Design of 60kW Solar PV Powered Charging and Parking Station for EV System in India.

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Abstract: Charging stations are the main source of energy for EVs and their locations are critical to the accessibility of EVs in a city. Thus, the demand for plug-in electric vehicles (PEVs) charging for public vehicle charging systems is increasing. This paper reports the design of a 60-kW solar photovoltaic (SPV) charging station for plug-in electric vehicles. The purpose of the proposed system is to create a powerful, intelligent charging station that is powered by solar energy for charging PHEVs at workplaces The selection and recommendation of PV modules, inverter rating, and battery bank is chosen on the results generated by an onlinetool PV Syst.. The EV charging station using MPPT based controller is designed and simulated in MATLAB Simulink. The system works satisfactorily under the given conditions and can be modified by adding protection and other component stoobtainamorerealistic result.This study will help in commercializing the renewable energy charging station of electric vehicles and satisfy the charging demand of EV users, most importantly, reduce the energy cost.

Keywords:electricvehicles(EVs),chargingstations,plug-inelectricvehicles(PEVs),solarphotovoltaic(SPV),MPPT,MATLAB.

1. Introduction

There is an emerging definition related to EVs technologies. Many primary ideas in the manufacture of EVs predateinternal combustionengines for fuels. Developments in energy storage, the design flexibility of vehicles, electric grid mechanization more over the value of EVs for Customers,companies,and government organizations would improveand encourage long-term moves to improved transportation alternatives[1].EVs are much more effective energy than petrol/diesel-powered motor cars and do not release carbon from engines.They are much smoother, less annoying, and need limited maintenance[2].

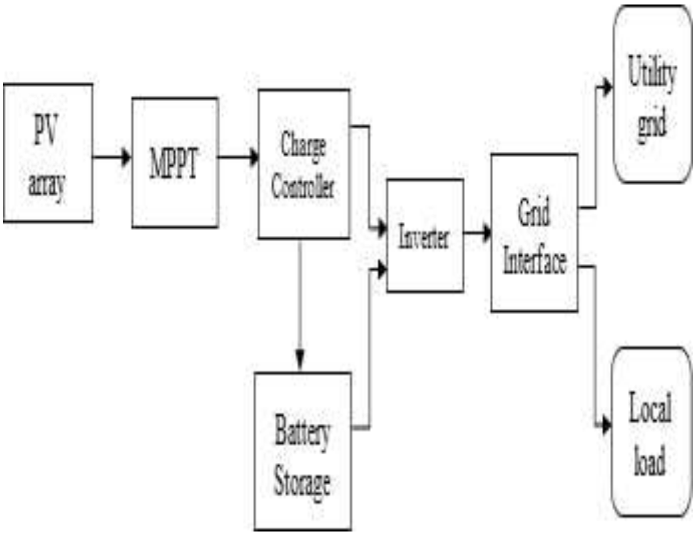

Figure1: Functional diagram of solar powered charging station connected to grid.

On the other hand, if EVs are charged from a grid that is mostly powered byrenewable power plants, net emission then is almost zero. The obstacle is therefore to use sustainable energy sourcest fuel electriccars in the future.The best renewable energy sources for electric vehicles would be wind, geothermal, biogas, solar, hydropower, and tidal energy. Including the use of photovoltaic solar panels for charging EVs, is an appealing option for several purposes:

- High accessibility PV power for EV users is available since Photovoltaic cells can be attached to the rooftop and as solar parking lots near the location of EVs. There is a huge amount of unusable PV capacity on top of buildings or parking lots, and this should be taken advantage of inthe future.
- The power demand and energy on the grid is decreased due to electric charging because the charge energy is provided locally "green" by solar panels [3].
- PV systems provide low noise, no moving components,and are virtually free of maintenance.
- The price of charging the electric vehicle from photovoltaic panels is lower than the grid and limits the effects of low tariff feed-in PV [4], [5].
- PV devices typically use a battery to store solar energy to handle the fluctuations in solar activity both daily and seasonal [6], [7].

Thesedays, with world wide concern for green house gases and environmental pollution, EVs are being produced at speed for commercial and personal uses.Users must charge the batteryof the vehicle when they run out of their battery at the charge station when these vehicles are used every day. Besides, electric vehicles do face the issue of charging their electric vehicles at some chargingstations as their car batteries are not matched with the adapter.There for it is anessential and critical connection to solve the environmental problems, to charge electric vehicles from renewable energy.

2. EV Charging Methodology

a) Charging an EV from Grid

Although charging EVs via grid can seem easy and comfortable, it is difficult method has different consequences on the grid infrastructure that runs today. The power demands can vary from 1kW to 60kW for a peak to nonpeak hours, based on the type of charging station, which creates higher power demand and strains grid infrastructure.Further, the research carried out in it suggests that the peak energy demand measured in the network was between 3 pm - 5 pm on a normal working day because of the EV activity. Also, the loading of these vehicles may affect grid stability without suitable scheduling or coordination of the charging of EV batteries. Additional influential effectsongridssince EVs will be used

- Higher generation costs with higher demand.
- Over crowding transmission line.
- Overloading of distribution transformers.
- Excessive damages and losses in the transmission line.
- The variations in the voltage of EVcharging sites.
- Grid infrastructurewear.

EV charging from the grid also has no positive effect on the atmosphere.It is a wrong assumption that people assume that EV-associated Carbon dioxide emissions are negligible.However,energy generation from other carbonizing sources (coal, gas, etc.) produces higher Carbon emissions used to charge these EVs. This is because the emission decrease advantages of charging stations decrease with the increased grid CO2 level.

b) Charging EV through Renewable Energy Sources

Renewable energy technologies have increasingly become an alternative to traditional fossil fuels. these source so felectricity can be found near the power station system efficiencies can be significantly increased with minimized losses,voltage changes, and cost of power infrastructure.

Also, through multiple types of research the variable nature of renewable energy sources (RES) over grids of power systems have been developed to reduce through Intelligentcoordination and storage capabilities of PHEVs [10].The places of the Solar Powered Charging Stations (SPCS) will mainly focus on the terms of operation of the EVs:

- Electric vehicles workareas(parking the carfor more than one hour).
- Electricvehiclesathouse.
- Electric vehicle sovertheroad.

3. System Modelling

The process suggested is done with MATLAB to design a 60kw of charging station powered by PV for EVs, however before we use MATLAB, we are going to use PV system study, size, and data analysis of complete PV systems. With ourfocus area, and also having an average annual temperature of 29 degrees centigrade. Based on data that we have entered on PVsyst programs such as latitude, longitude altitude (1000m abovesea level), country, and wherethex- axis represents azimuth (0°) and the y-axis represent sun height. Accordingto the figure below we can figure out, we will produce more energy in summer (1: June) more than in winter (7: December).

Figure 2 shows the solar annual average irradiance and temperature value in the daytime for each month of the year. According to the figure below, we can figure out that the values of global irradiance, diffusion of the sunlight, wind velocity, and temperature increase in summer and decrease in winter.If we take a look at the figure below, wecan figure out that (May, June, July, and April) have the highest value comparing to any other months in each column.

Month	Clearness index	Daily radiation [kWh m^{-2} day^{-1}]	Ambiant temperature' [°C] max, min, average
January	0.6	4.195	31, 9, 19
February	0.59	4.757	34, 12, 22
March	0.593	5.568	40, 13, 27
April	0.588	6.148	40, 17, 30
May	0.542	5.968	40, 18, 30
June	0.466	5.198	40, 21, 30
July	0.382	4.22	36, 22, 29
August	0.419	4.445	38, 18, 28
September	0.449	4.358	36, 18, 28
October	0.579	4.882	35, 16, 27
November	0.592	4.268	31, 16, 24
December	0.596	3.956	30, 9, 20
Average	0.533	4.829	36, 16, 26

Figure2: Solar annual average irradianceand temperature value inthe daytime for each month of the year

The main components being used in the specified design are photovoltaic systems, electric vehicle charging stations (EVCS), controller, inverter,connectors, cables, and mounting system is shown in Figure 3.1.

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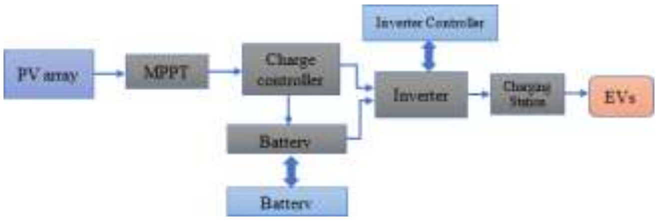


Figure3.1:MATLABimplementationoftheblocks.

a) Solar PV Array

For a 60kW system using PV System which has a PV array consists of a variety of separate PV modules or panels which are connected in 10 series and with 15 parallel string to transmit the current and voltage that any system's needs.The larger the array surfacearea,themoresolar energy would be produced overall.

b) Inverter

WearegoingtoselectABBinvertertypeandthepowerofour inverter based on the power of our design so, our design is 60 Kw then we need only one inverter with power 60Kw or we can use two inverters with power 25Kw for each one. The parameters used for this type of inverter, minimum voltage required to work the inverter = 300V, the maximum voltage thatcantheinverterholdout=950V,power of the inverter =60KWand maximum efficiency=98.54%.

c) Maximum Power Point Tracking (MPPT) Controller

Perturb&observe technique because of it seasein implementation.The advantage is the circuitry used for the method is simple and requires only twosensors.The algorithm is generated by perturbing a small increment in voltage of PV and observ in resultant change in power. If ΔP is positive, then perturbation will lead towards maximum powerpoint and if ΔP is negative, then operating point has moved away from maximum point. Hence the perturbation should be reversed to return back to the maximum point.

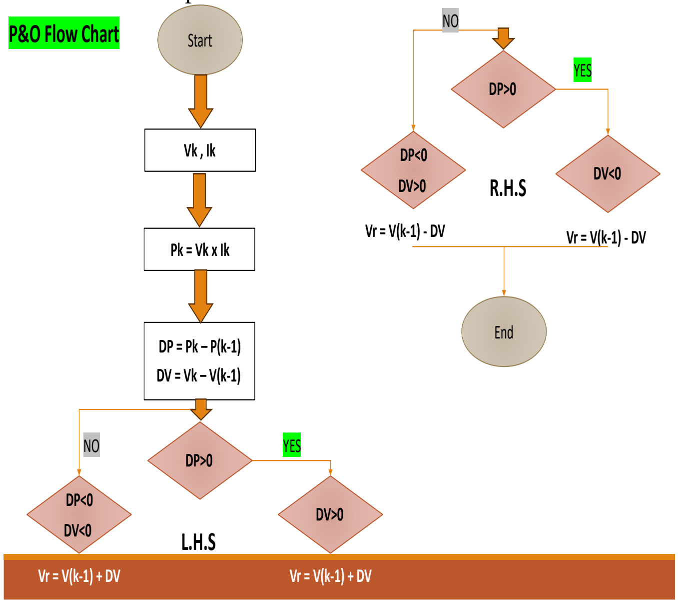


Figure3.2: Flow chart of the PerturbandObserve method.

d) Lithium-IonBattery

We have selected Lithium-Ion Battery of LG chem model namely EM048290P5B1 290Ah. There are at least 255 modules required to be connected 51 parallel string with each has 5 batteries in it. It gives a total of more than two days of autonomy.

e) MATLAB/SIMULINKImplementation

Simulink is a graphical extension to MATLAB for modeling and simulation of systems. In Simulink, systems are drawn on the screen as block diagrams. Many elements of block diagrams are available, such as transfer functions, summing junctions, etc., as well as virtual input and output devices such as function generators and oscilloscopes. Simulink is integrated with MATLAB and data can be easily transferred between the programs. We use the Simulink to simulate the PV charging station for EVs.

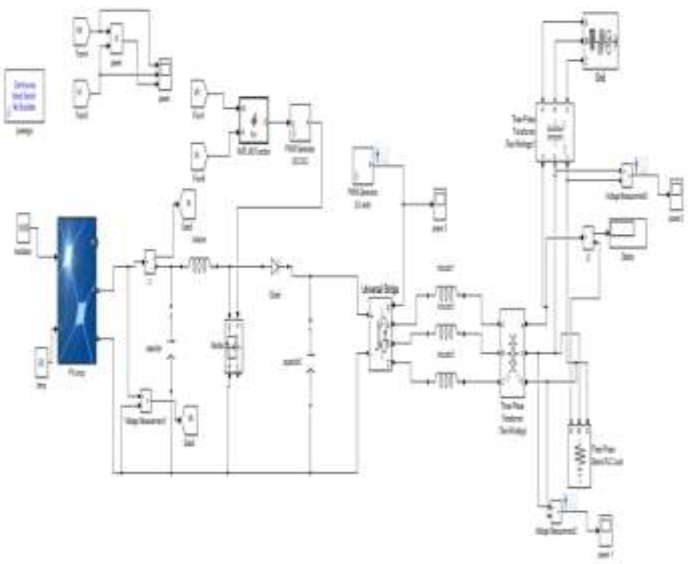


Figure4.1: Matlabimplementationof 60Kw charging station for EVs

In this simulation,there are ninephasesofthe SimulinkModel as shown in the following diagram. The MPPT algorithm is used for a charge controller with boost control charging. The discrete system with a time step of a 1e-6 second is used with the constant input of irradiation value and temperature to the solar array. The specifications of the solar array are already discussed above. There are 15 string of PV panels with each has 10 panels connected in series making an area of about 253 square metersto generateabout 60 kW of nominal power.

The MPPT is commonly used in many small and medium commercial solar PV charge controllers and grid-connected inverters due to its tracking effectiveness and simplicity of implementation. The MPPT algorithm track the maximum power of the PV arrayand output its dutycycle relevant to the tracked maximum power to the battery charge controller shown in Figure. 4.3.

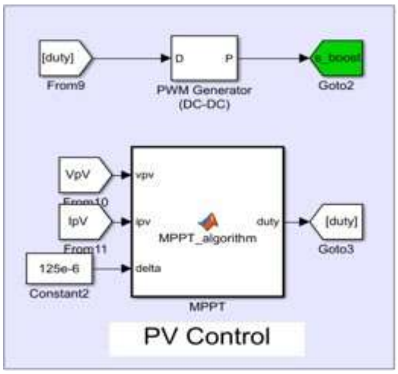


Figure4.3:MPPT PV control

The battery charge controller was developed to charge a Lithium-Ion battery using the 2-diode charging method. The method of charging includes two bidirectional converters each for charging and discharging respectively operated by a signal coming from the battery. According to the figure below we apply switching signals for both of the bidirectional converters for positive side switch (S-P) and for negative side switch (S- N). When the produced photovoltaic power lower than the required power for the charging station(load), thenthe battery must feed the charging station (load). For another case if the produced photovoltaic power higher than that the charging station need then the battery must charge to keep constant voltage.

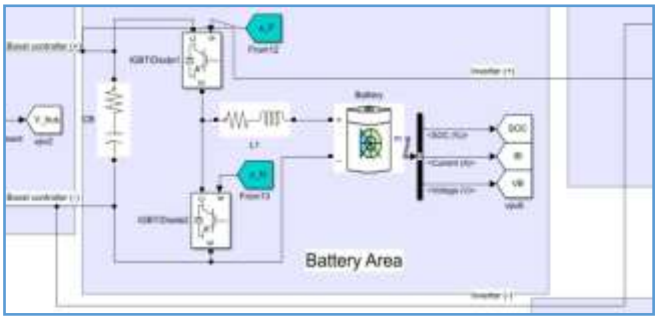


Figure4.4: Battery block

Battery controller block provide the signal to bidirectional converters connecting to the batteryblock to run alternately in caseofcharginganddischargingdependuponthesystem voltage and battery current using two PI controller and aPWM generator with specified values is used to obtain the desired results. According to figure 4.5 we use PWM generator to control battery side also to produce signals for positive and negative side of bidirectional converters. We use logical operator (Not) because we know that the positive side isa complementfor negative side. Also, we willgenerate duty signal for PWM generator we can generate it by using PI controller.

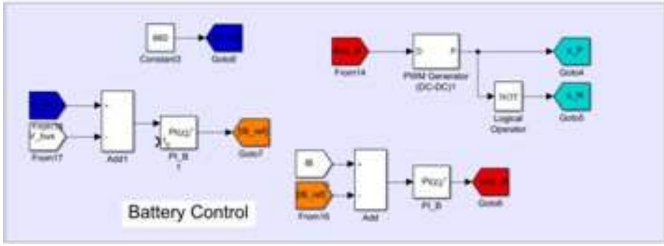


Figure4.5: Battery controller block

In inverter block single stage universal module with single filter is used with controlling signal coming from the controller block. 60kW inverter is selected for this purpose.

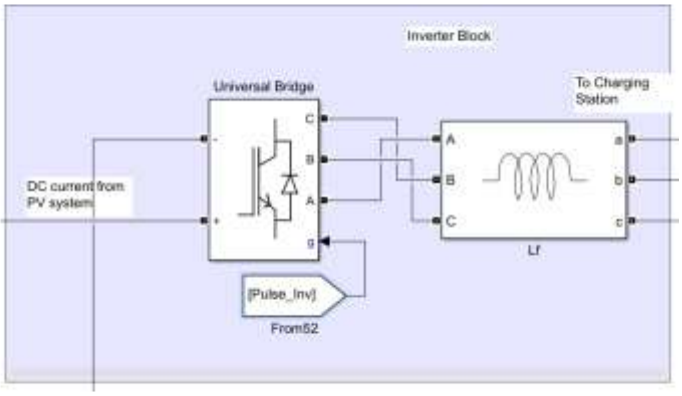


Figure4.6: Inverter block.

The purpose of inverter controller blockis providing the pulsating signal to the universal bridge whichconvertsthe DC current to AC current. It takes the Voltage and current fromthe AC signal and using PI Controller and system voltage allow the conversion of DC to AC maintaining the maximum active power using modulation and duty signal

4. Results

In this section, the simulation results are presented and analyzed of the proposed design of 60KW PV by using PVSYST and MATLAB software. high accessibility PV power for EV usersis available since photovoltaic cells can be attached to the rooftop and as solar parking lots near the location of EVs, as shown in Figure 5.1 drawn in SKETCH UP.There is a huge amount of unusable PV capacity on top of buildings or parking lots, and this should be taken advantageof in the future. Therefore, charging electric vehicles from the Photovoltaic panels will keep EVs economical and decrease the net costs of the charging infrastructure. This is the vision and motivation for this paper.

Figure5.1: Photovoltaic panel powered Evs charging stations where it installed at rooftop and parking lots.

Also

Table 1 shows the annual energy production of the system design.Accordingtothe table below we can figure out that we have horizontal global irradiation (Glob_Hor), horizontal diffuse irradiation (Diff_Hor), ambient temperature (T_Amb), global incidence (Glob_Inc), effective global (Glob_Eff), effective energy at the output of array (E_Array), energy injected to the grid (E_Grid) and performance ratio (PR). GlobHor represent the irradiation fallen on the system without tiltangle however, GlobInc represents the irradiation fallen on the system with tilt angle as we can see that GlobInc has a higher value compared to Glob_Hor value. represents the real irradiance.

Here we perfrom 60kw based solar charging station whose oprated using boost converter & P & O method

we perform solar based grid connected system where load requirtment first fullfil by solar at that time grid monitoring and when solar not able to fed load power so grid direct fed supply to load by 2 stage system the resultan wave form is show below.

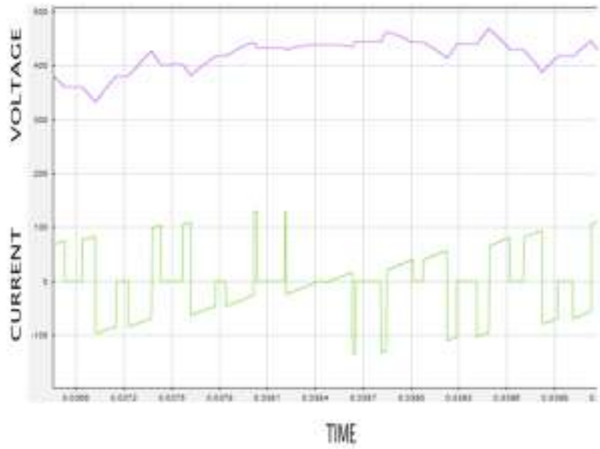
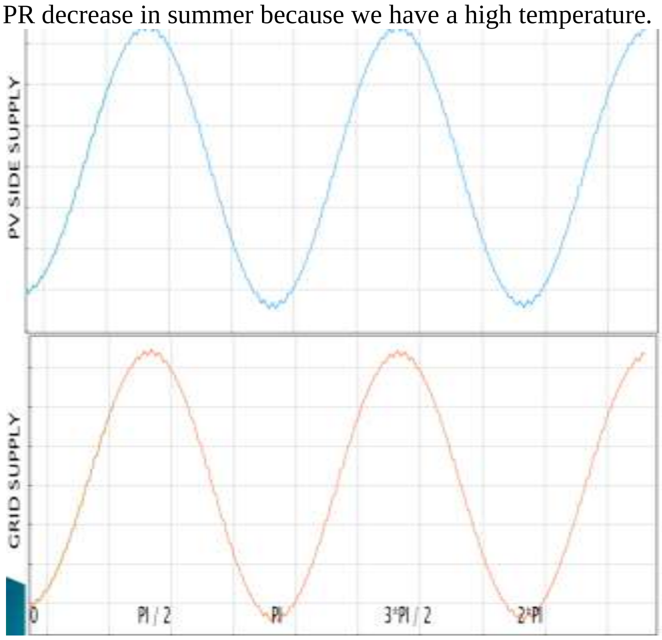


Figure4.6: Voltage and current Wave Form

The global horizontal irradiance kWh/m2 increases from January to July and then decreases from August to December. The highest value of global horizontal irradianc recorded as during May and lowest value of in December. The ambient temperature is highest in July

Figure 5.4 & 5 show the annual produced useful energy (inverter output) and performance ratio (PR). According to figure d below we can figure out that the red color represents annual production energy in summer the production will increase based on high temperature, the green and blue colors represent losses (PV array and inverter) also the lossesincrease in summer based on high temperature. According to figure e below, we can figure out that PR decrease in summer because we have a high temperature.



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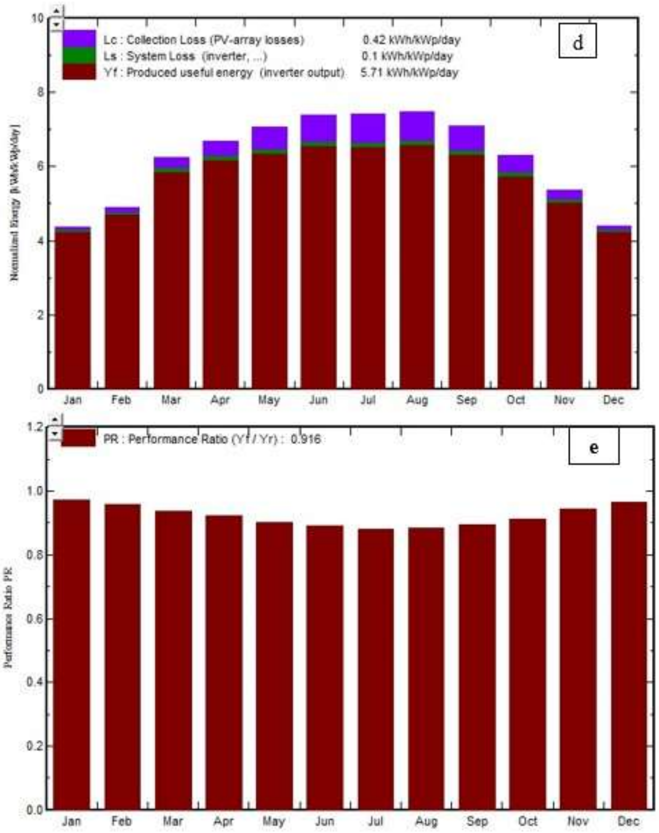
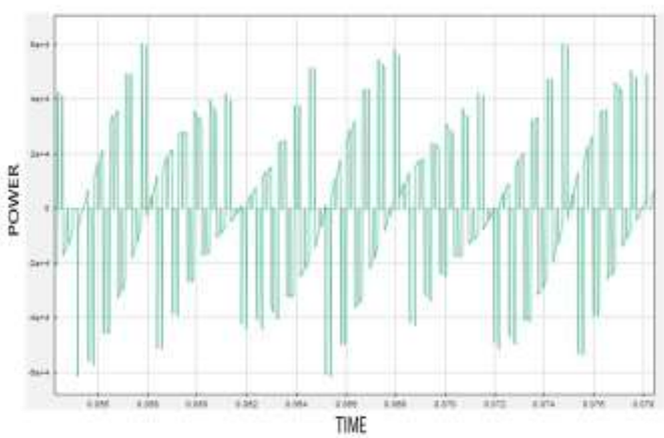


Figure5.4&5: Annual produced useful energy(inverter output) and performance ratio (PR).

the power is around 60 kW is achieving at the PV array terminal sasshowninFigure5.6.Thepowerisinitiallyzeroat t=0 sec and increases with time as expected it increase till 60 kW and flatten out.



5. Conclusion

The EV charging station using MPPT based controller is designedand simulated in MATLAB Simulink moduleat.The system is initially designed in PV system Software and the equipment selected from PVsystem is then selected in Simulink with their respective parameters and results in form of Voltage,power,current,andState of charge, etc. have been extracted in for of graph for all the major equipment. The result found is satisfactory with a slight error in the filtering process.Since solar power generation and charging takes place every day, the most electric car charging has to be carried out during working time by using solar cells to charge electric vehicles, which would greatly affect the reduction in carbon emissions during the day, which is the biggest human interest. Through this work, we hope that it will serve as the foundation for other research work in this field.

References

[1] V. E. Investement, "Planning for Installation and Operation," in Electric Vehicle Charging Station Guidebook,Vermont, U.S. Department ofTransportation, 2014, pp. 1-75.

[2] G. R. C. MOULI, "Charging electric vehicles from solar energy: Power converter, charging algorithmand system design,"DelftUniversityofTechnology,Chennai, India, 2018.

[3] X. Li, L. A. Lopes and S. S. Williamson, "On the suitability of plug-in hybrid electric vehicle (PHEV) charging infrastructures based on wind and solarenergy," in2009 IEEE Power &Energy SocietyGeneral Meeting, p. 1–8, 2009.

[4] G. R. Mouli, M. Leendertse, V. Prasanth, P. Bauer, S. Silvester, S. van de Geer and M. Zeman, "“Economicand CO2 Emission Benefits of a Solar Powered Electric Vehicle Charging Station for Workplaces in the Netherlands," Solar Powered Electric Vehicle Charging Station for Workplaces in the Netherlands,” in 2016 IEEE Transportation Electrification Conference and Expo (ITEC), p. 1–7, 2016.

[5] P. J. Tulpule, V. Marano, S. Yurkovich and G. Rizzoni, "Economic and environmental impacts of a PV powered workplace parking garage charging station," Appl. Energy, vol. 108, p. 323–332, 2013.

[6] G. R. Chandra Mouli, P. Bauer, and M. Zeman, "Comparison of system architecture and converter topology for a solar powered electric vehicle charging station," in 2015 9th International Conference on Power Electronics and ECCE Asia (ICPE-ECCE Asia), p. 1908–1915, 2015.

[7] G.R. Chandra, P.Bauer,and M.Zeman,"Systemdesign for a solar powered electric vehicle charging station for workplaces," Appl. Energy, vol. 168, p. 434–443, Apr. 2016.

[8] K. Saadullah and A. Aqueel, "A comprehensive review on solar powered electric vehicle charging system," p. 54–79, Dec.

[9] M. H. Amini, M. P. Moghaddam and O. Karabasoglu, "Simultaneous allocation of electric vehicles‟ parking lots and distributed renewable resources in smart power distribution networks.," Sustainable cities and society, vol. 28, pp. 332-342., 2017.

[10] S. J. Gunter, K. K. Afridi, and K. K. Perreault, "Optimal design of grid-connected PEV charging systems with integrated distributed resources.," IEEE Transactions on Smart Grid, vol. 4, no. 2, pp. 956-967, 2013.