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Wireless Power Transmission

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Abstract

A great concern has been voiced in recent years over the extensive use of energy, the limited supply of resourses, and the pollution of the environment from the use of present energy conversion systems. Electrical power accounts for much of the energy consumed. One of the major issue in power system is the losses occurs during the transmission and distribution of electrical power. As the demand increases day by day, the power generation increases and the power loss is also increased. The major amount of power loss occurs during transmission and distribution. The resistance of the wire used in the electrical grid distribution system causes a loss of 26-30% of the energy generated. This loss implies that our present system of electrical distribution is only 70-74% efficient.

The above discussed problem can be solved by choose an alternative option for power transmission which could provide much higher efficiency, low transmission cost and avoid power theft. Wireless power transmission is one of the promising technologies and may be the righteous alternative for efficient power transmission.

This paper focuses on the past and future possible advancements in WPT. Also the proposed method and technologies in WPT that will make the loss of energy during transmission and distribution to minimum are discussed.

Keywords: WPT – Wireless Power Transmission, MIT – Massachusetts Institute Of Technology, EHT – Extra High Tension, LOT – line output transformer, EMF – Electromagnetic Field, AC – Alternating Current, DC – Direct Current

Introduction

Imagine a world devoid of bulky batteries, free from the labyrinth of electric wires! However, the ever-so ubiquitous nature of batteries and wires in our day-to-day lives makes the previous statement sound more like some piece of science fiction. But what we perceive as science fiction today may become reality tomorrow! With this zeal to make the impossible, possible, scientists at the MIT physics research laboratory, after a series of diligent experiments, were able to light a 60W light bulb from a power source more than two meters away; there was no physical connection between the source and the appliance! Welcome, to what the MIT team refers to as "WiTricity" (as in wireless electricity).

Baffled? Perplexed?! That was my reaction too! It is worth nothing that almost trillions of dollars are invested in infrastructure to get electricity from its place of production to its final destination; 40 billion disposable batteries are manufactured every year! Incessant environmental issues related to battery disposal being raised as well as high infrastructure costs, this sure comes as huge relief to engineers and environmentalists alike!

But you may reason that in today's technologically cognizant society where wires are viewed as nothing more than an inevitable means, wireless power transmission does seem like a very "obvious" solution! So why didn't anyone think of it earlier?! Well, yes! More than 100 years ago one man way ahead of his time, dare to think differently; beyond the indoctrinated beliefs of those times.

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An aficionado of electrical engineering, wireless power transmission, in essence, was his brainchild Nicola Tesla who literally electrified the world through his numerous uncreated inventions, mainly in the field of AC power and AC operated devices, is now primarily remembered for his visionary ideas in the field of wireless electricity. He did work on his ideas and come up with the concept of Tesla coils which stepped up standard voltage of 120V to more than 500,000 volts.

Why witricity???

The Need for a Wireless System of Energy Transmission

A great concern has been voiced in recent years over the extensive use of energy, the limited supply of resources, and the pollution of the environment from the use of present energy conversion systems. Electrical power accounts for much of the energy consumed. Much of this power is wasted during transmission from power plant generators to the consumer. The resistance of the wire used in the electrical grid distribution system causes a loss of 26-30% of the energy generated. This loss implies that our present system of electrical distribution is only 70-74% efficient. A system of power distribution with little or no loss would conserve energy. It would reduce pollution and expenses resulting from the need to generate power to overcome and compensate for losses in the present grid system.

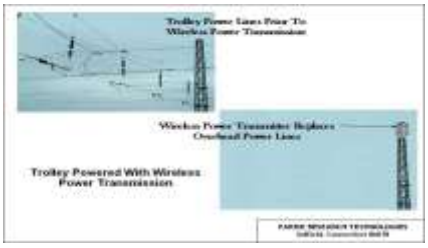

Fig1. Ttrolley powered with wireless power transmission

Methods for WPT

Induction

Transformers are probably the simplest example of wireless power transfer. The two circuits of a transformer are physically isolated, but transfer (and transform) power by magnetic coupling through induction. Induction cookers are a prime example of how this is used. In an induction cooker, energy is transferred directly and wirelessly into the pot or pan, where it is converted ohmically into heat for cooking. The main drawback to induction, however, is the short range. The receiver must be very close (nearly direct contact) to the inductor unit in order to magnetically couple with it.

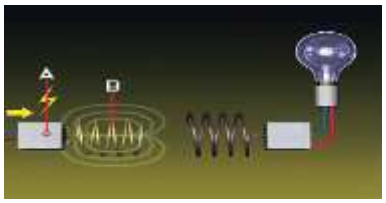

Fig2. Induction Principle

Electromagnetic transmission

Electromagnetic waves, commonly known as light, can also be used to transfer power wirelessly. By converting electricity into light, such as a laser beam, then firing this beam at a receiving target, such as a solar cell on a small aircraft, power can be beamed to a single target. This is generally known as "power beaming". There are several drawbacks to this, however. First, the conversion to light, such as a laser, is usually very inefficient.

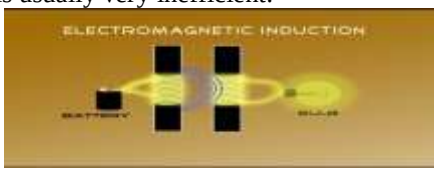

Fig3. Electromagnetic Induction

Also, atmospheric absorption causes further losses. Finally, this method requires a direct line of sight with the target, and is unsuitable for transmitting too many targets or over a broad area.

Evanescent wave coupling

Researchers at MIT believe they have discovered a new way to wirelessly transfer power using non-radiative electromagnetic energy resonant tunneling. Since the electromagnetic waves would tunnel, they would not propagate through the air to be absorbed or wasted, and would not disrupt electronic devices or cause physical injury like microwave or radio transmission. Researchers anticipate up to 5 meters of range.

Fig4. Evanscent wave couling

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One of the benefits is that most common materials do not interact with magnetic fields, so obstructing objects do not have much influence. This also goes for human tissue and therefore health risks are low. The coils shown above are too large for applications in i.e. a cell phone, but the receiving coil can be made smaller. The researchers state that the transmitted power can be kept constant, if the size of the sending coil is increased to keep the product of the sizes of both coils equal. The efficiency of the above setup is around 40 to 50% for wireless power transfer over 2 meters.

Types of WPT

Long-Distance Wireless Power Transmission

Microwave Energy

This long-distance wireless power transmission option necessitates the use of a large microwave transmitter on the ground. The airplane in the experiment had to fly in a circular path because it always had to be within range of the ground-based transmitter. This enabled it to receive the microwave energy through a rectenna or disc shaped rectifying antenna receiver that converts microwave energy into DC electricity.

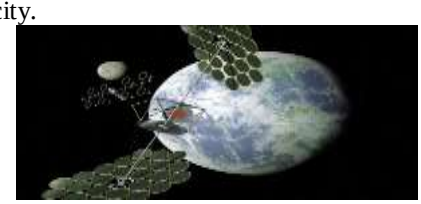

Fig5. Microwave Energy

Light Energy

Another option for wireless power transmission is NASA's infrared power transmission system that is capable of powering an airplane using an infrared laser that powers the photovoltaic cells located on the airplane's skin. These photovoltaic cells convert infrared energy to electricity. This also requires that the device being powered be always within sight of the transmitter.

Fig6. Light Energy

Short distance wireless power transmission

A short-range wireless power transmission and reception system and method are provided. Power is transmitted from the electrical utility mains power supply to electrically powered appliances via electromagnetic radiation. The appliances are capable of receiving the transmitted power, converting it into electricity and storing it for subsequent use, as well as using it directly to power the appliances.

Fig7. Short Distance Wireless Power Transmission

Working principle

The working principle behind wireless power transmission is electromagnetic induction. Let's look at it. We need a power source and a transmitting antenna, and also a receiving antenna to which we can connect the thing to be powered (the electrical load, or just the load). The power source will deliver a high power signal to the antenna. This will create electromagnetic waves that will travel out from the antenna and through the air.

The receiving antenna will be in the path of these waves, and the waves will pass by it "sweep" it with their moving electromagnetic fields. This will induce a signal in the receiving antenna proportional to the energy that the antenna captures. This signal will causes current flow that will power the load.

The problem with this system is that it is challenging to "direct" and "confine" the transmitted signal to optimize how much of it gets to the receiving antenna. Additionally, distance cause loss, and there will be a lot of loss over longer distance. More the distance, the signal travels, the much more loss. But the system works to a limited degree.

Fig8. Resonant Induction

Model for WPT

Tesla's model

The illustration for the patent of a transmitter consisting of an elevated capacitance, a coil, a signal generator, and a single electrode in the earth. The receiver is pictured as having a mechanism to oscillate at the same period as the transmitter, a capacitor, a detector, and two earthed plates.

As he described it the evacuated bulbs were place between the electrodes when we excite luminosity in exhausted tubes the effect is due to the rapidly alternating electrostatic potential; the medium is harmonically strained and released.

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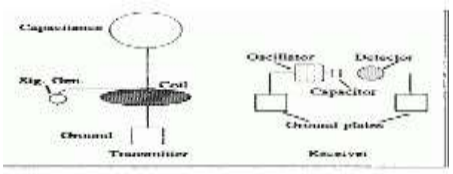

Fig9. Transmitter and Receiver

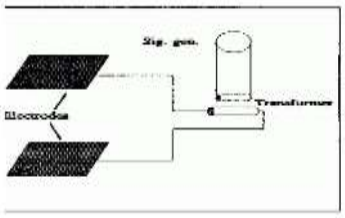

Fig10. Tesla Model

How does WPT work??

Wireless power transfer is a varied and complicated process. There is more than one system that works to complete the process. Three more scientifically sound ideas are space solar cells, lasers, and resonating electro-magnetic waves. While each process varies in the way the energy is collected and used, the mechanisms of converting from RF energy to DC energy and vise versa are the same for all WPT systems.

The process of converting DC to RF starts with the power- that power to be transmitted is first tapped from the main power grid at about 50Hz AC. The voltage is then reduced to a viable load for rectifying into DC.

The energy then is supplied to an oscillator-fed magnetron and electrons are emitted from the central terminal. A positively charged anode surrounds the inner cathode to attract the electrons. Due to the current flowing through the magnetron the, the magnetic field produced causes the electrons to experience the cyclotron effect.

The circling electrons pass resonating cavities of the magnetron and create pulsating magnetic fields which constitute an electromagnetic radiation in microwave frequency range. The voltage coming out of the rectifier that connects the AC grid to the magnetron controls the magnetron anode DC voltage. Since, the anode is attracting the electrons into it (the cyclotron effect), the DC voltage that is supplied to it will determine the strength of the magnetic field. The stronger the magnetic field the greater the force on the electrons through the resonating cavities. Although frequency of the radiation can be adjusted by varying the inductance or capacitances of the resonant cavities, the experimental transmitting frequencies with the highest success rate are 2.45GHz and 5.8GHz

Proposed work

Fig11. Assembled Project Of WPT

Block Diagram Of WPT

We require high voltage and high frequency for wireless transmission of power. This high voltage and high frequency can be obtained with the help of black-and-white portable TV kit. This kit works on 12V dc supply.

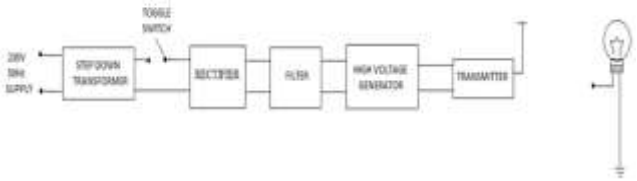

Fig12. Block diagram of Assembled WPT Model

To obtain this supply following components should be used-

Transformer

A 230V/18V step down transformer is used to step down the voltage to 18V ac.

Fig13. Step down Transformer

Rectifier

It is a circuit which employs one or more diodes to convert ac voltage into pulsating dc voltage. Full wave bridge rectifier It is the most frequently used circuit for electronic dc power supplies.

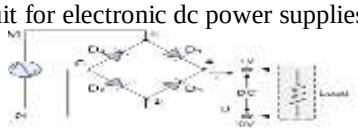

Fig14. Circuit diagram of rectifier

Working: During the positive input half cycle, terminal M of the secondary is positive and N is negative as shown in figure. Diodes D1 and D3 become forward biased (ON) where as D2 and D4 are reversed biased (OFF). Hence, current flows along MEABCFN producing a drop across RL.

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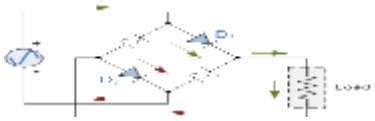

Fig15. For Positive Half Cycle

During the negative input half cycle, secondary terminal N becomes positive and M negative. Now, D2 and D4 are forward biased. Circuit current flows along NFABCEM as shown in figure. Hence, we find that current keeps flowing through load resistance RL in the same direction AB during both half cycles of the ac input supply. Consequently, point A of the bridge rectifier always acts as an anode and point C as cathode.

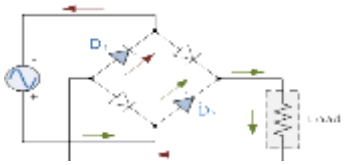

Fig16. For Negative Half Cycle

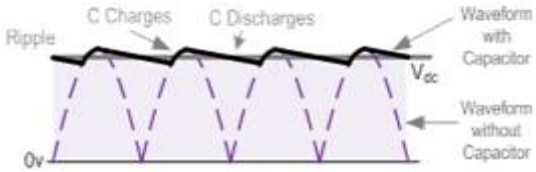

Fig17. Rectifier Output Waveform

Filter

The function of the filter is to remove the fluctuations or pulsations present in the output voltage supplied by the rectifier.

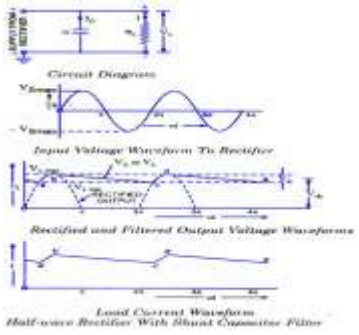

Fig18. circuit dig. and output waveform of filter

The function of the capacitor filter may be viewed in terms of impedances. The large value capacitor C offers a low impedance shunt path to the ac components or ripples but offers high impedance to the dc component. Thus ripples get bypassed through capacitor C and only dc component flows through the load resistance RL

Fig19. Filter

High voltage generation (EHT)

The method of generating EHT potential, as used in a monochrome receivers by an overwind on the LOT (line output transformer) is not satisfactory beyond 16 kV because of problems like flashover high impedance and poor regulation. Till recently a voltage tripler arrangement was used to obtain near 25 kV for a final accelerator. This needs many high voltage capacitor and several diodes. It has now been superseded by what IS known as the diodes split addition technique. It has many advantages like greater reliability, smaller size and lower cost.

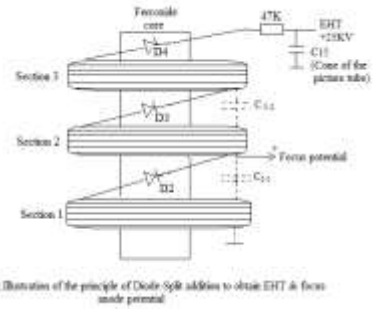

Fig20. Illustration of the Principle of diode-Split addition to obtain EHT and focus anode potential

Because of the close proximity of the individual layer, an inter layer capacitance exists between each of them. It is indicated in diagram by capacitance in the dotted chain form because these are no physical capacitors. If a diode is connected between the end of the one layer of winding and the start of the next, the ac voltage induced in each layer can be made to charge up all the inter-layer capacitances to the same voltage. The diode shown connected in series between the layer are physically are embedded in the winding and form an integral part of transformer.

The three winding are so designed that the voltage induced in each layer from the flyback transformer is 8.33KV. This makes the total potential equal to 25KV and forms the EHT supply source. In some design, the four layers of winding are used and each layer provides the voltage equal to 6.8KV.

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Transmitter

Transmitter is used to transmit power from EHT wirelessly by induction principle. This transmitter is consists of a PVC pipe on which copper wire (alloyed copper) is wound. The thickness of the wire is 2.5 gauges. This transmitter transmits the power at a frequency of 15,625Hz.

We used a neon lamp as load in this system. If we keep this lamp near the transmitter, it glows.

Daewoo Tv Kit Used In WPT

Power supply section in DAEWOO TV

All sections of TV works on definite DC supply. If this dc supply not constant, different sections of TV will not work properly.

In Daewoo TV 230V mains supply is passed through a fuse F901 to the primary winding of power transformer T901. We get 16V ac supply at secondary of this transformer which is then passed through an ON/OFF switch S901 to the bridge rectifier made up of four diodes D901-D904. One capacitor of 0.0047MF is connected across each diode. This capacitor is connected to avoid surge voltage occurring across a diode.

Advantages

1) Wireless energy transfer can potentially recharge laptops, cell phones without chords.
2) Although, the energy is different, the appliances use a very little amount.
3) Wireless Power Transmission system would completely eliminates the existing high-tension power transmission line cables, towers.
4) It has more freedom of choice of both receiver and transmitters.
5) The cost of transmission and distribution become less and the cost of electrical energy for the consumer also would be reduced.
6) The power could be transmitted to the places where the wired transmission is not possible.

Disadvantages

1) The transmitter and receiver also should be very powerful devices as the distance increases.
2) Wireless transmission of the energy causes some drastic effects to human body, because of its radiation.
3) Practical possibilities are not yet applicable as there is no much advancement in this field. Initially, the procedure will be very expensive.

Limitations

- The range can be increased by using pure copper in transmitter but it is not easily available in market.
- The range is more in case of resonance as compared to induction but is hard to get exact resonance by using resonance principle

Applications

- Direct wireless power and communication interconnection across rotating and moving "joints"(robots, packaging machinery, assembly machinery, machine tools)….eliminating costly and failure-prone wiring.
- Automatic wireless charging for mobile robots, automatic guided vehicles, cordless tools and instruments…complex docking mechanisms, and labor intensive manual recharging and battery replacement.
- Automatic wireless charging and for high tech military system (battery powered mobile device, convert sensors, unmanned mobile robots and aircraft, etc).

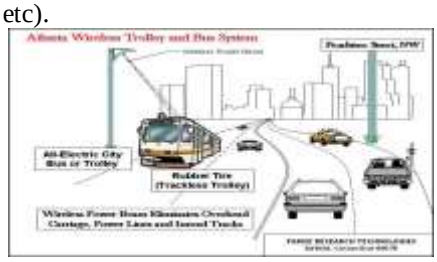

Fig21. Transportation Applications

Conclusion

What we wanted to explain in this paper is that the wireless trans-mission of the energy can be converted to electricity and then can be used for many appliances. If this technology develops much faster, we can soon see the radiated world; we mean the energy can be harnessed from any location of the earth. Let us work and wait for the day and we soon see the electrical revolution drastically changing.

Electrical energy can be economically transmitted without wires to any terrestrial distance. The economic transmission of power without wires is of crucial importance to man. It will enable him to dispense with innumerable causes of sinful waste. This technology opened up the possibility of

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constructing power stations on the moon. These power stations will be capable of transmitting power to earth using microwave energy. Such microwave energy would then be converted into electricity using a vast array of rectenna receivers on the earth.

Nevertheless with all the challenges that face wide-scale deployment of this new technology wireless power transmission for solar power satellite is still considered as a next-generation power transmission system.

Future vision

New research is bringing energy transfer into the wireless world. Soon, a central hub could be charging your batteries, laptop, televisions, electric cars, you name it… right through the air. You might never untangle a wire again. But wireless energy transfer is far from perfect. The coils still need to be shrunk down so they can be easily integrated into everyday electronics (unless you want giant metal rings all over your house). The distance limitation is a major hurdle, with the fields limited to a few meters at this point. The energy transfer isn't the most efficient process; MIT researchers transferred about 45% of the energy input, while Intel's recent project showed an 80% transfer. That kind of energy loss poses a significant roadblock to the commercial viability of these technologies, as energy air free.

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