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Simulation of Wireless Power Transfer

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Abstract

Wireless Power Transfer is the transmission of electrical energy without wires as a physical link. The intent of this paper is used to simulate a few possible circuits and to obtain the output voltage with respect to time. In this paper, five circuits have been simulated using MATLAB/Simulink. All the circuits are based on inductive coupling and they have both transmitter and receiver sections. This paper proposes simple and easy to design circuits for wireless power transfer.
Keywords: Induction, MATLAB/Simulink, Tesla Coil, Wireless Power Transfer, Tesla Coil

I. INTRODUCTION

By the late 1800s, electricity had long been discovered and was no longer considered a novelty. The science of how to store, enhance, or transmit electrical current was just beginning to evolve, and eccentric scientist Nikola Tesla (1856-1943) was on the cutting edge of that research.

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. Tesla Coil uses the phenomena of mutual induction.
Mutual induction is a phenomenon when a coil gets induced an electromotive force across it due to rate of change current in adjacent coil in such a way that the flux of one coil current gets linkage of another coil.

Inductive coupling is the oldest and most widely used wireless power technology and virtually the only one so far which is used in commercial products.

A. *An Ancient Technology*

In ancient Egypt, it is believed that similar technology was being used. The pyramids are believed to work as energy transmitters that would send energy to other receptors across Egypt, such as the Lighthouse of Alexandria and several other receiver devices similar to the antennas developed by Nikola Tesla thousands of years after. The pyramids were constructed with insulating properties that would allow energy taken from underground aquifers to be conducted towards the tip of the pyramid (in which there was located a gold capstone, that would efficiently conduct electricity) and from there emitted trough large distances all across the country. This system of current generation from aquifers used by this ancient civilization follows the exact same principles of the Wardenclyffe Tower Tesla built and successfully operated as a wireless power transmitter.

II. METHODOLOGY

Five wireless power transfer circuits have been designed and simulated on MATLAB/Simulink. The first three circuits have been designed keeping in mind the currently available devices and thus the simulated results are close to practical. The last two circuits are a bit imaginative in the sense that that transistors used in the circuit would not have been able to sustain the high voltage in real life at the current moment. This is perhaps possible for a future work to expand upon. In all the models the output voltage with respect to time in seconds in analyzed.

III. SIMULATION AND RESULTS

1) In the first circuit, an ideal transformer is used with a turns ratio of 1:60. An npn transistor is used with base resistance of 22 kilo-ohm. A DC source of 9V is provided as input and the output obtained at the receiver side is 539.3588V.

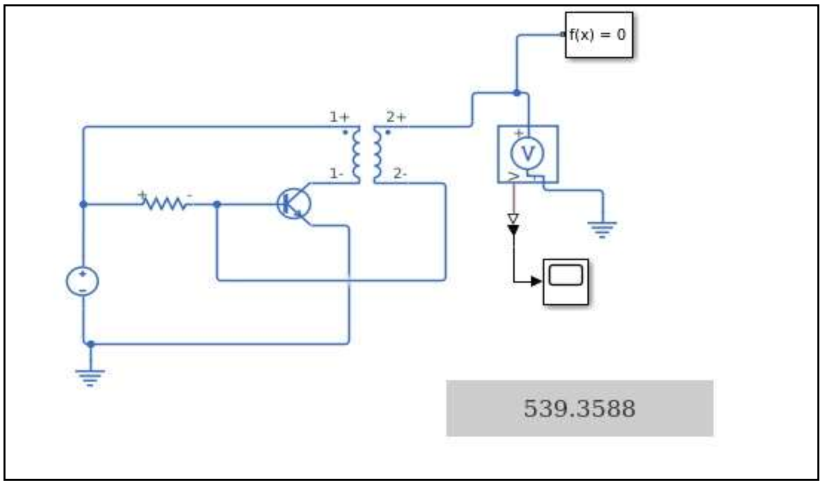

Fig. 1: Simulation Model of first circuit

Fig. 2: Output Voltage with respect to time(s)

2) In the second circuit, an ideal transformer is used with a turns ratio of 1:60. An npn transistor is used with base resistance of 22 kilo-ohm. A DC source of 9V is provided as input and the output obtained at the receiver side is 538.9095V. There is no electrical connection between the transmitter and the receiver.

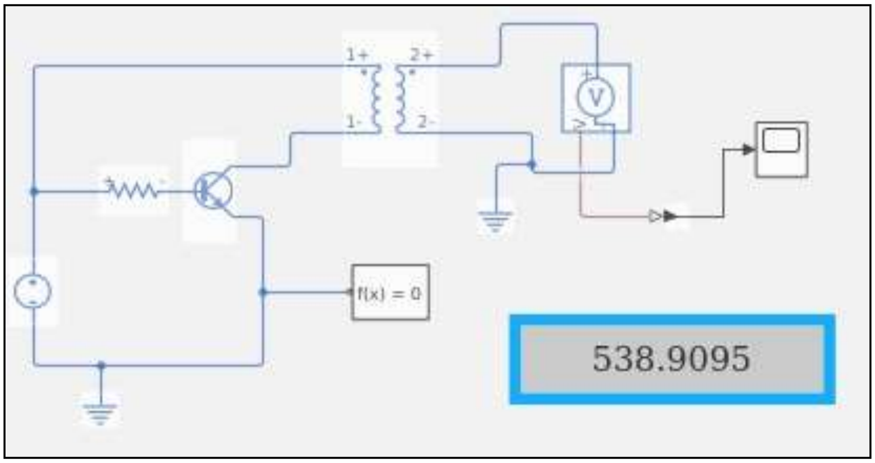

Fig. 3: Simulation Model of Second Circuit

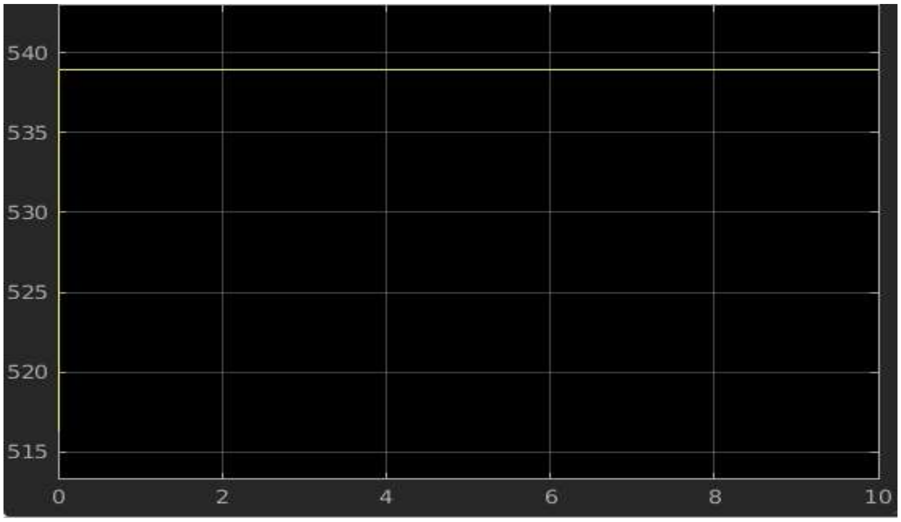

Fig. 4: Output Voltage with respect to time(s)

Here, the output voltage of Fig. 1 observed (shown in Fig. 2) is very high in simulation but in practice, this high voltage is not obtained. In Fig. 2, it is observed that the output voltage is constant but in practice, the output voltage is very oscillatory. In simulation, this constant high voltage is obtained due to measuring output voltage across the electrical reference (ground). The simulation result of Fig. 3 (shown in Fig. 4) is very close to the practical result.

3) In the third circuit an AC voltage source of 170V(amplitude) is applied across a mutual inductor having a coefficient of coupling of 0.6. The primary capacitance is 10H, the secondary capacitance is 0.1H, the primary inductance is 0.1mH, the secondary inductance is 10mH.

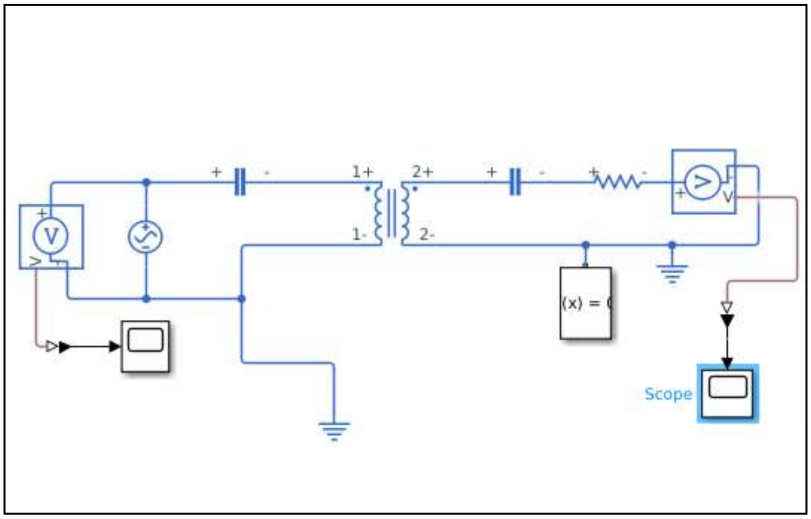

Fig. 5: Simulation Model of Third Circuit

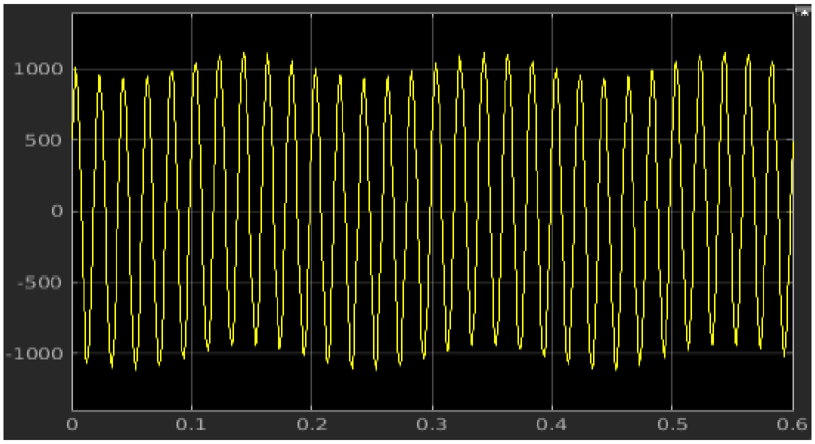

Fig. 6: Output Voltage with respect to time(s)

The peak output voltage of Fig. 5(observed in Fig. 6) is approximately 1117V. The ideal output should have been 1700V. The error is about 34%.

4) In this circuit, an ideal mutual inductor has been used with a coefficient of coupling of 0.6. The input voltage is 170V(peak)AC. The output is close to $3.8*10^3$V.

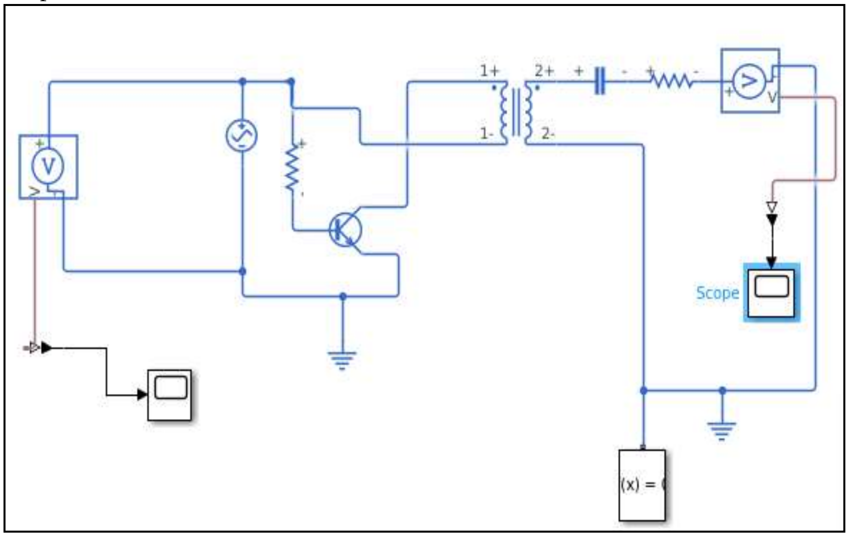

Fig. 7: Simulation Model of Fourth Circuit

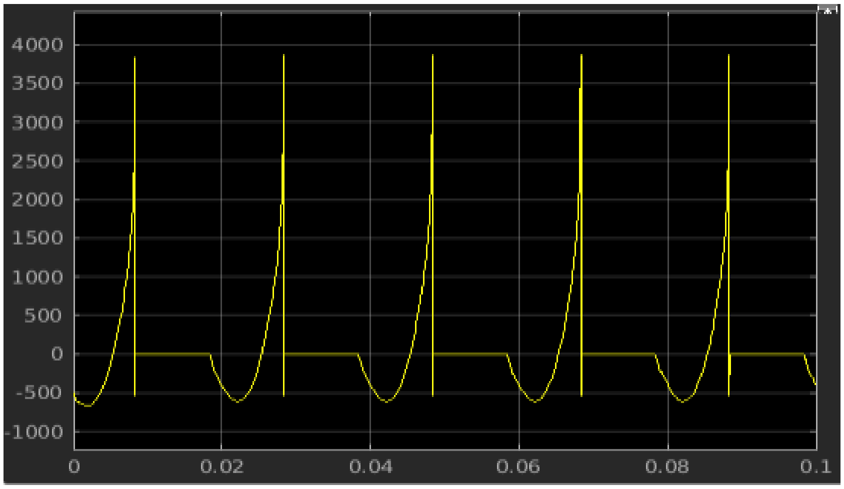

Fig. 8: Output Voltage with respect to time(s)

5) In this circuit, an ideal mutual inductor has been used with a coefficient of coupling of 0.6. The transistor has a base resistance of 2 kilo-ohm and collector resistance of 1.5 kilo-ohm. The input voltage is 170V (peak) AC. The output is $1.145*10^3$V.

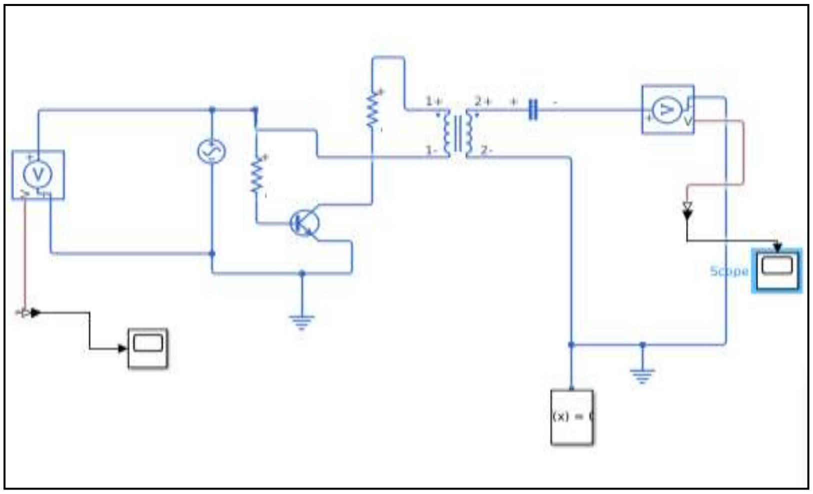

Fig. 9: Simulation Model of Fifth Circuit

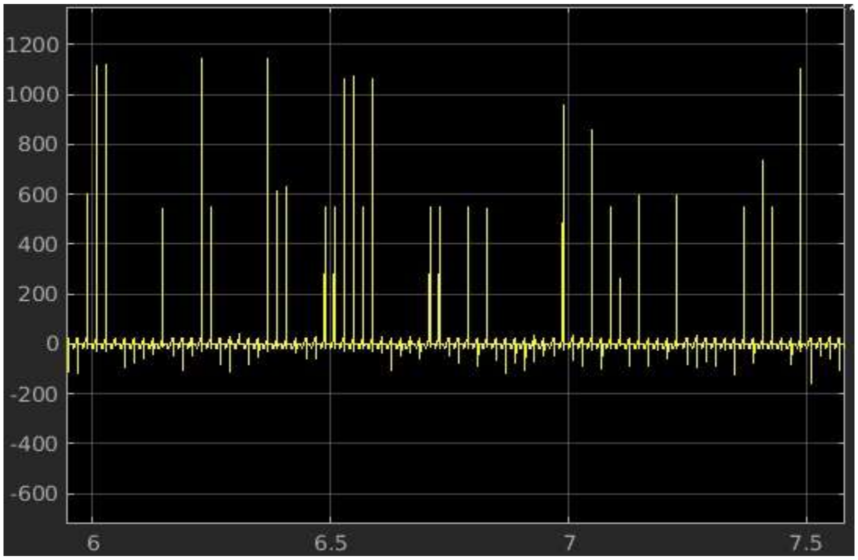

Fig. 10: Output Voltage with respect to time(s)

The simulation model of Fig. 7 and Fig. 9 is not currently practicable. There has not been such a transistor which can sustain such a high voltage. But if such a transistor ever be made, then these two circuits (Fig. 7 and Fig. 9) shall prove useful.

IV. CONCLUSION

Electrical power is crucial to modern systems. From the smallest of sensors to satellites, remote controlled airplanes, cars and robots, it is important to be able to deliver power by means other than wires or transmission lines. The use of wireless power transmission would allow for systems to operate remotely without the need for relatively large energy storage devices or routine maintenance. It shall also be employed in cases where interconnecting wires is inconvenient, hazardous or improbable such as in wet environments, rotating or moving joints as well as powering remote telecommunication equipment. With wireless electricity, the electrical system will be more secure as it will prevent user from electrocution of current and the power failure due to short circuit and fault or power loss on cable would never exist.

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