DESIGN AND SIMULATION OF A PHOTOVOLTAIC FED ELECTRIC VEHICLE CHARGING STATION

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ABSTRACT

The increasing popularity of electric vehicles (EVs) is putting a strain on the power grid. One way to mitigate this strain is to use photovoltaic (PV) solar panels to generate electricity for EV charging. However, the intermittent nature of solar power can make it difficult to ensure a reliable supply of electricity for charging EVs. This paper presents the design and simulation of an on-grid PV-fed EV charging station with battery energy storage system (BESS) backup. The PV system is sized to meet the average daily demand for EV charging, while the BESS is used to store excess solar energy and provide power during periods of low solar irradiance. The simulation results show that the proposed system is able to provide a reliable supply of electricity for EV charging, even under varying solar irradiance conditions. The system also has the potential to reduce the peak demand for electricity from the grid, which can help to improve grid reliability.

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INTRODUCTION

With the growing interest in decreasing the fossil fuel utilization and pollution, electric vehicles (EVs) have emerged as an applicable alternative to conventional gas engine vehicles [1]. The development and increasing utilization of EVs requires widely distributed charging stations due to the limited EV battery capacity. However, large scale of directly grid-connected charging stations, especially fast and superfast charging stations, stress power grid stability and reliability with peak demand overload, voltage sag, and power gap issues. Some researchers have been integrating photovoltaic (PV) generation with EV charging infrastructure; however, the PV integration is still considered as a minor portion of power source for EV charging stations in researches.

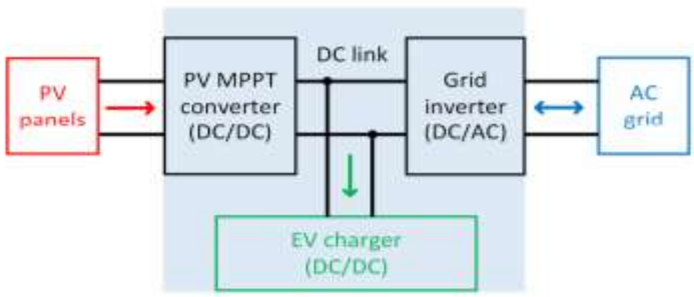

Fig 1 conventional architecture of EV charging stations integrated with PV

As for the higher demand of fast-speed charging during daytime, the rapid development of PV generation optimizes power consumption at peak hours with its adequate daytime generations. With respect to the intermittency of solar energy, a battery energy storage (BES) can be employed to regulate the DC bus or load voltage, balance power gap, and smooth PV power. Considering the high power density and high efficiency merits of the multiport power converters, a multiport DC/DC converter is employed in this paper for the EV charging station instead of using three separate DC/DC converters. Among the aforementioned research, the charging station architectures can be classified into two topologies: using AC bus or DC bus. As PV output and BES can both be regarded as DC current source,

DC bus charging station is chosen here to improve the utilization efficiency of solar energy and decrease the cost and losses of converters. Compared with isolated multiport converters, nonisolated multiport converters that are usually derived from buck or boost converters may feature a more compact design, higher power density, and higher efficiency compared with isolated multiport converters. Accordingly, a DC bus nonisolated structure with SiC switches is leveraged in this paper, to improve efficiency and minimize the power losses. To sum up, the works and contributions in this paper can be summarized as follows. First, the PV and BES integration, rather than the power grid, is considered as a predominant power supply for EV charging. Then, detailed operating modes, control scheme, and the interaction among PV, BES, power grid, and EV charging are developed and investigated, in a scenario of high penetration of PV integration and widely spread EV charging infrastructures. Additionally, detailed power losses and efficiency comparison is investigated

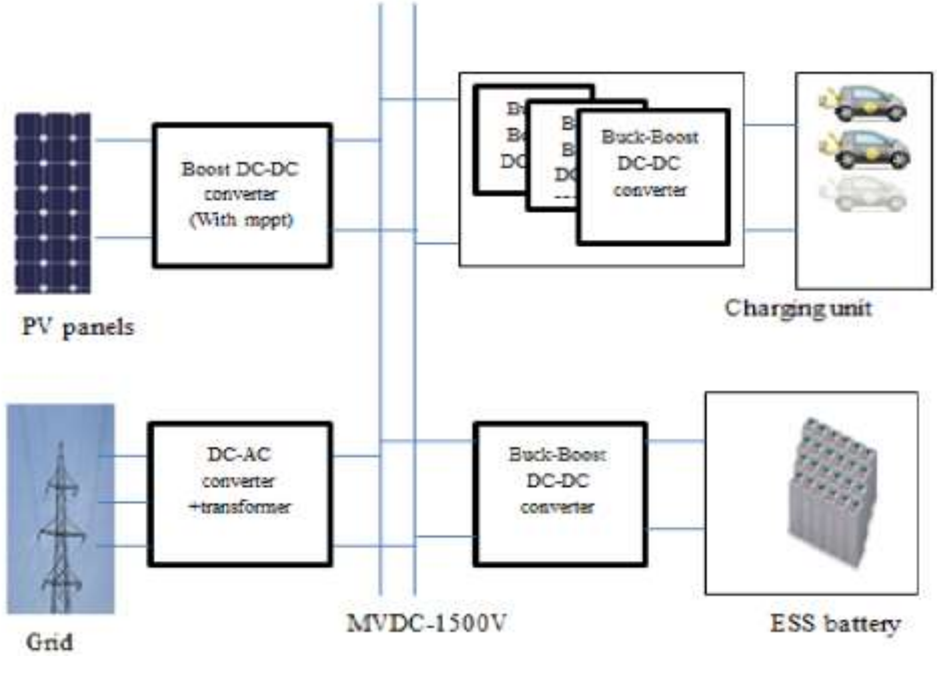

Fig 2 proposed multiport converter based EV charging station architecture integrated with PV and BES.

In the conventional architecture of DC bus charging station with PV integration (Fig. 1a), all the three power sources, including PV and EV charger unidirectional sources, and AC grid bi-directional source, are all connected through three separate converters. The proposed DC bus charging station (Fig. 1b), consists of one more bi-directional power source BES sharing the same DC bus. The BES is utilized to maintain the DC link voltage and balance power surplus/insufficiency.

LITERATURE SURVEY

Prem et al. (2020): This paper presents the design and analysis of a grid-connected solar PV-based EV charging station with battery backup. The system consists of a solar PV array, a battery energy storage system (BESS), an EV charger, and a control system. The control system is responsible for managing the power flow between the PV array, the BESS, and the EV charger. The paper presents simulation results that show that the proposed system can effectively charge electric vehicles while minimizing the impact on the grid.

Mahfouz and Iravani (2019): This paper presents the design, simulation, and evaluation of a system architecture and control structure for DC fast-charging stations for electric vehicles. The system architecture includes a solar PV array, a BESS, a DC fast-charging station, and a control system. The control system is responsible for managing the power flow between the PV array, the BESS, the DC fast-charging station, and the grid. The paper presents simulation results that show that the proposed system can effectively charge electric vehicles while minimizing the impact on the grid.

Killi and Samanta (2015): This paper presents a comparison of different charging station architectures for electric vehicles. The architectures are compared based on their power grid impact, modularity, and other characteristics. The paper concludes that the best architecture for a particular application depends on the specific requirements of that application.

Sharifa et al. (2018): This paper examines the adoption of PV–EV charging systems in depth. The paper discusses the challenges and opportunities associated with this technology, and it provides recommendations for its future development.

Wang et al. (2020): This paper proposes a method for finding the optimal charging or discharging time for electric vehicles. The method takes into account the initial state of charge of the battery, the feeding modalities, the arrival time, the leaving time, and the peak times. The paper presents simulation results that show that the proposed method can effectively reduce the charging cost of electric vehicles.

PROPOSED SYSTEM CONFIGURATION

The system consists of a solar PV array, a battery energy storage system (BESS), an EV charger, and a control system. The solar PV array generates electricity, which is stored in the BESS. The BESS can then supply power to the EV charger, or to the grid, as needed. The control system manages the power flow between the solar PV array, the BESS, the EV charger, and the grid. The system can be designed to meet the specific needs of the application. For example, the number of solar panels and the size of the BESS can be adjusted to match the expected demand for electricity. The control system can also be customized to optimize the performance of the system.

The proposed system can be used to charge electric vehicles while minimizing the impact on the grid. The BESS can store excess solar energy during the day and discharge it to the EV chargers or the grid at night or during peak demand periods. This can help to reduce the need for grid electricity and improve the efficiency of the system. The following are some of the benefits of using a photovoltaic fed EV charging station with BESS backup. The BESS can store excess solar energy, which can be used to charge electric vehicles at night or during peak demand periods. This can help to reduce the need for grid electricity. The BESS can help to improve the efficiency of the EV charging station by storing excess solar energy and discharging it when it is needed. This can help to reduce the amount of energy that is wasted. The BESS can help to improve the reliability of the EV charging station by providing backup power in case of a power outage. The use of solar energy and energy storage can help to reduce greenhouse gas emissions and improve air quality.

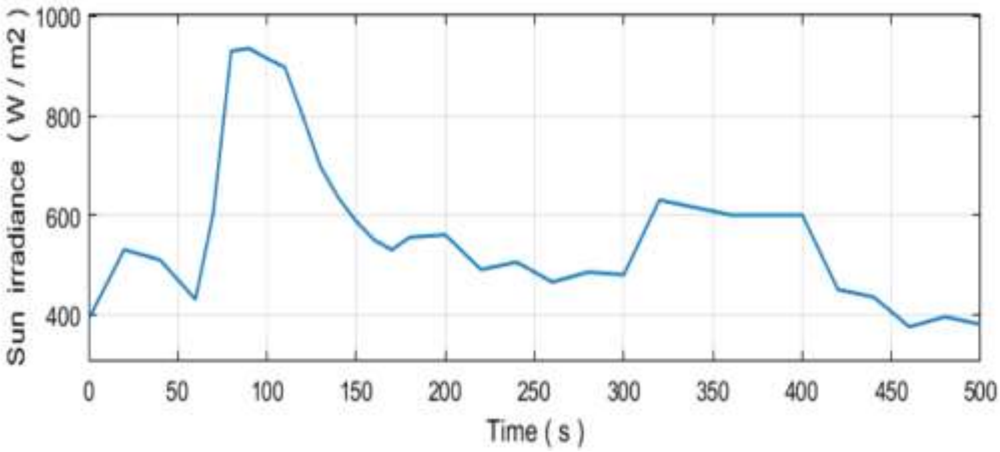

Fig 3 solar radiation vs time

The shape of the solar irradiation vs. time graph would depend on the location of the charging station. For example, a charging station located in a sunny area would have a higher solar irradiation level than a charging station located in a cloudy area. The power output of the solar PV array would also depend on the size of the array. A larger array would be able to generate more power than a smaller array. The solar irradiation vs. time graph is a valuable tool for understanding the performance of an on-grid photovoltaic fed electric vehicle charging station with BESS. It can be used to optimize the design of the system and to ensure that it meets the needs of the users.

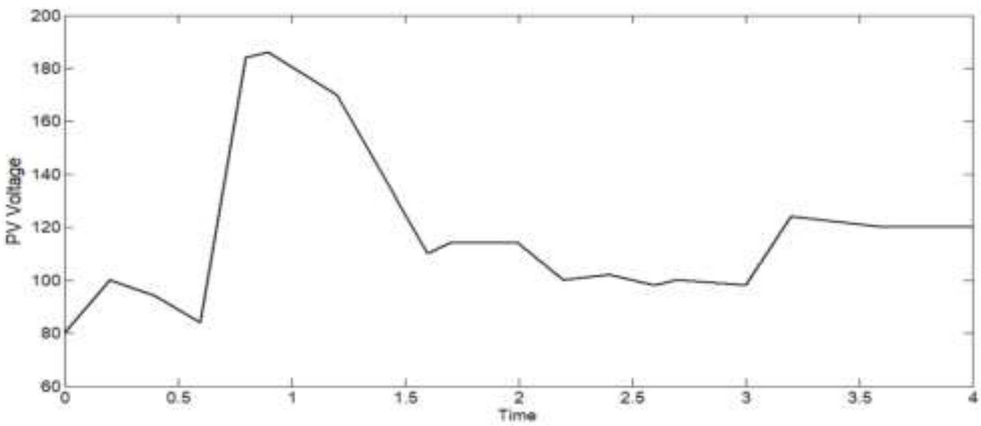

Fig 4 pv voltage vs time

The PV voltage graph in a simulation of an on-grid photovoltaic fed electric vehicle charging station with BESS will vary depending on the time of day, the weather conditions, and the amount of load on the system. However, in general, the PV voltage will be higher during the day when the sun is shining and lower at night when the sun is not shining. The PV voltage will also be lower when there is more load on the system, as the PV array will be supplying less power to the system.

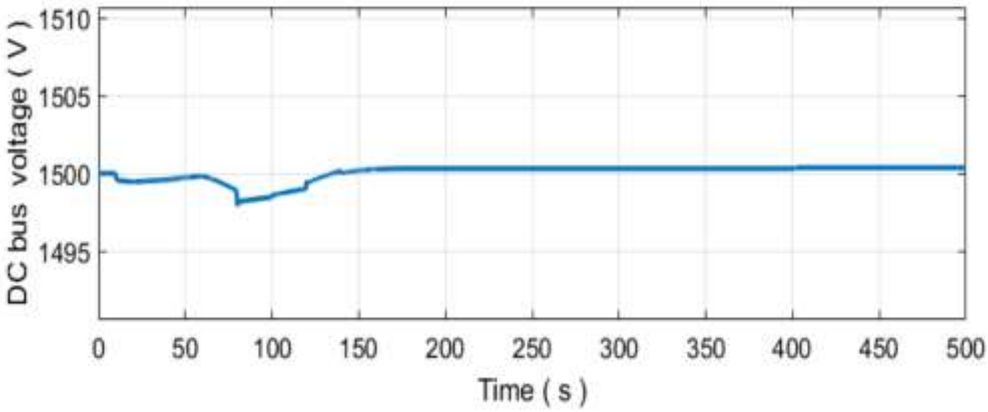

Fig 5 DC link voltage vs time

The DC link voltage will be higher when there is more solar irradiance and lower when there is less solar irradiance. The DC link voltage will also be lower when the power demand of the EV chargers is high and higher when the power demand is low. The state of charge of the BESS will also affect the DC link voltage, with a higher state of charge leading to a higher DC link voltage. The control strategy used to manage the power flow will also affect the DC link voltage. A control strategy that prioritizes the use of solar power will result in a higher DC link voltage than a control strategy that prioritizes the use of the grid.

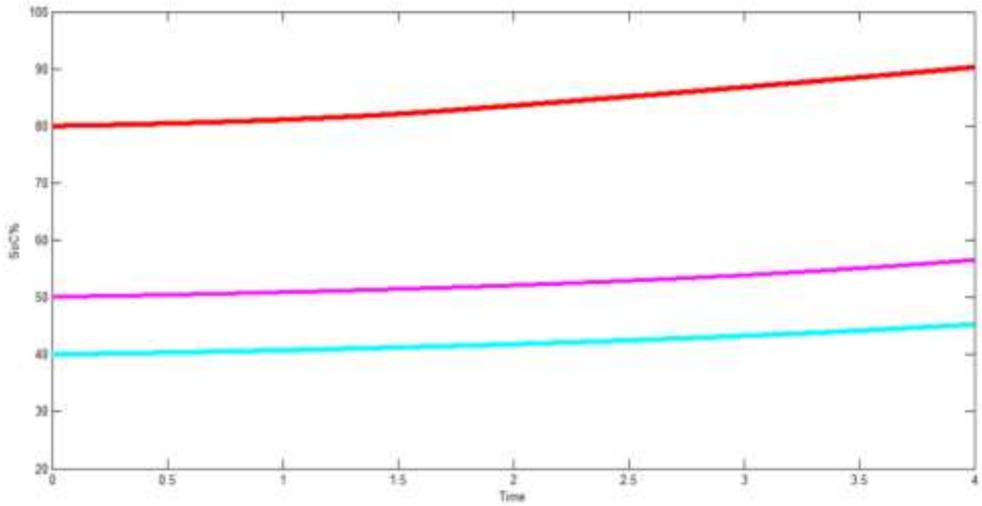

Fig 6 SOC’s of EV

The EV state of charge (SOC) graph in a simulation of an on-grid photovoltaic fed electric vehicle charging station with BESS would typically show a gradual increase in the SOC of the EV battery as it is charged by the solar PV array and/or the BESS. The rate of increase in the SOC would depend on the power output of the solar PV array, the capacity of the BESS, and the charging demand of the EV. The graph would also show some fluctuations in the SOC, which could be due to a number of factors, such as changes in the solar irradiance, the load on the grid, or the charging behavior of the EV

CONCLUSION

A Multiport converter based EV charging station with PV and BES is proposed. A BES controller is developed to regulate the voltage sag, and balance the power gap between wind, PV generation and EV charging demand. With the proposed control design, BES starts to discharge when wind, PV is insufficient for local EV charging, and starts to charge when wind, PV generation is surplus or power grid is at valley demand, such as during nighttime. As a result, the combination of EV charging, PV generation, and BES enhances the stability and reliability of the power grid. Different operating modes and their benefits are investigated and then, simulation and thermal models of the multiport converter based EV charging stations and the proposed SiC counterpart are developed in MATLAB.

REFERENCES

[1] V. Rallabandi, D. Lawhorn, J. He, and D. M. Ionel, "Current weakening control of coreless afpm motor drives for solar race cars with a threeport bi-directional dc/dc converter," in 2017 IEEE 6th International Conference on Renewable Energy Research and Applications (ICRERA), Nov 2017, pp. 739–744.
[2] Y. Liu, Y. Tang, J. Shi, X. Shi, J. Deng, and K. Gong, "Application of small-sized smes in an ev charging station with dc bus and pv system," IEEE Trans. on Applied Superconductivity, vol. 25, no. 3, pp. 1–6, June 2015.
[3] M. Ahmadi, N. Mithulananthan, and R. Sharma, "A review on topologies for fast charging stations for electric vehicles," in 2016 IEEE International Conference on Power System Technology (POWERCON), Sep. 2016, pp. 1–6.
[4] J. C. Mukherjee and A. Gupta, "A review of charge scheduling of electric vehicles in smart grid," IEEE Systems Journal, vol. 9, no. 4, pp. 1541– 1553, Dec 2015.
[5] H. Zhu, D. Zhang, B. Zhang, and Z. Zhou, "A nonisolated three-port dcdc converter and three-domain control method for pv-battery power systems," IEEE Trans. on Industrial Electronics, vol. 62, no. 8, pp. 4937–4947, Aug 2015.
[6] A. Hassoune, M. Khafallah, A. Mesbahi, and T. Bouragba, "Smart topology of evs in a pv-grid system based charging station," in 2017 International Conference on Electrical and Information Technologies (ICEIT), Nov 2017, pp. 1–6.
[7] B. Honarjoo, S. M. Madani, M. Niroomand, and E. Adib, "Non-isolated high step-up three-port converter with single magnetic element for photovoltaic systems," IET Power Electronics, vol. 11, no. 13, pp. 2151– 2160, 2018.
[8] S. Bai, D. Yu, and S. Lukic, "Optimum design of an ev/phev charging station with dc bus and storage system," in 2010 IEEE Energy Conversion Congress and Exposition, Sep. 2010, pp. 1178–1184.
[9] H. Zhu, D. Zhang, B. Zhang, and Z. Zhou, "A nonisolated three-port dcdc converter and three-domain control method for pv-battery power systems," IEEE Trans. on Industrial Electronics, vol. 62, no. 8, pp. 4937–4947, Aug 2015.
[10] H. Zhu, D. Zhang, Q. Liu, and Z. Zhou, "Three-port dc/dc converter with all ports current ripple cancellation using integrated magnetic technique," IEEE Trans. on Power Electronics, vol. 31, no. 3, pp. 2174–2186, March 2016.
[11] SunTech Power STP235-20-Wd, https://www.freecleansolar.com/ 235W-solar-panels-Suntech-STP235S-20-Wd-mono-p/stp235s-20-wd. htm, Accessed on 2018-12-19.
[12] CREE C3M0065090D MOSFET, https://www.wolfspeed.com/ c3m0065090d, Accessed on 2018-12-19.

[13] Infineon IPW90R120C3 MOSFET, https://www.infineon. com/dgdl/Infineon-IPW90R120C3-DS-v01 00-en.pdf?fileId= db3a3043183a955501185000e1d254f2, Accessed on 2018-12-19.