Research on Magnetically Coupled Resonance Wireless Transmission Practice Teaching Platform

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Abstract. Magnetically coupled resonant wireless transmission of practice teaching platform is a high-tech system, and magnetically coupled resonant wireless power transmission experiment design and verification can be carried out on this platform by students. This thesis discusses the importance of efficient wireless energy transfer technology applied to distance magnetically coupled resonance technology in the practice of teaching from the practice teaching system of magnetically coupled resonant wireless transmission mechanism, the establishment and application of practice teaching system. It provides a system platform for students to establish wireless power transmission model and to apply the mutual inductance principle and coupling theory to derive the transmission efficiency for obtaining the key factors that affect the transmission efficiency such as the resonant frequency, the coil mutual inductance and the coil quality factor, etc., and to draw the conclusions of the above theoretical analysis verified by experiments

Keywords. Magnetically coupled,resonators, wireless transmission, ANSYS, practice teaching

1 Magnetically coupled resonance wireless transmission mechanism of practice teaching system

Magnetically coupled resonance photoelectric wireless energy transmission technology is the use of non-radiative magnetic coupled resonance principle for photoelectric distance energy transmission[1]. Research the use of magnetic fields as a medium of energy transfer by Maxwell equations. Two electromagnetic systems having the same natural frequency, at a certain distance, due to the electromagnetic coupling, resonant energy transfer can be performed between two systems. This transmission is unique in the use of the resonance principle, two coils for wireless energy transfer from resonance, and the impedance of the coil circuit is minimized, so most of the energy transmitted to the resonance direction.

1, Effect of magnetic coupling coil resonant frequency of the energy transmission efficiency

Maxwell's equations coupled with the use of model theory (Coupled Mode Theory, CMT) energy transmission coupling body in such a strong research. Essence coupling model theory is coupled by the following differential equation expressed[2].

$$\dot{a}_m(t)=(i\omega_m-\Gamma_m)a_m(t)+\sum_{n\neq m} ik_{mn}a_n(t)+F_m(t)$$

In the above formula, the subscript m, n represents different resonance body, variable am (t) to determine the energy contained in the resonator body m, is ｜ am (t) ｜ 2, ω m is the natural frequency of the resonator body Γ m system natural decay rate (absorption and radiation losses). Kmn resonator body indicates m, the coupling coefficient between h, Fm (t) represents the driving conditions.

Magnetically coupled resonant wireless energy transfer key is to make two resonant objects of the same frequency produce a very strong mutual coupling. In this way, compared with the electromagnetic induction method, use of the magnetic field is much weaker, but

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can achieve a more long-distance power transmission, the transmission shown in Figure 1.

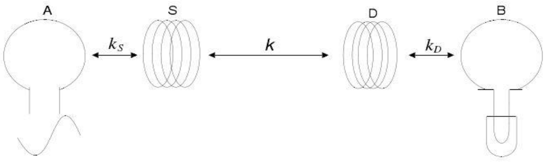

Figure 1 Magnetically Coupled Resonance Wireless Transmission Practice Teaching System Schematic

Schematic ks transmission distance S between the transmit coil and an oscillator coupled coils A, D and receiving coil coupled to resistive load coil B, A and S, D and B, kD is very small, and they are primarily between Proximity Coupling . Due to S and D of the resonant coil on the coil's inductance and distributed capacitance to achieve resonance matching focus, energy is coupled to the power transmitting coil by the oscillation circuit S A, S transmitting coil and a receiving coil D has the same resonant frequency since, in the coupling of the magnetic field under resonance, receiving coil loading coil B and D to achieve energy transfer by coupling, κ is magnetically coupled resonance distance.

The same frequency coil energy transfer

Resonant transmitting coil S and a resonant receiving coil D form a complete resonant system, the energy transfer between the two coils. Only the two resonant coils produced a strong resonance coupling in order to effectively transfer energy in the far distance. When no drive, using the coupled-mode theory (CMT) analysis of differential equations

$$\begin{cases} \dot{a}_s(t) = (i\omega_s - \Gamma_s)a_s(t) + ik_{SD}a_D(t) \\ \dot{a}_s(t) = (i\omega_D - \Gamma_D)a_D(t) + ik_{DS}a_S(t) \end{cases}$$

The above equation: as (t), aD (t) is the amplitude of the two coils midfield; ω s, ω D for their respective natural angular frequency of the two resonant coil, wherein, ω s = 2π fs ω D = 2π fD, fs, fD two a natural frequency of each resonance coil; Γ s, Γ D is inherent loss due to absorption and radiation caused; κ sD κ Ds is the coupling coefficient between the two resonant coils.

Coupling coefficient κ speed reflects energy transfer between the two resonant coils, the coupling coefficient between the two coils is larger, the energy from the transmitting coil to receiving coil used for shorter time spread, the faster the establishment of the two coils from a stable energy transmission channel, complete energy transfer. If the coupling coefficient κ and loss factor Γ appropriate values, you can complete the establishment of channels of energy transfer between the two coils before the energy attenuation finished, it can be said receiving coil energy loss due to various factors radiation emitted from a rate of less than coil energy transfer over the speed, it will have enough energy to supply the load back. If κ and Γ value is not appropriate, the transmission channel cannot be established, it cannot be transmitted energy.

Coupling coefficient κ distance between the two coils K and have a great relationship, the smaller the distance between the coils K, the greater the coupling coefficient κ . In WiTricity transmission system, the relationship showed the difficulty of energy transfer between the two coils, it is clear that the closer the distance between the two coils, the larger the coupling coefficient is, and the energy between two coils is easy to transport. Γ loss factor is directly related to the size of the coil energy decay rate, Γ larger own loss, loss of energy and radiation from the surrounding non-resonant objects between the greater by the coil, and therefore the system developed by WiTricity distance Γ ranges from K decision.

1) Coil frequency is not the same energy transfer

When WiTricity system natural frequency resonant coils two are not the same, namely ω s ≠ ω D, re-soluion equation:

$$\begin{cases} a_S(t) = e^{(x_S + x_D)t/2}\left[(x_S - x_D)\sin(\frac{dt}{2})\Big/d + \cos(\frac{dt}{2})\right] \\ a_D(t) = e^{(x_S + x_D)t/2}\left[2i\kappa\sin(\frac{dt}{2})\Big/d\right] \end{cases}$$

xs = iω s -Γ s， xs = iω D -Γ D，

$$d=\sqrt{4k^2-x_s{}^2+2x_sx_D-x_D{}^2}$$

Through the above mathematical model, to meet the strong coupling condition, the same natural resonant frequencies of the two coils with a different state, higher by experimental analysis of the energy-transfer efficiency which states the two resonant coils.

2, Analysis of the overall performance of the wireless transmission magnetically coupled resonance Practice Teaching System

Establishing mutual coupling model is magnetically coupled resonant wireless energy transfer, and ANSYS software tightly wound single coil excitation magnetic field simulation, and two closely wound coils magnetic field coupling between simulation, comparative analysis of the radius of the coil, the coil and the distance relationship receiving coil radius and the magnetic field coupling; transmission efficiency research and coil size, the relationship between the natural frequency, to obtain an effective method for improving transmission efficiency.

2 Magnetically coupled resonant wireless energy transfer system to establish teaching practice

According to the coupling resonator type photoelectric wireless energy transfer mechanism to transfer the device structure and circuit design, the transmission means comprises a DC power supply section, a signal generating section, a power amplification section, transmit coil section, the coil receiving portion, a rectifier circuit and a load seven parts, its transmission functional block diagram shown in Figure 2.

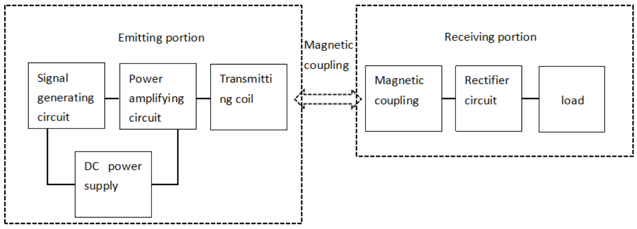

Figure 2 Transfer Schematic

Emitting portion signal generator to produce the desired frequency square wave signal by driving the power amplifier circuit and the load on the DC power supply to the square wave energy, the square wave generated non-radiative alternating magnetic field emitted by the coil there around. Receiving coil in the transmitter coil an alternating magnetic field generated by the resonance due to the coupling effect, the magnetic field receiving coil energy into electric field energy. Finally, after rectifying circuit load energy supply, complete energy transfer.

1、Using ANSYS software to analyze MAXWELL equations based on field

Using ANSYS software module electromagnetic simulation analysis of magnetic field coupling between the two coils and a single coil excitation; MAXWELL equations based on magnetic field analysis WiTricity transmission means and the coil coupling magnetic field simulation analysis; drive circuit design, power amplifier circuit and transmitting and receiving resonant circuit.

ANSYS is a kind of large general-purpose finite element analysis software[5], which can effectively block electromagnetic field analysis of a variety of devices. MAXWELL equations based on the magnetic field, by the scalar, vector potentials or boundary introduced MAXWELL equations and considering the electromagnetic nature of the relationship[6], developed equations suitable for finite element analysis is used to analyze a wide range of electromagnetic problems, such as inductors , capacitance, impedance, magnetic flux density, magnetic field strength, the electric field distribution, magnetic field lines, quality factor,

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characteristic frequency, magnetic force and torque, motion effects and energy losses.

As ANSYS analysis of other types, for harmonic magnetic analysis, to establish the physical environment, to model district to impart properties, mesh, boundary conditions and loads increase, solution, and then observe the results using ANSYS finite element software for electromagnetic fields module for single coil magnetic field and magnetic field coupling the two coils were analyzed frequency of the excitation signal derived from the excitation signal size, number of turns, coil radius and effect of coupling the two coils of the magnetic field distribution, magnetic resonance wireless power coupling transmission designed to provide the basis. ANSYS software and magnetic field coupling the two tightly wound coils of a tightly wound coil excitation of a single simulation, comparative analysis of the relationship between the two coupling magnetic field from the coil and the coil radius, analyze the coupling efficiency and the efficiency of energy transfer between the magnetic field relationship calculate the distance energy transmission.

2. Magnetically coupled resonance wireless transmission system circuit practice teaching model

The entire transmission system, the key is to analyze the relationship between the coupling between the transmitter and receiver coils, and therefore will be sending and receiving circuit as the research object, coupled resonator circuit model shown in Figure 3.

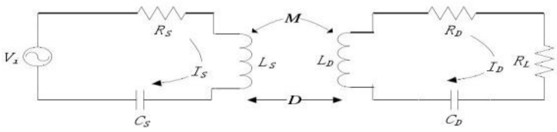

Figure 3 Coupled Resonator Circuit Model

Where l is the inductance of the high-frequency signal source, RS, RD are two resonant inductor parasitic resistance at high frequencies, CS, CD series resonant capacitor, RL is the load resistance, LS, LD are sending and receiving coils , M is the mutual inductance between the coils, D is the transmission distance.

3. Magnetically coupled resonance wireless transmission system set up practice teaching

Efficiency is the key to wireless power transmission systems electromagnetic emissions and electromagnetic receiving system. Magnetically coupled resonance wireless transmission practice teaching system configuration shown in Figure 4. System is mainly composed of two parts, the energy transmitter and energy receiver. Energy transmitter as a DC power input terminal, a high-frequency signal is amplified by the formation of a high-frequency excitation power source, so that the source is directly connected with the coil (the coil label 1) to resonate, and the source alternating field is formed around the coil. Transmit coil (coil label 2) alternating magnetic field induction source coil, and then with the formation of a resonance, a more powerful alternating magnetic field. Thus, the source of energy transmitted through the coil to the transmitter coil, and then passed out by the transmitter coil.

Energy receiving end comprises two coils, receiving coils respectively (label coil 3) and loading coil (coil label 4), wherein the load coil is directly connected with the electrical load. A receiving coil, the energy transfer of the transmit coil, and transmits it to the load coil. After loading coil connected energy conversion circuit, the high-frequency power conversion DC power supply directly behind load electricity use or storage.

The whole system is the most critical part of the high-frequency excitation and transmitter coil and the receiver coil design. Radio frequency excitation directly determine the entire frequency range of the energy transmission system, and the parameter transmitting coil and a receiving coil for energy transmission efficiency play a decisive role.

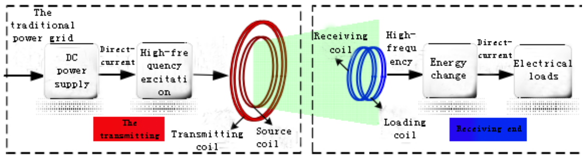

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Figure 4 Magnetically Coupled Resonant Wireless Power Transmission Output Practical Teaching System Components

Magnetically coupled resonant wireless power transmission output circuit shown in practice teaching system 14a, b. inductively coupled power transfer technology to transmit and receive modules based wireless power transmission system was designed on the transmitting and receiving circuit structures. Send and receive circuit in FIG. 5a, b.

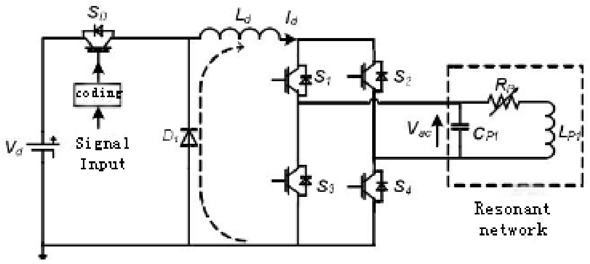

Figure 5a Transfer Schematic

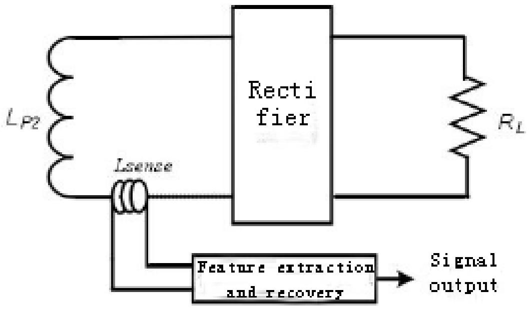

Figure 5b Receiving circuit

3.Magnetically coupled resonance wireless transmission Practice Teachi System

Magnetically coupled resonance wireless transmission system verifies practice teaching of modern power electronics technology theory, electromagnetic resonance technology to verify the effect of wireless power transmission;

Used to analyze a wide range of issues of electromagnetic fields, such as inductance, capacitance, impedance, magnetic flux density, magnetic field strength, the electric field distribution, magnetic field lines, quality factor, characteristic frequency, magnetic force and torque, motion effects and energy loss; using magnetically coupled resonance wireless circuit model of transmission through the system output power and efficiency of factor: the resonant frequency, distance, load, carry out a detailed analysis, the influence of magnetically coupled resonance wireless power transmission output power and efficiency of the impact factor.

Resolve conflicts magnetically coupled resonant wireless power transmission photoelectric transfer efficiency and distance cannot have both; technical issues to overcome transmission efficiency, transmission distance, safety and reliability aspects to provide a solution.

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