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Maximum Power Point Tracking Technique for Improving Power of Photovoltaic System

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ABSTRACT: In this paper, the MPPT technique extracts maximum power from the PV system. Solar is the main source of non-conventional energy since wind energy is also the form of solar energy. Solar energy is converted into electrical energy with the help of a Photo Voltaic system. Solar panels collect the sun's energy and convert it to electrical energy. Unfortunately, the sun is not consistent throughout the day due to cloud cover and the sun's angle relative to the solar panel's position. In this article evaluations among the most usual maximum power point tracking (MPPT) techniques, we are making meaningful comparisons concerning the amount of energy extracted from the photovoltaic (PV) panel [tracking factor (TF)] concerning the available power, PV voltage ripple, dynamic response, and use of sensors.

Keywords:- Photovoltaic system (PV), DC-DC Converters, Intelligent MPPT Techniques

I. INTRODUCTION

The growing energy demand coupled with the possibility of reduced supply of conventional fuels, evidenced by the petroleum crisis, along with growing concerns about environmental conservation, has driven research and development of alternative energy sources that are cleaner, are renewable, and produce little environmental impact. Among the alternative sources, the electrical energy from photovoltaic (PV) cells is currently regarded as a natural energy source that is more useful since it is free, abundant, clean, and distributed over the Earth and participates as a primary factor of all other processes of energy production on Earth. Moreover, despite the phenomena of reflection and absorption of sunlight by the atmosphere, it is estimated that solar energy incident on the Earth's surface is on the order of ten thousand times greater than the world energy consumption [1] for many years' fossil fuels have been the primary source of energy in the world; however, these resources are finite. The threat of climate change due to global warming (caused by the burning of fossil fuels) has prompted the search for renewable energy sources such as the sun and the wind. Solar energy is a sustainable, environmentally friendly, and cost-efficient source of energy available around the world.

For this reason, solar technologies using photovoltaic (PV) systems have penetrated the electric power production market, with the additional advantages of working quietly and with low maintenance costs. The use of flatness-based control strategies in electrical power systems has been explored in the last decade, where some works have reported the use of flatness-based controllers for power converters. The MPPT is a charge controller that compensates for the changing Voltage Current characteristic of a solar cell. The MPPT fools the panels into outputting a different voltage and current, allowing more power to go into the battery or batteries by making the solar cell think the load is changing when you cannot change the load [1]. The MPPT monitors the output voltage and current from the solar panel and determines the operating point to deliver the maximum amount of power available to the batteries. If our version of the MPPT can accurately track the always-changing operating point where the power is at its maximum, then the efficiency of the solar cell will increase. One of these factors: lower operational and maintenance costs, no audible noise, no fuel cost, and the generated energy is free of pollution [1].

The photovoltaic solar cells for home applications are also a good energy solution in remote and developing countries, especially those with a good amount of solar radiation. The maximum power point tracker is a DC/DC converter connected between the PV solar cells (panels) and the battery or inverter. The MPPT is used to control (increase or decrease) power output under the required conditions of the system. Accordingly, many MPPT algorithms have been studied, optimized, and developed [2,4]. This paper presents a brief review of the main MPPT strategies: general characteristics, advantages, and disadvantages of the suggested methods. Furthermore, this work is gathered from several papers from the last 5 years to present the current state of the art in MPPT technology and guide those who want to know more about the new tendencies in this field.

II. PHOTOVOLTAIC(PV)

A photovoltaic (PV) system is a solid-state semiconductor device that generates electricity when exposed to light. The building of a solar panel is the solar cell. A photovoltaic module is formed by connecting many solar cells in series and parallel to get maximum output voltage, PV modules are connected in series, and for obtaining maximum output current, they are connected in parallel. Solar PV power systems have been commercialized in many countries due to their merits, such as long-term benefits and maintenance-free. The major challenge in using PV power generation systems is to tackle the nonlinear characteristics of PV arrays. The PV characteristics depend on the level of irradiance and temperature. PV array experiences different irradiance levels due to passing clouds, neighbor buildings, or trees [3]. The block diagram of the PV generation system

2.1. GRID-CONNECTED PV SYSTEM

The grid-connected PV systems are designed to operate in parallel and connected with the electric utility grid system. They mainly consist of inverters to convert array produced DC into AC power with voltage and power quality requirements of the utility grid. A bidirectional interface is made between the PV system AC output circuits and electric utility network at onsite distribution panel or service entrance to allow AC power to either supply or feedback the grid when the PV system output is greater than load demand [5]. The block diagram of a grid-connected PV system is observed from given Figure 1. The PV system can operate in grid-connected and standalone modes using a multilevel inverter and boost converter to extract maximum power and feed it to the utility grid and standalone system Standalone Photovoltaic Systems. These are designed to operate independently of the electric utility grid and supply certain DC or AC electric loads. The simple type of standalone PV system is a direct-coupled system. It operates only during sunlight hours, and energy not be stored in the battery system. The main application includes ventilation fans, water pumps, and small solar thermal water heating systems.

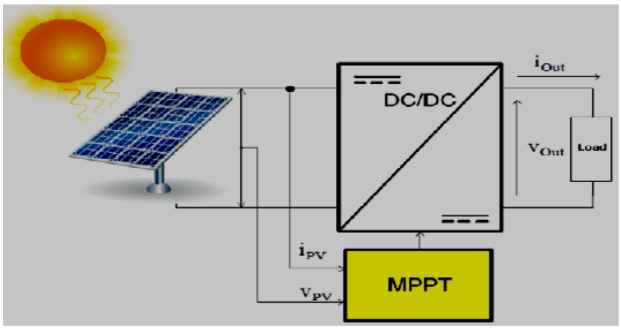

Figure 1: Module and dc/ dc converter with MPPT

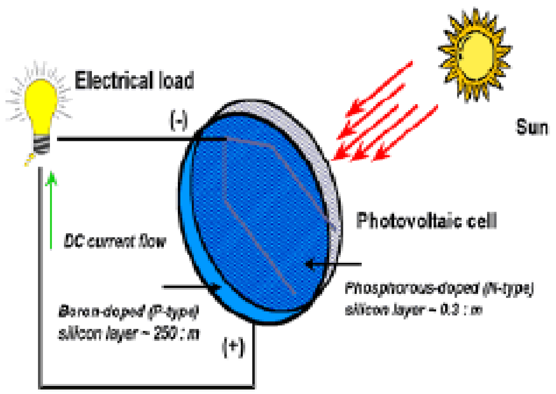

Figure 2: Working of Photovoltaic cell

The Block diagram of a direct-coupled PV system is as shown in Figure 1. For the above direct-coupled PV system, several studies such as continuous variations of solar radiation, quality of load matching, geographical location, climatic studies, degree of utilization, and accurate sizing are investigated to various loads have observed the behavior of the PV panel from a direct-coupled system with switched-mode converter and MPP algorithm. They have compared the V-I characteristics of the panel with and without the MPP algorithm. The design methodology in this study is mainly based on the variation of solar radiation; due to this, the results could not be safely applied over some time for specific input radiation time series. PV panels are connected in series-parallel combinations to the inverter; the difference in panel voltages can cause problems such as the location of global MPP at different positions under partially and fully shaded atmospheric conditions; to overcome It, optimizers are installed on each panel. It allows them to work independently from one another, optimizes energy output, and enables us to monitor the performance of each module. A standalone system incorporates a photovoltaic panel, regulator, energy storage system, and load has explained the minimization of shadow effect in a two-section module PV system by using active voltage sharing. It is observed that the active bypass does not produce losses under nonshadow/matching conditions.

MPPT (Maximum Power Point tracking):

A charge controller with MPPT capability is proposed in this paper to harvest maximum power from the PV panel. The two broad categories of MPPT techniques are indirect techniques and direct techniques. Indirect techniques include the fixed voltage, open-circuit voltage, and short circuit current Methods. In this kind of tracking, simple assumption and periodic estimation of the MPPT are made with easy measurements. For example, the fixed voltage technique only adjusts the operating voltage of the solar PV module at different seasons with the assumption of higher MPP voltages in winter and lower MPP voltages in summer at the same irradiation level. This method is not accurate because of the changing of irradiation and temperature level within the same season. Another most common indirect MPPT technique is the open-circuit voltage (OV) method. In this method, it is assumed that:

$$V_{MMP} = kXV_{oc}$$

Where k is a constant, and its value for crystalline silicon is usually around 0.7 to 0.8. This technique is simple and is easier to implement compared to other techniques. However, the constant k is just an approximation Leading to reduced efficiency, and each time the system needs to find the new open-circuit voltage (V, out) when the illumination condition changes. In order to find the new open-circuit voltage, the load connected to the PV module has to be disconnected each time, which can lead to a loss of power. Direct MPPT methods measure the current and voltage or power and thus are more accurate and have a faster response than the indirect methods. Perturb and observe (P&O) is one of the direct MPPT techniques used here with some modifications.

2.2 PERTURB ANDOBSERVEALGORITHM (P&O)

Typically, the P&O method is used for tracking the MPP. In this technique, a minor perturbation is introduced to

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cause the power variation of the PV module. The PV output power is periodically measured and compared with the previous power. If the output power increases, the same process is continued; otherwise, perturbation is reversed. In this algorithm, perturbation is provided to the PV module or the array voltage. The PV module voltage is increased or decreased to check whether the power is increased or decreased. If an increase in voltage leads to an increase in power, that means the operating point of the PV module is to the left of the MPP [26]. Hence further perturbation is required towards the right to reach MPP.
Conversely, if an increase in voltage leads to a decrease in power, this means the operating point of the PV module is on the right of the MPP, and hence further perturbation towards the left is required to reach MPP. The flow chart of the adopted P&O algorithm for the charge controller is given in Fig. 5. When the MPPT charge controller is connected between the PV module and battery, it measures the PV and battery voltages. After measuring the battery voltage, it determines whether the battery is fully charged or not. If the battery is fully charged (12.6 V at the battery terminal), it stops charging to prevent the battery from overcharging. If the battery is not fully charged, it starts charging by activating the DC/DC converter. The microcontroller calculates the existing power Pnew at the output by measuring the voltage and current and comparing this calculated power to the previous measured power Plod. If Pnew is greater than Plod, the PWM duty cycle is increased to extract maximum power from the PV panel. If Pnew is less than Plod, the duty cycle is reduced to ensure the system moves back to the previous maximum power. This MPPT algorithm is simple, easy to implement, and low cost with high accuracy [7,8].

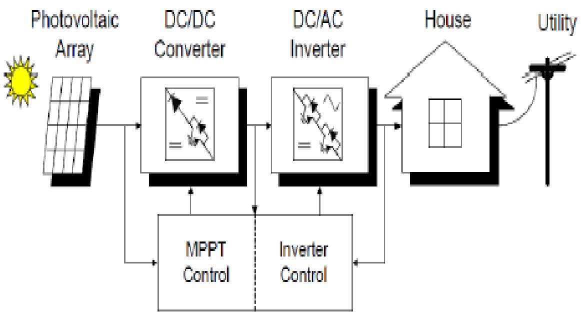

Figure 3: Structure of PV Power System

III. MPPT STRUCTURE

The power delivered by a PV system of one or more photovoltaic cells is dependent on the irradiance, temperature, and the current drawn from the cells. Maximum Power Point Tracking (MPPT) is used to obtain the maximum power from these systems. Such applications as putting power on the grid, charging batteries, or an electric motor benefit from MPPT. In these applications, the load can demand more power than the PV system can deliver. In this case, a power conversion system is used to maximize the power from the PV system. There are many different approaches to maximizing the power from a PV system, ranging from simple voltage relationships to more complex multiple sample-based analyses. [9-10]

IV. TYPES OF MPPT TECHNIQUE

a) Curve-Fitting Technique
b) Fractional Short-Circuit Current (FSCI) Technique
c) Fractional Open-Circuit Voltage (FOCV) Technique
d) One-Cycle Control (OCC) Technique
e) Hill Climbing/P&O Technique
f) Load Current/Load Voltage Maximization Technique
g) Incremental Conductance (Inc.-Cond) Technique
h) Ripple Correlation Control (RCC) Technique [11]

V. SIMULINK MODEL AND RESULT ANALYSIS

Fig. 3 shows a complete model of the Solar Photovoltaic system incorporating a boost converter that boosts the voltage from the Maximum Power Point Tracking algorithm (MPPT). The simulation of this model has been done by taking different values of Irradiance and Temperature.

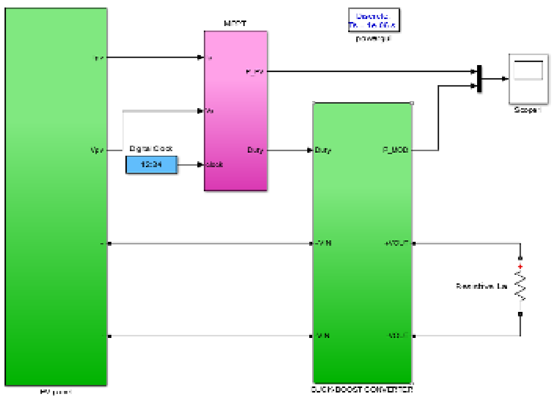

Figure 4: Simulink model of the proposed PV system

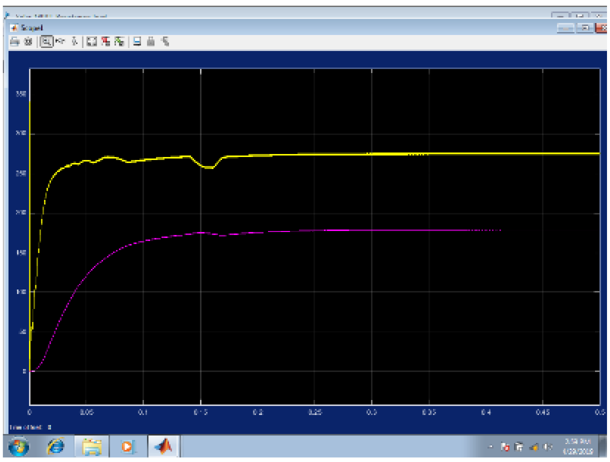

Figure 5: Simulink result

The variations of voltage and power with time are shown in the various graphs. The temperature and irradiance are varied, and the characteristic curves of voltage and power are plotted concerning time. From the graphs, it can be seen that as the irradiance increases, the voltage increases, so there is a change in the output waveform. Thus, a direct effect on the output voltage concerning the irradiance and temperature can be observed. The temperature, when increased, PVG gives a higher output power. It is observed from the graph that the variations are nonlinear and are rather exponential. The outputs as obtained are shown in Figure 5.

VI. CONCLUSION

P&O MPPT method is implemented with MATLAB-SIMULINK for simulation. The MPPT method simulated can improve the dynamic and steady-state performance of the PV system simultaneously. Through simulation, it is observed that the system completes the maximum power point tracking successfully despite fluctuations. When the external environment changes suddenly, the system can track the maximum power point quickly. Both buck and buck-boost converters have succeeded in tracking the MPP, but buck converter is much more effective, especially in suppressing the oscillations produced using the P&O technique.

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