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Solar Charging Station for LEV: A Design and Feasibility Study

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Abstract: As the need for sophisticated transportation system rises due to economic development and cultural comfort, global warming and some dangerous climate changes are becoming more frequent. Every government is promoting the use of electric vehicles to combat the problem of global warming caused by the transportation.(EVs), As the number of electric vehicles on the road increases, charging EVs using infrastructure based on fossil fuel is neither efficient nor cost effective. As a result, an electric vehicle charging station that uses renewable energy has tremendous potential and control. In the present situation, a battery energy storage system and a solar powered electric vehicle charging station are necessary. For effective power management in the charging station between solar, BESS, grid and EVs, an efficient charging station design with Incremental conductance (INC) voltage controlled MPPT, PI controller, grid with inverter is design and evaluated in MATLAB/Simulink. Additional grid assistance is advised to ensure that the charging station has uninterrupted power without adding to the load on the grid.

Keywords: Battery Energy Storage System, Incremental Conductance, Light Electric Vehicle, Maximum Power Point Tracking,

I. INTRODUCTION

Renewable energy, such as solar and wind power, is a more environmentally friendly and cleaner alternative to traditional fossil fuels. Furthermore, widespread adoption of electric vehicles (EVs) can help reduce greenhouse emissions while also improving air quality. However, for EVs to fully realize their potential as a clean transportation option, a reliable and convenient charging infrastructure [1]. Drastic reduction in the cost of solar photovoltaic modules, power electronic devices and digital signal processors, rigorous environment protection acts imposed by the government, and rapid consumption of conventional fossil fuel resources which are going to be last in the near future, have motivated the researchers, industrialists and consumers towards the use of solar photovoltaic technology [2]. This emerging and most promising power generation technology is everlasting, environment friendly, and has no maintenance and the charging station charges vehicles of different companies with different batteries with varying charging capabilities, increasing the demand for EVs and ensuring reliability. The easiest way to acknowledge this concept is that the charging mechanism takes to play by simply altering the current and voltage to deliver a specific power required by the battery for charging.

II. BLOCK DIAGRAM

A block diagram is representing the solar charging station for light electric vehicle. Fig.1 shows the block diagram of the proposed system. The boost converter uses the MPPT algorithm and exact maximum solar power at all instants. The bidirectional converter helps in charging and discharging of the station battery depending on source-load balance in addition to maintaining a constant dc bus voltage at its higher voltage terminal.

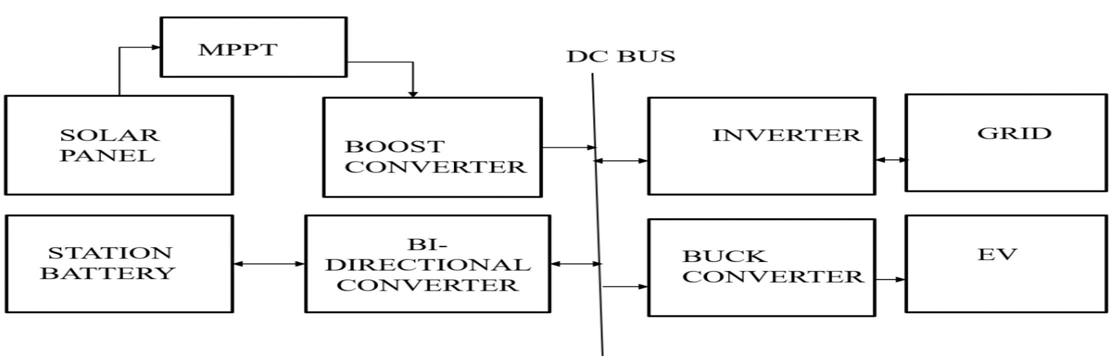

Fig. 1 Block diagram for solar charging station

The buck converters step down the bus voltage to EV battery voltage and the inverter converts the dc voltage to ac into grid from dc bus voltage. During night time, the grid and EV battery charge from the station battery.

III.DESIGN CALCULATION

In this paper, discuss about the design calculation of solar charging station. The various operating stages of the configuration. Such as the photovoltaic array, the boost converter, grid connected inverter and the battery are designed such that a satisfactory operation is always accomplished under any kind of variation in solar irradiance. The technical specifications of a selected in 48V lithium ion battery.

A. Considerations During System Design

- Bikes are parked for long durations of about 7h at the workplace.
- Charging station with solar generation as major source and additional grid connection is considered for this work.
- All Vehicle batteries are 48V 20Ah
- Electric vehicle charging station can charge two EV batteries at a time.

E Bike/E Scooter = 48V,20Ah (Lithium-Ion battery)
EV Charging station can charge two EV batteries at a time
Max power required =48x20x2=1920Wh
Total input power = 1920/0.92x0.92=2270Wh
Converter efficiency :92%

B. Solar Panel Selection

Average global horizontal irradiance = 5.86kWh/m^2/day
=2.27kWh/5.86
=388W
So, Solar panels of rating 250W to be used

C. Station Battery

The maximum energy to be stored in the station battery
=48x20x2=1920Wh
Minimum energy station must be store = 2270-1900
=370Wh
Station battery capacity = average of 1900,370 =1135Wh
Station battery current rating = 1135/48 = 22.63Ah ~20Ah
Station battery rating is 48V 20Ah

D. Boost Converter

Switching Frequency = 1000Hz
$V_{pv\,max}$=30.7V,$I_{pv\,max}$=8.15A,V_o=72 V
Duty ratio = 1-V_{pv}/v_o, D=0.583
Voltage Ripple = 0.1, Current Ripple = 0.1
L=(V_{pv}xd)/fxΔI =0.175H
C= I_{PV}Xd/fxΔV = 0.0475F

E. Bidirectional Converter

The difference between the maximum amount of solar power the panel can supply at particular irradiance and the power demand of the electrical vehicle determine whether the station battery is in charging or discharging state as the amount of solar power depends on the load which is connected to it[15].
Boost side: I_s max=2270/(7x48)=6.75A,V_b=48V
V_o=72V,D = 1-v_b/v_o=0.333
L=0.160, C=0.02247

Buck side: I_s max=2270/ (5.86x72)=5.38A,V_o=72V,
V_b=48V,D=V_b/V_o=0.66
L=161mH,C=0.125mF

F. Grid With Inverter

The 230V, 50 Hz, AC grid is being explored for the charging station's additional power requirements .A 230V AC source is connected to a 72V DC bus using an inverter.

Voltage = 230V, Frequency = 50Hz
Using single phase full bridge inverter,
Modulation Index = 0.9

G. Buck Converter

The vehicles are presented at the charging station for 7 hours and each battery capacity is 48V 20Ah. By maintaining the charging current at 2.85 A. The controller calculates the necessary current at which the vehicle battery should be charged based on its initial state of charge to charge the vehicle in 7 hours and also decreases the error between actual charging current and the necessary charging current with the help of PI controller. Duty ratio for the gate signal of IGBT of the buck converter depends on the error current.

Switching Frequency = 10kHz
V_o= 220V,V_b=48 V,
Duty ratio = V_b/v_o, D=0.41
Voltage ripple = 0.1, Current ripple = 0.1
L=0.0375H, C = 0.125µF

TABLE 1: Panel Specification

Number of PV cells	60
Watts(STC)	250W
Watts(PTC)	184W
V_{OC}	37.4V
I_{SC}	8.63A
V_{MPP}	30.7V
I_{MPP}	8.15A

IV. SIMULATION & RESULT

The simulation diagram of Solar panel is shown in Figure 5.1. In this simulation model, the irradiance of solar panel is 1000 W/m^2 and temperature is 25^0 c.

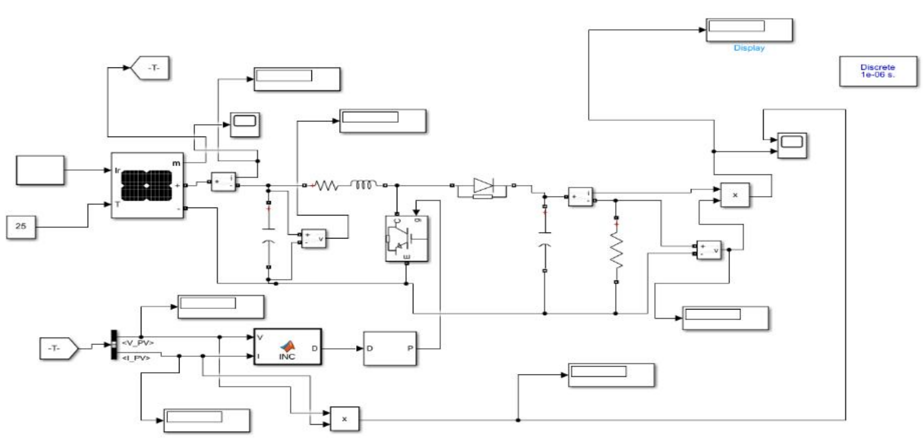

Fig. 2 simulation diagram of PV panel

The Boost converter is used to boost the voltage from the PV panel. The Simulation diagram of a boost converter is shown in Fig 3.

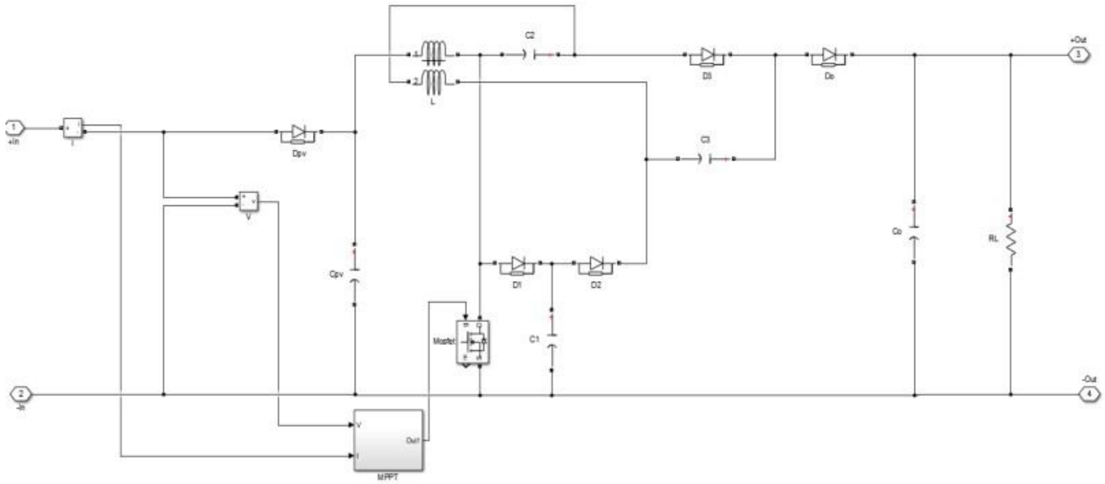

Fig. 3 Simulation Diagram of Boost Converter

The grid is interconnected the PV system and converts the voltage in dc to ac using single phase full bridge inverter.

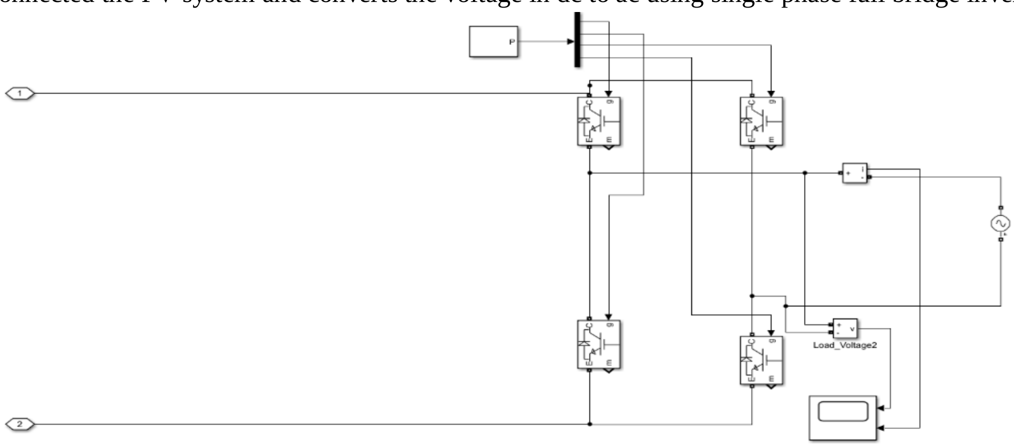

Fig.4 Simulation diagram of Grid connected inverter

The Station battery connected to the bidirectional converter. It’s used to step up and step down the voltage under the different irradiance condition. It shown in Fig 5

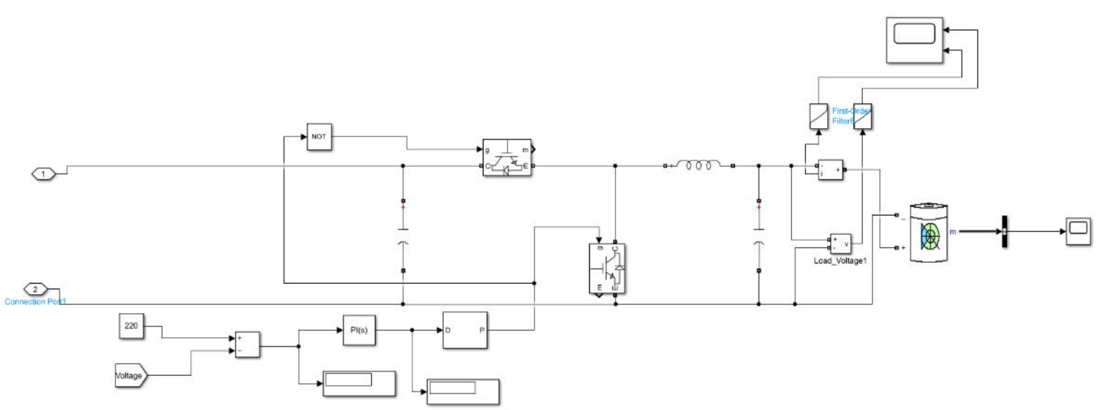

Fig. 5 Simulation Diagram of station battery connected converter

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The simulation diagram of EV battery is shown in the fig 5. the buck used to step down the dc bus voltage to charge the EV battery.

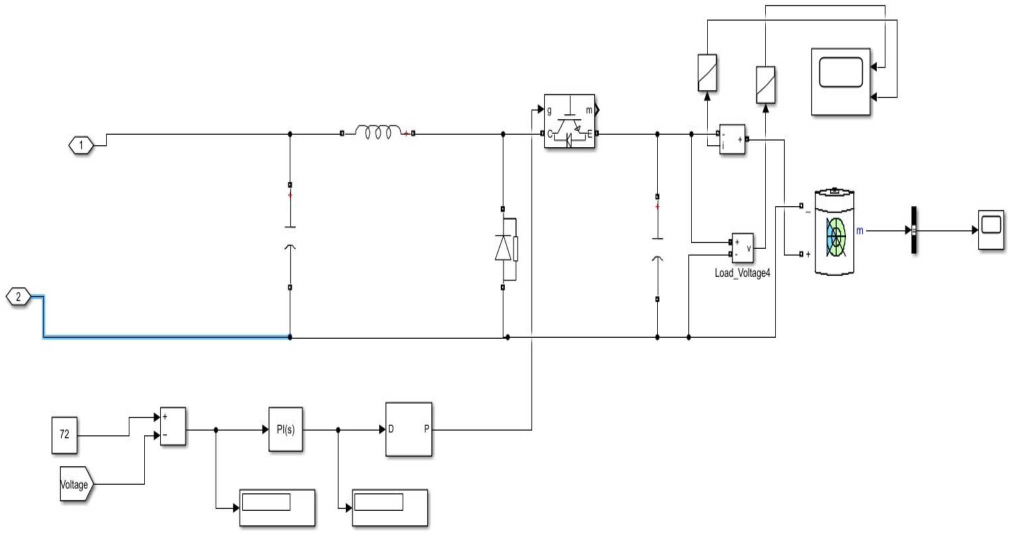

Fig. 6 Simulation Diagram of EV battery connected converter

The Simulation Diagram of Solar charging station for light electric vehicle shown in Fig 7

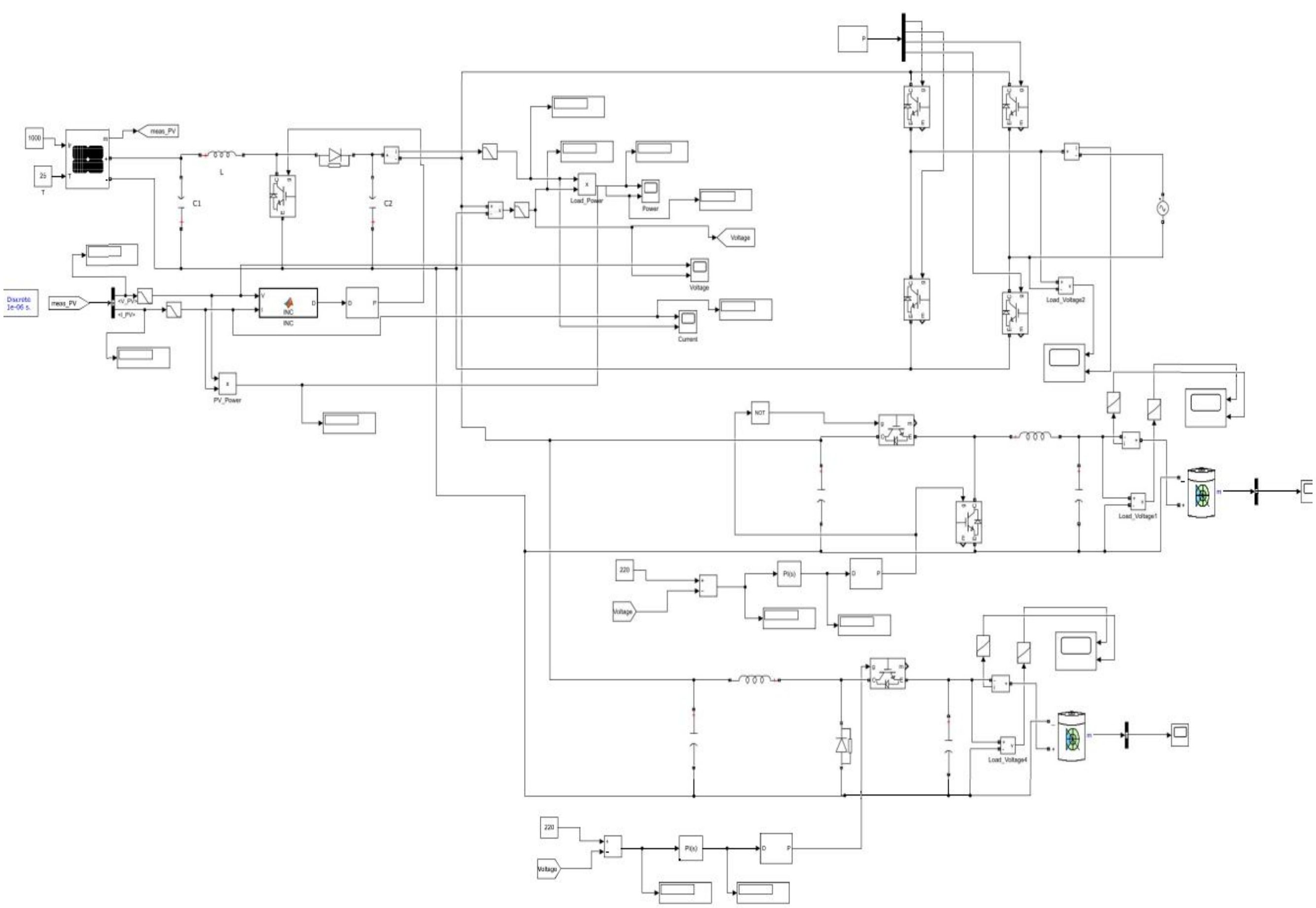

Fig. 7 Simulation Diagram of the System

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A. Output Waveform Of The System

The Output waveform of Solar panel is shown in Fig 8. In this waveform model, the irradiance of solar panel is 1000 W/m^2 and temperature is 25^0 c

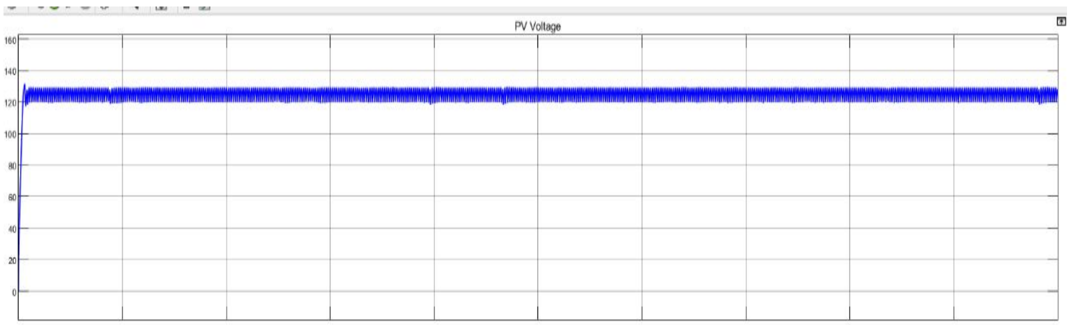

Fig.8 Output voltage of PV Panel

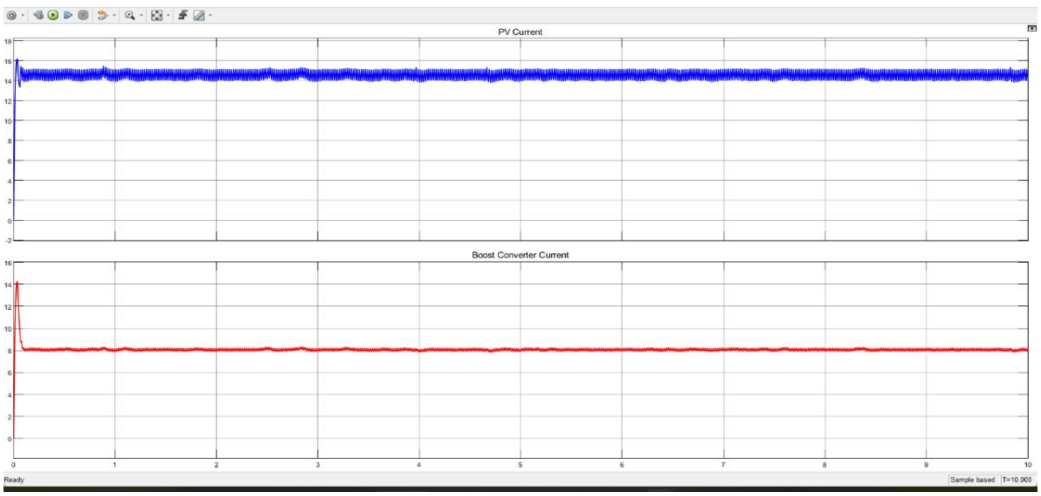

Fig .9 Current waveform for PV and Boost converter

Temperature is maintained constant at 250^0 C and Irradiance of PV array is varied in steps, PV power is 250W at maximum irradiance of 1000 W/m2 . PV voltage is constant and PV power varies with the variation of irradiance which ensures the maximum power extraction from the PV array as shown in Fig. 8 & Fig 9

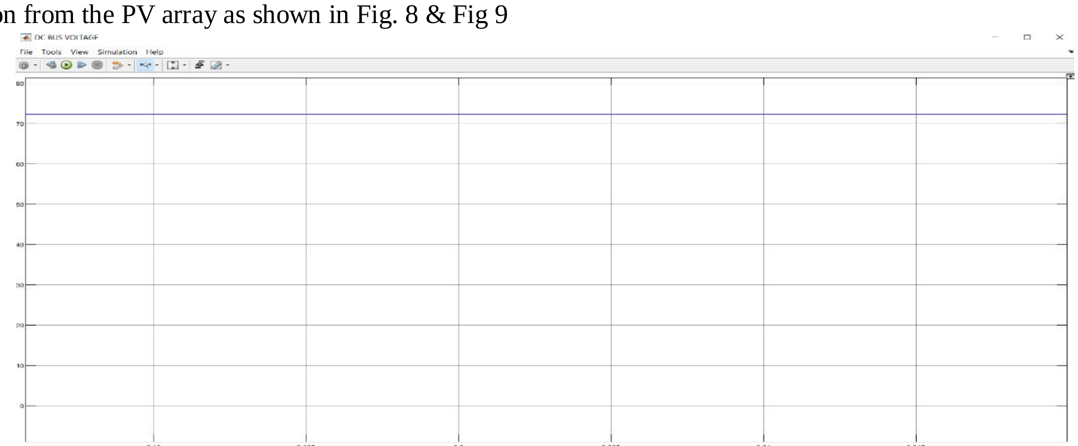

Fig.10 DC bus voltage waveform

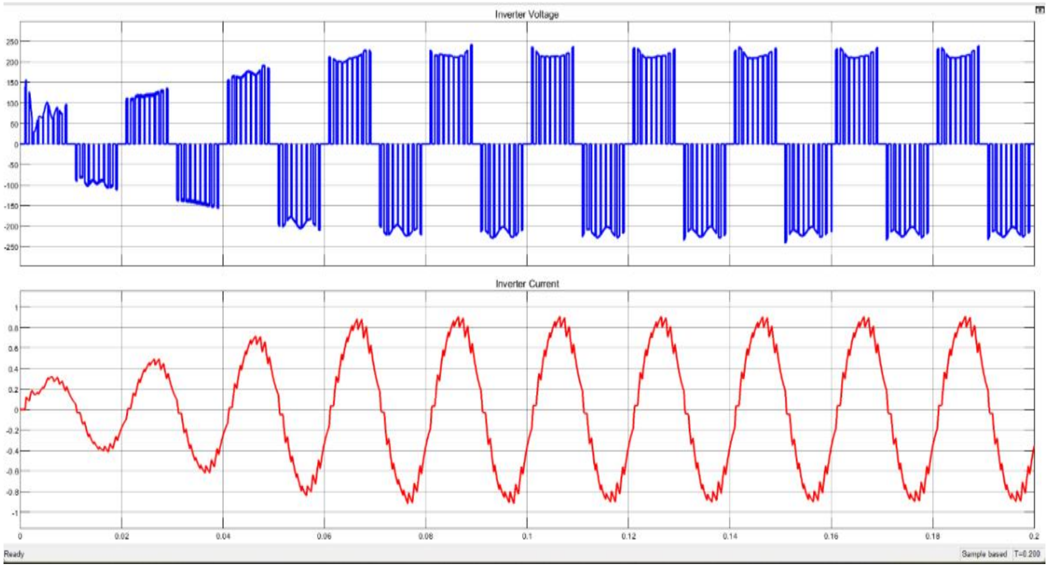

Fig .11 simulation waveform for inverter voltage and current

During night power supplied by PV array is zero, at simulation time of 0.1sec functional fitting neural network start controlling the power flow from the grid as shown in Fig.11. AC grid is connected to the DC bus through the inverter. when the grid is supplying power to the DC bus

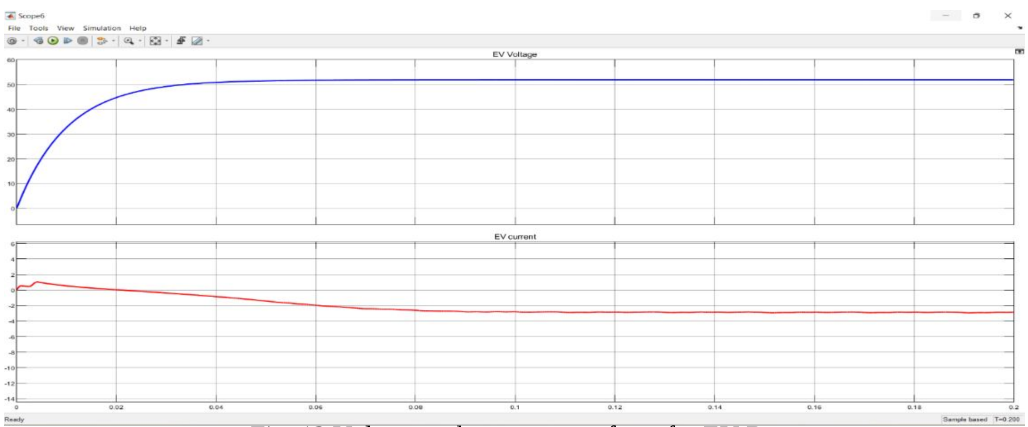

Fig. 12 Voltage and current waveform for EV Battery

EV battery is charged as shown in Fig.12. With the extraction of maximum power available from PV array at different irradiance and temperature.

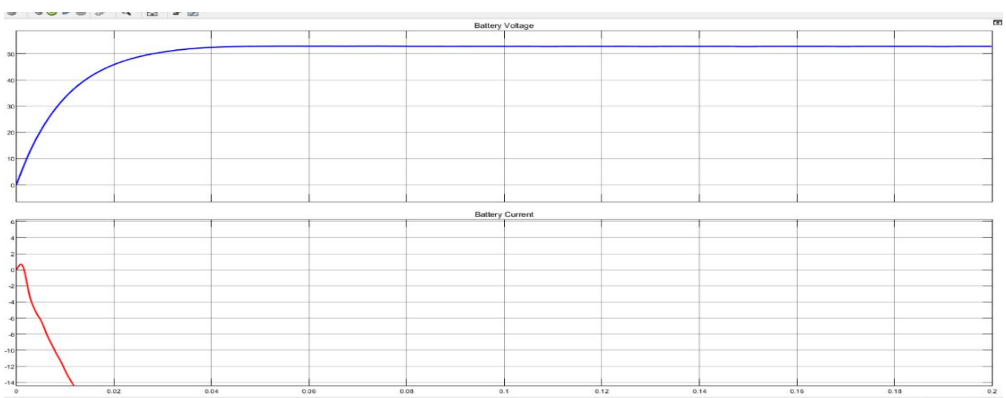

Fig. 13 Voltage and Current waveform for Station Battery

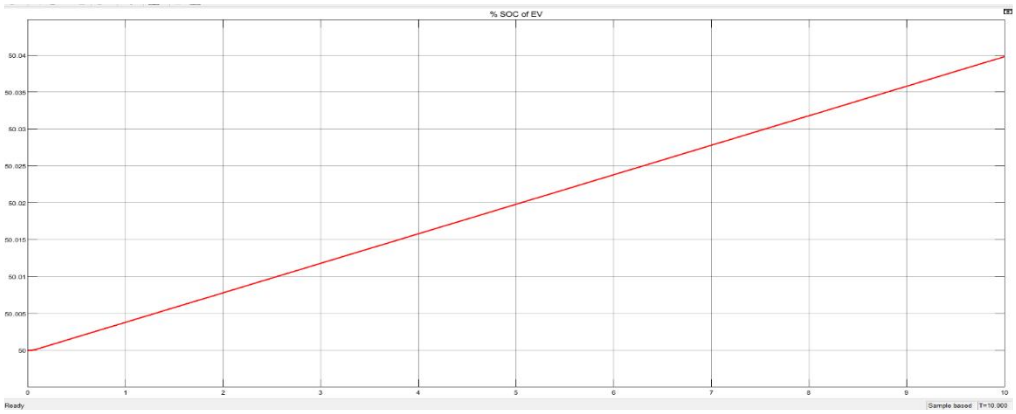

Fig. 14 %SOC of EV Battery

Fig.14. Shows that energy is transferred of EV battery which is represented by increasing of %SOC of EV battery.

V. CONCLUSION

In this paper, the light electric vehicles charging station must be designed. As there are more electric vehicles on the road, EV charging has grown to be a significant problem .Grid support improves a charging station that uses a PV array, a battery energy storage device, and a viable methodology. The INC voltage control, PI controller and converter are utilized to adapt to the changing requirements of all connected electric vehicles. The required power can be obtained by keeping a constant DC bus voltage. Using MATLAB/Simulink the suggested station power management is explained and verified. With more research into the suggested model for more electric vehicles. This can be done by installing an EV charging station at work (or) in the parking lot with a sizable power rating and capacity.

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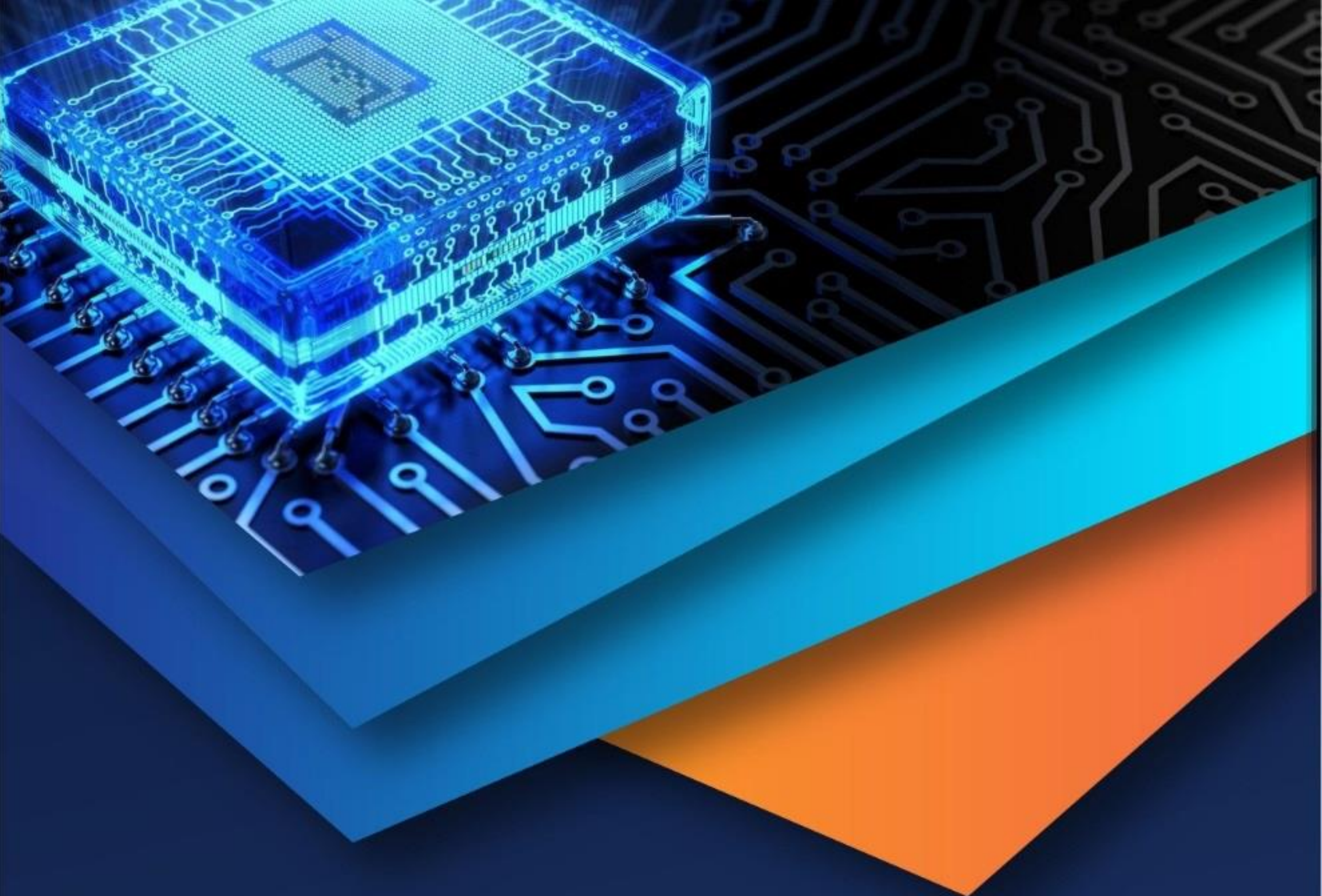

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