Against Misalignment Wireless Power Transfer System Using a Modified Helmholtz Coil

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Abstract- A novel magnetic resonance coupling based wireless power transfer system is presented. A transmitter (Tx) containing modified Helmholtz coils is proposed to construct a resonator. A receiver (Rx) is placed inside the Tx. The proposed system ensures that the magnetic field are uniform in the space of the Tx, leading to a high-power transfer efficiency over a wide range of lateral misalignment distances. Experimental results demonstrated that the proposed WPT system could achieve an efficiency of 85.6% at 85 kHz operating frequency. Based on the proposed Tx coils, the area with uniformity of the magnetic field over a normalized value of 0.9 is increased by 17.7% compared with the conventional method [1]. These designs are proved to be very good candidates for WPT applications where Rx moves inside the Tx.

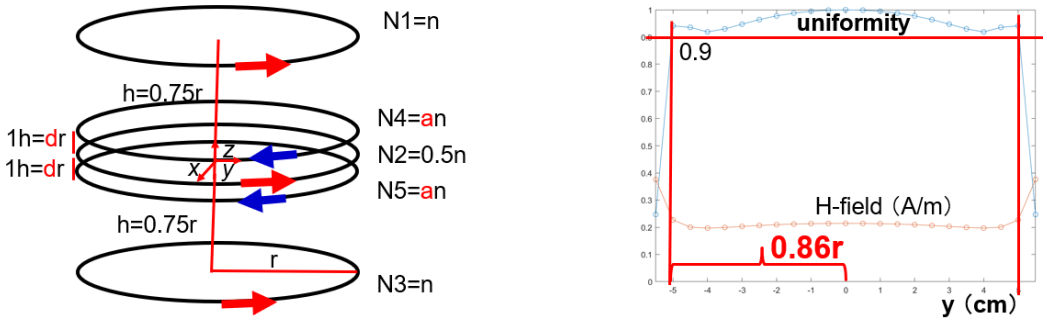

Fig.1. (a) Schematic of the proposed Tx coil. (b) The uniformity and the H-field against y-axial distance.

The schematic of the proposed Tx coil is shown in Fig. 1, which is composed of five groups of coils wound in opposite directions, coil N1 to N5, to control the magnetic field distribution inside the Tx. The current flowing in coil N1, N2 and N3 are in the same direction, which are conversed with the current in coil N4 and N5. Based on study in [2], the magnetic field distribution in the z-axial direction can be expressed as

$$H_z(y,z) = H(n) * H_z(y,z+h) + H(n) * H_z(y,z-h) + H(0.5n) * H_z(y,z) - H(an) * H_z(y,z+1h) - H(an) * H_z(y,z-1h) \quad (1)$$

And the uniformity in the z-axial direction can be expressed as

$$\gamma(y,z) = \left(1 - \frac{H_z(0,0) - H_z(x,y)}{H_z(0,0)}\right) \times 100\% \quad (2)$$

According to the calculation, the optimal performance can be achieved, where 1h=0.1r, h=0.75r, the turns of N4=N5=0.15n. Therefore, the proposed WPT system can maintain high efficiency over a wide range of lateral misalignment distance.

[1] Tsuchida, Yoshiki, Soichiro Ito, and Masahiro Fukui. "Development of magnetic resonant wireless power transfer system robust to position gap." *2018 IEEE International Conference on Consumer Electronics (ICCE)*. IEEE, 2018.

[2] M. R. Basar, M. Y. Ahmad, J. Cho and F. Ibrahim, "Stable and HighEfficiency Wireless Power Transfer System for Robotic Capsule Using a Modified Helmholtz Coil," in IEEE Transactions on Industrial Electronics, vol. 64, no. 2, pp. 1113-1122, Feb. 2017