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SIMULATION OF PV WIND BATTERY BASED MULTI PORT CHARGING SYSTEM

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ABSTRACT

This paper proposes A multiport converter based EV charging station with wind, 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 system is developed in MATLAB.

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.

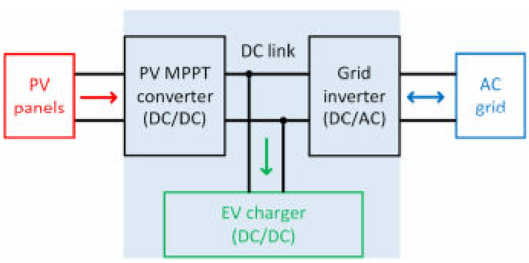

Fig 1 the conventional architecture of EV charging stations integrated with PV

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.

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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

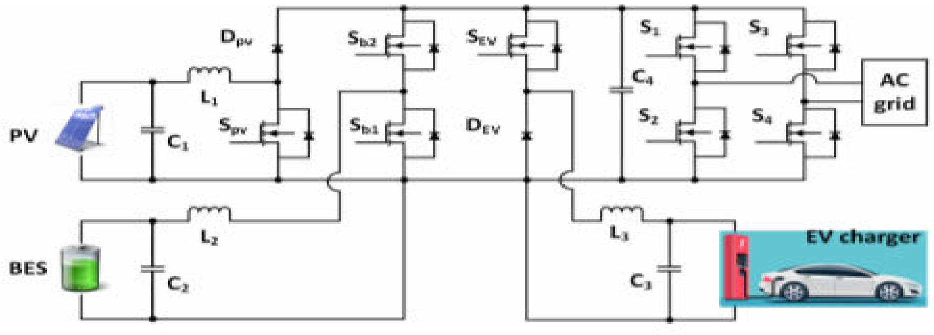

Fig 2 the conventional multiport converter based EV charging station architecture integrated with PV and BES.

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

PROPOSED SIMULATION SYSTEM

Charging stations can be found and will be needed where there is on-street parking, at taxi stands, in parking lots (at places of employment, hotels, airports, shopping centers, convenience shops, fast food restaurants, coffeehouses etc.), as well as in the workplaces, in driveways and garages at home. Existing filling stations may also incorporate charging stations. As of 2017, charging stations have been criticized for being inaccessible, hard to find, out of order, and slow; thus reducing EV expansion. At the same time more gas stations add EV charging stations to meet the increasing demand among EV drivers. Worldwide, hotels are adopting a policy of providing their guests with electric car charging.

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 [2]. 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 [3]. Some researchers have been integrating photovoltaic (PV) generation with EV charging infrastructure [4]; however, the PV integration is still considered as a

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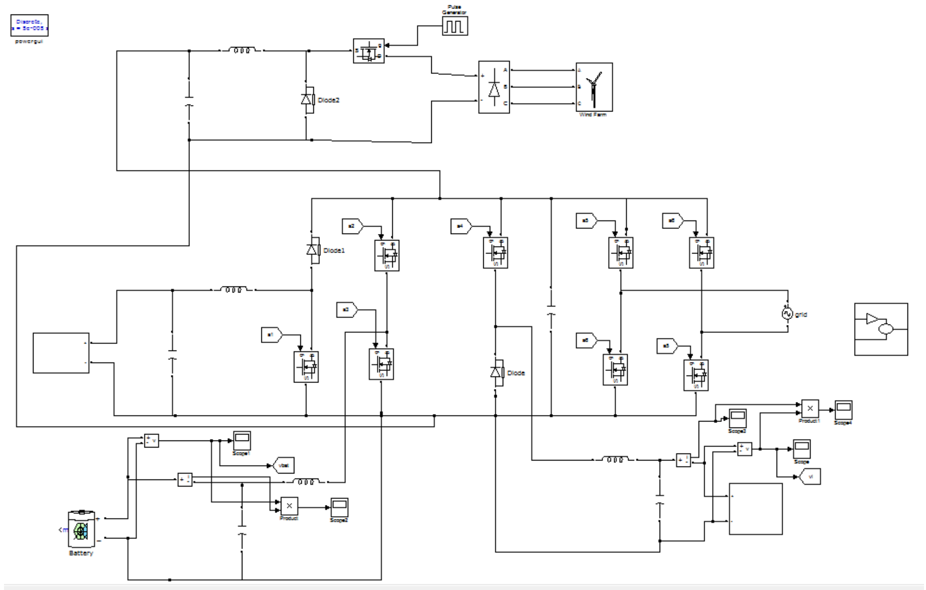

FIG 3 PROPOSED CIRCUIT CONFIGURATION

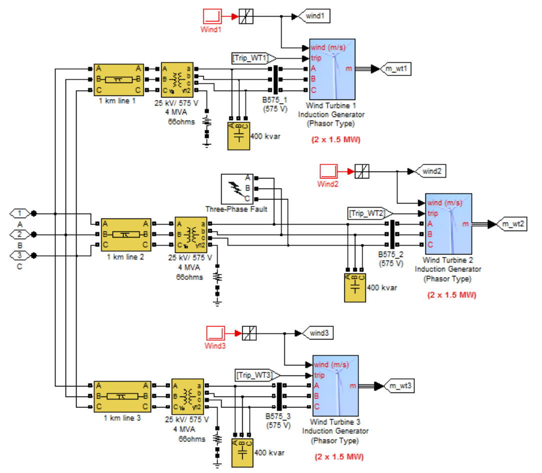

FIG 4 Proposed wind energy conversion system

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.

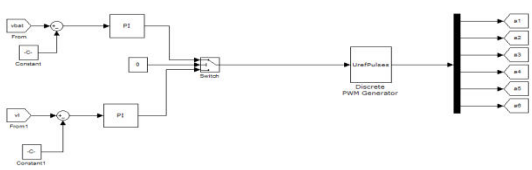

Fig 5 proposed controller

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 [5]. Considering the high power density and high efficiency merits of the multiport power converters [6], a multiport DC/DC converter is employed in this paper for the EV charging station instead of using three separate DC/DC converters.

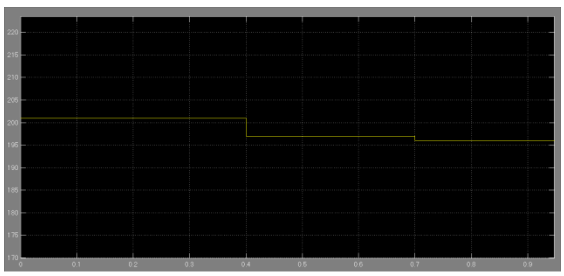

Fig 6 battery voltage

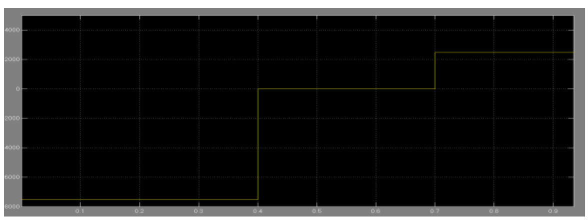

Fig 7 battery power

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Among the aforementioned research, the charging station architectures can be classified into two topologies: using AC bus or DC bus [7]. As PV output and BES can both be regarded as DC current source [8], 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 [9] [10].

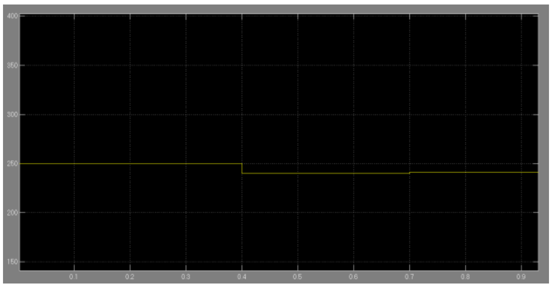

Fig 8 Terminal voltage

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. In the conventional architecture of DC bus charging station with PV integration,

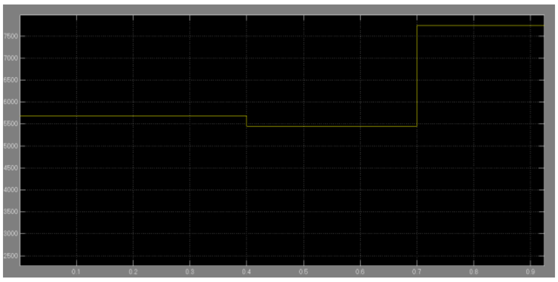

Fig 9 terminal power

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 from the PV. With this configuration, the function and operating modes can be discussed as follows in detail.

CONCLUSION

A multiport converter based EV charging station with wind, 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 system is developed in MATLAB.

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