BAT algorithm based MPPT technique for bidirectional converter in photovoltaic system under partial shading condition

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ABSTRACT A photovoltaic cell is related in nursing device. It converts energy of sunbeams directly into electricity by electrical process impact. Electrical phenomenon system could be a device that converts alternative energy into current. Partial shading has high affect on photovoltaic system. Photovoltaic system generates electrical power which relies on solar irradiance. The photovoltaic system is always affected by the partial shaded system. So that, the maximum power cannot be obtained easily. Some effects on photovoltaic system by partial shading are air, trees shadow, thunders. However, some techniques to find maximum power are PSO, P&L, FL and ANN. Maximum power point is tracked by BAT algorithm. Because, it is swarm intelligence based method. In the global optimization BAT algorithm has high accuracy, and good dynamic performance. It has quick convergence rate. In addition to BAT algorithm, bidirectional converter is used. A bidirectional converter allows power in both reverse and forward direction. It is capable of performing both step-up and step-down functions and it also performs continuous power flow in the circuit. By using BAT algorithm and bidirectional converter, maximum power can be tracked and output can be improved.

1. Introduction
Renewable energy resources play an important role in our day-to-day life. India is planning to produce 20Giga watts of solar energy. Photovoltaic model is used for analysation. A Photovoltaic cell is a tool that converts simple solar energy into electricity. To obtain higher efficiency, maximum power point tracker is used [1]. A Photovoltaic system is always affected by the partial shading. To generate electrical power photovoltaic system always depends on solar irradiance. If partial shading decreases, it is not easy to obtain power on Photovoltaic system. The Maximum power of partial system under fixed form and patterns of partial shading is unsusceptible in certain point. That point, the power we obtain is said to be Maximum Power Point. The shading molecules and shading heaviness becomes unaffected in the photovoltaic system when meets at certain critical point. The formulated equation can be used to find the maximum power under different shading molecule size [2]. Partial shading in the photovoltaic system can put together reverse biased solar cells. The power produced by solar cells represents the performance as an external consuming. The maximum power during partial shading drops excessively, that reduces the energy yield which is notable. Partial blurring will reduce the emissions of photovoltaic modules that bring the heat of the hotspot to photovoltaic modules where their current performance exceeds the dropped short-circuit current (ISC) of a shadowy or set of cells. When this condition happens, the damaged cells or set of cells are enforced into dissipates power & reverse bias, that leads to local temperature rise, which can permanently damage PV modules[3]. Solar energy is the most important force of energy. PV system is influenced by temperature, solar flare, dust accumulation, wind speed, and shading pattern. Partial
shading is the main cause for the less power generation. PV system characteristics have various peak points. In place of finding the Maximum Peak Point algorithm is used to track the maximal point. The main aim is to study and simulate the PV characteristics.[4] In partial shading, the maximum power can be decreased and reduces short-circuit current of a shadowed or defective cells, which can permanently damage PV modules. [5] Partial shading generates from solar photovoltaic system (SPVS) always have one global point and one peak point to obtain Maximal Peak Point. Partial shading will be deal with Maximal Power Point Tracking method. This method is used for maximizing the PV output power continuously under shading condition. To obtain track global peak point tracker methods are used. [6] The MPPT algorithm technique, a minor perturbation results in the power variation of the PV cells. In the Particle Swarm Optimization (PSO), tracing the Maximal Peak Point in addition to maximizing the PV arrangements by extracting maximal power, the partial shading effects can blown away by PSO algorithm. It is decrease their power out and energy group of the power to the duty cycle, voltage or current by applying the perturbation method. The MPPT is passing through optimization of dual mode phenomenon to upgrade the control variable of DC/DC converter, the equation describes the current and voltage cell characteristic of solar cell collector using Kirchhoff’s current law. The main problem and main concern of PSO is the usage of random values on the Photovoltaic system and lower number of particles to solution.[7][8] The Neutral Network (NN) has been verified by simulation of various partially shaded conditions and shown to perform well. The partially shading output of the power in the PV system, it is also be maximized using optimization of interconnection molecules. And the efficient energy in MPPT it is also possible with the use of electromagnetic. Specifically, the appearance with use of output current which is used to attain the analytical, iterative rules for regulating the Maximum Power Point voltage and irradiance evaluation.[9] We propose a world-class process for tracking power (MPPT) of a photovoltaic system using the BAT algorithm. Here, we have chosen a BAT algorithm to obtain Maximum Power Point in PV panel. BAT algorithm establishes MPPT represents good performance under partial shading & uniform conditions. So, this algorithm performs better than compared to other types of algorithm. The suggested technique is executed into Field Programmable Gate Array (FPGA).[10] Renewable energy resource has becomes the important on for generating power. It is little difficult to store energy with the grid. Renewable energy sources are most capable for using in the batteries. A bidirectional DC-DC converter allows to circulating for charging and discharging. Here, the power flows in both forward and reverse direction. Based on state of charge and current flow direction, charging and discharging is suppressed by duty cycle of the converter. During day time, the solar energy converter is used to charge battery when solar energy is unobtainable in buck mode, the collected energy in boost mode will supply power to DC load by converter .[11] In our proposed system, we are going to track Maximum Power Point from solar panel using BAT algorithm under partial shading condition. Bidirectional converter is capable of performing both step-up and step-down functions and it also performs continuous power flow in the circuit. Then, the Pulse Width Modulation is used to transform DC into AC power.

![Diagram of PV system under MPPT technique]

**Figure 1** General PV system under MPPT technique

### 2. Research methodology

#### 2.1 Existing system
The Solar panels are connected in parallel in order to get electrical energy. The NHS (Normal Harmonic Search) algorithm is the updated version of the harmony exploration operates probability distribution factor normally. It has been implemented for track the maximum voltage under partial shade condition. Grid voltage control scheme based on Neuro-Fuzzy interference based control, neutral point clamped scheme has been implemented. Conventional converter has been implemented in existing system. To attain Maximum Power Point various techniques are used, 2.1.1) P&O algorithm 2.1.2) Incremental Conductance 2.1.3) ANN algorithm

2.1.1) P&O algorithm
The one of the most frequently used MPPT algorithm is P&O method. In P&O algorithm, minor disturbances are introduced into the system. This perturbation efforts the power of the varying solar cell. The perturbation is lasted in the same direction if at the time of power increases due to the perturbation. After the peak power is reached to the Maximum Power Point will be zero and immediately decreases and consequently the perturbation reverses are shown in fig 2.1.a. When a stable condition arrives the algorithm revolves around a high power point. The P&O technique is advanced so that it sets a reference voltage of the identical modules to the maximal voltage. A PI controller is observed some loss of power to track the Maximum Power due to this perturbation under fast charging atmosphere condition.

2.1.2) Incremental Conductance
The progressive electrical phenomenon will verify the MPPT has attained the utmost electrical outlet and conclude disrupting the work surroundings. The perturb oscillation throughout peak electrical outlet of P&O methodology to trace the height power beneath quick varied climate is overcome by IC methodology. This algorithmic rule has benefits over P&O as a result of it will verify once MPPT reaches most Power, wherever P&O travels around most Power and Progressive Behavior will track rise and reduce radiation levels with higher accuracy than deviation and vision. The disadvantages of this algorithmic rule area unit progressively complicated.

2.1.3) ANN algorithm
The Artificial Neural Network (ANN) oriented MPPT method has proposed for searching Maximum Power Point quickly and exactly. The advantage of ANN oriented PV model method is the quick Maximum Power the ability of ANN according to the approximation base on the parameters of PV array that used. Training Neural Network Data brings anonymous work under the map from input to output. A single input and output size database provides a useful basis for performing performance measurement processes. Modern Neural method use non-linear function. In the existing system, the ability is given to the boost device. Then inverter converts DC to AC. After, it is given to the load.

2.2 Proposed system
The proposed system involves partial shading system which is implemented to track the Global Maximum Power Point. In our proposed system, solar panels are connected in parallel. Using PIC microcontroller, BAT algorithm is programmed. The BAT algorithm is a technique to track Maximum Power Point. It works as a type of sonar. Current and voltage sensor is used and connected to the PIC microcontroller. The LCD displays the Maximum Power. The tracked Maximum Power will give to the PWM driver. The use of PWM driver is to regulate the waveform obtained. The driver drives the power to the bidirectional converter. The bidirectional converter boosts the power and also stores the energy in the battery. After, power will be given to the inverter. The PWM inverter is used to transform the dc into digital modulated ac. The obtained output will be given to the load. That function is shown in Figure 2.2.
3. HARDWARE IMPLEMENTATION

3.1 Photovoltaic system
A panel is designed for generating electricity by absorbing the sun’s energy. Photovoltaic are one of the method for electricity generation by using solar cells which converts solar energy into electrons flow by the phenomenon photovoltaic effect. Solar cells create direct electricity from solar cell that can be used to power equipment. There are different types of photovoltaic cells and they are,

- Monocrystalline silicon PV panels: A Monocrystalline silicon panel consists of monocrystalline photovoltaic cells. A cylindrical silicon ingot grown up in a monocrystalline of silicon which these cells are made. They have purity as the way of semiconductor.
- Polycrystalline PV panels: Polycrystalline PV panels are either said to be “multi-crystalline” or multiple crystals in each and every cells; there is less space for the movement of electrons.
- Thick-film silicon PV panels: Thick-film silicon PV panel is a form on multicrystalline solar in which the silicon is placed on a base material gives a sparkling appearance in a continuous process. Thick film crystalline encloses in a thin insulating polymer by toughened glass cover and bounded by a module which is enclosed by metal.
- Amorphous silicon PV panel: Amorphous silicon PV is formed by placing silicon in a thin equivalent layer instead of developing a rigid structure of crystal. Light is absorbed more effectively by amorphous silicon rather than any crystalline silicon which is due to thinner cells.

3.2 Converter topology
Bidirectional dc to dc convertor is employed as a key device for the storage devices between supply and cargo in renewable energy system. The most purpose of storage of energy is for the continual flow of power as a result of thanks to the weather, the output of the renewable energy system fluctuates. Bi face converters area unit wide accustomed with efficiency manufacture a regulated voltage from that will or might not be controlled to al load that will or might not be constant. Once the circuit operates in boost mode, this within the electrical device flows from the low-tension to the high-voltage facet. The most work of bi face DC/DC convertor is to control the output voltage by control the duty cycle by PWM through MOSFET consistent with sure frequency and duty magnitude relation. The management of speed in the driver performs by operating the motor of “ON/OFF” ranging the duty cycle and pulses, the output voltage is “ON” which is fraction of time in comparison to its “OFF” of the heart beats whereas maintaining constant frequency.

Pulse dimension Modulation is employed to grant a gradual output voltage of 230 or 110v AC. The PWM inverters have extra circuits for cover and voltage management. The PWM electrical convertor accustomed modifies the ON and OFF periods of the electrical convertor parts. PWM minimizes the lower order harmonics. The PWM electrical convertor provides a compact resolution for changing...
current into digital pulse dimension modulated signal. A reference voltage is provided on the PWM output.

![General block diagram of PWM](image)

**Figure 3.2** General block diagram of PWM

### 4. SOFTWARE IMPLEMENTATION

#### 4.1 MATLAB R2017a

Math works currently introduced 2017a (R2017a) of new capabilities with wide range in mat lab with simulink, also test ADAS and automatic driving system. Updates will be included and 86 other products will be fixed by bug in R2017a. MATLAB 2017a in various sectors such as enabling technologies, health monitoring devices and robotic researches. The software is created for scientists to use in research and engineers to sketch and study the system and products of all types.

#### 4.2 Proposed algorithm: BAT algorithm

- Initialize the bat algorithm
- Explain frequency, loudness, and rates
- Modify frequency to start new solutions update velocities and positions
  - Yes: Initiate a local solution around best solutions
  - No: Initiate a new solution by flying randomly
    - Rand > ri
    - Rand < Ai
    - F(xi) < f(xbest)
      - Yes: Accept present solutions increase ri, reduce Ai
      - No: Keep the current solution
- Rank the bats then Find the current best position
The present research addresses the difficulties of the partial shading conditions by finding the new solution which MPPT for reducing the partial shading effects on tracking Maximum Power Point. BAT algorithm is known as bio-inspired optimizing method, which depends on the behavior of echolocation of the micro bats. There will be three axes with an echo view. The prey how far will be identified by the difference of time between transmitted sound pulse and echo. The sound pulse recognizes the size, speed. Compared to the previous methods, the shape of the output characteristic curve can be easily tracked by BAT algorithm. BAT algorithm is ideal for the MPPT of PV system because of one variable that has a low-dimensional optimizing problem. Under PS condition, addressing the problem of identifying the MPPT in PV applications, the BAT can be apply; it was addressed by few research groups across the world. BAT algorithm has performed with low-dimensional problem in most studies so that it is said to be novel developmental optimizing algorithm.

5. Simulation result
The simulation circuits and the stimulation results are enclosed. BAT algorithm has been implemented in MATLAB and the performance has been compared. The simulation results with BAT algorithm are shown in figure 5.1.
Figure 5.2 Voltage characteristics of Real Time Data drawn between Voltage & Current

From Figure 5.2 shows the simulation output waveform of Voltage characteristics of Real Time Data drawn between voltage & current. The workspace of the waveform has been shown in below figure.

The output waveform has been varied based on the power obtained from the solar panel. These functions have been noted for the 24 hours of time for the better result. If any partial shading condition performs in this process the output voltage and current has been varied by the high and low peak point.

6. Result
6.1 Hardware result
Figure 6.1 Hardware Structure

The project work under solar connected setup is shown in figure 6.1. It consists of 12V solar panel, 12V battery, inverter, bidirectional converter. The BAT algorithm is used to trace the Maximal Peak Point using bidirectional converter. The bidirectional converter boosts the power and then given to the inverter. While comparing to the above mentioned algorithm (ANN, P&O, Incremental Conductance) in existing system BAT algorithm tracks the Maximum Power Point faster and gives maximum peak power.

7. Conclusion

We concluded that, these are the things that we are proposed in our paper. Here we are implementing the Maximum Peak Power by bidirectional converter in Photo Voltaic system established on BAT algorithm under Partial Shading condition. While comparing to others, Bat algorithm has high tracking efficiency. So, we have chosen this technique to track Maximum Power Point in PV system.

The main advantage of BAT algorithm has improved dynamics, robustness, and reduction of operating switching frequency, simplicity & high search efficiency.

8. References

[1] J. Ahmed and Z. Salam, “An enhanced adaptive P&O; MPPT for fast and efficient tracking under varying environmental conditions,” IEEE Trans. Sustain. Energy, vol. 9, no. 3, pp. 1487–1496, Jul. 2018.
[2] W. Zhu, L. Shang, P. Li, and H. Guo, “Modified hill climbing MPPT algorithm with reduced steady-state oscillation and improved tracking efficiency’s. Eng., vol. 2018, no. 17, pp. 1878–1883, Nov. 2018.
[3] T. Tuffaha, M. Babar, Y. Khan, and N. Malik, “Comparative study of different hill climbing MPPT through Simulation and experimental test bed,” Res. J. Appl.Sci., Eng. Technol., vol. 7, no. 20, pp. 4258–4263, Sep. 2016.
[4] Y.-Y.Hong, P. M. P. Buay, and A. A. Beltran, “Maximum power point tracking of photovoltaic system using Taguchi-based fuzzy logic control,” in Proc. IEEE Milan PowerTech, Milan, Italy, Jun. 2019, pp. 1–6.
[5] A. Ilyas, M. Ayyub, M.R.Khans, A. Jain, and M. A. Husain, “Realization of incremental conductance the MPPT algorithm for a solar photovoltaic system,” Int. J. Ambient Energy, vol. 39, no. 8, pp. 873–884, Nov. 2018.
[6] J.C.Teo’, Rodney H.G Tan’, V.H.Mok’, Vignesh K.Ramachandramurthy2 and Chio Kwang Tan-2019”Impact of Partial shading on the PV characteristics and the maximum power of a Photovoltaic string” 2018
[7] Ramali, S Twaha,K Ishaque, YA Al-Turki “A review on maximum power point tracking for photovoltaic system with and without shading condition”-2017
[8] K. Kaced, C. Larbes, N. Ramzan, M. Bounabi, and Z. E. Dahmane, “Bat algorithm based maximum power point tracking for photovoltaic system under partial shading conditions,” Solar Energy, vol. 158, pp. 490–503, Dec. 2017.
[9] M. Karagöz and H. Demirel, “Novel MPPT method for PV arrays based on modified bat algorithm with partial shading capability,” Int. J. Comput. Sci. Netw. Secur, vol. 17, no. 22, pp. 61–66, 2017.
[10] N. Priyadarshi, S. Padmanaban, P. Kiran Maroti, and A. Sharma, “An extensive practical investigation of FPSO-based MPPT for grid integrated PV system under variable operating conditions with anti-islanding protection,” IEEE Syst. J., vol. 13, no. 2, pp. 1861–1871, Jun. 2019.
[11] H. M. Farh and M. Ali Eltamaly, “Maximum power extraction from the photovoltaic system under partial shading conditions,” in Modern Maximum Power Point Tracking Techniques for Photovoltaic Energy Systems. Cham, Switzerland: Springer, 2020, pp. 107–129.
[12] A. M. Eltamaly, H. M. Farh, and M. S. Al-Saud, “Grade point average assessment for metaheuristic GMPP techniques of partial shaded PV systems,” IET Renew. Power Generate., vol. 13, no. 8, pp. 1215–1231, Jun. 2019.
[13] X. S. Yang, “A new metaheuristic bat-inspired algorithm,” in Proc. NICSO, Berlin, Germany, 2010, pp. 65–74.