ISSN 2063-5346

MPPT SOLAR EV CHARGING STATION

Dr. R. Durga Rao

Article History: Received: 10.05.2023 Revised: 29.05.2023 Accepted: 09.06.2023

Abstract

The usage of solar panels and charging stations for electric vehicles (EVs) significantly reduces our reliance on fossil fuels. This study presents the design and development of a solar-powered charger for EVs. The station's battery voltage is increased from the solar panels' voltage using a dc-dc boost converter, and the panels' output is maximised by Maximum Power Point Tracking (MPPT). Using a buck converter, the voltage from the charging station is reduced to the level required by the electric car. Both consistent voltage and steady current charging procedures are used to keep up with the vehicle's battery. Using MATLAB and its SIMULINK environment, a thorough simulation analysis of the system is performed.

Keywords: *MPPT, buck converter, boost converter, constant current technique, and constant voltage method.*

Associate Professor & Head, Department of EEE, JNTUH University college of Engineering, Manthani

DOI:10.48047/ecb/2023.12.9.12

I.INTRODUCTION

With their far lower reliance on fossil fuels, electric cars represent the transportation mode of the future. Developed and emerging nations alike are promoting the use of electric cars as a viable, environmentally friendly transportation option. findings contradict the idea that recharging an electric car is environmentally favourable. The grid, which is powered by fossil fuels, must be used once again to charge the battery of an electric car, rendering the vehicle no longer environmentally benign. If you're looking for the greenest way to charge your EV, go no farther than soaking up the sun's rays. Maximum electricity Point Tracking (MPPT) is used to augment sun powered charger effectiveness and electricity generation. In order to keep the panel's efficiency at its highest possible level, MPPT keeps it running at its maximum power point at all times. It's important to charge the electric vehicle's on-board Lithium-Ion battery while avoiding any drops in voltage below the set threshold. To accomplish this, we use two distinct charging strategies: constant current (CC) and constant voltage (CV). By maintaining a constant current until the battery's state of charge (SOC) is almost at the rated value, the CC charging technique is used. Once the State of Charge (SOC) hits 100%, charging is completed via the CV technique. In order to control the output voltage of the electric vehicle's battery, the MOSFET of the buck converter is driven by the pulse from the CC and CV feedback loops.

II. CHARGING MODES

The solar panel is at its most efficient when it is charging a station's battery. The buck converter at this charging station allows for both steady current (CC) and predictable voltage (CV) charging modes, which are shown in Fig. 1. CC and CV charging modes recognize the battery voltage and current via a feedback loop.

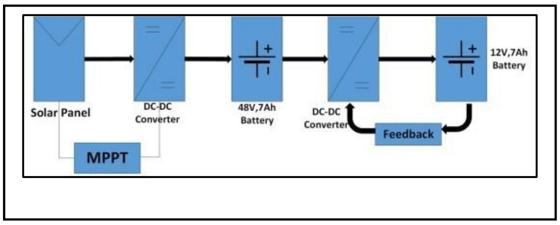


Fig.1 Solar battery charger block schematic

A. CC Charging Mode

The CC charging mode is finished when the battery's SOC reaches 95%. CV charging mode concludes after the battery achieves 95% SOC. As can be seen in Fig.2, a PID controller is fed the difference (error) between the load current and the reference current at all times while operating in CC mode. A comparator compares the PID output signal to a saw tooth wave, changing the saw's obligation cycle correspondingly [2]. The buck converter is activated by the output of the comparator.

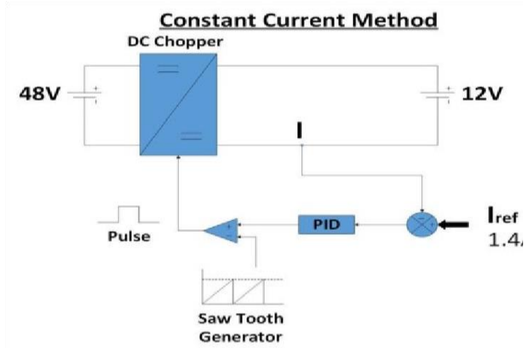


Figure 2: The CC Charging Flow

B.Charging in the CV mode

When charging in CV mode, the voltage across the battery is ceaselessly looked at to 12V as a benchmark. The reference current is then contrasted with the heap current, with the difference between the two serving as the error. A PID controller is then given the difference and its output is contrasted with a saw tooth wave with decide the obligation pattern of the result wave. In Fig.3, this is displayed as the door beat for the MOSFET in the buck converter. A social administrator and a change from CC mode to CV method of charging when the SOC of the battery hits 95% [2]

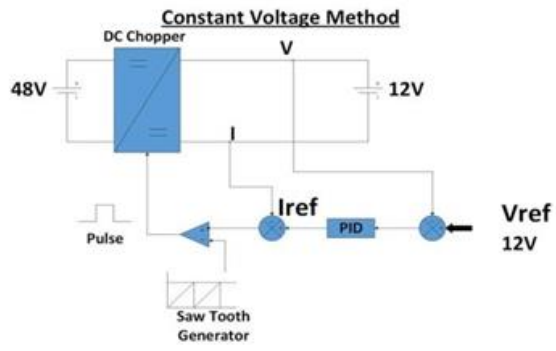


Fig.3.Charging mode for a CV device

III. DESIGN OF POWER CIRCUIT

A. *The Buck Converter Design Process*

The manufacturer has assigned a C5 charge rating to the 12V,7Ah battery pack used in EVs[7]. Therefore, a battery's charging current should be close to 75=1.4A.

Therefore, in CC charging mode, 1.4A should be used as the reference current.

The battery at the charging station can simultaneously power up to four automobiles. Since 12V * 4 = 48V.

The station battery specification becomes 48V, 7Ah
The load is the electric vehicle battery 12V, 7Ah
The load has a resistance(R) of 1Ω
The switching frequency, f =2kHz
The source is the station battery 48V, 7AH
Duty Ratio=12/48=0.25
Inductor = L_{min}=(1-D)R/2f=240µH
L=L_{min}*1.25=300µH
C=(1-D)/8L(ΔVo/Vo)f=1.5mF

B. Structure of solar cells

The battery rating should be used to guide panel selection [4]. It is believed that Tamil Nadu receives four hours of daylight at its peak. It is predicted that batteries would operate at a 77% efficiency. Station battery needs = 48V * 7Ah = 336Wh The output of the panel is 436.8Wh per year given the following formula: Power output of the panel at its highest, in watts, is calculated as follows: Used panels have outputs of 16.5V and 68W.

C .Design of boost converter

The panel has sent in a voltage of 16.5V. The station's battery requires a voltage of 48V in order to be charged. The panel's voltage output must thus be amplified. A boost converter is employed for this purpose. The station's battery requires a voltage of 48V, and the boost converter may increase that voltage from its standard 16.5V.

1-D=16/48=0.25
L=L_{min}(1.5)=1.65µH
L_{min}=D(1-D)2R/2f=1.1µH
C=D/R(ΔV0/V0)f=550mF

IV. DEVELOPMENT OF MAXIMUM POWER POINT TRACKING

Solar energy may be somewhat inconsistent. This is because to the weather's extreme variability, particularly with regards to sunlight and temperature. This means that solar panel efficiency is poor. The board's greatest power point is the working place where it delivers the most energy. The greatest power point (MPP) happens at a specific voltage, and the MPPT is used to determine this point. Some examples of MPPT implementations include the current sweep and the constant voltage approaches, as well as the perturb and monitor incremental conductance approach. Incremental Conductance

Theory is used here. Figure 5 is a flowchart depicting this procedure.

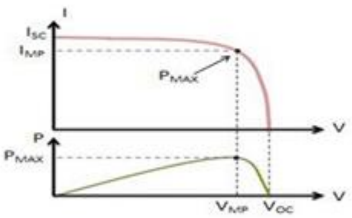


Fig. 4(a) PV characteristic curve(I to V)
4(b)PV characteristic curve(P to V)

A. Method of Incremental Conductance

Most extreme power point following is utilized to keep the board at its optimal power output. The incremental conductance technique uses the difference between the array conductance and the incremental conductance to determine the maximum power point. If there is no difference between the two, the panel is functioning at MPP. If there is a discrepancy, the MPP is found by shifting the point of operation to the left or right, depending on the polarity. Inc is assumed to be 0.01.

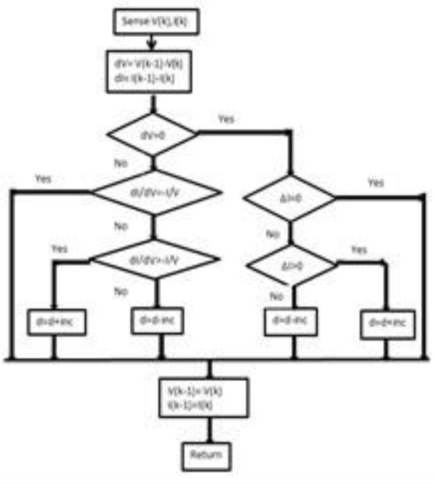


Figure 5: The Increasing Conductance

V. SIMULATION RESULTS

With the help of MATLAB Simulink, we model the suggested solar charging system. Each component of the system's output has been simulated independently, and the results are shown in Figures 6, 7, and 8.

A.CC charging

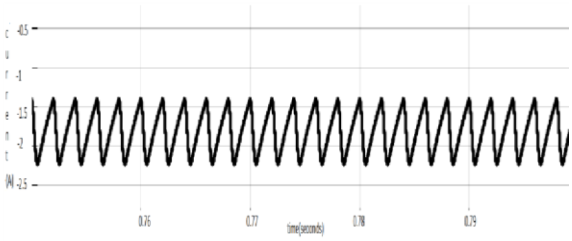


Figure 6 (a): Voltage across the battery during a mimicked CC mode drive.

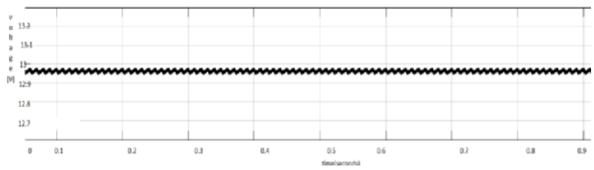


Figure 6b shows a simulation of the current (A) flowing through an electric vehicle operating in CC mode.

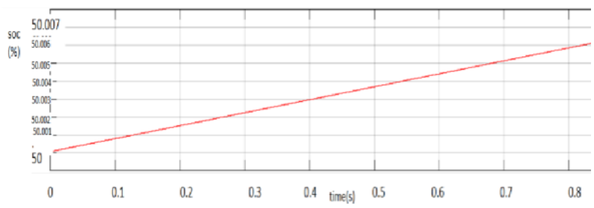


Figure 6(c): State-of-Charge (%) vs. Time (s) when in CC Mode

Figure 6(b) reveals a current range of 1.4A to 2.2A [3]. This is the greatest current that may be supplied to the battery without damaging it, as specified by the manufacturer. As can be observed in Fig. 6(a), the battery's charging voltage is close to 13V [3]. It can be observed that the SOC of the battery increases at a quicker pace than in CV mode, and that it will arrive at 100 percent as arranged in 5 hours.

B. CV charging

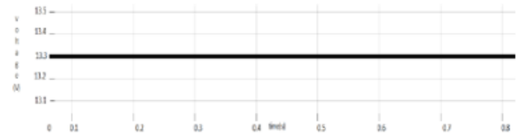


Fig.7 (a) voltage(V) of the electric vehicle battery in CV mode

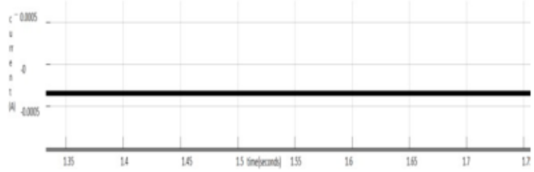


Fig.7(b) Battery Current (A) for Electric Vehicles

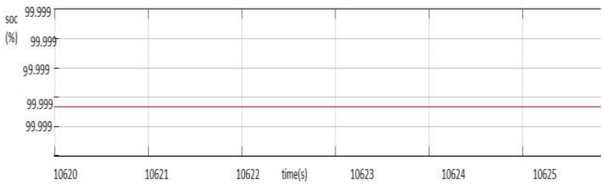
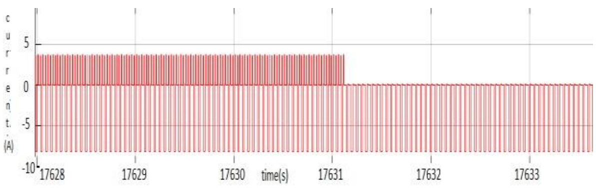


figure 7(c) state of charge battery electric vehicle convertible mode

Consistent voltage charging, where voltage is stayed aware of as shown in Fig.7 (a) and current is minuscule, should be visible from the recreation brings about Fig. 7(b), where the current has reduced to milliamperes (Mother) [3]and the voltage is stayed aware of at 13V(fully charged battery voltage)[3].Compared to charging in CC mode, this approach results in a considerably more gradual rise in SOC.



In Fig. 8(a) displays the station battery current (A) in relation to time.

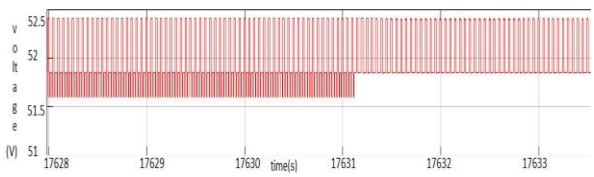


Fig.8(b) Simulation of Station Battery Voltage (V)

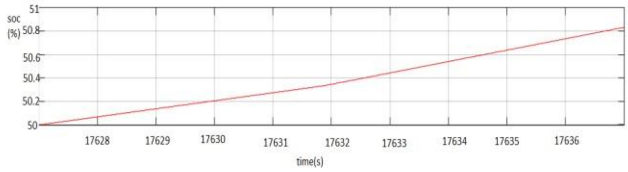


Fig.8 (c) Station battery SOC (%)

The station's battery output is shown in Fig. 8(a), where charging and discharging may be seen in alternating cycles. In CC mode, it receives power from the solar panels and sends power back to the station battery, though CV mode is the sole time the station battery receives power from the vehicle battery. Since a battery charges to a more conspicuous voltage than its apparent voltage, the figure in Fig.8 (b) indicates a value of around 52V. As can be seen in Fig.8(c), the SOC rises very gradually, indicating that the station battery is being charged. The charging time for the battery may be determined using the simulation's charging rate. Manufacturer-recommended charging time for a vehicle's battery is 5 hours (C5 rating). When there is no load attached to the charging station, the battery may be fully charged in 53 minutes. Three hours = time spent at the station charging batteries while they are concurrently being discharged.

VII. CONCLUSION

The whole sun based charger circuit is replicated, allowing the battery to charge in the correct way. Therefore, the battery is charged using energy harvested from the sun. Through the use of solar energy, the batteries may be recharged. By shifting to electric cars, nonrenewable assets like non-renewable energy sources that are currently used in ordinary vehicles might be preserved, making it possible to extend the grid. Vehicles may use their own eco-friendly charging system, which relieves pressure on power grid infrastructure.

REFERENCES

1) Hong-Yi Yang, Tse-Hsu Wu, Jiann-Jong Chen, Yuh-Shyan Hwang and Cheng-Chieh Yu "An Omnipotent Li-Ion Battery Charger With Multimode Controlled Techniques" *Power Electronics and Drive Systems (PEDS),* IEEE 10th International Conference (2013) : 531534
2) Van-Binh Vu, Van-Tuan Doan, Van-Long Pham and Woojin Choi "A New Method to Implement the Constant Current Constant Voltage Charge of the Inductive Power Transfer System for Electric Vehicle Applications" *IEEE Transportation Electrification Conference and Expo, Asia - Pacific* (ITEC) (2016) : 449-453
3) Hao Nguyen-Van, Thang Nguyen, Vu Quan, Minh Nguyen and Loan Pham-Nguyen "A Topology of Charging Mode Control Circuit Suitable for Long-Life Li-Ion Battery Charger" *Communications and Electronics (ICCE),* IEEE Sixth International Conference *(*2016) : 167-171
4) Driss Oulad-abbou, Said Doubabi, Ahmed Rachid "Solar Charging Station for Electric Vehicles" *Renewable and Sustainable Energy Conference (IRSEC),* 3rd International (2015)
5) Naotaka Kawamura, Mitsuharu Muta "Development of Solar Charging System for Plug-in Hybrid Electric Vehicles and Electric Vehicles" *Renewable Energy Research and Applications (ICRERA),* International Conference (2012)
6) Ahmad Musa, Leonardo H. Pratomo, Felix Y. Setiono "Design and Implementation of Solar Power as Battery Charger using Incremental Conductance Current Control Method" *1st International Conference on Information Technology, Computer and Electrical Engineering (ICITACEE)* (2014)
7) *EEMB lithium-ion battery data sheet,* EEMB Co.,Ltd, California, U.S.A .2010
8) *Allegro ACS712 datasheet,* Allegro MicroSystems, Massachusetts,U.S.A.2017
9) *EKT ArduinoVoltage Sensor,* EKT, China. *International RectifierIRFZ44N, I*nternational Rectifier, California, U.S.A.
10) H. Suresh *et al*., "Efficient charging of battery and production of power from solar energy," *2014 International Conference on Embedded Systems (ICES)*, Coimbatore, 2014, pp. 231-237.