

Wireless Transmission of Electricity using Embedded System

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Abstract: In the present paper the various technologies available so far for wireless transmission of electricity and the need for a Wireless System of Energy Transmission is being discussed to find its possibility in actual practices, their advantages, disadvantages and economical consideration. This paper is mainly concentrated on: i) the most popular concept known as Tesla Theory and ii) Resonant charging of electrical and electronic appliances. Many concepts, research papers, patents are available on wireless transmission of electricity but the commercial technologies are yet to be materialized. The paper also discusses the possible ways to get useful and practical results out of all research carried out so far elsewhere.

Keywords: *Load Balancing, Computational Grid, Gridsim, job scheduling, Resource state, Response Time, communication cost*

Introduction

A switch to cleaner transmission of power, as computer stores large amount of data in its memory, those using it are named a paper less society. Now is the time to make people a wireless society, and this is possible by means of wireless energy transfer methods. As time and technology advance, wireless transmission of power seems to be promising one.

1.1 Drawbacks in wired systems

Electrical power accounts for much of the energy consumed. Much of this power is wasted during transmission from power plant generators to the consumers. The resistance of the wire in the electrical grid distribution system causes a loss of 26% to 30% of the energy generated. There fore, the loss implies that our present system of electrical transmission is 70% to 74% efficient. We feel pretty whimsical while watching poles, towers and substations, on the roadside, which carry man-made conductors for transferring power through long distances. In our country which is hugely populated and consume high megawatts of power there arise frequent faults[4,5,6,7,8].

1.2 A fault arises mainly due to

- Technical problems in a substation
- Lightning discharges on the conductor
- Tree falling on the lines
- Short circuiting the phases by birds

1.3 Broadly classified as

- Shunt fault (short circuit)
- Series fault (open conductor)

A shunt type of fault involves a power conductor connected to ground, or short circuit between the conductors. These types of faults are characterized by increase in voltage, frequency, and fall in current in the faulted phases.

1.4 Shunt faults are classified as

- Line to ground fault
- Line to line fault
- Double line to ground fault
- Three phase fault

1.5 Series faults are classified as

- single open conductor fault
- two open conductors fault

These are the disadvantages while power is transmitted through conductors. In order to avoid these transferring power.

Methods

—Wireless transmission of power is the process that takes place in any system where electromagnetic energy is transmitted from a power source to an electrical load without inter connection of wires. The wireless energy transfer methods are important in our present life.||

2.1 Near Field:

1. Electro magnetic induction
2. Resonant Induction

2.2 Far Field:

1. Tesla Theory
2. Electro magnetic radiation
3. Microwave Transmission

2.3 Electro magnetic induction

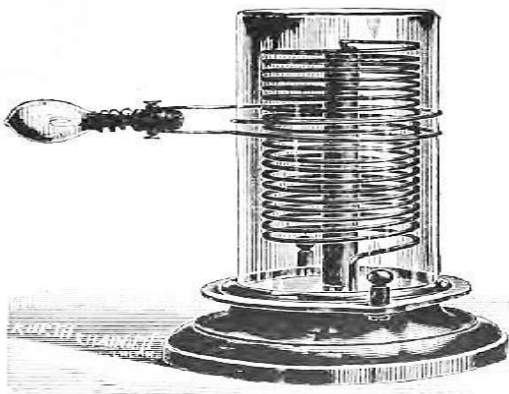


Fig.1 shows Wireless bulb by electromagnetic induction.

The transfer of energy takes place by electro magnetic coupling through a process known as induction.

Examples:

- The electrical transformer is probably the simplest example for wireless energy transfer.
- In the induction cooker electrical energy is wirelessly transferred into the cookware where it is converted into heat for cooking.

2.4 Drawbacks:

- The receiver must be relative close proximity to the transmitter in order to be coupled with it.
- It is short lived.

2.5 Resonant induction

"Resonant inductive coupling" has key implications in solving the main problem associated with nonresonant inductive coupling and electromagnetic radiation; specifically, the dependence of efficiency on transmission distance. 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 in the secondary. This results in a 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. 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.

2.6 Tesla theory

Nicola Tesla – a great physician, concluded that the earth is an electrical conductor, and that an electric current can be made to propagate undiminished for distances of thousand miles. It was also found that earth's natural electrical charge can be made to oscillate by impressing upon it very low frequency current waves of certain length – definitely related to its diameter ; and resistances of the and relative shortness compared to its diameter.

In the distant future this method could allow for elimination of many existing high tension power transmission lines and facilitate the inter connection of electric generation plants in a global scale. In this process, the air will serve as a conductor for the current produced and also be the transmission medium. This system may be of even less resistance than through ordinary copper wire.

2.7 Electro magnetic radiation

It is in the form of either radio waves or light, and can also be used to transfer power wirelessly. In case of radio waves, efficient power can be achieved by using shorter wavelength of electromagnetic radiation typically in the microwave range. A rectenna is used to convert microwave energy back into electricity.

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

2.8 Drawbacks:

- Conversion of light such as laser is usually very inefficient.
- Atmospheric absorption causes losses.
- Causes cancer for living organisms due to radiation.

2.9 Microwave 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.

As the electro-magnetic induction and electro-magnetic radiation has disadvantages we are going for implementation of electrical conduction and resonant frequency methods. Of this, the resonant induction method is the most implementable due to the reasons given later.

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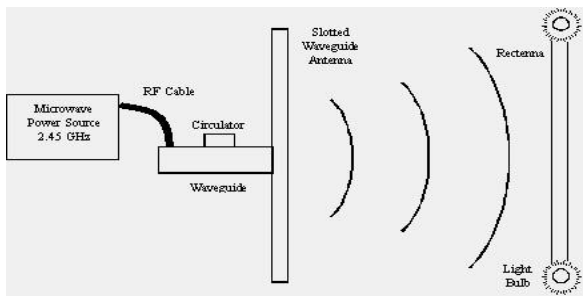


Fig.2 shows Block diagram for wireless energy transfer

The block diagram given shows how power can be transferred through free space by microwaves. The components of the block diagram are:

- Microwave source
- Transmitting antenna
- Receiving antenna

Power delivered to ground	5GW
Overall dimensions	10 x 5 x 0.5 km
Mass	$-50 * 10^6$ kg
Orbit	GEO
Transmission antenna diameter	1KM

The microwave source consists of a microwave oven magnetron with electronics to control the output power. The output microwave power ranges from 50w to 200w at 2.45GHz. A coaxial cable connects the output of the microwave source to a coax-to-wave adaptor. This adaptor is connected to a tuning waveguide ferrite circulator, which is connected to a tuning waveguide section to match the waveguide impedance to the antenna input impedance.

The slotted waveguide antenna consists of 8 waveguide sections with 8 slots on each section. These 64 slots radiate the power uniformly through free space to the rectifying antenna (rectenna). The slotted waveguide antenna is ideal for power transmission because of its high aperture efficiency (>95%) and high power handling capability.

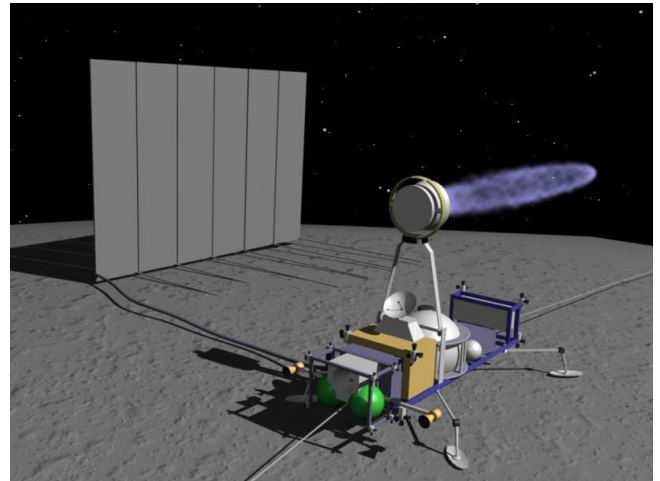


Fig.3 shows a Rectenna.

A rectifying antenna called a rectenna receives the transmitted power and converts the microwave power to direct current (DC) power. This demonstration rectenna consists of 6 rows of dipole antennas, where 8 dipoles belong to each row. Each row is connected to a rectifying circuit which consists of low pass filters and a rectifier. The rectifier is a GaAs Schottky barrier diode, that is impedance matched to the dipoles by a low pass filter. The 6 rectifying diodes are connected to the light bulbs for indicating that the power is received.

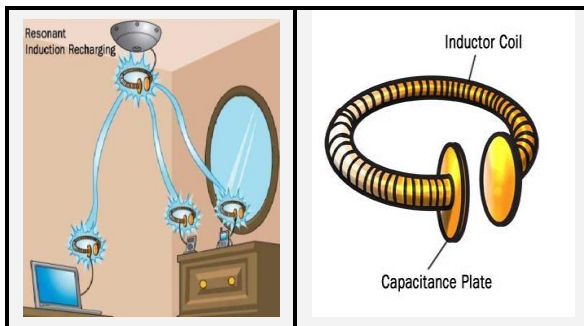
The light bulbs also dissipate the received power. This rectenna has a 25% collection and conversion efficiency, but rectennas have been tested with greater than 90%.

2.10 Resonance frequency method:

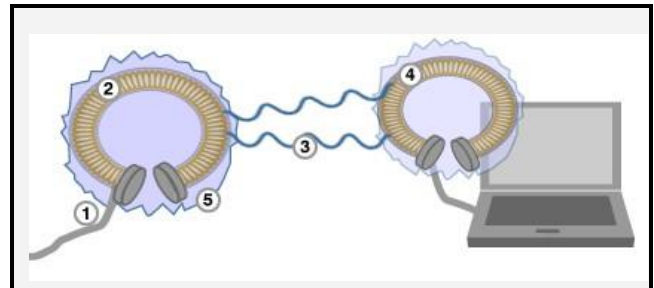
Resonance phenomena:

A body vibrating at some frequency makes another body to vibrate at the same frequency. This is Resonance.

- Example – while a playing a trumpet one can cause nearby trumpet to vibrate if both trumpets have same resonant frequency.
- The induction of power can be different if electro-magnetic fields around the coils resonate at same frequency.
- Using resonant frequency wireless power can be implemented for a house





- Here inductor is a curved coil of wire.
- Capacitance plate which can hold charge is attached to each end of the coil.
- As electricity travels through the coil it begins to resonate.
- The resonant frequency is a product of inductance of a coil and capacitance of the plate.
- The efficiency of power transmission between the two coils will be greater than 90%.



1)	Power from mains to antenna, which is made of copper
2)	Antenna resonates at a frequency of 10KHz, emitting electromagnetic waves of dia 1m
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 10KHz. 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 10KHz of dia 30cm

	Resonance occurs according to the scrodinger equation $-\hbar^2/2m\nabla^2\psi=E\psi$	
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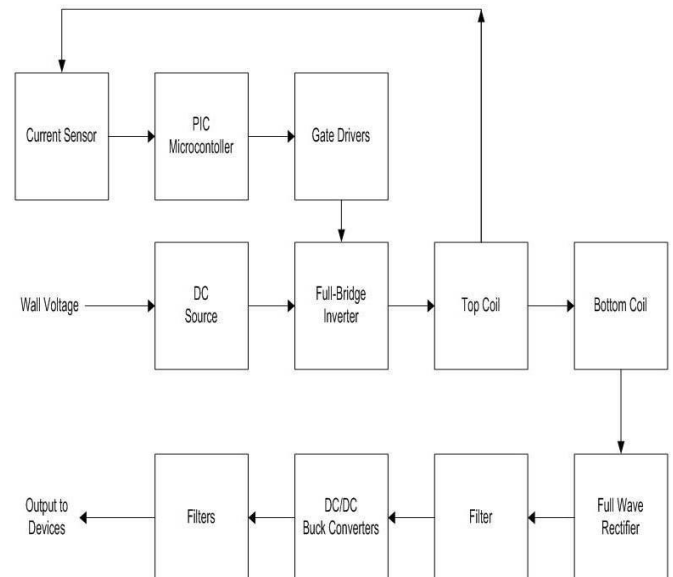
BENEFITS IN WIRELESS CHARGING	
Normal charging	Wireless charging
Problems	Benefits
<ul style="list-style-type: none"> ☐ Different charger per device 	<ul style="list-style-type: none"> ☐ One charger for different devices

<ul style="list-style-type: none"> ❑ Finding and connecting charger 	<ul style="list-style-type: none"> ❑ Convenience - remove the last wire
<ul style="list-style-type: none"> ❑ Battery technology outpaced by power demands 	<ul style="list-style-type: none"> ❑ Easy frequent charging
<ul style="list-style-type: none"> ❑ Connectors - unreliable, design limits 	<ul style="list-style-type: none"> ❑ Sleek, waterproof and dustproof devices
	

- DC Source: A power supply that takes in wall AC voltage and outputs a DC voltage that we will experimentally determine.
- Full-Bridge Inverter: This inverter takes in the voltage from the DC source and using the PIC and gate drivers, outputs signal in the form of a square wave with a frequency that is controlled by the PIC and is adjusted based on induced current in the coil.
- Gate Drivers: The gate drivers are drivers that take in the signal from the PIC and put out the right amount of power/voltage to turn on and off the power in the full-bridge inverter.
- PIC Microcontroller: The PIC will control the frequency of the signal that is driving the coil. It will also adjust the frequency based on the current that is sensed through the top coil to get the most power transmitted through the coils

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Current Sensor: A very low resistance resistor will be put in series with the coil and the voltage measured across it to sense the current through the coil based on the voltage drop and resistance



- Top Coil: An inductor that we make with about 100 turns and a diameter of around 1m. It will also have a current limiting resistor in series to make sure nothing burns up.
- Bottom Coil: An inductor like the top coil that will receive the electromagnetic waves transmitted by the top coil and have a current and voltage induced to power the devices.

- Full Wave Rectifier: Combinations of four diodes that will take the signal induced and make it positive the whole time, creating a DC signal.
- Filter: A series inductor and a capacitor that will filter the signal output by the rectifier making it a smoother signal.
- DC/DC Buck Converters: A buck converter that will step down the voltage that we get to the voltage that we need (about 18V) to power a laptop and if possible to power a cell phone charger (about 5V).
- Filters: This filter will even out the waveform given by the buck converter and will be the final step before outputting to the devices.

Wireless Power Applications

The wireless system would reduce pollution and expenses resulting from the need to generate power, and to overcome and compensate for losses in the present grid.

This method would eliminate the need for an inefficient, expensive, and capital intensive grid of cables, towers and substations. There are some areas in the world where there is still in need for electrical power.

Examples in the global scale are....

- Africa is in need of power to run pumps to tap into the vast resources of water under the Sahara desert.
- Rural areas in countries like India and China

For the above mentioned areas, if power is not delivered they will for all time be left in darkness and never compete with other nations.

Wireless transmission of power would provide worldwide distribution of off-peak demand capacity. Some nations like US have the capacity to generate more power than needed. The extra power available from the power plants is transmitted to other nations using wireless system of energy transmission.

Application In Various Fields

- Types of devices that can be charged wirelessly (handset, MP3, headset, DSC, etc)
- The way devices are enabled with wireless power (adaptor, integrated receiver)
- Standalone charger configurations (single device, multiple device, form factor, etc)
- Embedded charger configurations (in printers and other CE products)
- Location of charger: (home, office, travel, car, public, etc)
- Market (consumer, office equipment, industrial, medical, etc)
- Accessory companies distributing chargers and portable electronic devices
- Confidential radio-communication
- Optical free-space interconnects for electronic logic circuits
- Energy supply for nano-robots 4.1

Induction chargers

- High efficiency receiver which can be configured to match device charge specifications



➤ Real time legitimate device detection to prevent charger misuse

- Automatic low power down, meeting European Energy Star guidelines
- Scalable magnetic topologies to support immediate and future product markets

The MIT system is about 40% to 45% efficient — meaning that most of the energy from the charging device doesn't make it to the light bulb. Soljagic believes it needs to become twice as efficient to be on par with the old-fashioned way portable gadgets get their batteries charged. The MIT team stresses that the "magnetic coupling" process involved in WiTricity is safe on humans and other living things. And in the initial experiments on the light bulb, nothing bad happened to the cell phones, electronic equipment and credit cards in the room — though more research on that is needed.

Advantages

- No conductor cost.
- The efficiency of wireless transmission of energy is in the range of 90% to 94%.
- Rid the landscape of wires, cables and transmission towers.
- Great flexibility in power transmission.

Conclusion

Imagine a future in which wireless power transfer is feasible: cell phones, household robots, mp3 players, laptop computers and other portable

electronics capable of charging themselves without ever being plugged in, freeing us from that final, ubiquitous power wire. Some of these devices might not even need their bulky batteries to operate. The increasing demand for electrical energy in industrial nations is well documented. Therefore, there is an expectation of even faster rise in the demand for electric power in the near future. If this wireless transmission of power becomes a reality, then one day oil producers will become electricity suppliers to the world without adding green house gases – and a global energy grid could be in space.

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