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High Coupling Characteristics of Coil for Superconducting Wireless Power Transfer

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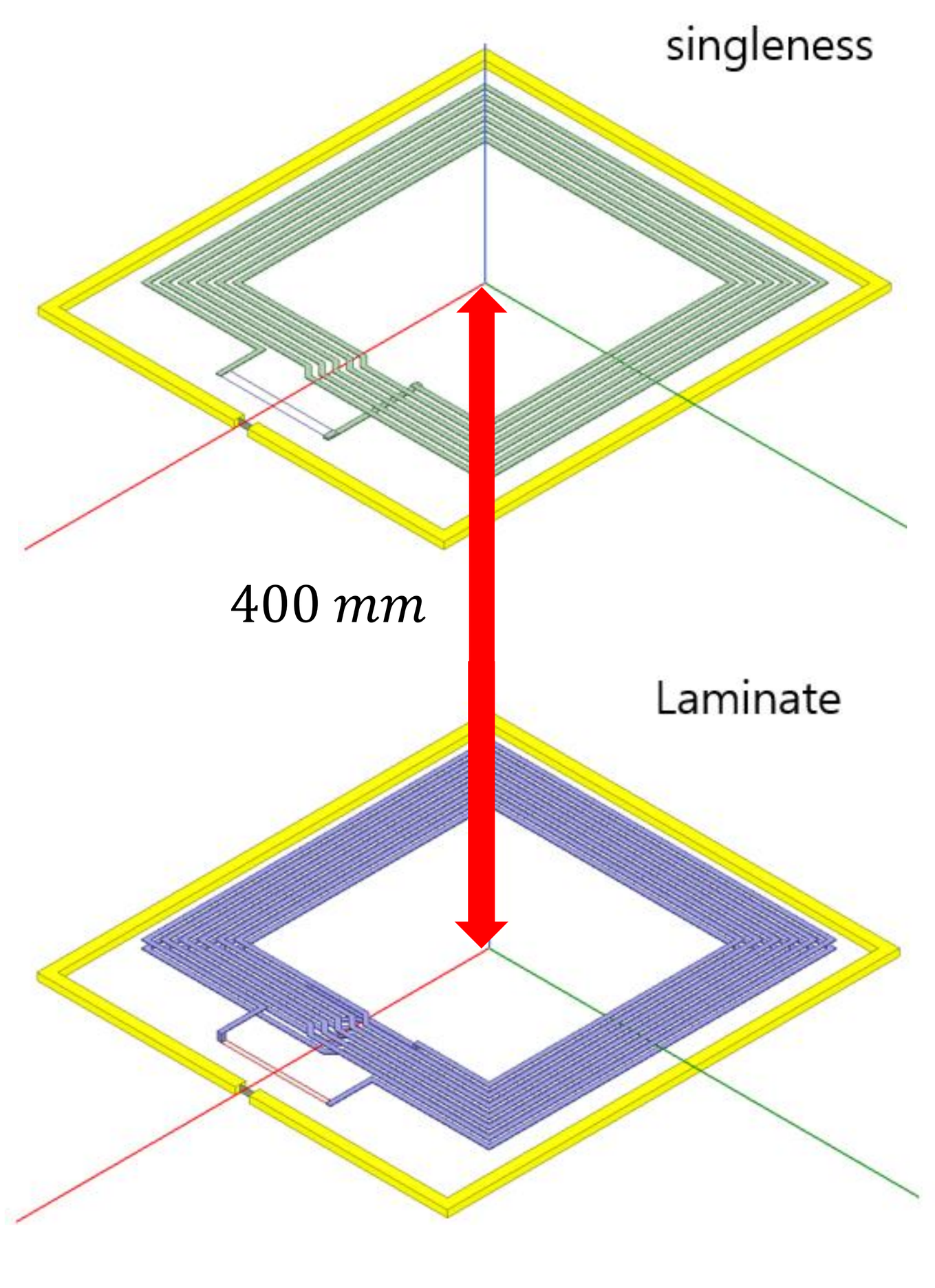
Abstract

- We research team proposed a WPT technique using superconductors.
- In this paper, a spiral-type coil with a laminated structure was applied as a resonant coil for wireless power transmission for electric vehicles (EV).
- As a result, it is possible to implement wireless power transmission with higher efficiency than the conventional wireless power transmission methods.
- Simulation analysis was performed using High-Frequency Structure Simulation (HFSS), an electromagnetic field analysis program.

Resonance Coil Design and Parameters



< Resonance Coil Modelling >

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ÅÀÎÆ ˛	ÎõÒÚŸÛú ÿÒÞÛø	ÅĐđđÛø	ÎÙãÜÿÛ ÿÒõÛø	ÅĐđđÛø
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< Structure of WPT Coil >

íÛÕĐãÒãÚÛ ÅĐÙÿ			
åÙýÙÕÙĐã	value	åÙýÙÕÙĐã	value
îÝøã	–	èÙõÚü ÓÃÃÔ	–˛–
îüÙÚŸãÛÕÕ ÓÃÃÔ	˝	ÌÙúõü ÓÃÃÔ	–˛–
ÌÙúõü ÓÃÃÔ	ˏ˙˙	çÛÙÜüõ ÓÃÃÔ	ˏ˙˙

< Resonance Coil Parameter >

åÙýÙÕÙĐã		ÅÀÎÆ ˝	ÅÀÎÆ ˛	ÅÀÎÆ ˛
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	ÅÒđÒÚÙõÒã ÚÛ	˝˝˝ˇ ãæ	˛˙ ãæ	˛˙ ãæ
íÛÚÛĐýÛø	ÉãúÝÚõÒãÚÛ	˛˙˘ˏ Ýç	˛˙˘ˏ Ýç	˛˙˘ˏ Ýç
	ÅÒđÒÚÙõÒã ÚÛ	˝˝˝ˇ ãæ	˝˝˝ˇ ãæ	˝˝˝ˇ ãæ

< Inductance and Capacitance of WPT Coils>

$$\Phi = \frac{\lambda}{N} = \frac{LI}{N}$$

$$M = k\sqrt{L_A \times L_B}$$

$L\uparrow \rightarrow$ $\Phi\uparrow$ $M\uparrow$ → Efficiency ↑

< Laminated Structures Theory>

$$Q = \frac{f}{\Delta f} = \frac{\omega L}{R} = \frac{2\pi f L}{R}$$

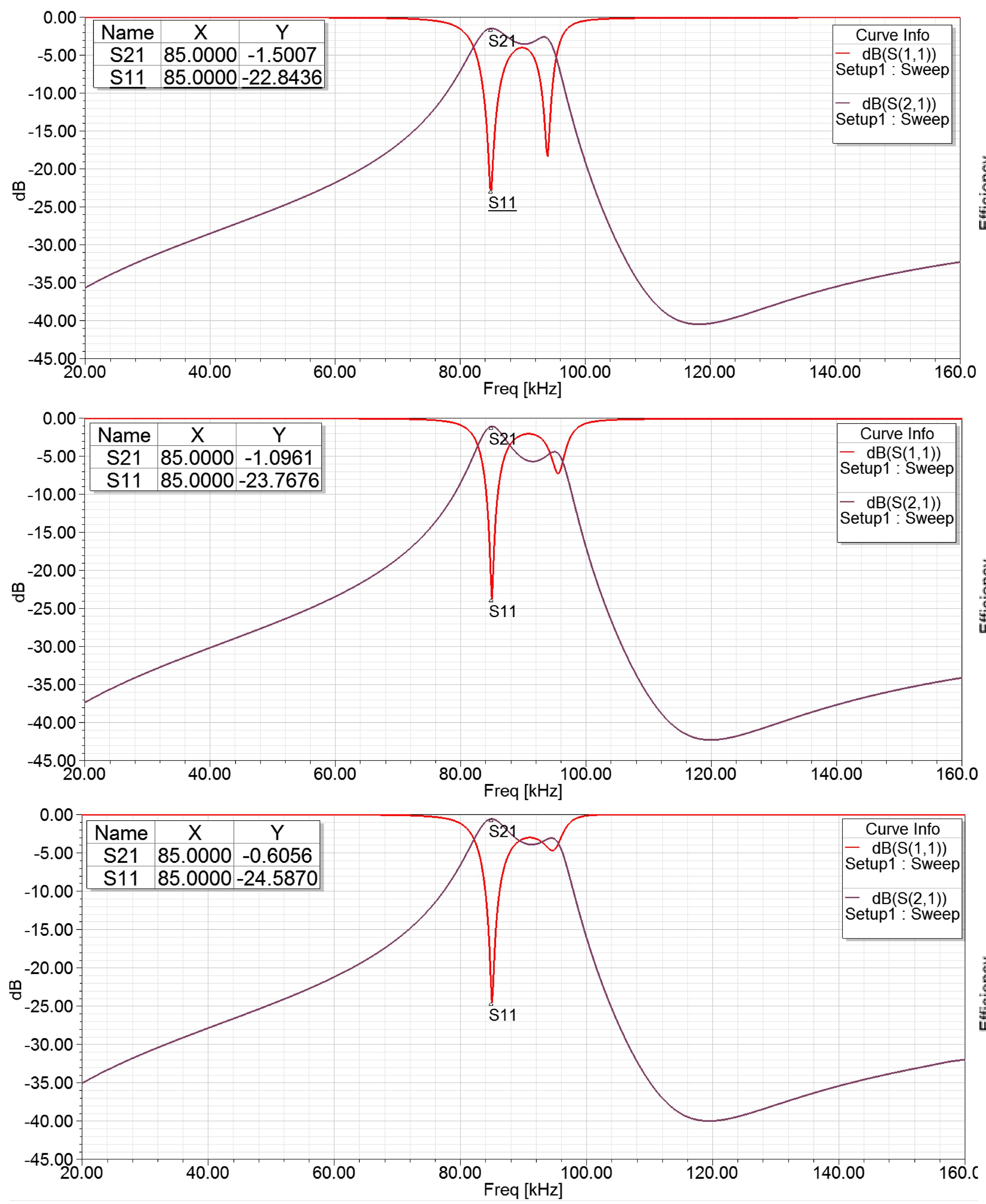
$R\downarrow \rightarrow Q\uparrow$ → Efficiency ↑

< Superconductivity Theory>

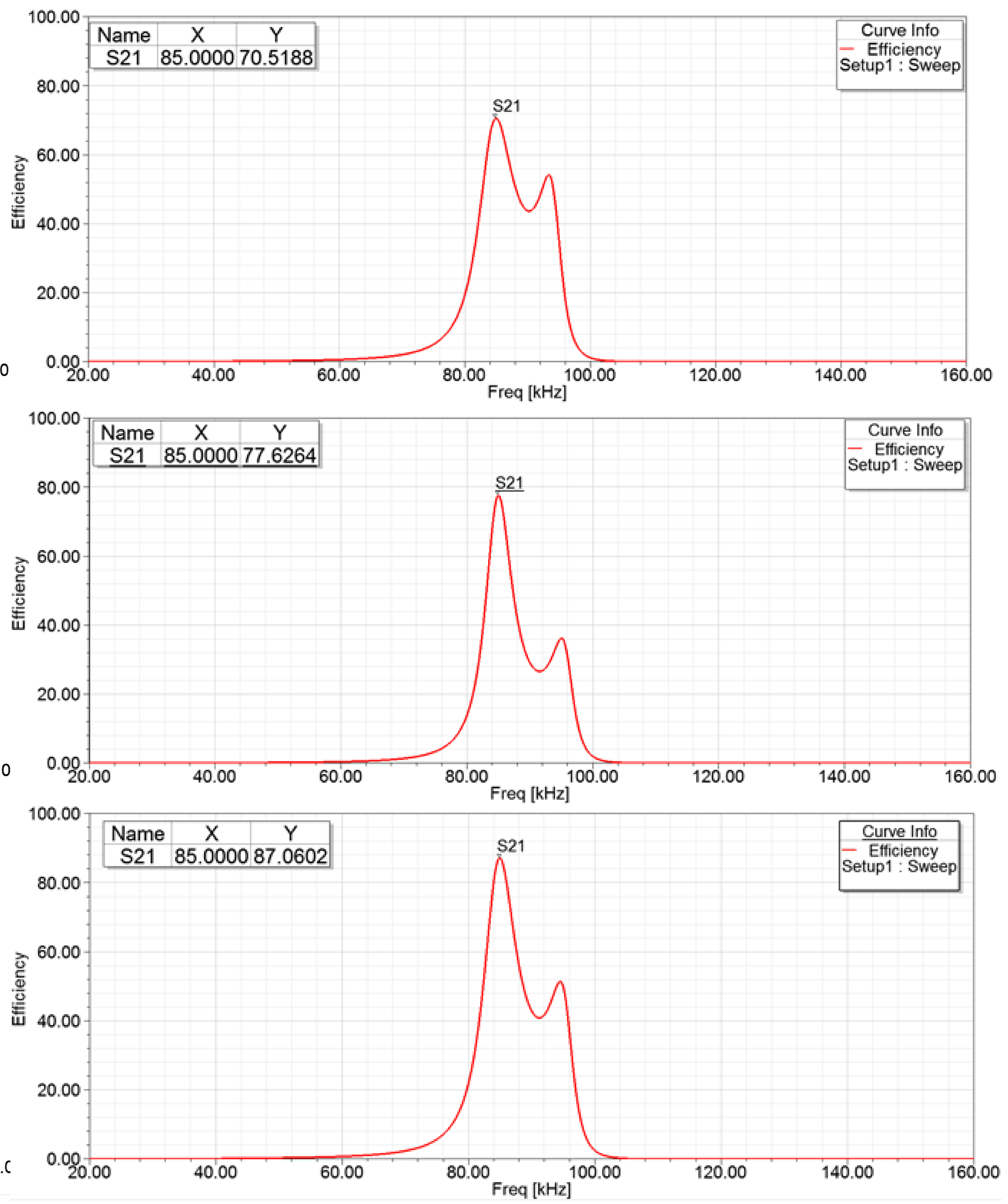
Conclusion

- In this paper, a spiral-type superconducting resonance coil for maximizing the efficiency of wireless power transmission is proposed and analyzed.
- As the transmission resonant coil was laminated, the increase in efficiency was confirmed when a superconductor was applied. Due to the laminated structure, the efficiency was confirmed to be about 7% higher than that of the conventional single layer, and was increased by about 16% when a superconductor was applied.
- Based on the analysis results presented in this paper, it can be concluded that the wireless power transmission efficiency can be maximized when the superconducting spiral-type resonant coil is applied to electric vehicles.
- In addition, it is thought that rapid charging will be made possible by the application of a superconductor during wireless power transmission.

Simulation results



< S – Parameter according to Transmission Coils>



< Efficiency according to Transmission Coil>

- The lower the reflection coefficient and the higher the transmission coefficient, the better the efficiency.
- The transfer factor can be used in the program to indicate efficiency.

$$\eta\,\% = (mag(S(T2,T1)))^2 \times 100$$

< Efficiency measurement method using HFSS program >

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Î˝˝	‚¸¸ʼßˇ	‚¸˛˘¯	‚¸ˇʼˏß
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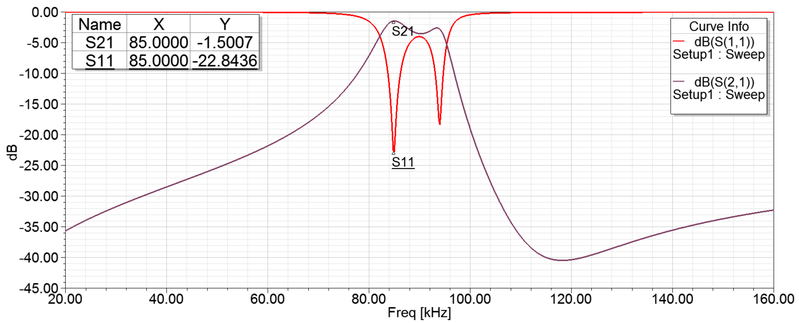
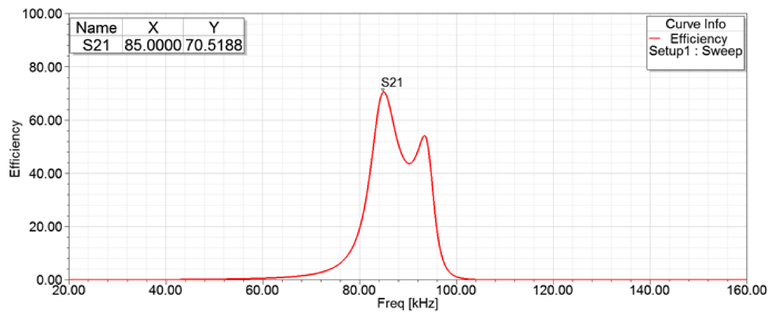
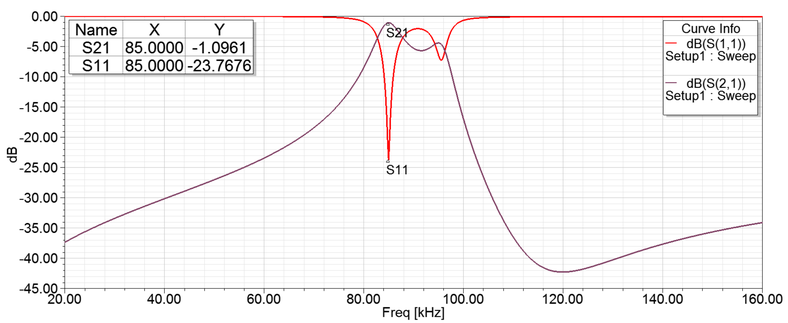
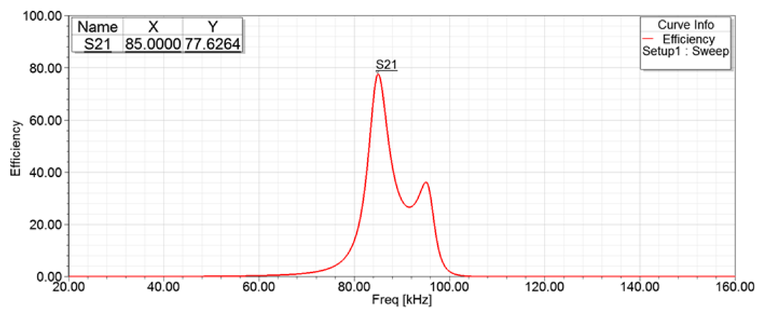
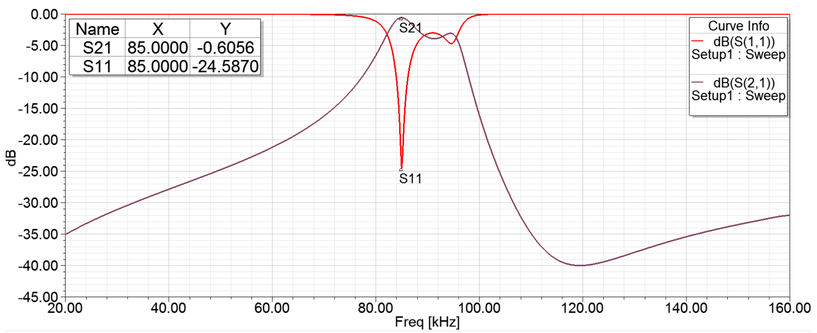
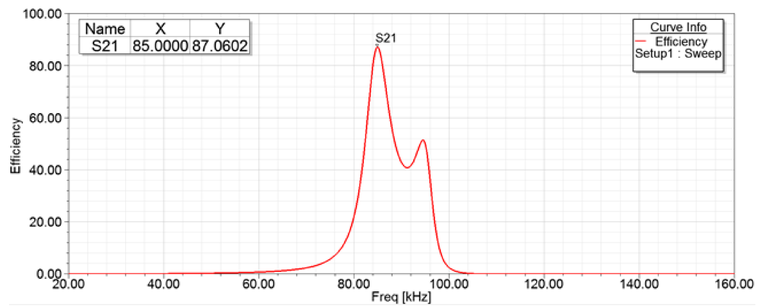

Name X Y
S21 85.0000 -1.5007
S11 85.0000 -22.8436
Curve Info
dB(S(1,1))
Setup1 : Sweep
dB(S(2,1))
Setup1 : Sweep
S21
S11
dB
Freq [kHz]


Name X Y
S21 85.0000 70.5188
Curve Info
Efficiency
Setup1 : Sweep
S21
Efficiency
Freq [kHz]


Name X Y
S21 85.0000 -1.0961
S11 85.0000 -23.7676
Curve Info
dB(S(1,1))
Setup1 : Sweep
dB(S(2,1))
Setup1 : Sweep
S21
S11
dB
Freq [kHz]


Name X Y
S21 85.0000 77.6264
Curve Info
Efficiency
Setup1 : Sweep
S21
Efficiency
Freq [kHz]


Name X Y
S21 85.0000 -0.6056
S11 85.0000 -24.5870
Curve Info
dB(S(1,1))
Setup1 : Sweep
dB(S(2,1))
Setup1 : Sweep
S21
S11
dB
Freq [kHz]


Name X Y
S21 85.0000 87.0602
Curve Info
Efficiency
Setup1 : Sweep
S21
Efficiency
Freq [kHz]