# Development of Level Three Solar Based Fast Charging Station for Electric Vehicles

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***Abstract***

***The whole research is based on the charging process of electric vehicle as this is the emerging future of Pakistan. To reduce environmental pollution the whole world is transferring towards renewable energy, so the transportation sector is also a great source of causing environmental pollution. To reduce this problem the transportation section is moving toward pollution-free vehicle as the electric vehicle is now a days in market. But the charging of electric vehicles must be pollution free to reduce pollution impact. To achieve this goal, the charging strategy must be pollution free so renewable energy is the best solution and to reduce the charging time the fast-charging station is presented to charge a battery in less time using renewable energy. The advanced used batteries are lithium-ion batteries these batteries have two charging modes of charging combining these two will generate more effective results for charging in less time. By using two hybrid sources the system become reliable in case of weather dependent situation***

## I. INTRODUCTION

The development of the economy is mainly based on the transportation sector implemented in the country[1]. In the present the internal combustion engine ICE is commonly but the main fault is the long tail pipe of emission which has an adverse effect on environment [2, 3]. The transportation system of the country is participating up to 24% of the total carbon di oxide emission which is affecting the human life as well as the ecosystem. The main source of carbon dioxide emission is from burning fossil fuel like coal natural gas which is used to generate electricity in the grid[4]. Figure 1 shows the emission of $CO_2$ from the burning of fuel which is going to increase in upcoming year with the increase in number of industries and the number of vehicles[5] to solve the above-mentioned problem there is a need to select and alternative solution for the transportation system rather than internal combustion engine.

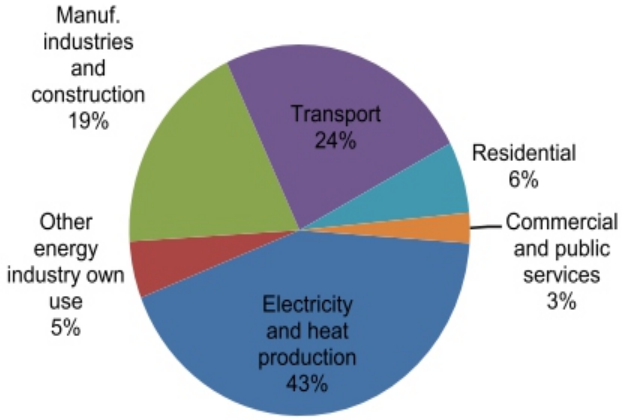


Fig. 1. Pie chart of pollution [1]

To overcome the difficulties in the internal combustion engine the EV (electric vehicle) are the most suitable replacement of the tail emission of internal combustion engine that provide improved air quality reduce pollution. As time passed EV are now provided with much more efficiency, emission less, having low cost per mile. As compared to the point of energy consumption ICE (internal combustion engine) consume only 12-13% of the energy provided by its engine while on the other hand EV used 80-85% of energy provided by the battery banks of Electric vehicle[6]

## II. LITERATURE REVIEW

When the world is transformed toward electric vehicle rather than internal combustion engine. The oldest method to power an EV is through energy storage system means battery. This requires a huge battery having rating more enough to power the battery of electric vehicle. The other more advance method is now used to power an EV through electricity which is either available through the grid station or by any other way. Recent research suggested the use of li ion battery in EV to gain more efficiency[7, 8].

Another struggle in the implementation of the EV is the location of its charging station that must replace the gas/fuel pumping stations. Charging stations must be located at proper locations specially highways to allow long distance transportation –[9, 10]. Charging an electric vehicle with AC grid causes destructing harmonic effect on the grid and its load profile[11].

Therefore, the charging station which reduces impact on AC grid distribution system is an urgent requirement specially at the location of long distances such as highways to charge the vehicle in long distance travelling –[12]. Two types of

charging methods are suggested inductive or wireless charging method, conductive charging method. Conductive charging method is further sub divided into two types on board charging and off board charging[13].

In an on-board charging station, the charging infrastructure is located in an EV structure while in an OFF board charging station the charging infrastructure is not required to place inside an EV. The charging setup is all placed on the charging station.

## III. METHODOLOGY

Fig. 2. Implementation of solar based charging station [14]

This paper suggests the off board charging station based on solar so that to reduce the dependency on AC grid, to eliminate the greenhouse gas emission ejecting from the internal combustion engine. There are three standards of charging available. In this paper level three charging station is proposed with a charging topology of constant current constant voltage method. Figure 2 below shows the solar based charging station. Figure 3 below shows the block diagram of the proposed model.

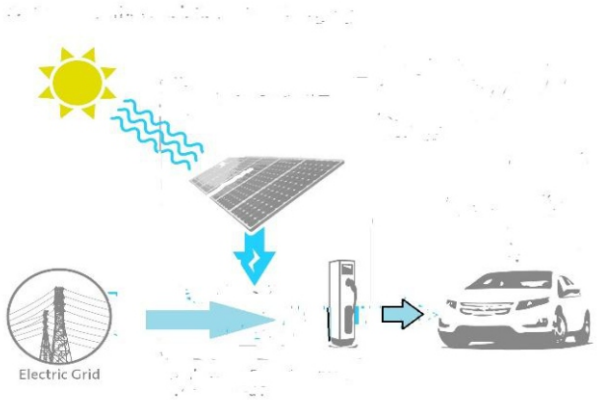


Fig. 3. Proposed model

## IV. SIMULATION MODEL

Renewable energy is mostly used now a days in place of electricity from grid because it pollutes the environment and impact the health of the living beings. To reduce these harmful impacts all over the world is entirely shifting towards renewable resources. The transportation sector is causing a high rate of pollution in overall pollution contribution towards the world.

To reduce the pollution and emission from vehicle electrification of transport is important now a days. This model is based on solar. The voltage generated by PV array is 300V and then there is boost converter placed which steps up the voltage to the required level of fast charging station. This is the level three model so the required level is (i.e. 600V and 400A). The required output voltage of boost converter is 600V.

The other alternating current source is placed as a backup source which is mostly useful in nighttime and the days when solar is not available due to weather condition and low irradiance. Alternating source is an on-board charger for the electric vehicle so the charging infrastructure must posses the AC to DC converter while using the rectifier there is need of step-up transformer as well to step up the voltage to required level of fast charging station.

Both the sources are coupled together through DC link capacitor which acts as s bus bar to both the sources. There are two buck converters available which are located inside the charger of the EV which steps down the voltage to the battery voltage level so that battery is not damaged through excessive voltage or overvoltage.

The battery of electric vehicles is mostly 300V battery. It is cost effective to use li-ion battery in an electric vehicle.

There are two charging modes available, one is constant current and other is constant voltage. This model used the combined technique of both methods constant current constant voltage (CCCV).

In this method an initial 95% of battery is charged through constant current by comparing reference voltage with battery voltage. The remaining 5% is charged through constant voltage by comparing reference current with respect to charging current. Figure 4 represents the whole Simulink model.

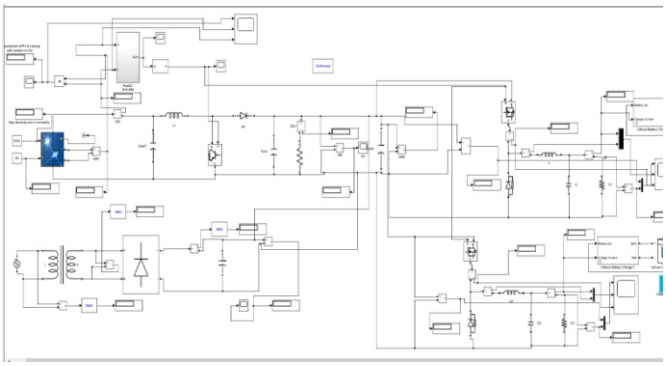

Fig. 4. Simulink model

## V. SIMULATION RESULTS :

### A) PV parameters:

Figure 5 below shows the parameters obtained from the solar panels. The parameters include voltage current and power.

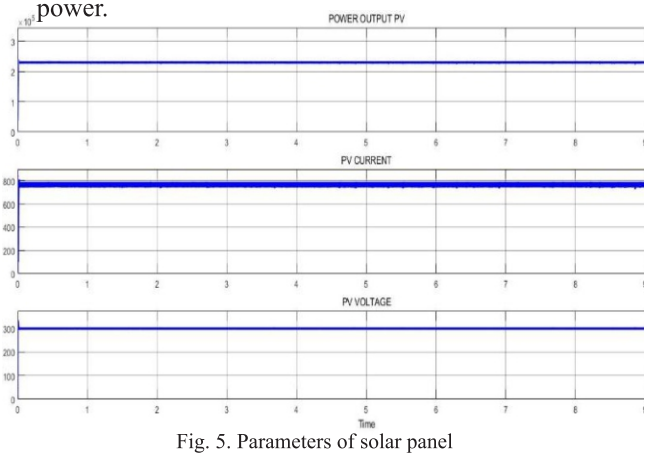


Fig. 5. Parameters of solar panel

### B) Output of boost converter

Figure 6 below shows the output voltage of boost converter

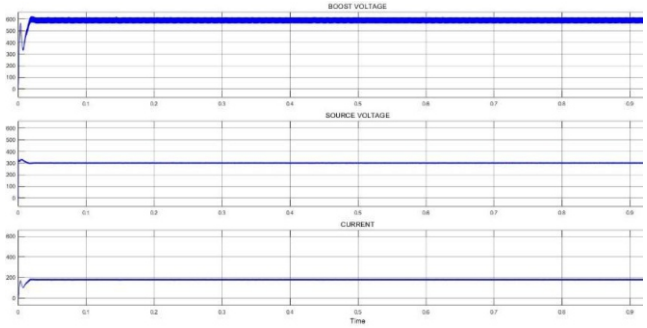


Fig. 6. Output of boost converter

### C) Backup source:

Figure 7 below shows the backup source available. In case of unavailability of solar irradiance

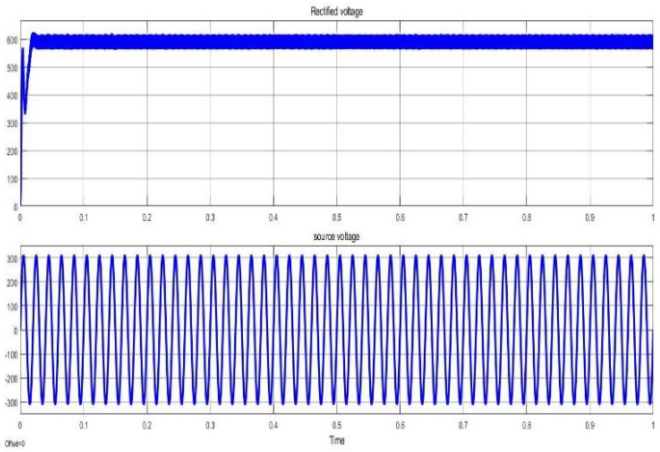


Fig. 7. Output voltage of backup source

### D) Output of buck converter:

Figure 8 below represents the output of buck converter

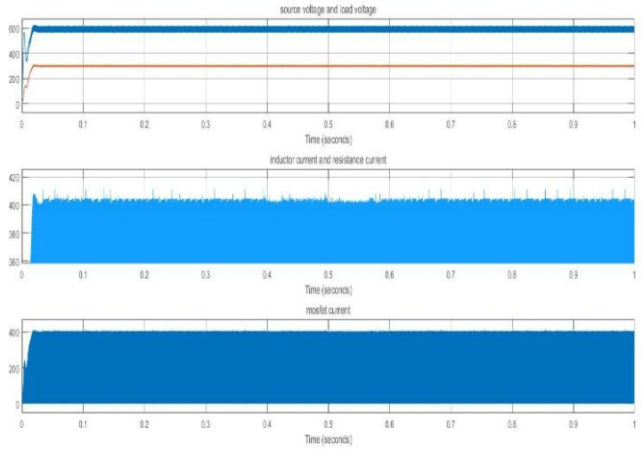


Fig. 8. Output of buck converter

### E) Battery charging graph

Figure 9 below shows the battery charging curves with constant current constant voltage method

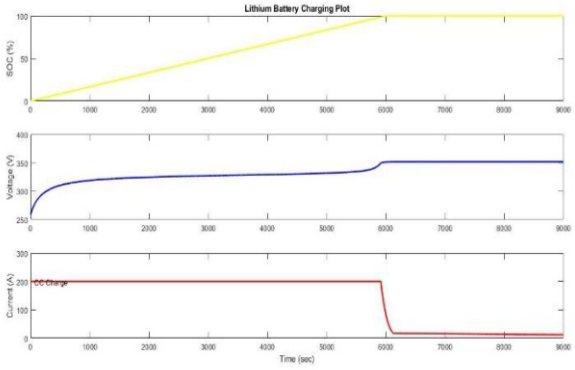


Fig. 9. Battery charging curve

Fig. 10. Solar panel

## VI. HARDWARE IMPLEMENTATION

The hardware implementation of the model of level three solar based fast charging station for electric vehicle is done, the results were obtained, and the comparative analysis is also done in both the obtained result. It is observed that the result obtained from the simulation model are most satisfactory and efficient due to constant average radiation assumed on solar plate but in actual it varies from time-to-time location to location and the location of sun as well.

List of components is given below

### *A) Solar panel:*

The hardware model is constructed by using poly-crystalline panel having low cost, but efficiency is also but it suitable for smaller projects. The power output of the panel is 10 watts. The maximum voltage is 18.00V and the current is 0.56A. The panel is light in weight and easy to carry. Figure 10 shows the solar panel used.

### *B) Boost converter:*

It is placed to step up the output from solar plate to the required level and maintain a constant voltage level for fast charging station. Boost converter is also known as step up dc chopper having two semiconductor devices and two energy storing elements. Figure 11 shows the voltage controlled boost converter.

Fig. 11. Boost converter

Fig. 12. MPPT controller

### *C) MPPT controller:*

MPPT is the maximum power point tracker which tracks the maximum power point of power so that the panel is fully utilize maximum power point changes with each and every instant. MPPT detects the maximum power point at each instant and try to operate at this point figure 12 shows the MPPT controller used.

### *D) Automatic transfer switch*

This switch is placed between the two sources to automatically control the switching between the sources this work on the principle of operation of relay. The operation of relay is to sense the signal and operate the switch either NO to NC or NC to NO. In this hardware model two auxiliary relays are used having model no JQC3FT73 figure 13 shows the automatic transfer switch used in the prototype

### *E) Buck converter:*

Buck converter is a step-down voltage converter whose output voltage can be controlled so it steps down the voltage from 20V to 12 V or 9V depending on the battery connected so that it may not damage by excessive voltage figure 14 shows the buck converter used in the hardware model

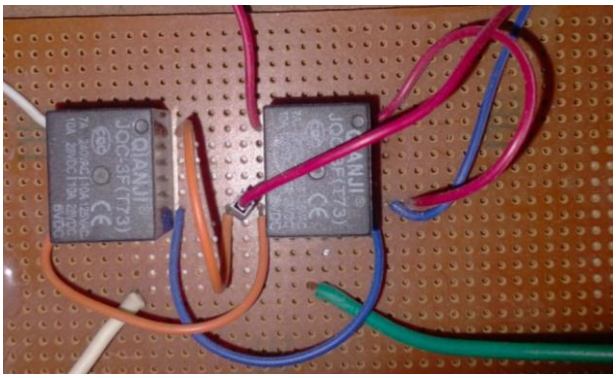

Fig. 13. Automatic transfer switch

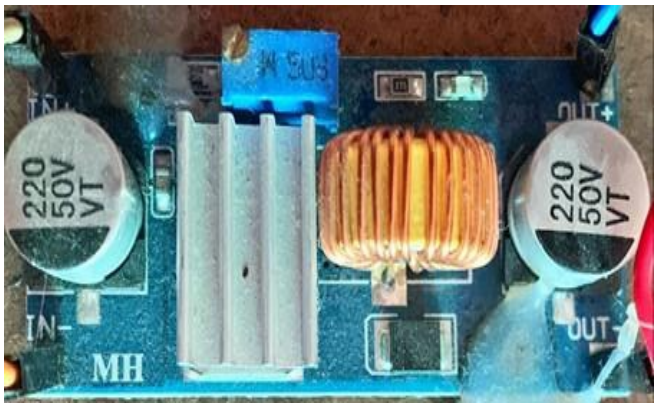


Fig. 14. Buck converter

### *F) Rectifier circuit:*

Rectifier is used for converting the AC (alternating current) into DC (direct current). In case of AC source used to charge an EV battery it must be first converted into DC and remove the ripples. Figure 15 below shows the rectifier circuit

## VII. HARDWARE MODEL

The whole hardware model is implemented by using the above-mentioned components and the result obtained are satisfactorily The solar plate basically works on the principle of conversion of light into electricity. Its maximum power output is 10 watts.

There are two adjustable boost converters in our project. Adjustable boost converter is very efficient we can adjust the voltage until we get out desired ratings. The input voltage is 10 to 32V. The output voltage is 12 to 35V adjustable by using adjustable knob the output current is 10A max when it is exceeded by 10A the more heat sink must be provide in our case the input to boost converter is fixed to 12V and it steps up the voltage to 20v so that required voltage for the system is 20v


Fig. 15. Rectifier circuit

for the fast charging station this is a voltage controlled boost converter in which output voltage can be controlled but changes with reference to voltage

The operation of relay is to sense the signal and operate the switch either NO to NC or NC to NO. In this hardware model two auxiliary relays are used having model no JQC3FT73

There is one adjustable buck converter in this project. The output voltage of the buck converter is adjusted according to the requirement of the battery voltage

While using the AC Source single phase supply is taken so that this is based on prototype model so here we require a step down transformer to step down the 220V to the required prototype voltage here we used 220/12V transformer

In case of AC source used to charge an EV battery it must be first converted into DC and remove the ripples.

After removing of ripples there is a comparison between two inputs to ATS to either switch to one source figure below shows the complete hardware model of the level 3 fast charging station for electric vehicle based on solar figure 16 below shows the complete Hardware model.

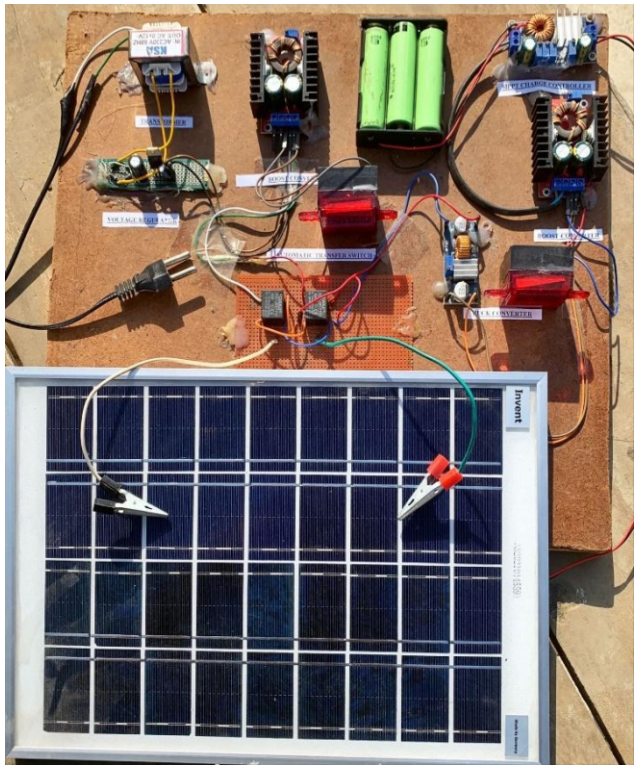


Fig. 16. Hardware model of level 3 charging Station

## VIII. RESULTS

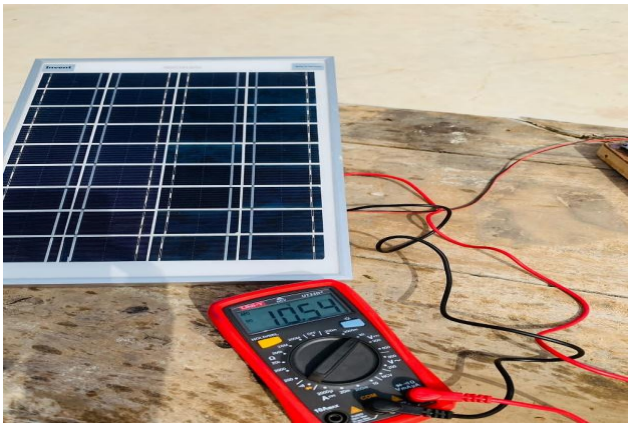

Fig. 17 Output voltage from solar panel

Fig. 18. Output voltage of lithium cell

The battery charging time reduces with the implementation of the fast charging station based on solar which is more important in terms of long distance travel with zero emission and less pollution. Electric vehicle use is enhanced by such kind of charging station at different locations like gas pump at each ad every location . The above proposed model is very much efficient in application of Electric vehicle

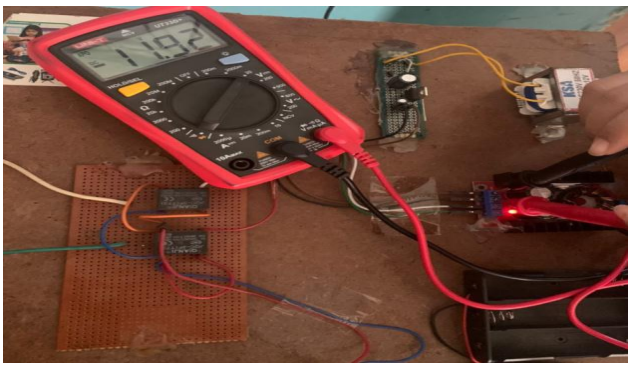

Fig. 19. Output voltage of rectifier circuit

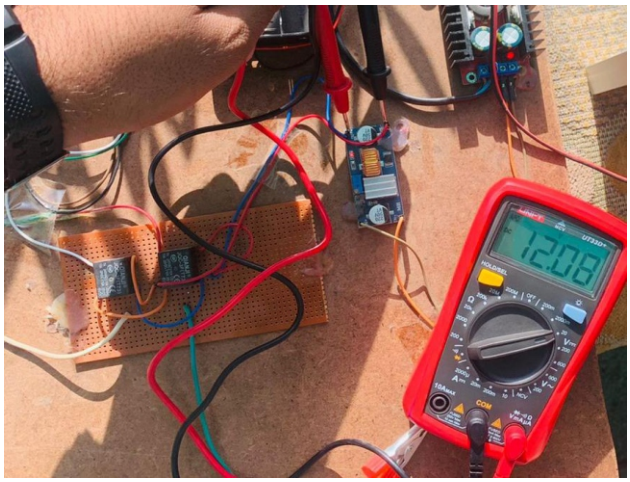

Fig. 20. Output voltage of buck converter

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2. "If you can't explain it to a six-year-old, you don't understand it yourself." - Albert Einstein
3. "Clarity is the most important characteristic of good scientific writing." - Randy Moore
4. "The goal of scientific research is not to discover truths, but to discover ways to talk about phenomena." - Mikhail Gromov
5. "The purpose of science is not to analyze or describe but to make useful models of the world. A model is useful if it allows us to get use out of it." - Herbert Simon
6. "Writing is thinking. To write well is to think clearly. That's why it's so hard." - David McCullough
7. "The more we know, the more we realize how much we don't know." - Anonymous
8. "A scientist in his laboratory is not a mere technician: he is also a child confronting natural phenomena that impress him as though they were fairy tales." - Marie Curie
9. "Good science writing makes us understand how science can explain the world around us and what it doesn't yet explain." - Deborah Blum
10. "Scientific discovery and scientific knowledge have been achieved only by those who have gone in pursuit of it without any practical purpose whatsoever in view." - Max Planck

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13. "A writer is a person for whom writing is more difficult than it is for other people." - Thomas Mann
14. "The scariest moment is always just before you start. After that, things can only get better." - Stephen King
15. "Never, never, never, never give up." - Winston Churchill
16. "If you wait for inspiration to write you're not a writer, you're a waiter." - Dan Poynter
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