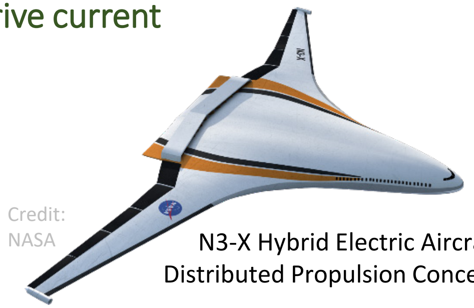
Extreme Performance Scalable Inverter Architecture for More Electric Aircraft (MEA) Propulsion

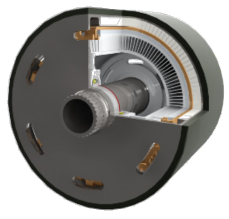
arpa·e BPEC Berkeley Power and Energy Center

Motivation and Application

- Commercial aviation benefits from electric & hybrid vehicles
- Electric engines can be quieter and cleaner than jet engines
- Electric drive system must be **power-dense** and **efficient**
- Advanced power dense motors[2] need **low THD, high frequency drive current**



N3-X Hybrid Electric Aircraft Distributed Propulsion Concept



University of Illinois 1 MW Motor Concept[2]

NASA MEA Roadmap[1]

NOx emissions

80%

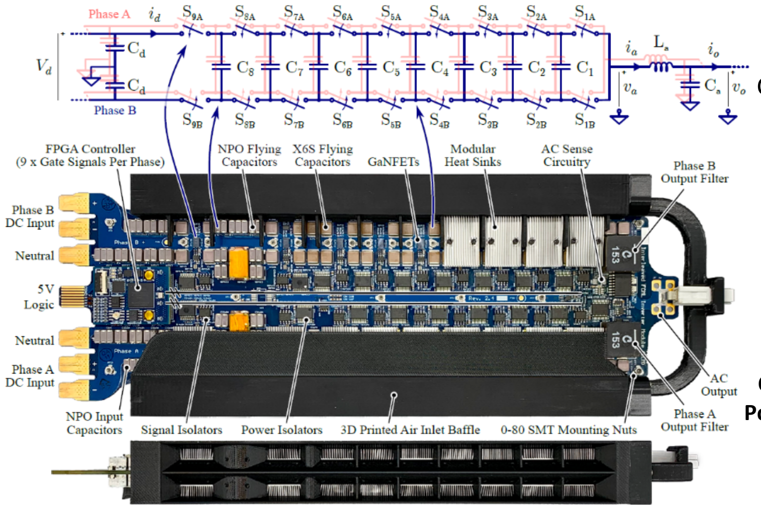
fuel consumption

60%

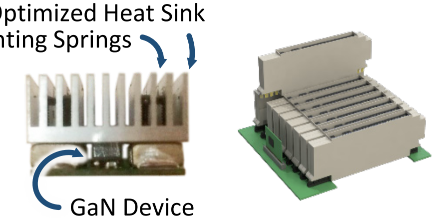
acoustic noise

71dB

Electrical, Mechanical and Thermal Management Hardware



Load Shedding



Thermal Design Impacts

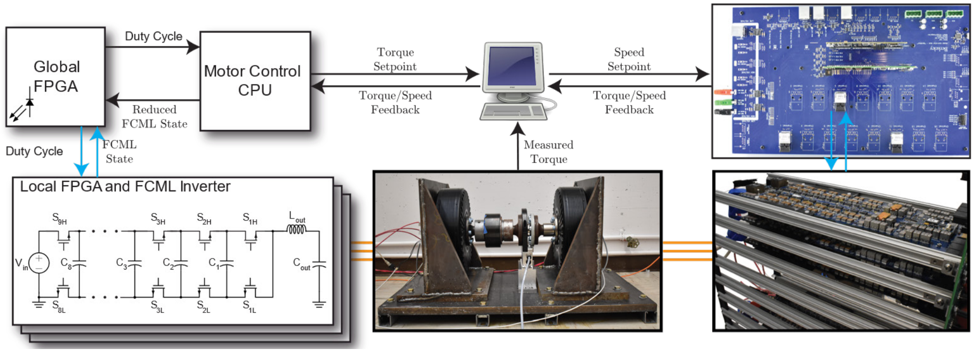
Chip-Scale GaN Power Transistors → Compact Layout → Faster Switching

New Cooling Challenges

Higher Power Density

High Power Dynamometer

- Dyno incorporates two low-inductance Emrax 348 machines (peak power: 260 kW)
- Testing validated the Flying Capacitor Multilevel Converter's (FCML) strength in a realistic motor drive system



Experimental Verification or Other

- Prototype meets NASA performance metrics for turbo-electric aircraft[4]
- Integration of advanced thermal management will boost maximum output power and efficiency
- Modular design provides for power scalability and fault resiliency
- Next steps: verification of floating-point motor control algorithm and high-power dyno and next generation inverter hardware development

	NASA Target	This Work
Peak Efficiency	99%	98.95%
Power Density	19 kW/kg	38.4 kW/kg

References:

N. Pallo, R. S. Bayliss and R. C. N. Pilawa-Podgurski, "A Multi-Phase Segmented Drive Comprising Arrayed Flying Capacitor Multi-Level Modules," IEEE APEC 2021

[1] N. Madavan, et al., "A NASA Perspective on Electric Propulsion Technologies for Commercial Aviation," 2016.

[2] X. Zhang and K. Haran, "High-Specific-Power Electric Machines for Electrified Transportation Applications Technology Options," IEEE ECCE 2016.

[3] N. Pallo, et al., "Power-Dense Multilevel Inverter Module using Interleaved GaN-Based Phases for Electric Aircraft Propulsion," IEEE APEC 2018.

[4] N. Pallo, C. Kharangate, et al., "Modular Heat Sink for Chip-Scale GaN Transistors in Multilevel Converters," IEEE APEC 2018.

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