Maximum Transfer Efficiency of Wireless Power Transfer System

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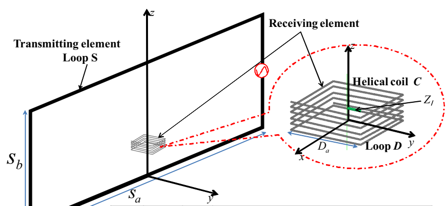
1 Introduction

Wireless power transfer (WPT) is interested again because of its potential application to charge laptops, cell-phones, household robots, MP3 players and other portable electronics without cords. A practical WPT system has been proposed and the parametric study of transfer efficiency of the above WPT system and the effect from a nearby human body have been carried out in [1]-[3] by present authors. The optimum load for maximum transfer efficiency of wireless power transfer system will be presented in detail in this report by using S-paramters.

2 WPT System

A rectangular loop S and a square loop D with a parasitic square helical coil C are used as the transmitting element and receiving element, respectively. All elements are made of copper wire (σ=5.8 × 10^7S/m) which has radius of 2 mm. As described in [2], the power is transfered efficiently between two loops when they resonate at the same frequency of 19.22MHz.



S_a [m]	S_b [m]	D_a [m]	Helix C Side length [m]	Pitch[m]	Turn number
6	2	0.3	0.3	0.02	5

図 1 Proposed WPT system

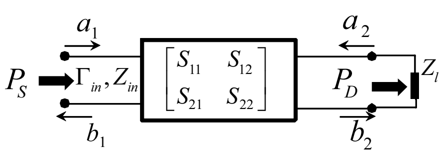


図 2 Equivalent 2-ports network

The WPT system shown in Fig. 1 can be equivalent to a 2-ports lossy network shown as in Fig. 2, where the transmitting port is defined as port 1 and the receiving port is defined as port 2. Therefore, the transfer efficiency between port 1 and port 2 is

$$\eta = \frac{|s_{21}|^2 \left(1 - |\Gamma_l|^2\right)}{|1 - s_{22}\Gamma_l|^2 \left(1 - |\Gamma_{in}|^2\right)}, \qquad (1)$$

where Γ_l is the reflection coefficient related with the

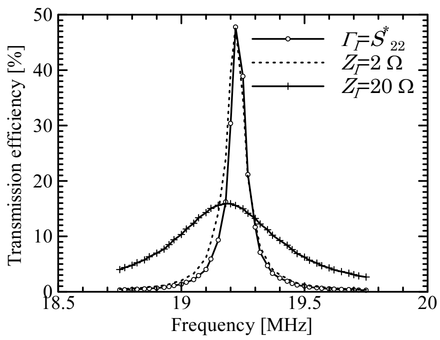


図 3 Transfer efficiency with different loads

load impedance and defined as

$$\Gamma_l = \frac{Z_l - Z_0}{Z_l + Z_0}, \qquad (2)$$

and Γ_{in} is the reflection coefficient at the port 1 and defined as

$$\Gamma_{in} = s_{11} + \frac{s_{12}s_{21}\Gamma_l}{1 - s_{22}\Gamma_l}, \qquad (3)$$

where s_{11}, s_{21}, s_{12} and s_{22} are the scattering parameters which can be obtained by MoM simulation or measurement, Z_0 is the characteristic impedance and is set to be 50 Ω. If the mismatching at the transmitting port or port 1 is omitted, the maximum transfer efficiency can be achieved when the load is satisfied with the following matching condition,

$$\Gamma_l = s^*_{22}. \qquad (4)$$

The transfer efficiencies for Z_l=2Ω, Z_l=20Ω and Γ_l=s^*_{22} are compared in Fig. 3, showing the transfer efficiency achieving the maximum when Z_l=2Ω or Γ_l=s^*_{22}. Because the reflection coefficient when Z_l=2Ω is almost satisfied the matching condition Γ_l=s^*_{22}, the transfer efficiency when Z_l=2Ω approaches to the maximum.

3 Conclusion

The optimum load for maximum transfer efficiency of wireless power transfer system has been presented by using S-parameters when the WPT is regarded as 2-ports network. This approach can be applied to the WPT at the presence of human body and other non-resonant objects.

References [1] 袁 巧微, その他, 2008 年総合大会講演論文集, B-1-214. [2]Q. Yuan, et al, ISAP'08. [3] 袁 巧微, その他, AP2008-91, p.95-99, 2008 年 9 月.