ICE-G Platform Development

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• Iris Technology has a long history of designing and developing cryocooler control electronics (CCEs)

• Recently Iris Technology has made efforts to advance the state-of-the-art in CCEs by introducing new innovations utilizing the latest available space-grade parts

• These innovations have added three new CCEs, equivalent in performance to legacy devices in the Iris Technology product line

• In addition, Iris Technology is developing a 1000-watt CCE to address higher-power cryocoolers
Nomenclature

ICE-G2-200C

- Any combination of these characters: C=COTS, I=IRF, B=balancer, L=launch locks, T=transformer isolated
- Total maximum rated output power
- Number of outputs 1, 2, 3=3-phase rotary
- M=MOSFET output, G=GaNFET output
- ICE=Iris Control Electronics
Introduction to ICE-G

• The ICE-G series of cryocooler control electronics (CCE) provides cost and performance enhancements to the Iris CCE product line

• These enhancements are provided through the addition of GaN FET output stages and microcontroller-based control
  - Higher efficiency power performance
  - Easy customization to meet mission needs
  - Lower unit costs

ICE-G Provides Cost and Performance Enhancements
First Target - mLCCE to ICE-G1-30

• The first development was a size reduction of the mLCCE
• The mLCCE is a successful product used in the SmallSat community
• The ICE-G1-30 reduced the volume of the CCE by 32%
• First delivery 2019
ICE-G1-30 Block Diagram

- **28V Power**
  - EMI & Inrush Filter
  - Internal Power Converter
    - 10.5V
    - 6.8V
    - 5V
    - 3.3V
    - 1.5V
  - Signal Conditioning
    - Temp Sensor

- **Master Comm**
  - Microcontroller

- **Surge Protection**

- **GaN FET Drive**
  - Motor A
Next Development ICE-G2-60

- The ICE-G2-60 is a reduced-size version of the LCCE with several enhancements
  - Active vibration control
  - Multi-CCE communication
  - Multi-CCE synchronization (w/ arbitrary phase)
- The ICE-G2-60 reduced the volume of the CCE by 25%
- First delivery 2020
ICE-G2-60 Block Diagram

- **28V Power**
  - EMI & Inrush Filter
  - Internal Power Converter
  - Signal Conditioning

- **Internal Power Converter**
  - 10.5V
  - 6.8V
  - 5V
  - 3.3V
  - 1.5V

- **Surge Protection**

- **Microcontroller**
  - Master Comm
  - Peripheral Comm
  - Sync In
  - Sync Out

- **FPGA**

- **GaN FET Drive**
  - Motor A
  - Motor B

- **Accelerometer**
- **Temp Sensor**
ICE-G2-60 Measured Vibration Reduction

• The ICE-G2-60 incorporates Iris Technology’s patented vibration cancellation algorithm
  – This algorithm can significantly reduce the vibration in the axis of piston motion

![Vibration Signal Before Correction](image1)

![Vibration DFT Before Correction](image2)

![Vibration Signal After Correction](image3)

![Vibration DFT After Correction](image4)
Next Development ICE-G2-200I

• The ICE-G2-200I is a lower-cost, higher-performance version of the HPLCCE2 (ICE-M2-200I) with several enhancements
• Cost and performance enhancements while adding new features
• Note that this model is a performance demonstration that could be reduced in size
• First delivery 2022
ICE-G2-200I Block Diagram

- **28V Power**
  - EMI & Inrush Filter
  - Input Ripple Filter
  - Surge Protection

- **Internal Power Converter**
  - 10.5V
  - 6.8V
  - 5V
  - 3.3V
  - 1.5V

- **Signal Conditioning**
  - Accelerometer
  - Temp Sensors

- **Microcontroller**
  - Master Comm
  - Peripheral Comm
  - Sync In
  - Sync Out

- **FPGA**
  - Sync In
  - Sync Out

- **Output Drives**
  - Motor A
  - Motor B
The ICE-G2-200I is not only less expensive than the MOSFET version but also more efficient.

The ICE-G2-200I shows a clear efficiency advantage over the ICE-M2-200I.
Current Development ICE-G2-1000IL

- Iris Technology is currently developing a higher-power ICE unit, the ICE-G2-1000IL
- This unit will target a design that provides
  - Up to 82 peak volts
  - Up to 17 peak amperes
- Currently being funded on Iris IRAD
- Expecting brass board completion in Fall 2023
ICE-G2-1000IL Block Diagram

28V Power → EMI & Inrush Filter → Input Ripple Filter → Surge Protection

Internal Power Converter

- 10.5V
- 6.8V
- 5V
- 3.3V
- 1.5V

Signal Conditioning

- Accelerometer
- Temp Sensors

Master Comm → Microcontroller

Peripheral Comm → Sync In → Sync Out

FPGA

Output Drives

- Launch Lock
- Motor A
- Launch Lock
- Motor B
Power levels and capabilities continue to increase

- Aerospace market continues to require designs with increasing power and additional features

- Iris continues to fund IRAD projects

- Future designs will be flexible with the ability to incorporate various design modifications

- Modifications can include:
  - Higher power level
  - Launch locks
  - Input ripple filters
  - Multiple CCE synchronization
  - Temperature-based power limiting
  - Additional temperature sensors

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Customization Available on all ICE Gx Platforms

- Customization of existing designs is a feature of the ICE-Gx products
- Algorithm customization is easily accomplished through software updates
- Hardware customization is also available
- For instance, a customer wanted an input ripple filter (IRF) and launch locks on an ICE-G1-30 CCE
  
  - Develop a second (stacked) board with new electronics
  - Developed a clamshell enclosure to house the board stack
Conclusions

• Iris Technology has developed a new ICE architecture that is smaller, less expensive, and more robust than current-generation CCEs

• This new architecture is extensible to our entire line of ICE from 30 Watts to 1000 Watts
Thank you!

https://www.iristechnology.com/aerospace/control-electronics/