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DEVELOPMENT OF GRID CONNECTED PHOTOVOLTAIC SYSTEM USING FUZZY LOGIC CONTROLLER

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Abstract:

This paper describes a Development of grid connected Photovoltaic (PV) system using Fuzzy Logic Controller (FLC). The Modified Single Ended Primary Inductor Converter (Mod. SEPIC) with the fuzzy logic based Maximum Power Point Tracking (MPPT) provides a constant voltage for a PV system. This converter is highly preferred to obtain a high voltage gain. The output of Mod-SEPIC converter is given to three phase Hex bridge inverter which helps to invert the incoming DC into AC. The proposed system is designed and monitored with an embedded controller which generates a control signal and activates the driver unit. The main objective of this paper deals with the PV system to supply required renewable power to the AC load and the excess power produced from the PV array can be fed into the grid. The excess during peak radiation period can be utilized effectively and fed to the grid thereby reduces the cost of the system. The whole system is developed and tested using MATLAB/Simulink software under various climatic and load conditions.

Index Terms: Photovoltaic System, Mod SEPIC Converter & Fuzzy MPPT Control

1. Introduction:

The increasing of world energy demand due to the industrial development and population growth is motivating rapid investments in alternative energy sources in order to improve energy and power quality issues. The penetration of power from the photovoltaic (PV) systems into electricity is rapidly increasing which results in cost reduction of the power electronic device. A grid connected system is a large independent public electricity and feeds these energy directly into the grid. This energy can be shared by a residential or grid commercial building before or after the revenue measurement point [1]-[3]. Due to the high output gain flexibility the modified-single-ended- primary-inductor converter (Mod. SEPIC) plays a major role which changes its output voltage according to the duty cycle. The selection of a proper Mod SEPIC converter takes a role of Maximum Power Point Tracking (MPPT) operation.

The important aims of the grid-connected PV systems are to increase the efficiency and reliability and also in reduction of cost. The Mod SEPIC is a type of DC/DC converter should allows the voltage greater than, less than or equal to its input. The buck or boost converters are not preferable, due to low output voltage flexibility. There is no general agreement in the literature deals which one of the two converters is better, i.e., the Mod SEPIC or the Cuk [4]-[6]. Another desirable features are component cost, and size. This converter has the capability to produce better efficiency compared to the buck-boost converter and fly-back converter [7].

The Mod SEPIC converter helps in turn to make the output voltage without any changes, and extract the maximum power from the PV array. The perturb and observe technique (P&O) is used to extract the maximum power [8] rather than the algorithm provided for the MPPT technique is fuzzy based MPPT. The MPPT algorithm represents optimal load for PV array, produces corresponding voltage for the load. The PV array yields exponential curves for current and voltage in which the maximum power occurs at the curve's mutual knee [9], [10]. Hence using this MPPT technique radiation and voltage has been increased is an additional advantage. The purpose of MPPT is controlling the duty cycle and thereby, obtaining the maximum power from the PV array [11]-[13].

The PI controller is sensitive to parameter variations and weather conditions. Therefore there is need to apply a more efficient controller to handle the uncertainties. The sliding-mode controller is famous for signal stability and easy implementation [14]-[18]. Different authors used one cycle control for MPPT [19] whereas, the authors used conventional PI regulator along with the MPPT scheme [20], [21].

Among different intelligent controllers, the fuzzy logic is the simplest way to integrate with the system and provides greater response than conventional controllers [22]-[24]. The weather variations from the PV array can be accurately noticed using FLC. The MPPT algorithm is integrated with the FLC so that the overall system can always provides maximum power transfer from the PV array under unpredictable weather conditions.

2. Proposed System:

The change of voltage is fed to the Mod SEPIC converter is the main function of this paper. The purpose of this converter keeps the voltage without any changes with the help of fuzzy MPPT. The voltage level can be increased or decreased depending on the maximum power. The three phase Hex bridge inverter helps to invert the incoming signal from the converter. This paper seeks to use Mod SEPIC converter with a fuzzy based MPPT to extract the maximum power under various load and climatic conditions is shown in figure 1.

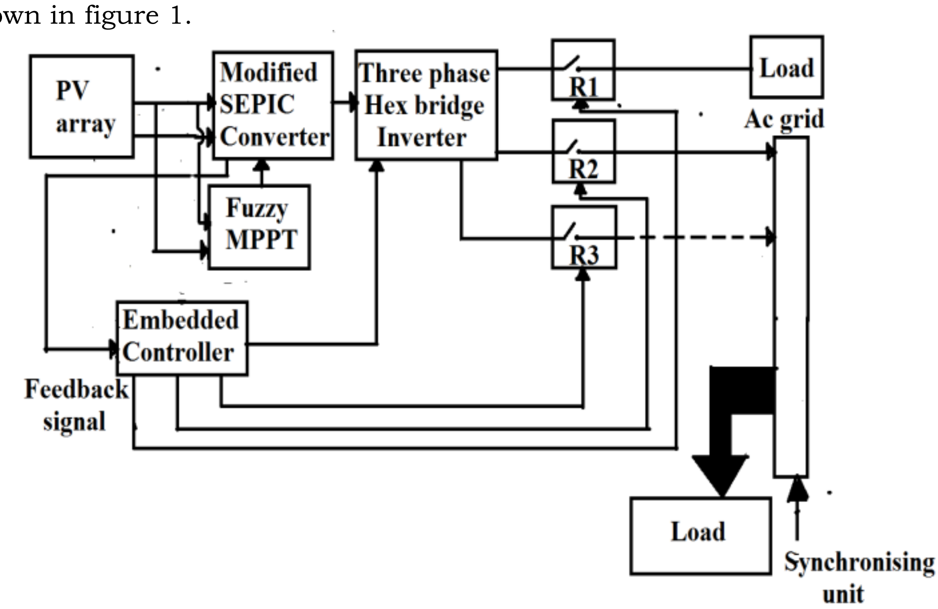

Figure 1: Block diagram for the proposed system

3. Fuzzy Logic Controller (FLC):

The FLC which makes use of the fuzzy logics to control the output of the embedded controller. The main components in MPPT controller based on fuzzy logics are fuzzification, rule-base, inference, and the defuzzification unit as shown in Fig. 2.

The error e(k) and change in error Δe(k) these are the two inputs to the controller. The Fuzzification block converts the inputs of crisp into inputs of fuzzy the rules which are formed in rule base and are applied in inference block. The defuzzification converts the fuzzy into the crisp output. The fuzzy inference is carried out by using Mamdani's method and the defuzzification uses the centre of gravity. The inputs to the fuzzy controller are change in PV array Power (ΔPPV) and PV array current (ΔIPV) are the corresponding to the two sampling time instants. The two inputs are processed by the Fuzzy controller and the output is the incremental reference current (ΔIref). This output is given to the Mod. SEPIC converter. The first input variable (ΔPpv) for the FLC is divided into seven Fuzzy sets. They are Positive Big (PB), Positive Medium (PM), Positive Small (PS), Zero (ZZ), Negative Small (NS), Negative Medium (NM) and the Negative Big (NB). The second input variable (ΔIpv) for the FLC is divided into 3 Fuzzy sets. They are Negative (N), Zero (Z) and Positive (P). The only one of the output variable (ΔIref) is divided into 7 Fuzzy sets. They are Positive Big (PB), the Positive Medium (PM), the Positive Small (PS), Zero (Z), Negative Big (NB), Negative Medium (NM) and Negative Small (NS). The rules are formed as shown in Table 1.

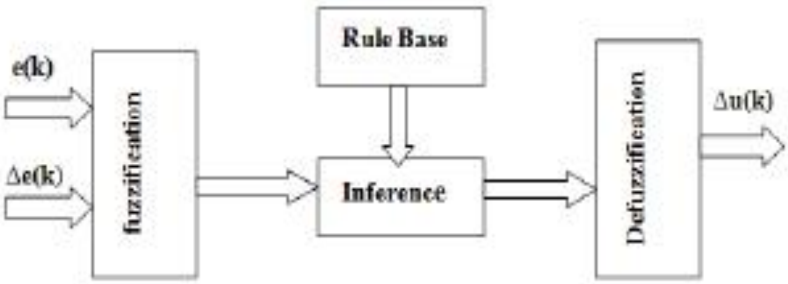

Figure 2: Fuzzy logic block diagram

Table 1: Fuzzy Rules

ΔPpv ΔIpv	PB	PM	PS	ZZ	NS	NM	NB
P	PB	PM	PS	PS	NS	NM	NB
Z	PB	PM	PS	ZZ	NS	NM	NB
N	NB	NM	NS	NS	PS	PM	PB

The design of fuzzy controller was done using Mamdani's method for both converter and three phase Hex bridge inverter. The FLC which mainly consists of membership fuctions is shown in figure 3.

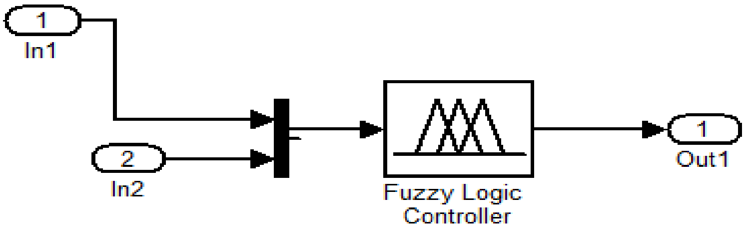

Figure 3: Diagram for Fuzzy logic controller

A. Membership Functions:

The error e(k), change in error Δe(k), and the output variable plots are shown in figure 4, 5, 6.

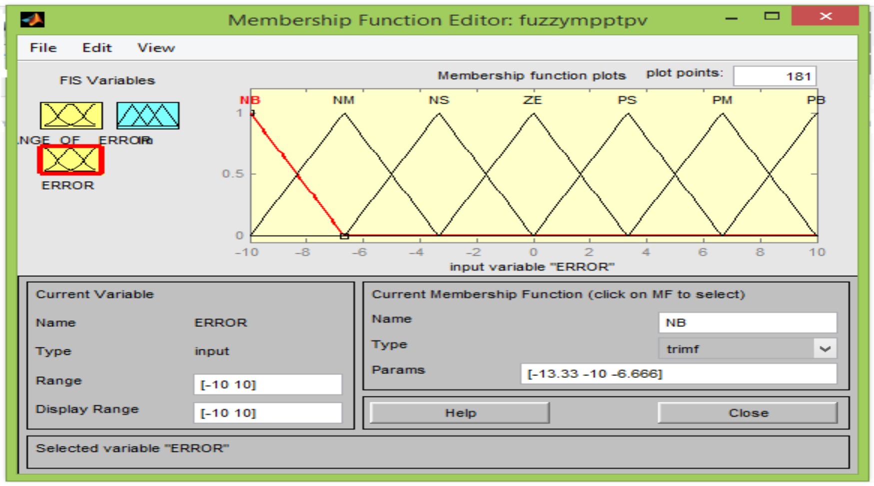

Figure 4: Membership function for error e(k)

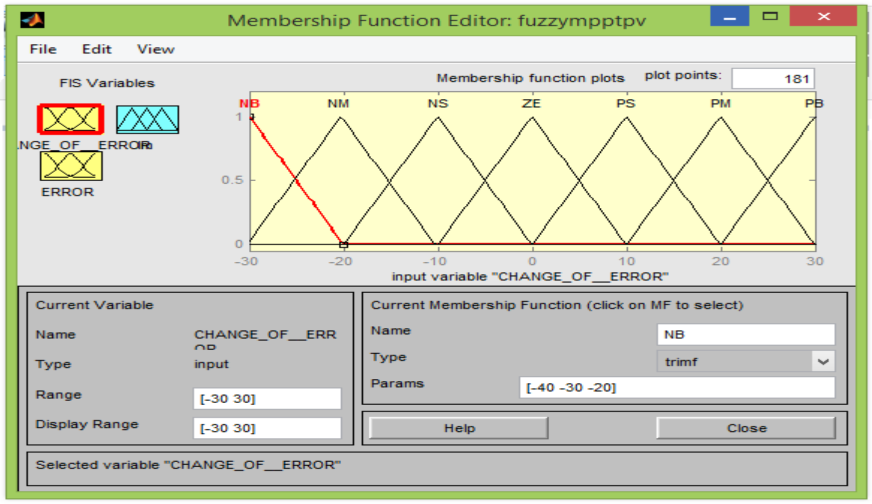

Figure 5: Membership function for Change in error Δe(k)

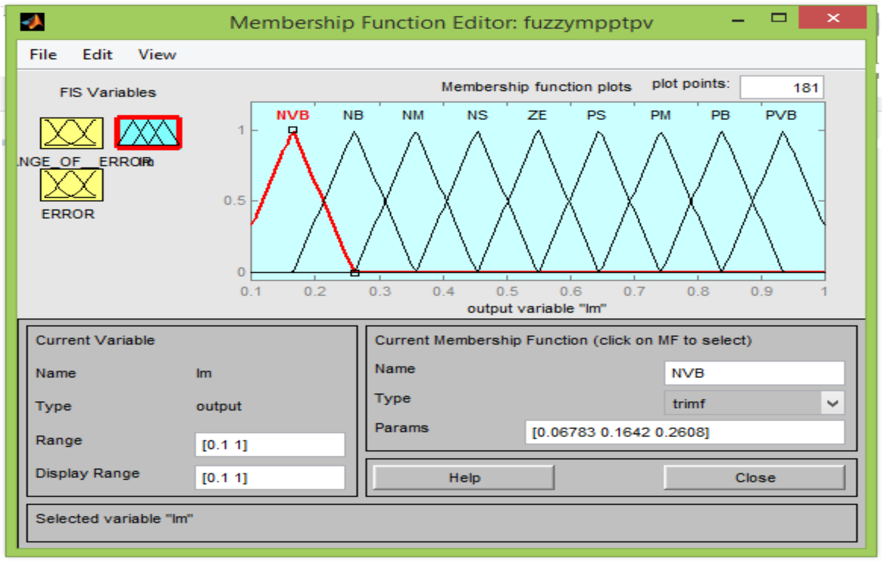

Figure 6: Membership function for output variable

4. Simulation Results:

Simulation was applied on the MATLAB / Simulink to verify the practical implementation of the simulation of the proposed Mod. SEPIC for the three phase Hex bridge inverter. The waveform of three phase Hex bridge inverter is shown in figure 7.

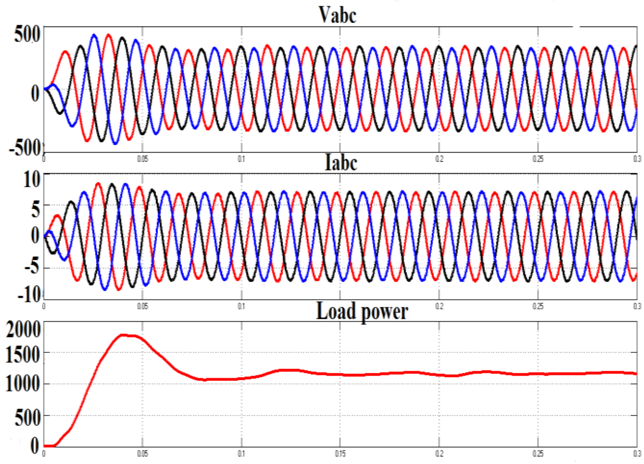

Figure 7: Output waveform of three phase Hex Bridge Inverter

The Irradiance 940,385,120W/m² and the corresponding relay condition and the working status are listed in Table II.

Table 2: Output for Different Radiation

Sl.No	Radiation W/m²	P_{solar} (Watt)	P_{Load} (Watt)	Relay Condition			Working Status
				Solar to Load (R1)	Grid to Load (R2)	Solar to Grid (R3)	
1	940	1889.5	1000	ON	OFF	ON	P_{Gen}=2000W $P_{solar} > P_{Load}$ $P_{Gen}=R_1+R_3$ ON
2	385	1280	1000	ON	OFF	OFF	P_{Gen}=1224W $P_{solar} > P_{Load}$ $P_{Gen}=R_1$ ON
3	120	215	1000	OFF	ON	OFF	P_{Gen}=174.5W $P_{solar} < P_{Load}$ $P_{Load}=R_3$ON

B. Flow Chart:

The diagram which consists of PV array and Mod. SEPIC converter is given to fuzzy MPPT and three phase Hex bridge inverter is shown in figure 8. The corresponding conditions are listed as below

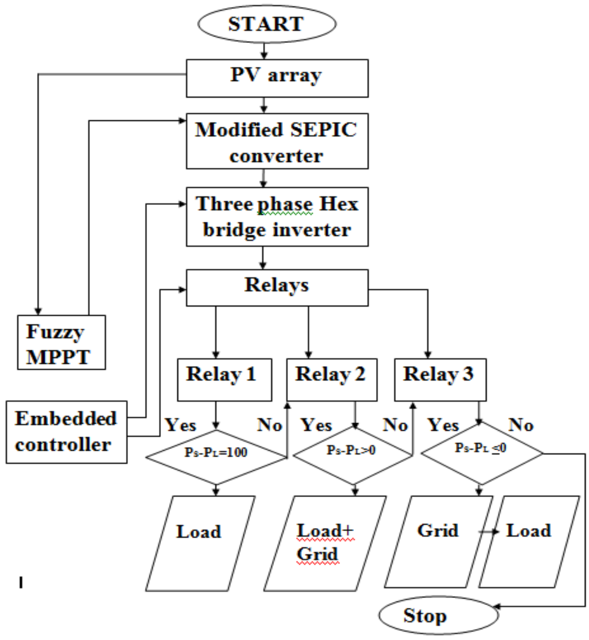

Figure 8: Flow Chart

- The first condition shows that, if P_S-P_L is greater than 0 (P_S-P_L > 0) the power from the solar array feeds the power to the load and results shows that first relay/breaker (R1) is activated.
- The second condition shows that, if P_S-P_L is greater than or equal to 100 (P_S-P_L=100) the solar array feeds the power to the grid and results shows that second relay/breaker (R2) is activated.
- The third condition shows that, if P_S-P_L is less than or equal to 100 (P_S-$P_L \leq 0$) the power should be fetched from the grid and it supplies to load and results shows that third relay/breaker (R3) is activated.

C. Solar Power Generation for 940w/m² Radiation:

The graph which consists of Irradiance, solar power, load power, and grid power. The radiation is set to 940W/m² and the solar panel generates power of about 1889.5W. The corresponding load power is 1000W. In this case, P_{solar} > P_{Load} and as a result first and third relays (R1 and R3) are activated. The generated power is feed to solar to load as well as to grid. The corresponding power generation is shown in figure 9.

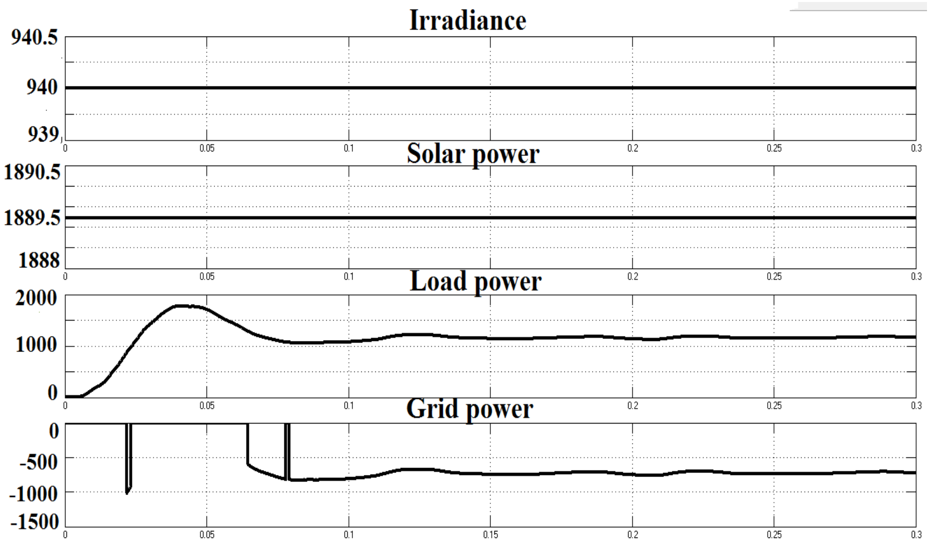

Figure 9: Power Generation at 940W/m² Radiation

The relay function in figure 10 shows that the solar to load (R1) and solar to grid (R3) are activated.

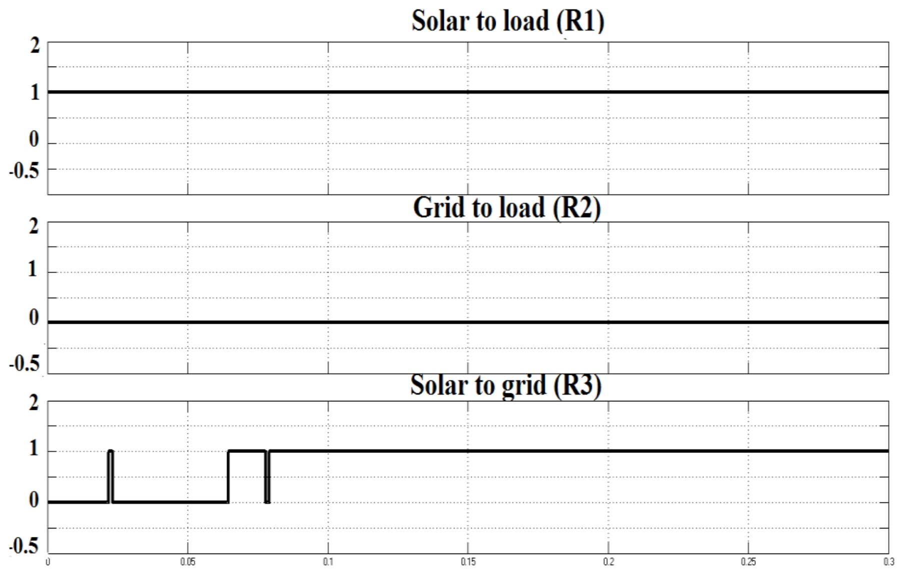

Figure 10: Switching function at 940W/m² Radiation

D. Solar Power Generation for 630 w/m² Radiation:

The radiation is set to 630W/m² and the power generation of 2000W from the PV array reduces to 1280W. The corresponding load power is 1000 W. In this case, P_{solar} > P_{Load} and as a result first relay (R1) should be activated. The generated power is feed to source to load. The corresponding power generation is shown in figure 11.

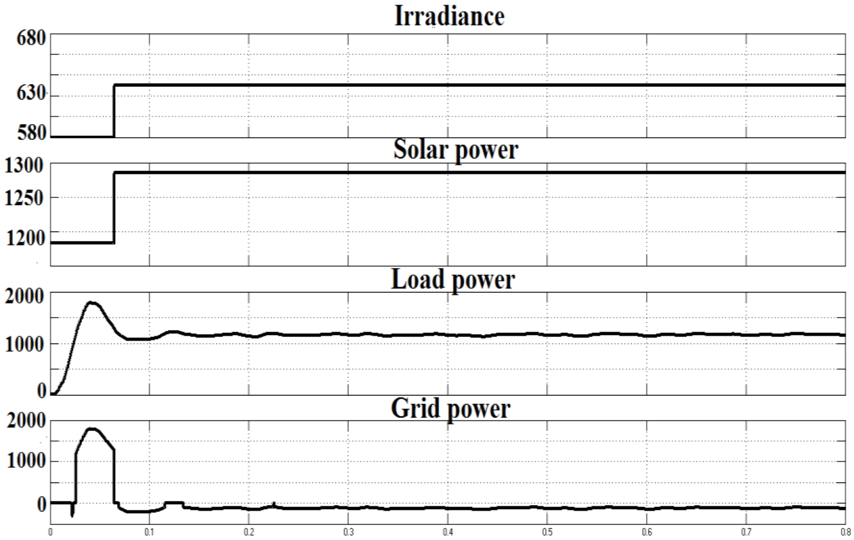

Figure 11: Power Generation at 630W/m² Radiation

The relay function in figure 12 shows that the solar to load (R1) is activated. At this condition the generated solar power is equal to the load demand hence there is no excessive power generated by the PV array therefore it is capable to supply only to the load and not to the grid.

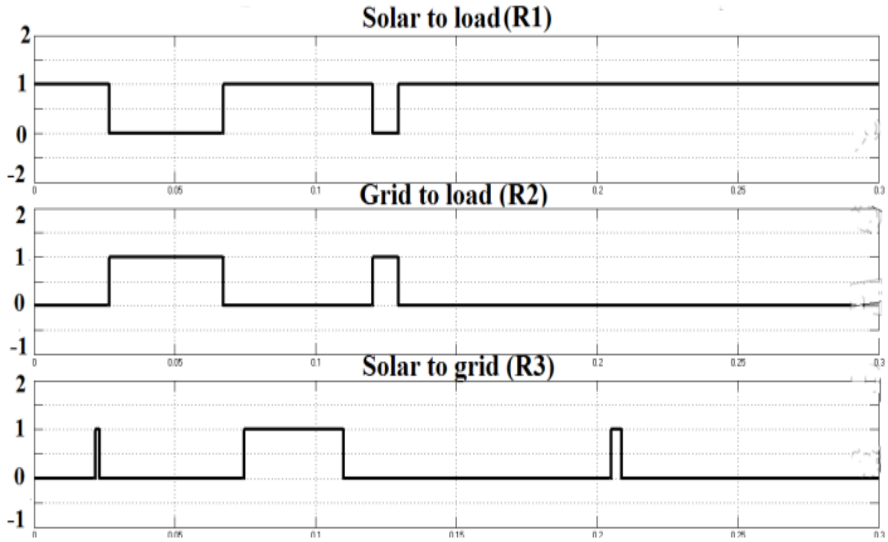

Figure 12: Switching function at 630w/m² Radiation

E. Solar Power Generation for 120 w/m² Radiation:

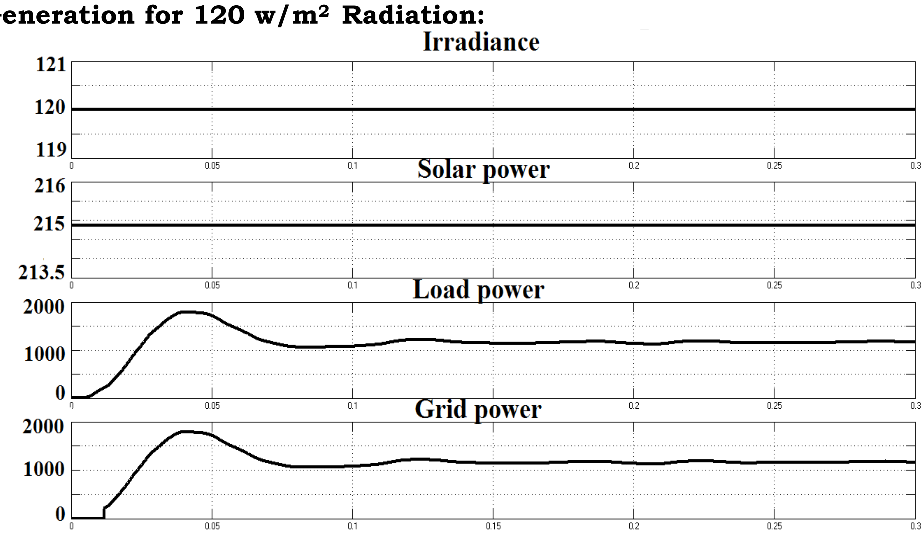

Figure 13: Power Generation at 120W/m² Radiation

The radiation is set to 120W/m² and the power generation of 2000W from the PV array reduces to 215W. The corresponding load power is 1000 W. In this case, $P_{solar} < P_{Load}$ and as a result second relay (R2) should be activated. The generated power is feed to grid to load. The corresponding power generation is shown in figure 13.

The relay function in Fig. 14 shows that the grid to load (R2) is activated and the remaining relays (R1 and R3) are deactivted. At this condition the generation of solar power is not enough to meet the requirement of the load hence if fetches the supply from the grid and supplies to the load.

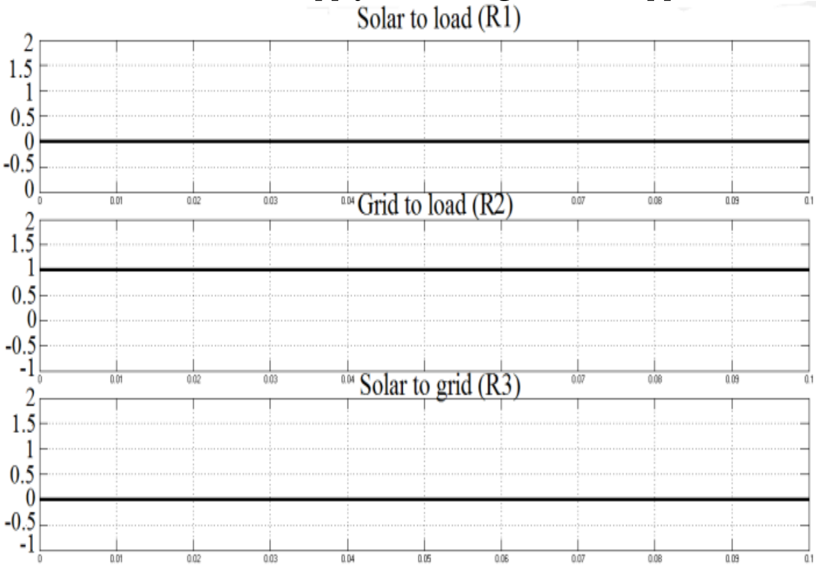

Figure 14: Switching function at 120W/m² Radiation

6. Conclusion:

The development of grid connected photovoltaic system using Fuzzy Logic Controller has been presented in this paper. The better performance can be achieved with the help of fuzzy based MPPT to track the maximum power thereby increases the reliability and efficiency of the system. The purpose of three phase Hex bridge inverter was explained and the system was monitored using embedded controller. The simulation was performed by using MATLAB/ Simulink software. The results were discussed has tabulated also shown in different output waveforms under different radiations. The whole system has been analyzed and tested under different climatic and load conditions.

7. References:

1. Qinglin Zhang, Liran Dor , Dikla Fenigshtein , Weihong Yang , Wlodzmierz Blasiak,
2. Gasification of municipal solid waste in the Plasma Gasification Melting process, Applied Energy, Available online from 21 March, 2011.
3. L. Tang, H. Huang, H. Hao, K. Zhao Development of plasma pyrolysis/gasification systems for energy efficient and environmentally sound waste disposal, Journal of Electrostatics: 71(2013) p 839-847.
4. Qinglin Zhang, Yueshi Wua, Liran Dor, Weihong Yan, Wlodzimierz Blasiak, A thermodynamic analysis of solid waste gasification in the Plasma
5. Gasification Melting process, Applied Energy: 112(2013)405-413.
6. Seok-Wan Kim, Hyun-Seo Park, Hyung-Jin Kim, 100kW steam plasma process for treatment of PCBs(polychlorinated biphenyls) waste,Vacuum:70(2003)59-66.
7. Ashok V. Shekdar, Sustainable solid waste management: An integrated approach for Asian countries, Waste Management: 29 (2009) 1438–1448.
8. X. Lu, K. Nakajima, H. Sakanakura K. Matsubae c, H. Bai,T. Nagasaka, Thermo dynamic estimation of minor element distribution between immiscible liquids in Fe–Cu-based metal phase generated in melting treatment of municipal solid wastes,Waste Management:32 (2012) 1148–1155.
9. Shane Morrin, Paola Lettieri, Chris Chapman, Richard Taylor, Waste Management:34 (2014) 28–35
10. Liqing Yang, Haojing Wang, Hongfei Wang, Dapeng Wang, Yue Wang, Solid waste plasma disposal plant, Journal of Electrostatics: 69 (2011) 411-413.
11. E. Gomez, D. Amutha Rani, C. R. Cheeseman, D. Deegan, M. Wise, A. R. Boccaccini, Thermal plasma technology for the treatment of wastes: A critical review, Journal of Hazardous Materials :161 (2009) 614–626.
12. Biswajit Ruj, Subhajyoti Ghosh, Technological aspects for thermal plasma treatment of municipal solid waste-A review, Fuel Processing Technology:126 (2014) 298–308.
13. K. Ramachandran, N. Kikukawa, Vacuum: 59 (2000) 244}251.
14. Massimiliano Materazzi, Paola Lettieri, Luca Mazzei, Richard Taylor, Chris Chapman, Thermodynamic modelling and evaluation of a two-stage thermal process for waste gasification, Fuel: 108(2013)356-359.
15. Joachim Heberlein and Anthony B Murphy, Thermal Plasma Waste Treatment, Journal of Applied Physics. D: Appl. Phys. 41 (2008) 053001 (20pp)
16. Maoyun He, Zhiquan Hu, Bo Xiao, Jianfen Li, Xianjun Guo, Siyi Luo, Fan Yang, Yu Feng,

Guangjun Yang, Shiming Liu, Hydrogen-rich gas from catalytic steam gasification of municipal solid waste (MSW): Influence of catalyst and temperature on yield and product composition, International journal of hydrogen energy 34(2009)195–203
17. Shane Morrin, Paola Lettieri, Chris Chapman, Luca Mazzei, Two stage fluid bed-plasma gasification process for solid waste valorisation: Technical review and preliminary thermodynamic modelling of sulphur emissions, Waste Management 32 (2012) 676–684