

Chapter 1

Solar PV-Based Electric Vehicle Charging System with Power Backup



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1 Introduction

With the rapid increase in technologies and popularity of EV, a need develops for the improved charging infrastructure for their successful propulsion [1].

The charging could basically be powered by electricity generated from either conventional or non-conventional source of energy. But to make the concept of EVs completely environment-friendly a charging station powered by a renewable source of energy is considered to be the best [2].

Out of many types of renewable sources present on earth like tidal, geothermal, solar, wind energy, etc., the use of solar PV array for the EV charging station is preferred the most due to its easy availability, ease of installation, and less maintenance due to the absence of moving parts [3, 4].

The solar-powered charging system with power backup provides various advantages to the infrastructure where it is installed as it provides free fuel for the EVs throughout its lifetime, 20–25 years approximately, after a single investment and also eliminates the need of the power backup sources like diesel generator, inverters, etc. as it can supply the load by the EV batteries under emergency conditions [5].

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2 System Description

See Fig. 1.

2.1 PV Array

A solar PV array of 1 Soltech 1 STH-215-P is used with 10 series modules and 40 parallel strings. The PV and IV characteristics of the PV array are as follows (Figs. 2).

Characteristics of PV array

See Fig. 3.

2.2 Boost Converter

A boost converter is a DC–DC converter that steps up voltage (while stepping down the current) from its input to output. It is a category of SMPS (switch mode power supply) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element, a capacitor, an inductor, or two in combination (Fig. 4).

2.3 Single-Phase Full Bridge Inverter for R-L Load Inverter

A single-phase square wave type voltage source inverter produces square-shaped output voltage for a single-phase load. Such inverters have very simple control logic and the power switches need to operate at much lower frequencies compared to switches in some other types of inverters (Fig. 5).

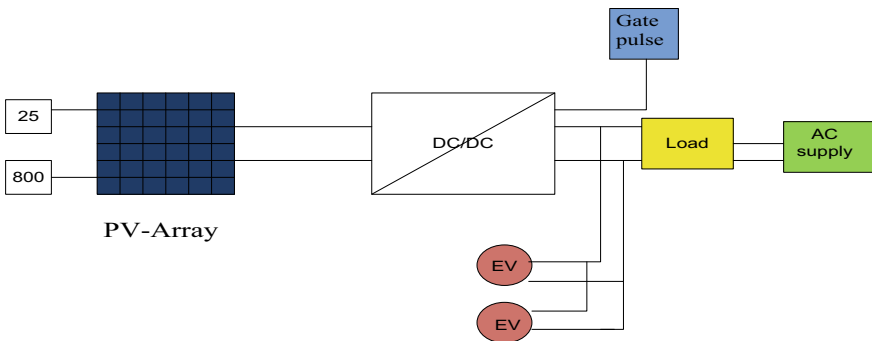


Fig.1 Block diagram of the system

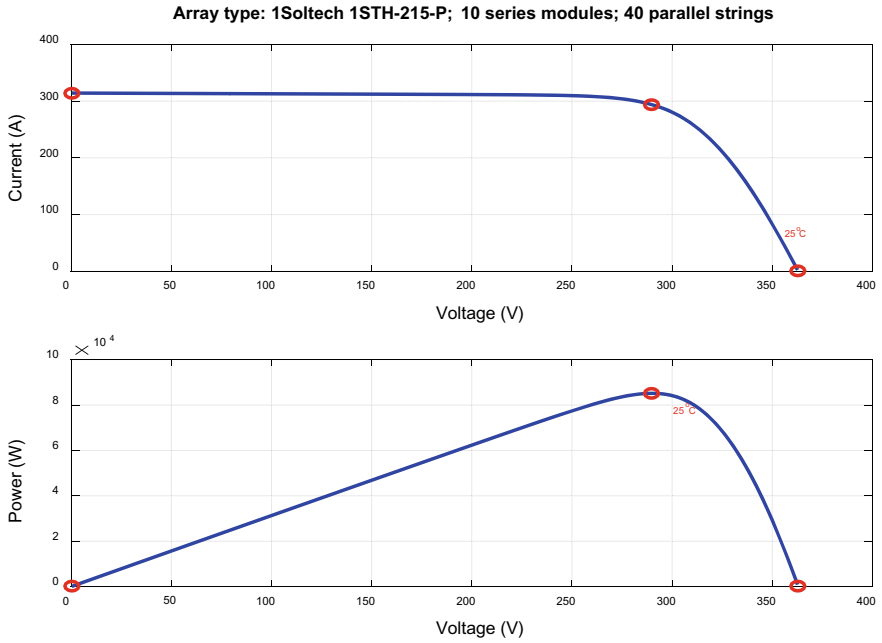


Fig. 2 The PV and IV characteristics of the PV array are as follows

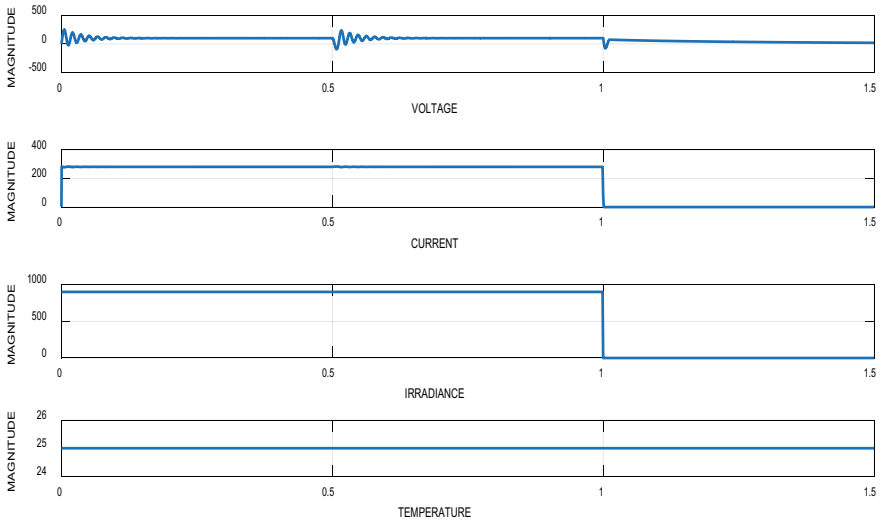


Fig. 3 The output waveform of the PV array used in this system

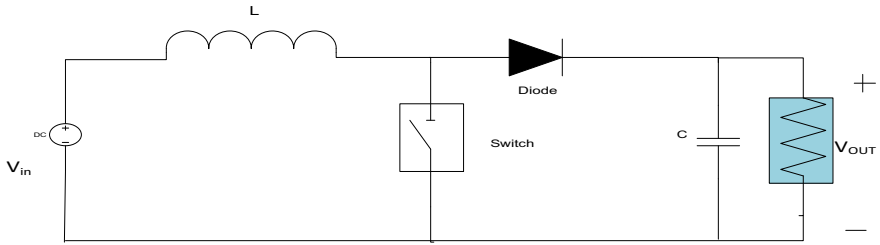


Fig. 4 Basic diagram of a boost converter

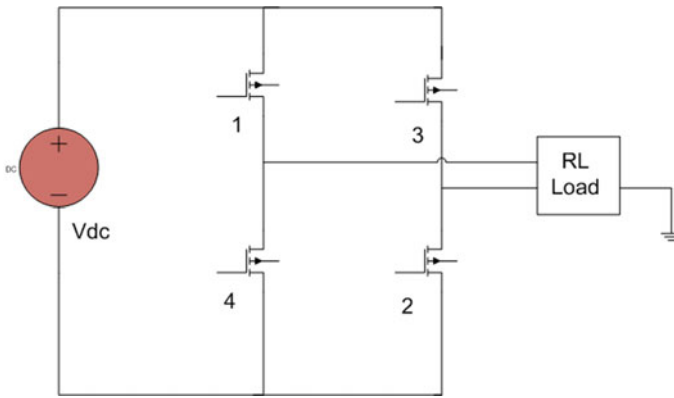


Fig. 5 Basic diagram of a single-phase inverter

2.4 Single-Phase AC Supply

A supply of peak voltage of 180 V and frequency of 50 Hz is used to supply the load under normal conditions.

2.5 Load

A resistive load of 5000 ohms is taken in this system.

3 Working of the System

The working of this system is explained basically in three modes.

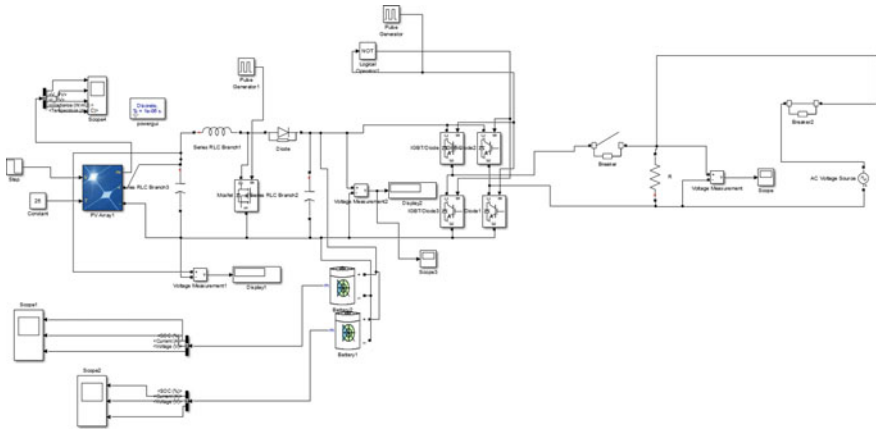


Fig. 6 Simulation model of the system in Matlab

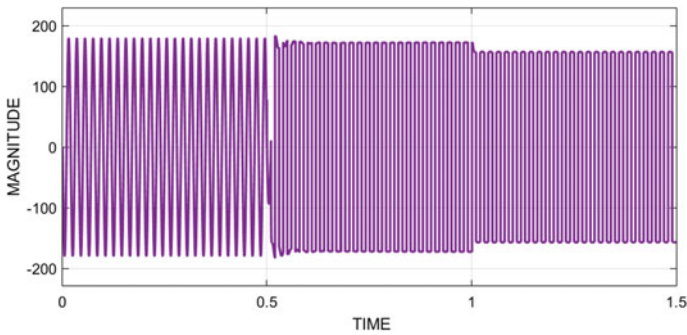


Fig. 7 Output waveforms across the load

MODE-I In this mode, both the grid and the SPV are ON where the grid supplies the load and the SPV charges the batteries of electric vehicles.

MODE-II In this mode, the grid is absent and the SPV maintains the supply across the load through a single-phase inverter and also charges the batteries of the EVs.

MODE-III In this mode, both the PV and the grid are absent and the batteries of the EVs supply the load and their discharging could be seen (Figs. 6, 7 and 8).

4 Simulation Model and Results

In Mode 1, i.e., from a time period of 0–0.5, the output waveforms across the load show sinusoidal waveforms as in this period of time the load is supplied by the grid

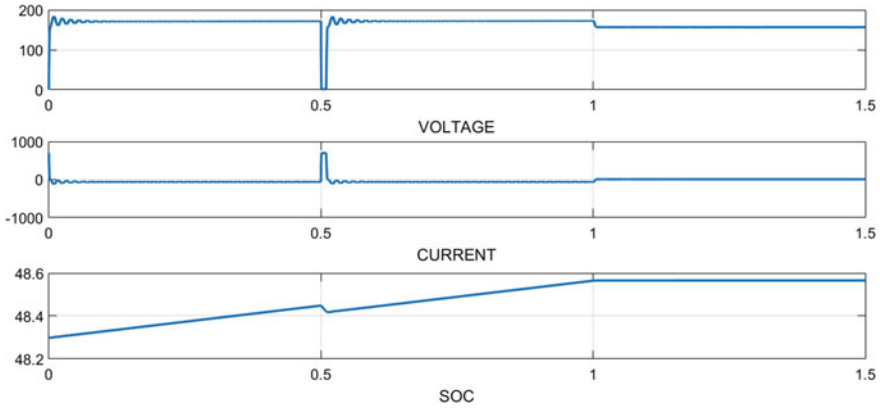


Fig.8 Output waveforms across the battery

and the output waveforms across the battery show an increasing value of SOC as it is getting charged by the solar PV array at this time.

In Mode 2, i.e., from time period of 0.5–1, the output waveforms across the load can be seen as a square wave as it is supplied by the solar PV inverter via a single-phase inverter in the absence of grid and the output waveforms across the battery show the increasing SOC as it is getting charged by the solar PV array.

In Mode 3, i.e., from time period of 1–1.5, the output waveforms across the load show the square wave of 144 V approximately which is supplied by the battery via a single-phase inverter due to the absence of both the sources (solar and grid) and discharging of the batteries can be seen in the output waveforms across the battery.

5 Conclusion

The charging station developed in this system proves to be a very economical system as with eliminating the requirements of expensive power backup sources. It also provides free fuel to the EVs throughout its life. The system could be further expanded and could be made more useful by applying some control techniques.

References

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