Enhancement of Hybrid Power Generation System using Three Energy Generation Source

Goutam Kumar Yadav[1] Deena Lodwal Yadav[2] Dr. K T Chaturvedi[3]
[1]ME Scholar [2,3]Assistant Professor
[1,2,3]Department of Electrical and Electronics Engineering
[1,2,3]UIT RGPV, Bhopal, India

Abstract— The recent upsurge in the demand of PV (AC/DC SMART GRID) systems is due to the fact that they produce electric power without hampering the environment by directly converting the solar radiation into electric power. However the solar radiation never remains constant. It keeps on varying throughout the day. The need of the hour is to deliver a constant voltage to the grid irrespective of the variation in multilevel inverter. We have designed a circuit such that it delivers constant and stepped up dc voltage to the load. We have studied the open loop characteristics of the PV array with variation in multilevel inverter levels. Then we coupled the PV array with the boost converter in such a way that with variation in load, the varying input current and voltage to the converter follows the open circuit characteristic of the PV array closely. At various isolation levels, the load is varied and the corresponding variation in the input voltage and current to the boost converter is noted. It is noted that the changing input voltage and current follows the open circuit characteristics of the PV array closely.

Keywords: DER, GRID, PV Array

I. INTRODUCTION

The Conventional sources of energy are rapidly depleting. Moreover the cost of energy is rising and therefore photovoltaic system is a promising alternative. They are abundant, pollution free, distributed throughout the earth and recyclable. The hindrance factor is its high installation cost and low conversion efficiency. Therefore our aim is to increase the efficiency and power output of the system. It is also required that constant voltage be supplied to the load irrespective of the variation in solar irradiance and temperature. PV arrays consist of parallel and series combination of PV cells that are used to generate electrical power depending upon the atmospheric conditions (e.g solar irradiation and temperature). So it is necessary to couple the PV array with a boost converter. Moreover our system is designed in such a way that with variation in load, the change in input voltage and power fed into the converter follows the open circuit characteristics of the PV array. Our system can be used to supply constant stepped up voltage to dc loads.

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 [1-5].

Today electrical power demand is very much increasing. So to generate the required power, resources used for this purpose are also increase. Hence proper utilization of power is required whenever surplus power is available. This can be achieved by storing the surplus power through batteries in the form of DC and this stored energy can be re-utilized by the conversion device called it as "INVERTER" by converting DC power into AC power. The renewable energy sources have been tremendously increasing its production, out of all those renewable energy sources solar is popular and it needs an inverter for the conversion. The multilevel inverters are the advancement in power electronics. Now-a-days multilevel inverters in literature are updating according to the high power capability. Hence, multilevel inverters are capable of having good voltage spectrum and low voltage stress devices. Power electronic inverters are becoming popular for various industrial drives applications. In recent years, inverters have even become a necessity for many implementations such as motor controlling and power systems [6-8]. A multilevel inverter not only achieves high power ratings, but also enables the use of renewable energy sources. Renewable energy sources such as photo voltaic, wind, and fuel cells can be easily interfaced to a multilevel inverter system for a high power and Medium power application. Multilevel inverters have been mainly used in medium or high power system applications, such as static reactive power compensation and adjustable-speed drives [8-12].

A. *General Information Regarding Micro GRID:*

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 or hydro energy. Having micro sources 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 micro sources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances. This is identified nowadays as a micro grid. Figure 1.1 depicts a typical micro grid. The distinctive micro grid 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 micro grid often supplies both electricity and heat to the customers by means of combined heat and power plants (CHP), gas turbines, fuel cells, photovoltaic PV(AC/DC SMART GRID)) systems, wind turbines, etc.

The energy storage systems usually include batteries and flywheels [2].The storing device in the micro grid 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]. From the customer point of view, micro grids deliver both thermal and electricity requirements and in addition improve local reliability, reduce emissions, improve power excellence by supportive voltage and reducing voltage dips and potentially lower costs of energy supply. From the utility viewpoint, application of distributed energy sources can potentially reduce the demand for distribution and transmission facilities. Clearly, distributed generation located close to loads will reduce flows in transmission and distribution circuits with two important effects: loss reduction and ability to potentially substitute for network assets. In addition, the presence of generation close to demand could increase service quality seen by end customers. Micro grids can offer network support during the time of stress by relieving congestions and aiding restoration after faults. The development of micro grids can contribute to the reduction of emissions and the mitigation of climate changes. This is due to the availability and developing technologies for distributed generation units are based on renewable sources and micro sources that are characterized by very low emissions [4].

B. Technical Challenges in Micro GRID:

Protection system is one of the major challenges for micro grid which must react to both main grid and micro grid faults. The protection system should cut off the micro grid from the main grid as rapidly as necessary to protect the micro grid loads for the first case and for the second case the protection system should isolate the smallest part of the micro grid when clears the fault [3].A segmentation of micro grid, i.e. a design of multiple islands or sub micro grids must be supported by micro source and load controllers. In these conditions problems related to selectivity (false, unnecessary tripping) and sensitivity (undetected faults or delayed tripping) of protection system may arise. Mainly, there are two main issues concerning the protection of micro grids, first is related to a number of installed DER units in the micro grid and second is related to an availability of a sufficient level of short-circuit current in the islanded operating mode of micro grid since this level may substantially drop down after a disconnection from a stiff main grid. In [30] the authors have made short-circuit current calculations for radial feeders with DER and studied that short-circuit currents which are used in over-current (OC) protection relays depend on a connection point of and a feed-in power from DER. The directions and amplitudes of short circuit currents will vary because of these conditions. In reality the operating conditions of micro grid are persistently varying because of the intermittent micro sources (wind and solar) and periodic load variation. Also the network topology can be changed frequently which aims to minimize loss or to achieve other economic or operational targets.

II. OBJECTIVES OF THIS WORK

- To propose and develop a hybrid AC/DC micro-grid (with combination of Photovoltaic PV and a hydrogen storage system as backup) that consists of both ac and dc networks connected together by bidirectional converter.
- The Proposed Hybrid micro-grid would improve the dynamic performance of the Grid connected (GPV (AC/DC SMART GRID) S) in a day ahead market.
- This work deals with system integration and controller design for power management of a grid connected Micro grid system.
- A two level control system is implemented, comprising a supervisory controller, which ensures the power balance between intermittent PV generations, Hydrogen based energy storage, and dynamic load demand, as well as local controllers for the photovoltaic, electrolyze, and fuel cell unit.
- The coordination control algorithm is proposed for smooth power transfer between ac, dc links and Tie Line for stable system operation under various generation and load conditions.
- Profile of AC and DC bus voltages has been analyzed especially, when the operating conditions or load capacities change under the various modes of operation.

A. Motivation of Project Work:

The micro grid concept acts as a solution to the conundrum of integrating large amounts of micro generation without disrupting the operation of the utility network. With intelligent coordination of loads and micro-generation, the distribution network subsystem (or 'micro grid') would be less troublesome to the utility network, than conventional micro generation. The net micro grid could even provide ancillary services such as local voltage control. In case of disturbances on the main network, micro grids could potentially disconnect and continue to operate separately.

III. OBJECTIVE OF THE THESIS

The main objective of this thesis is the development of a hybrid Smart grid which will reduce the process of multiple reverse conversions associated with individual AC and DC grid by the combination of AC and DC sub-grid PV/Fuel cell system and Wind turbine generator

In order to analyze the operation of Smart grid system both the modeling and controlling of the system are important issues. Hence the control and modeling (to be discussed detail in Chapter 4) are also the part of this thesis work. As a part of the thesis work the overall system is simulated using MATLAB environment. In simulation work the system is modeled using different state equations.

IV. GENERAL INFORMATION REGARDING SMART GRID

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].

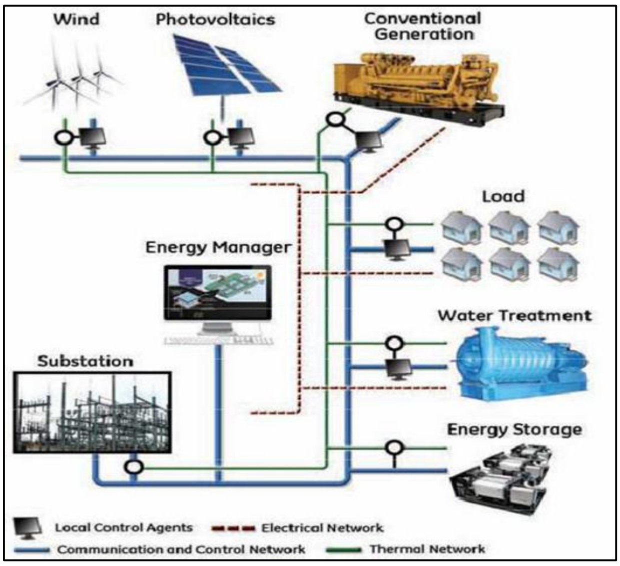

Fig. 4.1: Smart grid power system

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 or hydro energy. Having micro sources 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 micro sources, controllable loads and energy storage systems can operate in the islanded mode in case of severe system disturbances. This is identified nowadays as a micro grid. Figure 3.1 depicts a typical Smart grid. The distinctive Smart grid 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 Smart grid 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 Smart grid 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].

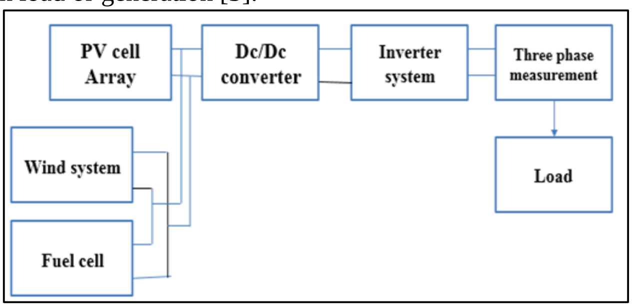

Fig. 4.2: Proposed System Block Diagram.

V. RESULT AND DISCUSSION

A hybrid Smart grid whose parameters are given in table 4.1 is simulated using MATLAB/SIMULINK environment. The operation is carried out for the grid connected mode. Along with the hybrid Smart grid, the performance of the doubly fed induction generator, photovoltaic system is analyzed. The solar irradiation, cell temperature and wind speed are also taken into consideration for the study of hybrid Smart grid. The performance analysis is done using simulated results which are found using MATLAB.

A. Solar, Wind, Fuel cell input Parameter:

Input parameters	value
Temperature/Irradiation	1000
Per panel voltage	666v
MPPT Power	$3X10^4$
Vocv	406v
Wind speed	12p
Wind generation voltage	$2.3x10^4$
Mean transient time	T<0.2s

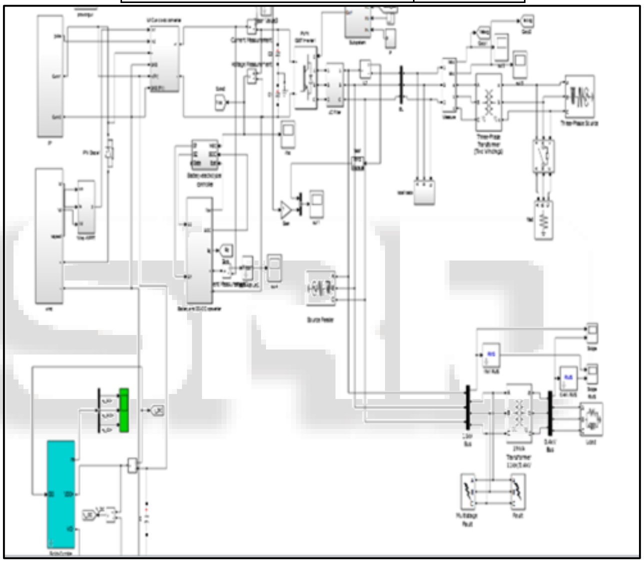

Fig. 5.1: Simulink modelling.

Fig (5.1) this is shows of hybrid modelling of Simulink in matlab 2015a.This model to connecting a faulty grid consist of Single and multistage fault.

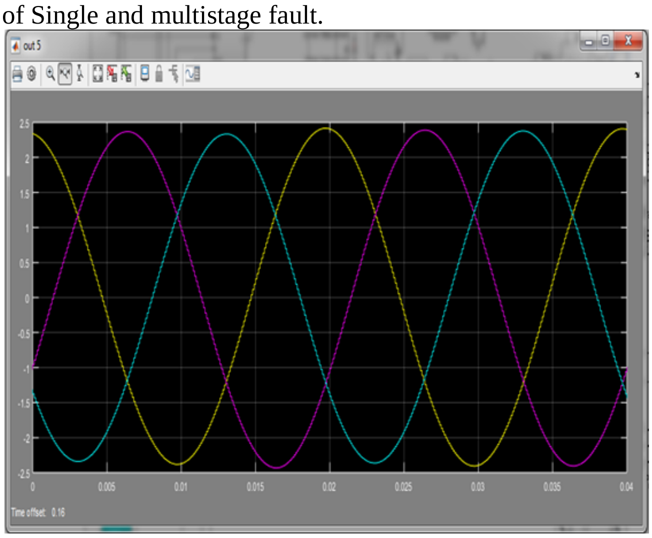

Fig. 5.2: Vabc Voltage Waveforms.

Fig (6.2) show by a three phase voltage (Vabc) wave form of faulty grid connected hybrid system. This is show without any distortion of THD in three phase voltage outcome

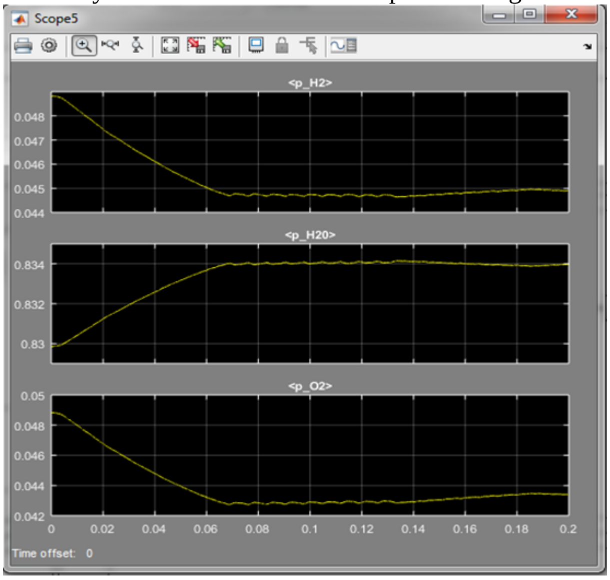

Fig. 5.3: fuel cell H2, O2 H2O gradient.

Fig (5.3) show by fuel cell chemical gradient of the power generation across the all over grid. The oxidation half reaction, represented by (1), shows the dissociation of hydrogen molecules to protons and electrons at the anode. After the dissociation, the protons are free and pass through the electrolyte, and recombine with the electrons (which move through the external circuit) at the cathode. In this process, which is often called the reduction half reaction, the electrons and hydrogen protons combine with the oxygen molecules from the surrounding air, according to (2), to form water.

VI. Conclusion

The modeling of hybrid Smart grid 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.

A. *Scope of future work*

1) The modeling and control can be done for the islanded mode of operation.
2) The control mechanism can be developed for a Smart grid containing unbalanced and nonlinear loads.

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