Energy Multiplier in Retarded Resonance

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Abstract

In this work, we describe a wireless power system in which the distance between the source and receiver is ¼ of wavelength. The induced electromotive force (EMF) from the receiver to the source is phase inverted due to the retardation so that the source absorbs energy instead of output energy. This system is an energy multiplier since both source and receiver gain energy.

Keywords: *energy multiplier*, *retarded resonance*

Introduction

Wireless power transmission has been a promising technique since the innovative work at MIT [1,2]. It is usually assumed that the energy is supplied immediately from the source to the receiver. However, this assumption is not correct. The retardation must be considered in remote resonance. A general description revealed that the energy transferred forth or back through the source is determined by the retarded phase [3]. In this work, we indicate that the source absorb energy instead of output energy when the distance between the source and receiver is ¼ of wavelength. Such a system is an energy multiplier.

Methods and results

Suppose we have a system composed of two circuits and one power source. As shown in Fig.1, the first coil is connected to the power source and the second coil is placed at distance r_{12}.

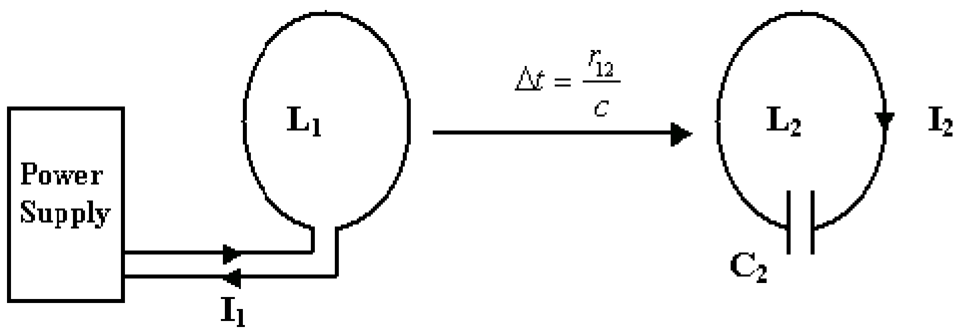

Figure1: Two resonant circuits at distance r_{12}. The circuit 1 is connected to a power source. The circuit 2 is composed of a coil and a capacitor.

The second coil is connected with a capacitor so as to resonate with the first coil. When the power source is turned on, there is current $I_1(t)$ in the first coil. The electromotive force $\varepsilon_2(t)$ in the second coil induced by $I_1(t)$ is calculated by [4]

$$\varepsilon_2(t) = -\frac{\mu_0}{4\pi}\frac{d}{dt}\oint\oint\frac{I_1(t-\frac{r_{12}}{c})\cdot ds_1}{r_{12}}\cdot ds_2 = i\omega M\cdot I_1(t-\frac{r_{12}}{c}) \tag{1}$$

where ω is the angular frequency, M is the mutual inductance between the two circuits,

$I_1(t-\frac{r_{12}}{c})$ is the retarded current in circuit 1, ds_1 and ds_2 are current elements. The

induced current $I_2(t)$ in the second coil is $\frac{\varepsilon_2(t)}{R_2}$, where R_2 is the impedance of the second coil. The consumed power $P_2(t)$ in the second coil is

$$P_2(t) = I_2(t) \cdot \varepsilon_2(t) = \frac{\omega^2 M^2}{R_2} I_1(t - \frac{r_{12}}{c}) \cdot I_1^*(t - \frac{r_{12}}{c}) \quad (2)$$

Consequentially, the electromotive force $\varepsilon_1(t)$ in the first coil induced by $I_2(t)$ is [4] :

$$\varepsilon_1(t) = -\frac{\mu_0}{4\pi} \frac{d}{dt} \oint \oint \frac{I_2(t - \frac{r_{12}}{c}) \cdot ds_2}{r_{12}} \cdot ds_1 = i\omega M \cdot I_2(t - \frac{r_{12}}{c})$$

(3)

where M is the mutual inductance and $I_2(t - \frac{r_{12}}{c})$ is the retarded current in circuit 2. The power $P_1(t)$ extracted from the source is determined by

$$P_1(t) = I_1(t) \cdot \varepsilon_1(t) = \frac{\omega^2 M^2}{R_2} I_1(t) \cdot I_1^*(t - \frac{2r_{12}}{c}) \quad (4)$$

When the distance r_{12} is equal to ¼ of wavelength, we have

$$\frac{2r_{12}}{c} = \frac{T}{2} \quad (5)$$

where T is the period of the wave, then

$$P_1(t) = -\frac{\omega^2 M^2}{R_2} I_1^2(t) \quad (6)$$

We see that $P_1(t)$ is always negative. The positive value of $P_1(t)$ represents energy flow out of the source. The negative value denotes energy flow inward the source.

In retarded resonance with distance of quarter wavelength, the receiver gains energy via EMF from the source and the source also gains energy via EMF from the receiver. This system becomes an energy multiplier.

Conclusion

In retarded resonance, the energy extracted from the source is determined by the retarded phase on the route. When the distance between the source and the receiver is ¼ of wavelength, the extracted energy from the source is negative. In that case, the source supplies EMF to the receiver without energy delivered. In the mean while, the current in receiver feed EMF back to source with inverted phase resulting to energy absorption in the source. The total energy of the system is increased since both source and receiver gain energy.

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