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Solar PV Based DGDSA DC Micro grid

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ABSTRACT:The paper details the power flow analysis between Solar module and BESS(Battery energy storage system) module of a typical home(Nano grid) of a DC micro grid. The proposed architecture of the DC micro grid is superior in comparison with existing architecture because of the distributed generation and distributed storage scheme. It is superior in terms of higher distribution efficiency, ability to provide power for communal loads, usage diversity and from the perspective of control. The proposed architecture thus eliminates the need for a central controller. The DC grid consists of several homes or Nano grids each having their own generation and storage capability. Each Nano grid is also capable ofsharing power between them in accordance with their power need. Power flow between Nano grids is controlled by Bidirectional converter. A detailed analysis is done in a Nano grid by analyzing their power flow and the results are published**.**

KEYWORDS: Solar module, Bidirectional Converter, Micro grid, Nano grid

I.INTRODUCTION

DC distributions are significantly more efficient as compared to AC considering the absence of DC to AC or AC to DC conversion. Furthermore, construction of large power plants and use of long distance transmission lines can be avoided. Shorter distance transmissions, along with fact that generation is distributed, avoids the costlier up conversions and down conversions of voltages. Hence, focus is on low voltage DC distribution systems, which have an end to end efficiency of approximately 80%. Solar PV- based micro grids generally use centrally located storage or distributed storage system, with a centrally located generation system. This is suitable in terms of controlling and monitoring but results in high distribution losses and affects future scalability. Moreover, a central generation is costly as it is quite difficult for a single large central solar power generation system to sustain all the households.

Considering the above mentioned problems, a Distributed Generation and Distributed Storage Architecture(DGDSA) is very much preferred over traditional DC grid architectures in terms of (a) Efficiency, (b) Scalability for future expansion, (c) Efficient aggregation of power for larger loads with limited rooftop PV, (d) Delivery of power to communal loads, (e) Reliable and simplified control without the need for a central controller.

II.ARCHITECTURE OF DGDSA DC MICROGRID

The micro grid is a system of interconnected self-sustained Nano grids, each of which constitute a household. This distributed generation and distributed storage system(DGDSA) is designed such that any surplus energy from households can fed to communal loads. So, each Nano grid consists of the fundamental generation and storage unit, that is, a roof-mounted solar panel and a battery, along with some DC loads.

Bidirectional flow of power is dictated by a Central Power Processing Unit(CPPU) which consist of a microcontroller, Maximum Power Point Tracking(MPPT) based DC-DC converter and a bidirectional flyback converter. Conversion of output voltage to values suitable for power supply and charging of the battery, while extracting maximum power from the solar panel, is done by the DC-DC MPPT converter. The Perturb and Observe(P&O) algorithm allows the controller to vary duty cycle of the converter to maintain conversion at maximum power point of the solar panel. Resource sharing between the micro grid and Nano grid is facilitated by the bidirectional flyback converter, whose characteristic bidirectional flow of power is achieved using a modified switch realization. This is done by replacing the diode in a traditional flyback converter with another MOSFET switch.

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Finally, a topology for interconnection of Nano grids must be selected. Two schemes were considered; radial interconnection, which is suboptimal due to uneven loading between the central and peripheral Nano grids, and a ring main scheme, which connects the peripheral Nano grids in a ring fashion. The ring main topology is much preferred for which is beneficial in case of grid disconnections due to damage or faults, since operation of the micro grid is not interrupted.

III.DESIGN OF THE SYSTEM

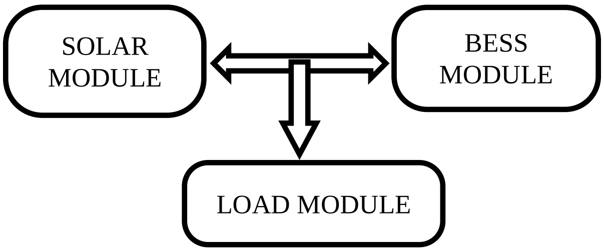

Fig 1. Block diagram of a Nano grid

The Solar module consists of solar array with maximum power rating of 100 watts corresponding to 17.8 volts and 5.6 amps. The output voltage of the Solar module is boosted by an Boost converter to 24 volts. The components of boost converter are designed such that switching frequency f_s =15Khz, Duty cycle D= 0.43, Inductance L= 2.066×10^{-2} , Capacitance C= 2.48×10^{-4} and resistance R =5.1 ohm.

Similar ratings apply for the bidirectional converter of the BESS module. A resistive element is taken as the load.

IV.MATHLAB SIMULATION

Both the Solar and the BESS module are integrated together such that they share the common load (represented by the resistor). The modules are integrated in such a way that both the Solar and the BESS modules are able to share power for the load in accordance with the load connected. If the load is connected in such a way that there is excess power after use consumption by load, excess power flows to the battery.

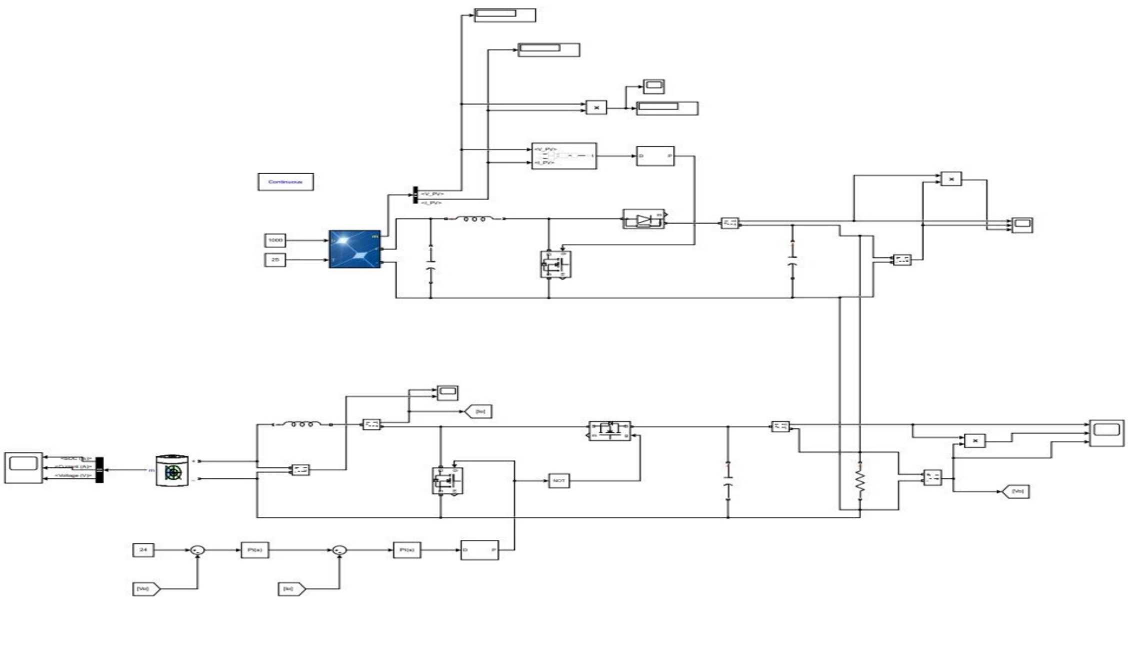

Fig 2. Simulink model ofintegrated Solar and BESS module

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The solar irradiance is taken as 1000W/m^2 and temperature as 25°C.The boosted output voltage of the Solar module is 24 volts. An output power of 100 to 168 watts is produced, with current ranging from5 to 7 amps.

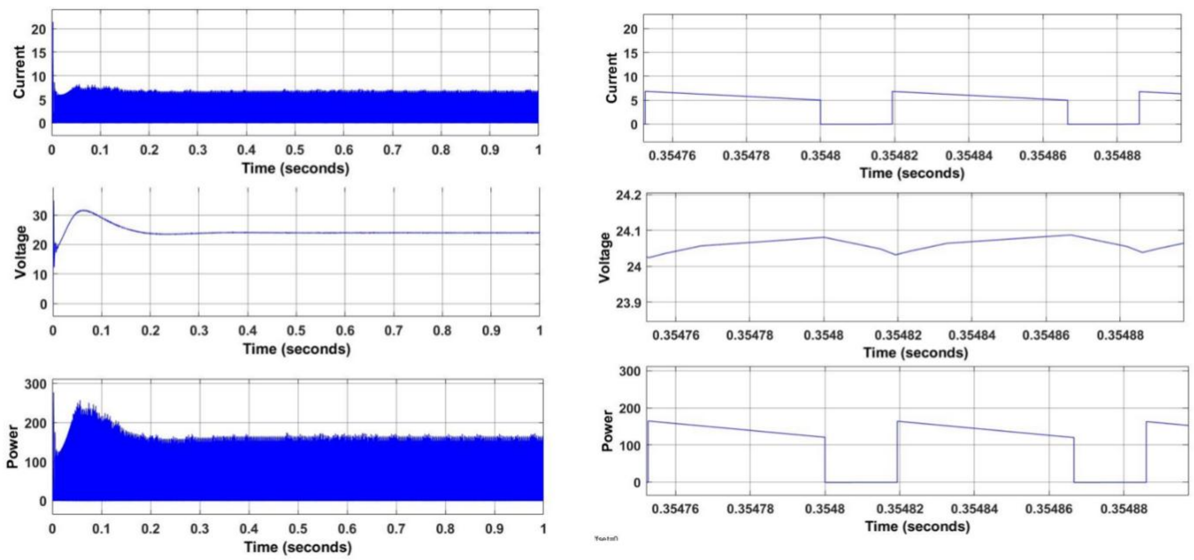

Fig 3. Graph shows the Current, Voltage and Power of the Solar module with Boost converter integrated

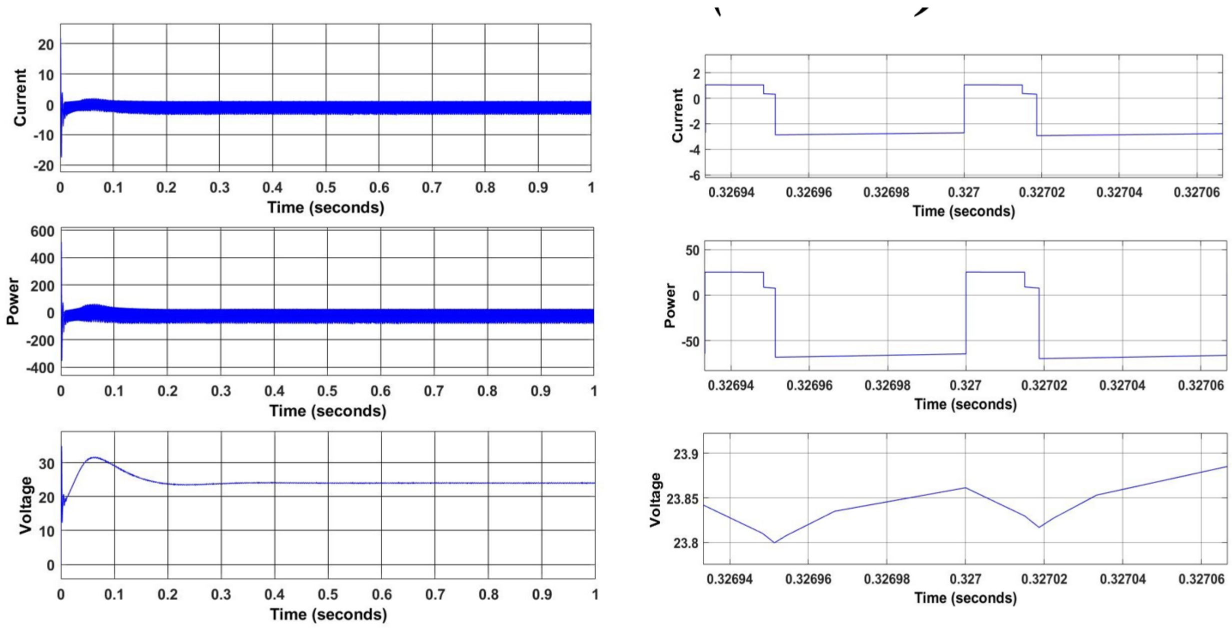

Fig4. Graph shows the Current, Power and Voltage of the bidirectional converter during charging stage

The current is negative because the battery is charging via the bidirectional converter by the excess power from the solar module. The voltage stays a nominal value of 24 volts. The power is showing negative value because the battery is charging.

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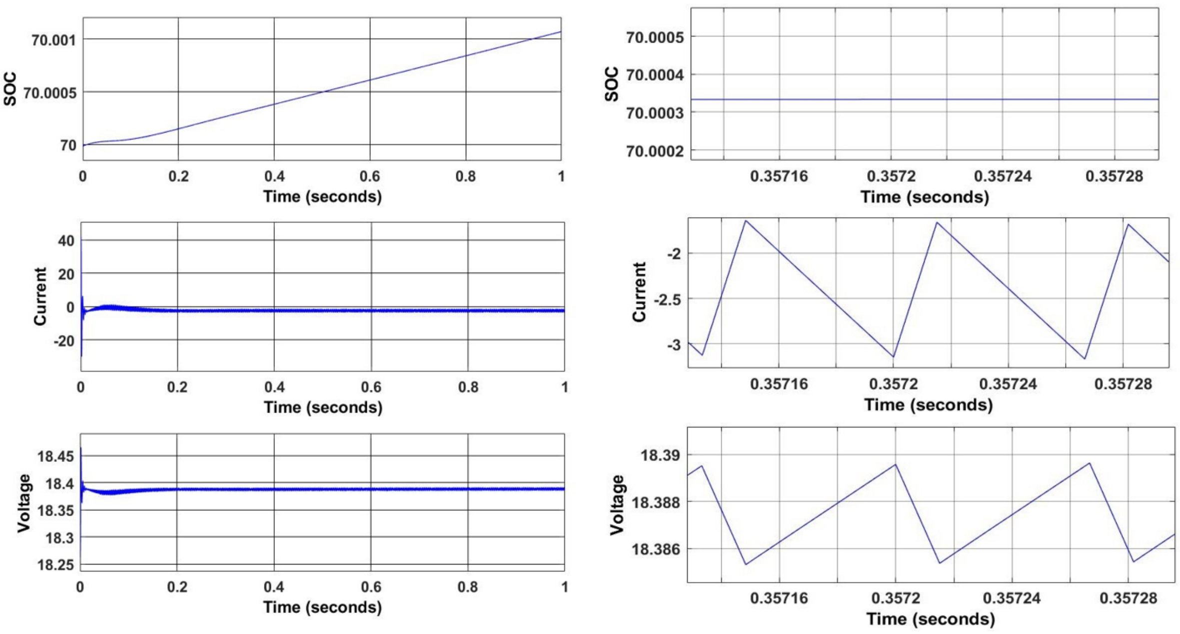

Fig 5. Graph showing the Battery parameters during charging stage.

The State of Charge (SOC) of the battery is increasing because excess power flows from the Solar module after consumption by the load. The current is negative because it is flowing into the Battery charging it. The voltage stays at a nominal value of 17 to 19 volts.

VI.CONCLUSION

This paper gives an optimized Nano grid architecture of a DGDSA Micro grid for rural electrification with emphasis on power sharing between the Solar and BESS modules. The result of the analyses shows that power flow from Solar and Bess module to the load in accordance with the load connected. Moreover, the DGDSA is scalable in terms of its design and operation. These gains in terms of efficiency and scalability are achieved through a modular interconnection of various contributing households (Nano grids) with distributed control.

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