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A Review Of Electrical Safety Consideration in Large- Scale Electrical Vehicles Charging Stations

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ABSTRACT: Several safety consideration to concerning the charging of electric vehicles (EVs) are developed to maintaining the electric safety and avoid the hunger accidence, so that safety reflection for electric vehicle supply equipment (EVSE) and the EV battery there are two main factors. In this situation , quantitative assessment of electrical safety considering the operation conditions of large-scale electric vehicle charging stations (EVCSs) has still remained a challenge. Driven by the hierarchy of hazard control mechanisms, this paper proposes a holistic approach to evaluate the electrical safety of the large scale EVCSs when coupled to renewable power generation. Our approach mainly focuses on several topics on the operational safety of EVCS primarily concerning: (1) the facility degradation which could potentially result in a compromised EVSE reliability performance and EVCS protection failure; (2) the cyber-attack challenges when the smart charging and the communication between EVCSs and electric utilities are enabled; (3) the potential mismatch between the renewable output and EVCS demand, which could trigger the system stability challenges during normal operation and inability to supply the critical EV loads during outages.

I. INTRODUTION

Transportation sector consumes a large portion of fossil fuel with massive air pollution and greenhouse gas emissions, which has raised significant environmental concerns. Organizations and governments have set ambitious targets for the integration of electric vehicles (EVs) into the modern power grids to build, plan, and operate a clean and sustainable energy landscape . With the decreasing cost of EVs, the number of EVs has increased dramatically, many EV charging facilities have been constructed, and many large EV charging stations (EVCSs) are being designed and planned to manage the charging needs of hundreds of EVs that are seamlessly integrated in the modern power grids of the future. Many standards and regulation policies related to safely operating an EV have been published, where the primary focuses are on the battery pack, the plugs and connectors, and the electric vehicle supply equipment (EVSE)

Communication Sector: EVCSs can also play an important role in power systems when the communication-assisted smart charging algorithms are deployed. Communications between the EVCS and the utility allow the EVCSs to effectively respond to the utility signals during the system transient operating states, acting as distributed energy resources (DERs) and achieved through effective control of EVs' charging and discharging schedules. The communication between the EVSE and the smart meters connected to EVs also enables the EVCS to manage the charging schedule of PEVs so that the EVs can mainly charge the batteries during the off-peak hours with low electricity prices. It will also increase the grid flexibility by dispatching the EV loads. The contribution of EVCSs to maintain the grid stability and enhance its flexibility will be significant with the increasing penetration of EVs in the coming future.

II. THE ARCHITECTURE OF AN EVCS

With the emerging advancements in the EV charging technologies, there are three main methods widely used to charge an EV;(i) conductive charging, where the battery is connected by a cable and plugged directly into an EVSE; (ii) inductive charging, also called wireless charging, where the electricity is transferred through an air gap from one magnetic coil in the charger to a second magnetic coil fitted into the car; and (iii) battery exchange, by swapping the EV battery with fresh ones in a battery swapping station (BSS). The conductive charging is currently preferred by the EV operators due to its lower cost, higher efficiency, and simpler business model.

EV Charging Standards and Requirements: The charging level describes the power level of a charging outlet using conductive charging mechanisms. Based on the SAE J1772 , there are two AC and two DC charging levels as follows:

- AC Level 1, also known as home charging, supports the voltage level of 120 V with max current level of 16 A.
- AC Level 2, supports 208–240 V and the maximum current is 80 A. As the maximum power here is 19.2 kW, it may be utilized at home, workplace and public charging facilities.
- DC level 1, with the DC output voltage of 50–1000 with the maximum current of 80 A
- DC level 2, with the same DC output voltage as DC level 1, but a maximum current that can reach 400 A.

While both AC levels require the EV with an on-board charger to receive the single-phase AC power from the EVSE, the DC levels charge the EV battery directly with DC power using off board charging, where the DC power can be converted from both single and three phase AC power supply of the utility.

The Proposed EVCS : Architecture We aim at large-scale EVCSs, corresponding to the long term-parking locations, such as parking garages and parking lots. These EVCSs typically offer 5 kW to 25 kW charging capacity through EVSEs (some of them may also offer charging power of 26–60 kW). Only a few EVSEs with the charging capacity of more than 60 kW will be installed by the EVCS operators as the EVSEs with very high charging capacity come at higher installation costs [29], higher degradation of the battery life cycle, and higher charging cost as they may get charged during peak hours with premium electricity price. An EVCS with several EVSEs are typically consisted of three parts: (i) the physical system that provides the EV charging services, (ii) the communication system, and (iii) the control center. In compliance with the recent recommended practices and standards, an architecture for a large EVCS is proposed to manage charging of tens to hundreds of EVs that also act as DERs in the grid. The cyber system transmits the signals between the physical system and the control center. Direct load control can be achieved by enabling and disabling the EV charging, or through proportional adjustments in the duty cycle of the DC/DC converter. The control center can coordinate the load control of EVs to enable smart charging, and the EVCS can participate into the utility demand side management programs as a DER. The control center will also communicate other signals with the utility.

III. EVS CHARGING STATIONS

European Standards and trend : European electricity companies, particularly distribution system operators (DSOs), are investing in the necessary infrastructure to stand-in a single European market for EV. European standards are indispensable to safeguard that drivers enjoy convenient EU-wide charging solutions that avoids a multiplicity of cables and adaptors and so retrofit costs. In June 2000, the European Commission issued a standardization mandate to the European standardization bodies CEN, CENELEC and ETSI (M/468) concerning the charging of EVs. The mandate stressed the need for interoperable plugs and charger systems to promote the internal market for EV and to discourage the imposition of market barriers. The Focus Group set up to respond to M/468 delivered a comprehensive and valuable report. However, given that the mandate objective was to achieve interoperability, not the adoption of a single connector, no recommendation has been made with regards to the choice of the AC mains connector.
. The actual standards provide a first classification of the type of charger in function of its rated power and so of the time of recharge, defining three categories here listed:

- Normal power or slow charging, with a rated power inferior to 3,7 kW, used for domestic application or for long-time EV parking;
- Medium power or quick charging, with a rated power from 3,7 to a 22 kW, used for private and public EV
- High power or fast charging with a rated power superior to 22 kW, used for public EV.

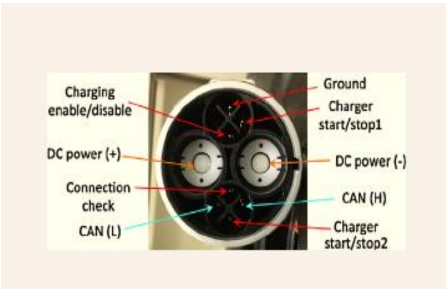

Fig. 1 CHAdeMO type connector

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American Standards and trend : For many years, the Society of Automotive Engineering (SAE) has been working on standard J1772 . Today SAE J1772 in its last version defines EV charging system architecture: it covers the general physical, electrical and performance requirements for the EV charging systems used in North America. In function of the rated power, voltage and current the charging systems for EV in North America are classified into three categories, which are AC Level 1, AC Level 2 and DC Level 3. In particular: - for Level I, the charger is on-board and provides an AC voltage at 120 or 240 V with a maximum current of 15 A and a maximum power of 3,3 kW; - for Level II, the charger is on-board and provides an AC voltage at 240 V with a maximum current of 60 A and a maximum power of 14,4 kW; - for Level III, the charger is off-board, so the charging station provides DC voltage directly to the battery via a DC connector, with a maximum power of 240 kW.

Fig. 2 SAE JI772

EVSE Standards for India : In 2019, on the request of ISGF, Bureau of Indian Standards (BIS) setup ETD 51 Committee for preparing the Indian Standards for EVSE. The EVs need to be connected to the electric grid for charging the battery and hence must comply with electricity grid code like other electrical equipment. Characteristics of the Indian power system is similar to that of Europe – 230V and 50Hz (unlike America: 110V and 60Hz) and we follow IEC standards. There is industry-wide consensus among electric vehicle companies and startups that one of the biggest problems in adoption of green mobility standards is the charging infrastructure. Simply put, India is not ready to support daily charging of millions of EVs and even where there is adequate charging infrastructure, the difference of opinion in selecting the right charging infrastructure standard for electric vehicles is one of the factors hindering widespread EV adoption.

Wireless Standards

The Society of Automotive Engineers and the International Electro technical Commission are currently in the very early stages of standards development for wireless technology and there is limited commercial availability. The standards reference for SAE is SAE J2954; the IEC reference is IEC 61851-1. The successful development and deployment of wireless technology presents the promise of having the convenience of pulling into your garage or a parking spot and having your car recharge without the need to connect and disconnect a cable. Some researchers are also exploring the possibility of embedding wireless charging in the roadway as a method of continuously recharging the vehicle while in transit; a system that would allow this would dramatically reduce battery size and extend the travel range of PEVs.

PEV Onboard Charger

PEVs are equipped with onboard chargers that regulate the amount of power used during battery recharging at Levels 1 and 2. Standard equipment chargers are typically rated at 3.3 kW; faster 6.6 kW chargers are usually available from the PEV manufacturer, primarily as part of a package of optional equipment. While all of these factors influence how long it will take to recharge the PEVs batteries, the driving habits of the PEV owner usually determine how frequently and for how long batteries need to be recharged.

IV. CONCLUSIONS

As we all know that development in the EVCS technology is at the top. So as an engineer we should at least be aware of the existing standards and development in this field. This seminar shows some common and important standards used internationally and some guidelines provided by the govt of india , it is possible to conclude that a good ESS for the coupling fast EV charging stations can be considered a system including batteries and ultra-capacitors: the first are suitable for their high energy densities and the second for their high power density. About the integration of ESSs, another important issue investigated is the way of integration in terms of electrical scheme. Two possibilities have been found in literature, based on an AC-bus configuration and DC-bus configuration. The AC-bus scheme is generally preferred, because the AC components have well defined standards, and AC technologies and products are already available in the market. However, DC-bus based system provides a more convenient way to integrate renewable energy sources and also higher energy efficiency thanks the inferior number of conversion stages.

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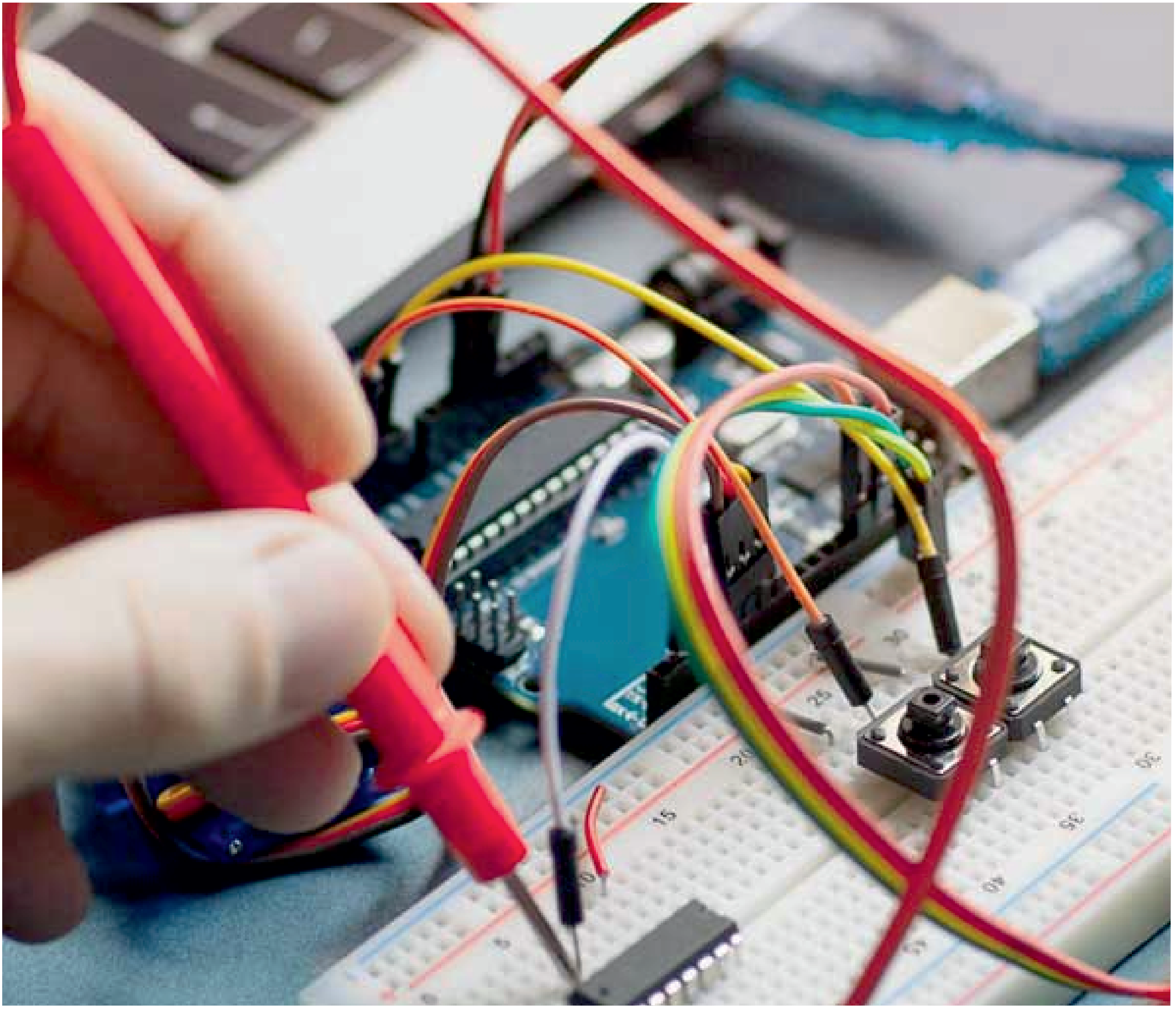

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