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Wireless Charging of Electrical Vehicle on Road

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Abstract: *Electric vehicles are seen as an alternative option in response to the depletion of resources. In order to increase the use of EVs in daily life, practical and reliable methods to charge batteries of EVs are quite important, accordingly wireless power transfer (WPT) is considered as a solution to charge batteries. In this project, a prototype system of wireless charger which has 60 kHz operation frequency is designed and implemented. Plug-in Electric Vehicles (PEV) are burdened by the need for cable and plug charger, galvanic isolation of the on-board electronics, bulk and cost of this charger and the large energy storage system (ESS) packs needed. But by using Wireless Charging system's Wireless charging opportunity. It Provides convenience to the customer, inherent electrical isolation, regulation done on grid side and reduces on-board ESS size using dynamic on-road charging. The main objective of our project is to design and develop an antenna system suitable for vehicle using resonant magnetic coupled wireless power transfer technology to electric vehicle charging systems. Application of WPT in EVs provides a clean, convenient and safe operation. At the core of the WPT systems are primary and secondary coils. These coils construct a loosely coupled system where the coupling coefficient is between 0.1-0.5. In order to transfer the rated power, both sides have to be tuned by resonant capacitors. The operating frequency is a key selection criterion for all applications and it especially affects the dimensions of the coils and the selection of the components for the power electronic circuit. A Resonant wireless transfer system for vehicle charging technology is designed.*

Keywords: Electrical Vehicle, Wireless Power transfer, Inductive Power Transfer, Battery

I. Introduction

The wireless solution is increasingly spreading as a method of battery charging for Electric Vehicles (EVs). The standard technology of wireless EV battery charging is based on the Inductive Power Transfer (IPT) between two coupled coils, one connected to the electrical grid and the other one connected to the rechargeable battery. The IPT provides benefits in terms of safety and comfort, due to the absence of a plug-in operation: through IPT, the electrocution risk typically arising from power cords is avoided and the battery charging operation can automatically start. According to the state of the EV, there are mainly two types of IPT for the wireless charging: static IPT, when the vehicle is stationary and nobody is inside it (e.g. in a parking area); dynamic or quasi-dynamic IPT, when the vehicle is being used (e.g. while in motion or during the traffic red light). The wireless power transfer obviously represents the only solution for the dynamic charging, since the wired connection would be impossible during the motion. In spite of the undeniable advantages brought by Inductive Power Transfer, the researchers have to deal with several issues in order to make this technology even more attractive for the EV market. First of all, an IPT system is inherently less efficient in terms of power transfer efficiency if compared to a conventional wire-based system. Indeed, due to the magnetic coupling between the coils, there is an unavoidable minimum leakage magnetic field, leading to an energy loss. Furthermore, some technical aspects need to be taken into account in the practical implementation of an IPT system: for example, in order to obtain the maximum coupling, the misalignment between the coils must be as small as possible. As far as safety is concerned, even if the IPT allows to reduce the electrocution risk, some care is required regarding the magnetic field exposure. In addition to design-related issues, other important considerations should be made, such as costs, infrastructural implications, standardization and customer reception.

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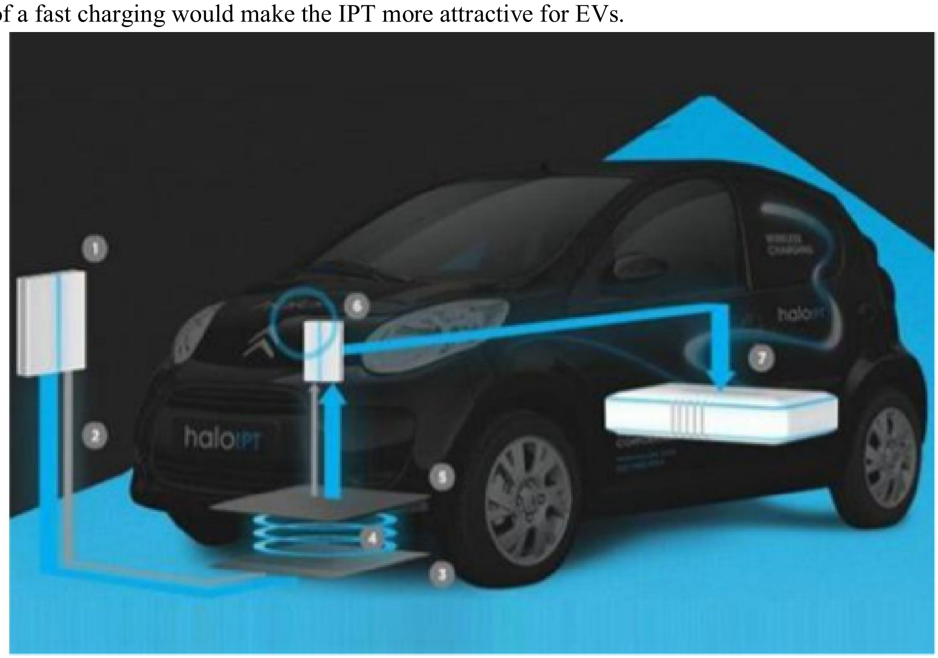
II. Proposed System

In an effort to address battery problems, the concept of roadway-powered electric vehicles has been proposed. With this system, the electric vehicle is charged on the road by wireless power charging, and the battery can hence be downsized and no waiting time for charging is needed. The main objective of our project is to design and develop antenna and wireless power transfer systems suitable for moving electric vehicles (EVs). Using resonant magnetic coupling principle, the wireless power transfer technology to the electric vehicle is designed. When the vehicle's power receiver's frequency is tuned in exact with the resonance frequency of the transmitter unit below the road, the electrical power will flow from the transmitter coil inside the platform to the receiving coil inside the bottom of the electric vehicle. This project describes the design and implementation of a wireless power transfer system for moving electric vehicles involving the model EV system.

III. IPT For Electric Car

Implemented through Inductive Power Transfer, the wireless charging for car drivers is convenient as far as safety and comfort are concerned: the user should not be worried about handling power cords, thus avoiding the electrocution risk, and could park the car in proper spaces, so that the charging operation can automatically start. The coils are generally placed in the following way: the one connected to the grid is placed on the ground and the other one, connected to the battery, is placed in the bottom of the vehicle chassis. The minimum power level for electric car charging is generally 3 kW. Different examples of commercial wireless charging stations for electric cars can be provided, since the EV companies are increasingly interested to this innovative charging technology. Among the car manufacturers, Toyota, Nissan, General Motors and Ford are some of the companies showing interest in the inductive charging method . Among the companies producing wireless charging systems for EVs, Evatran and HaloIPT are leaders in providing and improving the inductive charging technology. Evatran has created the inductive charging system Plug less Power., one of which images of the inductive charger , has been acquired by Qualcomm. The opportunity of a fast charging would make the IPT more attractive for EVs.



Furthermore, the scientific research is ever more focused on the investigation of different aspects related to the IPT for wireless electric car charging, and in other scientific work that will be cited in the following of the thesis. In the realistic scenario of an ever-growing use of EVs, one the most interesting challenges is represented by the possibility of an "on-the-road" charging, meaning that the battery can be recharged while the car is used.

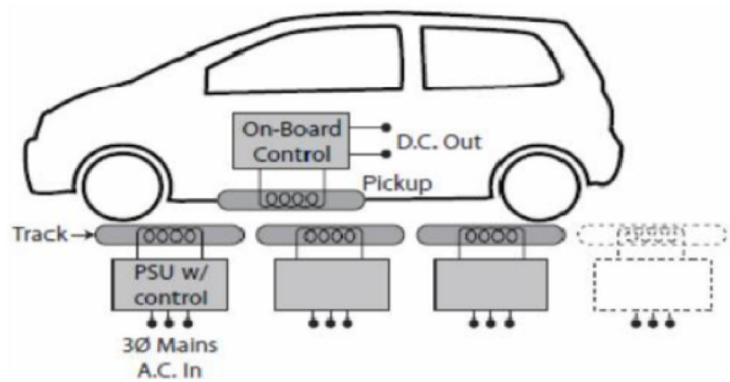
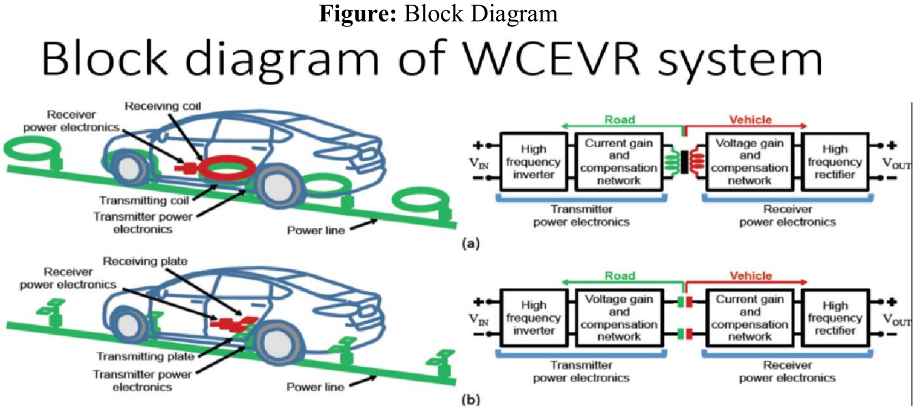


Figure: Block Diagram



3.1 Components

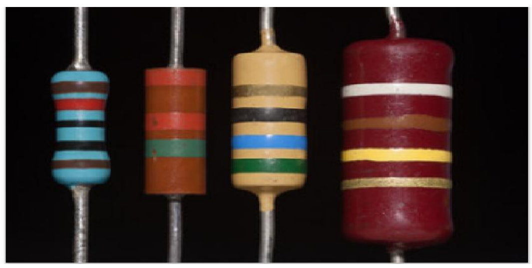
A) Electric Motor

Specifications

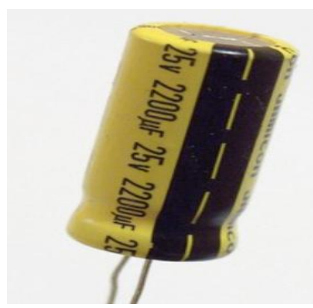
- Standard 130 Type DC motor
- Operating Voltage: 4.5V to 9V
- Recommended/Rated Voltage: 6V
- Current at No load: 70mA (max)
- No-load Speed: 9000 rpm
- Loaded current: 250mA (approx)
- Rated Load: 10g*cm
- Motor Size: 27.5mm x 20mm x 15mm
- Weight: 17 grams

B) Toy Car

C) Resistor



D) Capacitor



E) Copper Winding Pad

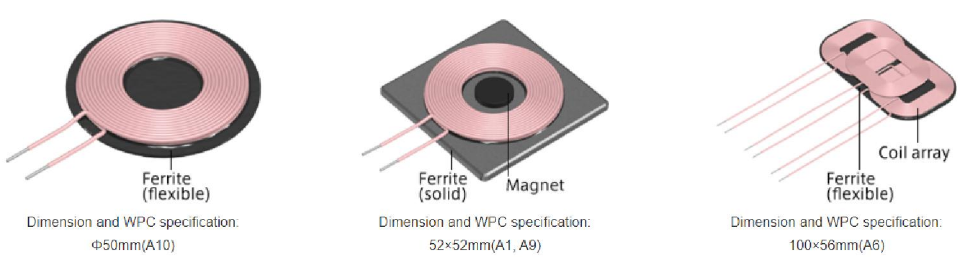


Figure4 TDK's WPC-compliant Tx coil units for wireless power transfer (example)

F) LED=5mm

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3.2 Electrical Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
REFERENCE SECTION						
Reference Output Voltage	VREF	-	4.6	5.0	5.4	V
Line Regulation	ΔVREF	VCC = 8V to 40V	-	10	30	mV
Load Regulation	ΔVREF	IREF = 0 mA to 20 mA	-	20	50	mV
Ripple Rejection	RR	f = 120Hz, TA = 25°C	-	66	-	dB
Short-Circuit Output Current	ISC	VREF = 0, TA = 25°C	-	100	-	mA
Temperature Stability	STT	-	-	0.3	1	%
Long Term Stability	ST	TA = 25°C	-	20	-	mV/KHr
OSCILLATOR SECTION						
Maximum Frequency	f(MAX)	CT = 0.001uF, RT = 2KΩ	-	350	-	KHz
Initial Accuracy	ACCUR	RT and CT constant	-	5	-	%
Frequency Change with Voltage	Δf/ΔVCC	VCC = 8V to 40V, TA = 25°C	-	-	1	%
Frequency Change with Temperature	Δf/ΔT	Over operating temperature range	-	-	2	%
Clock Amplitude (Pin 3)	V(CLK)	TA = 25°C	-	3.5	-	V
Clock Width (Pin 3)	tW(CLK)	CT = 0.01uF, TA = 25°C	-	0.5	-	μs
ERROR AMPLIFIER SECTION						
Input Offset Voltage	VIO	VCM = 2.5V	-	2	10	mV
Input Bias Current	IBIAS	VCM = 2.5V	-	2	10	μA
Open Loop Voltage Gain	GVO	-	60	80	-	dB
Common-Mode Input Voltage	VCM	TA = 25°C	1.8	-	3.4	V
Common-Mode Rejection Ratio	CMRR	TA = 25°C	-	70	-	dB
Small Signal Bandwidth	BWSS	GV = 0dB, TA= 25°C	-	3	-	MHz
Output Voltage Swing	VO(ERR)	TA = 25°C	0.5	-	3.8	V

Table: Electrical Characteristics Of KA3525 IC

3.3 Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	VCC	40	V
Reference Output Current	IREF	50	mA
Output Current (Each Output)	IO	100	mA
Oscillator Charging Current (pin 6 or 7)	ICHG(OSC)	5	mA
Lead Temperature (Soldering, 10 sec)	TLEAD	300	°C
Power Dissipation (TA = 25°C)	PD	1000	mW
Operating Temperature	TPOR	0 ~ +70	°C
Storage Temperature	TSTG	-65 ~ + 150	°C

Table: Absolute Maximum Ratings Of KA3525 IC

IV. RESULT

Working model of wireless car. Carsrun at a proper speed on a given track. It is smart, safe and sustainable. With high intelligence technology

V. CONCLUSION

This paper has dealt with Wireless Charging Systems for Electric Vehicle Batteries. An Inductive Power Transfer (IPT) system for an E-bike battery charging has been designed and assembled. The target is to build a prototype of toy car charging. After the magnetic design of the IPT coils, the electric model of the coupling structure has been gained and acquired from an electronic simulation tool, in order to complete the design of the whole system. From the experimental results, a 79 % coupling efficiency for an about 100 W level arises. A magnetic characterization of the region surrounding the assembled prototype has been made as well. According to the magnetic field exposure guidelines, by ICNIRP, a minimum 25 cm distance from the center of the system is suggested as a safety distance. After the experimental measurements on the power efficiency, alternative solutions of power electronics and coupling structures have to be investigated. For this system, an investigation has been carried out on different magnetic coupling structures, all compliant with an E-bike wheel, and the best option in terms of system efficiency and tolerance to lateral misalignment has been defined. The investigation has been made according to the results of 3D magnetic simulations and their elaboration.

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