Sustainable Energy Engineering Capstone Project Description - SEE 410W Fall 2023

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Project Title: Design of Plasma Diagnostic Device to Measure Magnetic Fields

Project Summary:
Nuclear fusion will play a pivotal role in meeting the long-term energy demand by providing continuous, clean energy to the grid. Fusion's exceptionally high energy density means that less fuel is required to produce more energy and this output is independent of weather and location. At General Fusion, PI3 is a plasma injector that forms a torus-shaped plasma in a vacuum vessel and shoots it into the reactor to be compressed. The main parameters in our plasma experiments are the magnitude of currents and electromagnetic fields inside and outside of the plasma volume. In order to perform and understand these experiments, it's crucial to be able to reliably measure these parameters.

The objective of this project is to design a device capable of measuring local 3-D magnetic fields inside, within the wall, and outside of PI3. Design considerations include sensitivity, accuracy, and compatibility with the environment, and sensor placement within the magnetic field.

Project Clients: General Fusion (Dr. Celso Ribeiro)

Potential Users: General Fusion

Project Design Objectives:

First Term (SEE 410W): September – December 2023

- Problem Definition: Determine the specific requirements. What range of magnetic fields do we need to measure? What is the required sensitivity, accuracy, and resolution? Consider the environmental conditions the sensor will operate in, such as temperature and other potential interferences.
- Conceptual Design: Select a sensing principle based on the requirements.
- Detailed Design: Design the physical layout and dimensions of the sensor. This includes the size, shape, and mounting considerations. For instance, if the sensor will be placed within the plasma injector, ensure that it's appropriately shielded from environmental factors. Create the electrical circuitry required for the sensor to work. The circuitry should be designed to minimize noise and interference, which could affect measurement accuracy.
- Calibration and Compensation: Develop calibration procedures to ensure accurate measurements. Compensation techniques may be needed to account for temperature effects, sensor drift, and other sources of error.
- Integration: Integrate the magnetic field diagnostic with the plasma injector system. Build the prototype of the sensor based on the detailed design. This will involve assembling the physical components, fabricating the required electronics, and connecting everything together.
- Economics and sustainability report

Second Term (SEE 411): January – April 2024

- Signal Processing: Process the raw sensor data to extract meaningful information about the magnetic field. This might involve filtering noise, applying compensation algorithms, and converting sensor readings into magnetic field values.
- Data Analysis: Analyze the collected magnetic field data to gain insights into the behavior of the plasma within and around the injector.

Documentation: Create comprehensive documentation for the magnetic field sensor design. This might include schematics, layout diagrams, calibration procedures, and any necessary operational instructions.

Recommendations for Next Iteration: Based on initial measurements and analysis, make suggestions such as adjusting sensor placement, improving calibration techniques, or enhancing data processing algorithms.