

Simulation of Maximum Power Point Tracking with Fuzzy Logic Control Method on Solar Panels Using MATLAB

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ABSTRACT

One of the newest sources energy is the sun. To limit the usage of fossil fuels, solar power facilities that harness sunlight are beginning to be created. Currently, research on solar panels is increasingly being carried out. Because solar panels are an unlimited source of energy. And solar panels can reduce exhaust emissions from conventional vehicles by 92%. However, the performance of solar panels is strongly influenced by several factors such as sunlight intensity and ambient temperature. So that solar panels can reach the maximum power point, the MPPT method is employed to maximize the performance of solar panels. In this research, an mppt system will be created using fuzzy logic control in matlab simulink. Fuzzy logic control is a method that can control the system against load changes. To analyze this fuzzy logic-based mppt system, simulations are carried out using matlab simulink. Simulink is software used to model, simulate, and analyze dynamic systems. From the simulations that have been carried out, solar panels without mppt have a duty cycle change time of 0.1 seconds while with mppt the duty cycle change is 0.7 seconds, where the duty cycle change time without mppt is faster but the operating value is unstable while power tracking with mppt the duty cycle change time is longer but the operating value is more stable.

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1. INTRODUCTION

One of the newest sources of energy is the sun. To limit the usage of fossil fuels, solar power facilities that harness sunlight are beginning to be created. Solar panels can harness sunlight and transform it into electrical energy. Due to their lack of waste, solar panels provide benefits like being environmentally beneficial. that causes pollution, cheap maintenance, and easy to implement [1], [2]. However, because the level of solar energy irradiation varies every day, the output power from solar panels varies and is not maximized [3].

Currently, research and use of solar panels are being promoted. Solar panels are a type of power plant that is environmentally friendly and does not cause air pollution. by the conversion of light energy into electrical energy, solar panels are the latest and low-emission energy source [4], [5]. Solar panels can reduce exhaust emissions from conventional vehicles by 92%. Unfortunately, a number of factors, like the solar panels' ambient temperature and irradiance, can affect how efficient they are [6]. To utilize the panel power maximally, Due to the solar cells' characteristic graph between voltage, power, and current, the voltage of the solar panel needs to be conditioned. [7]. Therefore, a technology is needed to optimize the output power of solar panels which is commonly called the maximum power point tracking (MPPT) method. Currently, there are at least 19 different MPPT methods including Hill Climbing, Perturb and Observe, Fuzzy Logic Control, Neural Network, and others [8], [9].

Solar cell modules are operated using the maximum power point tracking (MPPT) technique in order to generate as much power as they are capable of producing. In this research, we will use the fuzzy logic control method which can accelerate Increasing the system's reactivity to load changes and minimizing oscillations that happen at maximum power [10], [11].

2. The Comprehensive Theoretical Basis

2.1. Solar Panel

One of the new, sustainable energy sources that is actively being developed is solar energy [12]. Solar panels are equipment created to transform solar energy into electrical energy that may be used for a variety of reasons. Solar cells made of semiconductor materials, such as silicon, are also referred to as photovoltaic modules and are used to create solar panels. The energy conversion process in solar panels occurs when sunlight hits the solar cell which will be responded to by electrons, then electrons that are released from atomic bonds will produce an electric current that can be collected and used as an energy source [13].

2.2. MPPT

A photovoltaic (PV) panel is operated by an electrical system called MPPT, in order to produce the most power possible [14]. MPPT is a method to track the working point of an energy source in order to produce maximum power. The output voltage of the panel will be modified according to the maximum point using the result of the value tracked by MPPT to change the duty cycle of the converter. With MPPT control, maximum energy conversion is expected under various load conditions and atmospheric conditions [15].

2.3. Fuzzy Logic Control

A control system known as a fuzzy logic controller was created using fuzzy set theory. Fuzzification, inference, and defuzzification are the three steps of a fuzzy logic controller. The first step, A procedure known as "fuzzification" transforms data from a crisp to a fuzzy (linguistic variable), which is typically given as fuzzy sets with associated urban functions [16]. In the inference stage, the connection between input values (crisp input) and output values (crisp output) desired by the rules (rulers) is processed. This rule will determine the system response to various set point conditions and disturbances that occur in the system [17]. Finally, the defuzzification procedure transforms the output value of the fuzzy inference mechanism back into a firm form [17].

2.4. Simulink MatLab

One of Matlab's features, called Simulink, allows you to simulate a dynamic or embedded design or model in order to evaluate how well it performs. performance of a model or design system that has been created based on desired outcomes [19]. Simulink offers simulation, continuous testing, automatic code generation, embedded system verification, and system-level design. Simulink offers an editor view in graphical form. Simulink is also integrated with Matlab, making it possible to exchange information and data between Simulink and Matlab simultaneously. In other words, we can combine Textual Programming and Graphical Programming in simulating a system design. Thousands of algorithms available in Matlab can be easily included in the simulink block [20].

3. RESEARCH METHOD

Flowchart is a workflow of a process system. in this flowchart, it will explain how solar panels work using fuzzy logic with mppt (maximum power point tracking) using Simulink Matlab. Initially, the solar panel will absorb sunlight which will then be read by mppt then mppt will send a signal or data where the data will be fuzzified then the output of the fuzzy will be converted to crisp then all the data and fuzzification will be made in

Simulink Matlab then Simulink Matlab will produce an output in the form of an output graph from the solar panel mppt.

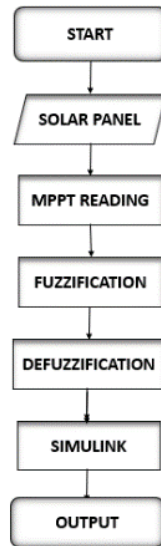


Figure 1. Flowchart

As shown in Figure 2 is the input and output used, this membership function uses 2 inputs consisting of voltage and current and the output is duty cycle. mamdani is a fuzzy logic control of this membership function.

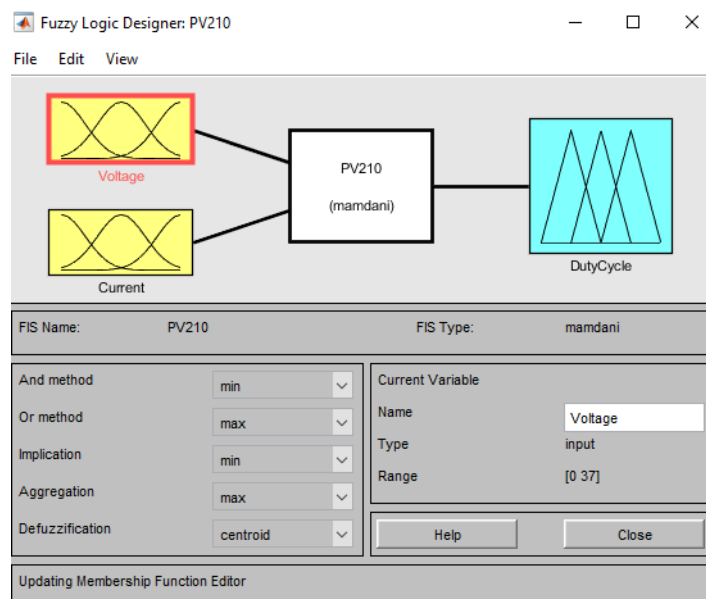


Figure 2. Input and Output Fuzzy

In figure 2 there are 2 fuzzy logic controls in the form of voltage and current which will be shown in figures 3 and 4. fuzzy logic control in this mppt serves to determine the maximum power of solar panels.

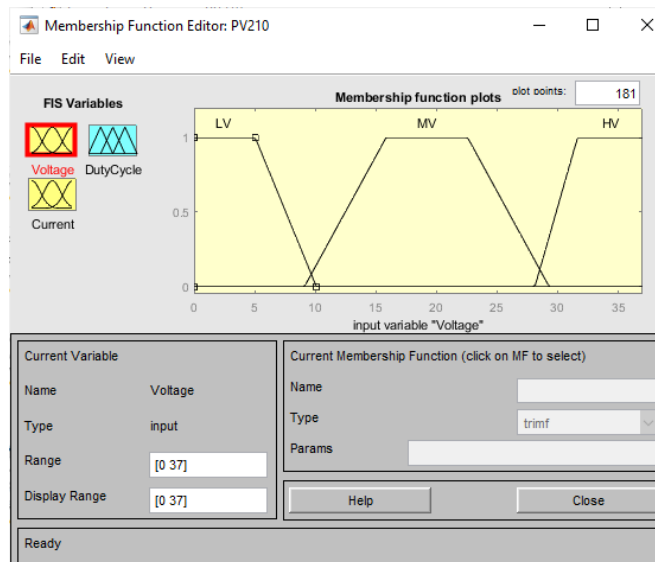


Figure 3. Voltage Design

In the picture above there are 3 states in the form of LV (Low Voltage), MV (Medium Voltage), and HV (High Voltage). Where the domain for this voltage is from 0-37 Volts. The domain of LV (Low Voltage) is 0-10.09 Volts, MV (Medium Voltage) is 9.1-29.29 Volts and HV (High Voltage) is 28.12-37 Volts.

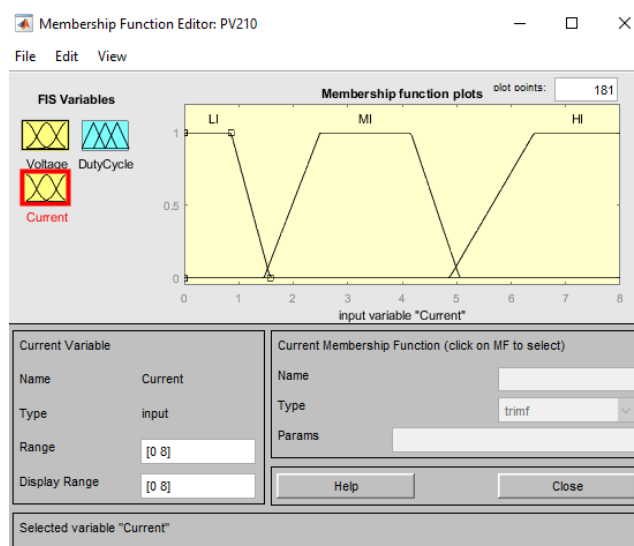


Figure 4. Current Design

Then the current input is exactly the same as the voltage input where there are 3 states in the form of LI (Low Current), MI (Medium Current), and HI (High Current). Where the domain for this current is from 0-8. The domain of LI (Low Current) is 0-1.57 A, MI (Medium current) is 1.46-5.05 A, and HI (High Current) is 4.86-8 A. I is a symbol of amperes.

Voltage:

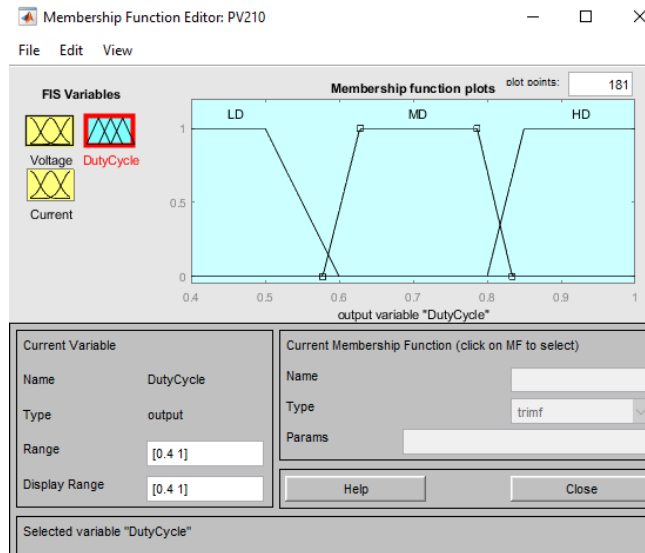


Figure 5. Duty Cycle

The figure above is the output of fuzzy logic in the form of a duty cycle which is divided into 3 states. with the domain of this duty cycle being 0.4 to 1. The first state is LD (Low Duty) with a domain of 0.4 to 0.6, the range of MD (Medium Duty) is 0.578 to 0.834, and the domain of HD (High Duty) is 0.85 to 1.

From the information above, we can determine the rule based on fuzzy by looking at the voltage and current values used as fuzzy input. in this case the rule based on fuzzy is used in the form of if-then. from 3 membership functions voltage and current, 9 rules are obtained that can determine the results of the output. the following is a fuzzy rule base table which will be shown in table 1.

Table 1. Fuzzy Rules

INPUT		OUTPUT
VOLTAGE	CURRENT	DUTY CYCLE
LV	LI	HD
LV	MI	MD

LV	HI	MD
MV	LI	HD
MV	MI	MD
MV	HI	MD
HV	MI	LD
HV	MI	LD
HV	HI	LD

4. RESULTS AND DISCUSSION

4.1. MPPT Simulation Circuit With Fuzzy Logic Control

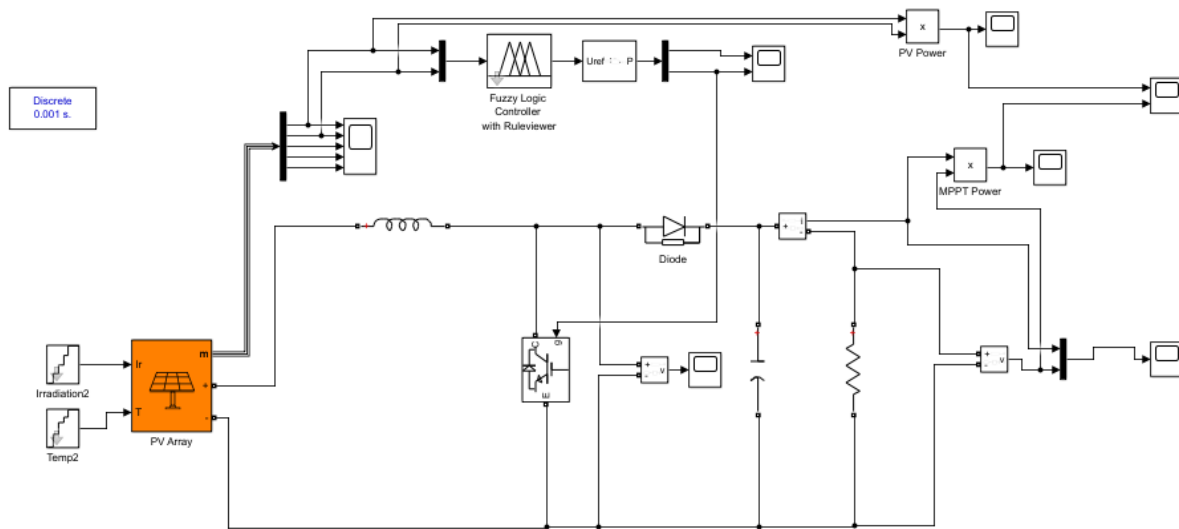


Figure 6. Solar Cell Simulation With MPPT

We can see in figure 5. is a simulation of solar panels using MPPT with fuzzy logic control. From the simulation, results will be obtained in the form of graphs from solar panels that use mppt and without mppt.

4.2. Graph Without MPPT

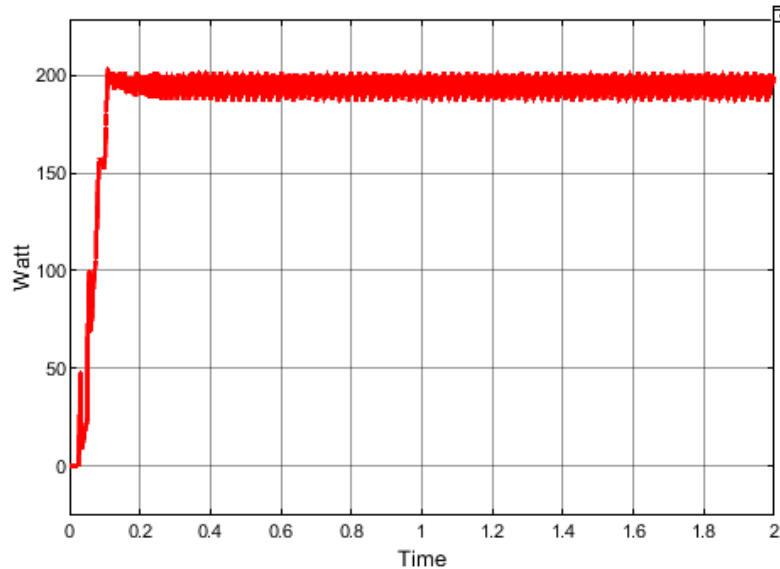


Figure 7. Graph Without MPPT

In solar panels without mppt, duty cycle changes occur with a time of 0.1 sec, but during the duty cycle process there are oscillations due to constant changes and cannot have a stable operating value. This operating value will always oscillate until it reaches a peak point.

4.3. Graph With MPPT

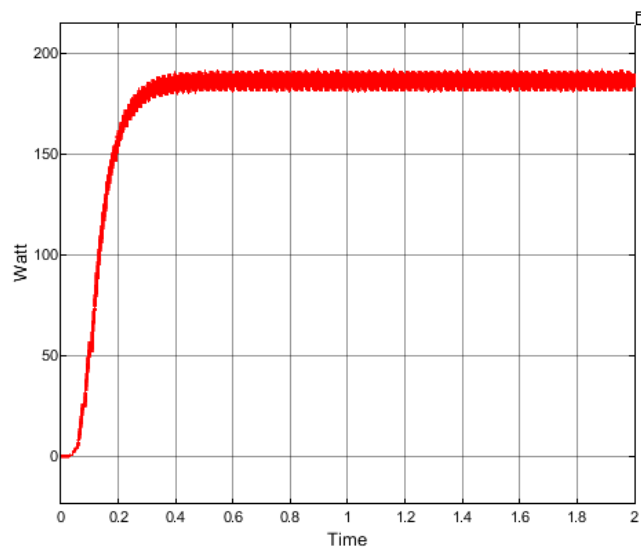


Figure 8. Graph With MPPT

In solar panels using MPPT the change in duty cycle occurs with a time of 0.7 sec, but at the time of the duty cycle process has no oscillations. This is because the change has a stable operating value compared to without mppt.

4.4. Graph Comparison With MPPT and Without MPPT

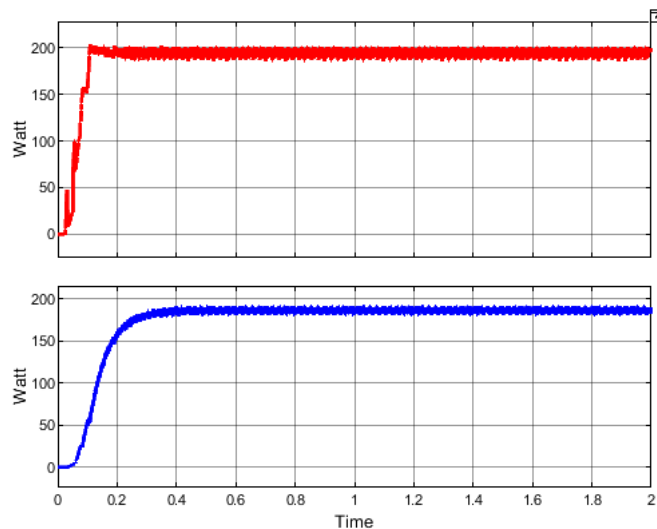


Figure 9. Graph Comparison With MPPT and Without MPPT

We can see in the comparison chart above, that if the solar panel is without mppt then the duty cycle changes will be faster than solar panels with mppt, but the oscillation is unstable and when it reaches the top, the solar panel without mppt the oscillation is higher than using mppt

4.5. Fuzzy Graph

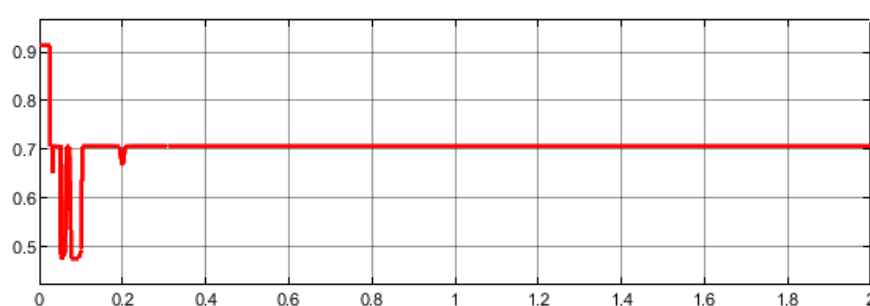


Figure 10. Fuzzy Graph

By using the fuzzy method, it will experience noise of 0.9 sec and then will stabilize after the noise is at 0.1 sec. In this method, the operation value when reaching the peak point has a more stable noise value.

5. CONCLUSION

From the discussion above it can be concluded that solar panels that use mppt, the power tracking is better than without mppt. the duty cycle change time without mppt is 0.1 seconds while with mppt it is 0.7 seconds which the duty cycle change time without mppt is faster but the operating value is unstable and continues to oscillate to the peak point. While tracking power using mppt, the duty cycle change time is longer but the operating value is more stable.

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