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Design and Simulation of Bidirectional Inverter for Hybrid Power Systems for Grid Mode and Island Mode

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Abstract: This paper exhibits continuous composed control of hybrid AC/DC microgrids including vitality stockpiling and beat loads. Network detached hybrid microgrid applications require exceptional contemplations because of the irregular age, online vitality stockpiling control and beat loads. In this work, we present an extensive recurrence and voltage control conspire for a hybrid AC/DC microgrid comprising of a synchronous generator, sunlight based age emulator and bidirectional (AC/DC and DC/DC) con-verters. A bidirectional controlled AC/DC converter, with a functioning and receptive power decoupling strategy is utilized to connect the AC transport with the DC transport while managing the framework voltage and recurrence. A DC/DC boost converter with a most extreme power point following (MPPT) work is actualized to expand the discontinuous vitality age from sun oriented generators. Current controlled bidirectional DC/DC converters are connected to associate every lithium-particle battery bank to the DC transport. Lithium-ion battery banks go about as vitality stockpiling gadgets that serve to build the sys-tem flexibility by retaining, or infusing, control.
Keywords: Ancillary services, battery bank, critical load, energy management, hybrid AC/DC power system, micro grid, solar energy.

I. INTRODUCTION

An electric distribution technology steps into the next century, many trends are becoming salient that will adjust the essential requirement of energy distribution. These modifications are being driven from both the demand licence side where higher energy availability and efficiency are desired and from the supply side where the integration of distributed generation and peak shaving technologies must be accommodated.

In [1] a voltage-power droop/frequency reactive power boost (VPD/FQB) control plot that permits various voltage source converters (VSCs) to work in parallel in a VSC encouraged microgrid. Every present controlled VSC in such a microgrid has its own VPD/FQB controller that sets its present references to manage the voltage also, recurrence of a typical microgrid transport. By the voltage reference of every controller against its genuine power yield, numerous VPD/FQB controllers mutually direct the microgrid voltage while having a typical load control in extent to a pre-decided proportion. As [2] some of the aspects related to the design, control, operation and protection of photovoltaic (PV)systems are presented and investigated. The photovoltaic systems understudy are integrating their power to the common DC bus of a hybrid AC/DC microgrid in a smart grid infrastructure, where a communication layer is allowing wide area monitoring, control and protection of the whole system. These PV systems[5]can be mainly operated either in a voltage control mode, when the DC side of the system is disconnected from the main AC grid, or in a maximum power point tracking (MPPT) mode. Electric vehicles (EVs)[4]are viewed as a standout amongst the best tools to decrease the oilrequests and gas discharges. Also, they are welcome soon for general street transportation. This [7] proposes a hybrid2ac/dc micro8grid to diminish the procedures of numerous dc-ac dc orac dc-ac changes in an individual ac or dc lattice.

The hybrid grid performs its operation in two modes. In grid mode mode the main converter is to provide stable DC bus voltage, and required reactive power to exchange power between AC and DC buses. Maximum power can be obtained by controlling the boost converter and wind turbine generators. When output power of DC sources is greater than DC loads the converter acts as inverter and in this situation power flows from DC to AC side. When generation of total power is less than the total load at DC side, the converter injects power from AC to DC side. The converter helps to inject power to the utility grid in case the total power generation is greater than the total load in the hybrid grid,. Otherwise hybrid receives power from the utility grid. The role of battery converter is not important in system operation as power is balanced by utility grid. In Island mode the battery plays very important role for both power balance and voltage stability. DC bus voltage is maintained stable by battery converter or boost converter.

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II. SYSTEM CONFIGURATION

Fig3.1 describes the hybrid system configuration which consists of AC and DC grid. The AC and DC grids have their corresponding sources, loads and energy storage elements, and are interconnected by a three phase converter.

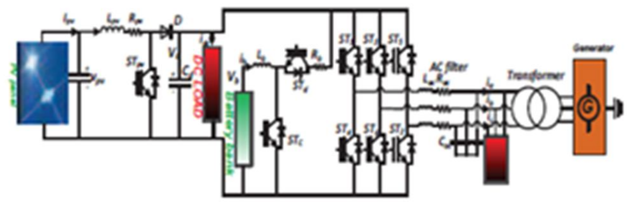

Fig 2.1 Proposed system block diagram

In the proposed system, PV arrays are connected to the DC bus through boost converter to simulate DC sources. A DFIG wind generation system is connected to AC bus to simulate AC sources. A battery with bidirectional DC/DC converter is connected to DC bus as energy storage. A variable DC and AC load are connected to their DC and AC buses to simulate various loads. PV modules are connected in series and parallel. As solar radiation level and ambient temperature changes the output power of the solar panel alters. A capacitor Cis added to the PV terminal in order to suppress high frequency ripples of the PV output voltage. The bidirectional DC/DC converter is designed to maintain the stable DC bus voltage through charging or discharging the battery when the system operates in the autonomous operation mode. The three converters (boost converter, main converter, and bidirectional converter) share a common DC bus. A wind generation system consists of doubly fed generator (DFIG) with back to back AC/DC/AC PWM converter connected between the rotor through slip rings and AC bus. The AC and DC buses are coupled through a three phase transformer and a main bidirectional power flow converter to exchange power between DC and AC sides. The transformer helps to step up the AC voltage of the main converter to utility voltage level and to isolate AC and DC grids.

III. COORDINATION CONTROL

In grid-connected mode, the AC side can be viewed as an infinite bus. Therefore the variances of the voltage amplitude and frequency can be ignored. In this case, the bi-directional AC/DC converter only needs to regulate the DC bus voltage. In order to operate in unit power factor, reference iq can be set as 0. The controller only need to control the id , which in the end will control the active power flow through the converter. What's more, if the grid needs the microgrid to provide ancillary services, such as V2G frequency regulation, the proposed configuration is also qualified.

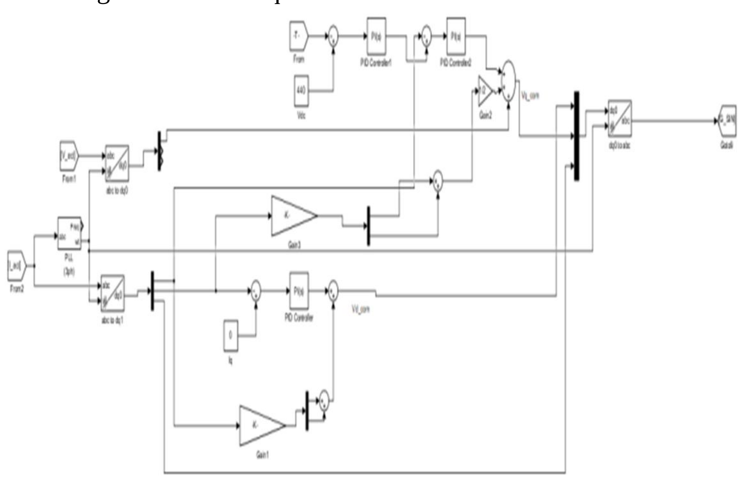

Fig 3.1 The control block diagram for bi-directional AC/DC converter in grid-connected mode

The Control scheme for the bi-directional AC/DC inverter in grid-connected mode shown in Fig 3.2. In islanding operation mode, the frequency and voltage amplitude of the three phases AC side are not so robust, therefore a device is needed to regulate them. The bi-directional AC/DC inverter is used to regulate the active and reactive power by controlling the id and iq respectively.

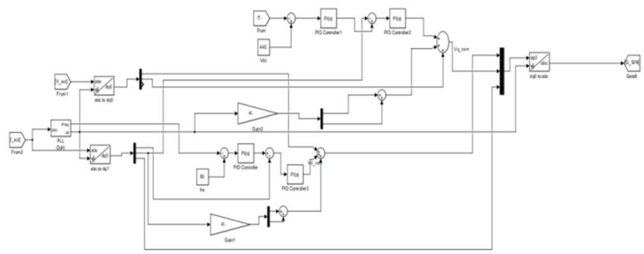

Fig 3.2 The control block diagram for bi-directional AC/DC converter in islanding mode

The Control scheme for the bi-directional AC/DC inverter in islanding mode shown in Fig 3.3In islanding operation mode, the frequency and voltage amplitude of the three phases AC side are not so robust, therefore a device is needed to regulate them. The bi-directional AC/DC inverter is used to regulate the active and reactive power by controlling the id and iq respectively

IV. SIMULATIONRESULTS

A. Grid mode

Fig 3.4 shows the simulation circuit in grid mode. In this mode the main converter is to provide stable DC bus voltage, and required reactive power to exchange power between AC and DC buses. Maximum power can be obtained by controlling the boost converter and wind turbine generator

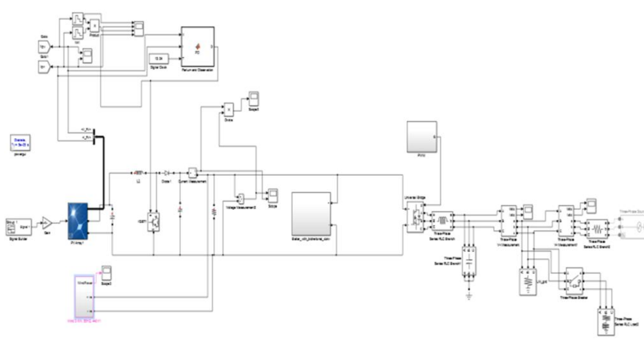

Fig4.1 Simulation circuit in grid mode

When output power of DC sources is greater than DC loads the converter acts as inverter and in this situation power flows from DC to AC side. When generation of total power is less than the total load at DC side, the converter injects power from AC to DC side. The converter helps to inject power to the utility grid in case the total power generation is greater than the total load in the hybrid grid,. Otherwise hybrid receives power from the utility grid. The role of battery converter is not important in system operation as power is balanced by utility grid

The PV board can be seen as a present source in parallel with a diode. In this paper, the SunPower SPR-305-WHT sun based cell, with 305W greatest yield control, is utilized. 33 cells are utilized as a part of the setup of 11 parallel strings, with 3 serially associated cells per string.

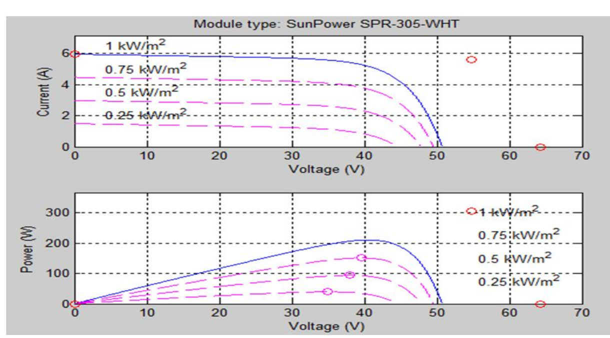

Fig 4.2 I-V and P-V curves for PV panel Sunpower SPR-305-WHT

Fig.4.2 demonstrates the non-direct P-V and I-V electric attributes of a solitary SunPower SPR-305-WHT sun oriented offer.

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The PV panel can be viewed as a current source in parallel with a diode. In this paper, the SunPower SPR-305-WHT solar cell, with 305W maximum output power, is used. 33 cells are used in the configuration of 5 parallel strings, with 5 serially connected cells per string.

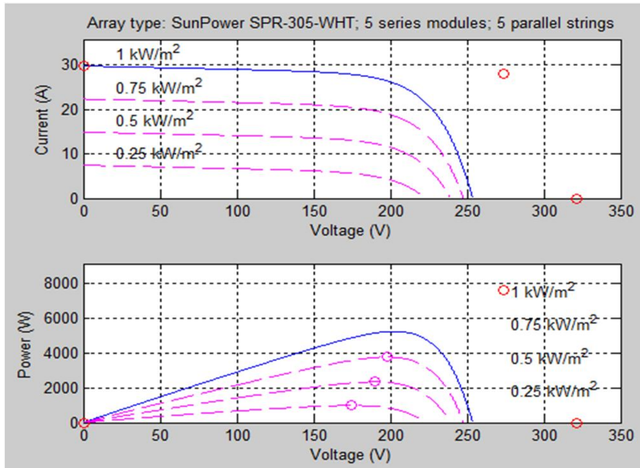

Fig 4.3 I-V and P-V curves for PV panel Sunpower SPR-305-WHT for 5 modules 5 parallel strings

Under various sun based illuminations, the most extreme control purposes of the power-voltage bends are related with various yield voltages. Likewise, under certain sun powered irradiance, the yield of the PV board is fluctuating with various terminal voltages.

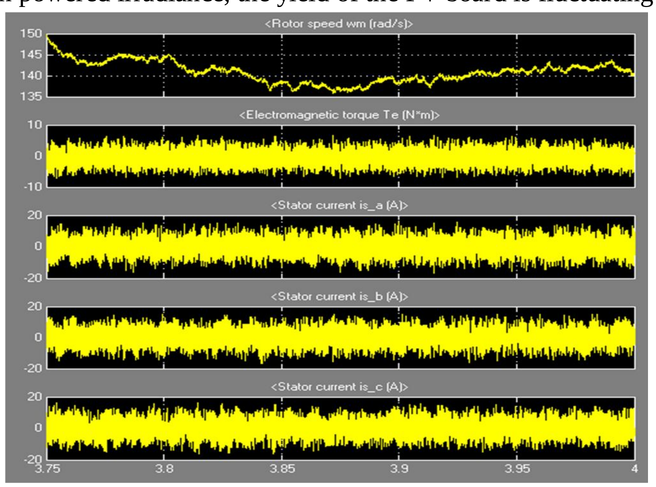

Fig 4.5 Simulation results for rotor speed, Electromagnetic torque, stator current

B. Island Mode

Fig 4.6 shows the simulation circuit in islanding mode. The battery plays very important role for both power balance and voltage stability.

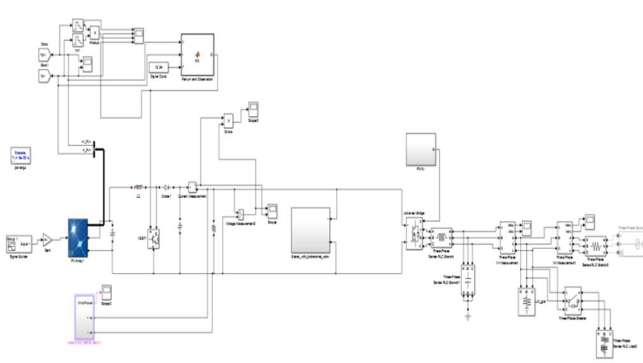

Fig 4.6 Simulation circuit in island mode

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DC bus voltage is maintained stable by battery converter or boost converter. The main converter is controlled to provide stable and high quality AC bus voltage

Fig 4.7 shows three phase voltage and current at load in grid mode. In grid mode the battery is in charging state the converter are designed with coordination control.

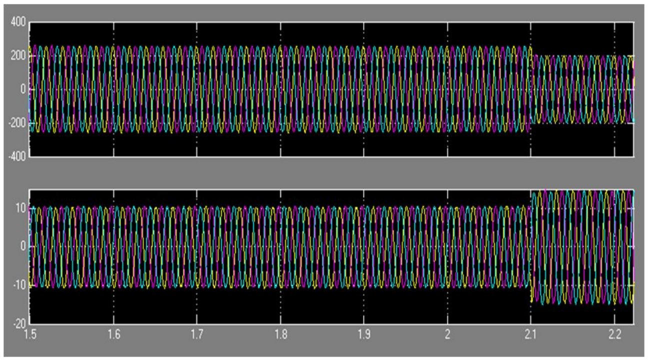

Fig 4.7 Three phase voltage and current at pulsed load in grid mode

The output at pulsed load is as shown in fig 4.2. In grid mode the generator and PV panel are in operating condition If there is any fault at the pv panel the grid generator will take care of the dc load by using the bidirectional converter which converter the ac to dc for feeding dc loads.

Island mode

The response of wind speed, three phase stator voltage and three phase rotor voltage are shown in the figs 3.4.

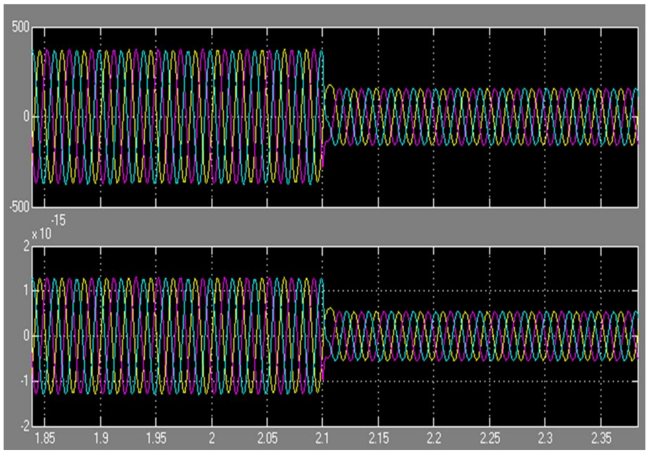

Fig.4.8 Three phase current and voltages at the load in island mode

Here the value of wind speed varies between 1.0 to 1.05 pu. The output voltage is set to 300V . The efficiency of the total system depends on the diminution of conversion losses and the increase for an extra DC link.

V. CONCLUSION

The modeling of hybrid microgrid for power system configuration is done in MATLAB/SIMULINK environment. The present work mainly includes the grid tied mode of operation of hybrid grid. The models are developed for all the converters to maintain stable system under various loads and resource conditions and also the control mechanism are studied. MPPT algorithm is used to harness maximum power from DC sources and to coordinate the power exchange between DC and AC grid. Although the hybrid grid can diminish the processes of DC/AC and AC/DC conversions in an individual AC or DC grid, there are many practical problems for the implementation of the hybrid grid based on the current AC dominated infrastructure. The efficiency of the total system depends on the diminution of conversion losses and the increase for an extra DC link. The hybrid grid can provide a reliable, high quality and more efficient power to consumer. The hybrid grid may be feasible for small isolated industrial plants with both PV systems and wind turbine generator as the major power supply.

VI. ACKNOWLEDGEMENT

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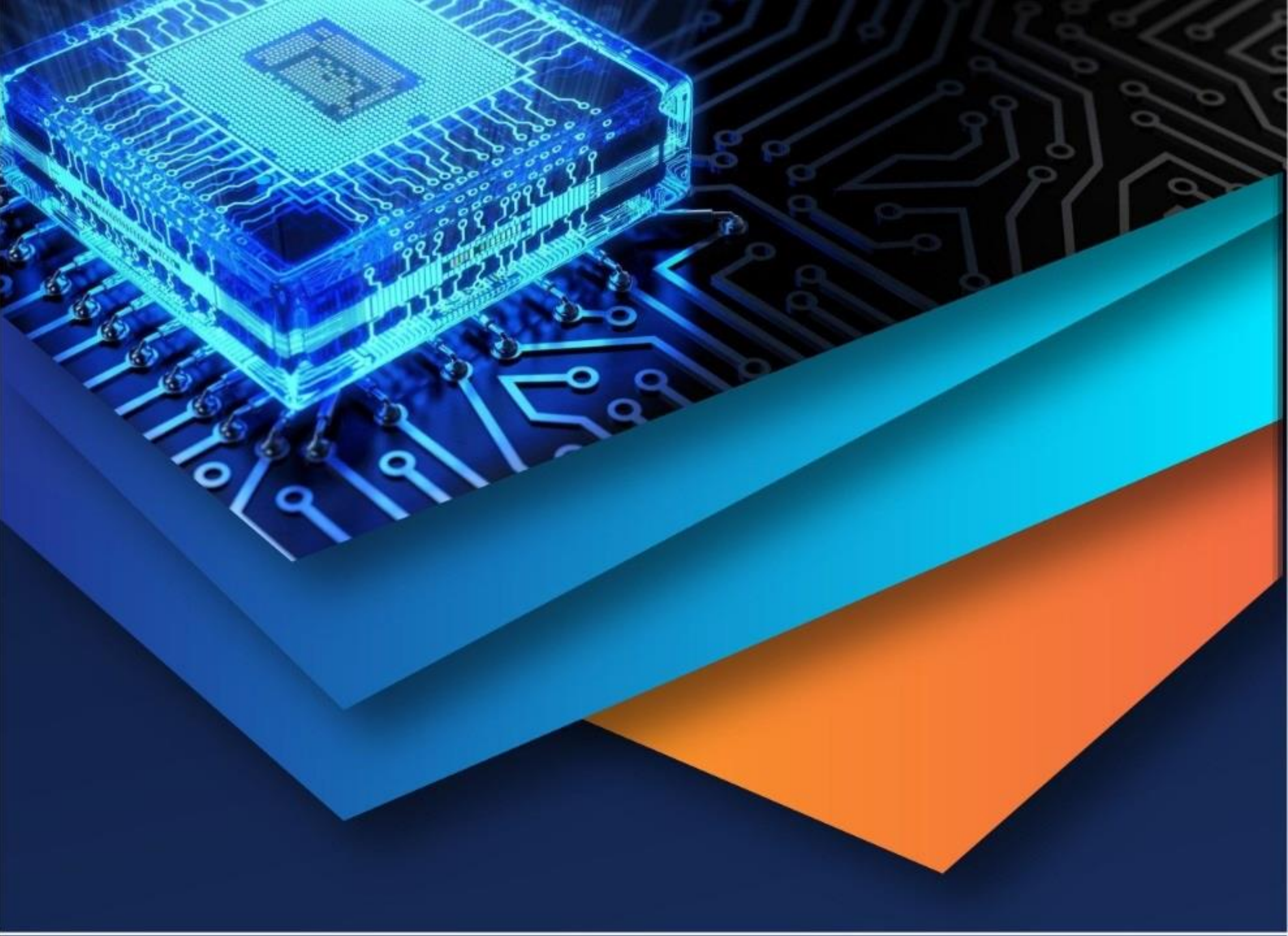

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