International Refereed Journal of Engineering and Science (IRJES)
ISSN (Online) 2319-183X, (Print) 2319-1821
Volume 5, Issue 8 (August 2016), PP.07-15

Design & Simulation of Micro grid

Adil Sheikh[1], Pranita Chavan[2]
[1]*Student, Department of Electrical Engg. YTIET, Karjat, Raigad, Maharastra*
[2]*Asst. Professors, Department of Electrical Engg. YTIET, Karjat, Raigad, Maharastra*

Abstract:- Renewable energy based distributed generators (DGs) play a dominant role in electricity production, with the increase in the global warming. Distributed generation based on wind, solar energy, biomass, mini-hydro along with use of fuel cells and microturbines will give significant momentum in near future. Advantages like environmental friendliness, expandability and flexibility have made distributed generation, powered by various renewable and nonconventional microsources, an attractive option for configuring modern electrical grids. A microgrid consists of cluster of loads and distributed generators that operate as a single controllable system. As an integrated energy delivery system microgrid can operate in parallel with or isolated from the main power grid. The microgrid concept introduces the reduction of multiple reverse conversions in an individual AC or DC grid and also facilitates connections to variable renewable AC and DC sources and loads to power systems. The interconnection of DGs to the utility/grid through power electronic converters has risen concerned about safe operation and protection of equipment's. To the customer the microgrid can be designed to meet their special requirements; such as, enhancement of local reliability, reduction of feeder losses, local voltages support, increased efficiency through use of waste heat, correction of voltage sag or uninterruptible power supply. In the present work the performance of hybrid AC/DC microgrid system is analyzed in the grid tied mode. Here photovoltaic system, wind turbine generator and battery are used for the development of microgrid. Also control mechanisms are implemented for the converters to properly co-ordinate the AC sub-grid to DC sub-grid. The results are obtained from the MATLAB/ SIMULINK environment.
Keywords: Renewable Energy, Microgrid, MATLAB, Distributed Generation

I. INTRODUCTION

As electric distribution technology steps into the next century, many trends are becoming noticeable that will change the requirements of energy delivery. These modifications are being driven from both the demand 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 [1].

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 (microsources) and some of them take advantage of renewable energy resources (RES) such as solar, wind or hydro energy. Having microsources close to the load has the advantage of reducing transmission losses as well as preventing network congestions. Moreover, the possibility of having a power supply interruption of end- customers connected to a low voltage (LV) distribution grid (in Europe 230 V and in the USA 110 V) is diminished since adjacent microsources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances. This is identified nowadays as a microgrid. The distinctive microgrid has the similar size as a low voltage distribution feeder and will rare exceed a capacity of 1 MVA and a geographic span of 1 km. Generally more than 90% of low voltage domestic customers are supplied by underground cable when the rest is supplied by overhead lines.

The microgrid often supplies both electricity and heat to the customers by means of combined heat and power plants (CHP), gas turbines, fuel cells, photovoltaic (PV) systems, wind turbines, etc. The energy storage systems usually include batteries and flywheels [2].The storing device in the microgrid is equivalent to the rotating reserve of large generators in the conventional grid which ensures the balance between energy generation and consumption especially during rapid changes in load or generation [3].

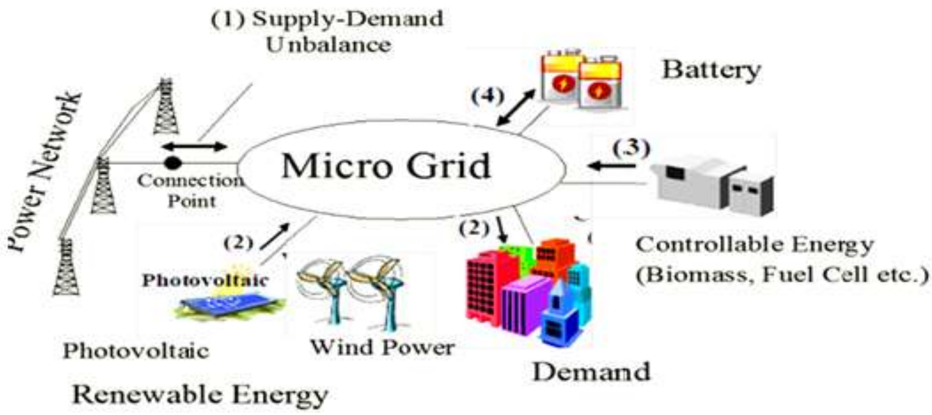

Fig. 1 General representation of hybrid micro grid [1]

II. AC/DC Microgrid

The concept of microgrid is considered as a collection of loads and microsources which functions as a single controllable system that provides both power and heat to its local area. This idea offers a new paradigm for the definition of the distributed generation operation. To the utility the microgrid can be thought of as a controlled cell of the power system. For example this cell could be measured as a single dispatch able load, which can reply in seconds to meet the requirements of the transmission system. To the customer the microgrid can be planned to meet their special requirements; such as, enhancement of local reliability, reduction of feeder losses, local voltages support, increased efficiency through use waste heat, voltage sag correction [3]. The main purpose of this concept is to accelerate the recognition of the advantage offered by small scale distributed generators like ability to supply waste heat during the time of need [4]. The microgrid or distribution network subsystem will create less trouble to the utility network than the conventional microgeneration if there is proper and intelligent coordination of micro generation and loads "5". Microgrid considered as a 'grid friendly entity" and does not give undesirable influences to the connecting distribution network i.e. operation policy of distribution grid does not have to be modified [7].

2.1 Configuration of the hybrid microgrid:

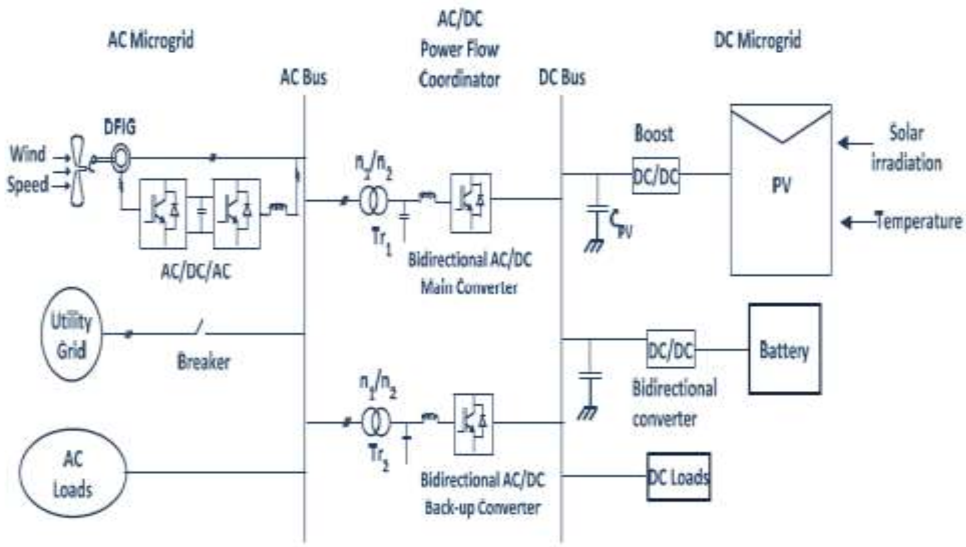

Fig 2: A hybrid AC/DC microgrid system

The configuration of the hybrid system is shown in Figure 1 where various AC and DC sources and loads are connected to the corresponding AC and DC networks. The AC and DC links are linked together through two transformers and two four quadrant operating three-phase converters. The AC bus of the hybrid grid is tied to the utility grid.

Figure 3 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. The AC bus is connected to the utility grid through a transformer and circuit breaker.

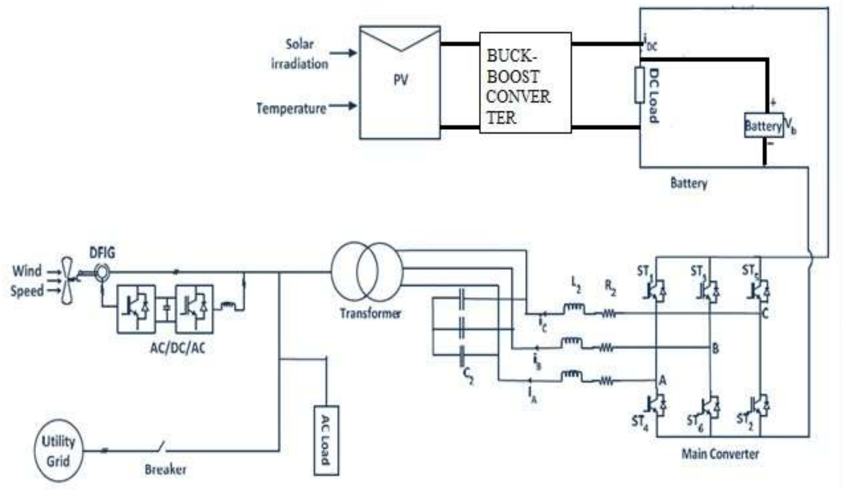

Fig 3: Representation of hybrid micro grid

In the proposed system, PV arrays are connected to the DC bus through buck-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 C_{pv} is 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 (buckboost converter, main converter, and bidirectional converter) share a common DC bus. A wind generation system consists of doubly fed induction 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.
The parameters used for the modeling of hybrid grid are shown in the table1.1 [16]

Table 1: Component parameters for the hybrid grid

Symbol	Value
C_{ap}	110 µf
L_1	2.5 MH
C_d	4700 µf
L_2	0.43 MH
R_2	0.3 ohm
C_2	60 µf
L_3	3 MH
R_3	0.1 ohm
f	50 Hz
f_s	10 kHz
V_d	400 V
V_{AC_rms}	400 V

2.2 Operation of grid

The hybrid grid performs its operation in two modes.

2.2.1. Grid tied 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 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.

2.2.2. Autonomous 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. The main converter is controlled to provide stable and high quality AC bus voltage.

III. SIMULATION & RESULTS

A hybrid microgrid whose parameters are given in table 1 is simulated using MATLAB/SIMULINK environment. The operation is carried out for the grid connected mode & autonomous mode. The performance analysis is done using simulated results which are found using MATLAB.

3.1 Simulation Model

The simulation model of a hybrid microgrid is developed using MATLAB as shown in figure below

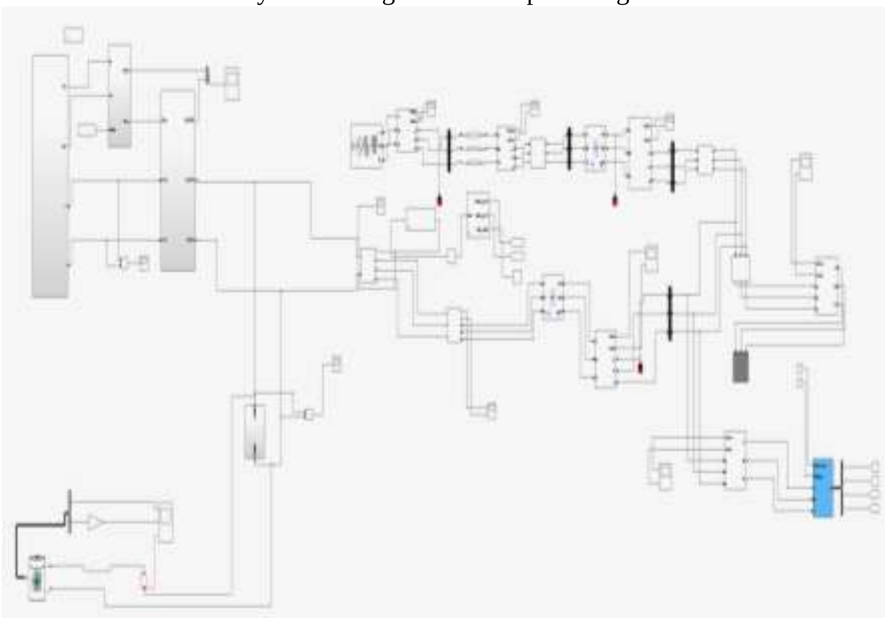

Fig 4. Simulink Model of Hybrid Microgrid

3.2 Results

The results are divided into two parts one is for grid connected mode & other is grid autonomous mode which are discussed as below

3.2.1 Grid connected mode

The various characteristics of the hybrid microgrid are represented by the figures (5) – (12). Here the microgrid operates in the grid tied mode. In this mode, the main converter operates in the PQ mode and power is balanced by the utility grid. The battery is fully charged. AC bus voltage is maintained by the utility grid and DC bus voltage is maintained by the main converter.

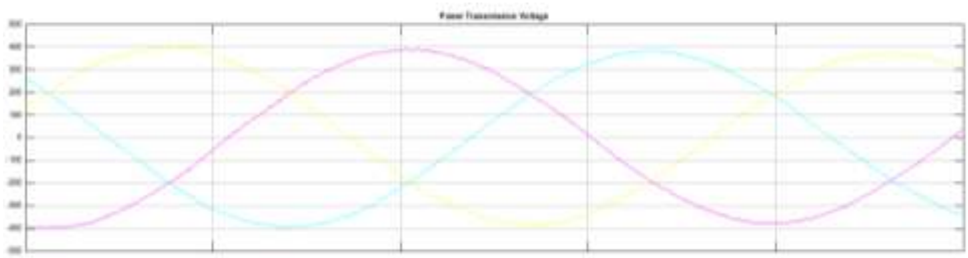

Fig 5. Three phase supply voltage of utility grid

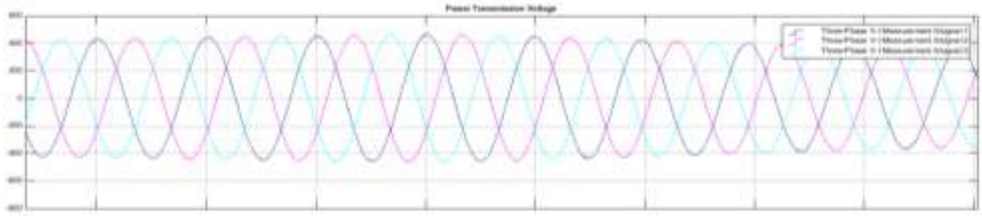

Fig 6. Three phase supply current of utility grid

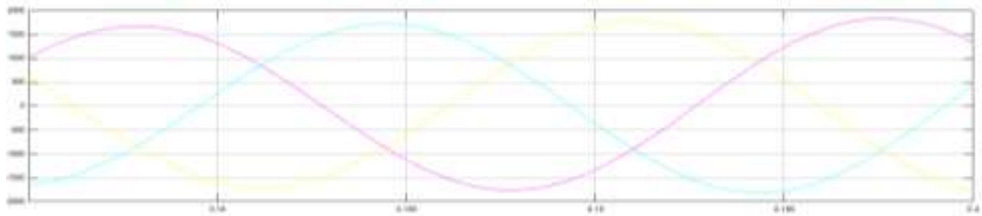

Fig 7. Output voltage of DFIG

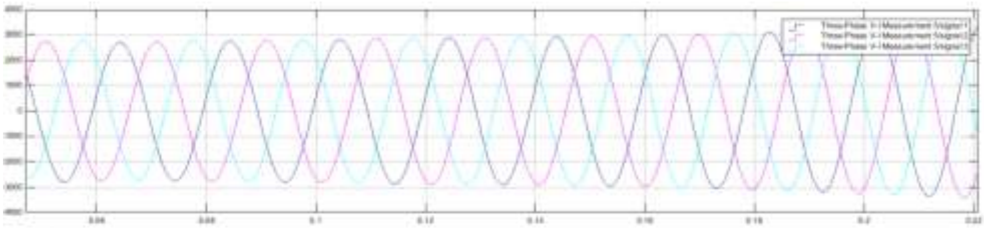

Fig 8. Output current of DFIG

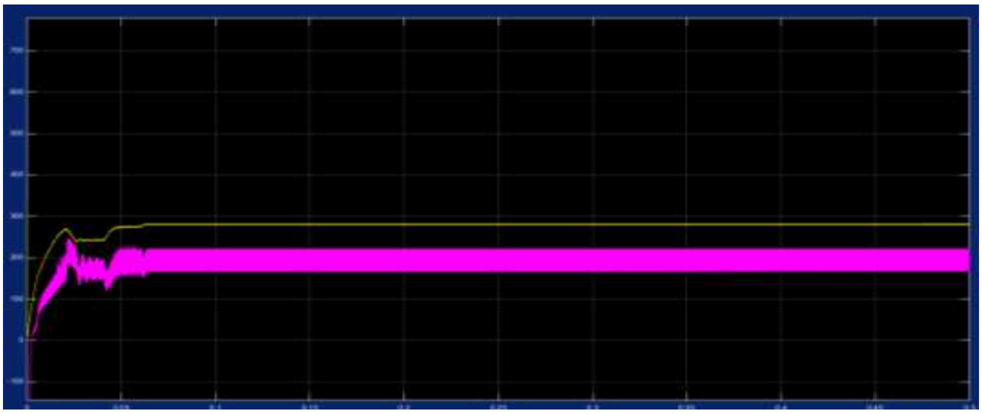

Fig 9. Output voltage of PV panel

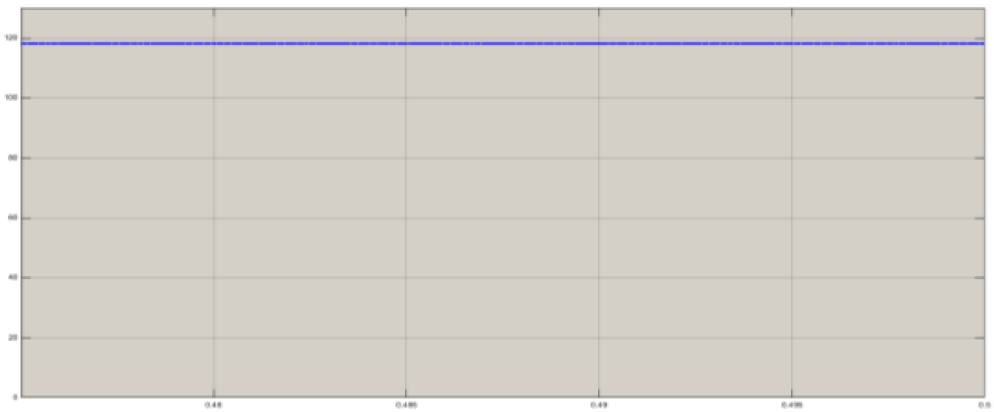

Fig 10. Power input and Power output of PV panel (MPPT)

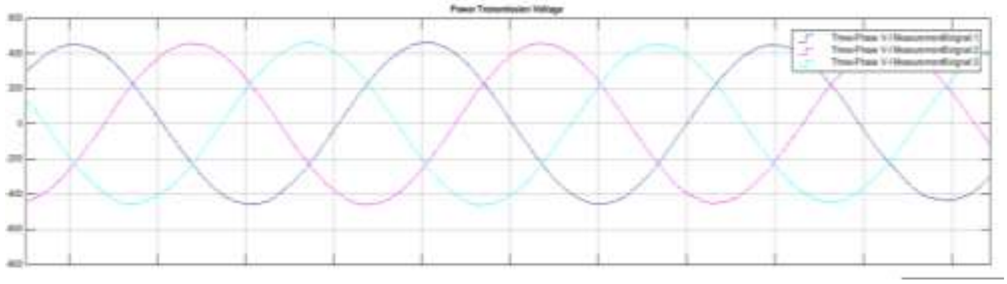

Fig 11. Output voltage across AC load

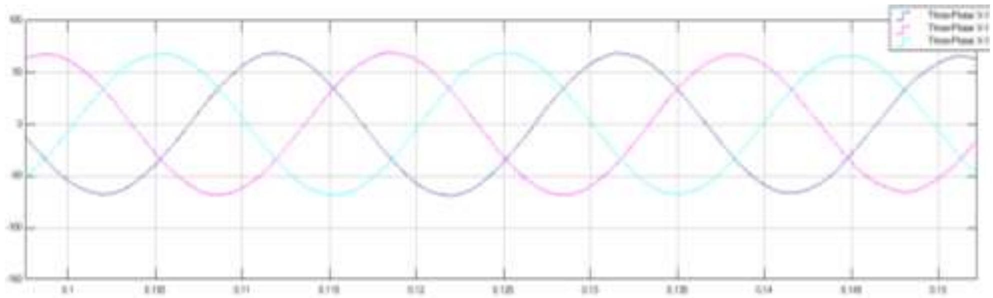

Fig 12. Output current across AC load

3.2.2 Grid autonomous mode

The various characteristics of the hybrid microgrid are represented by the figures (13) – (20). Here the microgrid operates in the grid autonomous mode. Here the utility get disconnected from the microgrid and load is satisfied from remaining different sources in microgrid

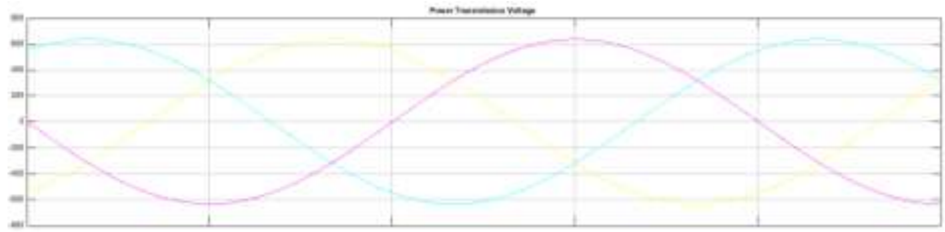

Fig 13. Three phase supply voltage of utility grid

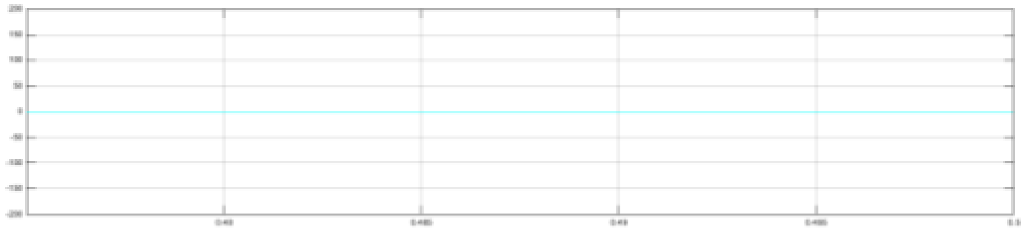

Fig 14. Three phase supply current of utility grid

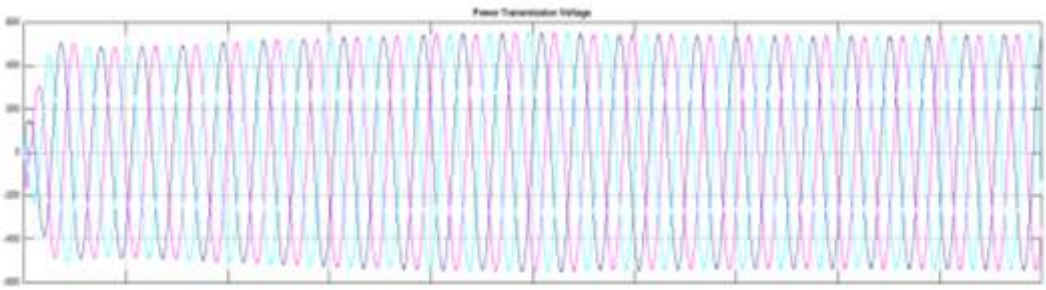

Fig 15. Output voltage of DFIG

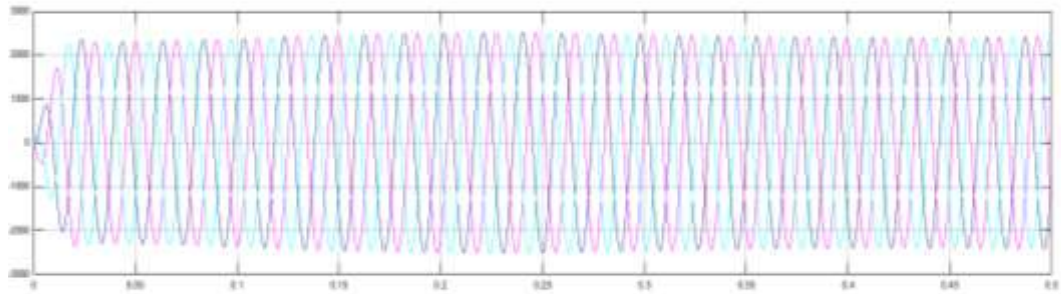

Fig 16. Output current of DFIG

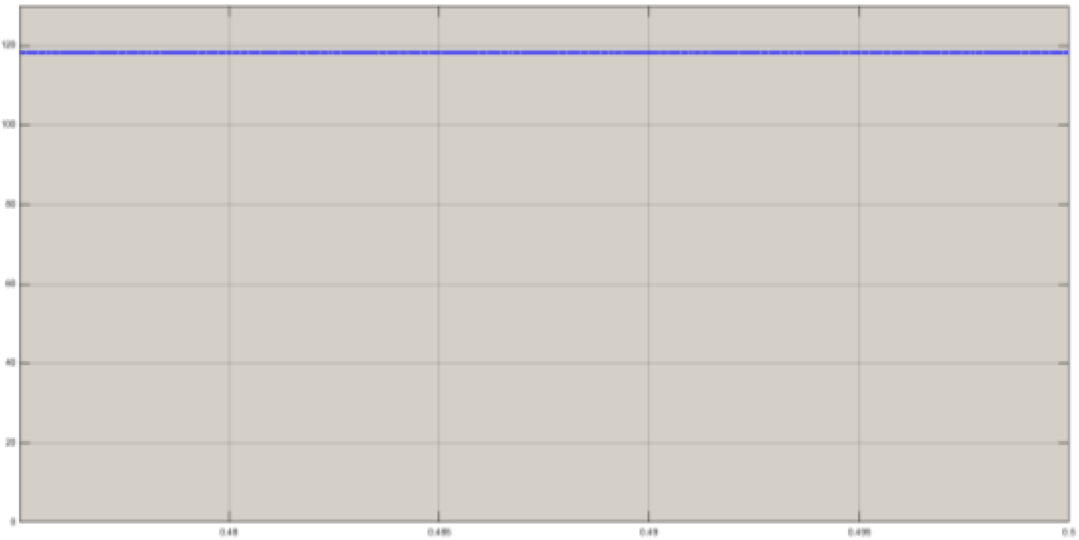

Fig 17. Output voltage of PV panel

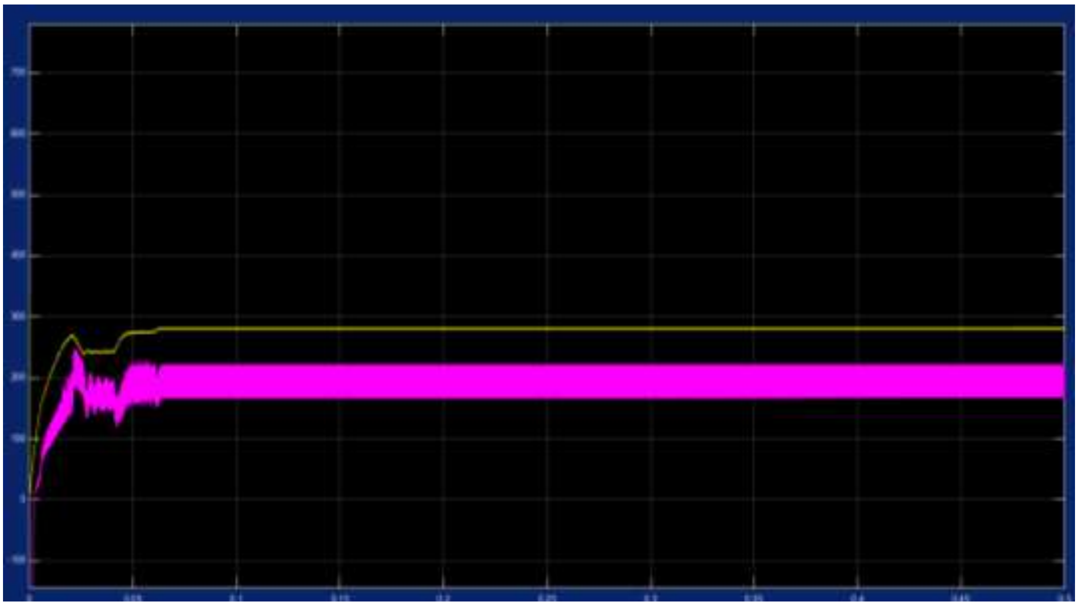

Fig 18. Power input and Power output of PV panel (MPPT)

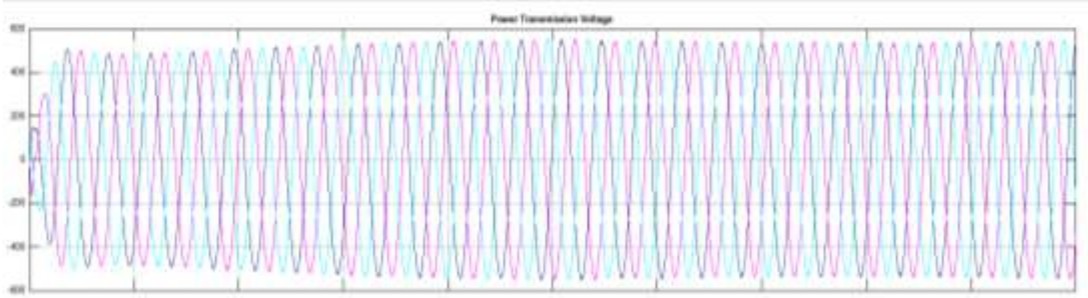

Fig 19. Output voltage across AC load

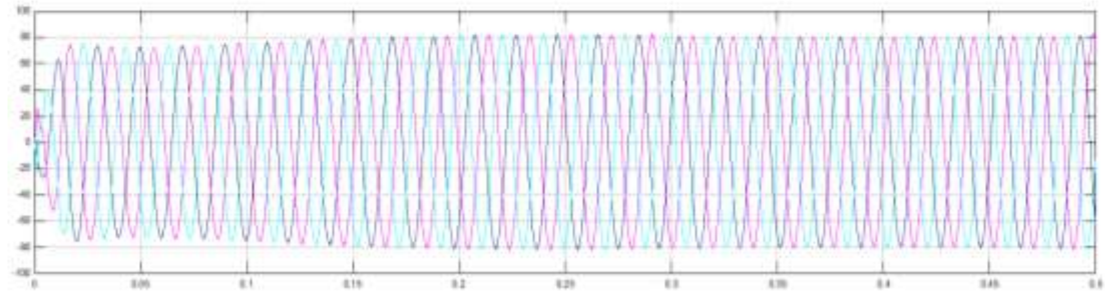

Fig 20. Output current across AC load

IV. 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.

References

[1]. S. Bose, Y. Liu, K. Bahei-Eldin, J.de Bedout, and M. Adamiak, “Tie line Controls in Microgrid Applications,” in iREP Symposium Bulk Power System Dynamics and Control VII, Revitalizing Operational Reliability, pp. 1-9, Aug. 2007.

[2]. R. H. Lasseter, “MicroGrids,” in Proc. IEEE-PES’02 , pp. 305-308, 2002.

[3]. Michael Angelo Pedrasa and Ted Spooner, “A Survey o f Techniques Used to Control Microgrid Generation and Storage during Island Operation,” in AUPEC, 2006.

[4]. F. D. Kanellos, A. I. Tsouchnikas, and N. D. Hatziargyriou, “Microgrid Simulation during Grid-Connected and Islanded Mode of Operation,” in Int. Conf. Power Systems Transients (IPST’05), June. 2005.

[5]. Y. W. Li, D. M. Vilathgamuwa, and P. C. Loh, Design, analysis, and real-time testing of a controller for multi bus microgrid system, IEEE Trans. Power Electron., vol. 19, pp. 1195-1204, Sep. 2004.

[6]. [6] R. H. Lasseter and P. Paigi, “Microgrid: A conceptu al solution,” in Proc. IEEE-PESC’04

[7]. F. Katiraei and M. R. Iravani, “Power Management St rategies for a Microgrid with Multiple Distributed Generation Units,” IEEE trans. Power System, vol. 21, no. 4, Nov. 2006.

[8]. P. Piagi and R. H. Lasseter, “Autonomous control of microgrids,” in Proc. IEEE-PES’06 , 2006, IEEE, 2006.

[9]. M. Barnes, J. Kondoh, H. Asano, and J. Oyarzabal, “ Real-World MicroGrids- an Overview,” in IEEE Int. Conf. Systems of Systems Engineering, pp.1-8, 2007.

[10]. Chi Jin, Poh Chiang Loh, Peng Wang, Yang Mi, and Frede Blaabjerg, “Autonomous Operation of Hybrid AC-DC Microgrids,” in IEEE Int. Conf. Sustainable Energy Technologies, pp. 1-7, 2010.

[11]. Y. Zoka, H. Sasaki, N.Yomo, K. Kawahara, C. C. Liu, “An Interaction Problem of Distributed Generators Installed in a MicroGrid,” i n Proc. IEEE Elect. Utility Deregulation, Restructuring and Power

Technologies, pp. 795-799, Apr. 2004.
[12]. H. Nikkhajoei, R. H. Lasseter, "Microgrid Protectio n," in IEEE Power Engineering Society General Meeting, pp. 1-6, 2007.
[13]. Zhenhua Jiang, and Xunwei Yu, "Hybrid DC- and AC-Li nked Microgrids: Towards Integration of Distributed Energy Resources," in IEEE Energy2030 Conf., pp.1-8, 2008.
[14]. Bo Dong, Yongdong Li, ZhixueZheng, Lie Xu "Control Strategies of Microgrid with Hybrid DC and AC Buses," in Power Electronics and Applications, EPE'11, 14thEuropean Conf., pp. 1-8, 2011.
[15]. Dong Bo, Yongdong Li , and Zedong Zheng, "Energy Ma nagement of Hybrid DC and AC Bus Linked Microgrid," in IEEE Int. Symposium Power Electronics for Distributed Generation System, pp. 713-716, 2010.
[16]. Xiong Liu, Peng Wang, and Poh Chiang Loh, "A Hybrid AC/DC Microgrid and Its Coordination Control," IEEE Trans. Smart Grid, vol. 2, no. 2, pp. 278-286 June. 2011.
[17]. Mesut E. Baran, and Nikhil R. Mahajan, "DC Distribution for Industr ial Systems: Opportunities and Challenges," IEEE Trans. Industry Applications, vol. 39, no. 6, pp. 1596-1601, Nov/Dec. 2003.
[18]. Y. Ito, Z. Yang, and H. Akagi, "DC Microgrid Based Distribution Power Generation System," in Proc. IEEE Int. Power Electron. Motion Control Conf., vol. 3, pp. 1740-1745, Aug. 2004.
[19]. A. Arulampalam, N. Mithulananthan, R.C. Bansal, and T.K. Saba, "Microgrid Control of PV -Wind-Diesel Hybrid System with Islanded and Grid Connected Operations," in Proc. IEEE Int. Conf. Sustainable Energy Technologies, pp. 1-5, 2010.
[20]. Poh Chiang Loh, Ding Li, and FredeBlaabjerg, "Auton omous Control of Interlinking Converters in Hybrid AC-DC Microgrid with Energy Storages," in IEEE Energy Conversion Congress and Exposition (ECCE), pp. 652-658, 2011.
[21]. M. E. Ropp and S. Gonzalez, "Development of a MATLA B/Simulink model of a single phase grid connected photovoltaic system," IEEE Trans. Energy Conv., vol. 24, no. 1, pp. 195-202, Mar 2009.
[22]. Mei Shan Ngan, Chee Wei Tan, "A Study of Maximum Po wer Point Tracking Algorithms for Stand-alone Photovoltaic Systems," i n IEEE Applied Power electronics Colloquium (IAPEC), pp. 22-27, 2011.
[23]. K. H. Hussein, I. Muta, T.Hoshino, and M. Osakada, "Maximum Photovoltaic Power Tracking: An Algorithm for rapidly changing atmospheric conditions," in Proc. Inst. Elect. Engg. Gener. Transm. Distrib., vol. 142, pp. 59–64, Jan.1995.
[24]. D. P. Hohm, M. E. Ropp, "Comparative Study of Maxim um Power Point Tracking Algorithms Using an Experimental, Programmable, Maximum Power Point Tracking Test Bed", in IEEE,pp.1699-1702, 2000.
[25]. Marcello Gradella Villalva, Jones Rafael Gazoli, and Ernesto Ruppert Filho, "Analysis and Simulation of the P&O MPPT Algorithm using a linearized PV Array model," in Industrial Electronics, IECON'09, 35 th Annual Conf., pp. 189-195, 2009.
[26]. Mohammad A. S. Masoum, Hooman Dehbonei, and Ewald F. Fuchs, "Theoretical and Experimental Analyses of Photovoltaic Systems with Voltage- and Current-Based Maximum Power-Point Tracking", in IEEE Trans. Energy Conversion, vol. 17, no. 4, pp. 514-522, Dec. 2002.
[27]. O. Tremblay, L. A. Dessaint, and A. I. Dekkiche, "A generic battery model for the dynamic simulation of hybrid electric vehicles," in Proc. IEEE Veh. Power propulsion Conf., pp. 284-289, 2007.
[28]. S. N. Bhadra, D. Kastha, S. Banerjee, "Wind Electri cal Systems," Oxford University Press, New Delhi, 2009.
[29]. B. K. Bose, "Modern Power Electronics and AC Drives ," Prentice-Hall, Inc., New Delhi, 2002.
[30]. A. Girgis and S. Brahma, "Effect of Distributed Generation on Protective Device Coordination in Distribution System," in Large Engineering Systems Conf. Power Engineering, pp. 115-119, 2001.
[31]. N. Kroutikova, C. A. Hernandez-Aramburo, and T. C. Green, "State-space model of grid connected inverters under current mode control," IET Elect. Power Appl., vol. 1, no. 3, pp. 329-338, 2007.
[32]. D. Sera, R. Teodorescu, J. Hantschel, and M. Knoll, "Optimized maximum power point tracker for fast-changing environmental conditions," IEEE Trans. Ind. Electron., vol.55, no. 7, pp. 2629-2637, Jul. 2008.
[33]. B. Bryant and M. K. Kazimierczuk, "Voltage loop of boost PWM DC-DC converters with peak current mode control," IEEE Trans. Circuits Syst. I, Reg. Papers, vol. 53, no. 1, pp. 99-105, Jan. 2006.
[34]. S. Arnalte, J. C. Burgos, and J. L. Rodriguez-amenedo, "Direct torque control of a doubly fed induction generator for variable speed wind turbines," Elect. Power Compon. Syst., vol. 30, no. 2, pp. 199-216, Feb. 2002.