

# Impact of a Wireless Power Transmission System using Medium Distance Mode for Low Power Applications

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**Abstract:** Wireless power transmission is still in its infancy as a topic. Although devices and applications have been designed that transmit power over short distances, their price and design complexity keep them out of the reach of ordinary users. There is a need for a simple, efficient and cost-effective system which can create the changing electromagnetic field required to initiate wireless power transfer. Wireless power transfer is a challenging task because very few people till now have ever been able to perform it efficiently at distances longer than few meters and then to only with a very low amount of power. At present also no one has been able to implement long distance wireless power transfer (exceeding 2meters) in our commercial and domestic applications, such as in our own homes to light a lamp / LED / fans without the actual hard cored wiring. The area of my research proposes in developing a wireless power transfer system (a simulation model with a appropriate tool or a prototype model) that is targeted at delivering enough power to light a lamp or LED / or switch ON the fan in our homes using the principle of resonance induction, coming under the category of middle distance wireless power transmission mode. There are many applications that would also benefit from the ability to transfer power wirelessly( even at low wattage ) such as charging a laptop, personal computer and cell phone ; for the appropriate technology must be developed to satisfy these applications.

**Index Terms—** domestic applications, low wattage, resonance induction, wireless power transfer system

## I. INTRODUCTION

Wireless power transmission is still in its infancy as a topic. Although devices and applications have been designed that transmit power over short distances, their price and design complexity keep them out of the reach of ordinary users. There is a need for a simple, efficient and cost-effective system which can create the changing electromagnetic field required to initiate wireless power transfer. In addition, this can be used to heat vessels as an induction coil based stove. By suitably replacing the induction coil element with an efficient antenna ,the system can be applied to deliver limited amounts of power wirelessly, for small applications like the charging of mobile handsets, or laptops. The aim is to design a system that can be constructed from easily available and low cost electronic components, thus facilitating the transfer of this technology for the benefit of humanity. The fundamental principle guiding this system is the use of a suitable inverter circuit to convert D.C voltage into an alternating supply. Such an alternating voltage would create a rapidly changing magnetic flux, as per the equation:

$$\phi = B * A * \text{Cos}\theta \quad (1)$$

where ‘ $\phi$ ’ is the magnetic flux, ‘B’ is the magnetic field density,

‘A’ is the cross sectional area of the loop and

‘ $\theta$ ’ is the angle between the magnetic field density and the surface of the loop.

This flux change induces an e.m.f (electromotive force) in any wire loop or metal surface that cuts the magnetic flux lines. Such an e.m.f, if suitably tapped, can be used either for heating (where it manifests itself in the form of eddy currents in the vessel to be heated) or for wireless power transfer. The system can be partitioned into 4 functional blocks, as described in Figure 1.



Figure 1. Functional Diagram

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 [1]. Power mainly is transmitted by wire or cable since Edison has invented DC and Nicola Tesla invented AC at 19 century, and power plant and all levels power consumers are also interconnected to a network through wire and cable, which realize power be sent to consumers continuously from power plant. However many disadvantages existed in the wire transmission. For instance, wire and cable are mainly

made of metal materials such as aluminum, copper etc. In addition due to the problems such as friction, abrasion, nudity, etc, exists in wire transmission system can easily bring spark, which influence the reliability and safety of power supply. At present, wireless transmission mode can be divided into five categories, and related products base on small power and short range wireless power transmission has been used in real application such as wireless charging system base on electromagnetism induction technology (fig.2) and microwave technology, wireless supply to alimentary tract endoscopy system, and other related surgery implantable equipment. It can be forecasted that in near future wireless power supply can be used in more and more fields.

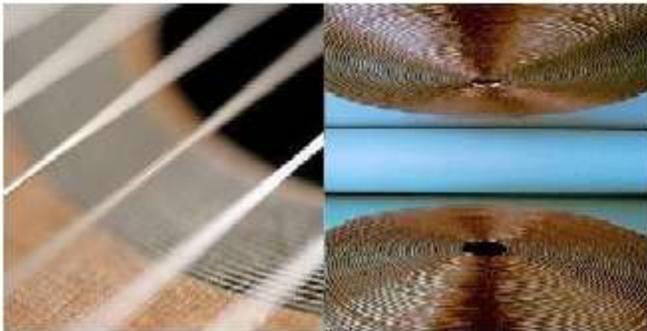


Figure 2. Evanescent wavic motion. Cross sectional view of coupled coils.

## II. NEED FOR WIRELESS POWER TRANSMISSION

- i. Wireless transmission is employed in cases where instantaneous or continuous energy transfer is needed, but interconnecting wires are inconvenient, hazardous, or impossible.



Figure 3. Interconnected wired network

- ii. Number of household points receives electricity at the same frequency using single transmitting coil as long as they all are at resonance. so this setup could recharge all the devices in a room at once.
- iii. The unmanned planes or robots (where wires cannot be involved viz oceans volcanic mountains etc.) which are run by the wireless power over an area, as they could fly for months at a time, could be used for research as well as a mini satellite.
- iv. A few proposals even involve sending power to the Earth from space.

## III. STATEMENT OF THE PROBLEM

Wireless power transfer is a challenging task because very few people till now have ever been able to perform it efficiently at distances longer than few meters and then to only with a very low amount of power.

At present also no one has been able to implement long distance wireless power transfer (exceeding 2meters) in our commercial and domestic applications, such as in our own homes to light a lamp / LED / fans without the actual hard cored wiring.

The area of my research proposes in developing a wireless power transfer system (a simulation model with a appropriate tool or a prototype model) that is targeted at delivering enough power to light a lamp or LED / or switch ON the fan in our homes using the principle of resonance induction, coming under the category of middle distance wireless power transmission mode. The various technologies incorporated for WPT are discussed below.

There are many applications that would also benefit from the ability to transfer power wirelessly( even at low wattage ) such as charging a laptop, personal computer and cell phone ; for the appropriate technology must be developed to satisfy these applications.

## IV. METHDOLOGY

### Domestic And International Current Research Situation

At the end of nineteen century, Heinrich Hertz and Tesla had validated the possibility of wireless transmission firstly in theory. Then Tesla, who put forward and realized AC, made further research to wireless transmission[6], and done a series of wireless transmission related experiments in hot Spring laboratory in Colorado of USA.. From then on, wireless transmission has began to be understood and accepted, more and more people engage in the research of related theory and application.

Recently as the development of electronics and information technology, great advancements about wireless power transmission has been achieved in domestic and international alike, and obtained a good many research productions and successful examples of business application. According to power transmission distance, wireless transmission can be divided into three categories: short distance, middle distance, and long distance .

### A. Short distance wireless power transmission mode

Short distance mode of wireless power transmission indicates that the furthest distance of power transmission is within several millimeters, and the typical representation of such transmission mode is based upon electromagnetism induction technology.

### Electromagnetism induction mode

Electromagnetism induction based wireless power transmission, also known as induction power transmission (IPT), is based upon electromagnetism induction theory to realize non-contacting power transmission from power source to load. IPT adopts non-contacting transformer, whose first wind and second wind are detachable, coil around different magnetism framework separately, and power transfer is realized through nonmagnetic material. Because transfer must be realized through non-magnetic material, so great transfer loss is unavoidable, especially to 50 HZ AC it is extremely difficult to realize efficient power transfer between first wind and second wind of non-contacting transformer. According to electromagnetism induction theory, the power of AC is directly proportional to its frequency. So it is necessary to increase working frequency of AV to overcome transmission loss and as working frequency is big enough, highly changing ratio of magnetic field will arouse very strong electromagnetism induction between first wind and second wind, at that time transfer power can reach strong level enough to overcome transmission loss and efficient power transfer become practicable. When transfer distance is limited in several millimeters, its transfer efficiency can reach 60%, but once beyond this range, efficiency will decrease greatly and be no longer fit for practical application.

So, IPT based wireless transmission is fit for short distance and high power wireless transmission. Presently application of IPT transmission are rather widely explored domestically and internationally[10,11], and now mainly focus on wireless charging system medical treatment equipment such as power supply to endoscopy, Biomicrosystem implantable to human body, etc.

#### B. Middle distance wireless power transmission mode

The furthest distance of middle distance mode is bound to several meters, which mainly includes two categories: ultrasonic and electromagnetism resonance induction.

##### Ultrasonic mode

Ultrasonic is sound wave which frequency is more than twenty thousand HZ and belongs to mechanical wave. Recently, as the enlargement of ultrasonic application in related economy industry, the research about mechanism and application of power ultrasonic technology has achieved comparatively development. Ultrasonic has been practically applied to many fields such as ultrasonic machining and processing technology, ultrasonic detecting and controlling technology. Ultrasonic power transmission utilizes piezoelectric effect and converse piezoelectric effect of piezoelectric material, which can convert mechanical power to electrical power, or electrical power to mechanical power, therefore realize the transformation of power, and realize the conversion of

ultrasonic power to mechanical power through the vibration of piezoelectric material, consequently realize power transmission. Ultrasonic possesses very strong direction property, which makes power focus on sink; in addition, ultrasonic is also famous for strong transfer power, so ultrasonic is very fit for medium of wireless power transmission. Ultrasonic wireless power transmission system is shown as figure 5. The realization process of it is that firstly converts AC source from sine wave to pulse, then magnify pulse source by amplifier and send it into ultrasonic transducer to realize conversion of electrical power to ultrasonic power and send it out; secondly converts the received ultrasonic power to electrical power through ultrasonic transducer, which is contrary process of production of ultrasonic; finally some measures such as commutating and regulating must be adopted to improve power quality and then send which to load circuit.

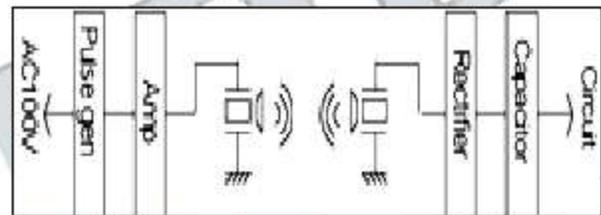


Figure 5: Experimental setup for the ultrasonic wireless power transmission system

The research about ultrasonic wireless power transmission is mainly focused on small power wireless charging system .

##### Resonance induction mode

Because electromagnetic wave possesses strong radiation property, when transmission distance is relatively long, transmission efficiency of IPT mode is very low, and receiver can only receive a very small power. To resolve this problem, through a lot of year's research, Marin Soljacic research group from MIT invented a kind of completely novel wireless power transmission mode-wireless power transmission mode based on resonance induction technology [ 11 ]. Resonance induction adopts electromagnetism field Syntony technology, as intrinsic frequencies of receiving antenna is in accord with electromagnetism field frequencies of sending antenna, the resonance will occur and coupling intension of magnetic field will increase, therefore its electrical power transmission efficiency is very high, and transmission distance can reach 3m to 4m, transmission power several KW. Their experiment was exposed to media firstly in Nov 2006 they successfully illumed 60W lamp by locating receiving winding (antenna) to 2m from sending antenna, and transmission efficiency can reach 40% (while distance

is 1m, efficiency can reach 90%). Resonance induction wireless power transmission of MIT is intended for wireless charge to mobile phone, notebook computer, and household electrical equipment. The present problem existed in this research is over-big antenna, its diameter reach 60cm, so more further investigation must be made to meet the need of utility.

#### Long distance transmission mode .

Transmission of long distance wireless power transmission can reach several decades KM, which mainly includes two categories: microwave transmission and laser transmission.

##### *i. Microwave mode*

Microwave is one kind of electromagnetic wave, whose wavelength is from 1mm to 1m, frequency from 0.3G HZ to 300G HZ. The investigation about microwave wireless power transmission can trace to more than 100 years ago, in 1899, Nicola Tesla firstly used microwave to realize wireless power transmission. While W. C. Brown successfully invented rectenna last century which can directly convert microwave into DC, therefore resolve a long time puzzling problem limited the development of microwave wireless power transmission, from then on microwave wireless power transmission comes into practical research period of microwave wireless power transmission. The microwave wireless power transmission main focus on wireless charging, SBSP- Space-based Solar Power-system and SSPS-Satellite Solar Power System. SBSP and SSPS take advantage of solar power to supply power to earth, planet, and spacecraft thereby ultimately solve energy source crisis facing to human being.

##### *ii. Laser mode*

Laser is famous for its better directional property, bigger power carrying capability, and so on. Common light source always scatters widely and a majority of power is wasted and efficiency is low, while laser has better directional property and scattering rather small, and therefore guarantee light intension. Compared with traditional wireless transmission mode, laser power transmission technology has one outstanding characteristic: without consideration to electric insulation and electromagnetism insulation. The realization theory of laser power transmission is simple and very similar to common laser generator, only different in power level and receiving style. Research spotlight to laser wireless power transmission focus on wireless charging system, SBSP and SSPS system.

#### **V. APPLICATIONS AND ECONOMICS OF WPT TECHNOLOGIES**

Witricity has a bright future in providing wireless electricity. There are no limitations in witricity power

applications. Some of the potential applications are powering of cell phones, laptops and other devices that normally run with the help of batteries or plugging in wires. Witricity applications are expected to work on the gadgets that are in close proximity to a source of wireless power, where in the gadgets charges automatically without necessarily having to get plugged in. By the use of witricity there is no need of batteries or remembering to recharge batteries periodically. If a source is placed in each room to provide power supply to the whole house, Witricity has many medical applications. It is used for providing electric power in many commercially available medical implantable devices. Another application of this technology includes transmission of information. It would not interfere with radio waves and it is cheap and efficient.

More reliable than ground based solar power:-In order for SPS-Solar Power Satellite to become a reality it several things have to happen:

- Government support
- Cheaper launch prices
- Involvement of the private sector

The SPS system would release less CO<sub>2</sub> / kWh than a nuclear power system. There is no other huge and clean energy source possible in the near future.

One application is the WPT for moving target, e.g., a fuel-free airplane, a fuel-free electric vehicle (EV), and moving robot in a limited area.

#### *Objectives*

##### *i. High Transmission Integrity and Low Loss*

To transmit wireless power to any distance without limit. It makes no difference what the distance is. The efficiency of the transmission can be as high as 90 or 97percent, and there are practically no loss and can be transmitted to any where in the globe and eliminate the need for an inefficient, costly, and capital intensive grid of cables, towers, and substations. The system would reduce the cost of electrical energy used by the consumer and get rid of the landscape of wires, cables, and transmission towers. It has negligible demerits like reactive power which was found insignificant and biologically compatible. It has a tremendous economic impact to human society. Many countries will benefit from this service. Monthly electric utility bills from old-fashioned, fossil-fuelled, lossprone electrified wire-grid delivery services will be optional, much like "cable TV" of today.

##### *ii. Non-radiative power transfer uses magnetic field*

##### *iii. Highly resonant coupling minimizes energy to off-resonant objects*

##### *iv. Benefits over electromagnetic radiation or radio waves*

Radio waves are not feasible for power transmission because the nature of radiations is such that it spreads across

the place and resulting into a large amount of radiation being wasted [1]. While lasers and microwaves require uninterrupted line of sight to transmit and also they are very dangerous. In this coupling system the energy that is not used by the receiver doesn't get radiated to the surrounding but remains in the vicinity of the transmitter. This ensures sampling as well as minimal wastage of power.

- **Safety**

Magnetic coupled resonance system transmits power even when there are obstacles in between the transmitter and receiver. Human beings or other objects placed in between the coils don't have any harmful effects on them. It is quite safe for humans. The magnetic field tend to interact very weakly with the biological tissues of the body and so are not prone to cause any damage to any living beings.

- **Constraints**

The only constraint that the system encounters is the decrease in efficiency when the receiver coil is moved away from the transmitter and also formation of nodes and antinodes. These are the areas that still need to be worked out and require further investigation.[8,9]

- **Negative health implications**

By the use of resonant coupling wave lengths produced are far lower and thus make it harmless. Wireless power transmission can be possible only in few meters. Efficiency is only about 40%. As witricity is in development stage, lot of work is done for improving the efficiency and distance between transmitter and receiver .

## CONCLUSION

To cast off energy crisis in the future, research endeavor of wireless power transmission will engage in acquiring electrical power from space. Through establishing space solar power plant can not only provide energy wirelessly to earth, but supply power to planets and spacecrafts in space. As the ever increasing and popularizing of personal intelligent, the widespread utilizing of household appliances, wireless power transmission will be very promising through wireless power supply and charge to those equipments. To supply power to these equipments by wireless mode will helpful for casting off bondage from wire and socket, therefore bring more convenience to human's daily life. Wireless power transmission will acquire great development in medical service. As the ever increasing of minitype equipment in clinical medicine, due to their comparatively small power demand, wireless power transmission can resolve their power supply; consequently make them more flexible and convenient. Wireless power transmission will also demonstrate its capability in disaster salvation. As disaster such flood, tsunami, earthquake, air crash, etc befallen, they usually will cause the break off of power source and brought great difficulty to rescue work. If power can be supplied by wireless style to disaster area timely, this

will bring revolutionary change to rescue work and capable for saving more lives and more properties. As the continuing development, efficiency and transmission distance of wireless power system will ever increase and improve, wireless power transmission will applied in more and more fields.

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