

## Review of Power Improvement on Wireless Power Transfer

A.H. Butar-Butar<sup>1,2</sup>, J. H. Leong<sup>2</sup>, M. Irwanto<sup>2,3</sup>

<sup>1</sup>Department of Electrical Engineering, Medan State University, Medan, Indonesia

<sup>2</sup>Fellow of Center of Renewable Energy, School of Electrical System Engineering, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia

<sup>3</sup>Departement of Electrical Engineering, Institut Teknologi Medan (ITM), Medan, Indonesia

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**Abstract:** The wireless power transfer (WPT) is a concept to transfer power from the transmitter side to the receiver side using an electromagnetic principle. The transmitted power is low because it does not use wire. Four concepts can be applied to improve the power on the receiver side of WPT system. They are the first is a WPT using relay coil, the second concept is the WPT using single input multi output (SIMO), the third concept is the WPT using multi input single output (MISO) and the last is the WPT using multi input multi output (MIMO). This paper reviews the four concept for improving power of WPT system.

**Keywords** – power improvement, wireless power transfer, relay resonant, SISO, SIMO, MISO, MIMO

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### I. Introduction

The wireless power transfer (WPT) transfers AC electrical energy from the transmitter coil to the receiver coil. If the AC voltage source is as main energy source of the WPT and it has fix frequency, thus the LC tank (suitable of connection and values of capacitor and inductor of transmitter and receiver coil) should has same frequency of the AC voltage source. It means that the value of capacitance of capacitors and inductance of transmitter or receiver coil on the LC tank of WPT should be calculated first to suite the frequency of AC voltage source. If the AC voltage source is generated by a function generator, whereas the frequency of AC voltage source can be varied, thus it is adjusted following the suitable of LC tank. It means that a suitable frequency has been achieved if an electromagnetic field has been generated and AC voltage has been induced on the transmitter coil of WPT [1].

A DC voltage source can be applied on the WPT system as a main DC voltage source. Based on the type of transmitter coil (transmitter coil with center tap and transmitter coil without center tap), the connection of DC voltage source to the transmitter circuit can be divided by two parts. The first part is that the DC voltage source is connected directly to the switching driver circuit that it has function to convert DC to AC using a full bridge circuit and it is connected to the transmitter coil without center tap [2], [3]. The second part is that two separated connection of DC voltage source are applied to the transmitter circuit of WPT. The first connection of DC voltage source is to supply the switching driver circuit that it has function also to convert DC to AC using a half bridge circuit and it is connected to the transmitter coil with center tap for its two terminal besides its center terminal. The second connection of DC voltage source is that the positive terminal of DC voltage source is connected to the center terminal of the transmitter coil and the terminal of DC voltage source is connected to the terminal connection of the transmitter circuit [4].

This paper presents a review of power improvement on WPT system. Four concepts are reviewed in this paper, they are the first is a WPT using relay coil, the second concept is the WPT using single input multi output (SIMO), the third concept is the WPT using multi input single output (MISO) and the last is the WPT using multi input multi output (MIMO).

### II. Power Improvement on Wireless Power Transfer

The output of WPT is classified in a low power transfer system. It is due to the power is transferred without wire. It uses an electromagnetic principle in the power transfer concept. Some concepts (relay coil, SIMO, MISO and MIMO) are needed to improve the power on the receiver side of the WPT system.

#### 2.1 Relay resonator for improving the WPT system

It is due to the transmission distance of electromagnetic induced WPT (EI-WPT) and magnetic resonant coil WPT (MRC-WPT) are not long transmission distance, thus some techniques of power improvement for the longer transmission distance are needed to be studied. [5] - [8] developed a technique to improve receiver power of EI-WPT using curved relay coil resonators for longer transmission distance between

the transmitter and receiver coil. The power improvement concept of proposed EI-WPT as shown in Figure 1. A fix frequency driver of 250 kHz is used to drive the switching components of inverter circuit on the transmitter coil. A relay resonator which consists relay coil is placed between the transmitter coil and receiver. The relay coil is matched by a tuning capacitor  $C_1$  to obtain the same AC frequency from the transmitter coil. The relay coil passes the magnetic field to the receiver coil that connected by a tuning capacitor  $C_2$  and generate 250 kHz AC voltage waveform. It is rectified by rectifier to supply the DC load. The technique improve the power and efficiency of EI-WPT, however the concept of tuning capacitor on the relay coil and the receiver coil are not sufficient to obtain the optimum value of capacitance of capacitor for matching the frequency of AC voltage waveform on the transmitter and receiver side of EI-WPT. Also the proposed transmission distance is very near around 2 cm.

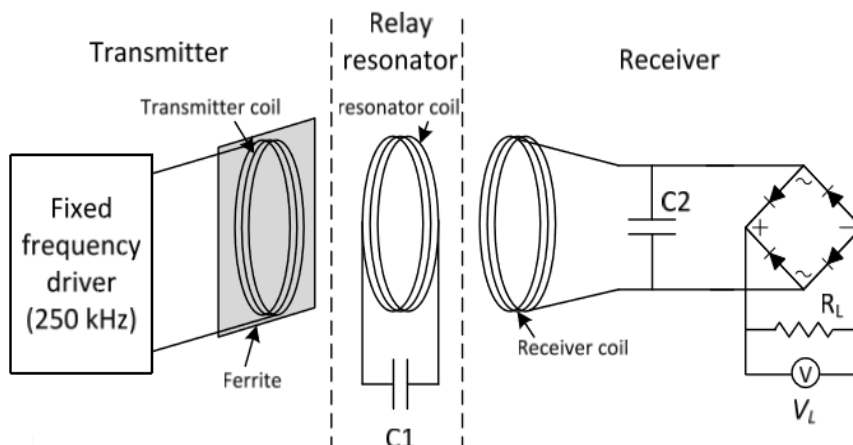


Figure 1: Power improvement concept of EI-WPT for longer transmission distance [5]

The MRC-WPT is developed by [9] for improving receiver power in the longer transmission distance. A placement technique of relay coil between transmitter and receiver coil of WPT is developed. The main objective is to capture the magnetic field generated by transmitter coil and transmitted again by the relay coil to the receiver coil. This technique improves the receiver power and improve the efficiency of MRC-WPT. However, the placement of relay coil causes more complex and the transmission distance is only 1 meter.

### 2.2 Single input multi output concept for improving the WPT system

Some link topologies of WPT can be constructed to improve the transmitted power. Single-input multiple-output (SIMO) links consist of single transmitter coil and interacting with multiple receiver coil of WPT, as illustrated by Figure 2. The mutual coupling,  $M$  and the coupling coefficient,  $k$  occur between transmitter coil to the first and the second receiver coil and also between the first and the second receiver coil. The SIMO links of WPT can improve the transmitted power and is applied for charge multiple design [10].

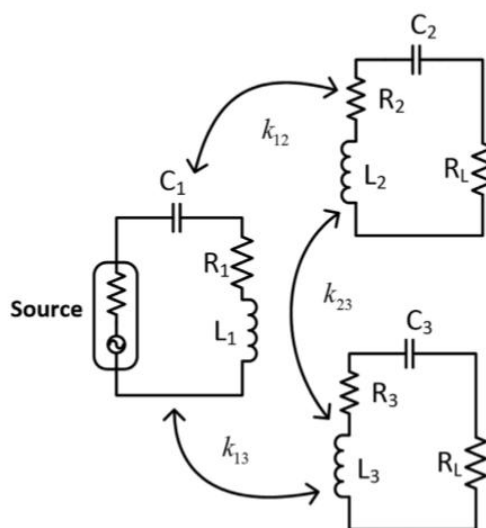


Figure 2. 14: SIMO links topology of WPT [11]

### 2.3 Multi input single output concept for improving the WPT system

Multiple-input single-output (MISO) link topologies, on the other hand, consist of an array of multiple transmitter coils, which are usually in interaction with a single receiver coil [12] as implied by Figure 3. The mutual coupling,  $M$  and the coupling coefficient,  $k$  occur between the first and the second transmitter coil and also between the receiver coil to the first and the second transmitter coil. MISO link topologies are often employed to continuously energize dynamic receivers [13]. An example of a MISO link design is reported by [14] which has been employed in an experimental system for focused wireless power delivery to multiple randomly moving objects.

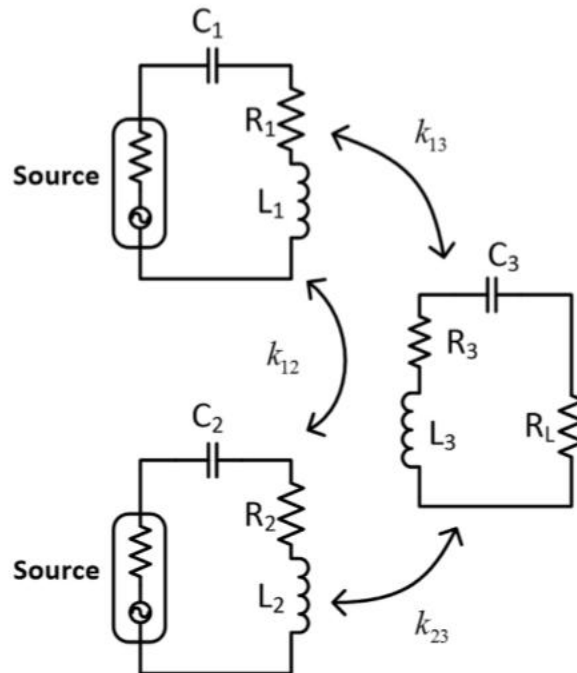


Figure 3: MISO links topology of WPT [11]

### 2.4 Multi input multi output concept for improving the WPT system

Multiple-input multiple-output (MIMO) topologies extend the dual-terminal energy transfer link concept to multi-node wireless energy transfer networks [15], as illustrated in Figure 4. A reported recent design of MIMO energy transfer is the MagMIMO system, which employs a field shaping approach, much akin to beam forming in MIMO antenna systems, for focused power delivery. However, it should be noted that the deployment of the MagMIMO is essentially a MISO topology, where the magnetic fields of multiple transmitter coils are focused on a single receiver coil. In this case, up to 40 cm increase in operating distance was reported, while still allowing for a flexible orientation of the receiver coil. The MagMIMO technique has subsequently been extended to a full MIMO near-field wireless energy transfer system implementation, known as MultiSpot. This technology emulates the operation of a miniature WiFi hotspot, and has been demonstrated to enable the support of simultaneous wireless charging of up to 6 heterogeneous devices at distances up to 50 cm [16].

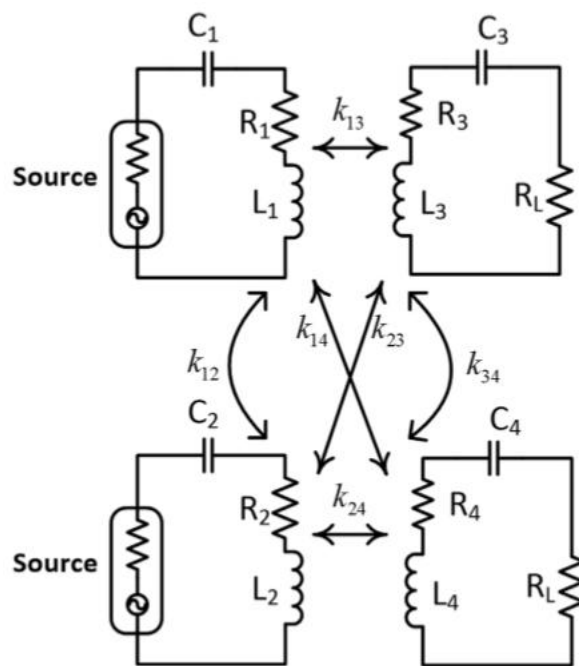


Figure 4: MIMO links topology of WPT [11]

### III. Conclusion

The wireless power transfer (WPT) is a concept to transfer power without wire. It causes the power on the receiver side on the WPT is low. Four concept can be applied to improve the power on the receiver side on the WPT. They are relay resonant concept, single input single output concept, single input multi output concept, multi input single output concept and multi input multi output concept.

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