Universal Wireless Charging Device

Affeeq Ismail ‘17
Faculty Advisor: Professor Harry J. Blaise
Trinity College Department of Engineering

ABSTRACT

This project’s goal was to design a wireless charging system that uses the wireless power system to transfer energy between the transmitter circuit and receiver circuit via an electromagnetic field. The wireless charging system was broken down into two different systems, the transmitter circuit and the receiver circuit. The transmitter circuit was a Colpitts Oscillator, which was composed of an amplifier and a resonant tank circuit. The receiver circuit was composed of a resonant tank circuit and a rectifier. The main objective of this project was to determine the possible efficiency and distance of the charging system by testing different aspects of the coil. The coil was the system’s primary tool to transfer energy between the transmitter and receiver circuit. Coils purchased from manufacturers and coils built by hand were tested and compared. A flat spiral coil made of Litz wire with a magnet core was able to maximize charging distance and had greater efficiency than other coils. It had 15 percent power transmission efficiency at a vertical distance of 5mm.

REFERENCES

1. “Power Transmission Analysis of a Wireless Power Transfer System with Opposing Cores.” JMAG. https://www.jmag-international.com/catalog/113_WirelessPowerTransfer_OpposingCores_PowerTransmission.html.

ACKNOWLEDGEMENTS

Nazri Abdilahi ’17
Caroline A. Lee ’17
Professor Harry J. Blaise
Professor John Mertens
Professor Deborah Fixel
Trinity College Department of Engineering

PROJECT DESCRIPTION

Wireless Power System (WPS) was invented by Nikola Tesla in the 1890s. WPS works by transmitting energy from a transmitter, which is connected to a power source, to a receiver across an air gap. Both the transmitter and receiver have a coil. The transmitter coil is energized by alternating current to induce a magnetic field, which is then received by the receiver coil.

GOAL

Design a wireless charging device that uses wireless power system to transfer energy between two objects via an electromagnetic field.

OBJECTIVES

1) Design a transmitter circuit that is able to convert DC into AC using an oscillator and transmit it via a transmitter coil.
2) Design a receiver circuit that able to receive AC current via a receiver coil and convert it back to DC.
3) Build a wireless charging system with discrete components.
4) Measure and record vertical distance of charging and power transmission efficiency of different coils.

THEORY

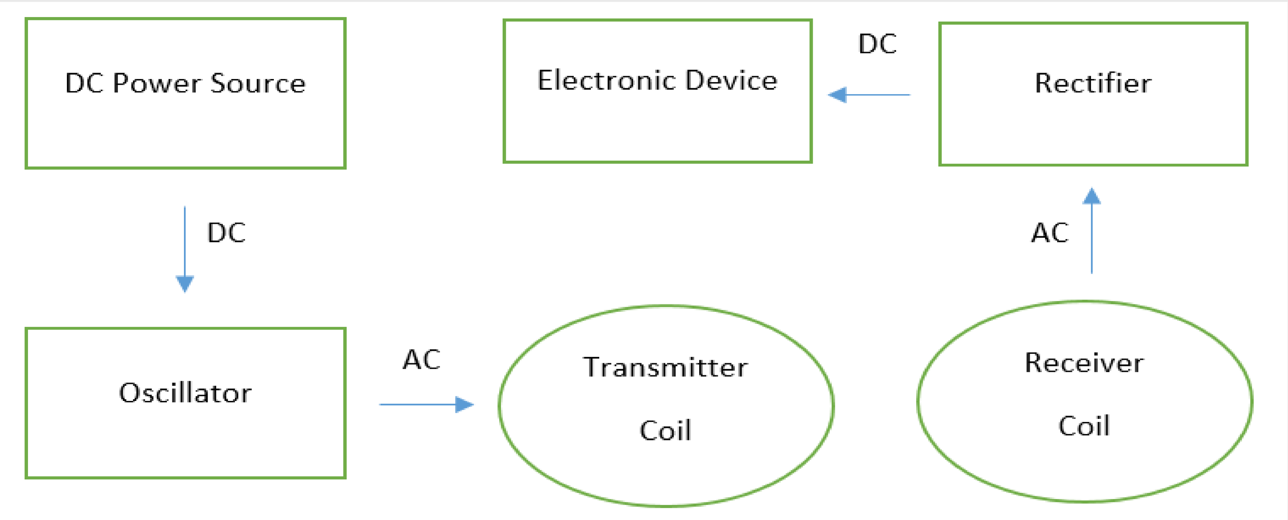
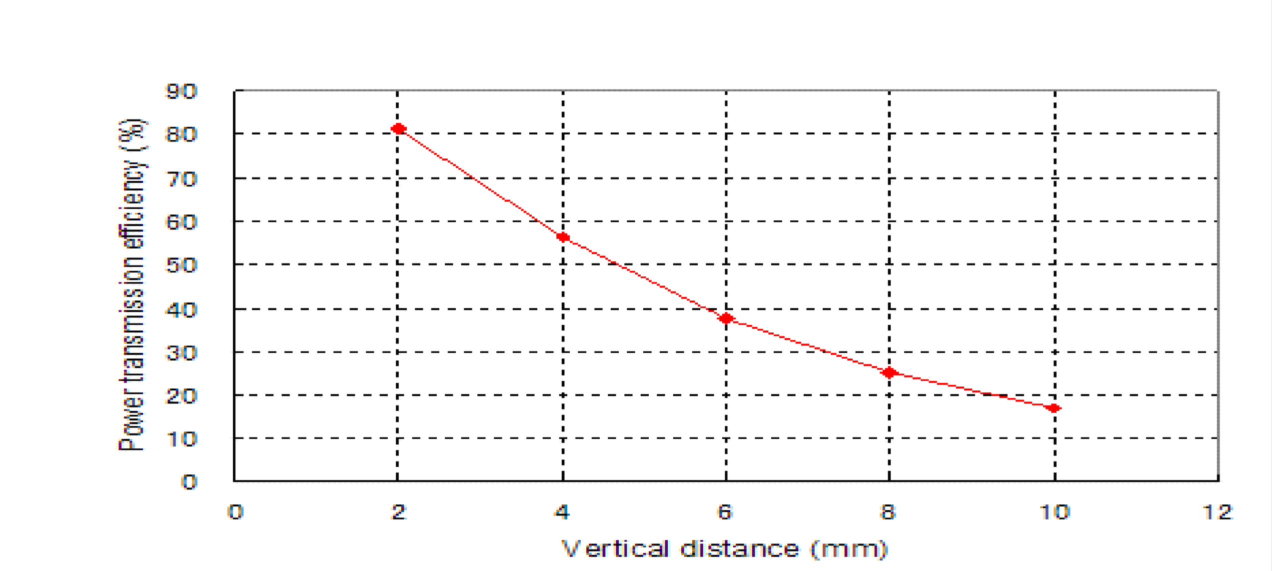


Figure 1: Wireless Charging Device Block Diagram



Graph 1: Measured Outcome from literature of Vertical Distance vs Power Transmission Efficiency [1]

PROCEDURE

1) A Colpitts Oscillator was built as a Transmitter Circuit. Colpitts oscillator composed of an amplifier and a resonant tank circuit. The resonant tank circuit had a capacitive voltage divider and an inductor that acts as the transmitter coil.
2) The receiver circuit had a resonant tank circuit and a rectifier. The resonant tank circuit had a capacitive voltage divider and an inductor that acts as the receiver coil. The rectifier was a Cockcroft-Walton two stage voltage multiplier. One stage of the voltage multiplier was composed of two diodes and two capacitors.
3) Two pairs of coils were bought from manufacturers and two pairs of coil were hand-build. Each pair of coils had different parameters.
4) Each pair of coils was tested for vertical distance of charging and power transmission efficiency.

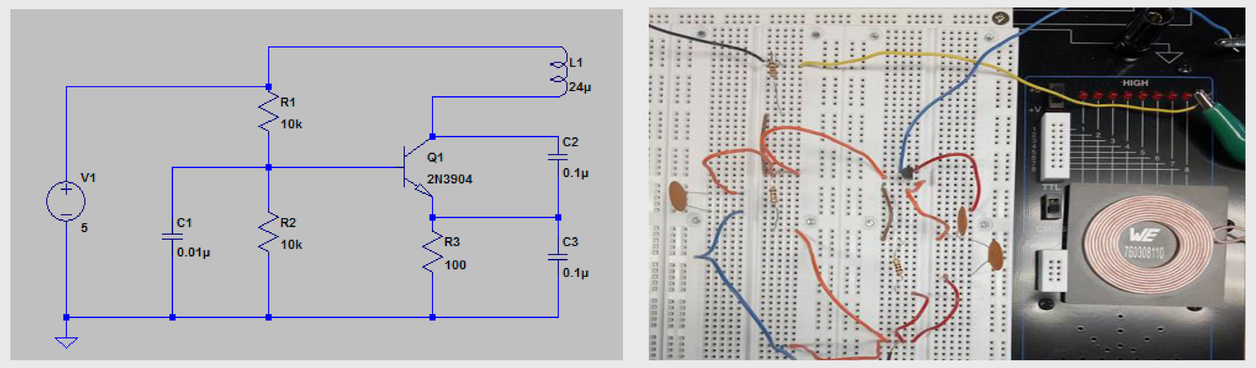


Figure 2: Schematic and Experimental Setup of the Transmitter Circuit

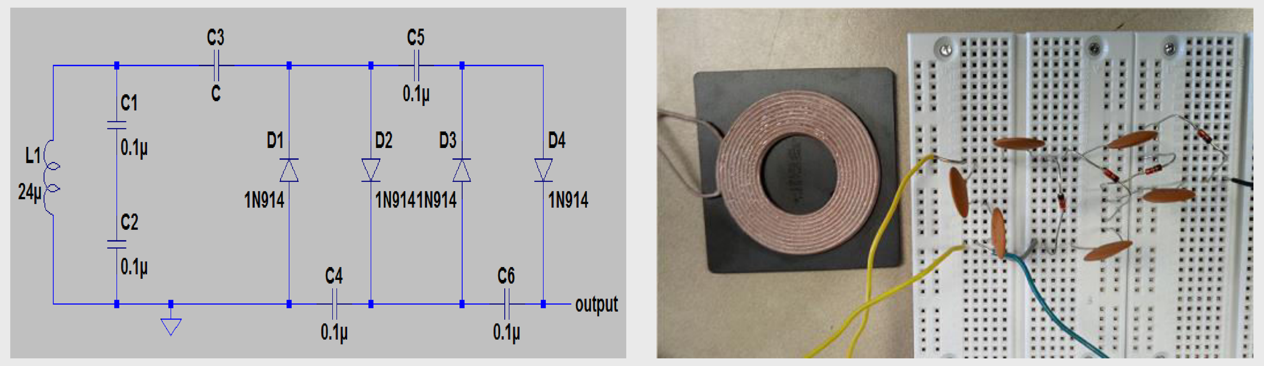


Figure 3: Schematic and Experimental Setup of the Receiver Circuit

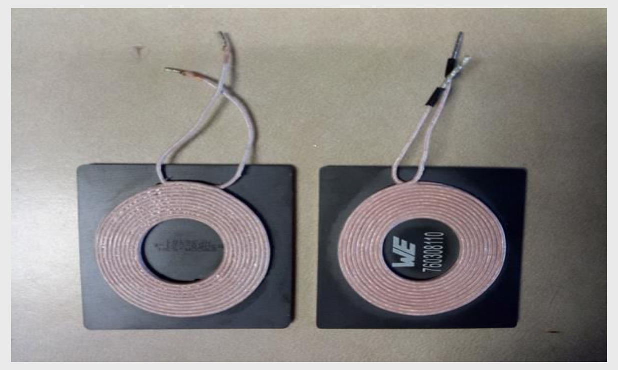


Figure 4: Litz wire 24µH flat spiral coils with a magnet core

Figure 5: Copper 30µH flat spiral coils

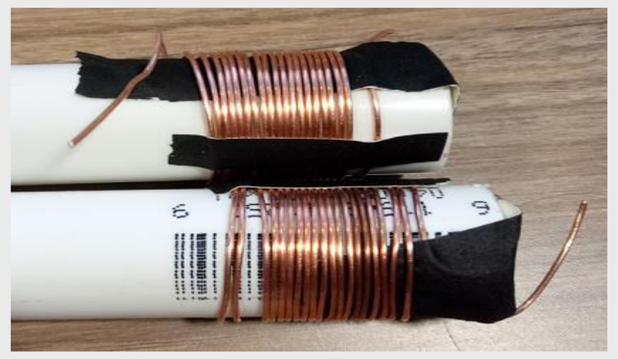


Figure 6: Hand-build copper 2µH cylindrical coils

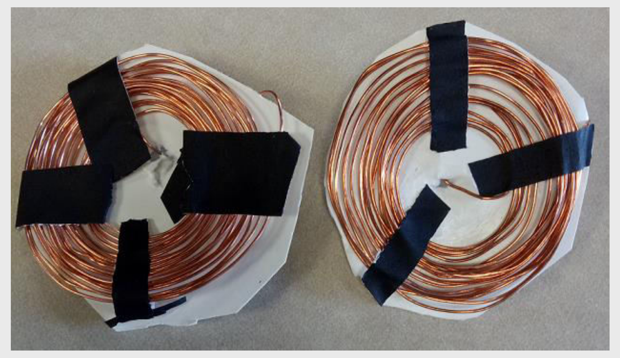


Figure 7: Hand-build copper 2.2µH flat spiral coils

RESULT

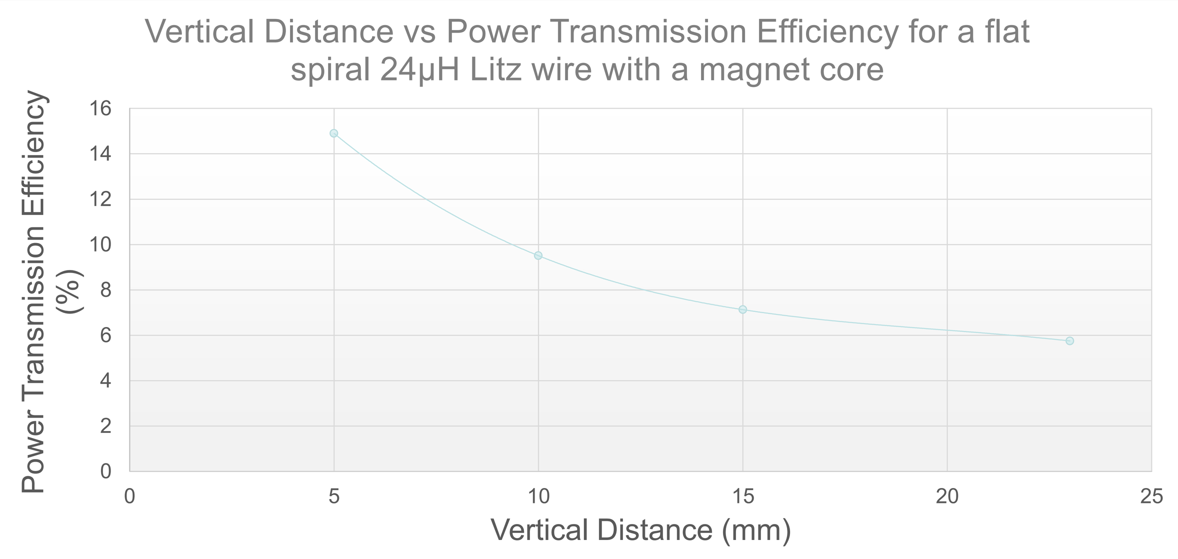
The flat spiral 24µH Litz wire coils with a magnet core had the best vertical distance of charging and power transmission efficiency for a tuned frequency of 146kHz.

Flat Spiral 24µH Litz wire with a magnet core			
Distance (mm)	Voltage (V)	Current (mA)	Power (W)
5	7.84	1.560	0.01223
10	7.17	1.087	0.00779
15	5.47	1.067	0.00584
23	4.91	0.9602	0.00471

Figure 8: Voltage, current and power output at different vertical distances

Power Transfer Efficiency for Flat Spiral 24µH Litz wire with a magnet core		
Power input at the transmitter = 0.0819 W		
Distance (mm)	Power (W)	Power Transmission Efficiency (%)
5	0.01223	14.9
10	0.00779	9.51
15	0.00584	7.13
23	0.00471	5.75

Figure 9: Power Transmission Efficiency of the flat spiral 24µH Litz wire with a magnet core at different vertical distances



Graph 2: Vertical Distance vs Power Transmission Efficiency for the flat spiral 24µH Litz wire with a ferrite core

DISCUSSION AND CONCLUSION

The wireless charging system was built to work best for the flat spiral 24µH Litz wire coil. The flat spiral Litz wire coil had a high quality factor at about a range of 100kHz-200kHz. The resonant tank circuit was tuned to oscillate at 146kHz.

The other coils were unable to work well due to two reasons; skin effect and radiated losses. These losses decrease the quality factor of the coils. In order to make them work better, the resonant tank circuit should be tuned to oscillate at an optimum frequency when their quality factor is at its highest.

The wireless charging system built using discrete parts was successfully able to transmit power wirelessly. The system had a power transmission efficiency of 15% at a distance of 5 mm. The system works best using a flat spiral 24µH Litz wire with a magnet core as its transmitter coil and receiver coil.