Design of Solar PV Based EV Charging Station with Battery Performance Enhancement

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Abstract -Currently renewable energy sources are adopted and embraced in completely all field. Nowadays electric vehicle also coming to concerns of each and every company. All countries are trying to increase its efficiency and completely keep it connected to renewable energy. Due to this the option of solar energy is selected as it is easy to install on each and every geographical condition. The work in this research displace the photovoltaic based charging station for electric vehicles so that the voltage fluctuations and voltage sag can be minimized as possible. After this all the work is tried to optimize by different technique namely Whale and PSO. Fuzzy controller is used for optimization. All the results are calculated by MATLAB simulations and a discussed thoroughly.

Keywords— PSO, PV, EV charging, Whale optimization, battery optimization

I. INTRODUCTION

Nowadays, pollution is a very significant problem worldwide, especially in developing countries. Countries are facing different types of pollution problems on different scales. Using fossil fuels like coal, petrol and diesel plays a vital role in electricity generation. On the other hand, these are the main source of pollution also. Due to global political issues, developing countries are also not sharing these technologies with others. Due to this sum of the countries are very enriched and upgraded in the scale of electricity and development. On the other hand, some are very deprived of it. Indian prime minister in November 2015 gave an idea to make in India aspect for solar. This was achieved by the alliance with different countries. There were nearly 121 countries united for this. This alliance is found on 13th November 2015 in Paris, and its headquarters is in Gurgaon, India. With all these invents, India is trying to be more independent from commercially used nonrenewable sources of electricity. Solar, Wind, Bio-mas, Hydro, and Tidal energy are the new electricity sources. Vigorous research has been conducted in the field of renewable energy resources. The paper here discusses solar and EV charging. Particles form optimization technique, and WOLF optimization technique are used in this research work algorithms and equations are thoroughly discussed and studied according to the simulation in MATLAB.

A. *Particle Swarm Optimization (PSO)*

James Kennedy and Russell C. Eberhart introduced the PSO algorithm in 1995, drawing inspiration Artificial intelligence (AI) based on swarms of autonomous, decentralized systems is known as swarm intelligence (SI). Ant colonies, bird flocking, mammal herding, bacterial development, and fish schooling are a few instances of SI in nature. It is an AI method for approximating solutions to numerical maximizing and minimization problems that are exceedingly challenging or unattainable. It is a reliable stochastic optimization approach that is based on how swarms move and function. The idea of social contact is used to solve problems. Many

The PSO looks for the best solution by updating generations after being initiated with a set of random particles (keys). After each time step, the particles are evaluated based on a fitness criterion as they progress across the solution space. Each particle is updated after two iterations using the "best" values. The first one is the most advantageous outcome (in terms of fitness) thus far (the fitness value is also stored). The name of this value is "pbest." The best value so far attained by each particle in the population is another "best" value that the particle swarm optimizer keeps track of. This second-best price is referred to as "gbest" and is a global best. The second-best matter is referred to as a local best and is known as "lbest" when a particle uses some of the population as its topological neighbors. Neighborhood bests enable simultaneous search space exploration and minimize the likelihood that PSO may enter local minima but slow convergence speed. According to the distance between its current location and "pbest" and the distance between its current position and "gbest," each particle strives to change its present position and velocity. The provided optimization function is

$$v_{z+1} = v_z + c_1 rand1() * (p_{best,z} - \text{Current Position}_z) + c_2 rand2 * (g_{best,z} - \text{Current Position}_z)$$

$$Current\ Position[z+1] = Current\ Position[z] + v[z+1]$$

Where, current position[z+1]: “position of particle at z+1th iteration”, current position[z]: “position of particle at zth iteration”, v[z+1]: “particle velocity at z+1th iteration”, vz+1: “Velocity of particle at z+1 the iteration", Vz : "Velocity of particle at zth iteration", c1 : "acceleration factor related to gbest", c2 : "acceleration factor related to lbest", rand(1): "random number between 0 and 1", rand2( ): "random number between 0 and 1", gbest: "gbest position of swarm", pbest: "pbest position of particle".

PSO Algorithm:

For each particle

Particle initialization using a workable random number

End

Do

For each particle

Determine the fitness value.

Whenever the fitness value exceeds the highest fitness value (pbest) in recorded history

Create a new pbest using the existing value.

End

As the gbest particle, pick the one with the highest fitness value among all the particles

For each particle

Determine the particle's speed using the velocity update equation.

Particle position should be updated using the position update equation

End

A. *Whale Optimization*

It is a high level problem independent algorithmic framework. Mimics to hunting technique of Humpback Whales. The bubble net hunting strategy of the Humpback Whales is the inspiration of this algorithm. The Foraging behavior of the Humpback whales which helps them in survival is called bubble net hunting strategy. The Humpback whales used to hunt close to the surface. They hunt for schools frills and small fishes. The foraging is done by creating a cyclone shape path of distinctive bubbles shown in fig.1 [X]. The two methods adopted by the Whales to form bubble net are first upward spirals in which the Whales dive 12 meter deeper than the prey and starts creating bubbles in spiral shape around the prey and move upwards other is double loops this includes coral loop, lob tail and capture loop.

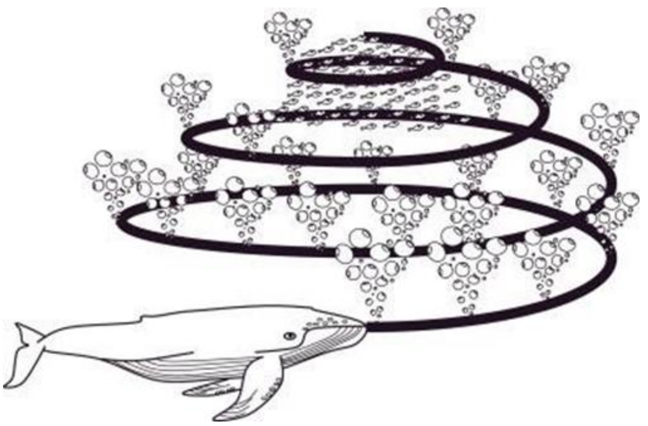


Fig 1. . Foraging behaviour of Humpback Whale

The WOA is based on the mathematical modeling of spiral bubble net feeding. The three stages involved in the WOA are:

1) Search for prey: Humpback whales search prey randomly in the sea as per their positions given by

$$\vec{D} = \left| \vec{C} \cdot \vec{X}^{*}(t) - \vec{X}(t) \right|$$

$$\vec{X}(t+1) = \vec{X}^{*}(t) - \vec{A} \cdot \vec{D}$$

$$\vec{A} = 2\vec{a} \cdot \vec{r} - \vec{a}$$

$$\vec{C} = 2 \cdot \vec{r}$$

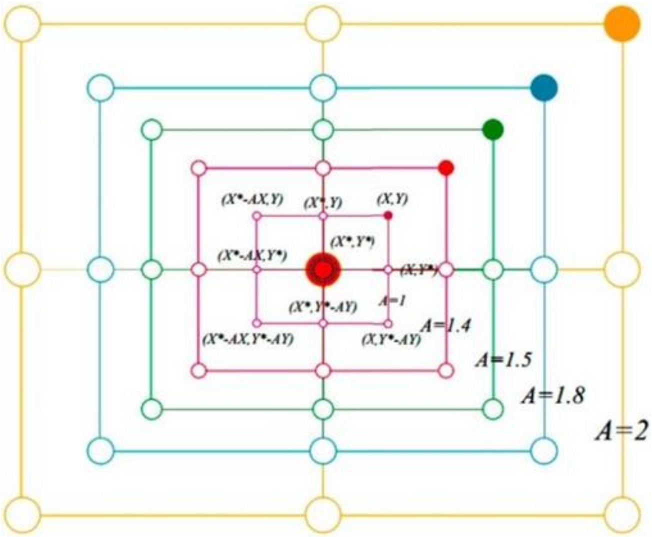


Fig.2. Exploration Mechanism of WOA

The main concerning topics in the field of EV is how to optimize the efficiency and energy stored in the energy storage unit as battery. Typically the vehicle is only dependent upon the source of energy in the circuit. To complete the cycle of transmission battery blazer vital role. Analyze this new advance optimization techniques algorithms by the researchers and keenly research upon. The work here is also discussing the optimistic work of battery in electric vehicle combined with solar harvesting units boost converters are installed which are typically used in EV charging stations. Typically the bus connecting the points of different charging ports is near about of the voltage of 300V. The study here is this place the hybrid design of battery based system in EV and PV hybrid powers source. The following structure shows the results part.

II. PROPOSED METHODOLOGY

The designed system consists of a load, a bi-directional converter, a PV module, and a battery. Solar radiation is the module's input, and once it reaches the module, it produces solar output current. The nature of the sun irradiation is variable.

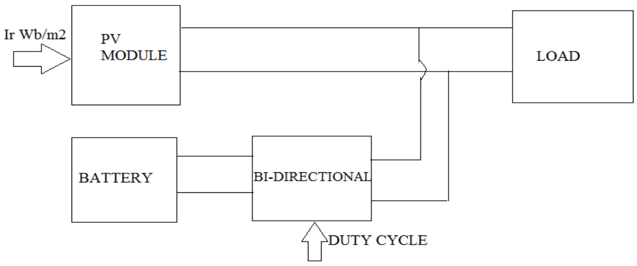


Figure 3 Block Diagram of Approach

Therefore, we connect a battery in parallel with the module to create a constant voltage at the load end. A bi-directional converter linked to the system and the batteries maintains the voltage at the load side constant even when the radiation level changes. The system components employed in the design of the suggested scheme are shown in figure 4.

Bi-directional converter switches' duty cycles are managed by a PI controller that is individually tuned by PSO and WOA. The fuzzy controller is also used to regulate them. The voltage error signal used by the PI controller is an error between the input and output voltage. This error signal is sent to the pi controller, whose output is sent to the dc-dc pwm block. This adjusts the duty cycle for switches based on the output signal of pi.

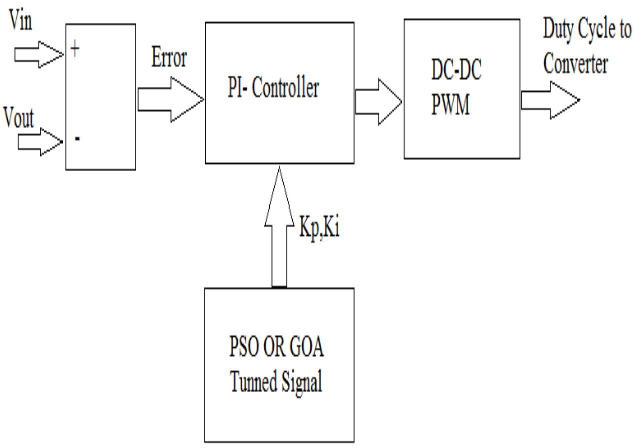


Figure 4 Block Diagram of Bi-directional Converter Switch duty cycle Generation

Voltage at the load side constant even when the radiation level changes. The system components employed in the design of the suggested scheme are shown in figure 4.

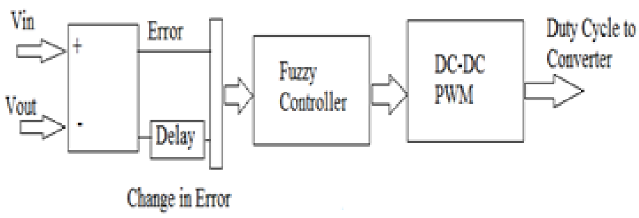


Figure 5 Block Diagram of Fuzzy logic Controller Duty cycle Generation

The above figure 5 is showing block diagram of fuzzy controller based model.

The following is the proposed system's main goal:

1. The goal is to create a simulation of a PV-based EV charging station with optimized battery performance.
2. Moreover, to reduce voltage drop within a set amount of time by employing various optimization algorithms.

PARTICLE SWARN OPTIMIZATION

To obtain the best value for a tuned pi controller, the PSO is employed. Figure 4 displays the block diagram of the PSO-based approach. The PV module input is shown in the diagram as temperature and radiation. The BMS and load are linked to the module in parallel. The saturation block, which limits the SOC value to between 25 and 100, is attached to the SOC. The battery, pi controller, bidirectional switches, inductor, and diodes that make up the battery management system. The battery connection with load and supply is controlled by the device. The bi-directional converter's function is to regulate the flow of current from the PV module to the battery and from the battery to the load.

FUZZY LOGIC

In a fuzzy controller, base duty cycle is computed and sent to switches in accordance with the rules.

Table 1 Rule base

E/C_E	NB	NS	ZE	PS	PB
NB	ZE	ZE	NB	NB	NB
NS	ZE	ZE	NS	NS	NS
ZE	NS	ZE	ZE	ZE	PS
PS	PS	PS	PS	PS	ZE
PB	PB	PB	PB	ZE	ZE

WHALE OPTIMIZATION

WO implementation Following is a full description of the algorithm:

1) Begin with some random responses
2) Update the positions of the search agents in relation to either the randomly selected search agent or the best outcome so far at the end of each cycle.
3) To offer the exploration and exploitation phase, the value is dropped from 2 to 0.
4) Compare the value of p and alternate between the spiral mechanism and the shrinking mechanism.
5) Pick a random search agent when A1 and A.

The WO algorithm is seen in figure 4.16 above. It outlines every step needed to obtain the best value for adjusting the PI controller. The Simulink figure is identical to that discussed in the PSO model section before. The only difference is that whale optimization, rather than PSO, is utilized to fine-tune the PI controller.

III. RESULT AND DISCUSSION

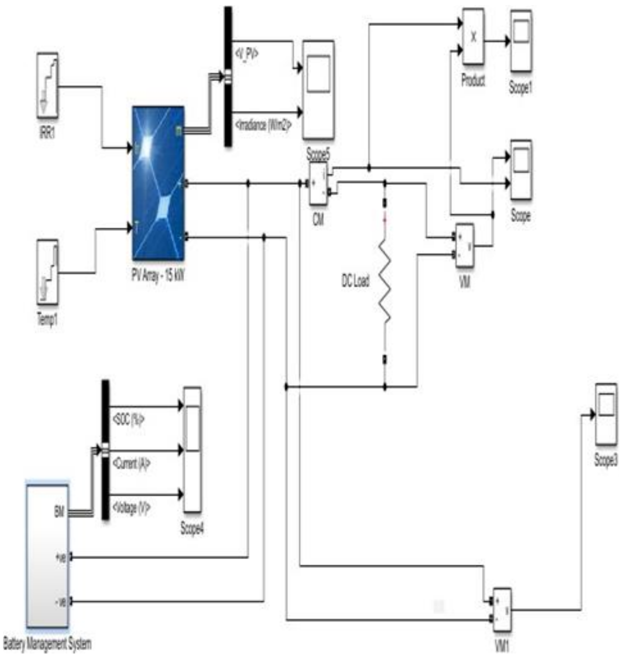


Fig.6. MATLAB simulation

MATLAB Simulink proposed work shows a PV array of 5 kw. Connected with the gradients and PV scope the input to the PV array is a radiance and temperature. In addition to this the hybrid function is also connected as a battery management system which is supplying power to the DC load which is connected directly to both of the sources the voltage meter is connected to give the scope value of the value provided to the DC load.

Figure 7 is showing the expression mechanism of whale optimization technique with generates charging specification for time in amplitude in the simulated in addition to simulated results. Value is not specified then it will be considered as zero otherwise all the parameters are more likely to be specified before the simulation start so that the data can be transmitted to the operating notes.

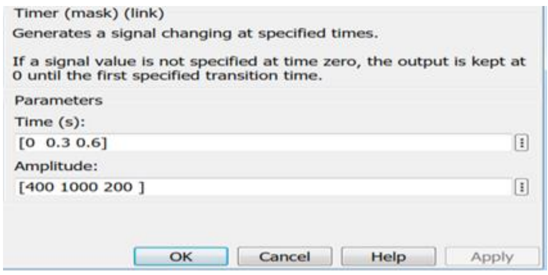


Fig.7. Exploration Mechanism of WOA

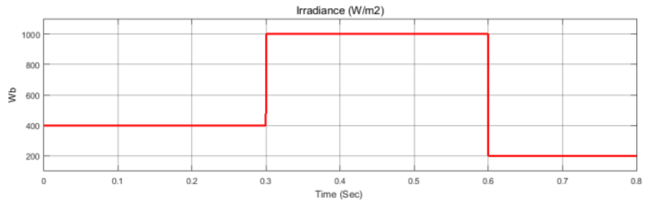


Fig.8. input solar irradiation

These are the radiance graph the figure 8 here is dispirit the radiation allowed to the simulation as a data. The irradiance starts from 400 and goes to 1000 irradiance. These are only I got the conditions according to Indian geographical conditions

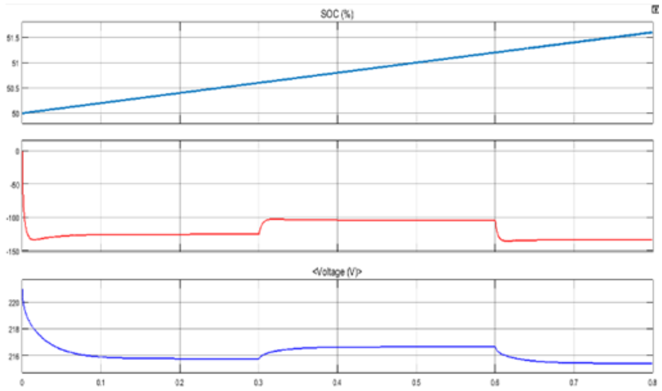
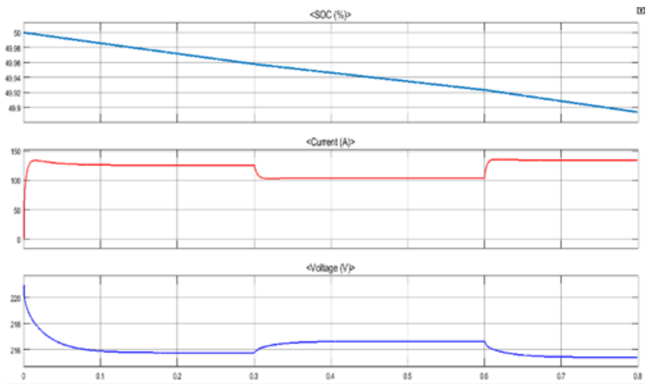


Fig.9.a. Battery charging



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3 Fig.9.b. Battery discharging

4 The flow of electrons are termed as current. The direction of the current is always opposite to direction of the electrons. Charges floors throw the battery and the plates in the battery holds them which is term as the charged battery or storage unit. The dissipation of these electrons through the battery is down as discharging of battery and holding all the electrons to itself is termed as charging of the battery. During the process of charging and discharge in the world current and voltage also changes accordingly. With respect to the load itsconnected to these are the characteristics which are shown in figure above display

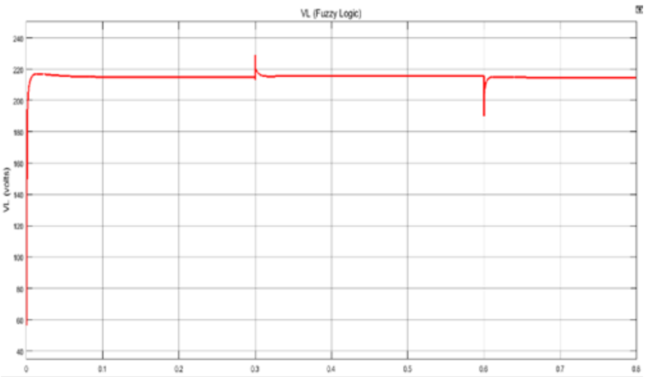

Fig.10. Output wave form of fuzzy logic controller

Optimisation by fuzzy controller are applied in the work the simulated model for the same is shown in the figure having the battery mosfets connected to the organized for optimisation generator is connected to the fuzzy logic controller to hold the commands. Figure 11 is showing the model for fuzzy controller. Figure 12 and 13 are showing the load voltage due to fuzzy logics and settling time of the controller respectively.

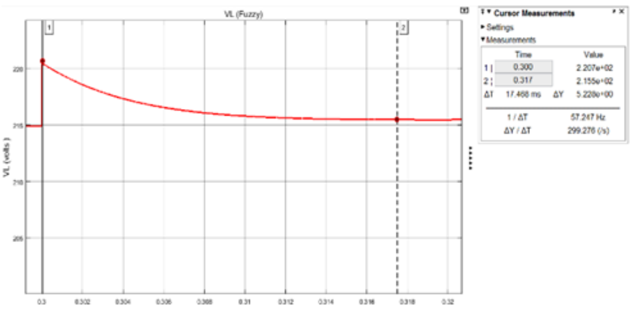

Fig.11. Settling time by fuzzy logic controller

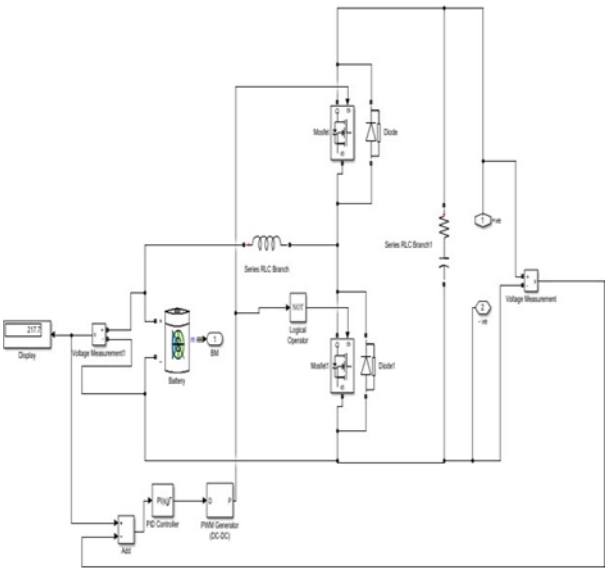

Fig.12. FUZZY optimization

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6 Fig.13. Tuning values for pso

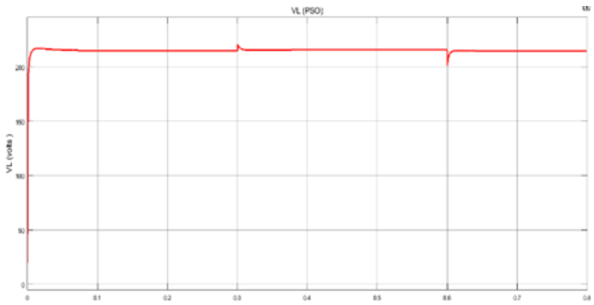

Fig.14. Results by using PSO

7 In further work PSO and whale optimization studied. The structure and results are showing how the voltage and output after the optimization techniques are considered for low terminals full stop settling time for both the techniques are visible through the graph resultant of the simulation work. Also the additional requirement of PSO is the tuning values for the model is shown in the above figure13.

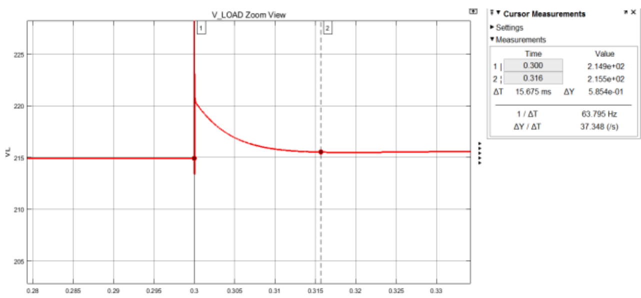

Fig.15. Settling time by PSO

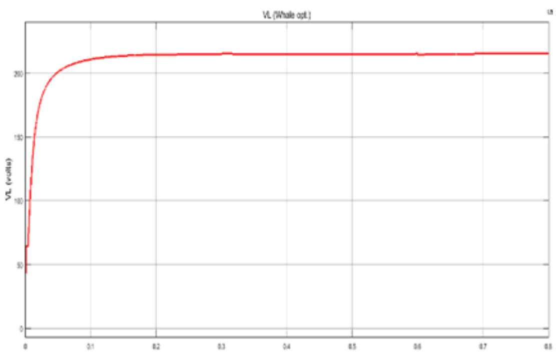

Fig.16. Results by using whale optimization

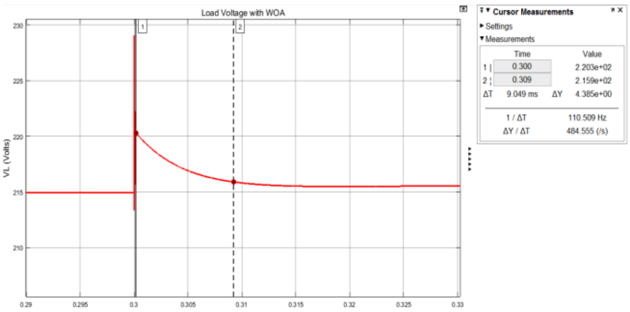

Fig.17. Settling time by whale optimization

Table.1. Comparative analysis

TECHNIQUES	SETTLING TIME IN (m sec)	PEAK VOLTAGE (volts)	OCCURING TIME
FUZZY	17.46	222	0.3
PSO	15.71	221	0.3
WHALE	9.82	217.3	0.3

IV CONCLUSION

The versatile study of PV and electric vehicle hybrid power system full stop specification for better backup and charging points for electric vehicles are studied under different optimization techniques. The comparative study are analyst in the paper and the peak voltage is measured accordingly. The resultant descriptions of the techniques are stated. First you optimization technique had maximum peak voltage of 222 volts. Settling time of fuzzy itself was quite big 17.46 millisecond. Irrespective to the settling time all the techniques used here namely PSO, WHALE optimization, fuzzy optimization have same occurring time that is 0.3 seconds. The future of the work here is how all different techniques can be studied and analyzed for this work.

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