WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Electric Vehicle DC Ultra-Fast Charging Station using Solid-State Transformer

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ABSTRACT

-In this contemporary world, emission of dangerous gases like carbon dioxide, carbon monoxide etc., into the air increases day by day causes major environmental problems. This is extremely due to the rapid usage of conventional vehicles. So it is necessary to take steps towards the non-conventional vehicles i.e. electric vehicles. The electric vehicles have higher efficiency and less maintenance compared to fossil fuel vehicles. But in electric vehicles, the major challenge is charging of battery, time of charging, etc., In order to decrease the charging time, we can use low frequency transformer, Solid-State Transformer and Hybrid transformer. Among them, Solid-State Transformer offers more advantages. So this paper majorly focused on Solid-State Transformer and this survey reviews how to decrease the charging time of battery i.e. ultra-fast charging of battery based on Solid-State Transformer (SST) and power electronic converter

Key Words Electric Vehicle, Solid-State Transformer, DC ultra-fast charging, Power electronic converters

INTRODUCTION

The battery fast charging cannot be achieved completely by using On Board Charger (OCB), in which the battery is charged using the single-phase or three-phase domestic supply. The charging time of fossil fuel electric vehicle is very less. So it is important to consider the parameter charging time of battery when going towards electric vehicle. To decrease the charging time of EV battery, more amount of DC power is required. In order to that, it is required to connect the charging station with medium voltage AC source. In this connection low frequency transformer, Solid-State Transformer and A Hybrid transformer can be used. Among them Solid-State Transformer have more advantages. Comparatively, Solid-State Transformer (SST) based DC ultra-fast charging offers the integration of renewable energy sources, energy storage. Low Frequency Transformer offers high reliability but it does not allow the integration of renewable energy sources. Also In this connection, switching converters, which converts MV-AC into DC in the range between 220V and 500V.

To decrease the voltage level, SST, LFT and HT can be used. But Low Frequency Transformer have some limitations like low efficiency, bulky size and high maintenance cost. Hybrid Transformer limitations like bulky size but it is more efficient and controllable than LFT. So comparatively, SST have small size, unlimited controllable, fault protection and medium reliability.

LITERATURE SURVEY

The EV market is affected by consumer perception of cost/return of investment, the public incentives, technological advances, government policies, city planning, and power utilities impact on the diffusion of EV charging infrastructure.[1]

The long charging time and the limited range per charge are challenging the growth of the electric vehicles market. Fast charging helps reducing the charging time. Hence, it is a major necessity for the transportation electrification adoption.[2]

The emergence of DC fast chargers for electric vehicle batteries (EVBs) has prompted the design of ad-hoc micro-grids (MGs), in which the use of a solid-state transformer (SST) instead of a low-frequency service transformer can increase the efficiency and reduce the volume and weight of the MG electrical architecture.[3]

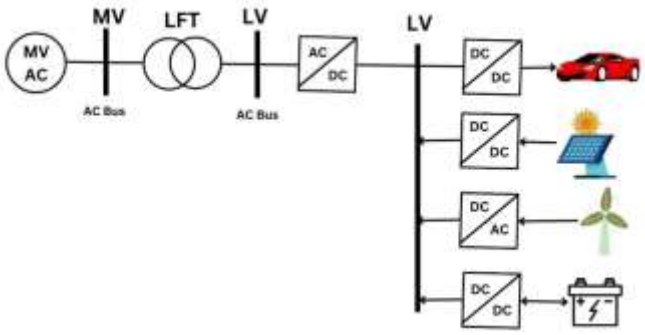
Battery technology is the keystone of advancement in EV adoption, as the battery cost alone can account for up to one-third of the overall EV cost and EV's weight is substantially increased with battery pack deployment.[4]

Ultra-fast DC-connected chargers are the key to electrification and the wide adoption of electric vehicles. A fast-charging experience will relieve the consumer driving range anxiety and accelerate the transition to sustainable energy use.[5]

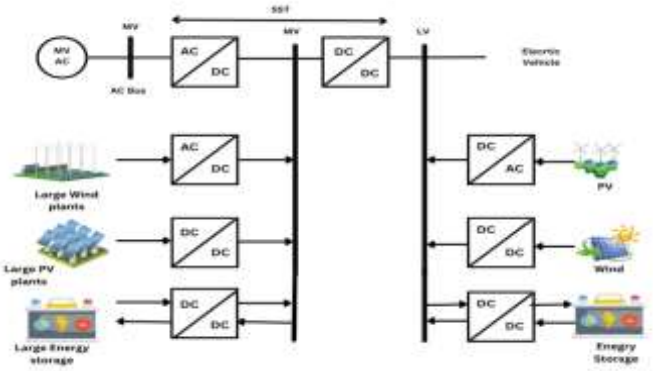
The provision of charging facilities from the low-voltage network will not only increase the distribution system's complexity and dynamics but will also challenge its operational capabilities, and large-scale upgrades will be required to meet the inevitably increasing charging demands.[6]

Bidirectional resonant converters become a preferable topology in terms of DC-DC applications. Resonant converters provide several advantages such as soft switching capability for all switches, high frequency operations, and high efficiency with low EMI and few components.[7]

METHODOGY:



DC LFT-based ultra-fast charging station



DC SST-based ultra-fast charging station

As said before, the solid-state transformer (SST) is offered as a tool to meet the requirements of the smart grid. Solid-state transformers are comprised of three primary parts: converter to produce high-frequency AC from input line frequency AC, isolation by a high-frequency transformer (HFT), and at last, converter to produce AC with line frequency from AC high frequency. Additionally, the isolation barrier partitions the transformer into two sections: high voltage and low voltage. In addition to being able to perform the same functions as a conventional transformer, SST provides a range of services to the grid, including reactive power compensation, power quality improvement, current limiting and voltage regulation power factor correction, etc., which can lead to improvements and establishing a connection between direct current (DC) and alternating current (AC) equipment.

Table 1:

Table 1 shows that the advantages of SST- based Ultra-fast charging station over LFT- based Ultra-fast charging station. Comparatively, it is better to use SST-based charging stations than LFT-based charging station.

Ultra-Fast charging Station	**Size**	**Controllability**	**Integration of Large Power Plants**
LFT-based	Big	Limited	No
SST-based	Small	Unlimited	Yes

CONCLUSION:

There are a lot of unanswered questions regarding the electrical design of an ultra-fast charging station. To improve control and save size and weight, an SST might be used in place of the low-frequency service transformer in that scenario. The use of solid-state transformers in DC ultra-fast charging systems offers several advantages. It dramatically reduces charging times, making EVs more convenient and practical for everyday use.

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