

Wireless Power Transmission: An Innovative Idea

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Abstract

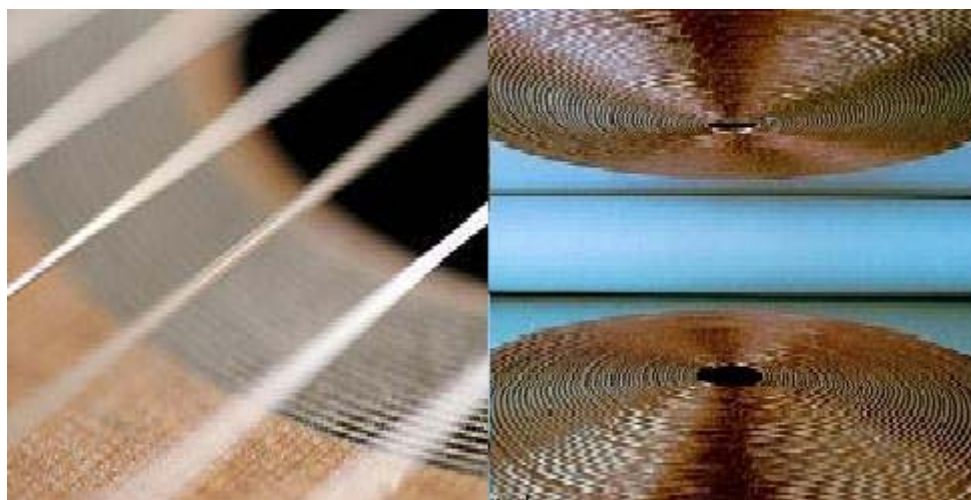
We cannot imagine the world without electric power. Generally the power is transmitted through wires. This paper describes an original idea to eradicate the hazardous usage of electrical wires which involve lot of confusion in particularly organizing them. Imagine a future in which wireless power transfer 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 effect 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 rectennas**. 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 varying in distances . .

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 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, but others are already in use. This paper provides the techniques used for wireless power transmission.



Evanescent wavic motion.

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*.

Short distance induction

These methods can reach at most a few centimetres. 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 dangerous. Ordinary electrical connections could also allow water to seep into the toothbrush, damaging its components. Because of this, most toothbrushes recharge through **inductive coupling**.

You can use the same principle to recharge several devices at once. For example, the Splashpower 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 Splashpower mat uses induction to recharge multiple devices simultaneously.

Moderate distance

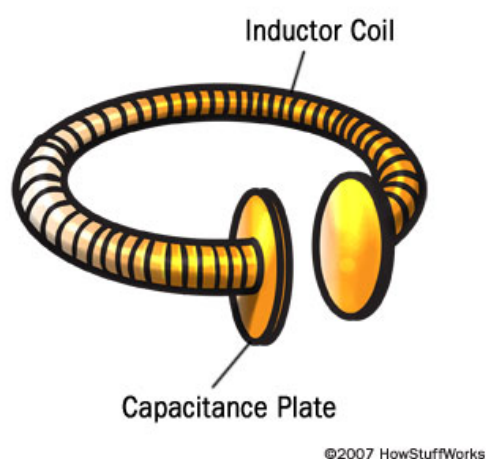
Resonance and Wireless Power

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.



The wireless power project uses a curved coil and capacitive plates.

Electricity, traveling along an electromagnetic wave, can **tunnel** from one coil to the other as long as they both have the same resonant frequency.

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 evanescent 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.



According to the theory, one coil can recharge any device that is in range, as long as the coils have the same resonant frequency.

"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 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 resonates at the same frequency. 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.

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..



(SHARP) 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 shottkey 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's circuitry.
4. The circuitry routes the electrons to the parts and systems that need them.

Efficiency

The efficiency of wireless power is the ratio between power that reaches the receiver and the power supplied to the transmitter. Researchers successfully demonstrated the ability to power a 60 watt light bulb from a power source that was seven feet (2 meters) away using resonating coils. This kind of setup could power or recharge all the devices in one room. Some modifications would be necessary to send power over long distances, like the length of a building or a city. 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.

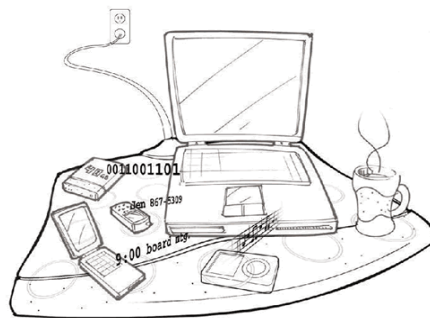
Wireless Power Transmission (using microwaves) is well proven. Experiments in the tens of kilowatts have been performed.

Need for wireless power transmission

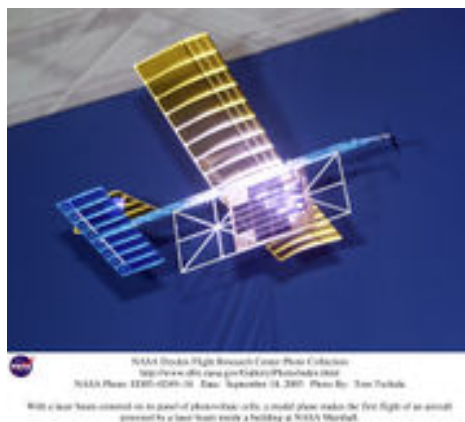
Wireless transmission is employed in cases where instantaneous or continuous energy transfer is needed, but interconnecting **wires are inconvenient, hazardous, or impossible.**



Number of household points receives electricity at the same frequency using single transmitting coil as long as they all are at resonance. So this setup could recharge all the devices in a room at once.



The unmanned planes or robots (where wires cannot be involved viz oceans volcanic mountains etc.) which are run by the wireless power over an area, as they could fly for months at a time, could be used for research as well as a mini satellite.



A few proposals even involve sending power to the Earth from space.

Conclusion

The crucial advantage of using the non-radiative 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 transmission, power can be sent from source to receivers instantaneously without wires, reducing the cost.

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