CHAPTER 5

A BATTERY PERFORMANCE AWARE OPTIMAL SOLAR TRACKING SYSTEM TO FULFIL HOME APPLIANCES

The solar energy is very desirable, which has improved energy which is required to create an extra attractiveness of renewable energy resources. The solar energy’s harvesting requirement becomes highly composite activity, which focus on the diverse researches with the target of achieving high power point. In previous work, HBAT-DEF algorithm is providing for recognizing the perfect values of angle and position of solar devices in order to acquire the high power point range. Alternatively, the photovoltaic panels won’t generate steady voltage and power results in battery performance deprivation and also the life of the battery will be reduced desirably.

To rectify this issue, in the proposed system, Battery Performance aware Optimal Solar Tracking System (BPOSTS) is presented. In this structure, the power production Dynamic programming based on Policy Iteration (DPPI) Algorithm is raised by providing the best possible values of angle and position of solar devices. Then for adjusting the voltage power, the Single-Stage Balanced Forward Flyback Converter (SSBFFC) used, they are unevenness while it is observed from the solar openly.

Finally, the battery lifetime performance is improved by using three phase charging method which can improve the storage performance, hence, the duration of the battery cell will be improved. Simulation result were done
and it is checked and proved, that the proposed works output is higher than the current work.

5.1 INTRODUCTION

Renewable energy resources become highly desirable widespread energy resources in present years, and researchers created an important and specific try to enhance the efficiency of these systems and to improve the functionality. The conservative energy crisis and rising rate of environmental chaos for instance the air pollution and global warming; result in highly rising rate of utilizing the non-conventional or renewable energy resources hence they are spotless and free from a harmful effect. The solar energy is considered as the most hopeful renewable energy resources.

PhotoVoltaic (PV) wraps up the conversion of light into electricity by semiconducting materials which disclose the photovoltaic effect, a reality assumed in physics, photochemistry and electrochemistry. A general photovoltaic system enforces the solar panels; and each has an amount of solar cells to create an electrical power. The initial stage is the photoelectric effect subsequent to an electrochemical process where the crystallized atoms gets ionized in a sequence, and creates an electric current Solar Cell – Chemistry Encyclopedia. PV installations possibly will be ground-mounted, rooftop mounted or wall mounted. They might be mounted in a stable direction in order to raise the production rate and the value or they might be mounted on trackers which follows the sun crossways on the sky.

A solar tracker is equipment on which solar panels are fixed which follows the navigation of the sun crossways the sky by confirming that the extreme number of sunlight hits the panels all the way through (Fam 2012). While it is matched up with the cost of the PV solar panels, the solar tracker’s price is comparatively less. The majority of photovoltaic (PV) solar panels are
fixed in a permanent location platform, for example, it is fixed on the slanting roof of a house or on structure set to the ground. As the sun moves crosswise the sky all through the day, this is distant is from a perfect resolution.

The photovoltaic panels won’t create a steady voltage and the battery performance will be less and as well the life time of the battery will be reduced desirably. This issue is rectified in the research by providing the new structure named as Battery Performance aware Optimal Solar Tracking System (BPOSTS). In order to raise the power production Dynamic programming dependent upon Policy Iteration (DPPI) Algorithm is presented in our work, to recognize the best possible values of angle and position of solar devices. Then for adjusting the voltage power, the Single-Stage Balanced Forward Fly back Converter (SSBFFC) is used, while it is observed from the solar openly. At last battery life span performance is enhanced by utilizing three stage charging method that will enhance the storage performance, therefore the life span of battery cells could be enhanced.

5.2 RELATED WORKS

One among the first explanations of a MPPT system had been created public while (Cheikh et al. 2007) described as a self-adaptive DC converter for spacecraft power supply. It was the initiating point of the huge growth of the domain, (Larbes et al. 2009). Bread board confirmation achieves energy transfer in the 50W range with the help of the hill climbing algorithm associated with bidirectional current mode power cell, (Esram & Chapman 2007) provides a switching system which modifies the cell array topology and connections or the configurations of the cells to obtain the required amount of voltage for the duration of diverse times of a day.
Kadri et al. (2011) addressed that if, battery doesn’t exists in the system, an uncomplicated control could be enforced, to tie the bus voltage at close to constant level. In (Masoum et al. 2002), thought that the boost converter is exhibited to have minor advantages over the buck converter primarily at minor light levels. In (Giraud & Salameh 2001) utilized PV system with storage batteries, as a MPPT equipment to enhance the battery charging. The enhancement should be higher than the interior loss of the device itself.

MPPT device below the different climatic conditions of Beijing and Gaungzhan in china was considered. In (Kolhe et al. 2003) detected that a PV array alone had comparatively less output power density and had desirably drooping I-V features. Accordingly, MPPT was used. This concept was achieved by simulation study by PSM and Lab view software. In (Eakburanawat & Boonyaroonate 2006) described a TE battery which uses the waste heat and explained a battery charger which was provided by TE power modules.

Salas et al. (2006) computed the MPPT techniques in relation to Quasi seeking techniques which has a wave filtering technique, backup table technique and so on and true searching techniques altogether with sampling techniques, differentiation technique and so on. In Xiao & Dunford 2004) proposed a modified hill climbing MPPT method for PV system installed as a test bench which uses the TMS320LF2407 controller for automatic testing mechanism.

Yu et al. (2011) presented the design and experimentation outcomes of improved dynamic MPPT performance with the help of P&O MPPT technique which was measured by European Standard EN 50530. Performance of P&O technique was measured by 250 KW PV inverter. It was disclosed that P&O technique confirms the maximum dynamic MPPT
effectiveness under EN 50530. G.M.S. In (Esram & Chapman 2007) presented a study of two high power point tracking techniques for grid connected photovoltaic systems. The perturbation and examination were considered to be an excellent forms and the incremental conductance were audited to detect the performances of photovoltaic systems.

Femia et al. (2005) presented the customization of duty cycle perturbations to the dynamic nature of the boost converter to gather the knowledge of P&O MPPT. They had disclosed that the P&O parameters have to be changed to the dynamic behaviour of the specific converter adopted. A hypothetical analysis allowing the best possible option of that parameter was done and was experimentally proved.

5.3 OPTIMAL SOLAR TRACKING SYSTEM WITH BATTERY PERFORMANCE IMPROVEMENT

Renewable energies were considered to be important energy resources that are pollution free and could generate the power energy resources. Solar energy is an important energy resource in the India, that too in Tamilnadu. Here, sun light will be available of about 90%. Photovoltaic cells were used to generate the power from the solar energy. Here in our work, the best possible dealing of photovoltaic machines concentrates on getting the perfect power production ability and it will protect the life time of the battery.

The energy storage is demanded in many PV systems, since the energy generation and usage doesn’t typically coincide, furthermore, till evening, the solar power produced in the day time isn’t necessary and hence, it has to be temporarily stored, to do so an electrical storage batteries were generally utilized in PV systems. Ideally, a battery bank should have the capacity to store power for 5 days of autonomy while in the cloudy weather.
If the battery bank is less than 3-day capacity, it has to undergo the cycle deeply on a regular basis and the battery will have a shorter life. System size, specific demands and expectations will define the best battery size for any system as,

\[
\text{Battery size} = \frac{W_{el}}{\text{system voltage}} \times \text{Autonomy days} \cdot \frac{1}{n_B \times \text{Max. DOD}} = \text{AH}
\]

where;

\( W_{el} \) : power from PV.

Autonomy Days : Number of days of non-sunshine often 2 days.

\( n_B \) : is the battery efficiency often (80%).

DOD : Depth Of Discharge (80%).

Our design’s target is to design automated solar tracking system. So, we have utilized the Arduino microcontroller, four LDR for identifying the light intensity and two PMDC motors for the horizontal and vertical movement. Along with this, we have deployed one application program with the help of embedded C++ which is loaded in Arduino microcontroller. In the simulation, the light sensitive LDR device is utilized as input to identify and track the sun position, according to the sensors reading and created sun tracking error. The Control unit (Arduino) produces the voltage which is utilized to command the circuit to drive the motor which results in the rotational displacement of electric motor, which is the movement of the solar tracking system.
A novel framework termed as Battery Performance aware Optimal Solar Tracking System (BPOSTS) is proposed. Here, to raise the power generation Dynamic programming according to the Policy Iteration (DPPI) Algorithm is proposed to identify the best possible values of angle and position of solar devices. After that Single-Stage Balanced Forward Fly back Converter (SSBFFC) is used for adjusting the voltage power which are 8unbalanced, while it is supervised from the solar openly. Finally, the life time of the battery performance is enhanced by three phase charging method which improves the storage performance, so this will enhance the battery life. The modules which are in the presented methodology are listed in this way:

- The best possible tracking of angle and position of solar devices by DPPI algorithm
- Voltage balance control by SSBFFC
- Battery life span protection by Three stage converter

The thorough illustration of the presented method is listed in the subsequent subsections.

5.4 OPTIMAL TRACKING OF ANGLE AND LOCATION OF SOLAR DEVICES USING DPPI ALGORITHM

The beam radiation on a tracking surface is increased by orienting the surface, inside the restrictions of the tracking apparatus, so the solar radiation incidence angle will be reduced. The incidence angle, θ is the angle between a ray from the sun and the normal to the surface. This paper gives a substitutive solution for one-axis trackers with the collector surface parallel to its axis.
The minimum incidence angle is rectified for by initially defining the necessary rotation of the surface about its axis. Next, the surface tilt and azimuth were defined from the rotation angle and the tilt of the tracker axis. At last, the value of the incidence angle is computed from the surface tilt and azimuth angles and the zenith and solar azimuth angles. Although the rotation angle is an intermediate value for defining the incidence angle, it has applications of its own for the managing the tracker movement and for modelling the solar radiation available for a collector. For a motorized tracker with fixed gearing, the tracker rotation is directly proportional to the number of motor revolutions; accordingly, the computed rotation angle can be utilized to define the number of motor revolutions to navigate the tracker to its optimum position. In the modelling collector solar radiation, the rotation angle was utilized to account for non-optimum tracking which happens when the optimum rotation angle goes beyond the rotation limits of the tracker.

5.4.1 Relationship between Rotation Angle and Surface Tilt and Azimuth

The surface tilt, $\beta$, and the surface azimuth, $\gamma$, are functions of the axis tilt, $\beta_a$, the axis azimuth, $\gamma_a$, and the rotation angle, $R$. Figure 5.1 is utilized to define the relationship among these angles. For the examinations, $\gamma_a$ is the azimuth of the tracker axis when it is noticed from the inclined end of the tracker axis, and $R$, also noticed from the inclined end of the tracker axis, is positive for clockwise rotation and negative for counter clockwise rotation. $R$ equals zero when the normal to the surface is in a vertical plane. In Figure 5.1, this normal is the unit normal which is denoted by the line OA. Line OB is the unit normal rotated angle $R$ about the axis. The triangles created by the unit normal and the vertical axis were utilized to derive equations for the surface tilt and azimuth.
Identifying those triangles AOC and DOE are similar triangles whose corresponding sides were proportional; the surface tilt is indicated as:

\[ \beta = \arccos[\cos R \cos \beta_a]. \quad (5.1) \]

The surface azimuth varies from the axis azimuth by the angle BED. Angle BED equals arcsin[\(\sin R \div \sin \beta\)]. Accordingly, the surface azimuth is indicated as:

\[ \gamma_a = \gamma_a + \arcsin[\sin R \div \sin \beta], \quad \text{for } \beta \neq 0, -90^\circ \leq R \leq +90^\circ \quad (5.2) \]

---

**Figure 5.1** Geometry for one-axis tracking surface
If $\beta$ equals zero (horizontal surface) $\gamma$ can’t be defined from Equation (5.2). So, $\gamma$ is allotted with any value, since the surface is horizontal and considered to have no azimuth response. Equation (5.2) also won’t provide exact solution when $R$ is outside the range of $-90^\circ$ to $+90^\circ$ since it doesn’t distinguish between trigonometric quadrants while proceeding the arcsine operation.

$$\gamma = \gamma_a - \arcsin [\sin R \div \sin \beta] - 180^\circ \text{ for } -180^\circ \leq R < -90^\circ \quad (5.3)$$

$$\gamma = \gamma_a - \arcsin [\sin R \div \sin \beta] + 180^\circ \text{ for } +90^\circ < R \leq +180^\circ \quad (5.4)$$

$R$ can fall outside the range of $-90^\circ$ to $+90^\circ$ when the solar azimuth varies by more than $90^\circ$ from the axis azimuth and the axis tilt is greater than zero. Utmost cases are midnight sun conditions for northernmost locations, where $R$ can range from $-180^\circ$ to $+180^\circ$ as the tracker follows a sun that never sets. For $R$ values outside the range of $-90^\circ$ to $+90^\circ$, either equation (5.3) or Equation (5.4) enforces.

### 5.4.2 Rotation Angle for Optimum Tracking

Different sources provide the following trigonometric relationship for the incidence angle:

$$\cos \theta = \cos \beta \cos \theta_z + \sin \beta \sin \theta_z \cos(\gamma_s - \gamma) \quad (5.5)$$

where $\theta_z$ and $\gamma_s$ are the zenith and solar azimuth angles, and can define from the time and location with the help of different algorithms. To bring-in angle $R$ into Equation (5.5) and to discard $\beta$ and $\gamma$, substitutions for $\cos \beta$, $\sin \beta$, and $\cos(\gamma_s - \gamma)$ are created with the help of Equation (5.1) and Equation (5.2) and different trigonometric identities. This procedure is given in the appendix. The resulting expression for the cosine of the incidence angle is:
\[
\cos \theta = \cos R \left[ \sin \theta z \cos (\gamma_s - \gamma_a) \sin \beta a + \cos \theta z \cos \beta a \right] + \sin R \sin \theta z \sin (\gamma_s - \gamma_a).
\]

(5.6)

For optimum tracking, the value of \( R \) has to provide the minimum incidence angle, thereby increasing the value of \( \cos \theta \). This value of \( R \) is defined by distinguishing the Equation (5.6) in terms of \( R \), setting it equal to zero, and solving for \( R \).

\[
d(\cos \theta)/dR = -\sin R \left[ \sin \theta z \cos (\gamma_s - \gamma_a) \sin \beta a + \cos \theta z \cos \beta a \right] + \cos R \sin \theta z \sin (\gamma_s - \gamma_a) = 0
\]

\[
\sin R/\cos R = \left[ \sin \theta z \sin (\gamma_s - \gamma_a) \right] / \left[ \sin \theta z \cos (\gamma_s - \gamma_a) \sin \beta a + \cos \theta z \cos \beta a \right]
\]

\[
R = \arctan (X) + \psi,
\]

(5.7)

where:

\[
X = \left[ \sin \theta z \sin (\gamma_s - \gamma_a) \right] / \left[ \sin \theta z \cos (\gamma_s - \gamma_a) \sin \beta a + \cos \theta z \cos \beta a \right]
\]

\[
\psi = 0^\circ \text{ if } X = 0, \text{ or if } X > 0 \text{ and } (\gamma_s - \gamma_a) > 0, \text{ or if } X < 0 \text{ and } (\gamma_s - \gamma_a) < 0
\]

\[
\psi = +180^\circ \text{ if } X < 0 \text{ and } (\gamma_s - \gamma_a) > 0.
\]

\[
\psi = -180^\circ, \text{ if } X > 0 \text{ and } (\gamma_s - \gamma_a) < 0.
\]

The variable \( \psi \) places \( R \) in the correct trigonometric quadrant. For defining which value of \( \psi \) to utilize in Equation (5.7), various \( \gamma_s - \gamma_a \) is computed, as the angular displacement among the two vectors, falls inside the range of \(-180^\circ \) to \(+180^\circ \). For instance, if \( \gamma_s = 20^\circ \) and \( \gamma_a = 210^\circ \), \( \gamma_s - \gamma_a \) is computed as \( 20^\circ + 360^\circ - 210^\circ = 170^\circ \) and not \( 20^\circ - 210^\circ = -190^\circ \).
5.4.3 Procedure for Determining Incidence Angle

The preceding equations are utilized to define the beam incidence angle on a one-axis tracking surface might be assumed as a series of steps:

- **Step 1** - Calculate $\theta_z$ and $\gamma_s$
- **Step 2** - Calculate $R$ using equation (5.7)
- **Step 3** - Calculate $\beta$ using equation (5.1)
- **Step 4** - Calculate $\gamma$ using Equation (5.2), Equation (5.3), or Equation (5.4), as appropriate
- **Step 5** - Calculate $\theta$ using equation (5.5).

To focus on collector, the procedure can be simplified slightly with the help of Equation (5.6) to compute the incidence angle after $R$ has been defined in Step 2. The surface tilt, $\beta$, is required to model the diffuse radiation for a flat-plate collector, has no role in defining the beam radiation for a concentrator; accordingly, steps 3–5 are substituted by the Equation (5.6). Then $R$ allows perfect modelling of tracker performance since it can be distinguished to a tracker’s design parameters to see if $R$ is inside the range of the tracker’s physical rotation restrictions. If not, an extra step in the procedure can set $R$ equal to the limit of the tracker rotation range before finishing the steps 3–5. A similar step could be done with the help of $\beta$, but $R$ is more suited, since for a provided tracker the physical limits of rotation, dislike the surface tilt, it doesn’t modify if the axis tilt were modified.

The tracker rotation limits were computed for Boulder, Colorado, latitude = 40.0°N, and Barrow, Alaska, latitude = 71.3°N, for a flat-plate one-axis tracker with a south facing axis azimuth and tilted from the horizontal at an angle equal to the site latitude. Monthly and yearly radiation available to the collector were modelled with the help of the typical meteorological year
hourly data, the Perez disseminate the radiation model, and the incidence angles were computed when two different rotation limits are imposed: $-180^\circ$ to $+180^\circ$ for unrestricted rotation and $-70^\circ$ to $+70^\circ$ to indicate the physical limits of the tracker. It is then distinguished with unrestricted rotation limits. The use of the $-70^\circ$ to $+70^\circ$ rotation limits for the Barrow site gets decreased for the accessible yearly radiation for the collector by 3.3% with a maximum monthly reduction of 5.5% occurring in June. For Boulder, the variations for the two rotation limits were minimal. The yearly collector radiation was decreased 0.3% and the June collector radiation was decreased 0.8%. Barrow showed larger variations for the two rotation limits since its more northerly location results in a wider range of spring and summer solar azimuths, this, in turn, demands a wider range of rotation limits for optimum tracking.

5.4.4 Optimal Tracking of Angle and Location

Our research focus on calculating the best possible ST trajectories for the day ahead, based on the current weather forecasts which could actually come from online providers without cost. For the final part, it uses the dynamic programming and, specifically an instinctive policy iteration method (and variants). The method interlaces two separate PI procedures which are used in few other fashions. The initial PI procedure, SlopePI, thinks a random input policy for the above MDP, e.g., a myopic one. Then it attempts to acquire better than that policy, and also in a common PI fashion, but assuming a permanent azimuthal policy, $\pi_k$. Specified this permanent $\pi_k$ policy, it calculates an appropriate best possible slope-positioning policy, $\pi_y$. The output policy is afterward giving in a second PI algorithm that guesstimates the best possible (given $\pi_y$) azimuth-positioning policy, $\pi_y$.

The method re-tries until merging, or till some computational or time confine is achieved. By consolidating the determined strategies figured
for each axis, we could sketch from a ST policy. The comparative PI algorithm could be enthusiastically connected for single axis tracking, with the activity decision process for the static axis (the slant one, in regards to VSAT) considering only an arrangement of permanent probable orientations for the total movement (so as to guesstimate the ideal settled slope angle for VSAT tracking all through the following day). The in general PI strategy is uncovered in ALGORITHM 1, while ALGORITHM 2 characterizes the PI procedure to sketch from an slope policy (the PI for beginning an azimuthal arrangement is totally indistinguishable). Observe that STPI effectively modified in the midst of settling MDPs with state-action spaces that are requests of greatness lesser than that required by the genuine issue. In spite of the fact that there are no legitimate affirmations for intersection to the best possible policy, 4 the strategy is instinctive, and indicates predominant conduct.

ALGORITHM 1

1. Procedure STPI ($\pi$)

2. Initialize $\pi_y$ and $\pi_k$ based on $\pi$

3. While $\pi_y$ and $\pi_k$ are not stable do

4. $\pi_y \leftarrow$ SLOPEPT ($\pi_y, \pi_k$)

5. $\pi_k \leftarrow$ AZIMUTHPI ($\pi_k, \pi_y$)

6. Derive $\pi'$ by combining $\pi_k$ and $\pi_y$

7. Return $\pi'$

ALGORITHM 2 : Slope policy iteration

1. Procedure SLOPEPI ($\pi_y, \pi_k$)
2. while \( \pi_y \) is not stable do

3. for all \( t \in I \) in descending order do

4. for all \( s \in S \) that can emerge based on \( \pi_k \) and \( t \) do

5. \( a \leftarrow <K_a = \pi_k(s,t), Y_a = \pi_y(s,t)> \)

6. \( V_t(s) \leftarrow \sum_{s'} P(s, a, s')(R_a(s, s') + V_{t+1}(s')) \)

7. For all \( t \in I \) (in any order) do

8. For all \( s \in S \) that can emerge based on \( \pi_k \) at \( t \) do

9. \( \pi_y(s, t) \leftarrow \arg\max_y \sum_{s'} P(s, a, s')(R_a(s, s') + V_{t+1}(s')) \)

10. Return \( \pi_y \)

### 5.5 VOLTAGE BALANCE CONTROL USING SSBFFC

To rectify the voltage imbalance problem, a high competence and high power factor single-stage balanced forward fly back converter is proposed and explained in Figure 5.1. As the proposed converter links the forward and fly back topologies, it could function as the forward and fly back converters while switch turn on and off periods, respectively. Accordingly, it couldn’t only proceed with the power transfer for the duration of an entire switching time nevertheless as well it acquires the high power factor. Specifically, as the charge balanced capacitor \( C_b \) could produce the proposed converter to proceed with the forward operation regardless of the input voltage, the magnetizing inductor offset current, core loss and transformer size could be minimized.
Figure 5.2 Proposed single stage PFC forward fly back converter circuit

Figure 5.2 explains the circuit diagram of the proposed forward fly back converter. As disclosed in this figure, its principal side is perfectly similar as that of the traditional fly back converter which has one power switch (M1) and one transformer. As a contrary, its secondary side has one output inductor (Lo) for forward operation, one DC blocking capacitor (Cb) for balancing operation and three output Diodes (D1, D2, D3). While M1 is conducting, the proposed converter works as a forward converter. Alternatively, if M1 is blocked, the presented converter works as a fly back converter. Nevertheless, in case it is assumed that the presented converter has no balancing capacitor Cb, aforesaid forward operation is generally simple, while the reflected primary voltage Vin/n to the transformer secondary side is higher to the output voltage Vo.
So, the forward converter is rooted from the buck converter. Accordingly, to the forward-fly back converter which proceeds as a simple fly back converter over the range of $Vin/n < Vo$. Specifically, at the least input voltage near $Vin=90\text{Vrms}$, $Vin/n$ is lesser than $Vo$, throughout a lot of periods and hence, the transformer has a large magnetizing offset current alike to the traditional fly back converter. The transformer core will be loosed and volume was furthermore larger to those of the traditional fly back converted. Preferably, if the balancing capacitor $C_b$ is successively added with the transformer secondary side, it could produce the average current via $C_b$ for the period of forward operation turn out to be perfectly identical as that for the period of fly back operation by the charge balance principle of $C_b$. In other terms, as the voltage across $C_b$ is charged by fly back operation, then it is appended to the $V_{sec}=Vin/n$ for the period of forward operation, $Vin/n+V_{cb}$ produced to be higher than $Vo$ and hence, the forward operation is apparent, even at $Vin/n<Vo$. Accordingly, the research forward-fly back converter with the balancing capacitor $C_b$ could as well as proceed with the forward and fly back converters aside the input voltage.

5.6 BATTERY LIFETIME PROTECTION USING THREE STAGE CONVERTER

The customized two stage Constant Current Constant Voltage (CC-CV) charging technique is nothing but a three stage battery charging methodology. In desire with the two way charging phases, it has three charging stages. The topology of the circuit is used to establish this charging algorithm which is similar to the two stage CCCV charging method as described beneath in the figure 5.3,
The required charging profile of the proposed three stage charging technique is disclosed in the Figure 5.4,
The three stage charge control logic is shown in Figure 5.5,

Figure 5.5  Control logic with PI controller for the three stage charge control algorithm

At the initial stage of the charging process, the discharged battery terminal voltage is matched up to the trickle charge voltage threshold. If the battery voltage is below the trickle charge voltage threshold (given by battery manufacturer) then the trickle charging phase will become easy. Here in the above Figure 5.5, the switch state termed as $V < V_{\text{Trickle}}$ is selected if the charging current is given to the trickle mode or not. When this state is right afterward the upper case (0.7 ampere) then it is enabled and in case if this is false afterward to the subsequent switch, this condition will come into action. The PI controller is meant in such a way that it minimizes the error amid the
real and the needed/reference value of charging current and in relation to that PWM (Pulse Width Modulation) signal is given to the dc-dc buck converter.

The buck converter is given to the preset trickle current of the battery. The trickle charge current point is set to C/10 amperes here C is the ability of the battery in Ampere-hour (Ah). The lead acid battery used here for experiment has a capacity of 7Ah. So, the trickle charging current set is 0.7 Ampere. The battery voltage initiates rising and then the trickle charge current is given to the battery till the battery voltage acquires the Trickle voltage threshold.

5.7 EXPERIMENTAL RESULTS

The experimentation assessment of the presented research method is performed in the MATLAB simulation environment. The presented research scenario called Battery Performance aware Optimal Solar Tracking System (BPOSTS) is matched up with our existing work Hybridized BAT with Differential Evolution function (HBAT-DEF) and the previous work called Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) to verify the performance enhancement. This assessment is carried out in opposition to diverse performance metrics, for instance

- Prediction accuracy
- Convergence rate
- Voltage level

These measures are assessed underneath changing load conditions and timing for both presented and previous research methods. The comparison assessment is shown in the graph format that is demonstrated in the subsequent Figures from 5.6 to 5.8.
5.7.1 Prediction Accuracy Comparison

Accuracy is described as, "The capability of a measure to match the real value of the quantity being deliberate". In the presented work accurateness is described as the capability of the research method to discover the location and place of sun properly with the intention that the greatest power point could be attained. In the subsequent figure 5.6 prediction accurateness comparison is demonstrated

![Accuracy Comparison](image)

**Figure 5.6 Accuracy comparison**

In the above figure 5.6, performance assessment of the research and previous techniques is specified. From this specified figure it could be verified that the research scenario results in giving superior result to the previous researches. The accurateness of the current methodology is enhanced 24% higher than the previous research techniques.
5.7.2 Convergence Rate

In arithmetical analysis, the speed where the convergent series approaches its boundary is considered as the rate of convergence. Even though securely speaking, a boundary doesn’t give enough information about any finite first part of the series; this concept is of realistic significance if we manage a series of consecutive rough computation for an iterative technique, since the afterward classically less iteration were necessary to create a helpful rough computation if the rate of convergence is higher. This might even produce the distinction amid required for ten or a million repetitions were irrelevant. The comparison of the convergence rate value of present and earlier research methods is explained in the Figure 5.7.

![Figure 5.7 Convergence Rate comparison](image-url)
In the above Figure 5.7, the performance assessment of the current and previous methodologies is given for the convergence rate. From this specified figure it is proved that the present research scenario’s output in the provided result is distinguished with the earlier research works. The convergence rate of the current research BPOSTS is superior to the previous works by discovering the worldwide solution in words of poor utilization of populations.

5.7.3 Voltage Level Comparison

Voltage level indicates the ability of the Photovoltaic power system to generate the power with the active navigation of sun. The system couldn’t generate extreme power point in case, it isn’t tracking the sun location and position best possibly.

![Figure 5.8 Voltage level comparison](image-url)
In the subsequent Figure 5.8, voltage level considered in the diverse sun locations is matched up for the proposed and earlier scenario.

In the above Figure 5.8, performance assessment of the proposed research method and earlier techniques is given for the voltage level. From this figure it is shown that the research scenario’s output the proposed works output is higher than the earlier research works. The voltage stability of the present research BPOSTS is higher than the earlier works by holding the voltage flow rate for diverse sun locations and positions.

5.8 SUMMARY

The target work in the research is the best possible solar tracking, in order to fulfil the requirements of the home based and industrial based applications. With the help of the new framework called Battery Performance aware Optimal Solar Tracking System (BPOSTS), this is acquired in the current research work. In the proposed system, the Dynamic Programming dependent upon Policy Iteration (DPPI) Algorithm is brought-in, to raise the power generation and also to identify the best possible values of angle and location of solar devices. Afterward Single-Stage Balanced Forward Fly back Converter (SSBFFC) is used for stabilizing the voltage power which are unbalanced while supervising from the solar openly. Then the battery life is improved by three stage charging method that would improve the storage performance, this will improve the battery life. The simulation output has been performed and the result is verified and proved that the BPOST is 4% better than HBAT-DEF, 25% better than GA and 49% better than PSO in terms of accuracy, 4% better than HBAT-DEF, 5% better than GA and 6% better than PSO in terms of convergence rate and 1% better than HBAT-DEF, 5% better than GA and 6% better than PSO in terms of voltage level.