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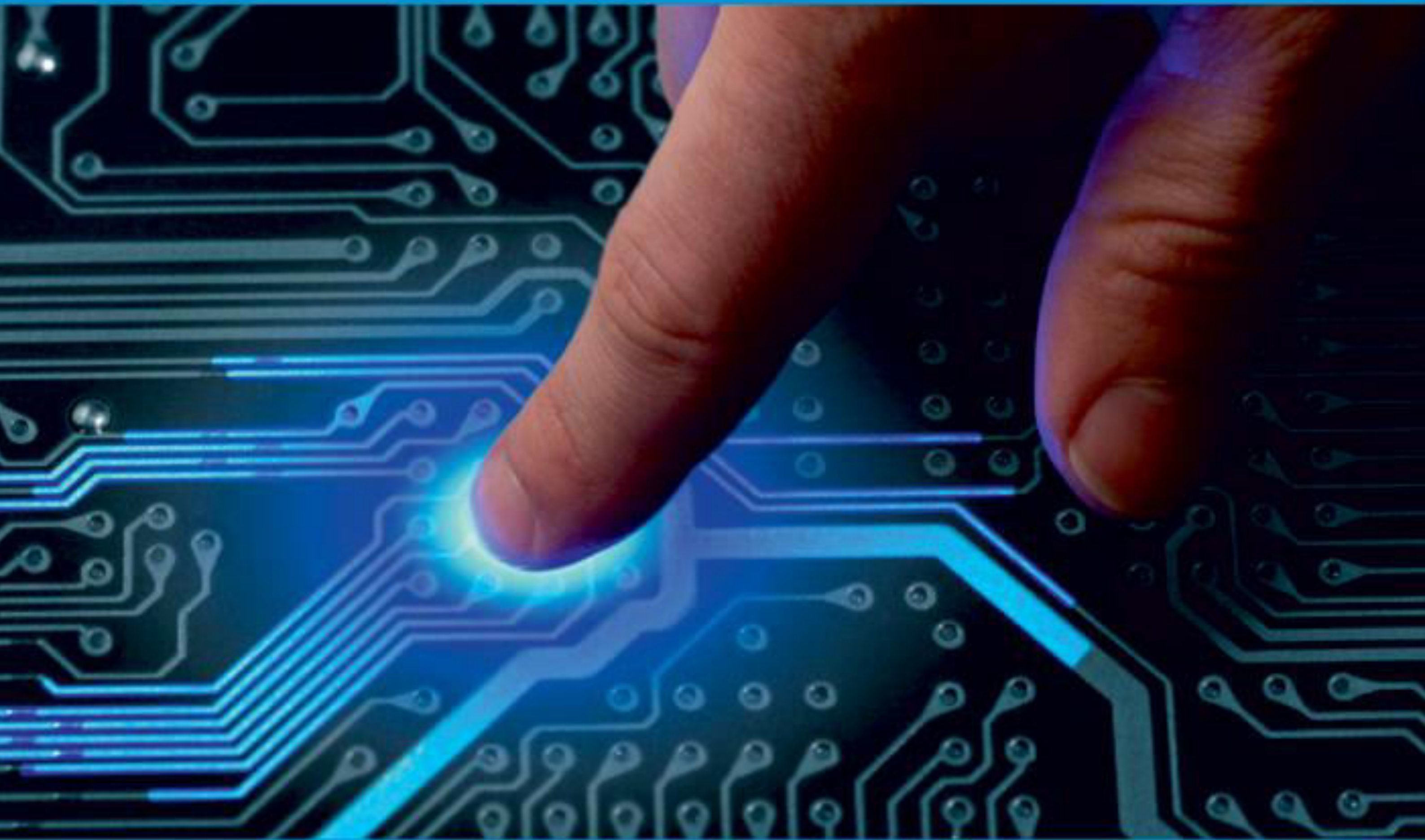

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System Design and Realization of a Solar-Powered Electric Vehicle Charging Station

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ABSTRACT: The main goal of this concept is to design such a station that is combined with solar energy for urban neighborhoods in large cities. The development of improved EV load models begins with an examination of the most well-known commercial EVs. The proposed solar-powered charging station would be built in a selected major metropolis and test new EV load patterns. In this study, the battery of an electric car is charged by the sun and a power supply. The primary source of power for an electric vehicle is sunlight; however, in the event that it is not available (during the winter or during a storm), the power board is used.

KEYWORDS*:* solar panel, MPPT controller PFC rectifier ,BUCK converter PI controlled ,EV battery

I. INTRODUCTION

Batteries are widely used as the primary energy source in a variety of applications, from small electronics to electric vehicles (EVs). When the primary EV first appeared in the middle of the nineteenth century, interest in EV batteries began to grow. Since EVs may reduce petroleum consumption by up to 75% today, EV batteries have gained renewed attention in the automotive industry. According to Boston Consulting Group, the global market for advanced batteries for electric cars is predicted to reach US $25 billion by 2020, more than double the size of the current total lithium-particle battery market for consumer devices.

In order to speed up the commercialization of cutting-edge batteries for EVs and crossover electric cars, the U.S. Committee for Automotive Research (USCAR) and the U.S. Progressed Battery Consortium (USABC) have established minimum targets for battery properties (HEVs). The top concerns of customers are safety and dependability, which will help EVs and HEVs gain market share. The battery technology and the battery management system, however, are responsible for the two of them. In this way, a battery management system (BMS), which serves as the link between the battery and the vehicle, is crucial for enhancing battery performance and maximising the safe and dependable functioning of the latter.

Given the rapid growth of the EV and HEV industry, it is imperative to promote a comprehensive and established BMS, similar to the motor management system in a gas car. In EVs and HEVs, the BMS must provide Lr. BMS indicators should provide information on the battery's health, use, performance, and lifespan. A lithium-particle battery might catch fire anytime cheated because to unpredictable behaviour, combustibility, and entropy fluctuations. This is a serious problem, especially in EV and HEV applications where a burst might result in a fatal accident. Additionally, excessive release results in lowered cell limit because of irreversible chemical reactions . As a result, a BMS must monitor and manage the battery based on the safety gear included inside the battery packs. When any unusual situations are found, such as overvoltage or overheating, the BMS should notify the customer and carry out the predetermined repair. In addition to these capabilities, the BMS also monitors the system.
The BMS in EVs and HEVs should provide temperature to provide an improved power usage plot and communication with specific parts and administrators. BMS indicators should display the battery's state of security, use, execution, and lifespan. A tricked lithium-particle battery may ignite due to variations in instability, combustibility, and entropy. This is a serious problem, especially in EV and HEV applications where a burst might result in a fatal accident. Additionally, excessive release reduces cell limit owing to irreversible synthetic reactions. A BMS must thus screen and manage the battery based on the security hardware integrated into the battery packs. When any unusual circumstances, such as overvoltage or overheating, are discovered, the BMS should notify the customer and carry out the predetermined

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correction method. In addition to these features, the BMS also communicates with individual components and administrators and monitors the framework temperature to provide a better power use graphic.

II. LITERATURE SURVEY

[1] proposes the design features and operational execution of the current Type-1 car connector-controlled level-2 solar-assisted electric vehicle charging station. In the MATLAB/Simulink environment, the planned model is produced, the circuit functioning is analysed, and a methodological model is derived to research the parametric design aspects. Additionally, a whole hardware setup has been created to verify the performance of the power factor correction under a steady-state situation with regard to load fluctuation using an input of 3 kW, 230 Vrms at 1-phase, 50 Hz rated, and to generate a 48 V buck converter dc output.

[2] The battery management system (BMS) is a crucial component of all electric and hybrid cars. The BMS's purpose is to guarantee safe and reliable battery operation. State checking and evaluation, charge regulation, and cell modifying are features that have been included in BMS to maintain the security and dependability of the battery. A battery behaves differently under varied functional and environmental settings since it is an electrochemical object. The execution of these capacities is put to the test by a battery's vulnerability display. Concerns of the present BMSs are discussed in Paper [2]. A BMS's fundamental responsibility is to analyse the state of a battery, including its charge, health, and longevity.

The major goal of [3] is to use solar energy and electric supply to intelligently charge our battery for electric vehicles. The purpose of this document is to correctly charge and discharge our battery while preventing harm to the battery and charging circuit. We use three distinct charging modes for this battery, each of which has advantages, and we balance the charge for optimal charging. By real-time balancing supply and demand, battery energy storage efficiently stabilises the electric grid and facilitates the incorporation of renewable energy. In highly populated metropolitan regions, where conventional storage methods like compressed-air energy storage and pumped hydroelectric energy storage are frequently impractical, the significance of such storage is particularly significant [4].

A Hierarchal Cascaded Multilevel Converter (HCMC) for constant, uniform SOC activity is shown in Paper [5]. The proposed HCMC is built using a combination of half-span converters and H-span converters, and the voltage may be lowered to two successive levels—the half-span level and the H-span level—before reaching an unquestionable level. The converter possesses the components necessary for high voltage and high power applications, as well as a calculated strategy for cost reduction and constant quality improvement. The suggested converter allows for consistent SOC activity without the need for additional regulating circuits. To evaluate the exhibition of the suggested converter, reenactment studies have been conducted.

Paper [6] analyzed the characteristics, advantages and disadvantages of cell balancing methods. Table 1 compared passive balancing methods and active balancing methods based on their advantages and disadvantages. A passive cell balancing method normally uses a low current. Therefore, its energy transmission efficiency is low because of its low heat dissipation although it requires long balancing time. A passive method is a suitable technique for portable tools and low-power systems.

[7] In order to address the energy demands for electrical, thermal, and transportation electrification, this review suggests combining the usage of fuel cells, combined heat and power (CHP), hot water tank storage, gas boilers, and photovoltaic (PV) generators.

[8]. This study also suggests an input current control approach that guarantees seamless operational mode changes that take place when a battery charger is functioning. The control is fully implemented in a microcontroller, ensuring input current operation with a low total harmonic distortion and high PF. Experimental evidence was used to confirm the mentioned converter's performance under the suggested control strategy.

[[9]. The major goal of the suggested work, according to this reviewer, is to deliver continuous power to the grid, improving the feasibility of the system's battery energy storage support.

[10] Analytical methods were proposed to obtain information about EV charging behavior, modes of charging station operation, and geolocation of charging station users. The methodology presented here was time- and cost-effective, and very helpful to the researchers and students in this field.

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In this study, a fuzzy logic inference system is used to control power effectively and to make use of V2H. It mimics the prioritisation of power management and emergency backup power supply decisions made in a typical home in poor nations like India to choose whether to charge or discharge the PEV battery.

[12]This paper provides a unique handshaking method that uses plug-in electric cars (PEVs) coupled to a solar (PV) aided charging station (CS) using a vehicle-to-grid (V2G) control technique to lessen transformer and line overloading.

[13] This review focuses on the design of future power networks, where cutting-edge technology will be crucial to the production, transmission, and distribution of electricity. The way we have produced, delivered, and used energy over the last century is changing as a result of the present power networks, which is going through an unparalleled shift.

[14] The proposed EV fast battery charger is based on a dual-stage power converter (ac-dc and dc-dc) sharing the same dc-link. The ac-dc stage is used as an interface between the power dc-link and the grid. It provides for the regulation of both the grid current and the dc-link voltage and is made up of the parallel association of two full-bridge voltage-source converters.
[15] The experimental validation of a novel architecture of an off-board, three-phase fast battery charger for electric vehicles (EVs) with innovative operation modes is presented in this paper. The proposed EV fast battery charger is based on a dual-stage power converter (ac-dc and dc-dc) sharing the same dc-link. The ac-dc stage is used as an interface between the power grid and the dc-link

[16] Using photovoltaic (PV) panels to charge electric vehicles (EVs) offers a sustainable transportation future. The creation of a 10kW EV charger that can be powered by both a PV array and the three-phase AC grid is discussed in this study. Realizing a three-port power converter with a high power density and efficiency while integrating the grid, solar panels, and electric vehicles while also meeting Chademo and CCS/Combo EV charging requirements is the objective.

III. PROPOSED SYSTEM

In order to determine whether zero carbon personal car travel is technically feasible, affordable, and realisable within the next ten years (by 2025), as well as whether zero carbon personal car travel compares favourably to current transportation systems in terms of cost, convenience, attractiveness, and co-benefits.

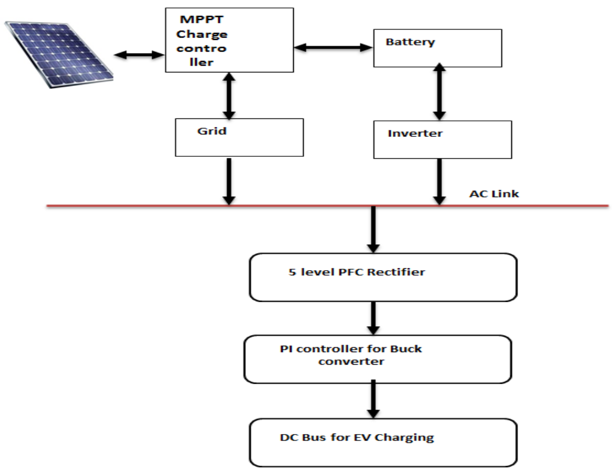

Fig 1. Architecture of proposed system

This framework intends to break down the potential for zero carbon vehicle travel by investigating whether: Zero carbon individual vehicle travel is in fact conceivable and reasonable, and can be accomplished in the following 5 years (by 2025); and Zero carbon individual vehicle head out analyzes well to introduce transport frameworks, when taken into account in terms of their cost, lodging, captivating quality, and co-benefits. The square schematics of the suggested charging framework are shown in Fig. 1. The electricity for the charging station comes from two sources that are also

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used to re-energize automobiles parked beneath sheds: standard utility lattice power and additionally sun-oriented PV-based power. As a result, the charging station provides solar capacity to the cars that arrive for charging by using solar energy during the day and normal structure electricity at night.

The PV framework showing focuses on the square components of the association under a PV structure, namely the sun powered charger, MPPT regulator, charge regulator, battery, sun based cross breed inverter, 5-level PFC rectifier, buck converter, and EV charger and battery as a heap. Power Factor Correction (PFC) modifies the power supply's information current to match the mains voltage and amplifies the actual power drawn from the mains. In a perfect PFC circuit, there is almost no info current and the information current follows the information voltage like a pure resistor.

IV. DESIGN OF ELECTRIC VEHICLES CHARGING STATION

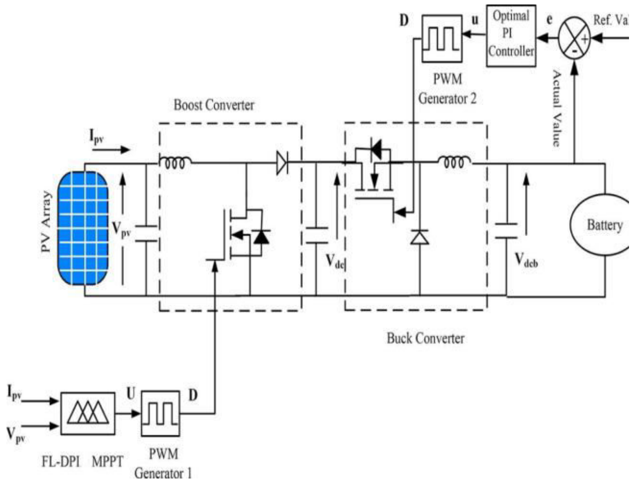

fig2. Circuit Design for EV battery

1. *Solar energy*

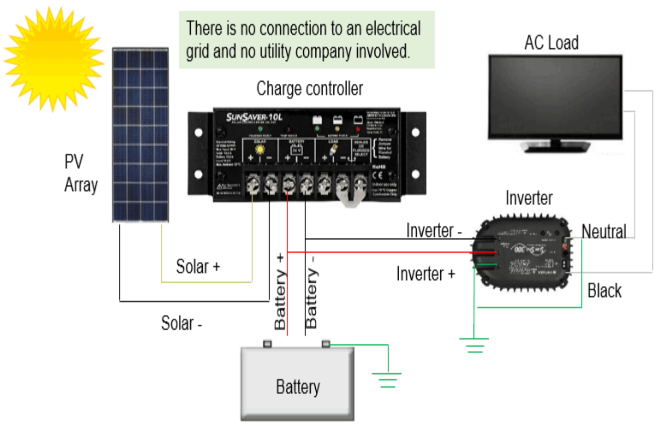

Fig 3. soalr power from sun

Solar energy is transformed into electrical energy by the PV cell. A single diode or two diode equivalent models may be used to electrically actualize the PV module's energy conversion process. Because it is simpler to build and has less complexity than the two-diode model, the single diode model as shown in the 3.Fig. below has been taken into consideration for the simulation in the work provided.

At the output terminals of PV module, the current I may be expressed by Eq. (1).

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$$I = Iph - Id - Ips \quad \text{...... (1)}$$

Where Id and Ips in (A) are the currents flowing through diode shunt resistance. The current due to incident photon energy Iph in (A) is given by Eq. (2).

$$Iph = (I_{sc,n} + K_1 dT)\frac{G}{Gn} \quad \text{..... (2)}$$

At standard circumstances of 1000 (W•m2) and 25 (C), Isc,n is the short circuit current. Short circuit current temperature coefficient is denoted by KI. The difference between the operating temperature T and the nominal temperature Tn is known as the dT and is represented as dT = T Tn (K). The irradiations under nominal and typical operating conditions are G and Gn in (W•m2), respectively. Eq. (3) gives the current via the diode as an expression.

$$I_d = I_0\left[exp\left(\frac{V+IRs}{V_t a}\right) - 1\right] \quad \text{..... (3)}$$

I0 in (A) is the diode reverse saturation current and the V in (V) is the output voltage of PV module. The diode ideality factor will be represented by a and its value lies in the range of 1 to 2. RS in (Ω) is the series resistance of the PV module. The thermal voltage Vt in (V) of the PV module is given by Eq. (4):

$$Vt = \frac{NSkT}{q} \quad \text{..... (4)}$$

where NS represents the number of series cells in a PV module. k is the Boltzmann constant (1.3806503 · 10−23 J·K−1) and q is the charge of the electron (1.60217646·10−19 C). The I0 is expressed as in Eq. (5):

$$I_0 = I_{0,n}\left(\frac{Tn}{T}\right) exp\left[\frac{qEg}{ak}\left(\frac{1}{Tn} - \frac{1}{T}\right)\right] \quad \text{..... (5)}$$

Eg in (V) stands for the bandgap energy of the p-n junction material and its value is 1.12 eV for polycrystalline silicon at 25 ◦C. I0,n in (A) is the diode reverse saturation current and is expressed as in Eq. (6):

$$I_{0,n} = \frac{I_{sc,n}}{exp\left(\frac{V_{oc,n}}{aV_{t,n}}\right) - 1} \quad \text{..... (6)}$$

Voc,n and Vt,n in (V) are the open circuit voltage and thermal voltage at nominal conditions. The current in shunt resistance is represented as in Eq. (7):

$$Ips = \frac{V + IRS}{Rp} \quad \text{.... (7)}$$

2. MPPT protocol

Most extreme Power Point Tracking (MPPT) strategies are utilized in photovoltaic (PV) frameworks to consistently boost the PV cluster yield power which by and large relies upon sun based radiation and cell temperature. MPPT techniques can be generally arranged into two classifications: there are ordinary strategies, similar to the Perturbation and Observation (P&O) strategy and the Incremental Conductance (Inc Cond) technique and progressed techniques, for example, fluffy rationale (FL) based MPPT technique. This paper presents a study of these techniques to dissect, reproduce, and assess a PV power supply framework under shifting meteorological conditions. Recreation results, got utilizing MATLAB/Simulink, show that static and dynamic exhibitions of fluffy MPPT regulator are superior to those of ordinary methods based regulator.

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3. BUCK converter by using PID controlled

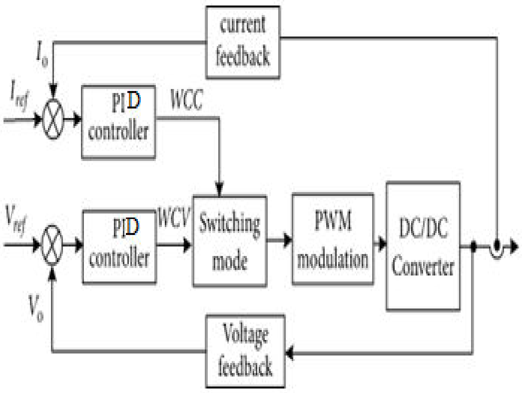

Fig .4 BUCK converter by using PID controlled

Figure 4 illustrates a constant current and constant voltage switching charging control mechanism. The output voltage Vo and the reference voltage Vref are compared in the constant voltage stage. The PI controller determines the error, and simulation yields the modulation signal. The modulation signal may also be obtained with MATLAB.

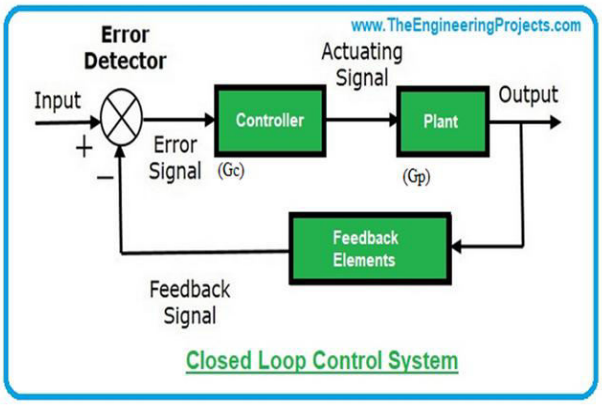

Fig 5. PID controller

Using only the proportional and integral terms as PI control is a version of proportional integral derivative (PID) control. Even more than complete PID controllers, the PI controller is the kind that is most often used. As the modified variable input, the system receives the value of the controller output u(t)u(t).

$$u(t) = K_p e(t) + K_i \int e(t)dt + K_p \frac{de}{dt} \quad \ldots.. (1)$$

When the controller is first converted from manual to automated mode, the u bias term is normally set to the value of u(t)u(t). If the error is zero when the controller is turned on, this results in a "bump less" transmission. The integral time constant II and the controller gain KcKc serve as the two tuning parameters for PI controllers. A greater value of KcKc makes the controller more aggressive in its response to errors away from the set point. KcKc is a multiplier on the

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proportional error and integral term. The process variable (PV) is the measured value that may differ from the intended value, whereas the set point (SP) is the goal value. The difference is the error from the set point. The error from the set point is the difference between the SP and PV and is defined as e(t)=SP−PV.

The transfer function of a PID controller is found by taking the Laplace transform of Equation (1).a

$$K_p + \frac{K_i}{s} + K_d s = \frac{K_d s^2 + K_p s + K_i}{s} \quad ....(2)$$

where Kd is the derivative gain, Ki is the integral gain, and Kp is the proportional gain. This form of feedback controller generates a control variable based on the difference between a user-defined set point and a measured process variable. A PID controller generates a corrective action that can change the process in order to reduce the difference between a measured process variable and a desired set point. Therefore, we were able to rectify the DC motor's fault and regulate the speed or position of the motor to the desired point or speed by connecting the PID controller to the DC motor. PID controllers, however, cannot be set such that the system achieves the required step response with the least amount of rise time and without overshoot for a given inertia, load, and speed reference. Only two control states—totally ON or fully OFF—are attainable with the usage of a basic, low-cost ON-OFF controller. When these two control states are sufficient to achieve the desired control result, it is employed in restricted control applications. However, the oscillating nature of this control restricts its application, and PID controllers are now taking its place. PID controllers operate in closed loops to maintain the output such that there is no error between the process variable and the set point or intended output. PID employs three fundamental control characteristics, which are described here.

PFC rectifier

Electronic device makers can enhance the power factor of their products using a number of techniques called power factor correction (PFC). The existence of displacement or distortion in the signal results in a poor power factor. Due to the fact that capacitors move the phase ahead while inductors move it back, displacement has a negative impact on the power factor that is very easy to correct. The phase of the current wave will be dragged forward until it is in phase with the voltage if a system's current wave is out of phase with the voltage. This may be accomplished by adding a capacitor with the appropriate impedance to the circuit (Figure6).

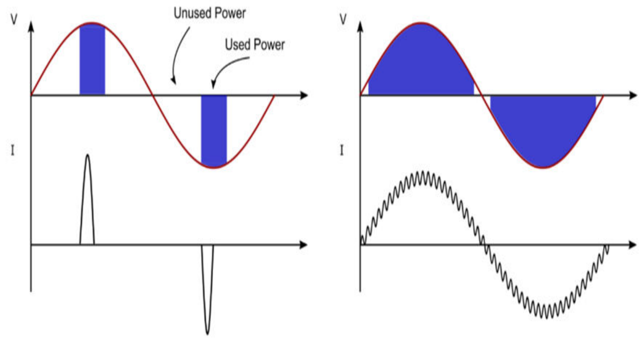

Figure 6: Low PF Power Transmission with No PFC (Left) and Power Transmission with Corrected Power Factor and PFC (Right)

A sine wave with a frequency of 50 Hz may be seen in the output current because the converter monitors the input voltage. This waveform, however, still differs significantly from a pure sinusoid, therefore it will naturally have a significant amount of harmonic components. These harmonic components will be very successfully filtered out since they are multiples of the switching frequency, which is significantly higher (50kHz to 100kHz) than the 50Hz fundamental. As a result, the power factor is greatly increased, which explains how certain switching power supply can achieve PF values of up to 0.99.

The three main categories of PFC approaches are passive (static), partial-switching, and active (switching). A reactor is connected in series with a power source by a passive (static) PFC. The size of the reactor will depend on the power

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source's capability. As a result, passive PFC is frequently employed for power supply with limited capacity. For the power supply of 100-VAC inverter air conditioners and other home appliances, partial-switching PFC is frequently utilised in conjunction with a voltage doubler rectifier.

The voltage and current output of solar panel showed changing of current and power with respect to change in voltage. We have used solar panel of 4 series modules with 2 parallel strings for simulation.

IV.RESULT AND DISCUSSION

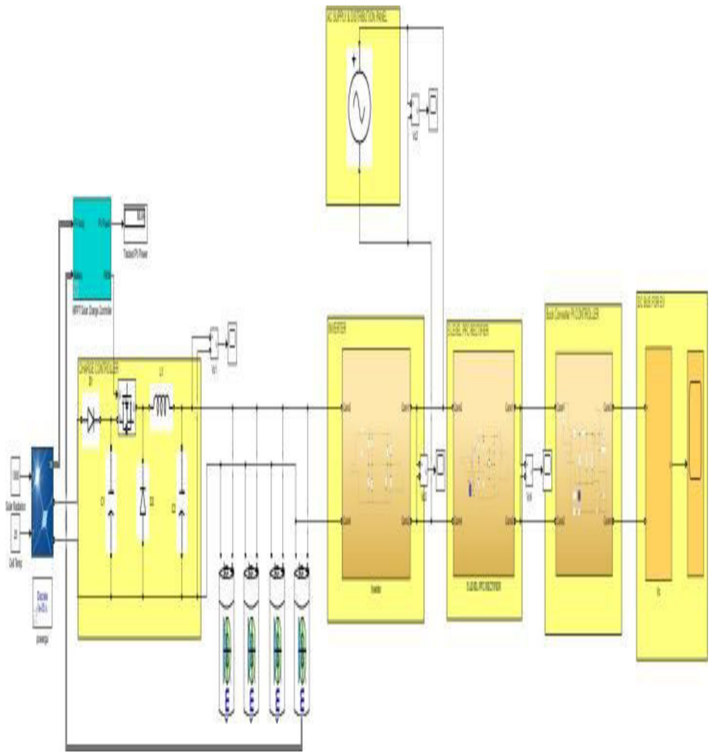

Fig 7. MATLAB simulation

MATLAB Simulation of "System Design and Realization of a Solar-Powered Electric Vehicle Charging Station" is show in fig 7. It consists of charge controller, inverter, rectifier, PI controller and distribution panel, respective results of this part is explained in succeeding sections

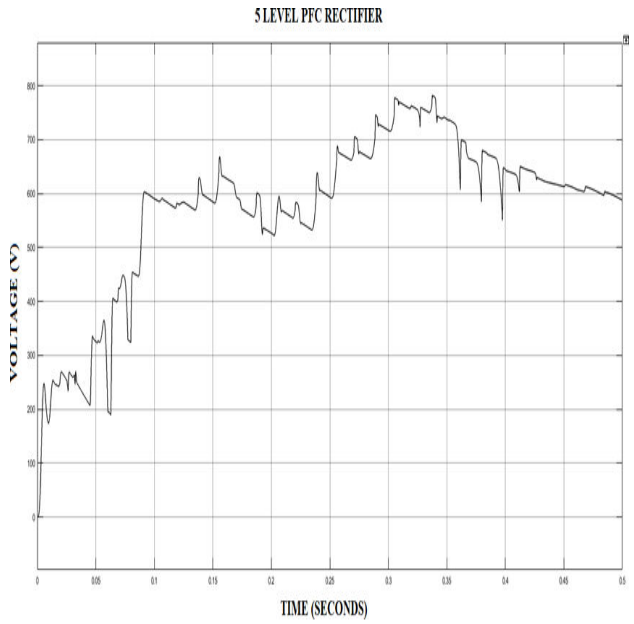

Figure 8.: Five level PFC rectifier output

Output voltage of 5-level PFC rectifier is given in fig 8. High power factor or PFC rectifiers are one of the mostly used equipment in the industries. The main concerns of such converters are the unity power factor operation and low harmonic distortion of the input AC waveforms that can be ensured by generating a DC voltage higher than the PV peak voltage amplitude, which makes use of switching devices inevitable. A cascaded PI controller has been designed to regulate the output DC voltage and to ensure the unity power factor mode of the input AC voltage shown in fig 8.

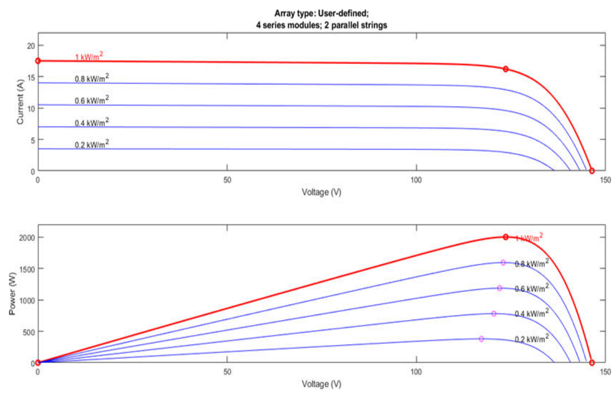

Figure 9. SOLAR

The voltage and current output of solar panel showed changing of current and power with respect to change in voltage. We have used solar panel of 4 series modules with 2 parallel strings for simulation.

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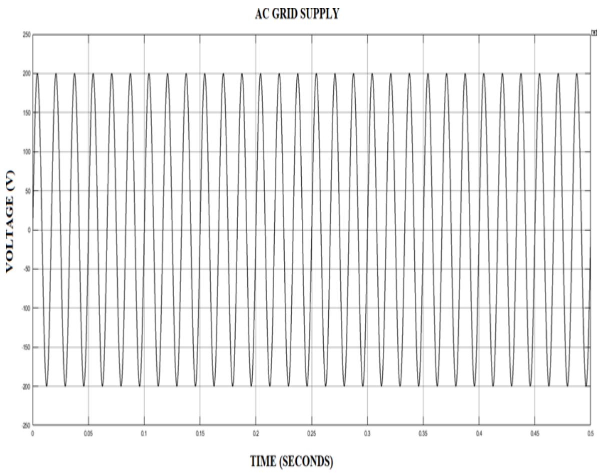

Figure 10 : AC grid supply

Output of AC grid supply, output voltage of charge controller and voltage of DC bus are shown in figure 8, 9 and 10 respectively.

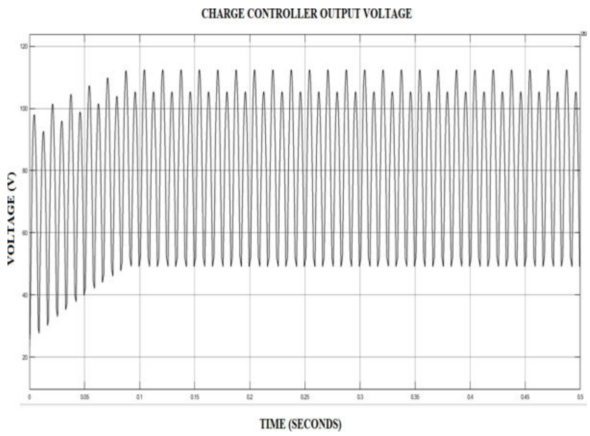

Figure 11: Charge controller output voltage

The charge controller adjusts the panel's output voltage from 16 to 20 volts to what the battery requires at the moment. This voltage varies between 10.5 and 14.6, based on the battery's level of charge, the kind of battery, the controller's mode, and the temperature.

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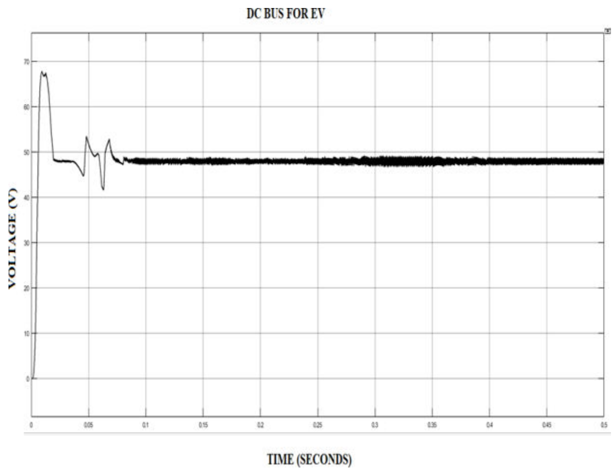

Figure 12: DC BUS FOR EV

The dc bus voltage is kept at the nominal value of desired Voltage throughout the simulation, and the dc current is steady, as shown in Fig12

V. CONCLUSION

A transportation innovation with zero outflows is electric automobiles. EVS, a personal vehicle setup that is powered by renewable energy and has no tailpipe emissions, can help address environmental change while also delivering a number of benefits. Battery technology, in particular, is developing swiftly and getting cheaper. We are soon approaching a tipping point when the lifetime costs of ices will be more significant than those of electric cars. Additionally, the development of a variety of electric personal versatility devices, including electric motorcycles and bikes, has exploded. The vehicle area is concurrently charging and growing. Above all, switching to 100% electric vehicles for solo urban travel would eliminate 6% of ozone-depleting pollutants. If local vehicle traffic is also included, this would increase to 8% of discharges. This would have a huge impact on India's discharges and move India closer to having an economy with zero emissions.

When feed-in fees are less than the cost of retail electricity, EV charging promotes PV self-utilization, which results in increased PV earnings. In this way, EV charging using solar energy is both effective and beneficial to the environment because to the dual benefits of lower fuel costs and emission. In the unlikely event that sunshine is not available, one may use electricity from a power board to provide a continuous power source.

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