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Design and Construction of Wireless Power Transfer System Charging Multiple Devices

Adedayo Asaolu, Joshua Godwin Oshoname
Lecturer: Department of Electrical & Electronics Engineering, Ekiti State University Ado-Ekiti, Ekiti State, Nigeria.
Student: Department of Electrical & Electronics Engineering, Ekiti State University Ado-Ekiti, Ekiti State, Nigeria.

Abstract:- Wireless power transfer system charging multiple devices, through inductive coupling method which is classified under near field transfer region. In this project, we intend to achieve wireless power transfer charging multiple devices such as mobile phone, toothbrush and other low end power devices without the use of conventional copper wire or cable between the transmitter module and receiver module. In this paper, result analysis was taken for voltage and distance of separation of coil of each receiving end device to know the efficiency of power transfer and graph are illustrated to show the comparison of voltage and distance of separation of coil of LED, DC fan, and mobile phone, digital camera, toothbrush.

Keywords *:- Wireless power transfer charging multiple devices, transmitter module, receiver module, mobile phone.*

I. INTRODUCTION

Wired innovation lately has turn into a basic issue which requires a wired plug to be connected to an electrical wall socket. This wired plug takes up a great deal of electric sockets space and not to mention the fact that each device has its own outline for the charging port which could be so untidy. Now an inquiry may emerge "consider the possibility that, a transmitter device can be designed to charge multiple receiver device at the same time without the utilization of wires or cables and not making a mess in the process while charging these devices?" The answer to these basic issue sexists in inductive coupling (near field region), propagating electromagnetic wave, and microwave power transfer (far field region), a viable way of transferring power wirelessly.In this paper we focused on wireless power transfer using inductive coupling method which is a near field region.

However, inductive coupling depends on transmitting power wirelessly due to Electromagnetic induction. It was first introduced and applied by Nikola tesla in which he effectively transmitted power from one place to another without the utilization of cable to power a low-end device such as fluorescent lights, tesla discoveries lead him to plan and construct the wardenclyffe tower which is utilized as a remote power transmitter [1- 3].

The fundamental of remote power transmission incorporates the inductive energy that can be transmitted from a transmitter coil (L1) to a receiver coil (L2) through an oscillating magnetic field (B, green) which reaches out to the secondary coil in the receiver unit and induces a voltage in it by faradays law of induction, the DC current supplied by a power source is changed into high frequency AC current by a particularly designed oscillator embedded into the transmitter in which the yield is provided to the push pull circuit then to the transmitter coil (L1) which acts as the primary coil (L1) therefore the power gets transferred through the primary coil (L1) to the receiver coil (secondary coil L2) that are separated by certain distance, the power being received by the secondary coil (L2) is then rectified and regulated before the output is supplied to the load[4].

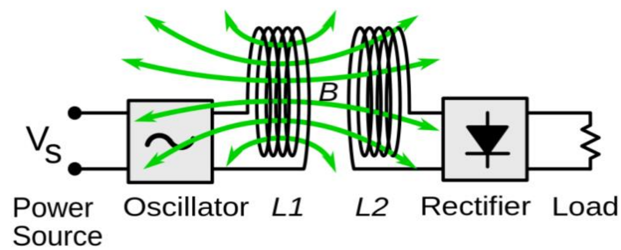

Fig 1:- simple wireless power transfer system via inductive coupling [4].

In this paper, we intend to design a wireless power transfer system that will charge multiple devices at the same time with the utilization of inductive coupling method as a technique for inducing sufficient power on the receiving devices [4, 5].

II. MATERIALS AND METHODS

In this paper, a circuit prototype is designed which implores the use of inductive coupling, it consist of a single transmitter module and multiple receiver devices which aids the complete wireless system.

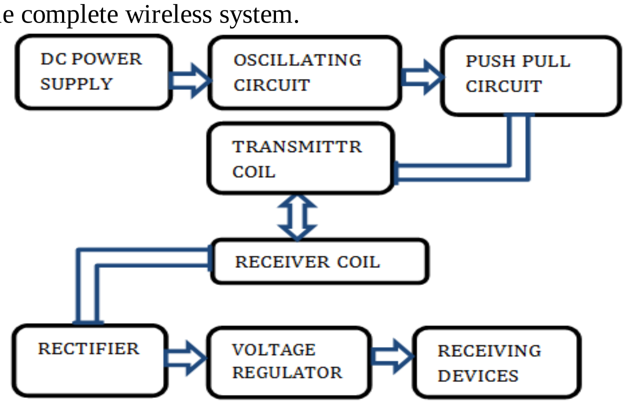

Fig 2:- Block Diagram of Wireless Power Transfer System.

DC Power Supply Circuit:

It consist of the following components

NAME	CODE VALUE	QUANTITY
Diode	1N4007	4
Capacitor	470uf (50v)	2
	103 (0.01uf)	1
	104 (0.1uf)	2
(Voltage Regulator)	7819 (19v)	1
Transformer	(230v – 19v)	1

Table 1. DC Power Supply Component.

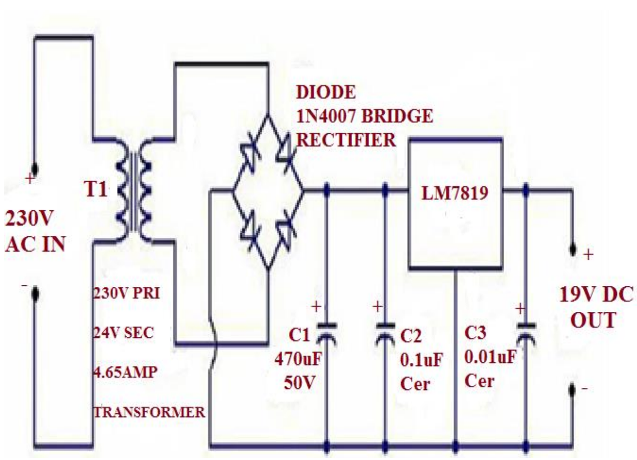

Fig 3:- DC Power Supply Circuit.

The power supply unit used however gave an output of 19V DC. The power supply contained a transformer section that stepped down the 230V AC supplied from the mainsto 24V AC. A full-wave bridge rectifier then rectified the 24V AC. Full wave bridge rectifier is favored over the half wave bridge rectifier since, for the half wave rectifier, an extensive capacitor will be required to hold up the voltage amid the gap whereby an AC cycle is skipped. The bridge rectifier has an efficiency of 80% subsequently the rectified output was less than the input. The output received was 19.5V DC. This voltage however is still pulsating therefore a smoothening capacitor is required. The smoothening capacitor supplies charge when as the rectifier voltage falls consequently evening out any variances by the signal. The smoothened dc voltage is then fed to the voltage regulator LM7819 which guarantees a stable output voltage of 19v DC.

Oscillating Circuit:
It consist of the following components

NAME	CODE VALUE	QUANTITY
Resistors	1k ohm	2
	4.7k ohm	4
	10k ohm	2
	220k ohm	2
	47 ohm	1
Capacitors	10uf (50v)	2
	103 (0.01uf)	1
	104 (0.1uf)	2
IC	SG3524N	1
IC socket	7812 (12v	1
(Voltage Regulator)	Heat zinc	1

Table 2. Oscillating Circuit Components

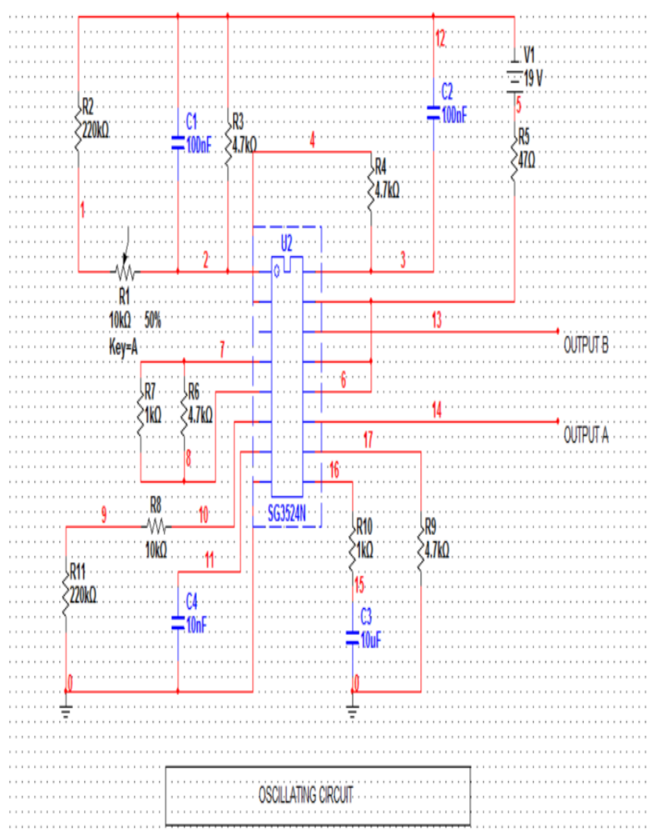

Fig 4:- Oscillating Circuit

For this project, an oscillator was designed with IC SG3524 which is an integrated switching regulator circuit that has all essential circuitry required for making a switching regulator in push-pull mode. The IC SG3524 operates at a fixed frequency; the oscillating frequency is determined by one timing resistor RT and one timing capacitor, also the oscillator controls the frequency of the SG3524 and is programmed by RT and CT according to the approximate formula [9]:

$$F = \frac{1.18}{R_T C_T} KHz$$

Where:RT = 230k ohm, CT= 10n farad

$$F = \frac{1.18}{230 \times 10^3 \times 10 \times 10^{-9}}$$

$$F = \frac{1.18}{2.3 \times 10^{-3}}$$

$$F = 513kHz$$

This high frequency alternating current is connected to the push pull (driver stage) which is connected to the transmitter coil where by creating an alternating magnetic field in the coil due to induction.

Fig 5:- Oscillating Circuit.

Push-Pull Circuit:
It consist of the following components

NAME	CODE VALUE	QUANTITY
Transistors	MOSFET IRZ44N	4
Capacitor	22nf (1000v)	1
Resistors	1k	4
	10k	4
Heat Zinc		2

Table 3. Push Pull Circuit Components.

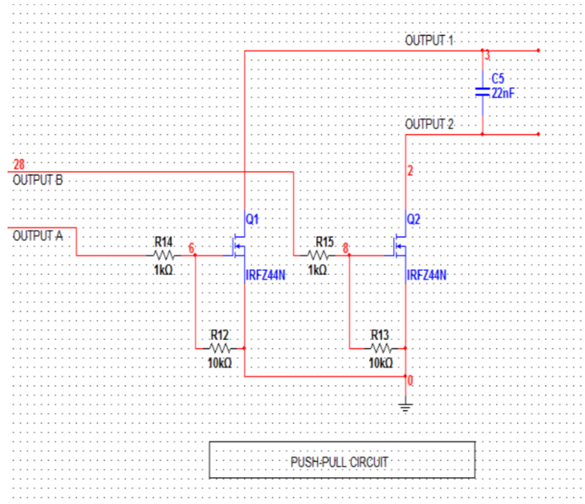

Fig 6:- Push Pull Circuit.

The driver stage consists of four power MOSFET, capacitor and resistors.

After assembling and fabricating the components on the Vero board two fans were used for cooling. The above three objectives formed the transmitter module. When assembled and fabricated it was as depicted in the Figure below.

Fig 7:- Push Pull Circuit.

Driver stage is the stage that is standing between the oscillating stage and the output stage. The output stage will usually have low input impedance and so the oscillating stage cannot drive the output stage alone. The reason for the driver stage is to produce enough current gain with a specific end goal to drive the output stage. Since there is adequate current gain, the driver stage produces considerable amount of power gain as well.

Transmitter (TX)coil
Receiver coil for our project is designed to80turns of copper laminated coil 16 gauge[5].

Fig 8:- Transmitter (TX) Coil

Fig 9:- Transmitter (TX) Module.

Receiver (RX) Circuit

The receiver module of our project is made up of a receiver coil, a rectifier circuit and a voltage regulator IC. An AC. voltage is induced in the receiver coil. The rectifier circuit converts it to DC and the voltage regulator IC helps to maintain a constant limited voltage at the load.

The following block diagram gives the receiver circuit, module and coil.

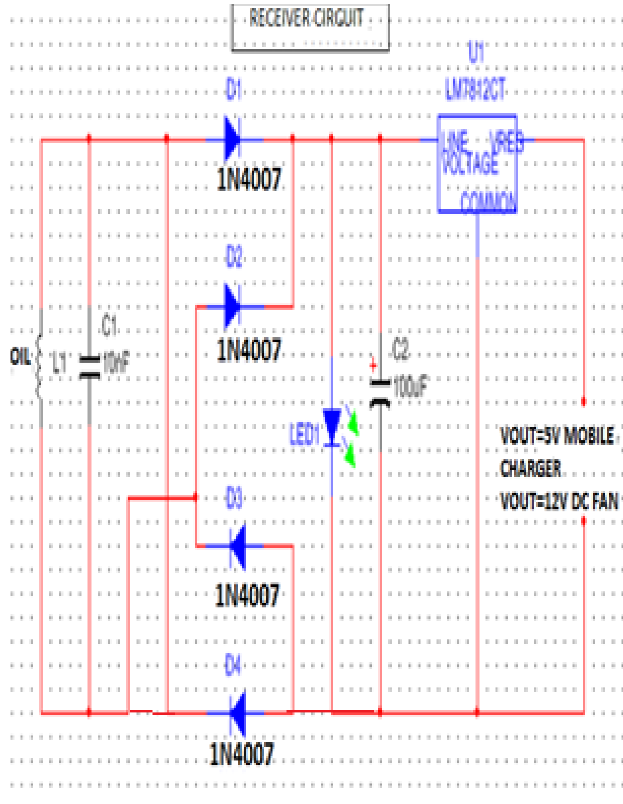

Fig 10:- Receiver (RX) Circuit.

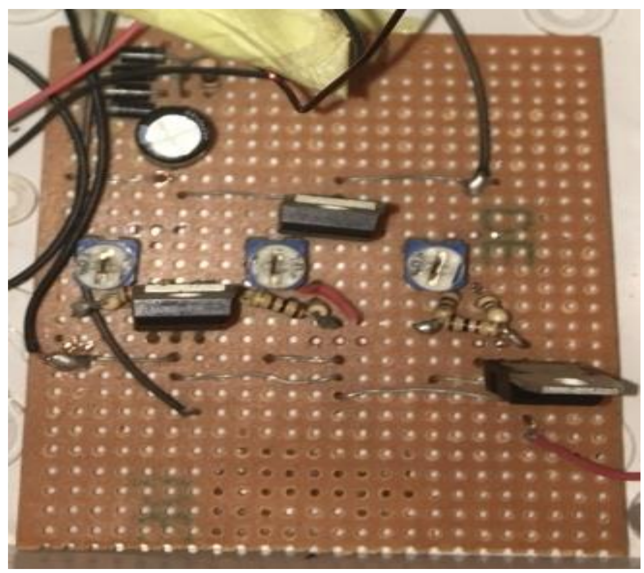

Fig 11:- Receiver (RX) circuit Module.

Receiver(RX)coil:
Receiver coil for our project is designed to 220 turns of copper laminated coil 16 gauge [5].

Fig 12:- Receiver (RX) Coil.

Fig 13:- Receiver (RX) Module.

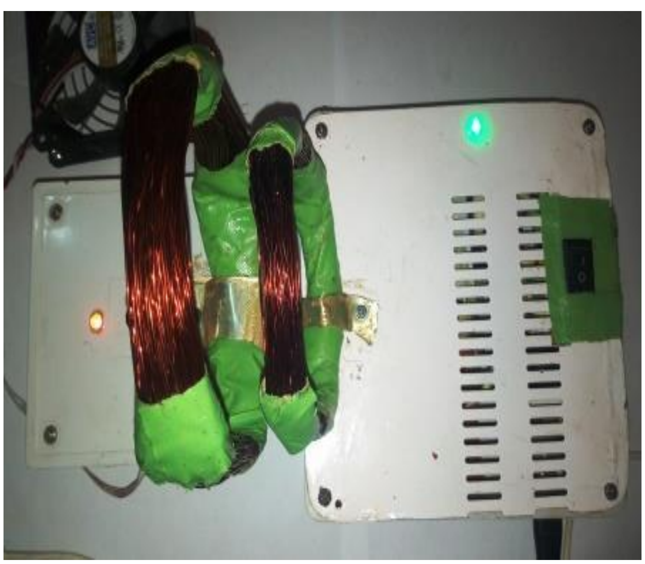

Fig 14:- Transmitter (TX) and Receiver (RX) Module.

III. RESULTS AND DISCUSSION

Result tabulation for LED

SL No	Distance (cm)	Voltage(volt)
1	0	2.11
2	4	2.05
3	8	1.97
4	12	1.80
5	16	1.25
6	20	1.02
7	24	0.87
8	28	0.26
9	32	0.13
10	36	0

Table 4. Voltage vs Distance for LED.

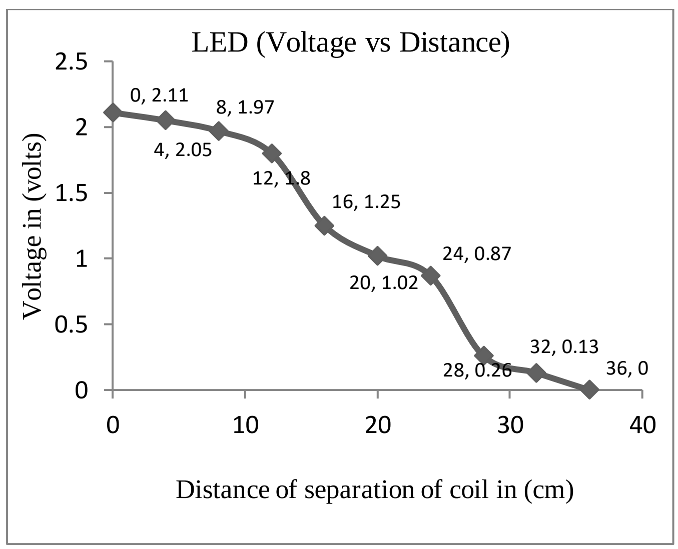

Fig 15:- Chart for LED (Voltage vs Distance).

Result Tabulation for Dc Fan

SL No	Distance (cm)	Voltage(volt)
1	0	12
2	4	11.98
3	8	11.86
4	12	0.28
5	16	0.12
6	20	0.03
7	24	0

Table 5. Voltage vs Distance for LED

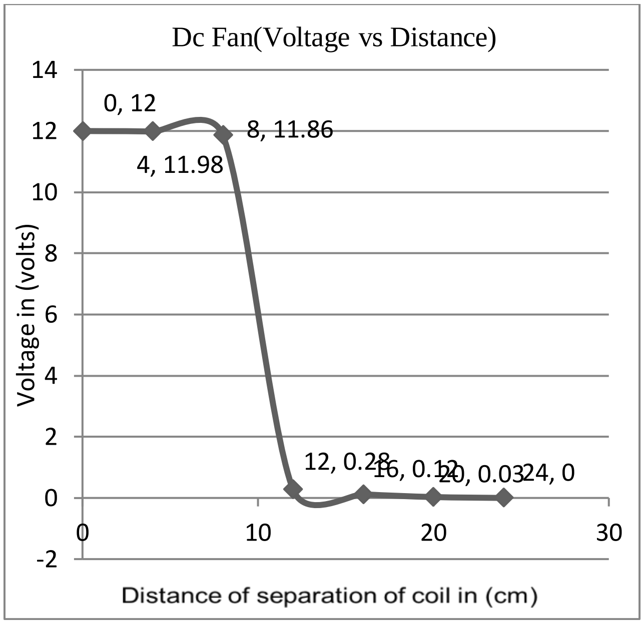

Fig 16:- Chart for DC Fan (Voltage vs Distance).

Result Tabulation for Mobile Phone

SL No	Distance (cm)	Voltage(volt)
1	0	5
2	4	4.54
3	8	3.17
4	12	0.24
5	16	0

Table 6. Voltage vs Distance for Mobile Phone

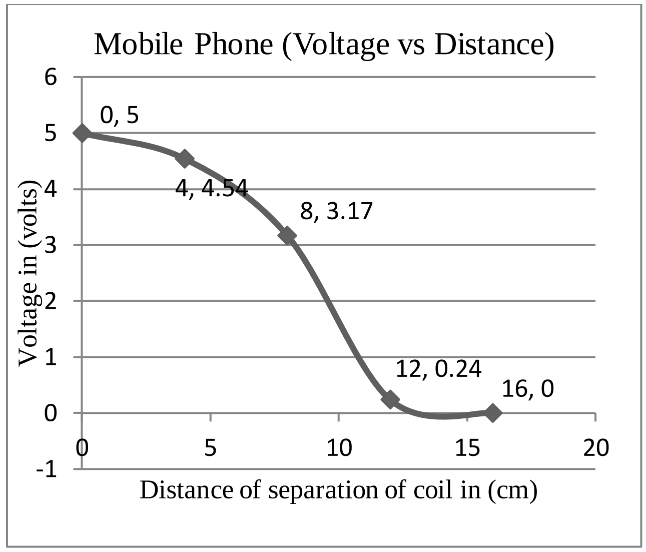

Fig 17:- Chart for Mobile Phone (Voltage vs Distance).

Result Tabulation for LED, DC Fan and Mobile Phone

SL NO	Distance (cm)	LED (Volts)	DC FAN (Volts)	MOBILE PHONE (Volts)
1	0	2.11	12	5
2	4	2.05	11.98	4.54
3	8	1.97	11.86	3.17
4	12	1.80	0.28	0.24
5	16	1.25	0.12	OFF
6	20	1.02	0.03	OFF
7	24	0.87	OFF	OFF
8	28	0.26	OFF	OFF
9	32	0.13	OFF	OFF
10	36	OFF	OFF	OFF

Table 7. Voltage vs Distance for LED, DC Fan and Mobile Phone.

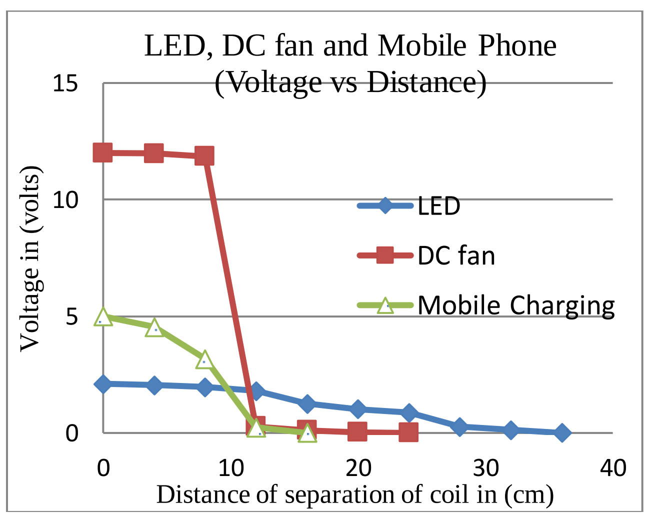

Fig 18:- Chart for LED, DC Fan and Mobile Phone (Voltage vs Distance).

IV. DISCUSSION

It was observed that efficient power transfer took place between transmitter (TX) and receiver(RX) coil of same resonating frequency. For efficient power transfer between coil TX and RX we considered several factors which are quality factor, coupling co-efficient, decay constant these factors are functions of frequency, so operating at high frequency gives a greater result. Number of turns is also a factor, it increases the radiation resistance therefore decay constant increases which gives a low quality factor. The length of coil, high conductivity, and greater cross sectional area of the coil are considered as factors which were implored to give an efficient power transfer. We observed the results for varying voltage and distance on each test device.

V. CONCLUSION

In this study, the goal of the project was to design a wireless power transfer system charging multiple devices via inductive coupling were achieved. It was observed that these factors has direct effect on the power transfer as follows: separation of coil (distance), oscillating frequency, number of turns, length of coil, cross sectional area of coil determines the power efficiency. Also the results shows that there was an exponential decrease for voltage versus distance of separation, from analysis at 0cm separation of distance, the power transferred was most efficient as seen by the brightness of the test lamps but after a distance of 8cm the power transferred drops significantly, result analysis clearly shows that inductive coupling can be used to deliver power wirelessly to each receiving device simultaneously.

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