Solar PV System for Water Pumping Incorporating an MPPT based Bat Optimization Circuits and Systems

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Abstract--- In this article, MPPT algorithm along with PV array system using bat optimized Proportional Integral (PI) controller with the aid of a Landsman converter fed with BLDC is designed and analysed and carried out more effectively. Landsman converter provides BLDC motor soft starting with necessary control. BLDCM speed can be limited with the help of VSI which is fed with BLDCM. Between the VSI and the solar array the converter is acts as interface and it feds the BLDC motor. Soft starting, Simplicity control, compactness of the BLDC motor has been included in the research work. The device stress is reduced by the operation of Landsman converter. By switching between exploitation and exploration stages, BAT optimization has provided a high accuracy which provides excellent dynamic performance and quick convergence. Utilizing a Landsman Converter with BAT optimization techniques results in optimized control of the converter response voltage. Better speed regulation and reduced torque ripple are noticed with the proposed BAT optimizer, the efficiency of the proposed system is proved.

Keywords--- PV Module, Landsman Converter, BLDC Motor and BAT Optimization.

I. Introduction

The researchers have been motivated towards the green energy fed pumping to come up various the challenges with a cost-effective, efficient, reliable and simple system. On developing an economical SPV array and energy efficient water pumping system, a noteworthy role has been played by an electric motor. The cost and size of a SPV array has been reduced by an efficient motor noticeably. For water pumps, DC motors are used by majority of viable systems. The operation of such BLDC type of motor is based on solar photovoltaic array, where the speed of the motor is related to the parameters controlling. The key idea of PI controller is related to increase in efficiency which is proportional to the PV based tracking response systems within values of Maximum Power Point.

Saravanan et al (2016) have suggested MPPT controller, which is based on Differential Evolution algorithm. The proposed MPP tracker is used to achieve the target within high convergence rate as compared to the conventional MPPT. The controller which is being proposed is related and examined the function of popular conventional technique with different conditions. The proposed PV system is modelled with the help of MATLAB 2016a software. From result, MPP can be track quickly (less than 0.3 seconds) while comparing existing techniques. The existing system takes greater than 10 seconds in computation time. Computation time is high by using MPP under partial shading condition.

Babaa et al (2014)presented a hopeful clarification about the impact of induction motor for water pumping concept. In north America the energy cost is compensated due to low water flow. BLDC is designed with minimal pulsating torque. The new controller is created on an adapted field concerned with control. The PCB controller is of double layers to propose a less expensive result. It was developed under best efficiency (98.2%) with the algorithm plotting the yield properties (Head, Flow) to the provided properties (speed, torque).

Sherin et al (2017)illustrated the analysis of PV system based with and without MPPT techniques. Two MPPT methods, P&O and IC are done by MATLAB a for transferring extreme power. The framework with MPPT use over 96% of electric vitality that are delivered from photovoltaic generator and, then again, another framework provides the accuracy of 34.9%. Balakrishnan et al (2017) presented the applications of heating, ventilating and air conditioning fans, and photo-voltaic system with a MPPT controller which is associated with some motor convertors. Based on a hereditary assisted, multilayer perceptron NN structure, the MPPT controller is created. The proposed system gives rise to best way to manage energy using such techniques in photovoltaic systems analysed in rural places that can be concluded from the results.

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Shobha Rani et al (2017) presented for daily inhabited energy wants of grid is prohibited in rural places systems and to employ Solar photovoltaic power systems. The proposed a standalone solar photovoltaic powered air-cooling system constitutes of DC to DC boost circuit, centrifugal water pump, fan and brushless motors. SaradaSet al (2017)have been suggested a survey on different MPPT algorithm in photovoltaic generators by considering fractional shading effect. This paper reviews the four groups of algorithms named as optimized MPPT, hybrid MPPT, designing approaches, and different converter topology. In addition, this method also suggests to perform an efficient research in future for the partial shaded PV systems. MPPT algorithms has developed by Priyanka Ket al (2018).Tracking time and oscillation drawbacks present around Maximum power point. To generate the matching ratio fed to a (PI/PID) controller. Under certain circumstance. In this way to obtain the MPPT irradiance value is 99.73%.

Balasubramaniam S V, et al (2018) has been developed sun-oriented PV system. For accomplishing a natural double voltage and power stream control, the three Port Converter was used and worked in unidirectional as well as bidirectional way and makes the framework more practical by all the while Switch check. For speed control of BLDC engine without relentless state blunder, a palatable shut circle execution has been accomplished. Santosh Singhet al (2018)illustrated how to enhance the solar photovoltaic generated power for Brushless DC water pump using MPPT technique. The phase current sensors for achieving a controlling operation. This leads to amplified price, dimensions, complication of the circuit and efficiency of the motor is very less. This project is solar photovoltaic system it will be converted solar energy to electric energy conversion system via water pump. Chandrasekhar P **et**al (2018)explained Brushless DC motor algorithm used for water pumping techniques. Quick reduction in conservative fossil fuel resources have caused energy crisis in our surrounding and a cost of solar photovoltaic system, provides operative application in photovoltaic methodology. So as to advance the sun oriented photovoltaic created power utilizing a most extreme MPP Technique, that normally DC motor required in sun-based PV.

Shanmugamet al (2018) suggests PV system for power energy an easy reduction, less cost and effectual. It delivers maximum energy as probable. At lower values of irradiance 200W/m2 the efficiencies are 92% for PO MPPT and 96% for Improving conductance MPPT because doesn't oscillate as much as P&O toward the MPP and intending to resolve the problematic of the perturb and observe algorithm. Ram Vara Prasad Bet al (2019) explained the solar PV system and water pumping algorithm along with the BLDC motor. The system is worked with a collective VSI loop, BLDC motor reach the stable state and the speed of the motor is 1745 rpm. A DC-DC converter provides the better result in brushless motor by using water pumping techniques. Furthermore, sensors are used to calculate the phase current and to eliminate this current.

Raghavendra Reddy et al (2019)demonstrated PV panel, MPPT controller considering slope climbing, irritate and watch calculations, displaying of BLDC engine. In rural areas the best method is chosen to be water siphoning structures established on the basis of sunlight. The examination fuses exhibiting and multiplication of PV energized BLDC motor for siphoning application. Bernal García LL, et al. 2012 have presented EM Linear VEH Using Sliding Stable Magnet Array and Ferrofluid as an Oil, an EM linear VEH with an array of four-sided stable magnets as a spring a lesser amount of resistant mass. Electrical power is produced through a display of copper winding shaped in the lowermost of aluminum guard. The evidence of harvesting had invented and verified through a vibration which exits a number of input rate of recurrence and accelerations. In addition, optimization should be the main task to extra growth in output strength, the possibility of applying ferrofluid as a lubricating material aimed at a spring much less EMVEH for less frequency vibrations have been positively verified.

Abdel-Rahman, et al. 2017 have introduced EM Energy Change at Recombination Fronts, Earth's magneto tail encloses magnetic energy resultant after the KE of SW. Transformation of that power returned to constituent part strength at last control of Earth, hotness the magnetosphere plasma & boosts the Van Allen energy belts. Wherever such EME change happens was uncertain. Hussein et al., 2013 introduces the EM harvesters in to electrical energy by turning a coil through the magnetic fields of the static magnets, in manner of encouraging the voltage through the coil. EM harvesters are very simple, rough and it will not require smooth material. However, it is very tough to create micro scale. The output voltages are less $(0,1)$.EM harvester was huge because of their huge magnetic mechanisms.

II. System Model

Using MPPT technique, the solar photovoltaic generates power for BLDC motor. Landsman converter is needed by a solar PV BLDCM and for controlling operation the motor requires phase current sensors. The solar

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photovoltaic array is capable of operating at its peak by using VSI. BLDCM consists of a position sensor to control the inverter in which a proper communication sequence could be provided.

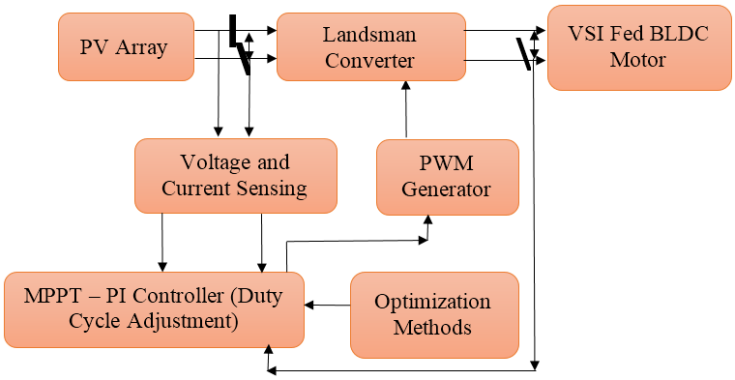

Figure 1: MPPT System Model

From figure 1 MPPT system model. The power supply is taken from the PV panel and then electrical energy will be generated and the Voltage source can be fed. The design and the operation of Landsman converter has not much amount of irradiance level and it contains losses. Adaptation of P& O method based MPPT scheme is used for optimum consumption of solar PV. The power to BLDC motor could be supplied by VSI. Electronic commutation offers switching arrangement for the VSI system. Hall Effect is produced based on the position of the rotor. To accomplish electronic commutation process completely, brushless DC motor has three inbuilt hall sensors.

Based on rotor position, six switching pulses are created by using an electronic commutation by functioning 3 phase VSI in conduction mode of 120°. The position of rotor is monitored for every 60° span by an inbuilt encoder in which a generated and the switching arrangement for voltage source inverter is created accordingly. Better performance could be obtained by PI controller esteem the controller speed and to minimize the computational load torque which is computational. Appropriate rotation of Brushless DC motor could be assured by commutation whereas the Figure 2 shows the schematic of proposed scheme.

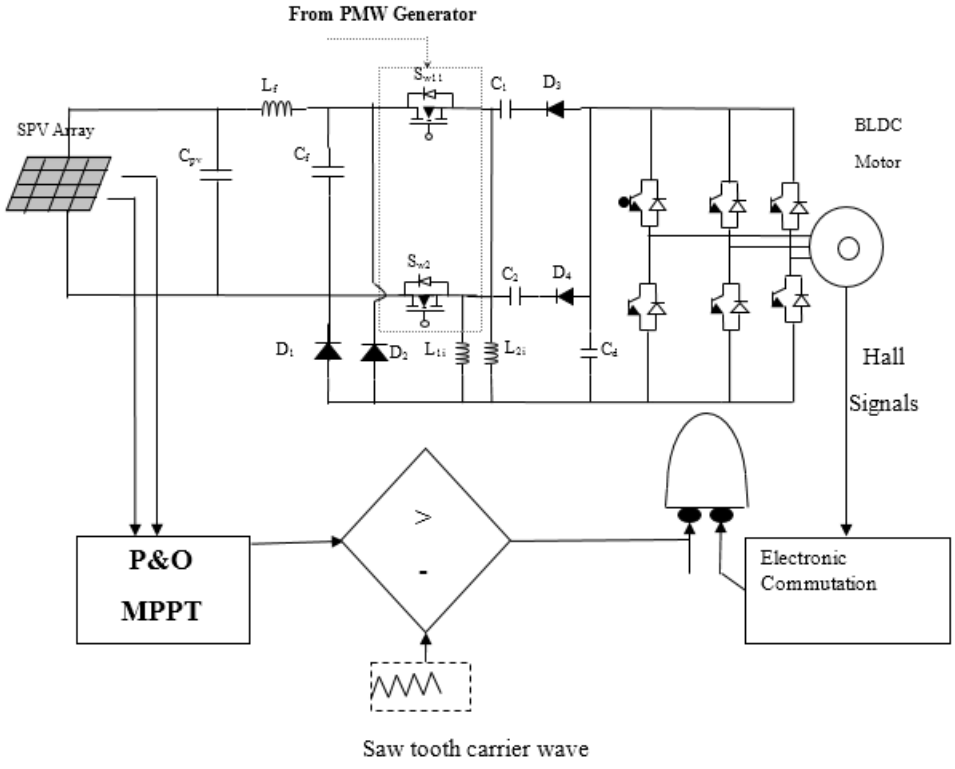

Figure 2: Schematic Diagram of Proposed System

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From figure 3 reflects the outline and operation of the projected SPV array fed landsman converter. SPV array is held along with the landsman converter. Small input inductor which is included in landsman converter which eliminates the damps because of the snubber components of the IGBT module. The landsman converters are consistent works in CCM because of reduce stress on the power devices.

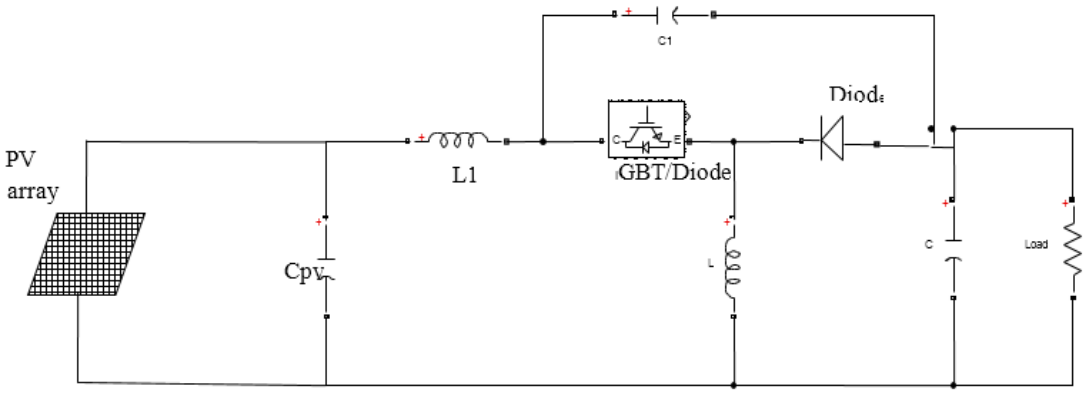

Figure 3: Configuration of SPV Exhibit – Landsman Converter

Need for input PV capacitor is nullified by the converter inherent design. A smooth supply has been provided to the system. IGBT switch acts as a snubber and protects the system.

The Basic equation of the solar PV system can be given by,

$$I = Is(e^{(Vd/nVt)} - 1) \quad (1)$$

$$I = I_{l-I_d} \quad (2)$$

The ripple in input current, IL1 evaluated using the waveform with the assumption that the ripple current in iL1 streams to C1. The spotted portion of V_{C1} represents the flux ΔΦ. The current peak ripple ΔI_{L1} is given below,

$$\Delta I_{L1} = \frac{\Delta\Phi}{L_1} = \frac{1}{L_1}\frac{1}{2}\frac{\Delta V_{c1}}{2}\frac{T}{2} \quad (3)$$

In off mode, the current to C1 is as

$$i_{C_1} = I_{L_1} = C_1 \frac{\Delta V_{C1}}{(1-D)T} \quad (4)$$

Where D and T be the duty ratio. The ripple voltage vc1 is expressed as

$$\Delta V_{C1} = \frac{I_{L_1}}{C_1}(1\text{-}D)T \quad (5)$$

Hence, substitute ΔV_{C1} from equation (5) in equation (6) and it gives

$$\Delta I_{L1} = \frac{1}{L_1}\frac{1}{2}\frac{I_{L1}}{2C_1}(1\text{-}D)\,T \quad (6)$$

$$\Delta I_{L1} = \frac{1}{8L_1 C_1} I_{L1} \frac{(1-D)}{\mathbf{f^2}sw} \quad (7)$$

It is normalized as

$$\frac{\Delta I_{L1}}{I_{L1}} = \frac{1}{8L_1 C_1}\frac{(1-D)}{\boldsymbol{f^2}sw} \quad (8)$$

Then, the relationship between input and output be,

$$I_{L1} = I_{dc}\frac{D}{1-D} \quad (9)$$

Where I_dc be the Landsman converter output current

Hence, substitute IL1 from equation (8) into equation (9) terms, Then it gives as,

$$L_1 = \frac{(DI_{dc})}{\mathbf{8}\boldsymbol{f^2}sw\,C_1\Delta I_{L1}} \quad (10)$$

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2.1 Brushless DC Motors (BLDC)

BLDC has more engaged region in various motor producers in this motors were progressively the favoured decision in numerous applications for example, capacity to work at high speeds, high productivity, and good heat dissemination.

The differential equations are given for 3 phase 2-pole BLDC motor. The stator will be star-associated concentrated. The hall-effect sensor can be provided with 120° phase shift.

$$V_X = R_X I_X + E_{\Psi X} \tag{11}$$

Where I_{XV_X} is the phase current and the voltage, X represented as A, B, C,$E_{\Psi X}$ is the emf induced and R_X is winding resistance. The emf induce can be expressed as,

$$E_{\Psi X} = \frac{d_{\Psi X}}{dt} \tag{12}$$

2.2 Maximum Power Point Tracking

MPPT is used to extract power from the module under definite conditions. At 'MPP' PV module delivers highest voltage at particular voltage. The power depends on solar, temperature of solar cell and ambient temperature. In addition, solar irradiation graph possess sudden variations throughout the day. The MPP changes constantly; under the conditions, therefore the working point should change to increase the energy.

This techniques states the PV generator voltage at the MPP is proportional toV_{OC}. The Equation (13) shows the constantK_1,

$$K_1 = \frac{V_{mpp}}{V_{oc}} \tag{13}$$

Where,

K_1– constant

V_{mpp} - mpp voltage

V_{OC}– open circuit voltage

2.3 BAT Algorithm

In BAT algorithm, random manner of bat population is defined. Here, virtual bats are assigned in a natural way. By moving virtual bats, new solutions are generated based on the below equation:

$$f_i = f_{min} + (f_{min} + f_{min})\beta \tag{14}$$

$$\boldsymbol{v_t^i = v_t^{i-1} + (x_t^i - x *) f_i} \tag{15}$$

$$x_i^t = x_i^{t-1} + v_i^t \tag{16}$$

Where β∈[0,1 as defined as a random vector. By comparing all the bats, $x *$ is found as the current global best solution. Here, we use$fmin = 0\ and\ fmax = 100$. Every bat is assigned with a frequency in a random way with min. and max. Frequency.

By the direct exploitation, Local search is done that is given in the equation:

$$x_{new} = x_{old} + \in \mathrm{A}^{\mathrm{t}} \tag{17}$$

Where ∈ [-1,1] is defined as a random number, while *At* is the best at this time step. The local search is launched depending on the rate *r*i of pulse discharge. If a bat is find the prey means, when the rate of pulse discharge rise automatically the loudness reduces and the loudness value is satisfactory. Thus, both features imitate the natural bats. Mathematically, these features are done with the following equations.

$$A_i^{t+1} = \alpha A_{i,}^t r_i^{t+1} = r_i^0 [1 - \exp(-\Upsilon\ t) \tag{18}$$

III. Result and Discussion

To show the effectiveness of landsman converter with BBMO algorithm optimizer the MATLAB software was used. The brushless takes the converter output.

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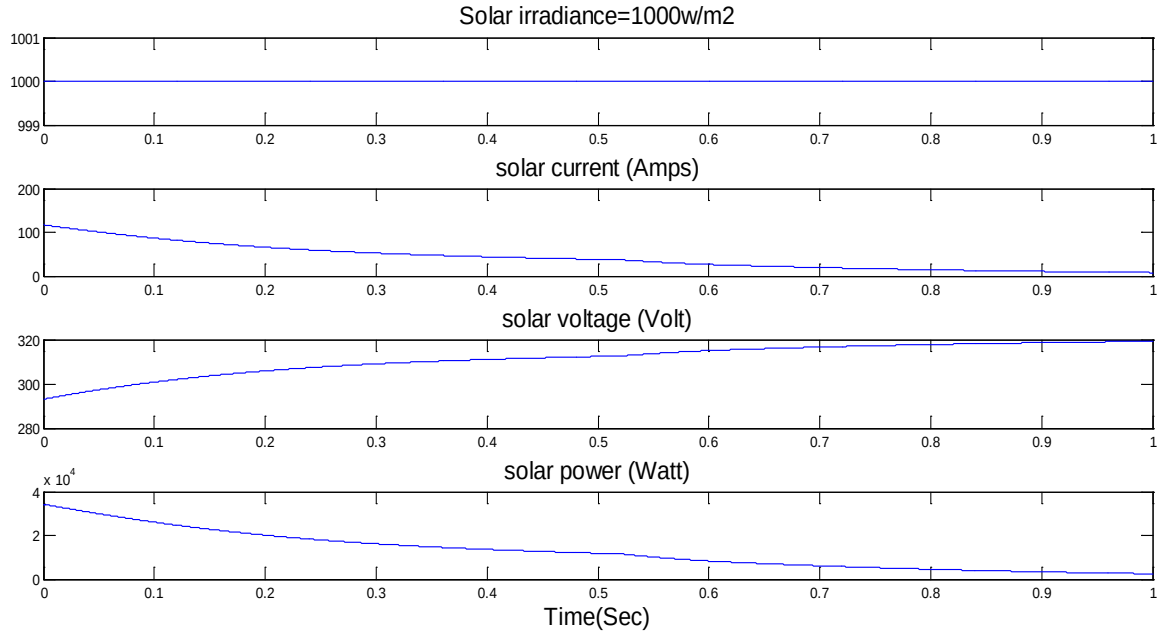

Figure 4: Simulation Results of PV Panel Outputs

The SPV panel output gives SPV voltage current, and power. The panel voltage is 140 voltage, panel current is 11. 2A, when shading condition is uniform, power of panel is 2438W and the irradiance is 1000w/m^2. From figure 5 represents the simulation output of BLDC motor characteristics of honey bee mating optimization in a condition said to be partial shading. The current of stator is 1.20A. Stator back electromagnetic force is 132.4V. Speed of Rotor is 1752 rpm and torque is 0.934N.m. The output voltage of converter is 262.4V is found as present in figure 6.

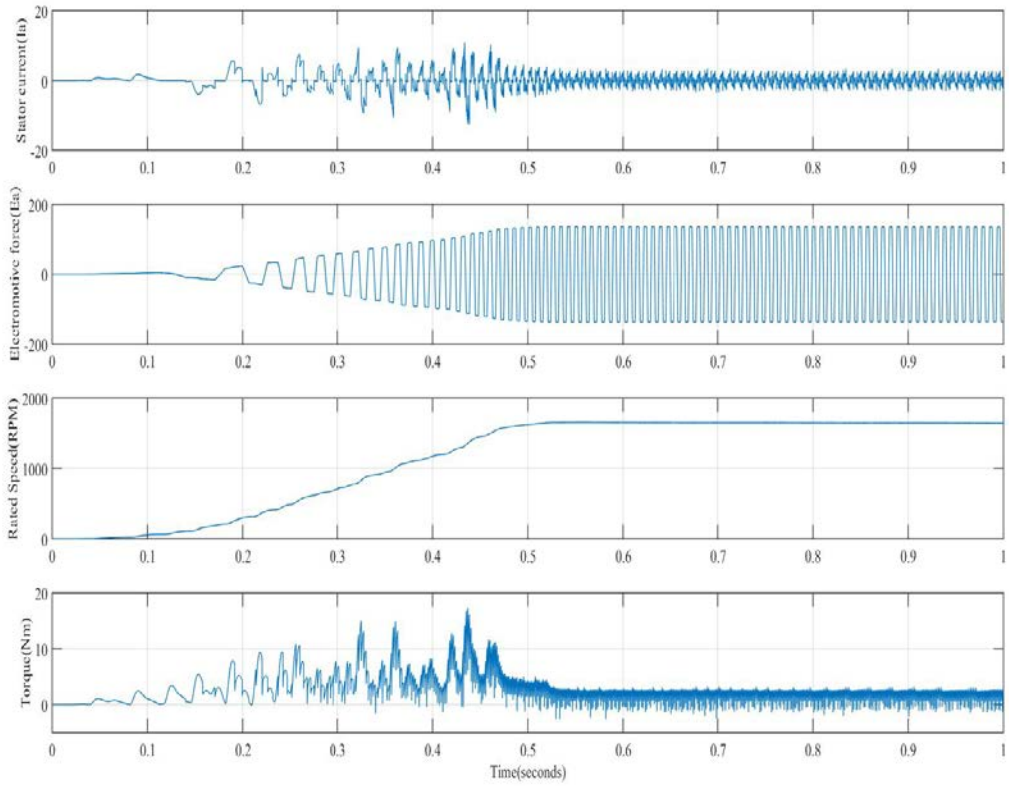

Figure 5: Simulation Result of Solar Array fed BLDC Motor under the Condition of Partial Shading in BAT

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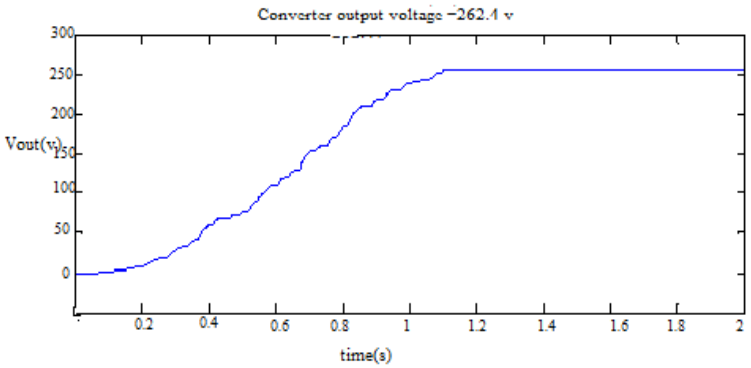

Figure 6: Simulation Result for Landsman Converter Under Condition of Partial Shading Using BAT Optimizer

From figure 7 shows the simulation output of SPV fed BLDCM bird mating optimizer in a condition said to be partial shading. In this condition, level of solar irradiation is non uniform. The converter output voltage is 265.8V. The simulation result of Brushless DC motor characteristics. The current of stator is 1.19A. Stator back electromagnetic force is 23V. Speed of Rotor is 1720 rpm and electromagnetic torque is 0.93Nm. The experimental results of the Landsman converter in Bird Mating Optimizer is given in figure 8 in a condition said to be partial shading.

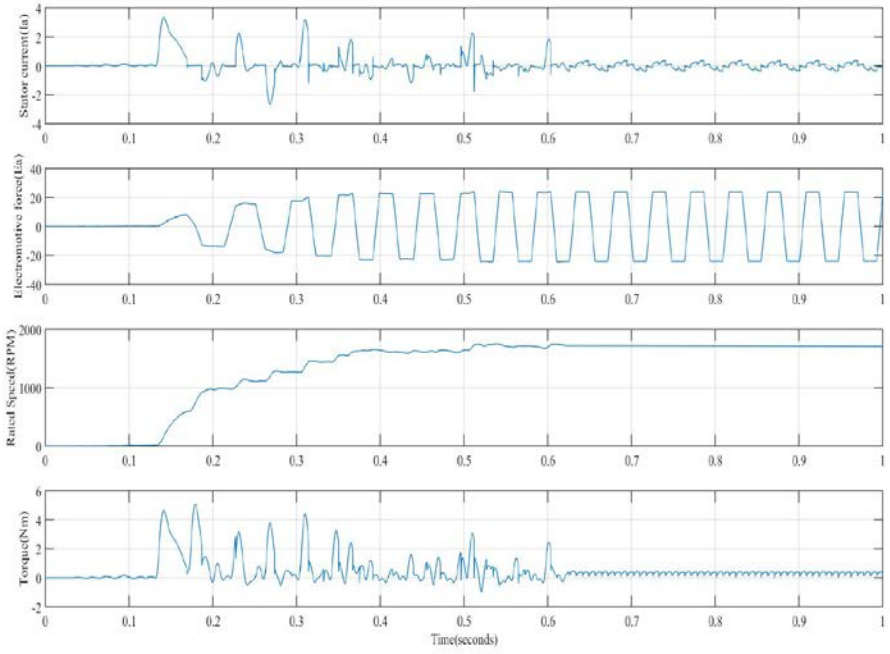

Figure 7

The comparison of SPV fed BLDCM characteristics of BAT and Bird Mating optimization under the conditions of partial shading are given in Table 1.

Table 1: Analysis of HBMO MPPT and BMO MPPT

Parameters	Converteroutputvoltage(V)	Statorcurrent(A)	Backemf (V)	Rotorspeed (rpm)	Electromagnetictorque (N.m)
BAT-MPPT	262.4	1.20	132.4	1752	0.934
BMO-MPPT	265.8	1.19	23	1720	0.93

From figure 8 clearly shows that the Landsman converter using BAT optimization is more efficient than the other existing ones. In this system the converter using BAT optimization algorithm is to achieve a fast response by

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low input current. This optimized system has an efficiency equal to 99.9% at full load condition for 100 W whereas for the same operating conditions the system operating in open loop condition, HBMO optimization algorithm can achieve only 83.9%, BMO optimization algorithm can achieve only 84.9%, & BBMO optimization can achieved 85%, respectively. This is evident from the obtained results.

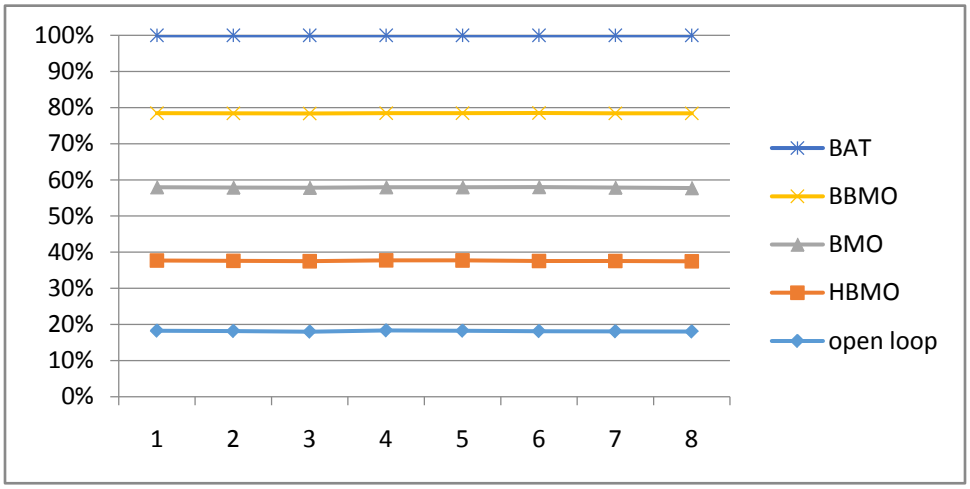

Figure 8: Efficiency of Landsman Converter

IV. Conclusion

In MATLAB SIMILINK environment, proposed system has been simulated utilizing a Landsman Converter using various optimization techniques. The job principally focuses on the development of an efficient PV array that are used for optimized controller of the converter voltage. Landsman Converter output is presented in the simulation result. The BAT Optimizer produces best active performance and rapid convergence rate and it can give better accuracy in the global optima. The BAT method provides that the converter feedback is enhanced than open loop, BMO and BBMO and Honey Bee Mating Optimization techniques. Better speed regulation and reduced torque ripple are noticed with the proposed BAT optimizer, effectiveness of the proposed system is proved.

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