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A Modified Firefly Algorithm based MPPT for Mutli-Junction Photo-Voltaic Arrays

Mamta Thakur[1] Baljit Singh[2]
M tech Student[1], DAV Institute of engineering and technology, Jalandhar
Assistant Professor[2,] DAV Institute of engineering and technology, Jalandhar
thakurmamta21@gmail.com[1]
Singh _baljit82@yahoo.com[2]

Abstract— Photovoltaic cells have been there in the energy sector for a very long time now. But, only recently have they seen extensive utilization in terms of commercial aspects. The recent advancements in the technology and the reduction of fossil fuel resources have further contributed to the cause. But still, there lies several challenges to it. One of the major obstacles in this field is to detect the highest power output from cell. High Peak Power Transfer methods can be projected in the literature for same. Perturb and Observe and Incremental Conductance etc are some to name a few. There have been many more planned in literature.

The thesis proposes a novel Adaptive Firefly algorithm based on Inference System for Maximum Peak Power Transfer technique for multi-junction solar cells. The multi-junction solar cells can be supposed to provide better efficiency as opposed to their single junction counterparts. Firefly based algorithm is designed utilizing fireflies behavior and firefly logic. The firing angle's optimal value is calculated and fed to the Boost converter. The results are compared to that of an PSO technique and it is found that the FIREFLY based MPPT performs quite better than its other counterparts in terms of transient state and the magnitude of voltage obtained.

Keywords— Maximum power point tracking(MPPT), Incremental Conductane (I&C),Modified Firefly algorithim (MFA)

1. INTRODUCTION

1.1Solar Technology

Nowadays, consumption of energy is increasing, idea of exploring renewable energy sources are also growing. Due to our limited energy sources, renewable energy sources are the future. Significant processes are made over the later years in development and research of [1] the renewable power systems such as sea, wind, solar energy and wave systems. With these resources, the sun power energy can be used nowadays as most reliable, and environmental friendly energy source. Although sun power energy systems can be suffer with high costs and low efficiencies. To control these problems, maximum power can be extracted from PV panel while using the MPPT methods to optimize an efficiency of all the PV system. The photovoltaic technology can be made attractive option because the features various merits like as low maintenance requirement, [2] environmental friendliness and absence of fuel cost. The efficiency of energy conversion a PV generation system may low because sun power cell exhibits to the nonlinear voltage and current and power versus voltage characteristics. These nonlinear characteristics contain weather functions conditions like as panel temperature and solar insolation. This is used to maintain the maximum power point tracking algorithm, efficient operation which can quick response and extract the [9] maximum power from PV arrays in the real time becomes important in PGSs.

1.2 Operating of cell

Photovoltaic cells area unit those devices which may absorb the daylight and convert into the power. These star cells could also be unremarkably created with the chemical element that's most precious components on the world. [3] The silicon is pure and actual poor conductor of the electricity that contains four outer valence electrons kind the tetrahedral crystal lattices.

The made lepton clouds area unit the crystalline sheets that are stressed to incorporate the trace amounts of the components that have three or five shell outer electrons that may alter the electrons to maneuver. These nuclei components match at intervals crystal lattice, but the only three shell outer electrons, that have few electrons to the balance out, and "positive holes" float with the lepton [4] cloud.

1.3 Multi-Junction cell

These multi-junction star cells are often found within the 2 configurations in series/tandem or in parallel. For these thin-film star cells with hetero-junctions, for the improved performances all layers [5] contain the lattice constants/ crystalline structures. Moreover, the discontinuities in lattice constants area unit result in dislocations or defects at interface which will be most well-liked to the recombination sites. In parallel configuration that is termed the multi-terminal bicycle for every cell which will be optimized severally, however whole system are often a lot of difficult. Moreover, [7]series/ bicycle of star cells are often used; that consists of the distinct tangency of sun power cells that area unit set one when alternative one, each utilized half of star spectrum could permit to the passage through alternative part. The star cells area unit high larger [11] band gap that the parameter is often shriveled increasingly in followed cells.

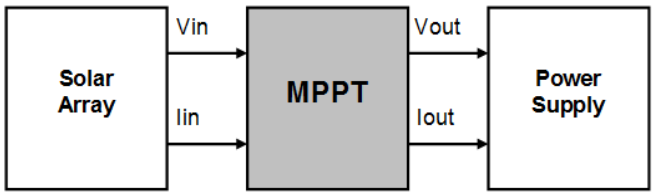


Figure 1: Basic Block Diagram

2.LITERATURE SURVEY

Various MPPT strategies are acceptable for the fast dynamical environments which are square measure projected in every analog and digital form. The discussion is concerned to merits and demerits of the analog MPPT ways can be presented [1] in the TrishanEsram and Patrick (2011). From analog MPPT ways give faster response than digital as a result of metric of analog loop may larger. However, most analog MPPT ways are required for analog multipliers which are the unit of power-consumption and measurement expensive. On opposite hand, various low-cost power microcontrollers come with integral hardware digital multipliers unit of the measurement out from IC vendors such as TX Instruments and micro chip. Therefore, digital implementation of the MPPT has well known in the medium and high power PV systems digital controllers unit of the measurement normally used. More so, digital implementation allows some options such as user interfaces and protection modes. Some researchers are worked on the digital MPPT schemes that are acceptable for fast dynamical environments.

Several current ways of the resolution MPPT draw back unit of measurement wide worked in the trade. An algorithmic rule has named perturb and observe MPPT methodology [2]. The methodology can be utilized additional perturbance component among current and voltage array to the constantly check if or not the system has get the nominal current or voltage price. If voltage can be changed to offer the direction per turbance and thus power output can be hyperbolic synchronic, that can be suggested the electric receptacle is attained with further such perturbance for voltage; on opposite hand, if facility output decreases with constant voltage perturbance that implies to the electric receptacle that can be found the current or voltage. The PO MPPT algorithmic rule must implement at an inexpensive worth, which has a constant technique that uses the oscillations to trace the most electric receptacle system which is already among steady state. The underlying issue results of Perturb & Observe MPPT may be hard to acknowledge the provision of the perturbance throughout system operational. Sometimes, the perturbance is the atmosphere modification and generally, the inherent generated perturbance. The result of noise or perturbance constantly that existed among the system, Perturb & Observe system can never be stable at the value.

In Hung-I Hsieh, Jen-Hao Hsieh, [3] voltage-based MPPT current-based MPPT approaches unit of the measurement is presented. Every unit of measurement can be simple and fast. Hence, these ways can track the low efficiencies for low irradiation levels. In this, K.H. Hussein (2004), a strategy has been projected supported to the analysis and derivation of the I–V characteristics of PV panel by [4] natural exponent index. This method offers the faster track speed than quality of hill-climbing methodology; the used index is solely too complicate for amount calculation exploitation in an inexpensive 8- or 16-bit lC. In C.Thulasiyammal, MPPT management rules unit of the measurement can be supported the prediction line which associates the MPP and optimum current. One of the parameter got to be non-inheritable through hill-climbing methodology that generates [5] commercially impractical. Noppadol Khaehintung and Phaophak Sirisuk (2008) extended previous analog RCC method to the digital domain for MPP track. The projected digital implementation could be plenty of versatile, smaller quantity expensive; ton of durable quite such as analog RCC methodology, inductive and physical phenomenon parasitic elements may have impact on the facility of RCC to drive system toward being MPP. To subsume the exchange between the steady-state performance and so the speed of track, C. S. Chin, P. Neelakantan, et al. (2011)steepest descent methodology, [6] variable step-size ways, parabolic prediction technique and FLC-based approach square measure projected for MPP.

These ways can display the faster dynamic response power tool to steady state than the standard MPPT algorithms. However, ways can be utilized 2 output samples a pair of steady-state operational points to compute the progressive price of the management variable. Therefore, operational purpose can be organized system ought to expect all transients to be settled before recording the data. Therefore, track speed of ways has been restricted to the dynamics of system. Extreme seeking controller can be projected [7] in Panom Petchjatuporn, Phaophak Sirisuk, et al., et al. (2010) fast supply convergence and sensible [] steady-state performance with the secured stability for number of parameters. The quite RCC methodology, E controller has been desired voltage and current ripple data, that unit of the measurement only few years of typical current and voltage. Therefore, high resolution analog to digital convertor has been required to increase the worth of system. A less complicate manner of the track MPP comes through estimation technique to support offline module characterization. In S. Yuvarajan and JulineShoeb (2008), link between the [8] values of panel current and voltage at MPP can be used to accelerate speed of the MPPT algorithmic rule. The conception is shown in Prof.Dr.IlhamiColak (2011) is extended to the digital domain [9]. The displayed methods model nonlinear I–V characteristics of device exploitation numerical approximations. To boost the polynomial interpolation, track efficiency technique is wont to emulate MPP locus. A pair of emulation results – piecewise line isometric and segments equation – unit of measurement won't to correct model MPP locus.

The S. G. Tesfahunegn et al. proposed the progressive physical phenomenon algorithmic rule (INC) [10] position to the most electric receptacle, per link between facilitate versus voltage, where the derivation of power with voltage can be ideally adequate zero. Various literatures are reported of robustness performance with the worth of code quality and hardware. As matter of reality like as condition can not be specific fulfilled because of division errors and noise live error. Meanwhile, Yuncong Jiang, Ahmed Hassan et al. INC algorithmic rule to boot can increase computation time of the MPPT algorithmic rule. [11] Besides the Perturb & Observe and so the INC algorithms, there unit of measurement many

various advanced algorithms square measure addressed, like formal logic and so neural network-based algorithms. These ways unit of measurement acceptable for resolution certain specific problems; however, Arash Shafiei et al. the idea of the system is irresistibly [12] sophisticated among code and hardware construction of device. Once the foremost electric receptacle is obtained, the correlation can be adequate zero. RCC methodology copes with several drawbacks of different algorithms. Multiple advantageous choices of the RCC, to the alternative given ways square measure mentioned and generalized in literature [12].

3.PROBLEM FORMULATION

The problem of drawing maximum power from solar panel which is to be solved using MPPT technique and improvement algorithm needs to be formulated so better performance. The basic equation can be described mathematically the IV characteristic of PV cell is

$$I_{pv} = I_g - I_S\left(\exp\left(\frac{q(V_{pv} + I_{pv}\cdot R_S)}{nkT}\right) - 1\right)$$

Where, n can be ideality factor, q is electron charge, k can be Boltzmann's constant, T can be temperature in the Kelvin, RS can be equivalent series resistance and Ipv, Ig and Is make the panel current, photo generated current, and saturation currents, respectively.

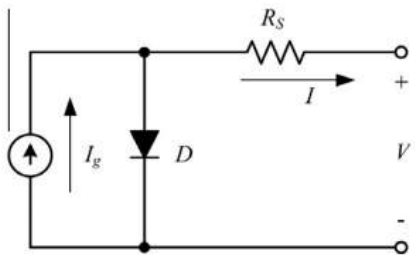


Fig. 1. Equivalent circuit of the PV cell.

In this, MPPT algorithm performance can be measured in dynamic and static ways; static MPPT efficiency can depict the ability of MPPT algorithm to find and hold the MPP under constant environment conditions, where as dynamic MPPT efficiency has been defined the ability in tracking MPP to consider the environmental conditions. The static MPP tracking efficiency gSTATIC is shown as

$$\eta_{STATIC} = \frac{P_O}{P_{MAX}} \times 100\%$$

Where, PO is an average output power that can be attained under the steady state and PMAX may the maximum power of the PV panel which is under the certain environmental conditions.

3.1 OBJECTIVES

The problem has to be solved using Modified Firefly algorithm and PSO technique. An algorithm for the improvement of the same needs to be designed. The major objectives of the thesis can be listed as:

- Analysis of the several algorithms used for MPPT technique used in literature.
- Design of converter and integration with some load.
- Development of a Firefly algorithm and its modification based algorithm.
- Application of the modified Firefly algorithm for improvement of MPPT technique.
- Comparison of result with PSO based appraoch.

4. PROPOSED METHODOLOGY

In this proposed methodology, we use Firefly model to improve the MPPT technique. This model can be simulated in algorithm that can implement and control the included load.

4.1Multi-Junction Solar cell model

First of all Multi-Junction Solar Cell can be designed by combination of characteristics of PV cell.

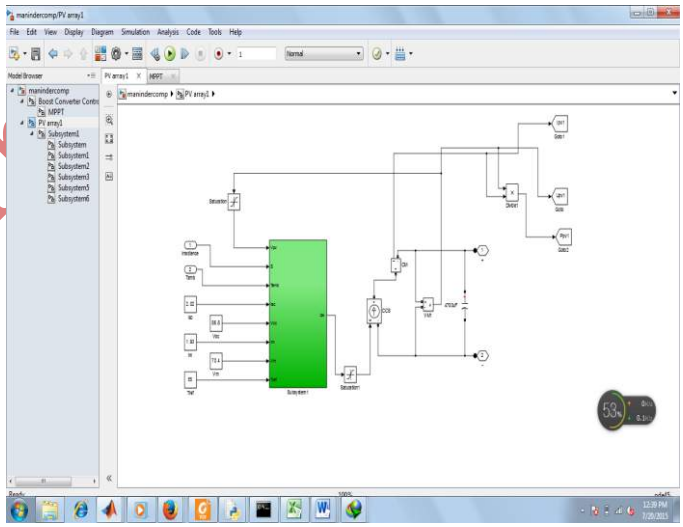


Figure 1: Representing the overall Solar cell model

4.2Modified Firefly algorithm

Modified Firefly algorithmic program was proposed within the book of rule. The sunshine intensity is varied at the space from the eyes of the observer. It's safe to mention that the sunshine intensity is weakened because the distance increases. The sunshine intensity additionally the influence of the air absorb by the environment, so the intensity becomes less appealing because the distance increase. Firefly algorithmic program was followed 3 idealize rules,

1) Fireflies area unit attracted toward one another notwithstanding gender.

2) The attractiveness of the fireflies is correlative with the brightness of the fireflies, so the less engaging firefly can move forward to the additional engaging firefly.

3) The brightness of fireflies rely on the target operate.
Structure of firefly algorithmic program

In firefly algorithmic program, there area unit 2 vital variables, that is that the intensity and attractiveness. Firefly is attracted toward the opposite firefly that has brighter flash than itself. The attractiveness is depended with the sunshine intensity.

Firefly Algorithm

1 **Begin:**

2 . *Initialize the algorithm parameters:*

3 *MaxGen: maximal number of generations*

4 *γ: the light absorption coefficient*

5 *r: the specific distance from the light source*

6 *d: the domain space*

7 *Define objective function of f(x), where* $x=(x_1,.....,x_d)$

8 *Generate an initial population of the fireflies or* x_i $(i=1,2 ,..., n)$

9 *Determine light intensity of* I_i *at* x_i *via* $f(x_i)$

10 **While** $(t<MaxGen)$

11 **For** $i = 1$ *to n (all n fireflies);*

12 **For** $j=1$ *to n (n fireflies)*

13 **If** $(I_j > I_i)$,

14 *move firefly i towards j by*

15 **end if**

16 *Attractiveness varies with the distance r via Exp* $[-\gamma r^2]$;

17 *Evaluate new solutions and update light intensity;*

18 **End for** *j;*

19 **End for** *i;*

20 *Rank the fireflies and find the current best;*

21 ***End while;***

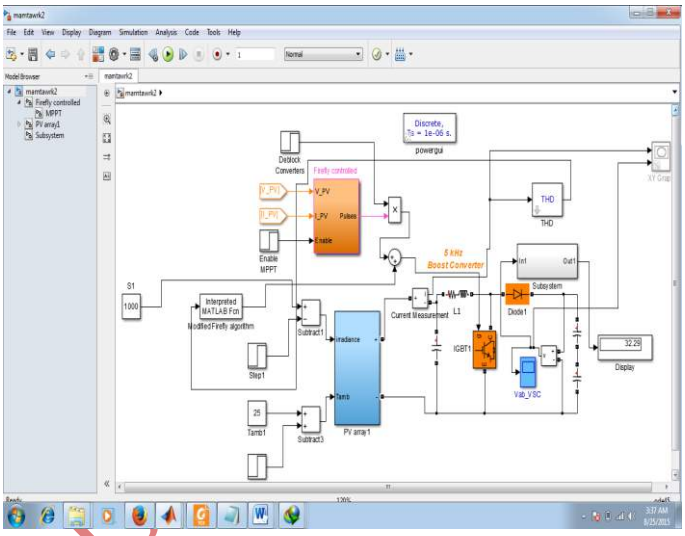
22 *Post process results and visualization;*

23 **End procedure**

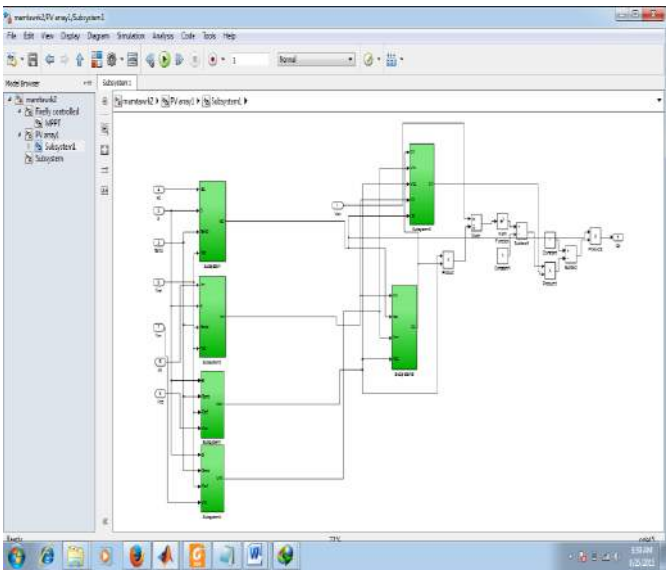
The light intensity so attractiveness is reciprocally proportional with the actual distance r from the sunshine supply. So the sunshine and attractiveness is decrease because the distance increases.

5. RESULTS

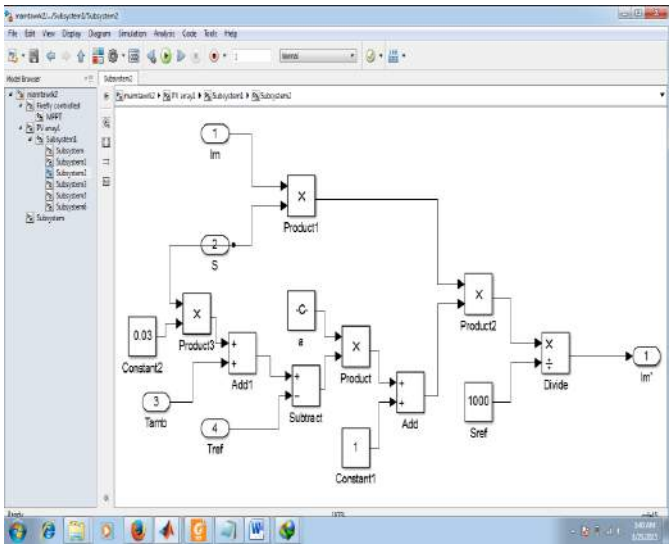
All the results have been simulated on 4 GB RAM, 2.7 GHz processor based system using MATLAB R 2013b. The whole model is described below.



The photo-voltaic cell is depicted below. It comprises of multi-junction which has been designed and constructed using subsystems for implementation of the various model equations.



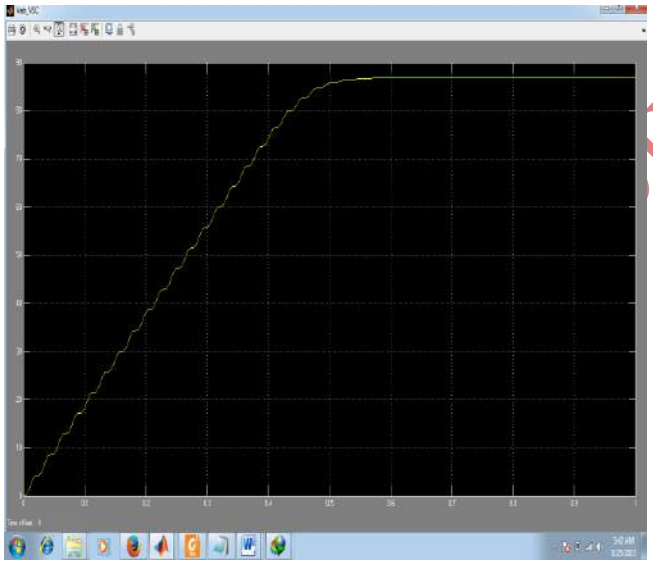
2. Solar cell modal



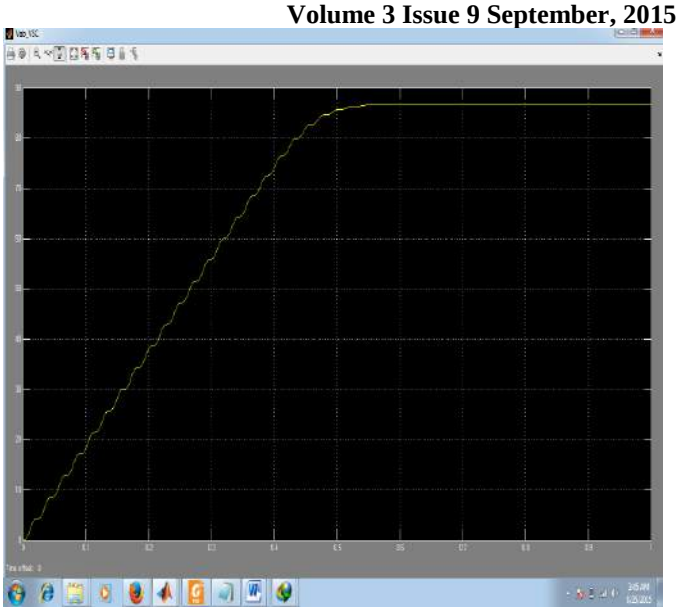
2. Solar cell equation

3. Equation of solar cell modal

The results of PSO technique for the output voltage are shown below. As it is observed that the voltage rise after a certain initial threshold and after certain time achieves around a certain value.



The below figure represents the same voltage using our porposed modified firefly approach and it is observed that the modeified firefly approach performs better than the PSO approach.



The performance is better in terms of both rise to the voltage and the voltage magnitude. While we achieve a voltage magnitutde of 32 V in modified FF algorithm, only 27 V is obtained using the PSO approach for all other initial conditions remaining same.

CONCLUSION AND FUTURE SCOPE

This thesis proposed a novel approach of utilising a firefly approach to solve the MPPT problem in multi-junction photo-voltaic cell. The multi-junction photovoltaic cell was assumed to provide better output in terms of voltage. The model for adaptive firefly system can be designed and developed. The firefly model is used to train itself and track the voltage output based on the THD values of the output. The THD of the voltage was fed as input to firefly model trained firing angle of the boost converter connected to it is computed. The solar cell model was designed and given to boost converter. The converter output was analysed. An incremental conductance technique was also implemented for comparison purpose.

The result of firefly algorithm was found to be quite better than the PSO in terms of output voltage magnitude and the transients. The transient state in firefly trained MPPT it quite smooth comparatively. Also when the current is compared, the oscillations die out very fast in case of firefly algorithm while in I&C approach it is more or less sustained.

In future this algorithm can be improved using other techniques and approaches. Also real time implementation of the algorithms can be done and hardware testing can be done. Hybrid with other algorithms can be utilised and the performances can be compared. Also clustering and other gradient learning methods can be utilised and the model can be tested for grid connection.

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