NASA Electric Aircraft Testbed (NEAT) Reconfiguration to Enable Altitude Testing of Megawatt-Scale Electric Machines

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NASA Glenn Research Center / GE Aviation

Electric Aircraft Technologies Symposium, August 24-26 2020

Virtual Event

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Overview

- NEAT overview
- STARC-ABL powertrain overview
- Reconfiguration
  - Electrical design
  - Mechanical design
- Problems encountered
- Mitigations implemented
- Final electrical configuration
- Conclusion

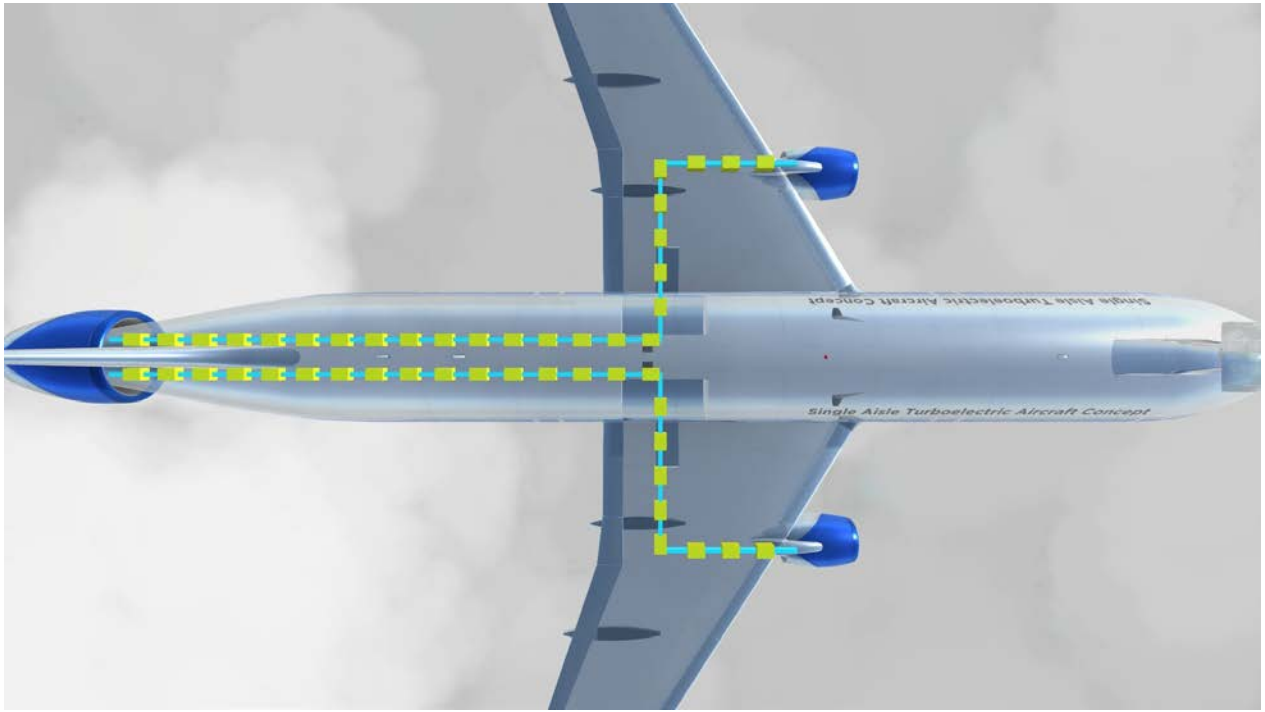
NEAT Overview

- Used for high power testing for hybrid-electric aircraft
- Designed to be reconfigurable
- Capable of testing systems or components
- Three distinguishing characteristics
  - Access to high power
  - Altitude simulation
  - Large footprint

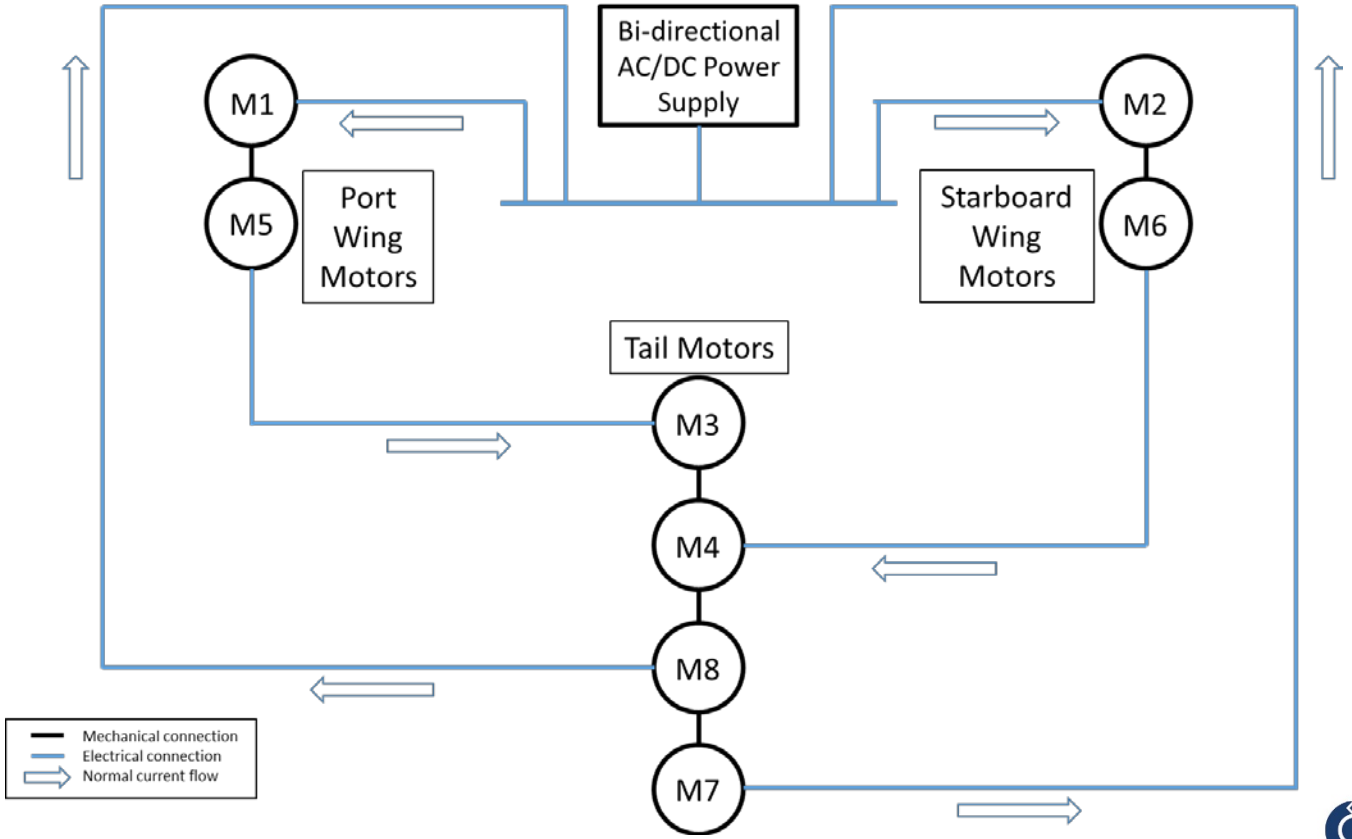
STARC-ABL Testing

- Powertrain consists of:
  - Port wing motor/generator pair
  - Starboard wing motor/generator pair
  - Tail motor/generator pair
- Tail set consisted of (4) 250 kW COTS motors on a common shaft
- Tail table converted to dynamometer for 1MW-class machine

STARC-ABL Testing



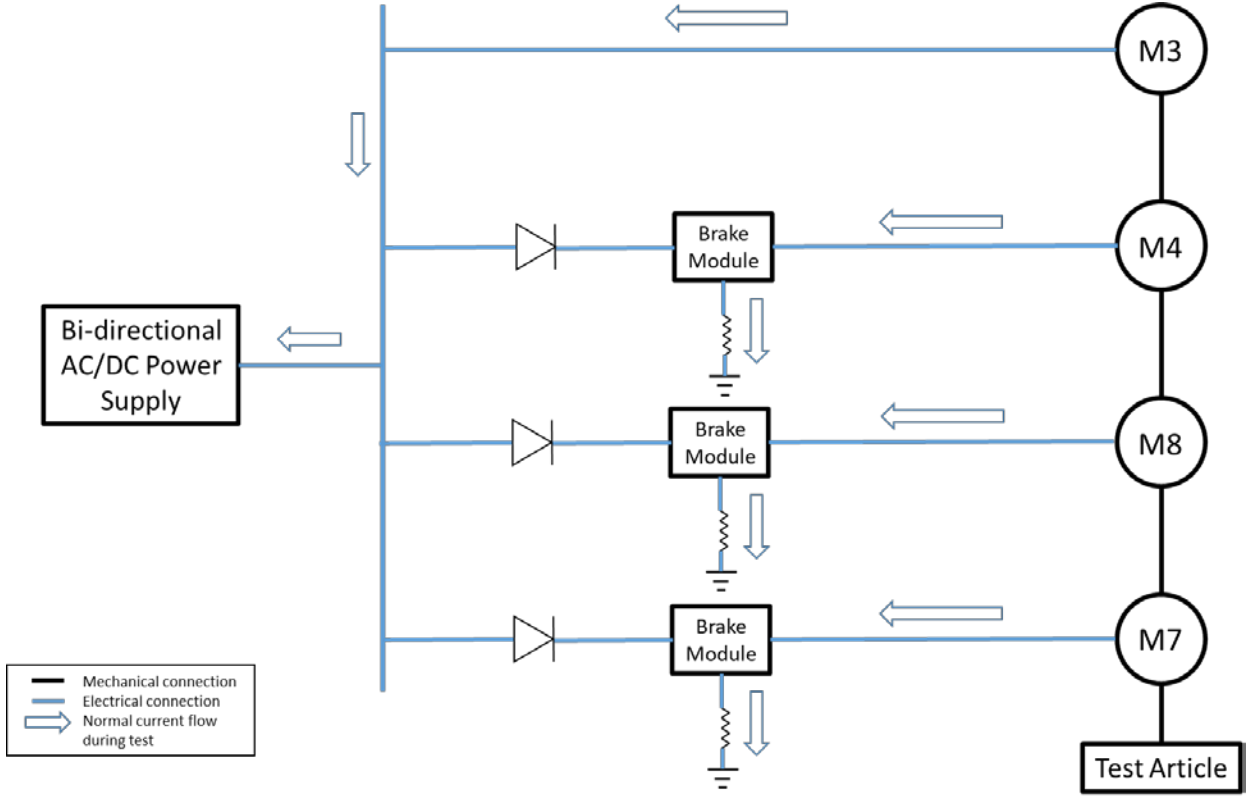
STARC-ABL Testing



Dynamometer Initial Design, Electrical

- Repurposed STARC-ABL tail system
- (4) 250kW COTS motors on common shaft formed a system capable of supplying a 1MW load to test article
- Current generated by dynamometer would be dissipated two ways:
  - Bi-directional DC power supply
  - Brake resistors applied via brake modules

Dynamometer Initial Design, Electrical



Dynamometer Initial Design, Mechanical

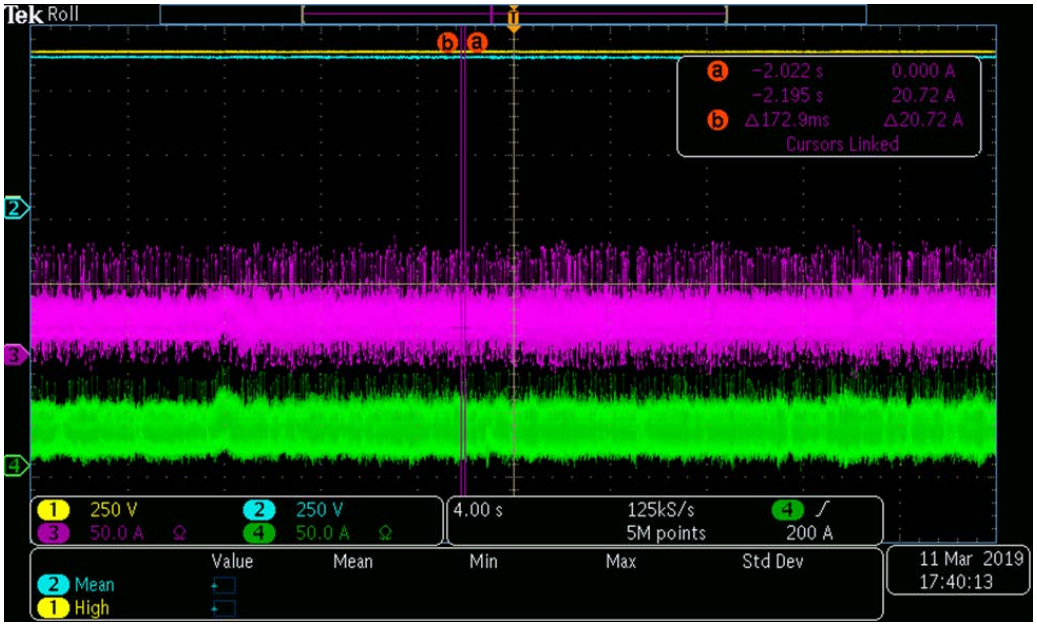
- Dynamometer system was installed entirely within the altitude chamber
- COTS equipment required protection from altitude conditions
- All dyno equipment was installed on a single table, and surrounded with a shroud designed to withstand 14 psi
- Interior of the shroud was vented to the high bay area, while the rest of the chamber was pumped down

Dynamometer Initial Design, Mechanical

Problems Encountered

DC Bus Current Ripple

- ~40A dc content
- ~90A peak-to-peak ripple
  - Negative current in troughs of Channel #3
- Relatively stable bus voltage
- Unknown source of ripple

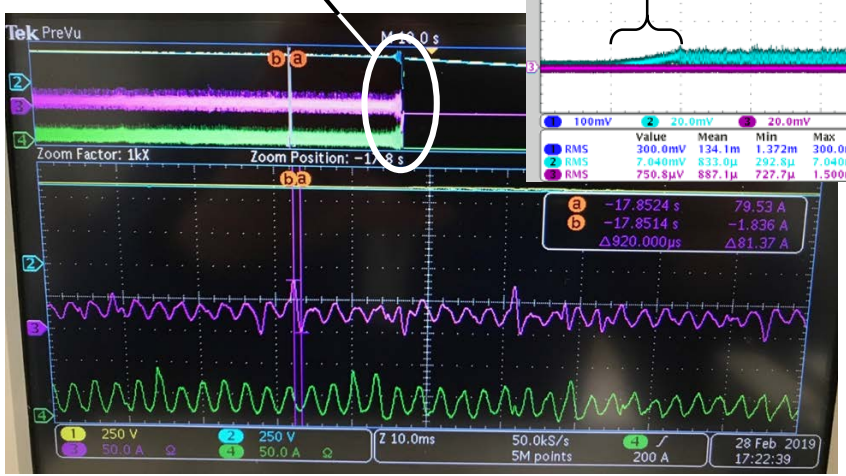


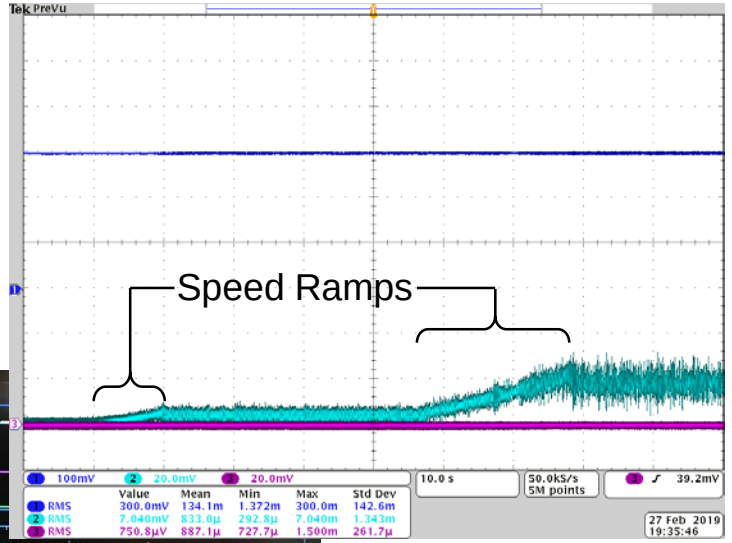
Problems Encountered

Fault Shutdowns

- Could not operate dyno through full speed range
  - Observed faults at higher speeds
- Increasing speed increased peak-to-peak ripple

Current and voltage bloom induce fault





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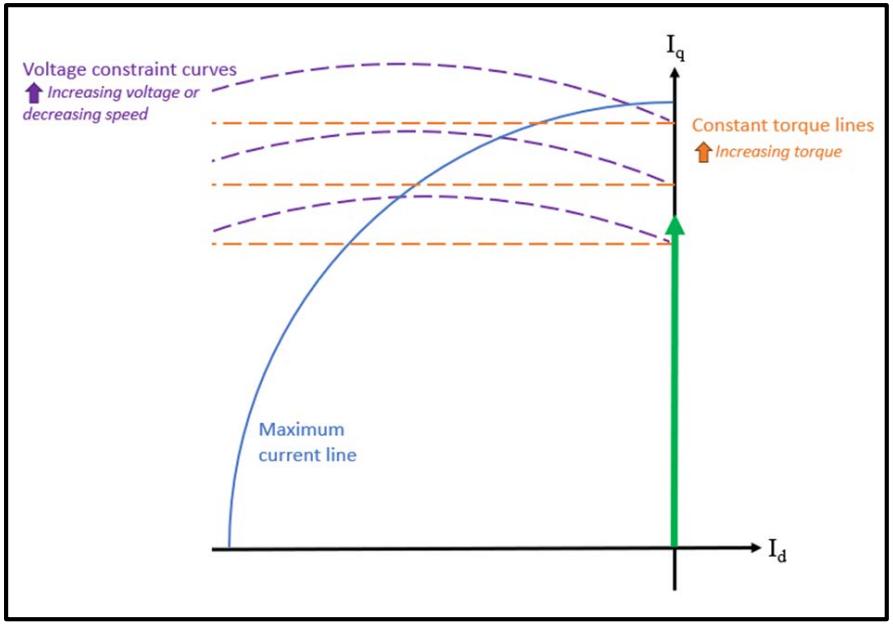
Problems Encountered

Low Speed Operation

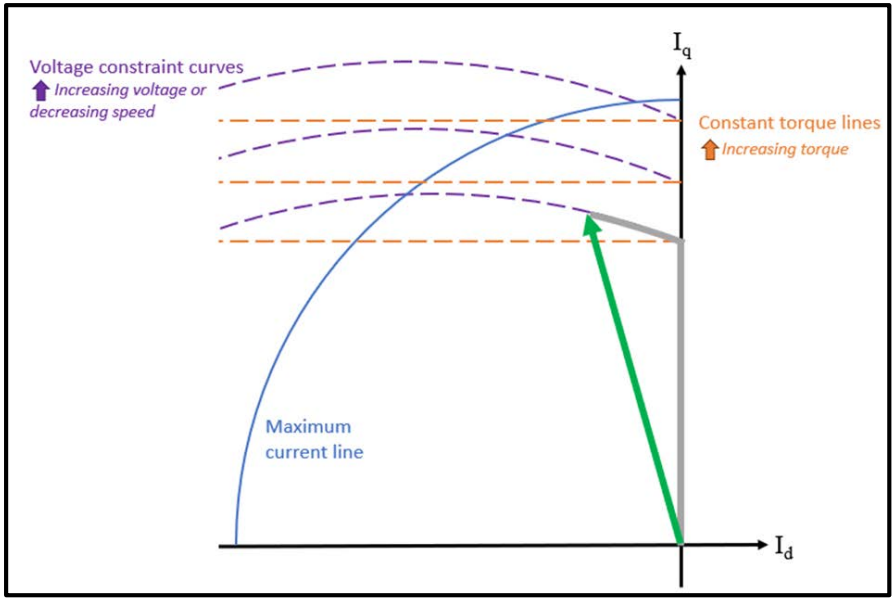
- No flux weakening at low speeds
  - No negative I_d current from inverter telemetry
- No faults observed at low speeds



Problems Encountered

High Speed Operation in Flux Weakening

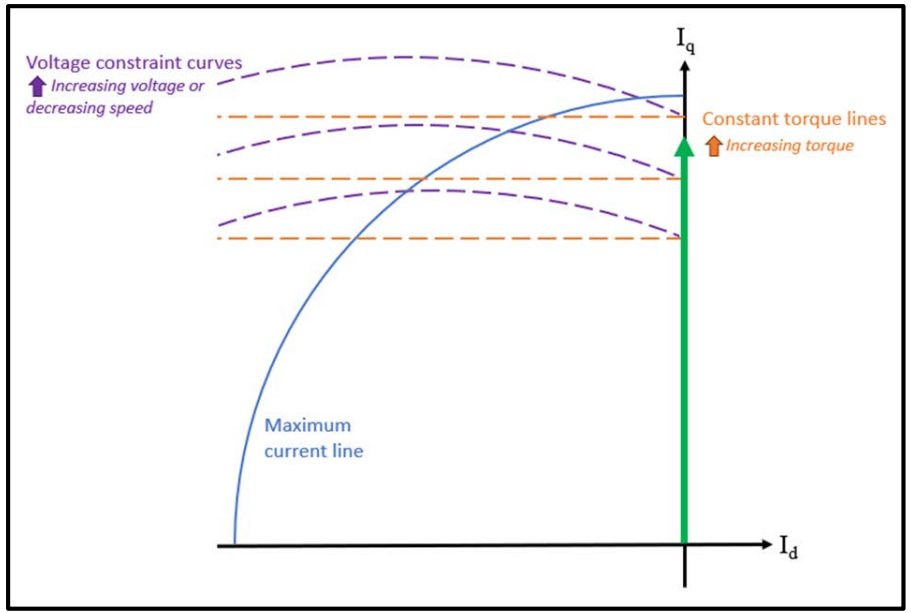
- Entered flux weakening at high speed
  - Negative I_d current from inverter telemetry
- DC bus voltage selection drove system into flux weakening at high speeds



Mitigations Implemented

Increased DC Bus Voltage

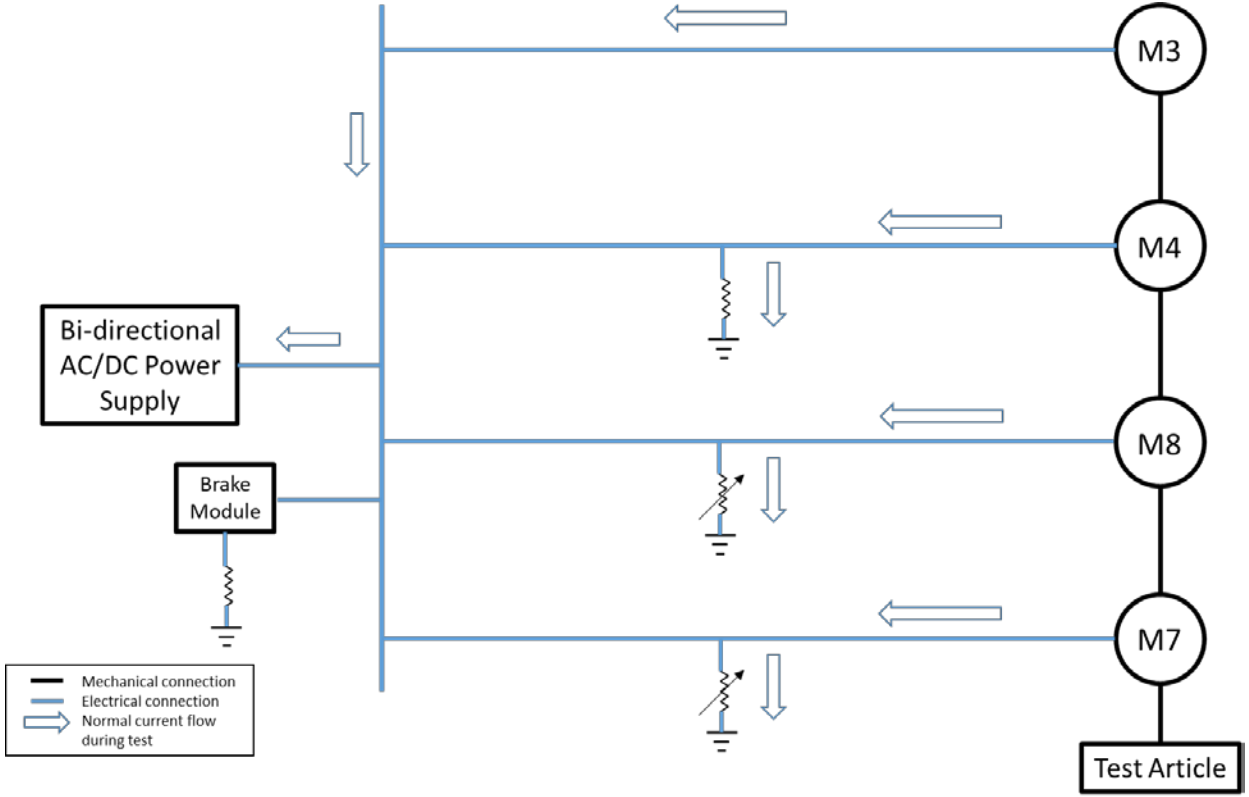
- DC bus voltage increased from 600V to 700V
  - Kept inverters out of flux weakening at high speeds
- Improved DC bus stability allowed for dyno operation throughout speed range



Final Electrical Configuration

- The diode/brake module systems were removed in favor of a passive load resistance
  - This removed a known source of ripple on the DC bus (brake modules)
- A constant resistive load was connected to M4
- Two variable loads were connected to M7 and M8

Final Electrical Configuration



Conclusion

- Reconfiguration and the mitigations discussed allowed the MW-scale electric machine test to be successfully completed
- Significant ripple was still seen on the DC bus during testing
  - Further testing is required to reduce as much as possible

Acknowledgments

- The NEAT reconfiguration was funded by NASA's Advanced Air Transport Technology project / Hybrid Gas Electric Propulsion subproject, with support from GE Aviation
- The authors would like to thank support from both NASA and GE
  - NASA: Ralph Jansen, Tim Dever, Pete Kascak, VPL staff and TFOME staff
  - GE: Paul Gemin, Di Pan, Fabian Isaza

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