Oval Double Spiral Coil for High Wireless Power Transmission Efficiency

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***Abstract*—We have proposed the oval double spiral coil having high wireless power transmitting efficiency. The 75 % wireless power transmission efficiency was obtained by rotate minor axis angle of the oval coil and by offset the receiving coil position relative to the transmitting coil.**

***Keywords*—double spiral coil; wireless power transmission; mobile phone**

I. Introduction

Recently, the research and development on wireless power transmission (WPT) attracts our attention because the WPT system enables us to charge mobile phones, note book computers. [1],[2] In special power transmission as shown in Fig.1 (a), a transmitting coil and a receiving coil were arranged in parallel for power charge of mobile phone with magnetically coupled resonance and transmitting efficiency has been analyzed in this condition. In this case, a circular spiral coil or a helical coil was used. In general use case as shown in Fig.1 (b), a transmitting coil was located on a table and a receiving coil of mobile phone was located in hand. So, these coils were not arranged in parallel. One of problems in this WPT becomes lower wireless power transmitting efficiency due to position offset between a transmitting coil and a receiving coil and angle change of each coil.

In this paper, we attempt to obtain high wireless power transmitting efficiency which does not depend on the position offset and the angle change between the transmitting coil and the receiving coil. For this purpose, we propose the oval double spiral coil. At first, the wireless power transmitting efficiency by angle change between the transmitting coil and the receiving coil is simulated. Second, the wireless power transmitting efficiency is simulated when the receiving coil is offset relative to the transmitting coil. And we propose the method to increase wireless power transmitting efficiency. Most efficient method is minor axis angle rotation of the receiving oval double spiral coil and offset the receiving oval double spiral coil relative to the transmitting coil.

II. Analytical Model

Fig.2 shows the proposed two type oval double spiral coil models. One is major axis rotation type and the other is minor axis rotation type. The proposed double spiral coil was used in each type. And the blue coil and the green coil are the double structure wound on an opposite direction. [3] Port 1 is power transmitting port and port 2 is power receiving port. In the oval coil, the length of minor axis is 60 mm and the length of major axis is 120 mm.

Fig.3 shows the side view of the transmitting and the receiving oval double spiral coil. The receiving coil is rotated angle θ related to the transmitting coil. The distance between the center of transmitting coil and the center of receiving coil is d. The other parameters of these coils are decided to resonate at 6.8 MHz as shown in Fig.3.

III. Simulated Results

Fig.4 shows the simulated results of wireless power transmission efficiency as a parameter of angle θ at d = 60 mm when the receiving coil is rotated at the center of transmitting coil. The angle θ is 0 degree when the receiving coil is in parallel to the transmitting coil. Two cases were simulated in the oval coil. One is major axis rotation and the other is minor axis rotation. It's also indicated in case of conventional circular coil to compare. From the simulated result, the wireless power transmitting efficiency was decreased by increasing angle θ. In oval coil, the maximum wireless power transmitting efficiency was obtained about 90 %. On the other hand, wireless power transmitting efficiency was 70% in conventional circular coil. So, it was clear that the proposed oval coil can increase the wireless power transmitting efficiency. Furthermore, almost same wireless power transmitting efficiency was obtained from +60 degrees to -60 degrees with 90 % when the minor axis rotated. However, the wireless power transmitting efficiency was 0 % at θ = ±90 degrees in every case.

To increase the wireless power transmitting efficiency of the oval coil at θ = ± 90 degrees, the wireless power transmitting efficiency was simulated as a parameter of angle θ when the receiving coil was offset from center of transmitting coil.

Fig.5 shows this simulated result of minor axis rotation. High wireless power transmitting efficiency was obtained at angle θ from 60 to 90 degrees. Furthermore, the wireless power transmitting efficiency at θ=90 degrees was obtained about 75 % when minor axis is rotated. Fig.6 shows this simulated result of major axis rotation. High wireless power transmitting efficiency was not obtained at angle θ from 60 to 90 degrees compared to minor axis rotation. 75 % wireless power transmitting efficiency at θ=90 degrees was obtained when minor axis is rotated. It was clear that high wireless power transmitting can be realized when the receiving coil is offset relative to the transmitting coil and is rotated minor axis the receiving coil.

To clarify the mechanism of the proposed oval coil, the magnetic distribution was simulated. Fig.7, Fig.8 and Fig.9 shows the simulated magnetic distributions in case of minor axis rotation. The red show the strong magnetic distribution and the blue shows the weak magnetic distribution.

It was clear that the transmitting coil and the receiving coil was not coupled when the receiving coil was perpendicular to the center of transmitting coil shown in Fig.7. On the other hand, the magnetic coupled was obtained when the receiving coil was offset 30 mm as shown in Fig.8. High wireless power transmitting efficiency was obtained using our proposed oval coil by position offset 30 mm and minor axis rotation angle 90 degrees.

IV. Conclusions

In this paper, we have proposed the oval double spiral coil for wireless power transmission. It can be improved the transmitting efficiency by offset the receiving coil position and rotate the minor axis angle of the oval coil. Proposed oval coil is useful wireless power transmission method for mobile phones.

References

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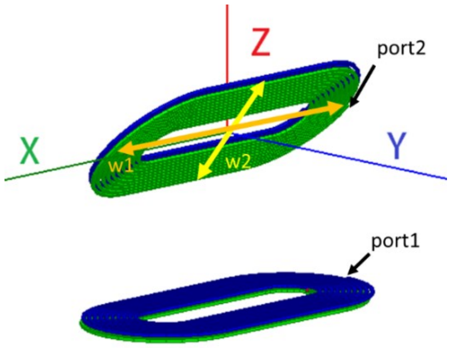
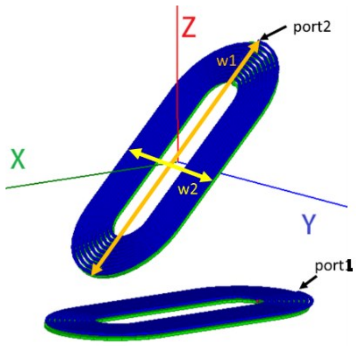
(a) Special use case (b) General use case

Fig. 1. Wireless power transmitting use cases.



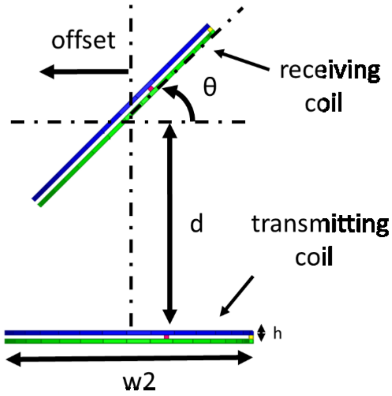
(a) Major axis rotation type



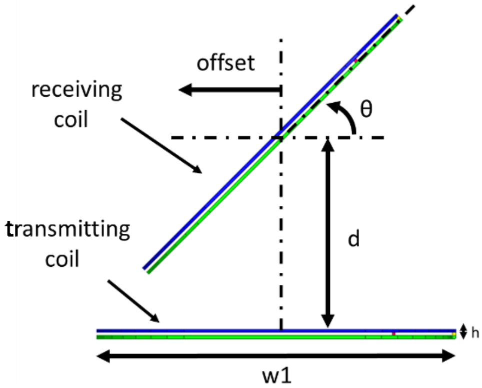
b) Minor axis rotation type

Port 1 : tranmitting port Port 2 : receiving port.

Fig. 2. Proposed two type oval double spiral coils.



(a) Major axis rotation type



(b) Minor axis rotation type

Fig. 3. Side view of transmitting and receiving oval double spiral coils.

resonant frequency = 6.8 MHz, line thickness=line width=pitch=1[mm], h=3mm, Number of turns=10×2[volume], w1=120[mm], w2=60[mm], d=60[mm], Short circuit in the capacity of 2pF, offset=parameter[mm]

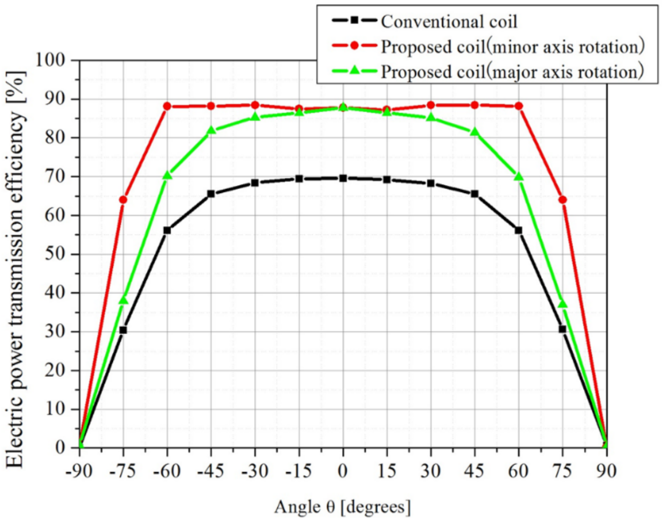


Fig. 4. The simulated results of wireless power transmission efficiency as a parameter of angle θ at the center of transmitting coil. (d = 60 mm)

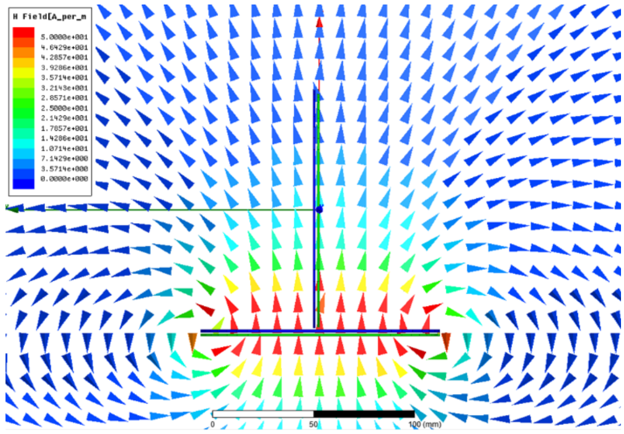


Fig. 7. Simulated magnetic distribution when the receiving coil was perpendicular to center of transmitting coil.

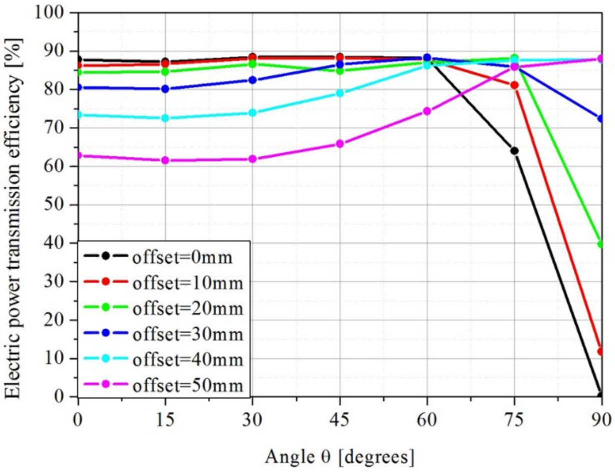


Fig. 5. The simulated results of wireless power transmission efficiency as a parameter of minor axis rotation angle θ and position offset from center of transmitting coil.

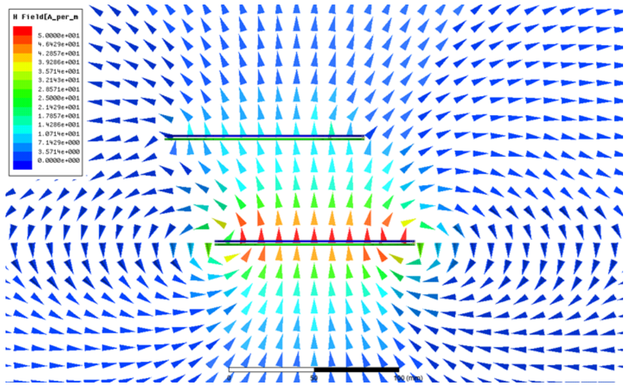


Fig. 8. Simulated magnetic distribution when the receiving coil was parallel to the transmitting coil at offset was 30 mm.

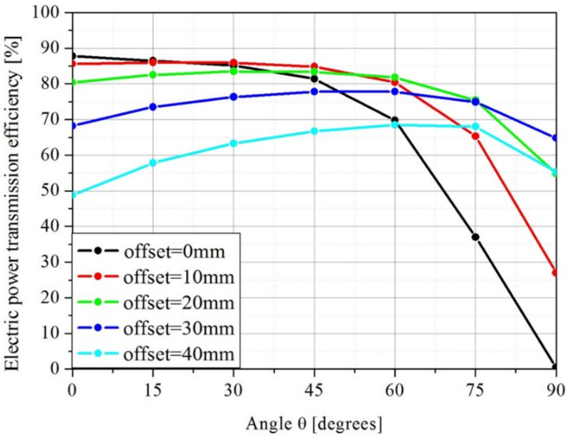


Fig. 6. The simulated results of wireless power transmission efficiency as a parameter of major axis rotation angle θ and position offset from center of transmitting coil.

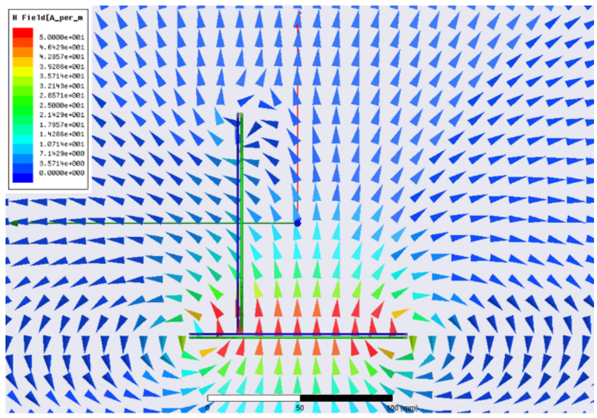


Fig. 9. Simulated magnetic distribution when the receiving coil was parallel to transmitting coil at offset was 30 mm.