Design and Implementation of AC/DC Hybrid Microgrid using MATLAB/Simulink

Suchitra S.S [1], Sharan Kumar S.S[2]
[1,2] Integrated M.Tech (P.E.E) – V/V Year , School of Engineering, C.U.K-585367, Karnataka, India ,

Abstract— This paper presents the design and implementation of AC/DC hybrid micro-grid using MATLAB/Simulink. The proposed hybrid-grid consists of a DC grid and an AC grid, operates in autonomous mode and grid-tied mode. Photo-voltaic (PV) array and battery energy storage system (BESS) with DC loads are tied to the DC grid whereas, conventional AC loads are connected to the AC grid. By using BESS, power can be easily managed for future use. The control algorithms are proposed to balance power flow between AC and DC grids and to maintain the required both DC and AC voltages. The simulation results shows that the system is stable under various load and supply conditions. Moreover, the extra feature of the developed hybrid grid is avoids the multiple conversion units and enables the higher efficiency than individual DC or AC micro grid

Index Terms— Micro-grid, hybrid systems, Photo-voltaic (PV), battery energy storage system (BESS), Maximum power point tracking (MPPT).

I. INTRODUCTION

The global warming issue is well known to developing countries across the world. The energy production fossil fuels burning in one of vital issue causing pollution leading global warming. Generation of clean energy from renewable energy (RE) sources like wind, hydro, biomass, solar etc is the optimal solution for the cause. Electric utilities and end users of electric power are becoming increasingly concerned about meeting the growing energy demand [1]-[2].

Among the RE sources based power generation systems, photovoltaic (PV) systems are more popular because of simplicity in installation, easy maintenance, noiseless etc... Nowadays, a microgrid system is being considered as one of the best practices to the growth in the electric energy around the world. Battery energy storage systems (BESS) are becoming popular in various aspects of the power system issues [3]-[5].

Microgrids are referred to as a low voltage supply networks. It is a active distribution network because it consists of distribution generation (DG) systems and loads. Direct current (DC) microgrids are being deployed globally as distributed energy, solar PV, energy storage, consumer electronics, and LED lights are inherently DC resources. As these devices make up a large share of generation and demand, it is only natural to string them together on DC microgrids [6]-[9].

Over view of this paper is organized as follows. Significance of RE based systems, integration of microgrid with BESS are discussed in Section 1. PV system configuration and operation is given in the Section 2. Proposed AC/DC hybrid grid configuration and control methods are discussed in Section 3. MATLAB/Simulink based output results are given in Section 4. Section 5 is given the Conclusion.

II. PV SYSTEM, BESS CONFIGURATION AND MPPT OPERATION

A photovoltaic (PV) system is a system which uses one or more solar panels to convert sunlight into electricity.

2.1 PV system design:

Fig1 shows the single diode equivalent circuit model of a PV-cell [10]. The specifications of the PV system are given in the Table.1.

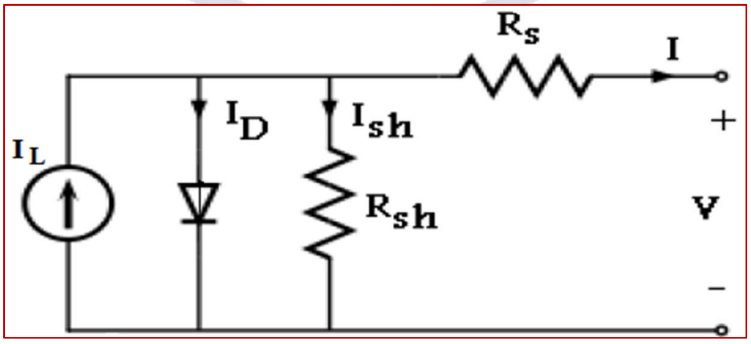

Fig.1. DC Equivalent Circuit of PV-Cell

2.2 MPPT Implementation:

In this paper, Incremental Conductance(IC) algorithm is adapted. t measures the voltage and current and sets conductance I/V and incremental conductance dI/ dV and decides the left or right operating point of the MPP respectively. The operational diagram of IC algorithm is given by Fig 2 [10].

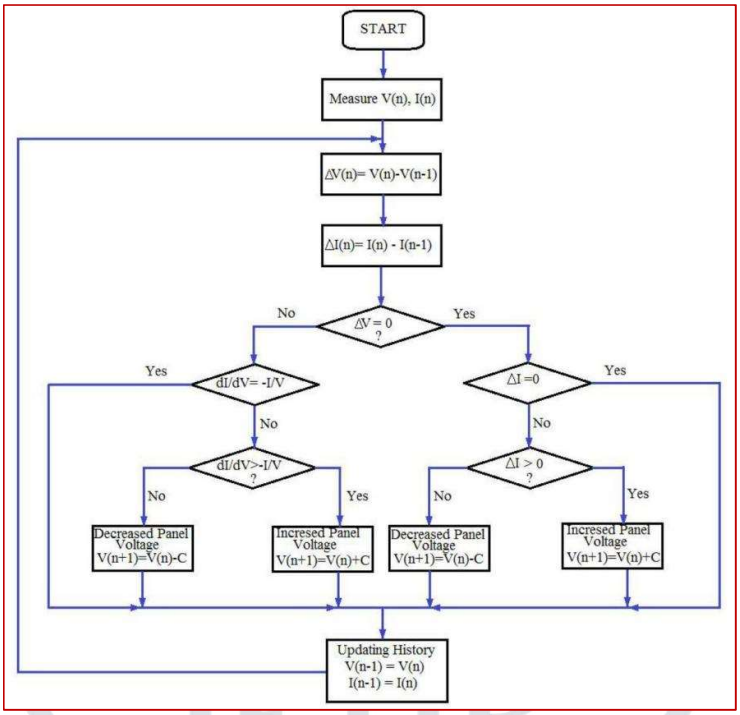

Fig.2. Operational diagram of IC Method

Table. I 25 kW PV Panel Parameters

Sl. No	Name of the parameter	Specification value
1	Number of modules connected in series	10
2	Number of modules in parallel	10
3	Reference irradiation	1000
4	Reference cell temperature	25
5	Voltage at Pmax Vmpp(V)	307
6	Open-circuit voltage Voc(V)	381
7	Short-circuit current Isc (A)	85.8
8	Current at Pmax Impp (A)	81.6
9	Diode ideality factor	1.5
10	Band gap energy	1.103

2.3 BESS Configurations:

The model of the BESS consists of battery, where input is given by the Vb i.e battery voltage and SOC i.e State of Charge. And the output of the battery is connected to set of two MOSFET which acts like a voltage controlled resistor. The parameters are given by Table. 2

Table.2 BESS Parameters

Battery type	Lithium Ion
Nominal Voltage(v)	96
Rated Capacity (Ah)	262
Initial SOC(%)	80
Maximum Capacity (Ah)	262
Fully Charged Voltage(V)	111.7128
Nominal Discharge Current(A)	113.913
Internal Resistance (Ohms)	0.0013
Capacity (Ah) at Nominal Voltage	236.9391
Exponential Voltage(V)	103.717
Exponential Capacity (Ah)	12.87217

III. Design of Proposed AC/DC Grid Configuration

Typical structure of DC microgrid connected to AC grid is shown in Fig 3.

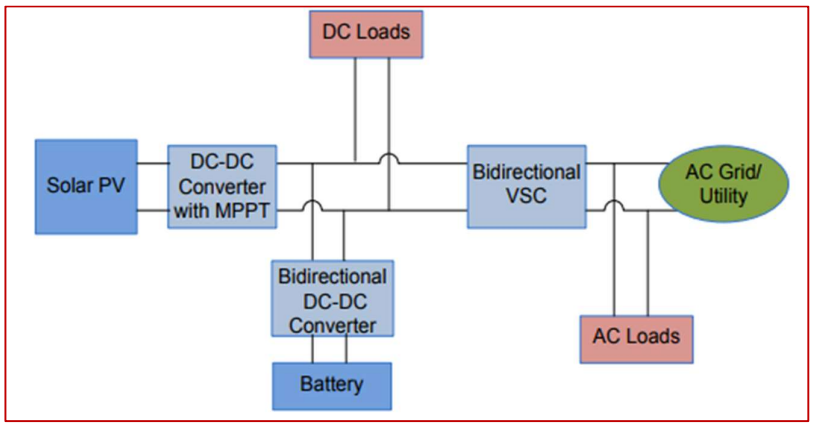

Fig. 3 Typical structure of DC Microgrid connected to AC grid

The model of ac/dc hybrid microgrid , consists of DC grid connected to the AC grid or utility grid. In the DC grid system, PV array and Battery storage system are present. The output of the PV array is connected to the Maximum Power Point Tracking, where the major principle of MPPT is to extract the maximum available power from PV module by making them operate at the most efficient voltage (i.e maximum power point).That is to say, MPPT checks output of the PV module, compares it to the battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into the battery. It can also supply power to the DC loads. The control system of the battery is to control the charging and discharging of the battery.

And the output of PV system and battery system is given to PLL where the concept of PLL is based around the idea of comparing the phase of two signals. The information about the error in phase or the phase difference between the two signals is then used to control the frequency of the loop.

Then the output from the PLL is given to the inverter, where it converts variable DC to fixed AC output. Then the output of the inverter and the output from the AC grid is connected to the 12 leg transformer. And then the AC loads are connected at the end. Block diagram representation of grid-interfacing inverter control is given by Fig 4 .

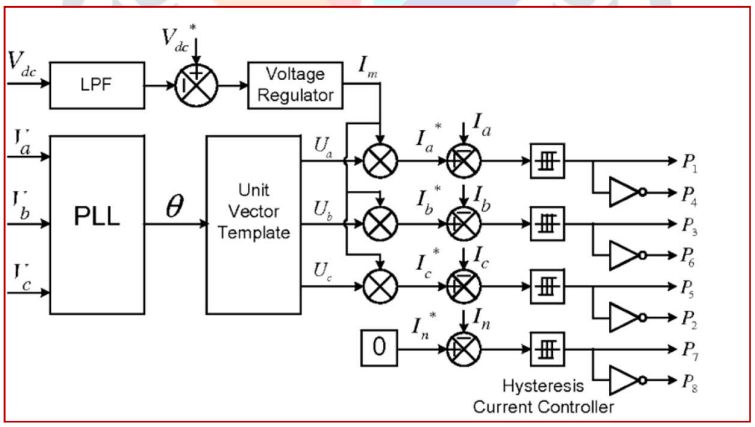

Fig 4. Grid-interfacing inverter control

IV. Results and Discussions

This sections converse the MATLAB/Simulink based results of the designed system. Simulation diagram of AC/DC hybrid microgrid connected to the utility grid is shown in Fig 5.

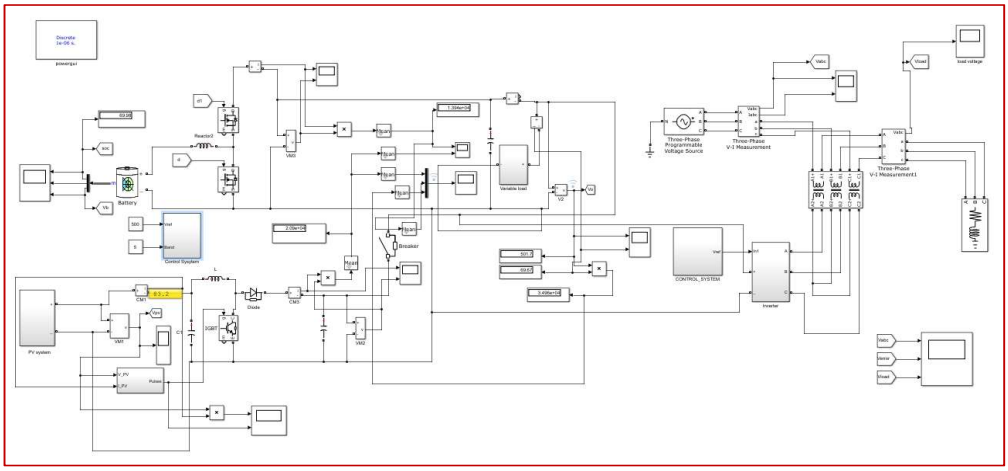

Fig 5. Simulation diagram of AC/DC hybrid microgrid

The output voltage and current response from the PV System is given by Fig 6.

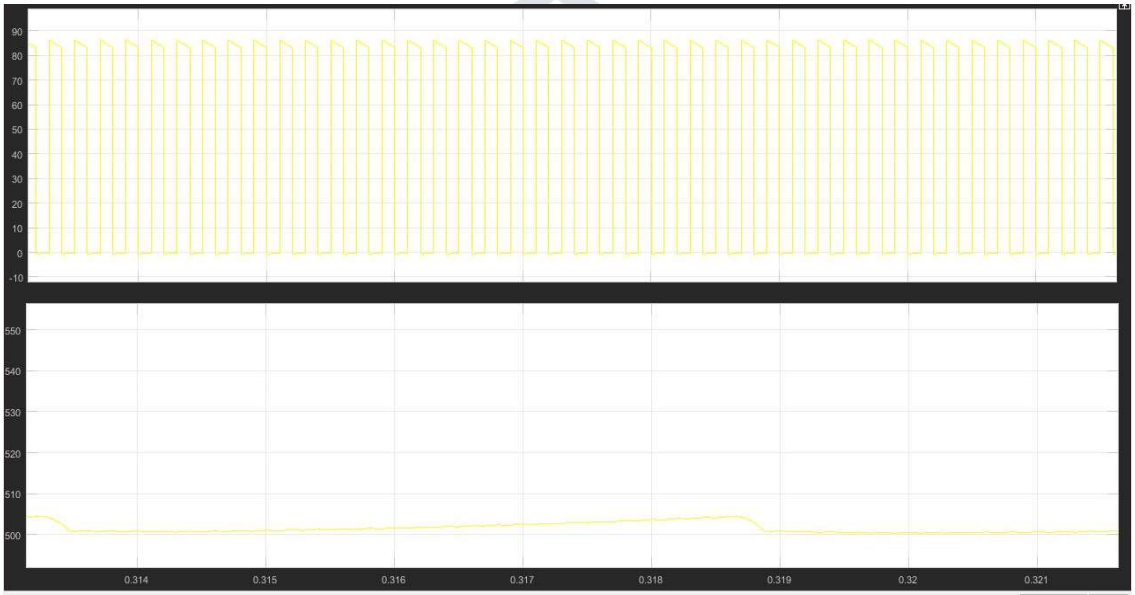

Fig.6 Output response of voltage and current from 25 kW PV system

The output of BESS is given by Fig 7.

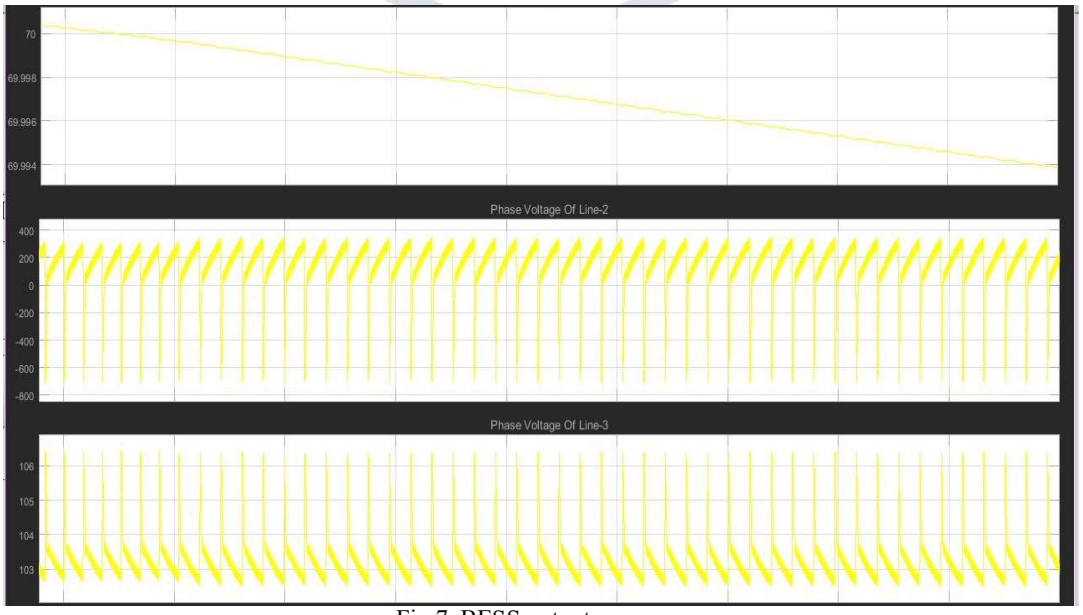

Fig 7. BESS output response

Output of the AC/DC hybrid microgrid simulation is given by Fig 8 and it indicating V_{abc}, V_{error} and V_{load}.

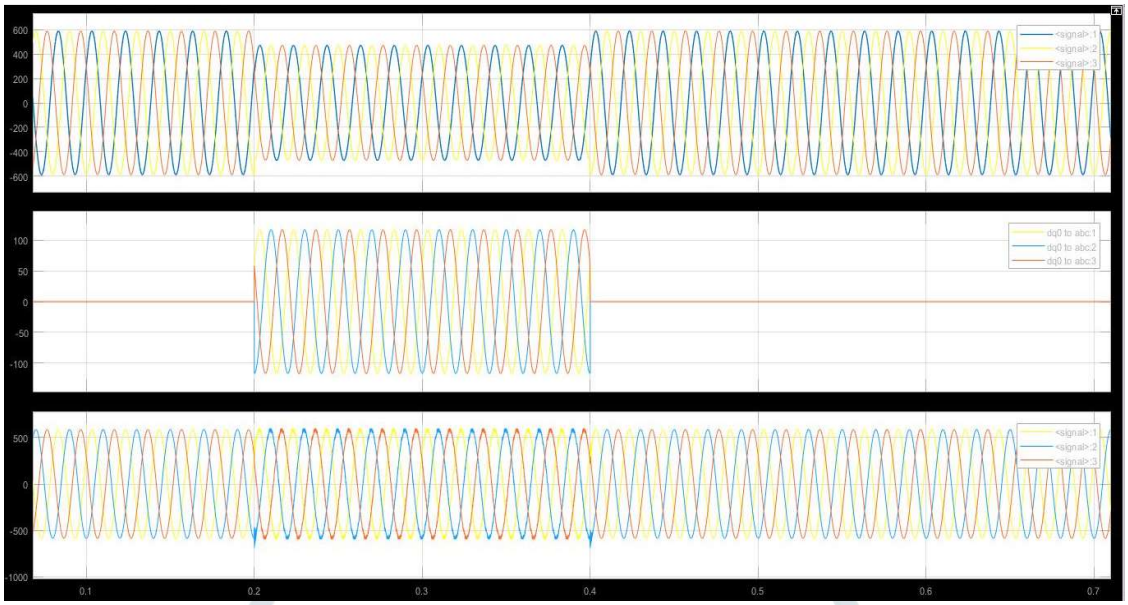

Fig 8. Output of the AC/DC hybrid microgrid simulation

V. CONCLUSION

In this paper, AC/DC hybrid micro-grid using MATLAB/Simulink has implemented. Simulation results at each individual block of the designed systems have given. The simulation results show that the system is stable under various load and supply conditions.

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