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Performance Analysis of Stand-Alone PV System Using Single Voltage Sensor Based MPPT Method

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Abstract: In this article, a SEPIC converter is taken into consideration because it can function as both a step-up and step-down converter; as a result, it will expand the voltage range over which PV systems can function.This topology has a number of benefits, including an output polarity that does not invert an easy-to-drive switch, and low current ripple at the input.A single voltage-sensor-based maximum power point tracking (MPPT) technique with a voltage reference control technique using a PI controller has been considered for the SEPIC converter.As a result, the Maximum Power Point Tracking (MPPT) technique with Voltage Reference Control (VRCT) combined with the Association of PI Controller can effectively improve the performance of the PV system.A step change in irradiance is used to test the performance of the proposed MPPT algorithm in conjunction with the PI controller.Matlab/Simulink can be used to implement the proposed work.

I. INTRODUCTION

Natural resources such as sunlight, wind, rain, tides, and geothermal heat all count as renewable sources of energy.These resources can be replenished in a natural way because they are renewable .As a result, for all intents and purposes, these resources can be thought of as being inexhaustible, in contrast to the traditional fossil fuels, which are beginning to run out[1].There are two primary applications for solar energy that can be carried out. To begin, the heat that is collected can be utilized as solar thermal energy, which has applications in the heating of indoor spaces. The transformation of incident solar radiation into electrical energy, which is the form of energy that can be put to the most practical use, is yet another possibility. This can be accomplished through the use of solar photovoltaic cells [6] or through the utilization of concentrating solar power plants.

In the P&O method, the MPP is tracked by iteratively adjusting the output voltage of the PV array located at the MPP, either by raising it or lowering it.This method not only has a control algorithm that is not overly complicated, but it also follows the MPP quite accurately. However, when the weather is normal, the operating point of the PV array moves around the MPP which results in the loss of some of the total energy that is available [3]. This technique takes a significant amount of time in environments where the atmospheric conditions are constantly shifting, and during this time, a sizeable amount of power is wasted [4]. The limitations of the P&O method inspired the development of a new method known as the IC method. The incremental conductance is compared to the instantaneous conductance in order for the IC method to determine the MPP of the PV array. As a consequence of this, the IC method performs admirably in situations where the atmospheric conditions are subject to rapid change. However, this method has a drawback in that it necessitates the use of a sophisticated control circuit.

The current-based MPPT method is yet another widely used MPPT approach. This method takes advantage of the fact that the operating current at the maximum power point (MPP) of a PV array is linearly proportional to the short circuit current of the array [3]. This method has a quick response speed for tracking the MPP in environments where the atmospheric conditions are constantly shifting. However, because of the online measurements of PV array short circuit current, current-based MPPT hardware becomes more difficult to implement and expensive [5].

The voltage-based maximum power point tracking (MPPT) technique is based on the observation that the PV array voltage that corresponds to the maximum power demonstrates a linear dependence with respect to the array open circuit voltage for a variety of irradiation and temperature levels. This observation is the foundation for the technique.

II. STANDALONE PHOTO VOLTAIC SYSTEM

The term "standalone solar electrical system" refers to a system that derives the majority of its power from the sun's rays alone.On this planet, there are a lot of spots where there is no access to any kind of electrical power source.In such places, a solar electrical system that operates independently may be the most suitable source of electricity.The fact that this system does not rely on the grid or any other kind of electricity supply is the primary benefit of utilizing it.

It is also known as an off-grid photovoltaic system due to the fact that it does not have any connection with the grid or any other type of electric supply line.Given that the sun is the only source of energy in this system, there ought to be some way to keep it operational even when the sky is dark.

III. MPPT BASED PHOTOVOLTAIC

Due to the ever-increasing level of demand, the current competitive environment in the power market places a significant emphasis on the importance of optimally operating photovoltaic power generation systems in relation to the economy of power generation.The need for more energy grows steadily day by day.Significantly, as a result of advancements in a variety of fields in this world as well as limitations imposed by fossil fuels, the researchers have shifted their attention to the search for alternative energy sources in order to satisfy the energy requirements of the world.Solar energy, wind energy, and nuclear energy all entered the picture as a result of this.Renewable energy, also known as clean energy, has gained popularity in recent years as a solution to environmental problems such as global warming. Examples of this type of energy include solar and wind power.These days, solar energy is utilized in a variety of applications, including electric vehicle applications, motor drive applications, distributed generation, active filtering, and PV to grid interconnection, to name a few.Increasing solar power generation's efficiency is the most important and workable solution to the problem of improving solar power generation. High overall system efficiency should be maintained in order to cut costs and shrink the size of the operation.

Solar cells have a non-uniform V-I characteristic, which shifts depending on the temperature and the amount of light hitting them. Numerous authors from all over the world have expressed their thoughts on the topic of solar energy applications. Solar power has been widely recognized.The photovoltaic system cell functions at a very low efficiency, and as a result, an advantageous control technique is required for the purpose of improving the efficiency of the solar cell. A comparative analysis of maximum power point techniques for photovoltaic systems. At the Maximum Power Point (MPP), this is a singular point on the characteristic curve, the solar system functions at its highest level of productivity and generates the maximum amount of power at the output terminal. This location is referred to all over the world as the Maximum Power Point (MPP).Even though its position is unknown, the MPP's position can be determined through the use of a computation method.Thus, the use of MPPT techniques is necessary.Maximum power point tracking, also known as MPPT, is a method that employs charge controllers and grid-connected inverters for the purpose of tracking the MPP of one or more PV modules.The primary purpose of the controller is to increase the system's steadiness as well as its degree of robustness. In order to generate the necessary duty cycle for the SEPIC converter, the discrete PI controller is utilized.

IV. SIMULATION RESULT AND ANALYSIS

In this section, a simulation utilizing Matlab/Simulink is carried out in order to validate the suggested topology.The Matlab Simulink diagram is shown in Fig.1.

In this section, simulations are given to demonstrate the validity and advantage of the proposed method. The considered MPPT algorithm with the designed PI controller is tested for a step change in irradiance from 270 to 480 W/m^2 with a perturbation time of 20ms and ΔV = 0.5 V (perturbation of voltage).The P–V characteristics of the simulated PV module for the above-mentioned irradiance conditions are shown in Fig. 2, and the corresponding MPP voltages are 15.13 and 16.16 V, respectively. The tracking waveforms with the proposed method are shown in Fig. 3, and it can be observed that the transient duration has been reduced and is tracking the corresponding MPP with minimum steady-state oscillations. Thus, the tracking performance of the MPPT controller is improved by the voltage reference control technique in association with the designed PI controller.

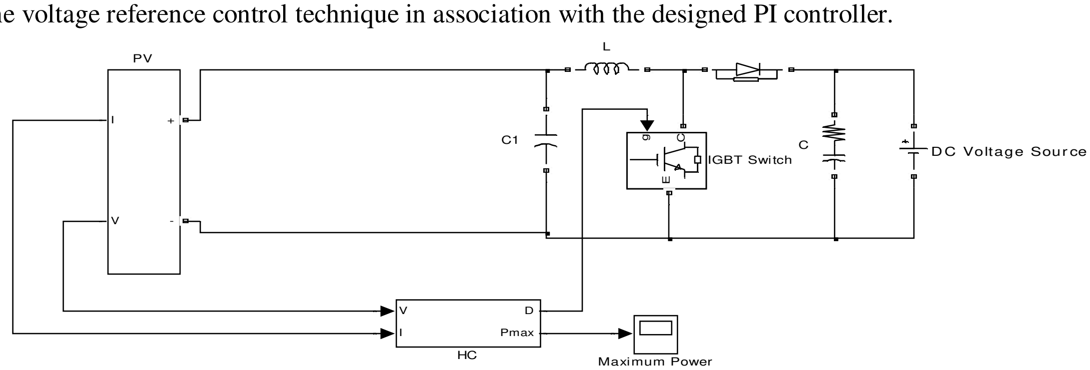


Fig.1: Block diagram of proposed system

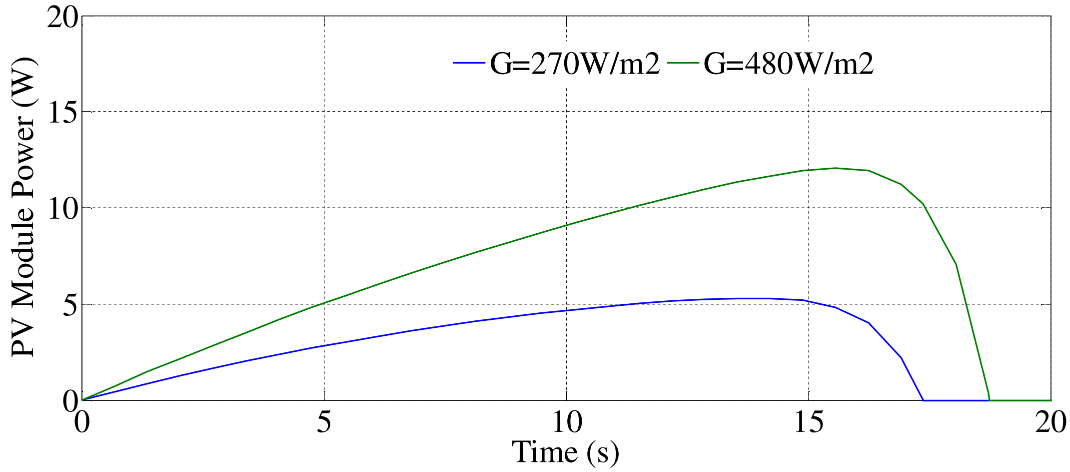
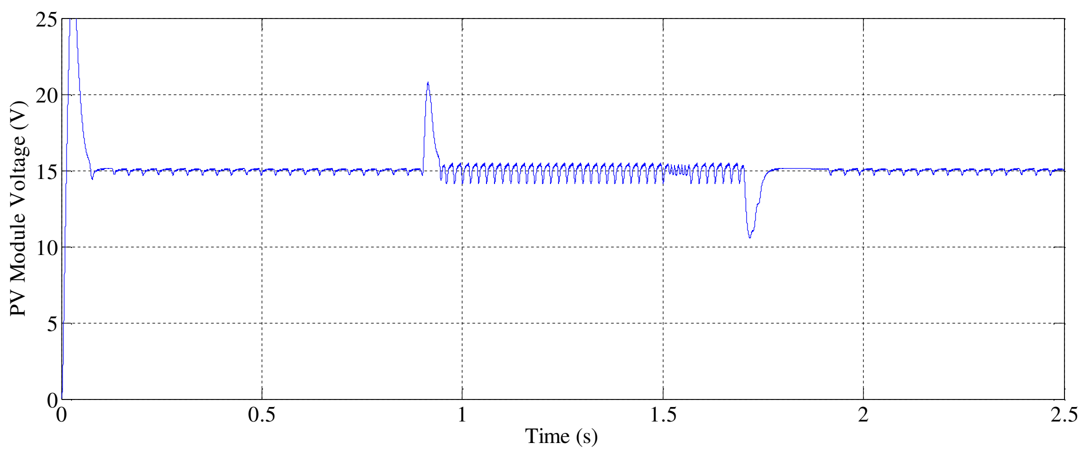
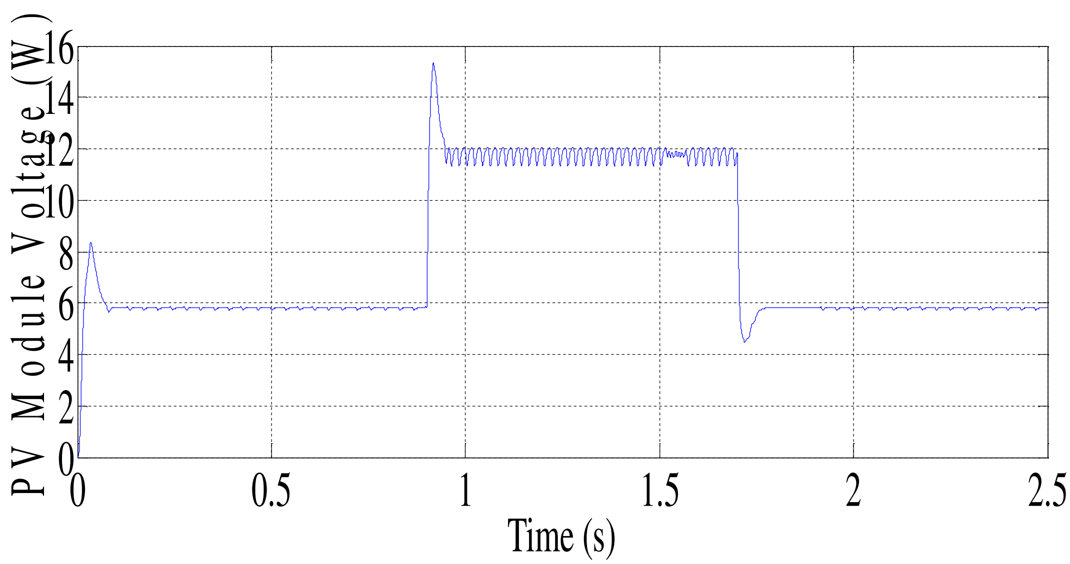


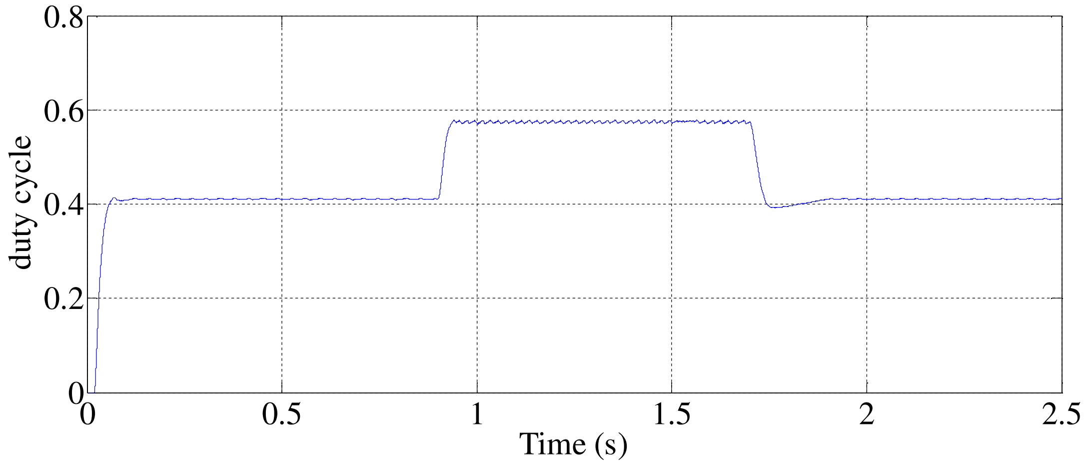
Fig. 2: P–V characteristics of the considered PV module



(a) Voltage



(b) Power



(c) Duty cycle

Fig.3: Simulated results with the proposed MPPT controller

V. CONCLUSION

In this work, an improved tracking performance has been achieved by implementing a voltage reference control technique coupled with a single voltage sensor-based maximum power point tracking (MPPT).The voltage reference control technique enhances the tracking performance of the MPPT controller. In contrast to the P&O and IncCond methods, the proposed algorithm needs only a single voltage sensor in order to function properly.The problems that can arise and the criteria that must be met in order to select the appropriate objective function for tracking the peak power using the MPPT algorithm with a single voltage sensor have both been meticulously illustrated.Through small-signal modeling of the system, the procedure for designing the PI controller has been clearly described, and the functionality of the MPPT algorithm has been validated with the designed PI controller.

The results of the simulations demonstrate that the proposed algorithm is effective in effectively improving both the dynamic and steady-state tracking performance of the PV system while simultaneously reducing the cost of doing so.The MPPT control architecture that was proposed can be easily implemented with other converter topologies; however, the objective function is dependent on the modulation index of the particular topology.

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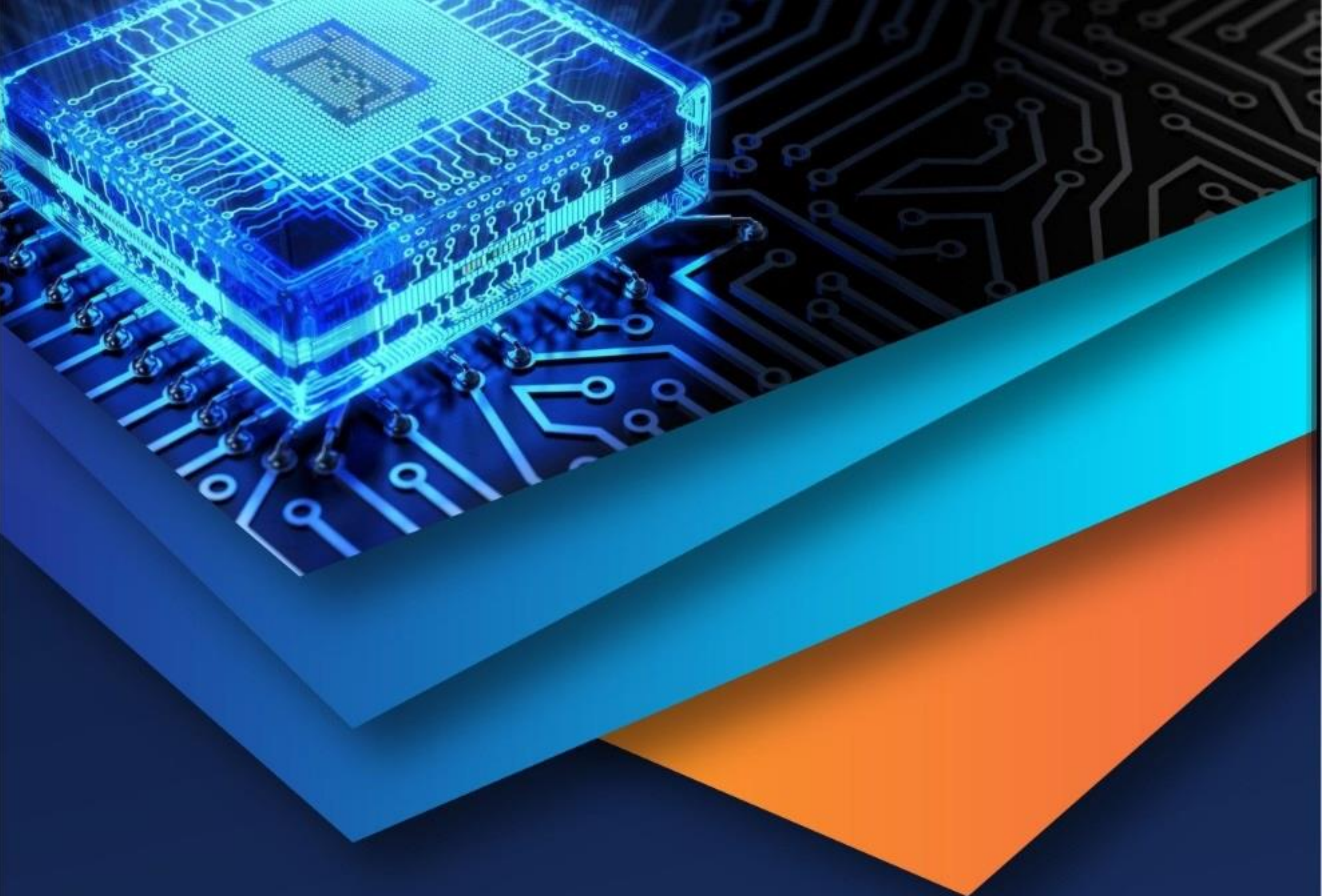

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