Impact of Fractal Loop on Wireless Power Transmission for Travelling Mobility Scooter

Yuuji Sakayanagi, Shota Togawa, Kenta Konagaya, and Yoshihiko Kuwahara
Graduate School of Integrated Science and Technologies, Shizuoka University

***Abstract* - A wireless power transmitting system for a traveling mobility scooter based on magnetic resonance has been developed. In the system, we have prepared 2 kinds of loop: ordinary square loop and fractal loop. In this paper, we demonstrate that the fractal loop can keep high efficiency in spite of lateral positioning deviation with a fixed matching circuit.**

***Index Terms* — Wireless Power Transmission, Magnetic Resonance, Fractal Loop, Lateral deviation, Mobility Scooter.**

1. Introduction

Electric vehicles are still not in widespread use yet, because of high price and a limited range per battery charge. If wireless power transmission to traveling electric vehicles was achieved, the range distance would become infinite, and lightweight and low cost electric vehicles could be produced [1]. To demonstrate wireless power transmitting to a moving electric vehicle, we developed a wireless power transmitting system to a traveling mobility scooter [2].

In the system, we used the magnetic resonant technology with a high efficiency and low unwanted emissions. When the power transmitting and receiving loops are aligned, power transmitting efficiency is high. However, when the loops deviate laterally, power efficiency is significantly reduced [3]. Although this problem can be alleviated using an appropriate matching circuit, an adaptive matching circuits are required. Because, matching conditions change continuously with vehicle motion. Implementing variable matching circuits is difficult since high power variable reactance has still not been fully developed [4].

To overcome this problem, we proposed to use a fractal structure in the transmitting and receiving loops. Using the optimized fractal loop, power transmission systems robust to lateral deviation are expected. We examined the validity of this technique with simulations and experimental work [5]. In this paper, we demonstrate that a fractal loop is capable of maintaining power efficiency even in the presence of considerable lateral displacement using the wireless power transmitting system for travelling mobility scooter.

2. Wireless Power Transmitting System for the Mobility Scooter

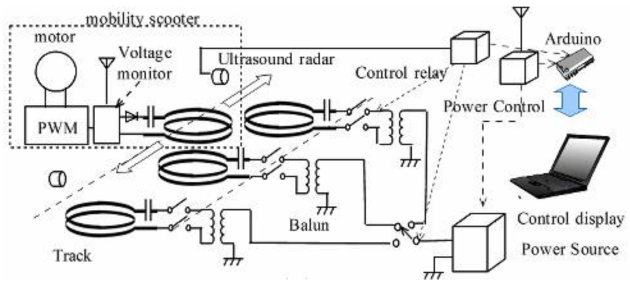

Fig.1 System Configuration

Fig. 2 WPT system for traveling mobility scooter.

Figure 1 shows the configuration of the developed system. The transmitting coils are embedded side by side along the traveling path where the mobility scooter passes with its receiving coil. Electric power from the high frequency power source is only supplied to the coil upon which the scooter is passing at the moment. To detect the position of the vehicle, ultrasonic sensors are installed on the roadside at every transmitting coil. The active transmitting coil is selected by the coaxial switch provided on the transmission side.

The battery was removed from the scooter, and a receiving coil, rectifier, voltage monitor, and an auxiliary battery system to handle instantaneous interruption has been installed on it. The rectified power voltage is monitored, and the information is sent to the transmission side by an XBee communication module. The DC power supply voltage to the power source is adjusted, so that the rectified output is 24V. Detection of the mobility scooter position, selection of the transmitting power coils, and transmitting power control are tasks automatically executed by an Arduino. Figure 2 shows a photograph of the system.

3. Fractal and Square Loop

(1) Square Loop
The power transmission coil is a 90cm sided square loop made with copper wire of 2 mm diameter. The receiving coil is a two - turn square coil of 55 × 40cm. A resonant capacitor and a balun for balanced - unbalanced conversion are connected to the coils. The distance from the transmitting to the receiving coil is 15 cm. If the receiving coil is located fully inside the area of the transmitting coil, the transmission efficiency is 90% or more. Figure 3 shows a transmitting and a receiving coil.

Figure 3 Transmitting loop and receiving coil.

(2) Fractal Loop
We use the same loop as the transmitting and receiving coil. Its side is 70cm. In the design, the transmission efficiency of the shape was calculated, keeping the loop distance constant and increasing the horizontal displacement between coils from 0% (complete alignment) to 100% (non-overlapping). The shape was designed so as to maintain high values of efficiency by Genetic algorithm. When the relative positions of the loops vary, a variable matching circuit would be required. However, it is difficult to obtain variable matching circuits at high power. Therefore, we used a fixed matching circuit whose parameters were chosen for high average power efficiency. The optimal component values of the matching circuit were decided using the pattern search function. A photograph of the fractal loop are shown in figure 4.

Fig.4 Fractal loop and matching circuit

4. Experiments

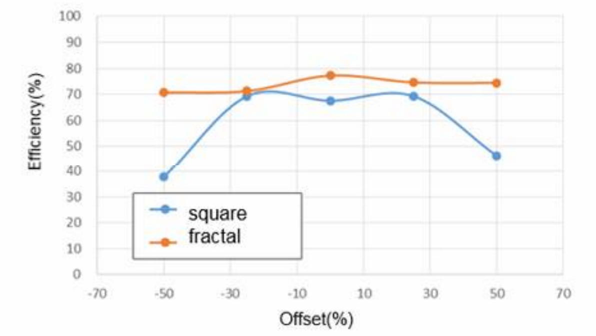

Figure 5 Transmitting power efficiency versus lateral deviation

Figure 5 shows the experimental results. x and y-axis denotes the lateral deviation and the transmitting power efficiency, respectively. Lateral deviation of 0% means that the transmitting and receiving loop meets face to face. In case of the square loop, increasing the deviation, the power transmitting efficiency degrades seriously. However, the efficiency hardly changes regardless larger deviation.

5. Conclusion

We demonstrate that the fractal loop can keep high efficiency in spite of lateral positioning deviation with a fixed matching circuit. It is advantageous on wireless power transmitting for traveling vehicles.

Acknowledgment

This work is supported by Suzuki foundation.

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