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DEMAND MANAGEMENT IN HYBRID MICROGRID

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Abstract — ***This paper presents a hybrid AC/DC micro grid which will reduces the process of several reverse conversions in an individual AC and DC grid. The renewable sources such as wind generators, photovoltaic panels and fuel cell are connected to a hybrid grid. AC sources and loads are linked with AC grid and DC sources and loads are linked with DC grid. The proposed hybrid grid operates in a grid-tied or autonomous mode. Both AC and DC networks are connected by a multi- bidirectional converter. This multi-bidirectional converter operates in parallel with AC and DC grid. Hence, demand over an individual grid can be coordinately controlled by multi-bidirectional converter. The co-ordination control algorithm at the bidirectional converter is proposed. Co-ordination control provides uninterrupted and smooth power transfer between AC and DC link. A hybrid grid has modeled and simulated using the Simulink in the MATLAB. The simulation results show that the system can provides uninterrupted power, smooth power transfer between AC and DC link and also manage the demand.***

Keywords— ***Demand Management, Hybrid Micro Grid (HMG), Bi-Directional Converter.***

I. INTRODUCTION

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. Power systems currently undergo considerable change in operating requirements mainly as a result of deregulation and due to an increasing amount of distributed energy resources (DER). In many cases DERs include different technologies that allow generation in small scale (micro sources) and some of them take advantage of renewable energy resources (RES) such as solar, wind, Fuel cell. Having micro sources close to the load has the advantage of reducing transmission losses. When power can be fully supplied by local renewable power sources, long distance high voltage transmission is no longer necessary [1].

AC micro grids [2]–[5] have been proposed to facilitate the connection of renewable power sources to conventional ac systems. The dc microgrid has been proposed [6]–[10] to integrate various distributed generators. However, a dc source of renewable energies such as photovoltaic (PV) panels or fuel cells has to be converted into ac by dc/dc boosters and dc/ac inverters in order to connect to an ac grid. Similarly, ac source of energies such as wind, diesel has to be converted into dc by AC/DC converters in order to connect to a dc grid.

Hence in an individual ac or a dc grid there will be lots of conversion process that will make the system more complex and add additional losses. The objective of building a smart grid is to offer reliable, high quality electric power to societies in sustainable way. One of most vital futures of a smart grid is the advanced structure which can enable the connections of various ac and dc generation systems, energy storage options, and various ac and dc loads with the optimal asset utilization, operation efficiency and demand management. To achieve those goals, power electronics devices plays a most vital role to interface different sources and loads to a smart grid.

The proposed hybrid micro grid will reduce several conversions process in an individual ac or dc grid and to enable the connection of various renewable ac, dc sources and loads to power system. Co-ordination control algorithm provides uninterrupted and smooth power transfer between AC and DC link. The advanced power electronics device used in this paper will make an upcoming power grid much smarter.

II. SYSTEM CONFIGURATION AND MODELING

Fig.1 shows the hybrid system configuration where various ac, dc sources and loads are connected to the corresponding dc and ac grids. The ac and dc grids are connected together through two four-quadrant operating three phase converters and two transformers. The ac bus of the hybrid grid is tied to the utility grid.

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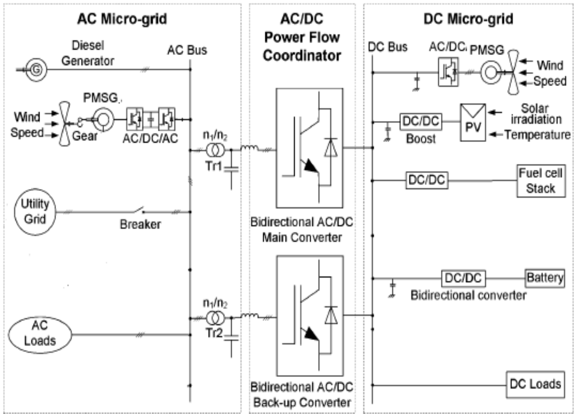

Fig 1: Simulation Model of Hybrid Micro Grid

A hybrid grid shown in Fig.1 is modeled using the Simulink in the MATLAB to simulate system operations and controls. The sources rating are shown in table below

TABLE 1 SIMULATION PARAMETERS AND RATING

S. No	*Simulation parameter*	*Values*
1	PV	50KW
2	Wind power	50KW
3	Fuel cell	50KW
4	Battery	10KW
5	load at AC side	50KW
6	load at DC side	50KW
7	Frequency	50Hz

2.1 Grid Operation

The hybrid grid can operate in two modes that is grid-tied and autonomous mode. In grid-tied mode, the main converter is to provide stable dc bus voltage and to exchange power between the ac and dc buses. The main converter is designed to operate bi directionally to incorporate complementary characteristic of power sources [11], [12]. When the output power of the dc grid side is larger than the dc load the bi-directional converter act as inverter and the power is transmitted to ac grid. Similarly when the output power of ac grid is larger than the ac loads the bi-directional converter act as converter and the power is transmitted to dc grid. When the total power generation is larger than the total load in the hybrid micro grid, it will inject power to the utility grid. Otherwise, the utility grid will provide power to hybrid micro grid.

III. CO-ORDINATION CONTROL IN HYBRID MICRO GRID

3.1 Co-ordination Control of Main Converter

The role of the main converter is to exchange power between AC and DC bus. The key purpose of main converter is to maintain a stable DC-link voltage in grid tied mode. When the converter operates in grid tied mode, it has to supply a given active and reactive power. Here PQ control scheme is used for the control of main converter. The PQ control is achieved using a current controlled voltage source. Two PI controllers are used for real and reactive power control. When resource conditions or load capacities change, the DC bus voltage is settled to constant through PI regulation. The PI controller is set as the instantaneous active current idm reference and the instantaneous reactive current iqm reference is determined by reactive power compensation command.

The model of the converter can be represented in ABC coordinate as

$$L_2\frac{d}{dt}\begin{pmatrix} i_A \\ i_B \\ i_C \end{pmatrix} + R_2\begin{pmatrix} i_A \\ i_B \\ i_C \end{pmatrix} = \begin{pmatrix} v_{SA} \\ v_{SB} \\ v_{SC} \end{pmatrix} - \begin{pmatrix} v_{CA} \\ v_{CB} \\ v_{CC} \end{pmatrix} \quad \text{...... (1)}$$

The above equation can be written in the d-q coordinate as

$$L_2\frac{d}{dt}\begin{pmatrix} i_{dm} \\ i_{qm} \end{pmatrix} = \begin{pmatrix} -R_2 & \omega L_2 \\ -\omega L_2 & -R_2 \end{pmatrix}\begin{pmatrix} i_{dm} \\ i_{qm} \end{pmatrix} + \begin{pmatrix} v_{Sd} \\ v_{Sq} \end{pmatrix} - \begin{pmatrix} v_{cd} \\ v_{cq} \end{pmatrix} \quad \text{.... (2)}$$

Where (iA, iB, iC) and (vCA, vCB, vCC) are three phase current and voltages of the main converter. Three phase voltage of AC bus voltage are represented by the notations as (vSA, vSB, vSC). The variables (idm, iqm), (vcd, vcq), (vsd, vsq) are d-q coordinates of three phase currents, voltages of main converter and voltage of AC bus respectively.

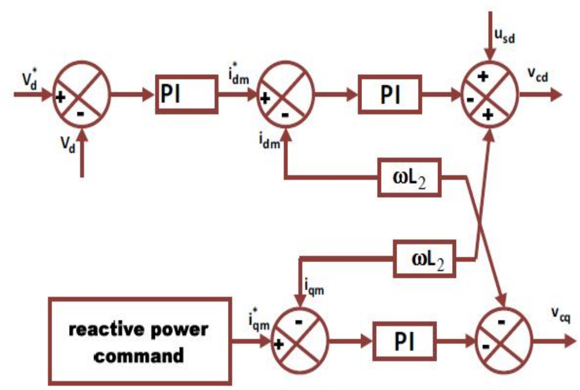

Fig 2 : Co-ordination control of Main Converter

In case of sudden DC load drop, there is power surplus at DC side and the main converter is controlled to transfer power from DC to AC side. The active power absorbed by the capacitor Cd leads to rising of DC-link voltage Vd. The negative error caused by the increase of Vd produces a higher active current reference i*dm, through PI control. A higher positive reference i*dm will force active current reference idm to increase through the inner current control loop. Therefore the power surplus of the DC grid can be transferred to the AC side.

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IV. SIMULATION RESULTS

4.1 DC Bus Voltage

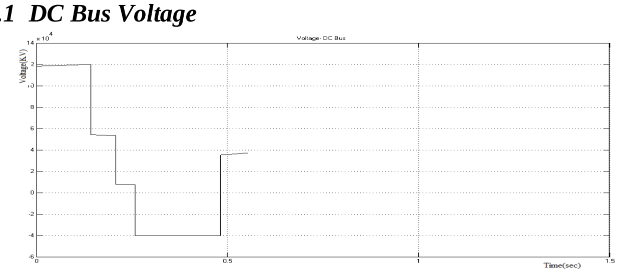

Fig 5 : DC Bus Voltage

Fig.5 shows the DC Bus Voltage. The DC bus voltage is taken as 120KV. At initial stage all the DC sources are ON condition. Due to the uncertainty characteristics of renewable sources it is shown that it gets switched off.

4.2 Inverter output voltage, DC power and current

Fig.6a shows the simulation result for inverter. When there is demand over the AC grid side the multi -bidirectional converter act as an inverter and the demand is managed. The backup converter works when there is failure occur in the main converter. The yellow color indicates the DC power.Fig.6b shows the current waveform that supplies the AC grid.

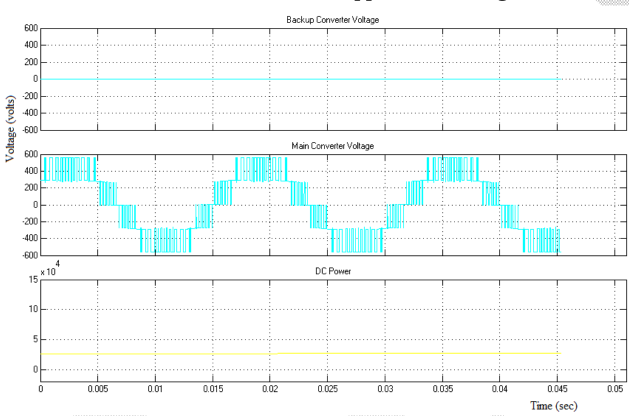

Fig 6a : Inverter Voltage and DC Power Waveforms

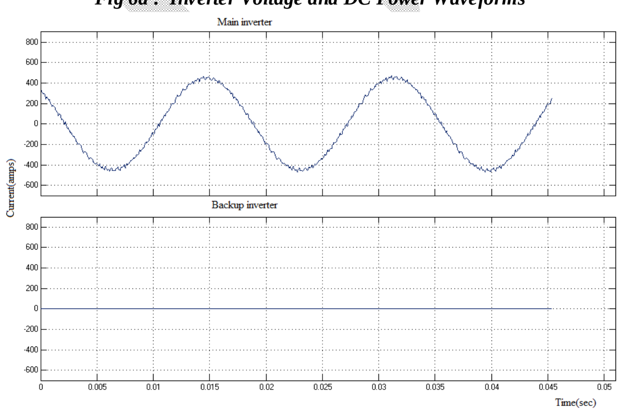

Fig 6b : Inverter Current Waveform

4.3 AC Load Voltage and Load current

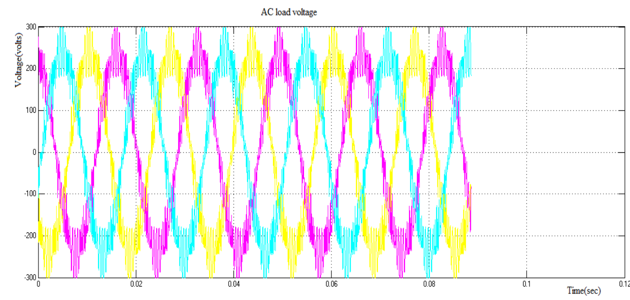

Fig 7a : AC Load Voltage Waveform

Fig.7a shows the AC load voltage waveform. 300 volt is supplied at the AC load side

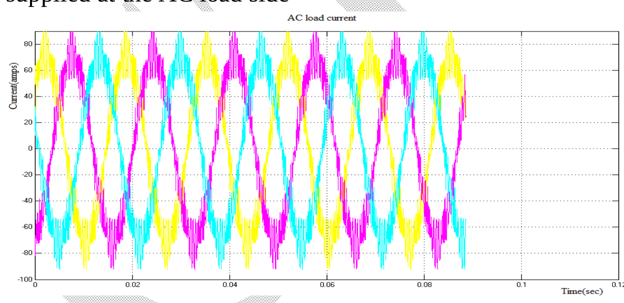

Fig 7b : AC Load Current Waveform

Fig.7b shows the AC load current waveform. 90 amps of current is supplied at the AC load side.

4.4 Converter Voltage and DC Power

Fig.8 shows the simulation results for converter voltage and DC power. When there is demand over the DC grid side the multi-bidirectional converter acts as an converter and the demand over the DC grid is managed.

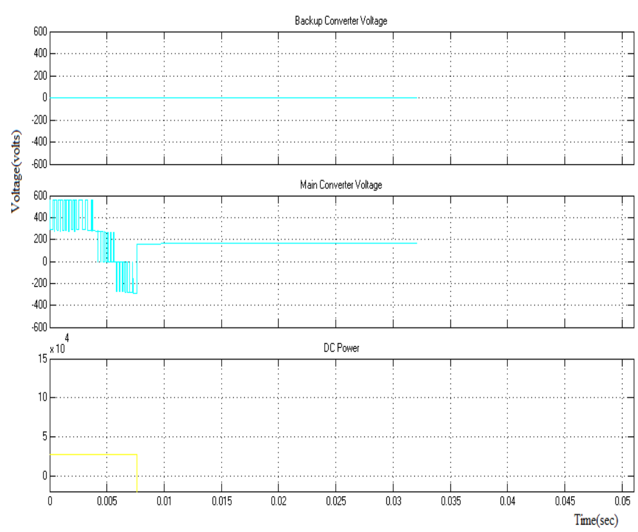

Fig 8 : Converter Voltage and DC Power

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4.5 Failure of the Main Converter

Fig.9 shows the simulation results for main converter. When the main converter operates to fail the backup converter starts to operate.

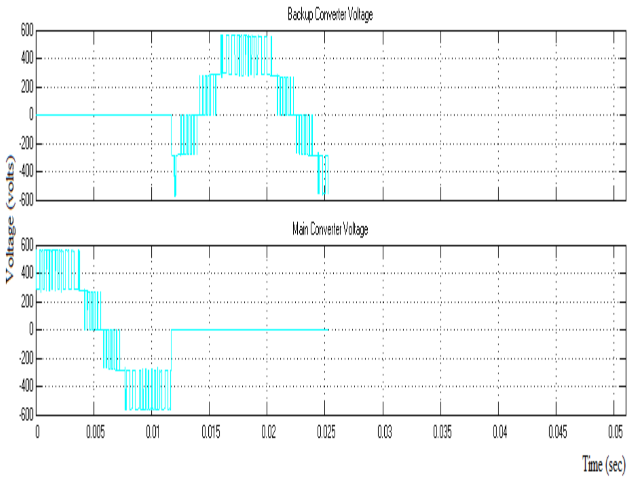

Fig 9 : Waveform of Backup Converter when Main Converter Fails

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 and autonomous 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 were proposed

Hybrid micro grid is proposed for electric power supply system. It integrates the multiple power sources thus enhancing the reliability of power supply. It also enhances the controllability of power supply by including power electronic interfaces. HMG can employ co-ordination control to control and supply the entire system. It can integrate multiple power sources, such as the utility grid and various renewable energy DGs, and energy storage into the electric power supply system, which can improve the reliability of the power supply. It provides both AC and DC buses for different power demand which can provide a reliable, high quality and more efficient power to consumer. And it will diminish the processes of DC/AC and AC/DC conversions in an individual AC or DC grid.

Doubtless, a co-ordination control employed in the HMG to control and supply the entire system. The HMG can be designed to be efficient which makes it very promising for power supply. High reliability coming from utilizing both the utility grid and the renewable sources, high efficiency owing to directly feeding of AC and DC loads. More importantly, because multiple power sources and energy storage are integrated and power electronic converters are used popularly, both the consumer-dominating demand side management is attained.

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