The Effect of Retarded Phase Factor in Single Wire Power Transmission

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Abstract

In this paper, we studied the effect of retarded phase factor in single wire power transmission. It is indicated that the effective resistance of load is negative when the length of wire is one quarter of wavelength. The loading current acts like a driving source to charge the transmitter so that the oscillating power of transmitter is amplified. It is anticipated that this technology can be used to generate electric power.

Keywords: single wire power transmission, retarded phase factor, negative resistance

Introduction

Nikola Tesla invented the technology of single wire power transmission in 1897 [1], which is different from conventional transmission line. Recently we have studied the effect of retarded phase factor in wireless power transmission [2-4]. In this work, we extend our study to single wire power transmission. We find that the effect of retarded phase factor also exists in single wire and it results in an enhanced effect than wireless systems.
**Methods**

The schematic of single wire power transmission is shown in Fig. 1. The transmitter on the left is composed of a power source $V$ and a transformer $T_1$. The receiver on the right is composed of a transformer $T_2$ and a load $R_L$. The length of wire is $D$.

![Figure 1: Schematic of single wire power transmission.](image)

The driving voltage propagates along the wire via the wave of electric density. Due to retardation on the wire, the driving voltage on $T_1$ and $T_2$ has the relation of

$$U_2(t) = U_1(t) \cdot \psi$$

(1)

where $U_1(t)$ and $U_2(t)$ is the driving voltage on $T_1$ and $T_2$ respectively and $\psi$ is the retarded phase factor:

$$\psi = e^{-i2\pi \frac{D}{\lambda}}$$

(2)

The current in $T_2$ is

$$I_2(t) = \frac{U_2}{R_L}$$

(3)

The current in $T_1$ is
\[ I_1(t) = I_2(t) \cdot \psi = \frac{U_1}{R_L} \cdot \psi \cdot \psi \]  

The effective resistance on T\(_1\) is

\[ R_1 = \frac{R_L}{\psi \cdot \psi} \]  

When the length D is short, \( \psi \approx 1.0 \), we have \( R_1 = R_L \). When the length D is equal to one quarter of wavelength, \( \psi = -1.0i \), we have \( R_1 = -R_L \). The effective resistance of load seen from the power source is negative. In this case, the phase of \( I_1(t) \) is inverted relative to the phase of \( U_1(t) \) and the electric power would flow into instead of out of the source.

**Conclusion**

In a single wire power transmission system, the current and voltage propagate along the wire via the wave of electric density. The effective resistance of load is negative when the wire length is \( \frac{1}{4} \) of wavelength. In this case, the loading current acts like a driving source to charge the transmitter. This technology can be used in the field of electric power generation.

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References


