Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 117 (2017) 268–274

Energy Procedia

www.elsevier.com/locate/procedia

1st International Conference on Power Engineering, Computing and CONtrol, PECCON-2017, 2-4 March 2017, VIT University, Chennai Campus

Efficient Power Management of Grid operated MicroGrid Using Fuzzy Logic Controller (FLC)

S. Angalaeswari, O.V. Gnana Swathika, V. Ananthakrishnan, J.L. Febin Daya, K.Jamuna*

School of Electrical Engineering, VIT University, Chennai-127, India
**jamuna.k@vit.ac.in, corresponding author*

Abstract

The exponential increase in electrical energy demand in the current scenario makes the world to turn towards the use of renewable energy sources naturally. The best way to utilize the renewable energy sources is in the form of microgrid. Microgrids are having multiple distributed energy sources and energy storage elements located nearer to the consumer. This paper implements a Fuzzy Logic Controller that efficiently manages the loads in a grid operated Microgrid. In this paper, maximum power point tracking (MPPT) with fuzzy logic controller is used for a grid operated microgrid constituted by solar system and battery. The system consists of Photo Voltaic (PV) system with MPPT controller, Battery with Buck boost converter, Inverter, critical and non-critical loads and utility grid. The simulation results prove that the efficiency of the fuzzy logic controller for different irradiation level with different load conditions has been improved.

Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.

Keywords: Fuzzy logic controller (FLC);Microgrid;PV system; Battery.

1. Introduction

The evolution of micro grid starts in the view that the power loss during the transmission can be greatly reduced, the maximum utilization of renewable energy sources can be achieved, reliable power to the consumers, pollution free environment etc. The MicroGrid (MG) is defined as the collection of various renewable energy sources such as solar, wind turbine, fuel cell etc, energy storage elements and loads. [1] The conventional power sources can also be included in the MicroGrid. The units of the microgrid (MG) are commonly located near to the consumer so as to meet the main objectives of the micro grid [2]. The microgrid operation may be considered as the autonomous mode

Peer-review under responsibility of the scientific committee of the 1st International Conference on Power Engineering, Computing and CONtrol.
10.1016/j.egypro.2017.05.131

of operation, connected with the conventional grid or transition mode of operation [3]. Depending on the power generation from the sources, the mode of operation is varied. In each mode of operation, the power management objectives are formed. In Autonomous mode, the system should be stable concerning the voltage and frequency. In grid connected mode, the cost of power supplied to the utility grid should be minimum and also the voltage in the micro grid must be optimum [4].The effective use of micro grid put down in the proper selection of the size and location of the distributed generation (DG) sources [5]. Many algorithms have been proposed for the optimal location and rating of the DG's, capacitors in the recent days.

The energy management in a microgrid is indispensable to maintain the supply- demand power balance. The authors proposed a double layer coordinated control approach for the energy management in grid connected and islanded mode of operation. The layers are schedule layer which gives an economical operation scheme and dispatch layer that follows the schedule layer in view of the voltage limits and power flows [6].The coordination of the above two layers has been considered in the micro grid and results in good convergence in either mode of operation. Micro grid Central Controller (MGCC) has been proposed in the paper [7] which is useful in managing the intermittent nature of power supply. This controller using Multi Agent System (MAS) with higher sampling rate is used for battery control management. During the power failure from the utility, the multiple diesel generators which are synchronized in a panel can be used by sequential programmable logic controller (PLC) [8].The authors [8] analyzed the significance of neutral isolating contractor and the grounding resistor in the protection of microgrid.

The MPPT based fuzzy logic control for stand-alone solar system has been proposed in [9]. For various weather conditions, the fuzzy controller results are compared with the perturbation and observation algorithm and the results prove that the proposed algorithm gives the better response in terms of tracking performance. Even the fuzzy logic controller is used for speed control of an induction motor [10]. The controller has the ability to track the speed of the induction motor in closed loop scenario. A fuzzy based control algorithm for analyzing the charging and discharging level of the battery used in hybrid wind and solar power system for stand-alone applications has been implemented in [11]. The SOC (State of Charge) of the battery is controlled using the fuzzy logic controller and compared with the conventional PI (proportional Integral) controller and results prove that the fuzzy control maintains the SOC level of the battery in the anticipated level for the long life of the battery. The fuzzy logic controller finds its application in the field of chemical process also. The liquid level and pH parameter can be maintained at desired level by the FLC [12]. The authors proposed several algorithms for the approximating model of interacting level and pH process. The results from FLC are compared with other control techniques like PI, Model predictive control (MPC) and PISPW (Proportional Integral Set point weighting).

The paper is organized as: Section 1 briefs the introduction about the micro grid, related literature work discussion; Section 2 discusses the block diagram and the components in the system; Modeling of the PV panel is given in section 3. Section 4 explains the concept of fuzzy logic controller with the membership functions and rules; Simulation results are elaborated in the section 5.Conclusion is offered in section 6.

2. Block diagram of the Proposed system

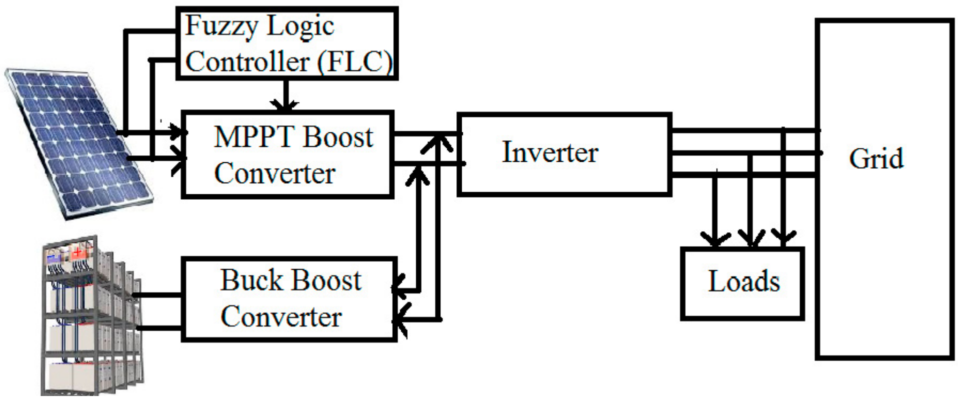

Figure 1.Block diagram of the system

The grid operated microgrid in Figure 1 consists of solar panel with MPPT control using Fuzzy logic controller (FLC), battery with buck-boost converter, Grid tied inverter and the critical and non-critical loads. Because of the nonlinear relation between the irradiation, temperature and the resistance of the solar cell, the output efficiency is also nonlinear in nature [13]. In order to extract the maximum power from the solar cell, maximum power point tracking (MPPT) is applied. For any load and weather conditions, the MPPT must be able to maximize the power output from the solar. In order to meet the load demand of the critical loads connected in the system, it is necessary to get consistent power from the source. This can be implemented with the help of the fuzzy logic controller (FLC) proposed in the system. Many papers have proposed the fuzzy logic controller mostly for stand-alone applications. This paper proposes a Fuzzy logic controller for the Grid connected solar system using Fuzzy logic controller with battery backup controlled by buck boost converter.

3. Modeling of PV system

The equivalent circuit of the solar cell is shown in Figure 2. The current source is connected in parallel with a diode. The series resistance R_s and shun resistance R_{sh} has the values of almost zero and infinity in ideal condition. The current from the diode can be represented by the equation (1)

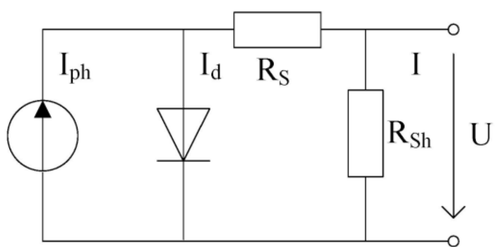

Figure 2. Equivalent Circuit of a solar cell

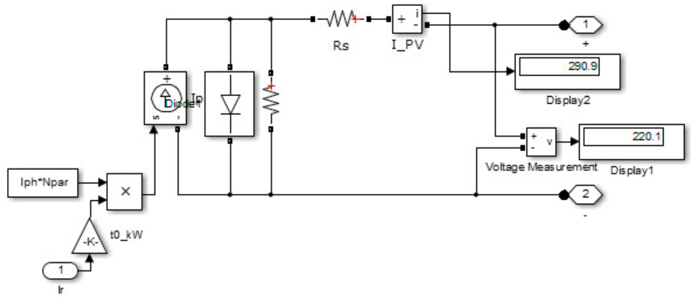

Figure 3.Simulation circuit of a solar cell

Diode characteristic can be specified as $I_d=I_{sat}*[\exp(V_d/V_T) -1]$ (1)

where I_d = diode current (A);

V_d = diode voltage (V);

I_{sat} = diode saturation current (A);

V_T = temperature voltage = $k*T/q*Q_d*Ncell*Nser$; (2)

T = cell temperature (K);

k = Boltzman constant = $1.3806e^{-23}$ J/K;

q = electron charge = $1.6022e^{-19}$ C;

Q_d = diode quality factor;

Ncell= number of series-connected cells per module;

Nser = number of series-connected modules per string;

The Simulink diagram for the solar cell is given in Figure 3. The power output from the solar panel is 86kW. The maximum power from the cell depends on the current and voltage. These factors also depend on the solar insolation and temperature. In spite of the varying climatic conditions, the solar output power should be constant for maintaining the voltage across the load constant. The irradiation is being considered as $1000W/m^2$ and $800W/m^2$ for validating the results.

4. Fuzzy Logic Controller (FLC)

Fuzzy logic is popularly used now a day for controlling various parameters in the system. In the Microgrid, FLC find its application for controlling the peak point in the MPPT. Fuzzy logic includes three basic function blocks such as Fuzzification block, Inference Engine and Defuzzification block. In the fuzzification block, all the real physical variables are changed in to fuzzy variables called linguistic variables. Here the voltage and the current from the solar panel is used for determining the power. The MPPT control is used for finding the change in the duty ratio of the DC-DC converter by considering the slope of the P-I characteristics of the solar cell. The slope is considered as the error E and change in the error (CE) is also taken as input variables to the Inference engine [9]. The input variables are converted to the fuzzy variables as NB (Negative Big), (NS) Negative Small, (Z) Zero, (PS) Positive Small, PB (Positive Big) using the fuzzy subset.

The Figure 4 shows the simulation circuit for the Maximum power point tracking subsystem used in the controller. The Fuzzy Inference System (FIS) takes the input and apply the fuzzy rules to make the fuzzy outputs.

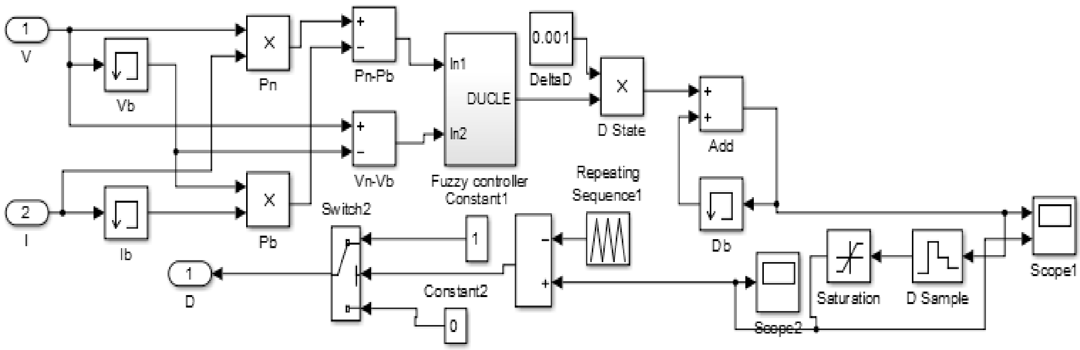

Figure 4 .Simulation circuit of the controller subsystem

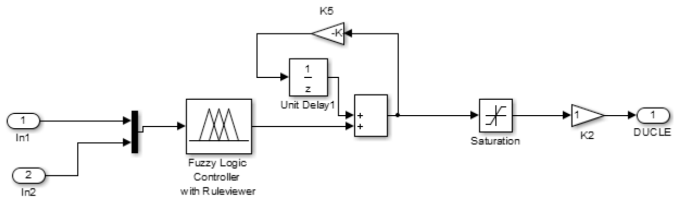

Figure 5. Fuzzy logic controller with rule viewer simulation circuit

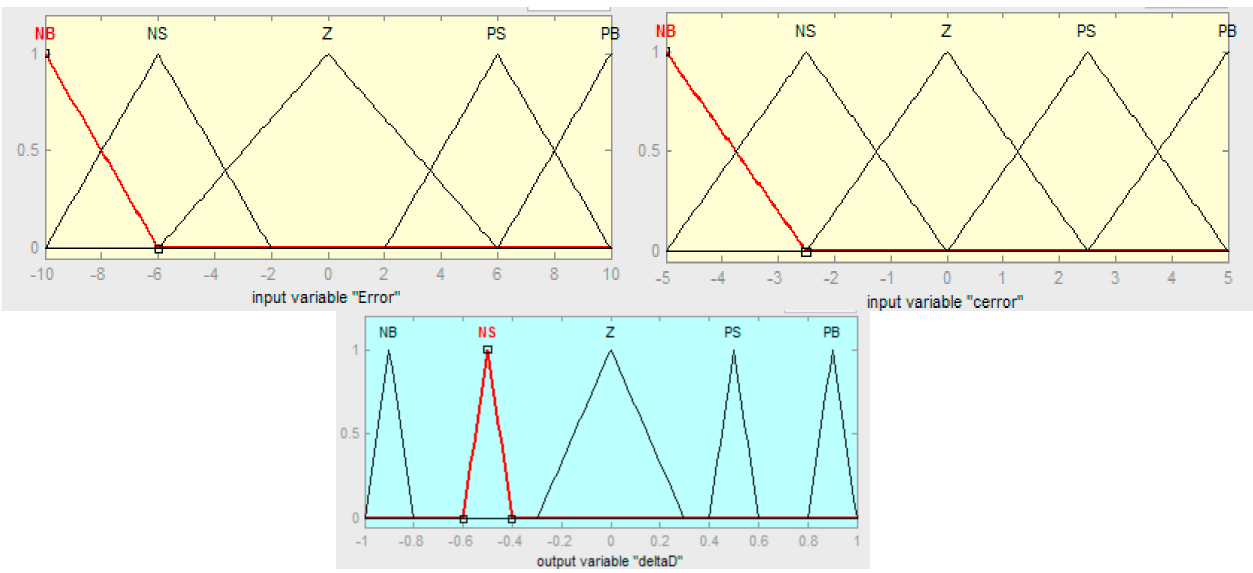

Figure 6.a) Input E b) Input CE and c) output delta D

The membership functions for the inputs and output are shown in Figure 6. The fuzzy rules are created and given in Table 1. The operating point at which the power output is maximum can be adjusted by adjusting the duty ratio. The proposed fuzzy rules give the maximum operating point and the constant voltage output at grid side.

Table 1.Fuzzy Control rules

ΔD		E				
		NB	**NS**	**Z**	**PS**	**PB**
CE	**NB**	**NB**	**NB**	**NB**	**NS**	**NS**
	NS	**NB**	**NB**	**NS**	**NS**	**NS**
	Z	**NB**	**NS**	**NB**	**PS**	**PB**
	PS	**PS**	**PS**	**PS**	**PB**	**PB**
	PB	**PB**	**PB**	**PB**	**PS**	**PS**

5. Simulation results

The Figure 7 shows the simulation circuit for the grid connected micro grid in MATLAB/Simulink. Fuzzy logic toolbox is used to implement the fuzzy logic controller (FLC). The loads considered as critical and non-critical loads. The constant DC voltage from the solar panel is synchronized with the battery voltage and it is given to the inverter. The inverter converts the fixed DC into AC supply for supplied to the grid. The simulation is carried out for 1000W/m^2 and 800W/m^2 irradiation level in offline condition .After running the simulation, the results, and the Fuzzy controller has the ability to maintain the constant voltage at the grid level.

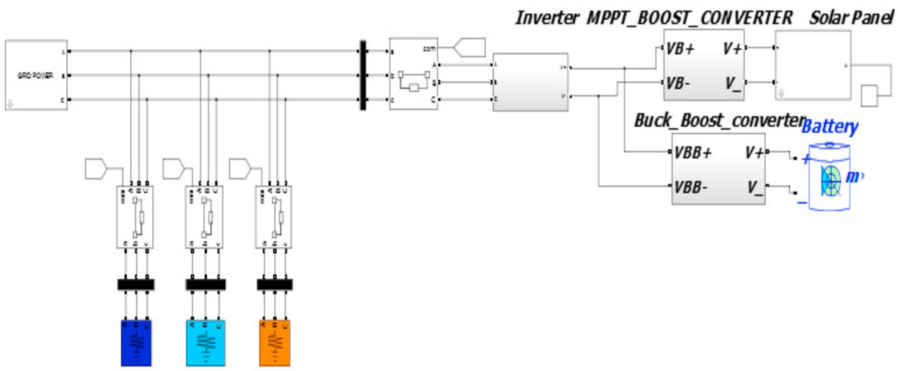

Figure 7. Simulation circuit for the Grid connected Micro grid

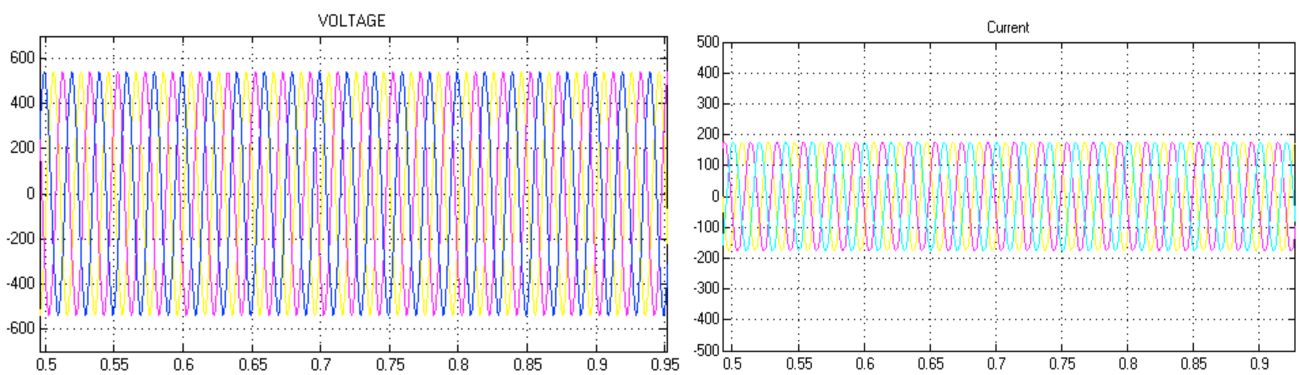

Figure 8. Grid voltage and grid current at 1000W/m^2 irradiation level

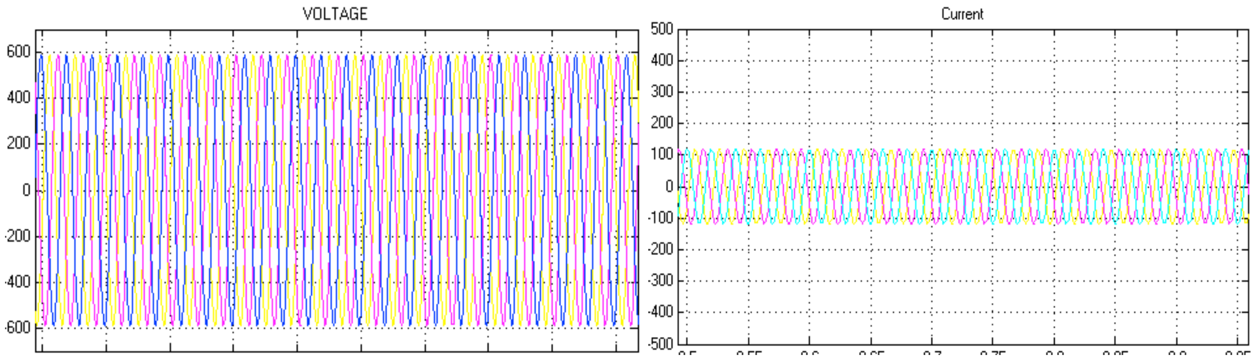

Figure 9. Grid voltage and grid current at 800W/m^2 irradiation level

The Figure 8 and 9 shows the grid voltage and current for irradiation level of 1000 W/m^2 and 800W/m^2 respectively. From the figure, it is proved that the voltage at the grid is maintained at constant level throughout the simulation period. The simulation is carried out for 1 second. The rule viewer diagram and the surface viewer are sown in the Figure 10.

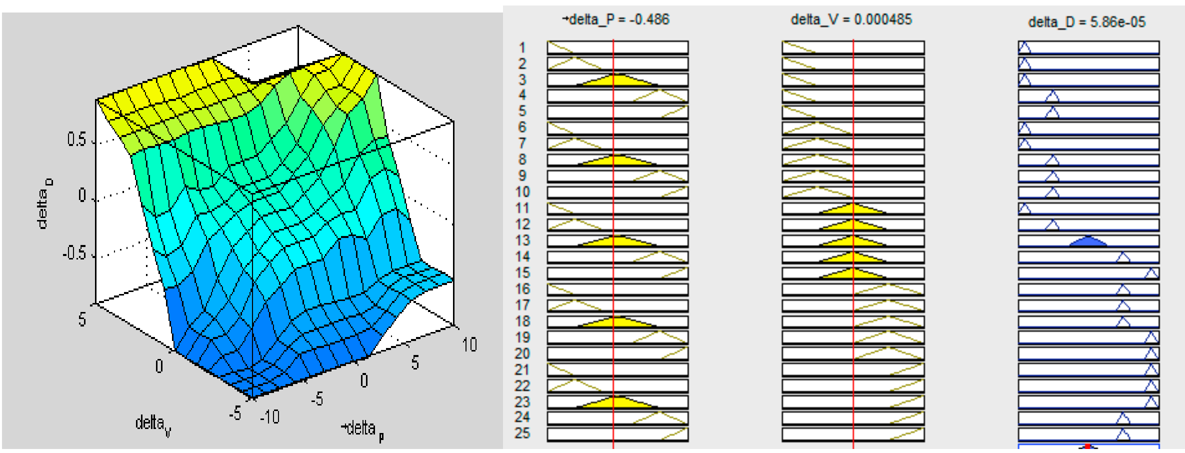

Figure 10. Surface viewer and rule viewer diagram

6. Conclusion

This paper proposes an efficient power management system that uses the Fuzzy logic controller (FLC) for adjusting the duty ratio of the controller in MPPT technique. The fuzzy rules are formed based on the error and change in error taken from the slope of the PV curves of the solar cell. The irradiation is changed to validate the results and the FLC could efficiently manage the required voltage and current level at the grid. The future scope of this work is to include the wind turbine in the system.

References

[1] Sam Koohi-Kamali, N.A. Rahim, H. Mokhlis. Smart power management algorithm in micro grid consisting of photovoltaic, diesel, and battery storage plants considering variations in sunlight, temperature, and load: Energy Conversion and Management.84 (2014) pp.no.562-582.

[2] S.Angalaeswari, K.Jamuna. Active Power Loss Minimization in Radial Distributed Micro grid Incorporating Distribution Generator: Emerging Trends in Electrical, Communications and Information Technologies, Lecture Notes in Electrical Engineering 394, Springer (2015) pp.no.353-360.

[3] S.Angalaeswari, K.Jamuna. Constrained Power Loss Minimization of DC Micro grid Using Particle Swarm Optimization: Proceedings of the International Conference on Data Engineering and Communication Technology, Advances in Intelligent Systems and Computing 468, Springer (2015) pp.no.379-389.

[4] Yoash Levron, Josep M. Guerrero.Optimal Power Flow in Micro grids with Energy Storage: IEEE Transactions on Power Systems (2013) pp.3226-3234.

[5] S.Angalaeswari, K.Jamuna. Optimal Placement and Sizing of Real Power Supporting DG in Radial Distribution Networks: IEEE Conference on Women in Engineering (WIECON-ECE 2015) (2015) pp no. 342-345.

[6] Quanyuan Jiang, Meidong Xue, Guangchao Geng. Energy Management of Micro grid in Grid-Connected and Stand-Alone Modes: IEEE Transactions on Power Systems, (2013) pp.no.3380-3389.

[7] Zaheeruddin, Munish Manas. Renewable energy management through micro grid central controller design: An approach to integrate solar, wind and biomass with battery: Energy Reports 1 (2015) pp.no.156–163.

[8] Swathika OV, Karthikeyan K, Hemamalini S. Multiple DG Synchronization and De-synchronization in a Micro grid Using PLC. Advanced Computing and Communication Technologies; Springer; (2016) pp.no.. 565-572.

[9] B. Bendib, F. Krim, H. Belmili, M. F. Almi, S. Boulouma. Advanced Fuzzy MPPT Controller for a stand-alone PV system: Energy Procedia (2014) pp.no.383 – 392.

[10] Febin Daya J L, Subbiah V, Sanjeevikumar P. Robust Speed Control of an Induction Motor Drive using Wavelet-Fuzzy based Self-tuning Multi resolution Controller: International Journal of Computational Intelligence Systems; (2013) pp .no. 724-738.

[11] A. Karuppa Samy, S. Jeyadevi. Fuzzy Logic Based Battery Power Management for PV and Wind Hybrid Power System: Asian Journal of Science and Applied Technology (2014) pp.no. 21- 27.

[12] Subbulekshmi.D, Kanakaraj. Linearization Algorithms for a Level and PH Process: Life Science Journal (2012) pp.no.2528-2533.

[13] T.Bogaraj, J.Kanagaraj, E.Shalini. Fuzzy Logic Based MPPT for Solar PV Applications: International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (2014) pp.no.1566-1571.