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Analysis of S-Parameter using Different Materials for the WPT Resonance coil

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Research Background

The wireless power transfer (WPT) system using magnetic resonance that was developed in 2007 was an expected future technology. The use of the superconducting coil was suggested to improve the efficiency of the magnetic resonance system, and the increase in the quality factor (Q-factor) was confirmed. The reflection coefficient of S-parameter (S11) was analyzed in this study under the mixed use of the superconducting coil and the normal conductor coil, as the mixed use of both coils is inevitable in actual applications.

Experimental set up

1) Resonance WPT

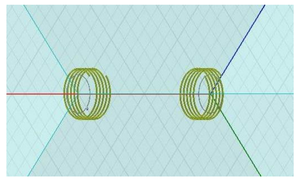
·The coil to save and transfer the electric power consumes it through the coil resistance
·It is quality factor(Q-factor), less the resistance is the higher the power consumption becomes.
·the efficiency and characteristics of WPT become higher. So, we apply superconducting coils
·Equation (1) stands for the Q-factor

$$Q-factor=\frac{\omega L}{R} \qquad (1)$$

2) Construction of Experimental setup

- We setup a magnetic resonance wireless power transfer(WPT) system using superconductor coil
- We design WPT system using high-frequency structure simulation(HFSS, Ansys)

[Experimental set up]



[Simulation design by HFSS]

[Parameter of WPT coils]

Parameter (unit)	Value
Coil distance (mm)	200
Coil height (mm)	300
Coil width (mm)	100
Coil pitch (mm)	50
Coil turn	5

[R,L and Q-factor of WTP coils]

	Superconducting coil	Copper coil
Resistance (Ω)	0.1	0.4
Inductance (μH)	22.3	12
Q-factor	1.6 e^4	2.2e^3

Experiment

1) Simulation

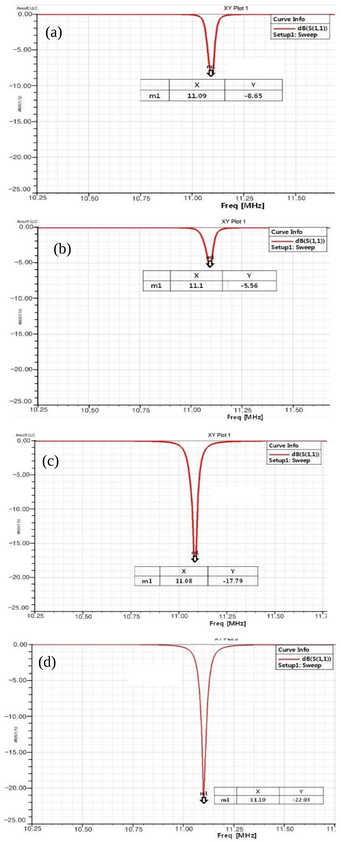


Fig. 1. S-Parameters of simulation
(a)Tx-copper, Rx-copper
(b)Tx-copper, Rx-superconductor
(c)Tx-superconductor, Rx-copper
(d)Tx-superconductor, Rx-superconductor

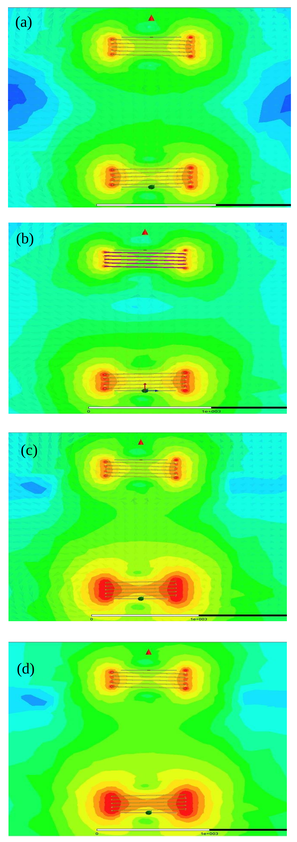


Fig. 2. E-field of simulation
(a)Tx-copper, Rx-copper
(b)Tx-copper, Rx-superconductor
(c)Tx-superconductor, Rx-copper
(d)Tx-superconductor, Rx-superconductor

2) With Superconductor (SC-DC FCL)

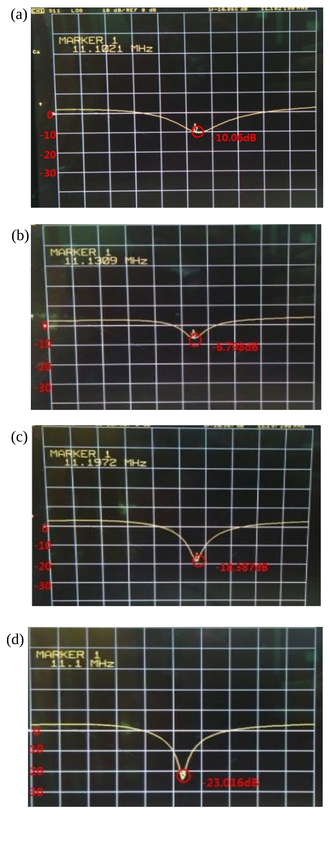
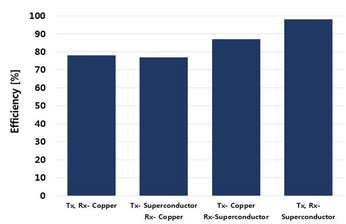


Fig. 3. S-Parameters of experiment
(a)Tx-copper, Rx-copper
(b)Tx-copper, Rx-superconductor
(c)Tx-superconductor, Rx-copper
(d)Tx-superconductor, Rx-superconductor

3) Efficiency



This figure represents the graph that transferred the S-parameter to the efficiency
Equation (3) was applied to efficiency conversion.

$$WPT\ efficiency=|S_{11}|^2\times 100 \qquad (3)$$

Conclusion

In this study, the superconducting coil was applied to improve the magnetic-resonance wireless power transfer (WPT) efficiency. The S-parameter was analyzed by applying the two different materials to the resonance coil. The coils were manufactured with the same resonance frequency for impedance matching after analyzing the inductances of the coils. The results of the experiment showed that when the superconducting coil was applied to the transmitter, more power transmission was possible compared to when the copper coil was applied. As the superconducting coil had lower resistance than the copper coil, it could have a higher Q-factor. This not only made more power transmission to the receiver possible but also increased the frequency selectivity.
WPT is the newly rising, promising future technology. The superconducting coil is believed to be able to increase the efficiency dramatically. Therefore, continuous studies in the future will make it possible to apply it to various areas, including electric vehicles and trains.