter output is fed to the load of the power grid.

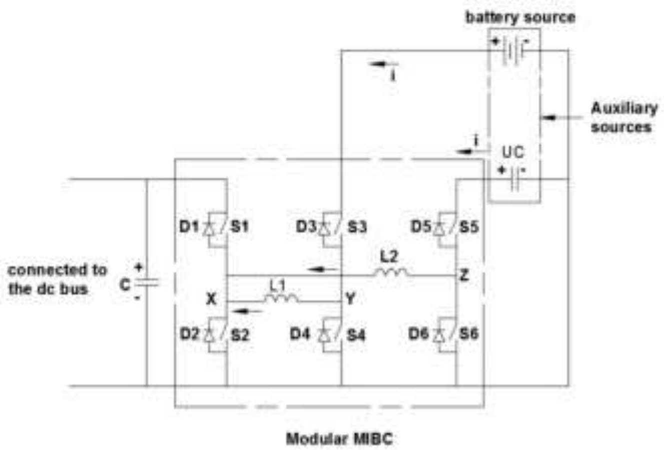


Fig.2. Circuit diagram of modular MIBC topology

5. DIFFERENT TYPES OF POWER TRANFER MODES

A) Transfer of energy in Battery and DC bus

During mode A1 operation the power supplied from battery to dc bus, then it is fed to the load. In the time interval T1 the switches 2 and 3 are turned on. In the second time interval the voltage in battery stores in inductor L1, this results in the rise of current of slope Vbt/L1.In the third interval ,the

2 switches are disconnected, diode D1 and D4 accumulates power in L1 and discharges energy to the bus.

During steady condition the dc voltage and voltage across battery are

$$Vdc = (T1/(T2 + T3))\, V_{bt}$$

During mode A2 operation the power supplied from dc bus to battery, then it is fed to the load. While the flow energy between dc link to battery and operating sequence In the time interval T1 the switches 1 and 4 are turned on.

During steady condition the voltage across battery and dc voltage and are

$$Vbt = (T1/(T2 + T3))\, V_{dc}$$

B)Transfer of energy in ultra capacitor and DC bus

During mode B1 operation the power supplied from ultra capacitor to dc bus, then it is fed to the load. In the time interval T1 the switches 2 ,5 operates. During interval T2 diodes 1 and 6 are turned on. In the third interval ,the switches 1 and 6 turned on and discharges energy to the bus.

During mode B2 operation the power supplied from DC bus to ultra capacitor then it is fed to the load. In the time interval T1 the switches 1 and 6 are turned on. In the second time interval Diodes 2 and 5 are turned on. In the third interval ,the switches 2 and 5 turned on and discharges energy to the ultra capacitor.

C)Battery & ultra capacitor

During mode C1 operation the power supplied from battery to ultra capacitor , then it is fed to the load. In the time interval T1 the switches 3 and 6 are turned on. In the second time interval Diodes 3 and 5 are turned on. In the third interval ,the switches 5 and 3 turned on and discharges energy to the ultra capacitor.

During battery ripple current is low when compared to the other modes the MIBC operate in boost mode. This will improves the battery life and reduces the peak time in current while charging and discharging.. During ultra capacitor ripple current is low when compared to the other modes the MIBC operate in boost mode. The voltage across battery has been boosted and energy stores in ultra capacitor.

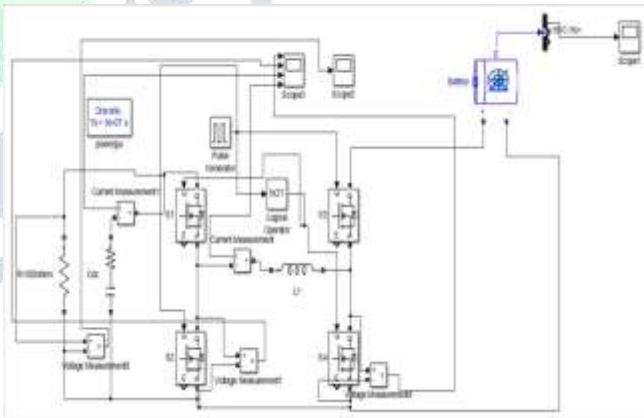
D)Battery and Ultra capacitor to DC bus

During peak demand auxiliary devices exhibits very fast response. There are five time intervals for a switching cycle. Similar signals are given to switches 1 and 6. Switches 2 and 5 incorporates complementary signals. By using synchronous rectifier the drop voltages at the switches can reduced. In the time interval T1 the switches 2, 3, 5 operates. During T2 diode 4, switches 2 and 5 operates. During T3 the switches 2,4 and 5 are turned on. During fourth time interval Diodes 1 and 6, switch 3 operates. In the last interval switches 2,3 and 5 turned on. Thus discharges energy from ultra capacitor and battery to dc link.

E)DC bus to ultra capacitor & battery

During mode E operation the power supplied from DC bus to ultra capacitor and battery, then it is fed to the load. In the time interval T1 the switches 1,3 and 5 operates. In T2, Diode 2 and switches 3 and 5 are turned on. In the third interval ,the switches 2,3 and 5 operates. In fourth, switches 2,4 and 5 operates. Finally switches 1 and 5 and diode 3 turned on. Thus energy flows from bus to ultra capacitor and battery. In this mode E dc bus charges both the axillary source.

6. SIMULATION AND RESULTS

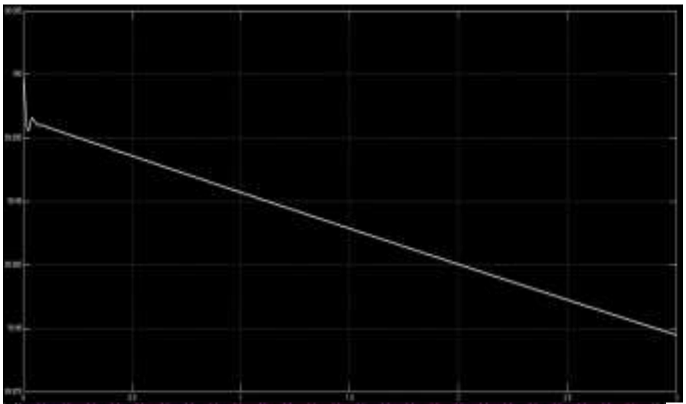


a)Power Transfer from battery to DC Link

Fig. 3. Simulink model for mode A

During this mode battery is discharged and power stores at dc link. Then dc link provide power to grid. Here inductor current passes to DC link through diodes thus stores energy in inductor. In this interval battery is discharged.

Fig. 4. Discharge of battery



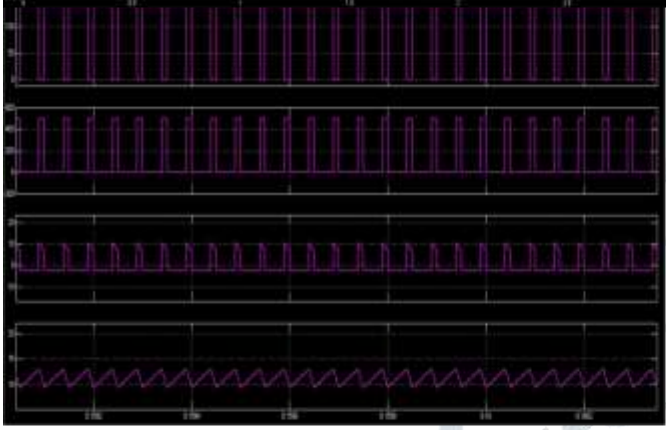
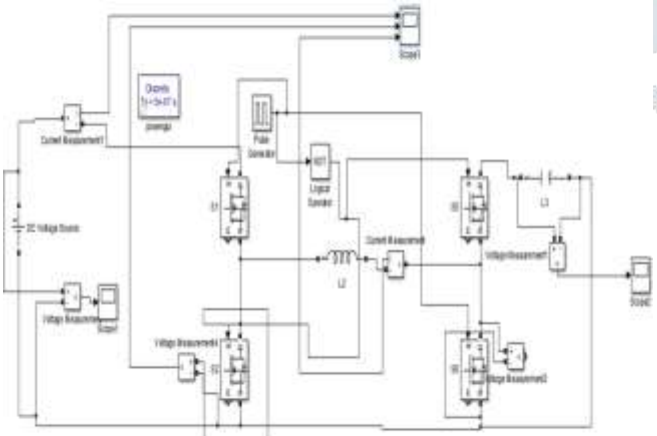


Fig. 5. current and voltage waveforms for mode A

b) Simulation output for mode B

In this mode of operation the ultra capacitor is charged. The energy discharges from dc link and stores in the ultra capacitor.



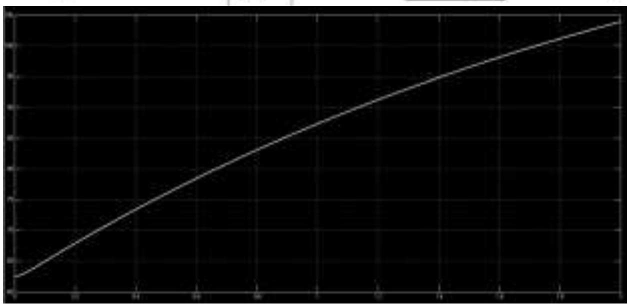


Fig.6. Simulink circuit for mode B2.

Fig.7. charging of ultra capacitor

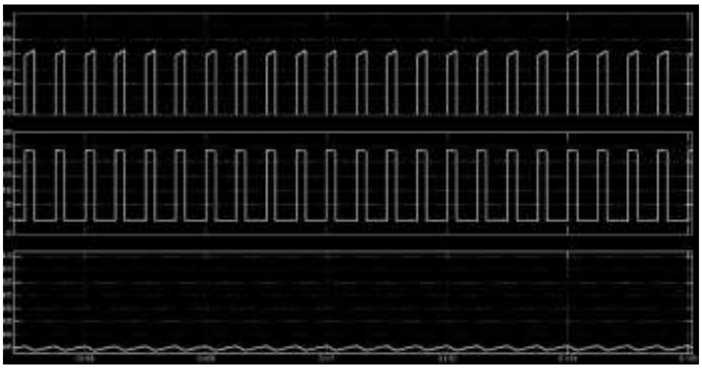


Fig.8. voltage and current waveforms for mode B2

c) Power transfer between battery and ultra capacitor

In this mode the energy stored in battery and discharges from ultra capacitor and vice versa. The results of charging and discharging are given below

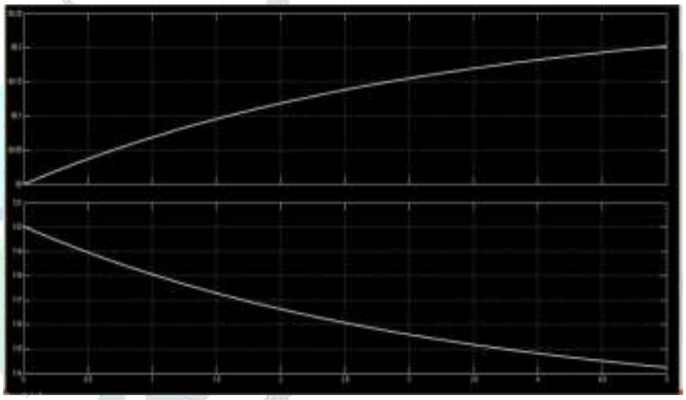


Fig.9. Charging of Battery and Discharging of ultra capacitor

d) Simulation output for mode D

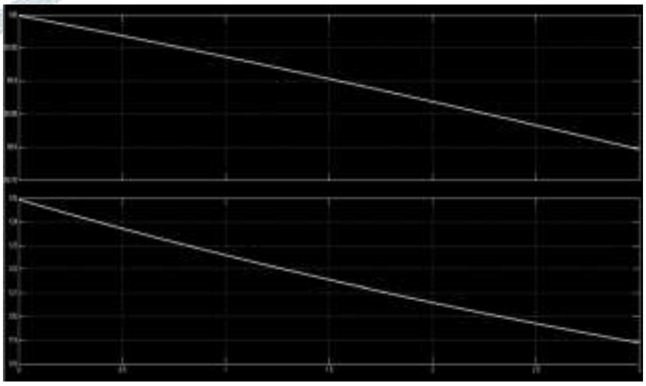


Fig.10. Voltage discharging from Battery to dc link and discharging of voltage from ultra capacitor to dc link.

e) Simulation output for mode E

During this mode of operation the energy supplied from DC link to ultra capacitor and also from dc link to battery, then it is supplied to the load. Therefore in this mode of operation both battery and ultra capacitor stores energy.

Fig.11.Charging of Ultra capacitor

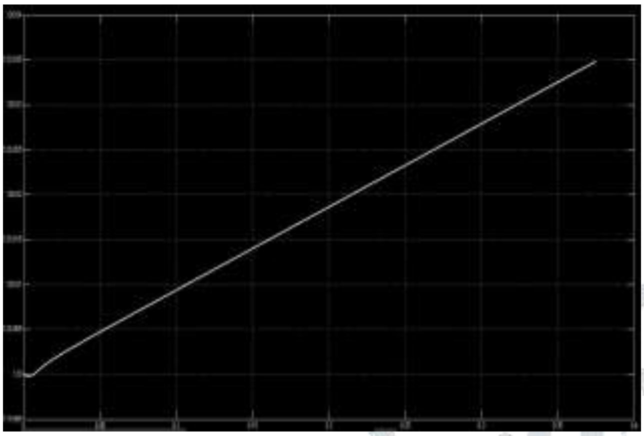
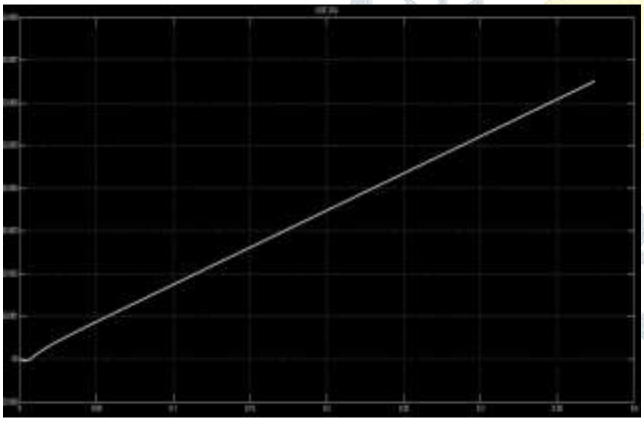


Fig.12.Charging of Battery



7. CONCLUSION

This examines a modular MIBC which interface the auxiliary sources is connected across the dc link are developed using simulation for charging and discharging of power. The performance of energy in different power transfer modes are obtained from the simulation output. The ultra capacitor and battery are connected to MIBC which gives best solutions. With simple circuit change there is a provision to add more number of sources to increase the efficiency and reduce the complexity. The modular MIBC used in power Grid applications, hybrid EV in which multiple sources are interfaced.

The simulation results of modular converter has validated the different modes of operation during energy transfer and storage process, which shows the effectiveness of the design. This converter applicable to grid and hybrid EV in which multiple sources are interfaced.

8.FUTURE SCOPE

The converter used in this project has three sources; the number of sources can be increase by adding two switches and one inductor in the circuit. Thus by simple circuit change more number of sources can be interfaced to transfer power transfer to the grid and also by using different MPPT technology we can improve the solar cell efficiency for more power extraction.

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BIOGRAPHIES

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