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A Study on Contactless Energy Transfer

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Abstract

One of the latest developments to draw the interest of all engineers is "Contactless Energy Transfer" for powering & controlling motors.It is the transmission of electrical energy from a Power Source to an Electrical Load without using conductors. The "Wireless Power Transmission" differs from that of wireless signal transmission such as radio and mobile telecommunication.The most common form of wireless power transmission is carried out using direct induction followed by resonant magnetic induction. Other methods under consideration include electromagnetic radiation in the form of microwaves or lasers.

1. Introduction

In this paper we are talking about the resent trends in "WIRELESS ENERGY TRANSFER" or "WIRELESS POWER" which is the transmission of electrical energy from a Power Source to an Electrical Load without using conductors. The "Wireless Power Transmission" differs from that of wireless signal transmission such as radio and mobile tele communication. Wireless power transfer technology can be used to provide:

Direct Wireless Power-- when all the power a device needs is provided wirelessly, and no batteries are required. This mode is for a device that is always used within range of its power source transmitter.

Automatic Wireless Charging-- when a device with rechargeable batteries charges itself while still in use or at rest, without requiring a power cord or battery replacement. This mode is for a mobile device that may be used both in and out of range of its power source transmitter.

This innovative technology creates new possibilities to supply mobile devices with electrical energy because elimination of cables, and/or slip-rings as well as plugs and sockets increases reliability and maintenance-free operation. The core of contactless energy transfer system is inductive or capacitive coupling and high switching frequency.

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The capacitive coupling is used in low power range (sensor supply systems) whereas inductive coupling allows transferring power from a few mW up to hundred kW.

If wireless energy were adopted in whole or in part, the use of it would greatly cut the cost to the environment of plastics and rubber used in the production of electrical wires, a lot of which cannot be recycled. The most common form of wireless power transmission is carried out using **direct induction** followed by **resonant magnetic induction**. Other methods under consideration include **electromagnetic radiation** in the form of **microwaves** or **lasers.**

2. Lectric Energy transfer

An electric current flowing through a conductor carries electrical energy. When an electric current passes through a circuit, there is an electric field surrounding the conductor. The electric field of a circuit over which energy flows has three main axes at right angles with each other:

1. The magnetic field, **concentric** with the conductor.
2. The lines of electric force, **radial** to the conductor.
3. The power gradient, **parallel** to the conductor.

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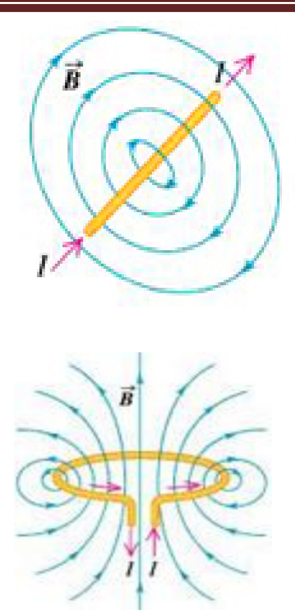
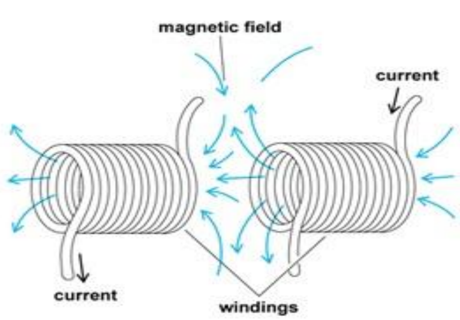


Fig: 1. the lines represent the magnetic field that is created when current flows through a coil. When the current reverses direction, the magnetic field also reverses its direction

3. Methodologies

3.1 Electrodynamic Induction Method

The electrodynamics induction wireless transmission technique is near field (The **near field** or near-field and **far field** or far-field are regions of the electromagnetic field around any object) where range is about less then **λ/4**(**λ** is wavelength). With electrodynamics induction, two copper coils were set up, **Primary coil** at the 'sender end' and **Secondary coil** at 'receiver end'. The Primary coil was attached to the power source, while the receiver coil was attached to the Load.



When power source switched ON, electric current flowing through a primary coil creates a magnetic field; secondarycoil then picks up the magnetic field producing a current within it,while the rest of environment is unaffected. The magnetic near field has several properties that make it an excellent means of transferring energy in a typical consumer, commercial, or industrial environment. Most common building and furnishing materials, such as wood, gypsum wall board, plastics, textiles, glass, brick, and concrete are essentially "transparent" to magnetic fields, enabling this technology to efficiently transfer power through them. Any obstacles sitting between the coils are inconsequential to the power transfer, and human beings are unaffected because the human body does not respond to magnetic fields.

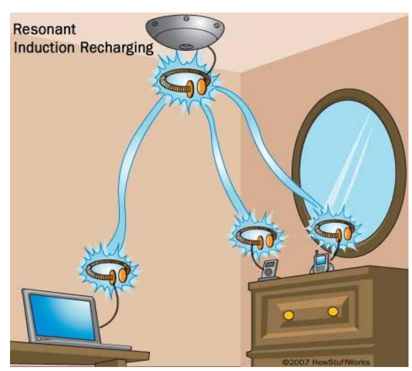
As the distance from the primary is increased the magnetic field misses the secondary. This action of an electrical transformer is the simplest form of wireless power transmission. The primary and secondary circuits of a transformer are not directly connected. Energy transfer takes place through a process known as **mutual induction.** Induction cookers use this method.

The **main drawback** to this basic form of wireless transmission is short range. The receiver must be directly adjacent to the transmitter or induction unit in order to efficiently couple with it.

3.2 Electrostatic Induction Method

Electrostatic or capacitive coupling is the passage of electrical energy through a dielectric. The electric field is created by charging the plates with a high potential, high frequency alternating current power supply. The electric energy transmitted by means of electrostatic induction can be utilized by a receiving device, such as a wireless lamp. The principle of electrostatic induction is applicable to the electrical conduction wireless transmission method.

3.3 Resonant Coupling Method



The application of resonance increases the transmission range. When resonant coupling is used, the transmitter and receiver inductors are tuned to the same natural frequency. When two objects have the same resonant frequency, they exchange energy strongly without having an effect on other surrounding objects. In this way significant power may be transmitted between two mutually-attuned LC circuits having a relatively low coefficient of coupling. Transmitting and receiving coils are usually single layer solenoids or flat spirals with series capacitors, which, in combination, allow the receiving element to be tuned to the transmitter frequency.

This mode of wireless power transfer is highly efficient over distances ranging from centimeters to several meters. Here we define efficiency as the amount of usable electrical energy that is available to the device being powered, divided by the amount of energy that is drawn by the *power* source. In many applications, efficiency can exceed 90% also when a powered device no longer needs to capture additional energy, the *Wireless* power source device will automatically reduce its power consumption to a power saving “idle” state.

Resonance is used in both the wireless charging pad (the transmitter circuit) and the receiver module (embedded in the load) to maximize energy transfer efficiency. This approach is suitable for universal wireless charging pads for portable electronics such as mobile phones. It has been adopted as part of the Qi wireless charging standard.

“Qi” (pronounced “chee”) is WPC’s (Wireless Power Consortium’s) standard for wireless power. The WPC is an open-membership cooperation of Asian, European, and American companies in diverse industries, including electronics manufacturers and original equipment manufacturers. Qi, creates interoperability between the device providing power (power transmitter, charging station) and the device receiving power (power receiver, portable device).

3.4 Electromagnetic radiation

Far field methods achieve longer ranges, often multiple kilometre ranges, where the distance is much greater than the diameter of the device(s). The main reason for longer ranges with radio wave and optical devices is the fact that electromagnetic radiation in the far-field can be made to match the shape of the receiving area (using high directivity antennas or well-collimated Laser Beam) thereby delivering almost all emitted power at long ranges. The maximum directivity for antennas is physically limited by diffraction.

3.5 Microwave Method

Power transmission via radio waves can be made more directional, allowing longer distance power beaming, with shorter wavelengths of electromagnetic radiation, typically in the microwave range. A **Rectenna** may be used to convert the microwave energy back into electricity.

A **Rectenna** is a **rect**ifying ant**enna**, a special type of antenna that is used to directly convert microwave energy into DC electricity. Rectenna conversion efficiency is more than 95%.Power beaming using microwaves has been proposed in future, for the transmission of energy from orbiting solar power satellites to Earth.

Fig: 4. Rectenna- power is beamed to a receiving antenna or “rectenna” on Earth [4]

3.6 Laser Method

In the case of electromagnetic radiation closer to visible region of spectrum, power can be transmitted by converting electricity into a **laser beam** that is then pointed at a **solar cell** receiver. This mechanism is generally known as "**Power beaming**" because the power is beamed at a receiver that can convert it to usable electrical energy.

Advantages of laser based energy transfer compared with other wireless methods are:

1. Collimated monochromatic wave propagation allows narrow beam cross-section area for energy transmission over large ranges.
2. Compact size of solid state lasers-photo voltaics semiconductor diodes fit into small products.
3. No radio-frequency interference to existing radio communications.
4. Control of access; only receivers illuminated by the laser receive power.

Its **drawbacks** are:

1. Conversion to light, such as with a laser, is inefficient
2. Conversion back into electricity is inefficient, with photovoltaic cells achieving 40%–50% efficiency.
3. Atmospheric absorption causes losses.
4. As with microwave beaming, this method requires a direct line of sight with the target.

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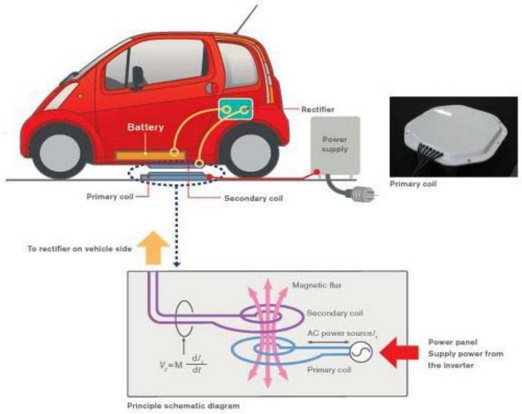

4. Application

4.1 Charging Mobile phones

Wireless-charging equipment based on electromagnetic induction. Researchers have also developed special “skins” for Blackberry smart-phones, so that they too can be charged without the need for an adaptor.

4.2 Charging Laptops, Idea Pads

Dell has released the first details on its wireless-charging Latitude Z laptopThe machine has power coils built into its base which allow it to charge wirelessly, very much like the Palm.

4.3 Automobile Charging

Nissan has opted for an electromagnetic induction method to this system. The distinct technology has achieved a charging efficiency of 80-90%, which is similar to that of cable charging. Electricity is applied to coils on the ground transmission unit in order to generate magnetic flux, which works to transmit electricity to the other coil on the vehicle receiver unit.

5. Contactless power for Olev (Online Electric Vehical)

Korea Advanced Institute of Science and Technology (KAIST), launched Online Electric Vehicle (OLEV) which gathers power magnetically from electric strips buried below the road's surface as it travels. A receiver mounted on the bus's chassis picks up the current through a **contact-free** magnetic system that collects electricity with 70 percent efficiency. That electricity powers the motor and recharges on-board batteries that kick in when the bus isn't near a charging area.

6. Conclusion

Wireless power transfer technology can be applied in a wide variety of applications and environments. The ability of our technology to transfer power safely, efficiently, and over distance can improve products by making them more convenient, reliable, and environmentally friendly. This technology is designed to be directly embedded in the products and systems. Wireless power transfer technology will make your products:

More Convenient:

- No manual recharging or changing batteries.
- Eliminate unsightly, unwieldy and costly power cords.

More Reliable:

- Never run out of battery power.
- Reduce product failure rates by fixing the ‘weakest link’: flexing wiring and mechanical interconnects.

More Environmentally Friendly:

- Reduce use of disposable batteries.
- Use efficient electric ‘grid power’ directly instead of inefficient battery charging.

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