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WIRELESS ENERGY TRANSFER

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ABSTRACT

Wireless energy transfer or wireless power transmission is the process that takes place in any system where electrical energy is transmitted from a power source to an electrical load, without interconnecting wires in an electrical grid. Wireless transmission is ideal in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires are inconvenient, hazardous, or impossible.Though the physics of both are related, this is distinct from wireless transmission for the purpose of transferring information (such as radio), where the percentage of the power that is received is only important if it becomes too low to successfully recover the signal. With wireless energy transfer, the efficiency is a more critical parameter and this creates important differences in these technologies, figure shows an artist's depiction of a solar satellite, which could send energy wirelessly to a space vessel or planetary surface

1.HISTORY

- **1864:** James Clerk Maxwell mathematically modeled the behavior of electromagnetic radiation.
- **1888**: Heinrich Rudolf Hertz confirmed the existence of electromagnetic radiation. Hertz's "apparatus for generating electromagnetic waves" is generally acknowledged as the first radio transmitter.
- **1894**: Jagdish Chandra Bose ignited gunpowder and rang a bell at a distance using electromagnetic waves, showing that communication signals can be sent without using wires.
- **1895**: Jagdish Chandra Bose transmitted signals over a distance of nearly a mile.
- **1897:**Guglielmo Marconi had transmitted Morse code signals over a distance of about 6 km.

- **1897**: Nikola Tesla (inventor of radio microwaves and Alternating current) filed his first patents dealing with Wardenclyffe tower.
- **1900**: Marconi failed to get a patent for Radio in the United States. The patent office mentioned "Marconi's pretended ignorance of the nature of a "Tesla oscillator" being little short of absurd.
- **1901**:, Guglielmo Marconi first transmitted and received signals across the Atlantic Ocean. Engineer Otis Pond working for Tesla, said, "Looks as if Marconi got the jump on you." Tesla replied, "Marconi is a good fellow. Let him continue. He is using seventeen of my patents."
- **1904**:, at the St. Louis World's Fair, a prize was offered for a successful attempt to drive a 0.1 horsepower (75 W) air-ship motor by energy transmitted through space at a distance of least 100 feet (30 m).
- **1964**: William C. Brown demonstrated on CBS News with Walter Cronkite a microwave-powered model helicopter that received all the power needed for flight from a microwave beam. Between 1969 and 1975 Brown was technical director of a JPL Raytheon program that beamed 30 kW over a distance of 1 mile at 84% efficiency.
- **1975**: Goldstone Deep Space Communications Complex did experiments in the tens of kilowatts.
- **2003**: NASA Dryden Flight Research Center demonstrated a laser-powered model airplane indoors.

- **2008**: Intel showed how to send power wirelessly to power a light bulb at 75% efficiency

2.SIZE,DISTANCE & EFFECIENCY

The size of the components is dictated by the distance from transmitter to receiver, the wavelength and the Rayleigh Criterion or Diffraction limit, used in standard RF (Radio Frequency) antenna design, which also applies to lasers.

The Rayleigh Criterion dictates that any beam will spread (microwave or laser) and become weaker and diffuse over distance. The larger the transmitter antenna or laser aperture, the tighter the beam and the less it will spread as a function of distance (and vice versa). Smaller antennae also suffer from excessive losses due to side lobes.

Then the power levels are calculated by combining the above parameters together, and adding in the gains and losses due to the Antenna characteristics and the transparency of the medium through which the radiation passes. That process is known as calculating a Link Budget.Ultimately, beamwidth is physically determined by diffraction due to the dish size in relation to the wavelength of the electromagnetic radiation used to make the beam. Microwave power beaming can be more efficient than lasers, and is less prone to atmospheric attenuation caused by dust or water vapor losing atmosphere to vaporize the water in contact

3.NEAR FIELD

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

3.1 INDUCTION

The 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.

3.2 RESONNT INDUCTION

In 2006, Marin Soljačić and other researchers at the Massachusetts Institute of Technology applied the near field behaviour well known in electromagnetic theory to a wireless power transfer concept based on coupled resonators. In a theoretical analysis, they demonstrate that by sending electromagnetic waves around in a highly angular waveguide, evanescent waves are produced which carry no energy. 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 or cause physical injury like microwave or radio wave transmission might. Researchers anticipate up to 5 meters of range for the initial device, and are currently working on a functional prototype.

On June 7, 2007, it was reported that a prototype system had been implemented. The MIT researchers successfully demonstrated the ability to power a 60-watt light bulb from a power source that was seven feet (2 meters) away at roughly 40% efficiency.

"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.

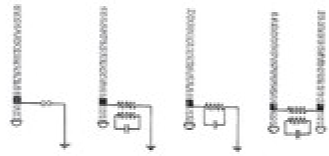
Beginning in the early 1960s resonant inductive wireless energy transfer was used successfully in implantable medical devices including such devices as pacemakers and artificial hearts. While the early systems used a resonant receiver coil later systems implemented resonant transmitter coils as well. These medical devices are designed for high efficiency using low power electronics while efficiently accommodating some misalignment and dynamic twisting of the coils. The separation between the coils in implantable applications is commonly less than 20 cm. Today resonant inductive energy transfer is regularly used for providing electric power in many commercially available medical implantable devices. Wireless electric energy transfer for experimentally powering electric automobiles and buses is a higher power application (>10kW) of resonant inductive energy transfer. High power levels are required for rapid recharging and high energy transfer efficiency is required both for operational economy and to avoid negative environmental impact of the system. An experimental electrified roadway test track built circa 1990 achieved 80% energy efficiency while recharging the battery of a prototype bus at a specially equipped bus stop. The bus could be outfitted with a retractable receiving coil for greater coil clearance when moving. The gap between the transmit and receive coils was designed to be less than 10 cm when powered. In addition to buses the use of wireless transfer has been investigated for recharging electric automobiles in parking spots and garages as well.

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.

4. 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



Means for long conductors of electricity forming part of an electric circuit and electrically connecting said ionized beam to an electric circuit.

4.1 RADIO & MICROWAVE

The earliest work in the area of wireless transmission via radio waves was performed by Heinrich Rudolf Hertz in 1888. A later Guglielmo Marconi worked with a modified form of Hertz's transmitter. Nikola Tesla also investigated radio transmission and reception.

Japanese researcher Hidetsugu Yagi also investigated wireless energy transmission using a directional array antenna that he designed. In February 1926, Yagi and Uda published their first paper on the tuned high-gain directional array now known as the Yagi antenna. While it did not prove to be particularly useful for power transmission, this beam antenna has been widely adopted throughout the broadcasting and wireless telecommunications industries due to its excellent performance characteristics.

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. Power beaming by microwaves has the difficulty that for most space applications the required aperture sizes are very large. For example, the 1978 NASA Study of solar power satellites required a 1-km diameter transmitting antenna, and a 10 km diameter receiving rectenna, for a microwave beam at 2.45 GHz. 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. Because of the Thinned array curse, it is not possible to make a narrower beam by combining the beams of several smaller satellites.

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/cm^2 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 at Goldstone in California in 1975 and more recently (1997) at Grand Bassin on Reunion Island.

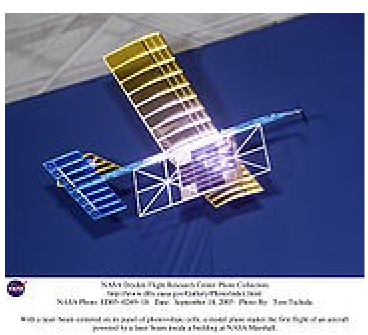
These methods achieve distances on the order of a kilometer.

LOW POWER

A new company, Powercast introduced wireless power transfer technology using RF energy at the 2007 Consumer Electronics Show, winning best Emerging Technology. The Powercast 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. It is expected for arrival late 2007.

A different low-power wireless power technology has been proposed by Landis.

4.2 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.

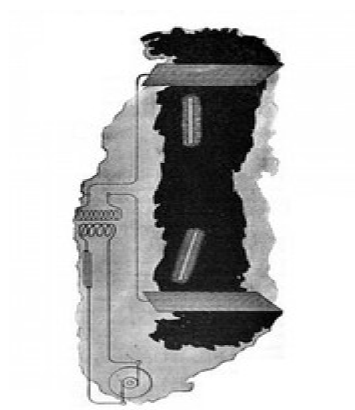
In the case of light, power can be transmitted by converting electricity into a laser beam that is then fired at a solar cell receiver. This is generally known as "powerbeaming". Its drawbacks are:

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. (Note that conversion efficiency is rather higher with monochromatic light than with insolation of solar panels).
3. Atmospheric absorption causes losses.
4. As with microwave beaming, this method requires a direct line of sight with the target.

NASA has demonstrated flight of a lightweight model plane powered by a laser

4.3 ELECTRIAL CONDITION

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.

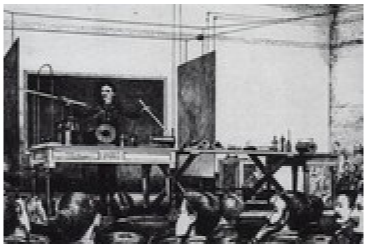


The **Tesla effect**.. A "world system" for "**the transmission of electrical energy without wires**" that depends upon electrical conductivity was proposed by Tesla Through longitudinal waves, an operator uses the Tesla effect in the wireless transfer of energy to a receiving device.

A "world system" for "the transmission of electrical energy without wires" that depends upon the electrical conductivity was proposed by Nikola Tesla as early as 1904. 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 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. Or else I suspend two sheets as each sheet being connected with one of the terminals of the coil, and their size being carefully determined. 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.

Through longitudinal waves, an operator uses the Tesla effect in the wireless transfer of energy to a receiving device. The Tesla effect is a type of high field gradient between electrode plates for wireless energy transfer.



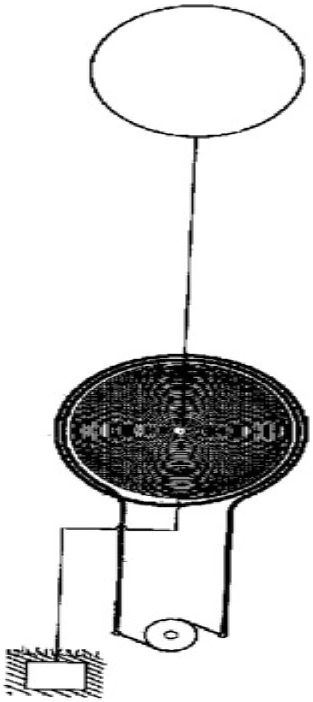
Wireless transmission of power and energy demonstration during his high frequency and potential lecture of 1891.

The Tesla effect uses high frequency alternating current potential differences transmitted between two plates or nodes. The electrostatic forces through natural media across a conductor situated in the changing magnetic flux can transfer power to the conducting receiving device (such as Tesla's wireless bulbs).

Currently, the effect has been appropriated by some in the fringe scientific community as an effect which purportedly causes man-made earthquakes from electromagnetic standing waves, related to Tesla's telegeodynamics mechanical earth-resonance concepts. A number of modern writers have "reinterpreted" and expanded upon Tesla's original writings. In the process, they have sometimes invoked behavior and phenomena that are inconsistent with experimental observation. On the other hand, a number of researchers have experimented with Tesla's basic wireless energy transmission system design and made physical observations that are inconsistent with some basic tenets of mainstream science

The Tesla world wireless system would combine electrical power transmission along with broadcasting and wireless telecommunications, allowing for the elimination of many existing high-tension power transmission lines and facilitate the interconnection of electrical generation plants on a global scale. However, a close reading of Tesla's patents suggests that he may have misinterpreted the 25-70 km nodal structures associated with lightning that he observed during his 1899 Colorado Springs experiments in terms of circumglobally propagating standing waves instead of as the well known local interference between direct and reflected waves between the ground and the ionosphere (not known to exist at the time). Many of the properties of the real earth-ionosphere cavity that have subsequently been mapped in great detail were unknown to Tesla, and a consideration of the earth-ionosphere waveguide propagation parameters as they are known today shows that Tesla's concept of a global wireless power grid is not practically realizable.

4.4 TESLA PATENTS



Tesla coil transformer wound in the form of a flat spiral. This is the transmitter form as described in.

Nikola Tesla had multiple patents disclosing long distance power transmission. Tesla, in described new and useful combinations of transformer coils. The transmitting coil or conductor arranged and excited to cause currents or oscillation to propagate through conduction through the natural medium from one point to another remote point therefrom and a receiver coil or conductor of the transmitted signals The production of currents at very high potential could be attained in these coils. describes a combined system for wireless telecommunications and electrical power distribution achieved through the use of earth-resonance principles.