Wireless Electromagnetic Chargers

ENEE 2611

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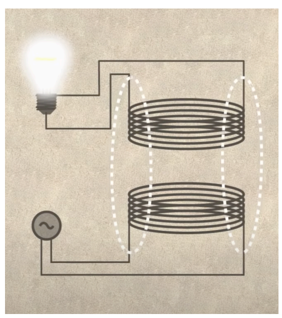
I. Introduction (*Wireless Charging*)

The technology behind wireless charging has been around since 1901 back when historical figure Nikola Tesla intuitively applied what Faraday discovered about electromagnetic fields, even further back in 1831. Nikola Tesla saw how electric current and electromagnets had a relationship and created a way to give power to a lightbulb. He used AC power connected to coils and ran a current through them. The lightbulb was also connected to a coil of wires that was then placed near the coil with current running through them.The current running through the wires near another set of coils caused what we know as faradays law to create a current in the second set of coils thus bringing light to the bulb wirelessly for the first time in human history. Nikola Tesla was a head of his time in many regards, and unfortunately this incredible discovery could not be integrated into much of the technology at the time. Wireless chargers for mobile phones were the major. use of them, about one-hundred years after Tesla's work. Now engineering can theorize making their own wireless chargers and theorize about how far wireless charging can go.



II. Ease of Use

A. Design

The basic design of any wireless charging system includes four components: AC current, a set of coils, a power rectifier and stabilizer, and the component that is being charged.

AC current must be used as electromagnets cannot induce current on one another with regular DC current.

The set of coils and equation are preferably copper as they have a low electrical resistance ideal for electromagnetic devices.

The power rectifier and and stabilizer is integrated because most devices that need charging require DC current and steady voltage which is best converted by these transmitter/receiver devices.

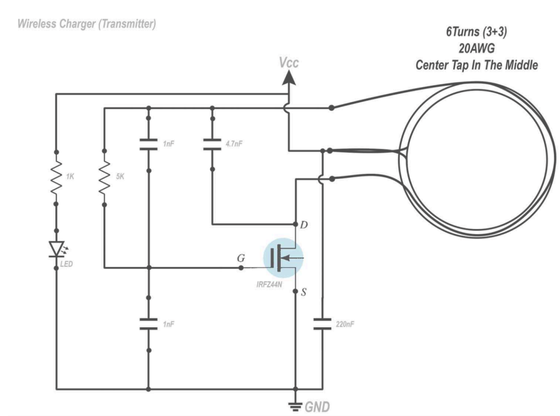
Many devices already carry a wireless charging system inside them, any that don't will require their own set of coils and simple components to receive this energy.

B. Worldwide use.

More and more people are using wireless chargers every day and from leaving your phone on a pad to parking a Tesla electric vehicle on a inductive parking spot, we are making quick progress on the effectiveness and the intricacies of electromagnetic charging to fit our everyday needs,

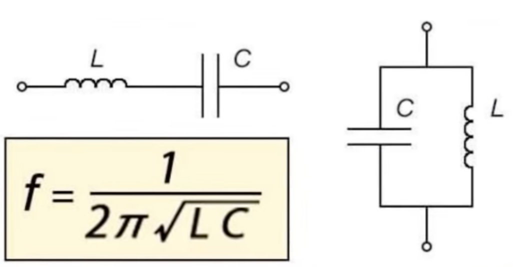
III. Transmitter

- Composed with aid from capacitors, diodes resistors, and a MOSFET transistor the transmitter has a simple schematic that can be analyzed by any student with any background with an electronics class.



C. Equations

The inductor from the coils and a capacitor in series is used to create an LC tank. This LC tank will be used to create the correct resonance for the transmitter. We start by finding the correct inductance using the frequency equation for and LC tank.



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

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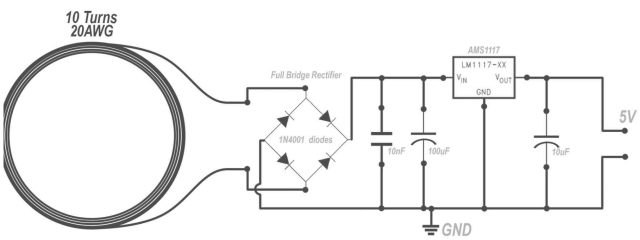
- Rearranging the equation, the inductance can be show to be:

$$L = \frac{1}{4\pi^2 F_R^2 C}$$

- The MOSFET transistor allows for the user to be able to switch the coil in the system with different resonating frequencies.
- Connecting the transmitter to a 5V alternating current supply, an oscillating frequency can be seen with an oscilloscope. After moving an electrically charge coil to the transmitter, it is immediately affected and the frequency amplitude and intensity maneuver according to the coil.

IV. Receiver

- Made with only diodes, and certain capacitors, the receiver is the component that will obtain the data given by the transmitter in order to be able to convert the AC current into something that a device can use for charging.



A. Equations

Turn ratio: The ratio between the number of coil loops in each side of the wireless charger will dictate how much voltage is applied and transferred from one coil to another, much like a transformer. If the number of of loops is the same for both, then the ratio is 1:1 and the resulting voltage is the same on both sides.

A third magnetic material can be added inside the loop to create a improve efficiency and to better canalize and navigate the magnetic field.

The four diodes create a rectifier that is used to basically convert AC current into DC current and allowing only voltage pulses to pass through. The rectifier essential converts every negative voltage from the AC voltage into positive and maintains a semi constant positive flow.

The capacitor at the output will stabilized the current and by storing it, will create a DC voltage source for the device.

Most devices will need the steady voltage that will be altered if the coil is moved away or closer to the receive which creates an issue effectively transferring power. To amend this a voltage regulator is installed to keep a constant output. An AMS111 voltage regulator will work perfectly and will keep the steady DC voltage at 5V when the current is transferred

The Voltage will now effectively be converted from AC power to DC power that will create a constant flow of electricity to charge the desired device..

V. Faradays Law

A. *The time varying magnetic field will induce a voltage dictated by faradays law of electromagnetism.*

Where A is the are of the coil, B is the amplitude of the magnetic field and w is frequency, having t as a time variable. We can manipulate the magnetic flux and field equation and isolate Voltage to find out how much voltage will applied to a device.

Magnetic Field and Magnetic Flux are show as

$$\phi = AB_0 cos(wt)$$

Rate of change= $\frac{d\phi}{dt} = -AB_0 wsin(wt)$

$$V_{emf} = NAB_o w$$

Area of the coil is show as

Area of coil A = $\pi(r)^2$

This is helpful to plug back into the previous equations to find necessary area you'll need for a specific device that may need more or less voltage as it is directly proportional to the amplitude of the voltage wave,

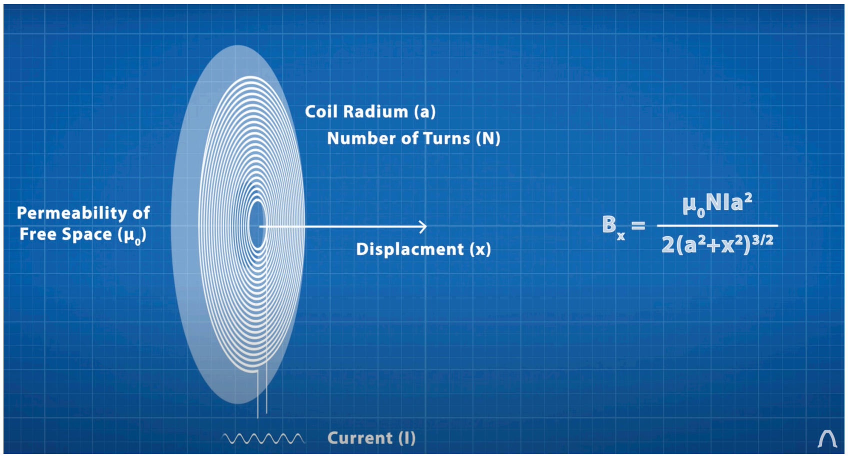
The current and Power of the wireless charging set up can be show through simple Ohm's law and Power law equations

$$R_{load} + R_{coil} = R_{req}$$

$$I = \frac{V_{emf}}{R_{req}}$$

$$P = I^2 \ R_{load}$$

B. The magnetic field that pairs with these equations will be directly interpreted from the equation below and the physical properties of the system itself:



VI. Should we Pursue Wireless charging

While a great many people consider wireless charging the next step in advancing as a civilization. There are some constrains and poor effects it can have on society that can negatively outweigh any good that can come from it if the world isn't careful.

The number of people who use wireless charging is exponentially growing, and with it the MW hours of electricity being used. Once companies find a way to make this technology more convenient, we may find ourselves in a situation where we can't make enough clean energy a day to compensate for the amount of electricity consumed.

The Wireless Consortium conducted a test on their wireless charger and found that with their wireless charger. It has an efficiency of around 59.4%. With 30 million iPhones sold in its first quarter alone, they provide around 415MWH per day after charging a phone once. With its efficiency they would add around 278 MWH to the grid everyday. In other words, 278 MWH is enough to power a home for 25 years. Keeping in mind that this is for only one phone and there are 2.5 billion phones in rotation and growing as of 2020. With induction charging this number could rise to more than twenty three thousand MHW of power used per day.

Creating clean energy to account for this load would equate to approximately one thousand four hundred new wind turbines created to account for this newly reported load. With teslas being accounted for this and each vehicle using the same power as a small family home a day, it would create problems upon problems to make up for this energy wasted. A city would theoretically keep up with this growth, despite this, the effort to provide convenience to only a percentage of a city's population added with the fact that this technology is still in its early stages and slightly inefficient. It does not seem worth the effort until the technology improves.

VII. The future

Improved bleeding edge technology might not be to distant however. Engineers are close to creating ways to have the same amount of voltage induced in devices with farther distances. Using lasers, brilliant minds are coming up with innovative ways to put satellites into orbit that send out electromagnetic beams that in theory could provide the a new revolutionary ways to charge devices without pads or parking spaces in more efficient ways.

With the help of solar ray technology, humans may be able to one day power devices around the globe through clean energy. Nevertheless, it is all based on numbers and systems yet to be effectively applied due to reenable energy causes.

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