NASA Glenn Faculty Fellowship Program

Glenn Research Center

Office/Division Name: LEM
Branch Name: Power Management and Distribution Branch
Research/Engineering Area / Topic: GaN Inverter Prototype

Description of Research/Engineering Work to Be Performed

Brief background and NASA mission/program support
To address the desire for greener aviation, NASA initiated a number of efforts to study electrified propulsion for both personal transports and larger single-aisle aircraft. The primary project investigating the development of electrical vertical take-off and landing (eVTOL) vehicles for smaller craft with shorter mission durations is the Revolutionary Vertical Lift Technology (RVLT) project. One of the key considerations for RVLT is the development of safe, reliable architectures. An early failure mode assessment report showed motors and their associated electronics to be some of the least reliable components in these architectures. As a result, there is high interest in advancing the state-of-the-art in both motor and drives.

To date, most motor inverters have been based primarily on silicon (Si) devices, with a few efforts developing silicon carbide (SiC) equivalents. Gallium nitride (GaN) devices are relatively new to the market but may offer potential advantages over Si/SiC in the areas of lower on-resistance, better thermal conductivity, higher operating temperatures, and faster switching speeds. As a result, RVLT is interested in potential benefits of GaN for the inverters needed in eVTOL vehicles.

Objective(s) of project
The primary objective would be to design and develop a GaN-based 3-phase motor inverter as a prototype for eVTOL vehicles and assess overall performance. This design would then be compared to traditional inverters of similar specifications, if the data is available.

The project member(s) would be expected to define what the DC input source would be (battery, fuel cell, etc.) to achieve the output specified under mission performance/requirements, along with the specifications (voltage, current) of such source.

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Mission Performance/Requirements
The main requirement would be to develop the inverter to achieve:

- 120-150 Vac 3-phase output
- Low power, <2-3 kW
- For motor operation up to 3,000 rpm

Key Considerations
Key considerations for any eVTOL vehicle are size, mass (including thermal management system), and reliability. The prototype should include sensors to measure voltage, current, and temperature at various points.

System Design
There are different manufactures which provide GaN power modules which can be used for this project, including (but not limited to):

- Mouser (https://www.mouser.com/ProductDetail/595-LMG3522EVM-042)
- GaN Systems, a subsidiary of Infineon Technologies (https://gansystems.com/newsroom/gan-power-module-evaluation/)

The inverter should take a DC input and convert to 3-phase AC output to drive a motor at low power.

Literature Resources (As Needed)
Overview article on potential GaN use for inverters:
Schweber, B. (2024). How to Use GaN Power Devices for Superior Mid-Range Motor Inverters. DigiKey, March 5, 2024.

https://www.digikey.com/en/articles/how-to-use-gan-power-devices-for-superior-mid-range-motor-inverters
Reports on the RVLT electric propulsion work at NASA GRC can be provided upon request.

Contact: GRC-NGFFP@mail.nasa.gov