2023 REU Project List

Project #	Project Lead	Collaborators (if any)	Project Title	Assignment Location	REU Project Title	REU Project Title Description
R1.019.22	Stillwell, A.	Haran, K.	Stillwell | Investigating Optimal Inverter Topologies for High-Frequency Low-Inductance Motors	Illinois	Inverter Evaluation and Design for High-Speed Electric Machines	High-speed motors exhibit extreme power densities needed for electric flight but require high voltage and low THD excitation beyond the capabilities of commercial motor drives. This project will explore state of the art inverter topologies for high-speed, low-inductance electric motors for electric aerospace applications. We will evaluate multilevel and current source inverter topologies and compare power density, efficiency, and output characteristics with an existing motor loss model. The final design will lead to a scaled prototype motor drive for a 4 kW high speed electric motor.
R1.020.22	Mantooth, H. Alan	Peng, Y.; Stillwell, A.; Zhao, Y.	Mantooth | PowerSynth 3D: Extending Design Automation from Modules to Converters	Arkansas	Big Data Collection for High-Density Power Electronics Performance Prediction	One task would be to take many representative circuit topology and device types and create a circuit creation tool that can automatically change circuit parameters and export for circuit simulations. The student will use PowerSynth to generate as many layout cases and evaluate them through the built-in electrical and thermal models. These training data will be used for calibration of the technology library for the system integration tool. The training data will train a Neural Network model so that performance metrics will be directly predicted from designs with similar design parameters without requiring a complete design cycle.
R1.021.22	Allison, James	James, K.; Miljkovic, N.	Allison |Integrated Thermal Management System (TMS) Design and Spatial Packaging Optimization for Battery Electric Vehicles (BEVs)	Illinois	Integrated Thermal Management System Design and Spatial Packaging Optimizationof Battery Electric Vehicles (BEVs)	This project aims to develop integrated design methods and robust tools to create unique battery electric vehicle (BEV) thermal system designs with reduced power demand, packaging volume, energy consumption, cost, complexity, and weight while satisfying a range of cooling and heating requirements and system constraints (geometric, topological, spatial, functional, component temperatures, working fluid,component sizing (mass/weight and cost), safety). This project involves active collaboration with POETS industry partners. REU students will be mentored by postdocs and/or graduate students to help participate in tasks such as using MATLAB/Simulink or CAD-based software tools to run simulations for BEV thermal system design. In addition, they will gain algorithmic thinking skills, experience in formulating research questions and associated research plans, and gain experience using optimization and/or heat transfer/thermodynamics methods for mobile transportation applications. Experience in one or more of the following domains would be beneficial for this project: 1) algorithm development/coding interest, 2) heat transfer/thermodynamics modeling and analysis, and 3) experience with MATLAB/Simulink and CAD design tools (e.g.,SolidWorks, Autodesk Fusion 360).
R2.036.22	Mantooth, H. Alan	Asheghi, M., Goodson, K., Huitink, D.; Miljkovic, N	Mantooth | Addressing DBC Warpage and Long-term Reliability of Microchannels in Heterogeneous SiC Power Modules	Arkansas	Heterogeneous SiC Power Modules with Active Cooling	For high power density power electronics application, high-cooling capability cooler and packaging solution are required in the power electronics system. Compared with traditional silicon wire-bonding power module, wide-bandgap (WBG) silicon carbide (SiC) wire-bondless power module has lower switching loss, higher power density and higher heat flux density. In order to fully utilize the benefits of WBG power module, advanced cooling packaging structure are required to ensure the power module's performance in high temperature operation and fast switching condition. This project will develop a structure protype of flip chip power module integration with micro-cooler, which has been optimized by thermal and electrical aspect. It will provide the potential technique for process manufacture micro-channel on DBC ceramic layer of flip chip power module and test the characteristics of DBC micro-channels. Such work will provide a highly integrated SiC power module architecture with advanced active cooling technique and be applicable in multiple markets.
R2.037.22	Banerjee, A.	Miljkovic, N.	Banerjee| Converter-Integrated Variable-Pole Induction Machine Drive for Heavy-Duty Vehicles	Illinois	FPGA-based machine drive controller for a variable-pole induction machine suitable for a heavy-duty electric vehicle.	This project aims to develop and design a variable-pole induction machine for a heavy-duty electric vehicle with a more holistic systems view. The research will include a detailed per-slot model of the electric machine, design of the power electronic drives, and cooling system in a *system-of-systems* design optimization framework. Functional integration of the electric machine and the power converter will lead to a compact, efficient, reliable, fault-tolerant, and inexpensive drivetrain suitable for a drivetrain design that has to operate in a harsh environment. The student will be required to learn and use FPGA (Field Programmable Gate Array) to control power converters that can change the pole count of an induction machine on the fly.
R2.038.22	Miljkovic, N.	Goodson, K.; Smith, S.; Zhao, Y.	Miljkovic | Microcooler Electro-Thermal Integration on GaN Devices Enables Ultra-High Power Density Converters with Robust Indirect Embedded Cooling	Illinois	Numerical Analysis of Hydrophobic Nanostructures in Microchannel Heat Sinks	The REU student will conduct thermal analysis of high-fidelity heat sink models under operating conditions specified by the peer mentor (Darryl Jennings). The student will explore the impact of hydrophobic nanostructures on microchannel flow. The student will generate trends and plots extrapolated from data provided by the numerical analysis. The student will also give weekly presentations about their progress.
R2.039.22	Mantooth, H. Alan	Chen, Z.; Ware, M.	Mantooth | A fast-switching SiC power module for high-temperature applications	Arkansas	Fast-switching SIC power for high temperatures	The REU student will assist in experimental work that explores SiC electronics for extreme environments, such as 200°C and up in electric transportation systems, and 400°C and up in certain industrial applications.
R2.040.22	Wang, P.	Haran, K.; Senesky, D.	Wang | Multi-fidelity Modeling and Sensor Data Fusion for Partial Discharge Diagnosis and Reliability Assessment	Illinois	Artificial Intelligence to Improve Electric Motor Reliability	In this REU project, an undergraduate student will work together with the POETS research team at UIUC to analyze a large data set obtained from electrical motor partial discharge condition monitoring using advanced sensors and use the state-of-the-art artificial intelligence (AI) tool to identify key influence factors and root causes for the electric motor partial discharge failures.
R2.040.22	Wang, P.	Haran, K.; Senesky, D.	Senesky| Multi-fidelity Modeling and Sensor Data Fusion for Partial Discharge Diagnosis and Reliability Assessment	Stanford	Chemical Sensors for Partial Discharge Monitoring	In this REU project, an undergraduate student will work together with the POETS research team at Stanford to characterize the outgassing signatures during partial discharge of motor elements via small-scale chemical sensors. The work supports the proposed Year 9 activities that aims to develop multi-modal sensors (B-field + chemical sensing).
R2.042.22	Smith, S.	Braun, P.	Smith | Design of Enhanced PCMs Materials for Embedded Battery Thermal Management	Howard	Thermal Management of Lithium Ion Battery Packs	The REU student will conduct simulations and optimization of candidate battery pack thermal management designsunder the direction of a graduate-student mentor. The student will explore the impact of vehicle operating temperatureas well as active and passive cooling designs on a small battery pack. The summer student will generate trends andplots extrapolated from data provided by experiments and computations. The student will also give weeklypresentations about their progress.
R2.044.22	Pop, E.	Goodson, K.	Pop | Thermal Modeling & Optimization of Wide Band Gap Transistors, Packaging, and Cooling Solutions for Power Electronics	Stanford	Modeling and Measurement of Wide Band Gap Transistors	Wide band gap (WBG) materials like GaN, AlN, and diamond areexpected to revolutionize power delivery and high-power RF communications. Due to high powerhandling, these devices also heat up significantly during operation, which impacts their reliability.In this project, we will develop computer models to understand the self-heating of such devicesduring operation, and to compare this with temperature measurements. Particular attention will bepaid to a new type of diamond capping layer, which acts as a build-in device heat spreader.

R3.037.22	Braun, Paul	Smith, S.	Braun|High Temperature Solid State Batteries	Illinois	Fabrication and Testing of High Temperature Solid-State Rechargeable Batteries at the University of Illinois	In this project, the student will fabricate high temperature rechargeable batteries using solid electrolytes. The energy storage devices will be fabricated in either coin cell or swagelok configurations and tested at both room temperature and the higher temperatures present within many electro-thermal systems. The student will perform post-mortem analysis of cells using optical microscopy and scanning electron microscopy.
R3.038.22	Goodson, K.	Huitink, D.; Pop, E.	Goodson|Replacing the Solder Ball Technology: Development of a Compliant Electrical (EIMs) and Thermal Interface Materials (TIMs) Interconnects using Copper Nano-wires (CuNWs)	Stanford	Development of a Compliant Electrical (EIMs) and Thermal Interface Materials (TIMs) Interconnects using Copper Nano-wires (CuNWs)	We are developing a composite electrical and thermal interface materials (EIMs and TIMs) using vertically aligned copper nanowires (CuNWs) with 30 µm thickness, 20-25% density. We will use porous polycarbonate track-etched membrane (Sterlitech Inc.) templates to electroplate copper, that will be subsequently substituted with soft polydimethylsiloxane (PDMS) to form the composite matrix. The proposed EIMs and TIMs composite is both thermally/electrically conductive due to high thermal and electrical conductance of aligned CuNWs and mechanically compliant due to presence of PDMS (or TBD) filler agent.
R3.039.22	King, W.	Mantooth, H.A.; Miljkovic, N.; Zhao, Y.	King | Phase Change Material Module Development and Testbed Integration to Demonstrate Increased Power Density of Aircraft Electro-Thermal Systems	Illinois	Phase Change Material Heat Sink	n this project, the student will design and test heat sink devices that use phase change materials (PCMs). A PCM is a material that stores thermal energy as it transitions between solid and liquid phases. When integrated with a heat sink designed for electronics cooling, the PCM can absorb heat pulses generated by the electronics. The REU student will build a PCM heat sink where the PCM material is paraffin wax. The PCM heat sink will be mounted onto a circuit board containing electronic devices. The student will measure the temperature changed in the electronics and heat sink using an infrared camera. The project requires knowledge of thermodynamics and basic electronics.
R3.040.22	Lyding, J.	Braun, P.; Huitink, D.; Li, X.	Lyding | 3D Printed Carbon Nanotube Applications	Illinois	Enhancing thermal conductivity of carbon nanotube-based composite materials	3D printed carbon nanotube-based materials have been developed with high thermal conductivity and low density. This project will involve learning the 3D printing process and then using thermal, chemical, and mechanical processes to increase the density of these materials with the goal of increasing their thermal conductivity. A dedicated thermal conductivity apparatus will be used to make these measurements.
R3.041.22	Ware, M.	Chen, Z.; Zhao, Y.	Ware | Packaged high temperature AlN capacitors	Arkansas	Packaged high temperature AlN capacitors	We have spent many years developing the growth of III-V semiconductors through molecular beam epitaxy and are focusing on high temperature electronics through the wide bandgap family of III-nitride semiconductors. REU students will gain experience in device development from the most fundamental level of the crystal growth. Materials characterization including, for example, structural, electrical, and optical, through xray diffraction, capacitance-voltage measurements, and photoluminescence, respectively, will be heavily relied upon. Specific focus will be on the high temperature response of these characteristics.