AN INTELLIGENT CONTROLLER FOR SOLAR PV AND BATTERY FED ELECTRICAL VEHICLE CHARGING STATION

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***Abstract*— The Electrical Vehicles (EVs) are gaining much popularity because of there use of clean and renewable energy resources. The huge progress in lithium-ion batteries have increased the development of electrical vehicles. But rapid growth in the EVs leads to huge increase in the power demand on the existing power grid. This leads to the exploration of clean and alternative resources of energy to charge the EVs. This paper presents a stand-alone DC bus charging station for Evs. The proposed topology consist of PV panel, Boost converter ,Buck converter, Bi-Directional dc-dc converter, Energy Storage Unit (ESU) and multiport charging points by providing constant voltage through dc bus. Initially, the power from the PV is used to charge the EV through the dc bus and station battery. When the PV is unable to supply enough power to charge the EV then the power from the battery is utilized and when PV generate excess power than required by the battery the station battery consumes it. Each unit is controlled independently and different operating scenarios are studied to regulate the dc bus voltage. The charge controllers are operated based on the concept of constant current/ constant voltage (CCCV) and power balance. The proposed topology has the advantages like low energy conversion losses when compared to the ac system and this topology reduces the energy demand on the existing ac grid. The proposed topology simulation is carried out with the help of MATLAB/ Simulink model.**

***Keywords*—**Electrical Vehicles(EVs), PV panel, Stand alone charging station, Energy Storage Unit(ESU), constant current /constant voltage(CCCV).

1. INTRODUCTION

As air pollution is one of the threatening consequence of conventional automobiles which use non-renewable energy resources like petrol, diesel. Due to the heavy traffic and rapid urbanization pollution become worse, to get the pollution free environment increasing the use of renewable energy resources in EVs is much advisable. More use of EVs in the automobile sector with non-renewable energy resources will prevent the environment. The Indian government has set targets for adoption of EVs due to their potential to reduce pollution and they many advantages like high torque, easy control and higher efficiency compared to conventional ICEs. But if all the ICEs are replaced with the EVs in large rate then their high penetration leads to heavy power demand on the power grid, this may cause the power grid to collapse.

Renewable energy is the alternative resource that has attained much demand in the recent years and it can be used to mitigate power demand on the power grid due to EV chargers. Solar energy is favourable resource for EV charging as it can be easily integrated in urban areas.

The system implemented in this paper incorporates a PV panel which is connected to the boost converter , P&O algorithm is used to track the MPPT, a bidirectional dc-dc converter, buck converter, ESU. If the energy output from the solar PV is less to meet the demand of EV charger then ESU supply the needed power. If the solar generates high power the ESU consumes it. The system has been implemented in the MATLAB/ Simulink to know the performance.

2. STAND ALONE DC BUS CHARGING STATION.

The main target is to propose an intelligent control for EV charging station using a PV source and a station battery. The proposed system consist of solar PV panel with boost converter , a bi-directional dc-dc converter and buck converter at charging ports for EV charging. The PV system consist of PV panel with mppt controller which uses P&O algorithm to tract the maximum power point at any given irradiance. Several mppt techniques are developed but we adopted the most frequently used Perturb and Observe (P&O) algorithm. The pv array is controlled to move is operating point towards the increasing power point until it reaches the mpp depends on the solar irradiance. After the mpp is achieved the algorithm calculates the voltage value and apply it to the boost conveter.

The main objective of the boost converter is to increase the voltage of the pv panel to the desired level of Dc bus voltage (48V). From the Dc bus it goes to the station battery and EV battery. The station battery consist of bi-directional dc-dc converter which operate in both the modes. When pv generates the excess power it operate in the buck mode to charge the station battery ,if solar PV generate less power the bi-directional battery operate in the boost mode to supply required power to the EV charging ports and to maintain the Dc bus at constant voltage. This mode may also be activated when additional high power loads are plugged in at the charging ports. The CCCV charging method is implemented based on the state of charge (SOC) of the EV battery.

3. BLOCK DIAGRAM

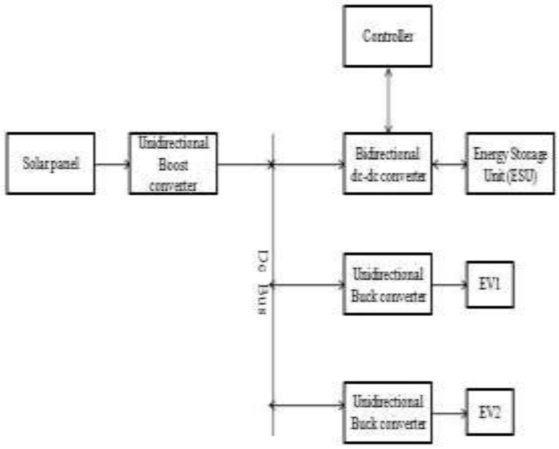

Fig.1. Block diagram of the proposed model

4. CONTROL SCHEMES

4.1. Unidirectional boost converter control.

The unidirectional boost converter control depends on the voltage generated from the mppt. PI control block is used to regulate the converter to work at maximum power point.

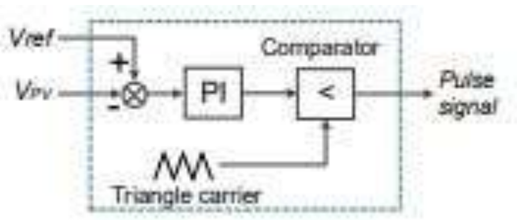

Fig. 2. Boost converter control.

4.2. Unidirectional buck converter control.

The aim of this controller is to charge the EV battery.It consist of overcharging limit function which is based on the detection of SOC of battery. When SOC reaches 100% it will limit the charging current and cut of the battery from the DC dus.

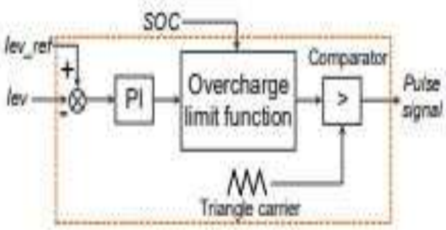

Fig. 3. Buck converter control.

4.3. Bi-directional DC-DC converter control.

This bi-directional converter control is the combination of two modes, buck mode and boost mode. The current supplying the station battery is not fixed it is the function of reduced power in the dc bus that is nothing but it is the difference between the maximum power from the PV and EVs absorved power.

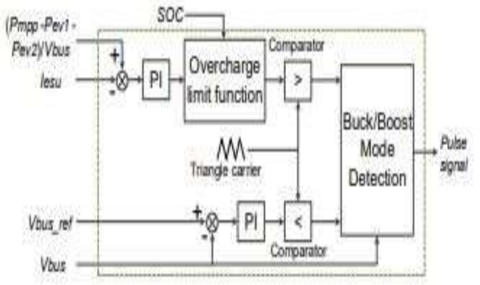

Fig .4 .bidirectional dc-dc control

The control algorithm operate in two modes; buck mode and boost mode. When the dc bus voltage (48v) is less the bus reference voltage the control algorithm operate in the boost mode(the bi-directional converter will discharge) & when the dc bus voltage is grater than the bus reference voltage the control algorithm operate in the buck mode(the bi-directional converter will charge.) And along with this control schemes constant current / constant voltage algorithm is implemented in this paper

4.4 CCCV control algorithm.

CCCV control mainly depends on the state of charge (SOC) of the battery. The charger limits the current until it reaches the battery value of soc. The charging current will decrease as the battery approaches the value of soc. This is used to charge the EV battery at full speed and helps to reduce the risk of over charging.

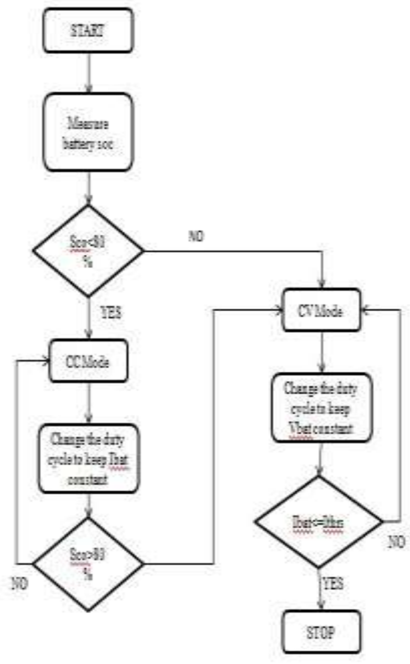

Fig.5. CCCV algorithm

Firstly the battery charge with the constant current mode of operation up to 80% of battery capacity and after 80% the control jumps to constant voltage mode of operation. Thus, this change in the duty cycle helps to maintains the battery voltage at a constant value.

5. SIMULATION MODEL AND RESULTS.

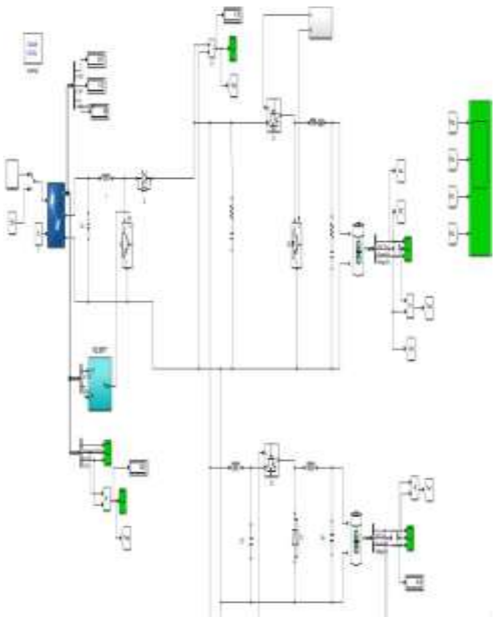

Fig. 6 .simulation diagram of the system.

Vol 12, Issue 06, JUNE /2021
ISSN NO:0377-9254

The Fig.6.consist of solar pv panel with the output of 26V and that is fed to the boost converter which step up the voltage to 48V.i.e, dc bus voltage. The bi-directional converter and the buck converter are connected to the dc bus. The charging points (buck converters) can be increased as per the requirement.

The Fig.7,Fig.8 are the bidirectional control schemes. If the photovoltaic power is grater than the consumed EV power then the switch S1 turns ON ,the bi-directional converter operate in the buck mode(charging the station battery) ,when the photovoltaic power is less than the consuming power of EV the switch S1 turns OFF and S1 turns ON, the bi-directional converter switches to the boost mode of operation(discharging of station battery).

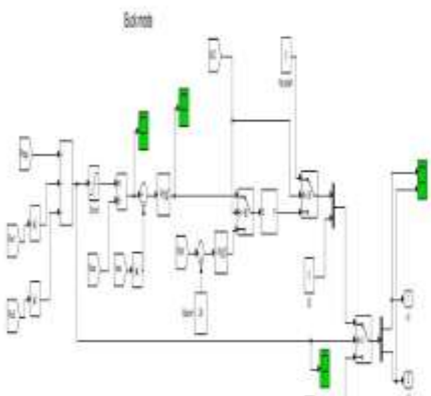

Fig. 7 .buck mode control

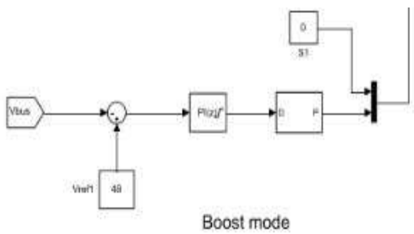

Fig . 8 .Boost mode control

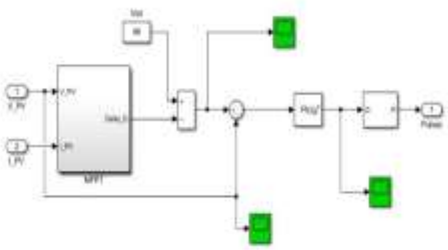

Fig . 9. Gate pulses to the boost converter

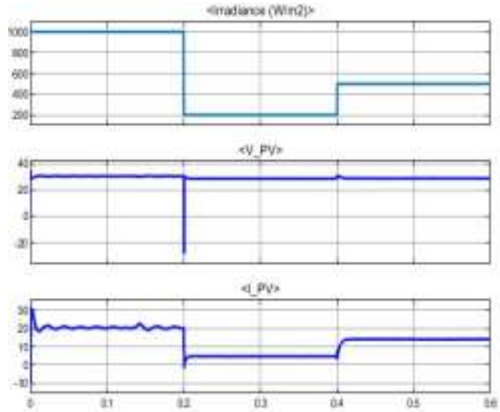

Fig .10 .PV array irradiance W/m2, voltage, current.

The irradiance of the solar panel changes with respect to the time from time t=0sec to time t=0.2sec the irradiance is taken as 1000W/m2 and from time t=0.2sec to t=0.4sec it reduced from 1000W/m2 to 200W/m2 and from t=0.4sec to t=0.6sec again it increased from 200W/m2 to 500W/m2.

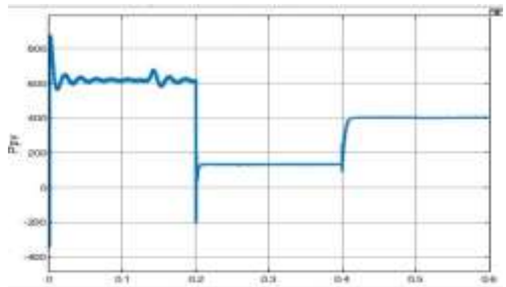

Fig.11.Solar panel output power with respect to time at changing irradiance.

Vol 12, Issue 06, JUNE /2021
ISSN NO:0377-9254

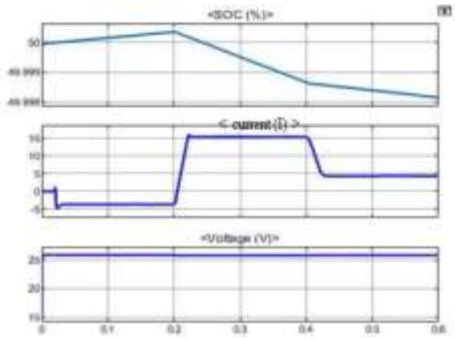

Fig. 12. Station battery behavior

The station battery behavior is shown at 50% SOC .From time t=0sec to 0.2 sec the irradiance is 1000W/m2 at this point of time the battery is charging ,as we can see the increase in the SOC and the current is in the negative value. At t=0.2sec the irradiance falls suddenly from 1000W/m2 to 200W/m2 at this point of time the SOC starts decreasing and it tends to decrease up to time interval of 0.4sec at in this time span the current value goes to positive value as the battery tends to discharge to maintain the constant dc bus voltage. From time t=0.4sec to 0.6sec again the irradiance increased from 200W/m2 to 500W/m2 in this time span the battery tends to charge.

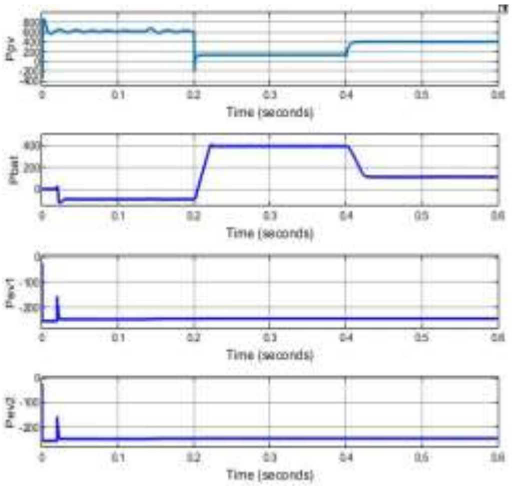

Fig.13.Power graphs of solar PV, station battery and EVs

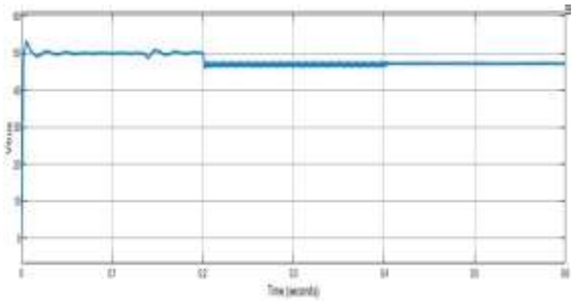

Fig.14.DC bus voltage (48V)

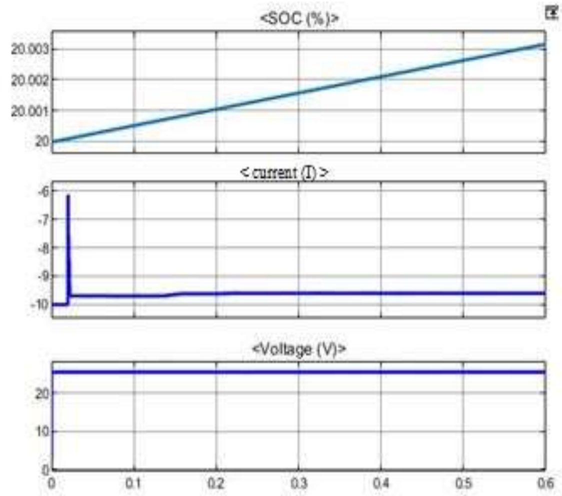

Fig.15. Battery characteristics at 20% SOC of EV1 and EV2.

CONCLUSION

The growth in the technology of EV industry will helps us to replace the conventional automobiles with EV in future. The main advantage of EV is to use renewable energy resources rather than the non-renewable sources like fossil fuels. So, this helps to reduce the emissions from the conventional ICEVs and to save our mother earth from the pollution.

This paper proposed a intelligent control for stand-alone dc bus EV charging station system which is mainly based on the solar PV. Suitable dc-dc converters and control schemes and algorithms are discussed.

The proposed model is simulated with the help of MATLAB/ simulink.

Vol 12, Issue 06, JUNE /2021
ISSN NO:0377-9254

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