UPII Honors Project

Wireless Power

By: Bryan Casillas

Lab Section: H2

Due April, 26, 2011

Bryan Casillas

UPII Lab: H2

Dr. John Stewart

Due: April 26, 2011

Wireless Power

The demand for consumer electronics has increased exponentially throughout the last decade. The past ten years have seen the development of more consumer technology than any past century. The personal computer, or PC, has made its way into millions of homes. Innovations in telecommunications have developed a booming market for cellular phones, laptops, PDAs, and other information oriented devices. Portable music was revolutionized by the introduction of the Apple iPod in late 2001. Households have gone from possessing a single television to having one in every living area. Consumer electronics have truly made their way into nearly every part of life.

One thing that these consumer electronics all have in common is a thirst and requirement for power. A problem that arises when one owns multiple electronic devices is getting power into the device's batteries or finding a plug to supply the required amount of power. Each electronic device has its own separate means of receiving power. Electronics without batteries must have their own separate plugs, and many electronics with batteries have a unique adapter that only works with that specific brand, model series, or product. There are jumbles of wires to fuss over, and many hazardous electrical arrangements arise that overload power strips and breakers. As technology makes daily tasks easier the troubles of supplying power to these devices remains ever so exasperating. The answer to this growing problem is widespread implementation wireless power enabled devices.

The physics allowing wireless power transmission to be possible involves the creation of magnetic fields through the use of current and the induction of an associated current in a separate device. The current in the second wire is induced because of an electromotive force, or EMF. Michael Faraday is credited with the discovery of electromagnetic induction and the equation for calculating EMF. Through his experiments, Faraday made a peculiar observation. He noted that once the current in the primary wire was constant no current was induced in the secondary wire. Faraday then began changing the current in the primary wire, which induced a current in the secondary wire (Bragg 1931). This observation is the discovery of electromagnetic induction.

Electromagnetic induction is defined as, "The production of an electromotive force in a conductor when there is a change of magnetic flux when there is a relative motion of the conductor across an magnetic field" (Daintith and Martin 2010). Faraday's equation relates the EMF produced to the time rate of change of magnetic flux:

$$emf = -\frac{d\phi_m}{dt}$$

Where ϕ_m is the magnetic flux with respect to time. The equation for magnetic flux of a flat coil is as follows:

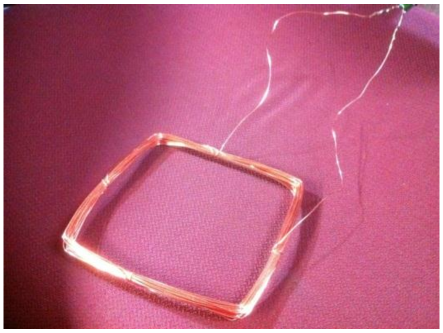
$$\phi_m = NBA$$

Where N is the given number of turns for the coil, B is the magnetic field in which the coil rests, and A is the area of the coil. In order for there to be a current induced in the secondary coil, the magnetic field must be moving or the coil must be moving through a magnetic field (Visser 2005). Both of these movements induce current, because according to Lenz's Law, "When a magnetic field and an electrical circuit are moved in relation to one another, an electric current is induced in the circuit such that it forms a magnetic field opposing the motion" (Allaby 2008).

This definition is an expansion of Faraday's Law that defines the direction of the induced current when the motion of either the magnetic field or coil is known.

For my experiment I wanted to demonstrate a simple wireless energy transfer. To do this I required the following materials: 22-gauge wire, 30-gauge wire, 0.02µF capacitors, 2.6 volt LEDs, and an AC square wave generator. To demonstrate wireless energy transfer I constructed a primary coil and 2 secondary coils. The primary coil consists of 22-gauge magnet wire with 26 turns and a 0.02µF equivalent capacitor attached to the tails. The two secondary coils consist of 30-gauge magnet wire with 0.02µF equivalent capacitors and a red 2.6V LED attached to the tails. One of the secondary coils has 26 turns (same as primary coil), and the other has 52 turns (double primary coil). All wires were sanded at the tips to remove the enamel coating. The LEDs and capacitors are soldered in place to ensure a secure electrical contact. The primary coil is attached to the AC square wave generator using alligator clips. When the wave generator is turned to 51kHz and one of the secondary coils placed within the changing magnetic field produced by the primary coil, the LED attached to the secondary coil illuminates. This is because the AC current flowing through the primary coils creates a constantly changing magnetic field. This changing field induces current in the secondary coil, which powers the LED.

Pictures:



Primary Coil

Secondary Coils

In conclusion, the experiments of Michael Faraday allow the possibilities of wireless power transfer to be possible. With an increasing demand for consumer electronics, the demand for widespread installation of wireless power will grow. Wireless power will soon make its way into the homes of nearly all with consumer electronics. Possible applications of wireless power transfer include effortless charging of one's cellphone and laptop within their home. Wireless power will one day be expanded to the roadways of America, where cars will no longer require fuels to propel them. The road will have power flowing through coils and every vehicle will have a secondary coil mounted to the undercarriage of a vehicle. Wireless power is just beginning its journey into the lives of millions.

Bibliography

Allaby, Michael. *Dictionary of Earth Sciences.* Oxford University Press, 2008.

Bragg, William H. "Michael Faraday." *The Scientific Monthly*, December 1931: 481-499.

Daintith, John, and Elizabeth Martin. *Dictionary of Science (6th Edition).* Oxfor University Press, 2010.

Visser, Hubregt J. *Array and Phased Array Antenna Basics.* John Wiley & Sons, 2005.