Enhancement of Solar Photovoltaic Cell by Using Short-Circuit Current Mppt Method

1Burri Ankaiah, Jalakanuru Nageswararao 2

1Assistant Professor, Department of Electrical and Electronics Engineering, Vignan Institute of Technology and Science, Vignan Hills, Deshmukhi Village, Pochampally Mandal, Nalgonda District, Andhra Pradesh, India- 508284.

2Assistant Professor, Department of Electrical and Electronics Engineering, Global Institute of Engineering & Technology Chilkur (V), Moinabad (M), R.R (dist) Andhra Pradesh, India.

ABSTRACT: Photovoltaic (PV) energy is the most important energy resource since it is clean, pollution free, and inexhaustible. Due to rapid growth in the semiconductor and power electronics techniques, PV energy is of increasing interest in electrical power applications. It is important to operate PV energy conversion systems near the maximum power point to increase the output efficiency of PV arrays. The output power of PV arrays is always changing with weather conditions, i.e., solar irradiation and atmospheric temperature. Therefore, a MPPT control to extract maximum power from the PV arrays at real time becomes indispensable in PV generation system. In recent years, a large number of techniques have been proposed for tracking the maximum power point (MPP). Maximum power point tracking (MPPT) is used in photovoltaic (PV) systems to maximize the photovoltaic array output power, irrespective of the temperature and radiation conditions and of the load electrical characteristics the PV array output power is used to directly control the dc/dc converter, thus reducing the complexity of the system. The resulting system has high-efficiency; lower-cost this paper proposes a maximum-PowerPoint tracking (MPPT) method with a simple algorithm for photovoltaic (PV) power generation systems. The method is based on use of a short circuit current MPPT method of the PV to determine an optimum operating current for the maximum output power. This work proposes on short circuit current Based maximum Power Point Tracking for Photovoltaic System, to have the advantages of low frequency switching.

Keywords: Photovoltaic System, Modeling of PV Arrays, short-circuit current MPPT algorithm

I. INTRODUCTION

Renewable sources of energy acquire growing importance due to its enormous consumption and exhaustion of fossil fuel. Also, solar energy is the most readily available source of energy and it is free. Moreover, solar energy is the best among all the renewable energy sources since, it is non-polluting. Energy supplied by the sun in one hour is equal to the amount of energy required by the human in one year. Photovoltaic arrays are used in many applications such as water pumping, street lighting in rural town, battery charging and grid connected PV systems. As known from a Power-Voltage curve of a solar panel, there is an optimum operating point such that the PV delivers the maximum possible power to the load. The optimum operating point changes with solar irradiation and cell temperature. Therefore, maximum power point tracking is essential for PV panel. A variety of maximum power point tracking (MPPT) methods is available. This paper deals with Short Circuit Current MPPT algorithm method due to its simple approach.

II. PHOTOVOLTAIC CELL

Photovoltaic cell generates electricity from the sun. PV panel works under the phenomenon of photoelectric effect. It directly converts sunlight into electricity. The diagram of PV based system is shown in Fig. 1.
The positive and negative charges created by the absorption of photons are thus encouraged to drift to the front and back of the solar cell. The back is completely covered by a metallic contact to remove the charges to the electric load. The collection of charges from the front of the cell is aided by a fine grid of narrow metallic fingers. The p-n junction provides an electrical field that sweeps the electrons in one direction and the positive holes in the other. If the junction is in thermodynamic equilibrium, then the Fermi energy must be uniform throughout. Since the Fermi level is near the top of the gap of an n-doped material and near the bottom of the p-doped side, an electric field must exist at the junction providing the charge separation function of the cell.

III. CONVERSION EFFICIENCY AND POWER OUTPUT

A solar cell usually uses a p-n junction its physical configuration is shown schematically in fig2

Current and voltage relationship is given by

\[ I = I_c \left( \exp \left( \frac{V}{kT} \right) - 1 \right) \]

Where

- \( I_c \) = cell output current
- \( V_c \) = cell output voltage
- \( I_{ph} \) = light generated current
- \( I_o \) = reverse saturation current
- \( R_s \) = series resistance of the cell
- \( I_o \) is the saturation current also called the dark current and is applied when a large negative voltage is applied across the diode.
V is the voltage across junction.
e is the electronic charge
k is Boltzmann’s constant
T is the absolute temperature

When light impinges on the junction, electron hole pairs are created at a constant rate providing an electrical flow across the junction. The net current is thus the difference between the normal diode current and light generated current $I_L$. The internal series resistance $R_s$ is mostly due to the high sheet resistance of the diffused layer which is in series with the junction. The light generated current acts as a constant current source supplying the current to either the junction or a useful load depending on the junction characteristic and the value of the external load resistance. The net current $I$ is given by

$$I = I_L - I_i = I_L - I_0 \left[ \exp \left( \frac{qE}{kT} \right) - 1 \right]$$

The internal voltage drop in a cell can usually be minimized, and for ideal cell $R_s$ may be assumed equal to zero i.e. $R_s = 0$. With these the corresponding I-V plot is given in figure. Open circuit voltage $V_{oc}$ for the ideal cell is then given by

$$V_{oc} = \frac{qE}{e} \ln \left[ \frac{I_L}{I_0} + 1 \right]$$

Since $I_L \gg I_o$, the 1 in the equation can be neglected. Then open circuit voltage

$$V_{oc} = \frac{qE}{e} \ln \left[ \frac{I_L}{I_0} \right]$$

In practice the open circuit voltage of the cell decreases with increasing temperature. The maximum power that can be derived from the device is given by

$$P_{max} = V_{mp} I_{mp}$$

Where $V_{mp}$ and $I_{mp}$ are the voltage and current at maximum power point as shown in figure 3 respectively. It can be seen that the maximum efficiency for the cell is obtained by dividing $V_{mp} I_{mp}$ by the total power density of the sunlight $P_{sun}$. Thus

$$\eta = \frac{V_{mp} I_{mp}}{P_{sun}}$$

$$\eta = \frac{I_{mp} V_{mp}}{P_{sun}} = \frac{I_{mp} V_{oc}}{I_0 V_{oc}} \frac{\frac{qE}{kT}}{E_g}$$

Where $E_g$ = Forbidden energy gap

The fill factor (FF) for a solar cell is defined as the ratio of two areas shown.

$$FF = \frac{V_{mp} I_{mp}}{V_{oc} I_{mp}}$$

Solar cell designers, strive to increase the fill factor values, to minimize the internal losses. Maximum – power can be defined in terms of $V_{oc}$ and $I_L$ is given by

$$P_{max} = \frac{V_{oc} I_L}{FF}$$

A typical value of the fill factor for a good silicon cell is about 0.8. The voltage factor ($eV_{oc}/E_g$) is determined by the basic properties of the materials in the cell and typically about 0.5 for a silicon cell.
IV. SHORT-CIRCUIT CURRENT MPPT METHOD

This method exploits the assumption of linear relationship between the “cell current corresponding to the maximum power ($I_{MP}$)” and the cell-short circuit current ($I_{SC}$). This relationship can be expressed as:

$$I_{MP} = K \cdot I_{SC}$$

where $K$ is called the current factor. Peak Power of the module lies at about 90% of its short circuit current. The Flowchart of Short-circuit current MPPT is shown in Fig 4.

![Flow Chart For the Short-Circuit Method](image)

V. SIMULATION CIRCUIT

![Simulation Circuit of the Short-Circuit Method](image)
VI. SIMULATION RESULT

Fig. 6.1 PV Module Output Voltage with MPPT Controller

Fig. 6.2 PV Module Output Current with MPPT Controller

Fig. 6.3 PV Module Output Power with MPPT Controller

Fig. 6.4 Comparison of Power with and without MPPT control
VII. CONCLUSION
The paper proposes a simple short-circuit current method. The proposed MPPT algorithm is called short-circuit current MPPT Method. However, by using this MPPT method we have increased efficiency. This method compute the maximum power and controls directly the extracted power from the PV. The proposed method offers different advantages which are: good tracking efficiency, response is high and well control for the extracted power.

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REFERENCES