

IMPLEMENTING A 1KW SOLAR-POWERED STAND-ALONE DC GRID FOR LED LIGHTING AND GADGET CHARGING IN BUILDING SPACES

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ABSTRACT:

All of the sophisticated electric applications found in commercial buildings, such as lighting, information technology (IT), and telecommunications equipment, as well as speed-controlled drives in HVAC and ventilation systems, can have an efficient direct current (DC) supply thanks to the use of contemporary power electronics. LED lights and most electronic loads in the built environment are powered by DC power sources. Conversely, the dc nature of LED luminaires leads to large power conversion losses. Typical fluorescent lights, on the other hand, are mostly powered by the ac grid. When using equipment that requires a suitable power supply for high performance requirements, the reduced power supply in AC may cause malfunctions. Because of these demands for great performance, DC was necessary. The inefficiency of AC/DC converters used with LED lighting may be seen as a benefit since LED lights only need DC power. The project being presented would include information on a DC grid that is integrated with solar MPPT units. This grid powers a DC lighting system, a DC electric vehicle charger for a small area, and a DC low power supply for IT infrastructure (micro grid). A physical prototype and a MATLAB simulation would be created in order to validate the results.

Keywords: DC grid, boost converter, nano grid, MPPT, LED lighting, PV panel, and DC-DC converter.

I. INTRODUCTION

Like food and water, energy is something that can't be done without. Everything in our environment has a need for energy. Over the course of recent history, there has been a rise in the population of the

planet, which is exactly proportionate to the amount of energy that has been used as well [1]. To work, each and every conceivable piece of hardware and appliance need some kind of energy in some form or another. The depletion of fossil fuel reserves makes it imperative to locate feasible renewable energy supplies that may reduce reliance on fossil fuels in order to lessen the severity of the global energy crisis. As the global population continues to rise and the economies of emerging nations continue to grow—which is predicted to result in a tripling of those economies by the year 2050 [2], there will be an ever-increasing need for energy.

In today's world, our sources of energy originate from hydrocarbon fuel, which is a limited resource that is often cited as one of the primary factors contributing to wars and tensions on a global scale. Many nations, even oil-producing nations, see solar power as one of the most promising forms of alternative energy supply. However, the ongoing rise in the price of oil is compelling many nations to search for alternate sources of energy. For instance, in countries such as Jordan, the average daily solar radiation is between 5.5 and 7.5 kWh/m², and the sunlight length is 3000 hours per year [3-5]. [Citation needed] Photovoltaic (PV) technology offers a workable answer to a wide range of power application issues, both in remote locations and in the heart of major urban regions [6-7]. One of the most widespread uses of photovoltaic energy is in the production of independent PV lighting systems [8]. Because the use of energy-efficient lighting is an essential component of sustainable development and energy strategies [9], the combination of high-efficiency PV with LEDs paves the way for the release of stand-alone PV lighting systems that offer a feasible energy-efficient solution for lighting systems.

II. LITERATURE SURVEY

Solar photovoltaic (PV) systems have emerged as a favorite option for RES because to their low upfront costs and streamlined installation processes. Small-scale solar power systems, such as those described in [10], are increasingly being erected on roofs in metropolitan areas, with the dual goals of supplying environmentally friendly electricity and lowering utility costs. The fact that photovoltaic rooftop systems are often dependent on the AC grid for operation and are unable to function in stand-alone mode is one of their primary advantages. Extending the main grid to more rural places is a laborious and time-consuming endeavor that must be undertaken. Building microgrids, which are separate power systems that do not need to rely on the main grid [11], is one potential approach that might be taken to address this issue. [11] These systems tap into RES in close proximity to the local demand, which effectively eliminates the expense required to draw lengthy cables from the main grid and reduces reliance on power production based on the use of fossil fuels. Microgrids may be either alternating current (AC) or direct current (DC) [12]. In order to connect to the lines in AC microgrids, energy sources that generate DC power, such as photovoltaic panels and fuel cells, would, of course, need a DC-to-AC conversion. It is interesting to note that power sources that provide AC current [13], such as wind, hydro, and geothermal, may need AC-to-DC-to-AC conversion in order to achieve a more synchronized link to the grid [14]. However, in a DC microgrid, both DC-producing sources and AC-producing sources may only need a single conversion. This results in a decreased demand for converters, which in turn leads to an increase in overall efficiency. These days, DC microgrids are becoming more popular [15] as a result of their ease of use and superior power quality as compared to their AC counterparts [16]. Because there is no need to worry about synchronization or reactive power in a DC system, the control may be made more

straightforward. [17] In the research that has been done, several DC microgrid solutions have been suggested. The references [18,19] discuss microgrids that are dependent on an AC utility for their power supply. These systems are similar to the ones described in [20] in that they function best in congested metropolitan areas where there is a dense concentration of wireless networks. A DC microgrid system developed for rural regions is shown to be capable of operating independently even in the lack of a power network in [21]. However, the system only has a stand-alone mode, which indicates that it does not have the potential to share power with other devices. Constructing microgrids that are centralized is not the best option for rural locations [22]. The socio-environmental factors of rural communities are to blame for this phenomenon. To begin, the topography presents some challenging obstacles. Because of this, the system must be one that can be moved and set up with relative ease [23]. Second, towns tend to emerge in clusters, with houses, schools, hospitals, and other public buildings being constructed at different locations from one another. This indicates that a centralized generating system would have a significant amount of conductor losses [24]. Thirdly, there is a deficiency in the communication infrastructure in rural regions. As a result, the system has to be capable of functioning in a mode that is independent of any outside influence. In order to support potential future growth, the components of the system that will be used must be modular and capable of being inserted in a plug-and-play fashion [25].

III. SYSTEM DESIGN

Proposed Model

The suggested block diagram of MPPT controller-based PV energy management systems is shown in Figure 1. To propose an intelligent control of MPPT and Bus Controller by using PV strings is the primary purpose of this project. The suggested system would include solar PV strings equipped with buck converters, a bi-directional dc-dc converter, and nano

grids installed at charging ports for electric vehicle charging.

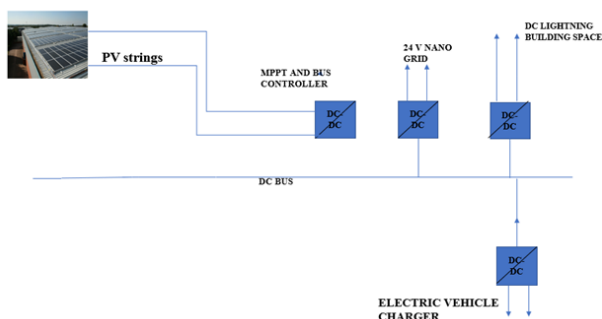


Figure 1. Proposed block diagram.

The photovoltaic (PV) system is made up of PV panels and an MPPT controller. This controller makes use of the P&O algorithm to track the maximum power point regardless of the irradiance. Although there are a few other MPPT strategies that have been created, we decided to go with the one that is called the Perturb and Observe (P&O) algorithm. The PV array is managed in such a way that its operating point is moved closer and closer to the growing power point until it achieves the maximum power point (MPP), which is determined by the amount of solar irradiation. Following the completion of the MPP, the algorithm will compute the voltage value and input it into the boost converter. The primary purpose of the boost converter is to get the voltage of the photovoltaic panel up to the level of the DC bus voltage that is wanted (110V). It then makes its way to the station battery and the EV battery from the DC bus. The station's battery is made up of a bi-directional dc-dc converter that can work in either mode. If solar PV generates less power than required load or if additional high loads are plugged in, then the bi-directional converter operates in the boost mode (discharging) to supply required power to the EV charging ports and to maintain the DC bus at a constant voltage. When PV generates more power than is required by EVs, it operates in the buck mode (charging) to charge the station battery. When PV generates more power than is required by EVs, it

operates in the boost mode (discharge). This mode may also be enabled by plugging extra high-power loads into the charging ports, which is another way to trigger its activation. The CCCV charging technique is applied to the electric vehicle (EV) battery in accordance with its state of charge (SOC).

3.1 Perturb and Observe (P&O) algorithm

The efficient technique is proposed to track the maximum output power by adjusting the load of the photovoltaic system is called MPPT algorithm. MPPT can be achieved through the several ways like fuzzy logic, pilot cells, and neural networks. The utmost extensively used techniques are Perturb and Observe (P&O) and Incremental Conductance (INC) algorithms because of these are economical. Control algorithm is applied for the system due to its comfort of execution. The operation P&O algorithm is by measuring voltage and current of PV segment and then it will calculate the power from voltage and current. This power compares with the previous value, if any deviation in the power means the voltage can be altered. For example, if the power of PV module is increased then the control algorithm corrects the operating point of the module in that direction; otherwise, it operates in the opposite direction. These steps will continue until the power reaches at maximum level. The speed of the MPP is mainly depends on the perturbation of voltage, if the lower perturbation, then the system response to reach MPP is to be low. If perturbation is larger than the system response to reach MPP is high. There is no need of previous knowledge on characteristics of PV in this control algorithm.

The flow chart of P&O MPPT control algorithm is as shown in Figure 2. Figure 1 displays the diagrammatic sketch of the MPPT control system of PEMFC with Boost converter, which is mainly composed of PEMFC, boost converter, MPPT controller, PWM generator and external load resistance. Because the Boost converter has the advantages of simple structure, easy control and voltage amplification, it is used in the system to improve the output voltage and as a regulator to realize the MPPT control scheme. Te

output of PWM generator is a series of square waves with different duty cycle, which is used to control the ON and OFF of the Boost convertor. The output duty cycle of the PWM controller is represented by D. For the system shown in Fig. 2, the equivalent load resistance of PEMFC can be expressed according to the knowledge of power electronic technology as;

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$$R_{eq} = \frac{U}{I} = (1 - D^2) * R_L$$

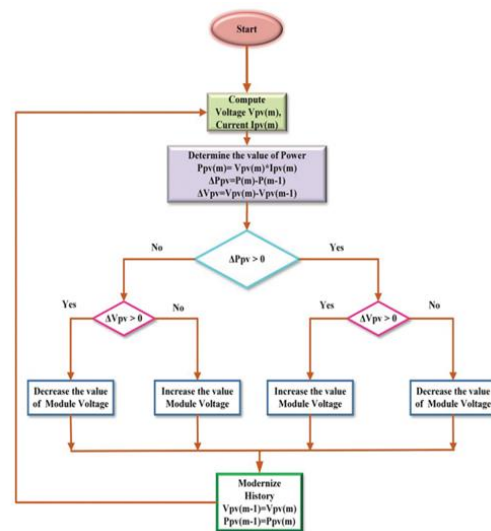


Figure 2. Flowchart of efficient control algorithm.

In this case, the real load resistance, also known as the load resistance at the output of the Boost converter, is denoted by the symbol R_L. It is common knowledge that the output power of an electric source can only achieve its utmost potential if and only if the source's internal resistance and its external resistance are equal to one another. According to equation (1), the objective of altering the equivalent load resistance may be accomplished by adjusting the duty cycle of the Boost converter. This can be done in order to achieve the purpose of adjusting the equivalent load resistance. As a result, the equivalent load resistance of the PEMFC may be made equal to its internal resistance via the process of modifying the duty cycle in order to accomplish the goal of producing the greatest amount of power. The P&O approach is now the MPPT technique that sees the most widespread use. A positive disturbance voltage is applied to the fuel cell, its output voltage

and current are sampled, and the change rate of the fuel cell's voltage and power are calculated. This is the fundamental premise behind the method. If the output power increases after the disturbance, it indicates that the direction of the disturbance voltage is the direction of the increase of the output power, and the disturbance should be continued in this direction; if the output power decreases after the disturbance, it indicates that the disturbance should be in the opposite direction. In accordance with the shifting direction of voltage and power, the fuel cell receives a continuous application of the disturbance voltage until the maximum output power is progressively approached, which enables the maximum power point tracking algorithm to be realized. The flowchart of P&O algorithm is shown in Fig. 3, in which “k” denotes the sampling point, $-d$ stands for the increment of duty cycle. P&O has the advantages of simple calculation and convenient implementation, but it can only keep the system oscillating infinitely near the maximum power point, and cannot accurately track the maximum power point, so it cannot effectively solve the problems of tracking accuracy and speed.

IV. RESULTS

In this part, a comprehensive analysis of the simulation findings as well as a comparison with state-of-the-art methods are presented. Using the MATLAB/Simulink software, a modeling and simulation result comparison of the solar-powered LED lighting system with a traditional boost converter without MPPT Technique and an efficient suggested power converter with MPPT Technique is carried out. The effectiveness of the control strategy's implementation has been evaluated. The solar panel in Figure 3 has an output of 110 V, and this voltage is sent into the boost converter as an input. The boost converter then increases the voltage to 150 V, which is the dc bus voltage. The DC bus incorporates both the bi-directional converter and the buck converter into its design. The number of charger ports, also known as buck converters, has been expanded in response to

customer feedback. When compared to the design circuit of a traditional boost converter with a lower duty ratio, the circuit of a high voltage gain power converter delivers a far more efficient output than the conventional boost converter. The ripples that are present in the waveforms of the output voltage and current may also be reduced by the power converter.

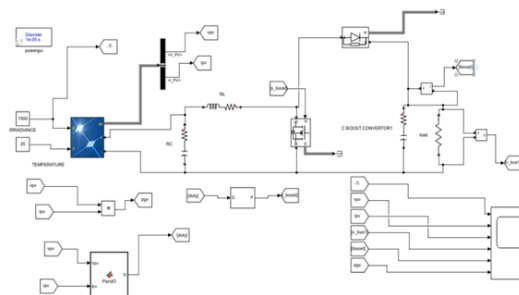


Figure 3. Simulation diagram of proposed model.

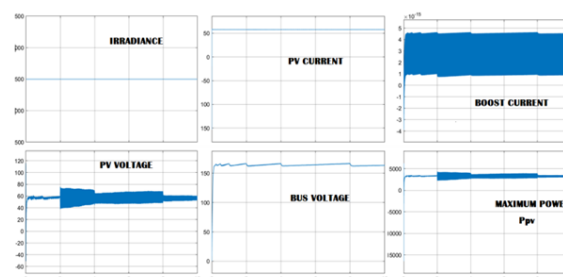


Figure 4. Simulation outcome.

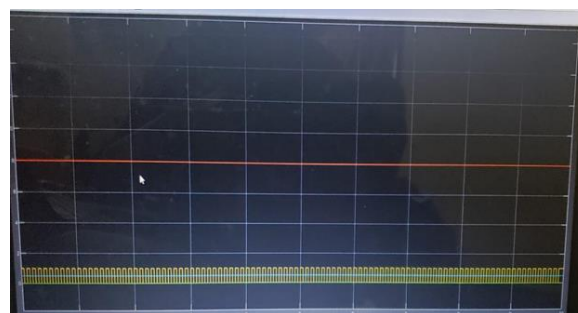


Figure 5. Output Waveform of SIMO based DC-DC converter.

The results of the simulation of the suggested approaches are shown in Figure 4, and the output waveform of the DC-DC converter based on Single Input Multiple Output (SIMO) is displayed in Figure 5. In this case, the irradiance of the solar panel varies with respect to time. From time $t=0$ seconds to time $t=0.2$ seconds, the irradiance is taken as 1000 W/m², and from time $t=0.2$ seconds to time $t=0.4$ seconds, it

decreased from 1000 W/m² to 500 W/m², and from t=0.4 seconds to t=0.6 seconds, it increased from 500 W/m² to 600 W/m². In addition, the voltage.

V. CONCLUSION

This article presents a 120-Watt solar-powered LED lighting system together with an energy-efficient fast tracking maximum power point tracking (MPPT) circuit that uses a high gain power converter to run at a constant irradiance level. A transformer-less power converter has an easy-to-understand structure that makes regulation simple. This adjustment has resulted in a reduction in voltage stress and current ripple across the switch. In terms of gain, the power converter is far superior than the traditional boost converter. The simulation's findings indicate that the MPPT controller was able to observe the maximum power point more rapidly and clearly, as well as the power converter's performance characteristics in contrast to those of the boost converter.

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