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Highly Efficient Maximum Power Point Tracking Control Technique for PV System Using Different Controller and Converter with Modular Multilevel Inverter

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Abstract

In order to operate photovoltaic (PV) systems using maximum power point tracking (MPPT), three distinct combinations of controllers and converters are proposed in this research and compared. Using MATLAB/Simulink simulation, these strategies are assessed based on the output parameters of time, power, and current. The demand on power production has increased manifold in recent years and on the other hand, the conventional resources utilized for it will be vanished in near future. The requirement of PV based generation is getting increased. The procedure of getting solar energy from a solar panel is common. With MPPT, here the output obtained must be the same quantity of energy even when the source of that energy is partially available. Climate change and other issues could be to blame for this inefficiency. In this project three distinct converters and three distinct controllers have been compared. All three converters are linked to each controller individually, and measurements of current, voltage, and power are analysed. By which the result is obtained. After the comparison of nine outputs, the most powerful and efficient combination is identified. By doing this, the converters and controllers produce high D.C voltage. Direct voltage transmission to the MMI. A.C. voltage is created by converting D.C. voltage. Increase the MMI's output by doing this. The voltage generated by the MMI is sent to the grid for domestic usage. Even when the source is not readily available, the solar panel's voltage can still be used.

Keywords: MPPT algorithm, FLC, M2I, output boosting, PID controller, Sepic converter, Pi controller, Luo converter, MATLAB/Simulink, PV system, renewable energy

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1.Introduction

Due to their Solar radiation is not constant, so the output voltage is not constant, and the load will be damaged. For this reason, we use a Maximum Power Point Tracker (MPPT) to obtain the maximum energy. Maximum Power Point Tracking (MPPT), in which system voltage and current are controlled to maintain the maximum power point, is a major concern of PV systems. High energy efficiency and maximum energy production in photovoltaic systems are made possible by MPPT control algorithms. The proposed methods use a variety of inverters and control mechanisms to achieve the maximum power point of the PV system, considering various environmental factors. MATLAB/Simulink simulations are used to evaluate the effectiveness of the proposed methods and compare them to determine which controller and inverter combination has the best output characteristics. The research will contribute to the development of practical and efficient MPPT control methods for photovoltaic systems that can be used in the renewable energy industry. The project can help develop advanced control and converter technologies that can maximize the performance of renewable energy systems. The modular multilevel inverter is a complex device that can deliver high voltage and power with improved efficiency and reliability compared to conventional inverters. The project aims to integrate the controller and inverter into the MMI and evaluate their compatibility and effectiveness in maximizing the power system performance. The project will investigate different types of controllers such as fuzzy logic controllers, PID controllers, and PI, as well as different types of converters such as SAPIC, Luo, and Boost. Each type of controller and converter has its own characteristics and performance criteria, and the goal is to find the best combination that can maximize the performance of the system.

2. System Methodology

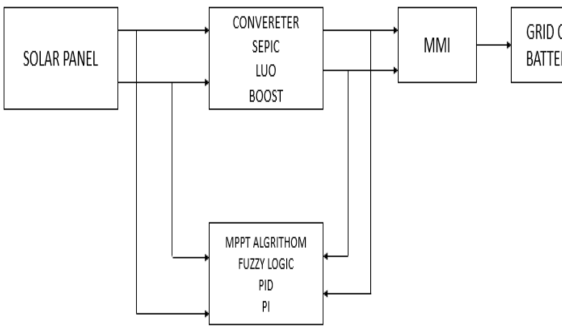

Figure 1: Block Diagram

2.1 Solar Panel

A solar panel, usually referred to as a photovoltaic (PV) panel, is a machine that uses the photovoltaic effect to turn sunlight into electricity. Solar cells, the building blocks of solar panels, are silicon wafers that have undergone various doping processes to produce positive and negative charges. As sunlight strikes a solar cell, an electric field is produced. This electric field produces an electrical current, which may be used to generate energy. Solar panels are frequently used to generate electricity from the sun in home, commercial, and industrial settings. They are a clean and sustainable source of energy and a crucial part of the shift to a future with more sustainable energy.

2.2 MPPT Algorithm

Solar panel power output is optimised using the maximum power point tracking (MPPT) technique. Via load adjustments and output maximisation of the current and voltage, the MPPT algorithm continually monitors the solar panel's maximum power point (MPP). To do this, it is necessary to continuously operate the solar panel at its maximum power output, which is done by monitoring the voltage and current output of the solar panel and changing the load's input impedance. When the weather is unpredictable or the panel is not positioned properly, MPPT is crucial for maximising the power production of solar panels. MPPT can improve the efficiency of the solar panel and the overall power output by continuously adjusting the load to match the MPP of the solar panel. This improves energy production efficiency and lowers the price per kilowatt-hour of power generated by solar panels.

2.3 Fuzzy Logic Controller

A fuzzy logic controller (FLC) is a kind of control system that uses fuzzy logic to make judgements in the face of confusing or inaccurate data. FLCs use linguistic variables and rules to make decisions as opposed to conventional control systems, which depend on exact mathematical models and formulae. An FLC processes the inputs according to a set of user-defined rules after converting them into fuzzy sets. The controller's output is then defuzzied to produce a precise output value. FLCs are frequently employed in control systems, such as temperature or pressure control systems, where it is challenging to exactly represent the input or output. In situations where numerous inputs or outputs need to be regulated simultaneously, they are also employed. When typical control methods are ineffective, such as in nonlinear systems or systems with a lot of noise or uncertainty, FLCs are especially helpful. They can make control systems more effective overall and simplify the control algorithm, making them simpler to design and maintain.

2.4 PI Controller

A proportional-integral (PI) controller is a kind of control system that adjusts an output based on the difference between a desired setpoint and the actual measured value in order to govern a process. The proportional error between the measured value and the setpoint is used by the PI controller to integrate the error over time and change the output. The integral term in a PI controller adjusts the output based on the cumulative error over time, whereas the proportional term adjusts the output depending on the current error.

2.5 PID Controller

A proportional-integral-derivative (PID) controller is a kind of control system that adjusts an output based on the difference between a desired setpoint and the actual measured value in order to govern a process. The proportional error, temporal integration of the error, and derivative of the error are all used by the PID controller to modify the output.

2.6 SEPIC Converter

A particular kind of DC-DC converter called a single-ended primary inductance converter (SEPIC) can increase or decrease the input voltage. It is a common option for power supplies with a wide variety of input voltages and a regulated output voltage need. Two inductors, a capacitor, and a switch are used by the SEPIC converter to move energy from the input to the output. The switch regulates the flow of energy between the inductors, which serve as energy storage devices. The capacitor serves to even out the output voltage by acting as a voltage multiplier.

2.7 LUO Converter

A DC-DC converter with a high efficiency and minimal output ripple is known as a Luo converter. It is a variation on the SEPIC converter and is renowned for being straightforward and capable of working with a variety of input and output voltages. The Luo converter functions by converting energy from the input to the output using a single inductor and a capacitor. In order to lessen the output ripple, the inductor undergoes two charges and discharges per switching cycle. The capacitor assists in energy storage and release, enabling the converter to manage fluctuating input and output voltages.

2.8 Modular Multilevel Inverter

A voltage-source inverter called a modular multilevel inverter (M2I) is a device that transforms DC electricity into AC power. Several power modules, each made up of a string of power switches and capacitors, make up this modular system. The modules are linked in series to produce a waveform called a staircase that nearly resembles a pure sine wave. High voltage ratings, low harmonic distortion, and the capacity to support a range of loads are characteristics of M2I inverters. Applications for them include electric vehicles, industrial drives, and renewable energy systems. M2I inverters are appropriate for high-power applications because they can run at high voltages and frequencies. Also, they are scalable, so more modules might be added to boost the power output. M2I inverters are a well-liked option in a variety of applications because they are effective, dependable, and adaptable.

2.9 Matlab/Simulink

Engineering and scientific research both rely heavily on the potent software platform known as MATLAB/Simulink. For the analysis, design, and simulation of complex systems, it offers a complete set of tools. Data analysis and numerical computations are carried out using the high-level computer language MATLAB. It is widely used in applications like signal processing, control systems, and image processing and is renowned for being simple to use and versatile. A graphical interface for modelling and simulating dynamic systems is called Simulink. It enables users to design block diagrams that depict a system's behaviour and then simulate the system in different scenarios.

2.10 Battery

An electrochemical device known as a battery transforms chemical energy into electrical energy. Positive and negative electrodes are found in one or more cells that are connected by an electrolyte. A chemical reaction that results in a passage of electrons from the negative electrode to the positive electrode when a battery is connected to a circuit produces an electrical current.

3. Experiment Result

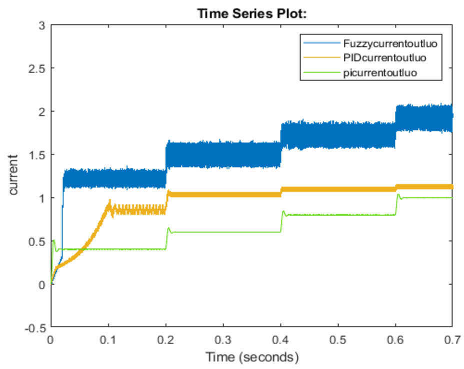

Figure 2: Output of Power from the Luo

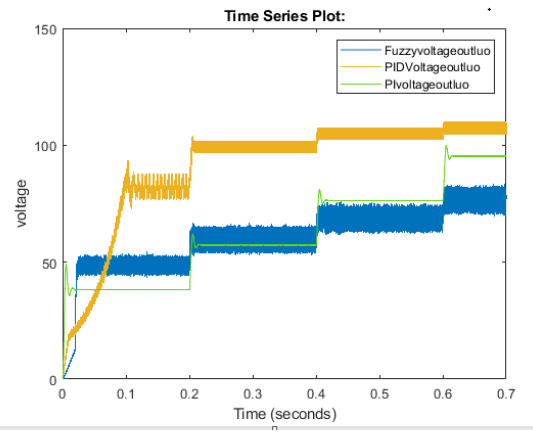

Figure 3: Output of voltage from the Luo

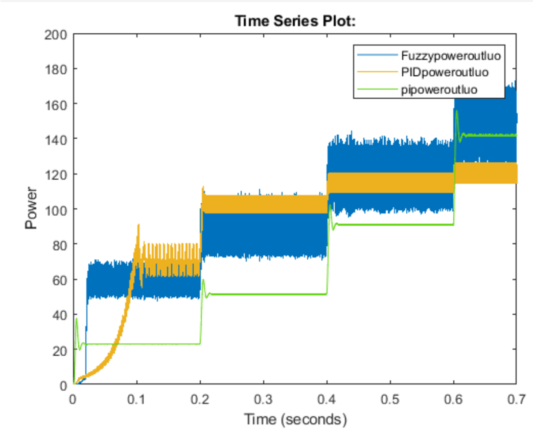

Figure 4: Output of Power from the Luo

The proposed project has the three different controllers with sepic converter first we changed the irradiance level with respective to time and the irradiance levels were 400,600,800 and 1000. Now connect the controller, one by one at a time and we observed the following results in the graph. when the PI controller is connected, at the beginning stage the output obtained will be low, but it will gradually increase with the time and irradiance. Next if the fuzzy controller is connected, the output will be higher than the others and the variations are higher, and the increasing rate will be slower than PI controller. where PID and fuzzy logic controller has same average output.

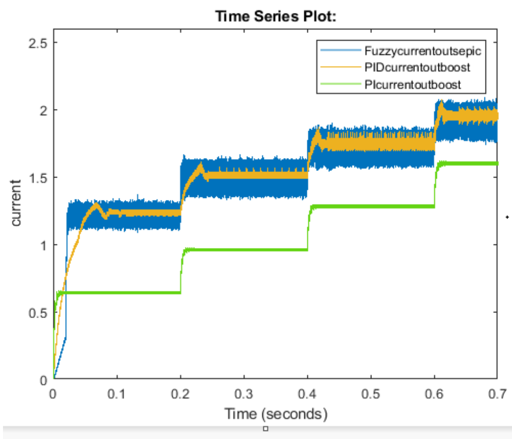

Figure 5: Output of voltage from the Boost converter

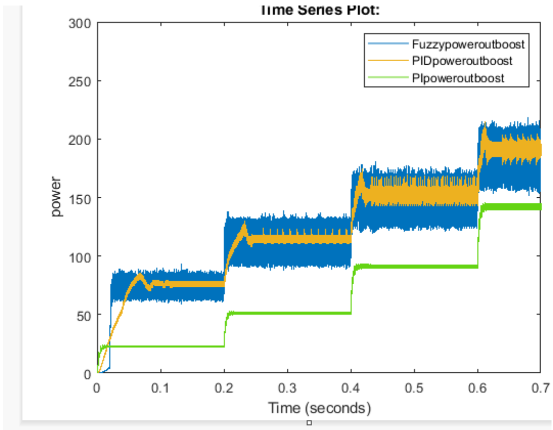

Figure 6: Output of voltage from the Boost converter

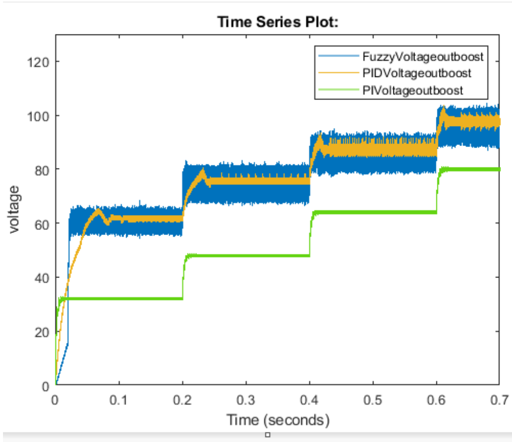

Figure 7: Output of voltage from the Boost converter

The proposed project has the three different controllers with sepic converter first we changed the irradiance level with respective to time and the irradiance levels were 400,600,800 and 1000. Now connect the controller, one by one at a time and the following results are observed in the graph. when the PI controller is connected, at the beginning stage the output obtained is low, but it will gradually increase with the time and irradiance. Next if the fuzzy controller is connected, the output will be higher than the others and the variations are higher and the increasing rate will be slower than PI controller. where PID and fuzzy logic controller has same average output.

CONVETER / CONTROLLER	Irradiance W/m^2	Time (s)	LUO			BOOST			SEPIC		
			V	I	P	V	I	p	V	I	P
PI	400	0	38.19	0.39	14.89	31.85	0.63	20.06	39.94	0.42	16.99
	600	0.2	56.89	0.58	32.99	47.76	0.94	44.89	58.99	0.62	36.2
	800	0.4	76.54	0.78	59.70	63.30	1.24	68.49	78.61	0.84	62.8
	1000	0.6	94.41	0.97	91.57	78.82	1.40	94.67	99.06	1.05	104.02
PID	400	0	93.03	0.96	89.3	62.6	1.23	76.37	62.53	1.21	75.6
	600	0.2	103.42	1.07	110.6	66.6	1.40	93.2	79.41	1.48	132.3
	800	0.4	106.34	1.10	116.9	89.01	1.62	63.19	90.32	1.79	163.0
	1000	0.6	109.78	1.13	124.05	96.17	1.84	178.05	98.28	1.97	193.6
FUZZY	400	0	52.56	1.32	69.3	66.7	1.32	88.04	83.84	1.32	113.3
	600	0.2	65.12	1.62	105.4	73.31	1.5	117.465	105.4	1.64	173.74
	800	0.4	72.83	1.83	133.4	92.12	1.80	165.86	119.04	1.78	211.8
	1000	0.6	81.51	2.02	164.6	99.02	1.97	195.06	131.94	2.04	269.1

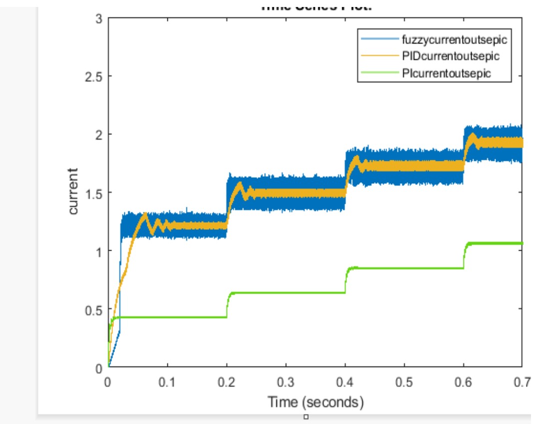

Figure 8: Output of voltage from the SEPIC converter

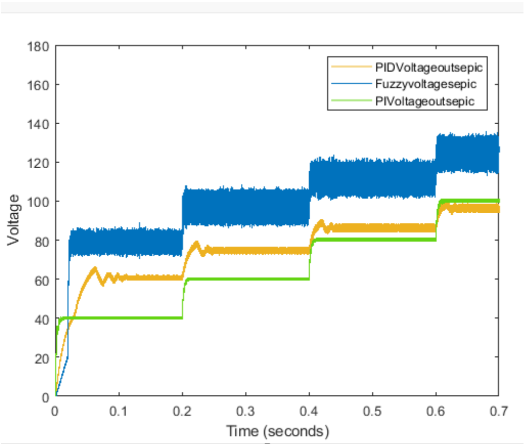

Figure 9: Output of voltage from the SEPIC converter

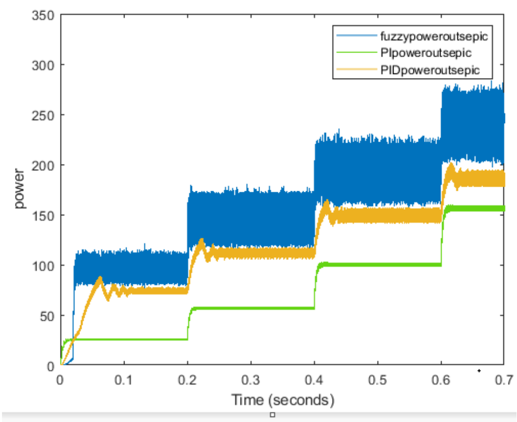

Figure 10: Output of voltage from the SEPIC converter

4. Tabulations

The proposed project has the three different controllers with SEPIC converter first we changed the irradiance level with respective to time and the irradiance levels were 400,600,800 and 1000. Now connect the controller, one by one at a time and the following results are observed in the graph. when the PI controller is connected, at the beginning stage the output obtained will be low but it will gradually increase with the time and irradiance. Next if the fuzzy controller is connected, the output will be higher than the others and the variations are higher and the increasing rate will be slower than PI controller. where PID and fuzzy logic controller has same average output.

5. Conclusion

In this project, the comparison of different inverters and controllers have done to identify the highly efficient performance for the output power. The existing system have only the low-level comparison.

The proposed system has the nine kinds of comparison to make highly efficient performance with the three kinds of converters and controllers. The combinations of these controllers, converters, MPPT algorithm to make a highest performance as mentioned above, the project can be extended to several future application areas to further improve the performance and reliability of the system and enable its application in a wide range of industries and fields. At the end of the project, it should be noted that the use of a modular multilevel inverter in combination with various controllers and converters offers several advantages. The modular multi-level inverter offers high-quality output waveform, low harmonic distortion and low electromagnetic interference (EMI), making it suitable for various applications such as motors, renewable energy systems and DC high-voltage (HVDC) transmission systems). . In addition, the various control strategies used in the project, such as PID, PI, and fuzzy logic controllers, have their unique advantages and limitations. The selection of the control strategy depends on the application requirements, system specifications and performance criteria. By using these control strategies in combination with the modular multilevel inverter and various converters, the project was able to achieve the desired performance and improve the overall system performance. The project has potential applications in various sectors such as automotive, aerospace, renewable energy, and industrial automation. The project can help to improve the efficiency and reliability of electrical systems, reduce energy consumption, costs, and minimize the environmental impact of power generation.

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