

Design and Analysis of Magnetic Resonance Coupling for Wireless Switched Reluctance Motor Drives

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Abstract: Wireless Power Transfer (WPT) has emerged as a transformative technology for delivering electrical energy without physical interconnections. This paper presents a comprehensive design and analysis of a magnetic resonance coupling-based WPT system for Switched Reluctance Motor (SRM) drives. The proposed system eliminates the need for secondary-side converters, thereby simplifying system architecture and improving reliability in isolated and maintenance-free environments. A beamforming-based transmission approach is incorporated to enhance efficiency and directional power delivery. Simulation and analytical results demonstrate improved transmission efficiency, reduced losses, and enhanced operational flexibility compared to conventional systems

Keywords: *Wireless Power Transfer, Magnetic Resonance, Beamforming, Converter-less System., SRM Drive etc.*

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I. INTRODUCTION

Recently, wireless power supply devices which supply electric power wirelessly (in the medium of air) to apparatuses without power cables or the like have come to be in practical use. The principles upon which wireless electric power transmission is realized are generally categorized into three types: Electromagnetic induction type, Radio reception type and Resonance type.

Electromagnetic induction non-contact power transmission employs the phenomenon in which application of an electric current to one of adjacent coils induces an electromotive force in the other coil with magnetic flux as the medium. Wireless power transfer (WPT) is a breakthrough technology that provides energy to communication devices without the power units. With the remarkable progress being made recently, this technology has been attracting a lot of attention of scientists and R&D firms around the world. Recently, the usage of mobile appliances such as cell phones, PDAs, laptops, tablets, and other handheld gadgets, equipped with rechargeable batteries has been widely spreading.

Wireless Power Transfer eliminates physical wiring and improves flexibility in energy delivery systems. Switched Reluctance Motors (SRMs) benefit from WPT due to their robust design and reduced dependency on complex hardware

➤ Background and Theory

Wireless power transfer techniques include inductive coupling, magnetic resonance coupling, and radiative transfer. Magnetic resonance offers an optimal balance between efficiency and distance

II. LITERATURE SURVEY

Recent research focuses on converter-less SRM drives, resonant coupling, and beamforming techniques to improve efficiency and reduce complexity. For exemplification, a prototype is designed and constructed, which can provide WPT up to 150 mm transmission distance and achieve up to 72.8% transmission efficiency.

S. Sheik Mohammed, Faculty of Engineering, Dhofar University Wireless Power Transmission – A Next Generation Power Transmission System. In this paper, we present the concept of transmitting power without using wires i.e., transmitting power as microwaves from one place to another is in order to reduce the transmission and distribution losses. This concept is known as Microwave Power transmission (MPT). We also discussed the technological developments in Wireless Power Transmission (WPT). The advantages, disadvantages, biological impacts and applications of WPT are also presented. One of the major issue in power system is the losses occurs during the transmission and distribution of electrical power. As the demand increases day by day, the power generation increases

and the power loss is also increased. The major amount of power loss occurs during transmission and distribution. The percentage of loss of power during transmission and distribution is approximated as 26%. The main reason for power loss during transmission and distribution is the resistance of wires used for grid.

III. EXISTING SYSTEM

A novel class of wireless secondary-converterless switched reluctance motor (WSCSRM) drives is proposed and experimentally validated. The core innovation lies in the development of a dedicated wireless power transfer (WPT) system that directly energizes the SRM without requiring any motor-side power converter. This architecture is particularly advantageous for isolated and maintenance-free environments. By employing selective WPT, the SRM phase windings are sequentially energized through a single transmitter featuring a newly designed compound coil structure. Furthermore, duty-ratio modulation of the transmitter signals enables effective speed regulation of the WSCSRM. Comprehensive simulation and experimental studies confirm the feasibility of the proposed approach. A prototype system was constructed, achieving wireless

transmission over 150 mm with a peak power transfer efficiency of 72.8%, thereby demonstrating the practicality of the concept.

IV. PROPOSED SYSTEM

We introduce a novel energy beamforming technique employing a Class-E amplifier for magnetic resonant coupling-based wireless power transfer (WPT), designed to minimize unnecessary leakage flux. By controlling the phase differences of transmitting antennas, the delivered energy can be dynamically directed toward any desired orientation. A crossed-loop antenna configuration is demonstrated as the optimal structure for beamforming, owing to its minimal mutual coupling between the two transmitters. The receiver operates on principles analogous to radio reception, requiring proximity within the transmitter’s effective range. Through resonant magnetic fields, Witricity enables efficient electricity transfer while reducing power wastage. The present prototype system targets power transmission up to 100 W, and future consumer products leveraging this technology may be branded as “Witric” or “Witric’s.”.

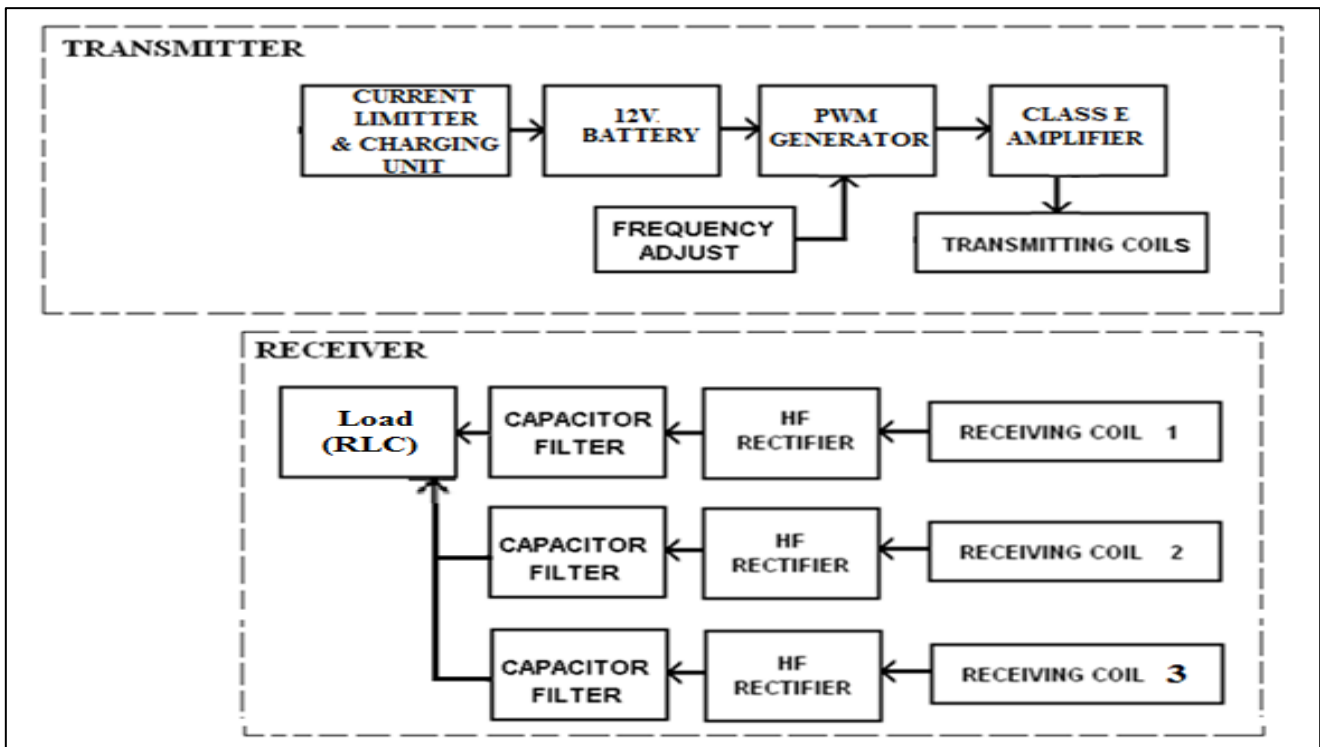


Fig 1 Functional Block Diagram of the System

➤ *Beamforming Technique:*

Beamforming is a signal processing method used to control the directionality of an antenna array during transmission and reception. By adjusting the phase and relative amplitude of signals at each transmitter element, a beamformer creates patterns of constructive and destructive interference in the wavefront, steering energy toward desired directions. On the receiving side, signals from multiple

sensors are combined to preferentially enhance the expected radiation pattern.

Conventional beamformers rely on fixed weightings and time delays (phasings) based solely on sensor geometry and target wave directions. In contrast, adaptive beamforming integrates this spatial information with the properties of the actual received signals, enabling dynamic suppression of interference and unwanted noise. Adaptation typically

follows a criterion such as minimizing output noise power, and can be implemented in either the time domain or the frequency domain. For wideband systems, frequency-domain processing is often preferred due to noise variation across frequencies.

Beamforming can be computationally demanding. For example, sonar phased arrays operate at relatively low data rates, allowing real-time software-based processing that can flexibly transmit or receive in multiple directions simultaneously. Conversely, radar phased arrays generate extremely high data rates, traditionally requiring dedicated hardware for single-direction operation. However, advances in field-programmable gate arrays (FPGAs) now enable real-time radar beamforming with reconfigurable architectures, effectively bridging the gap between hardware speed and software flexibility.

➤ *Wireless Power Transmission:*

Wireless power transmission is not a new concept. Nikola Tesla demonstrated the transmission of electrical energy without wires in the early 20th century using electromagnetic induction principles. Later, in 1964, William C. Brown successfully demonstrated a microwave-powered model helicopter, which received all the energy required for flight through a microwave beam. In 1975, he further achieved the transmission of 30 kW of power over a distance of one mile with an efficiency of about 84%, without the use of physical cables.

Over time, researchers have developed various techniques for transmitting electricity wirelessly over short and long distances. Some of these methods remain experimental or in the prototype stage, while others are already commercially available and widely used.

A common modern example is wireless charging for electronic devices. In this system, a device is simply placed on a charging pad, and power is transferred without any direct electrical contact. The charger is connected to a power supply, and energy is transferred to the device through electromagnetic fields, eliminating the need for physical connectors.

Earlier approaches to wireless power transmission, including Tesla's systems and microwave-based methods, relied on radiative power transfer. While radiative transfer is widely used in wireless communication, it is generally less suitable for efficient power transmission due to significant energy losses and its omnidirectional nature, which causes power to disperse in multiple directions

V. CONCLUSION

Wireless power transfer (WPT) offers a convenient and user-friendly solution for battery charging and powering electronic devices, eliminating the need for cables and connectors. Devices can simply be placed on a charging pad, making the process seamless and intuitive. Such systems hold strong potential to evolve into standardized charging platforms. By optimizing the coupling coefficient between

transmitter and receiver coils, overall system performance can be significantly enhanced. A key finding of this work is the demonstrated effectiveness of WPT with multiple receiving coils, which is highly practical for real-world applications. This paves the way for industry adoption of high-efficiency wireless charging systems for mobile consumer electronics.

From an efficiency perspective, wireless resonant power transfer is feasible for general applications only when transmitter and receiver coils are maintained in close proximity, as efficiency drops sharply with increasing distance. To address this, a resonant inductive power pad has been developed, capable of charging battery-operated devices while simultaneously powering nearby electronics. This design supports arbitrary device positioning and local detection, further enhancing usability and practicality.

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