A New Integration Method for an Electrical Apparatus Wireless Power Transfer System by using CLC Compensation

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Abstract— This project was developed in the wireless power transfer by using air core copper coil. The copper coil should be made up of thick copper wires. This project can be used for charging the electrical apparatus like mobile phone, laptops, and electrical vehicles etc. it transfer power from transmitter to receiver coil without any losses. This project can be designed to reduce the losses of power transfer in one end to other end and improve the efficiency of the power from transceiver to receiver end. In this project is possible to transfer power such as kv level in WPT technology is used to improving the transmission efficiency and distance. In the inductive coupling and the magnetic concept is used to transfer power from transmitter coil to the receiver coil using high voltage supply. Air core inductor is used to generate a magnetic field. In inductive coupling (CLC) primary of an air core transformer. The secondary coil should be developed a high frequency voltages. In the distance range should be improved in (5cm).in primary coil can be transmitted the power. The secondary coil can be received the power to run a load.

Key words: HF Transmitter Coil, HF Receiver Coil, Rectifier, Voltage Regulator, Filter, Batteries, CFL Lamp, BLDC Fan

I. Introduction

Wireless power transfer (WPT) technologies have been widely used in many areas, e.g., the charging of electric toothbrush, mobile phones, and electric vehicles. This chapter provides fundamental principles of three WPT technologies, i.e., inductive coupling-based WPT, magnetic resonant coupling-based WPT, and electromagnetic radiation-based WPT, together with discussions of their strengths and weaknesses. Main research themes are then presented, i.e., improving the transmission efficiency and distance, and designing multiple transmitters/receivers. Several WPT applications are described.

II. Inductive Coupling

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.

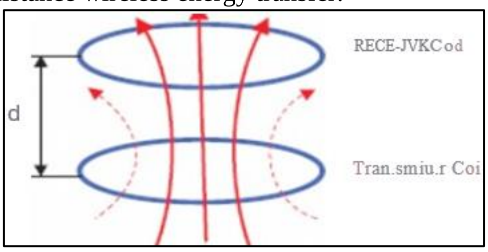

Fig. 1:

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.

III. Transmitter & Receiver

Transmitter and receiver coils are the air core inductor coils which are used to transfer the power over a specified distance. The power transfer done by the means of mutual induction. The magnetic coupling is specified for some fixed distance. This distance depends upon magnetic field of the coil Greater the magnetic field greater the distance over which the power is transferred coil.

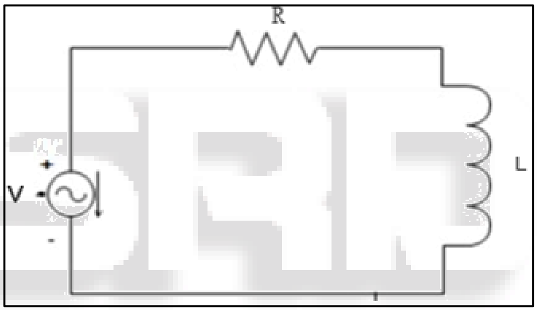

Fig. 2:

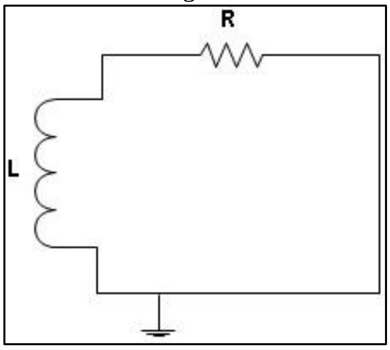

Fig. 3:

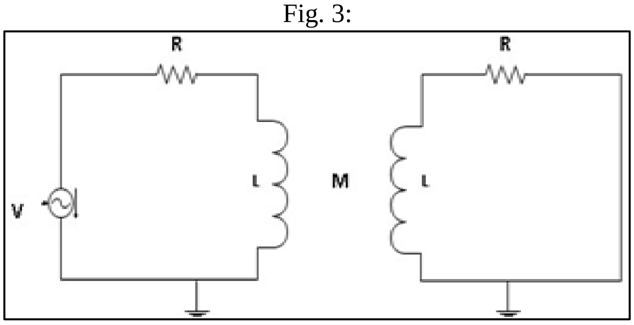

Fig. 4:

An inductor usually consists of a conductor that is wound around a magnetic core. From circuit theory the voltage, VL, created by the current, i, across the inductor can be expressed as

$$V_L = L\,di/dt$$

Where L is the inductance of the inductor. Another way to explain the same voltage is to use Faraday's law which says that

$$V_L = N\,d\Phi/dt$$

Where N is the number of turns of the conductor and Φ is the magnetic flux flowing through the coil. By putting these equations together one gets

$$Li = N\Phi$$

Where the left side is the circuit quantities and the right is the field quantities. The inductance can then be expressed as

$$L = N\Phi/I$$

The relation between Φ and i is nonlinear when using ferromagnetic materials and it is important to connect this equation with the magnetic flux density, B, and the field intensity, H. The magnetic flux can be expressed as

$$\Phi = \iint B\,dA$$

If the magnetic flux density is even across the core the equation simply becomes

$$\Phi = BA$$

Where A is the cross sectional area of the core. The magnetic flux density can then be expressed as

$$B = \mu_o \mu_r H$$

Where μ_o is the permeability of vacuum and μ_r is the relative permeability of the core material.

The relative permeability is the prime factor when determining the amount of energy that the inductor can store, especially when the space for the inductor is limited. The energy stored can be expressed as

$$W = 1/2\,LI^2$$

(14)Finally, the connection of the magnetizing force and the current flowing in the inductor can be expressed according to Ampere's law as

$$Ni = \oint H\,dl$$

This equation states that the current equals the integral of the magnetizing force surrounded by an arbitrary part d*l*. If the loop d*l* surrounds the full inductor current the equation becomes

$$Ni = Hl$$

Where *l* is the mean magnetic path length in the core of the inductor. The relation between the flux density and the magnetizing force is best described using the magnetization curve, especially for ferromagnetic materials because of the nonlinearity of the material.

IV. TYPES OF INDUCTOR

Inductor is classified based on size, core material, types of winding etc. so they are used in wide range of applications.

The maximum capacity of the inductor gets specified by the types of core material and the number of turns on coil will be discussed on next chapter 2.

- Basic magnetic concept of the inductor is briefly explained in this.
- The BH-curve characteristics or magnetization curve and core loss such as eddy current and hysteresis loss of the materials were studied in ref [1].
- The reason for the saturation in ferromagnetic materials can be explained by using the model of magnetic domains. Types of the inductor is based on the size, core material has discussed here.
- Materials used in each type of the core material and advantages made over it and the iron core and ferrite core has compared in this.
- The temperature and humidity are important factors that affect the PTE. Some semiconductors are also sensitive to the temperature [2].
- In addition, adding a ferrite core can improve the magnetic field strength and increasing magnetic flux, thus leading to higher PTE [3].
- Wireless power transfer is a new technology to transfer electrical power without any physical contact between the source and the load. Basic principle of WPT is described in this.
- Three different types based on wireless power transfer such as inductive coupling, resonant magnetic coupling and electromagnetic radiation coupling and need of the WPT is discussed in this paper[4].
- The concept of wireless power transfer is explained by inductive coupling and the magnetic concept is used to transfer power from transmitter coil to the receiver coil using high voltage supply.
- Air core inductor is used to generate a magnetic field and application for wireless power transfer has been discussed here [5].
- In the inductive coupling-based WPT, the ratio of the transmitter coil diameter and transmitted distance (air gap) can also affect the transmission efficiency [6]
- In this power transfer and coupling between two partially coupled coils using a ferrite core were discussed.
- In some contactless application, working with core to increase the coupling between the coils is necessary.
- In this case core is used in inductor at high frequencies, losses like eddy current and hysteresis losses are important to take into account.
- In this paper, the losses has ignored by ferrite core has mainly discussed [7]
- Some approaches of the magnetic parameter that define the coupling between the coils were done by analytical calculation and also simulation by an FEMM.
- LT-SPICE is a general purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers.
- Simulations for magnetic flux density are done by Ansys in this paper. Optimized design of the proposed stepped core surface temperature and power loss were analyzed by this software. [8]

A. Inductance

If a changing flux is linked with a coil of a conductor there would be an emf induced in it. The property of the coil of inducing emf due to the changing flux linked with it is known as inductance of the coil.

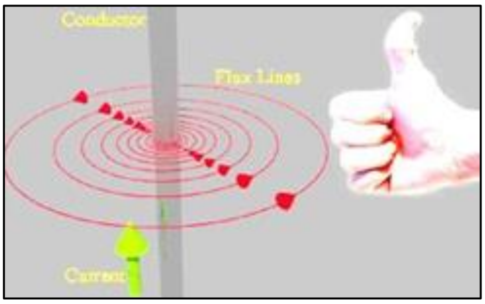

Fig. 5:

The unit of inductance is the Henry (H). One Henry is the inductance of a coil when a current, changing at a rate of one ampere per second, induces one volt across the coil.

B. Self-Inductance

– Whenever changing flux links with a circuit an emf is induced in the circuit. This is Faraday laws of electromagnetic induction. According to this Law,

e= -Nd /dt

Where, e= induced emf; N=No of turns;
d /dt = rate of change of flux linkage with respect to time.
Self-inductance is defined as

$L = A\mu_o\mu_r N^2/l$

Where, L=self-inductance;
A= area of the cross section of the coil;
μ_o = permeability of free space;
μ_r = relative permeability; N = number of turns;
l = length of the coil these are the four factor which affect the amount of inductance.

C. AC Inductance with a Sinusoidal Supply

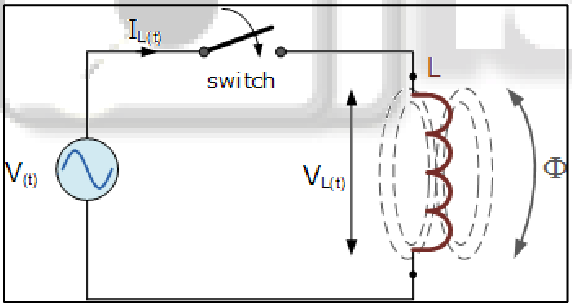

Fig. 6:

This simple circuit above consists of a pure inductance of L Henries (H), connected across a sinusoidal voltage given by the expression:

V (t) = Vmax sin t

When the switch is closed this sinusoidal voltage will cause a current to flow and rise from zero to its maximum value. This rise or change in the current will induce a magnetic field within the coil which in turn will oppose or restrict this change in the current.

But before the current has had time to reach its maximum value as it would in a DC circuit, the voltage changes polarity causing the current to change direction.

This change in the other direction once again being delayed by the self-induced back emf in the coil, and in a circuit containing a pure inductance only, the current is delayed by 90^o.

The applied voltage reaches its maximum positive value a quarter ($1/4f$) of a cycle earlier than the current reaches its maximum positive value, in other words, a voltage applied to a purely inductive circuit "LEADS" the current by a quarter of a cycle or 90^o as shown below.

D. Sinusoidal Waveforms for AC Inductance

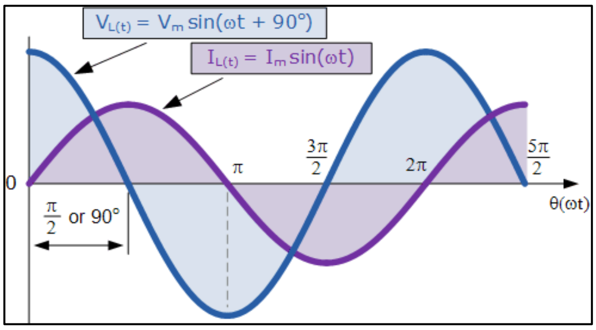

Fig. 7:

This effect can also be represented by a phasor diagram were in a purely inductive circuit the voltage "LEADS" the current by 90^o. But by using the voltage as our reference, we can also say that the current "LAGS" the voltage by one quarter of a cycle or 90^o as shown in the vector diagram below.

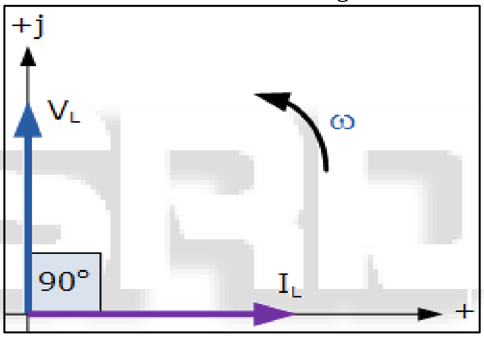

Fig. 8:

So for a pure loss less inductor, V_L "leads" I_L by 90^o, or we can say that I_L "lags" V_L by 90^o.

E. Mutual Inductance

It 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"

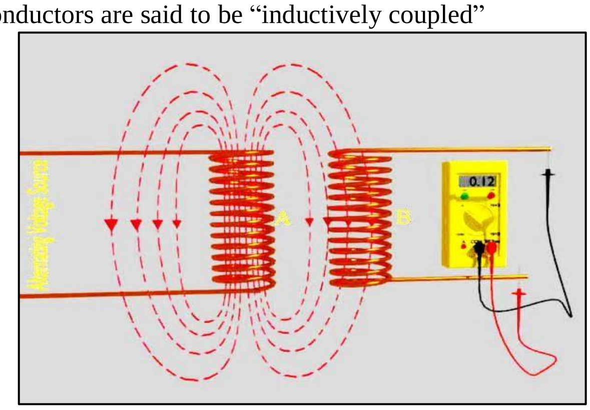

Fig. 9:

If current i_1 flows through circuit 1 then emf e_2 is induced in the nearby circuit is given by,

$e_2 = [-M di_1/dt]$ volt

Where, e_2 = induced emf defined in the figure 2.5

M is the mutual inductance

$$M = N_2\ \ 1/i_1 \quad (5)$$

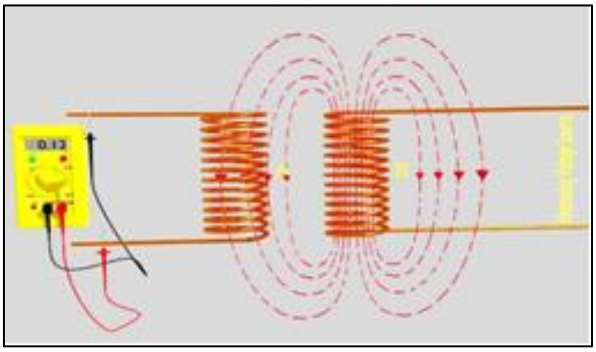

Fig. 10:

If current i_2 flows through circuit 2, then emf e_1 is induced in the nearby circuit 1 is given by,

$e_1 = [-M di_2/dt]$ volt (6)

Where, $M = N_1\ \ 2/i_2$

V. PROPOSED SYSTEM BLOCK DIAGRAM

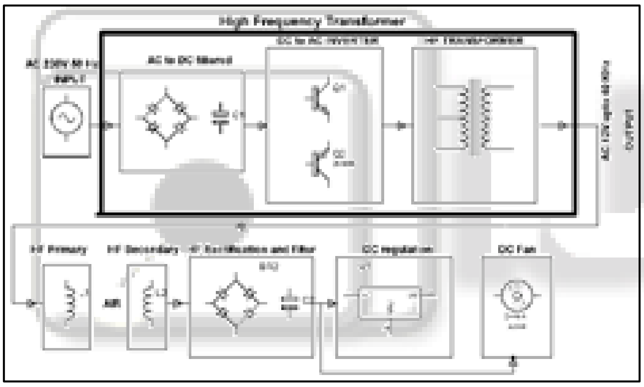

Fig. 11:

A. *Working*

Wireless power transfer is new technology to transfer electrical power without any physical contact between the source and the load.

The aim of this project is to propose the use of a simple, cheap and easy technique for charging any mobile. The main problem is how power is transferred wirelessly without any bad effect on environment and human.

So that core material used in the inductor for transmitting the power wirelessly for charging any mobile, laptop and electrical apparatus.

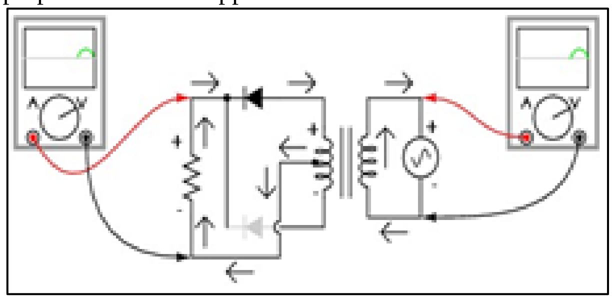

Fig. 12:

During the next half-cycle the AC polarity reverses. Now, the other diode and the other half of the transformer's secondary winding carry current while the portions of the circuit formerly carrying current during the last half-cycle sit idle. The load still "sees" half of a sine wave, of the same polarity as before: positive on top and negative on bottom:

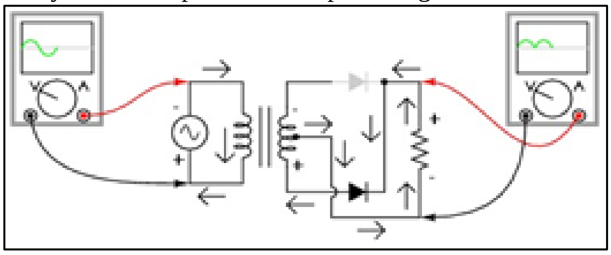

Fig. 13:

One disadvantage of this full-wave rectifier design is the necessity of a transformer with a center-tapped secondary winding. If the circuit in question is one of high power, the size and expense of a suitable transformer is significant. Consequently, the center-tap rectifier design is seen only in low-power applications. Is shown in fig (b).

IN4001 is the diode that is used to construct rectifier. If we need to rectify AC power so as to obtain the full use of both half-cycles of the sine wave, a different rectifier circuit configuration must be used. Such a circuit is called a full-wave rectifier. One type of full-wave rectifier, called the center- tap design, uses a transformer with a center-tapped secondary winding and two diodes, like this

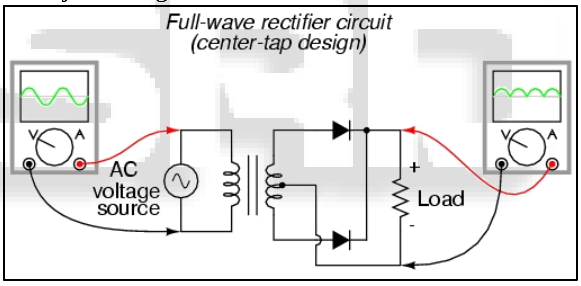

Fig. 14:

This circuit's operation is easily understood one half-cycle at a time. Consider the first half-cycle, when the source voltage polarity is positive (+) on top and negative (-) on bottom. At this time, only the top diode is conducting; the bottom diode is blocking current, and the load "sees" the first half of the sine wave, positive on top and negative

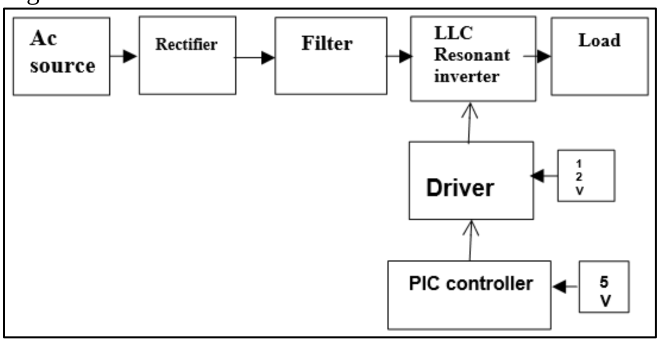

Fig. 15:

VI. CIRCUIT DIAGRAM

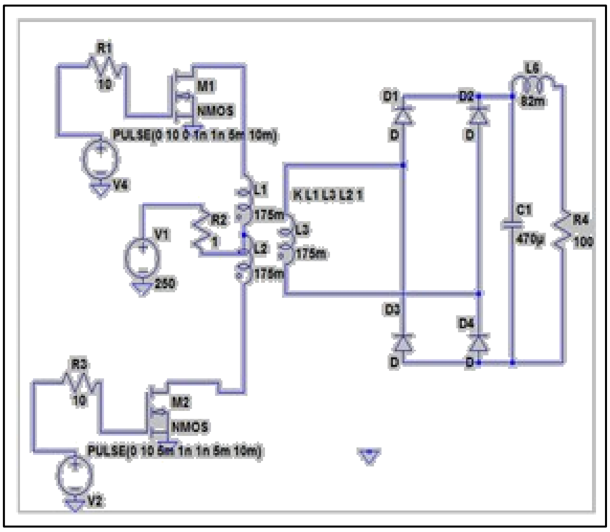

Fig. 16:

This high frequency alternating current, which is linked with the wireless power transmitting coil, would create an alternating magnetic field in the coil due to induction, to transmit energy.

- In the wireless power receiver section, the receiver coils receives that energy as an induced alternating voltage (due to induction) in its coil and a rectifier in the wireless power receiver section converts that AC voltage to a DC voltage.
- In the following transmitting coil L1&L2 and the receiving coil L3 in that may be called as the high frequency coils.
- This circuit's operation is easily understood one half-cycle at a time. Consider the first half-cycle, when the source voltage polarity is positive (+) on top and negative (-) on bottom.
- At this time, only the top diode is conducting; the bottom diode is blocking current, and the load "sees" the first half of the sine wave, positive on top and negative
- Wireless power transfer is new technology to transfer electrical power without any physical contact between the source and the load.

VII. INTRODUCTION TO LT-SPICE

LT-SPICE is a general purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers.

So LT-SPICE, which enables to simulate tests or working conditions, enables to test in wireless power transfer virtual environment before manufacturing prototypes of products. Furthermore, determining and improving weak points, computing life and foreseeing probable problems are possible by simulations in virtual environment.

A. *Input Source Voltage*

1) *Gate Pulse M1*

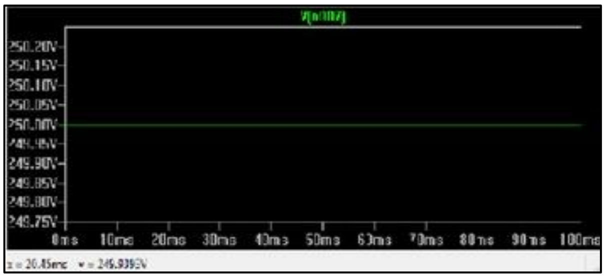

Fig. 17:

2) *Gate Pulse M2*

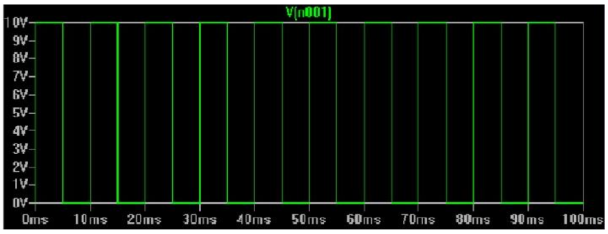

Fig. 18:

- The following simulation of input gate pulse in (m1 and m2). And input hf source voltage wave form simulation is shown
- In the several of the frequency of the coil should be represented on the following circuit operation
- Wireless power transfer is new technology to transfer electrical power without any physical contact between the source and the load.
- If M1 will be ON condition means if M2 will be OFF state of the switching will be change continuously can be operated.

3) *HF (V&I) IN L1&L3*

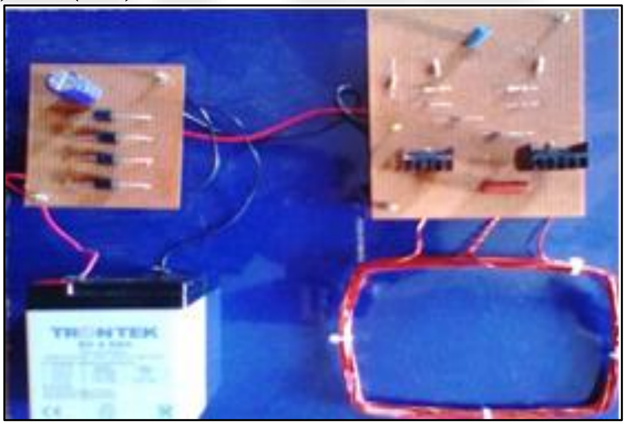

Fig. 19:

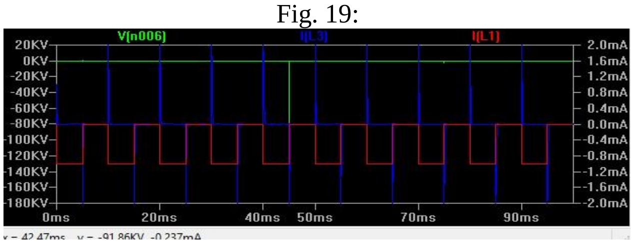

Fig. 20:

B. HF (V&I) IN L3

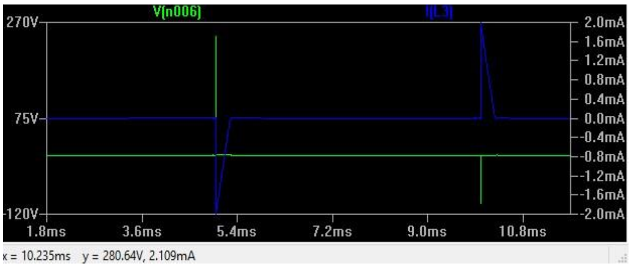

Fig. 21:

C. HF (V&I) IN R4

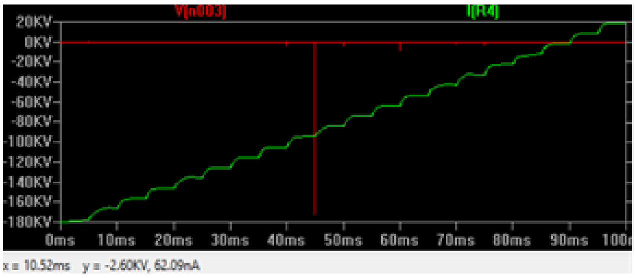

Fig. 22:

VIII. HARDWARE IMPLEMENTATION & RESULT

TRANSMITTER CIRCUIT

In transmitter coil that should may be called as the L1&L2 in the high frequency coil.

– MOSFET will be placed in the coil they are M&M2.
– The proctoring device are placed in the circuit they can protect the MOSFET circuit.

A. Receiver Circuit

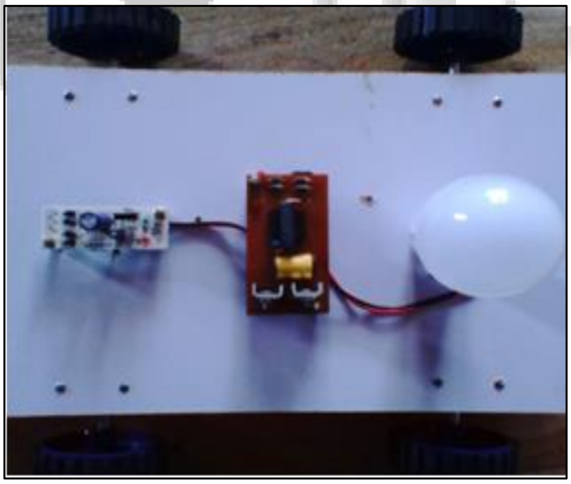

Fig. 23:

In receiver circuit high frequency receiving air core coil should be placed (L3).

– In rectifier circuit will be placed on the receiver circuit they can be converted AC in to DC of the following arriangement.
– Then step up the voltage level to in 12V can be converted in to the 240V to given to the load circuit of the arriangement.

B. Both Transmitter & Receiver Circuit

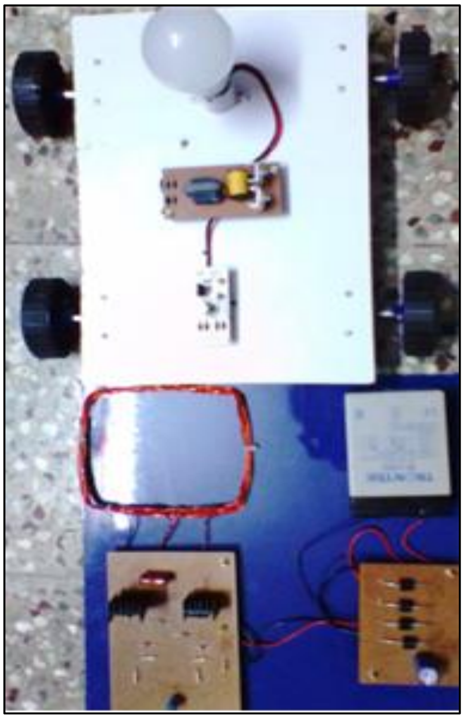

Fig. 24:

– In transmitter coil that should may be called as the L1&L2 in the high frequency coil.
– MOSFET will be placed in the coil they are M&M2.
– The proctoring device are placed in the circuit they can protect the MOSFET circuit.
– In receiver circuit high frequency receiving air core coil should be placed (L3).
– In rectifier circuit will be placed on the receiver circuit they can be converted AC in to DC of the following arriangement.
– Then step up the voltage level to in 12V can be converted in to the 240V to given to the load circuit of the arriangement.

IX. CONCLUSION

In this project wireless power transfer system using inductive coupling has been proposed. It can be used to transfer power from solar panel and batteries.it has made this possible by inductive coupling. It can power certain devices and can also be used to transfer power from solar panels and also other household applications such as lighting and sensing. As per we discussed in the research theme temperature and humidity are the main factor to improve the efficiency and distance so that coil is wrapped around the core such as iron or ferrite in this project and analysis are done by simulation tool.

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