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Wireless Power Transmission

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Abstract

In today's rapidly growing industries power source is a major aspect of any field. The use of wires is becoming redundant day by day. Considering this as a major issue, the fundamental idea here is to wipe out the utilisation of wires. This may be achieved by implementing wireless power transmission techniques which are far better than the standardised methods of transfer of power. Using close range and far range methods is dependent on the medium of its application.

Keywords: Electricity, Magnetism, Electromagnetism, Magnetic induction, Power coupling, Resonance, Resonating magnetic coupling, wireless power transmission, wireless power transfer.

1. Introduction

To be able to understand the concepts of wireless power transmission one must be thorough with the following concepts.

Electricity- The transfer of electrons through a conductor which is the simplest way to supply energy between two points.

Magnetism- An attracting or repelling force acting on materials which possess certain properties.

Electromagnetism- Interdependence of time varying electric and magnetic fields. Fundamentally, a magnetic field is generated from an oscillating electric field and vice – versa.

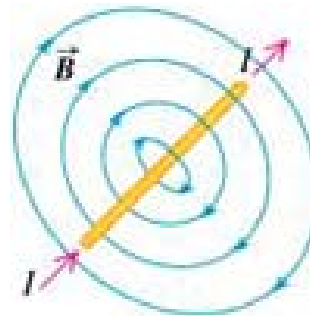


Fig 1: Current through wire generating magnetic field.

In a *wire*, when current I flows, it produces a magnetic field B which is a vector quantity which encompasses itself on the wire. The direction of current and magnetic field are directly proportional.

In a *coil*, the magnetic field generated is widely dispersed into all directions.

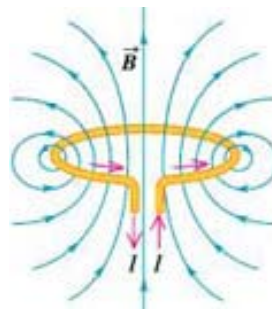


Fig 2: Current through coil producing magnetic field.

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Magnetic Induction- A polyurethane copper wire is used as the conductive material for carrying alternating current, AC. For instance, a transformer uses this principle which has a primary winding of a coil and a secondary winding of another coil. These are not directly connected and yet the primary coil manages to trap oscillating magnetic field which eventually induces an electric current in the secondary coil. This can be used to supply power to other devices. Electric generators operate on the same principle.

Power coupling- It is a method to transfer energy to another object. This occurs when the magnetic field of one object induces an electric current in the other object due to their interaction.

Resonance- It is defined as the natural frequency at which energy can most effectively be added on to an oscillating system.

Resonating magnetic coupling- This phenomenon occurs when natural frequencies of two bodies are closely the same.

2. Inductive power transfer

This is also known as wireless power transfer (WPT). This can be used for long range or short range transfer of energy. Inductive power transfer is quick, efficient and requires very low maintenance for being kept under working conditions. Fundamentally, there exist two categories of inductive power transfer.

A. Low proximity methods

B. High proximity methods

These methods are used based on the situation analysis.

A. Low proximity methods

These are near field methods used in close range only. They successfully avoid the compromising security issues and unavoidable climatic conditions which are prone to result in interference. There are three types of near field methods.

I. Electromagnetic Radiation

II. Inductive Coupling

III. Magnetic Resonant Coupling

I. Electromagnetic Radiation

The electromagnetic radiation is energy transfer from transmission end to the receiving end via radioactive EM waves. These can be classified into omnidirectional and unidirectional radiation. In omnidirectional radiation, there is dispersion all around the transmitter which sends out the EM waves in every direction. In unidirectional radiation, the EM wave is strictly sent across one stream to reach the receiver.

II. Inductive Coupling

In inductive coupling when two coils moved away at a slow pace the rate transfer of power diminishes over time. This is basically the coupling done with a couple of LC circuits with similar resonating frequencies. This possesses a primary and a secondary coil formed through a wire and both of these are never interconnected directly with each other. Primary coil is at the transmitting end and the receiving end has the secondary coil.

Table 1: Comparison of some of the methods.

Comparison		
Method	Merits	Demerits
Inductive Coupling	Beam can be interrupted without power loss. Small size of system hardware.	Low efficiency. Short transmission distance. Inductance between receivers affects the resonance frequency
Microwave	Specific position for receivers relative to transmitter is not required. Highest efficiency amongst all types.	Interference between energy and microwave data. Large size and weight of system hardware.
Laser	Power can be easily directed to a load. Smallest size of system hardware	Long distance affects the beam collimation. System hardware is affected by the heat generated by the laser beam.

III. Magnetic resonant coupling

This is one of the most useful technique for near field methods. Considering two bodies under the influence of inductive coupling, then in addition to this phenomenon if there exists a resonance effect where the natural frequencies of these two bodies are closely the same, it results in magnetic resonant coupling.

B. High proximity methods

These set of far field methods are only used for reaching out to bodies at a long range. They provide high intensity power transmission but at the expense of the target body being in the line of sight.

This has two methods.

- I. Microwave Power Transmission
- II. Laser Power Transmission

I. Microwave Power Transmission

This method involves point to point power transmission. Lower frequency electromagnetic waves suffer from directivity issues and lesser efficiency. The Rayleigh Criterion determines that any radio wave, microwave or laser beam undergoes dispersion over a distance and over time. Microwave radiation is used to make the power transmission of radio waves more directional, allowing them to provide beaming power over a longer distance using shorter wavelengths.

Table 2: Comparison of attributes within far field techniques.

Attribute	Microwave	Laser
Interference	Radio Frequency interference	Astronomical interference
Aperture Size	Large	Small
Attenuation	Penetrates clouds and rain	Obstructed by clouds
Space efficiency	High	Moderate
Ground efficiency	High	Moderate
Safety	Avoid aircraft from beam	Perfectly safe

II. Laser Power Transmission

Laser power transmission generates coherent and non-dispersed beam of energy across a long distance but only as long as the intended target body is within the line of sight. This method successfully avoids the loss of energy due to scattering. It also enables the reduction of transmitting apparatus size.

3. Application of Wireless Power Transmission

There is an immense amount of growth in the desire and need to implement wireless power transmission in whichever area

is possible. There are five fields in discussion when it comes down to the application of WPT.

- I. Electric Vehicles (EV)
- II. Military Defence Systems
- III. Medical Implementation
- IV. Consumer Electronics
- V. Solar Powered Satellites (SPS)

I. Electric Vehicles

The standard rechargeable electric vehicle batteries can be powered up at a station designated for wireless transfer of power specially designed for EV's alone. The station will resemble a standard parking lot appearance but will be internally embedded with a fixed platform where the transmitting end of the WPT apparatus is installed. Furthermore, the EV has to approach the parking space platform and the proximity sensors will be rigged in such a way that when any object hovers over that specified spot and remain in a stationary position for at least 10s then the sensor will trigger the initialisation process of the transfer of power from transmitter in the platform to the receiver in the EV. As long as this is in sync with the line of sight of whichever method that is used for this WPT procedure, the application is highly efficient and fast.

II. Military Defence Systems

When it comes to military applications, there exist numerous ways and opportunities to implement WPT especially while on the field. Every high tech military system like covert sensory devices, any kind of battery powered devices, unmanned aerial vehicles (UAV), unmanned robots will greatly benefit from the implementation of inductive power transmission. One manned vehicle can be provided with a transmitter which would be driven around to wherever there is another robot or high tech gadget or sensory device which is in need of a recharge. While the troops are inside the vehicle, they can charge their equipment from within the vehicle and thus saving time and effort giving them an edge over their opponents in battle.

III. Medical Implementation

In the field of medicine, there can be much ease after getting rid of the wires involved in recharging the devices and not to mention the implantable parts in animals and humans. These handheld instruments need frequent charges which is a tedious job and this can be discarded by installing WPT apparatus within them. As far as implantable devices are concerned, there are animals and humans using devices to fill in the void of having a fully functional organ or anything which can be supported by the implantable instruments which in some cases like support for kidneys or lungs, require there to be wires connecting to the implanted instruments from the inside. This is a major setback for the patient as well as the monitoring doctors as it becomes a delicate process to handle. For eliminating the high risk factor, the usage of inductive power transfer seems to be the best alternative.

IV. Consumer Electronics

In the present day, there are billions of portable electronic devices and non-portable electronic devices in use. To enable the termination of the unappealing wiring throughout these devices systems and to bring up automatic wireless charging of mobile devices as soon as they enter the vicinity of the transmitter end of the WPT apparatus.

V. Solar Power Satellites

This application will enhance the capabilities of wireless power transmission like its range and other limitations like directional objections. Discarding these is made possible by having a satellite positioned in the geosynchronous orbit which is the most optimal orbit that may enable the satellite to deliver high power to any field or a focused body on earth. Among the five methods of implementation which were discussed previously, the most suitable one for this mode of application would be microwaves.

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