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Research Article

Key Technical Research on Power Electronics and Information Transmission System

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Abstract: Power electronics is a new technology of power transmission and control. Compared with the traditional power transmission, non-contact power transmission has the advantages of low wear rate, safety, reliability, convenience and flexibility. In this way, it avoids the problems of friction, wear, aging and so on in the traditional power supply mode, saves a lot of wires, makes up for the shortcomings of the traditional power transmission mode, and has a wider application range. Therefore, it is of great practical significance to study the key technology of power electronic information transmission for promoting the intelligent development of power transmission in China.

Keywords: Power electronics; Information transmission; Technology application

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1 Principles to be followed in power electronic information transmission

1.1 Timeliness principle

For electronic information data, its obvious characteristic is that it has strong timeliness. Electronic information data are all real-time information data. Because of this characteristic of electronic information data, electronic information plays a more important role than other information. Therefore, the principle of timeliness should be followed in electronic information data transmission. That is to say, the relevant electronic information data should be able to achieve real-time transmission, to ensure the timeliness of these information data, so as to make these electronic information data get better application in practice and play the due value of electronic information data.

1.2 Safety principle

In the process of electronic information data transmission, it mainly uses computer network for transmission. The network virus and network intrusion in the computer network will affect the security of data transmission, resulting in the destruction of electronic information data. Therefore, in the electronic information data transmission, we need to pay attention to the principle of security. Thus effective preventive measures should be taken to ensure the security of transmission, to guarantee the better transmission and application of electronic information data, so that its role can be better played.

2 Wireless energy transmission method of power electronics

2.1 Wireless transmission of magnetic coupling and resonant mode

The basic principle structure of the magnetic-coupling resonant-mode wireless energy transmission method is shown in Figure 1. The system consists of two parts: power terminal and load terminal. The power terminal includes a high frequency power supply which provides electric energy and a coil which is wound by a wire and paralleled with a capacitor. The receiving terminal includes a load and another coil in parallel with the capacitor. The capacitors at both ends are connected with the inductors to form a resonant body. The energy of the resonant body oscillates freely in space at the self-resonant frequency, generating a time-varying magnetic field and exchanging energy at the same

frequency.

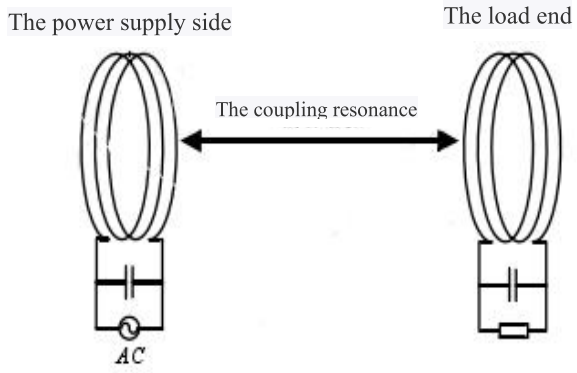

Figure 1. Wireless energy transmission structural diagram of magnetic coupling and resonance mode

The source coil generates a time-varying magnetic field around the inductance through the AC current of the main line, and charges the capacitor at the same time; the receiver coil induces a magnetic field, generates an electromotive force, and the secondary capacitor is charged. When the current direction of the primary coil changes, the direction of the alternating magnetic field also varies; the receiving coil generates the reverse electromotive force, and the parallel capacitor discharges; the current of receiving coil increases continuously, which provides energy for load and realizes wireless energy transmission. The magnetic field of the coil acts as the mutual inductance between the two coils. The influencing factors of the system include coil self-inductance, mutual inductance, resonance capacitance, coil resistance and load.

According to the law of total current, the magnetic field generated around the coil and the induced electromotive force generated by the receiving coil can be expressed as:

$$\nabla \times H_1 = J_1 + \frac{\partial}{\partial t} D_1 \tag{1}$$

In formula (1): E_2——Conduction current density of source coil;

$\frac{\partial}{\partial t} D_1$——Displacement current density of source coil;

H_1——Magnetic field strength around the coil.

$$\nabla \times E_2 = -\mu_0 \cdot \frac{\partial}{\partial t} H_{12} \tag{2}$$

In formula (2): J_1 —— Induction electric field strength of receiving coil;

H_{12}——Magnetic field of the hinge of source coil and receiving coil;

μ_0——Vacuum magnetic conductivity.

The receiving coil satisfies the Eigen equation of isotropic medium:

$$J_1 = \gamma \cdot E_2 \tag{3}$$

In formula (3): γ——the intensity of the induced electric field of the receiving coil. Assuming the system load is 0, the electromagnetic energy of the hinge between the source coil and the load coil is calculated by using the vector magnetic potential as follows:

$$W_2 = \int A_{12} \cdot J_2 \, dV \tag{4}$$

In formula (4): W_2—— alternately oscillating magnetic field energy / electric field energy of source coil and receiving coil;

A_{12}——Vector magnetic potential produced by the source coil at the position of the receiving coil.

Therefore, when the magnetic field is excited by a single frequency, the power expression is as follows:

$$Q := j\omega_1 \cdot M \cdot i_1 i_2 \tag{5}$$

In formula (5): ω_1——Angle frequency of magnetic field change excited by source coil;

$i_{1,2}$——Source and receiving coil current;

M——Mutual inductance between source coil and receiving coil.

2.2 Wireless transmission of microwave radiation mode

The system includes DC power supply, DC-RF converter, transmitting antenna and rectifying antenna. The microwave power generator converts the direct current into microwave energy, which is focused by the transmitting antenna and efficiently transmitted to the rectifying antenna. Microwave energy is transmitted to the rectifying antenna through free space, and converted into DC power through filtering, which supplies power for the load.

The conversion efficiency of DC-RF, transmitting efficiency of transmitting antenna, transmitting efficiency, receiving efficiency of receiving antenna and rectifying efficiency of rectifying circuit should be considered in microwave radiation WPT. Its total transmission efficiency is:

$$\eta := \eta_d \cdot \eta_r \cdot \eta_s \cdot \eta_t \cdot \eta_g \tag{6}$$

In the calculation, the transmitting and receiving efficiency of the antenna depends on the distribution design of the antenna aperture field. The conversion efficiency is mainly affected by the design of converter and rectifier circuit. The transmission efficiency of the microwave in free space can reach 100%. According to the calculation, the maximum receiving power is obtained:

$$P_m := \left(\frac{\lambda}{4\pi d}\right)^2 G_1 \cdot G_2 \cdot P_t = \frac{A_1 \cdot A_2}{\lambda^2 d^2} \cdot P_t \quad (7)$$

In formula (7): P_t—— Transmitting antenna power;

G_1, G_2——Gain of transmitting and receiving antenna;

A_1, A_2——Effective area of transmitting and absorbing antenna;

d —— Transmission distance;

λ—— Operating wavelength.

3 Underwater wireless signal transmission technology

3.1 Underwater wireless electromagnetic wave communication

Using water as medium, using electromagnetic wave of different frequency as carrier wave to transmit information, this communication mode is underwater wireless electromagnetic wave communication. Because the penetration depth of electromagnetic wave in the conductor with resistance is directly related to the frequency, the attenuation degree increases with the increase of frequency, and the penetration degree also decreases. Therefore, the transmission distance of short wave, medium wave, microwave and other infinite electromagnetic waves which can be normally transmitted on land will be greatly reduced in underwater communication. Now, the underwater electromagnetic wave communication which can carry out more effective information transmission mainly uses low frequency band, including VLF, SLF and ELF. These three bands have a short propagation distance and a small communication depth. In the process of propagation, the attenuation of low frequency band is relatively small, the reliability is high, and the environmental impact is also small.

VLF communication frequency range is 3-30 kHz, the wavelength is 10-100km, and it can penetrate 10-20 meters of sea water. But its signal strength is very low, the underwater target is difficult to receive, it needs to float to the receiving depth to be able to communicate, and its security is low. At present, it is still a more effective means of communication for submarine, which is widely used in the world.

SLF communication frequency range is 30-300Hz, the wavelength is 1000-10000km, and it can penetrate sea water about 100m deep. Its propagation attenuation in water is relatively small, and it is a one-way high reliability communication system. If more advanced receiving antenna and detection equipment are used, the band can achieve signal reception at 400m underwater, the communication distance can reach thousands of nautical miles, and the anti-interference ability is strong. However, the frequency band of ultra-low frequency communication is very narrow and the transmission rate is low, but it can only send signals to underwater targets in one way. In practice, only a few symbol combinations are used for simple communication.

The frequency range of ELF communication is 3-30Hz, and the wavelength is 10000-100000km. It can meet the safety depth of submarine when it is submerged. This mode of transmission is stable and reliable, but the transmission rate is slow. Thus only simple communication can be carried out. ELF is the only technical means of submarine for underwater safety communication, which is not affected by the environment. It is an important means of underwater communication. Through the development of superconducting antenna and superconducting coupling device, and the improvement of radiation efficiency of transmitting antenna, the underwater infinite electromagnetic wave communication can further improve the transmission efficiency and transmission rate. This is also a widely used means of underwater communication.

3.2 Underwater acoustic communication

Underwater acoustic communication is a means of underwater information transmission using acoustic wave, which is widely used in long-distance underwater communication at present. The attenuation of sound wave in water is smaller, and the propagation distance in sea water is far greater than that of electromagnetic wave, which can achieve relatively high frequency information transmission. Underwater acoustic communication transforms information into electrical signal, then uses encoder for digital processing, and then uses underwater acoustic transducer to transform

into acoustic signal, and transmits the information carried to the receiving terminal. In the opposite way, the acoustic signal is reduced to electrical signal and decoded.

3.3 Underwater magnetic resonance communication

Magnetic resonance wireless transmission technology uses the change of electric field between two electrode plates to transfer electric energy. It has no directional selectivity, and the transmission speed is faster and the distance is farther. However, this technology is still in the stage of research and development, which is a long way from practical application.

Magnetic resonance communication can realize long-distance and high-speed two-way communication. Different from the transmission methods of sound and light, MRC can realize encryption and covert transmission, and can meet more requirements of information transmission, as shown in Figure 2. Because the propagation rate of this method can reach the same rate as that of electromagnetic wave, it is possible to realize instant communication in practical application. This can play a great role in underwater emergency communication and other applications, and the faster propagation speed also greatly reduces the Doppler Effect. In the process of multi-path transmission, the energy can be converged, and only a small part of the energy will have radiation attenuation.

The channel quality of MRC is less affected by the environment, and water quality and external biological factors have little influence on the channel transmission. Comparatively speaking, the way of communication with light and sound as the medium is easy to be polluted by light or influenced by biology. Therefore, the noise level of MRC can be kept at a lower level.

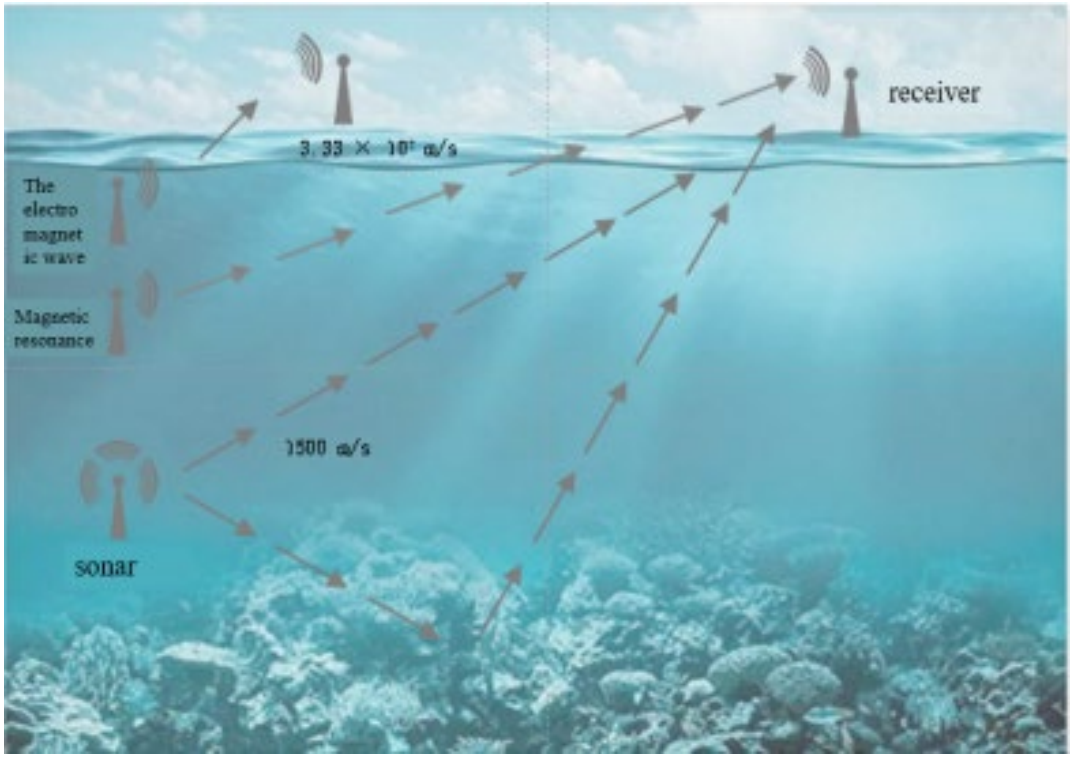

Figure 2. Transmission path diagram of magnetic resonance underwater communication

4 Space modulation technology

The MIMO system of modern wireless communication technology can improve the channel capacity and spectrum utilization rate without increasing the total transmission power of the system bandwidth antenna. But this technology also has some limitations and shortcomings. This capacity gain of the system is limited by the spatial position of the antenna, the synchronization of the transmitting antenna and the degree of the interference cancellation between the channels at the receiving terminal. However, the solution to this limitation is space modulation technology.

Space modulation technology maps a fixed amount of information into a signal and transmits it through

an antenna. Based on the traditional modulation, the spatial dimension is added, so that the spatial position can also be used as an information source to transmit information. This modulation mode enables flexible selection of the modulation order and the number of transmitting antennas on the premise of ensuring a certain rate of spectrum utilization. For example, when transmitting 3bits data, you can choose either 4-antenna and BPSK modulation mode, or 2-antenna and QPSK modulation mode.

Because the transmitted signal includes not only the transmission symbol, but also the actual physical location of the transmitting antenna, the receiver needs to detect and demodulate the symbol at the same time. If there is an error in the serial number detection of the antenna, the receiver cannot recover the original information accurately. Therefore, the detection algorithm of antenna sequence number is an important part in the research field of space modulation technology. At present, spatial modulation technology has begun some practical applications in the communication system, such as digital modulation, signal processing at the receiving and transmitting terminals, estimation of the link and system capacity, and operation of wireless system. Moreover, it will further develop more new ideas and applications.

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