A PROJECT REPORT

on

Design Of Standalone Photovoltaic (PV) Integrated Charging Of Electric Vehicle (EV) Battery Using MATLAB/Simulink

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by

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gautam nag

Name and Signature of the student

ABSTRACT

The world today is steadily moving towards an era of sustainable energy. In this fast changing world it is important to keep in mind the resources one has at the hands and how one uses them. One such crucial resthece available at the disposal is ‘fuel’. one needs fuel to run the factories, power the electrical grid, automobiles, etc. So for the project one has narrowed the domain to the field of automobiles and electric vehicles (EV) in particular.

The project aims to achieve at least 75% SOC of an EV vehicle of battery built Li - Ion using a photovoltaic system integrated standalone with the battery. The project is therefore centered around this problem and presents a solution statement that if one could integrate the charging of EVs using solar power it would spread out the load on the grid used by EV chargers. Using the data published by Power Magazine (Issue 2020), using PV integrated EV chargers will save the cost required/sector of demand by $1500 (Rs, 1,11,577) per month. This is a simulation based project and one has used MATLAB/Simulink for the work.

To work on the productivity of the sunlight based charger MPPT is utilized. As per the most extreme power point hypothesis, yield power of any circuit can be expanded by changing source impedance equivalent to the heap impedance, so the MPPT calculation is identical to the issue of impedance coordinating. In present work, the Converter is utilized as impedance coordinating with gadget among information and yield by changing the obligation pattern of the converter circuit.

A significant benefit of converters is that high or low voltage is obtained from the accessible voltage as per the application. Output voltage of the converter is based upon the obligation cycle, so MPPT is utilized to compute the obligation cycle to get the most extreme yield voltage since, in such a case that yield voltage increments than power additionally increments. In this paper Perturb and Observe (P&O) and consistent obligation cycle strategies are utilized, on the grounds that these require less equipment intricacy and minimal expense executions.

For our project we have aimed at utilizing MPPT’s algorithm to harness the maximum power possible to charge an EV battery. We are bent on utilizing an algorithm as otherwise most of the power generated by PV modules gets wasted and the consumer in possession of a Li - Ion battery does not get his/her money’s work. So even though this paper is titled towards charging an EV, we believe that after using appropriate algorithms we can even utilize this approach to charge batteries (Ni - Cad, Li Ion..etc) at home.

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INTRODUCTION

Now the electrification of transport is increasing day by day, which is a greener and cleaner innovation in the automotive industry. Global warming and the impending disappearance of fossil fuels have given the electric vehicle a great opportunity (EV) to be part of the automotive industry. Transport industry, which is the means of reducing vehicle emissions, which in turn reduces the risk of climate change, but at the same time places an additional burden on the grid systems, i.e. renewable energy sources, in particular solar or photovoltaics (PV), which are available in abundance during business hours , is a preferred energy source for charging electric vehicles (EV) with improved energy efficiency, fuel consumption, but also the additional load on the network. System that would be able to redirect rapid changes in photovoltaic power to the direct load on the photovoltaic.

Lately, ecological issues brought about by fuel vehicles and efficiency become increasingly genuine. The vehicles of new energy, which is green, harmless to the ecosystem and affordable, is a significant objective for monetary and social improvement of numerous nations, yet in addition the future advancement bearing of the vehicle. Electric vehicle (EV) is a vehicle with zero contamination outflows, mileage and fuel vehicles can be commonly equivalent electric vehicles. Battery mileage equivalent to that of fuel-controlled vehicles. Vehicles (electric vehicles, EV) is a battery as a power wellspring of a zero contamination outflows, mileage and fuel vehicles can be commonly practically identical electric vehicles. It is accounted for that heap limit insights information of new tasks in on energy capacity innovation, lithium-particle battery framework is the most noteworthy limit of 113.8 MW, representing 54.7% of the worldwide limit all out in 2015 as expressed in [1-3]. Likewise, lithium-particle batteries have turned into the standard of auto power batteries. Lithium-particle batteries enjoy many benefits, like high energy thickness, high open circuit voltage, little self-release, no memory impact, etc. Lithium-particle batteries have great possibilities for improvement in the field of electric vehicles. Sun based power is an elective innovation that will ideally lead us away from our petroleum subordinate energy sources. The serious issue with sunlight based charger innovation is that the efficiencies for sun oriented power frameworks are as yet poor and the expenses per kilo-watt-hour (kwh) are not cutthroat, as a rule, to rival oil energy sources. Sun powered chargers themselves are very wasteful (around 30%) in their capacity to change daylight over to energy. Nonetheless, the charge regulators and different gadgets that make up the sun based power framework are likewise to some degree wasteful and exorbitant. We will likely plan a Maximum Power Point Tracker (MPPT), a particular sort of charge regulator that will use the sunlight based charger to its greatest potential.

It was 115 years since Edmond Becquerel discovered the photovoltaic effect in 1839 before Chapin and his colleagues announced a practical device in 1954 at Bell Laboratories in Murray Hills, New Jersey. As we know that these solar cells are quite efficient and there have been some drastic improvements in manufacturing technology for solar modules, installations have been carried out in recent years. Photovoltaics is still in the evolutionary phase and is expected to grow in the next few decades. The interest in photovoltaic energy is increasing both in the public and in the planning arenas of the electricity communities. photovoltaic solar has had an annual growth rate of 25% to 35% over the past 15 years or so. Photovoltaic modules, commonly known as solar cells, are simply converters. Solar cells produce electricity when exposed to light without any strain on the hardware or the raw source, which means that energy can be produced with very low maintenance and operating cost. The amount and variety of batteries of electric vehicles connected to the grid continues to increase sharply, which leads to a large load on the grid, so that photovoltaic charging stations will be very helpful in reducing this load. Some preliminary criteria need to be considered during the initial planning phase of the photovoltaic system. The establishment of photovoltaic charging stations will also be a very good platform for future research on photovoltaic charging of electric vehicles.

LITERATURE REVIEW

I) BRIEF

Electric vehicles (EVs) have received a lot of attention recently due to their sustainable use of energy. The advancement of lithium-ion batteries has accelerated the development of electric vehicles. However, the increasing number of electric vehicles creates a large demand for electrical energy, which increases the pressure on the electricity system. This leads to a search for alternative and clean energy sources to power electric vehicles. This project implements a solar energy system for the construction of a charging station for the use of electric vehicles. The charging station uses a constant voltage DC bus to allow charging through multiple ports. Charge regulators work on the principle of equalizing current and charging with constant current / constant voltage. Experimental and simulation results are used to validate the performance of the charging system. In a survey done by Global EV outlook done in 2020 it was found that there are over 6.5 million private chargers in the world, the major consumers being:

Name of the Country	**No. of private chargers**
United States of America	15,00,000
China	24,00,000
Japan	2,00,000

PV energy, on the other hand, fluctuates with changes in irradiance and hence cannot create consistent energy. Therefore we need an energy storage device so that we can match the energy demand and in doing so we can increase the ability to work successfully on the station. As a result, a system containing an energy storage system also known as ESS, as onell as a PV source and an EV charger, has been proposed. The EV and energy storage system have been charged and discharged using the BDC. When the energy provided by photovoltaic is insufficient to fulfil demand due to a lack of reduction in the amount of radiation received from the sun, the electronic switching system can be used to sustain the need.

An off-grid charging station or more commonly known as 'OGCS' is important for increasing the use of electric vehicles (EV) in rural regions while reducing grid burdening in urban areas. The OGCS aims to obtain energy from renewable stheces (RES). Photovoltaic (PV) is the most ideal renewable energy among all RES due to its abundance and ease of installation. Also as mentioned in the IEEE 2020 conference paper, "Due to falling electricity prices andand a raise in the cost of electricity, the user consumption of photovoltaic hardened electricity is important. Instead of doing the selling business of electricity all over again the electricity produced at a low profit, and at the same time it has to consume or in other cases devise a way to store as much electricity as possible temporarily. Today, this consumption in kilowatts can be up to 24, (electricity costs: 21 to 30 ct / kWh)."

With a median consumption of a standard electrical vehicle, illonerke will conceal as much as 3,10,000 metric linear units annually with solar energy that is generated annually with 100 percent free from emission. Now for another thing, with about 15 thousand km driven by a single electric vehicle, up to twenty one electric vehicles per annum may be operated strictly with self-generated star power. CED Greentech did a survey in 2019 where it was published that the majority of EV chargers onere grid powered and contributed to 11.33% of USA's annual electricity demand. The current battery capacities of electric vehicles vary between 17.6 kWh for the ‘Smarteq For two’ ranging at 93.3 kilometers to 100 kWh in the Tesla Model S and Model X, which can drive more than 482 km. This leads to considerable cost savings, because the electricity produced is not being fed directly into the grid, but is rather put in use to help charge electric vehicles. These aforementioned problem statements could be tackled using a standalone solar power approach where using the data published by Power Magazine (Issue 2020), using PV integrated EV chargers will save the cost required/sector of demand by $1500 (Rs, 1,11,577) per month.

II) MPPT

In a paper published by Dalila Beriber and Abdelaziz Talha it proposes a nitty gritty review of the 4 most extreme power following procedures:

1. Perturb and Observe (P&O),
2. Incremental Conductance (InC),
3. fluffy rationale based following strategy
4. technique utilizing just the photovoltaic current estimation.

The disadvantage of the 3 concentrated on techniques; P&O, InC and one sensor calculation, is that at constant expression the working point sways around the most extreme power point, bringing about the misuse of the yield board's accessible energy. Reenactment results show that the proposed fluffy rationale regulator (FLC) can give quicker and stable following most extreme power when contrasted with the other concentrated techniques.

The MPPT for our project is a charge regulator that makes up for the changing Voltage Current trait of a sun powered cell. The MPPT fools the boards into yielding an alternate voltage and current permitting more ability to go into the battery or batteries by making the sun powered cell think the heap is changing when you truly can't change the heap. The MPPT screens the yield voltage and current from the sunlight based charger and decides the working point that will convey that most extreme measure of power accessible to the batteries. In the event that our form of the MPPT can precisely follow the continually changing working point where the power is at its most extreme, then, at that point, the effectiveness of the sun oriented cell will be expanded.

A vast amount of major mathematical modeling and calculation has been brought forward for the following greatest power point of a PV. These calculations fluctuate in adequacy, intricacy, combination speed, sensors required and cost. Four MPPT strategies are concentrated in this paper; the P&O strategy, the Incremental Conductance technique, the fluffy rationale technique and just current estimation strategy.

In a paper published in The Science Direct a detailed comparison was made between the different MPPT techniques based on time complexity, reliability, speed and implementation. After carefully studying the paper and jotting down relevant point the below mentioned table was constructed:

MPPT Technique	Speed	Complexity	Reliability	Implementation
Fractional Voc	Medium	Low	Low	Digital/Analog
IncCloud	Varies	Medium	Medium	Digital
Hill Climbing	Varies	Low	Medium	Digital/Analog
Fuzzy Logic	Fast	High	Medium	Digital
Neural Network	Fast	High	Medium	Digital
P&O	Medium	Medium	High	Digital/Analog

Another paper of interest that we came across that provided a deep insight into the topic was from Springer Open where it has been proposed that in order to collect the most extreme power from the PV board an accuse regulator of MPPT ability is proposed in this paper. The two general classifications of MPPT procedures are the backhanded methods and direct strategies. Backhanded procedures incorporate the decent voltage, open circuit voltage and short out current strategies. In this sort of following, straightforward presumption and intermittent assessment of the MPPT are made with simple estimations. For instance, the proper voltage strategy just changes the working voltage of the sun based PV module at various seasons with the presumption of higher MPP voltages in winter and lower MPP voltages in summer at a similar light level. This strategy isn't exactly a result of the changing of light and temperature level inside a similar season.

A general formula for this was proposed by (the derivation is out of the scope of this paper):

$$Vmm = k * Voc$$

Where;
k = constant value for crystalline silicon is usually to be around 0.7 to 0.8

This method is basic and is simpler to carry out contrasted with different procedures. But keeping the trivial stuff aside, the consistent k is only an estimation Leading to decreased productivity, and each time the framework needs to track down the new open circuit voltage (Vout) when the light condition changes. To track down the new open circuit voltage, each time the heap associated with the PV module should be separated causing power misfortune. Direct MPPT techniques measure the current and voltage or power and consequently are more precise and have quicker reaction than the aberrant strategies. Perturb and observe (P&O) is one of the direct MPPT procedures, which is utilized here for certain changes.

This paper has also discussed a technique for minor perturbation where the change in Delta D is acquainted with, because of the PV output power variety of the PV module. The PV yield power is occasionally estimated and contrasted and the past power. On the off chance that the yield power expands, a similar interaction is proceeded with in any case annoyance is switched. In this calculation perturbation is given to the PV module or the cluster voltage. The PV module voltage is expanded or diminished to check whether the power is expanded or diminished. At the point when an expansion in voltage prompts an increment in power, this implies the working mark of the PV module is on the left of the MPP. Consequently further annoyance is needed towards the option to arrive at MPP. Then again, if an increment in voltage prompts an abatement in power, this implies the working place of the PV module is on the right of the MPP and thus further annoyance towards the left is needed to arrive at MPP.

At the point when the MPPT charge regulator is associated between the PV module and battery, it estimates the PV and battery voltages. Subsequent to estimating the battery voltage, it decides if the battery is completely energized or not. On the off chance that the battery is completely energized (12.6 V at the battery terminal) it quits charging to forestall battery overcharging. On the off chance that the battery isn't completely energized, it begins charging by initiating the DC/DC converter. The microcontroller will then, at that point, ascertain the current power Pnew at the yield by estimating the voltage and current, and contrast this determined power with the past estimated power Pold. In case Pnew is more prominent than Pold, the PWM obligation cycle is expanded to remove the most extreme power from the PV board. In case Pnew is not exactly Pold, the obligation cycle is diminished to guarantee the framework to move back to the past most extreme power. This MPPT calculation is basic, simple to execute, and minimal expense with high exactness.

III) LI - ION BATTERIES

For this section of the report the look up has been focused on the modeling characteristics of the Li - ion batteries. In our research we found out that the gold medal winner paper from HEZE University China by Zhai Haizhou provided a complete analysis. The paper depicts the standard and charging/releasing attributes of lithium-particle batteries. It is as the examination protests that Lithium-particle batteries with positive and negative materials of $LiMn_2O_4$ and Li_xC_6 were chosen. A numerical model is made for recreating the electrochemical conduct of Lithium-particle batteries. It is set up that the electrochemical cell model and the one RC cell model are dependent on previously mentioned. The instance of voltage, current, temperature, SOC and the charging/releasing qualities were examined. The model is dynamic, and it mirrors the transient condition of the battery yield. This is essential for a lab arrangement used to test power arrangement of an electric vehicle or cross breed vehicle to recreate electrochemical energy stockpiling. The outcomes show that exact battery charging/releasing procedure, the board and SOC estimation can be accomplished.

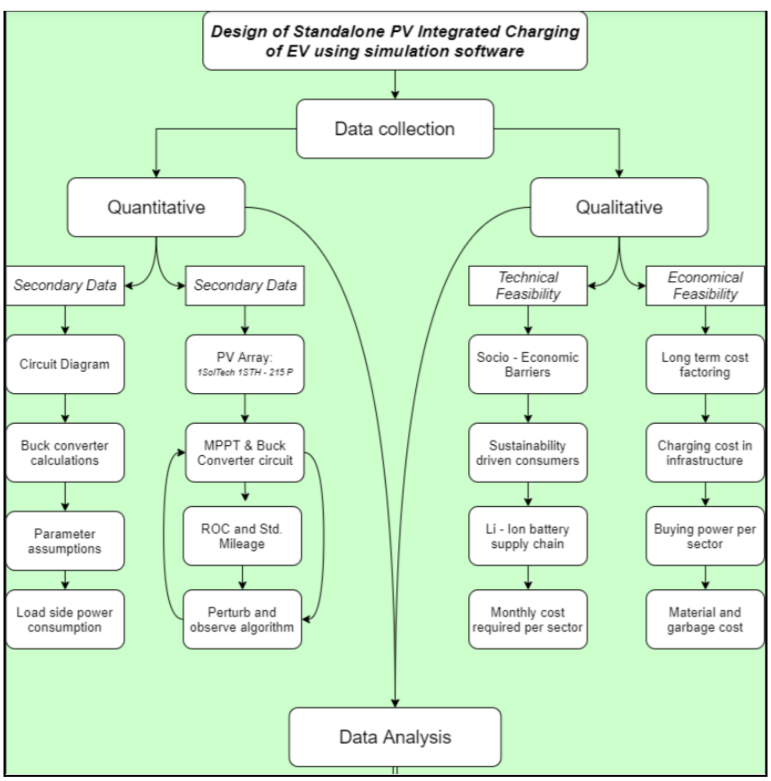
The paper covers the characteristic principle of charging and discharging of Li - Ion batteries and has used modeled examples to prove the point. The initial phase in fostering a precise battery model is to fabricate and define the same circuit to mirror the nonlinear conduct of the battery and the reliance on temperature, SOC, SOH and current. This reliance is remarkable to the electro-science character of every cell and not set in stone dependent on the estimations on the battery cell. SoC is characterized as the proportion of the leftover limit of the battery to the appraised limit under similar conditions at a specific release rate.

Power battery SoC assessment issue is a common non-straight, high accuracy and complex logical and specialized issues, continuous precise assessment is undeniably challenging. Many components influence the battery SoC, summarized fundamentally include: charge and release rate, charge and release times, polarization impact, temperature, self release, battery maturing. As of now, the normal examination on SoC assessment strategy for power batteries fundamentally incorporates: release test technique, open circuit voltage technique, Anshi estimation strategy, fake neural organization strategy, Kalman channel technique, etc. An-hour estimation strategy is the most regularly utilized technique for SoC assessment. It computes the measure of power conveyed from the battery or the battery power as a straightforward hour.

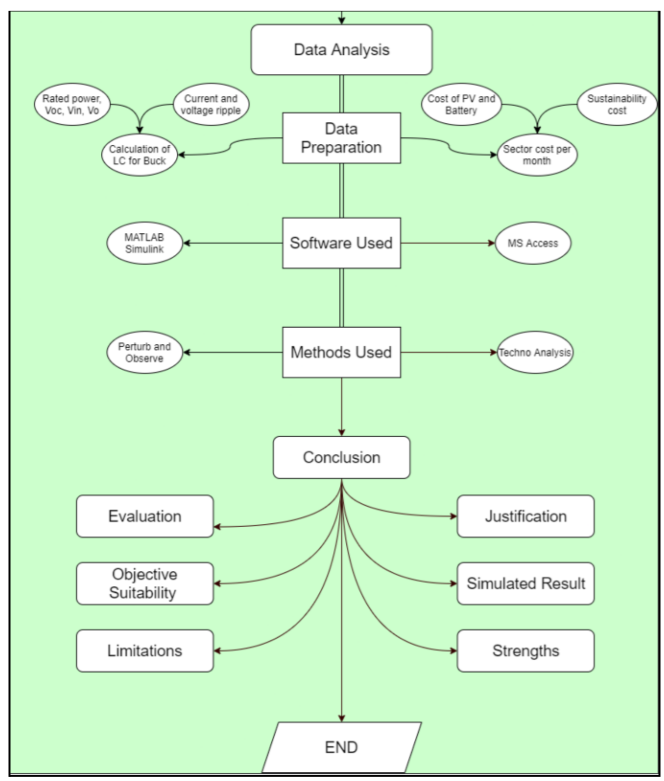
The center thought of Kalman channel hypothesis is to utilize the base mean square blunder as the ideal assessment measure to track down a bunch of recursive assessment calculation, which depends on the state space model of sign and commotion, utilizing the assessed worth of the past time and Time evaluations of the state factors to acquire appraisals of the current time. Applying to battery SoC gauges that the battery is viewed as a power framework, SoC is an inner condition of the framework. The center of the SoC calculation is a set of recursive conditions that incorporate SoC assesses and mirror the assessment mistake and covariance network. The covariance network is utilized to give the assessed blunder range. This strategy is reasonable for the assessment of straight frameworks in background noise with high precision and continuous execution.

So finally after going through the paper we can conclude that the circuit model of lithium particle battery was set up by utilizing the second - request RC circuit model, and the battery was recreated progressively. Through the boundary setting, this model can carry on the reenactment research in the perplexing circumstance. The current, open circuit voltage, SOC state and battery temperature change of the battery under various charge and release are examined. This reproduction model is supportive for the streamlining and plan of lithium particle batteries. It is as the examination objects that Lithium-particle batteries with positive and negative materials of $LiMn_2O_4$ furthermore, Li_xC_6 were chosen. A numerical model is made for reproducing the electrochemical conduct of Lithium-particle batteries. It is set up that the electrochemical cell model and the one RC cell model are dependent on previously mentioned. The instance of voltage, current, temperature, SOC and the charging/releasing attributes were contemplated. The model is dynamic, and it mirrors the transient condition of the battery yield. The outcomes show that exact battery charging/releasing procedure, the board and SOC estimation can be accomplished.

METHODOLOGY



Flowchart (STAGE 1)



Flowchart (STAGE 2)

The project is divided into stages. The 1st stage is Data Collection. In this stage two kinds of data are collected namely quantitative and qualitative. Quantitative data is further divided into two types namely Primary and Secondary. Primary data is the data that is not already available and needs to be created/collected firsthand. For the project this includes the circuit diagram, the data parameters for the buck converter (incl. calculations), assumptions for theoretical calculation and load side power consumption. The secondary data on the other hand is the data that has already been collected by someone else and is available open source and data that is pre defined in terms of specifics and cannot be altered in the project. This includes the PV array type and specification, PV built, MPPT algorithm, and Perturb and Observe algorithm.

The qualitative data on the other data is the data that deals with the technical and economical feasibility of the project and methods. It is divided into two parts namely Technical feasibility and economic feasibility. The technical data for this includes the socio - economic barriers in the society, sustainably driven consumers, supply chain production of PV and Li - ion batteries, cost per sector. The economic data includes long term cost factoring, infrastructure cost, buying power of the mass and material and garbage cost.

The next stage i.e. 2nd Stage is the data analysis part. This includes the simulation part and the model calculation along with the code for writing the algorithm used in Perturb and Observe. The specification for the buck converter is calculated and the value for filter capacitor and filter inductor is calculated using the following formula (found from Power Electronics by Mohammed H. Rashid): Then for the 3rd stage the code for MPPT is written in a separate MATLAB function block and is fed the input parameters (V and I) from the PV array via unit delay blocks with sample time 1e-4. Then the output of the MATLAB function block is fed to a comparator along with a repeating sequence and the combined output is fed back to the mosfet (buck converter). The output of battery charging and solar output is then finally compared.

A PV module reproduction was performed utilizing MATLAB-Simulink. 36 sun based cells in series association structure a module. The open circuit voltage Voc of every cell is 22.1 V, and the short out current Isc is 4.8 A. The sun based cluster is framed by the blend of such modules. The greatest power is 80 W with voltage at greatest power Vmp of 17.6 V, and the current at most extreme power Devil is 4.55 A. Figure presents the variety through the I–V and P–V bends taken from the sun based cell module with MPP conduct when the irradiance changes from 200 to 1000 W/m2 Appl. Sci. 2020, 10, x 4 of 29 circuit current Isc is 4.8 A. The sun based cluster is framed by the blend of such modules. The greatest power is 80 W with voltage at most extreme power Vmp of 17.6 V, and the current at greatest power Imp is 4.55 A. This presents the variety through the I–V and P–V bends taken from the sun based cell module with MPP conduct when the irradiance changes from 200 to 1000 W/m^2.

A PV exhibit shaped from two equal associations of four modules in series was utilized in the reproductions, as displayed in Figure 2. To stay away from "areas of interest", sidestep diodes were applied, furthermore, to end the "opposite progression of current", impeding diodes were applied. In a uniform light circumstance, an extraordinary greatest point was delivered in the P–V bend, while various tops were made in the P–V bend under incomplete concealing conditions dependent on the force of concealing. Various situations were reproduced to exhibit the P–V qualities of the concentrated on PV exhibit under incomplete concealing conditions with various degrees of solidarity. On account of the presence of various pinnacles of force in the PV exhibit P–V bend, a reasonable system which can definitively and successfully track the GMPP is required. The general productivity of the PV framework will be influenced by the utilized strategy's presentation.

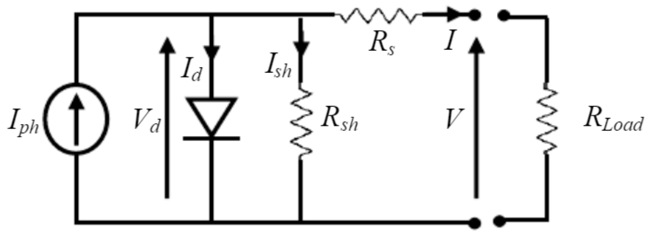
Then for the 3rd stage the code for MPPT is written in a separate MATLAB function block and is fed the input parameters (V and I) from the PV array via unit delay blocks with sample time 1e-4. Then the output of the MATLAB function block is fed to a comparator along with a repeating sequence and the combined output is fed back to the mosfet (buck converter). The output of battery charging and solar output is then finally compared.

PROJECT ANALYSIS

It is to be noted here that as far as the scope of this project is concerned, the parameters namely 'aging effect' and 'temperature decay' of the Li - ion battery are ignored and assumed to be not present for maintaining an ideal environment.

I. DESCRIPTION

The electrical identical circuit of a sun based cell is drawn below. It is made out of a light-produced current source, diodes, series opposition, and equal obstruction



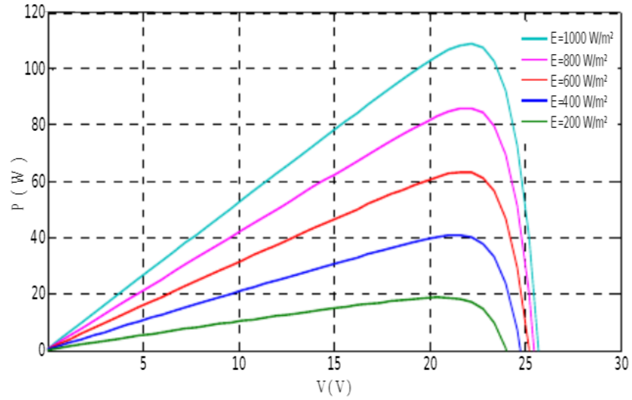
EdSim circuit

Characteristic equation for the current and voltage of a solar cell is:

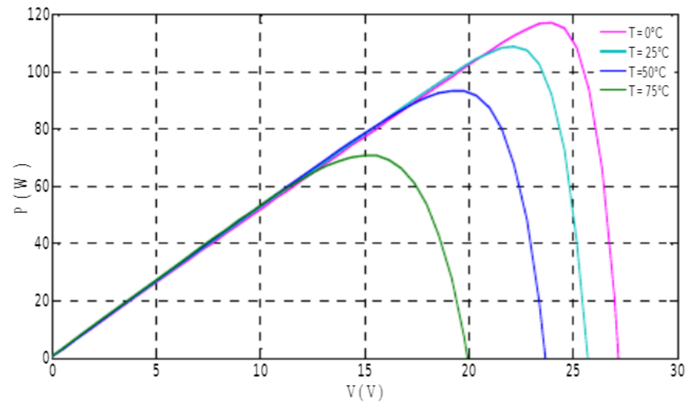
$$I = I_{ph} - I_{sat}.[\exp(\frac{q.(V + R_s.I)}{nkT}) - 1] - \frac{V + R_s.I}{R_{sh}}$$

Where;
1. I denotes a current of a solar array (A),
2. V denotes an output voltage of a solar array(V),
3. Iph denotes the light generated current (A),
4. Isat denotes a diode reverse saturation current (A),
5. q denotes the electronic charge =1,6.10-19C,
6. n denotes a dimensionless deviation factor from the ideal p–n junction diode,
7. k is Boltzmann's constant =1.3807.10-23 JK-1,
8. T denotes a cell temperature (K),
9. Rs denotes a series resistance (Ω)
10. Rsh denotes a shunt resistance (Ω)

Now if we have a look at the standard P (W) vs V (V) graph for irradiance and temperature below we can evaluate that the yield qualities of the sun powered exhibit is nonlinear and imperatively influenced by the sun based radiation, temperature and burden condition.



P (W) vs V (V) - irradiance



P (W) vs V (V) - Temperature

Therefore we can safely imply that in order to amplify the yield power from a sunlight based module, it must be worked at an interesting point with determined voltage and current qualities, or at the end of the day, at a predetermined burden obstruction. So, for this we will require a different power converter circuit for the maximum power point tracker.

Hence for our project, a lift type buck converter will be used to coordinate with the heap to the PV cluster to extricate the greatest power.

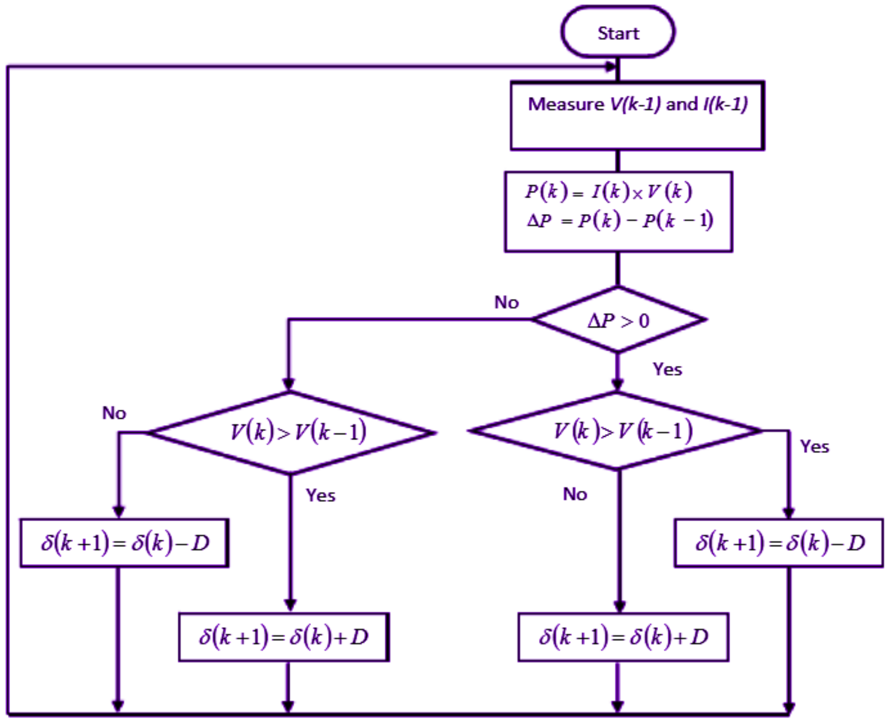
II. ALGORITHM

As mentioned above from the inference of the literature survey, the most extreme power point (MPP) of photovoltaic power age framework relies upon cluster temperature and sun based light, so it is important to continually follow MPP of sun based exhibits. For quite a long time, research has zeroed in on different MPP control calculations to draw the most extreme power of the sun powered cluster. In this segment, the adequacy of these four distinctive control calculations are completely researched through mathematical recreation.

The perturb and Observation technique has been generally utilized because of its simplicity of execution. P&O calculation will drive the PV framework to deal with the greatest power point by expanding or diminishing the PV board yield voltage.

Therefore for this work, an MPPT charge regulator dependent on the P&O procedure is planned, to work a decent PV module at MPP. The equipment execution of the planned 200 W MPPT charge regulator is completed and the model is tried for the PV charging framework. The outcomes show that such sort of MPPT regulator works on the effectiveness of PV boards when contrasted with regular charge regulators.

The flowchart has been drawn below for lookup:



P&O Flowchart

To discover the heading change for augmenting power, the P&O strategy irritates the working voltage of the PV board; in the event that power expands, the working voltage is additionally bothered in a similar way, though assuming it diminishes, the bearing of annoyance is switched. This cycle is rehashed intermittently until the MPP is reached . The framework then, at that point, wavered around the MPP. The obligation cycle bother at time (t+1) can be settled based on the accompanying relationship.

For the above flowchart P(t) and V(t) are, separately, the power and voltage drawn from the PV board. The wavering around the MPP can be limited by lessening the irritation step-size D. Anyway, unique execution is hampered by more modest annoyance step-size. This compromise requires cautious tuning of the obligation cycle annoyance step-size.

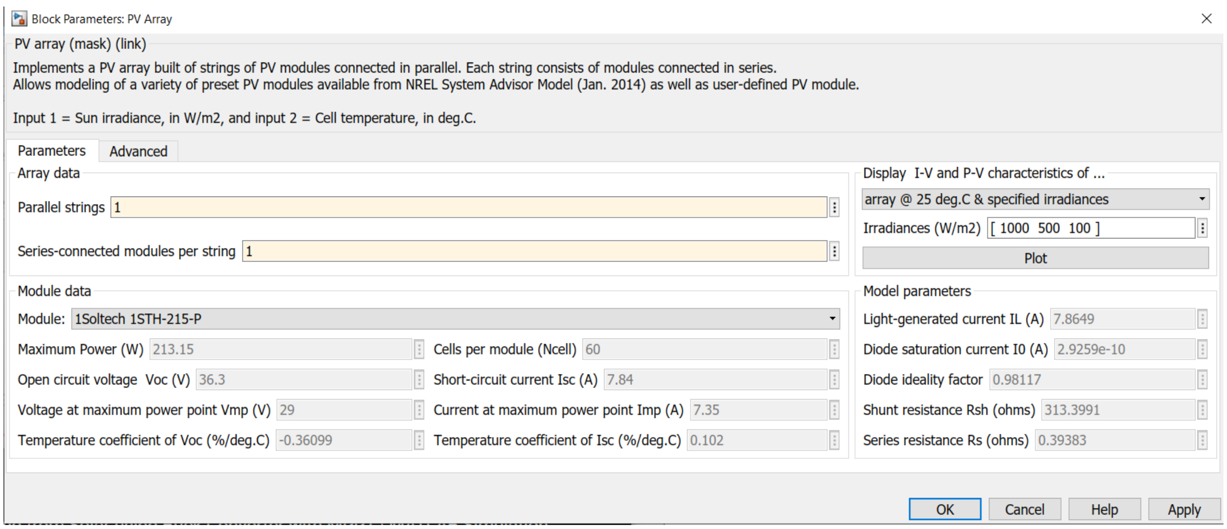
III. Algorithm Expected Outcome

Perturb and observe regulator is therefore expected to be very basic and can be executed without any problem. A downside of P&O calculation is that, at consistent express, the framework's working point wavers around the MPP bringing about the misuse of the accessible power. The picking of the irritation step-size is exceptionally basic; the progression size decides how quick the MPP is reached, optimizing can be accomplished with greater advance size, yet the motions around the MPP will be raised. There is a tradeoff between the dynamic and consistent presentation. The InC technique, which is more mind boggling than the P&O, licenses a slight decrease in the wavering's adequacy, however the framework probably won't work at the MPP. InC strategy experiences similar issues related to P&O calculation like necessity of specially appointed tuning boundaries, tradeoff among elements and consistent state execution. The significant benefit of the single current sensor strategy is the way that it utilizes the estimation of only one variable: the photovoltaic current. The proposed

FLC gives a quicker and stable following of greatest power when contrasted with the other MPPT strategies concentrated in this paper.

IV. Modeling

To begin with we first add the 1Soltech 1STH -215-P PV block with array rating at 25 deg C and parallel string 1 and series connected modules per string as 01. Then the time constant for the PV block is set to 1e-6 seconds. Then two constant blocks are added to supply the input value for irradiance and temperature. After this the output of the PV array is noted at standard 25 deg C and 1000 irradiance. Then we feed the output of the PV array to two unit delay boxes via a bus selector with the output Voltage and Output current of the PV array as select parameters. We added a unit delay box for each Voltage and current output of the pV array. Sinc the input to the MATLAB function block needs to be delayed by 10^{-4} seconds we set the sample time for the unit delay block at 10^{-4} seconds.

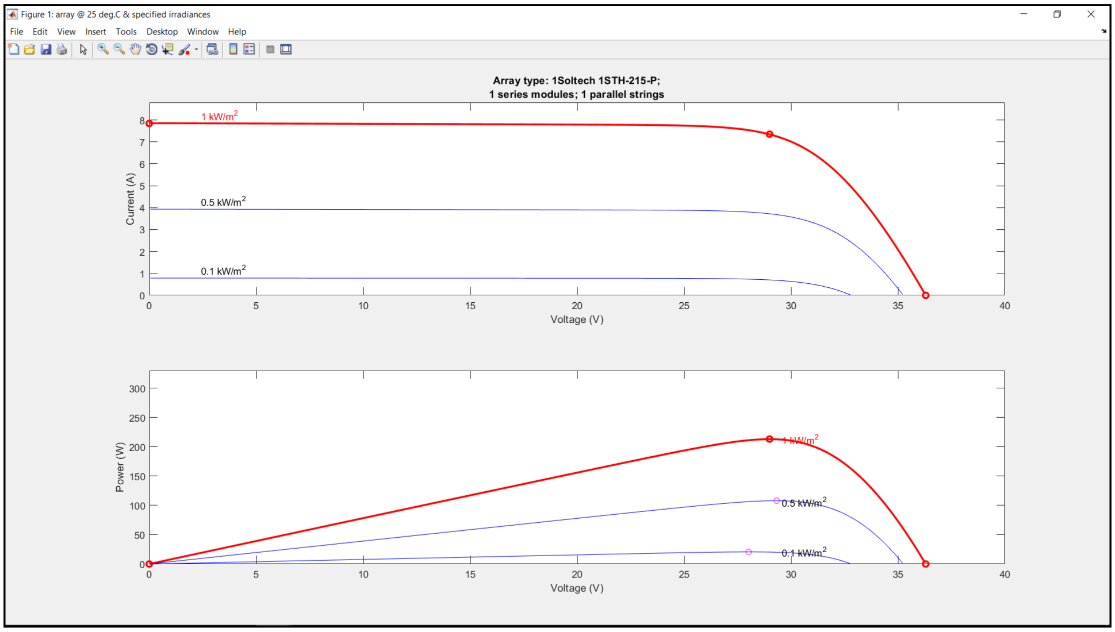


1Soltech 1STH -215-P PV block

The matlab function block has the code written for the duty ratio and MPPT algorithm and compares the difference between the initial Voltage and Current to the difference with the set value which is initialised to zero. The output of this function block is fed to the comparator along with a repeating sequence of 5 Khz switching frequency with time value in the range (0, 0.0002) and output value parameter of [0 1]. A separate product block is added to the bus output to monitor the power output of the PV array in real time.

Then the net output of the comparator which is either 0 or 1 is fed back to the buck converter. Which uses this information along with the output of the PV to step down the voltage so that we can charge the battery. Finally the battery is connected at the end of the converter along with a bus selector to separately look and study the charging of the battery.

The circuit model of lithium particle battery was set up by utilizing the second - request RC circuit model, and the battery was recreated progressively. Through the boundary setting, this model can carry on the reenactment research in the perplexing circumstance. The current, open circuit voltage, SOC state and battery temperature change of the battery under various charge and release are examined. This reproduction model is supportive for the streamlining and plan of lithium particle batteries. It is as the examination objects that Lithium-particle batteries with positive and negative materials of LiMn2O4 furthermore, LixC6 were chosen. A numerical model is made for reproducing the electrochemical conduct of Lithium-particle batteries. It is set up that the electrochemical cell model and the one RC cell model are dependent on previously mentioned. The instance of voltage, current, temperature, SOC and the charging/releasing attributes were contemplated. The model is dynamic, and it mirrors the transient condition of the battery yield. The outcomes show that exact battery charging/releasing procedure, the board and SOC estimation can be accomplished.



1Soltech 1STH -215-P PV block SPECIFICATIONS

From the above current and power bend for various sun powered illumination and consistent temperature, it tends to be seen that current and power of the PV module increments with expanding the sun powered illumination. The recreation aftereffects of I-v bend and p-v bend of PV model for consistent sun oriented illumination (β = 800 W/m2) and distinctive temperature are displayed in the above figure. From the above it tends to be seen that voltage and power of the PV module diminishes with expanding the cell temperature.

The Power Point Tracker is a high-recurrence DC to DC converter. They take the DC input from the sun powered chargers, change it to high-recurrence AC, and convert it back down to an alternate DC voltage and current to precisely coordinate with the boards to the batteries. MPPT's work at exceptionally high sound frequencies, as a rule in the 20-80 kHz range. The upside of high-recurrence circuits is that they can be planned with exceptionally high-effectiveness transformers and little parts. The plan of high-recurrence circuits can be exceptionally interesting as a result of the issues with segments of the circuit "broadcasting" actually like a radio transmitter causing radio and TV impedance. Commotion separation and concealment turns out to be vital.

There are a couple non-advanced (that is, straight) MPPT's charge controls around. These are a lot simpler and less expensive to construct and plan than the computerized ones. They do further develop productivity to some degree, however by and large the effectiveness can fluctuate a ton - and we have seen a couple lose their "following point" and really deteriorate. That can happen every so often if a cloud disregards the board - the direct circuit looks for the following best point however at that point gets excessively far out on the profound finish to discover it again when the sun comes out. Fortunately, very few of these are around any longer.

The force point tracker (and all DC to DC converters) works by taking the DC input current, transforming it to AC, going through a transformer (normally a toroid, a donut looking transformer), and afterward redressing it back to DC, trailed by the yield controller. In most DC to DC converters, this is totally an electronic interaction - no genuine smarts are involved with the exception of some guideline of the yield voltage. Charge regulators for sunlight based chargers need significantly more smarts as light and temperature conditions shift consistently the entire day, and battery voltage changes.

Here it is important to note that the perturb and observe (P&O) method tracks the maximum power point (MPP) by repeatedly increasing or decreasing the output voltage at the MPP of the Photovoltaic. The implementation of the method is relatively simple, but it cannot track the MPP when the irradiance varies quickly with time. In addition, it may cause system oscillation

All new models of advanced MPPT regulators accessible are microchip controlled. They realize when to change the yield that it is being shipped off the battery, and they really shut down for a couple of microseconds and "look" at the sun powered charger and battery and make any required changes. Albeit not actually new (the Australian organization AERL had some as right on time as 1985), it has been as of late that electronic chips have become modest enough to be practical in more modest frameworks (under 1 KW of the board). MPPT charge controls are presently produced by a few organizations, like Outback Power, Xantrex XW-SCC, Blue Sky Energy, Apollo Solar, Midnite Solar, Morningstar and a couple of others.

V. CODING

```
function D = DuyRatio(V, I)

Dmax = 0.95;
Dmin = 0;
Dinit = 0.95;
deltaD = 0.0001;
persistent Vold Pold Dold;

dataType = 'double';

if isempty(Vold)
   Vold = 0;
   Pold = 0;
   Dold = Dinit;
end

P = V*I;
dV = V-Vold;
dP = P-Pold;

if dP ~= 0
   if dP<0
      if dV<0
```

```
            D = Dold - deltaD;
        else
            D = Dold + deltaD;
        end
    else
        if dV<0
            D = Dold + deltaD;
        else
            D = Dold - deltaD;
        end
    end
else D = Dold;
end

if D >= Dmax || D <= Dmin
    D = Dold;
end

Dold = D;
Vold = V;
Pold = P;
```

The code is written to dive into Maximum Power Point Tracking (MPPT), as it identifies with upgrading the gadgets of a sunlight based PV framework inverter. So say for example;

The board puts out 7.4 amps. Your battery is sitting at 12 volts under charge: 7.4 amps times 12 volts = 88.8 watts. We lost more than 41 watts - however you paid for 130. That 41 watts are not going anywhere, it simply isn't being delivered in light of the fact that there is a helpless match between the board and the battery. With an exceptionally low battery, say 10.5 volts, it's surprisingly more dreadful - we could be losing as much as 35% (11 volts x 7.4 amps = 81.4 watts. I.e the loss is around 48 watts.

Note here that lost power is really getting changed over into heat. It's not really missing, it's simply not usable by the charge regulator.

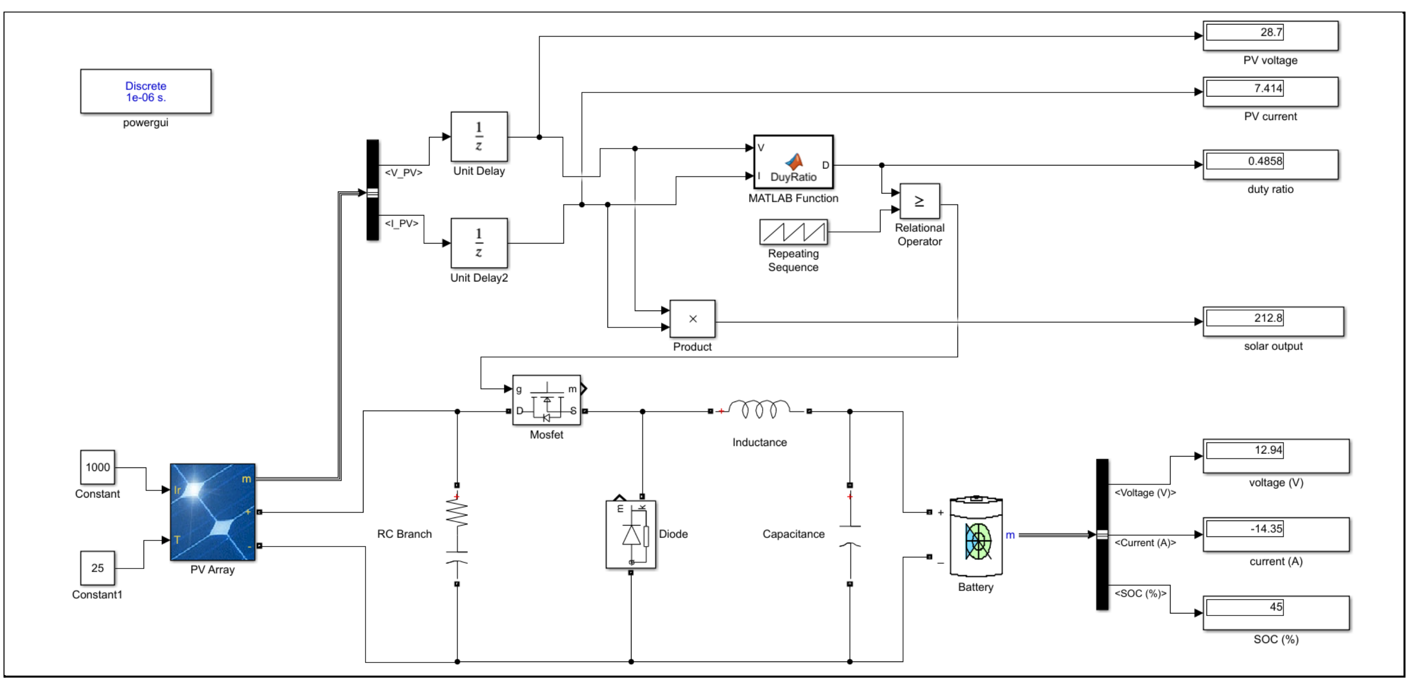
Catch is that the board is appraised at 130 watts at full daylight at a specific temperature (STC - or standard test conditions). On the off chance that the temperature of the sunlight based charger is high, you don't get 17.4 volts. At the temperatures seen in numerous warm environment regions, you may get under 16 volts. On the off chance that you begin with a 15-volt board (like a portion of the purported "automatic" boards), we are in a tough situation, as we will not have sufficient voltage to place a dash into the battery. Sunlight powered chargers must have sufficient elbowroom worked in to perform under the most exceedingly awful of conditions. The board will simply stay there looking imbecilic, and your batteries will settle the score more moronic than expected.

Most extreme Power Point Tracking is electronic following - generally advanced. The charge regulator takes a gander at the yield of the boards and thinks about it to the battery voltage. It then, at that point, sorts out what is the best force that the board can put out to charge the battery. It takes this and converts it to the best voltage to get the most extreme AMPS into the battery. Most current MPPT are around 93-97% effective in the change. We normally get a 20 to 45% force gain in winter and 10-15% in summer. Genuine addition can shift generally depending on climate, temperature, battery condition of charge, and different components.

Grid frameworks are turning out to be more famous as the cost of sun based drops and electric rates go up. There are a few brands of framework tie just (that is, no battery) inverters accessible. These have inherent MPPT. Proficiency is around 94% to 97% for the MPPT transformation on those. Here is the place where the enhancement or most extreme force point following comes in. Expect your battery is low, at 12 volts. A MPPT takes that 17.6 volts at 7.4 amps and converts it down so what the battery gets is presently 10.8 amps at 12 volts. Presently you actually have right around 130 watts, and everybody is glad.

Preferably, for 100% force change you would get around 11.3 amps at 11.5 volts, however you need to take care of the battery at a higher voltage to compel the amps in. What's more, this is a work on clarification - in established truth, the yield of the MPPT charge regulator may differ constantly to adapt to getting the most extreme amps into the battery. A MPPT tracks the greatest force point, which will be not quite the same as the STC (Standard Test Conditions) rating under practically all circumstances. Under freezing conditions a 120-watt board is really equipped for putting over 130+ watts in light of the fact that the force yield goes up as board temperature goes down - however on the off chance that you don't have some method of following that force point, you will lose it. Then again under extremely hot conditions, the force drops - you lose power as the temperature goes up. That is the reason you get less of an increase in summer.

DESIGN & MODELING



MATLAB/SIMULINK Model

In the above model we have incorporated a buck converter along with a MATLAB function block containing the MPPT code to harness maximum power from a PV module to charge a Li - Ion battery.

Initially the specification for the buck converter is calculated. For our project we are keeping the rated power at 210W. The range of the solar input voltage is kept between 28V to 36V. The battery output voltage is nominal of 12V - 13V with a switching frequency for the PWM generator of 5 kHz. For our project the voltage ripple is kept at 1% of the output voltage and the current ripple is kept at 1% of the output current.

Now,

Iout = Rated power/Vout = 210/12 = 17.5A ---- (1)
Iripple = 10% of Iout = 10% of 17.5A = 1.75A ---- (2)
Vripple = 1% of Vout = 1% of 12V = 0.12V ---- (3)

Filter inductance = {Vout(Vin - Vout)}/(Fsw * Iripple * Vripple)
= {12 * (28 - 12)}/(5000*1.75*0.12)
= 0.783 mH ---- (4)

Filter capacitance = Iripple/(8 * Fsw * Vripple)
= 1.75/(8 * 5000 * 0.12)
= 364 uF ---- (5)

A detailed table with the parameters of the block and any specifications taken into consideration while creating the model is mentioned below for lookup:

Title	**Parameters**
Circuit (design) specifications	1. Rated power = 210W (1000 irad) - 300W (1500 irradiation) 2. Solar input voltage (V_{in}) = 28V - 36V 3. Battery Voltage (V_{out}) = 12V - 14V 4. Switching frequency (F_{sw}) = 5 KHz 5. Current ripple (I_{ripple}) = 10% 6. Voltage ripple (V_{ripple}) = 1% 7. Output current (I_{out}) = 17.5 A - 21.4 A 8. I_{ripple} = 10% of I_{out} = 1.75A - 2.14 A 9. V_{ripple} = 1% of V_{out} = 0.12V - 0.14V
PV Array block	1. Model = 1Soltech-1STH-215 P 2. Array rated = 25 deg C 3. Parallel string = 01 4. Series connected modules per string = 01 5. I-V & P-V ratings: a. 29V and 213.1 watt @ 1000 rad b. 29.33V and 108 watt @ 500 rad c. 28.02V and 20.68 watt @ 100 rad

	6. Time constant = 10^{-6} seconds
Input Bus (RC) block	1. Resistance = 0.0001 ohm 2. Capacitance = 10000^{-6} farad
Mosfet block	Standard
Diode block	Standard
Filter inductor block	Inductance = 0.738 mH
Filter capacitor block	Capacitance = 364 uF
Battery block	1. Type = Li - Ion 2. Nominal Voltage = 12V - 14V 3. Rated Capacity = 100Ah 4. State of Charge (SOC) = 90% 5. Response time = 1 second
Bus Selectors (x2) block	Standard
Unit Delay Blocks (x2) block	Sample time =10^{-4} seconds
Relational Operator block	Comparator symbol: >=
Repeating Sequence block	1. 5KHz sawtooth signal is used as the carrier for PWM generation 2. Time value = [0 0.0002] 3. Output value = [0 1]
Product block block	Standard
Powergui block block	1. Type = Discrete 2. Sample time = 1e-6
MATLAB Function block	1. Input parameters = V, I 2. Dmax = 0.95 3. Dmin = 0 4. Dinit = 0.95; 5. Duty cycle = [0 - 1] 6. Enable input = Set to 1 7. Variable scope = persistent (values are retained in memory between calls to the function) 8. Conditional statements (dV = V - Vold ; dP = P - Pold which are initially set to 0) : a. dP ~= 0 b. dP < 0 and dV < 0 or dV > 0 c. dP <= 0

	d. dP > 0 e. dP >= 0

FINDINGS

After running the simulation for 30+ irradiation level and temperature the output data was obtained in terms of PV voltage, PV current, PV power, Battery voltage, battery current, battery output power and duty ratio.

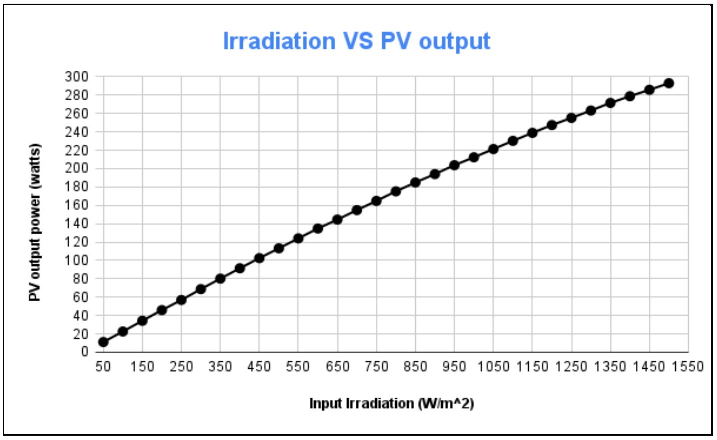


Figure 1

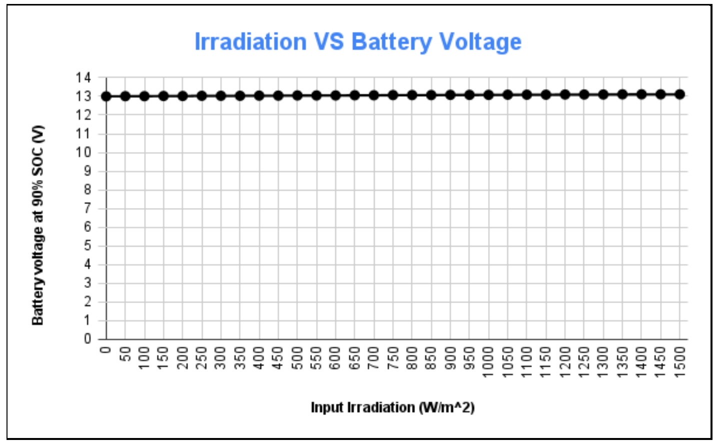


Figure 2

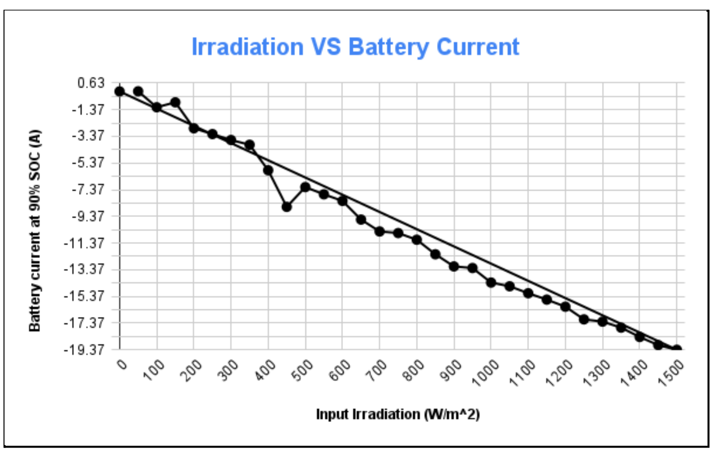


Figure 3

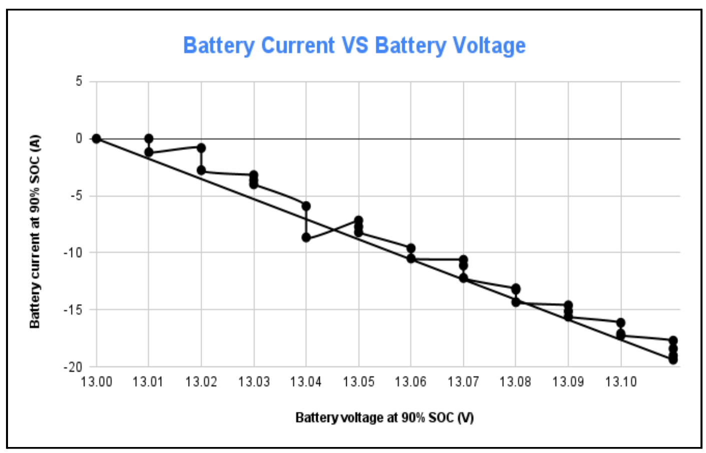


Figure 4

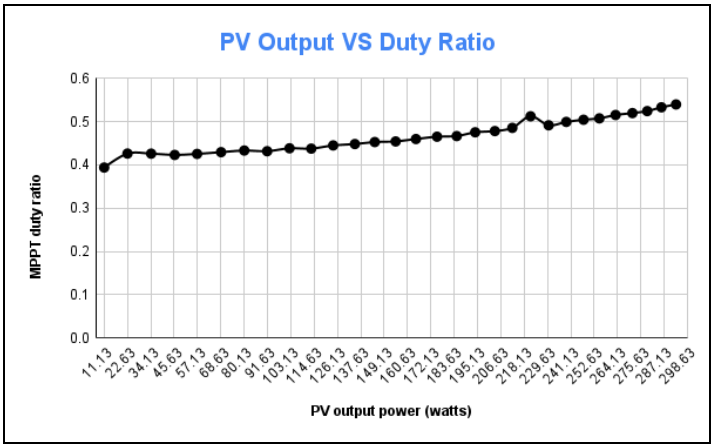


Figure 5

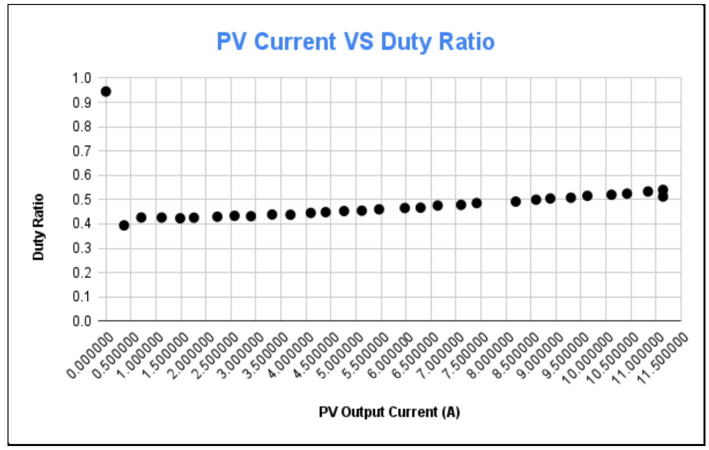


Figure 6

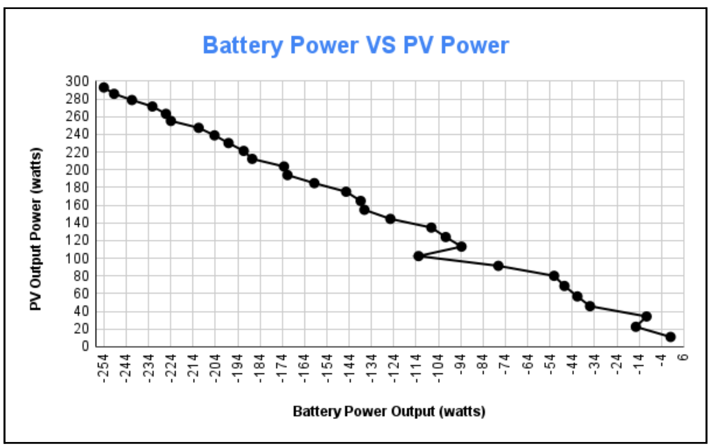


Figure 7

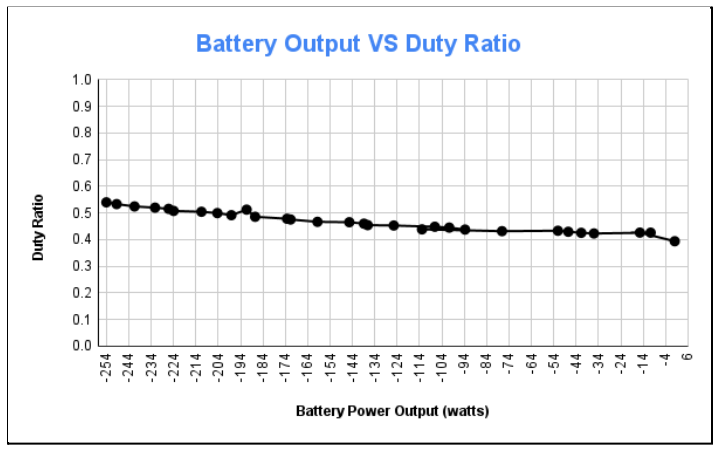


Figure 8

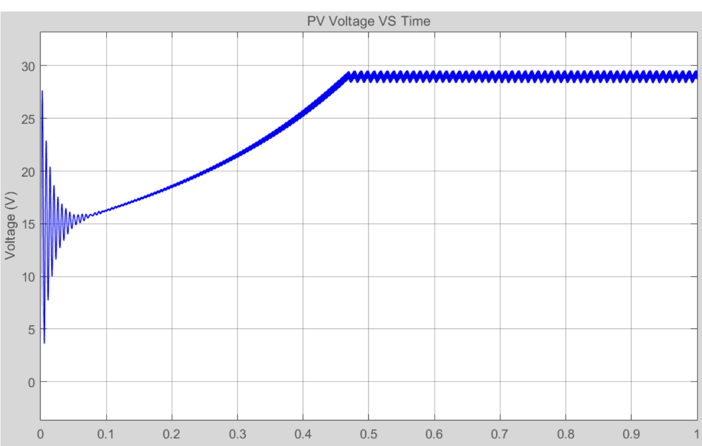


Figure 9

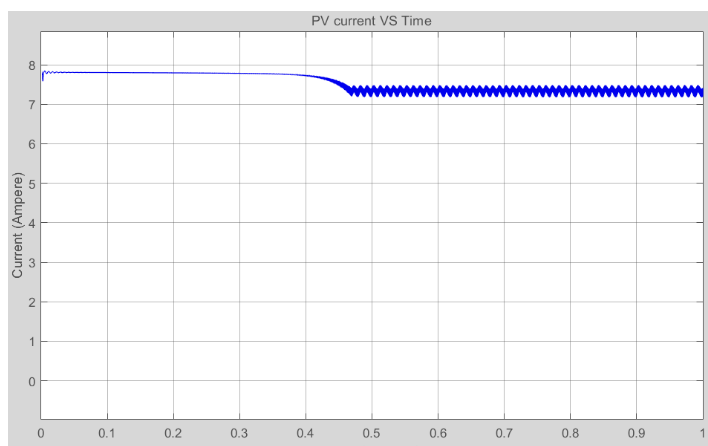


Figure 10

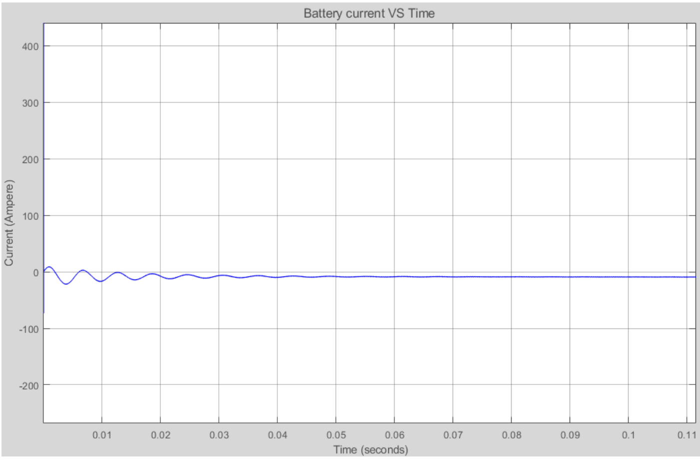


Figure 11

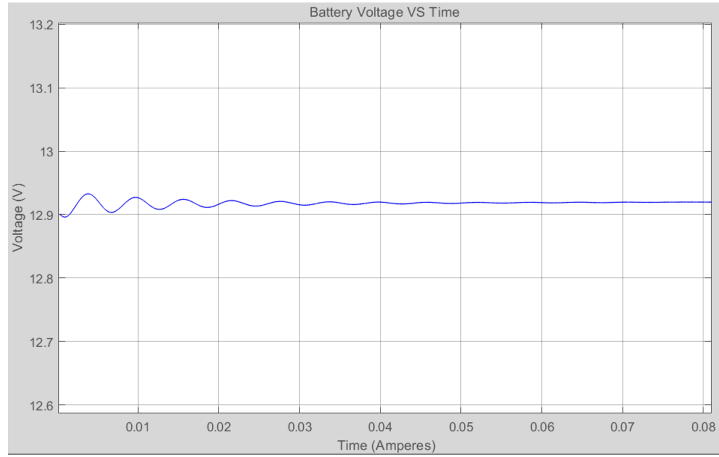


Figure 12

Input Irradiation	Input Temperature	PV Output Voltage	PV Output Current	PV output power	Battery Voltage	Battery Current	Battery Power Output	Duty Ratio block output
Watt/m^2	*Celcius*	*Volt*	*Ampere*	*Watts*	*Volt*	*Ampere*	*Watts*	*N/A*
0	0	12.91	-3.47E-08	4.62E-07	13	4.60E-08	5.97E-07	0.9449
50	1.25	30.68	0.3629	11.13	13.01	0.008728	0.11355128	0.394
100	2.5	31.98	0.7068	22.62	13.01	-1.188	-15.45588	0.4264
150	3.75	30.58	1.115	34.28	13.02	-0.8182	-10.652964	0.4262
200	5	30.78	1.485	45.89	13.02	-2.765	-36.0003	0.4232
250	6.25	32.42	1.76	56.93	13.03	-3.198	-41.66994	0.4256
300	7.5	30.78	2.228	68.75	13.03	-3.643	-47.46829	0.4296
350	8.75	31.21	2.572	80.18	13.03	-3.999	-52.10697	0.4334
400	10	31.52	2.901	91.46	13.04	-5.912	-77.09248	0.4318
450	11.25	30.8	3.323	102.5	13.04	-8.655	-112.8612	0.4386
500	12.5	30.69	3.69	113.2	13.05	-7.173	-93.60765	0.4378
550	13.75	30.17	4.096	124	13.05	-7.715	-100.68075	0.4452
600	15	30.66	4.394	134.7	13.05	-8.209	-107.12745	0.4484
650	16.25	30.47	4.762	144.5	13.06	-9.608	-125.48048	0.453
700	17.5	30.35	5.117	154.8	13.06	-10.5	-137.13	0.4544
750	18.75	30.27	5.462	164.8	13.07	-10.62	-138.8034	0.46
800	20	29.19	5.977	175.2	13.07	-11.12	-145.3384	0.4654
850	21.25	29.37	6.292	184.9	13.07	-12.21	-159.5847	0.4668
900	22.5	29.31	6.634	194	13.08	-13.12	-171.6096	0.4756
950	23.75	28.59	7.102	203.7	13.08	-13.24	-173.1792	0.4784
1000	25	28.7	7.414	212.3	13.08	-14.33	-187.4364	0.4858
1050	26.25	27.59	11.14	221.3	13.09	-14.61	-191.2449	0.5126
1100	27.5	28.1	8.195	230.2	13.09	-15.13	-198.0517	0.4918
1150	28.75	27.72	8.602	238.9	13.09	-15.61	-204.3349	0.4996
1200	30	27.85	8.886	247.4	13.1	-16.14	-211.434	0.5046
1250	31.25	27.48	9.298	255.2	13.1	-17.09	-223.879	0.5078
1300	32.5	27.39	9.627	263.2	13.1	-17.26	-226.106	0.5156
1350	33.75	26.79	10.11	271.5	13.11	-17.71	-232.1781	0.52
1400	35	26.75	10.42	278.8	13.11	-18.41	-241.3551	0.5246
1450	36.25	26.37	10.84	285.8	13.11	-19.02	-249.3522	0.5334
1500	37.5	26.36	11.14	293	13.11	-19.37	-253.9407	0.54

Data set Table

INFERENCES

In **Figure 1** study the trend of *Irradiation VS PV output* and as expected see that as the irradiation increases the output power of the PV also increases. The relationship is directly proportional with a linear trend with a slight curve at (650, 134.7). **In Figure 2** study the trend of *Irradiation VS Battery Output voltage* and one see that even though the irradiation is increasing, the output voltage at the battery side after attaining 90% SOC stays approx. constant. Therefore one can conclude that the relationship is independent. **In Figure 3** one studies the trend between *Irradiation VS battery current* and one sees that as the irradiation increases (after 100 irradiation) the battery begins to charge and the charging current keeps on increasing as the irradiation increases. Therefore one concludes that the relationship is directly proportional.

In Figure 4 one study the trend between *Battery current VS Battery voltage* and expect to see that the trend is directly proportional. **In Figure 5** one plots the *PV output power VS Duty ratio* and one sees that the change in duty ratio (increase) is there but very slight compared to the increase in power output of the PV array. From this one infer that the relationship is directly proportional with a constant value of less than one. **In Figure 6** one plots *PV output current VS Duty Ratio* and sees that there is a strong dip in duty ratio during the first change in output current but after that the remaining step increase in PV output current shows a very slight increase in duty ratio. **In Figure 7** one plots the trend between *Battery power VS PV power* and see that the trend is linear with a sharp decrease at (-107.12, 134.7) and it trends back to its original trend after that till battery output reaches 253 watts.

In Figure 8 one studies the relation between *Battery output power VS Duty Ratio* and see that even though the battery output is increasing, the change in duty ratio is very slight. **In Figure 9** one looks at the trend in PV voltage with increase in time and see that there is a slight periodic fluctuation in the first part with a steady increase in the next half and a steady voltage output in the final time. **In Figure 10** one looks at the trend in PV current with increase in time and see that there is a steady output in the first half of the simulation with a trickle oscillation in the next half. **In Figure 11** we see the charging current changes w.r.t time and after studying the trend we can infer that during the initial period the charging current oscillates but then it stabilizes after a certain period. Similarly we can see **In Figure 12** that the voltage oscillates for an initial time frame but then stabilizes around 12.7 - 12.9V and maintains that level until SOC of 90% -95% is made.

CONCLUSION

So, finally we conclude by stating that the need for renewable resources is far more in demand today than it was ever. Therefore we need to switch towards a more sustainable source of energy i.e. Solar Energy. Hence after the completion of our project we have found that to gain or extract maximum performance out of a PV module it is necessary to incorporate certain algorithms to maximize the battery charging output. So after a comparative analysis we have found out that by using a module 1Soltech-1STH-215 P PV array rated at 25 deg C for 1000 irradiation one can charge a Li - Ion battery rated at 1.3KWh at 90% SOC with a nominal voltage at 12V - 14V.

LIMITATIONS

Now that one has concluded the project it is worthwhile to mention that the approach has some limitations that one would like to mention. It must also be noted that these limitations are by no means to undermine the field of EV but to bring up the challenges one think will be faced by integrating a standalone PV integrated charging. Firstly by using a PV module the max battery capacity that can be efficiently charged is rated at 1000Ah or 12kWh whereas the current world leader at EV vehicles, Tesla has Li - Ion batteries that are rated at 13.5kWh at level 1 charging. Moreover the PV installation could add extra cost to the car and will increase the total number of movable parts installed on the car as the PV module would require to be aligned with the sun.

So, it is advisable to use this form of charging on smaller rated vehicles such as Electric Rickshaws, Electric Autos, etc i.e. vehicles that are not built for high end uses.

FUTURE SCOPE

Every one of the electric vehicles accompany a 120-volt level 1 versatile charger. These chargers can be connected to a straightforward family outlet, and don't need any uncommon establishment. Most makers give a fundamental level 1, 120 Volt charger, and these can take between 8 and 20 hours, contingent upon the battery limit of the vehicle. Electric bicycles give new potential, particularly in relaxation deals and are popular in a few vacationer locations. To advance the wellbeing climate, the presence of an e-bicycle charging framework is urgent. The absolute most famous areas for e-bicycle charging stations are vacation spots, eateries, lunch rooms, facilities, and recreation offices or sights.

The squeezing natural concerns involving gridlock and contamination in the Asia Pacific locale has prompted a more noteworthy accentuation on the offer of electric vehicles with 56.0% of the business coming from East Asia and 37.0% of Southeast Asia prepared to purchase an electric vehicle. The Asia Pacific locale held a critical portion of the overall industry of electric vehicle charging stations in the year 2019 and is probably going to observe a sound development pace of 39.6% in the gauge time frame.

Key members incorporate Chargepoint, Inc., ABB Ltd., Tesla Inc., BP Chargemaster, EVGO Services LLC, Semaconnect Network, Greenlots, and EV Connect, among others. In February 2020, Avis India, vehicle rental specialist organization, declared to collaborate with Quikk India, an e-versatility specialist co-op, for the improvement of incorporated arrangements planned for corporate electric portability administrations. The organizations in coordinated effort have fostered a notable, incorporated AI-based model, which joins transportation administrations, just as admittance to hearty charging foundation, at costs roughly comparable to those of existing ICE vehicles.

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