Low-Cost Space Hardware and Software

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Abstract

The goal of this project is to demonstrate and support the overall vision of NASA's Rocket University (RocketU) through the design of an electrical power system (EPS) monitor for implementation on RUBICS (Rocket University Broad Initiatives CubeSat), through the support for the CHREC (Center for High-Performance Reconfigurable Computing) Space Processor, and through FPGA (Field Programmable Gate Array) design. RocketU will continue to provide low-cost innovations even with continuous cuts to the budget.

NASA introduced Rocket University for research and development in rockets, unmanned aerial systems, weather balloons and the Neo liquid engine test bed. This particular opportunity pertains to small, low-cost space vehicles (CubeSats) which will provide low-altitude experimentation and training. With the shutdown of the Space Shuttle program, this research will provide crucial opportunities for engineers to demonstrate and improve their flight engineering skills. RocketU has created the opportunity to design an EPS monitor and to support a custom space processor design for implementation of FPGAs in CubeSats.

The EPS monitor was specifically designed for RUBICS and will provide temperature, current, and voltage data from a Lithium Ion battery with the use of a microcontroller. The data being monitored was measured and calibrated using analog sensors accompanied by an analog-to-digital converter onboard the microcontroller. Testing was conducted in a controlled environment to ensure that the sensors were working properly. The acquired data will be telemetered from the CubeSat to a ground station where it can be monitored and recorded.

RocketU is advancing its avionics platform and moving to technologies such as the FPGA.The limitations of the microcontrollers are being reached so the parallel processing capability and higher sampling rates of the FPGA are demanded. The CHREC Space Processor design is currently underway to provide an affordable FPGA platform. Kennedy Space Center (KSC) has partnered with the CHREC lab at the University of Florida to support and critique their design. Numerous design reviews of the hardware and software were conducted to ensure that specifications and requirements are met in the final product. To get the FPGA vision initiated, RocketU provided a three-day training course which provided project tutorials using the Xilinx design tools. After the course, I was assigned to working out the bugs and design flows with a design project on a ZedBoard (development platform). The project involved integrating and sampling a three-axis accelerometer with the FPGA at 10,000 samples per second. I wrote a manual to familiarize any RocketU engineer with the Xilinx design tools and the implementation of a design on the ZedBoard.

To conclude, RocketU has proven that it can provide flight engineering skills by using low-cost platforms. RocketU has provided me with invaluable knowledge and skills including microcontroller design, improvements in C programming, FPGA design, VHDL (VHSIC (Very High Speed Integrated Circuit) Hardware Description Language) programming, and familiarity with Xilinx design tools. This knowledge will be extremely helpful with design projects I do in the future.