

# Wireless Transmission of Electricity

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**ABSTRACT:** *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. The technology used for wireless power transmission is known as witrlicity. Wireless power transmission is not a new idea; Nikola Tesla proposed theories of wireless power transmission in the late 1800s and early 1900s. Tesla's work was impressive, but it did not immediately lead to wide spread practical methods for wireless power transmission. Since then many researchers have developed several techniques for moving electricity over long distances without wires. Some exist only as theories or prototypes, but others are already in use. In 2007 researchers at Massachusetts Institute of Technology led by Marine Soijacic discovered an efficient way to transfer power between coils separated by a few meters. They have dubbed this technology as witrlicity. Witrlicity is based upon coupled resonant objects. Two resonant objects of the same resonant frequency tend to exchange energy efficiently, while not interchanging the surroundings. The researchers demonstrate the ability to transfer 60W with approximately 40% efficiency over distance in excess of 2 meters. Currently the project is looking for power transmission in the range of 100watts. As witrlicity is in the development stage, lots of work is to be done in improving the range of power transmission and efficiency.*

**KEYWORDS:** *Electricity, reliable, wireless transmission, witrlicity technology.*

## INTRODUCTION

In present electricity generation system we waste more than half of its resources. Especially the transmission and distribution losses are the main concern of the present power technology. 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. We have to think of alternate state of art technology to transmit and distribute the electricity. Now- a- days global scenario has been changed a lot and there are tremendous development in every field. If we don't keep pace with the development of new power technology we have to face a decreasing trend in the development of power sector. The transmission of power without wires may be one noble alternative for electricity transmission. This is one of the downfalls of electricity. While it can make people's lives easier, it can add a lot of clutter in the process. For these reasons, scientists have tried to develop methods of wireless power transmission that could cut the clutter or lead to clean sources of electricity. Wireless power transmission is not a new idea. Many researchers developed several methods for wireless power

transmission. But witrlicity is a new technology used for wireless power transmission. By the use of this technology transmission of electrical energy to remote objects without wires can be possible. The inventors of witrlicity are the researchers from Massachusetts Institute of Technology (MIT). They developed a new technology for wireless electricity transmission and this is based upon the coupled resonant objects. In this resonant magnetic fields are used. So the wastage of power is reduced. The system consists of witrlicity transmitters and receivers. The transmitters and receivers contain magnetic loop antennas made of copper coils and they are tuned to the same frequency.

## FIRST WIRELESS TRANSMISSION OF ELECTRICITY

In this remarkable discovery of the "True Wireless" and the principles upon which transmission and reception, even in the present day systems, are based, Dr. Nikola Tesla shows us that he is indeed the "Father of the Wireless." The most well known and famous Wardencllyffe Tower (Tesla Tower) was designed and constructed mainly for wireless transmission of electrical power, rather than telegraphy. The most popular concept known is Tesla Theory in which it was firmly believed that Wardencllyffe (Fig.1) would permit wireless

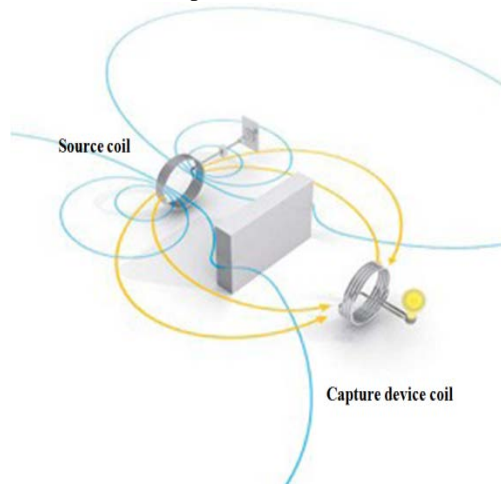
transmission and reception across large distances with negligible losses. In spite of this he had made numerous experiments of high quality to validate his claim of possibility of wireless transmission of electricity. But this was an unfortunate incidence that people of that century was not in a position to recognize his splendid work otherwise today we may transmit electricity wirelessly and will convert our mother earth a wonderful adobe full of electricity.



**Fig.1 187-foot Wardencliff Tower**

#### WITRICITY TECHNOLOGY

Witricity power sources and capture devices are specially designed magnetic resonators that efficiently transfer power over large distances via the magnetic near-field. These proprietary source and device designs and the electronic systems that control them support efficient energy transfer over distances that are many times the size of the sources/devices themselves. The Witricity power source, left, is connected to AC power. The blue lines represent the magnetic near field induced by the power source. The yellow lines represent the flow of energy from the source to the Witricity capture coil, which is shown powering a light bulb. Note that this diagram also shows how the magnetic field (blue lines) can wrap around a conductive obstacle between the power source and the capture device.



**Fig.2 An illustration**

Blue lines-Magnetic near field

Yellow lines- flow of energy, Power transfer is Omni directional and more efficient. Bulb is connected to capture device

#### THE INVENTION OF WITRICITY TECHNOLOGY

##### HOW IT STARTED

The story started late one night a few years ago, with MIT Professor Marin Soljatic's standing in his bedroom, staring at his cell phone on the kitchen counter. It was probably the sixth time that month that he was awakened by his mobile phone beeping to let him know that he had forgotten to charge it. At that moment, it occurred to him. "There is electricity wired all through this house, all through my office everywhere. This phone should take care of its own charging! But to make this possible, one would have to find a way to transfer power from the existing wired infrastructure to the cell phone—without wires. Soljatic's started thinking of physical phenomena that could make this dream a reality.

##### COUPLED RESONATORS WAS FIT FOR THE SITUATION

To achieve wireless power transfer in a way that is practical and safe, one needs to use a physical phenomenon that enables the power source and the device (in this case, the mobile phone) to exchange energy strongly, while interacting only weakly with living beings and other environmental objects, like furniture and walls. The phenomenon of coupled resonators precisely fits this description. Two resonant objects of the same resonant frequency tend to exchange energy efficiently, while interacting weakly with extraneous off-resonant objects. A child on a swing is a good example of a resonant system. As wing exhibits a type of mechanical resonance, so only when the child pumps her legs at the natural frequency of the swing is she able to impart substantial energy into the motion of the swing.

##### STRONG COUPLING

Coupled resonators are said to operate in a strongly coupled regime if their energy transfer rate is substantially higher than the rate at which they lose energy due to factors such as material absorption and radiation. In the strongly coupled regime, energy transfer can be very efficient. These considerations are universal, applying to all kinds of resonances (e.g., acoustic, mechanical, electromagnetic, etc.). Sojatic and his colleagues at MIT (Karalis and Giannopoulos) set out to explore and develop the physical theory of how to enable strongly coupled magnetic resonators to transfer power over distances that would enable the kind of wireless device

charging that Soijacic first imagined. Their theoretical results were published first in 2006, and again in 2008 in the Annals of Physics. Once the physical theories were developed, Soijacic and his team (Kurs, Karalis, Moffatt, Giannopoulos, and Fisher) set out to validate them experimentally. The theory was developed to cover a broad range of coupled resonator systems, but the experimental work focused on proving that magnetically coupled resonators could exchange energy in the manner predicted by the theory and required for the wireless charging of devices, such as cell phones. The team explored a system of two electro-magnetic resonators coupled through their magnetic fields. They were able to identify the strongly coupled regime in this system, and showed that strong coupling could be achieved over distances that greatly exceeded the size of the resonant objects themselves. The team had proven that in this strongly coupled regime, efficient wireless power transfer could be enabled. Their successful experiment was published in the journal, Science, in 2007.

#### WITRICITY TECHNOLOGY IS BORN

#### BASIC PRINCIPLE:

The basic concept behind Witricity-Wireless Electricity is Magnetic Resonance. Two resonant objects of the same resonant frequency tend to exchange energy efficiently, while dissipating relatively little energy in extraneous off-resonant objects. In systems of coupled resonances, there is often a general "Strongly Coupled" regime of operation. If one can operate in that regime in a given system, the energy transfer is expected to be very efficient. Midrange power transfer implemented in this way can be nearly Omni directional and efficient, irrespective of the geometry of the surrounding space, with low interference and losses into environmental objects. The above considerations apply irrespective of the physical nature of the resonances. The experimental design consisted of two copper coils, each a self-resonant system. One of the coils, connected to an AC power supply, was the resonant source. The other coil, the resonant capture device, was connected to a 60 watt light bulb. The power source and capture device were suspended in mid-air with nylon thread, at distances that ranged from a few centimeters to over 2.5 meters (8.2 ft). Not only was the light bulb illuminated, but the theoretical predictions of high efficiency over distance were proven experimentally. By placing various objects between the source and capture device, the team demonstrated how the magnetic near field can transfer power through certain materials and around metallic obstacles. Thus Prof. Soljacic's

dream of finding a method to wirelessly connect mobile electric devices to the existing electric grid was realized. Witricity Corp. was soon launched to carry this technology forward from the MIT laboratories to commercial production.



Fig.3 Evanescent wave coupling

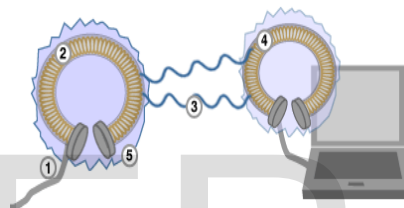


Fig.4 working fig

- 1) Power from mains to antenna, which is made of copper
- 2) Antenna resonates at a frequency of about 6.4MHz producing electromagnetic waves
- 3) 'Tails' of energy from antenna 'tunnel' up to 5m (16.5ft)
- 4) Electricity picked up by laptop's antenna, which must also be resonating at 6.4MHz. 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 6.4MHz

#### TRANSMITTER AND RECEIVER COILS

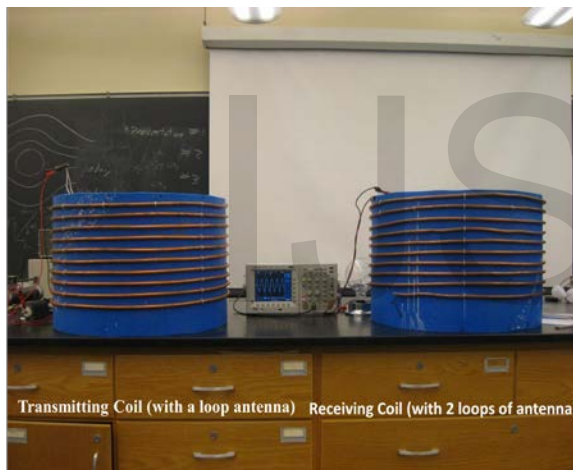
The transmitter and receiver circuit combined is called the coupling circuit. It is the heart of the entire system as the actual wireless power transfer is carried out here. The efficiency of the coupling circuit determines the amount of power available for the receiver system.

#### DESIGN

The transmitter and receiver coils were designed by former Cornell students, Lucas Jorgensen and Adam Culberson. The coils had a resonant frequency of 4.8 – 5.3 MHz, which could be tuned with our oscillator (later a signal generator) to get to the resonance

frequency of the coils. The basic configuration of the design can be seen from the table and the image below.

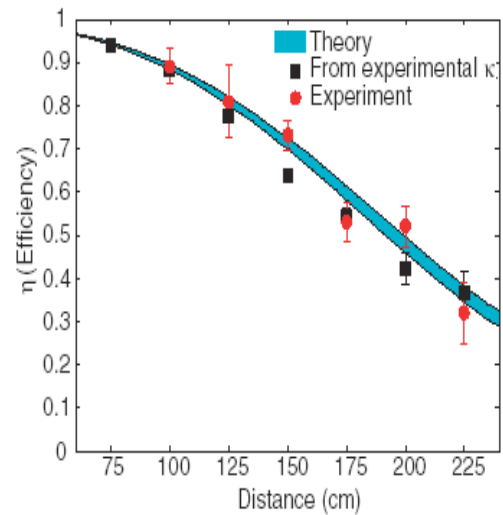
Transmitting Coil	No of turns	10
	Diameter of each turn	60.32 cm
	Diameter of copper tube	0.95 cm
Receiving Coil	No of turns	10
	Diameter of each turn	60.32 cm
	Diameter of copper tube	0.95 cm
Transmitting Antenna	No of turns	1
	Diameter of each turn	56.1 cm
	Diameter of copper wire	0.23 cm
Receiving Antenna	No of turns	2
	Diameter of each turn	44.6 cm
	Diameter of copper wire	0.23 cm



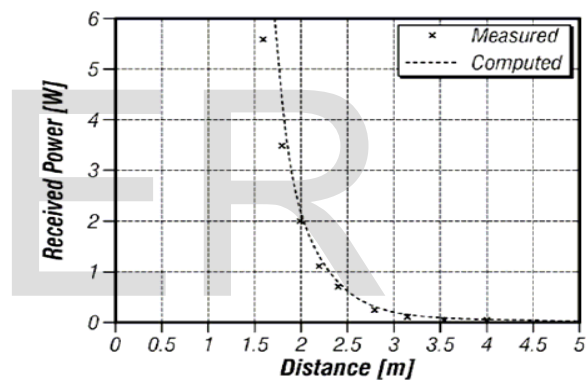
**Fig.5 Structure of the coils.**

#### IMPLEMENTATION OF SYSTEM AND RESULTS

Two identical helical copper coils, one for the source and one for load, were constructed by the MIT team for magnetic coupling. By fine tuning the height of coils, they were able to cause strong magnetic resonance coupling between two coils at a midrange distance. The source coil was in turn inductively coupled to a single copper wire loop which is attached to Colpitts oscillator. The receiving magnetic coil was inductively coupled to a copper wire loop attached to a 60 W bulb. To test the accuracy of their theoretical derivations, MIT team compares theoretical and experimental values. Experimental and theoretical values of efficiency with distance are compared.



**Fig.6 Efficiency over Distance**



**Fig.7 Received Power over Distance**

#### ADVANTAGES OF WITRICITY

##### ADVANTAGES

1. No need of power cables and batteries - Witricity replaces the use of power cables and batteries.
2. Does not interfere with radio waves
3. The nature of power delivery is Omni directional i.e. in every direction
4. Reduction of e-waste by eliminating the need for power cords
5. Less costly - The components of transmitter and receivers are cheaper. So this system is less costly.
6. Negative health implications – By the use of resonant coupling wavelengths produced are far lower and thus make it harmless.

## PRACTICALITY AND SAFETY

1. Witricity demonstration is still too recent, and too focused, to produce any definite conclusions.
2. With the witricity method ,they anticipate transmitting power over distances about a meter, which is much less than ideal but still very impressive.
3. If the technology is improved and honed to a point where it can be “productized”, it stands to turn any number of industries on their respective ears.
4. The MIT team said its discovery is different from all previous effort because it uses “magnetically coupled resonance”, which means it will not only be safe but it will be fairly efficient.

## 10. APPLICATIONS

Witricity wireless power transfer technology can be applied in a wide variety of applications and environments. The ability of our technology to transfer power safely, efficiently, and over distance can improve products by making them more convenient, reliable, and environmentally friendly. Witricity technology can be used to provide.

**DIRECT WIRELESS POWER:** when all the power a device needs is provided wirelessly, and no batteries are required. This mode is for a device that is always used within range of its Witricity power source.

**AUTOMATIC WIRELESS CHARGING:** when a device with rechargeable batteries charges itself while still in use or at rest, without requiring a power cord or battery replacement. This mode is for a mobile device that may be used both in and out of range of its Witricity power source. Witricity technology is designed for Original Equipment Manufacturers (OEM’s) to embed directly in their products and systems.

**IN MOBILE:** Recently the search has been done in the mobile communication also, the various Companies also using the same technology, for larger output or for more benefit and for sake of them. For example: 1) Samsung Galaxy  
2) Lumia  
3) Apple  
4) Toyota

These are the latest launch version in wireless transmission of electricity.

## WITRICITY TECHNOLOGY WILL MAKE YOUR PRODUCTS

### MORE CONVENIENT:

- No manual recharging or changing batteries.
- Eliminate unsightly, unwieldy and costly power cords.

### MORE RELIABLE:

- Never run out of battery power.
- Reduce product failure rates by fixing the ‘weakest link’: flexing wiring and mechanical interconnects.

### MORE ENVIRONMENTALLY FRIENDLY

- Reduce use of disposable batteries.
- Use efficient electric ‘grid power’ directly instead of inefficient battery charging.



**Fig. 8 Electronic equipment**

## CONSUMER ELECTRONICS

•Automatic wireless charging of mobile electronics (phones, laptops, game controllers, etc.) in home, car, office, Wi-Fi hotspots. While devices are in use and mobile.

•Direct wireless powering of stationary devices (flat screen TV’s, digital picture frames, home theater accessories, wireless loud speakers, etc.) Eliminating expensive custom wiring, unsightly cables and “wall-wart” power supplies.

•Direct wireless powering of desktop PC peripherals: wireless mouse, keyboard, printer, speakers, display, etc...eliminating disposable batteries and awkward cabling.

## INDUSTRIAL

•Direct wireless power and communication interconnections across rotating and moving “joints” (robots, packaging machinery, assembly machinery,

machine tools) ... eliminating costly and failure-prone wiring.

.Direct wireless power and communication interconnections at points of use in harsh environments (drilling, mining, underwater, etc.) where it is impractical or impossible to run wires.

#### ADDITIONAL REMARKS

Many concepts, research papers, patents are available on wireless transmission of electricity but most research work were carried out in isolation, so it needs a joint collaborative efforts to get a very useful results on this advanced technology on power transmission for the benefit of mankind globally in future. Whatever the future may bring, the universal application of these great principles is fully assured, though it may be long in coming. With the opening of the first power plant, incredulity will give way to wonderment, and this to ingratitude, as ever before. People neglected him and his good work. He deserved much better treatment from the tycoons of his age, than to spend the last 40 years of his life in abject poverty. However, he was too much of a gentleman to hold a grudge. Instead, regarding the magnifying transmitter, Tesla wrote in his autobiography, "I am unwilling to accord to some small-minded and jealous individuals the satisfaction of having thwarted my efforts. These men are to me nothing more than microbes of a nasty disease. My project was retarded by laws of nature. The world was not prepared for it. It was too far ahead of time. But the same laws will prevail in the end and make it a triumphal success. If this has had not been happened, then today we will be in a wonder world of plenty of power using the technology of wireless transmission of electricity.

#### FUTURE SCOPE

No more batteries, no more chargers and no more wire spaghetti. This is the future promised by "wireless power", a means of broadcasting electricity through the air to laptops, iPods and other gadgets without the need for cables and sockets. Audio speakers and digital picture frames are expected to be among the first commercial products demonstrated in Las Vegas this week at the International Consumer Electronics Show, the world's biggest gadgets tradeshow. Experts believe this is just the beginning and that eventually wireless electricity - dubbed "Witricity" by some - could do for battery life what Wi-Fi did for the internet. In a world without wires, laptop users in cafes and airport terminals would be inside an "electricity hotspot" and no longer have to delve past legs, bags and furniture in search of an awkwardly located socket.

#### CONCLUSION

The transmission of power without wires is not a theory or a mere possibility, it is now a reality. The electrical energy can be economically transmitted without wires to any terrestrial distance. Wireless transmission of electricity have tremendous merits like high transmission integrity and Low Loss (90 – 97 % efficient) and can be transmitted to anywhere 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. Monthly electric utility bills from old-fashioned, fossil-fuelled, loss prone electrified wire-grid delivery services will be optional, much like "smart phone" of today.

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