Electric Vehicle Battery Charger: Wireless Power Transfer System Controlled by Magnetic Core Reactor

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Abstract — **This paper presents a control process and frequency adjustment based on the magnetic core reactor for electric vehicle battery charger. Since few decades ago, there have been significant developments in technologies used in wireless power transfer systems, namely in battery charger. In the wireless power transfer systems is essential that the frequency of the primary circuit be equal to the frequency of the secondary circuit so there is the maximum energy transfer. The magnetic core reactor allows controlling the frequencies on both sides of the transmission and reception circuits. Also, the assembly diagrams and test results are presented.**

Keywords: Wireless power transfer, magnetic core reactor, electric vehicle, magnetically couple resonators.

I. INTRODUCTION

The Wireless Power Transfer (WPT) can be considered as an efficient power transmission process, from one point to another point through the vacuum or the atmosphere without electrical cables or any other conductive material [1].

The technologies applied in WPT systems are categorized as near-field, mid-range and far-field. The near-field is used to very short distances, few millimeters, employing the inductive power transfer technology. The mid-range is used to cover distances between a few centimeters and a few meters, is using the magnetic resonant technology. These two technologies are no radiative. In contrast, the technology employed in far-field category is radiative and requires special care in antenna alignments because they have to be in line to sight [1,2].

The Figure 1 shows the wireless power transfer via strongly coupled magnetic resonance schematic block diagram. The driving coils supply power to each resonant LC circuits (transmitter and receiver). The both resonant circuits are galvanically insulated from other circuits but magnetically linked through the mutual inductance of the transmitter and the receiver coils [3].

The resonators should have high quality factor and the same resonant frequency.

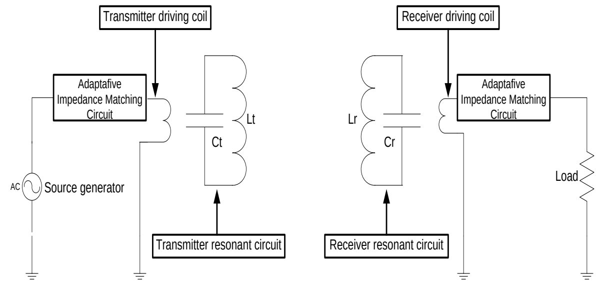

Fig. 1. WPT via strongly coupled magnetic resonance.

However, the distance between the transmitter and the receiver can vary and misalignments may also occur. When this happens, the impedances of the resonators change. For to achieve a constant efficiency, the resonators frequency must be adjusted [2].

The WPT process is essential for spread of electric vehicles (EV). To achieve wireless charging, the WPT system must satisfy these three conditions: high efficiency, large air gaps and high power. The WPT via strongly magnetic resonance satisfy these three conditions [3].

The wireless EV charging system includes several stages. First the AC power from the grid is converted to a DC power. The DC power is converted to high-frequency AC to drive the transmitter coil. The transmitter resonant circuit should oscillate to the resonant frequency determined by LC set. The high-frequency current in transmitting coil generates an alternating magnetic field, which induces an AC voltage on receiver coil. At the last, the AC transferred power is rectified to charge the battery.

The magnetic core reactor (MCR) comprises one core and two windings. One of the windings is the AC component and the other winding is the DC control. Varying the DC current through the control winding vary the inductance and implicitly changed the inductive reactance this device. These devices work at the beginning of the knee of the saturation curve of the ferromagnetic core [3,4].In this paper it is shown the use of this device for equalizing the frequencies of the transmitter and receiver in a WPT system [4].

II. MODELING

The amount of signal can be adjusted to the set point of the reactor flux by the amount $\Delta\phi$ to any given point of the magnetic loop in accordance with Faradays Law is given by,

$$\Delta\phi = \frac{1}{N_C}\int E_C dt \,, \qquad (1)$$

where E_C is the power from the source, N_C is the turns number of the control winding.

III. TEST RESULTS

The test results were performed on a WPT system for the battery charger prototype. The inductance variation function of the DC control current is shown in Figure 2.

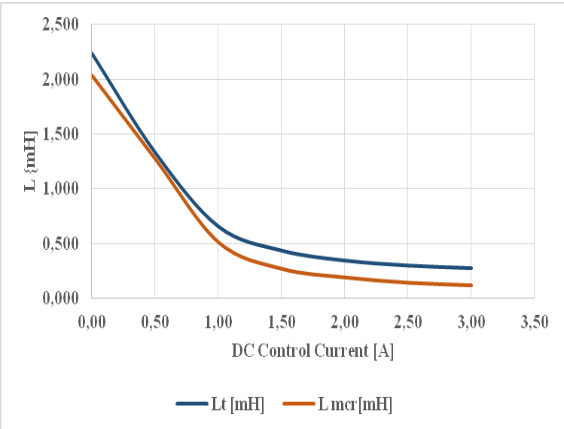

Fig. 2. Inductance variation with the DC control current.

In Figure 2 the orange line is the inductance variation of the MCR AC coil L_r, C_r, and the blue line is the inductance variation due to the DC control current change. For the inductance variation study, the MCR is connected in series with the transmitter coil L_t.

A comparison between the two curves (Figure 2) reveals the inductance variation by variation of the DC control current. Hence, inductance variation by variation of the DC control current allows the frequency set point of the WPT.

The tuning capacity (inductance and capacity values) of MCR circuit in series connected with transmitter coil, i.e., the transmitter circuit are shown in Figure 3.

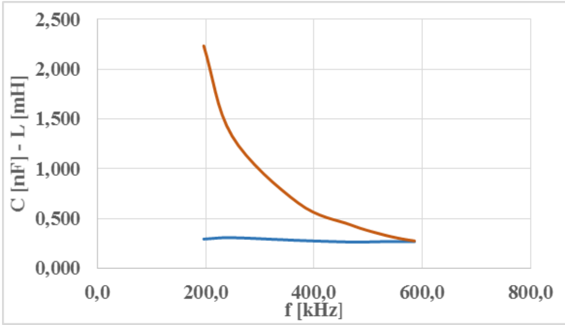

Fig. 3. Tuning of the transmitter circuit.

V. CONCLUSION

This study allows conclude that, inductance variation by variation of the DC control current enable the frequency set point of the WPT. With the frequencies adjust s is possible to matching the impedances between transmitter and receiver circuits and increase the efficiency of the contactless power transmission system.

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