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A Study on Battery Charging Infrastructure using Solar Energy

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ABSTRACT

Electric vehicles (EVs) are gaining widespread popularity worldwide. In contrast to conventional grid-based EV charging, utilizing photovoltaic (PV) power for EV charging has the potential to significantly reduce carbon emissions. However, the scarcity of charging stations remains a limiting factor in the global adoption of EVs. As the use of EVs continues to rise, more charging stations are being incorporated into public spaces. Nevertheless, relying on the current utility grid, which is predominantly powered by fossil fuel-based generation, for EV charging can negatively impact the distribution system and lacks ecological benefits. Therefore, the objective of this project is to examine the functionality of the existing charging infrastructure. This research aims to explore ways to power the charging infrastructure and the city's power grid using renewable energy sources. The project involves analyzing data on the frequency of charging sessions throughout the year, month, and day. This data allows for the creation of charging session curves and provides insights for planning the subsequent phases of the study.

Keywords: Infrastructure, Battery, Recharging, Solar Energy, Optimize, Sustainable, Recharging.

1. INTRODUCTION:

The Electric vehicles (EVs) are hailed as environmentally friendly transportation options in the industry. Many countries acknowledge the development of EVs as an effective strategy for achieving a low-carbon economic transition and ensuring energy security. However, there are still significant challenges to address since EVs require a connection to the electrical grid for charging. To begin with, the composition of the electricity generation mix in a particular regional power system can influence the indirect emissions associated with EVs [1]. The environmental benefits of EVs are not clear-cut when coal-fired power plants constitute a substantial portion of the grid's energy production. Additionally, meeting the increased charging demands of EVs will necessitate substantial investments in enhancing generation, transmission, and distribution capacities. Photovoltaic (PV) energy, being a renewable and clean energy source, holds promise for EV applications, including urban settings. To effectively enhance EV emissions reduction and reduce dependence on the power grid, one potential solution is the direct integration of PV systems with EV charging infrastructure. On one hand, incorporating an energy storage system with EVs can mitigate the intermittent nature of PV generation. On the other hand, PV generation can assist EVs in decreasing their reliance on the power grid. The development of fast-charging infrastructure is crucial for advancing EV adoption [2]. Regrettably, current battery technology falls short of providing a full charge within 30 minutes. For the past century, battery systems have played integral roles in various industries, including transportation and energy storage. The synergy between electric vehicles (EVs) and the electric grid can be optimized with the use of battery energy storage, which has been recognized as a facilitator for smart grid and transportation electrification applications [3]. In high-power applications like electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs), battery packs often consist of battery modules or cells connected in series to boost voltage and connected in parallel to increase capacitance [4]. Nevertheless, imbalances in these systems can diminish their overall energy efficiency due to variations stemming from production and differing operational conditions [5].

2. HARDWARE EXPERIMENT AND RESULTS

When sunlight hits the solar panels, they generate DC electricity. This DC electricity is then sent to the solar charge controller. The solar charge controller regulates the incoming DC electricity from the solar panels. It adjusts the voltage and current to match the requirements of the battery bank [6]. The regulated DC electricity is then fed into the battery bank, where it charges the batteries [7]. The BMS monitors the battery bank's status and ensures that the batteries are charged safely and efficiently [8]. The BMS continually monitors the battery bank's status and communicates data to the system's controller or user interface. This data helps users or system operators make informed decisions about maintenance, usage patterns, and optimizing the system's performance [9].

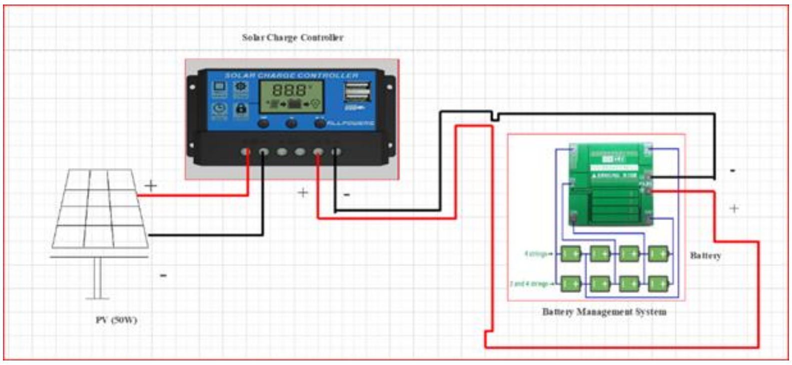

Fig.2.1. Circuit diagram

3. COMPONENTS

Solar Panel

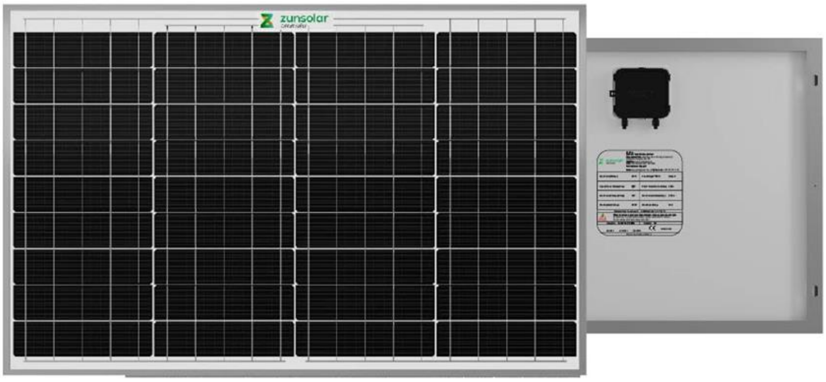

Fig.3.1. 50W-12V Zunsolar Panel

Parameters Of Solar Panel

Type	**Monocrystalline**
Materials	Silver Anodized Aluminium Frame
Max power (Pmax)	50W
Open circuit voltage (Voc)	22.5V
Max Power Voltage (Vmp)	20V
Short Circuit Current (Isc)	2.65A
Max Power Current (Imp)	2.5A
No of Cells	36cells

Table.3.1. Parameters of Solar Panel

BATTERY PACK:

Fig.3.2. Battery Connections (Series and Parallel)

Battery Parameters

Type:	Lithium-ion
Voltage:	14.8V
Capacity:	17.6Ah
Nominal Voltage:	15.6V
Number of Cells	8
Fully Charged Voltage:	16.8V
Cutoff Voltage:	11.1V
Charging Time	4Hrs
Nominal Discharge Current:	7.12A

Table.3.2. Battery Parameters

Solar Charge Controller

Fig.3.3. Solar Charge Controller

Solar Charge Controller Parameters:

Type	PWM
Output Voltage	12V/24V
Maximum Output Current	10A
Maximum Input Power	120W
Charge Stage	4
Load Controller	Yes

Fig.3.4. Solar Charge Controller Parameters

Battery Management System:

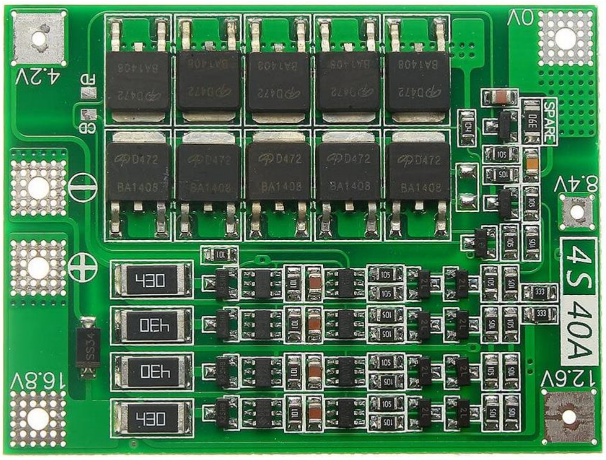

Fig.3.4. Battery management system

The BMS is responsible for managing and protecting the battery bank. Its key functions include:

1. Balancing the individual cells within the battery bank to ensure they all charge and discharge evenly.

2. Tracking the battery's level of charge (SOC) and its overall condition (SOH) for each individual battery.[10].

3. Protecting against overcharging and over-discharging.

4. Temperature monitoring to prevent overheating.5. Managing cell voltage and current to ensure the battery operates within safe limits

RESULTS:

Lithium-ion batteries are quantified in kilowatt-hours (kWh) in terms of their capacity. Typically, the average capacity hovers around 40 kWh, although certain vehicles are now equipped with batteries boasting capacities of up to 100 kWh. It's important to note that your car's battery capacity significantly influences its driving range, which represents the distance you can cover on a single full charge. In essence, the greater the kWh rating, the more favorable it is in terms of range. To illustrate, Nissan suggests that its Nissan Leaf model, equipped with a 40 kWh battery, can provide a range of 168 miles.

Therefore, the battery capacity of an electrical vehicle is = 40kWh.

The time taken for charging the 274Wh battery by using 50W panel at normal day condition is Approximately 4 Hours.

Number of 50W panels required for an 40kWh load = 40,000/274

= 145.985~146 Panels.

Number of 50W panels can be replaced if we use a 350W panel = 350 / 50

Number of 350W panels are required = 146 / 7

= 20.85 ~ 21 Panels

Hence, by using 21 of 350W panels at normal day condition we can charge a 3 Electrical Vehicles which are having a capacity of 40kWh battery pack.

Which can occupy a space of 35 squares meters. For entire charging stations.

4. SIMULATION AND RESULTS:

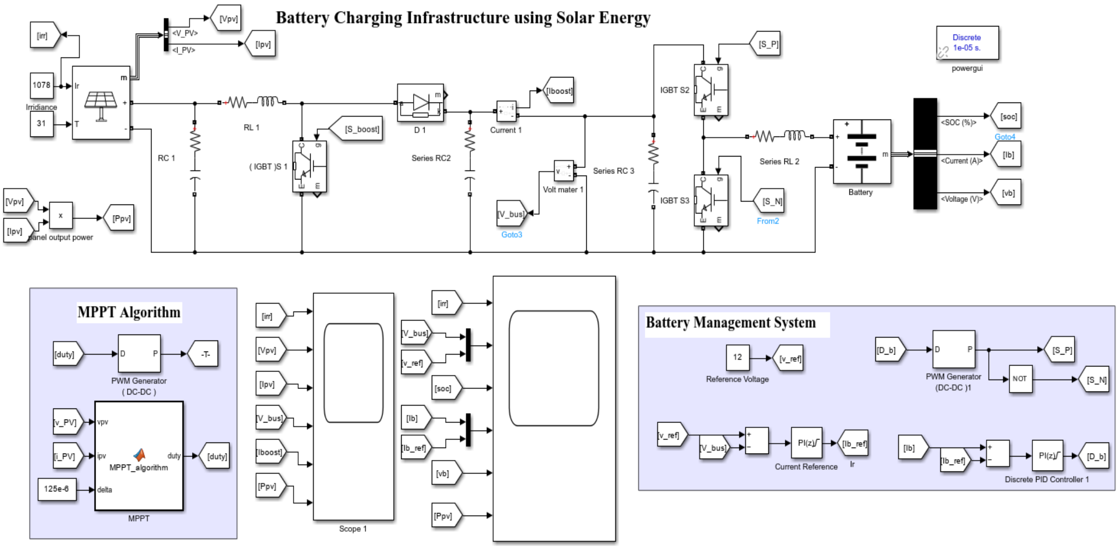

Fig4.1. Simulation diagram of Battery charging infrastructure using solar energy

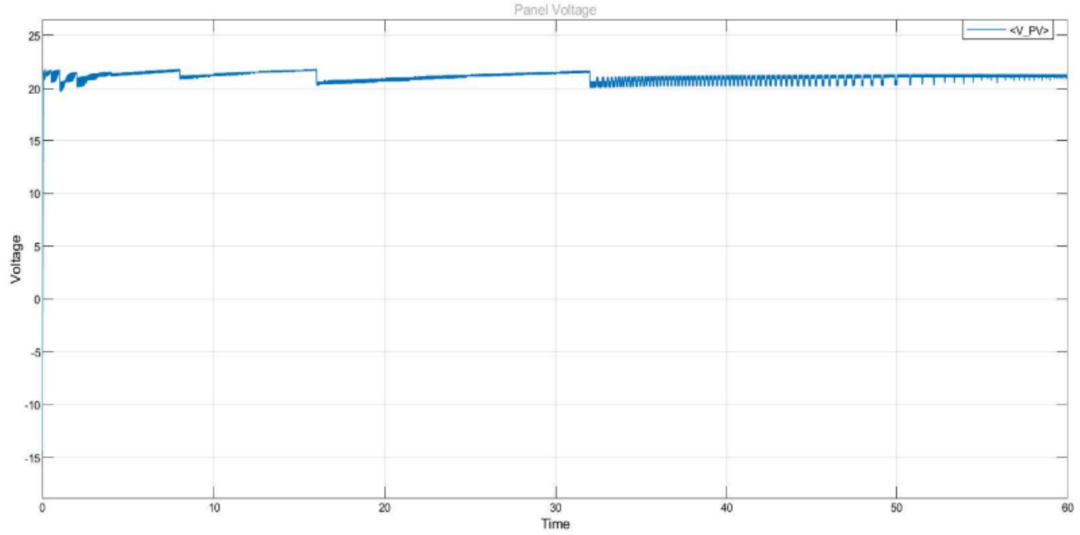

Fig.4.2. PV panel output voltage in Simulink model

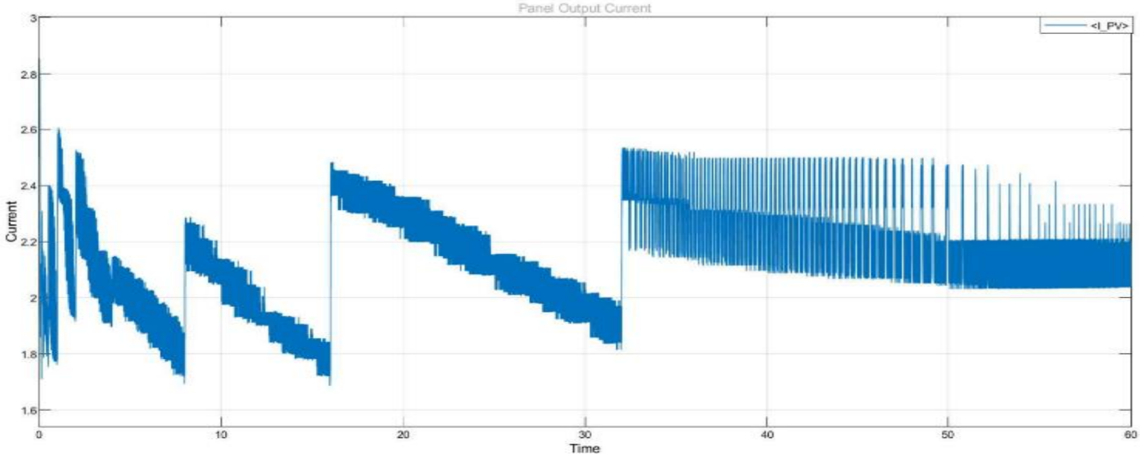

Fig.4.3. PV panel output Current in Simulink model

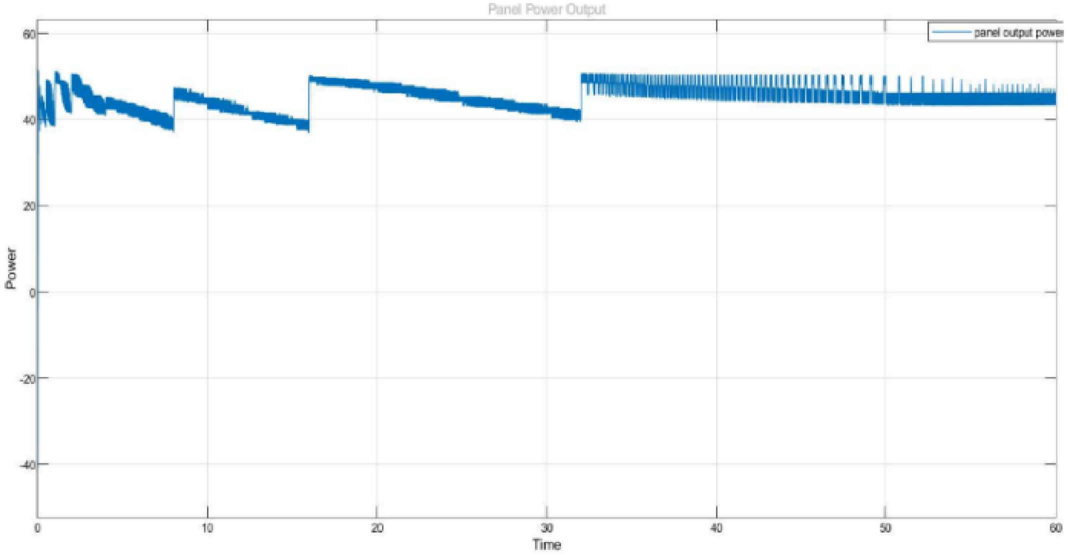

Fig.4.4. PV panel output Power in Simulink model

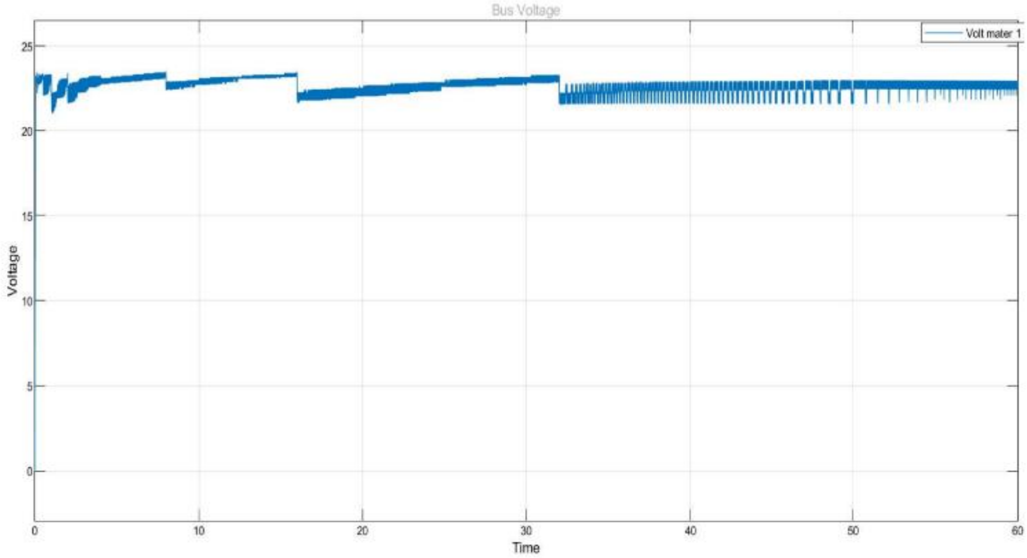

Fig.4.5. DC Bus voltage in Simulink model.

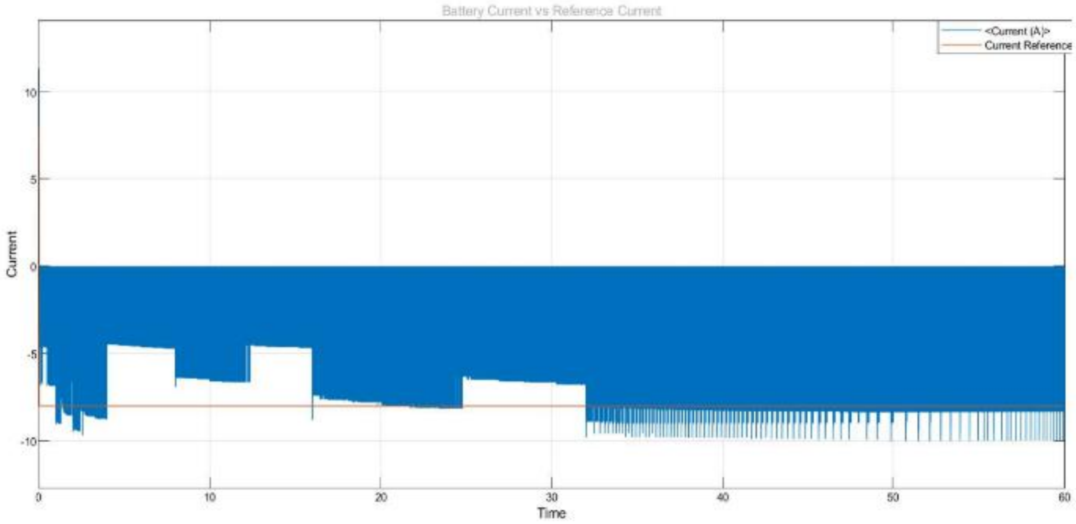

Fig.4.6. DC Bus Current in Simulink model

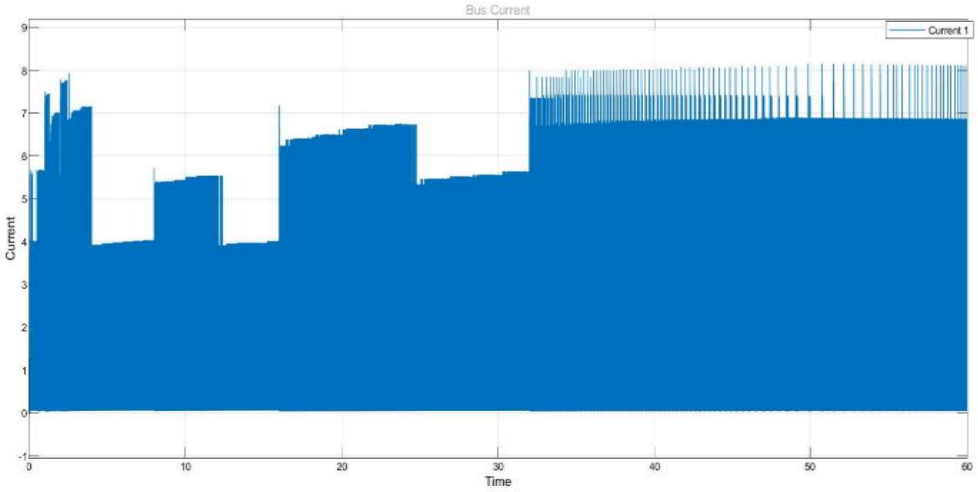

Fig.4.7. Battery Current compared to Reference Current in Simulink model

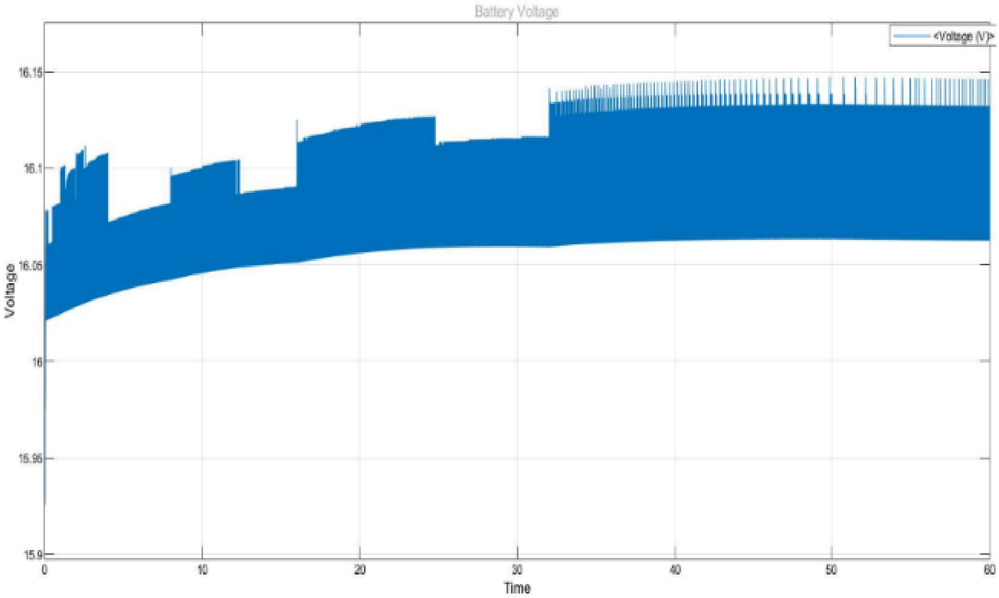

Fig.4.8. Battery Voltage in Simulink model

Algorithm for MPPT

Maximum The maximum power point tracking (MPPT) is an algorithm employed to optimize the power output of a photovoltaic (PV) system [11]. It achieves this by continuously adapting the operational voltage of the PV array to the level where the highest power generation occurs [12]. MPPT algorithms play a crucial role because the power output of a PV array fluctuates based on factors such as solar irradiance and PV cell temperature [13]. At any given moment, there exists a specific point on the power-voltage curve of the PV array where the maximum power output is achieved, known as the maximum power point (MPP) [14]. MPPT algorithms function by monitoring the voltage and current of the PV array and then computing the power output. Subsequently, they compare the current power output with the previous output and make adjustments to the operational voltage of the PV array accordingly [15]. This iterative process continues until the MPP is reached. Among MPPT algorithms, the Incremental Conductance method (ICC) stands out as a widely adopted technique in commercial PV systems. It is a more intricate algorithm compared to the perturb and observe (P&O) method, but it also boasts greater efficiency. The ICC method operates by calculating the incremental conductance of the PV array and utilizing this data to fine-tune the operational voltage of the PV array. The workflow for the ICC method can be represented as follows: [Include flow chart if available].

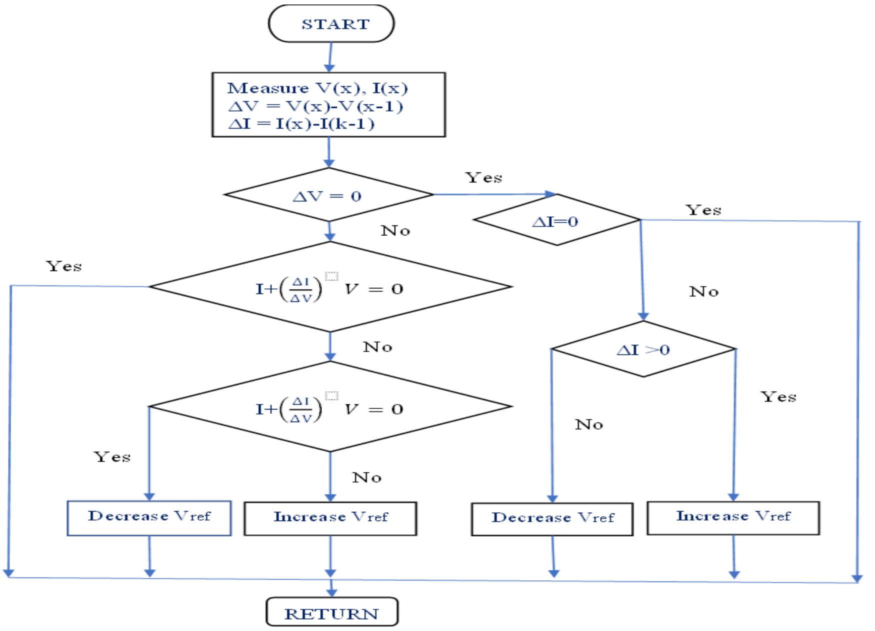

Fig.4.9. Flowchart for ICC Method.

MPPT Code:

```
function duty = MPPT_algorithm(vpv,ipv,delta)
% I used the MPPT algorithm in the MATLAB examples
% I only modify somethings.
duty_init = 0.1;
% min and max value are used to limit duty between
% 0 and 0.85
duty_min=0;
duty_max=0.85;

persistent Vold Pold duty_old;
% persistent variable type can be store the data
% we need the old data by obtain difference
% between old and new value
if isempty(Vold)
   Vold=0;
   Pold=0;
   duty_old=duty_init;
end
P= vpv*ipv; % power
dV= vpv - Vold; % difference between old and new voltage
dP= P - Pold;% difference between old and new power
% the algorithm in below search the dP/dV=0
% if the derivative equal to zero
% duty will not change
% if old and new power not equal
% &
% pv voltage bigger than 30V
% the algorithm will works
if dP ~= 0 && vpv>30
   if dP < 0
      if dV < 0
         duty = duty_old - delta;
      else
         duty = duty_old + delta;
      end
   else
      if dV < 0
         duty = duty_old + delta;
      else
         duty = duty_old - delta;
      end
   end
else
   duty = duty_old;
end
%the below if limits the duty between min and max
if duty >= duty_max
   duty=duty_max;
elseif duty<duty_min
   duty=duty_min;
end
% stored data
duty_old=duty;
Vold=vpv;
Pold=P;
```

5. CONCLUSIONS

Solar-powered charging infrastructure is essential for the transition to a sustainable transportation system. However, there are a number of challenges that need to be addressed before it can be widely adopted. These challenges include high upfront cost, lack of standardization, integration with the grid, and public awareness and education. Researchers are working to address these challenges through a variety of initiatives. For example, they are developing new solar panel technologies with higher efficiency and lower cost, as well as new battery storage technologies with higher capacity and longer lifespan. Additionally, they are developing new power electronics devices for charging and discharging EVs, and new control and management systems for solar-powered charging stations. In the future, researchers will need to continue to focus on developing new technologies and strategies to reduce the cost and improve the efficiency of solar-powered charging infrastructure. They will also need to work to develop standards and guidelines to promote its standardization. In addition, they will need to educate the public about its benefits and dispel any concerns about its reliability or safety.

6. REFERENCES

[1] A. Hafeez, R. Alammari, and S. Member, “Utilization of EV Charging Station in Demand Side Management Using Deep Learning Method,” IEEE Access, vol. 11, no. December 2022, pp. 8747–8760, 2023, doi: 10.1109/ACCESS.2023.3238667.

[2] N. Liu, Q. Chen, S. Member, X. Lu, J. Liu, and J. Zhang, “A Charging Strategy for PV-Based Battery Switch Stations Considering Service Availability and Self-Consumption of PV Energy,” IEEE Trans. Ind. Electron., vol. 62, no. 8, pp. 4878–4889, 2015, doi: 10.1109/TIE.2015.2404316.

[3] C. Duan et al., “A Solar Power-Assisted Battery Balancing System for Electric Vehicles,” IEEE Trans. Transp. Electrif., vol. 4, no. 2, pp. 432–443, 2018, doi: 10.1109/TTE.2018.2817123.

[4] V. T. Tran et al., “An Efficient Energy Management Approach for a Solar-Powered EV Battery Charging Facility to,” IEEE Trans. Ind. Appl., vol. 55, no. 1, pp. 6517–6526, 2019, doi: 10.1109/TIA.2019.2940923.

[5] J. S. Goud, S. Member, R. Kalpana, and B. Singh, “An Online Method of Estimating State of Health of a Li-Ion Battery,” vol. 36, no. 1, pp. 111–119, 2021, doi: 10.1109/TEC.2020.3008937.

[6] G. Alkawsi, Y. Baashar, D. A. U, and A. A. Alkahtani, “applied sciences Review of Renewable Energy-Based Charging Infrastructure for Electric Vehicles,” 2021.

[7] P. Sarikprueck, W. Lee, A. Kulvanitchaiyanunt, S. Member, V. C. P. Chen, and J. M. Rosenberger, “Bounds for Optimal Control of a Regional Plug-in Electric Vehicle Charging Station System,” IEEE Trans. Ind. Appl., vol. 54, no. 2, pp. 977–986, 2018, doi: 10.1109/TIA.2017.2766230.

[8] S. Deb et al., “Charging Coordination of Plug-In Electric Vehicle for Congestion Management in Distribution System Integrated With Renewable Energy Sources,” vol. 56, no. 5, pp. 5452–5462, 2020, doi: 10.1109/TIA.2020.3010897.

[9] A. K. Karmaker, A. Hossain, and S. Member, “Energy Management System for Hybrid Renewable Energy-Based Electric Vehicle Charging Station,” IEEE Access, vol. 11, no. March, pp. 27793–27805, 2023, doi: 10.1109/ACCESS.2023.3259232.

[10] Y. Deng, Y. Zhang, F. Luo, and Y. Mu, “Operational Planning of Centralized Charging Stations Utilizing Second-Life Battery,” vol. 12, no. 1, pp. 387–399, 2021, doi: 10.1109/TSTE.2020.3001015.

[11] H. M. Abdullah, A. Gastli, and S. Member, “Planning and Optimizing Electric-Vehicle Charging Infrastructure Through System Dynamics,” IEEE Access, vol. 10, pp. 17495–17514, 2022, doi: 10.1109/ACCESS.2022.3149944.

[12] J. Park, M. Jeong, J. Kang, and C. Yoo, “Solar Energy-Harvesting Buck – Boost Converter With Battery-Charging and Battery-Assisted Modes,” IEEE Trans. Ind. Electron., vol. 68, no. 3, pp. 2163–2172, 2021, doi: 10.1109/TIE.2020.2975491.

[13] A. Grid, M. H. Mobarak, S. Member, R. N. Kleiman, and J. Bauman, “Solar-Charged Electric Vehicles : A Comprehensive Environmental Benefits,” vol. 7, no. 2, pp. 579–603, 2021, doi: 10.1109/TTE.2020.2996363.

[14] A. J. Alrubaie, M. Salem, K. Yahya, M. Mohamed, and M. Kamarol, “A Comprehensive Review of Electric Vehicle Charging Stations with Solar Photovoltaic System Considering Market , Technical Requirements , Network Implications , and Future Challenges,” 2023.

[15] Y. Wang, S. Member, and J. S. Thompson, “Two-Stage Admission and Scheduling Mechanism for Electric Vehicle Charging,” IEEE Trans. Smart Grid, vol. 10, no. 3, pp. 2650–2660, 2019, doi: 10.1109/TSG.2018.2807158.

[16] Jalli, R. K., Mishra, S. P., Naik, J., Sharma, P., & Senapati, R. (2020, September). Prediction of Wind Speed with optimized EMD based RVFLN. In 2020 IEEE-HYDCON (pp. 1-5). IEEE.

[17] Mishra, S. P., Krishna Rayi, V., Dash, P. K., & Bisoi, R. (2021). Multi‐objective auto‐encoder deep learning‐based stack switching scheme for improved battery life using error prediction of wind‐battery storage microgrid. International Journal of Energy Research, 45(14), 20331-20355.

[18] Majumder, I., Dhar, S., Dash, P. K., & Mishra, S. P. (2020). Intelligent energy management in microgrid using prediction errors from uncertain renewable power generation. IET Generation, Transmission & Distribution, 14(8), 1552-1565.

[19] Mishra, S. P., Ali, S. M., Pradhan, A., Mohapatra, P., & Singh, V. (2013). Increasing energy efficiency in India by the use of green building. International Journal of Renewable Energy Technology, 4(4), 406-415.

[20] Sharma, P., Das, S., Senapati, R., Mishra, S. P., & Senapati, R. N. (2020, September). Performance Evaluation of PV-SOFC Grid Integrated 3P3W System by UPQC with Sinusoidal Current Control Strategy at Constant Irradiance. In 2020 IEEE-HYDCON (pp. 1-6). IEEE.