

# Wireless Energy Transfer Technology Using Electromagnetic Coupling System

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**Abstract:** This paper proposes a traditional electromagnetic coupling technique, to transfer electrical energy between the devices, when their operating frequencies are not the resonant frequency. This technique increases the efficiency of the system over the short range of distance. Thus the efficiency of the system will be increased by considerable amount when compare to the other methods. This investigation indicates that it is feasible to use wireless energy transfer technology to recharge batteries, particularly in implant devices.

**Keywords:** Electro - magnetic coupling, wireless energy transfer, strong coupling, witrlicity

## 1. Introduction

More than a century ago, Nikola Tesla built magnetic coils that transmitted power without cables. Now; researchers announced their own coil-based breakthrough in wireless electricity called WiTricity that's mercifully plasma free. WiTricity exploits a phenomenon known as magnetically coupled resonance, which allows two objects resonating at the same frequency to exchange energy efficiently. The team was able to wirelessly power a 60-watt light bulb using a pair of 20-in.-dia. copper coils. Drawing power from an electrical outlet, the source coil created a magnetic field, which was 7 ft. in diameter, transmitting at a frequency of 10 MHz. (Many cell phones, by comparison, operate at 2 GHz.). Seven feet away, a receiving coil was also resonating at 10 MHz, pulling enough energy from the field to power the bulb. In this paper, we have transmitted the electric power wirelessly over the distance of 1feet by using electromagnetic induction principle. There are so many methods to transmit the electrical power wirelessly such that RF transmission, microwave transmission, laser transmission, infrared source, ultrasonic sound waves, electromagnetic induction etc., This paper deals with the technique of electromagnetic induction in order to increase the efficiency of the system over the short range of distance. Thus the efficiency of the system will be increased by considerable amount when compare to the other methods.

## 2. Theory and Design of the Proposed Witrlicity System

As a new wireless power transfer technology, Witrlicity is based on the concept of near-field and strongly coupled magnetic resonance. The fundamental principle is that resonant objects can exchange energy efficiently, while non-resonant objects only interact weakly. The source resonator is coupled to the driving loop which is linked to an oscillator that supplies energy to the system. The device resonator coil is coupled to the output loop to provide the power to an external load. Due to its large physical separation, wireless inductive coupling transformers have large leakage inductances and small mutual inductance. Thus the coupling rates are very small, quite often less than 0.1, while those for conventional transformers are between 0.95–0.98 . Judging

on this aspect, inductive coupling technology is impractical. For the Witrlicity system, the coupling rate can however be as high as 0.7–0.9 by virtue of the strong resonant frequency coupling between primary and secondary windings. To achieve high coupling rate and transmission efficiency, sources with certain resonant frequency (in the MHz range) is fed to the primary windings.

## 3. Basic RC Oscillator Circuit

The RC Oscillator which is sometimes called a Phase Shift Oscillator produces a sine wave output signal using regenerative feedback from the Resistor/Capacitor combination. The oscillator is a circuit to create oscillations in the dc voltage. This regenerative feedback from the RC network is due to the ability of the capacitor to store an electric charge, (similar to the LC tank circuit).

### a. Working

This Resistor/Capacitor feedback network can be connected as shown below to produce a leading phase shift (Phase Advance Network) or interchanged to produce a lagging phase shift (Phase Retard Network) the outcome is still the same as the sine wave oscillations only occur at the frequency at which the overall phase-shift is  $360^\circ$ .

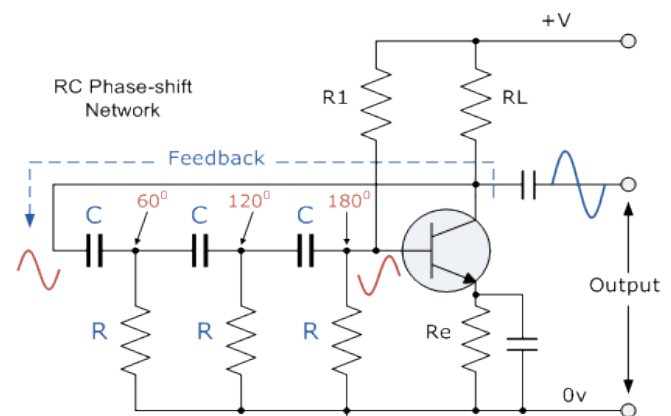


Figure 2: RC oscillator

By varying one or more of the resistors or capacitors in the phase-shift network, the frequency can be varied and generally this is done using a 3-ganged variable capacitor. By varying the resistance and inductance/capacitance the output frequency can be varied. If all the resistors, R and the capacitors, C are equal in value, then the frequency of oscillations produced by the oscillator is given as:

$$f = \frac{1}{2\pi \sqrt{2NRC}}$$

Where:

f is the Output Frequency in Hertz

R is the Resistance in Ohms

C is the Capacitance in Farads

N is the number of RC stages and in our example N = 3

Linear electronic oscillator circuits, which generate a sinusoidal output signal, are composed of an amplifier and a frequency selective element, a filter. An oscillator circuit which uses an RC network, a combination of resistors and capacitors, for its frequency selective part is called an RC oscillator.

#### 4. Power Transistor

We are using power transistor for the high switching speed at high power rating. The maximum voltage across the base emitter junction of the 2N3055 is 60v. the main drawback with 2N series transistor is it, will dissipates more heat.

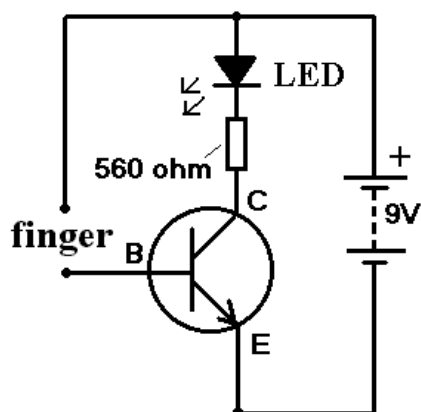


Figure 3: Transistor as an amplifier

The common-emitter amplifier is designed so that a small change in voltage in ( $V_{in}$ ) changes the small current through the base of the transistor and the transistor's current amplification combined with the properties of the circuit mean that small swings in  $V_{in}$  produce large changes in  $V_{out}$ .

From mobile phones to televisions, vast numbers of products include amplifiers for sound reproduction, radio transmission, and signal processing. The first discrete transistor audio amplifiers barely supplied a few hundred milli watts, but power and audio fidelity gradually increased as better transistors became available and amplifier architecture evolved. Modern transistor audio amplifiers of up to a few hundred watts are common and relatively inexpensive

#### 5. Power Transformers

A transformer is a device that transfers electrical energy from one circuit to another by electromagnetic induction (transformer action). The electrical energy is always transferred without a change in frequency, but may involve changes in magnitudes of voltage and current. Because a transformer works on the principle of electromagnetic induction, it must be used with an input source voltage that varies in amplitude.

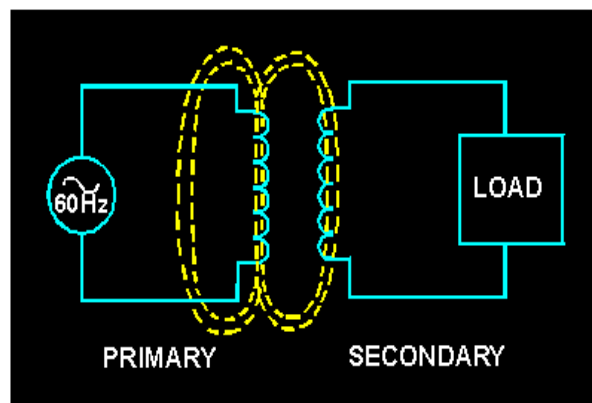


Figure 4: Basic transformer action

A very simple road to your basic high voltage generator is the transistor driven flyback transformer. This circuit uses a common flyback transformer to boost typical battery voltages up to the multi-kilovolt range. It will make a several thousand-degree continuous 2 cm plasma arc.

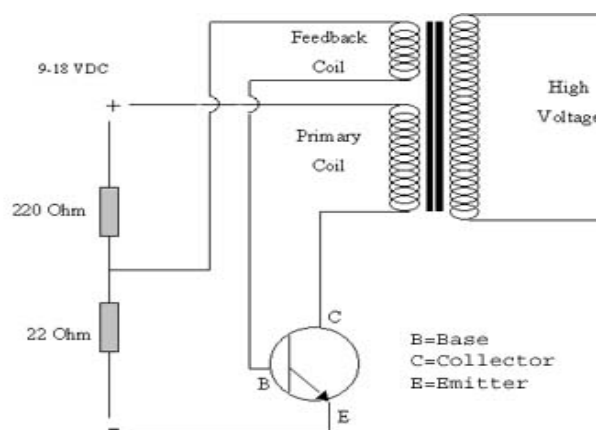


Figure 5: Flyback transformer circuit

##### b. Circuit Operation

Passing a current through the transistor to the main set of coil windings induces a field on the ferrite core which also induces a current in the feedback winding. The feedback current signals the transistor to stop conducting and the field on the ferrite core collapses, causing a high voltage pulse on the output side. After the feedback signal collapses, the transistor again conducts current to the primary windings. This seems all nice and good, but it doesn't explain why some transistors work well and some don't. The transistors should only be switching the current at a fixed voltage off and on so as long as the transistor is fast enough, the output should be the same for every transistor. This is clearly not the case in my mind.

In my experience, the output voltage is strictly dependent on the individual transistor, not even the specifications for the transistor. Many transistors are getting fried for no apparent reason and almost instantly. Initially, the circuit operates as the simple feedback system. The transistor conducts, induces a voltage on the feedback coil and then stops conducting. When the transistor stops conducting, the induction in the primary coil causes the voltage to go up, way way up. So way way up that the voltage exceeds the breakdown voltage of the Vce on the transistor. This high voltage spike is now allowed to "escape" through the transistor and is brought back to nominal voltages.

This high voltage spike I think is what is causing the high voltage output, not the nominal 12V input. The HV spike is also causing the transistors to get fried as their Vce voltage is being greatly exceeded. So the transistors that work well apparently are very "robust" and are handling this rapid breakdown of the Vce and are recovering with no permanent damage to the transistor.

This is why only a few transistors work for this application. So to get a \*nice\* spark your transistor needs to have a high Vce voltage, AND it needs to be special to not get fired by repeated over voltages.

## 6. Magnetic Field

A magnetic field can be created with moving charges, such as a current-carrying wire. A magnetic field can also be created by the spin magnetic dipole moment, and by the orbital magnetic dipole moment of an electron within an atom.

This is the **Right Hand Rule for magnetic field** from flowing current, and for magnetic field in a coil. When current flows in a wire, a magnetic field is created around the wire. To visualize this, take your right hand, curl the fingers, and stick the thumb straight out. Now, point your thumb in the direction of the current flowing in the wire.

The direction your fingers are curved around the wire is the direction of the magnetic field around the wire. For example, if the current were coming straight out of this page toward you, your thumb would be pointing toward you and your fingers would indicate a counter-clockwise direction to the magnetic field around the wire.

### Magnetic Field Produced by a Coil

When a current carrying conductor is formed into a loop or several loops to form a coil, a magnetic field develops that flows through the center of the loop or coil along its longitudinal axis and circles back around the outside of the loop or coil. The magnetic field circling each loop of wire combines with the fields from the other loops to produce a concentrated field down the center of the coil. A loosely wound coil is illustrated below to show the interaction of the magnetic field. The magnetic field is essentially uniform down the length of the coil when it is wound tighter.

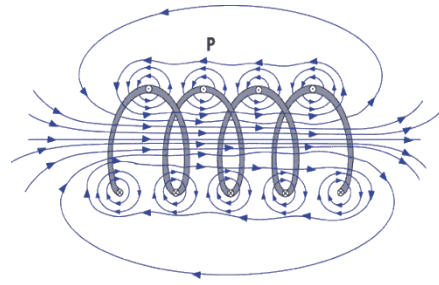


Figure 6(a)

The strength of a coil's magnetic field increases not only with increasing current but also with each loop that is added to the coil. A long, straight coil of wire is called a solenoid and can be used to generate a nearly uniform magnetic field similar to that of a bar magnet. The concentrated magnetic field inside a coil is very useful in magnetizing ferromagnetic materials for inspection using the magnetic particle testing method. Please be aware that the field outside the coil is weak and is not suitable for magnetizing ferromagnetic materials.

### Magnetic field of a coil

Fig. 6(a) illustrates that the magnetic field around a current-carrying wire exists at all points along the conductor. Fig. 6(b) illustrates that when a straight wire is wound around a core, it forms a coil and that the magnetic field about the core assumes a different shape. Magnetic field produced by a current-carrying coil,

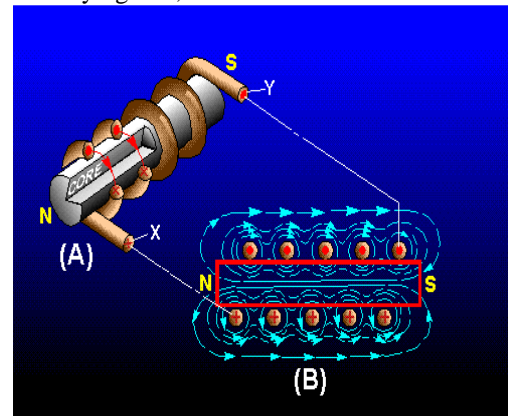


Figure 6(b)

When current is passed through the coil, the magnetic field about each turn of wire links with the fields of the adjacent turns. The combined influence of all the turns produces a two-pole field similar to that of a simple bar magnet.

## 7. Receiver

The receiver has been wound over the circular card board sheet having the dimension of 96 turns, diameter of 30cm by using 20 gauge wire. We have designed the receiver coil in order to utilize the maximum flux transmitted by the transmitter.

When the receiver is get into the magnetic field according to the Faraday's law of electromagnetic induction," when the magnetic field cuts the conductor the emf will be induced and the current will starts to flow if the circuit is closed".

The power will be received by the receiver, by using that power the light has been glows by us. The LED has been connected as the load at the receiver side.

## 8. Load

Like a normal diode, the LED consists of a chip of semi conducting material doped with impurities to create a p-n junction. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode, but not in the reverse direction. Charge-carriers electrons and holes flow into the junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon. The wavelength of the light emitted, and therefore its color, depends on the band gap energy of the materials forming the p-n junction. In silicon or germanium diodes, the electrons and holes recombine by a non-radioactive transition which produces no optical emission, because these are indirect band gap materials. The materials used for the LED have a direct band gap with energies corresponding to near-infrared, visible or near-ultraviolet light. Most materials used for LED production have very high refractive indices. This means that much light will be reflected back in to the material at the material/air surface interface.

## 9. Conclusion

At the end of the research, we were able to design a system for transmitting watts of power wirelessly from the transmitting coil to the receiving coil that was enough to light a LED bulb. We were able to design discrete components such as the relaxation oscillator, switch mode-power amplifier and a full bridge voltage rectifier for the system design process. We were also able to increase the efficiency of the system by a considerable amount when compare to the other methods.

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