Volume-13, Issue-04, April 2024
JOURNAL OF COMPUTING TECHNOLOGIES (JCT)
International Journal
Page Number: 01-04

Solar Energy with Hybrid Storage based Electric Vehicle Charging Station

Reeha Chouhan[1], Sachindra Kumar Verma[2]
[1,2]Department of Electrical and Electronics Engineering
[1]NRI Institute of Research and technology, Bhopal, India
[1]reehachouhan24@gmail.com, [2]skvme19@gmail.com

***Abstract*—The hybrid energy system for a solar-powered electric vehicle charging station is presented in this article. A hybrid energy storage system consists of both a supercapacitor and a battery. When the storage system is employed as a power source, changes in solar production need quick adjustments in supply from the storage system, which results in power fluctuations. One battery is not enough to counteract this sudden change in the clause. For charging stations that use solar energy to power electric vehicles, a hybrid energy storage device made up of a battery and a super capacitor is recommended as a solution to these issues. Additionally, the hybrid energy system reduces power fluctuations. MATLAB SIMULINKS is utilised to obtain the outcomes.**

Keywords*— Solar PV system. Storage battery, Super capacitor(SC), Electric Vehicle Charging Station, Electric Vehicle. Boost converter Power Management System.

I. INTRODUCTION

In recent years, the demand for electrical power has risen due to the addition of new loads, such as charging stations for electric vehicles (EV), surpassing the quantity of energy being generated [1]. Due to the finite nature of non-renewable sources and their detrimental impact on the environment, the significance of renewable energy sources in power grid accessibility is growing. Solar energy exhibits significant potential, although its output is constrained by temporal factors such as diurnal variations, seasonal fluctuations, and geographical positioning. Additional variants of sustainable energy, such as hydropower and wind energy, are similarly environmentally favourable and capable of being maintained indefinitely. High-capacity photovoltaic (PV) array systems have the ability to operate a continuous power-generating electric car charging station [2]. However, most unconventional sources are characterised by a lack of uniformity, leading to fluctuations in power at the charging station. Power fluctuations can be effectively controlled by either grid support or the utilisation of a hybrid energy storage system (BS). Dependence on the power grid would ultimately result in a rise in pollution [3,4]. This study proposes the use of BS as a method for controlling fluctuations in power flow. The absence of power balance in the PV side is decomposed into slow and rapid variable dynamics, which are regulated by the BS to control dynamic fluctuations. The storage battery will be responsible for mitigating the slow and gradual changes in dynamics, while the super capacitor storage system will be responsible for mitigating the rapid and sudden changes in dynamics [5, 6, 7, and 8].

A variety of studies have suggested the use of a power management strategy (PMS) as a means of controlling the transfer of electricity between solar panels and batteries, as well as other types of energy storage. This article proposes a revolutionary energy management system to control the power flow between solar energy and the storage battery and super capacitor. Figure 1 depicts the fundamental configuration of an electric vehicle charging station.

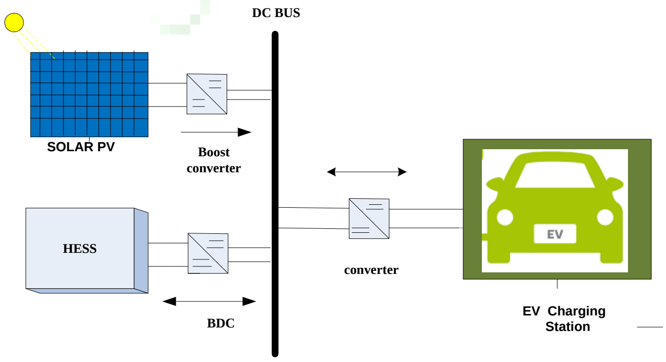

Fig.1. Basic topology of EV charging station

The paper's contribution is:

- Solar along with hybrid energy storage based a DC charging station is proposed.
- Power flow manages efficiently between solar, battery, super capacitor and DC EV load.

II. SYSTEM CONFIGURATION

The system consists of photovoltaic panels and a hybrid storage unit. BS is a hybrid energy storage system that combines a storage battery (SB) with a Super capacitor (SC). All the components are interconnected to a shared electric vehicle (EV) charging station, as seen in Figure 1.

PV modelling:

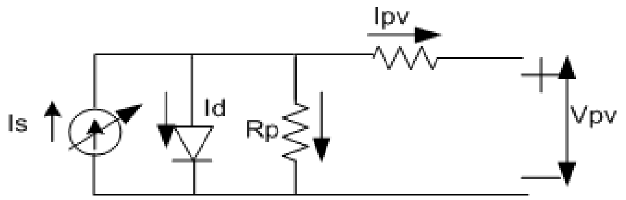

Fig.2. PV array equivalent circuit

$$Ipv = \left(\frac{\gamma}{\gamma ref}\right) Isref + \alpha isc(Ta - Tref) - Io\left[\exp\left(\frac{Vd}{Vt}\right) - 1 - Vpv + RsIpvRp\right. \quad (1)$$

Where, γ indicate irradiance measure in w/m2, Ta shows temp in SI unit, αISC coefficient of short circuit current and ISREF, TSREF and γref are rated valu, IS source current in amp, Ip is current through Rp resistance in amp, ID is diode current in amps, VPV is PV array voltage in volt, VD is voltage across diode in volt.

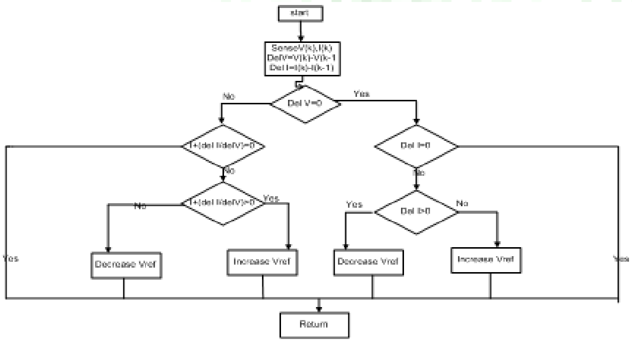

Fig.3. Incremental conductance MPPT algorithm flowchart

Figure 3 shows the flow chart for INC MPPT method. Because of the irradiance in the PV array, there is a variation in the power that is generated and the maximum power point tracking (MPPT). In order to trace the MPPT, an incremental conductance (INC) MPPT method is performed with an adjustable variable step size. This algorithm has the ability to change the step size in order to observe the maximum power point (MPP) with a step size adaptation coefficient. Furthermore, a user predefine fix value is not important for the junction of this MPPT method, which helps to clarify the design of the PV system. [9]

Storage battery:

In the world of electric power, a battery is a source of power that is composed of one or more electrochemical cells. Figure 4 illustrates the circuit that is comparable to it. SB units are designed to reduce the amount of electricity that is produced by solar slow power fluctuations. In order to determine the state of charge (SOC) of the battery, the method of current integration is utilised. In this approach, Q (t0) represents the initial charge that was applied to the battery at the time to, α represents the efficiency of discharge and charge, and I represent the current.

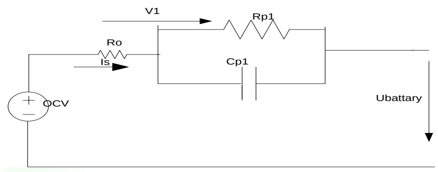

Fig.4. Storage battery equivalent circuit

$$U_{battery} = Vocv - V1 \quad (2)$$

Where, Ubattery is terminal voltage of SB, Vocv is open circuit voltage and V1 is the voltage drop in the battery

$$SOC(t) = \frac{Q(to) + \int_{to}^{t} \alpha.i.dt}{Rated\ Capacity} * 100 \quad (3)$$

Super capacitor:

As a means of compensating for the rapid power variation of the solar photovoltaic system, the primary objective of the SC addition in the proposed system is to provide support for the SB. The SC serves as a short-term power supply and energy buffer unit, which contributes to an improvement in the profile of the electric vehicle charging station. The ratio of the total energy (Qc) to the rated energy (Qo) is what determines the SOC of the SC bank. This ratio is found by applying the equation [3].

$$SOC = \frac{Qc}{Qo} = \frac{\frac{C.Vc^2}{2}}{\frac{CVmax^2}{2}} \quad (4)$$

Where, C is the equivalent capacitor of the SC bank. VC is voltage and VMAX is the maximum value of SC bank voltage at full charge.

III. POWER MANAGEMENT STRATEGY

A PMS design is utilised in this system in order to maximise the utilisation of power. The PV system is connected to the electric vehicle load by a DC-DC boost converter, and the battery storage system is connected through a two-sided converter in order to control the discharging and charging processes. Both the SB system and the SC unit are connected to one another through a two-sided converter in order to handle the process of charging and discharging. sun output power is subject to fluctuations as a result of variations in sun irradiation. As a

result, BS is utilised in this work to successfully satisfy the need for electric vehicle loads in order to synchronise the swings in the flow of power. The SC storage system is responsible for meeting the requirements of the SB, whereas the SB is responsible for meeting the requirements of the SC storage system.
The PMS works based on the following equation (5)

$$Ppv \pm Phss = Pdcload \qquad (5)$$

Where, Ppv are the power supplies by solar panel, $Pbat$ is power supplies by storage battery,$Pscis$power supplied by SC. Positive sign indicates battery and super capacitor in discharging mode and negative sign shows the both SB and SC in charging mode. Here, power is provided by PV array to the EV load. MPPT controller is used to optimize the power. But due to variation in irradiance in solar system, the power is decreasing. To compensate EV demand, BS is controlled by voltage controller and delay is used for SB due to the time response in it. Current IBAT is the current from SB. Slow changing dynamics are remunerated by SB and fast changing dynamics are remunerated by SC. ISC current through SC. Flow chart of PMS is shown in Fig.6. Whenever the solar power becomes greater than the load demand, only Solar PV system supply to EV charging station and also supply to battery and SC for charging. Whenever the solar power is less than the load demand, Solar PV system and HSS supply to EV charging station. When HSS is supplying the power then both SB and SC are in discharging mode. In case, the solar power and load demand are equal than only Solar PV system supply power to EV charging station. Both SB and SC are in idle condition.

IV. RESULT AND DISCUSSION

PV system and HSS are utilised for an electric vehicle load in this planned electric vehicle charging station. As seen in Figure 5, the power generated by photovoltaic cells changes depending on the amount of irradiation. The initial power output of a solar photovoltaic panel is 2000 watts per second; after one second, the power output drops to 1500 watts, and so on. The minimum power of solar photovoltaics (PV) is 150W from t=4 seconds to t=5 seconds. The suggested system, which is a constant DC electric vehicle load of 1000W, constantly draws power from the solar photovoltaic system up to t=2 seconds. After this, the EV load draws power from both the solar PV system and the battery storage system for a time span ranging from t=2 seconds to t=5 seconds. Both a battery and a super capacitor are incorporated into the system in order to compensate for the fluctuation in solar output and to satisfy the requirements of the charging station. There is a constant reduction in solar power after t=3 seconds, and solar power is less than load demand following this. Additionally, a super capacitor and a battery are utilised in order to satisfy the load demand. The instantaneous support of SC at t=3 seconds and t=4 seconds is depicted in Figure 7. Due to the fact that battery duration is constant, there is a delay period of battery. The battery is able to compensate for the variation in solar output over an extended period of time, as demonstrated in Figure 6. Figure 8 illustrates the nature of SB both with and without SC in a straightforward and concise manner. This contributes to the enhancement of the SB's longevity.

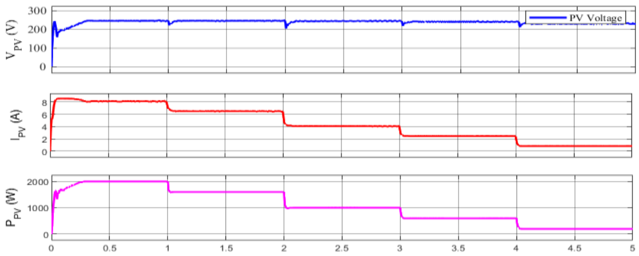

Fig.5. PV result (a) PV voltage, (b) PV current, (c) PV power

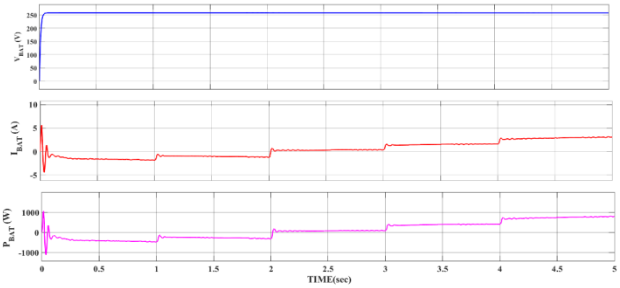

Fig.6.Battery waveform (a) Voltage waveform of battery, (b) Current waveform of battery, (c) Power waveform of battery

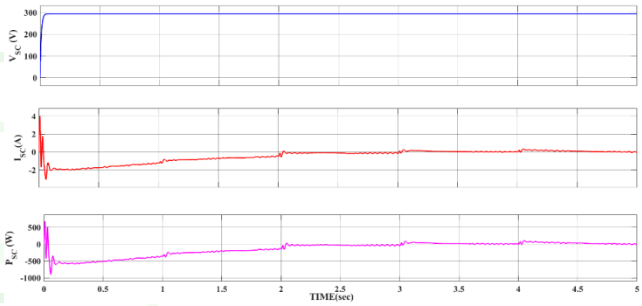

Fig.7 Super Capacitor (SC) waveform, (a) SC voltage, (b) SC current, (c) SC power.

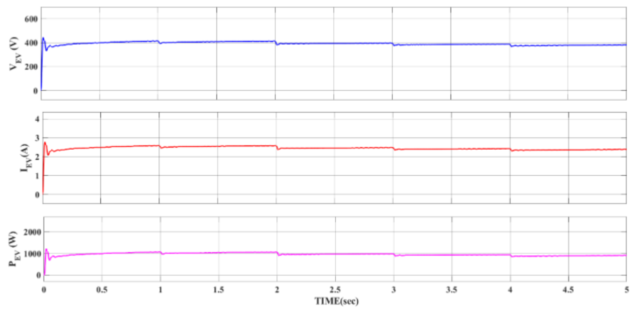

Fig.8. Charging station (a) voltage (b) current (c) power waveform

V.CONCLUSION

The PMS that has been suggested is responsible for managing the power fluctuation efficiency of solar photovoltaic systems. While SC is able to adjust for power fluctuations that are highly short-term, storage batteries are able to compensate for power changes that are long-term and serve to fulfil the load demands of electric cars. SC is able to correct for power variations that are extremely immediate. A further demonstration of the correctness of the suggested system was provided by the results of the simulation. The integration of the solar system with the grid has the ability to bring about the development of the work that is planned.

REFERENCES

[1.] J. Hong, J. Yin, Y. Liu, J. Peng and H. Jiang, "Energy Management and Control Strategy of Photovoltaic/Battery Hybrid Distributed Power Generation Systems with an Integrated Three-Port Power Converter," in IEEE Access, vol. 7, pp. 82838-82847, June. 2019

[2.] Z. Yi, W. Dong, and A. H. Etemadi, “A unified control and power management scheme for PV-Battery-based fusion microgrids for both grid-connected and islanded modes,” IEEE Trans. Smart Grid, vol. 9, no. 6, pp. 5975–5985, 2018, doi: 10.1109/TSG.2017.2700332.

[3.] R. H. Lasseter and P. Paigi, “Microgrid: A conceptual solution,” PESC Rec. - IEEE Annu. Power Electron. Spec. Conf., vol. 6, pp. 4285–4290, 2004, doi: 10.1109/PESC.2004.1354758.

[4.] S. Kewat, B. Singh and I. Hussain, "Power management in PV-battery-hydro based standalone microgrid," in IET Renewable Power Generation, vol. 12, no. 4, pp. 391-398, 2018.

[5.] Y. lin, J. Yin, Y. Liu, J. Peng and H. Jiang, "Power Management Strategy of Photovoltaic/Battery Hybrid Distributed Power Generation Systems with an Integrated Three-Port Power Converter," in IEEE Access, vol. 7, pp. 82838-82847, June. 2019

[6.] X. Jin, W. Zong, and A. Etemadi, “Power management scheme for PV-Battery-based fusion microgrids for both grid-connected and islanded modes,” IEEE Trans. Smart Grid, vol. 9, no. 6, pp. 5975–5985, 2018, doi: 10.1109/TSG.2017.2700332.

[7.] A. P. Singh and Y. Kumar, "Advanced Power Management System for Renewable energy-based fusion Microgrid," 2022 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS), 2022, pp. 1-4, doi: 10.1109/SCEECS54111.2022.9740835.

[8.] K. R. Naik, B. Rajpathak, A. Mitra and M. Kolhe, "Adaptive Energy Management Strategy for Optimal Power Flow Control of Hybrid DC Microgrid," 2020 5th International Conference on Smart and Sustainable Technologies (SpliTech), 2020, pp. 1-6, doi: 10.23919/SpliTech49282.2020.9243716.

[9.] Pradyumna Kumar Behera, Bibhudatta Mishra, Monalisa Pattnaik, "Geometrical Interpretation of Incremental Conductance MPPT Algorithm for a Stand-alone Photovoltaic System", 2021 Innovations in Power and Advanced Computing Technologies (i-PACT), pp.1-6, 2021.

