Wireless Power Transfer

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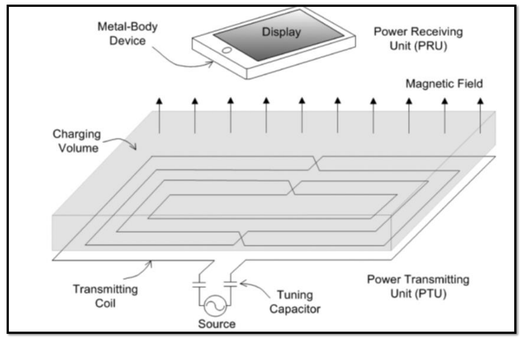
ABSTRACT

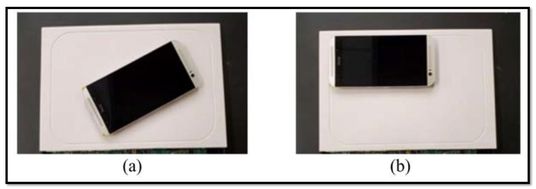
This project aims to both explore the key physical concepts, such as self-inductance, mutual inductance, resonant energy transfer, and the electromagnetic far field, that underpin WPT and to improve upon the existing technology in WPT. Numerous simulations will be conducted using Ansys Maxwell for both one and two coil systems. Mutual inductance and the coupling of the coils will then be calculated and analyzed. Frequently in applications, the system will be placed inside of a metal enclosure

INTRODUCTION

- Wireless power transfer (WPT) transmits energy to a device without the need for physical wires or cords
- A transmitter generates an electromagnetic field that transmits power to a receiver which extracts power from the field and supplies it to an electrical load



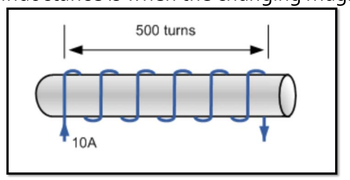
- Ultimately, we seek to increase the efficiency of a wide range of electronic devices and technologies
- Applications frequently require that the system be in a metal enclosure
  - Tightly coupled inductive charging technologies:
    - Requires a particular alignment between the PTU and PRU at high frequencies
    - Eddy current generates a significant amount of heat which prohibits charging

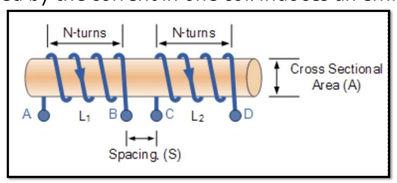


METHODS & RESULTS

Understand the physical principles underpinning WPT :

- Self-inductance is when the changing magnetic flux produced by the current in a coil induces an emf in the *same* coil, while mutual inductance is when the changing magnetic flux produced by the current in one coil induces an emf in *another* coil





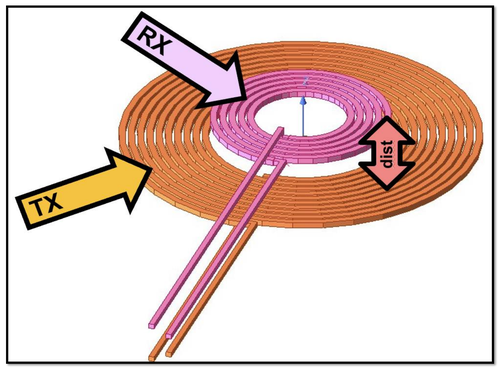
- Faraday's Law: Explains how a change in magnetic field induces an electromotive force (emf)

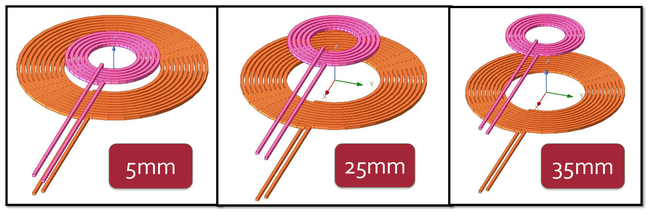
$$\varepsilon = -N\frac{d\Phi}{dt}$$

- Inductive Coupling transmits energy between coils through the varying magnetic field over time
- An alternating current in the transmitter produces such a fluctuating magnetic field. Then, a nearby coil is placed so that the changing magnetic field will create a changing magnetic flux through the receiver which induces an emf that produces a current to the load

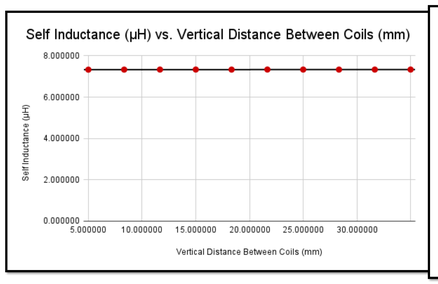
Simulate WPT System:

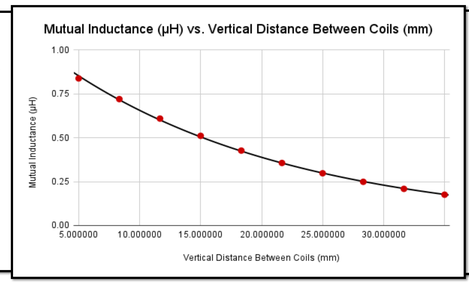
- Create the geometry for a 2-coil system using Ansys Maxwell
- Offset the alignment between coils and observe change:
  - How does variance in the *z-direction* influence values?
  - Vary the vertical distance (dist) between the transmitter coil (TX) and the receiver coil (RX)

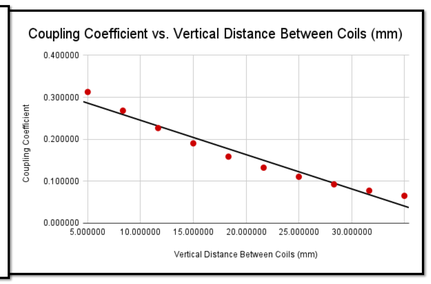




- Calculate and analyze the self-inductance, mutual inductance and coupling coefficient or the system:
- Self-inductance stays essentially constant, variation due to mesh
- Mutual inductance and coupling coefficient both monotonically decay to zero as distance increases

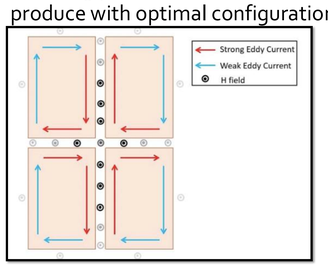


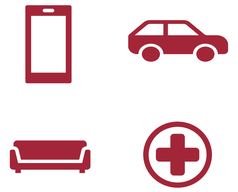




CONCLUSIONS/SIGNIFICANCE

- Alternating the orientation of the transmitting coil and the receiving coil will impact the power outputted by the system
- Wires and cords can be a hindrance to the capabilities of electronic devices due to mobility issues or harsh conditions
- Increasing usage in a wide range of electronic devices, including phones, vehicles, furniture, and medical device, produce with optimal configuration





FUTURE DIRECTIONS

- Offset in other directions and observe changes in self-inductance, mutual inductance, and coupling coefficient
- Mitigate challenges posed by segmenting the metal enclosure with a thin gap
- Utilize the induced eddy current, which is strongest near the gaps and weakest on the perimeter, to generate the magnetic fields that coupled to the PRU

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