EML4551-2

VIRTUAL DESIGN REVIEW 1

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TEAM 501: HTS COILS PROJECT FOR THE APPLIED SUPERCONDUCTIVITY CENTER

Applied Superconductivity Center
HTS Coils Project
Team 01

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The Applied Super Conductivity Center (ASC)

- ASC, located in Tallahassee FL
- Association with the National High Magnetic Field Laboratory
- Advances science of superconductivity and superconductivity applications
- ASC is presently researching new types of high field magnets

- Lance Cooley, Ph.D. Project Advisor
- Director of ASC
- University of Wisconsin-Madison Alumni

- Ernesto Bosque, Ph.D. Project Sponsor
- ASC Research Faculty
- Florida State University Alumni

Benjamin Walker

Project Brief

- Design a probe with better properties for inserting superconducting device into an external magnet
- Probe must carry high electrical current from room temperature to approx. -450 °F without excessively heating cold environment
- Fabricate and test this probe under the supervision of the Applied Superconductivity Center

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Objective

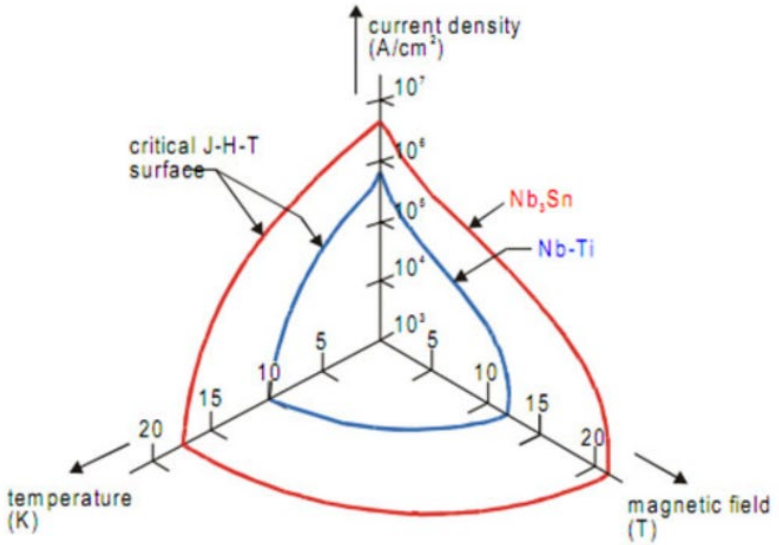
- The objective of this project is to provide the ASC with a 700 A probe for high magnetic field insert coils that will be used in tandem with larger outsert magnets
  - The minimum objective is to deliver a probe to carry current to the test device without optimization for heat loss
  - The stretch objective is to deliver a probe that will carry 1000 A and be thermally optimized to limit cryogen boil off

Purpose

- To develop a probe that our sponsor will use with a specific external magnet at the Applied Superconductivity Center
- The probe will be used for high current tests of new superconducting magnets
  - Some new magnets are associated with the NHMFL
  - Some new magnets are associated with the Department of Energy Office of High Energy Physics

Project Background

Achieving Superconductivity in Coils



- When material such as Niobium Titanium alloy (Nb-Ti), and Nb_3Sn are cooled below a transition temperature they become 'superconducting'
  - The superconducting state has zero electrical resistance and high current density
  - Selection of cryogenic coolant usually establishes operating temperature

- Beside temperature, there are limits on critical current density and magnetic field
- The above graph with temperature, current density and magnetic field as axes shows the area inside which superconductivity is achieved for Nb3Sn and Nb-Ti

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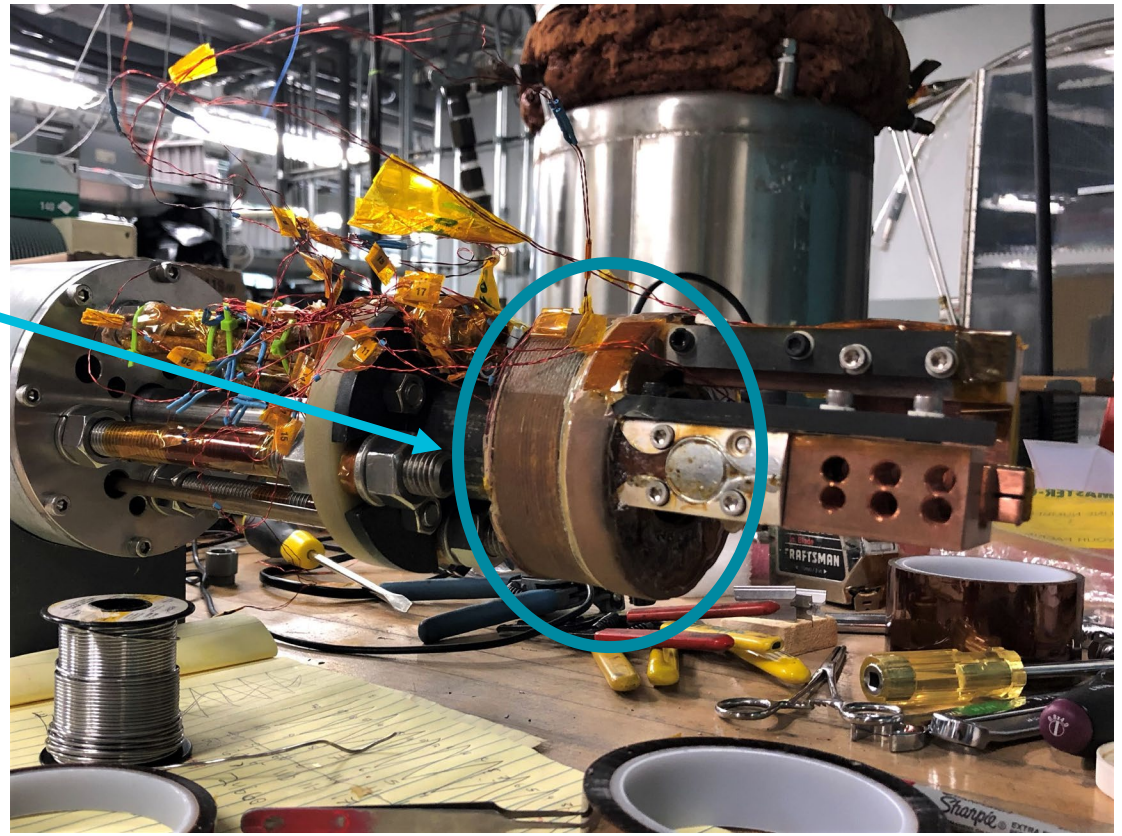
- Superconductive wire can be wounded into an electromagnet
- High current density results in high magnetic field
    - hafkjahsdf



- Inserting an electromagnet inside an external magnet can result in extremely high magnetic fields

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Detailed Scope - Project Description

- Design probe using CAD software and run COMSOL simulations
- Fabricate on site using available machine shop at ASC
- Test and validate probe performance at ASC

Christopher Reis

Detailed Scope - Markets

- **Primary**
  - High field test coil programs for high energy physics

- **Secondary**
  - Medical field in the advancement of Magnetic Resonance Imaging technology research
  - Critical current testers of superconducting materials
  - US Department of Energy
  - Cryogenic feed throughs

Christopher Reis

Detailed Scope - Stakeholders

- **Primary**
  - Applied Superconductivity Center
  - Florida State University
  - FAMU-FSU College of Engineering
  - Mark Vanderlaan, Ph. D.

- **Secondary**
  - National High Magnetic Field Laboratory
  - Cryogenic Safety
  - Lab Safety

Detailed Scope – Customer Needs

Question?	Customer Statement	Interpreted Need
How can we help you?	I want a new probe that provides power to coils for electromagnet prototype testing	Assemble a probe to run electricity to an electromagnet
Where is the power coming from?	It is running from a power source on the outside to the coil in the cryostat	Probe withstands room temperature-supercooled thermal gradient
What engineering challenges does this probe present?	The probe needs to be able to conduct 700 amps of electricity without releasing too much heat	Probe can transfer large amounts of electricity with low thermal conductivity, while thermal dissipation doesn't cause liquid helium bath to evaporate
Are there any other key goals desired for the design?	I want the probe to be versatile	Probe is adaptable to be used with various electromagnets using standardized tools and instruments

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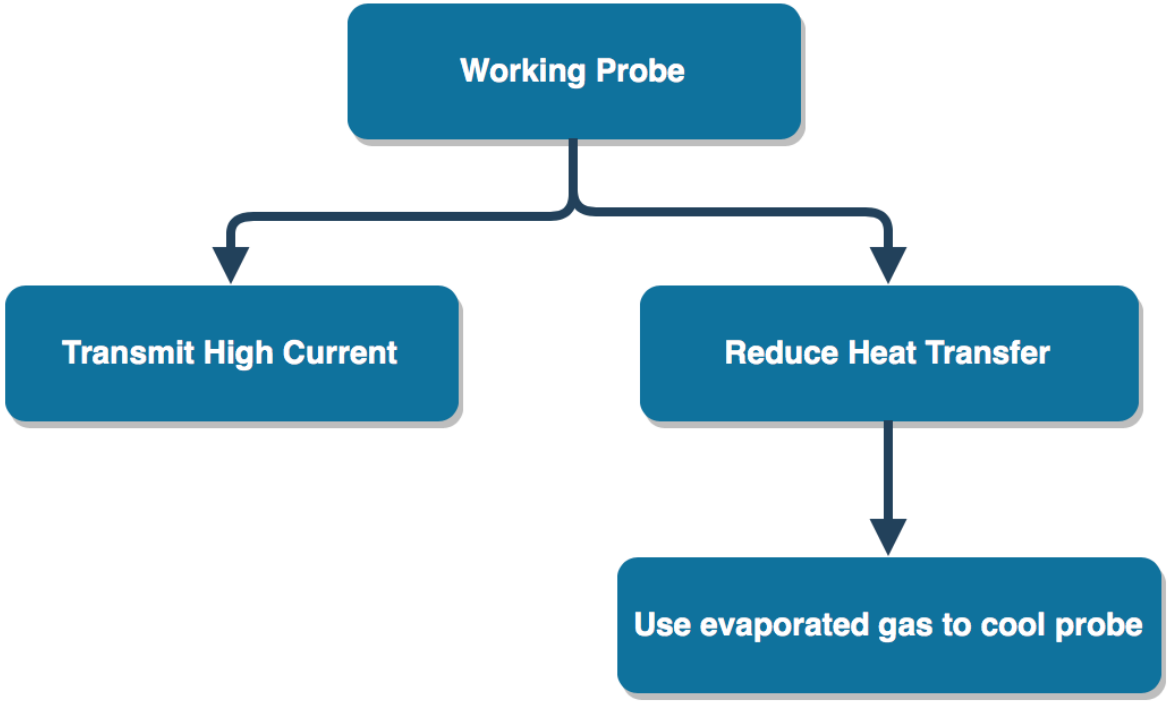
Functional Decomposition



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Budget

- Should not be more expensive than commercially available probes
- Waiting for quotes.
  - Estimated to be about $10,000

Summary

- All communication with the sponsor, as detailed in the customer needs and the project scope has defined the assignment as a superconducting magnet probe design and fabrication experiment

- Team seeks to use literature to understand the underlying principles of these probes and use analytical skills from background as mechanical engineers to overcome current design limitations

Next Steps

- Research
  - Survey of standard materials with intended properties
  - Mechanical configurations conducive to desired probe characteristics
  - Exploration of advanced materials and techniques including the applicability of superconductors
- Preliminary designs
  - Brainstorming ideas and filtering best of the best
  - Software design and appropriate simulations
  - Bill of materials for final design
- Acquire materials and assemble prototype

Christopher Reis

References

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- https://nationalmaglab.org/magnet-development/magnet-science-technology/magnet-projects/32-tesla-scm
- Shayne McConomy, *Engineering Design Methods,* lecture slide sets, FAMU-FSU College of Engineering, Spring 2018

Questions