

Wireless power transmission

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Abstract. Wireless power transmission is a modern method that has many advantages and disadvantages. In this article, we defined the method of wireless power transmission and talked about the methods, advantages and disadvantages.

Keywords. Wireless, power

Introduction

Wireless Power Transfer (WPT) is a technology that can transfer electrical energy from the source to an electrical load without any conducting wire. It can eliminate the use of wires, and connections for electricity transmission. It is very useful technological development for applications where wired connections are not possible for electricity transfer. Also, it eliminates the use of batteries that will help to reduce use of toxic materials resulting from disposal of batteries on a large scale every year. Non-radiative and radiative power transfer are the two types of this technology. Non-radiative is used for shortrange to midrange power transmission. For short-range power transmission, induction coupling method is used to transfer energy from source to load and range is less than the diameter of the transmitter coil. Capacitor coupling method is also considered for short range charging. In mid-range power transmission, resonant inductive method is used to transfer energy. The range of resonant inductive power transfer is one to 10 times the transmission coil's diameter[3]. Radiative method is used for long range or far-field power transmission. Microwave and Laser Photo electricity methods are used for long range transmission. The range of far-field power transmission is twice of the wavelength of the transmitting signal from the antenna. Laser photo electricity has very week efficiency and it emits harmful radiation.

History

Nikola Tesla he is who invented radio and shown us he is indeed the "Father of Wireless". Nikola Tesla is the one who first conceived the idea Wireless Power Transmission and demonstrated "the transmission of electrical energy without wires" that depends upon electrical conductivity as early as 1891. In 1893, Tesla demonstrated the illumination of vacuum bulbs

without using wires for power transmission at the World Columbian Exposition in Chicago. The Wardenclyffe tower shown in Figure 1 was designed and constructed by Tesla mainly for wireless transmission of electrical power rather than telegraphy.

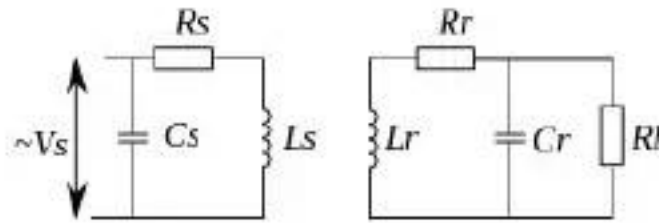
In 1904, an airship motor of 0.1 horsepower is driven by transmitting power through space from a distance of least 100 feet. In 1961, Brown published the first paper proposing microwave energy for power transmission, and in 1964 he demonstrated a microwave powered model helicopter that received all the power needed for flight from a microwave beam at 2.45 GHz from the range of 2.4GHz – 2.5 GHz frequency band which is reserved for Industrial, Scientific, and Medical (ISM) applications. Experiments in power transmission without wires in the range of tens of kilowatts have been performed at Goldstone in California in 1975 and at Grand Basin on Reunion Island in 1997. The world's first MPT experiment in the ionosphere called the MINIX (Microwave Ionosphere Non-linear Interaction Experiment) rocket experiment is demonstrated in 1983 at Japan. Similarly, the world's first fuel free airplane powered by microwave energy from ground was reported in 1987 at Canada. This system is called SHARP (Stationary High – Altitude Relay Platform) . In 2003, Dryden Flight Research Centre of NASA demonstrated a laser powered model airplane indoors. Japan proposed wireless charging of electric motor vehicles by Microwave Power Transmission in 2004. Power cast, a new company introduced wireless power transfer technology using RF energy at the 2007 Consumer Electronics Show. A physics research group, led by Prof. Marin Soljačić, at the Massachusetts Institute of technology (MIT) demonstrated wireless powering of a 60W light bulb with 40 efficiency at a 2m (7ft) distance using two 60cm-diameter coils in 2007 . Recently in 2008, Intel reproduced the MIT group's experiment by wirelessly powering a light bulb with 75 efficiency at a shorter distance.



Wireless power transmission methods

1. Transformer Coupling or Induction

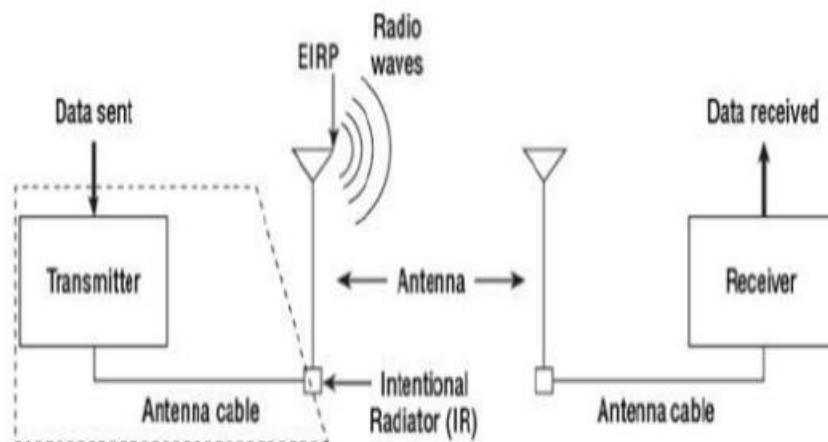
Energy transfer between two coils through magnetic fields however in this technique, distance between two coils really should be too close. The principle of mutual induction between two coils can be used to the transfer electrical energy without using wires. The best demonstration of how mutual induction works would be the transformer, where there isn't a physical contact between primary plus the secondary coils. The transfer of energy develops due to electromagnetic coupling relating to the two coils



2. Radio Frequency Radiation

Radio frequency (RF) radiation is one of the methods used in wireless power transmission. Generally, radio frequency transmits electromagnetic signals with the main purpose of sending and receiving information from both far and near distances with the aid of special devices. The power transmitted using this technique contains a very low efficiency, which makes the method not suitable to supply enough electrical energy to charge the devices. The process of transmission of data begins with the aid of a transmitter which sends out the alternating current (AC) in the form of electrical energy signal, this is achieved by means of a transporting medium connected to an external antenna. A coaxial cable serves as a good conductor and is capable of conveying a reasonable amount of electrical signal from the transmitter to the antenna. Electromagnetic waves sent from the antenna are picked up by another antenna connected to base stations containing receivers configured to accept such signals; Radio frequency works with different ranges of frequencies which are normally used to transmit and receive signals from one station to another.

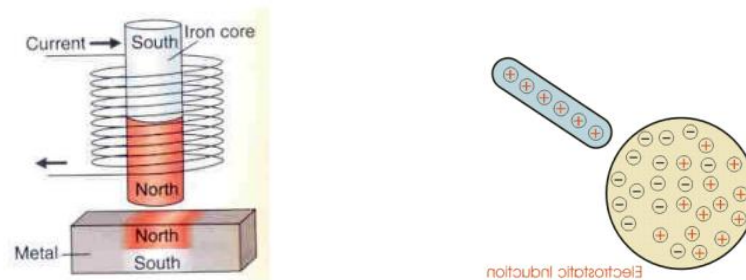
The figure below shows an example of two based stations sending and receiving data using the radio frequency transmission of wireless power.



3. Electrostatic Induction and Electro-dynamic Induction

Generally known as capacitive coupling can be an electric field gradient or differential capacitance between two elevated electrodes over the conducting ground plane for wireless energy transmission involving high frequency ac potential differences transmitted between two plates or

nodes. Also referred to as resonant inductive coupling resolves the foremost problem in connection with non-resonant inductive coupling for wireless energy transfer; specifically, the dependence of efficiency on transmission distance. When resonant coupling should be applied the transmitter and receiver inductors are tuned for your mutual frequency as well as the drive current is modified from the sinusoidal into a non-sinusoidal transient waveform. Pulse power transfer occurs over multiple cycles. This way significant power can be transmitted spanning a distance all the way to a number of times how big the transmitter.



4. LASER Beam Transfer

In this particular method, laser is beamed for the photovoltaic cells which extract the electrical energy. This method is quite challenging to implement and manage.



Advantages, Disadvantages

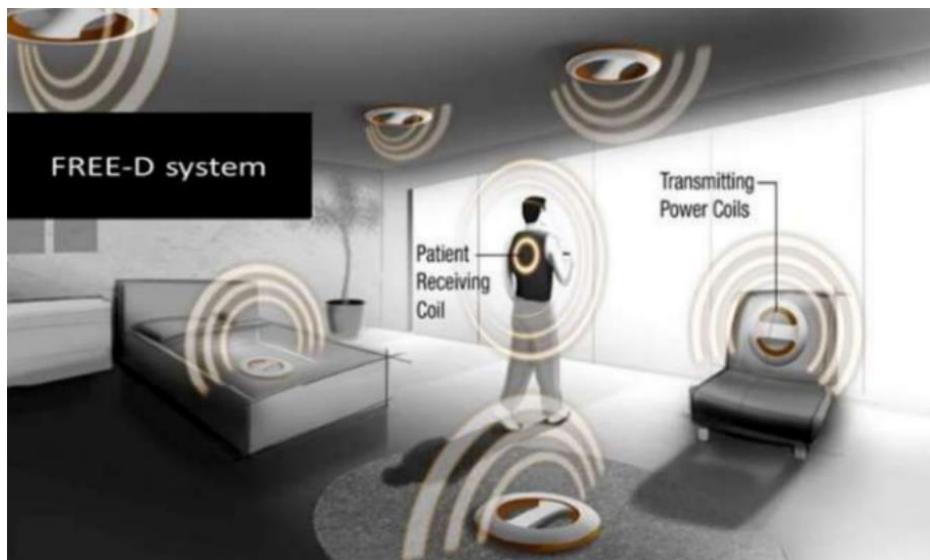
Wireless power transmission is the only process through which we could eliminate the existing system of high power transmission lines, towers and substations, which is inefficient and costly way of energy transmission. This will lead to a globally efficient and cheap transmission system. The cost of the transmission and receiving power would lower for the daily users and the large scale reduction of power tariff would be easily visible. The loss of transmission will be decreased and the power could easily be transferred to any place irrespective of the geographical situations. Power failures minimization will become possible which are caused by short circuit and faults. It will make the system more efficient and environment friendly system. The natural disasters

such as floods, earthquakes, landslides or tornados would not become the reason for power cuts and damages to the system. The usage of land for the installment of the system would completely be eliminated. As Dr. Neville of NASA states “You don’t need cables, pipes, or copper wires to receive power. We can send it to you like a cell phone call where you want it, when you want it, in real time”. In terms of portability, this system is very superior to any other existing system. However, the most important concern remains the biological impacts. But according to the safety studies and research it indicates clearly that the radiation level achieved by the wireless power transmission is very close or slightly higher than the radiation of cellular phones or never greater than microwave oven exposure. Therefore, public exposure of wireless power transmission will be within the acceptable limits.

Disadvantages of the system include very high initial cost for the system's practical installation. Since microwaves are used for the transmission then the line of sight becomes the basic need. Any sort of interference in the line of sight could actually stop the transmission. The microwave power transmission can cause high interference problems for telecommunication infrastructure. As the energy will be available freely in the air energy; chances of the theft will be increased.

Applications

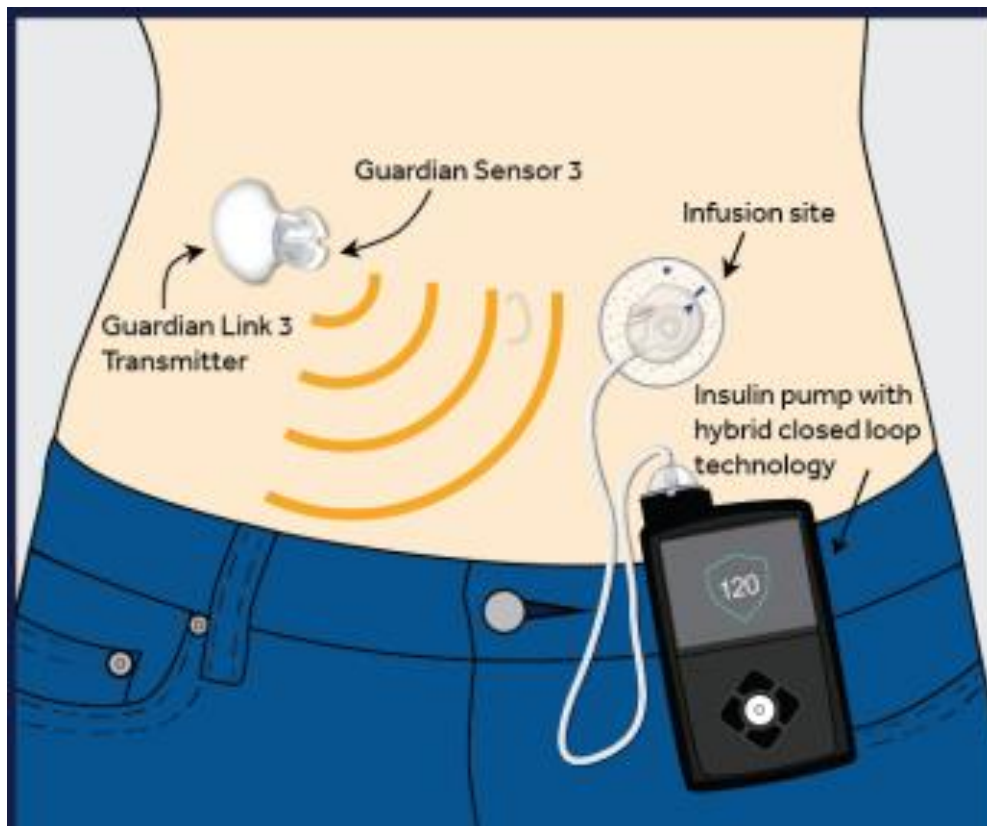
1. Venticular assist devices- Patients can’t exercise correctly because their Ventricular assist devices (VADs) are tied to a battery or external power supply. Patients can be free using wireless power transmission technology and have the opportunity to roam around and exercise like a regular human being. There are no power cords poking through the skin when using wireless power transfer, which reduces the danger of infection and impregnation.



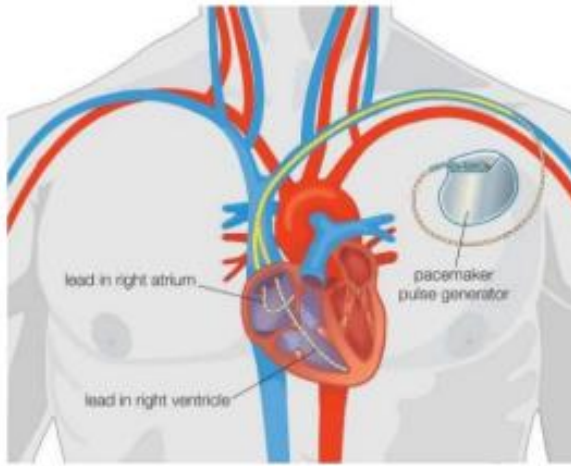
The free-range resonant electrical delivery (FREE-D) wireless power transmission system is used in magnetically coupled resonators for efficient power transmission for short range

transmission across a distance to a Ventricular assist devices (VADs) implanted in the human body, as well as to provide robustness to VAD position changes without interrupting.

2. Insulin Pump- Insulin pumps is used to measure blood glucose continuously to understand the patient's current blood glucose. Based on the current results and previous data learning, closed loop insulin pump infuse an appropriate amount of insulin. The study found that the most common occurrences were battery life termination within 72 hours of usage (50.0 percent), insulin pump suspension (21.2 percent), and battery fluid leakage (4.5 percent). A total of 53.2 percent of the insulin pumps reported required to be changed, with 37.1 percent of them recovering when the battery was changed. There is a danger of infection due to the battery fluid leaks



3. Cardiac Pacemakers- Cardiac Pacemakers are medical electronic devices that stimulate the heart with electrical impulses to maintain the normal heartbeat. It consists of a tiny computer, a generator and a battery along with wires that connects to a pacemaker to the heart of patients. This device make patients heart beat close to normal. An artificial pacemaker attach to patient's heart always. Wireless Power Transfer will eliminate the replacement of the battery in the cardiac pacemakers. The risk of failure of the pacemaker will be negligible with this technology.



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