Development of Control Electronics for a High-Capacity 90 K Turbo-Brayton Cryocooler

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Creare and West Coast Solutions (WCS) designed and performed an initial demonstration of control electronics for a turbo-Brayton cryocooler in support of NASA's initiatives for zero-boil-off cryogen storage. The ultimate goal of the program is to produce a flight-qualified set of Cryocooler Control Electronics (CCE) to drive a single-stage reverse turbo-Brayton cryocooler used to produce 150 W of refrigeration at 90 K and reject heat at 300 K. On the current project, Creare and WCS developed an initial flight CCE design as well as final engineering model CCE design. Development included electronics, mechanical hardware, and firmware for the CCE. The design comprises four boards encased in an aluminum enclosure designed to survive NASA GEVS shock and random vibration environments with key functions including power conversion and conditioning, turbomachine speed control, system-level control, and telemetry processing. To perform an initial demonstration of the design, the team built and tested a fully functional brassboard version of the CCE using parts representative of the flight versions in form, fit, and function. The brassboard CCE was tested with passive loads as well as a custom-built turbomachine simulator to represent the loads and sources of the cryocooler turbomachines. The turbomachine simulator allowed for more rigorous testing of the hardware as well as advanced features of the CCE firmware. Brassboard testing demonstrated functionality and also helped to identify favorable architectural changes to further improve efficiency and overall robustness of the design. The engineering model design is now poised for fabrication and testing on a future project.