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Design and Implementation of Photovoltaic System Using Improved MPPT Techniques with Rapidly Tracking Features

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Abstract: Recently, residue of traditional energy resources (*i.e.*, fossil energy) is highly limited and would be exhausted in near future. Hence, developing renewable-energy resources to replace traditional ones has been a research of great urgency. Among all renewable-energy resources, solar energy becomes most attractive recently, because it is noiseless, pollution-free, non-radioactive and inexhaustible. Since the output characteristics of photovoltaic (PV) arrays are influenced by irradiation and temperature levels, the maximum power point tracking (MPPT) techniques are necessary for PV applications to improve conversion efficiency. In this project an improved method to track the maximum power point through a combination of linear approximation (LA) and perturbation and observation (P&O) is proposed. In the first stage, the LA rapidly takes the point closer to the MPP. In the second stage, the P&O continuously tracks the MPP with some steps. Therefore steady state can be achieved. The proposed maximum power point tracking (MPPT) method has the advantages of faster tracking, fewer fluctuations, and higher accuracy over the conventional MPPT methods. The experimental results demonstrate the feasibility of the proposed MPPT algorithm.

Keywords—*Renewable energy sources, MPPT, Linear approximation method, Perturb & Observe method, Photovoltaic cells* **.**

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I. INTRODUCTION

Photovoltaic's (PVs) are exhibits (mix of cells) that contain a sun oriented voltaic material that changes over sun based vitality into electrical vitality. PV cell is an essential gadget for Photovoltaic Systems. Such frameworks incorporate numerous parts like mechanical and electrical associations and mountings and different method for directing and (if required) altering the electrical yield. Materials that are utilized for photovoltaic are mono-crystalline silicon, polycrystalline silicon, microcrystalline silicon, cadmium telluride and copper indium selenide. The current and voltage accessible at the PV gadget terminals can be specifically used to bolster little loads like lighting frameworks or little DC engines.

Keeping in mind the end goal to concentrate most extreme measure of force from PV exhibit we need to model converters with the goal that it can track Maximum Power Point (MPP). In this venture we have proposed an enhanced system to track the most extreme force point (MPP) of photovoltaic exhibits through the mix of the direct estimation linear approximation (LA) technique and the bother and-perception (P&O) strategy.

The LA technique quickly takes operation point to inside of an extent near the genuine MPP, and after that the P&O system consistently tracks the precise MPP with fine annoyance steps. In this way, the vacillations in relentless state can be minimized. The proposed most extreme force point following maximum power point tracking (MPPT) system has the benefits of speedier following, less variances, and higher precision over the routine MPPT techniques.

II. CHARACTERISTICS OF PHOTOVOLTAIC ARRAYS

Photovoltaic use semiconductor materials to convert sunlight into electricity. The technology for doing so is very closely related to the solid-state technologies used to make transistors, diodes, and all of the other semiconductor devices that we use so many of these days. Fig 1 shows the equivalent circuit of a solar cell.

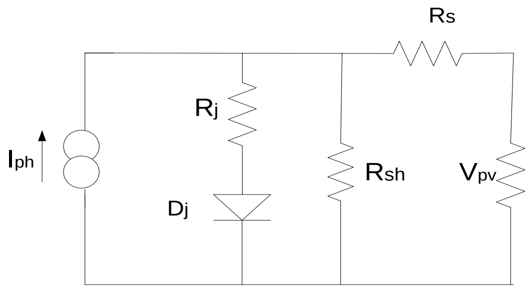

Fig.2. The equivalent circuit of a solar cell.

ELECTRICAL PARAMETERS OF THE PV ARRAY

Maximum power, Pmpp	75 W
Voltage at Maximum power, Vmpp	17.2 V
Current at Maximum power, Impp	3.9 A
Open circuit voltage, Voc	21.2 V
Short circuit current, Isc	4.5 A

The electrical parameters of the PV array show the characteristics of the PV array. A current source *Iph* represent the cell photocurrent, it is a functions of PV array temperature *T* and irradiation *Si*, and in which *Rs* and *Rsh* are the serial resistances and intrinsic shunt as shown in Fig. 1

$$I_{ph} = [I_{SSO} + K_i(T - T_r)]S_i/100, \quad (1)$$

Where

- I_{sso} is the short circuit current.

- K_i is temperature coefficient of the short circuit current.
- D_j is the p-n junction of a solar cell.
- R_j is the nonlinear resistance.

The p-n junction of a solar cell is depends on the saturation current I_{sat} and it can be expressed as follows:

$$I_{sat} = I_{rr}[\frac{T}{T_r}]^3 \exp[\frac{qE_G}{KA}(\frac{1}{T_r} - \frac{1}{T})] \quad (2)$$

Where E_G is the band-gap energy of the semiconductor, k is the Boltzmann's constant (1.6×10^{-19} Coulomb), q is the charge of an electron ($1.38\times10^{-23} J/^{\circ}K$), I_{rr} is the reversed saturation current at T_r, A is the ideality factor of the p-n junction.

The output characteristics equations of the PV array which shows the n_s cell connected in series and n_p cells connected in parallel can be represented by following equations:

$$I_{PV} = n_p I_{ph} - n_p I_{sat}[\exp(\frac{q}{kTA}\frac{V_{PV}+I_{PV}R_S}{n_s}) - 1] - \frac{V_{PV}+I_{PV}R_S}{R_{sh}} \quad , (3)$$

$$P_{PV} = V_{PV} I_{PV} \quad , \quad (4)$$

The following equations are shows the characteristics of photovoltaic arrays. The electrical parameters/ characteristics voltage, current and power are calculated. Then by using linear approximation method the operating point is bought into the range close to actual MPP and in the second stage by P&O method the operating point is tracked closed to MPP. The combination of LA and P&O can be shown in fig.

III. THE PROPOSED MPPT METHOD

Considering the equivalent circuit of solar cell as shown in fig.1 with high shunt resistance than calculate the approximated values for PV power from (3) and (4):

$$P_{PV} = \alpha I_{PV}.\ln[\frac{(I_{ph}+I_{sat}-I_{PV})}{I_{sat}}] - I_{PV}^2 R_S \quad (5)$$

The constraint equation of the MPP can be expressed by calculating the partial derivative of (5) with respect to I_{PV} and grand it to b zero at the MPP, where $\alpha=(KTA/q)$.

$$P_{PV} - \alpha I_{PV}.\ln[\frac{\alpha I_{PV}^2}{(P_{PV} - I_{PV}^2 R_S)}] + I_{PV}^2 R_S = 0 \quad (6)$$

In fig.2. A straight line approximate above equation, the power-versus-current characteristic curves of the PV array is shown in figure. At fixed temperature 25°C in which irradiation varies from 20mW/cm2 to 80mW/cm2. It is obvious that the interconnection of all MPPs is almost a straight line. The slope of this approximated line can be obtained from the electrical parameters of PV arrays, and it is easy to implement in either analog or digital control circuits to achieve MPPT.

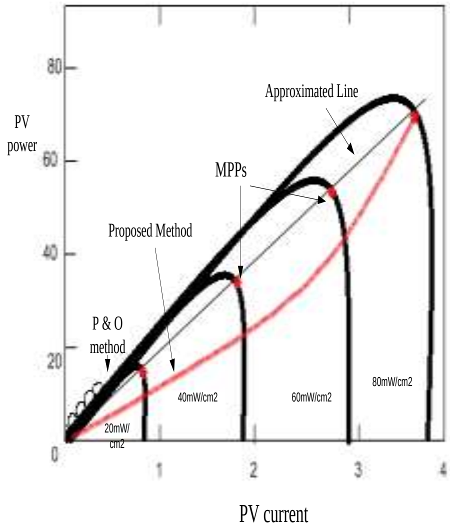

Fig. 2. Basic concept of the proposed MPPT method shown with the PV P-I characteristics curve and approximation line of MPPs.

The conceptual tracking-loci of both the proposed MPPT method and the P&O method are also indicated in above Fig. It can be seen that the P&O method requires many steps and long time to achieve the actual MPP, resulting in a large amount of energy consumption. The proposed method takes the OP immediately within a range close to the actual MPP, and then fine perturbation-steps are used to track the accurate MPP and to compensate both the influences on temperature variations and the decay of PV characteristics. Therefore, the proposed MPPT method has the advantages of faster tracking, fewer fluctuations, and higher accuracy over the conventional MPPT methods.

The flowchart for the proposed MPPT algorithm in which the combination of LA and P&O methods can be shown in flowchart. First, the approximated line of MPPs can be determined from the electrical parameters of PV arrays. The reference command of current Iref can be determined according to the approximated line and the measured PV voltage and current. Then, the difference ΔI between PV output current I_{PV} and Iref can be calculated to modulate the duty-cycle Dnew of gate-driving signal. When the magnitude of ΔI is small enough, it means the OP is very close to the actual MPP. The control algorithm switches to the P&O method with fine perturbation-steps so that the OP can dynamically track the accurate MPP. If there are rapidly climate changes occurring, the magnitude of ΔI will become large again. Therefore, the control algorithm needs to switch back to the LA method to re-determine Iref.

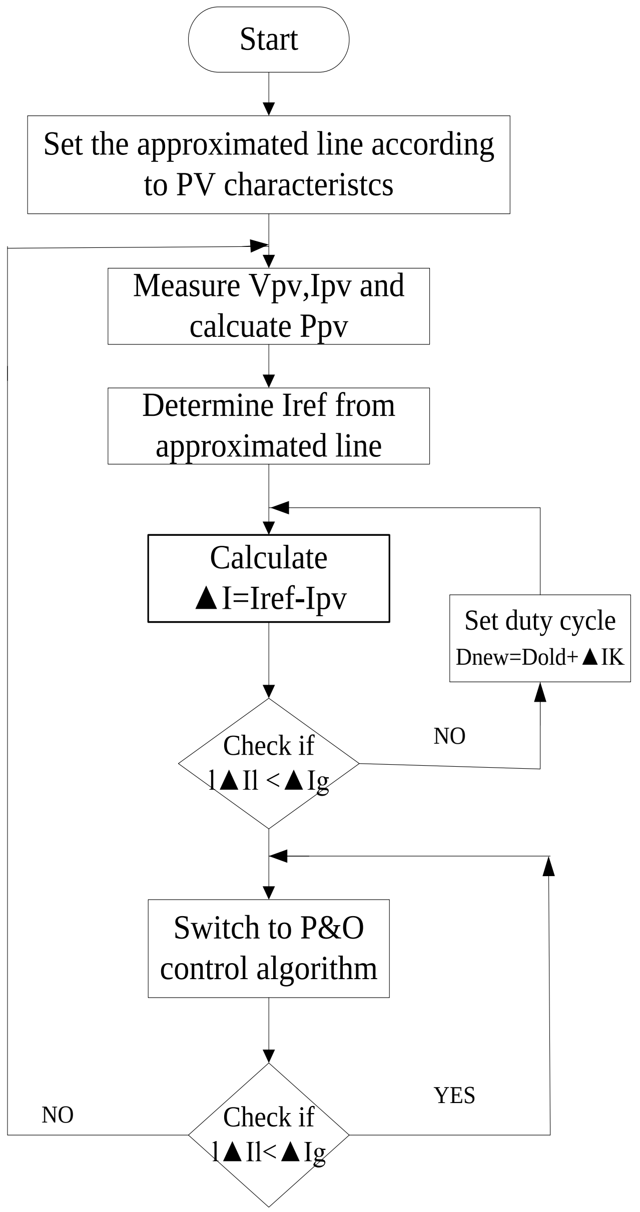

Fig. 3. Flowchart of proposed MPPT algorithm.

IV. RESULT

In this paper to overcome this problem of extracting maximum power we have proposed an improved method to track the maximum power point (MPP) of photovoltaic arrays through the combination of the linear approximation (LA) method and the perturbation-and-observation (P&O) method. The proposed algorithm can be divided into two stages:

- First, the LA method is applied to force the operation point (OP) rapidly within a range close to the actual MPP.
- In the second stage, the P&O method is then used to bring the OP to the exact MPP. The P&O method can compensate not only the influences on the temperature variation but the decay of PV characteristics. Because the operation point is already very close to the MPP in first stage, fine perturbation steps can be used in the second stage to track the accurate MPP. Therefore, the level of fluctuations in steady-state can be minimized.

The LA method rapidly takes operation point to within a range close to the actual MPP, and then the P&O method continuously tracks the exact MPP with fine perturbation steps. Therefore, the fluctuations in steady-state can be minimized.

V. CONCLUSION

The usage of energy from PV panels is a reality, and its intensive use will become extremely important in finding solutions to energy and environmental problems very soon. In this context, the used MPPT techniques are the most important to extract the maximum power available in PV. A combination of different methods can be implemented for maximum power tracking. The accuracy and efficiency can be improved even further.

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