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Simulation of Grid Connected EV Charging Station with Renewable Energy Source

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ABSTRACT

This paper helps to understand the configuration of grid connected EV charging station which is integrated with Renewable energy system. Which is an Solar PV rooftop system and act as a backup system for meeting power demand of an EV charging station which help to reduce stress on grid. Renewable energy sources is an best solution for production of energy as an local generation of power which help charging station run economically as it collaborate with grid connected charging station at off peak period the power is taken by grid for operation of station and at that time the solar pv system charges the backup batteries which are connect to station for supplying power to charge EV's at peak hours .As well as the backup battery bank which charge whole day with Solar PV system can be used for battery swapping for EV's .MATLAB/SIMULINK is used to simulate the grid connected EV charging station with renewable energy sources which help to obtain results of simulation model .

Key words: Electrical vehicle, Solar Photovoltaic system, Charging station, Backup battery.

1. INTRODUCTION

The present senior of worldwide is that global warming is increasing day by day one of the main reason for global warming is emission of carbon by conventional vehicle .one of the best solution proposed over the conventional vehicle that is electrical vehicle owing there advantages they are zero carbon emission, reduction of greenhouse gases, ecofriendly ,consumption of fissile fuels is zero .

EV is a perfect solution for energy crises which required negligible amount of conventional energy sources which is able to make balance between energy resources. Before adopting the technology of EV there is an anxiety among people is that limited driving range ,long charging time and economical aspects .before moving toward EV technology the infrastructure should be setup for reliable operation of EVs the infrastructure include charging station and EV service station .The charging station plays an key role in EV technology to remove the limitations of charging of EVs, charging station location should be short accessible area, the charging time of EV should ne reduces and perfect battery management solutions should be implemented for long driving range .

Charging of EVs is an main and important aspect where charging can be done by two method on board and other is off board charging ,Where different levels of charging is defined by J1772 for Dc charging is shown in table 1.[1]

Charging station Required huge amount of power from grid to fulfill the demand on station. There is an alternative to reduce the stress on grid is adopting renewable energy sources ,Integrating renewable energy sources with EV charging station with will help to meet power demand of EV charging station.

Table 1: Charging levels with its V,I & Power

Charging Level	Charging Voltage(V)	Charging Current(A)	Charging Wattage(Kw)
1	200/450	80	36
2	200/450	200	90
3	200/450	400	240

In renewable energy sources solar PV system is more famous due its arability ,reliability ,low maintenance and it can setup easily .By integrating the solar with EV charging station is an prefect combination for reducing stress on grid and locally generated power by solar PV system can easily charge the backup batteries and which can be utilized at peak hours of grid so that charging station can run economically in peak hours.

In this paper an system details described .system model and Matlab simulation of EV charging station is carried out where in section I)System detail in explained II) design of circuit is consider and control method of charging of EV's. EV Station simulation is consider in section III) with its results and at the end conclusion with its future scope**.**

2. SYSTEM DETAILS

In an EV charging station main component are inverter with is interface with grid an RCL filter, transformer and a DC bus feed and battery chargers[1,2].

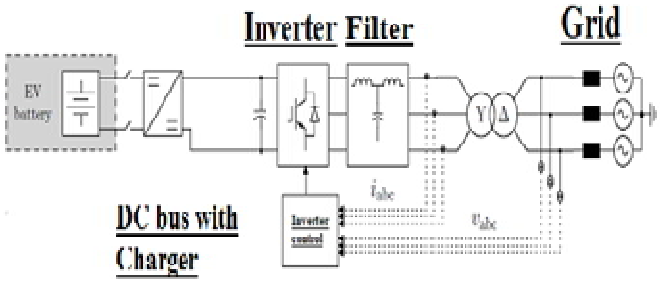

Figure 1:.Block Diagram EV charging station

The rated capacity of Stated in VAR is defined as

$$S_{Rate} = \frac{K_{Load}\ N_{Slot}\ P_{Ev}}{COS\varphi}$$

Where N_{slot} is amount of charging slot P_{ev} max power rate of an individual EV and cosϕ and K_{load} is overload factor to cover overload transient.

The block diagram is show were an inverter is connected to grid with LCL filter and Inverter is controlled by control of inverter which use reoffered value from grid at the end DC off board charger with battery is show .

According to grid voltage Dc line voltage is set

$$V_{DC} \leq \frac{V^{min}}{m_{min}}$$

Where

V^{min} = minimum battery voltage

m_{min} = minimum modulation index

3. EV BATTERY

The Thevenins equivalent base mode is used to represent the battery module where V_{oc}=open circuit voltage which depends upon soc and R_{series} is used for V-I[1] characteristics where as Transient t response of battery is shown by RC_{II}

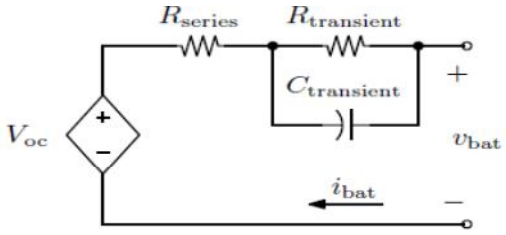

Figure 2: Thevenin Equivalent Circuit for battery model

Battery is a heart for an EV which pumps power all over the EVs for the activities. In an market various types of battery available, which are used for EV. But now a days Li-ion battery get too popular for EV's. [3]

Table 2.Batteries Storage Systems [5]

Type	Energy Efficient [%]	Power Density[W/kg]	Energy Density [Wh/kg]
Li-ion	85-95	300-2000	100-200
Ni-Cd	60	140	40-60
Ni-MH	50-80	220	60-80
Pb-Acid	70-80	25	20-35
Super caps	90+	5000-20000	25-75
Li-polymer	80-90	300-2000	100-200

4. BATTERY CHARGER

A Battery charger having a bi-direction convertor with power electronic s/w which operated complimentary to each other with respective control signals.[1] In a convertor a buck-boost operation is carry out, Bock-Boost depend upon the switching of the tree power electronic s/w. A boost action occurs at the left side voltage V_{bat}. When lower s/w is operated or triggered and buck mode is activated when upper s/w is operated**.**

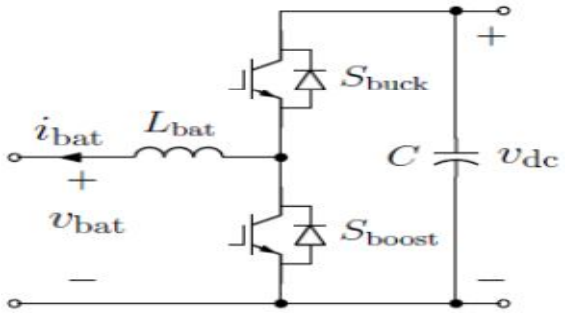

Figure 3: Battery charger

5. THREE PHASE INVERTER

The inverter is connected between sources and battery charging module and its control is done by inverter control system which provide and gate pulse trigger s/w of invertor and LCL filter is also connected with invertor as shown in figure 4.

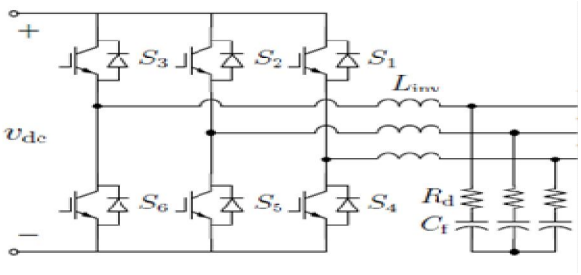

Figure 4.Three phase inverter with LCL filter

6. LCL FILTER

The passive filter is implemented to reduce harmonics which cause disturbance in line current and voltage which result an poor power quality and make an impact on system. LCL filter

connected between source and invertor. Filter carry out function to filter out current harmonics which make an balance between source and invertor. An LCL filter prefer for a 3rd order low pass filter which provide good harmonics attenuation and small filter in size.

7. CONTROL SYSTEM

Control system is an key aspect in a modeling of an any system it keep eye on working of system at different phases and adjust the input value according to system requirement to get proper desirable results.

7.1. Inverter control

Invertor is utilized to power exchange between AC grid to DC bus. The control strategy implemented cascaded control in dq frame and PWM generator is used give an gate pulse for s/w of invertor which help to maintain DC bus voltage[1]The cascade control have an inner current loop and outer voltage loop .Phase locked loop(PLL) is used to synchronization with grid voltage .the control is shown on figure.

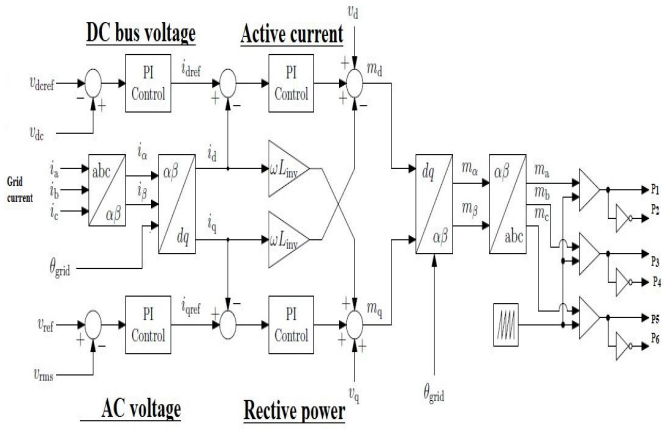

Figure 5: Inverter control [1]

The PLL shown in fig .6 where the input measurement of three phase voltage in PLL where output signal vd, θgrid, w are to use in dq frame inverter control.

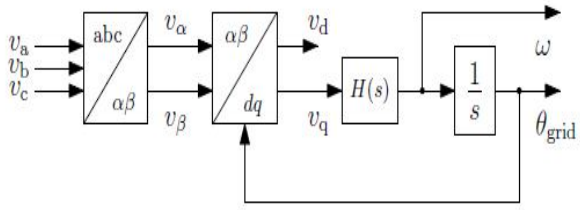

Figure 6: PLL [1]

7.2. Battery control

Two controls are proposed for battery charge control one is constant current and another is constant voltage. whereas constant current is an initial stage of charging which is shown in fig7and constant voltage shown in figure 8[1].

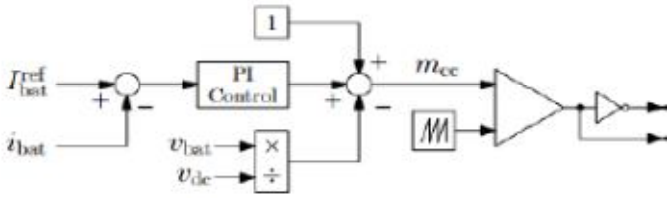

Figure 7. Constant current

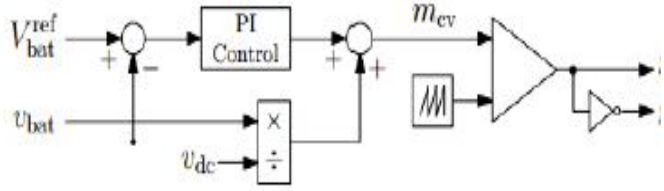

Figure 8: Constant voltage

8. SIMULATION AND RESULTS

8.1. Simulation of SOLAR PV with boost converter

The solar PV is use for charge the backup battery with help of boost converter [3].the solar PV module use in simulation is 1kw Sun power SPR-X20-255with specification in the Table.3.The Solar PV output is boosted and applied for charging process of battery , [4,5] A Li-ion battery of 24V is utilized which will act as backup system to charging station .Simulation result is shown in figure 10 where an charging of battery is observed by increasing of SOC where minimum SOC is kept 50% which is increasing as show in output result of simulation.

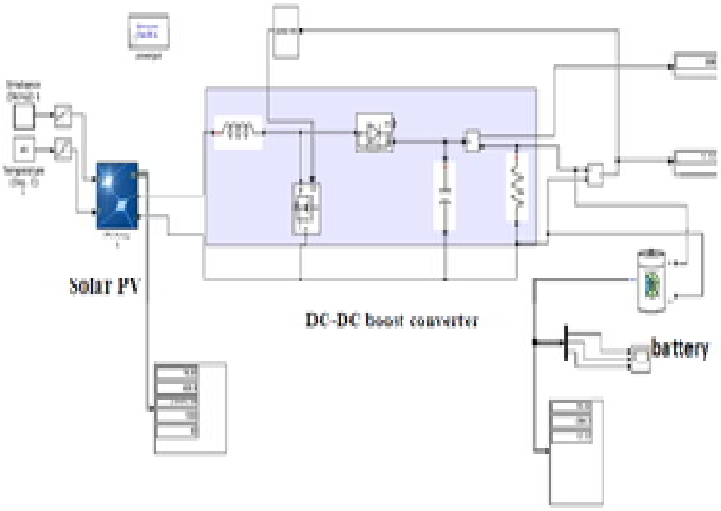

Figure 9: Solar PV with boost converter

Table 3: Solar PV specification

Parameter	Values
Maximum Power (W)	256.66
Voc (V)	51
SC current Isc (A	6.33
Voltage at maximum power point Vmp (V)	42.8
Current at maximum power point Imp (A)	5.95
Series-connected modules per string	5
Parallel strings	64

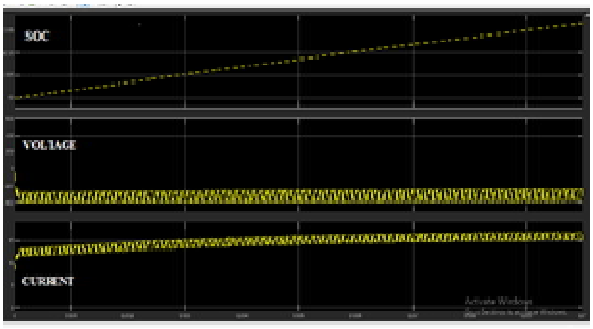

Figure 10: Charging of backup battery

8.2. Simulation of EV charging station

The MATLAB simulation of EV charging station is represent in fig 11 [1]where whole station is connected grid sources of 11KV where power is feed to transformer , filter ,inverter and battery charging unit that is boot charger and functions of EV charging is carried out. The result is shown in fig 12 where battery of 42V is charged with 50% SOC which is increasing gradually when it simulated in MATLAB as shown in output .Increasing of SOC shows the charging of EV battery with its respective voltage and current. The charging of different batteries are carry out as different EV's has different battery systems and result is shown in table 4.[4]For an example an battery is taken of 42V,100AH and simulated for 60sec at initial SOC of 50% .

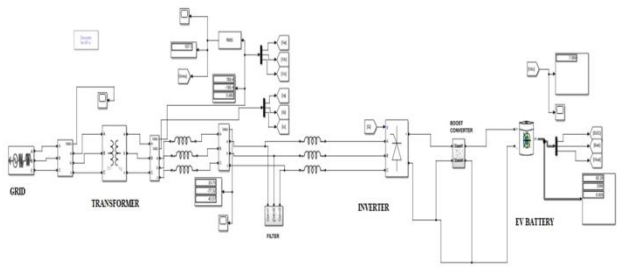

Figure 11: Simulation model of Grid connected EV charging station.

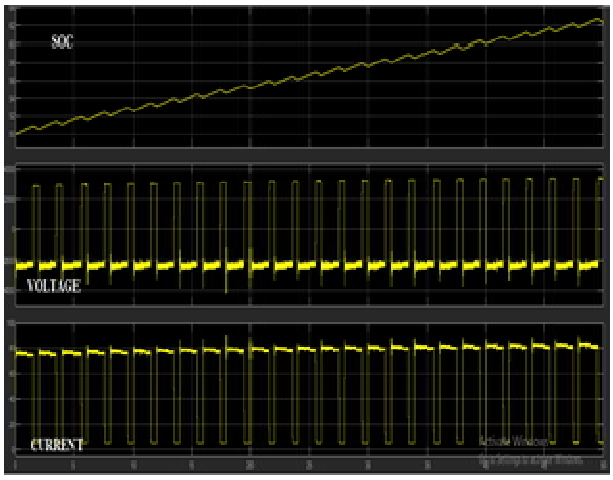

Figure 12: Result of charging of EV battery.

Table 4: Different types of EV Battery charged

Battery type	SOC %
Li-ion	**63.6**
Lead acid	**71.3**
Nickel metal hydride	**64.1**
Nickel cadmium	**64.5**

9. CONCLUSION

Simulation of Grid Connected EV charging station with Renewable Energy is explained with its various Equipment used in station configuration .The control strategy used in bidirectional inverter is also show in paper for proper understating .The solar PV system is utilized with the station for economic and technical aspects where as backup battery's provide solution power demand in peak hours of station which successfully reduces stress on grid and swapping of battery facility can also made available on station. Charging of EV is successfully cared out with their result represented with different battery types which help to study and understand the charging rate behavior with their respective composition.

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