ELECOMP CAPSTONE
SYMPOSIUM
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THE UNIVERSITY OF RHODE ISLAND

THINK BIG WE DO™

Contactless Charging

Contactless DC Battery Charging in Underwater Environments

GENERAL DYNAMICS
Electric Boat

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Project Motivation

This project will investigate and assess technology options for next generation contactless ("wireless") Direct Current (DC) Battery Charging in ocean environments. Next generation technology/systems are required to provide the platform with the capabilities to recharge external payloads, tethered and untethered. The ability to reliably charge/recharge externally hosted payloads without the need for physical mating interfaces will enable changing payloads over time without platform changes, increase platform flexibility and enable new missions. System development to provide a capability that can support a range of voltages and charging component distances in a range of sea water conditions including temperature, salinity and pressure (depth) is required.

Anticipated Best Outcome

Our goal is to develop a contactless DC Charging system concept model for use in ocean environments including applicable components' Technology Readiness Level (TRL) and potential risks for maturity of that technology. The Sponsor will provide the required documentation and guidance on TRL determination and mapping. Following the system concept model approval, the student(s) will develop a prototype development plan to support a proof-of-concept demonstration. To control the transfer of sensitive information, the Sponsor will utilize commercial system-based information and publicly available oceanographic conditions information.

Fig. 1: Autonomous Underwater Vehicle

Key Accomplishments

Research on Background Information - In order to start this project we needed to research a lot of background information such as AUV Background Research and Three Phase Power (**Fig. 1**)

Technologies of interest

EM Induction - Inductive charging is a type of wireless power transfer. It uses electromagnetic induction to provide electricity to devices. The equipment can be placed near a charging station or inductive pad without needing to be precisely aligned or make electrical contact with a dock or plug.

Resonant Inductive Coupling - An inductive power transfer system is comparable to that of a transformer. An alternating current in a transmitting coil generates a varying magnetic field that induces a voltage across the terminals of a receiving coil. Power transmission efficiency is higher when the transmitter coil and the receiver coil are close and aligned.

Microwave Power Transfer - Microwave wireless power transfer with a frequency range of 300 MHz to 300 GHz enables power transfer to long distances up to a few meters. The microwave wireless power transfer system consists of an energy-radiating antenna and a rectenna, which converts the microwave power into DC power.

Magnetic Couplers - A loosely coupled transformer for autonomous underwater vehicle applications is a split transformer in which the primary and secondary are physically separated, with the primary housed in a charging platform and the secondary housed on an AUV.

Linear Coaxial Winding Transformers - LCWTs, also known as sliding transformers, are electrically similar to
conventional transformers but differ in construction with their primary and secondary windings placed coaxially with each other. The main advantage of LCWTs is improved cooling and the ability to charge multiple underwater vehicles simultaneously.

Down-selection using Pugh Matrix - Our Pugh Matrix Down-selection was essential in determining, out of all our technologies, which one we were going to use for our prototype proposal.

Engineering and analysis work using Ansys Maxwell (**Fig. 2**)

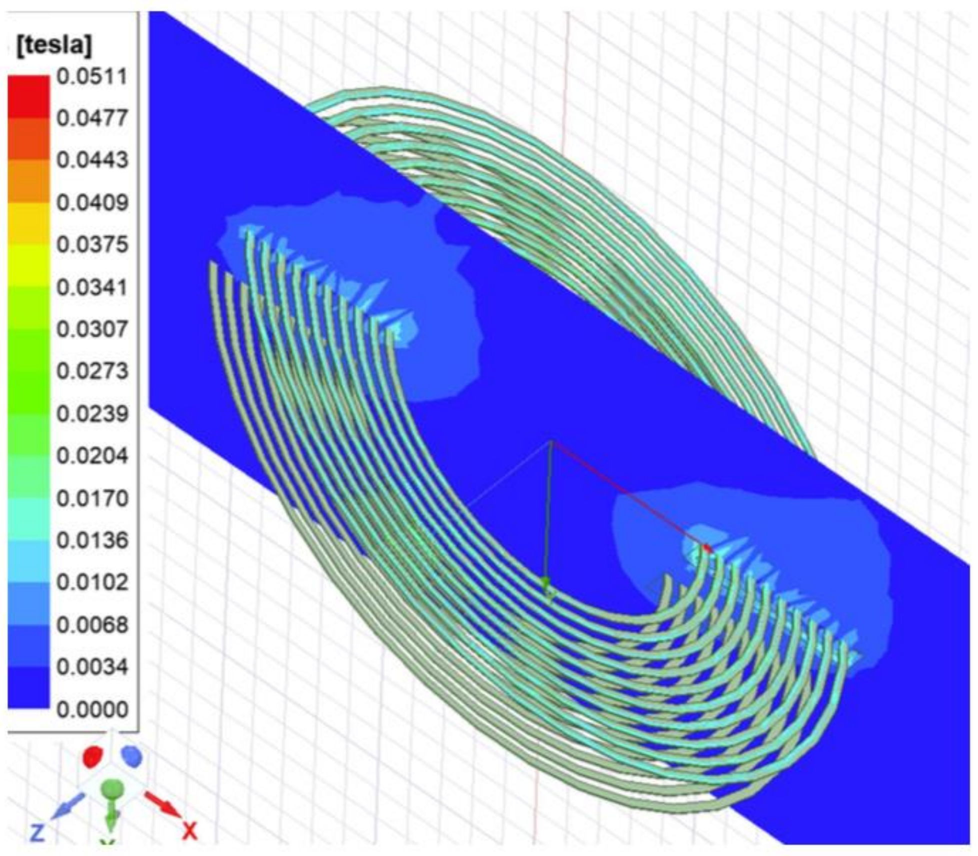

Fig. 2: Ansys Maxwell Simulation of EM Inductive Charging

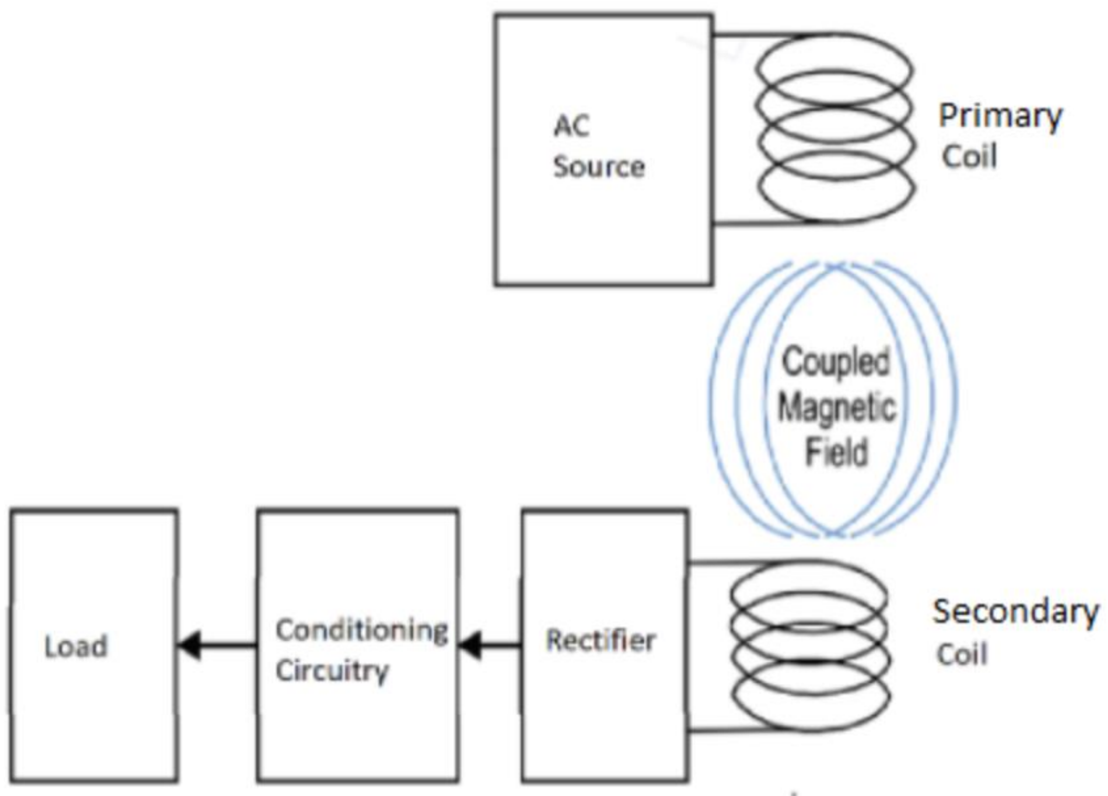

Fig. 3: Wireless Power Transfer System Block Diagram

Remaining Technical Challenges

Pugh Matrix down selection final version:
A final technology down selection will be performed using the data that was collected through the finite element analysis simulations. This final downselection will determine the technology that will be used for the project prototype and how it will be executed.

Data Collection:
Continue work within finite element analysis simulations on the chosen technologies of interest that will be used to simulate the prototype in order to visualize and collect data on how it will operate using a three phase naval ship power source. This data will allow an estimation of the power transfer efficiency, transmission distance, and the wireless power leakage of the project prototype within the ocean environment.

Prototype proposal:
A prototype proposal must be created which includes system components, insulation systems, coil designs, core materials, and technologies used. The prototype proposal will outline the materials required in order to build a prototype wireless power transfer system for demonstration. The prototype must fit within a design space no larger than 24 Inches long x 24 Inches tall x 12 Inches deep (Box) or 16 Inches in diameter and 12 Inches Deep (Disk).

Prototype Development and Testing:
Before building a physical prototype testing a virtual prototype in Ansys will take place. When testing, the prototype will need to withstand the various elements in a real-world environment such as saltwater. When developing a physical prototype for this project discussion of materials that it will be made of is a huge factor as well as the space constraint. The prototype will be developed according to the proposal laid out in phase one of the project. The required hardware will be procured and used to fabricate the prototype. Laboratory testing of the prototype will need to be done in order to ensure the prototype's performance in real world environments.

Implications for Company & Economic Impact

As new unmanned vehicles and platform tethered sensor bodies are being developed and deployed, the ability to maintain DC power systems is becoming more critical. The ability to reliably charge externally hosted payloads without the need for mating interfaces will increase platform flexibility and enable new missions for our military. It will also allow General Dynamics Electric Boat to help guide its development and concept of operation. The development of a prototype wireless charging system is the first step to increasing General Dynamics Electric Boat's ability to reliably deploy AUV's in various missions.

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