

Saving of Power in Wireless Power Transmission System using IR Sensor and Relay

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ABSTRACT

As all we know that today's live is not possible for a moment if we think without electricity after our basic needs that are air, water, food, cloth and shelter. Because without it we can not think about our mobility, But it has also many disadvantages because of the transmission of electricity through wire which cause many time sock due to which living thing may get injured or many time they get unexpected death.

Hence for establishing the transmission of electricity without hazards today's world started working on the removal of the net of the wires over the world and this is possible only by transmitting electricity wirelessly.

This principle was early given by a charming and mysterious inventor and engineer **Nikola Tesla(1891-1898)** by inventing **Tesla coil**. But in wireless electricity transmission, there is a lot of wastage of energy when power is transferred to the load. If there is no loads are available around the receiving antenna(coil), power will be wasted and this is a one of the major disadvantage of this principle.

So by using IR Sensor we can save this power from being waste which will allow the antenna to transmit the power only when the objects are available to receive this transmitted power.

Keywords-- Tesla Coil, Wireless Power Transmission, IR Sensor, IR LED, Electricity, Inductive Coupling

I. INTRODUCTION

The word electricity become one of the most important word because it is playing most important role for human being, now a day without electricity we can not predict the world for few hours. Along with the application of electricity, mesh of transmission wires are connected around area to area for the transmission of the electricity, which is being harmful for all living things and also there is major factor is that transmission of electricity cause a lot of losses of power i.e. 20-30% of generated power from the source get lost during transmission because of resistance of wires thus we are able to utilize only 74-70% of total power transmitted from the source, Besides the heavy energy

losses more resources, infrastructures, manpower, and expenditure involved makes present technique of wired transmission not an all-time business but to find other alternate state of technology to transmit and distribute Electricity efficiently and economically. Thus there is an alternate option for the transmission of electricity is wireless power transmission(WPT).

The word wireless transmission came in state after the invention of electromagnetic wave by Maxwell. Meaning of wireless power transmission is that the transmission of power from a source to destination without using any kind of transmission wires i.e. in this case medium for the transmission of signal is free space. But in these days wireless power transmission mainly used for the transmission of audio, video, texts and images. But transmission of electricity without using transmission wires was made possible after the invention of Tesla's Coil, because Nikola Tesla had demonstrated it practically during 19th century. From 1891 to 1898 he investigated wireless transmission of electrical energy using his radio frequency resonant transformer called the Tesla coil, which produces high voltage, high frequency alternating currents. The Tesla coil was first developed as a high-voltage radiofrequency power supply for his "System of Electric Lighting" patented in 1891[3]. With this basic resonance transformer design concept he was able to transmit electrical energy over short distances without interconnecting wires by means of resonant magnetic inductive coupling. The transformer's primary LC circuit acted as a transmitter. The transformer's secondary LC circuit was tuned to the primary LC circuit's resonant frequency and acted as a receiver. The Tesla coil transformer itself could be configured as a wireless transmitter and used to transmit energy by capacitive inductive coupling..

This Wireless Transmission is useful in cases where interconnecting wires are inconvenient, hazardous, expensive or impossible. With wireless power, the efficiency is the more significant parameter. A large part of the energy sent out by the generating plant must be optimally received at the end[2].

Though the criticism was faced by Nicola Tesla

for its biological impact, but there could have been safety mode for the same. Since the world is already gridded with wires, lighting the globe would be a great challenge to lose all the present royalties but it will be a great blessing in the face of humanity[2].

After the all above achievements there is a big issue again also of power loss in a large amount because when power transmitted from primary to secondary winding of transformer, from where it get used by the all chargeable devices, When there is a device to receive power from secondary winding then there is no issue but when there will be no devices to receive the transmitted power, a large amount of power will be wasted.

My contribution in this research thesis is that I will try to stop the transmission of power using IR Sensor when there will be no device available to receive power from the receiver section of transformer.

II. WIRELESS POWER TRANSMISSION (WPT)

Near-Field Techniques

a) Electromagnetic (EM) Radiation

Energy/signal from the transmitting antenna of a power source to the receiving antenna through radioactive EM waves is the process of emission by EM radiation. Through omni-directional radiation process, broadcasting EM waves via transmitter in an assigned ISM band. If there is a clear line-of-sight (LOS) path exists in the process of unidirectional radiation, it can gain high power transmission over a much longer distance for example by using a microwave or laser beam the range can be in kilometre.

By the experiment it was found that when a receiver is 30 cm away from the RF transmitter, power transfer efficiency is only 1.5% [47]. In addition, to protect potential health hazards of humans from EM radiation, only appropriate process is omni-directional radiation for ultra-low-power sensor nodes for example up to 10 mW with very low sensing activities like temperature, moisture and light.

b) Inductive Coupling

Inductive coupling generally defined as coupling between to LC circuits where resonant frequency is same. It works by using magnetic field induction that is the natural part of current's movement through wire, as an example alternating current in a primary coil that is connected to a source can produce a varying magnetic field that induces a voltage across the terminals of a secondary coil at the receiver.

c) Magnetic Resonant Coupling

The last and most important category of WPT technology under the section of near field techniques is magnetic resonant coupling. This technology was developed by Kurs et al., which enable to make the

interactions between two different objects very strongly because of the combination of inductive coupling and resonance. In addition, energy will be shifting back and forth between magnetic field surrounding the coil and electric field around the capacitor.

In this technology, energy can be transferred efficiently from a source coil to a receiver coil with little loss of energy to alternating current in a primary coil (connected to a source) generates a varying magnetic field that induces a voltage across the terminals of a secondary coil at the receiver.

Some Other Advanced Techniques for WPT

There are some advanced techniques for WPT which are advanced from the concept of inductive coupling technique such as:-

1. Qi technology
2. Alliance for WPT technology
3. Power matter alliance

Challenges in WPT

To sustain the constant power level, there are few challenges in WPT. This is because of the freely scattering of EM wave in space as it propagates, which causes the efficiency to be much lower, leaving some amount of energy unused or transferred into unused.

Other major challenges that are in front for the success of WPT is the outer space transmission system in its design. This system for WPT uses massive solar panels to collect the Sun's rays and sends that energy to the Earth through microwaves. The concerns that some environmentalists are placing is the depletion of ozone layer by the radiation. But this technology is young and many researches are underway to incorporate the shortcomings[6].

Since the world is lit by wires and every electrical device is fed with wires, it will be biggest challenge to implement the WPT technology. There should be complete revolution in the electrical world for manufacturing and designing. Still the safety of the microwaves remains a question for the public. Some of the countries which depend on electrical energy for the economy like a country Bhutan, it will be a heavy blow. This was the main reason that Tesla failed to convince then the sponsors and entrepreneurs of his time to carry out his project.

Safety Measures

Many thinks that WPT is not safe and fear its impact in human health and environment, but as per the IEEE standard, but the safety studies has been taken that its radiation level would be never higher than the dose received while opening the microwave oven door, meaning it is slightly higher than the emissions created by cellular telephones [1]. Thus the public exposure of WPT fields would be below existing safety guidelines (ANSI/IEEE exposure standards)[6].

III. MY CONTRIBUTION IN WPT

As we have seen that there are many challenges in the field of wireless power transmission. There is one of the most important challenge is continuous power transmission from the transmitting source in the free space and most of these power get unused when there is no devices for receiving power to get charged, thus a huge of power become waste. But this can be controlled as I am going to demonstrate a mini project in front of you.

This challenge can be tackled up by using IR Sensor or any other electronic chip.

Thus power from the WPT source will be transferred only when there will be a device to receive power/to get charged.

Working Principle

When a charging device will come in contact with IR sensor, then relay will be short circuited and which make enable the Tesla coil so that it can transmit power , and when no device will come in contact with IR sensor switch will go into OFF state, and thus power will be transmitted only when there will be any devices/objects.

In such a way we can save a large amount of power from being waste and this power can utilized for any efficient task.



Fig:1 In ON State In OFF State

a) Tesla Coil

- A Tesla coil is an electrical resonant transformer circuit designed by inventor Nikola-Tesla in 1891.
- It is used to produce high-voltage, low-current and high-frequency alternating-current electricity.
- Tesla experimented with no. of different configuration consisting of two or sometimes three coupled resonant electric circuit.
- Tesla used these circuits to conduct innovative experiments in electrical lightning, phosphorescence, X-ray generation, high-frequency ac phenomena, energy transmission without wires.

- Tesla-coil were used commercially in spark gap radio transmitters for wireless telegraphy until 1920s. and in medical equipment such as electro- therapy and violet ray-devices.
- Today their main application in the field of entertainment and educational display

Here our purpose to use the Tesla-coil for the transmission of electrical energy without wires.



Fig:2 Tesla-coil
Fig source: Google scholar

b) Operation of Tesla Coil



Fig:3 Operation of tesla-coil
Fig source: Google scholar

A Tesla-coil is a radio-frequency oscillator that derives an air-core double-tuned resonant transformer to produce high-voltage, high-frequency and low-current.

It uses spark-gap to excite-oscillation in the tuned transformer. But more sophisticated design uses transistor or thyristor switches or vacuum tube electronic oscillators to derive the resonant transformer. Tesla-coil can produce output voltage from 50 kilovolts to several million Volts for large coil. Output current in Tesla-coil is in low radio frequency usually between 50 kHz to 1 MHz.

D) Resonant Transformer

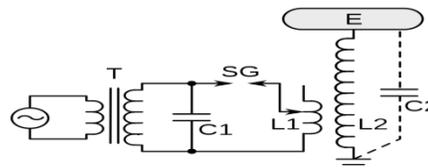


Fig:4 Resonant transformer
Fig source: Google scholar

- The specified transformer used in Tesla-coil circuit is called a resonant transformer/oscillation transformer/radio-frequency transformer.
- It functions differently from an ordinary transformer used in ac power circuit. While an ordinary transformer is designed to transfer energy efficiently from primary to secondary winding of the transformer, the resonant transformer is also designed to temporarily store electrical energy.
- Each winding has capacitance across it and functions as LC circuit, storing oscillating electrical energy.
- The primary coil have few no. of turns of heavy copper wires or tubing connected to a capacitor C1 through spark gap.
- The secondary coil have large no. of turns (hundreds to thousands) of fine wires on a hollow cylindrical forms inside the primary. And secondary winding is not connected to an actual capacitor but it also works as a LC circuit.
- The inductance of L2 resonates with stray capacitance C2.
- The sum of the stray parasitic capacitance between the winding of the coil and the capacitance of the toroidal metal electrode attached to the high-voltage terminal.
- The primary and secondary winding are tuned so they resonates at same frequency, they have the same resonant frequency. This allow them to exchange energy, so the oscillating current alternates back and forth between the primary and secondary coil.
- The peculiar design of the coil is dictated by the need to achieve low resistivity energy losses (high-Q factor) at high frequency which results in the largest secondary voltage.

e) Specification and Output

- Diameter of primary winding: 0.2 cm having six no. of turns of copper wire
- Diameter of secondary winding: 0.1 cm having 350 no. of turns of copper wire
- Input given to the circuit is: 9 Volt DC
- Output from the circuit is about 180-230 Volt AC (50 Hz frequency)
- Covering range about 8-10 cm with good efficiency i.e 80-50% of full efficiency and decreasing rapidly after this covering area.



Fig:5 Application of tesla coil during experiment

f) Operating Cycle

The circuit operates in a rapid repeating cycle in which the supply transformer charges the primary capacitor C1 up which then discharge in spark through the spark gap creating a brief pulse of oscillating current in the primary circuit which excites a high oscillating voltage across the secondary operating frequency:-

$$f_1 = \frac{1}{2\pi} \sqrt{\frac{1}{L_1 C_1}} \quad \text{and} \quad f_2 = \frac{1}{2\pi} \sqrt{\frac{1}{L_2 C_2}}$$

- Conditional resonance:-

$$L_1 C_1 = L_2 C_2$$

- More precise condition of resonance:-

$$L_1 C_1 = (1 - k^2) L_2 C_2$$

Where k is the coupling-coefficient of the transformer

Transformer Input and Output

$$E_p I_p = E_s I_s$$

EP = primary voltage

IP = primary current in amps

ES = secondary voltage

IS = secondary current in amps

Capacitive Reactance

$$X_c = \frac{1}{2\pi FC}$$

XC = capacitive reactance in ohms

F = frequency in hertz

C = capacitance in farads

Inductive Reactance

$$X_L = 2\pi FL$$

XL = inductive reactance in ohms

F = frequency in hertz

L = inductance in henrys

Helical Coil Inductance

$$L = \frac{(NR)^2}{9R + 10H}$$

Secondary Coil Dimensions

$$L = \frac{\pi D A H}{12}$$

$$T = AH$$

$$A = \frac{1}{B}$$

L = length of wire in feet

D = outer diameter of coil form in inches

H = height of windings in inches

A = number of turns per inch

T = total number of turns

B = thickness of wire in inches

IR Sensor

An IR sensor is basically a device which consists of a pair of an IR LED and a photodiode which are collectively called a photo-coupler or an opto-coupler. The IR LED emits IR radiation, reception and/or intensity of reception of which by the photodiode dictates the output of the sensor. Now, there are so many ways by which the radiation may or may not be able to reach the photodiode.



Fig:6 IR sensor with IR transmitting & Receiving LED

g) Operation of IR Sensor

Infrared technology addresses a wide variety of wireless applications. The main areas are sensing and remote controls. In the electromagnetic spectrum, the infrared portion is divided into three regions: near infrared region, mid infrared region and far infrared region. The wavelengths of these regions and their applications are shown below.

Near infrared region — 700 nm to 1400 nm — IR sensors, fiber optic

Mid infrared region — 1400 nm to 3000 nm — Heat sensing

Far infrared region — 3000 nm to 1 mm — Thermal imaging

The frequency range of infrared is higher than microwave and lesser than visible light.

For optical sensing and optical communication, photo optics technologies are used in the near infrared region as the light is less complex than RF when implemented as a source of signal. Optical wireless communication is done with IR data transmission for short

range applications.

An infrared sensor emits and/or detects infrared radiation to sense its surroundings.

The working of any Infrared sensor is governed by three laws: Planck's Radiation law, Stephen – Boltzmann law and Wien's Displacement law.

Planck's law states that "every object emits radiation at a temperature not equal to 0⁰K". Stephen – Boltzmann law states that "at all wavelengths, the total energy emitted by a black body is proportional to the fourth power of the absolute temperature". According to Wien's Displacement law, "the radiation curve of a black body for different temperatures will reach its peak at a wavelength inversely proportional to the temperature".

The basic concept of an Infrared Sensor which is used as Obstacle detector is to transmit an infrared signal, this infrared signal bounces from the surface of an object and the signal is received at the infrared receiver.

There are five basic elements used in a typical infrared detection system: an infrared source, a transmission medium, optical component, infrared detectors or receivers and signal processing. Infrared lasers and Infrared LED's of specific wavelength can be used as infrared sources. The three main types of media used for infrared transmission are vacuum, atmosphere and optical fibers. Optical components are used to focus the infrared radiation or to limit the spectral response.

Optical lenses made of Quartz, Germanium and Silicon are used to focus the infrared radiation. Infrared receivers can be photodiodes, phototransistors etc. some important specifications of infrared receivers are photosensitivity, detectivity and noise equivalent power. Signal processing is done by amplifiers as the output of infrared detector is very small.

IR LED

Fig:7 IR LED

Image source: Google scholar

An Infrared light emitting diode (IR LED) is a special purpose LED emitting infrared rays ranging from 700 nm to 1 mm wavelength. Different IR LEDs may produce infrared light of differing wavelengths, just like different LEDs produce light of different colors.

IR LEDs are usually made of gallium arsenide or aluminium gallium arsenide. In complement with IR receivers, these are commonly used as sensors.

The appearance of IR LED is same as a common LED. Since the human eye cannot see the infrared radiations, it is not possible for a person to identify if an IR LED is working. A camera on a cell phone camera solves this problem. The IR rays from the IR LED in the circuit are shown in the camera.

An IR LED is a type of diode or simple semiconductor. Electric current is allowed to flow in only one direction in diodes. As the current flows, electrons fall from one part of the diode into holes on another part. In order to fall into these holes, the electrons must shed energy in the form of photons, which produce light.

It is necessary to modulate the emission from IR diode to use it in electronic application to prevent spurious triggering. Modulation makes the signal from IR LED stand out above the noise. Infrared diodes have a package that is opaque to visible light but transparent to infrared. The massive use of IR LEDs in remote controls and safety alarm systems has drastically reduced the pricing of IR diodes in the market.

h) Principle of Working

An IR sensor consists of two parts, the emitter circuit and the receiver circuit. This is collectively known as a photo-coupler or an Opto-coupler.

The emitter is an IR LED and the detector is an IR photodiode. The IR photodiode is sensitive to the IR light emitted by an IR LED. The photo-diode's resistance and output voltage change in proportion to the IR light received. This is the underlying working principle of the IR sensor.

The type of incidence can be direct incidence or indirect incidence. In direct incidence, the IR LED is placed in front of a photodiode with no obstacle in between. In indirect incidence, both the diodes are placed side by side with an opaque object in front of the sensor. The light from the IR LED hits the opaque surface and reflects back to the photodiode.

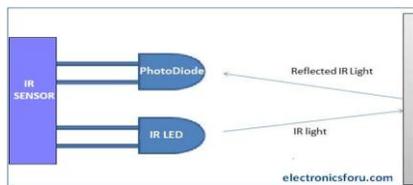


Fig:8 working of IR sensor with transmitting and receiving LED

Image source: www.electronicsforu.com

IR sensors find a wide variety of applications in various fields. Let's take a look at few of them.

Relay

A **relay** is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple

contact forms, such as make contacts, break contacts, or combinations thereof.

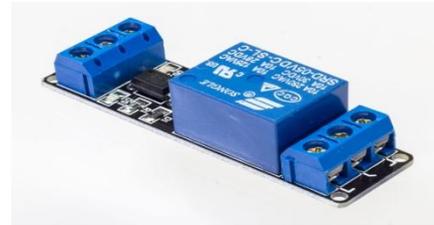


Fig:9 Relay

Image source:

https://robu.in/wpcontent/uploads/2016/12/hires_single_channel_screw_term_relay_1000_hires-1.jpg

i) Working

Relay in NORMALLY CLOSED Condition

When no voltage is applied to the core, it cannot generate any magnetic field and it doesn't act as a magnet. Therefore, it cannot attract the movable armature. Thus, the initial position itself is the armature connected in normally closed position (NC).

Relay in NORMALLY OPENED Condition

When sufficient voltage is applied to the core it starts to create a magnetic field around it and acts as a magnet. Since the movable armature is placed within its range, it gets attracted to that magnetic field created by the core, thus the position of the armature is being altered. It is now connected to the normally opened pin of the relay and external circuit connected to it function in a different manner.

Note: The functionality of the external circuit depends upon the connection made to the relay pins.

So finally, we can say that when a coil is energized the armature is attracted and the switching action can be seen, if the coil is de-energized it loses its magnetic property and the armature goes back to its initial position.

Applications

Applications depend on the uses of low power devices that can be wireless sensor or different electronic mobile devices, power range (less than 1W) and high-powered devices in the field of industrial area, power range (not more than 3KW). Devices like led lights where supplying energy is directly connected with load can be defined direct wireless powering and different charging devices need to be battery or capacitor charge defined wireless charging could be two types of implemented system [6].

A. Field of Electronics

Electronics that is the largest application field of using Wireless charging system is being implemented in electronic products such as laptop by using a wireless power source deployed behind the corkboard. This device enables to deliver over 20 watts of power. It can also charge

at a distance over a 40 cm from the wireless charging source. The source and device resonators are oriented perpendicular to each other

B. Medical Devices

Wireless power transmission has been widely used for implanted medical devices including LVAD heart assist pumps, pacemakers, and infusion pumps.

C. Electric Vehicles

Rechargeable hybrid and battery electric vehicles can be directly powered with wireless charging systems.

D. LED Lighting

With using wireless power transmission in LED (light emitting diode) lights, we can directly charge our devices using wireless electricity so it can eliminate the need for batteries in under-cabinet task lighting. Moreover, it can also help architectural lighting designers to create products that seemingly float in mid-air with no power cord.

E. Defense Systems

To improve the reliability, ergonomics, and safety of electronic devices by wireless charging in the defense systems designers are creating new design for the future defense technology. As an example Talon tele-operated robot is being equipped with wireless charging so that it can be recharged while it is being transported by truck from site to site

F. Solar Power Satellites (SPS)

It is the largest application of WPT by using satellites with giant solar arrays and placing them in Geosynchronous Earth Orbit. These satellites play a pivotal role to generate and transmit the power as microwaves to the earth. Another application of WPT is Ubiquitous Power Source or Wireless Power Source, Wireless sensors and RF Power Adaptive Rectifying Circuits (PARC).

IV. COCLUSION

The concept of wireless power transmission is presented. There recent technological applications that make the human life more beneficial in the present world have been discussed. Three new standard of wireless power technology that is already in competition with each other is also mentioned here. But after discussion on WPT we got that there is major issue, a large amount of power being wasted because power transmitted continuously from the transmitter source and then we find an idea to save this power from being waste with the help of IR Sensor and RELAY and also some electronic components. And finally we reached at that stage that now we are able to save this power and can be utilized for another useful task.

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