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An Optimisation Technique for Enhancing Ultrasonic Wireless Power Distribution Performance During Information Exchange

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Introduction

Ultrasonic waves have a high potential for wireless energy transmission and information transfer inside and outside of sealed metal devices due to their excellent directivity, high penetrability, and lack of electromagnetic shielding. Traditional ultrasonic-based energy transmission methods, on the other hand, typically result in significant energy consumption due to impedance mismatch during communication impedance modulation. This paper describes an optimal design method for transferring energy efficiently during ultrasonic communication. Only the acoustic-electric channel scattering parameters are used to create the channel equivalent circuit model.

During communication, the equivalent circuit model performs channel impedance matches with a weak mismatch state. As a result, the impedance modulation effect is maintained while the energy transmission efficiency is reduced. Finally, the 11 mm thick 304 stainless steel plate is used for simultaneous energy transmission and impedance modulation. The modulation rate is 10 Kbps, and the transmission power is 37.86 W with a transmission efficiency of 45.75%. When compared to traditional methods, our proposed energy transmission efficiency is 17.62% higher. The results validate the proposed method's effectiveness and the model's high accuracy. The proposed method has a wide range of engineering applications and potential applications in the condition monitoring of metallic environments.

Description

Modern equipment, such as engines, nuclear material containers, missiles, submarines, and space stations, are shielded by sealed metal structures to withstand extreme temperatures and pressures, as well as special use requirements. In some cases, such as the health monitoring of aero engines and the wireless power and data transmission between some sealed compartments of submarines, the equipment must penetrate the sealed metal casing to transmit necessary data and energy during long-term operation [1-3]. The sealed metal shell structure, on the other hand, seriously impedes the development of the aforementioned technology, which is primarily manifested in the power supply of the internal monitoring system and the reliable return of monitoring data.

Perforation is used in conventional technology for power supply and data transmission. This will put the structure's strength and sealing design to the test. Ultrasound, on the other hand, has a high energy density, good directionality, and no electromagnetic shielding effect. Furthermore, the piezoelectric ceramics used to generate ultrasonic waves have acoustic impedance similar to metal [4,5]. As a result, ultrasound for energy transmission and communication has a wide range of applications in the internal state monitoring of sealed metal equipment. To achieve communication from inside to outside while transferring energy from outside to inside, the concept employs 2ASK modulation based on the impedance modulation technique.

Conclusion

Because this modulation method does not require a high-power carrier generation module for the internal system and the MOSFET is the key component for impedance modulation, the internal communication circuit is simple and consumes very little power. Since then, researchers have conducted more extensive and detailed studies. However, there are numerous obstacles to overcome in the development of this technology. Such as how to improve energy transmission efficiency, increase communication rate, and system integration and application. The channel transmission efficiency improves significantly after the SCIM, and 56.2 W of power is transmitted through the 9.53 mm thick HY-80 stainless steel plane. The efficiency of channel energy transfer (the ratio of channel output AC power to channel input power) is 70.8%. The efficiency of channel DC energy transfer (the ratio of channel output DC power to channel input power) is 19%.

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