

# Inductive Charging Technique

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## ABSTRACT

The fuels like petrol, diesel etc. cost is increasing day by day because of increased number of vehicles and proportional fuel usage. Also the sources of these fuels are depleting in nature. As a solution to this problem, here we are proposing a model which will solve the above problem. However it also has some limitations. Proposed project is an innovative application of Faraday's laws of electromagnetic induction. According to Faraday's law, EMF is induced in a coil when it is linked with the flux produced by another coil. This induction principle, is applying to hybrid electric vehicles. Inductive charging uses the electromagnetic field to transfer energy between two objects. A charging station sends energy through inductive coupling to an electrical device, which stores the energy in the batteries. Because there is a small gap between the two coils, inductive charging is one kind of short-distance wireless energy transfer. Induction chargers typically uses an induction coil to create time varying electromagnetic field within a charging base station, and another induction coil which is attached with the portable device receives power from the electromagnetic field and stores the energy in the battery. Through a rectifier the two induction coils in proximity combine to form an electrical transformer.

## 1. INTRODUCTION

### 1.1 Inductive Charging

In this era of modernization, electricity has become the cup of life. A moment without electricity makes your thinking go dry. The major source of conventional form of electricity is through wires. The continuous search and development has brought forward a major breakthrough, which provides electricity without the medium of wires. This wonder baby is called Inductive charging.

There are certain small but very useful discoveries made in history, which changed the world for ever, Newton's gravitational law, Watt's steam engine, Thomson's bulb and many more. But a renaissance occurred with the invention of Electromagnetic Waves by Maxwell. And with this there started a new era called WIRELESS TECHNOLOGY. Today, as we can see the word 'wireless' is common in day – to – day life. Wireless communication has made the world smaller. Almost each and everything is

wireless or cordless. Cordless mouse, cordless keyboard, satellite communication, mobiles, cordless microphones and headphones, wireless internet service i.e. WIFI, etc. And these have definitely increased the standard of living.

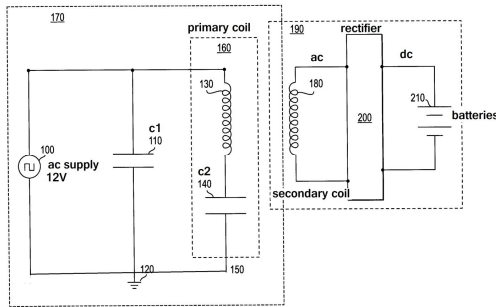
In fact it dates back to the 19th century, when Nikola Tesla used conduction based systems instead of resonance magnetic fields to transfer wireless power. As it is in Radioactive mode, most of the Power was wasted and has less efficiency. Further, in 2005, Dave Gerding coined the term Inductive charging which is being used by the MIT researchers today.

Moreover, we all are aware of the use of *electromagnetic radiation* (radio waves) which is quite well known for wireless transfer of information. In addition, lasers have also been used to transmit *energy* without wires. However, radio waves are not feasible for power transmissions because the nature of the radiation is such that it spreads across the place, resulting into a large amount of radiations being wasted. And in the case of lasers, apart from requirement of uninterrupted line of sight (obstacles hinder the transmission process). It is also very dangerous.

Transmission of electrical energy from one object to another without the use of wires is called as Inductive charging. Inductive charging will ensure that the cell phones, laptops, iPods and other power hungry devices get charged on their own, eliminating the need of plugging them in. Even better, because of Inductive charging some of the devices won't require batteries to operate.

Now a days there is a Rapid development of autonomous electronics like Laptops, Cell-phones, House-hold robots and all those devices typically rely on chemical energy storage(Battery) As they are becoming daily needs to present generation, Wireless energy transfer would be useful for many applications as above and they need midrange energy

## CIRCUIT DIAGRAM



## 2. CIRCUIT DESCRIPTION

### 2.1. Working Principle

Inductive charging works on the principle of transformer. A **transformer** is a device that transfers electrical energy from one circuit to another through inductively coupled conductors—the transformer's coils. A varying current in the first or *primary* winding creates a varying magnetic flux in the transformer's core and thus a varying magnetic field through the *secondary* winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage", in the secondary winding. This effect is called *mutual induction*.

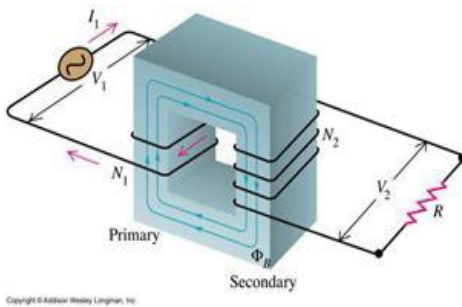


Fig 1: Basic Transformer

### Near field

Near field is a wireless transmission technique over distances comparable to, or a few times the diameter of the device(s), and up to around a quarter of the wavelengths used. Near field energy itself is non radioactive, but some radioactive losses will occur. In addition there are usually resistive losses. Near field transfer is usually of 3 types:

- ❖ Induction
- ❖ Electro dynamic induction
- ❖ Electrostatic induction

### 2.1.1 Induction

The action of an electrical transformer is the simplest instance of wireless energy transfer. The primary and secondary circuits of a transformer are not directly connected. The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction. (An added benefit is the capability to step the primary voltage either up or down.) The battery charger of a mobile phone or the transformers on the street are examples of how this principle can be used. Induction cookers and many electric toothbrushes are also powered by this technique. The main drawback to induction, however, is the short range. The receiver must be very close to the transmitter or induction unit in order to inductively couple with it.

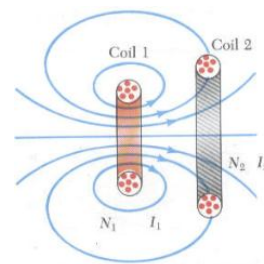


Fig 2: Electric Toothbrushes

### 2.1.2 Electro dynamic induction

The "electro dynamic inductive effect" or "resonant inductive coupling" has key implications in solving the main problem associated with non-resonant **inductive coupling** for wireless energy transfer; 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. The range is negligible because most of the magnetic field misses the secondary. Even over relatively small distances the induction method is inefficient and wastes much of the transmitted energy. The application of resonance improves the situation somewhat. When resonant coupling is used the transmitter and receiver inductors are tuned to a mutual frequency and power transfer occurs over multiple cycles. In this way significant power may be transmitted over a distance of up to a few times the size of the transmitter. Unlike the multiple-layer windings typical of non-resonant transformers, such transmitting and receiving coils are usually single layer solenoids or flat spirals with series capacitors, which, in combination, allow the receiving element to be tuned to the transmitter frequency and reduce losses. A common use of the technology is for powering

contactless smartcards, and systems exist to power and recharge laptops and cell phones.

### **Power transfer**

Because the  $Q$  can be very high, even when low power is fed into the transmitter coil, a relatively intense field builds up over multiple cycles, which increases the power that can be received—at resonance far more power is in the oscillating field than is being fed into the coil, and the receiver coil receives a percentage of that.

### **Voltage gain**

The voltage gain of resonantly coupled coils is proportional to the square root of the ratio of secondary and primary inductances.

### **Transmitter coils and circuitry**

Unlike the multiple-layer secondary of a non-resonant transformer, coils for this purpose are often single layer solenoids (to minimize skin effect and give improved  $Q$ ) in parallel with a suitable capacitor, or they may be other shapes such as wave-wound litz wire. Insulation is either absent with spacers or low permittivity, low loss materials such as silk to minimize dielectric losses.

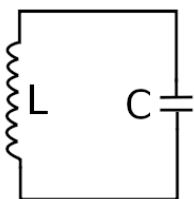


Fig 3: Tuning circuit

A capacitor stores energy in the electric field between its plates, depending on the voltage across it, an inductor stores energy in its magnetic field, depending on the current through it

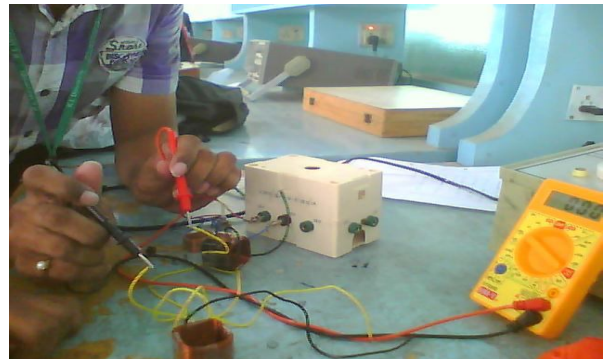
### **Receiver coils and circuitry**

The secondary receiver coils are similar designs to the primary sending coils. Running the secondary at the same resonant frequency as the primary ensures that the secondary has a low impedance at the transmitter's frequency and that the energy is optimally absorbed. To remove energy from the secondary coil, different methods can be used, the AC can be used directly or rectified and a regulator circuit can be used to generate DC voltage.

### **Electrostatic induction**

The "electrostatic induction effect" or "capacitive coupling" is an electric field gradient or differential capacitance between two elevated electrodes over a conducting ground plane for wireless energy transmission involving high frequency alternating current potential differences transmitted between two plates or nodes. The electrostatic forces through natural media across a conductor situated in the changing magnetic flux can transfer energy to a receiving device (such as Tesla's wireless bulbs). Sometimes called "the Tesla effect" it is the application of a type of electrical displacement, i.e., the passage of electrical energy through space and matter, other than and in addition to the development of a potential across a conductor.

### **Hardware Picture:**



## **3. HARDWARE DESCRIPTION**

- 1. Transmitter**
- 2. Receiver**
- 3. AC to DC Converter**
- 4. Frequency Oscillator**

### **3.1 Transmitter**

Power supply is given to the primary coil. It acts as the Transmitter. Copper coil is wound into number of turns as per the requirement . when the power is supplied to Transmitter the coil energizes and results in the magnetic coupling. Hence the power is transferred .



Fig 4: Transmitter Coil

### 3.2 RECEIVER COIL:

Receiver coil is similar to that of transformer primary coil. The secondary receiver coils are similar designs to the primary sending coils. Running the secondary at the same resonant frequency as the primary ensures that the secondary has a low impedance at the transmitter's frequency and that the energy is optimally absorbed. To remove energy from the secondary coil, different methods can be used, the AC can be used directly or rectified and a regulator circuit can be used to generate DC voltage.



Fig 5: Receiver coil

### 3.3 AC to DC CONVERTER

#### AC to DC converter

This converter will convert the 120 V AC from the power outlet to a 9 V DC voltage across the input of the frequency oscillator. This converter is basically a rectifier circuit composed a diode network and a capacitor.

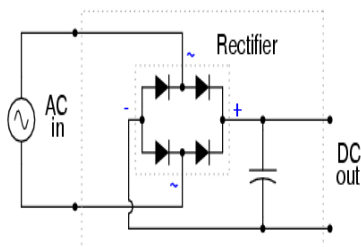


Fig 6: AC to DC converter

### 3.4 Frequency oscillator

The frequency oscillator is the device that will create the magnetic field that will allow the transmitter and receiver coils to exchange energy. This device will be composed of components such as resistors, inductors and capacitors. In order to achieve a resonance frequency in the oscillator circuit the inductive reactance and the capacitive reactance of the resonator coil will equal such that:

$$wL = \frac{1}{wC} \rightarrow L = \frac{1}{C}$$

Where  $w = 2\pi * f$ ,  $L$  is the inductance in 'Henry'

And  $C$  the capacitance in 'Farad'

In other word the resonance frequency that will allow us to initiate the wireless power transfer from the transmitter and receiver coils will be calculated using the values of the inductance and capacitance of the coils in the following formula.

$$f = \frac{1}{\sqrt{LC}}$$

Where:  $f$  is the resonance frequency in 'Hertz'

When current starts to flow in the first coil loops, electric (E) and magnetic (B) fields are created. The turns in the loops acts as capacitor as the circulating current deposits positive and negative charges and an electric field is generated. On the other hand, the magnetic field is generated all along each loop and strengthens with an increase in number of turns of the coil. By making the gap between the turns small in the 2 cm, the E-field will be weak and therefore restricted near the transmitting coil. By having more number of turns in the range of 30, the B-field will be strong enough to reach the receiving coil. The reason why the focus is on the B-field is because its strength is easily adjustable by varying the number of turns or the intensity of the current. In other word, an increase in either of these parameters will result in an increase in the magnetic field.

The magnitude of the B-field can be calculated the following formula:

$$B = \mu \frac{N}{l} I \text{ In Tesla, where } N = \text{number of turns, } l =$$

length of coil,  $I =$  current in Amps

And  $\mu =$  permeability of free space

The electric (E) and magnetic (B) fields are energy carrying wave and their energy densities can be calculated as follows:

$$W_E = \frac{1}{2} \epsilon E^2 \text{ Where } \epsilon = \text{permittivity of free space.}$$

$$W_B = \frac{1}{2} \frac{B^2}{\mu} \text{ And } \mu = \text{permeability of free space}$$

When the energy carrying B-field strikes the receiving coil, it induces a voltage or an emf (electromotive force) which supplies power to the load and is given by:

$$V = -N \frac{d\phi}{dt}$$

Where  $\phi =$  flux =  $B * A$  with  $A =$ area of the coil.

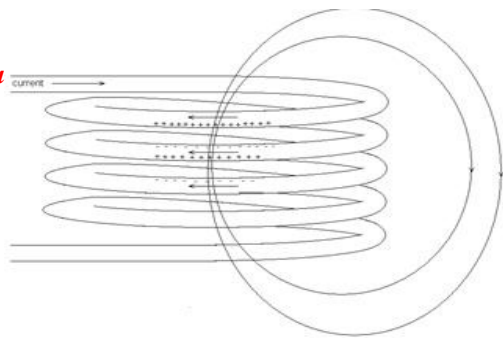


Fig 7: B in Field Coils

## 4. MISCELLANEOUS

### 4.1 ADVANTAGES

Inductive charging carries a far lower risk of electrical shock, when compared with conductive charging, because there are no exposed conductors. The ability to fully enclose the charging connection also makes the approach attractive where water impermeability is required; for instance, inductive charging is used for implanted medical devices that require periodic or even constant external power, and for electric hygiene devices, such as toothbrushes and shavers, that are frequently used near or even in water. Inductive charging makes charging mobile devices and electric vehicles more convenient; rather than having to connect a power cable, the unit can be placed on or close to a charge plate.

#### Highly Resonant Strong Coupling Provides High Efficiency Over Distance

In Inductive charging power transfer is highly efficient over distances ranging from centimeters to several meters. Efficiency may be defined as the amount of usable electrical energy that is available to the device being powered, divided by the amount of energy that is drawn by the *Inductive charging* source. In many applications, efficiency can exceed 90%. And *Inductive charging* sources only transfer energy when it is needed.

#### Energy Transfer via Magnetic Near Field Can Penetrate and Wrap Around Obstacles

The magnetic near field has several properties that make it an excellent means of transferring energy in a typical consumer, commercial, or industrial environment. Most common building and furnishing materials, such as wood, gypsum wall board, plastics, textiles, glass, brick, and concrete are essentially “transparent” to magnetic fields—enabling *Inductive charging* technology to efficiently transfer power through them. In addition, the magnetic near field has the ability to “wrap around” many metallic obstacles that might otherwise block the magnetic fields. Inductive charging applications engineering team will work with you to address the materials and environmental factors

that may influence wireless energy transfer in your application.

#### Non-Radioactive Energy Transfer is Safe for People and Animals

Inductive charging technology is a non-radioactive mode of energy transfer, relying instead on the magnetic near field. Magnetic fields interact very weakly with biological organisms—people and animals—and are scientifically regarded to be safe. Professor Sir John Pendry of Imperial College London, a world renowned physicist, explains: “The body really responds strongly to *electric* fields, which is why you can cook food in a microwave. But it doesn't respond to *magnetic* fields. As far as we know the body has almost zero response to magnetic fields in terms of the amount of power it absorbs.” Evidence of the safety of magnetic fields is illustrated by the widespread acceptance and safety of household magnetic induction cooktops. Through proprietary design of the *Inductive charging* source, electric fields are almost completely contained within the source. This design results in levels of electric and magnetic fields which fall well within regulatory guidelines. Thus *Inductive charging* technology doesn't give rise to radio frequency emissions that interfere with other electronic devices, and is not a source of electric and magnetic field levels that pose a risk to people or animals. Limits for human exposure to magnetic fields are set by regulatory bodies such as the FCC, ICNIRP, and are based on broad scientific and medical consensus. *Inductive charging* technology is being developed to be fully compliant with applicable regulations regarding magnetic fields and electromagnetic radiation.

#### Non-Radioactive Energy Transfer is Safe for People and Animals

Inductive charging systems can be designed to handle a broad range of power levels. The benefits of highly efficient energy transfer over distance can be achieved at power levels ranging from milliwatts to several kilowatts. This enables Inductive charging technology to be used in applications as diverse as powering a wireless mouse or keyboard (milliwatts) to recharging an electric passenger vehicle (kilowatts). Inductive charging technology operates in a “load following” mode, transferring only as much energy as the powered device requires.

#### Flexible Geometry Allows *Inductive charging* Devices to be Embedded Into OEM Products

Inductive charging technology is being designed so that it can be easily embedded into a wide variety of products and systems. The physics of resonant magnetic coupling enables Inductive charging engineers to design power sources and devices of varying shapes and sizes, to match both the packaging requirements and the power transfer

requirements in a given OEM application. Inductive charging has designed power capture devices compact enough to fit into a cell phone.

#### **4.2 DISADVANTAGES**

The main disadvantages of inductive charging are its lower efficiency and increased resistive heating in comparison to direct contact. Implementations using lower frequencies or older drive technologies charge more slowly and generate heat for most portable electronics. Inductive charging also requires drive electronics and coils that increase manufacturing complexity and cost.

Newer approaches diminish the transfer losses with ultra thin coils, higher frequencies and optimized drive electronics, thus providing chargers and receivers that are compact, more efficient and can be integrated into mobile devices or batteries with minimal change. These technologies provide charging time that are the same as wired approaches and are rapidly finding their way into mobile devices. The Magnetic Charge system employed high-frequency induction to deliver high power at an efficiency of 86% (6.6 kW power delivery from a 7.68 kW power draw).

#### **4.3. APPLICATIONS**

##### **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 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.

##### **Transportation**

Automatic wireless charging for existing electric vehicle classes: golf carts, industrial vehicles. Automatic wireless charging for future hybrid and all-electric passenger and commercial vehicles, at home, in parking garages, at fleet depots, and at remote kiosks.

##### **Other Applications**

Direct wireless power interconnections and automatic wireless charging for implantable medical devices (ventricular assist devices, pacemaker, defibrillator, etc.).

Automatic wireless charging and for high tech military systems (battery powered mobile devices, covert sensors, unmanned mobile robots and aircraft, etc.).

#### **5. CONCLUSION**

Modern science has now made it possible to use electricity without having to plug in any wires for charging. This concept is called inductive charging which seems to have a bright future.

Researchers developed inductive charging using resonance where energy is transmitted between two copper coils that resonate at the same frequency. Of these two coils, one is the power transmitter and the other, the receiver. As long as the object to be powered has a source of wireless power, in its vicinity, the appliance charges automatically without having to be plugged in. Just imagine the future, with where there will be no need of power cables. With inductive charging, there will be no need of charging batteries with human interference it is equal to self charging. However despite these contraindications, **Wireless electricity** has a bright future with the many advantages it provides in terms of weight, convenience and portability of electrical appliances.

#### **6. FUTURE WORKS**

Wireless electricity is a recently developed technology for wireless power transfer is an application of inductive charging . It has been demonstrated that it is feasible to transmit a significant amount of power at a high efficiency that has never been achieved previously. Despite this significant development, its effective transmission distance is limited by the size of the resonator. In many applications , it is highly desirable to extend the distance of transmission and allow the route of transmission to follow a curved path in space. In this work, we take advantage of the relay effect in resonant physical systems and present an effective solution using more than two resonators. Both theoretical and experimental results show that this approach overcomes the drawbacks of two-resonator system, allowing much longer and more flexible power transmission without sacrificing efficiency.

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