Dynamic Charging of Electric Vehicles by Wireless Power Transfer

ADVANCEMENTS in the charging infrastructure of battery-energized electric vehicles (EVs) are recognized as one of the major deciding factors to make EVs competitive with thermal vehicles. In this context, the most recent advancement is constituted by the dynamic (or roadway) wireless charging (DWC). It keeps the same features of static wireless charging (SWC), i.e., of being safer, more reliable, and more user-friendly compared to its wired counterpart. In addition, it frees EVs from battery shortcomings such as cost, size, weight, and long charging duration because charging power is directly drawn from the road while EVs are cruising. Wireless power transfer (WPT) systems for DWC are quite different from those for SWC in the infrastructure layout, coil design, power track supply, and operation principle. Indeed, by SWC, an EV is properly positioned over the charging post so that power is transferred in nearly optimal coupling and efficiency conditions, and with no demanding constraints for the control and management of the SWC systems. By DWC, more EVs cruising down the road interact with the power track for a short time and in a variable and, possibly, misaligned manner, and this leads to a neither constant nor optimal power transfer, which results in more challenging requirements for the design and government of the DWC systems.

Power transfer capacity, efficiency, lateral tolerance, electromagnetic field containment, dimensions, and cost of the DWC systems have been improved by virtues of innovative semiconductor switches, higher operating frequency, better coil designs, optimized compensation networks, and suitable track construction. However, there are a variety of problems to be solved to arrive at a widespread commercialization of the DWC systems. Narrow width track and interoperability between WPT systems for DWC and SWC are examples of these problems.

This "Special Section on Dynamic Charging of Electric Vehicles by Wireless Power Transfer" of the IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS is intended to take stock of the recent advances in the field of DWC for EVs. It contains ten papers, addressing various aspects of DWC. Reference [1] is an overview paper on DWC, focusing on recent advances in that field. In a few countries, including Korea, Japan, Germany, and Spain, specific solutions for DWC are proposed and being commercialized. The paper extensively covers key achievements in those countries. The other papers [2]–[10] deal with specific technical issues on DWC. In detail, [2] presents a novel DWC system that combines the advantages of pads-array and segmental long coils coupler, where several paralleled LCC reactive power compensation networks in the primary side are excited by a sole inverter and the power distribution is realized automatically. Reference [3] introduces an LCC compensation network to DWC, and elaborates parametric design for both the LCC network used in the secondary side and the LCC network used in the primary side. Neighboring effects resulting from the combination of the LCC compensation network and the inevitable intercoupling between adjacent segments are investigated. Reference [4] presents an equivalent model to analyze switch-ON process of DWC. The equivalent model can describe transient sources and system transfer functions. Reference [5] proposes a continuous DWC system that reduces power pulsations during the charging process. Multiple rectangular unipolar coils are used at the primary side as the transmitters, and another unipolar coil works as a receiver at the secondary side. Reference [6] proposes a reformed compensation network based on traditional LCL topology to realize robust reaction to large coupling variation that is common in DWC. Reference [7] is concerned with DWC systems exploiting the capacitive coupling and demonstrates their merits under electric field resonance, such as the high power factor for the source and low sizing power for the capacitors. Experiments on a scaled-down DWC prototype for railway vehicles are given to prove the concept. Reference [8] presents a three-phase to one-phase matrix converter with soft-switching operation for the DWC system supply. The converter, built up around seven switches with reverse blocking capability, is able to regulate either the current or the voltage or the power injected into the primary by making use of eight operating modes. Reference [9] reviews at first the demand side management techniques assuring the power balance between the grid supply and the SWC requests with the aim of assessing their applicability to DWC systems. Then, it picks up one of them, the additive increase multiplicative decrease method, and checks its capabilities in complying with the short interaction and prompt service constraints posed by DWC. Reference [10] refers to a lumped track and provides a procedure to design longitudinal dimension and distance of the track coils for the pickup to receive a predetermined amount of energy. Diagrams are worked out that put in relation the design objectives to the current in the track coils and the maximum mutual inductance between the track and pickup coils.

The Guest Editors maintain that the papers included in this Special Section represent a concrete effort in proposing viable solutions to some of the problems posed by DWC of EVs and hope for a stimulating action that they can have on research activities toward the development of affordable DWC systems.

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