University of Tennessee engineering team develops chip for Mars rover

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Ben Blalock, professor of electrical engineering and computer science, and two graduate students — Stephen Terry, now an alumnus, and Robert Greenwell — designed a tiny microchip that weighs close to a paper clip and helps control the motors on the rover.

There are about 80 of these Quad Operational Amplifier (op amp) microchips powering the rover's 40 motors. Without them, the rover would not be able to traverse the Martian surface, collect samples with its robotic arm, or maneuver the cameras for sending back pictures of the Red Planet — all central to the mission of finding clues of Mars being able to sustain microbial life.

"These analog chips are in the motor controller electronics that make the camera move, pan around, go up and down," said Blalock. "They also make the robotic arms move around and operate the wheels on the rover. All these things require motors."

Although op amps are common in consumer electronics, this analog microchip is unique in that it can withstand 500 days of potential radiation exposure and temperatures ranging from minus 180 degrees Celsius to positive 120 degrees Celsius, more than sufficient for the minus 120 degrees Celsius to positive 20 degrees Celsius temperature swings on the Martian surface each day. The chip underwent rigorous testing, such as operating in thermal ovens, to ensure it could withstand the elements.

"We not only had to design it to meet the Martian surface environment requirements, we also had to overdesign it to operate in environments even colder than minus 120 degrees Celsius to help enable reuse of the microchip for other extreme environment robotic missions in the future," said Blalock.

The researcher says the innovation represents a paradigm shift in the application of extreme environment electronics in space avionics, possibly opening up the field of space exploration.

"Now, we have access to electronics that are capable of operating out in the ambient," Blalock said. "This gives us a lot of opportunities that did not exist in the past because we had to worry about their functionality. NASA eventually hopes to go beyond Mars and possibly send rovers to asteroids and moons of planets." Using these chips enabled more electronic systems to be implemented on Curiosity's exterior, which helped minimize cabling headaches on the rover and made room for the addition of more scientific instrumentation. This is providing NASA's scientists even more information about the Red Planet.

UT and JPL had worked together in the past, so when JPL needed help designing electrical circuits for Curiosity, they gave Blalock and his Integrated Circuits and System Laboratory team the opportunity. JPL engineers worked in lock-step with Blalock's team yielding success for Curiosity. Blalock and his students worked on the chip from 2004 to 2007. To see their hard work finally come to fruition is very fulfilling.

"I'm thrilled that the students had this opportunity," said the professor. "It helps them grow as circuit designers and makes them more marketable. They were able to do a level of analog chip design that far exceeds whatever they would be called upon to do in the commercial industry. I know for a fact we're one of the very few university teams—if not the only university team—that's been able to develop space flight microelectronic hardware."
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Two other professors, Linda Kah and Jeffrey Moersch, associate professors in the Department of Earth and Planetary Sciences, are also working on the mission. The Curiosity launched on November 26, 2011, and landed on Mars on Monday.

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