小型アンテナと共振型無線電力伝送技術に関する比較研究

Comparative study of small antenna and resonance-type wireless power transmission technology

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Abstract This paper compares the antennas for communication use and power transmission(WPT) systems as employing a small antenna technology. Antenna design for communication use is simple and basic characteristics are determined in almost the size. But it becomes very complex considering for mobile antenna. WPT system antenna design is complex because of using near field and coupling. Characteristics are determined by the antenna structure. Therefore, it is necessary to design according to the application.

.Keyword　small antenna, wireless power transmission

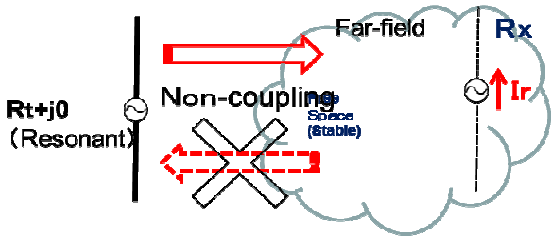
キーワード ワイヤレス電力伝送，電界結合

1. Introduction

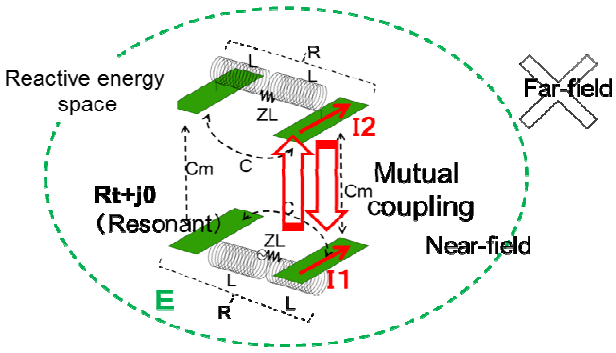
Wireless power transmission(WPT) is very important technology in order to realize a ubiquitous society. In this society, every kinds of equipment or everywhere people can communicate with each other. Thus, the energy to communicate is needed in any situation or any equipment. Wireless power transmission is a very effective technique to provide the energy to a communication device without the power unit. Recently, strong-coupled wireless power transmission technology is proposed and demonstrated(1)(2). On the other hand mobile communication technology is already a major contribution in modern society. In this technology a small antenna is used for mobile phones(3). Both are the same of the using a small antenna technology, but design technologies are quite different from the purpose and use. This paper compares these two techniques. This provides to be promoted each optimal antenna design. And It is intended to and assistance for enhancing design technology of small antenna.

2. Comparison of the basic technology

The biggest difference between the two is the operation mode and electrical quantity to handle. Communication antenna deals with Information but WPT antenna handles electric power. Next, the operating state is different. The former is basically one antenna for transmitting or receiving antenna In each time, but the latter using the two antennas as a set for power transmitting. Figure 1 is operating principle. The role of communication antenna is well radiating or receiving a RF signal waves from the space. Space is a very stable space without the near object Inference. The role of WPT antenna is in the power transmission to the port from the port. In other words, it is the same as the power cable. The characteristic varies with structure and relative positions of each antenna for using space coupling. It is most important to obtain high transmission efficiency over long distances.



(a) Communication antenna



(b) Resonance WPT Antenna

Fig.1 Operating principle comparison

Table 1 shows a comparison for the characteristic item. The most significant difference is fields to the operation. For this reason, the detailed structure of the antenna

affects the characteristics on WPT system. Approximate characteristic is determined in antenna size on communication antenna. Therefore, WPT antenna is necessary to design the structure in detail In order to obtain high efficiency even a small antenna,.

Table 1 Rough comparison of small communication antenna and WPT antenna system

	Small antenna	WPT
Resonant state	Self resonant antenna	Coupled resonant
Transmission distance (to λ)	Long distance	Short distance
Freedom of Rx	Relatively high (broad radiation pattern)	Fairly limited (changes in the coupling state)
Transmission method	Far-field (free space transmission)	Near-field (coupled transmission)
Effect of Antenna structure	not too much(only, size and polarization)	large impact(electric or magnetic coupling ,etc.)
Influence in the vicinity object	Major impact	Major impact
Outer radiation	Strong structure	Suppression structure
Output characteristic	Broadband and high linearity	Nonlinearity allowed (but, noise suppression)
Interface with the circuit	Zin=50Ω(Usually)	Not determined
Main Evaluation criteria	Error rate, transmission speed(including modulation, error correction technology, etc.)	Power transmission efficiency (including AC/DC converter, etc.)

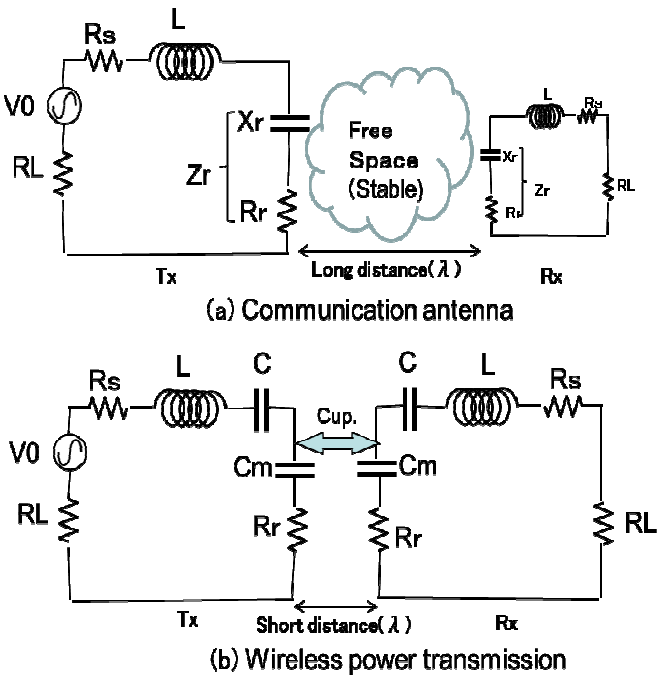


Fig.2 Equivalent circuits of small and WPT antenna system

In both antennas using the equivalent circuit is made in Figure 2. They are necessary to interface with the circuit to actually use.

3. Small antenna design guidelines

A basic design concept is relatively simple. But small communication antenna is greatly influenced by the surrounding material. Consideration with the impact of the human body and implementation in mobile telephone complicates the antenna design. Basic small antenna characteristics substantially determined by only the size of antenna. Fig.3 and Fig4 show typical small dipole antenna and radiation impedance. Small antenna has very low resistance and high reactance in absolute value. Radiation resistance Energy consumed by Rr is an energy that is radiated into space. Rr decreases rapidly in both antenna size

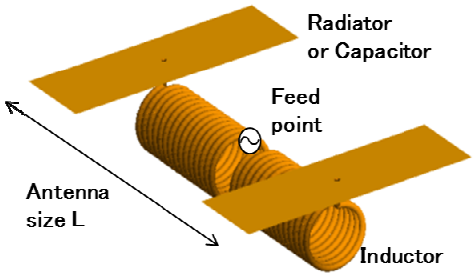


Fig.3 Small dipole communication antenna

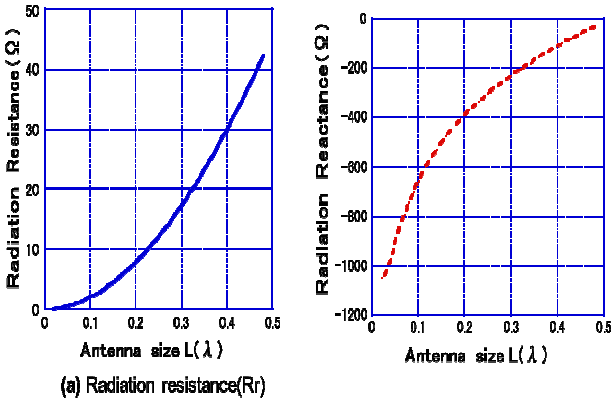


Fig.4 Radiation impedance characteristics of small antenna

On the other hand, radiation reactance rapidly increases in both antenna size Therefore, It have to be connect the opposite reactance(L or C) to the antenna for Input reactance going to zero(resonant). Ratio of Rr and Resistance (Rloss) of L or C is the basic antenna efficiency Antenna efficiency shoes Figure 5. Antenna size (at a wavelength ratio) is small as rapidly efficiency deteriorates rapidly.

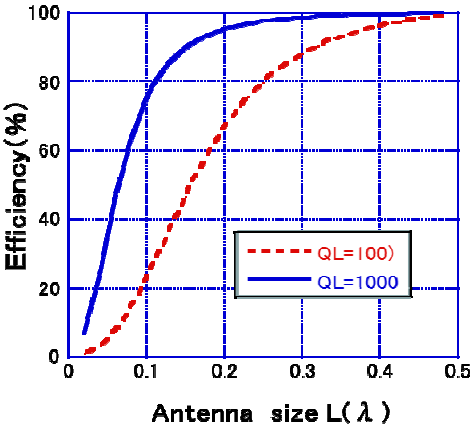


Fig.5 Radiation Efficiency characteristics of small antenna

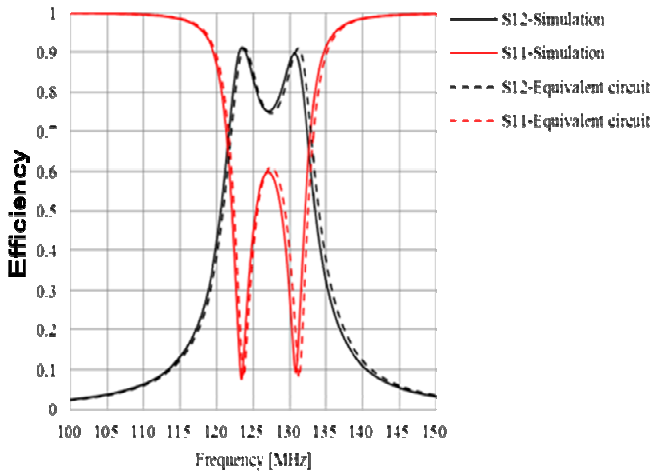


Fig.7 Efficiency characteristics on the frequency (D=5cm)

4. WPT antenna design guidelines

Antenna characteristics depend on the detailed structure So, It decided to show representative example.

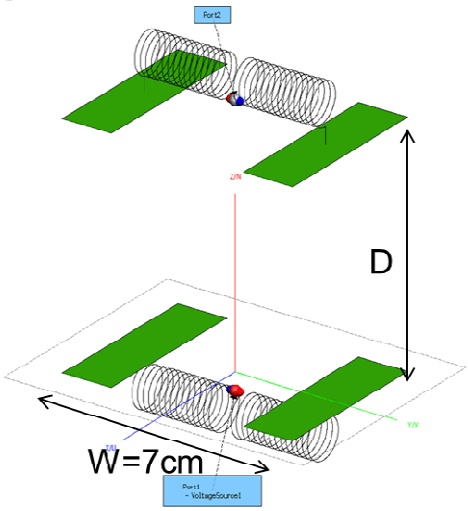


Fig.6 Electric coupling WPT system

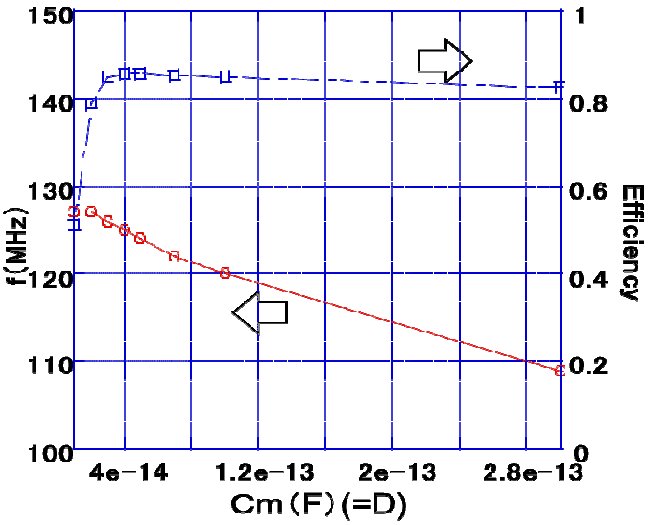


Fig.8 Cm(=D) and efficiency depend on frequency

Fig.6 shows one of WPT system using electric coupling type. Antenna element is the same as small antenna (as shown in Fig.3). Transmission characteristics on frequency are shown in Fig.7.

High efficiency is dependent on the frequency. It is much lower than cable at 90% on maximum. Loss of LC, far-field radiation and leakage electric field are this cause. The frequency obtained the maximum efficiency is as illustrated in Fig.8. These results are derived from the equivalent circuit. Because the horizontal axis is in coupling capacitance, it indicates that the far left as the distance D.

it can be seen that a change in the frequency of the maximum efficiency with changing the distance D. Then the maximum efficiency is determined by the frequency and distance. It means Rx antenna is fixed by operating frequency and there is no degree of Rx freedom.

On the other hand, the input impedance is also changed in the load resistance of the Rx antenna. Figure 9 shows efficiency characteristics on RL and frequency. It is clear that efficiency is depending on load resistance RL. WPT system is not sending the accurate signal Therefore, practically good method, It seems to be

connecting Matching circuit of a variable shape corresponding to the frequency and load variation. Means for practical use of WPT system, it appears to be that used to fixed secure the transmission and reception antenna or adding a variable mechanism.

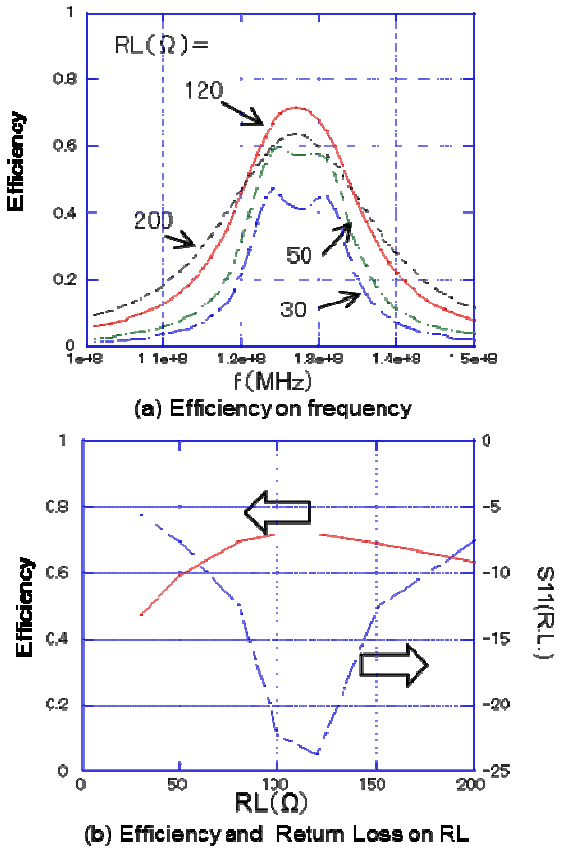


Fig.9 Efficiency depend on RL

5. Conclusion

This paper compares the antennas for communication use and power transmission (WPT) systems as employing a small antenna technology. Antenna design for communication use is simple and basic characteristics are determined in almost the size. But it becomes very complex considering the human body, surrounding object and peripheral product (implementation) for mobile antenna. WPT system antenna design is complex because of using near field and coupling. Characteristics are determined by the antenna structure. Therefore, it is necessary to design according to the application. And it seems to be need adding the some kind of auto-adjustment function (As an example, variable matching circuit or frequency tuning etc.). This paper briefly described these things.

References

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