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C1Or1A-06: Micro-Sized Cryocooler Controllers for Space

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The explosion in SmallSat and CubeSat deployments has led to a need for miniaturized cooling solutions for sensors that require cooling. Since there are limited opportunities for miniaturization in the thermal mechanical unit (TMU) portion of the cryocooling system, much of the pressure to reduce size falls on the cryocooler control electronics (CCE). In the world of digital electronics, continuous size reduction is the expected norm, however, in the world of power electronics this is not the case. The number of components and their variety is greatly limited when selecting space grade electronics, typically resulting in designs that make space grade electronic solutions much larger than an equivalent circuit made of commercial grade electronics.

One way to reduce the size of the power components is to switch at a higher speed. The current generation CCE devices built by Iris Technology utilize MOSFET power transistors to perform power conversion. The characteristics of the power MOSFETs limit the switch rate to something on the order of 100 kHz, thus driving the energy storage requirements of the capacitors and inductors. If we could switch faster we reduce the required energy storage and thus the size of the inductors and capacitors.

One solution to the switching frequency problem is the use of Gallium Nitride (GaN) FETs which can be switched on the order of 1 MHz. GaN FETs are inherently radiation tolerant, however recently GaN FETs have become available with space grade packaging. The space grade packaging is available with an integral radiation hardened high/low side driver. This integrated part provides further size reduction to the electronics design.

Recently, high performance space grade microcontrollers have become available. These parts offer another integration opportunity, as the FPGA and ADC functions can be combined into a single smaller chip. Space grade GaN FETs when combined with the space grade microcontrollers provide an opportunity for significant reduction in the volume required for the CCE portion of a cryocooler system.

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