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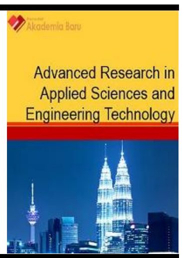


# Comparison Techniques for Optimization Switching Frequency In Energy Encryption Of Wireless Power Transfer System

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**ABSTRACT**

This paper reviews the techniques for optimization switching frequency used in Wireless power transfer (WPT). WPT is one of the most useful ways to transfer power. Based on distances power transfer, the WPT system can be divided into three categories, namely, near, medium, and far fields. Inductive coupling and capacitive coupling contactless techniques are used in the near-field WPT. Magnetic resonant coupling technique is used in the medium-field WPT. Electromagnetic radiation is used in the far-field WPT. From the comparison in this paper, a model and design algorithm to optimize switching frequency for energy encryption of medium field wireless power transfer system are purposed. The maximum value of the performance are suitable to compute the optimal circuit parameter by algorithm itself.

***Keywords:***
Wireless power transfer system; optimization switching frequency; medium field WPT; magnetic resonant coupling

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## 1. Introduction

Wireless power transfer (WPT) technologies can be categorized into inductive coupling, capacitive coupling, magnetic resonance, and electromagnetic radiation [1,10,17]. WPT requires different optimization criteria for two uses, namely, continuous power delivery and periodic charging. However, for continuous charging of vehicles, whether under the stationary or moving states, wireless communication should be fast, reliable, and energy efficient [2].

According to Stielau *et al.*, [3], the magnetic resonant coupling technique has been used on energy encryption of the WPT system. Analysis of magnetic resonant coupling considers efficiency, frequency, and performances by different methods, such as impedance matching (IM) and increasing power levels. In Stielau *et al.*, [3], variable coupling methods was presented for the analysis of high efficiency on resonant coupling WPT system. A large turn ratio, and source load resistance is converted to large effective resistance parallel to the internal resonator are achieve for high

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efficiency. Therefore, the attachment of external loading element in their resonators even with high-efficiency WPT is maintained.

In Wang *et al.*, [4], the frequency characteristics of resonance were investigated. When the frequency of the source of the transmitter equals the resonant frequency of the entire system, the load will achieve maximum energy. However, the transmitted power of load power constraints actions to minimize load power by using the charging control algorithm for optimizing the receiver loads resistance.

This paper examines a medium-field WPT by using the magnetic resonant coupling technique. In addition, chaos theory technique of encryption is applied in WPT for security performance. However, during power transfer process found the difficulty to optimize tuning switching frequency. This review examines the techniques used in different methods of optimization switching frequency for energy encryption and WPT systems [5]. Finally, this paper explores the advantages and disadvantages of optimization switching frequency technique for the energy encryption in the WPT system.

## 2. Methodology

A model of optimization switching frequency was designed and fabricated in several of techniques, which is symbolic analysis algorithm, dual layer nested using differential evolution (DE) and dynamic parameter tuning algorithm [6-8]. The designed was exactly based on the algorithm used in each technique.

Symbolic analysis algorithm generated by using liner or linearized lumped circuit. The frequency domain depends on the circuit parameters and on the frequency in coefficient expressions. A wide spectrum of algorithms based on network functions can be used by assuming one or more circuit parameters are unknown. However, by consider two series-series resonators inductively coupled as in Fig 1. The electrical parameters of two identical coaxial coils where L1 =L, L2=L, RL1=RL, RL2 = RL, C1=C, and C2=C.

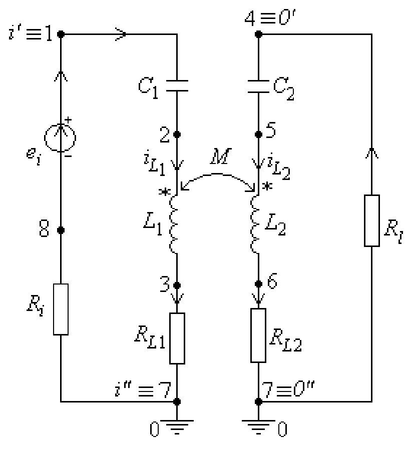


**Fig. 1.** Equivalent circuit model for wireless transfer of electromagnetic energy [6]

We want to find the optimal resonator parameters which provide the maximum of the power transfer efficiency η21. Because the symbolic expression of this quantity does not depend neither on C1 nor L1, the study will be focused on the parameters: L2, M, RL1, RL2, C2, Ri and Rl. Using SYMNAP (Symbolic Modified Nodal Analysis Program) [9].

Second technique is dual layer nested using differential evolution (DE) to optimize the wireless power system. First layer (outer layer) to optimize the parameters of the coils based on its simulation models, and the second layer (internal layer) is to optimize the compensation capacitances to evaluate the performance of the whole system [7]. Fig. 2 shows the specified schematic and equivalent circuit of the wireless power transfer system based on magnetically coupling resonator.

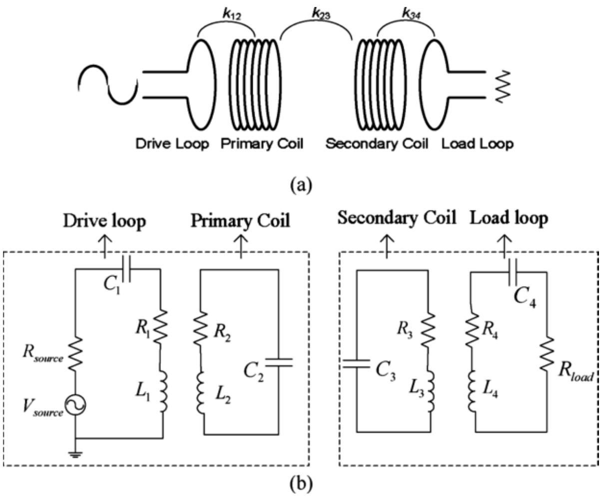


**Fig.2.** (a) Simplified schematic of the wireless power transfer system based on magnetically coupling resonator $k_{12}$, $k_{23}$ and $k_{34}$ are the coupling coefficients between each coil, respectively.
(b) Equivalent circuit of this system [7].

Furthermore, to analyze the wireless power transfer system, equivalent circuit method is applied. Fig. 3 shows the flowchart of the proposed optimization procedure for wireless power transfer system based on magnetically coupling resonator.

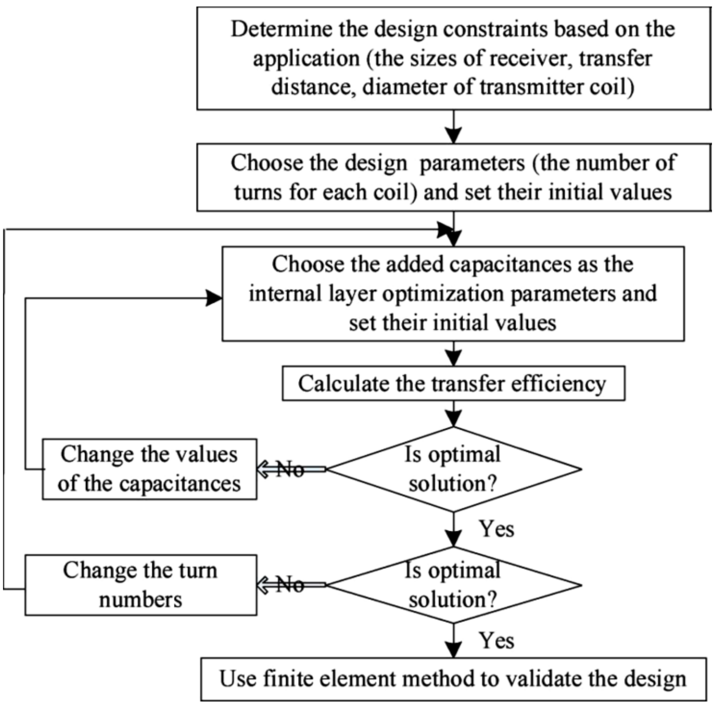


**Fig. 3.** Flowchart of the proposed optimization procedure [7].

Third technique for optimize is dynamic parameter tuning algorithm. Circuit model of the 2-coil WPT system using magnetically coupled resonator show in Fig. 4. Resonant frequency are same for both Tx coil and Rx coil [8]. In dynamic parameter tuning algorithm, the optimization were divided into 4 ways which is : effects of the parameter in circuit model, tuning of frequency, tuning of the coil resonant frequency and tuning algorithm.

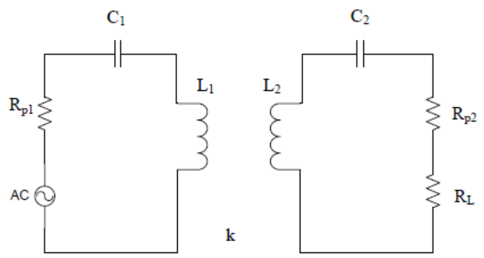


**Fig. 4.** Circuit model of two-coil WPT system [8].

## 3. Results

### *3.1 Comparison Techniques for Optimization Switching Frequency*

This section discusses the comparison obtained for techniques optimize switching frequency in energy encryption of wireless power transfer system shows in Table 1 [10-15].

**Table 1**
Advantages and disadvantages for optimization switching frequency technique of WPT

| **Optimization switching frequency technique for energy encryption of WPT system** | **Pros** | **Cons** |
|---|---|---|
| 1. Symbolic Analysis Algorithm | • Reach maximum power transfer efficiency at frequency of 1.207MHz [13]. | • Not efficient for power transfer when magnetic couplings less than three [13]. |
| 2. Dual Layer Nested using Differential Evolution (DE) | • By using optimal values capacitance optimization method, power transfer efficiency reaches maximum value at 0.8MHz from resonant frequency 0.65MHz [14]. | • Depend on determination of the parameters of the coils to achieve maximum power transfer [14]. |
| 3. Dynamic Parameter Tuning Algorithm | • Able to deliver 20W power for 2.2m distance [15].<br>• To track best performance with drifting parameters [15]. | • Communication between both sides Tx and Rx not required in simplified system [15]. |

## 4. Conclusions

Comparison for techniques of optimization switching frequency can be concluded that, a model to optimal frequency at resonant depend on the parameters were be used which is capacitance and inductance. However, an algorithm one of medium to implement the maximum parameters for mutual inductance (capacitor and inductor) into wireless power transfer system circuit. From the comparison in this paper, a model and design algorithm to optimize switching frequency for energy encryption of medium field wireless power transfer system are purposed.

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