ISSN 2349-4506
Impact Factor: 2.785

Global Journal of Engineering Science and Research Management

WIRELESS POWER TRANSMISSION USING INDUCTIVE RESONANCE COUPLING IN MOBILE CHARGERING

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DOI: 10.5281/zenodo.154540

KEYWORDS: Coupled resonance, Electromagnetic field, tesla coil.

ABSTRACT
The objective of this technical report is to provide electrical energy to remote objects without wires. Wireless energy transfer also known as wireless energy transmission is the process that takes place in any system where electromagnetic energy is transmitted from a power source to an electrical load, without interconnecting wires. The principle of wireless electricity works on the principle of using coupled resonant objects for the transfer of electricity to objects without the use of any wires. A witricity system consists of a witricity transmitter and another device called the receiver. It is with the help of resonant magnetic fields that witricity produces electricity, while reducing the wastage of power. The present report on witricity aims at power transmissions in the range of 100 watts. May be the products using witricity in future might be called Witric or Witric's.

INTRODUCTION
In wireless power transfer, a wireless transmitter connected to a power source conveys the field energy across an intervening space to one or more receivers, where it is converted back to an electrical current and then used. Japan and China both have national ambitions to begin on-orbit testing of Solar Power Satellites by the 2030s which may accelerate both technical and regulatory progress. An important issue associated with all wireless power systems is limiting the exposure of people and other living things to potentially injurious electromagnetic fields.Wireless transmission is useful to power electrical devices in cases where interconnecting wires are inconvenient, hazardous, or are not possible.

POWER TRANSFER PROCESS
In general a wireless power system consists of a "transmitter" connected to a source of power such as a main power line, which converts the power to a time-varying electromagnetic field, and one or more "receiver" devices which receive the power and convert it back to DC or AC electric current which is used by an electrical load. At the transmitter the input power is converted to an oscillating electromagnetic field by some type of "antenna" device. The word "antenna" is used loosely here; it may be a coil of wire which generates a magnetic field, a metal plate which generates an electric field, an antenna which radiates radio waves, or a laser which generates light. A similar antenna or coupling device at the receiver converts the oscillating fields to an electric current. An important parameter that determines the type of waves is the frequency f in hertz of the oscillations. The frequency determines the wavelength $\lambda = c/f$ of the waves which carry the energy across the gap, where c is the velocity of light. Wireless power uses the same fields.

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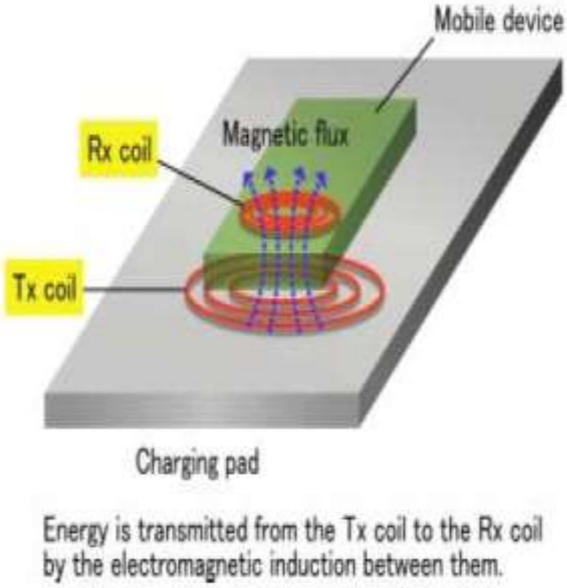
WIRELESS BATTERY CHARGER CIRCUIT PRINCIPLE



This circuit mainly works on the principle of mutual inductance. Power is transferred from transmitter to the receiver wirelessly based on the principle of "inductive coupling".Inductance is the property of the conductor, in which the current flowing in a conductor induces a voltage or electromotive force in it or in another nearby conductor. There are two types inductance.
1) Self-inductance
2) Mutual Inductance.

"Mutual inductance" is the phenomena in which, when a current carrying conductor is placed near another conductor voltage is induced in that conductor. This is because, as the current is flowing in the conductor, a magnetic flux is induced in it. This induced magnetic flux links with another conductor and this flux induces voltage in the second conductor. Thus two conductors are said to be inductively coupled.

FIELD REGIONS

Electric and magnetic fields are created by charged particles in matter such as electrons. A stationary charge creates an electrostatic field in the space around it. A steady current of charges (direct current, DC) creates a static magnetic field around it. The above fields contain energy, but cannot carry power because they are static. However time-varying fields can carry power. Accelerating electric charges, such as are found in an alternating

THOMSON REUTERS ENDNOTE

[Krishnan et al., 3(9): September, 2016] ISSN 2349-4506
Impact Factor: 2.785

Global Journal of Engineering Science and Research Management

current (AC) of electrons in a wire, create time-varying electric and magnetic fields in the space around them. These fields can exert oscillating forces on the electrons in a receiving "antenna", causing them to move back and forth. These represent alternating current which can be used to power a load. The oscillating electric and magnetic fields surrounding moving electric charges in an antenna device can be divided into two regions, depending on distance D_{range} from the antenna. The boundary between the regions is somewhat vaguely defined. The fields have different characteristics in these regions, and different technologies are used for transferring power.

NEAR-FIELD OR NONRADIATIVE REGION

This means the area within about 1 wavelength (λ) of the antenna. In this region the oscillating electric and magnetic fields are separate and power can be transferred via electric fields by capacitive coupling (electrostatic induction) between metal electrodes, or via magnetic fields by inductive coupling (electromagnetic induction) between coils of wire. These fields are not *radiative*, meaning the energy stays within a short distance of the transmitter. If there is no receiving device or absorbing material within their limited range to "couple" to, no power leaves the transmitter. The range of these fields is short, and depends on the size and shape of the "antenna" devices, which are usually coils of wire. The fields, and thus the power transmitted, decrease exponentially with distance, so if the distance between the two "antennas" D_{range} is much larger than the diameter of the "antennas" D_{ant} very little power will be received. Therefore, these techniques cannot be used for long distance power transmission.

Resonance, such as resonant inductive coupling, can increase the coupling between the antennas greatly, allowing efficient transmission at somewhat greater distances, although the fields still decrease exponentially. Therefore the range of near-field devices is conventionally divided into two categories:

- ***Short range*** – up to about one antenna diameter: $D_{range} \leq D_{ant}$. This is the range over which ordinary non resonant capacitive or inductive coupling can transfer practical amounts of power.
- ***Mid-range*** – up to 10 times the antenna diameter: $D_{range} \leq 10\ D_{ant}$. This is the range over which resonant capacitive or inductive coupling can transfer practical amounts of power.

FAR-FIELD OR RADIATIVE REGION

Beyond about 1 wavelength (λ) of the antenna, the electric and magnetic fields are perpendicular to each other and propagate as an electromagnetic wave; examples are radio waves, microwaves, or light waves. This part of the energy is *radiative*, meaning it leaves the antenna whether or not there is a receiver to absorb it. The portion of energy which does not strike the receiving antenna is dissipated and lost to the system. The amount of power emitted as electromagnetic waves by an antenna depends on the ratio of the antenna's size D_{ant} to the wavelength of the waves λ, which is determined by the frequency: $\lambda = c/f$. At low frequencies f where the antenna is much smaller than the size of the waves, $D_{ant} << \lambda$, very little power is radiated. Therefore the near-field devices above, which use lower frequencies, radiate almost none of their energy as electromagnetic radiation. Antennas about the same size as the wavelength $D_{ant} \approx \lambda$ such as monopole or dipole antennas, radiate power efficiently, but the electromagnetic waves are radiated in all directions (omnidirectionally), so if the receiving antenna is far away, only a small amount of the radiation will hit it. Therefore, these can be used for short range, inefficient power transmission but not for long range transmission. However, unlike fields, electromagnetic radiation can be focused by reflection or refraction into beams. By using a high-gain antenna or optical system which concentrates the radiation into a narrow beam aimed at the receiver, it can be used for ***long range*** power transmission. From the Rayleigh criterion, to produce the narrow beams necessary to focus a significant amount of the energy on a distant receiver, an antenna must be much larger than the wavelength of the waves used: $D_{ant} >> \lambda = c/f$. Practical *beam power* devices require wavelengths in the centimeter region or below, corresponding to frequencies above 1 GHz, in the microwave range or above.

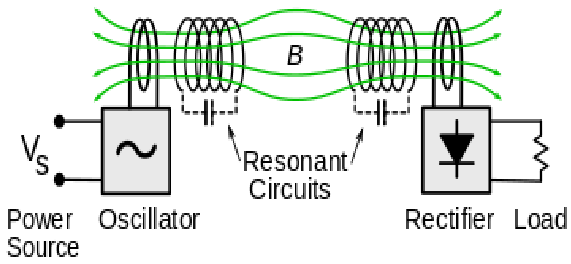
NEAR-FIELD

At large relative distance, the near-field components of electric and magnetic fields are approximately quasi-static oscillating dipole fields. These fields decrease with the cube of distance: $(D_{range}/D_{ant})^{-3}$. Since power is proportional to the square of the field strength, the power transferred decreases as $(D_{range}/D_{ant})^{-6}$ or 60 dB per decade. In other words, if far apart, doubling the distance between the two antennas causes the power received to decrease by a factor of $2^6 = 64$. As a result, inductive and capacitive coupling can only be used for short-range power transfer, within a few times the diameter of the antenna device D_{ant}. Unlike in a radiative system where the maximum radiation occurs when the dipole antennas are oriented transverse to the direction of propagation, with dipole fields the maximum coupling occurs when the dipoles are oriented longitudinally.

INDUCTIVE (MAGNETIC) COUPLING

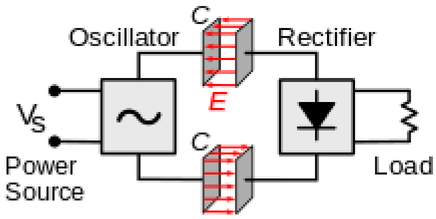
In inductive coupling (*electromagnetic induction* or *inductive power transfer*, IPT), power is transferred between coils of wire by a magnetic field. The transmitter and receiver coils together form a *transformer*. An alternating current (AC) through the transmitter coil *(L1)* creates an oscillating magnetic field *(B)* by Ampere's law. The magnetic field passes through the receiving coil *(L2)*, where it induces an alternating EMF (voltage) by Faraday's law of induction, which creates an AC current in the receiver. The induced alternating current may either drive the load directly, or be rectified to direct current (DC) by a rectifier in the receiver, which drives the load. A few systems, such as electric toothbrush charging stands, work at 50/60 Hz so AC mains current is applied directly to the transmitter coil, but in most systems an electronic oscillator generates a higher frequency AC current which drives the coil, because transmission efficiency improves with frequency. Inductive coupling is the oldest and most widely used wireless power technology and virtually the only one so far which is used in commercial products. It is used in inductive charging stands for cordless appliances used in wet environments such as electric toothbrushes and shavers, to reduce the risk of electric shock. Another application area is "transcutaneous" recharging of biomedical prosthetic devices implanted in the human body, such as cardiac pacemakers and insulin pumps, to avoid having wires passing through the skin. It is also used to charge electric vehicles such as cars and to either charge or power transit vehicles like buses and trains. However the fastest growing use is wireless charging pads to recharge mobile and handheld wireless devices such as laptop and tablet computers, cell phones, digital media players, and video game controllers. The power transferred increases with frequency and the mutual inductance ***M*** between the coils, which depend on their geometry and the distance D_{range} between them. A widely used figure of merit is the coupling coefficient This dimensionless parameter is equal to the fraction of magnetic flux through ***L1*** that passes through ***L2***. If the two coils are on the same axis and close together so all the magnetic flux from ***L1*** passes through ***L2***, $k = 1$ and the link efficiency approaches 100%. The greater the separation between the coils, the more of the magnetic field from the first coil misses the second, and the lower ***k*** and the link efficiency are, approaching zero at large separations. The link efficiency and power transferred is roughly proportional to k^2. In order to achieve high efficiency, the coils must be very close together, a fraction of the coil diameter D_{ant}, usually within centimeters, with the coils' axes aligned. Wide, flat coil shapes are usually used, to increase coupling. Ferrite "flux confinement" cores can confine the magnetic fields, improving coupling and reducing interference to nearby electronics, but they are heavy and bulky so small wireless devices often use air-core coils. Ordinary inductive coupling can only achieve high efficiency when the coils are very close together, usually adjacent. In most modern inductive systems resonant inductive coupling *(described below)* is used, in which the efficiency is increased by using resonant circuits. This can achieve high efficiencies at greater distances than non-resonant inductive coupling.

RESONANCE COUPLING



Resonant inductive coupling (*electrodynamic coupling*, *strongly coupled magnetic resonance*) is a form of inductive coupling in which power is transferred by magnetic fields *(B, green)* between two resonant circuits (tuned circuits), one in the transmitter and one in the receiver *(see diagram, right)*. Each resonant circuit consists of a coil of wire connected to a capacitor, or a self-resonant coil or other resonator with internal capacitance. The two are tuned to resonate at the same resonant frequency. The resonance between the coils can greatly increase coupling and power transfer, analogously to the way a vibrating tuning fork can induce sympathetic vibration in a distant fork tuned to the same pitch. Nikola Tesla first discovered resonant coupling during his pioneering experiments in wireless power transfer around the turn of the 20th century. But the possibilities of using resonant coupling to increase transmission range has only recently been explored. In 2007 a team led by Marin Soljačić at MIT used two coupled tuned circuits each made of a 25 cm self-resonant coil of wire at 10 MHz to achieve the transmission of 60 W of power over a distance of 2 meters (6.6 ft) (8 times the coil diameter) at around 40% efficiency.The concept behind resonant inductive coupling is that high Q factor resonators exchange energy at a much higher rate than they lose energy due to internal damping. Therefore, by using resonance, the same amount of power can be transferred at greater distances, using the much weaker magnetic fields out in the peripheral regions ("tails") of the near fields (these are sometimes called evanescent fields). Resonant inductive coupling can achieve high efficiency at ranges of 4 to 10 times the coil diameter (D_{ant}) .This is called "mid-range" transfer, in contrast to the "short range" of nonresonant inductive transfer, which can achieve similar efficiencies only when the coils are adjacent. Another advantage is that resonant circuits interact with each other so much more strongly than they do with non-resonant objects that power losses due to absorption in stray nearby objects are negligible. A drawback of resonant coupling is that at close ranges when the two resonant circuits are tightly coupled, the resonant frequency of the system is no longer constant but "splits" into two resonant peaks, so the maximum power transfer no longer occurs at the original resonant frequency and the oscillator frequency must be tuned to the new resonance peak. Resonant technology is currently being widely incorporated in modern inductive wireless power systems. One of the possibilities envisioned for this technology is area wireless power coverage. A coil in the wall or ceiling of a room might be able to wirelessly power lights and mobile devices anywhere in the room, with reasonable efficiency. An environmental and economic benefit of wirelessly powering small devices such as clocks, radios, music players and remote controls is that it could drastically reduce the 6 billionbatteries disposed of each year, a large source of toxic waste and groundwater contamination.

CAPACITIVE COUPLING



In capacitive coupling (electrostatic induction), the conjugate of inductive coupling, energy is transmitted by electric field between electrodes such as metal plates. The transmitter and receiver electrodes form a capacitor, with the intervening space as the dielectric. An alternating voltage generated by the transmitter is applied to the transmitting plate, and the oscillating electric field induces an alternating potential on the receiver plate by electrostatic induction, which causes an alternating current to flow in the load circuit. The amount of power transferred increases with the frequency the square of the voltage, and the capacitance between the plates, which is proportional to the area of the smaller plate and (for short distances) inversely proportional to the separation.Capacitive coupling has only been used practically in a few low power applications, because the very high voltages on the electrodes required to transmit significant power can be hazardous, and can cause unpleasant side effects such as noxious ozone production. In addition, in contrast to magnetic fields electric fields interact strongly with most materials, including the human body, due to dielectric polarization Intervening materials between or near the electrodes can absorb the energy, in the case of humans possibly causing excessive electromagnetic field exposure. However capacitive coupling has a few advantages over inductive. The field is largely confined between the capacitor plates, reducing interference, which in inductive coupling requires heavy ferrite "flux confinement" cores. Also, alignment requirements between the transmitter and receiver are less critical. Capacitive coupling has recently been applied to charging battery powered portable devices and is being considered as a means of transferring power between substrate layers in integrated circuits.

ENERGY HARVESTING

In the context of wireless power, *energy harvesting*, also called *power harvesting* or *energy scavenging*, is the conversion of ambient energy from the environment to electric power, mainly to power small autonomous wireless electronic devices. The ambient energy may come from stray electric or magnetic fields or radio waves from nearby electrical equipment, light, thermal energy (heat), or kinetic energy such as vibration or motion of the device. Although the efficiency of conversion is usually low and the power gathered often minuscule (milliwatts or microwatts), it can be adequate to run or recharge small micropower wireless devices such as remote sensors, which are proliferating in many fields. This new technology is being developed to eliminate the need for battery placement or charging of such wireless devices, allowing them to operate completely autonomously.

TESLA'S EXPERIMENTS

Tesla demonstrating the transmission of electrical energy without wires during a lecture at Columbia College, New York, in 1891. The two metal sheets are connected to his Tesla coil oscillator, which applies a high-voltage radio frequency alternating current. An oscillating electric field between the sheets ionizes the low-pressure gas in the two long Geissler tubes in his hands, causing them to glow, similar to neon tubes

An experiment at Tesla's Experimental Station in Colorado Springs, demonstrating the wireless transmission of electrical energy sufficient to power a 10-watt incandescent lamp at a distance of 1,938 feet (591 m) from the station's magnifying transmitter. Tesla's unsuccessful Wardenclyffe World Wireless system station prototype.Resonant wireless power demonstration at the Franklin Institute, Philadelphia, 1937. The vacuum tube oscillator transmits electrical energy inductively to the resonant circuit receiver lighting the bulb. Visitors could adjust the receiver's tuned circuit with the two knobs. When theresonant frequency of the receiver was out of tune with the transmitter, the light would go out.

CONCLUSION

The electrical energy can be economically transmitted without wires to any terrestrial distance. Many researchers have established in numerous observations, experiments and measurements, qualitative and quantitative. Wireless transmission of electricity have tremendous merits like high transmission integrity and Low Loss (90 – 97% efficient) and can be transmitted to anywhere in the globe and eliminate the need for an inefficient, costly, and capital intensive grid of cables, towers, and substations. Many countries will benefit from this service.

REFERENCES

1. Nikola Tesla, "The Transmission of Electrical Energy without Wires as a Means for Furthering Peace," Electrical World andEngineer. Jan. 7, p. 21, 1905.
2. Nikola Tesla, My Inventions, Ben Johnston, Ed., Austin, HartBrothers, p. 91,1982.
3. Thomas F. Valone, "Tesla's Wireless Energy... For the 21stCentury!!! One Step beyond Direct TV!!!" Extra Ordinary Technology, 1, no. 4, Oct/ Nov/ Dec2003.

ISSN 2349-4506
Impact Factor: 2.785
Global Journal of Engineering Science and Research Management

4. James O. McSpadden, "Wireless Power Transmission Demonstration", Texas A&M University, June, 1997.
5. Thomas W. Benson,"Wireless transmission of power now possible", News Letter, pp1118 9, March, 1920
6. Science reporter magazine
7. Wikipedia the free encyclopedia.
8. Brown., W. C. (September 1984). " The History of Power Transmission by Radio Waves ". Microwave Theory and Techniques, IEEE Transactions on (Volume: 32, Issue: 9 On page(s): 1230- 1242 + ISSN: 0018-9480). http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=113283.
9. HISTORY OF WIRELESS Tapan K. Sarkar Robert J.Mailloux Arthur A. Oliner Magdalena Salazar-Palma Dipak L. Sengupta.
10. POINT-TO-POINT WIRELESS POWER TRANSPORTATION IN REUNION ISLAND 48th International Astronautical Congress, Turin, Italy, 6-10 October 1997 - IAF-97-R.4.08 J. D. Lan Sun Luk, A. Celeste, P. Romanacce, L. Chane Kuang Sang, J. C. Gatina - University of La Réunion - Faculty of science and technology