

An aerial photograph of a rocket launch at night. The rocket is white with a black nose cone and is being launched from a mobile launcher. Bright orange flames and white smoke are visible at the base of the rocket. The launch pad is surrounded by various structures, including a large building and a tall antenna tower. The background shows a dark forest and a bright sky.

Micro-Sized Cryocooler Controllers for Space

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Iris Control Electronics (ICE)

- Iris is the premiere provider of space cryocooler control electronics
- We are committed to supporting the space cryocooler community by delivering high performance control electronics
- We have delivered control electronics models providing power from 25W to 800W
- We have delivered control electronics for most cryocooler configurations
- We continue to evolve the design of space control electronics to enhance performance and SWaP-C



ICE Product Line

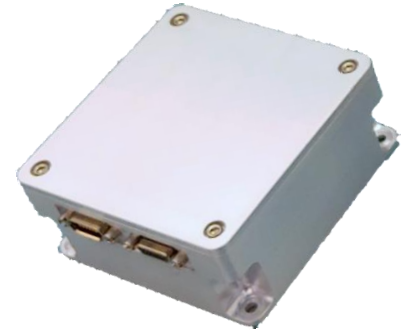
- The Iris Control Electronics shown in the graphic are our standard models
- ICE products are not targeted at specific coolers, rather are designed to address any coolers in the power category
- Vibration mitigation is included in units above 100 watts
- In addition, Iris has delivered a number of customized units addressing unique customer requirements
- Higher power units (500W and 800W) are currently in development

IRIS CONTROL ELECTRONICS (ICE)

	Mini Low Cost Control Electronics (mLCCE)	Low Cost Control Electronics (LCCE)	2nd Generation LCCE (LCCE-2)	High Power LCCE (HP-LCCE)	Single Piston LCCE (SP-LCCE)
	25W	100W		200W	180W
GENERAL					
Application	Tactical, Low Cost Space, Microsat	Low Cost Space	Low Cost Space	Low Cost Space	Low Cost Space
# of Motors	1	2	2	2	1 + Balancer
PHYSICAL					
Mass	< 400 grams	750 grams	1700 grams	1800 grams	3100 grams
Volume (cm)	9.1 x 9.1 x 3.1	12.6 x 14.2 x 3.1	15.6 x 22.3 x 4.5	18.6 x 18.6 x 4.9	28 x 18.5 x 6.6
POWER					
Input Voltage (V_{DC})	9 to 35	22 to 37	22 to 37	22 to 37	22 to 37
Total Output Power (W_{AC})	25	100	100	200	180
Efficiency	94%	95%	>90%	>90%	85%
TEMPERATURE TELEMETRY					
# of Temp. Sensors	1	2	2	2	2
ADVANCED FEATURES					
Vibration Control	No	No	Yes	Yes	Yes
Input Ripple Filter	No	No	Yes / Optional	Yes	Yes / Optional
TRL Level	8	6	6	6	8

The μ LCCE

- We are continuously improving our control electronics designs
- Iris Technology teamed with Lockheed Martin Space to perform a NASA SBIR (2017 S1.09 - Cryogenic Systems for Sensors and Detectors)
 - Cooling power of 0.3 W at 35 K, with a heat rejection temperature of 150 K
 - Desired masses and input powers are < 400 grams and < 5W
- The Phase II effort resulted in the Deep Space Cryocooler System (DSCS)
- The technology advancements in the DSCS control electronics will propagate across the Iris control electronics product line



μLCCE Size Reduction Goals

- The mLCCE design was the performance target for the μLCCE development
- Size reduction while maintaining performance and space worthiness was the primary goal for the control electronics
- Size reduction target were in three design areas leveraging newly available components
 - Power Conversion Circuits
 - System Processing Circuits
 - Signal Sensing Circuits

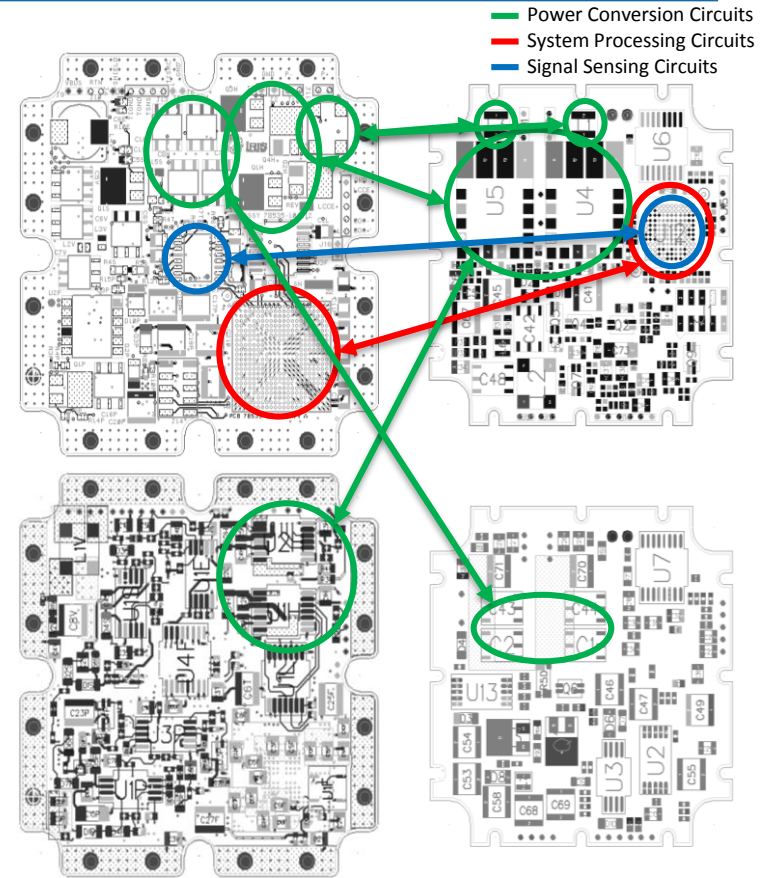
mLCCE (3.6 x 3.6 x 1.357 in)
288 cc



μLCCE (3.1 x 3.1 x 1.24 in)
195 cc

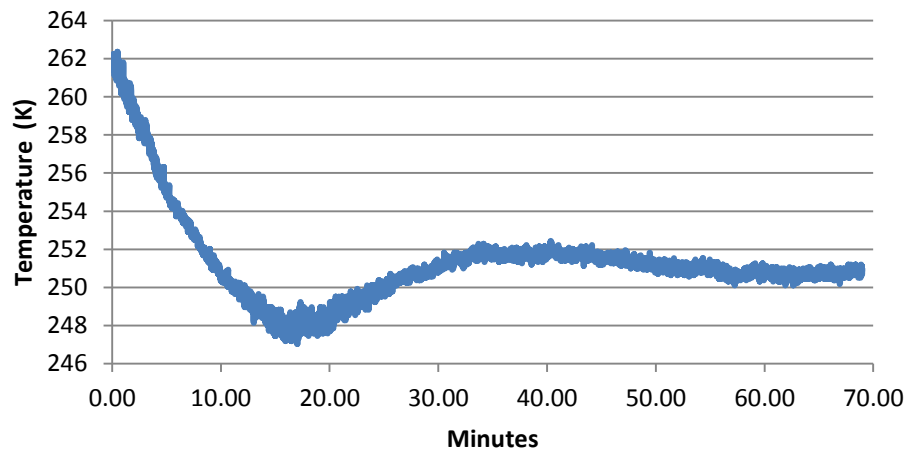
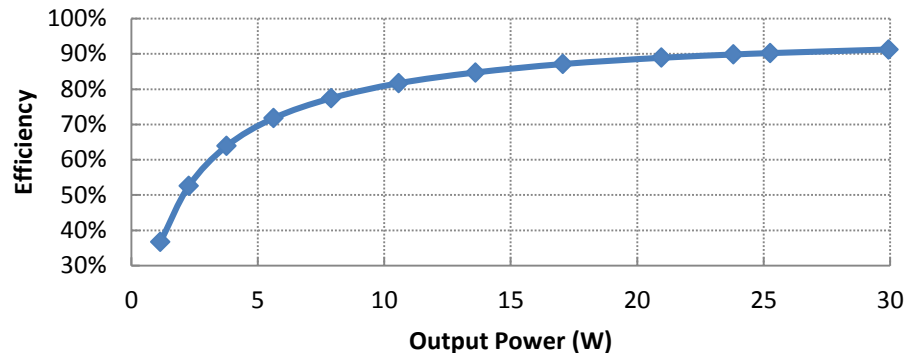
μLCCCE Size Reduction Results

- Size Reduction Targets
 - Power Conversion Circuits
 - Switch from MOSFET to GaN FET
 - Switching speed increases from 100 kHz to 500 kHz
 - Inductor and capacitor sizes reduced
 - System Processing Circuits
 - Switch from FPGA to microcontroller
 - Smaller footprint
 - Lower quiescent power
 - Signal Sensing Circuits
 - Switch from discrete ADC to μ C built-in
 - Reduces board area
 - Lower power internal signaling
- Result
 - 28% reduction in circuit board area
 - 32% reduction in unit volume



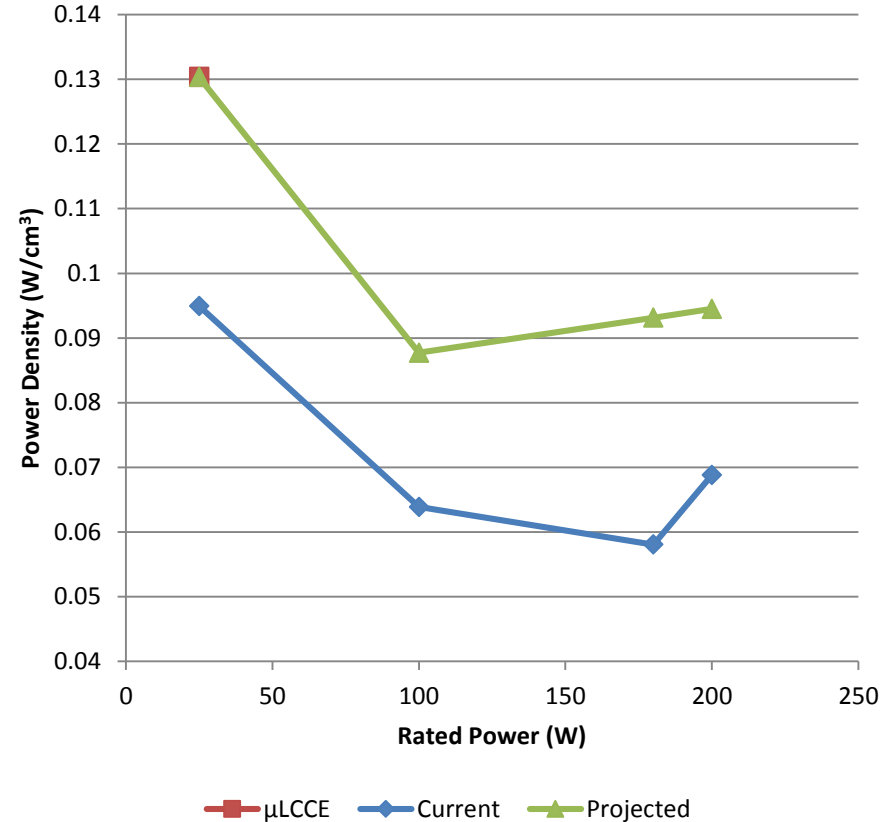
μ LCCE Performance

- The μ LCCE was able to achieve 90% efficiency at rated power
 - Consistent with mLCCE design
- The μ LCCE demonstrated the ability to control temperature to a defined setpoint using a control loop
 - Settled to a standard deviation of ± 1 bit of resolution



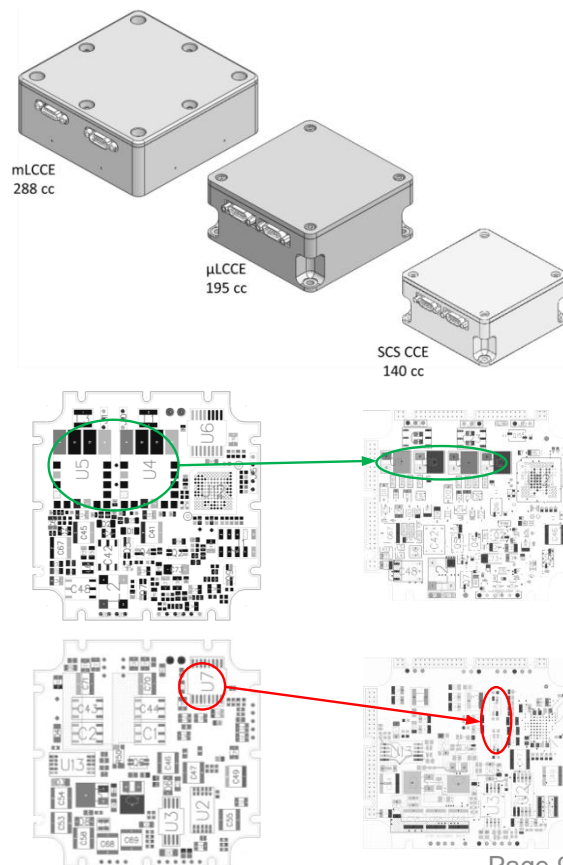
μ LCCE Projected to ICE Product Line

- The μ LCCE demonstrated improved power density that can be projected across the ICE product line
- There are several factors which adversely affect the power density as power increases
 - Current ripple filter
 - Power isolation
- Going forward Iris intends to include these architectural advances in all new developments
 - Facilitates reductions in SWaP-C



Further Developments

- Iris Technology teamed with Northrop Grumman Aerospace Systems and the University of Wisconsin to perform an MDA STTR (MDA17-T003 High-Efficiency, Low-Volume, Space-Qualified Cryogenic-Coolers)
 - Cooling to 110K with 300K reject temperature, size less than 500 cc including space-qualified electronics
- Further size reductions of the 25W class control electronics were achieved by utilizing smaller discrete GaN FETS, designing out some large interface ICs, and optimizing the power supplies
- Phase I provided a complete design
 - Unit has not been built at present



Wrap Up

- Iris is the leader in space grade cryocooler controllers and we are continuously improving our control electronics
- Iris control electronics are designed to be cooler agnostic
- Improvements shown in this presentation are extensible across the ICE product line
- Iris can provide system level recommendations/solutions
 - control electronics + cooler
- Control electronics have utility beyond cryocoolers
 - More production helps reduce prices
- Core design concept reduces supply chain issues
 - Established parts flow reduces time-to-build

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- Further enhancements were supported by MDA STTR funding for MDA17-T003 High-Efficiency, Low-Volume, Space-Qualified Cryogenic-Coolers
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THANK YOU!