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Enhancing the Performance of Building Integrated Photovoltaic Systems (BIPVs) Using High Efficient Power Modules

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Abstract* - A Building Integrated Photovoltaic Systems (BIPV) consists of PV modules which are integrated in to the Buildings as facades, roofs, windows, etc., The Photovoltaic PVs are mainly implemented to convert the solar irradiance in to electrical energy. These building integrated PVs are placed in different orientations and angles. However, due to the variation of the solar irradiance, temperature and also due to mismatch of electrical parameters the performances of the BIPV systems are getting affected. Also Power configurations are becomes difficult, which leads to reduced reliability and energy efficiency. Hence, this paper intends to introduce high efficient DC-DC converter by implementing a novel enemy to friend optimization algorithm technique with the use of MPPT. Initially, the solar irradiance obtained by the solar panel is converted into DC by using the Maximum Power Point Tracking (MPPT). In which, the Pulse Width Modulation (PWM) is generated based on the optimization process, for this purpose, an E2F algorithm is implemented. In this technique, the enemy who has the minimum anger (i.e. the duty cycle which has the minimum value) is selected and then make it as a friend. The output power obtained after implementing the DC-DC converter is given as the input for inverter. Finally the output of the inverter is connected to Grid or Load. In simulation, the efficiency of the proposed power module with DC – DC converter is evaluated and analyzed using the measure of those outputs with varying temperature.
***Keywords:* Photovoltaic Systems, High Efficient Power Modules, BIPV**

I. INTRODUCTION

Nowadays environmental issues are becoming the serious concern all over the world and also the global energy crisis due to strain on fossil fuels like coal, oil & gas leads to lot more research in the area of renewable energy. Due to this, researches are giving more focus on the applications of solar PV systems in various arenas. Building Integrated PV system (BIPV) becoming the emerging technology were the photovoltaic arrays can be integrated in to the various parts of the buildings like facades, window shutters, roof tops, etc., and the power extracted from the solar PV cells are utilized to that particular building loads or it can be connected to the grid. The main features of the BIPV system are the buildings becomes self-source of generators, reduced cost, building beautification, etc.,[2]. However the performances of the PV module were affected with the partial shading and due to the electrical parameters mismatch [6]. Due to the partial shading and time changing in a day, solar PV cells undergoes changing temperature and irradiance. This intern affects the performance of the solar PV modules. The variation with temperature and changing irradiance becomes a bigger issue in the BIPV modules, since it is fabricated very close to the building envelopes and also with low ventilation. Due to this, power loss will be more and hence the efficiency of the system is getting reduced. Hence, the operating temperature of the BIPV modules has to be closely observed in different working conditions.

In practice, the partial shading cannot be avoided in the building integrated PV cells and hence various researches are being conducted in order to enhance the efficiency of the power module and to make them highly suitable for the BIPV applications. Perturb and Observe (P&O) is the technique which has been broadly used in the MPPT implementation. This method continuously act on the voltage of the PV array and by using the duty cycle it finds out the new power. Then, it compares the new power with previous one. The biggest defect in this technique is that, it could not able to perform in an efficient manner under varying temperature and solar irradiance. Also, it produces continuous oscillations with low irradiance. The response time is very slow.

Therefore, the primary objective of this work is to propose a new Enemy to friend optimization algorithm based Dc-Dc converter, which out performs efficiently under changing temperature and solar irradiance conditions. Initially, this paper reviews the existing control strategy available for the BIPV systems. Afterword's the E2F based optimization technique and the generation of PWM pulses under changing temperature and irradiance. Finally, the performances of the existing and proposed methods were analyzed in a detailed manner using the simulation results with conclusion.

II. RELATED WORKS

Cavalcanti, Oliveira, Azeredo, Neves [1] highlighted that the Perturbation and Observation technique could not able to perform in a better manner when the solar irradiance varies more often and much quicker with respect to time. Hence the results obtained from the P&O method is not good enough in case of quick changes in temperature and irradiance.

Akash Kumar Shukla, Sudhagar, Prashant Baredar [2] pointed out that the building integrated PV system can be installed almost all the building areas as envelop. BIPV modules can very well install as facades at the surface of the buildings. However, rooftops are the high preferred area for the BIPV installation.Chihchiang Hua, Chihming Shen [15] highlighted that due to four sensor requirement the incremental conductance method that requires more conversion time which intern high losses of power. On the other hand, by increasing the P&O method's execution speed the system losses can be decreased.

Nabil Karami, Nazih Moubayed , Rachid outbib [16] pointed out that the MPPT techniques with intelligent control is the highly used method and shows very good performance when compared with the conventional P&O method. These AI based MPPT methods are fastest and stable.

Yaquab Javed, Ali Faizal Murtaza, Qiang ling, Shahid Qamar [20] authors proposed a new method of MPPT called generalized pattern search (GPS) which is derivative free algorithm and exhibits fastest convergence. Since partial shading cannot be avoided in the BIPV systems, the proposed MPPT technique should be adoptive in nature and have proficient operation to search global maxima.

Bangyin liu, Tao cai [21] presented an improved power configuration with efficient and cost effective, since the conventional configurations are different to obtain higher energy efficiency and reliability. The author also highlighted that the photovoltaic (PV) modules performance was affected due to the partial shading and also due to electrical parameters mismatch. Hence, there is a high requirement in improving the performance of the power module during the partial shading.

Kai chen, Shulin Tian, Yuhua Cheng, Libing Bai [22] When the PV arrays are comes under partial shading situations, the power voltage characteristics of the pv arrays shows various local power points (LPP). The author suggested a new method to track global maximum power point (MPP) of that particular pv. Features of this method are identifying the partial shading, calculating pv curve peaks and assuming the GMPP and LMPP locations. This reduces the energy loss due to blind scan.

Jian Zhao, Xuesong Zhou, Zhiquiang Gao, Youjie Ma, Zhenwei Qin [23] to track the maximum power point under changing environmental condition and partial shading, it is necessary to find output current of a solar cell with respect to the global maximum power point (GMPP). Since the conventional methods are not satisfied in the control process, author proposed a novel algorithm for GMPPT. In this method, the non-linear relation between the changing environment parameters and the output current of solar array at every MPP has been identified and then GMPPT rules are created accordingly.

III. PROPOSED DC-DC CONVERTER FOR THE BIPV SYSTEM

In this section, the proposed converter design is presented in a detailed manner. Here, it is mainly focussed to develop a new optimization based Dc-Dc converter for a BIPV system. The suitability of this proposed converter with the BIPV system is ensured by implementing a novel Enemy to Friend algorithm (E2F). This work aims to observe the changing temperature and solar irradiance. Accordingly, it computes the duty cycle using this novel optimization technique. The Fig. 1 shows the various blocks of the proposed system.

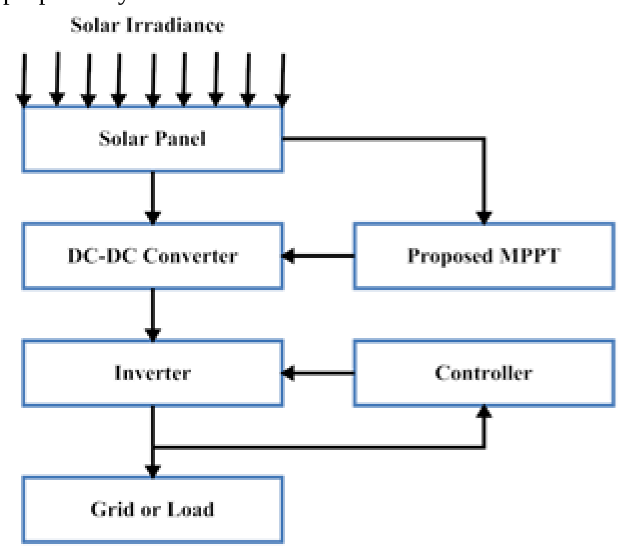

Fig. 1 Various Blocks Of The Proposed System

The Overall simulation of the proposed system has been carried out using MATLAB Simulink and the simulation illustration is depicted in Fig. 2, which consists of pv cells, proposed MPPT technique, Dc-Dc converter.

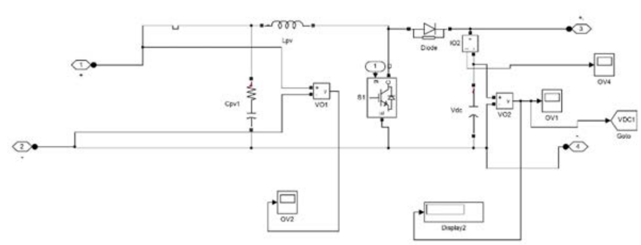

Fig. 2 Simulation Diagram of Proposed DC-DC Converter

A. Impact of Solar Irradiance & Temperature

When the photovoltaic (pv) cells are integrated in the buildings, solar irradiance and the temperature variations have high impact in the power generation and becoming the major issues. The impacts are in the form of power fluctuations in the load side/ Grid, power shortage, inadequate storage, etc. With increasing in solar irradiance the maximum power point (MPP) varies. The temperature also plays a vital role in determining the efficiency of the solar cell. It is observed that, when the temperature raises the cell voltage drops by 2.2 Mv per degree. Here the solar irradiance is converted in to electrical energy by using the dc-dc converter with use of MPPT techniques. Here the solar cell is specified as follows.

$$I = I_{ph} - I_s * \left(e^{\left(\frac{V+I*R_S}{N*V_t}\right)} - 1\right) - I_{s2} * \left(e^{\left(\frac{V+I*R_S}{N_2*V_t}\right)} - 1\right) - \frac{(V+I*R_S)}{R_p} \quad (1)$$

$$I_{ph} = I_r * \left(\frac{I_{ph0}}{I_{r0}}\right) \quad (2)$$

B. Description of DC-DC Converter

The input of the dc-dc converter is fed by the power from the solar panel as an average output voltage. The proposed converter will obtain an optimum power of the BIPV system using E2F algorithm. Also, this converter intends to maintain the voltage, current, and power with varying duty cycle, irradiance and temperature. This proposed algorithm is written based on the core concept of Thirukurral – 875 “One who is alone and helpless while his enemies are two, he should attain one of them as an friend to himself” At first, the No. of enemies is initialized and their angers were estimated by computing the duty cycle based on the voltage and current. Then, after collecting the duty cycle of each enemy, the enemy who has the best duty cycle is selected. Afterword’s the enemy who have minimum anger is selected and made as a friend. Consequently, PWM pulses are generated based on the duty cycle, with this process, the dc-dc conversion is performed.

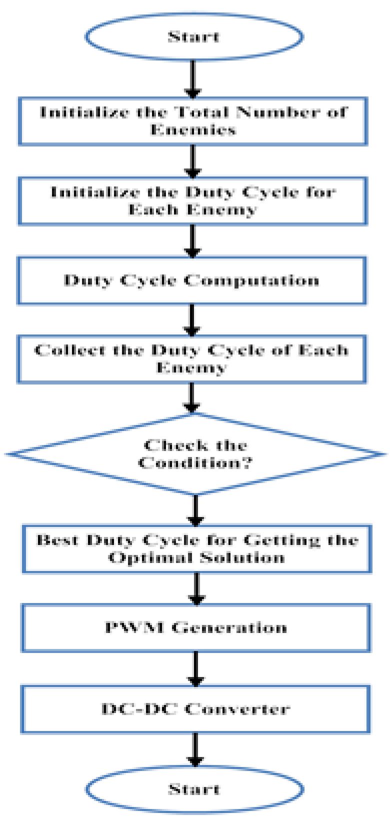

Fig. 3 Process Flow of Dc - Dc Conversion

C. Algorithm I – Enemy to Friend Algorithm

Step 1: Initialize the enemies with anger;
Step 2: Initialize the reference;
Step 3: if previous power of PV panel > Current power of PV panel

$$Pmax = Previous\ power\ of\ panel$$

Else

$$D1 = eD1 + (V/reference)$$

This step is repeated for all the enemies;
Step 4: $V_m = 4.4 \times 10^{-6} \times (S - 638.25)^2 + 16.918 + 0.0504 \times (25 - T)$
Step 5: $I_m = 8.58 \times 10^{-3} \times S + (T - 25) \times 2.145 \times 10^{-5} \times S$
Step 6: $M = -3.0825 \times 10^{-11} 1.033 \times 10^{-7} S^2 - 1.9627 \times 10^{-4} S + 0.11683 + 2 \times 10^{-7} \times (25 - T)(S - 750)$
Step 7: $D = 1 - \sqrt{\frac{V_m}{I_m \times R_L}} - \frac{M}{\sqrt{R_L}}$
Step 8: Compare the duty cycle of enemies with D;
Step 9: Choose the duty cycle which is equal to D;
Step 10: Apply this final duty cycle to the switch of the DC to DC converter;

After initializing the total number of enemies, the duty cycle selection is performed as follows:

```
If D1 <= D
        D = D1;
Else if D2 <= D
        D = D2;
Else if D3 <= D
        D = D3;
Else if D4 <= D
        D = D4;
Else if D5 <= D
        D = D5;
Else if D6 <= D
        D = D6;
Else
        D = D;
End if
```

IV. PERFORMANCE ANALYSIS OF PROPOSED DC-DC CONVERTER

Performance of the Dc-Dc Converter has been analysed by evaluating and comparing the simulation of both existing and proposed system. Various performance measures like Output power, MPPT Power tracking, and DC-DC converter output were taken for analysis. The output power of the Dc-Dc converter was computed for various temperatures and the solar irradiance value, output power was estimated for both existing and proposed techniques. From the output power analysis, it is observed that, the output power of the proposed dc-Dc converter is increased, when compared with the existing technique. Fig. 4. shows the power output of both existing and the proposed converter with respect to the various temperature of solar irradiance.

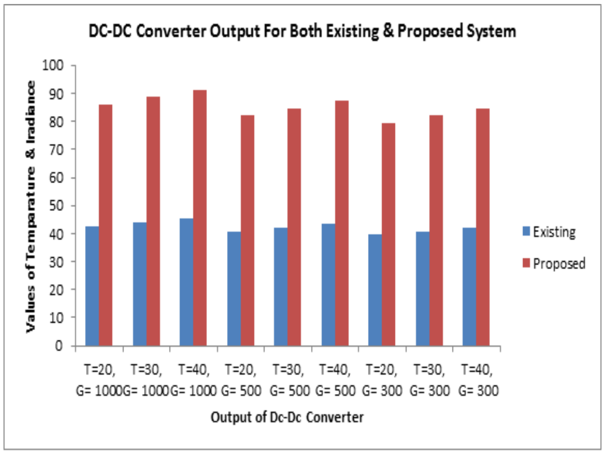

Fig. 4 DC-DC Converter Output for Both Existing & Proposed System

Here, the voltage is estimated at constant temperature i.e. for 0s to 0.5s, the irradiance level is 1000W/m2. Then for 0.5s to 1s, the irradiance level is 500 W/m2 and 1s to 1.5s, the irradiance level is 1000 W/m2 with respect to the temperature of 40°C. Fig.5 shows the output voltage of DC-DC converter for both existing and proposed techniques.

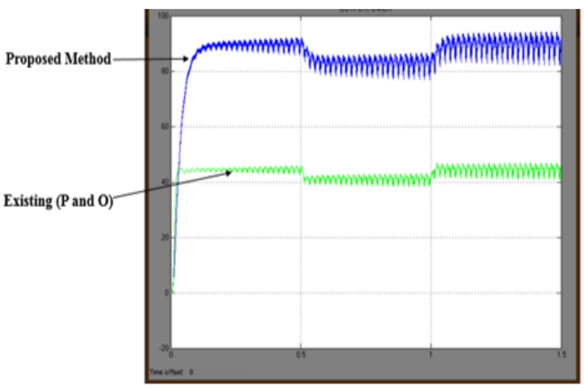

Fig. 5 Output Voltage of DC-DC Converter

V. MPPT POWER TRACKING

The MPPT Power tracking efficiency of both existing and proposed technique is depicted in Fig. 6 and Fig. 7. In this analysis, the value of T is <= 0.03 at G = 1000, and T > 0.03 at G = 500 are considered for evaluating the efficiency of the power tracking techniques. In this simulation, it is proved that the proposed MPPT efficiently tracks the power from the solar panel, when compared to the existing technique.

VI. CONCLUSION

A new optimization based Dc-Dc converter has been presented and discussed in this paper. This novel optimization is called E2F optimization, which is developed for MPPT in order to generate suitable PWM pulses. Here, the variation of temperature and the solar irradiance are closely observed by computing the duty cycle. The main features of this proposed converter are reduced power loss, increased efficiency and better optimization. Using different performance measures in the simulation, the proposed control strategy has been evaluated. The better performance of the proposed converter, under varying temperature and solar irradiance was proved by comparing the same with the existing methodology. The simulation result shows the superiority of the proposed E2F optimization based Dc-Dc converter with the existing technique.

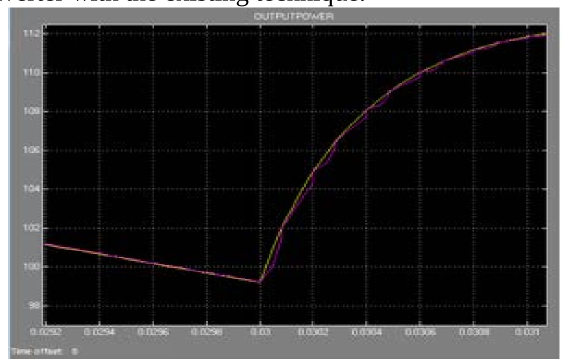

Fig. 6 Power tracking of existing method

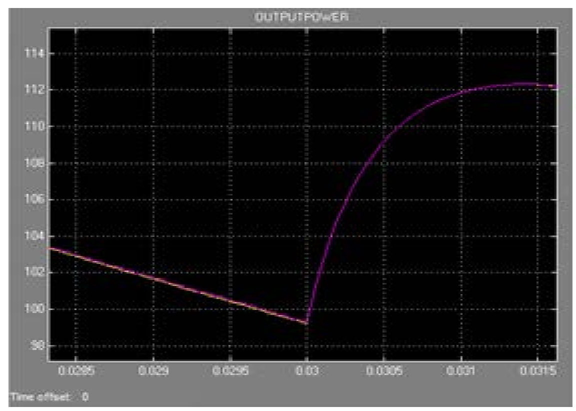

Fig. 7 Power tracking of proposed method

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