Design of wireless power transfer charge station for electric vehicle

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Abstract - *Wireless power transfer (WPT) is the current technology using magnetic resonance which could set error free from the frustrating wires. In fact, the WPT adopts the same concepts which has already been developed with the term inductive power transfer. WPT technology is developing hastily in recent years. At kilowatts power level, the transfer distance increases from several millimeters to several hundred millimeters with a grating to load efficiency above 90%. This enhancement makes the WPT very attractive to the electric vehicle (EV) charging applications in both stationary and dynamic charging situations. This paper reviewed the technologies in the WPT area suitable to EV wireless charging. By introducing WPT in EVs, the obstacles of charging time, range, time and cost can be easily mitigated. Battery technology is no longer similar in the mass market penetration. It is hoped that scientists could be encouraged by the state-of-the-art achievements, and push forward the further growth of WPT as well as the expansion of EV.*

Key Words: Wireless power transfer, electric vehicle, Magnetic resonance, Inductive resonance coupling, wireless charging.

1. INTRODUCTION

For energy, environment, and many other aspects, the electrification for transportation has been carrying out. In railway systems, the electric locomotives have already been well urbanized for many years. However, for electric vehicles (EVs), the high elasticity makes it not easy to get power in a similar way. Instead, a high power and large capacity battery pack is usually prepared as an energy storage unit to make an EV to operate for an acceptable distance. Owner has to face some complex scenarios by means of this wired EV.Until now, the EVs are not so attractive to consumers even with many government motivation programs. Government subsidy and tax incentive are one key to increase the market share of EV today. The problem for an electric vehicle is nothing else but the electricity cargo space technology, which requires a battery which is the bottleneck today due to its unacceptable energy density, limited life time and high cost.

Wireless charging depend upon the principle of Inductive Power Transfer (IPT) or magnetic resonance. This is the method of transferring an electrical current between two objects through the use of coils to induce an electromagnetic field. Supply voltage is converted into high frequency alternating current which is sent to the transmitter coil by the transmitter circuit.Then the alternating current induces a time varying magnetic field in the transmitter coil. Alternating current flowing within the transmitter coil induces a magnetic field which tends to the receiver coil (when within a specified distance).The magnetic field produces current within the receiver coil. The method in which the energy is transmitted between the transmitter and receiver coil is also referred to as magnetic or resonant coupling and is achieved by both coils resonating at the same frequency.

An RFID system consists of tags, readers, communication protocols, computer networks, and databases. The tag consists of miniature chip containing product information with an affixed radio antenna. The tag is merged to an item or its packaging and contains a unique serial number called an electronic product code which is used to uniquely identify the pallet, case, or item. For low-cost tags, a reader transmits a radio signal to the tags to energize them so that the tag can transmit its code. A reader can be either stationary in a fixed state or portable. There are communication protocols that define the exchange of messages from the tag to reader and vice versa. The readers are connected to a computer network so that they can be enquired by a management system. Then the management system can inquire a database determined by the electronic product code to find out more information about the item to which the tag is attached.

1.1 Existing approach

One of the major issues in existing power system is the losses occurring in the transmission and allocation of energy to the end users. Because claim drastically increases daily, the power generation increases and also the power loss can be increased. The percentage of loss of power during transmission and circulation is approximated as 26%. The primary reason for power loss during transmission and circulation may be the resistance of wires used for grid. The efficiency of power transmission may be increased to a particular level by employing high strength composite over head conductors and underground cables who use warm super conductor. But, the transmission is incompetent. The EVs cannot get ready immediately if they have no energy. To overcome this, the owner has to find any possible opportunity to plug-in and charge the battery.The charging cables may cause tripping hazards. Leakage from cracked old cable, in particular in cold zones, can provide additional hazardous conditions to the owner and it produce some back EMF during transmission.

1.2 Proposed approach

Our proposed concept is to implement an automatic electric vehicle charging station via wireless power transfer (WPT) and RFID. Our modern electric vehicle consists of power sensor to analyze the amount of the power EV has and if the battery power is low it will point out to charge in nearest WPT station. The Automatic WPT station implemented with RFID reader. Then the user needs to show their electronic License card. Reader reads all info from that card and then it will enquire for license, insurance verification. Once everything is clear the user needs to specify the amount of unit power via Lab view Based Digital Info board. Finally the power is transferred via wirelessly to the Electric vehicle using WPT technique the unit the user entered and also amount will be deducted via user bank account.

2. Block diagram and methodology

When the card is swiped in the charging station, emf is generated in the RFID reader and all the details of corresponding car driver can be cross checked with the details stored in the server. After that PC with lab view panel is used. When using Labview many settings can be changed remotely instead of manually. For instance it will ask to use Labview to make voltage measurements for a circuit. After the evaluation of the information from the lab view, the output '1 or '0' is delivered from the microcontroller to the control unit that is switching unit. When '0' as input from the microcontroller there is no AC power supply provided. When the 1 as input is given to the control unit 230 V AC source is step down to 12 V and it is rectified to the 12 V of Direct Current. It is amplified in terms of DC for reducing the loss and attaining the good quality of the power. Then again Direct Current is converted to AC for generation of emf in the coil. The current flow in the primary coil will induce the emf in the secondary coil by the principle of the magnetic resonant coupling. The charging of the vehicle can be done by the wireless power transfer charger (DC motor) from the underground in the parking area.

The primary and secondary coils are described by their geometry, material and type of wire, i.e. solid or litz wire. Both the self and mutual inductance increase with larger coil radius and number of coil windings.

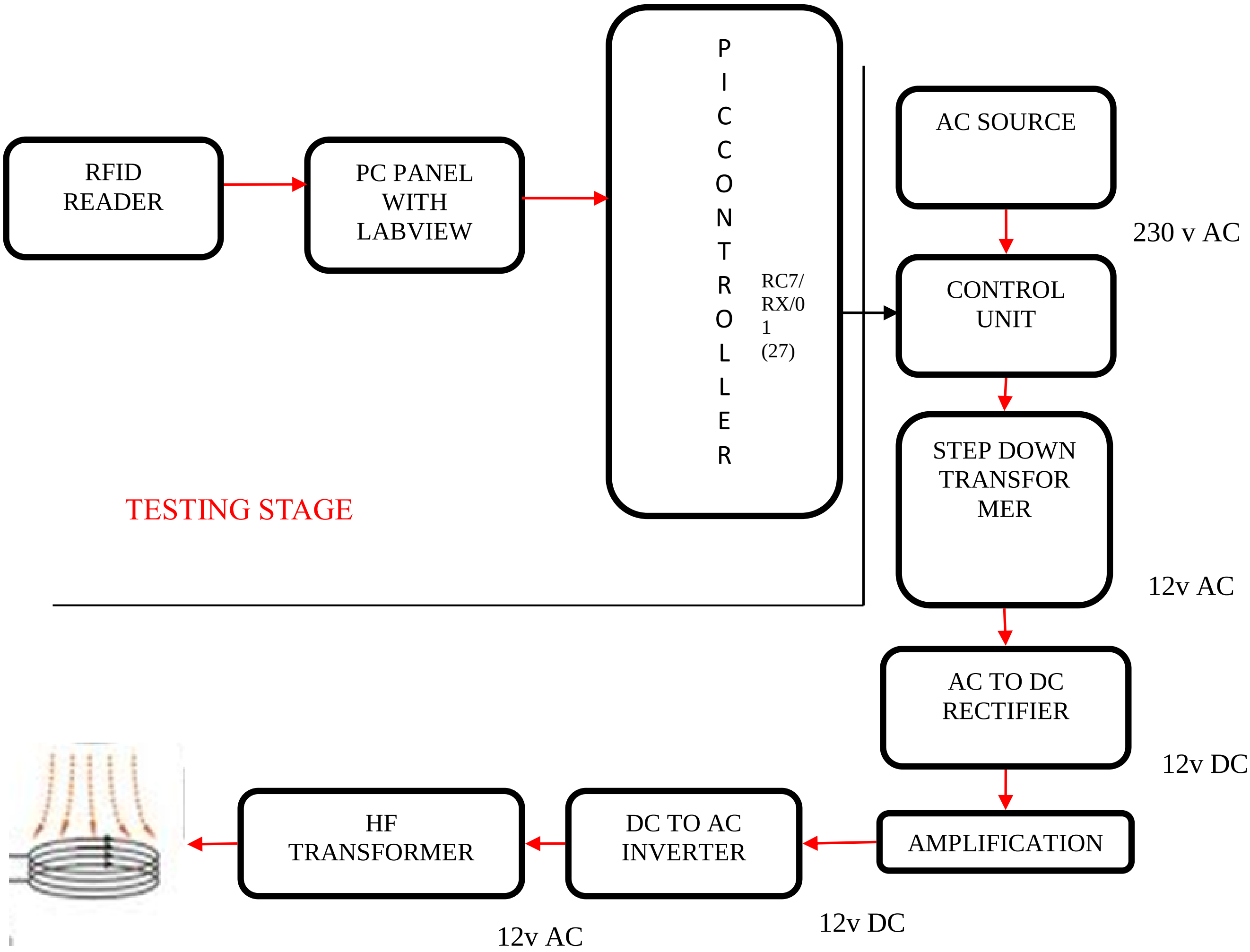

Fig -1:Transmitter

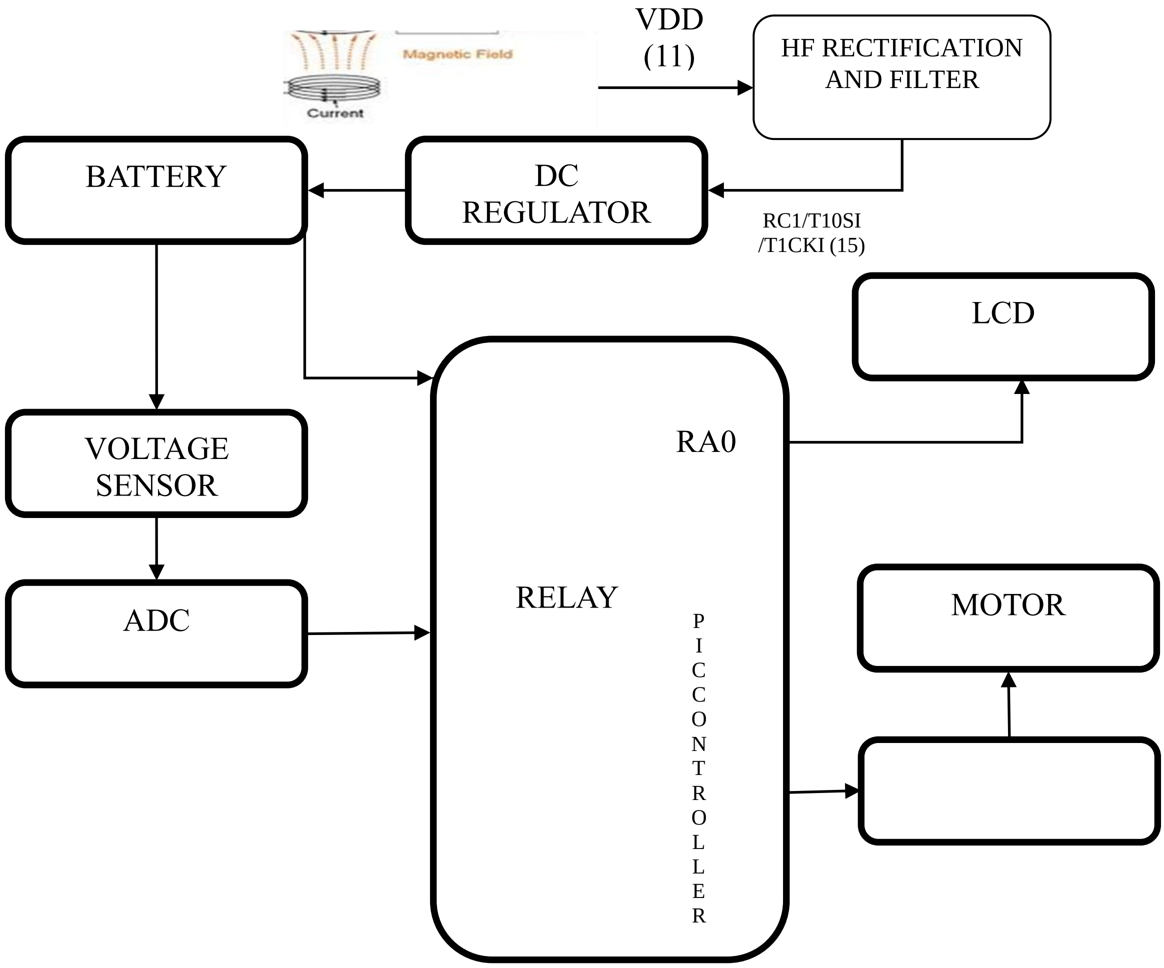

Fig -2:Receiver

As similar the total length of the wire, and thus the wire resistance, is directly proportional to the radius and the number of windings. The wire radius affects mainly the self-inductance and resistance. For the frequencies of interest, it is clear that the resistance of a litz wire is less than that of a solid wire, where it is assumed that the radius of the wire strands constituting the litz wire is small enough and the total conductive area of the litz wire is comparable to the solid wire.

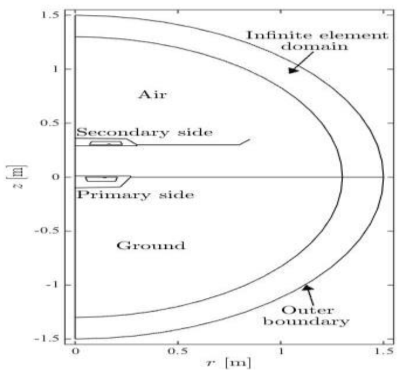

Fig -3: Boundary of emf generation

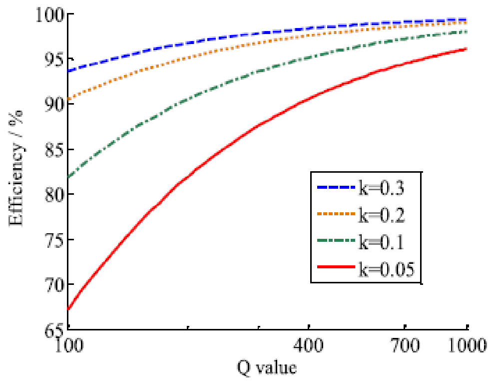

Chart -1: Theoretical maximum transfer efficiency between two coils.

The ground under the energy transfer system can feature both resistive and dielectric losses. By considering the conductivity and permittivity of moist ground at radio and these material properties is used to study the losses in the ground.

3. CONCLUSIONS

In this paper, we implemented wireless energy transfer systems based on resonant inductive coupling with application to the charging of electric vehicles. In this work we also analyzed the implications of metal plates, ferrites and ground adjacent to the energy transfer system. The main outcome is presented together with what should be focused on in future studies. A wireless energy transfer system based on two inductively coupled resonant circuits separated by an air gap. It is showed that the coupled wireless energy transfer system has two resonance peaks and that the separation of these peaks increase with increasing coupling coefficient. To avoid the self-resonance of the coils, the length of the coil wire such that the self-resonance frequency appears at much higher frequencies than the frequency of operation is limited. Metal plates above the secondary coil can efficiently shield the surrounding from magnetic fields. However, the magnetic fields induce eddy currents in the metal plates, which decrease the coupling coefficient and increase the resistive losses. Ferrites, a material with very low eddy currents and high permeability, is placed on both the primary (transmitter) and secondary side (receiver) and it efficiently cancel the negative effects of the shielding plates and improve the coupling coefficient. Gradient based optimization technique is used to for the geometry of the coils, metal plates and the ferrites in order to maximize the coupling coefficient.

Adding conductive and ferromagnetic materials in the vicinity of the coil have varying effects on the coupling coefficient and losses of the energy transfer system. Metal plates can significantly lower the coupling coefficient and increase the resistive losses. It is well know that the metal plates can efficiently shield the interior of the car from magnetic fields and protect the passengers from the potentially harmful magnetic fields. The well-designed ferrites can completely cancel the negative effects of the metal shields. From the reluctance of a simplified model of the system, it is found that the relative permeability of the ferrites does not need to be very large and $\mu_r \approx 100$ can be sufficient for some situations.

For the optimized coil geometries, we achieve coupling coefficients between 0.09 and 0.15. Restricting the currents in the coils further, we can transfer approximately 1.3 kW with 89% efficiency without exceeding the 8.84 μT peak-value limitation. This is achieved with the optimized coil geometry, where we used a large penalization on the magnetic field strength and this resulted in a coupling coefficient of 0.09.

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