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Wireless electric vehicle charging stations based on the resonant inductive power transformers

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Abbreviations

AAMI	American Association of Medical Instrumentation
AC	Alternative Current
AFE	Active Front End
ANPR	Automatic Number Plate Recognition
BEV	Battery Electric Vehicle, also known as all electric vehicle
BP	Bipolar
CAN	Controller Area Network
CAPEX	Capital Expenditure
DC	Directive Current
DD	Double D
DDQ	Double D Quadrature
DSO	Distribution System Operators
DSRC	Dedicated Short Range Communications
EC	European Commission
ECU	Electronic Control Unit
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCC	Federal Communications Commission
FEM	Finite Element Method
FMA	Fundamental Magnetic Analysis
GHG	Greenhouse Gases
GPS	Global Positioning System
GV	Gasoline Vehicles
HEV	Hybrid Electric Vehicle
HF	High Frequency
HMI	Human Machine Interface
IEC	International Electro Technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated Gate Bipolar Transistor
IPT	Inductive Power Transformer
LPG	Liquefied Petroleum Gas
MPE	Maximum Permission Exposure
NPPs	Non-Polarized Pads
OBC	On-Board Charger
OECD	Organization for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
OPEX	Operating Expense
PEV	Plug-in Electric Vehicle
PFC	Power Factor Correction
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate matter term to describe solid particles and liquid droplets found in the air
PP	Parallel-Parallel
PPs	Polarized Pads
PS	Parallel-Series

PSSF	Power Source Sizing Factor
PUMLC	p.u. Magnitude of the Load Current
PV	Photo Voltaic
QDQ	Quad D Quadrature
RCSF	Receiver Coil Sizing Factor
SAE	Society of Automotive Engineers
SAR	Specific Absorption Ratio
SP	Series-Parallel
SS	Series-Series
SUV	Sport Utility Vehicle
UL	Underwriters Laboratories
V2I	Vehicle to Infrastructure.
WCS	Wireless Charging System
WEVCS	Wireless Electric Vehicle Charging System
WPTS	Wireless Power Transfer System
ZCS	Zero Current Switching
ZVS	Zero Voltage Switching

Abstract

Development in E-mobility is rapidly increasing. Electric vehicles and their charging stations are such important applications in today's world. The E-mobility industry is changing day-to-day with new ways to reduce charging time of electric vehicles, ease of use in charging process, increasing the efficiency and sometimes remote control access of the charging system.

To accomplish this, resonant inductive power transfers is one of the method that can be hired to transfer power to electric vehicles (EVs) over an air-gap and can remarkably improve the range, safety and convenience of the EV battery charging. This technology has been studied in many universities and even used at least for local scale to install in household application within the power range of 3.7 to 7.3 kW. However, implementation of a large scale wireless charging infrastructure of electric vehicles (e.g. for taxi fleet in a city) is still one of the major difficulties of such technology. Issues related to determining the physical sizes of the coil pads, standardization, technical interoperability, safety and designing the appropriate wireless charging system to be used for different EVs are among those difficulties.

This dissertation discusses inductive wireless charging technology, different type of WPTs, compensation method and different types of coil structure. The important target of doing this study is to understand the feasibility of installation of wireless charging stations for electric vehicle in terms of technical and financial issues, and understanding that which size of chargers are needed to install for electric vehicles. Electrical synchronization and interoperability of primary and secondary coils which are known as transmitter and receiver, are other issues investigated in this article. In the following chapters, financial and economic analysis of implementation of the wireless charging infrastructure for the taxi and van fleet in an urban area are discussed.

It can be concluded that implementation of wireless charging infrastructure for electric vehicles in urban areas for taxi fleet and delivery van drivers could bring many advantages because of specific working routine and stop time that they have during each working day. Increment of anxiety range, and reduction of charging time (which also results directly in reduction of battery size and final price of electric vehicle), convenience and ease of use, being needless of tedious conventional charging cables, saving money are among major advantages that EV driver will take benefit of them by using wireless charging infrastructure.