

A Review of Wireless Power Transfer

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Abstract—This is a review of wireless power transfer technology including problem statement, applications, literature review etc. You will understand what is the WPT and why it is useful. The approaches and solutions for the transmission and the efficiency of transmission will also be included.

Keywords—wireless, system, distance, power

I. INTRODUCTION

WPT (wireless power transfer) or WEF (wireless energy transfer) is the technology that electrical energy can be transferred without wires as a link between a power supply and an electric device.

Since Mr. Nikola Tesla pointed out the fact that energy can be transferred wirelessly in 1904 [1], many scientists and engineers have tried a lot to make this technology possible to be applied in people's daily life, for example, city power system, and city illumination system.

Despite the fact that we do have improvements on WPT through about 100 years' research, the main problem of this technology is still remained, which makes us sad. There is still a long way for us to build the world system of wireless transmission of energy [2].

II. PROBLEM STATEMENT

A. The biggest problem

The biggest problem of WPT is the limited transmission distance, which is caused by the fast decay of energy during the transferring. We can only transfer power in a close range. This limitation is really disappointing. Because of it, city wide or national wide or even global wide wireless power transmission can't be achieved.

Today, we can use high frequency waves like microwaves to transfer power from a long distance by radiative technology [3]. However, exposing to the high frequency electromagnetic fields may do harm to people's health or other animals like birds.

As you can image, to solve the biggest problem, many other side-problems may occur.

B. Why WPT is useful

You may wonder that why it is useful? Why we need this technology? The wire system we are using nowadays has already been well developed. I will show you three parts of the importance of WPT.

First, city power is transferred by wires today. However, in some poor areas and mountain areas where the wire system can never have a chance to be built up, it is impossible for people who live in these areas to normally use electronic equipment like lights, TVs, computers, phones, etc. This technology can fix this problem and has the potential to make people's life easier, better and more convenient since there will be no limit by wires.

Second, power supply is very important for vehicles. Despite the fact that we have invented and improved electric vehicles, the power supply is still a problem for electric cars. There are many factors that affect a battery's output, like battery aging, temperature, battery materials, etc. We may need to charge batteries frequently so that we can avoid losing power while we are driving. Moreover, old batteries are not safe. Explosions may happen. However, we can all fix these by transferring power wirelessly. There will be no battery needed and we will never need to worry

about losing power since energy can be obtained directly from space. Not only e-vehicles but also all electrical machines can be fully charged all the time.

Third, for people who have artificial body organs, like an artificial heart, they need power to keep their artificial organs working well. If artificial organs can be powered wirelessly, it will be good news for those patients. They won't worry about power cut accidents or changing batteries. See? This technology can be used in medical areas, saving people's lives.

III. APPLICATIONS

In this section, 6 applications are introduced to you. 3 of them have already been applied. The other 3 applications are under researches and may be possible in the future.

A. Applied applications

1) *Wireless phones/devices charging (close range)*: By using inductive coupling, small electric device wireless chargers have already been in sale. Fig. III.A.1 shows a phone wireless charger designed by Samsung.



Fig. III.A.1: Samsung Nokia Htc Wireless Charger Cell Phone Mini Charge Pad For Qi-Abled Device

2) *Wireless e-vehicles charging (close range)*: By using inductive coupling, e-vehicles chargers, as the same as device chargers, have already been

applied. Fig. III.A.2 shows a e-vehicle charger designed by WiTricity.



Fig. III.A.2: WiTricity has partnered with BMW to release the first consumer-ready remote charging system for an electric vehicle.

3) *Biomedical Implants (close range)*: By using capacitive coupling, we can now charge biomedical implants like chips in bodies.[4][5]

B. Possible applications in the future

1) *Powering e-vehicles anywhere and anytime*: Since we have already achieved close range charging technology for electrical cars, it is reasonable for us to find a way to charge e-vehicles in real time wherever the cars are going to be.

2) *Solar power satellite*: We can use the sun as our energy source. We collect solar energy by satellite. Then, we transfer the collected power to the earth by radiative technology. As it is out space, there should be limited harm to human and other living beings.

3) *Powering aircraft*: If the global WPT system can be applied, there will be no space limits caused by wires. Not only vehicles but also electrical aircrafts like drone aircrafts can be fully charged all the time without worrying about losing power.

IV. LITERATURE REVIEW

A. The approaches and solutions for WPT

1) *Inductive Coupling*: Inductive coupling and capacitive is most common and widely used methods for people to transfer power wirelessly. Coupling is really easy to be applied. Fig. IV.A.1 shows how it works. When an alternating current goes through the power supply coils, generating an oscillating magnetic field, by Ampere's law and Faraday's law, the receiver's coils will induce an alternating voltage and then generate an alternating current in receiver's coils. As the result, the power will be obtained directly from the field by the receiver. [6]

Since mutual inductance matters here, it is easy to figure out that frequency and the shape of receiver's coils. The higher frequency is and more magnetic flux can be obtained, the further power can be transferred. However, although we know how to increase the transmission distance when we use inductive coupling, because of using fields, the power decrease exponentially, which means it is not an efficient way for distant power transmission.

As a result, it is only can be used for shot range transmission, for example, phones wireless chargers.

However, it is still the easiest method of WPT. We are trying to design and improve inductive coupling method so that we can have longer transmission distance while we are using coupling method. For example, resonant inductive coupling is a way using vibration to increase the distance.

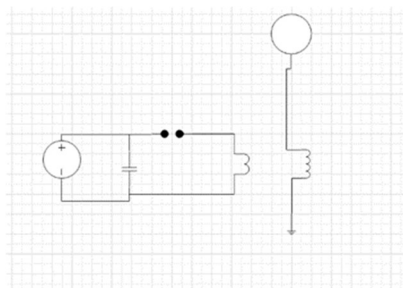


Fig.IV.A.1: an example circuit diagram for inductive coupling

2) *Radiative technology*: Radiative technology is for far-field transmission. It makes use of the good directivity of high frequency waves like microwaves and light waves. Because these waves have great directivity, energy is gathered and can be transferred in one direction. It is a very efficient way for distant transmission. The disadvantage of it is that we have to make sure the antennas aim exactly at the receiver. [6]

B. The links between frequency and T-distance

Table. IV.B shows the links between frequency and transmission distance.

<i>Frequency</i>	<i>Range</i>	<i>Directivity</i>
Low	Short	Low
High	Long	High

Table. IV.B: Links between frequency and T-distance

V. OPEN SOURCE PROJECT

There are different open source projects for people to get information about WPT.

For vehicles:

<https://www.newscientist.com/article/mg22129534-900-wireless-charging-for-electric-vehicles-hits-the-road/>

<http://www.bbc.com/future/story/20121120-pulling-the-plug-on-electric-cars>

For device:

http://www.eenewseurope.com/news/israeli-startup-turns-luminaires-wireless-power-chargers#new_tab

For introduction:

<https://www.youtube.com/watch?v=RNqEyfVrEug>

https://www.youtube.com/watch?v=TFGXC_paeA

VI. MY FAVORITE AREA

My favorite area of WPT is Inductive coupling. So, I focus on this area and study from the open source and made a model of Inductive coupling coils for WPT.

As you can see from Fig. VI.1 and Fig. VI.2, the bulbs are lighted without wires. This is evidence to show that energy can be obtained directly from space without wires.



Fig. VI.1: Inductive coupling a



Fig.VI.2: Inductive coupling b

VII. REFERENCE

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