IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

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ENERGY MANAGEMENT STRATEGY OF A PHOTOVOLTAIC

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Abstract:

The adoption of the photovoltaic electric vehicle charging stations has been on the rise. In this paper, a grid connected electric vehicle charging station powered a by photovoltaic solar system and a pack of batteries as storage system, is evaluated and analyzed. The most important parameter for supervising the system is the direct current bus voltage. The grid or the energy storage system can supply the electric vehicle charging station to maintain the bus voltage at its level. This supervision is tested by simulating the charging system under different irradiance conditions taking into account the cost of the energy transmission and the state of charge of the battery. The results validate the performance of the proposed energy management and the proper operation of electric vehicle charging station .

I.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.

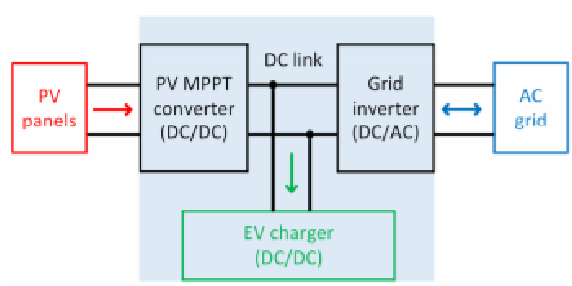

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Fig 1 the conventional architecture of EV charging stations integrated with PV

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. 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

II.BATTERY STORAGE SYSTEM

INTRODUCTION

A battery is a device consisting of one or more electrochemical cells with external connections for powering electrical devices such as flashlights, mobile phones, and electric cars. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal is the anode.The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal. When a battery is connected to an external electric load, a redox reaction converts high-energy reactants to lower-energy products, and the free-energy difference is delivered to the external circuit as electrical

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energy. Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to include devices composed of a single cell.

Primary (single-use or "disposable") batteries are used once and discarded, as the electrode materials are irreversibly changed during discharge; a common example is the alkaline battery used for flashlights and a multitude of portable electronic devices. Secondary (rechargeable) batteries can be discharged and recharged multiple times using an applied electric current; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium-ion batteries used for portable electronics such as laptops and mobile phones.

The sealed valve regulated lead–acid battery (VRLA battery) is popular in the automotive industry as a replacement for the lead–acid wet cell. The VRLA battery uses an immobilized sulfuric acid electrolyte, reducing the chance of leakage and extending shelf life.VRLA batteries immobilize the electrolyte. The two types are:

Gel batteries (or "gel cell") use a semi-solid electrolyte.

Absorbed Glass Mat (AGM) batteries absorb the electrolyte in a special fiberglass matting.

Other portable rechargeable batteries include several sealed "dry cell" types, that are useful in applications such as mobile phones and laptop computers. Cells of this type (in order of increasing power density and cost) include nickel–cadmium (NiCd), nickel–zinc (NiZn), nickel metal hydride (NiMH), and lithium-ion (Li-ion) cells. Li-ion has by far the highest share of the dry cell rechargeable market. NiMH has replaced NiCd in most applications due to its higher capacity, but NiCd remains in use in power tools, two-way radios, and medical equipment.

In the 2000s, developments include batteries with embedded electronics such as USBCELL, which allows charging an AA battery through a USB connector,[28] nanoball batteries that allow for a discharge rate about 100x greater than current batteries, and smart battery packs with state-of-charge monitors and battery protection circuits that prevent damage on over-discharge. Low self-discharge (LSD) allows secondary cells to be charged prior to shipping.Many types of electrochemical cells have been produced, with varying chemical processes and designs, including galvanic cells, electrolytic cells, fuel cells, flow cells and voltaic piles.A wet cell battery has a

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liquid electrolyte. Other names are flooded cell, since the liquid covers all internal parts, or vented cell, since gases produced during operation can escape to the air. Wet cells were a precursor to dry cells and are commonly used as a learning tool for electrochemistry. They can be built with common laboratory supplies, such as beakers, for demonstrations of how electrochemical cells work. A particular type of wet cell known as a concentration cell is important in understanding corrosion. Wet cells may be primary cells (non-rechargeable) or secondary cells (rechargeable). Originally, all practical primary batteries such as the Daniell cell were built as open-top glass jar wet cells. Other primary wet cells are the Leclanche cell, Grove cell, Bunsen cell, Chromic acid cell, Clark cell, and Weston cell. The Leclanche cell chemistry was adapted to the first dry cells. Wet cells are still used in automobile batteries and in industry for standby power for switchgear, telecommunication or large uninterruptible power supplies, but in many places batteries with gel cells have been used instead. These applications commonly use lead–acid or nickel–cadmium cells.

III.SOLAR SYSTEM

Introduction

The most important issue of all is probably why solar energy is important to you, personally.

- Fossil fuels, like gas and oil, are not renewable energy. Once they are gone they can't be replenished. Someday these fuels will run out and then mankind will either need to come up with a new way to provide power or go back to life as it was prior to man's use of these things.
- Fossil fuels create massive pollution in the environment. This pollution affects waterways, the air you breathe, and even the meat and vegetables that you eat.
- These fuels are expensive to retrieve from the earth and they are expensive to use. Other, more Eco-friendly energy sources like wind and solar energies are relatively inexpensive and easy to produce.

Background

World is moving towards the greener sources of energy to make the planet pollution free and environment friendly. The major utilization of these sources with grid integration is the challenging task. It is therefore Distribution Generation (DGs) particularly single phase rooftop PV system are major research area for grid integration, since these sources have huge opportunity of generation

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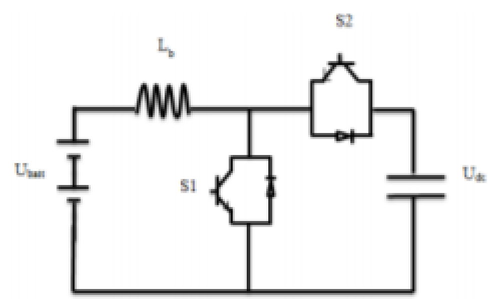
near load terminal. The rooftop application involving single phase DG's fed with PV source can be not only utilized for household use but the excess energy can be transferred to the grid through proper control scheme and adequate hardware. Control scheme based on instantaneous PQ theory has been presented in some literatures for single phase system.

Other control scheme such as synchronous reference frame (SRF) is mainly used with three phase system in which sinusoidal varying quantities are being transferred to dc quantities that provides better and precise control than PQ based control even under distorted condition of mains. But SRF based control scheme can be customized for single phase which can't be utilized to get the desired dc quantity to generate required reference command. PV sources are interfaced with the grid through voltage source converters (VSC's). VSC's can be controlled either in PWM based voltage control method or hysteresis based current controlled method (HCC). HCC based controller gives fast response and better regulation but its major drawback lies with Variable frequency.

IV.PROPOSED POWER CONVERTER

buck–boost converter

Buck boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is equivalent to a flyback converter using a single inductor instead of a transformer. Two different topologies are called buck–boost converter. Both of them can produce a range of output voltages, ranging from much larger (in absolute magnitude) than the input voltage, down to almost zero.



Proposed converter

V.PROPOSED SYSTEM SIMULATION

An electric vehicle charging station, also called EV charging station, electric recharging point, charging point, charge point, electronic charging station (ECS), and electric vehicle supply equipment (EVSE), is an element in an infrastructure that supplies electric energy for the recharging of plug-in electric vehicles—including electric cars, neighborhood electric vehicles and plug-in hybrids.

For charging at home or work, some electric vehicles have converters on board that can plug into a standard electrical outlet or a high-capacity appliance outlet. Others either require

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or can use a charging station that provides electrical conversion, monitoring, or safety functionality. These stations are also needed when traveling, and many support faster charging at higher voltages and currents than are available from residential EVSEs. Public charging stations are typically on-street facilities provided by electric utility companies or located at retail shopping centers, restaurants and parking places, operated by a range of private companies.

Charging stations provide a range of heavy duty or special connectors that conform to the variety of standards. For common DC rapid charging, multi-standard chargers equipped with two or three of the Combined Charging System (CCS), CHAdeMO, and AC fast charging has become the de facto market standard in many regions.

Charging stations fall into four basic categories:

1. Residential charging stations: An EV owner plugs into a standard receptacle (such as NEMA connector in the US) when he or she returns home, and the car recharges overnight.[2] A home charging station usually has no user authentication, no separate metering, but may require wiring a dedicated circuit to have faster charging.[3] Some portable chargers can also be wall mounted as charging stations.
2. Charging while parked (including public charging stations) – a private or commercial venture for a fee or free, sometimes offered in partnership with the owners of the parking lot. This charging may be slow or high speed and often encourages EV owners to recharge their cars while they take advantage of nearby facilities.[4] It can include parking for an organization's own employees, parking at shopping malls, small centers, and public transit stations. Typically,
   AC Type1 / Type2 plugs are used.
3. Fast charging at public charging stations >40 kW, capable of delivering over 60-mile (97 km) of range in 10–30 minutes. These chargers may be at rest stops to allow for longer distance trips. They may also be used regularly by commuters in metropolitan areas, and for charging while parked for shorter or longer periods. Common examples are J1772, Type 2 connector, Combined charging system, CHAdeMO, and Tesla Superchargers.
4. Battery swaps or charges in under 15 minutes. A specified target for CARB credits for a zero-emission

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vehicle is adding 200 miles (approx. 320 km) to its range in under 15 minutes. In 2014, this was not possible for charging electric vehicles, but it is achievable with EV battery swaps. It intends to match the refueling expectations of regular drivers and give crane mobile support for discharged vehicles where there is no charging station.

There are two main types of safety sensor:

- Current sensors which monitor the power consumed, and maintain the connection only if the demand is within a predetermined range. Sensor wires react more quickly, have fewer parts to fail and are possibly less expensive to design and implement.[citation needed] Current sensors however can use standard connectors and can readily provide an option for suppliers to monitor or charge for the electricity actually consumed.[citation needed]
- Additional physical "sensor wires" which provide a feedback signal such as specified by the undermentioned SAE J1772 and IEC 62196 schemes that require special (multi-pin) power plug fittings.

Until 2013, there was an issue where Blink chargers were overheating and causing damage to both charger and car.[13][14] The solution employed by the company was to reduce the maximum current.

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 minor portion of power source for EV charging stations in researches.

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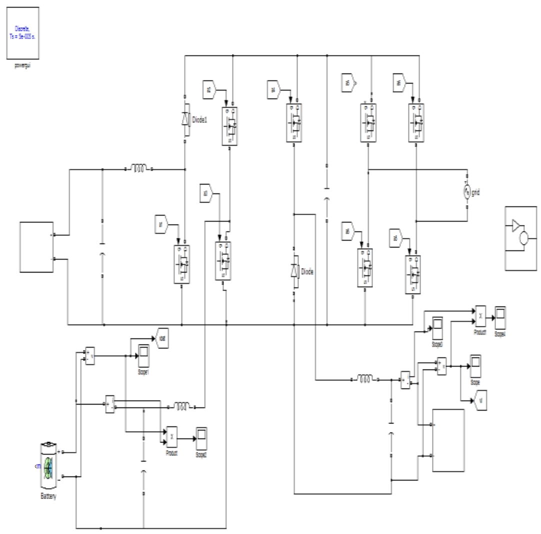

Fig 5.1 proposed simulation circuit

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.

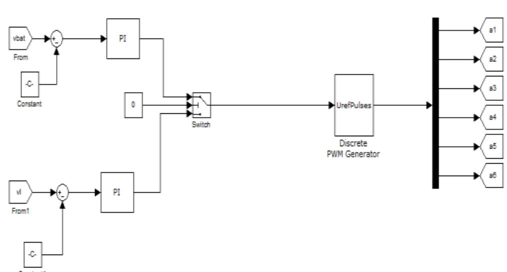

Fig 2 proposed controller

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.

CONCLUSION

A multiport converter based EV charging station withPV 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.

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