Wireless Power Charging -A new trend for Electric Vehicle Charging

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***Abstract*— — In today's world, the significance and usage of electrical energy have been increased and almost every household has equipment that mostly operates on the electrical network. Conventional internal combustion engines were also being shifted to the electrical vehicle due to their various advantages over the IC engines. Paper presents, an analysis of the wireless power control for an electrical vehicle that has been carried out using LC resonance, and its various parameters have been recorded. The object of the project is to study various aspects of a high-efficiency wireless power transfer system for charging an electric vehicle.**

***Keywords*— Wireless Power transfer, resonance power transfer, Mono resonant power transfer, Dynamic power transfer system, Cordless Charging.**

I. Introduction

Electrical vehicles are gaining more popularity and it's being recognized as an alternative for conventional IC engines due to its various advantages. Electrical vehicles use an electrical form of energy to drive the car. As we know that electrical energy is the most efficient form of energy available to date in the world hence it's very obvious to get dependent on the form of energy source. Electrical vehicles are getting increased on the road and in India government is also emphasizing the usage of electrical vehicles for public transport and private vehicle. EVs have battery banks installed inside to store the electricity and the same electricity is used to drive the electrical vehicle depending on the capacity of the battery. Electrical vehicles are equipped with on-board charging which is used for slow charging and can also use to charge the vehicle from the domestic power supply. DC fast charging is also used to charge the battery at a faster rate to reduce the charging time. Though the electrical vehicles having various advantages over the conventional IC engines it has some disadvantages and majorly it is related to the charging of the batteries and charging time. The charging time can be reduced by introducing DC fast charging. The second most hurdle in using the electrical vehicle its travel distance in the single charge. The conventional IC engines as it runs on the fossil fuel it can conveniently store in the fuel tank and it can travel more distance as compared to an electrical vehicle which has very limited running distance i.e. up to 300km per charge.

Various charging methods use the electrical cable to charge the battery of the electrical vehicle. Various DC charging plugs are used and have different charging connectors as below.

CHAdeMO – Nissan and other Japanese companies like Mitsubishi

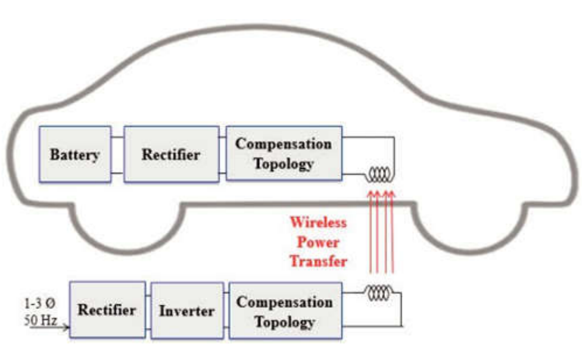
SAE Combo Charging System (CCS) – (BMW, GM, VW, and other carmakers)

Supercharger – Tesla standard connector

GB/T - BYD among other Chinese companies uses this. Mahindra and Tata electric cars also use this standard.

Various e-vehicle manufacturers using various charging connectors depending on the country and region. The same type of charging connector must be made available to sell such vehicles in the entire world. As of now, the transport vehicles that have not been yet introduced in e-vehicle may require another size of the connectors as the charging current will be at a higher rate which again leads to the addition of the connector in the charging infrastructure.

Fig -1: Figure



II. Design Method and Topologies

Topologies:- There are various topologies used to transfer electrical power such as mono resonant and multi resonant which in this experiment we will be using the mono resonant circuit which has a combination of the LC Series –Series resonance.

In the LC Series-Series resonance, the Capacitor placement is also done in various combinations like series, parallel, etc. in this research we are using the series capacitor.

Material and Coil Selection:-

Selection of the material of the coils is very crucial, it is recommended to use a wire with low resistance because reduced losses in the inductors lead to the increased overall efficiency of the wireless charger. The equivalent resistance of a wire depends on its length and also on the operational frequency. Thus, we define two terms: the DC and the AC winding loss. The DC losses are mainly due to the resistivity of the conductor whereas the AC losses are caused by the eddy current effects to overcome the issue Litz cables introduced in the experiment. Once the coil is designed it will generate magnetic flux will be generated in all areas and some magnetic flux will be lost to avoid the same ferrite cores are introduced to channelized the magnetic flux in one direction to achieve maximum efficiency of the charging system.

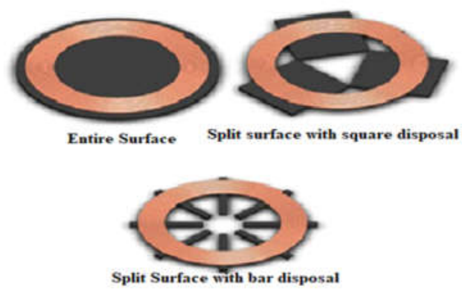


Fig -2: Figure

III. MODELLING AND ANANLYSIS

For this project, we have used a single-phase 230v AC supply, and then it is step-down to 12V with help of a step-down transformer or SMPS. The DC voltage is then directly utilized for WPT. The 12 V DC supply is fed to the transmission coil with help of the MOSFET at a certain switching frequency to produce HF alternating DC voltage across the transmission coil. A capacitor is connected in series with the transmitting coil to produce the resonance to transfer in the identical receiving resonant coil. Air is media used for transferring the power we also need to consider that the resonance frequency is too high hence it will break the air core and can effectively transfer the power to receiving coil with very few losses.

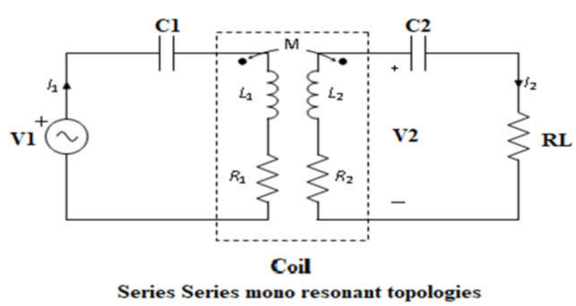


Fig -3: Figure

For Circular coil geometric the L can be calculated using below equation.

$$L = \mu 0 * N^2 * R * \left(\ln \frac{16 * R}{6} * \frac{7}{8} \right)$$

μ0 is the vacuum permeability,

N is the number of turns,

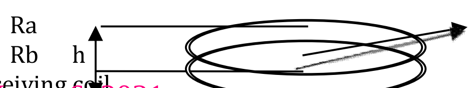
R is the radius of the inner turn,

d corresponds to the equivalent diameter of the coils can be diameter can be calculated from below equation. $d = 2 * \sqrt{\frac{N * S}{\pi}}$

Where,

S is the cross-section of the cable.

N is Number of turns.



Rb= Transmitting coil
H= Distance between two coils
Series-Series compensation network consist of two pairs of the coil with its corresponding capacitors which constitute two separate resonant tanks at the same operational frequency. (ω0) The value of inductor and capacitor can be calculated using the below equation.

$$\omega 0 = \frac{1}{\sqrt{L1C1}} = \frac{1}{\sqrt{L2C2}}$$

ω0 = Resonance frequency
L1 = Transmitting coil inductance
L2= Receiving coil inductance
C1 = Transmitting side Capacitor value
C2= Receiving side Capacitor value
Ideal Resonance condition
XL = XC Means the XL and XC values must be identical or nearby same to achieve the resonance frequency for the highest efficiency during the power transfer.

Circuit Operation:-

- 1 phase 230v is fed to the step-down transformer and voltage is reduced to 12V by using bridge rectifier and filtering circuits.
- 12VDC is regulated by using the 7805 regulator to feed the 5v to Arduino-Uno and control circuits.
- Arduino Uno will generate the signal for MOSFET driver it will trigger the MOSFET driver circuit.
- H Bridge topology of MOSFET operation is used to transmit the power to the transmitting coil.
- Capacitor which is connected in series with the coil then creates resonance circuit.
- Rx coil and Capacitor combination is same as the Tx.
- Voltage from Rx circuit is fed to the Battery charging using high speed bridge rectifier and Arduino is also powered by using the 7805 Regulator.
- The battery charging will begin once the voltage is available at the charging terminal.
- BMS (battery management system) will continuously generated the various parameters of the battery and it will be fed to the Arduino. Parameters like Battery voltage, Charging Current and SOC.
- Battery charging status is also sent to the Transmission with help wireless transceiver.
- Transmitter side Arduino will also communicate wirelessly.
- All the battery parameters from the BMS is fed to Tx Arduino and same will be displayed in 16X2 LCD at Tx side.
- Once the battery voltage is achieved the all operation from the Tx side will also stop.
- Use of two display is made purposefully as the one is located at EV side and second one is located at Charging station.
- The communication between this two must be wireless and hence the suitable wireless communication to be selected.

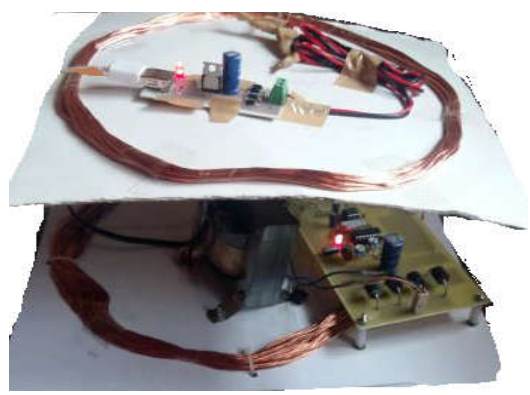


Fig -4: Figure

Material used in this project:-

45 SWG copper wire is used in this project Coil and has radius of 110mm and diameter of the coil is 220mm

Cross section area of the coil is 0.04572mm

No. of turns selected for the coil is 15no.

μ_0=1.2566*10-7

P = Resistivity of Copper = 1.796x10-8

Winding resistance

R = ρl/A Length of the coil
l = Circumference of coil x
N= 2π x 110x15= 10362mm
A = 2πr(r+h) = 7944.2mm
h= width of the winding =5mm
R = 2.62 MΩ

Resonant Frequency:

f = 1/2π √LC
L = 7.87µH
C = 1nF
f = 1.8 MHz

Resonance Condition
XL = XC
Where XL =Reactance of Coil
XC = Capacitive Reactance
XL = 2π x f x L = 88.713 Ω
XC = 1/2π x f x C = 88.713 Ω
Thus, XL = XC and so Resonance occurs resulting in

Hence power is transferred wirelessly from one coil to another coil.

To avoid the loss of the electromagnetic flux we have used the ferrite core to direct the magnetic flux and avoid an leakages to achieve high efficiency of the WPT.

To avoid the proxy effect in the conductor the Litz wire is used and hence efficient transfer of the power occurs from Tx to Rx.

IV. CONCLUSION

Aim of project to develop wireless near field charger using the principle RIC i.e. resonance inductive coupling. After analyzing the whole procedure the stepwise circuit was developed and implemented.

It is observed that the resonance inductive coupling can be used to transfer the power wirelessly with high efficiency and which further changes the charging infrastructure and its topologies and will provide the better utilization of the power transfer while driving an electric car.

In addition to this lot of research, we are still required to achieve dynamic car charging, which can be enabled by the same methodology we have applied in our project. A lot of research is still being done to utilize electric power wirelessly and shift our dependencies from fossil fuel to electrical energy which can be generated through non-conventional sources of energy like wind, Solar, etc.

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