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Control Strategy for Bidirectional AC-DC Interlinking Converter in AC-DC Hybrid Microgrid Using PV System

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***Abstract-* This paper presents optimize energy extraction in photovoltaic (PV) energy systems. The maximum power of the photovoltaic module will change due to changes in temperature, solar radiation and load. To maximize efficiency, the photovoltaic system uses a maximum power point tracker (MPPT) to continuously extract the most power that the solar panel can generate and then pass it on to the load. The overall structure of the MPPT system consists of a DC-DC converter (an electronic device that converts DC energy from one voltage level to another) and a controller. During changes in weather conditions, MPPT uses a tracking algorithm to find and maintain operation at the point of maximum power. Many different algorithms for MPPT have been proposed and discussed in the literature, but most of these methods have disadvantages in terms of efficiency, precision, and flexibility. Due to the non-linear behavior of the current voltage characteristics of the PV module and the non-linearity of the DC-DC converter due to switching, conventional controllers cannot provide an optimal response, especially when dealing with a wide range of shifting line parameters and transients. The purpose of this work is to design and implement a maximum power point tracker using fuzzy logic control algorithms. Fuzzy logic naturally provides an excellent controller for such nonlinear applications. This method also benefits from artificial intelligence methods that can overcome the complexity of modeling nonlinear systems. To make this work a success, Simulink designed and simulated an MPPT system consisting of photovoltaic modules, DC-DC converters, batteries, and fuzzy logic controllers. Perform the characterization of the buck, boost and buck-boost converter to find the most suitable topology for the PV system used. The integrated model of the PV module with the identified converter and battery was simulated in MATLAB to gain the necessary experience to formulate and adjust the fuzzy logic controller. The simulation results show that fuzzy logic.**

***Keyword*:- MPPT, Solar Panel, Fuzzy Logic ,Grid,DC-DC Converter**

I. INTRODUCTION

Power electronics has established an important position in the latest technology and has completely changed the management methods for electricity and energy. As the switching characteristics of power semiconductor devices improve and as the voltage and current rating of devices is greatly increased, the application area of electrical electronic devices is expanded. A DC-to-DC converter is an electronic current circuit that converts available DC at one voltage level to DC at another voltage level. The high frequency electronic power processor is used for DC-DC power conversion. The DCDC converter adjusts the DC output voltage according to load and line changes. Buck, boost, buck-boost and Cuk converters are the four basic DC-DC converter topologies. Popular isolated versions of these converters are forward converters, push-pull converters and back converters. DC-DC converters are widely used in photovoltaic power generation, which can convert low voltage PV power to the voltage required by the load. Conventional sources of electrical energy used to generate electrical energy are not environmentally friendly and they no longer exist.

The global energy crisis provides new impetus for growth and use of clean and renewable energy. Solar photovoltaic (PV) power generation is becoming increasingly important as a renewable energy source due to benefits such as no fuel costs, low maintenance costs and no noise and wear caused by moving parts. With the development of photovoltaic technology, the price of photovoltaic modules has fallen sharply. Photovoltaic-based systems are increasingly used in various applications at home and business level. However, the nonlinear current voltage characteristics (I-V) hinder its control design to achieve maximum power extraction. To extract the maximum available power, DC-DC converters with current maximum power point tracking (MPPT) algorithms are widely used. The controller that tracks the path to the maximum power point in the PV array is called the maximum power point tracker. Due to the high cost of solar cells, it is necessary to operate the photovoltaic array at the maximum power point. To get the system running optimally, the load line must match the position of the maximum power point in the PV array. This point varies with temperature, insulation and load conditions and must be continuous Monitored to respond to rapid changes the two ways of operating the photovoltaic module at the maximum power point are open-loop control and closed-loop control methods.

The open loop method is based on the assumption that the maximum power point voltage is a linear function of open circuit voltage. Closed loop control involves changing the input voltage around the optimum value by alternately giving the input voltage a small increment or a small increment. Then evaluate the output power output and make further small adjustments to the input voltage. This control is called mountaineering control. Various climbing controls include the "disturbance and observe" method, the "incremental conductivity" method, and the "incremental resistance" method. MPPT can be achieved using some artificial intelligence-based tracking (e.g., fuzzy logic-based control, neural control with and without optimization techniques). For some photovoltaic applications, such as UPS, DC networks, etc., the constant output voltage must be maintained under variable load conditions, and the source voltage fluctuations must also be maintained.

Various voltage regulators using DC to DC converters with different control schemes are used to improve the efficiency of the controller. Due to advances in power electronics technology and the improvement of technology, it is expected that there will be stricter requirements for accurate and reliable regulation. This leads to the need for more advanced and reliable design of controllers for DC-DC converters. There are various analog and digital control methods for DC-DC converters, including voltage and current state control techniques. [1][2]

II. RELATED WORK

The two ways of operating the photovoltaic module at the maximum power point are open-loop control and closed-loop control methods. The open loop method is based on the assumption that the maximum power point voltage is a linear function of open circuit voltage. Closed loop control involves changing the input voltage around the optimum value by alternately giving the input voltage a small increment or a small increment. Then evaluate the output power output and make further small adjustments to the input voltage. This control is called mountaineering control.[3][4] Various climbing controls include the "disturbance and observe" method, the "incremental conductivity" method, and the "incremental resistance" method. MPPT can be achieved using some artificial intelligence-based tracking (e.g., fuzzy logic-based control, neural control with and without optimization techniques). For some photovoltaic applications, such as UPS, DC networks, etc., the constant output voltage must be maintained under variable load conditions, and the source voltage fluctuations must also be maintained. Various voltage regulators using DC to DC converters with different control schemes are used to improve the efficiency of the controller. Due to advances in power electronics technology and the improvement of technology, it is expected that there will be stricter requirements for accurate and reliable regulation. This leads to the need for more advanced and reliable design of controllers for DC-DC converters. There are various analog and digital control methods for DC-DC converters, including voltage and current state control techniques..

Chandra Sekhar Nalamati et.al. (2018) the growing popularity of renewable energy and electricity (EV) has transformed the structure of the global energy industry. In the charge-coupled charge system for renewable energy, bidirectional AC / DC converters are used for more reliable power generation operations. This paper presents a bidirectional AC / DC converter that combines an AC-DC bidirectional converter (GBC) and a bidirectional De-Battery (BBC) battery charger. The GBC printer can facilitate bidirectional flow between the AC and DC networks, while the BBC converter can provide bidirectional power between the energy storage / EV and DC grid systems. In order to transmit power in the trunk, powerful power management technology is required. Hysteresis based power management technology is used to inject electrical energy into the container. AC-DC conversion offers asymmetric PWM strategies with minimal conversion. PSCAD tools are used in simulation to validate the proposed control algorithm.[5][6]

III. PROPOSED SYSTEM

The proposed network-connected bi-directional simple power conversion converter system with low input battery voltage for the proposed converter, only one power processing stage is needed to perform bidirectional power flow control and meet common interface standards. The current input and output of the folded network represents the power flow and the transmitted power level. It also includes power quality on the grid side. Therefore, controlling the input and output of the folded grid current can lead to the feasibility of the proposed converter for individual power conversion. This project designs and proposes a fuzzy controller for the Buck-boost DC-DC converter. To control the output voltage of the buck-boost converter, the controller is designed to change the converter duty cycle. The mathematical model of the buck-boost converter and the fuzzy controller is derived, and the simulation model is designed. The simulation was developed in the MATLAB simulation program. To verify the effectiveness of the simulation model, an experimental device was developed. He developed a buck-boost circuit using MOSFET as the switching element. The fuzzy logic controller that generates the PWM signal duty cycle is programmed. Simulation and experimental results show that the output voltage of the buck-boost converter can be controlled according to the value of the duty cycle.

BLOCK DIAGRAM

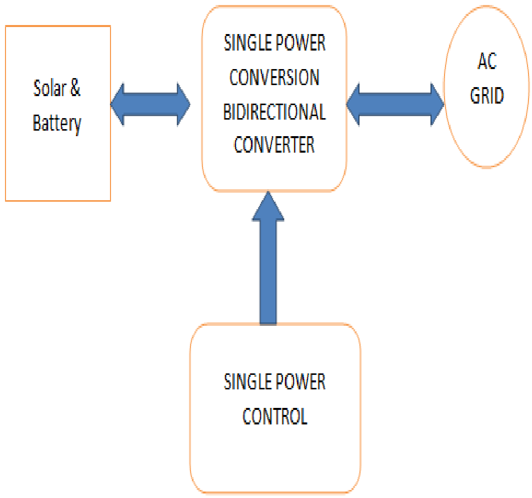

Fig 1. Proposed Block Diagram.

Due to the small signal model, the dc-dc boost converter is a non-linear duty cycle function, and its control method has been applied to boost converter control. Fuzzy controllers do not require precise mathematical models. Instead, they are designed according to the general knowledge of the factory. The diffuse controller is designed to adapt to changing operating points. The Fuzzy Logic Controller is designed to use the Mamdani Fuzzy Inference System to control the boost DC-DC converter output.

Module

- Bidirectional DC-AC converter bridge
- AC power network
- Simple energy conversion control
- Fuzzy controller
- Solar
- Boost converter
- Bidirectional converter
- Battery

The main switches Sp and Ss in the proposed converter operate at a frequency significantly higher than the mains frequencyherefore, the gate voltage vg can be considered constant during the switching period Ts, and it is assumed that the folded gate voltage vo is the same as the absolute value of the gate voltage vg. The proposed converter only has the following two sub-ranges: the on state of the main switch Sp and the off state of the secondary main switch Ss, or the off state of the main switch Sp and the on state of the secondary main switch Ss. Two modes of operation. Suppose that the duty cycle of the primary circuit breaker Sp defines the duty cycle of the primary circuit breaker D. The fuzzy logic controller has been applied to the system by developing a fuzzy logic control algorithm. The design and calculation of the inductor components have been completed to ensure that the converter operates in continuous driving mode.

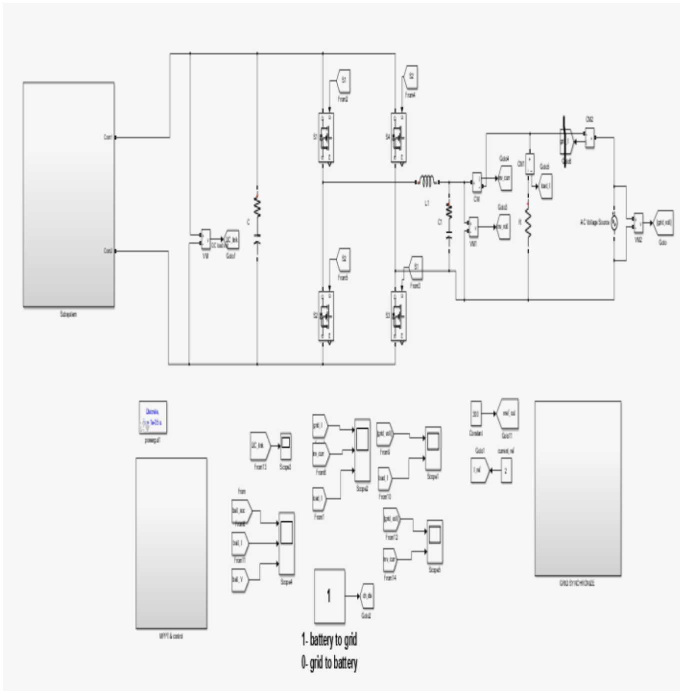

Fig 2. Proposed Simulink Model.

IV. FUZZY CONTROLLER STRUCTURE

The structure of the fuzzy logic controller is based onfuzzy sets, where variables are members of one or more sets with a specific degree of membership. The advantage of using fuzzy logic is that it allows us to simulate human inference processes in computers, quantify inaccurate information, and make decisions based on fuzzy information, such as connecting resistive loads to photovoltaic modules through booster DC / DC converters The block diagram of the MPPT-based fuzzy logic control is shown in Figure 3.

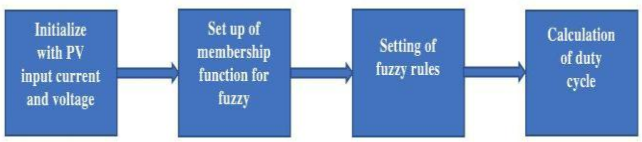

Fig 3. Block diagram of the fuzzy logic algorithm.

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1. Membership functions of the proposed fuzzy system- The definition of fuzzy sets for each input and output variable is shown in Figure 4. Three fuzzy subsets; select the input and output variables of the fuzzy controller as small, medium, and high. As shown in Figure 4-4, the membership function uses a trapezoidal shape. The input membership range is the PV voltage and the PV current is,

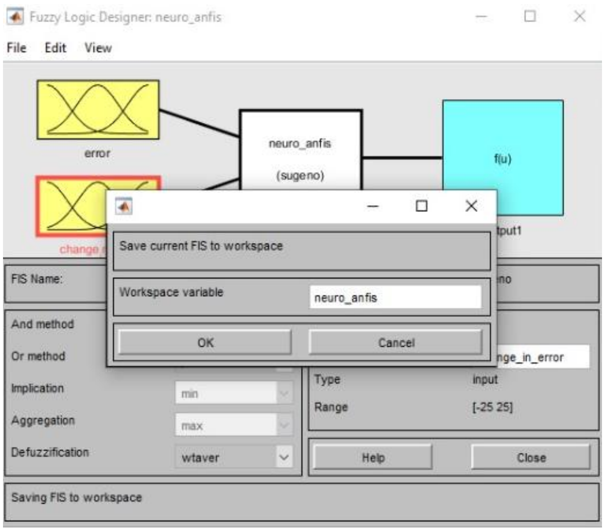

Fig 4. Membership functions fuzzy system of save current to workspace.

The characteristics of the proposed photovoltaic module (Voc @ 22 V, Isc = 15 Arespectively. Similarly, the duty cycle that the fuzzy controller output represents is between 0 and 1 to provide more flexibility to change the buck-boost converter.

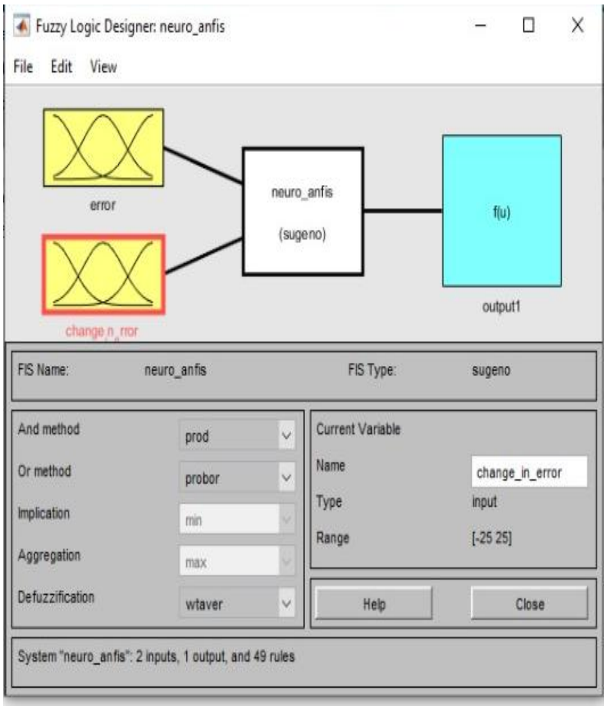

Fig 5. The Membership Function plots of change error.

Figure5 illustrates the surface of the fuzzy controller ruler, which is a graphical representation of the ruler base. Figure 6 shows the rule viewer, which indicates the operation of the fuzzy controller during input changes.

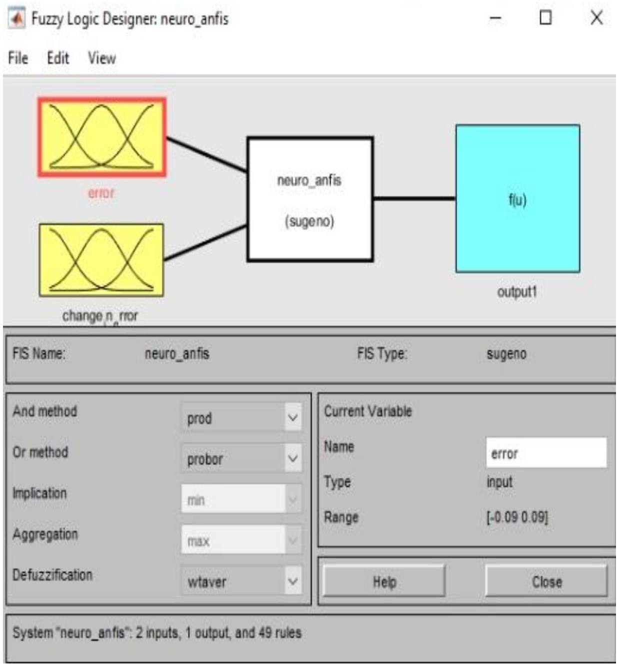

Fig 6. The Membership Function plots of error.

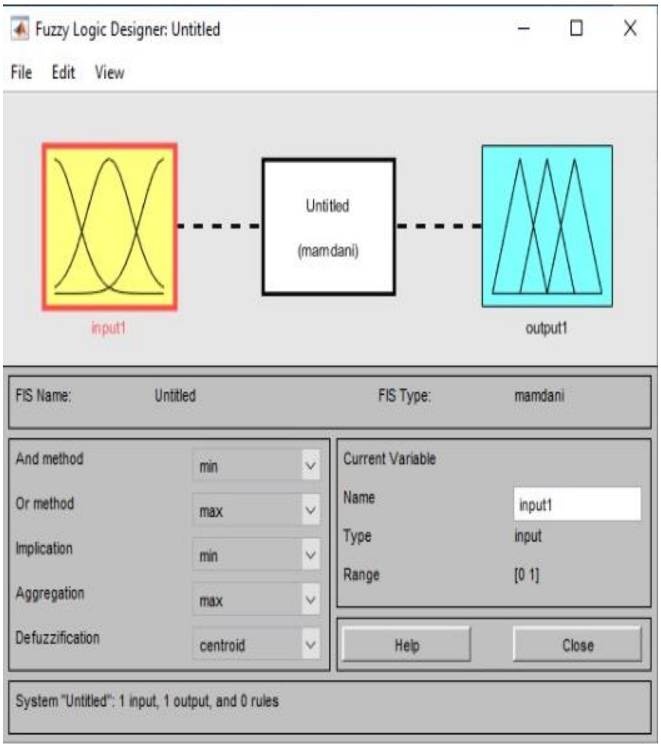

Fig 7. The Membership Function plots of duty ratio.

2. Fuzzification:
Each input / output variable is required in a fuzzy logic controller, and these variables define a control surface that can be represented in a language-level fuzzy set symbol.

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Each input and output variable of the linguistic value divides its emission range into adjacent intervals to form a membership function. The value of the member indicates the degree to which the variable belongs to a specific level. The process of converting variable input / output processes at the language level is called fuzzification.

3. Inference:

A set of rules is used to control the behavior of the control surface related to the input and output variables of the system. A typical rule is: if x is A THEN y is B. Under the premise of each rule with real degree, reading a set of input variables will activate a rule and help form a control to approximate it. Then, when all the rules are activated, the generated control interface will appear. It is expressed as a fuzzy set representing the restricted output. This process is called inference.[9]

4. Single power conversion:

For the proposed converter, only one power processing stage is needed to perform bidirectional power flow control and meet common interface standards. The current input and output of the folded network represents the power flow and the transmitted power level. It also includes power quality on the grid side Therefore, controlling the input and output of the folded grid current leads to the feasibility of a single energy conversion in the proposed converter.

5. Control: The converter proposed by a single AC-DC power conversion converter with a high power factor is obtained by integrating a full-bridge diode rectifier and a series resonant active clamp DC-DC converter. The proposed converter achieves a high power factor without a power factor correction circuit by using a novel control algorithm for power factor correction and output control, thus providing a unique power conversion. Compared to the two-stage AC-DC converter, the traditional single-stage AC-DC converter has higher voltage voltage or lower power factor. Similarly, PFC circuits used in single-stage AC-DC converters require DC link electrolytic capacitors and inductors. DC bus electrolytic capacitors and inductors increase the size and cost of the converter. To resolve these problems, the DC link electrolytic capacitors must be removed from the circuit.

A high power factor based single power conversion AC-DC converter, which is obtained by integrating a full bridge Mosfet diode rectifier and a series resonant active clamp DC-DC converter to obtain a high power factor without power correction circuit. The proposed converter provides a unique power conversion by using a new control algorithm for power factor correction and output control. Similarly, the active clamping circuit clamps the breaker overvoltage and recovers the energy stored in the leakage inductance of the transformer. Additionally, it provides a zero voltage conduction switch for the switch. Also, the series resonant circuit of the output voltage duplicator eliminates the problem of reverse recovery of the output diode. The proposed converter can provide a maximum power factor of 0.995N and a maximum efficiency of 95.1% at full load. Analyze and verify the operating principle of the converter. Experimental results were obtained from a 400 W AC-DC converter at a constant switching frequency of 50 kHz to show the performance of the proposed converter.[8]10]

6. Solar power :

Standard Solar, Inc. recently completed one of the first grid-interactive battery pack solar microgrid systems in the country. The first challenge is to make this project a reality after months of dedication, innovative engineering design and coordination with key partners, public services and government departments. The first half of this article will set the stage explaining how to set up the microgrid, its features, and its uniqueness. Then, I will discuss the time required to design and install a solar microgrid system, the lessons learned from this groundbreaking project, and what technical considerations should be considered when implementing this new technology.

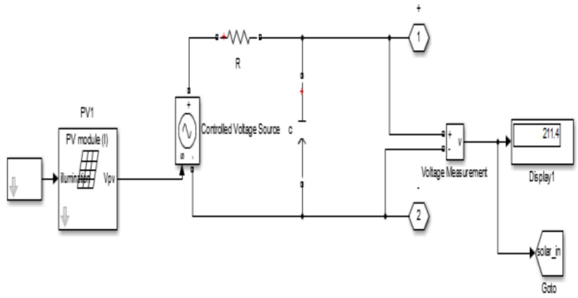

Fig 8. Solar Panel.

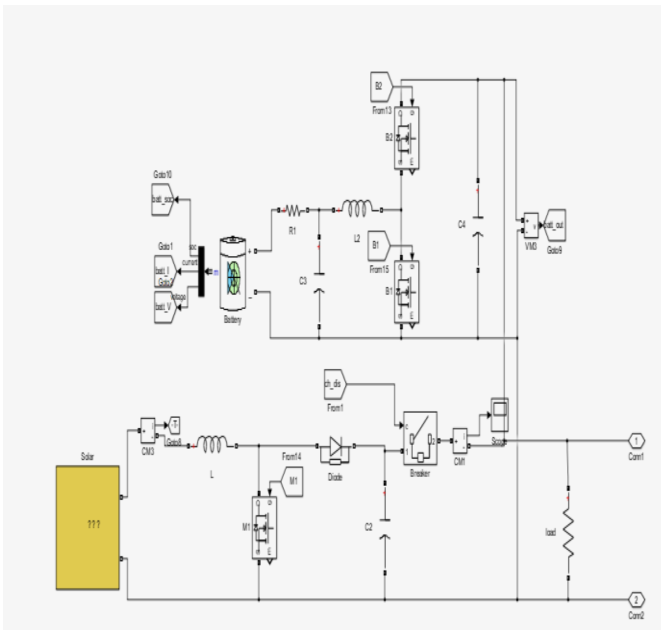

Fig 9. Solar Panel.

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The solar microgrid system is designed to operate in two modes: network interaction and island mode. In the grid interaction mode, the battery system works in parallel with the photovoltaic system. Photovoltaic systems generally function as a grid-connected photovoltaic solar system. During peak daylight hours, the battery system is less active, but when the PV system does not use most of the inverter's capacity (for example, at night), it can actively participate in the frequency response fast response.

The control system is designed to always prioritize the use of the inverter capacity for the generation of photovoltaic solar energy, and then use the rest for frequency regulation. In the case of total sunlight, photovoltaic systems generally require approximately 700 W of capacity, while the remaining 75 W of reverse capacity can be used in the frequency regulation market. When the power grid is interrupted, the microgrid system will detect the loss of the power grid and send a signal to the isolation breaker to trip and switch to island mode. The system will automatically adjust from the grid connected current source to the island voltage source in a few cycles.

As long as there is enough sunlight to generate and enough charging capacity or battery to absorb, the PV system will continue to generate electricity. The energy storage system acts as a buffer between the PV and the load, so users will not notice power fluctuations due to unstable sky conditions. The duration of the power supply is difficult to predict because it depends on the amount of available sunlight, the demand for the selected backup charge and the state of charge of the battery system when it is isolated from the grid.

V.MAXIMUM POWER POINT TRACKING

The power of photovoltaic (PV) modules is highly dependent on the operating voltage of the connected load, the battery temperature, and the level of solar radiation. By connecting 70 variable load resistors R between the module terminals, the operating point can be determined from the intersection of the load characteristics I-V and the I-V curve of the module. The area of the current source is area I, and the area of the voltage source is area II. The internal impedance of the module in zone I is high, whereas in zone II the opposite occurs.

The inflection point of the power curve is the point of maximum power Pmp. The increase in short-circuit current is due to the increase in temperature under constant solar radiation, resulting in a decrease in internal impedance. This is due to the decrease in open circuit voltage.When the load impedance and the internal impedance of the source are equal, according to the theory of maximum power transmission, the transmission of power to the load will be maximized. The load characteristics can be determined by the slope of the straight line with I / V = I / R. When the module only uses a value close to Isc as a constant current source in the AB region, R is very small. In contrast, when the module is used as a constant voltage source, the value in the CD area is close to Voc, so R is large.

By searching for the best Ropt equivalent output resistance and adjusting the load and weather conditions, you can track the point of maximum power. In this way, by using the controller to change the drive's duty cycle, the DC-DC converter can be used to perform load line adjustment. Optimal Identification of Inverter Topology for Maximum Power Point Tracking In this section, different inverter topologies will be analyzed to identify the performance and applicability of maximum power point tracking of the required system.

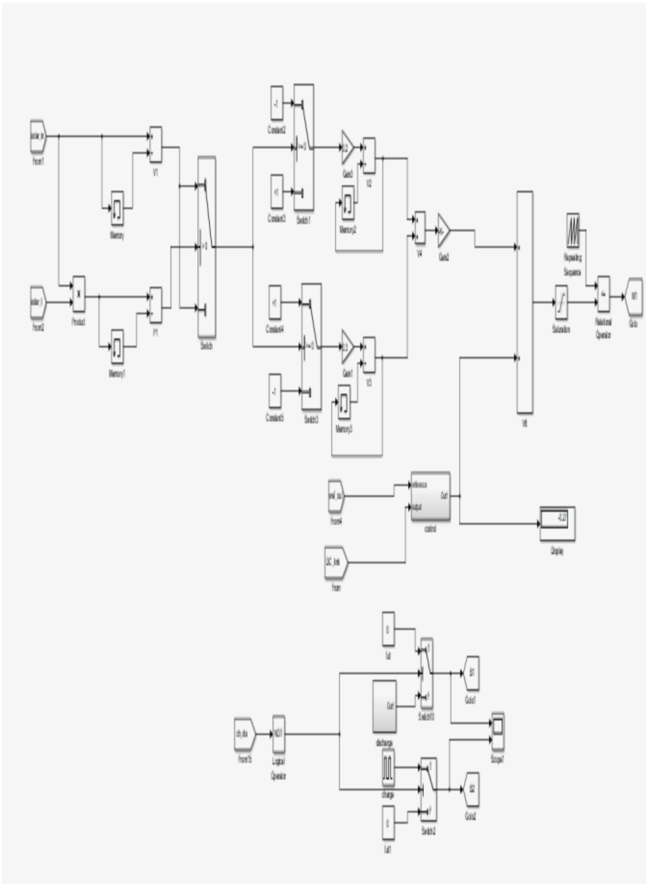

Fig 10. Grid Synchronization.

Grid synchronization is an important part in the control of grid-connected electronic power converters. The basic phase angle at the common coupling point must be tracked online to control the energy transfer. Digital implementation allows the implementation of high performance algorithms that are very robust in the presence of power quality phenomena. However, various distortions will lead to a reduction in effective bandwidth,

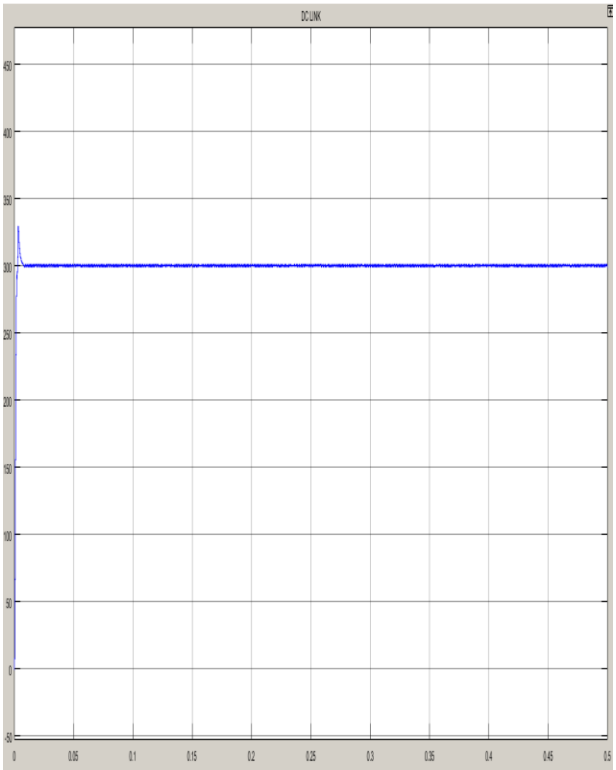

Fig 11. Dc Link.

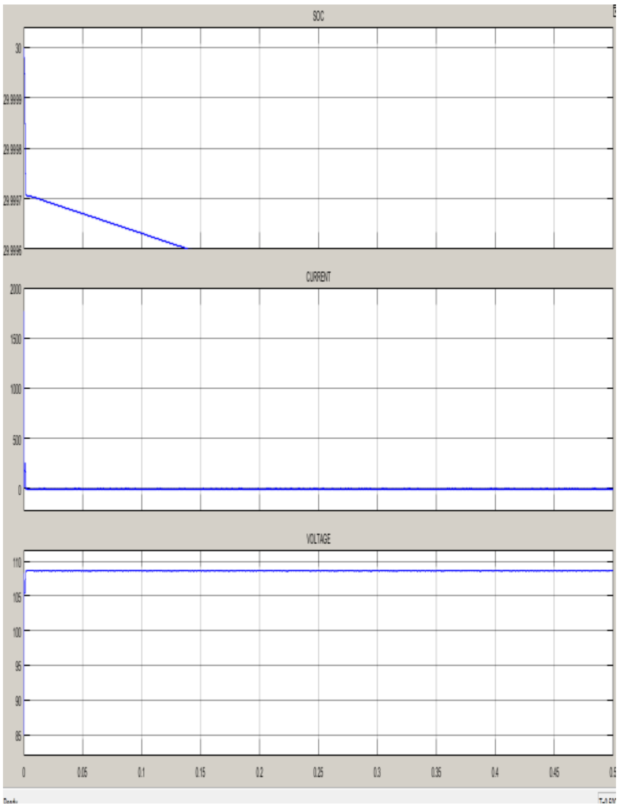

Fig 13. Battery Soc, Voltage and Current.

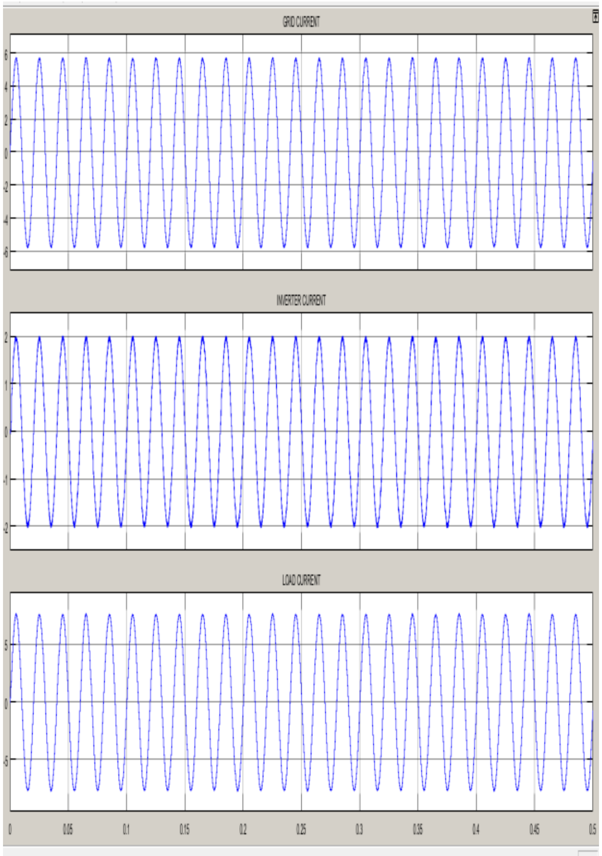

Fig 12. Grid, Inverter and Load Current.

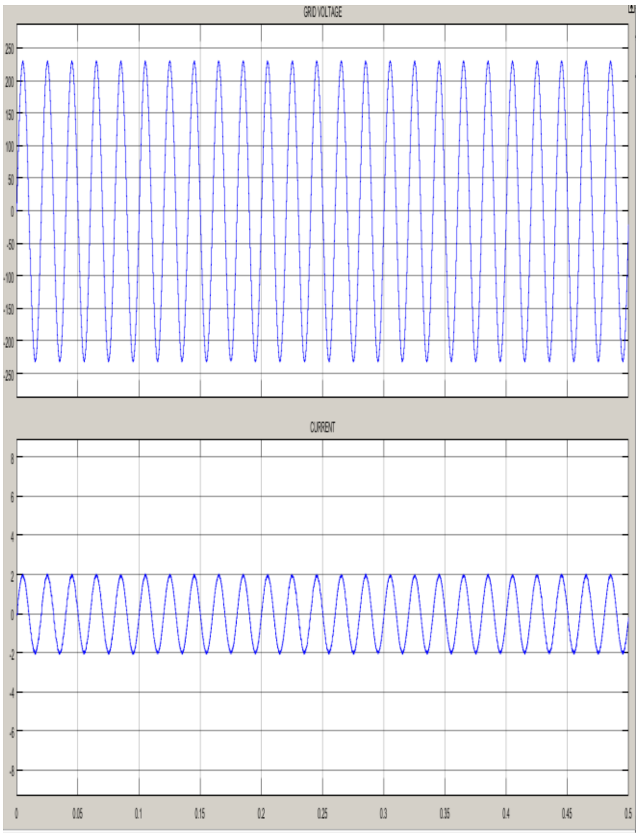

Fig 14. Grid Voltages and Current.

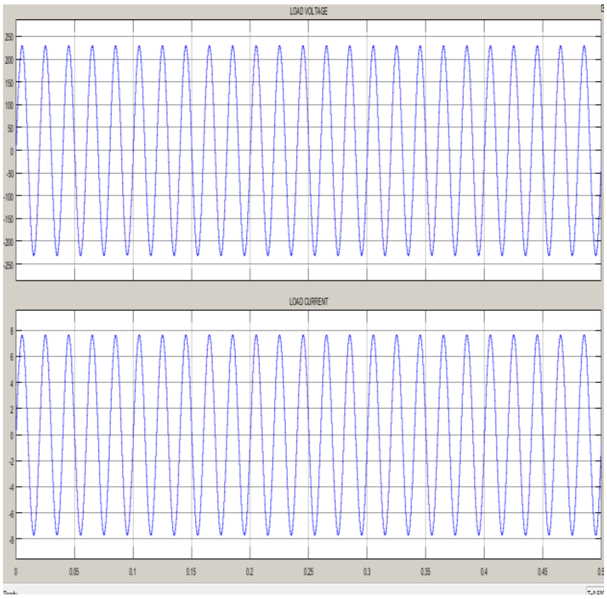

Fig 15. Load Voltage and Current.

VI. CONCLUSION

A fuzzy controller to track the maximum power point of the photovoltaic power source, and simulates it in Simulink / MATLAB. The controller is based on the basic modules of the fuzzy system, namely fuzzification, reasoning and de-fuzzification. These blocks read ambiguous inputs and program the device process, and convert the programs into output actions respectively. In this controller, the trapezoidal shape of the input and output membership functions is proposed, and the Mamdani fuzzy inference method and centroid method are also selected as the deburring process. The entire system includes photovoltaic, booster converter, diffuse controller and modeling and simulation of the load under different irradiance changes. The results show that the proposed fuzzy controller performs well and is effectively applied to real-time systems.

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