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Transmission of Power through Wireless Systems

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Abstract- We cannot imagine the world without electric power. Generally the power is transmitted through wires. This paper describes an original idea to eradicate the hazardous usage of electrical wires which involve lot of confusion in particularly organizing them. Imagine a future in which wireless power transfer is feasible: cell phones, household robots, mp3 players, laptop computers and other portable electronics capable of charging themselves without ever being plugged in, freeing us from that final, ubiquitous power wire. Some of these devices might not even need their bulky batteries to operate. This paper includes the techniques of transmitting power without using wires with an efficiency of about 95% with non radiative methods. Due to which it does not affect the environment surrounding. These techniques Includes resonating inductive coupling in sustainable moderate range. The coupling consists of an inductor along with a capacitor with its own resonating frequency. In any system of coupled resonators there often exists a so-called "strongly coupled" regime of operation. If one ensures to operate in that regime in a given system, the energy transfer can be very efficient. Another technique includes transfer of power through microwaves using rectenna. This is particularly suitable for long range distances ranging kilometers. With this we can avoid the confusion and danger of having long, hazardous and tangled wiring. This paper as a whole gives an effective, high performance techniques which can efficiently transmit the power to the required area vary in given distances for the power transmission through induction.

Index terms-Induction, Power, Receiver, Short distance, Transmitter, Transmission, Wireless, Wires.

I. INTRODUCTION

Unless you are particularly organized and good with tie wrap, you probably have a few dusty power cord tangles around your home. You may have even had to follow one particular cord through the seemingly impossible snarl to the outlet hoping that the plug you pull will be the right one. This is one of the downfalls of electricity. While it can make people's lives use This paper provides the techniques used for wireless power transmission easier, it can add a lot of clutter in the process.

For these reasons, scientists have tried to develop methods of wireless power transmission that could cut the clutter or lead to clean sources of electricity. Researchers have developed several techniques for moving electricity over long distances without wires. Some exist only as theories or prototypes.

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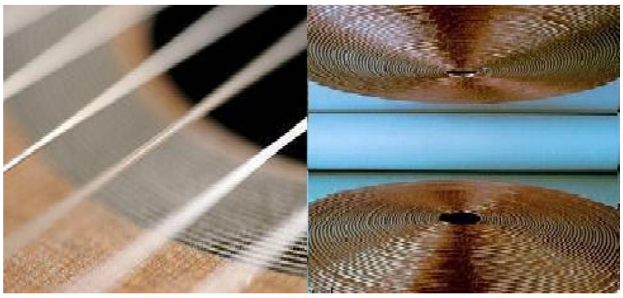


.cross sectional view of coupled coils

These techniques are briefly classified into three depending on the distance between the transmitter and receiver. These are: Short range, Moderate range and Long range.

These methods can reach at most a few centimeters. The action of an electrical transformer is the simplest instance of wireless energy transfer. The primary and secondary circuits of a transformer are electrically isolated from each other. The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction. (An added benefit is the capability to step the primary voltage either up or down.) The electric toothbrush charger is an example of how this principle can be used. A toothbrush's daily exposure to water makes a traditional plug-in charger potentially harmful dangerous. You can use the same principle to recharge several devices at once. Ordinary simple and good electrical Connections could also seep into the toothbrush, damaging its components. Because of this, most toothbrushes recharge through **inductive coupling**.

A splash power mat

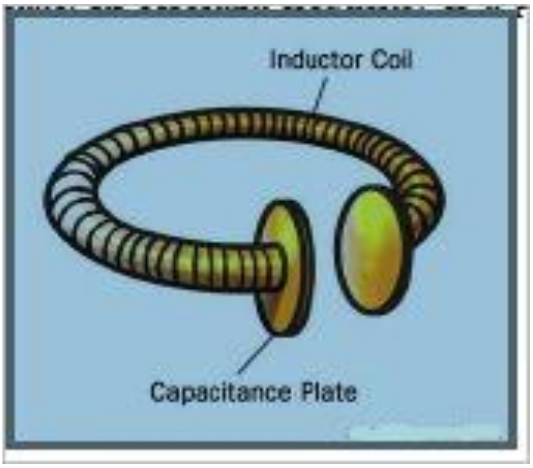
For example, the Splash power recharging mat and Edison Electric's Power desk both use coils to create a magnetic field. Electronic devices use corresponding built-in or plug-in receivers to recharge while resting on the mat. These receivers contain compatible coils and the circuitry necessary to deliver electricity to devices' batteries A Splash power mat uses induction to recharge multiple devices simultaneously.

1.1Moderate Distance Power Transmission:

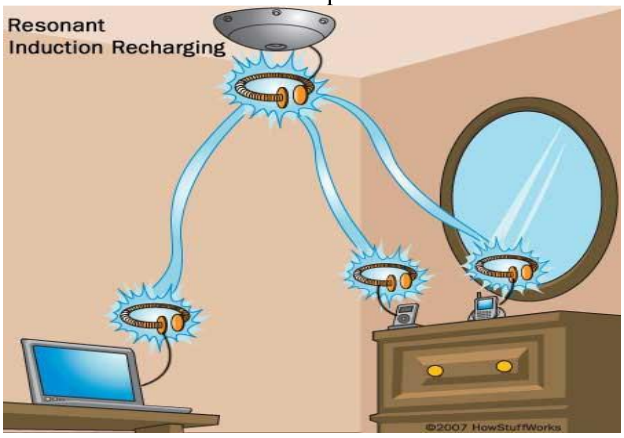
Household devices produce relatively small magnetic fields. For this reason, chargers hold devices at the distance necessary to induce a current, which can only happen if the coils are close together. A larger, stronger field could induce current from farther away, but the process would be extremely inefficient. Since a magnetic field spreads in all directions, making a larger one would waste a lot of energy.

An efficient way to transfer power between coils separated by a few meters is that we could extend the distance between the coils by adding resonance to the equation. A good way to understand resonance is to think of it in terms of sound. An object's physical structure like the size and shape of a trumpet determines the frequency at which it naturally vibrates. This is its **resonant frequency**. It's easy to get objects to vibrate at their resonant frequency and difficult to get them to vibrate at other frequencies. This is why playing a trumpet can cause a nearby trumpet to begin to vibrate. Both trumpets have the same resonant frequency.

Induction can take place a little differently if the electromagnetic fields around the coils resonate at the same frequency. The theory uses a curved coil of wire as an inductor. A **capacitance plate**, which can hold a charge, attaches to each end of the coil. As electricity travels through this coil, the coil begins to resonate. Its resonant frequency is a product of the inductance of the coil and the capacitance of the plates.



In a short theoretical analysis they demonstrate that by sending electromagnetic waves around in a highly angular waveguide, evanescent waves are produced which carry no energy. An evanscent wave is nearfield standing wave exhibiting exponential decay with distance. If a proper resonant waveguide is brought near the transmitter, the evanescent waves can allow the energy to tunnel (specifically evanescent wave coupling, the electromagnetic equivalent of tunneling to the power drawing waveguide, where they can be rectified into DC power. Since the electromagnetic waves would tunnel, they would not propagate through the air to be absorbed or dissipated, and would not disrupt electronic devices.As long as both coils are out of range of one another, nothing will happen, since the fields around the coils aren't strong enough to affect much around them. Similarly, if the two coils resonate at different frequencies, nothing will happen. But if two resonating coils with the same frequency get within a few meters of each other, streams of energy move from the transmitting coil to the receiving coil. According to the theory, one coil can even send electricity to several receiving coils, as long as they all resonate at the same frequency. The researchers have named this **non-radiative energy transfer** since it involves stationary fields around the coils rather than fields that spread in all directions.



"Resonant inductive coupling" has key implications in solving the two main problems associated with non-resonant inductive coupling and electromagnetic radiation, one of which is caused by the other; distance and efficiency. Electromagnetic induction works on the principle of a primary coil generating a predominantly magnetic field and a secondary coil being within that field so a current is induced within its coils.

This causes the relatively short range due to the amount of power required to produce an electromagnetic field. Over greater distances the non-resonant induction method is inefficient and wastes resonates at the same frequency. Much of the transmitted energy just to increase range. This is where the resonance comes in and helps efficiency dramatically by "tunneling" the magnetic field to a receiver coil that Unlike the multiple-layer secondary of a non-resonant transformer, such receiving coils are single layer solenoids with closely spaced capacitor plates on each end, which in combination allow the coil to be tuned to the transmitter frequency thereby eliminating the wide energy wasting "wave problem" and allowing the energy used to focus in on a specific frequency increasing the range.

1.2 Long-distance Wireless Power:

Whether or not it incorporates resonance, induction generally sends power over relatively short distances. But some plans for wireless power involve moving electricity over a span of miles. A few proposals even involve sending power to the Earth from space.

In the 1980s, Canada's Communications Research Centre created a small airplane that could run off power beamed from the Earth. The unmanned plane, called the Stationary High Altitude Relay Platform (SHARP), was designed as a communications relay. Rather flying from point to point, the SHARP could fly in circles two kilometers in diameter at an altitude of about 13 miles (21 kilometers). Most importantly, the aircraft could fly for months at a time.

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Unmanned plane

The secret to the SHARP's long flight time was a large, ground-based microwave transmitter. The SHARP's circular flight path kept it in range of this transmitter. A large, disc-shaped rectifying antenna, or rectenna, just behind the plane's wings changed the microwave energy from the transmitter into direct-current (DC) electricity. Because of the microwaves' interaction with the rectenna, the SHARP had a constant power supply as long as it was in range of a functioning microwave array. Rectifying antennae are central to many wireless power transmission theories. They are usually made an array of dipole antennae, which have positive and negative poles. These antennae connect to shot key diodes. Here's what happens:

1. Microwaves, which are part of the electromagnetic spectrum, reach the dipole antennae.
2. The antennae collect the microwave energy and transmit it to the diodes.
3. The diodes act like switches that are open or closed as well as turnstiles that let electrons flow in only one direction. They direct the electrons to the rectenna circuitry.
4. The circuitry routes the electrons to the parts and systems that need them.

II. METHODS OF WIRELESS TRANSMISSION OF ELECTRICAL POWER

2.1 Induction

The principle of mutual induction between two coils can be used for the transfer of electrical power without any physical contact in between. The simplest example of how mutual induction works is the transformer, where there is no physical contact between the primary and the secondary coils. The transfer of energy takes place due to electromagnetic coupling between the two coils.

2.2 Electromagnetic Transmission

Electromagnetic waves can also be used to transfer power without wires. By converting electricity into light, such as a laser beam, then firing this beam at a receiving target, such as a solar cell on a small aircraft, power can be beamed to a single target. This is generally known as “power beaming”.

2.3 Evanescent Wave Coupling

Researchers at MIT believe they have discovered a new way to wirelessly transfer power using non- radiative electromagnetic energy resonant tunneling. Since the electromagnetic waves would tunnel, they would not propagate through the air to be absorbed or wasted, and would not disrupt electronic devices or cause physical injury like microwave or radio transmission. Researchers anticipate up to 5 meters of range.

2.4 Electro dynamic Induction

Also known as "resonant inductive coupling" resolves the main problem associated with non-resonant inductive coupling for wireless energy transfer; specifically, the dependence of efficiency on transmission distance. When resonant coupling is used the transmitter and receiver inductors are tuned to a mutual frequency and the drive current is modified from a sinusoidal to a non-sinusoidal transient waveform. Pulse power transfer occurs over multiple cycles. In this way significant power may be transmitted over a distance of up to a few times the size of the transmitter.

2.5 Radio and Microwave

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. Rectenna conversion efficiencies exceeding 95% have been realized. Power beaming using microwaves has been proposed for the transmission of energy from orbiting solar power satellites to Earth and the beaming of power to spacecraft leaving orbit has been considered.

2.6 Electrostatic Induction

Also known as "capacitive coupling" is an electric field gradient or differential capacitance between two elevated electrodes over a conducting ground plane for wireless energy transmission involving high frequency alternating current potential differences transmitted between two plates or nodes

III. CURRENT TECHNOLOGY IN THE FIELD OF WIRELESS POWER TRANSMISSION

3.1 Microwave Transmitter

The most current research and proposals use microwaves as the frequency range of choice for transmission. At present an efficiency of 76% is possible using current technology for microwave power transmission. For transmission efficiency the waves must be focused so that all the energy transmitted by the source is incident on the wave collection device. Higher frequencies are also impractical because of the high cost of transmitters and the relative low efficiency of current optical and infrared devices.

The most common transmitters for microwaves are the travelling wave tube (TWT), klystron and magnetron. The TWT is far too expensive and power restrictive making it impractical for the task of power transmission. The klystron has been the DC to microwave converter of choice however it is also somewhat expensive. Many researchers are looking to use magnetrons instead because they are cheap and efficient. Magnetron frequency output is not as precisely controllable as the klystron or TWT but power transmission is more lenient to frequency fluctuations than communication systems are. One of the more common proposals would be for an array of magnetrons to be used as the transmitter.

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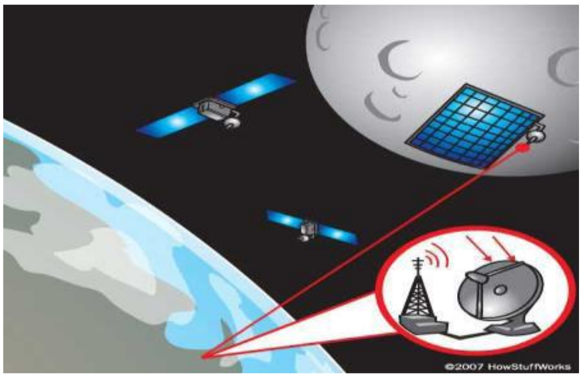
One of the main advantages to using many smaller magnetrons as opposed to a few klystrons is that 300W to 1kW magnetrons are already mass produced for microwave ovens. The efficiency of magnetrons is inconsistently reported.

3.2 Use of Microwave Power Transmission in Solar Power Satellites (SPS):

Solar power generating satellites launched into space and transmitting power to Earth stations. This idea was first proposed in 1968 and all of the experiments have only been carried out in terrestrial laboratories. The SPS satellites would be put in high earth orbit at geosynchronous location. This would allow them to receive light 99% of the year. A large rectenna array facility will be built on the Earth to collect the incoming microwaves. To maintain a good lock on the rectenna the satellite will need to be built with a retro directive transmitter which locks on to a pilot beam emanated from the ground station.



Solar power satellite

Since most of the research is done in the 2.4 GHz to 5.8 GHz range there are some spectrum regulatory issues to deal with. Also since the retro directive antenna system is unproven. There is the health concern that the microwave beam could veer off target and microwave some unsuspecting family. However, a Japanese government agency is planning
to send up 10 to 100 kW low earth orbit satellite to prove its feasibility.

IV. FUTURE ASPECTS

4.1Power-Generating Solar Satellite Inhabitant

Japan wants to power up three million houses with wireless solar-panel-equipped satellite into space that could wirelessly beam a gig watt-strong stream of power down to earth.

Japan's wireless, power-generating, solar satellite in habitat

A small test model is scheduled for launch in 2015. To iron out all the kinks and get a fully functional system set up is estimated to take three decades. A major kink, presumably, is coping with the possible dangers when a 1-gigawatt microwave beam aimed at a small spot on Earth misses its target. The $21 billion project just received major backing from Mitsubishi and designer IHI (in addition to research teams from 14 other countries).

4.2 Third-Generation Wireless Power

Powerby Proxi has developed a 3G wireless power delivery system. Earlier generations of wireless power technology were based on split transformers consisting of two halves: an input side (primary) and an output side (secondary). Electrical energy applied to the primary is converted to an electromagnetic field that induces a current in the secondary, which passes the energy to a load. The essential difference between earlier generations of wireless power solutions and the one developed by Powerby Proxi is that the PowerbyProxi system offers high efficiency levels in relatively loose coupling arrangements across an air gap or through any nonmetallic substrate.

A demonstration model of the PowerbyProxi technology.

PowerbyProxi takes a different approach to wireless power with its patented ProxiWave (Figure) technology. It uses coils to transmit and receive power between a power transmitter (PTx) and power receiver (PRx). These coils are analogous to antennas used for radio communication. A converter, powered through AC mains, a truck battery, or other source, is used to drive the PTx coil. The Proxy Wave power controller regulates the power flow from the receiving PRx coil to the target electrical device or electronics, depending on their specific power requirements.

V. MERITS AND DEMERITS

5.1 Merits

The system would reduce the cost of electrical energy used by the consumer and rid the landscape of wires, cables, and transmission towers. The electrical energy can be economically transmitted without wires to any terrestrial distance, so there will be no transmission and distribution loss. The efficiency of the transmission can be as high as 96 or 97 per cent, and there are practically no losses.

5.2 Demerits

Calculating the circulating reactive power, it was found that the frequency is very small and such a frequency is very biologically compatible.

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VI. CONCLUSION

The crucial advantage of using the non-radioactive field lies in the fact that most of the power not picked up by the receiving coil remains bound to the vicinity of the sending unit, instead of being radiated into the environment and lost. With such a design, power transfer for laptop-sized coils are more than sufficient to run a laptop can be transferred over room-sized distances nearly Omni-directionally and efficiently, irrespective of the geometry of the surrounding space, even when environmental objects completely obstruct the line-of-sight between the two coils .As long as the laptop is in a room equipped with a source of such wireless power, it would charge automatically, without having to be plugged in. In fact, it would not even need a battery to operate inside of such a room." In the long run, this could reduce our society's dependence on batteries, which are currently heavy and expensive. At the same time for the long range power. Wireless power transmission of electrical power can be considered as a large scope in electrical engineering for future prospects of power generation and transfer. Solar power satellites are the future of supplying non conventional energy. The various methods and aspects regarding wireless transmission of electrical power are discussed. The evolution of the technology from the time of Tesla has been overviewed**.**

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