A TECHNICAL PAPER PRESENTATION ON

WITRICITY

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ABSTRACT:

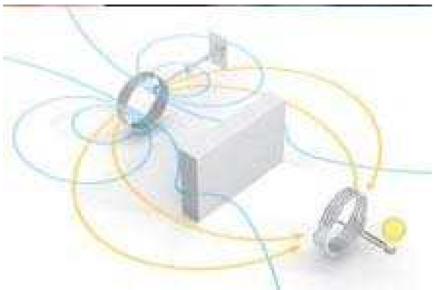
The aim of this paper is to introduce a new system of transmitting the power which is called wireless electricity or witricity. **Witricity** is based upon coupled resonant objects to transfer electrical energy between objects without wires. The system consists of a **Witricity transmitter** (power source), and devices which act as **receivers** (electrical load). It is based on the principle of resonant coupling and microwave energy transfers. The action of an electrical transformer is the simplest instance of wireless energy transfer. There are mainly two types of transfers i.e. short range and long range transmission. The short range are of 2-3metres where as the long range are of few kilometers. Wireless transmission is ideal in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires are inconvenient, hazardous, or impossible. The tangle of cables and plugs needed to recharge today's electronic gadgets could soon be a thing of the past. The concept exploits century-old physics and could work over distances of many metres. Consumers desire a simple universal solution that frees them from the hassles of plug-in chargers and adaptors. "Wireless power technology has the potential to deliver on all of these needs." However, transferring the power is the important part of the solution.

Witricity, standing for wireless electricity, is a term coined by MIT researchers, to describe the ability to provide electricity to remote objects without wires. Using selfresonant coils in a strongly coupled regime, efficient non-radiative power transfer over distances of up to eight times the radius of the coils can be done.. Unlike the conduction-based systems, Witricity uses resonant magnetic fields to reduce wastage of power. Currently the project is looking for power transmissions in the range of 100 watts.

With wireless energy transfer, the efficiency is a more critical parameter and this creates important differences from the wireless data transmission technologies. To avoid the conflicts like recharging and carrying its appliances of electrical and electronic devices, wireless power transmission is desirable. Wireless power transmission was originally proposed to avoid long distance electrical distribution based mainly on copper cables. This can be achieved by using microwave beams and the rectifying antenna, or rectenna, which can receive electromagnetic radiation and convert it efficiently to DC 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.

Magnetic resonance was found a promising means of electricity transfer because magnetic fields travel freely through air yet have little effect on the environment or, at the appropriate frequencies, on living beings and hence is a leading technology for developing witricity.

HOW IT WORKS



Wireless light: Researchers used magnetic resonance coupling to power a 60-watt light bulb. Tuned to the same frequency, two 60-centimeter copper coils can transmit electricity over a distance of two meters, through the air and around an obstacle. The researchers built two resonant copper coils and hung them from the ceiling, about two meters apart. When they plugged one coil into the wall, alternating current flowed through it, Creating a magnetic field. The second coil, tuned to the same frequency and hooked to a light bulb, resonated with the magnetic field, generating an electric current that lit up the bulb--even with a thin wall between the coils. How wireless energy could work-

"Resonance", a phenomenon that causes an object to vibrate when energy of a certain frequency is applied. Two resonant objects of the same frequency tend to couple very strongly." Resonance can be seen in musical instruments for example. "When you play a tune on one, then another instrument with the same acoustic resonance will pick up that tune, it will visibly vibrate," Instead of using acoustic vibrations, system exploits the resonance of electromagnetic waves. Electromagnetic radiation includes radio waves, infrared and X-rays. Typically, systems that use electromagnetic radiation, such as radio antennas, are not suitable for the efficient transfer of energy because they scatter energy in all directions, wasting large amounts of it into free space. To overcome this problem, the team investigated a special class of "non-radiative" objects with so-called "long-lived resonances". When energy is applied to these objects it remains bound to them, rather than escaping to space. "Tails" of energy, which can be many metres long, flicker over the surface. If another resonant object is brought with the same frequency close enough to these tails then it turns out that the energy can tunnel from one object to another. Hence, a simple copper antenna designed to have long-lived resonance could transfer energy to a laptop with its own antenna resonating at the same frequency. The computer would be truly wireless. Any energy not diverted into a gadget or appliance is simply reabsorbed. The systems that are described would be able to transfer energy over three to five metres. This would work in a room let's say but can be adapted to work in a factory. It could also be scaled down to the microscopic or nanoscopic world.

HOW WIRELESS POWER COULD WORK

1. Power from mains to antenna, which is made of copper

2. Antenna resonates at a frequency of 6.4MHz, emitting electromagnetic waves

3. 'Tails' of energy from antenna 'tunnel' up to 5m (16.4ft)

4. Electricity picked up by laptop's antenna, which must also be resonating at 6.4MHz. Energy used to re-charge device

5. Energy not transferred to laptop re-absorbed by source antenna.

People/other objects not affected as not resonating at 6.4MHz

Short range power transmission and reception –

Power supply for portable electronic devices is considered, which receives ambient radio frequency radiation (typically in an urban environment) and converts it to DC electricity that is stored in a battery for use by the portable device. A Power transmission unit (PTU) is connected to the electrical utility, typically in a domestic and office environment, and uses the electricity to generate a beam of electromagnetic radiation. This beam can take the form of visible light, microwave radiation, near infrared radiation or any appropriate frequency or frequencies, depending on the technology chosen. The beam can be focused and shaped using a focusing mechanism: for example, a parabola shape may be chosen to focus light waves at a certain distance from the PTU. A Power reception unit (PRU) receives power from one or several PTU's, and converts the total power received to electricity, which is used to trickle charge a storage unit such as a battery or transferred directly to the appliance for use, or both. If transferred to the storage unit, the output of the storage unit can power the appliance. Similarly to the focusing of the transmitted power, it is possible to concentrate the received power for conversion, using receiving arrays, antennas, reflectors or similar means. It is possible to construct power "relay units", consisting of PRU's powering PTU's, whose function is to make the transmitted power available at further distances than would normally be possible.

Long-distance Wireless Power- 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. The Stationary High Altitude Relay Platform (SHARP) unmanned plane could run off power beamed from the Earth. The secret to the SHARP's long flight time was a large, ground-based microwave transmitter. A large, disc-shaped **rectifying antenna**, or **rectenna**, near the system changed the microwave energy from the transmitter into direct-current (DC) electricity. Because of the microwaves' interaction with the rectenna, the system 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 of an array of dipole antennae, which have positive and negative poles. These antennae connect to semiconductor 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. .

TYPES OF WIRELESS TRANSMISSION

Near field

1. Induction
2. Resonant induction

Far field

1. Radio and microwave transmission
2. Laser
3. Electrical conduction

Near field-

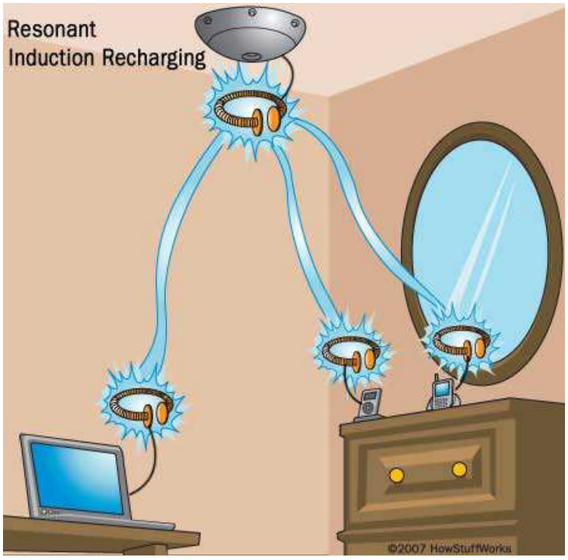
These are wireless transmission techniques over distances comparable to, or a few times the diameter of the device(s).

Induction

Inductive couplingThe action of an electrical transformer is the simplest instance of wireless energy transfer. The primary and secondary circuits of a transformer are not directly connected. 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 battery charger of an electric toothbrush is an example of how this principle can be used. The main drawback to induction, however, is the short range. The receiver must be very close to the transmitter or induction unit in order to inductively couple with it.

Resonant induction

A trumpet's size, shape and material composition determine its resonant frequency.



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

By designing electromagnetic resonators that suffer minimal loss due to radiation and absorption and have a near field with midrange extent (namely a few times the resonator size), mid-range efficient wireless energytransfer is possible. The reasonment is that, if two such resonant objects are brought in midrange proximity, their near fields (consisting of so-called 'evanescent waves') couple (evanescent wave coupling) and can allow the energy to transfer from one object to the other within times much shorter than all loss times, which were designed to be long, and thus with the maximum possible energy-transfer efficiency. Since the resonant wavelength is much larger than the resonators, the field can circumvent extraneous objects in the vicinity and thus this mid-range energy-transfer scheme does not require line-of-sight. By utilizing in particular the magnetic field to achieve the coupling, this method can be safe, since magnetic fields interact weakly with living organisms. "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

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

A trumpet's size, shape and material composition determine its resonant frequency.

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.

Some of these wireless resonant inductive devices operate at low milliwatt power levels and are battery powered. Others operate at higher kilowatt power levels. Current implantable medical and road electrification device designs achieve more than 75% transfer efficiency at an operating distance between the transmit and receive coils of less than 10 cm.

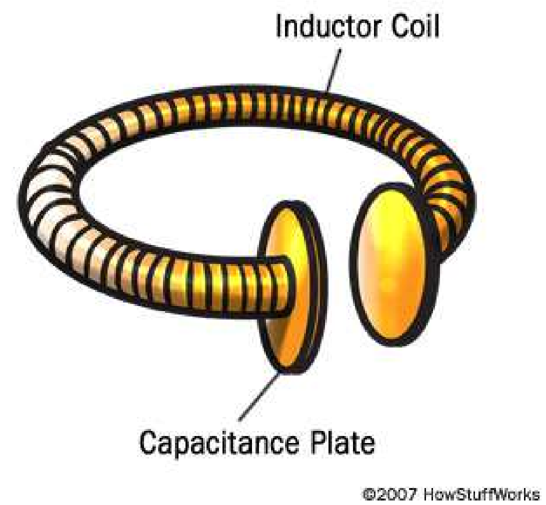
Resonance and Wireless Power-

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.

The distance between the coils can be extended by adding resonance to the equation. A good way to understand resonance is to think of it in terms of sound.

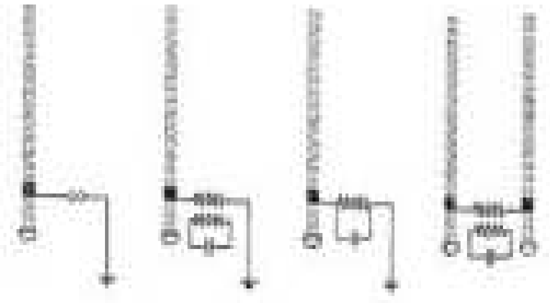
An object's physical structure -- like the size and shape of a trumpet -- determines the frequency at which it naturally vibrates. This is its resonant frequency**.** It's easy to get objects to vibrate at their resonant frequency and difficult to get them to vibrate at other frequencies. This is why 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. As with an electric toothbrush, this system relies on two coils. Electricity, traveling along an electromagnetic wave, can **tunnel** from one coil to the other as long as they both have the same resonant frequency. The effect is similar to the way one vibrating trumpet can cause another to vibrate. 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. 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.



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

Far field-



Means for long conductors of electricity forming part of an electric circuit and electrically connecting said ionized beam to an electric circuit. These methods achieve longer ranges, often multiple kilometre ranges, where the distance is much greater than the diameter of the device(s).

Radio and microwave-

Microwave power transmission 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.

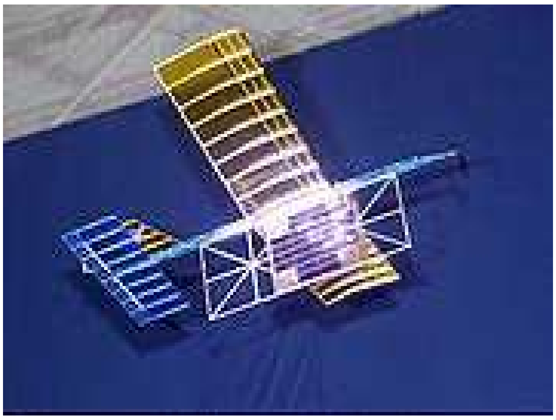
Power beaming using microwaves has been proposed for the transmission of energy from orbiting solar power satellites to Earth and the beaming of power to spacecraft leaving orbit has been considered.

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

Power beaming by microwaves has the difficulty that for most space applications the required aperture sizes are very large. These sizes can be somewhat decreased by using shorter wavelengths, although short wavelengths may have difficulties with atmospheric absorption and beam blockage by rain or water droplets. For earthbound applications a large area 10 km diameter receiving array allows large total power levels to be used while operating at the low power density suggested for human electromagnetic exposure safety. A human safe power density of 1 mW/cm2 distributed across a 10 km diameter area corresponds to 750 megawatts total power level. This is the power level found in many modern electric power plants. High power- Wireless Power Transmission (using microwaves) is well proven. Experiments in the tens of kilowatts have been performed, achieving distances on the order of a kilometer. Low power- A new company, Powercast introduced wireless power transfer technology using RF energy; this system is applicable for a number of devices with low power requirements. This could include LEDs, computer peripherals, wireless sensors, and medical implants.

Currently, it achieves a maximum output of 6 volts for a little over one meter.

Laser-



With a laser beam centered on its panel of photovoltaic cells, a lightweight model plane makes the first flight of an aircraft powered by a laser beam inside a building at NASA Marshall Space Flight Center. In the case of light, power can be transmitted by converting electricity into a laser beam that is then fired at a solar cell receiver. This is generally known as "power beaming".

Its drawbacks are:

1. Conversion to light, such as with a laser, is moderately inefficient (although quantum cascade lasers improve this)
2. Conversion back into electricity is moderately 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.

Electrical conduction Electrical energy can also be transmitted by means of electrical currents made to flow through naturally existing conductors, specifically the earth, lakes and oceans, and through the atmosphere — a natural medium that can be made conducting if the breakdown voltage is exceeded and the gas becomes ionized. For example, when a high voltage is applied across a neon tube the gas becomes ionized and a current passes between the two internal electrodes. In a practical wireless energy transmission system using this principle, a high-power ultraviolet beam might be used to form a vertical ionized channel in the air directly above the transmitter-receiver stations. The same concept is used in virtual lightning rods, the electrolaser electroshock weapon and has been proposed for disabling vehicles.

The Tesla effect- A "world system" for "the transmission of electrical energy without wires" that depends upon electrical conductivity was proposed by Tesla. Through longitudinal waves, an operator uses the Tesla effect in the wireless transfer of energy to a receiving device. The *Tesla effect* is the application of a type of electrical conduction (that is, the movement of energy through space and matter; not just the production of voltage across a conductor). Tesla stated, “Instead of depending on induction at a distance to light the tube [... the] ideal way of lighting a hall or room would be to produce such a condition in it that an illuminating device could be moved and put anywhere, and that it is lighted, no matter where it is put and without being electrically connected to anything. I have been able to produce such a condition by creating in the room a powerful, rapidly alternating electrostatic field. For this purpose I suspend a sheet of metal a distance from the ceiling on insulating cords and connect it to one terminal of the induction coil, the other terminal being preferably connected to the ground. An exhausted tube may then be carried in the hand anywhere between the sheets or placed anywhere, even a certain distance beyond them; it remains always luminous.” The Tesla effect is a type of high field gradient between electrode plates for wireless energy transfer.

ADVANTAGES-

- Wireless electric energy transfer for experimentally powering electric automobiles and buses is a higher power application (>10kW) of resonant inductive energy transfer.
- The use of wireless transfer has been investigated for recharging electric automobiles in parking spots and garages as well.
- Any low-power device, such as a cell phone, iPod, or laptop, could recharge automatically simply by coming within range of a wireless power source, eliminating the need for multiple cables—and perhaps, eventually, for batteries.
- With the advent of wireless communication protocols such as Wi-Fi or Bluetooth, consumers are realizing that life without physical cables is easier, more flexible and often less costly.
- As the population continues to grow the demand for electricity could out space the ability to produce it, eventually wireless power may become a necessity rather than just an interesting idea.

DRAWBACKS-

• The wireless transmission of energy is common in much of the world. Radio waves are energy, and people use them to send and receive cell phone, TV, radio and Wi-Fi signals every day. The radio waves spread in all directions until they reach **antennae** that are tuned to the right frequency. This method for transferring electrical power would be both inefficient and dangerous.

• The main drawback to induction, however, is the short range. The receiver must be very close to the transmitter or induction unit in order to inductively couple with it.

• Many people would resist the idea of being constantly bathed in microwaves from space, even if the risk were relatively low.

APPLICATIONS-

1. Researchers have outlined a relatively simple system that could deliver power to devices such as laptop computers or MP3 players without wires. The concept exploits century-old physics and could work over distances of many metres, the researchers said.

2. A UK company called Splashpower has also designed wireless recharging pads onto which gadget lovers can directly place their phones and MP3 players to recharge them. The pads use electromagnetic induction to charge devices, the same process used to charge electric toothbrushes.

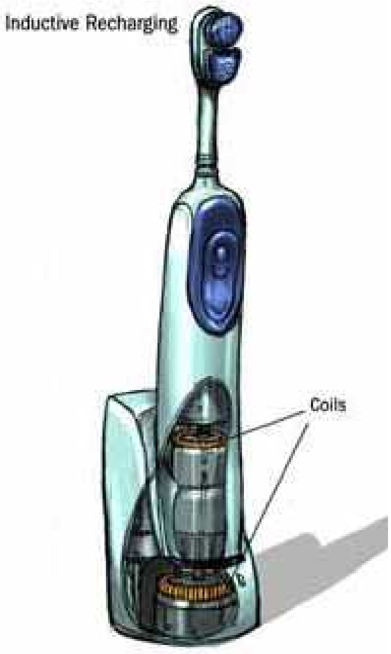
3. Resonant inductive wireless energy transfer was used successfully in implantable medical devices including such devices as pacemakers and artificial hearts. While the early systems used a resonant receiver coil later systems implemented resonant transmitter coils as well.

4. Today resonant inductive energy transfer is regularly used for providing electric power in many commercially available medical implantable devices.

5.some of the applications with the diagram are shown below:

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

inductivecoupling



An electric toothbrush's base and handle contain coils that allow the battery to recharge.

Most electric toothbrushes recharge through inductive coupling.

How a transformer works, and its how an electric toothbrush recharges. It takes three basic steps:

1. Current from the wall outlet flows through a coil inside the charger, creating a magnetic field. In a transformer, this coil is called the **primary winding**.

2. When you place your toothbrush in the charger, the magnetic field induces a current in another coil, or **secondary winding**, which connects to the battery.

3. This current recharges the battery.

You can use the same principle to recharge several devices at once. For example, the Splashpower recharging mat and Edison Electric's Powerdesk 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. Eliminating the power cord would make today's ubiquitous portable electronics truly wireless.

A
Splashpower mat uses induction to recharge multiple devices simultaneously

CONCLUSION

Most electric toothbrushes recharge

through inductive coupling. An electric toothbrush's base and handle contain coils that allow the battery to recharge. A Splashpower mat uses induction to recharge multiple devices simultaneously.

From these researches and discoveries it can be said that wireless power transmission is going to be a major field of interest for scientists and for people. The facts that the power can be transmitted from space to earth will revolutionize the field of satellites. Since the uses of wireless power transmission are many, from easy installation, neatness, easy maintenance to multi-equipment working are amazing, the area for researchers on this field seems very interesting. Rather concentrating on the false beliefs, the concentration should be put on advantages of witricity for further increasing the efficiency of wireless power transmission with more safety measures. It is a rocking technology provided the researches continue to move in same speeding direction.