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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- In this article, a single-stage bidirectional converter that is connected to the grid is suggested. This converter would have a power conversion stage and an unfolding circuit. The power conversion stage would be a two-way DC-DC converter. The goal of this research is to get the most energy out of photovoltaic (PV) energy systems as possible. When the temperature, the amount of sunlight, or the load changes, so does the maximum amount of power that the photovoltaic module can produce. The photovoltaic system uses a maximum power point tracker (MPPT) to keep getting the most power out of the solar panel and send it to the load. This is done so that the system is as efficient as possible. The Maximum Power Point Tracking (MPPT) system is made up of a controller and a DC-DC converter, which are its two main parts. The DC-DC converter is a piece of electronic equipment that changes the voltage of DC energy from one level to another. MPPT uses a tracking algorithm so that it can find the place with the most power and keep working there even when the weather changes. Many different algorithms for MPPT have been made and talked about in published research, but most of these methods have problems with how well they work, how precise they are, and how well they can be changed. Conventional controllers can't give the best response because the PV module's current-voltage characteristics don't behave in a linear way and switching makes the DC-DC converter behave in a non-linear way. This is especially true when the line parameters and transients change in a lot of different ways. The goal of this work is to make a maximum power point tracker and then use it. This will be done by using fuzzy logic control algorithms. When fuzzy logic is used, it is natural that a good controller will be made for nonlinear applications. This method also uses techniques from artificial intelligence, which can make modeling nonlinear systems easier and offer other benefits. Simulink was used to build an MPPT system with solar modules, DC-DC converters, batteries, and fuzzy logic controllers, and to simulate it. This had to be done so that the job could be done well. Characterize the buck, boost, and buck-boost converters to find out which topology is best for the PV system being used. In MATLAB, a model of the PV module, the indicated converter, and the battery were all put together to get the experience needed to build and tune the fuzzy logic controller. The results of the simulation show what happens when the parameters are changed.

Keywords- 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]

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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]

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III. PROPOSED SYSTEM

The suggested network-connected bi-directional power conversion converter system with low battery voltage has a simple power conversion. For the proposed converter to meet the requirements of common interface standards and be able to control the flow of power in both directions, it only needs one power processing stage. The folded network's current input and output can be used to show both the flow of power and how much power is being sent. It also includes the quality of the power coming from the grid. So, the input and output of the folded grid current can be used to make the suggested converter work better for individual power conversion. In this study, a fuzzy controller for a Buck-boost DC-DC converter is designed and suggested.

The output voltage of the buck-boost converter can be changed by changing the duty cycle of the controller, which was made for that purpose. So, the mathematical model of the buck-boost converter and the fuzzy controller can be found, and then the simulation model can be made. A test device was made so that it could be seen whether or not the simulation model gave accurate results. He came up with a buck-boost circuit in which MOSFET was used as the switching element. The fuzzy logic controller, which is in charge of making the PWM signal duty cycle, is programmed. The duty cycle can be used to control the output voltage of a buck-boost converter. This has been shown both by simulations and by the results of experiments.

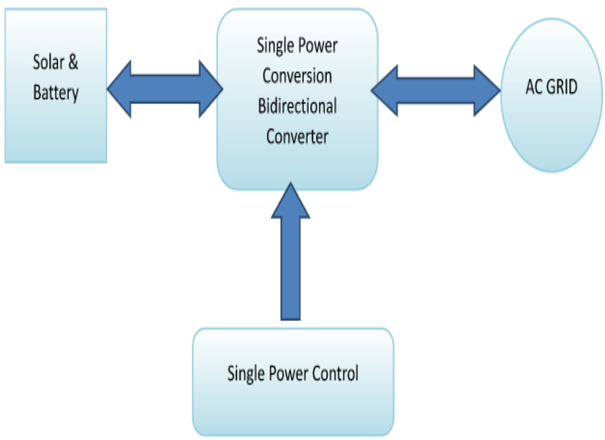

Fig 1. Proposed Block Diagram.

Because of the small signal model, the duty cycle of the dc-dc boost converter is not linear. The small signal model's control method has been used to control the boost converter. Fuzzy controllers do not require precise mathematical models. Instead, they are made by applying the factory's knowledge to the process of design. The diffuse controller was made to be easy to adjust to different operating point changes. The Mamdani Fuzzy Inference System controls the output of the boost DC-DC converter through the Fuzzy Logic Controller, which is made to use fuzzy logic.

As a result, the gate voltage vg can be assumed to be constant during the switching period Ts, and the folded gate voltage vo is assumed to be the same as the absolute value of the gate voltage vg. This is because the proposed converter's main switches Sp and Ss operate at a significantly higher frequency than the mains. As a result, the mains frequency is significantly lower than the proposed converter frequency.

With the proposed converter, there are only two sub-ranges available: the condition in which the main switch Sp is on and the secondary main switch Ss is off, or the condition in which the main switch Sp is off and the secondary main switch Ss is on. There are two modes of operation. Assume that the duty cycle of primary circuit breaker Sp determines the duty cycle of primary circuit breaker D.

The system now employs the fuzzy logic controller, which was created by developing a fuzzy logic control algorithm. The design and calculation of the inductor components have been completed in order to verify that the converter operates in continuous driving mode.

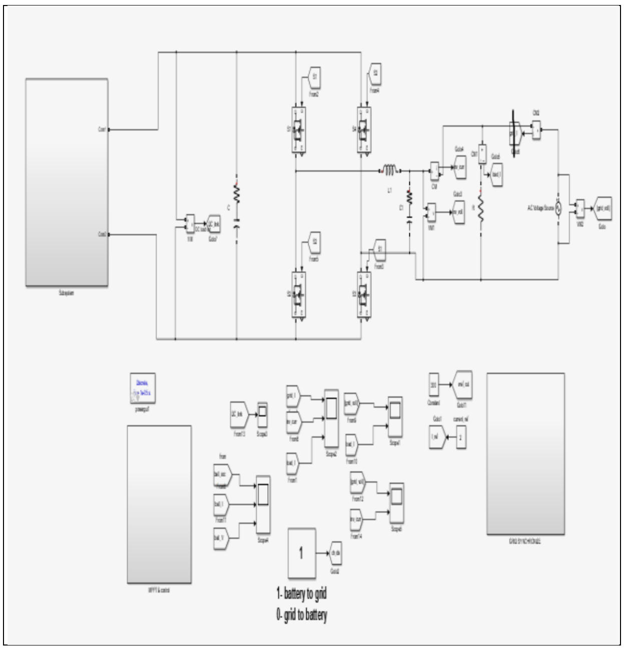

Fig 2. Proposed Simulink Model.

IV. FUZZY CONTROLLER STRUCTURE

The fuzzy logic controller is built on fuzzy sets, which are groups of variables that belong to one or more sets to a certain degree. The benefit of fuzzy logic is that it lets us simulate human inference processes in computers, quantify inaccurate information, and make decisions based on fuzzy information, like connecting resistive loads to

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photovoltaic modules through booster DC/DC converters. Figure 3 shows the block diagram of the MPPT-based fuzzy logic control.

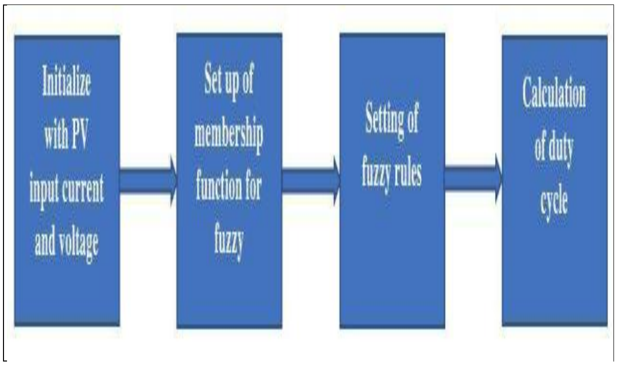

Fig 3. Block diagram of the fuzzy logic algorithm.

1. Membership functions of the proposed fuzzy system: Figure 4 shows the definition of fuzzy sets for each input variable and each output variable. There are three different kinds of fuzzy subsets. For the input and output variables of the fuzzy controller, you can choose low, medium, or high values. Figure 4 show that the membership function is given a trapezoidal shape.

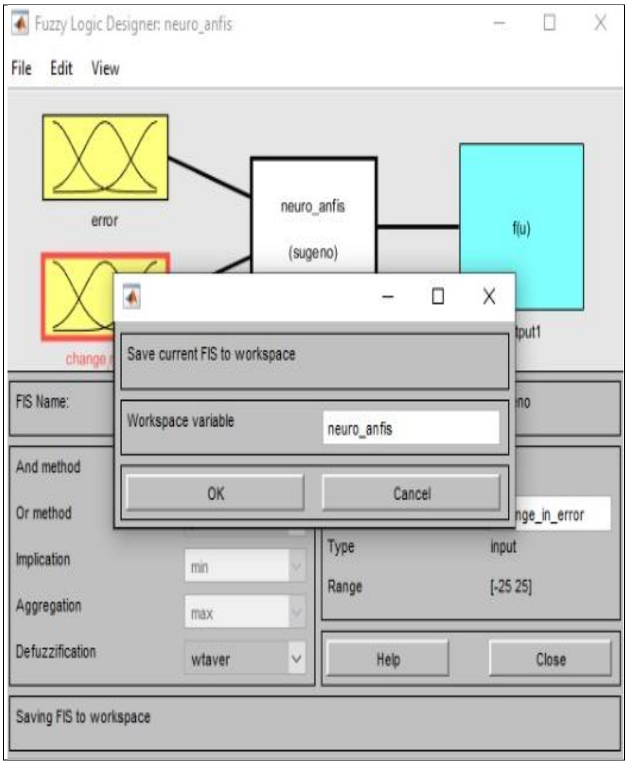

Fig 4. Membership functions fuzzy system of save current to workspace.

The characteristics of the proposed photovoltaic module (Voc @ 22 V, Isc = 15 A respectively. 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.

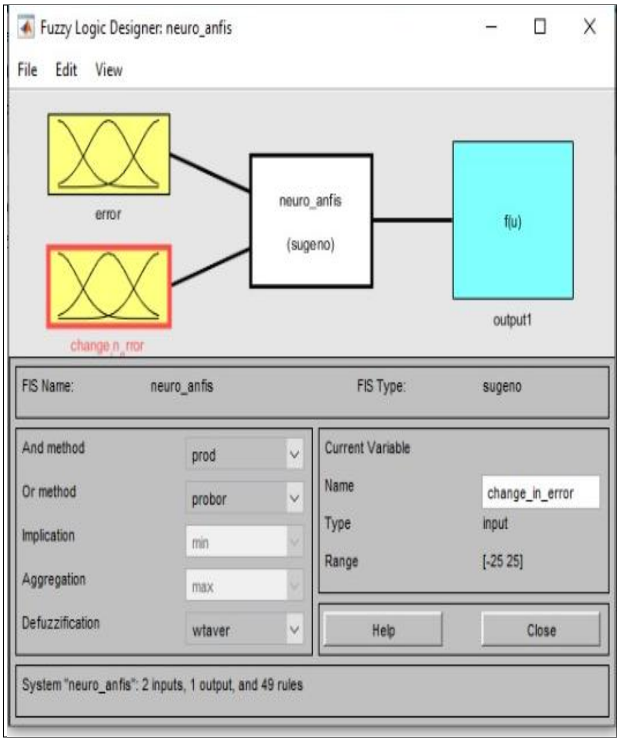

Fig 5. The Membership Function plots of change error.

Figure 5 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.

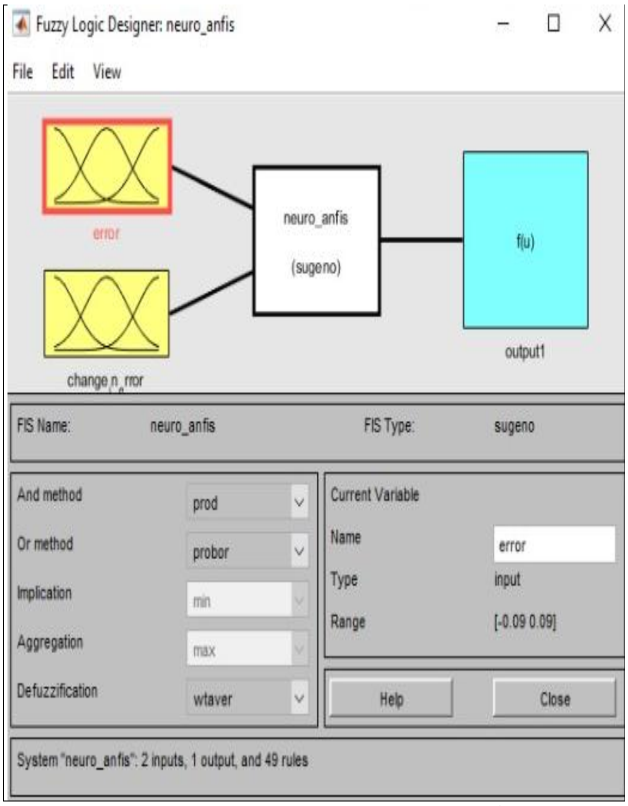

Fig 6. The Membership Function plots of error.

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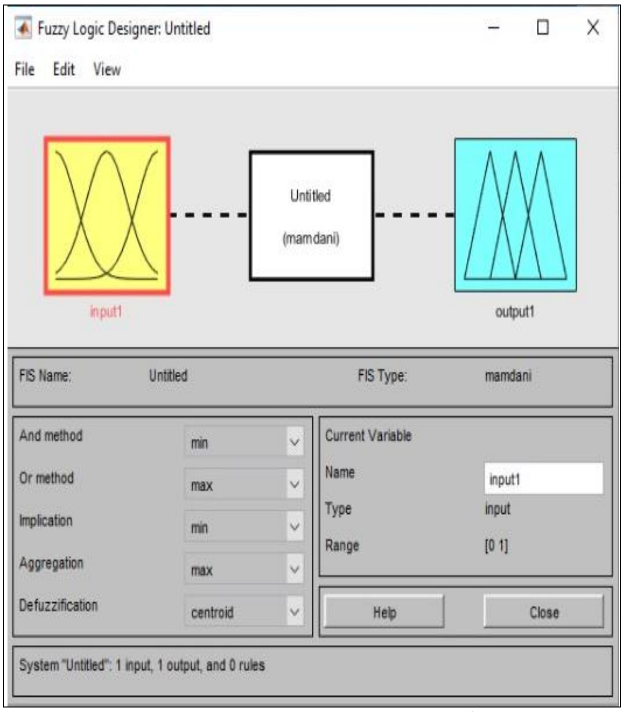

Fig 7. The Membership Function plots of duty ratio.

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. 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]

V. 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.

VI. CONTROL

By putting together a full-bridge diode rectifier and a series resonant active clamp DC-DC converter, a converter with a high power factor can be made that works with both AC and DC power. This means that the power factor of the converter will be high. The suggested converter can get a high power factor without using a power factor correction circuit. It does this by using a new control algorithm for power factor correction and output control. This means that a one-of-a-kind power conversion is made possible. Compared to the two-stage AC-DC converter, the conventional single-stage AC-DC converter has a higher voltage output but a lower power factor.

In the same way, AC-DC converters that use single-stage PFC circuits need DC link electrolytic capacitors and inductors. When DC bus electrolytic capacitors and inductors are added, the converter gets bigger and costs more. The only way to fix these problems is to get rid of the DC link electrolytic capacitors. To get a high power factor without using a power correction circuit, a full bridge MOSFET diode rectifier and a series resonant active clamp DC-DC converter are combined into a single power conversion AC-DC converter. This makes it possible to make a single power conversion AC-DC converter with a high power factor. The proposed converter is a one-of-a-kind way to convert power because it uses a new control algorithm to correct the power factor and control the output. In a similar way, the active clamping circuit recovers the energy stored in the transformer's leakage inductance while stopping the breaker's overvoltage. It also has a zero voltage conduction switch that can be used with the switch.

Also, the output voltage duplicator's series resonant circuit stops the output diode from recovering in the wrong direction, which can be a problem. The proposed converter can reach a maximum power factor of 0.995N and a maximum efficiency of 95.1% when running at full load. Check out the converter and make sure you understand how it works. To show how well the proposed converter works, experiments were done with a 400 W AC-DC converter whose switching frequency was kept at 50 kHz. [8]10]

VII. SOLAR POWER

Standard Solar, Inc. just finished building one of the first grid-interactive solar microgrid systems in the country. After months of hard work, creative engineering design, and working with important partners, public agencies, and government offices, the first challenge is to make this project happen. In the first half of this piece, I'll set the stage by talking about how to set up the microgrid, as well as what makes it unique. After that, I'll talk about how long it takes to design and install a solar microgrid system, what we learned from this ground-breaking project, and what technical issues we need to think about when putting this new technology to use.

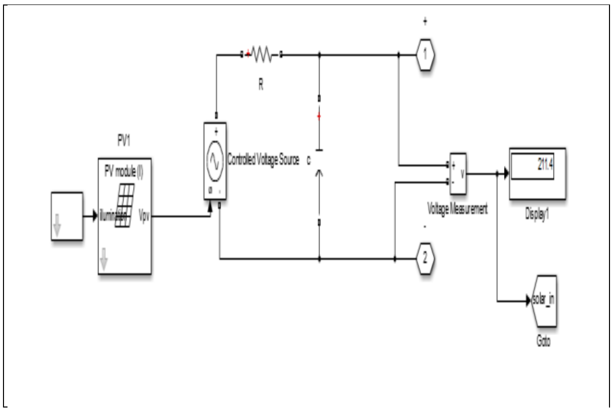

Fig 8. Solar Panel.

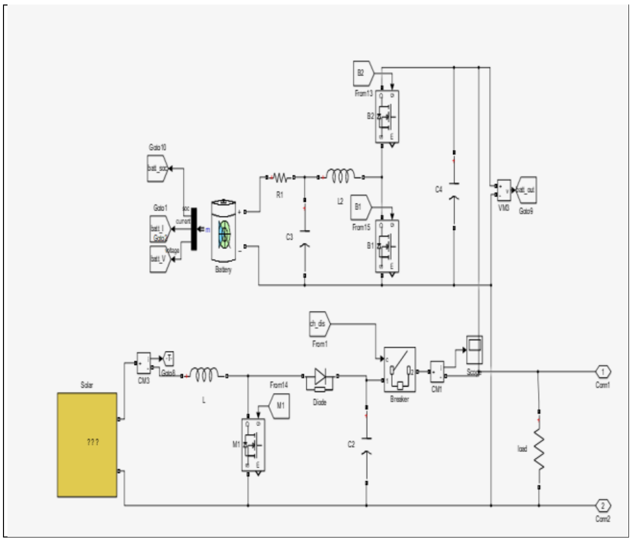

Fig 9. Solar Panel.

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.

VIII. 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.

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,

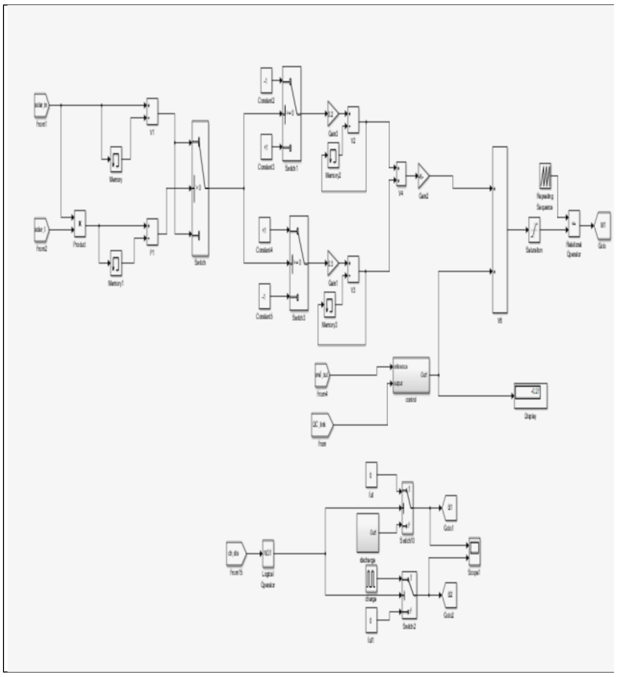

Fig 10. Grid Synchronization.

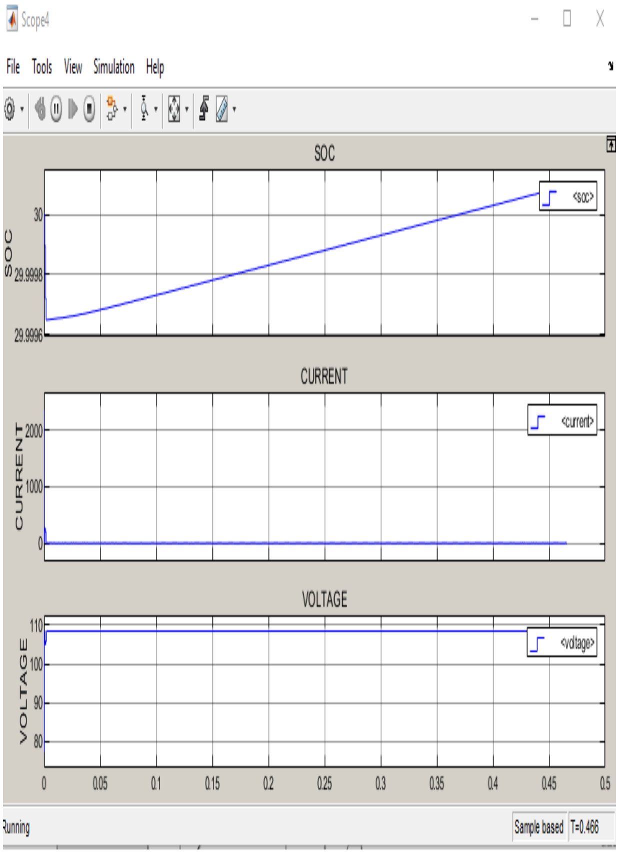

Fig 12. Battery Soc, Voltage and Current.

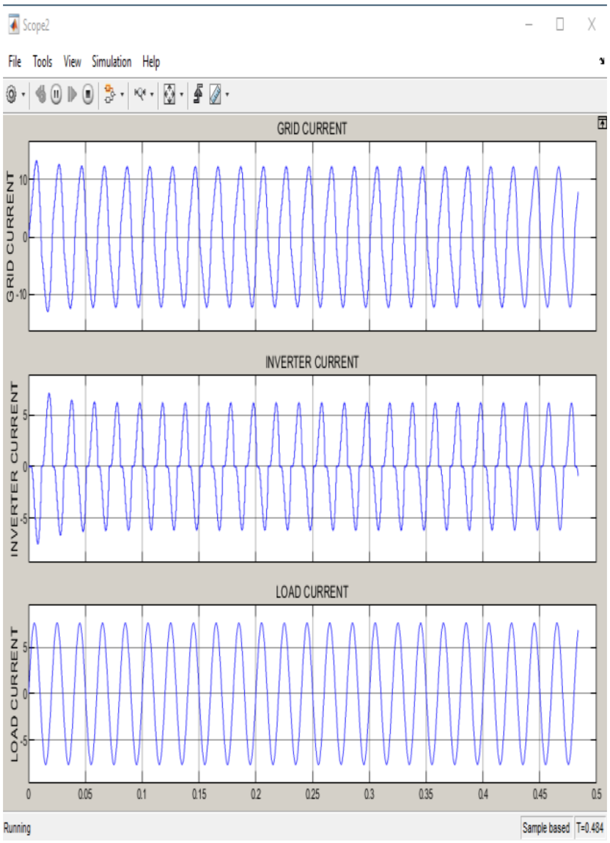

Fig 11. Grid, Inverter and Load Current.

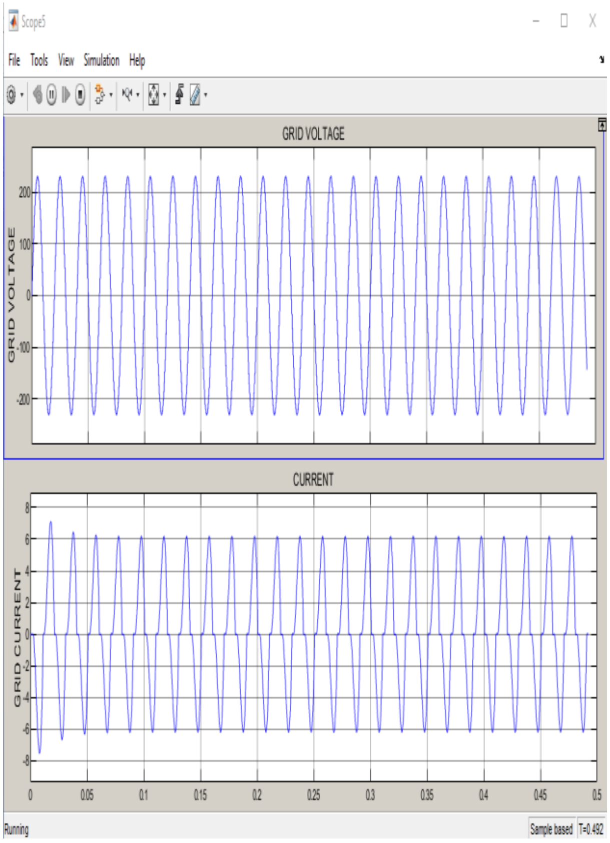

Fig 13. Grid Voltages and Current.

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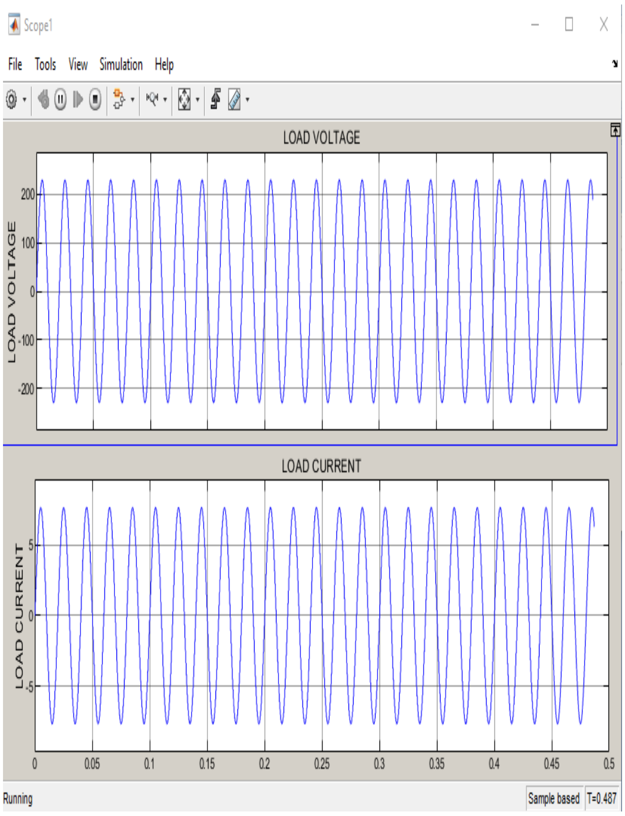

Fig 14. Load Voltage and Current.

IX. CONCLUSION

A fuzzy controller that acts like a photovoltaic power source in Simulink and MATLAB to find the time when the photovoltaic array is putting out the most power. The fundamental parts of the fuzzy system—fuzzification, reasoning, and de-fuzzification are the basis for how the controller works. These blocks read inputs that are hard to understand, programme how the device works, and then turn the programmers into output actions.

For the deburring process in this controller, both the Mamdani fuzzy inference approach and the centroid method were chosen as good choices. Also, it has been suggested that the input and output functions of the controller should be in the shape of a trapezoid. The whole system is made up of photovoltaic technology, a boost converter, a diffuse controller, and modeling and simulation of the load while it is exposed to irradiance. The results show that the proposed fuzzy controller works well when put to use in systems and is successful at doing so.

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