iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** VI **Month of publication:** June 2020

DOI: http://doi.org/10.22214/ijraset.2020.6018

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com

Simulation of Wireless Mobile Charging Model in LTSpice Software

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***Abstract:** The use of mobile phones is everywhere and the mobile users must face the burden of carrying the chargers. Wireless mobile charging ensures safety from shock as well as ensures increased convenience and protects the electronics from corrosion as there is no exposure to atmosphere. A model is designed and simulated in LTSpice software, which provides five volts DC at the output with current around one ampere. The model comprises of a transformer, transmitter and receiver.*
***Keywords:** LTSpice software, Modified Royer's oscillator, IC 7805 and IC 7815, Bridge wave rectifier, 230V supply.*

I. INTRODUCTION

Wireless power transfer is a collective term that utilizes electromagnetic fields to refer to a number of 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.

Around 1891, Nikola Tesla conducted the first experiments in wireless electrical energy transmission using a radio frequency resonant transformer called Tesla coil which produces high voltage, high frequency alternating currents. This technology has progressed since then and with the introduction of cordless devices such as electric toothbrushes and electric razors to minimize the danger of electrical shock.

Portable wireless networking devices such as cell phones, tablets and laptops have been pushing the advancement of wireless computing and charging technology to a new level in recent years. 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. Ease of implementation, convenient operation, and ensured safety makes inductive charging suitable.

II. 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 AC to DC by using a bridge wave rectifier and then is converted to 5V DC by using an IC7805 voltage regulator.

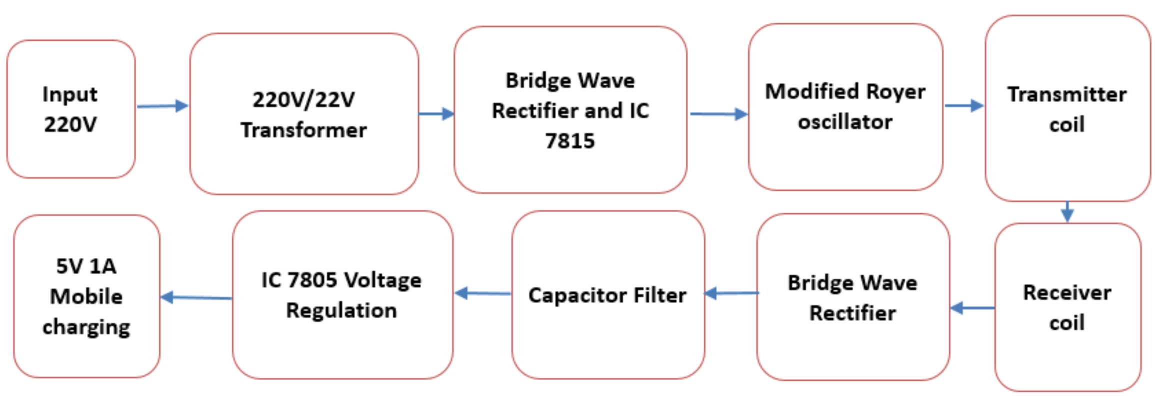

Fig. 1 Methodology

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A. 220/22V transformer

The input 220V, 50Hz is connected to a 50m ohm 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 100u and that of secondary is set to 1u. The coupling coefficient is set as 1. The turns ratio is 10:1. Therefore the voltage induced in secondary coil is 22V.

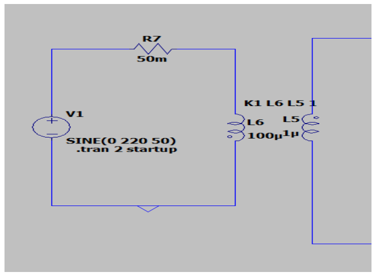

Fig. 2 220/22V transformer

B. Transmitter

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

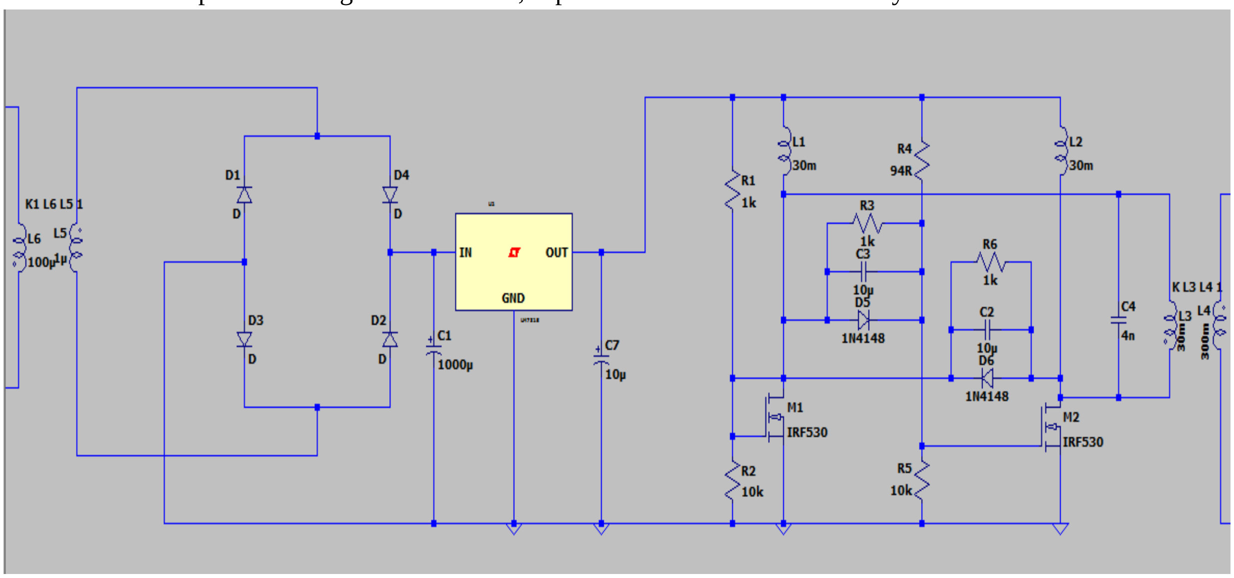

Fig. 3 Transmitter circuit

C. 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.

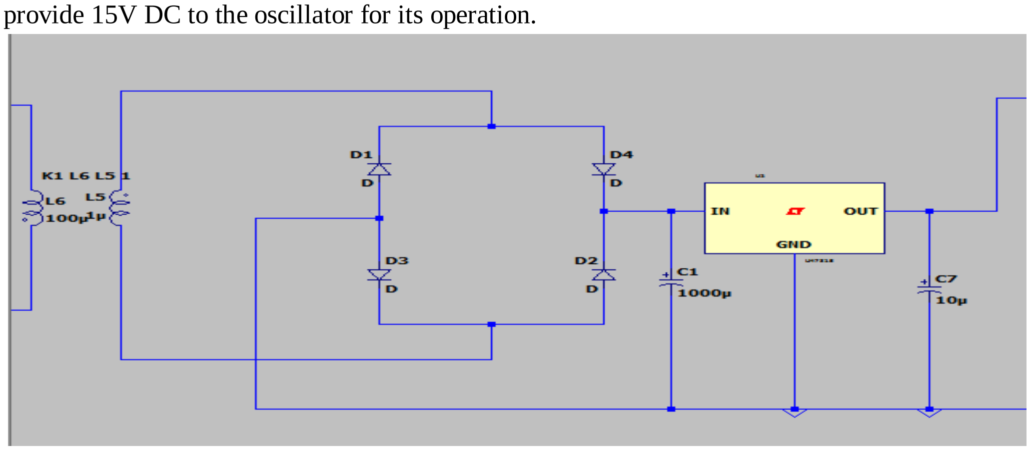

Fig. 4 Bridge wave rectifier and IC7805 regulator

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D. 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.

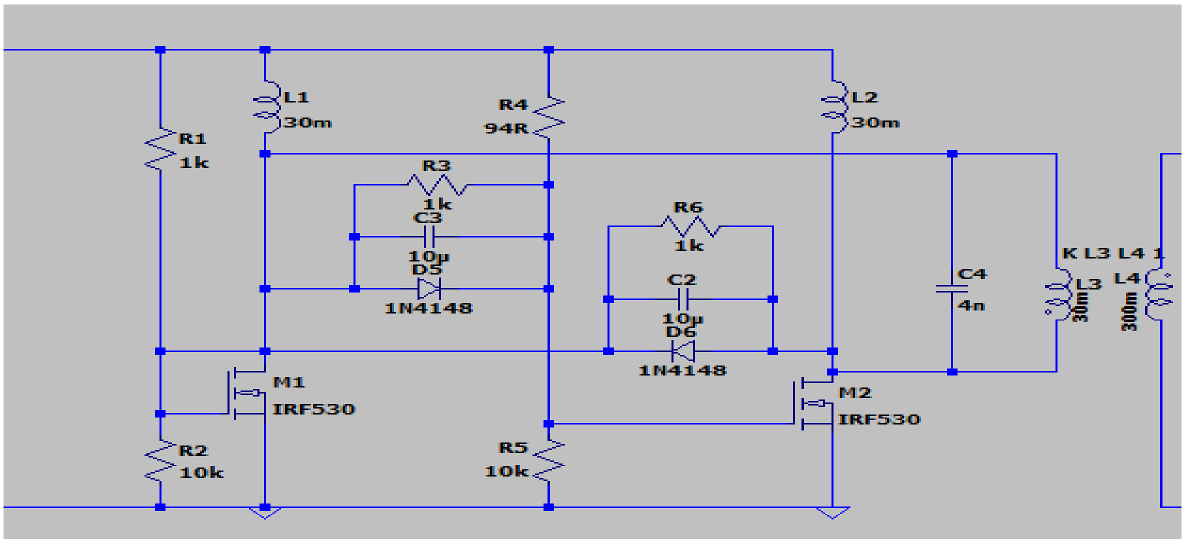

Fig. 5 Modified Royer's oscillator

E. 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.

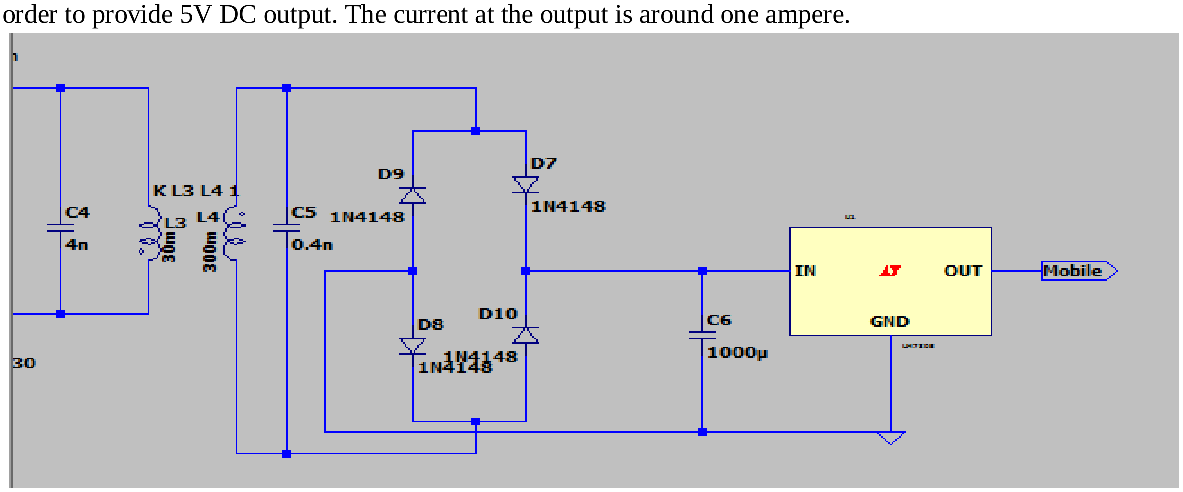

Fig. 6 Receiver circuit

F. 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:-

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$$\frac{1}{2\pi\sqrt{LC}} = f_r\ H_Z$$

While taking safety guidelines for public exposure into account, and maximum power transfer, a suitable frequency for the circuit can be obtained based on the standard chart by International Commission on Non-Ionizing Radiation Protection(ICNIRP), which is an international commission on specialized in non-ionizing protection.

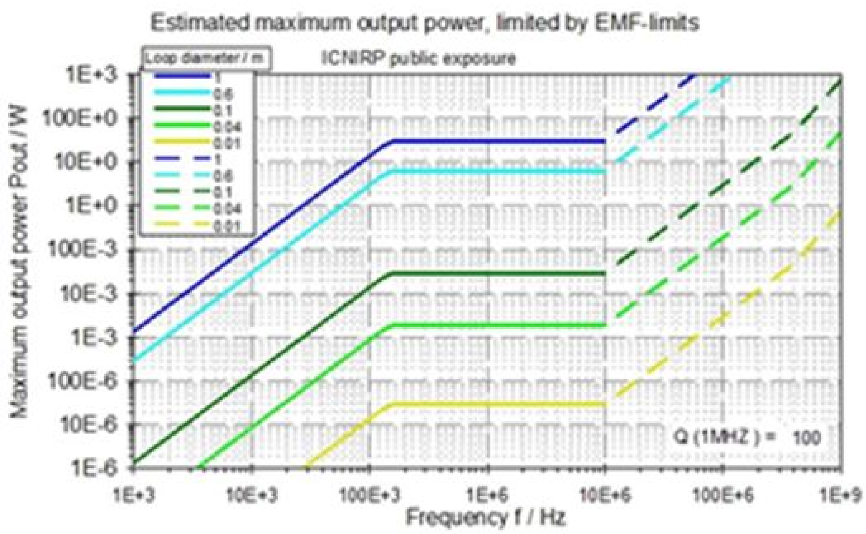

Fig. 7 Maximum power output at various frequencies

From the chart it is clear that for frequency range between 150kHz and 10MHz, the maximum power is independent of the operating frequency. For frequencies lower than 150kHz, the maximum power reduces with reducing frequency. Considering interference, charging distance, transmission efficiency, thermal properties lower frequencies are more preferred than higher frequencies. Hence, resonant frequency of 460kHz is taken in this project.

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

$$f = \frac{1}{2\Pi\sqrt{4*10^{-9}*30*10^{-6}}}$$

$$f = \frac{1}{2\Pi\sqrt{120*10^{-15}}}$$

$$f = \frac{10^{7}}{2*\Pi*3.4641}$$

$$f = 459.44kHz$$

Fig. 8 Resonant frequency calculation

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III. RESULTS AND DISCUSSION

The circuit diagram shows step down transformer, transmitter and receiver coils, as shown in figure 9.

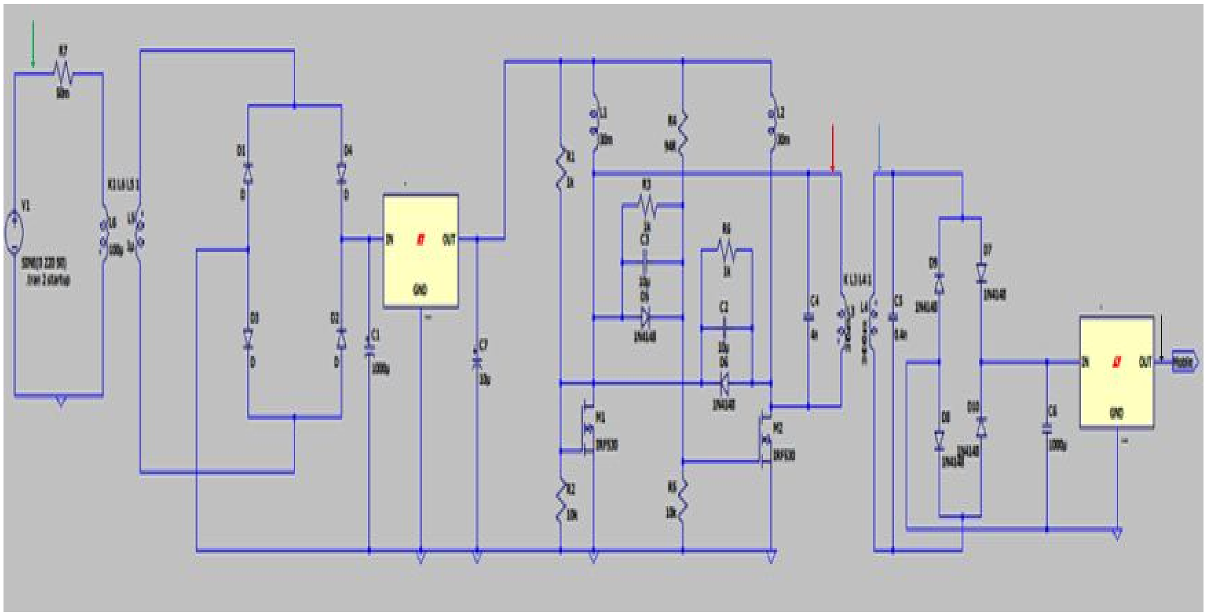

Fig. 9 Circuit diagram of the designed model

Figure 10 shows the waveform at the input voltage supply which is marked by a green arrow as shown in figure 9. The input voltage is an alternating voltage with an amplitude of 220V and a frequency of 50Hz. X-axis represents the voltage in volts and y-axis represents time in seconds.

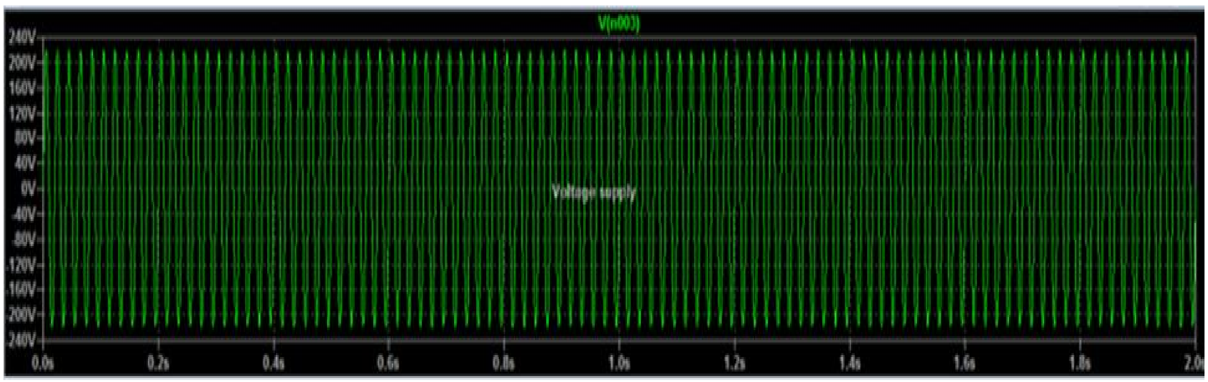

Fig. 10 Waveform of supply voltage

Figure 11 shows the waveforms at transmitter coil marked by a red arrow as shown in figure 9. Sine wave of amplitude nearly 5V is produced at the output of transmitter coil. X-axis represents the voltage in volts and y-axis represents time in seconds.

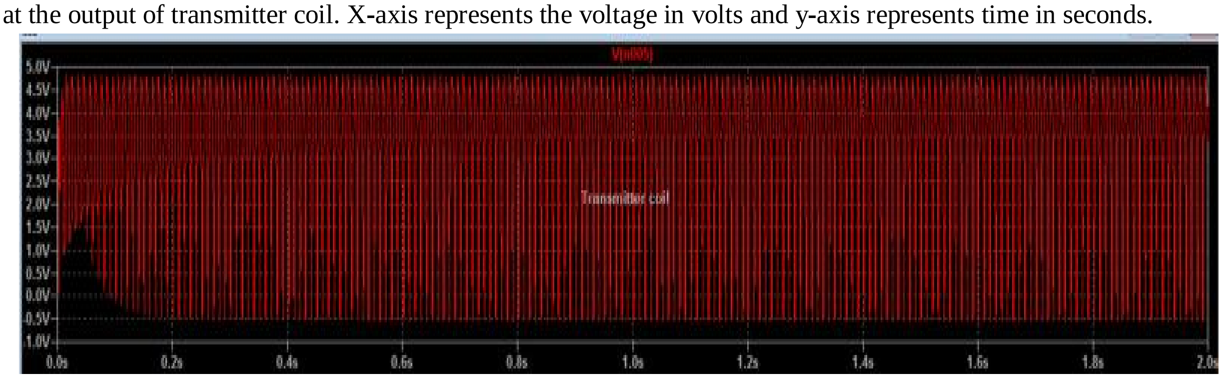

Fig. 11 Waveform at transformer coil

Figure 12 shows the waveform at receiver coil marked by a blue arrow as shown in figure 9. The receiver coil produces a sine wave of amplitude around 8.1V. X-axis represents the voltage in volts and y-axis represents time in seconds.

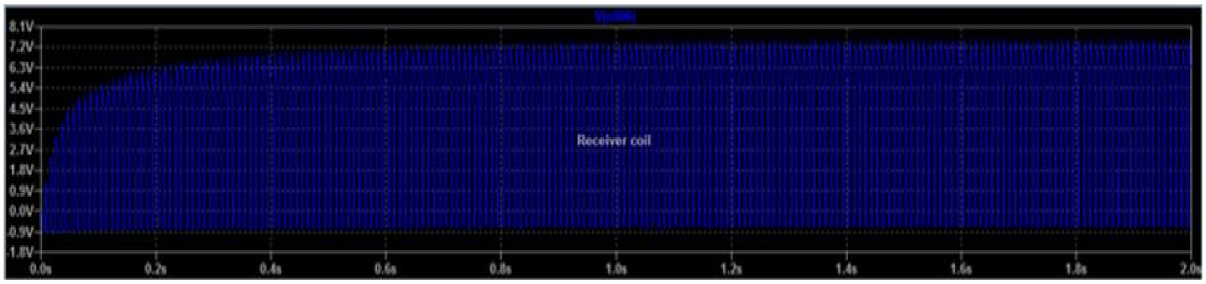

Fig. 12 Waveform at receiver coil

Figure 13 shows the waveform at the output marked by a red arrow. 5V output is obtained at the output of IC7805 voltage regulator. IC7805 specification tells that the output current is around one ampere.

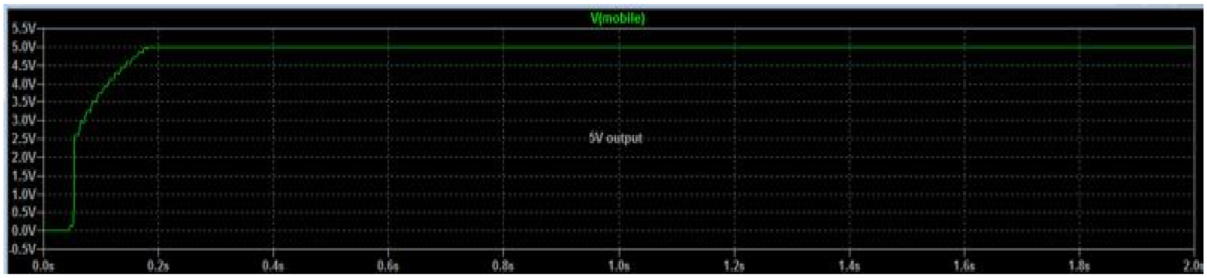

Fig. 13 5V DC output

IV. CONCLUSION AND FUTURE SCOPE

The model designed in the paper can be used to charge a number of electronic gadgets like ipads, ipods, propeller clocks etc. The method comes with many advantages, the important of which are increased convenience, cluttering of wires, reduced e-waste and many more. Wireless charging can be used in large scale only if the efficiency of the power transmission increases. A model can be designed so that all the devices could get charged by a single power transmitting source that eventually comes under a designed radius region providing no harm to human beings. In future, the amount of power lost between the charging pad and the device must be reduced. Also, the distance between the charging pad and the device must be increased. The designed model must be made cost effective.

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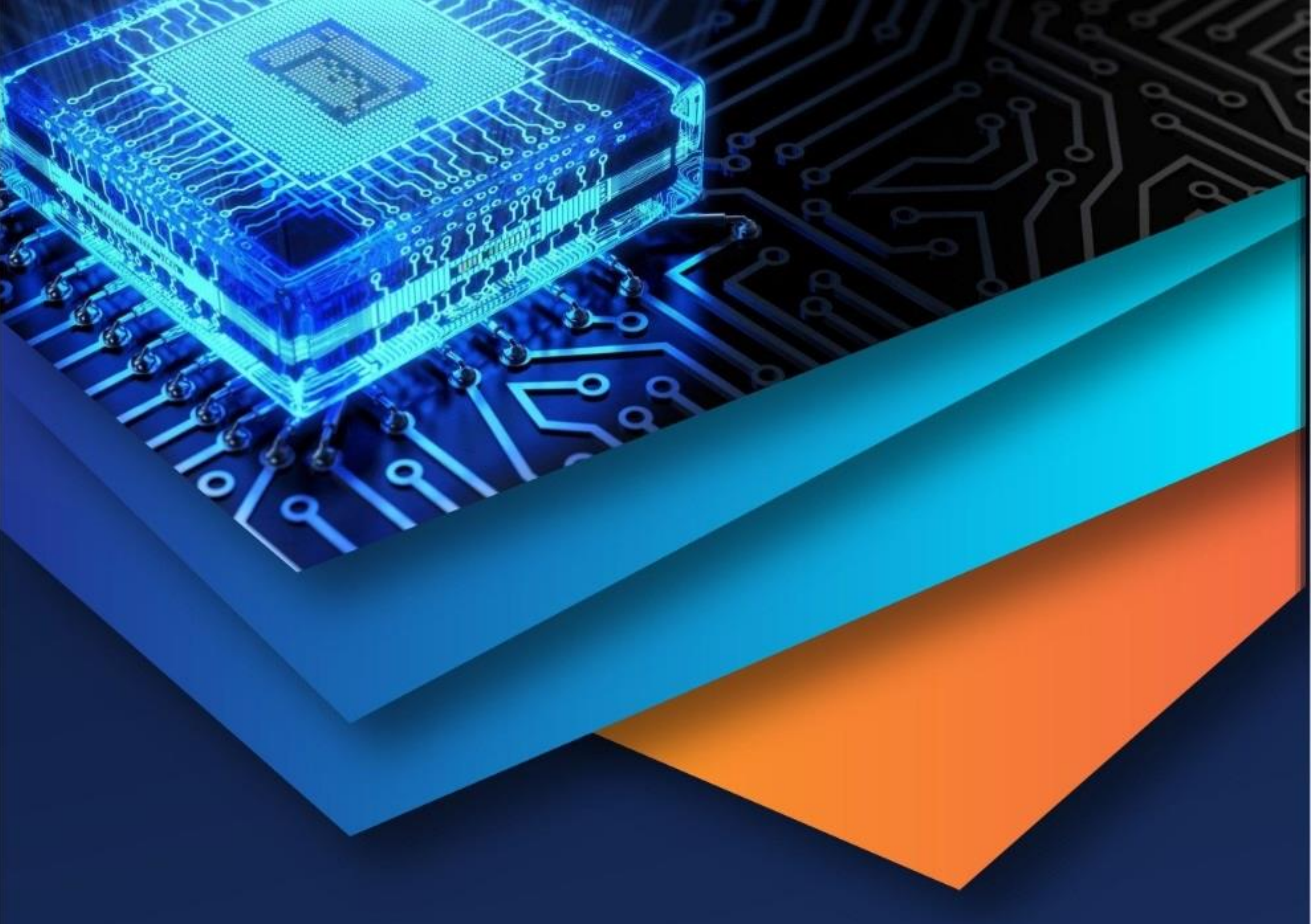

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