International Journal of Scientific & Engineering Research Volume 10, Issue 5, May-2019
ISSN 2229-5518

Voltage Control of Hybrid Solar and Fuel cell In a DC Micro Grid

Neha Jakati[1], Nandakumar C[2]
.
1 P.G. Scholar, Department of Electrical and Electronics Engineering, SDMCET, Dharwad, India
2 Asst. Professor, Department of Electrical and Electronics Engineering, SDMCET, Dharwad, India

Abstract— A DC micro grid is a hybrid renewable system in which the renewable resources suppy the average load, while non renewable generation and storage sytems maintain the power balance in presence of renewable resources. Distributed generations have the advantages of low loss, low investments, high reliability and high efficiency. However, it has some disadvantages such as small output capacity compared to the traditional power generation methods such as thermal power generation and nuclear power generation. These disadvantages can be overcome by connecting the distributed generations to a large power networks. since this network is not the existing power grid, there may exists the problems such as real-time monitoring, short circuits, controlling and adjustments of the system. These problems can be solved by connecting distributed generations by DC bus which results in DC distribution system, that is to say DC micro grid. In this paper hybrid solar and fuel cell is used as renewable resources. Since, solar energy is varying during day time we don't get the constant output voltage. Hence, in this paper controller is designed for pv and fuel cell that will give the stable output voltage. Simulation model is developed in matlab and results are obtained.

Index Terms— fuel cell, DC micro grid, PID controller, solar PV, Voltage control

1 INTRODUCTION

Distributed generations mainly contain solar photo-voltaic, micro-turbine generators, small wind turbines,fuel cell and etc. A DC micro grid is a system which contains small scale distributed generation located near by users whose capacity is 5000W-50MW supplies electrical energy independently and improve the reliability and power quality of the existing power gird. A DC micro grid is composed of renewable sources, storage systems and non renewable generation. The uncontrollable renewable sources supply the average load demand, while the storage systems act as a electrical energy buffer which blances the short term power differences between source and the load.in the event of long term shortage of renewable energy such as lack of solar energy during rainy season, non renewable generation is included to improve the system reliability. in order to maximize the use of the renewable sources, the system must be controlled in an optimal fashion according to a sytem control law. The conventional control method is central control using center controller that has the information of each component in the system. This control method can achieve the optimal control of the system, but the thing is that it it depends upon central controller and communication lines.[2,3]

in recent years, in order to improve the reliability of the system distributed control stratergy was proposed which was to make each power supply share the DC bus information and control each power supply independently. DC-bus signaling is a means of controlling a DC micro grid in a distributed fashion. There is no doubt that the current energy system based on high energy density fuels extracted from fossil fuels will evolve to a new stage. There are two main reasons for this statement:(1) fossil fuel reserves are not sufficient to meet the growing global energy demand.[6] and (ii) the negative impact of this type of fuel is already a matter of international concern. Currently, fuels like coal, oil and gas supply the global energy demand by more than 80% [4]. The demand has been continuously rising since the 1970s and this rise is expected to continue due to the rapid world technological advance. If this fuel source composition number does not change an irreversible climatic damage, driven by the emission of carbon dioxide in the combustion of fossil fuels, will occur causing serious environmental effects. In order to cope both the increasing energy demand and the climatic change there is a need for efficient and carbon-free energy sources. In this future scenario, hydrogen energy and fuel cell are being considered a key element.

By considering the small scale DC micro grid for the study. This paper expatiates a novel DC micro grid voltage control-principle in detail by using the PID controller.

2 DC MICRO GRID

The conventional electrical system in place today sees our electrical devices powered by AC mains. But as renewable technologies such as solar photovoltaics and wind power become more prevalent at a household level, DC micro grids could be a cheaper and more efficient alternative. Take lighting and 'gadgets' for example. Lighting is widely considered to account for around 20% of global electricity consumption, and a recent report from the International Energy Agency estimates that up to 15% of domestic energy is consumed through 'gadgets' - i.e. computers and consumer electronics. LEDs are emerging as a preferred option for high efficiency lighting, and they run on DC power. Similarly, most gadgets operate on DC power, so these two sectors alone add significant and increasing global consumption of electricity by DC devices. But these are presently powered by AC mains via multitudinous individual transformers. Fuel cells and many

small scale renewable natively generate low voltage DC power. Most of these generators supply power to AC mains networks and require costly and inefficient power inverters;even where the power may ultimately be delivered to a DC device. The figure 1 shows the DC micro grid.

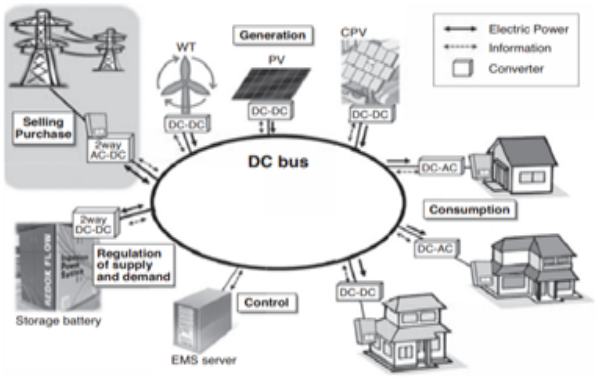

Fig.1. DC micro grid

A DC micro grid comprises:

- DC power generation (i.e fuel cell, solar PVpanels, or micro wind turbines);
- DC electrical storage (i.e battery or super capacitor);
- DC power distribution (i.e wiing and control);
- DC gadgets (i.e laptops, telephones, satellite, TV controllers);
- DC lightning (i.e LEDs);

Whilst homes generally require an AC supply for inherently "high" power devices such as washing machines kettles and hair dryers, there are surprising number of environments, such as site offices and outdoor events, where these devces are not used.

In such cases a DC micro grid could be sole power provider. The elimination of inverter cost, simplified installation and reduced fuel costs yielded by a DC micro grid system potentiely make it cost effective to operate independently of the electricity grid and conventional mains and power generators.

3 PEM Fuel Cell

Fuel cells are electrochemical (chemical to electric) devices that convert chemical energy of fuel directly into DC electricity without the intermediate combustion process. Since fuel cell produce electrical energy directly from chemical energy, they are often far more efficient than combustion engines. A fuel cell cell requires a constant suppy of fuel and oxidant to keep the electrochemical reactions proceeding. The reactants for fuel cells, normally hydrogen and oxygen, are fed into two electrodes, the anode and the cathode, separated by an electrolyte. Hydrogen can be in its pure form, or it can be in a mixture of other gases (such as CO2, N2, CO), or in hydrocarbon such as natural gas(CH4), or in liquid hydrocarbon such as methanol(CH3OH). The essential principle of the hydrogen fuel cell is electrolysis reversed i.e hydrogen and oxygen recombined to produce electricity. Figure. 2 shows the PEM fuel cell.

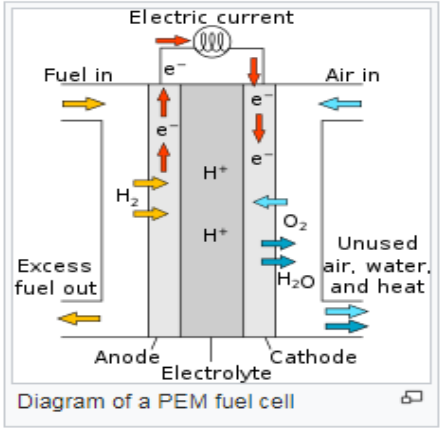

Fig. 2. Diagram of PEM fuel

4. Structure and control law of the system

The research subject is based on full scale system that encompassestwo generation/load buses located 1.5km apart. The system is composed of photovoltaic (PV) systems, a fuel cell, and a storage battery they are at different location of the system.

4.1 PID CONTROLLER FOR PV

Since, the solar energy is variable all the time during day time, the output voltage is not stable it is varying. Hence in this paper a madlab model is designed to obtain the controlled output voltage of solar PV. Using the transfer function[4]. The controller for PV is as shown in the figure.3. Here, constant used in the model indicates solar PV output voltage, Which is then fed to the PID controller.

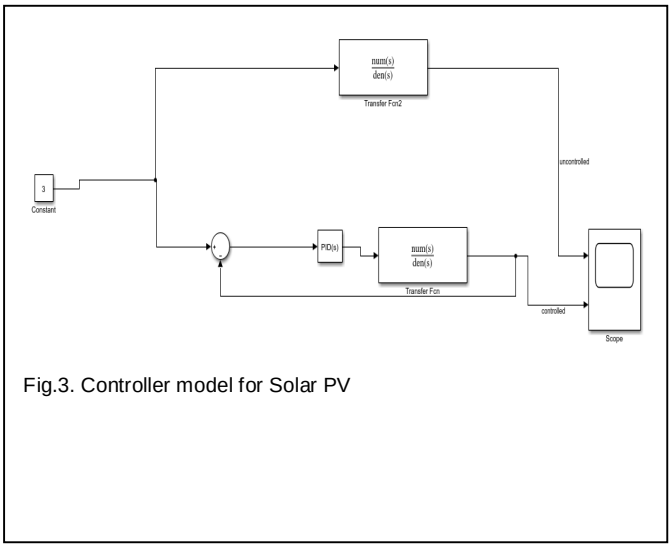

Fig.3. Controller model for Solar PV

Here input voltage is given as 3v and the controlled output is observed.

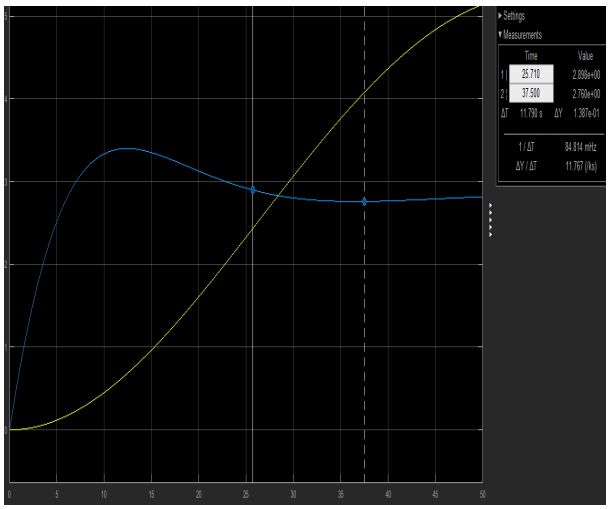

Fig. 4. Ouput voltage of PV with and without controller for 110V DC

In the above figure.4 the blue line indicates the controlled output voltage while the yellow line indicates the ouput voltage whithout controller. We can see that without controller the output voltage is initially low, less than ouput voltage of PV, which act as input to the controller and gradually increases. While with controller the ouput voltage is stable.

For input voltage of 110V dc

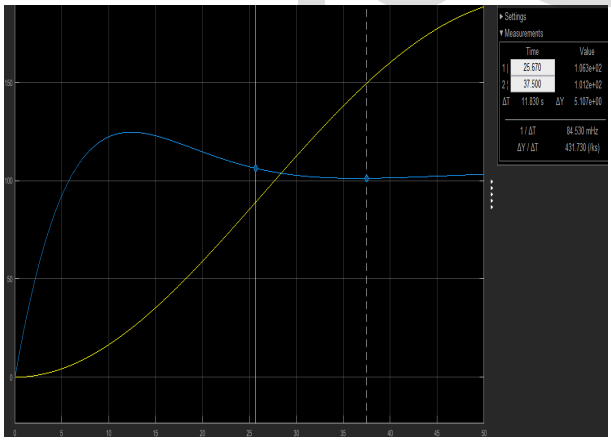

Fig. 5. Output voltage of PV with and without controller for input voltage of 110V DC

Figure.4 and figure.5 shows the ouput voltage of PV with and without controller for 3V and 110v respectively. In the same way the output values are obtained for different inputs as shown in the table. 1.

TABLE 1

Input voltage(V)	Time(S)	With controller output voltage(V)	Without controller Output voltage(V)
3V	25.7	2.898	2.434
24V	25.7	23.19	19.48
40V	25.7	38.64	32.46
60V	25.7	57.96	48.70
78V	25.7	75.35	63.30
110V	25.7	106.3	89.28

Output voltage of solar PV with and without using controller for a particular time at different voltages

For the same time at different voltages the ouput voltage of PV with and without controller is obtained as given in table. 1.

5 HYBRID SOLAR AND FUEL CELL MODEL

Matlab simulink model of hybrid solar and fuel cell is developed without using controller. The model is implemented and results are obtained.

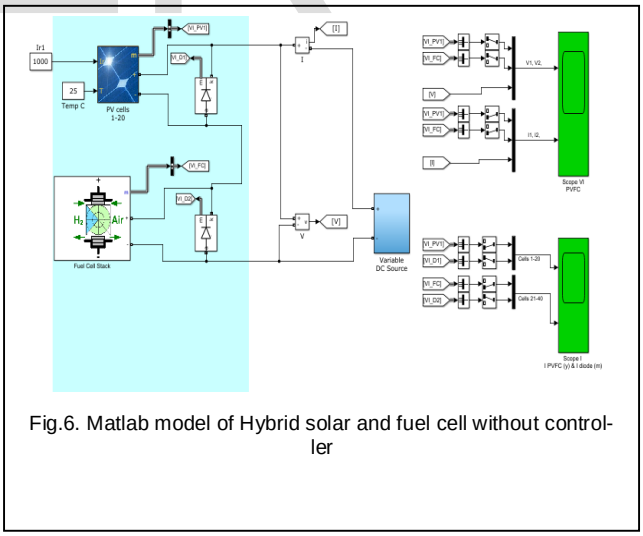

Fig.6. Matlab model of Hybrid solar and fuel cell without controller

Figure.7 shows the current and power curves of hybrid solar and fuell cell model without using controller. The performance of hybrid solar and fuel cell system without using controller is observed.

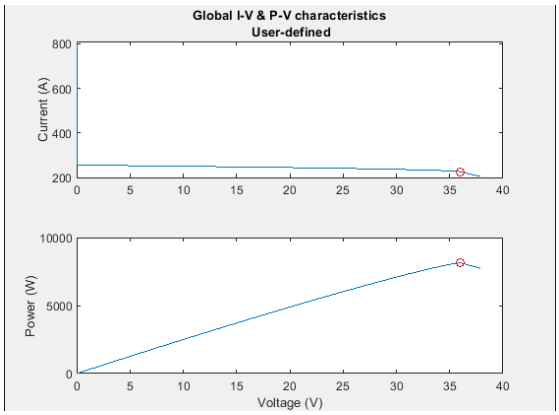

Fig.7. I-V and P-V characteristics of hybrid solar and fuel cell without using controller

6 CONCLUSION

The controller is designed to controll the output voltage of PV, PV controller model is successfully implemented in MATLAB SIMULINK. And the ouput values for different voltages at a perticular time is observed, hence controller performs its function irrespective of input voltage. Also the hybrid solar and fuel cell model is developed and implemented without using controller and results are obtained.

REFERENCES

[1] Xiaofeng Sun, Zhizhen Lian, Baocheng Wang and Xin Li, "Electrical Engineering institute, Yanshan University, Qinhuangdao, 066004, China

[2] Weizhong Tang and R.H. Lasseter, "An LVDC Industrial Power Distribution System Without central Control Unit, " *IEEE*, pp.979-984, 2000

[3] Per Karisson, Jorgen Svensson, "Voltage Control and Load Sharing in DC Distribution System, "*IEEE Transactions On Power Electronics*, Vol. 18, NO. 6, pp. 1405-1412, Nov 2003.

[4] "International Energy Agency. Key World Energy Statistics 2016"

[5] D.S.Mircea Grigoriu, Marius-Constantin Popescu, Valentina Balas, Doinu, "Control Systems for Solar Energy Conversion".

[6] John Schonberger, Richard Duke and Simon D. Round, "DC-Bus Signaling: A Distributed Control Stratergy for a Hybrid Renewable Nanogrid," *IEEE Transaction On Industrial Electronics*, Vol. 53, NO.5, pp. 1453-1460, Oct 2006.

[7] Bannerjee S, Jeevananathan (2010) Modelling of PV array and performance enhancement by MPPT Algorithm. Int J Comput Appl 7:35-39 (0975-8887).

[8] Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo and Massimo Tracking Method," *IEEE Transactions on Power Electronics*, vol. 20, No. 4, pp. 963-973, July 2005.

[9] Ed Fontes and Eva Nilsson, "Modelling the Fuel Cell," *American Institute of Physics*, pp. 14-17, Aug 2001.

[10] Carl John Rydh, "Energy Analysis of Batteries in Photovoltaic Systems," *EESAT*, pp. 27-29, Nov 2003.

[11] John Sch onberger, Simon Round and Richard Duke, "Autonomous Load Shedding in a Nanogrid using DC Bus Signaling," *IEEE*, 2006.

[12] Final Report Exide Management and Technology Company, "Handbook of Secondary Storage Batteries and Charge Regulators in Photovoltaic Systems," unpublished

[13] J. Brayn, R. Duke, S. Round, "Decentralized Generator Scheduling in a Nanogrid Using DC Bus Signaling*," Power Engineering Society General Meeting*, 2004, pp.977-982.

[14] Youngseok Jung, Junghun So, Gwonjong Yu and Jaeho Choi, "Improved Perturbation and Observation Method (P&O) of MPPT Control for Photovoltaic Power Systems, "*Photovoltaic Specialists Conference*, pp. 1788-1791, 2005.