PROJECT IMPACT SHEET

arpa-e PROGRAM

ADVANCING ELECTRIFICATION OF HEAVY EQUIPMENT AND AIRCRAFT

UPDATED: NOVEMBER 15, 2020

PROJECT TITLE: Reliable, High Power Density Inverters for Heavy Equipment Applications
PROGRAM: CIRCUITS
AWARD: $2,964,828
PROJECT TEAM: *University of Arkansas (Lead)*, University of Illinois, Urbana-Champaign, Caterpillar, Wolfspeed
PROJECT TERM: March 15, 2018 – Sept. 14, 2021

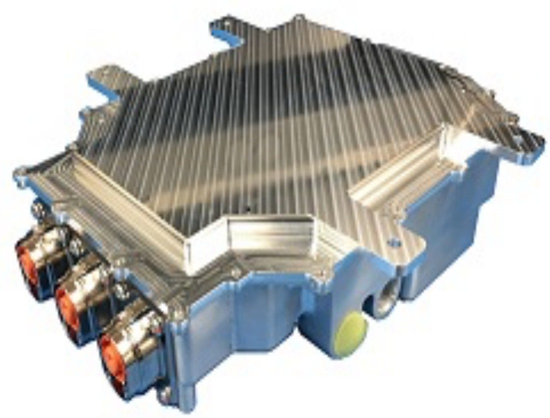
MOTIVATION

Heavy equipment providers are increasingly investing in electrification capability to perform work in harsh environments. As with all electrified systems, size, weight and power (SWaP) considerations must be met by these systems. Particularly challenging in the context of these power levels is managing the tradeoff between the required large number of devices for current carrying capacity and power density. Additionally, higher complexity circuit topologies achieve lower harmonic content in order to reduce filter requirements, but this can also work contrary to efficiency and power density targets. A diverse team from Caterpillar, Wolfspeed, the University of Arkansas (UA), and the University of Illinois at Urbana-Champaign (UIUC) with expertise from devices through applications will undertake the challenge of designing a world-leading dual inverter system for heavy equipment applications. Designing and building cost-effective, high performance power electronics is a challenge best met by emerging wide bandgap technologies. This team is meeting this challenge using new circuit techniques, electrothermal co-design, and hierarchical, multi-objective optimization methods to evaluate both cabinet-level and module-level electro-thermal design parameters establishes a framework upon which a vast array of wide bandgap applications can be realized including those for the electrified transportation, electric power grid, data centers, and energy exploration. A recent addition to the project was the application of this design approach to a 200 kW propulsion inverter on a Cessna 337 hybrid electric aircraft. Both of these motor drives are shown in Figs. 1 and 2.

TECHNICAL OPPORTUNITY

The commercialization of fast-switching wide bandgap power semiconductor devices makes this investigation feasible and timely. Silicon carbide and gallium nitride have each been shown to reduce size, weight, and power for power electronic applications. With these technologies now being applied to renewable energy resource interfaces such as solar inverters, there is strong interest in understanding the impact they might have on transportation systems to achieve increased mileage, reduce fuel consumption in hybrid applications, extend the lifetime of traditional power electronics, and reduce cooling requirements at the system level. The heavy equipment industry (e.g., John Deere, Caterpillar, Case, etc.) have all recently begun investigations into the use of hybrid electric platforms to address these issues. Aircraft represent a significant growing segment of transportation and are not historically very environmentally friendly, particularly smaller aircraft. The aerospace inverter being designed here will simultaneously promote the hybridization of small aircraft and extended flight range.

Figure 1: Picture of 250 kW dual inverter for Caterpillar heavy equipment applications 250 kW inverter for AmpAire hybrid aircraft.



ADVANCED RESEARCH PROJECTS AGENCY-ENERGY

U.S. DEPARTMENT OF ENERGY
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