IOP Conference Series: Materials Science and Engineering

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To cite this article: Yungui Zhang *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **322** 072051

IOP Conf. Series: Materials Science and Engineering **322** (2018) 072051 doi:10.1088/1757-899X/322/7/072051

MPPT Algorithm Development for Laser Powered Surveillance Camera Power Supply Unit

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Abstract. Photovoltaics (PV) cells, modules which are semiconducting materials, convert light energy into electricity. Operation of a PV cell requires 3 basic features. When the light is absorbed it generate pairs of electron holes or excitons. An external circuit carrier opposite types of electrons irrespective of the source (sunlight or LASER light). The PV arrays have photovoltaic effect and the PV cells are defined as a device which has electrical characteristics: such as current, voltage and resistance. It varies when exposed to light, that the power output is depend on direct Laser-light. In this paper Laser-light to electricity by direct conversion with the use of PV cells and its concept of Band gap Energy, Series Resistance, Conversion Efficiency and Maximum Power Point Tracking (MPPT) methods [1].

1. Introduction

Wireless Power Transmission (WPT) has been improved feasible in recent years as a result of advances in applications of transfer techniques. LASER Electric Power Transmission in comparison with microwave energy transmission, is supportive in association of characteristics and properties effectively. Certainly, this is advantageous in remote or critical locations where a conventional electric power supply based on copper wiring is not possible or challenging to install. The salient advantage in the proposed system is the opportunity of reaching a less voltage, higher current Direct (DC) Current electricity power supply avoiding much interference. In optic electrical DC power system, when loss of optic basically reduces the output power of electricity yet there is not disturbance for the load voltage. The clean, steady voltage gained by Photovoltaic power generation is well suited for lower voltage driven IC chips located in circuits [11].To launch this system without ‘‘AC–DC’’ converters.

During previous years, various laser light generated wireless power transmission research studies, implication is recommended and approved. The below diagram s shows the fully autonomous rover vehicle prepared with photovoltaic cells receiver in Fig.1 [2, 3,7].

Fig.1 Fully laser powered autonomous rover

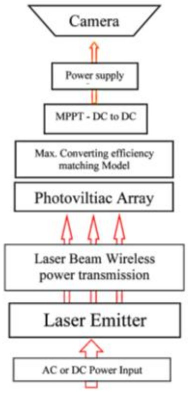

Fig.2 Laser powered surveillance camera system

2. Laser Powered Surveillance Camera System

At present wireless power transmission through LASER beaming is the greatest selection to advance relative technology like video surveillance systems. Therefore, this paper proposes laser powered video surveillance camera system as shown in Fig.2.

2.1. Laser Emitter

LASER emitter is a device that generates light emitted through a procedure for optical amplification structured on the emitted stimulus of the electromagnetic monochromic radiation. A laser is consisted of the electrons in atoms in special crystals, or gases absorb energy from an electrical current and turn into “excited”.

2.2. PV Module Equivalent Circuit

From the equivalent circuit as shown in Fig.3,obviously we can build up the following elementary equations: Load current in amperes

$I = I_{pv} - I_d - I_{sh}$, Voltage across the shunt branches $V_{sh} = V + IR$, Current through the shunt resistor

$I_{sh} = \frac{V_{sh}}{R_{sh}} = \frac{V + IRs}{R_{sh}}$, The current passes through the photodiode is certain by Shockley's equation:

$$I_d = I_o\left[\exp\left(\frac{V_{sh}}{nV_T} - 1\right)\right] = Io\left[\exp\left(\frac{V + IR_s}{nV_T} - 1\right)\right] \text{ And } V_T = \frac{kT}{q}$$

Therefore the characteristic equation for Photovoltaic cell (module)

$$I = I_{pv} - I_o\left[\exp\left(\frac{V + IR_s}{nV_T} - 1\right)\right] - \frac{V + IR_s}{R_{sh}}$$

Therefore the PV array has non linear I-V characteristic[15].

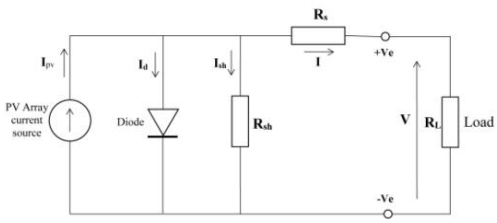

Fig. 3 PV module equivalent

3. Maximum Power Point Tracking (MPPT)

MPPT, (Maximum Power Point Tracking) methods are functioned in charge controllers at Photovoltaic (PV) electrical power generating systems for successful utilization of PV array output electrical power that is determined by light irradiation and ambient temperature. Therefore, Its out-put characteristics are non-linear. It can be effortlessly obtained through simulation via

MATLAB/Simulink software, the Power(P) vs Voltage(V) curve and current(I) vs Voltage(V) curves are illustrated in Figure.4.

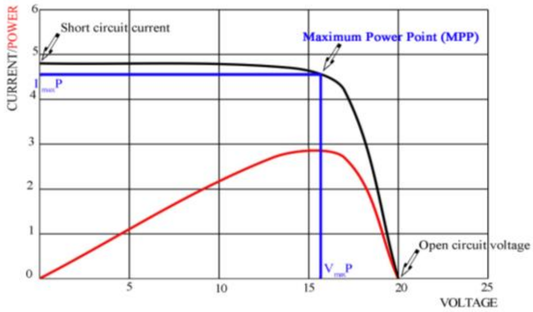

Fig. 4 Output characteristics of photovoltaic (PV)

The given open circuit voltage, $V_{oc} \approx nV_T \ln[I_{pv}/I_o + 1]$ The short circuit current, $I_{sc} \approx I_{pv}$

The significant recommendation of MPPT technique is to extract ideal power generation from PV module manipulating them to work and no more productive voltage (maximum power point). MPPT look at put voltage and current thinks about to battery voltage at that point where it fixes the best optimum electrical power generated from the PV module in order to charge the battery and proselytes it to the best voltage to get most extreme current in to battery.

3.1. *Perturb and Observe Method (P&O)*

Perturb and Observe method algorithm can be altered by the functioning voltage or current of the Photovoltaic (PV) array until draw out maximum power from it. The tracker purposes in increasing or decreasing the PV array voltage. When ever increasing the voltage of the PV array, increasing power output of PV array then the system consistently raise the operating voltage until power output begins to lessening [9]. If Current power = P_k , Previous power = P_{k-1} [14].

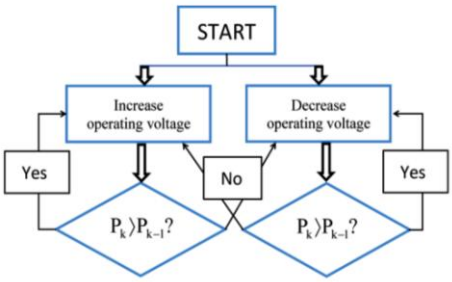

Fig. 5 Flowchart for Perturb and Observe

3.2. *Incremental Conductance Method (INC)*

The Incremental Conductance algorithm is founded on the factor that the gradient of the curve electrical Power verses Voltage of the Photovoltaic (PV) module has to be naught at the MPP, positive on the left side of it while negative on the right side, as can be perceived in Fig.6 [9]. The power derivative can be shown as: $\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V\frac{dI}{dV}$, $I + V\frac{dI}{dV} \cong I + V\frac{\Delta I}{\Delta V}$

It can be can written as follows: $\frac{dP}{dV} = 0, \frac{dP}{dI} = 0$, $\frac{\Delta I}{\Delta V} = -\frac{I}{V}$ at the MPP.

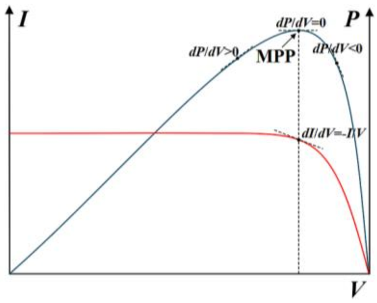

Fig. 6 Output characteristics of

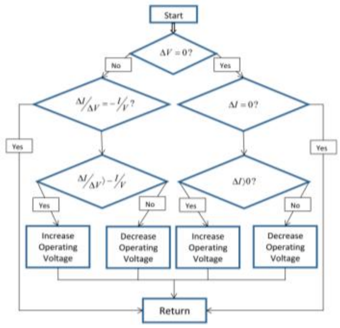

Fig. 7 Flow chart for INC

$\frac{dP}{dV}\rangle 0, \frac{dP}{dI}\langle 0$, $\frac{\Delta I}{\Delta V}\rangle -\frac{I}{V}$ on the left of MPP $\frac{dP}{dV}\langle 0, \frac{dP}{dv}\rangle$ $\frac{\Delta I}{\Delta V}\langle -\frac{I}{V}$ on the right of MPP

The principle is to investigate the gradient of Voltage(V) verses Current(I) curve $(\Delta I/\Delta V)$ which is called the incremental conductance to the Instantaneous Conductance(I/V). Depending on the result, the PV array operating voltage is either fluctuate until the MPP is met. Therefore, incremental conductance ceased absorbing to the operating voltage of the MPPT contrller when the appropriate value reached unlike in the above discussed Perturb and Observe method algorithm which fluctuate surrounding the maimum power generation point (MPP), algorithm flow chart as shown in Fig. 7. The same functionality may be reched by using the prime equation of power derivative $(\Delta P/\Delta V)$depending on the ambient conditions[6].

4. Maximum Conversion Efficiency through Optimal Use of Laser (Photon) Energy

In converting high power intensity LASER optic into electrical power there are two significant parameters are considered. The foremost temperature rise due to brightness of the high power LASER beaming , and another is the internal series resistance (R_s) of the Photovoltaic cell. We consider these two factors highly as they directly affect the Conversion efficiency of Photovoltaic (PV) modules. If we intellectually consider heat radiation of LASER beam and internal series resistance (R_s) of PV materials , we can get maximum conversion efficiency[11].

Semiconductor PV array can only make practice of light with wavelengths up to the band gap. The Silicon band gap energy is 1.12 eV, equivalent to a wavelength of approximately 1100 nm. For photovoltaic laser beam power converters the situation is different as monochromatic laser light comprises only one wavelength, only photons of a exact photon energy required to be absorbed. Then an absorber material with optimally matched band gap energy can be used so that transmission and thermalization losses are condensed to a minimum and highest conversion efficiency can be achieved [9]. By using III-V compound semiconductors, similar gallium arsenide (GaAs), indium phosphide (InP) materials for laser power converters are accessible for each and every of these laser wavelengths [9, 11].

According to the previous studies [11] of *Miyakawa's (2005)* $\lambda_c = hc/qE_g$ .The maximum conversion efficiency can be obtained through illuminating the Photovoltaic receiver by the LASER beam matching the cutoff wavelength. Through a confident LASER beam intensity L_{int} .The short-circuit current density J_{sc} and the open-circuit voltage V_{oc} for an model Photovoltaic (PV) module. When the maximum electrical power output at the LASER beaming can be taken from power condition $\Delta P/\Delta J = 0$,to the following [11],

$$\frac{nkT}{q}\left[\frac{J_m}{J_m + (J_{sc} + J_s)} + \ln\left(\frac{J_{sc} - J_m}{J_s} + 1\right)\right] - 2R_s J_m = 0, V_m = \frac{nkT}{q}\ln\left(\frac{J_{sc} - J_m}{J_s} + 1\right) - 2R_s J_m$$

Using the above theory we develop our model based on maximum current density J_m and the maximum voltage V_m ,calculation conversion efficiency η_{eff}^{cal} are given by $\eta_{eff}^{cal} = J_m V_m / L_{\text{int}}$, respectively[11].

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5. Proposed Mythology

This paper use the ideas developed for both MPPT and PV array conversion efficiency introduce based on series resistance and effective heat radiation for laser beamimg. (temperature increase due to radiation).The conventional approach was to make use MPP without the knowledge of the PV array conversion efficiency, the method we consider in the application of a Neural Network (NN)[13] approach(with point method[10] to calculate series resistance) to sense the conversion efficiency, after reaching the maximum conversion efficiency switch to the MPP tracking method.

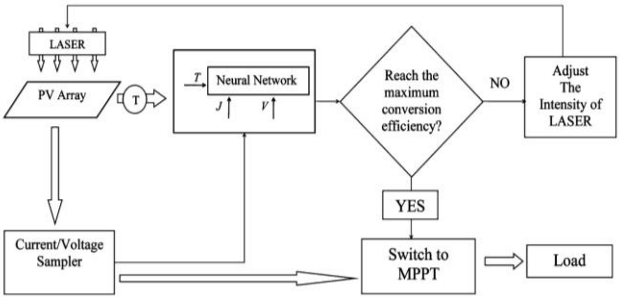

Fig.8 Schematic of the proposed system.

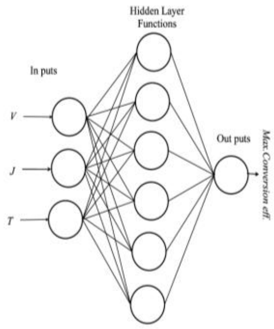

Fig.9 Neural network

Fig.8 illustrates the typical block diagram of the method. This proposed approach measure the voltage across the cell terminals, current and cell temperature effectively. These quantities are fed into a properly trained NN algorithm as shown Fig.9 which computes the conversion efficiency with great accuracy[13].

6. Conclusion

In considering the above theoretical analysis, we intellectually consider heat radiation of LASER beam and internal series resistance (R_s) of PV materials , we can get maximum conversion efficiencies. The laser power converter, the optimum laser wavelength resolute to be in the range where the external quantum effectiveness is highest, but weighted by the photon flux of the laser. We suggest calculating Conversion Efficiency by using NN algorithm. Moreover, to determine MPP by using Incremental Conductance algorithm. Confidently we propose when using the PV array for receiving laser beam compound semiconductors must be used in order to obtain the Optimum Conversion Efficiency.

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