Collecting and Storing Wireless Power from a RF Source

Justin D. Blair

Department of Microelectronic Engineering, 82 Lomb Memorial Dr., Rochester, NY 14623

Abstract – This study involved transferring power wirelessly through inductive coupling. The goal was to create a receiver device capable of powering a rectifying circuit and charging a capacitor while being at least 20 mm away from the transmitter device. This device should also be capable of receiving power when separated by non-conductive mediums other than air. The study was successful at transmitting power through an RF transmitter into an RF receiver at voltage ranges of 1V – 14V and ranges of 0cm – 20cm. It was able to charge an 80 nF capacitor to 8.39 V and had a fall time of 573 ms.

VII. Introduction

Wireless power over inductive coupling has been in development for decades. Currently there are few commercial products on the market and most are related to charging mobile devices consumers carry with them throughout the day. Another area where this technology would be useful is the medical industry. A pacemaker is a medical device that regulates the patient's heart and is implanted under the skin. The device runs off a battery and has a lifespan of 7 to 10 years. Every time the battery runs out on one of these devices the patient must undergo surgery to have a new battery installed. If the pacemaker had a receiver device attached to it that was capable of receiving wireless power it could charge the battery through the skin and increase the lifespan of the pacemaker, which would reduce the number of surgeries the patient would have to go through.

VIII. The Transmitter and Receiver circuits

For wireless power from inductive coupling to work two devices are necessary, the transmitter and the receiver. One device is physically connected to an external power source while the other receives power from the other via inductive coupling of coils.

A. The Transmitter Device

The circuit diagram for the transmitter device used in this study is shown below in figure 1. The device consists of an AC power source connected to a current amplifier, which then powers the transmission coil. The current amplifier has a +/- 15 V DC source supplied to the source of each BJT. This device is designed to supply an AC signal to the transmission coil with a very high current.

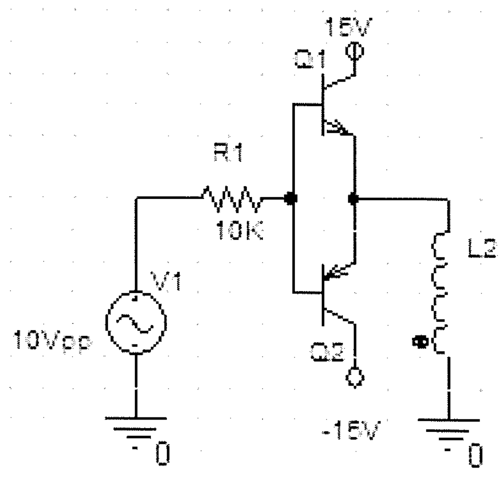

Fig. 1. PSPICE circuit diagram of the transmitter device

B. The Receiver Device

Below in figure 2 is the receiver device circuit diagram. This device has three major components: the coil, the rectifier circuit, and the capacitor. The receiver coil collects RF signal from the air and

converts it to AC signal. This signal is fed into the rectifier circuit, which consists of four PMOS transistors. The purpose of the rectifier circuit is to convert the AC signal to a DC signal. This signal will then charge the capacitor.

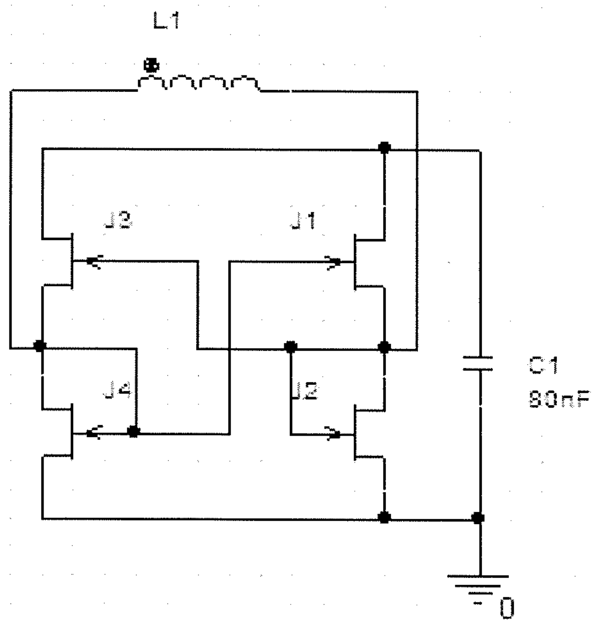

Fig. 2. PSPICE circuit diagram of receiver device

C. *The Fabricated Setup*

Shown below in figure 3 is a picture of the fabricated setup. The transmitter device is on the left and was constructed on a breadboard. The transmitter coil is 75 mm diameter and has 50 turns. On the right side is the receiver device. A PCB was designed and fabricated for the receiver, as it was the focus of this study. The receiver coil sits behind it and is also 75 mm diameter with 50 turns.

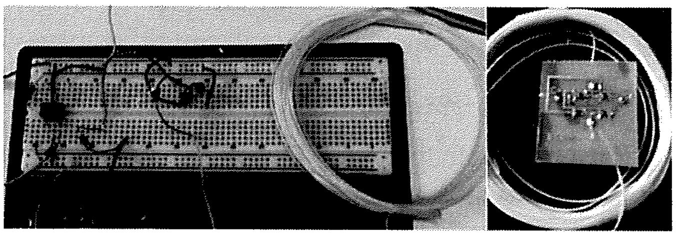

Fig. 3 Picture of the transmitter and receiver devices taken in the test lab at RIT.

IX. Measurement Results

A. *Coil Dimensions*

Figure 4 is a plot of voltage on the receiver coil vs. distance from the transmitter coil for various coil dimensions. For both the transmitter and receiver coil the diameter and number of turns were varied to determine the maximum range while maintaining a reasonable size. The coil diameter ranged from 50 mm – 70 mm and the number of turns from 5 to 50.

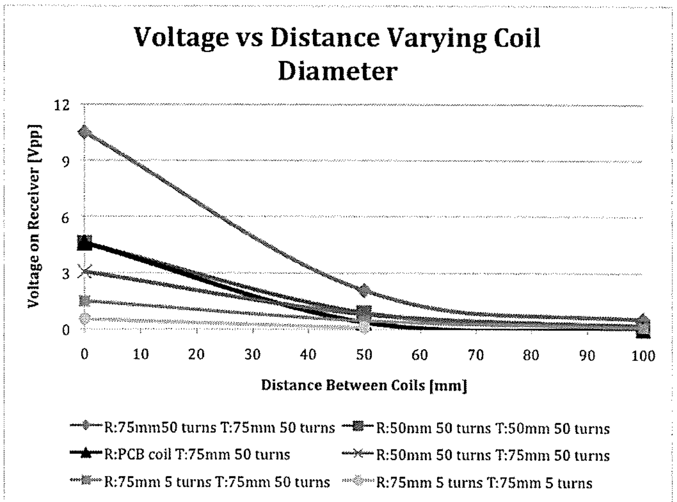

Fig. 4. Excel plot of voltage vs. distance for various transmitter and receiver coils. Coil diameter was varied from 50 mm to 75 mm. The number of turns in the coils were varied from 5 to 50 turns.

The maximum voltage measured on the receiver coil was 10.5 Vpp. This was captured using 75 mm diameter coils with 50 turns on both the receiver and transmitter device. These coils have an operating range of about 50 mm and recorded a voltage at a range of 200 mm.

B. *Charging the Capacitor*

The figure below (figure 5) is an oscilloscope capture of the 80nF capacitor on the receiver device discharging. The maximum voltage on the capacitor was 8.39 V and the fall time was 573 ms.

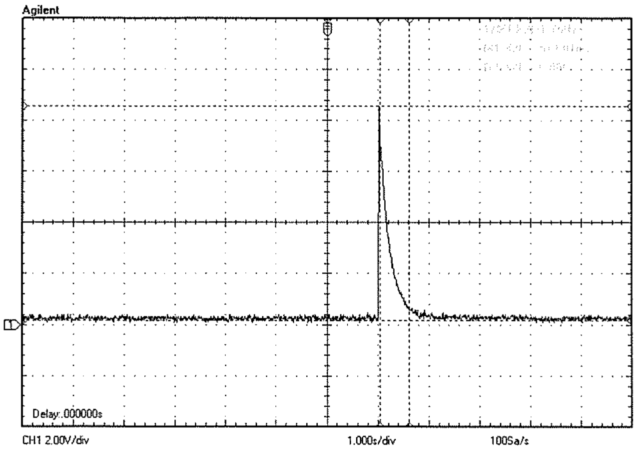

Fig. 5. Oscilloscope capture of a discharging capacitor attached to the receiver device. Vmax was 8.39 V and fall time was 573 ms.

C. Charging the Capacitor

Figure 6, shown below is an oscilloscope capture of the receiver coil while it was placed 25 mm away from the transmitter coil. In this setup the coils were separated by water instead of air. This was to simulate the implantation of the receiver device. The recorded voltage was 5.55 Vpp, which was discernable from the capture with air as the medium.

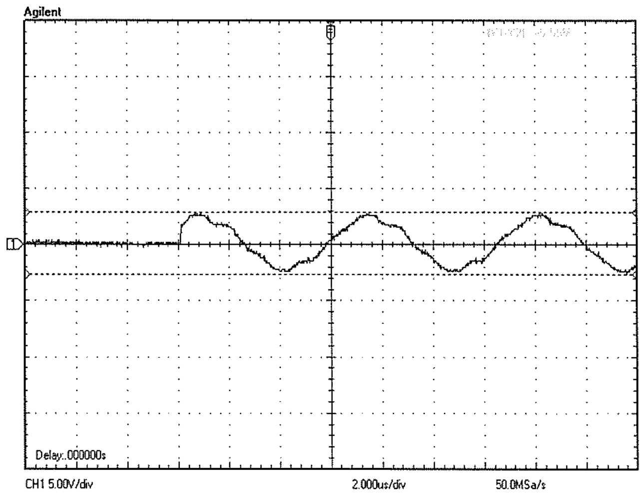

Fig. 6. Oscilloscope capture of the receiver coil when separated from the transmitter coil by 25 mm of water. Vmax was 5.55 Vpp.

X. Conclusion

This study looked at the transmission of power wirelessly from a transmitter device to a receiver device via RF. Other goals included being able to charge a capacitor with this power and also being able to transmit the power through mediums other than air. Every task assigned was completed and proved successful.

The device was capable of transmitting a maximum voltage of 10.5 Vpp at no separation. The device had an operating range of 50 mm and was able to see a voltage at a distance of 200 mm. This means that the device would be capable of reaching a device implanted in the body.

The receiver device also operated properly and was successful at charging an 80 nF capacitor to 8.39 V. The capacitor was recorded discharging over 573 ms. This means the device would be capable of charging the battery of an implanted device while the transmitter device is supplying RF signal to the receiver coil. This means the patient could wear the transmitter device on their body when they sleep and provide a trickle charge that would increase the lifespan of the implanted devices battery.

Finally the receiver coil was able to receiver 5.55 Vpp when separated from the transmitter coil by 25 mm of water. This means it will be capable of transmitting power through the skin of a patient. There was no discernable loss when transmitting through water vs. air.

In conclusion, using wireless power through inductive coupling to charge implanted device should be possible. This technology could increase the lifespan of implanted devices that run off of fixed batteries and reduce the number of surgeries the patient must under go to replace said devices.

Acknowledgment

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References

[1] Christian Sauer, Power Harvesting and Telemetry in CMOS for Implanted Devices", IEEE Transactions on Circuits and Systems: Regular Paper, Vol 52, pp 2605 – 2613, December 2005