Superconducting Power Distribution Design for Zero-Emission Aircraft

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IZEA Integrated Zero Emission Aviation

NASA Partner

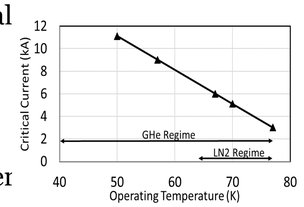
Introduction

- Zero emission electric aircraft are being developed as a means to reduce carbon dioxide (CO_2) emissions from the aviation industry
- Currently the aviation industry account for ~10% of all CO_2 emissions
- NASA and other funding agencies have been developing conceptual all electric aircraft such as the N3-X
- All electric aircraft enables new fuselage designs which have greater aero dynamical efficiencies which enable significant fuel reductions
- For all electric aircraft to be a feasible solution it is necessary for the required electrical devices such as generators, fuel cells, motors, cables, power electronics, and protection devices to achieve a certain power density
- Power density refers to the weight per power production of the electrical device – for electric aircraft power densities of 14 kW/kg are currently the target
- FAMU-FSU College of Engineering was recently awarded a NASA University Leadership Initiative award to develop Integrated Zero Emission Aviation (IZEA)
- As part of my work on the IZEA project I was asked to investigate the superconducting power distribution design which connect the generation units (fuel cell and generators) to the propulsion motors

NASA N3 –X Conceptual All electric aircraft

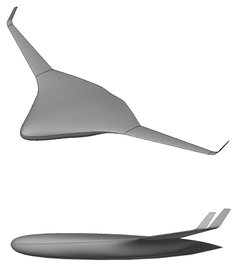
Superconducting Power Cables

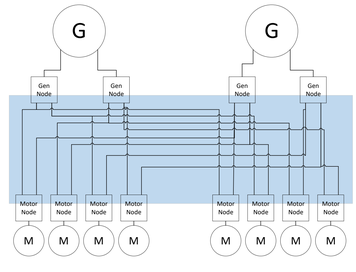
- Superconducting cables exhibit zero electrical resistance when operated below their critical temperature
- Currently superconducting cables require cryogenic operating temperatures
- This enables high current densities and power densities to be achieved
- Superconducting cables are being considered for electric transport application such as aircraft and ships where space and weight are limiting factors
- The team I am working with at Florida State University Center for Advanced Power Systems (FSU-CAPS) are responsible for designing the distribution network which connect the generation units (fuel cells and generators) to the propulsion motors

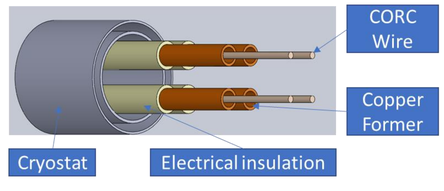


IZEA Power Distribution Network

- It is necessary to consider the physical constraints of the IZEA aircraft when design the power distribution network
- It is also necessary to include factors such as safety, reliability, resiliency, and efficiency
- As part of my research, I was asked to explore how the cryostat, which the superconducting cable will be installed in, can be fabricated in a modular manner
- A modular design enables greater system level efficiencies







Skills learnt through UROP

- The cryostats could be discretized to 3 components – a tube, tee, and a S bend
- I learned how to make informed design-related decisions, specifically the creation of these 3 components in Creo as well as understanding how these parts must have a repeatable design to create the overall assembly for the superconducting cable infrastructure.
- Through UROP I was able to work at FSU-CAPS in an inter-disciplinary team which consists of undergraduate, graduate, postdocs, research faculty and professors which helped improve my ability to work in a group setting.

Conclusion

- Zero emission aviation is an ongoing area of multi-disciplinary research which constantly requires iteration and multi-objective optimization
- I was able to learn about the physical, electrical and thermal constraints of the IZEA aircraft
- The opportunities provide by UROP allowed me to further my skills as an electrical engineer

Acknowledgements

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References

Cheetham, Peter, et al. "Superconducting DC Power Distribution Networks for Electric Aircraft." *Prepared for EATS Conference.* Received as an internal document.

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