Wireless Power Supply Technology for Running Vehicles

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(Key words) electric vehicle, wireless power supply, electricity supply in running state

1. Wireless power supply technology

Wireless power supply is already in use by cell phone terminals, some home appliances, and industrial equipment, etc. There are two types of wireless power supply technology: the electromagnetic induction method and magnetic resonance method. Many systems now in practical use are based on the electromagnetic induction method. And among wireless power supply technologies used around the world, the greatest efforts are directed to adopting the magnetic resonance method because of its characteristics, which include the ability to lengthen the distance from the supplier side to the supplied side, and the high degree of freedom of positioning it permits. Research is now being done to expand the distance between supplier and supplied sides and to transmit more power.

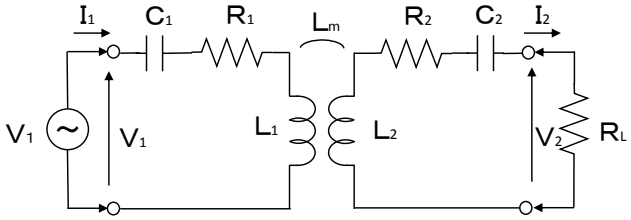
The NILIM has been cooperating with the University of Tokyo to develop and verify magnetic resonance technology that can supply electric power to and charge an electric automobile while it is running, and has confirmed that it is possible to stably supply power while running at the model level. A power transmission/reception unit with diameter of 35cm was used, successfully transmitting electric power on an actual road over the hypothetical gap of about 80cm.

2. Equivalent circuits of wireless power supply technology

The magnetic resonance method consists of series resonance circuits on both the power transmitting and receiving sides to transmit power in resonant state. The equivalent circuit of the magnetic resonance method consists of RLC series circuit configuration on both the primary side (power transmitting side) and the secondary side (power receiving side) as shown in Figure 1. L_1 and L_2 represent reactance of the coils, C_1 and C_2 represent the resonance use capacitance, R_1 and R_2 represent line resistance, and L_m is the mutual impedance between the coils on the power transmitting side and power receiving side, and these vary according to the positional relationship of the transmitting side coil and the receiving side coil (automobile). And because the magnetic field is caused to resonate on the power transmitting side and power receiving side, the resonance frequencies on both sides conform, establishing the following formula.

Figure 1 Equivalent Circuits of the Magnetic Resonance Method

$$\omega_0 = \frac{1}{\sqrt{L_1 C_1}} = \frac{1}{\sqrt{L_2 C_2}}$$



The magnetic resonance method can transmit power even when the axis of each coil on the power transmitting and receiving sides are not straight. This is related to the mutual inductance L_m in Figure 1. And it was shown that during wireless power supply while running, when L_m varied continually, even if the values of voltage and current transmitted to the power receiving side change, the phase itself does not change.

3. Supplying electricity for running vehicles

Wireless power supply now in use is done with the positions of the power transmitting side and power receiving side fixed, so the circuit should be turned on or off after making sure that the power transmitting side and power receiving side are in their preset positions. Using wireless power supply technology of an electric vehicle, while it is running on the other hand, it is necessary to perform switching only when the vehicle being supplied is in a place where power can be transmitted, and it consists of a circuit that is a parallel resonance circuit with infinitely high impedance when there is no vehicle, and is a series resonance circuit with impedance of zero when there is a vehicle, and it is necessary to confirm or verify electric power at or above a certain degree.