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MODELING AND SIMULATION OF EV CHARGING STATION WITH DYNAMIC VOLTAGE CAPABILITY

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ABSTRACT

Electric vehicles are promoted in large numbers by government of India to reduce environmental pollution and climatic change. Major anxieties while introducing electrical vehicles is their driving range and initial cost. Enough number of normal, medium and fast charging stations and battery swapping stations are to be planned and installed for smooth conveyance of electrical vehicles. This paper deals with a normal charging station implemented at a workspace. A solar power plant is used as the major source of electrical energy. An alternate connection to the station storage battery is used for importing/exporting the electrical power at times of deficient/excess solar power generation. The performance of the system is verified with MATLAB/Simulink.

INTRODUCTION

An electric vehicle (EV) is one that operates on an electric motor, instead of an internal-combustion engine that generates power by burning a mix of fuel and gases. Therefore, such as vehicle is seen as a possible replacement for current-generation automobile, in order to address the issue of rising pollution, global warming, depleting natural resources, etc. Though the concept of electric vehicles has been around for a long time, it has drawn a considerable amount of interest in the past decade amid a rising carbon footprint and other environmental impacts of fuel-based vehicles.

Plug–in electric vehicles (PEVs) which comprise all electric vehicles and plug-in hybrid electric vehicles provide the chance to modify the transportation energy demands from petroleum to electricity. Although, the impact of charging the electric vehicles (EVs) via the electrical grid, especially during the peak demand period cannot be neglected, it cause many problems such as harmonics, voltage outages and fluctuations [1]. The use of charging stations integrated with distributed generation based on renewable energy sources (RES), to boost the power generation, can be a viable solution to mitigate this problem [2]. In addition, the combination of these distributed energy sources into the charging infrastructure has an important role to decrease the environmental effects and to enhance the efficiency of the charging system. Due to the stochastic nature of RES, there is a persistent need to add an energy storage system (ESS) which has a crucial role in the incorporation of electric vehicle charging station (EVCS). The photovoltaic (PV) power is known as the most competitive source of energy to support the grid utility thanks to the persistent decreasing tendency on the prices of the PV panels [3]. Furthermore, the PV system, in terms of fuel and labor is approximately maintenance free [4]. The use of the PV power to supply the EVs is improved by the advancement in the power conversion technologies [5]. One of the important challenges for the EVCS, particularly the public ones, is making the charging duration as short as possible.

There are many standards organizations in the world that work to define the electrical characteristics of

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EVCS i.e. the Society of Automotive Engineering (SAE), CHAdeMO association and International Electro technical Commission (IEC). The latter develops four modes of charging basing on the type of the charging rate, the level and the type of voltage, the mode of communication between the EVs and the CS and the presence of the protections and its location.

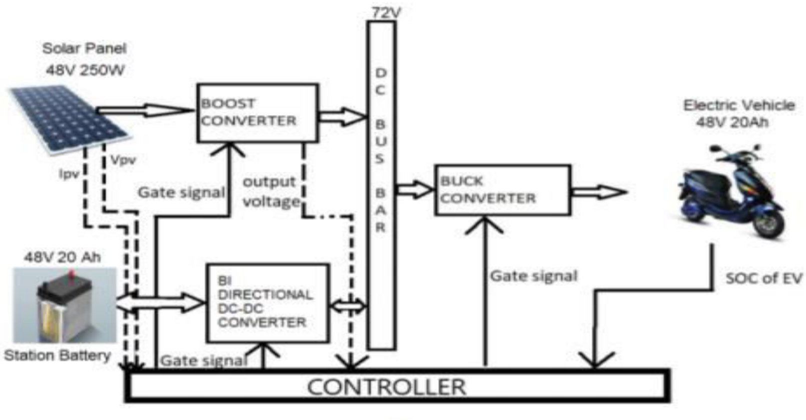

Fig 1 Proposed system

These fast charging station (FCS) present two topologies normalized by the IEC 61851-1, the first is tied to a common AC bus suppling all the AC-DC converters ,on the other hand, the second topology is based on a common DC bus which feed the various DC-DC chargers. Experimental studies showed that the second architecture is the best option due to the reduced number of the conversion stages, the nature of loads and fluent integration of energy storage systems or distributed generation. Apart from that, the synchronous charge of a fleet of EVs can cause an increase in the peak power demand to the utility grid. Dealing with a fleet of EVs at different poles of charging needs a study on appropriate management strategy, so two ways have been suggested, i.e. centralized or decentralized management strategy. The latter strategy, applied to the EVCS, is based on local controllers, and each source of energy works independently from the others, in addition to that the energy flow management between the sources of energy is accomplished without the necessity of communication interface between the energy sources or between the energy management system (EMS) and sources of energy. It facilitate the extension of the charging system and the medium voltage direct current (MVDC) network by adding new element such as others sources of energy (ESS, RES) or new EVs, the EMS does not need to be changed. Also, comparing these two strategies, it was concluded that the adoption of the decentralized strategy represents the most feasible option thanks to the benefit of not needing a communication interface [8]. In our study, a PV-grid charging station is studied to maximize the use of the photovoltaic power whenever it possible and to use the grid or/and the ESS as a buffer system when the solar irradiance is unavailable or there is an excess of power [9], This strategy allows the buffer‘s connection taking into account the energy transmission cost (ETC) and the state of charge of the battery (SOC). The proposed approach promotes the smart grid concept by combining the RES with the utility grid [10]. In order to get more revenues, Vehicle to Grid (V2G) technology can be also integrated where EVs owners can realize a balance of demand between charging and discharging modes [11]. However, this approach would produce a short lifetime of the EV‘s battery and other unsolved problems

LITERATURE SURVEY

In India, the first concrete decision to incentivise electric vehicles was taken in 2010. According to a Rs 95-crore scheme approved by the Ministry of New and Renewable Energy (MNRE), the government announced a financial incentive for manufacturers for electric vehicles sold in India. The scheme, effective from November 2010, envisaged incentives of up to 20 per cent on ex-factory prices of vehicles, subject to a maximum limit. However, the subsidy scheme was later withdrawn by the MNRE in March 2012.

In 2013, India unveiled the 'National Electric Mobility Mission Plan (NEMMP) 2020' to make a major shift to electric vehicles and to address the issues of national energy security, vehicular pollution and growth of domestic manufacturing capabilities. Though the scheme was to offer subsidies and create supporting infrastructure for e-vehicles, the plan mostly remained on papers. While presenting the Union Budget for 2015-16 in Parliament, then finance minister Arun Jaitley announced faster adoption and manufacturing of electric vehicles (FAME), with an initial outlay of Rs 75 crore. The scheme was announced with an aim to offer incentives for clean-fuel technology cars to boost their sales to up to 7 million vehicles by 2020.

In 2017, Transport Minister Nitin Gadkari made a statement showing India’s intent to move to 100 per cent electric cars by 2030. However, the automobile industry raised concerns over the execution of such a plan. The government subsequently diluted the plan from 100 per cent to 30 per cent.

In February 2019, the Union Cabinet cleared a Rs 10,000-crore programme under the FAME-II scheme. This scheme came into force from April 1, 2019. The main objective of the scheme is to encourage a faster adoption of electric and hybrid vehicles by offering upfront incentives on purchase of electric vehicles and also by establishing necessary charging infrastructure for EVs.

ELECTRIC VEHICLE CHARGING STATION

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 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.

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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.[5][6] 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.[7]
4. Battery swaps or charges in under 15 minutes. A specified target for CARB credits for a zero-emission 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.

Battery capacity and the capability of handling faster charging are both increasing, and methods of charging have needed to change and improve. New options have also been introduced (on a small scale, including mobile charging stations and charging via inductive charging mats). The differing needs and solutions of various manufacturers has slowed the emergence of standard charging methods, and in 2015, there is a strong recognition of the need for standardization.

The charging time depends on the battery capacity and the charging power. In simple terms, the time rate of charge depends on the charging level used, and the charging level depends on the voltage handling of the batteries and charger electronics in the car. The U.S.-based SAE International defines Level 1 (household 120V AC) as the slowest, Level 2 (upgraded household 240 VAC)

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in the middle and Level 3 (super charging, 480V DC or higher) as the fastest. Level 3 charge time can be as fast as 30 minutes for an 80% charge, although there has been serious industry competition about whose standard should be widely adopted. Charge time can be calculated using the formula: Charging Time [h] = Battery Capacity [kWh] / Charging Power [kW][8]

The usable battery capacity of a first-generation electric vehicle, such as the original Nissan Leaf, is about 20 kWh, giving it a range of about 100 mi (160 km). Tesla was the first company to introduce longer range mass production electric vehicles, initially releasing their Model S with battery capacities of 40 kWh, 60 kWh and 85 kWh, with the latter having an estimated range of about 480 km (300 mi). Plug-in hybrid vehicles have capacity of roughly 3 to 5 kWh, for an electrical range of 20 to 40 kilometers, but the gasoline engine ensures the full range of a conventional vehicle.

For normal charging (up to 7.4 kW), car manufacturers have built a battery charger into the car. A charging cable is used to connect it to the electrical network to supply 230 volt AC current. For quicker charging (22 kW, even 43 kW and more), manufacturers have chosen two solutions:

- Use the vehicle's built-in charger, designed to charge from 3 to 43 kW at 230 V single-phase or 400 V three-phase.
- Use an external charger, which converts AC current into DC current and charges the vehicle at 50 kW (e.g. Nissan Leaf) or more (e.g. 120-135 kW Tesla Model S).

The user finds charging an electric vehicle as simple as connecting a normal electrical appliance; however to ensure that this operation takes place in complete safety, the charging system must perform several safety functions and dialogue with the vehicle during connection and charging.

Other charging networks are available for non-Tesla vehicles. The Blink network of chargers has both Level 2 and DC Fast Chargers and charges separate rates for members and non members. Their prices range from $0.39 to $0.69 per kWh for members and $0.49 to $0.79 per kWh for non members, depending on location.[11] The ChargePoint network has free chargers and paid chargers that drivers activate with a free membership card.[12] The paid charging stations' prices are based on local rates (similarly to Blink). Other networks use similar payment methods as typical gas stations, in which one pays with cash or a credit card per kWh of electricity.

SIMULATION RESULTS

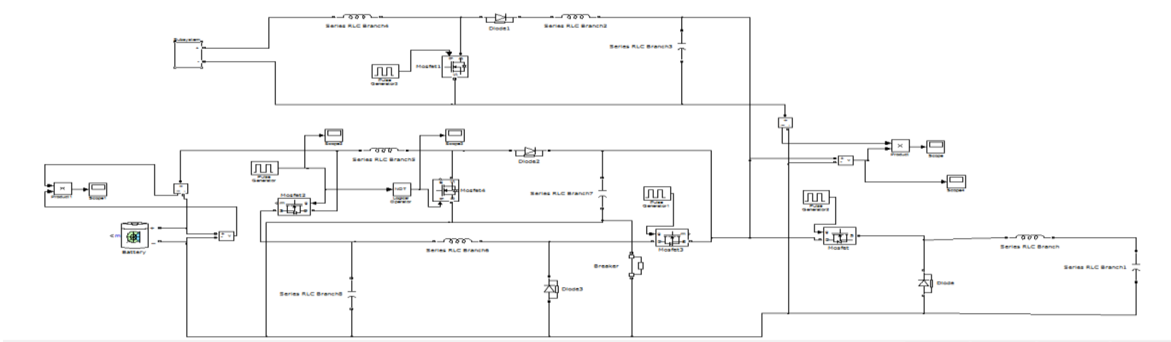

Fig 2 proposed circuit configuration

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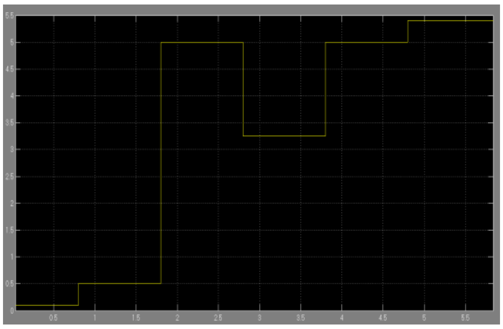

Fig 3 solar current

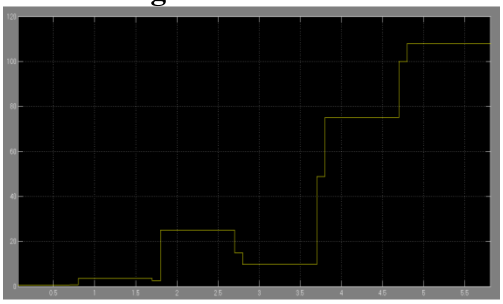

Fig 4 solar power

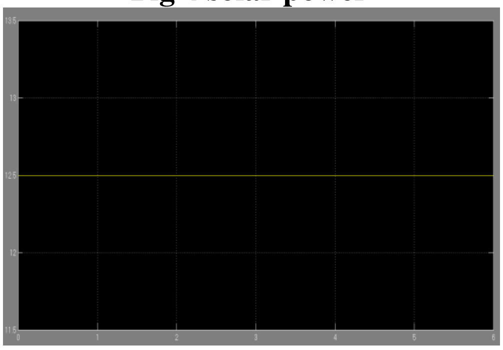

Fig 5 dc bus voltage

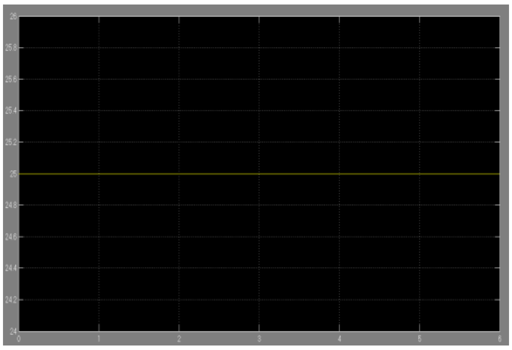

Fig 6 dc bus power

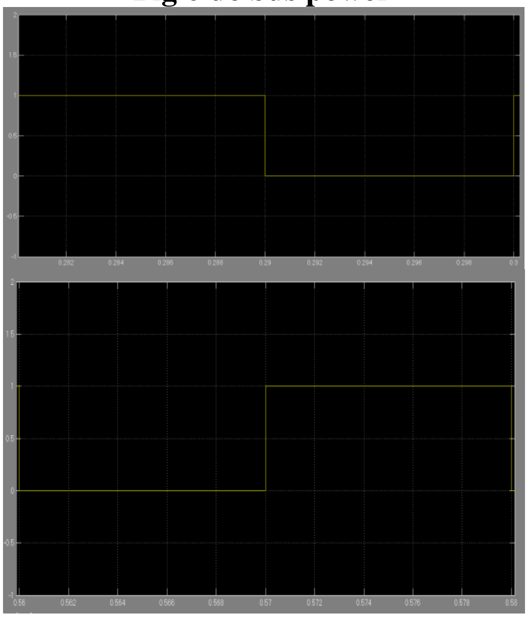

Fig 7 IGBT gate signal

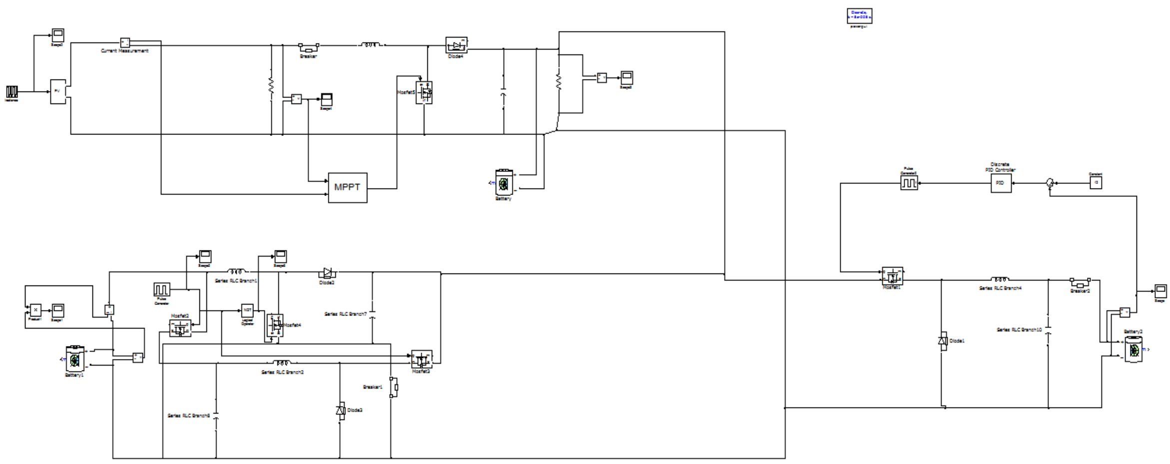

Fig 8 Proposed system configuration

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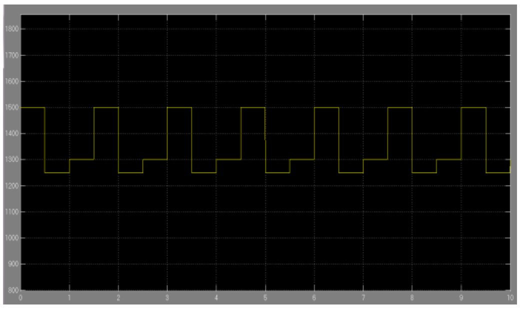

Fig 9 Irradiation on solar panel

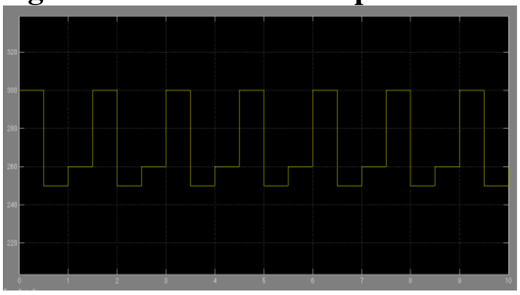

Fig 10 Solar output voltage

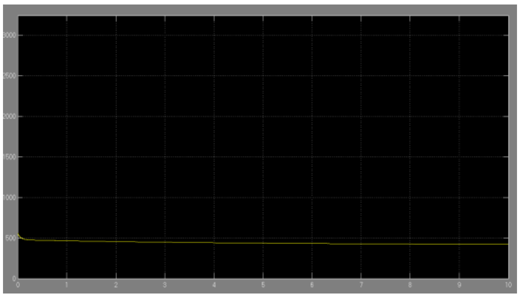

Fig 11 Dc link output voltage

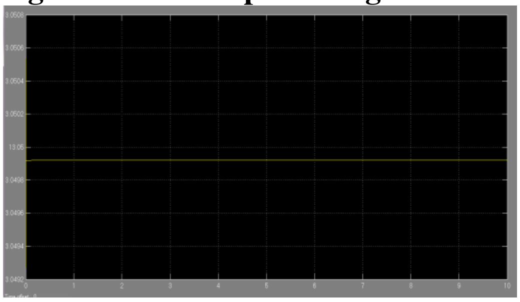

Fig 12 Battery voltage

CONCLUSION

The solar EV charging station controller is implemented in MATLAB and control desk and its effectiveness is tested under different solar power generation and battery power requirement. It is found that the power supplied by the solar panel depends on the load across it at a specific irradiance and temperature. Constant current charging is employed so that the vehicle batteries can be charged. Grid connection may be added to the system to account for the cases where both the solar energy and station battery SOC are insufficient.

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