VELLORE INSTITUTE OF TECHNOLOGY

BECE301L-ANALOG COMMUNICATION SYSTEMS

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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AIM : **To design a Wireless Mobile Charging model using hardware.**

Nowadays, electricity is very important in daily life. Without any electrical appliance, the world will stop working. Some electrical and electronic appliances require charging, some examples been mobile phones, cameras, Bluetooth headsets and also car phone charging systems. A copper wire is used to transfer the current from the supplier to the load.

The study is therefore aimed at eliminating the above problems as well as the sparks and debris associated with so many wires or cables in contact and also promoting greater convenience and ubiquity for charging everyday devices.

By designing and constructing a method by circuit to transmit wireless electrical power (to transmit voltage) wirelessly from source to device (through space and charge a designated low power device) will eliminate the use of cables in the charging process thus making it simpler and easier to charge a low power device. It would also ensure the safety of the device since it would eliminate the risk of short circuit.

INTRODUCTION :

With the emerging technology, and introduction of mobile phones has changed our lives a lot. These advancements provide many services such as text, internet etc. But although there are many advancements in the technology, we still rely on the wired battery chargers. Each phone will have its own designed battery charger. Thus, the battery chargers are required to carry everywhere to keep the battery backup.

This circuit mainly works on the principle of mutual inductance. Power is transferred from transmitter to the receiver wirelessly based on the principle of "inductive coupling". Inductance is the property of the conductor, in which the current flowing in a conductor induces a voltage or electromotive force in it or in another nearby conductor. There are two types inductance. 1) Self-inductance, 2) Mutual Inductance.

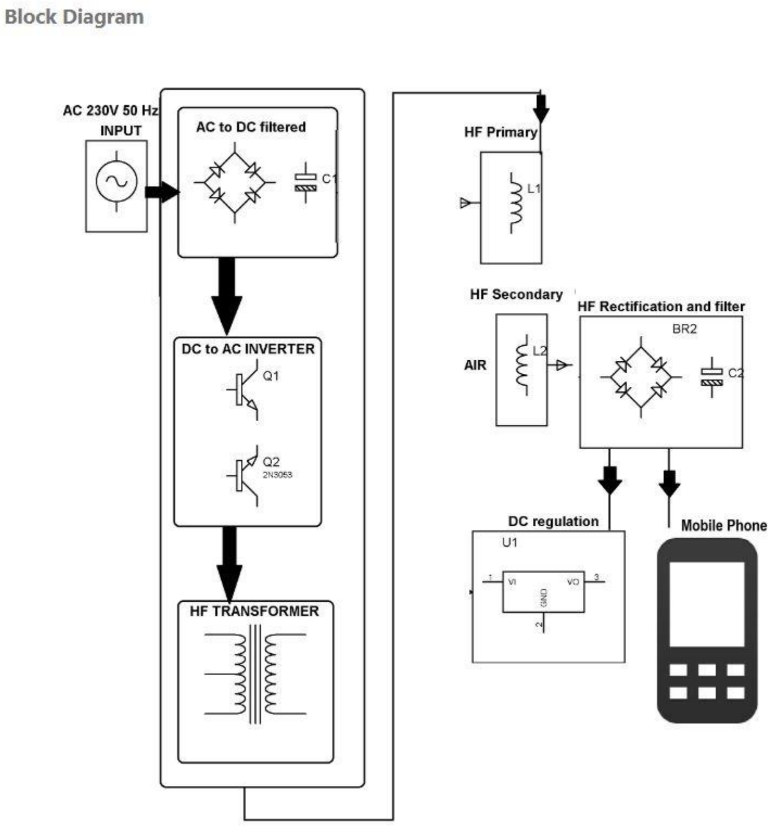
"Mutual inductance" is the phenomena in which, when a current carrying conductor is placed near another conductor voltage is induced in that conductor. This is because, as the current is flowing in the conductor, a magnetic flux is induced in it. This induced magnetic flux links with another conductor and this flux induces voltage in the second conductor. Thus, two conductors are said to be inductively coupled.

Wireless energy harvesting is a useful method of powering electrical devices in cases where it is inconvenient, hazardous, or impossible to connect wires. Inductive power transfer mechanism is implemented for wireless mobile charging. It comprises of primary coil that generates varying magnetic field across the secondary coil of the energy receiver within the field.

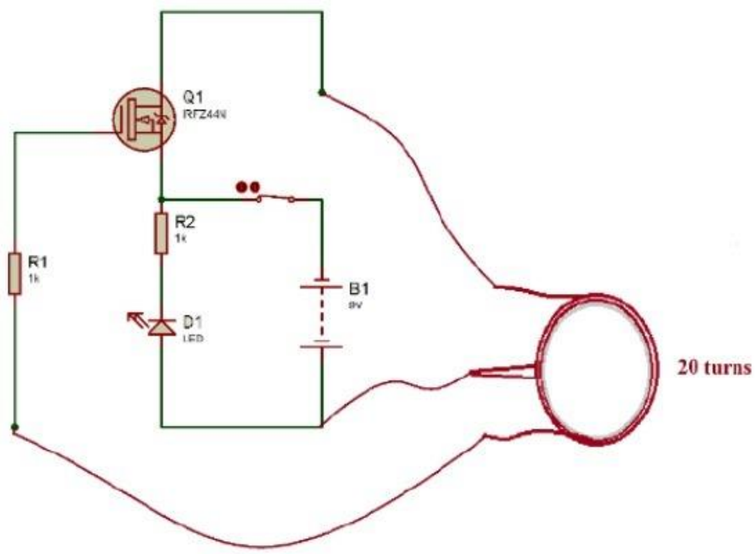
Wireless power transfer is a collective term that utilizes electromagnetic fields to refer to several different technologies for transmitting energy. These technologies differ in the distance they can transfer power over, but they all use time-varying electric field. Wireless charging currently continues to evolve in the mainstream market for most consumer electronics Demand for wireless charging is constantly being explored in a world confronted with a variety of handheld devices. Wireless charging is having its obstacles on its performance.

CIRCUIT DIAGRAM AND COMPONENTS REQUIRED –

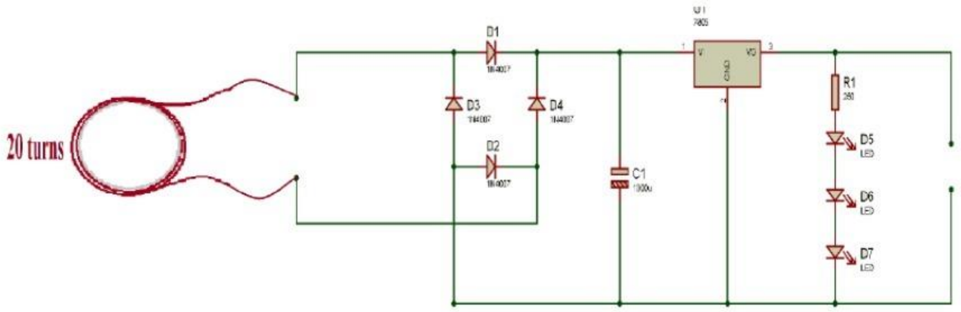
Block Diagram:



Transmitter Circuit:



Receiver Circuit:



COMPONENTS:

- **IRFZ44N transistor -** The IRFZ44N is a N-channel MOSFET. Its features include very low on state resistance, high speed processing technology, completely avalanche rated etc. The transistor possesses high speed switching capability which makes it ideal to use in applications where high speed switching is a crucial requirement.

- **1N4007 diodes -** 1N4007 is a rectifier diode, designed specifically for circuits that need to convert alternating current to direct current. It can pass currents of up to 1 A, and have peak inverse voltage (PIV) rating of 1,000 V.

- **7805 voltage regulator -** 7805 is a three terminal fixed linear voltage regulator IC with a fixed output voltage of 5V which is useful in a wide range of applications.

- **LEDs -** It is a semiconductor device which emits light when an electric current passes through it. Holes from p-type semiconductor recombine with electrons from n-type semiconductor to produce light.

- **Resistors (1kΩ) -** It limits or regulates the flow of electric current in an electrical circuit.

- **Capacitor (1000µF) -** A capacitor is a device that uses the accumulation of electric charges on two nearby objects that are electrically isolated from one another to store electrical energy in an electric field. It has two terminals and is a passive electrical component.

- ❖ **Switch -** This is required to connect or disconnect the conduction path in an electrical circuit.

- ❖ **Enamelled copper wire -** Copper offers high electrical conductivity and has superior short-circuit resistance capabilities and thus is chosen to prepare the transformer in the circuit.

- ❖ **9V batteries -** It is used to establish an electric potential difference between the two end of the transmitter circuit.

- ❖ **Type C charging cable -** It is used to supply the induced current in the receiver circuit to a mobile phone and verify the circuit operation.

- ❖ **Solder and soldering wire -** It is used to connect all the components of the circuits with the wires.

METHODOLOGY –

The input 220V, 50Hz is stepped down using a step-down transformer to 22V. The stepped down voltage is then converted to DC voltage by using a bridge wave rectifier and the oscillator is provided with a 15V DC voltage by using an IC7815 voltage regulator. The Royer's oscillator provides sine wave at 460kHz. The linking between the transmitter and receiver coils takes place. The receiver coil rectifies the received Alternating Current to Direct Current by using a bridge wave rectifier and then is converted to 5V DC by using an IC7805 voltage regulator.

- **220/22V transformer –**

The input 220V, 50Hz is connected to a 50 mΩ resistor. Transient analysis is given with the stop time set to 2s. DC offset voltage is set to 0V. The inductance of the primary coil is set to 100µ and that of secondary is set to 1µ. The coupling coefficient is set as 1. The turns ratio is 10:1. Therefore the voltage induced in secondary coil is 22V.

- **Transmitter**

The transmitter model comprises of bridge wave rectifier, capacitor filter and a modified Royer's oscillator.

- **Bridge Wave Rectifier and IC7805 Regulator**

The alternating 22V is converted to DC by using a bridge wave rectifier. The capacitor filter is used to remove the DC ripples. The IC7815 is used to provide 15V DC to the oscillator for its operation.

- **Modified Royer's Oscillator**

Royer oscillator was most preferred because of its simplicity, low component count, rectangle waveforms which can be turned into sine waves easily. Modified Royer oscillator utilizes N-channel mosfet chosen for its fast-switching speed and high gain. A capacitor is introduced across to obtain proper tuning for resonance. The transmitter coil is driven by two power mosfets in push pull configuration. The resonating capacitor C4 causes the voltage across the coil to first rise and then fall into a standard sine wave pattern. The diodes provide positive feedback thus generating oscillation. A RC snubber circuit is employed in parallel to the diode to enhance the performance of the switching mosfet and to suppress the voltage spikes and damp the ringing caused by the circuit inductance when the mosfet opens. The oscillator oscillates at 460kHz.

- **Receiver**

The receiver model comprises of bridge wave rectifier, capacitor filter and IC7805. The received AC voltage is converted to DC by using a bridge wave rectifier. The capacitor filter removes all the DC ripples. The rectified voltage is then sent to IC7805 voltage regulator in order to provide 5V DC output. The current at the output is around one ampere.

- **Working frequency**

The oscillating frequency is determined by the parallel combination of inductance (L3) and capacitance (C4). Resonance of a circuit involving capacitors and inductors occur because collapsing magnetic field of the inductor generates an electric current in its windings that charges the capacitor, and then the discharging capacitor provides an electric current that builds the magnetic field in the inductor. This process is repeated continuously back and forth creating a resonant frequency. The resonant frequency is calculated by:-

$$f_0 = 1/2\pi\sqrt{LC}$$

Resonant Frequency Formula $f_0 = 1/2\pi\sqrt{LC}$

Theoretical Calculations :-

Details of Transmitting Coil :-

Radius of transmitting coil (r_t) = 4.5 cm

Radius of cross-section (a) = 0.09 cm

Number of transmitting coil turns (N) = 9

Coil wire size = 26 gauge

Diameter = 9cm

Width of winding = 11.139

Details of Receiving Coil :-

Radius of receiving coil (r_r) = 4.5cm

Radius of cross-section (a) = 0.225cm

Number of receiving coil turns (N) = 36

Coil wire size = 26 gauge

Diameter = 9cm

Width of receiving coil winding = 11.139

Theoretical Calculation :-

- Inductance of Winding :- Inductance of transmitter coil

$$= N^2 \mu_0 r \left[\ln\left(\frac{8r}{a}\right) - 1.75\right]$$

$$= 9^2 \times 4\pi \times 10^{-7} \times 8 \left[\ln\left(\frac{8 \times 4.5}{0.225}\right) - 1.75\right]$$

$$= 2.708 \text{ mH}$$

Inductance of receiver coil :- $N^2 \mu_0 r \left[\ln\left(\frac{8r}{a}\right) - 1.75\right]$

$$= 36^2 \times 4\pi \times 10^{-7} \times 8 \left[\ln\left(\frac{8 \times 0.45}{0.225}\right) - 1.75\right]$$

$$= 43.3 \text{ mH}$$

- Resistance of winding $(R) = \frac{\rho l}{A}$

Length of transmitter coil = Circumference of coil × N

$= 2\pi DN$

$= 2\pi \times 9 \times 9$

$= 508.938$ cm

Length of receiver coil (l) = Circumference of coil × N

$= 2\pi DN$

$= 2\pi \times 9 \times 36$

$= 2035.752$ cm

$A = 2\pi r(r+h)$, $h \rightarrow$ width of winding

$= 2\pi(4.5)[4.5 + 11.139]$

$A = 442.24$ cm

P = Resitivity of Copper $= 1.796 \times 10^{-8}$

Resistance of transmitter coil $= 2.066 \times 10^{-8}\ \Omega$

Resistance of receiver coil $= 8.267 \times 10^{-8}\ \Omega$

- Resistance of Leakage Path :-

$R = \frac{\rho L}{A}$ $\qquad$ P = Resistivity of Air (10^6)

l = length of air gap $= 6.5$ cm

A = Area of air gap

$R = 1.54\ M\Omega$

- Resonant frequency :-

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

$$f = \frac{1}{2\pi\sqrt{0.0047 \times 2.708 \times 10^{-3} \times 10^{-9}}}$$

$f = 1.4$ MHz

- Resonant Condition :- $X_L = X_C$

$$X_L = 2\pi f L = 23820.812\,\Omega$$
$$= 23.8\ k\Omega$$

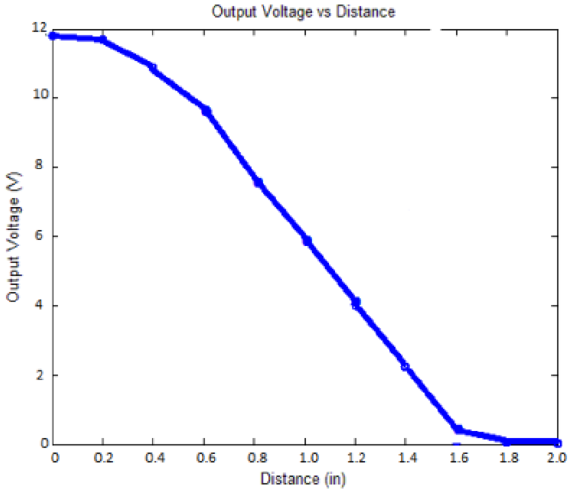
$$X_C = 2\pi f C$$
$$= 24188\,\Omega = 24.188\ k\Omega$$

Thus $X_L = X_C$ and so Resonance occurs resulting in transfer of power.

RESULTS:

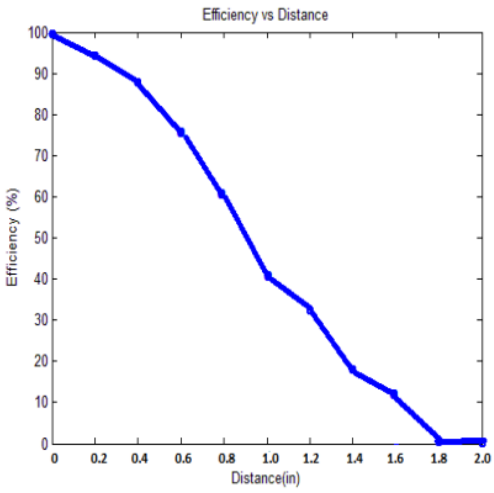
From the Graph:

- The voltage being transmitted to the receiver drops as the distance between the transmitter circuit and the receiver circuit increases.



Graph between Voltage and Distance

- The efficiency of the power being transmitted drops as the distance between the transmitter circuit and the receiver circuit increases.



Graph between Efficiency and Distance

From the above shown graphs it is clearly visible that the system is suitable for use only when the distance between transmitter coil and receiver coil ranges from 0 to about 1.4inches.

DISCUSSION:

The system of charging a mobile application works satisfactorily up to a certain distance and up to certain minimum DC Voltage. However, the voltage decays exponentially as the distance increases because the magnetic field strength decreases as the distance increases. The current decays exponentially when the distance increases. This is also correlated to the magnetic field strength. The power continues to decrease as the distance increases. This is due to low current supplied from the source. This limits the distance of the system of charging a mobile application. This is because to generate a strong and wide magnetic field, a greater current is needed because magnetic field is proportional to current. Several improvements can be made to improve the performance of the system. First, increasing the input power can improve the power received by the receiver side and the distance as current is correlated with magnetic field. Besides that, a current amplifier could increase the performance at the receiver side. In addition, a redesigned coil can amplify the electromagnetic force at the receiver side, according to Faraday's Law of Magnetic Induction.

CONCLUSION:

Wireless charging can be as efficient as wired charging. Based on the above report and collected data, suggests that wireless power transmission could be feasible. Modern science has now made it possible to use electricity without having to plug in any wires for charging. This research paper gives a clear glance of the method of using the inductive charging power to charge the mobile phones without the usage of wired chargers. Many 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. This is more feasible than other techniques and is safer than wired charging systems. The circuit for this purpose has been designed, fabricated, implemented and tested. This circuit consists of a transformer, rectifier, oscillator tank circuit, transmitter coil, receiver coil, current amplifier. So, this provides a great advantage to the mobile phone users. Hence, they can carry their mobile phones everywhere even if the place is devoid of facilities for charging. It has the effect on human beings similar to that from cell phones at present. Wireless power transmission has been the subject of many studies in the past, and will continue to be so in the future.

FUTURE WORK:

The paper's model can be used to charge a variety of electrical devices such as iPads, iPods, propeller clocks, and so on. The technique has numerous benefits, the most important of which are increased convenience, reduced wire clutter, reduced e-waste, and many others. Wireless charging can only be used on a large basis if power transmission efficiency improves. A model can be created in such a way that all devices can be charged by a single power transmitting source that ultimately falls within a specified radius region while causing no harm to humans. The amount of power lost between the charging pad and the device must be decreased in the future. Additionally, the charging pad's distance from the gadget must be increased. The designed model can also be made cost-effective.

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