ADVANCED COOLING TECHNOLOGIES

The Thermal Management Experts | www.1-ACT.com

WEBINAR

RUGGEDIZED AND COMPACT THERMAL SOLUTIONS

Enhanced Heat Transport and Thermal Storage for Harsh Environment Applications

ADVANCED COOLING TECHNOLOGIES

The Thermal Management Experts | www.1-ACT.com

Cutting edge thermal solutions for all Military environments

Technologies to manage high heat loads for Space applications

Custom Environmental Control Systems for Extreme Conditions

Patented innovations in electronics cooling for diverse market use

Founded in 2003

- Over 200 Employees
- Over 140,000ft² / 13,000m²
- ISO 9001:2015 & AS9100D Certified
- Awards
  - 2020 Military & Aerospace Product Innovation Awards
  - US SBA Tibbetts Awards
  - Patents and Scientific Publications

Solutions@1-ACT.com

www.1-ACT.com

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LANCASTER, PENNSYLVANIA 17601, USA

Greg Hoeschele:

Lead Engineer, Product Development

B.S. Mechanical Engineering: Lafayette College, M.S. Mechanical Engineering: Cornell University

Greg Hoeschele has been working for ACT since 2015 and has worked across various markets and industries developing passive and active two-phase technologies. He is well versed with the demands of the military and aerospace industry and has worked on a wide range of simple to highly complex embedded computing system level and sub-system level thermal management projects.

Adam Say:

International Business Development Manager

Adam is dedicated to expanding ACT's international customer partnerships. No matter which stage of product development you are working on, he is happy to set up a web conference to discuss the initial feasibility of ACT's thermal solutions.

Adam brings over 18 years of experience in international sales from a vast portfolio of industries and clients. He holds a Master's Degree in Business Administration and a B.S. in International Business and has traveled to more than 55 countries around the world.

ACT

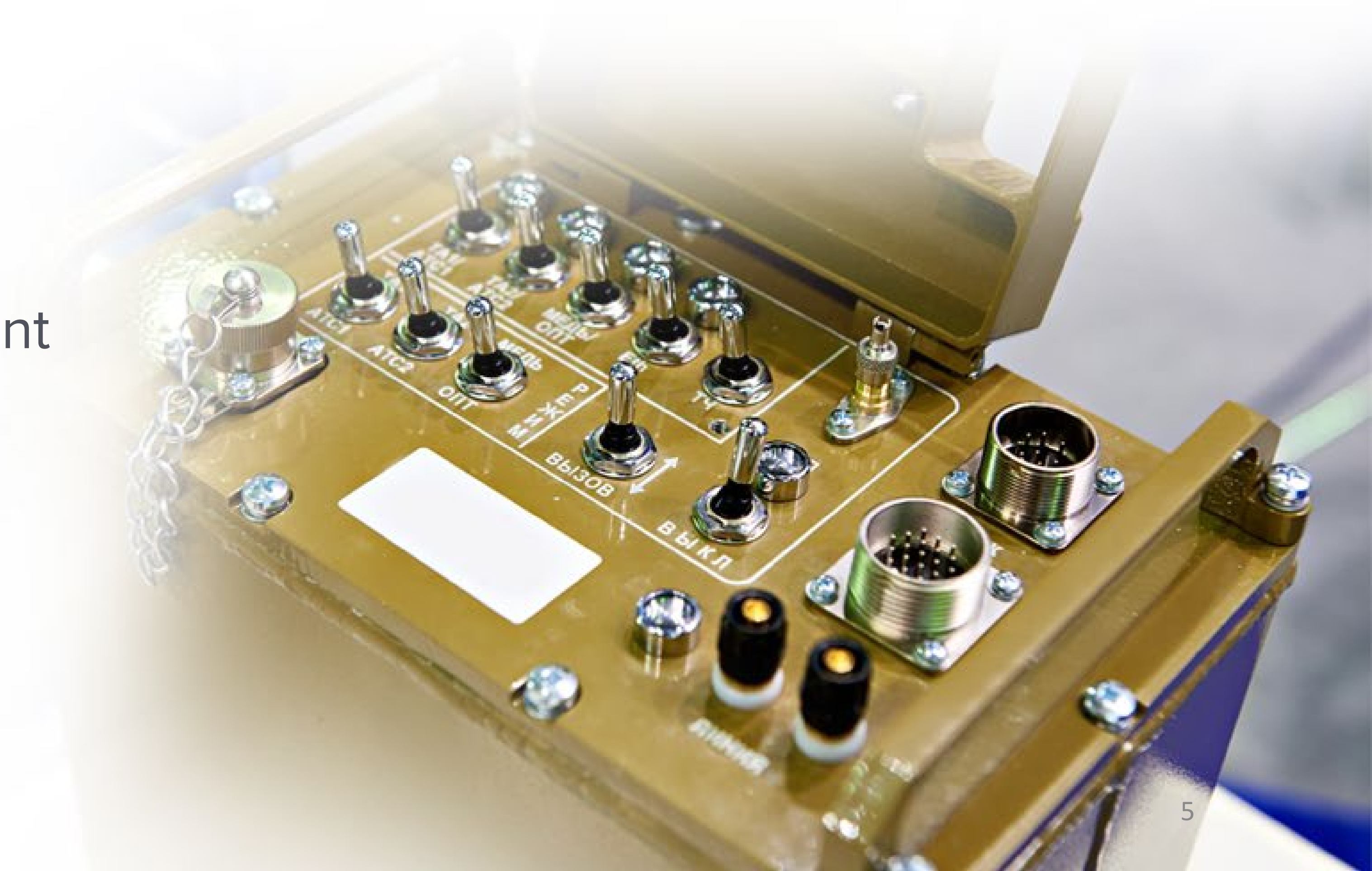
SPEAKERS

AGENDA

- **Common Environmental Conditions for Ruggedized Solutions**
- **Market Trends**
- **Heat Pipes and HiK™ Plates**
  - Product Overview
  - Environmental Condition Impacts
  - Case Study
- **Phase Change Material Heat Sinks**
  - Product Overview
  - Environmental Condition Impacts
  - Case Study

OVERVIEW OF APPLICATIONS

- **The approaches discussed in today's webinar will focus on passive, rugged electronics cooling. Some typical applications include:**
  - Avionics
  - Radar
  - Embedded Computing
  - Communication Equipment
  - Signal Intelligence
  - Electro-optics
  - UAV Control Electronics



COMMON MECHANICAL REQUIREMENTS

- **MIL-STD-810-G**
  - Corrosion Resistant & Protected Electronics
    - Dust, Rain, Humidity, Salt fog
  - Shock/Vibration
  - Acceleration
  - Altitude
- **Minimize Weight**
- **Meet Structural Requirements**
- **Volume/Geometric Restrictions**

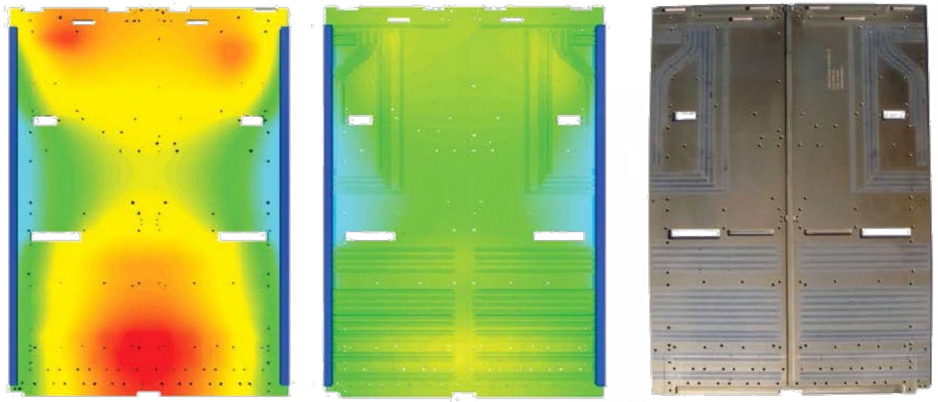
COMMON THERMAL CHALLENGES

- **Ambient Temperature Range**
  - Minimum Temperature ~ -25 C
  - Maximum Temperature + 45 C
- **Sink Temperature (if applicable)**
  - Maximum Temp = 85 C
- **Electronics Temperature**
  - Key Requirement: Max Case Temperature (from electronics supplier)
  - Typical Value: +135 C
- **Altitude (if applicable)**
  - Low ambient temperature
  - Lower air density

COMMON THERMAL PROBLEMS

- **Conduction Limitations**
  - Localized hotspots due to high heat flux electronics
  - Long heat transfer distances (> 3”)
  - Remote Heatsink (cannot couple source and sink)
  - Material Property Limitations:
    - Aluminum ~ 170 W/m-k
    - Copper ~ 400 W/m-k (Adds significant weight)

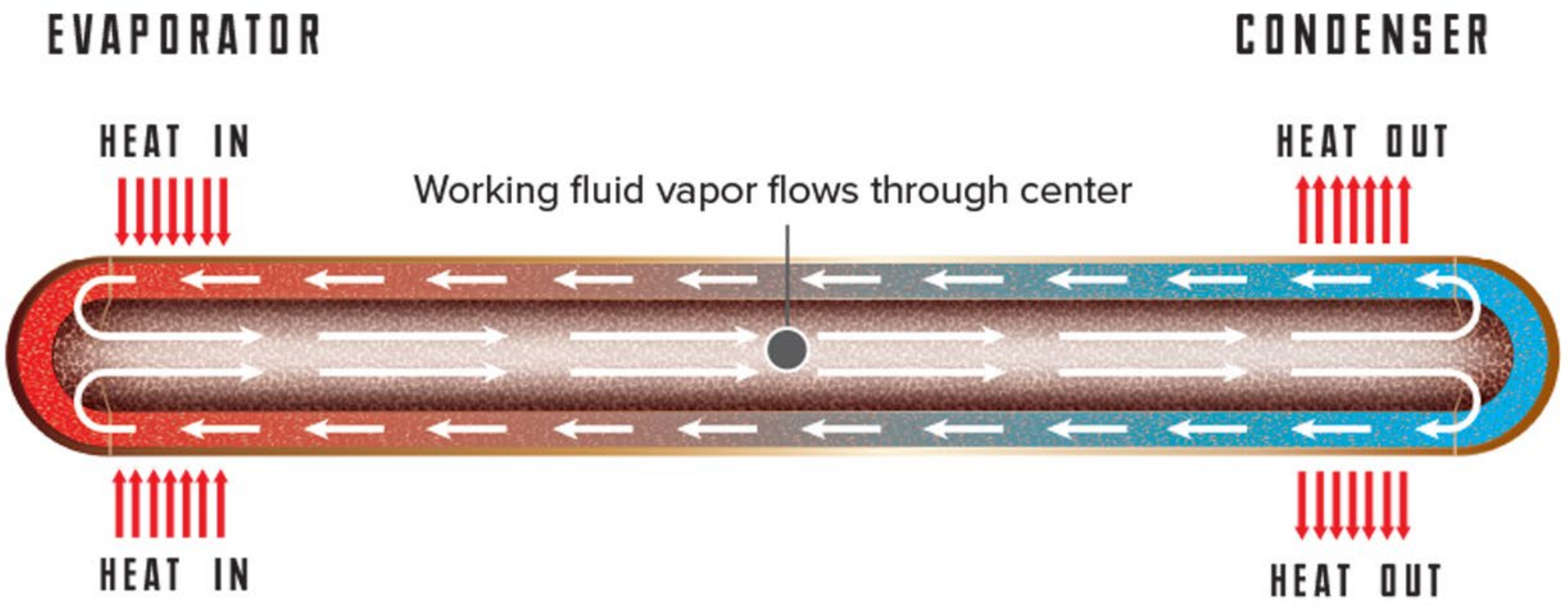
- **Transient Power**
  - Designing to peak power adds volume, weight, complexity
  - Many systems such as directed energy, transmit/receive devices, operate on duty cycles < 50%
  - If waste heat < 100s of Watts, significant savings are possible with thermal storage

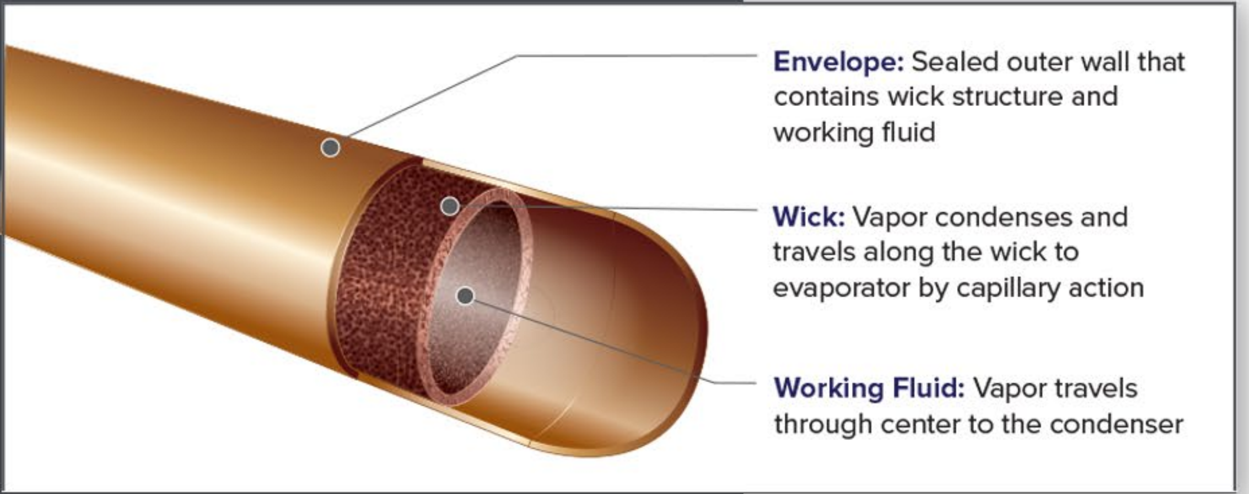


Solution = HiK™ Plates

Solution = PCM Heatsink

HEAT PIPE
SOLUTIONS





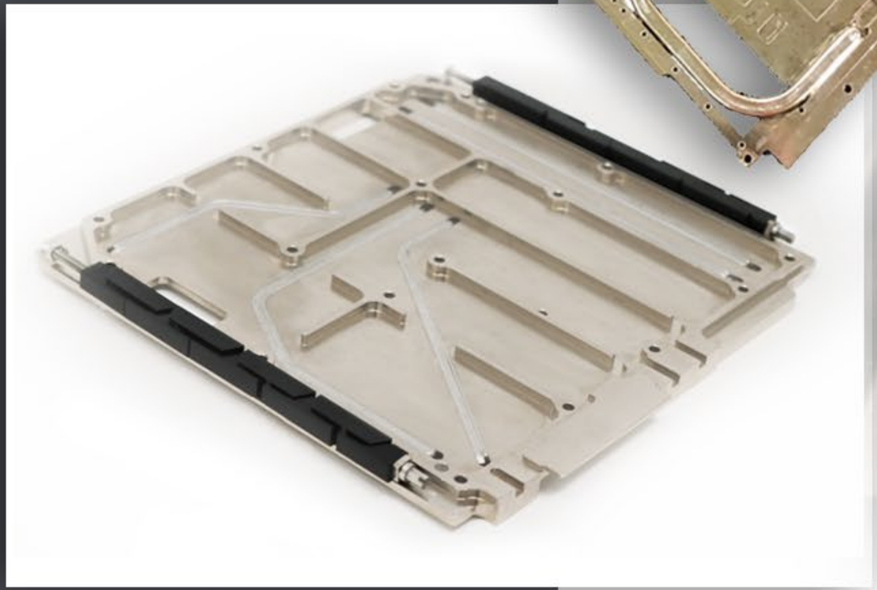
THERMAL SUPER CONDUCTORS

- Heat Pipes (why it works, etc.)
- Integrating / Designing with heat pipes
  - Source/Sink considerations
  - Power Considerations
  - Orientation & Acceleration Considerations
  - Quick design example using the calculator

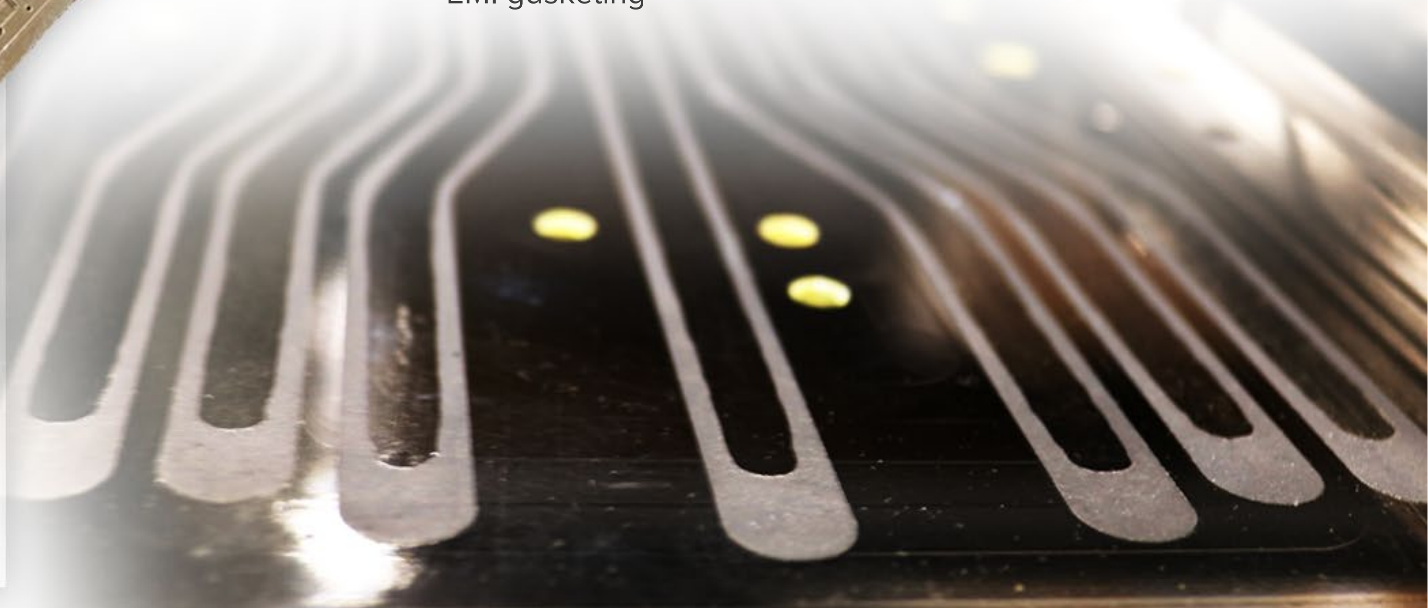
HIK™

HIGH CONDUCTIVITY

- HiK™ are heat spreaders with embedded heat pipes to transport heat as desired in your system.
  - Aluminum Frame: k = 167 W/m-K
  - HiK™ Frame: k = 650 W/m-K (For 6U form factor)
- Similar Weight as Aluminum
- Similar Strength as Aluminum
- All critical features can be maintained



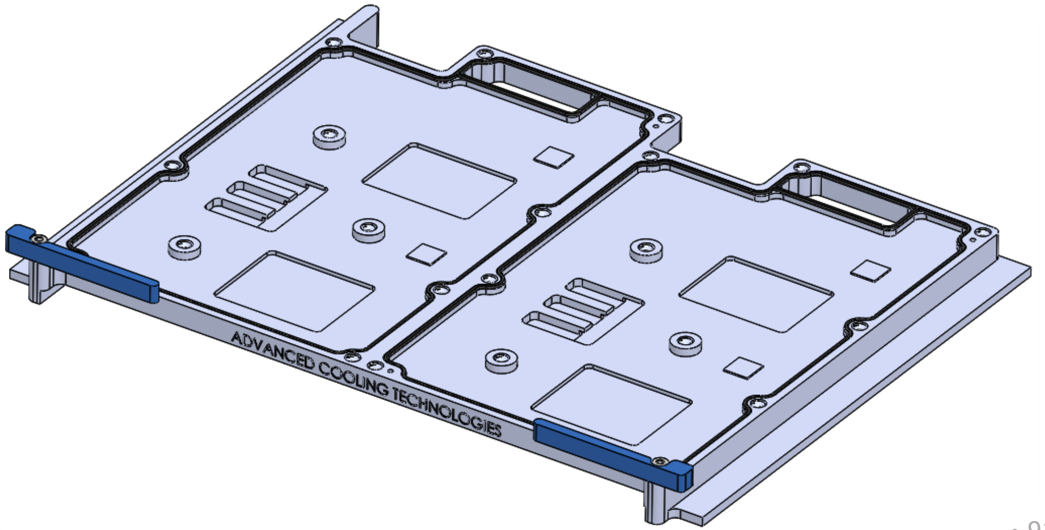
- Value-added manufacturing capabilities
  - Coatings
  - Helicoils
  - Dowel pins
  - Thermal interface Pads
  - ICE-Lok™ Integration
  - EMI gasketing

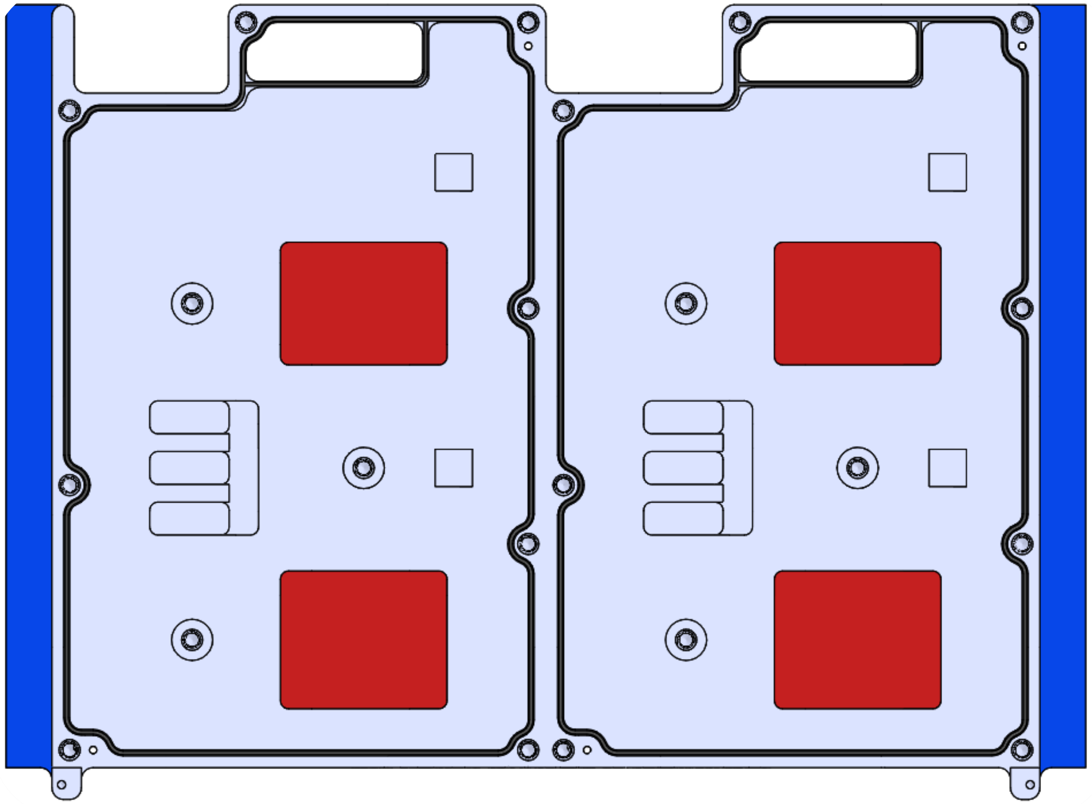


HIK CASE STUDY

Design Requirements for 4.5 U Conduction Card:

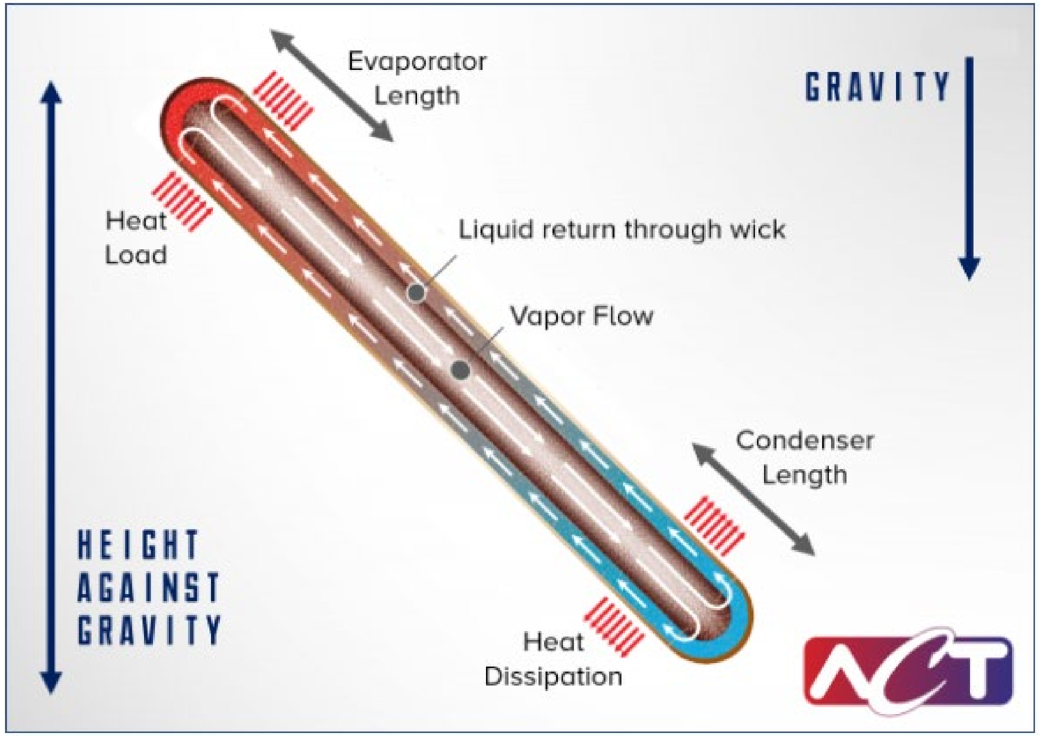
- Heat Loads: Four 90W heat loads (Red)
- Rail Temp: 60°C (Blue)
- Card Thickness: 5.5mm
- Operation in any Orientation

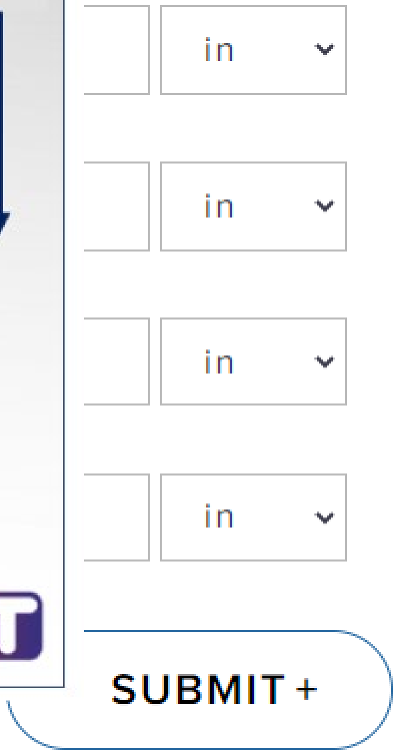




HIK CASE STUDY

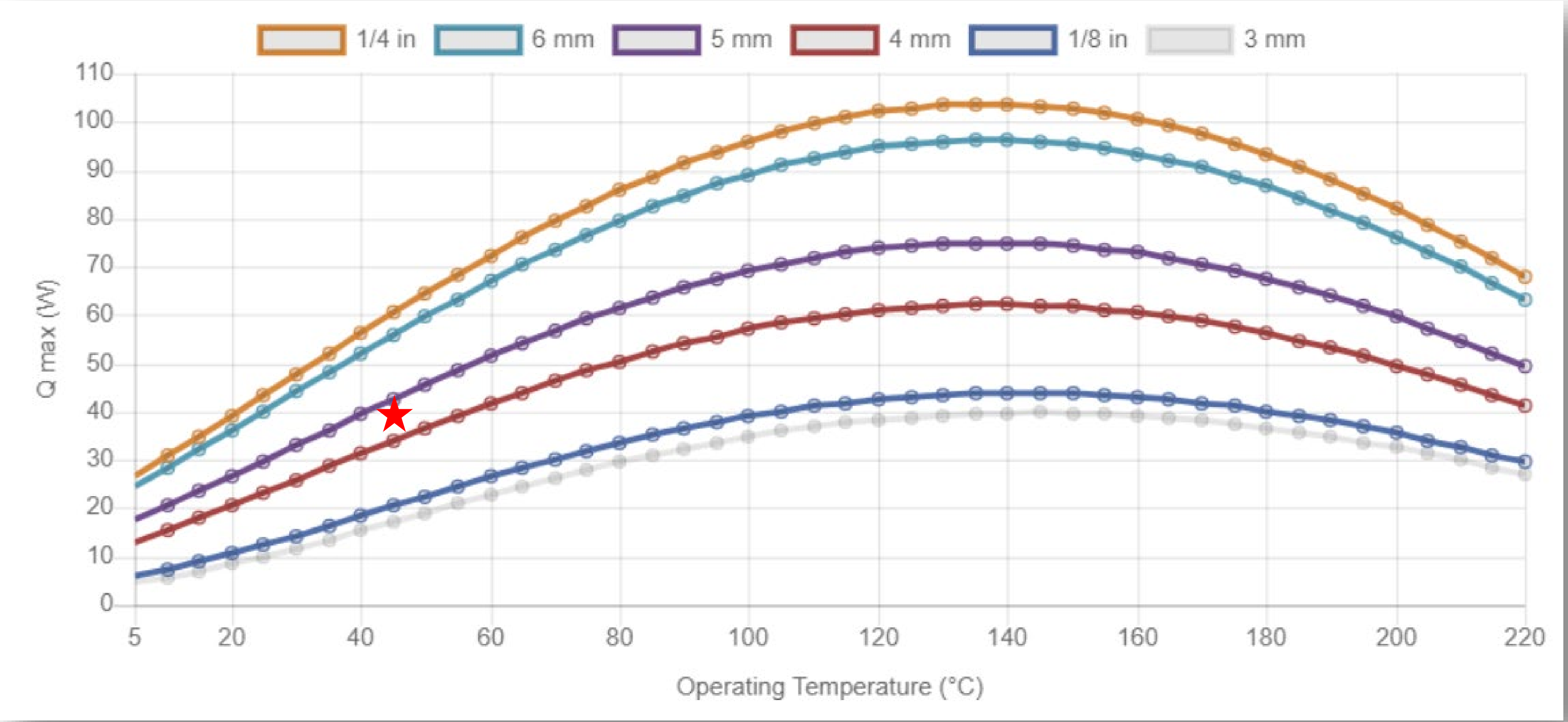
www.1-act.com/resources/heat-pipe-calculator/





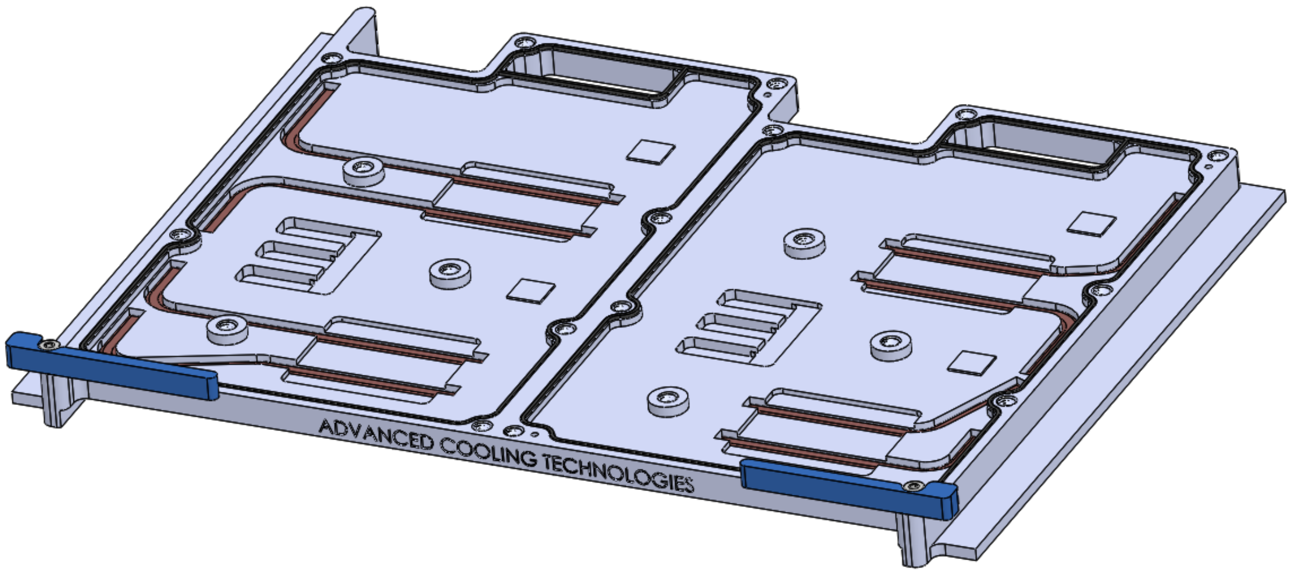
- ✓ Value for Heat Pipe Length
- ✓ Value for Evaporator Length
- ✓ Value for Condenser Length
- ✓ Value for Height Against Gravity

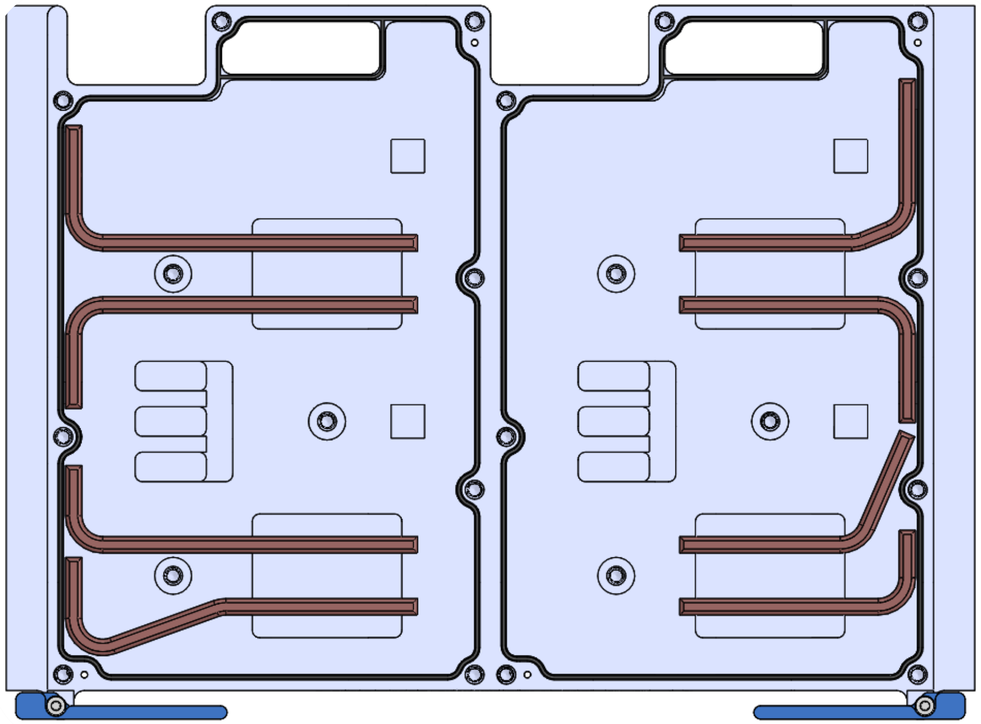
HIK CASE STUDY



HIK CASE STUDY

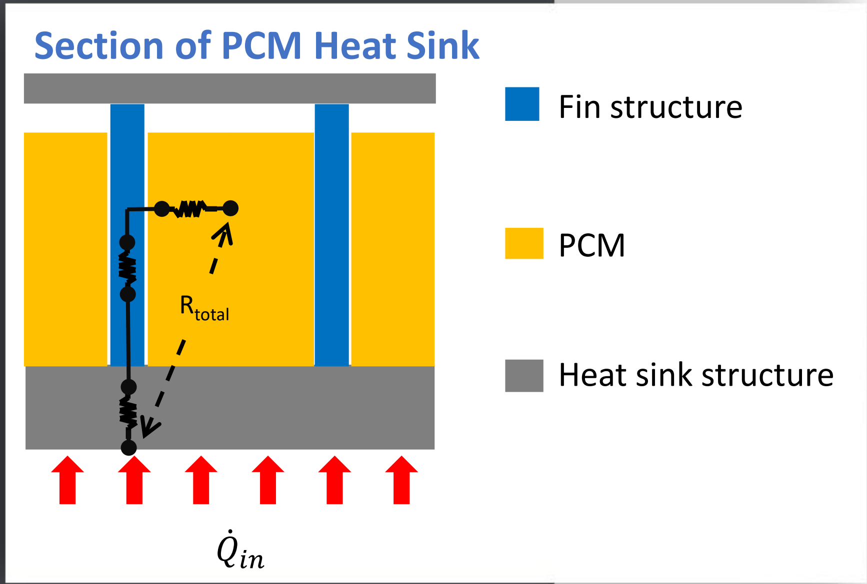
- Two 5mm heat pipes under each heat source





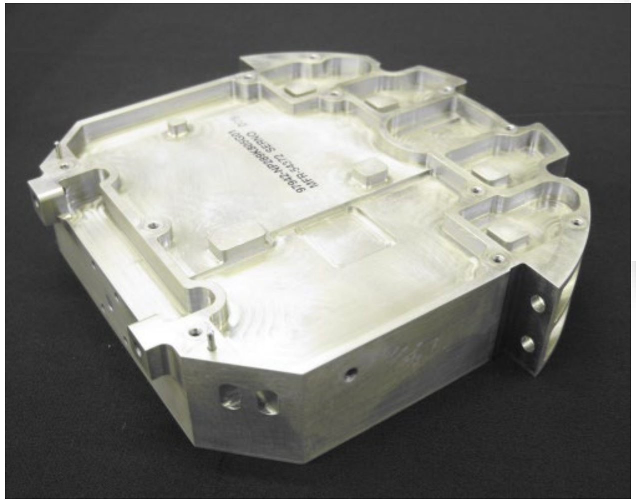
PHASE CHANGE MATERIAL HEAT SINKS

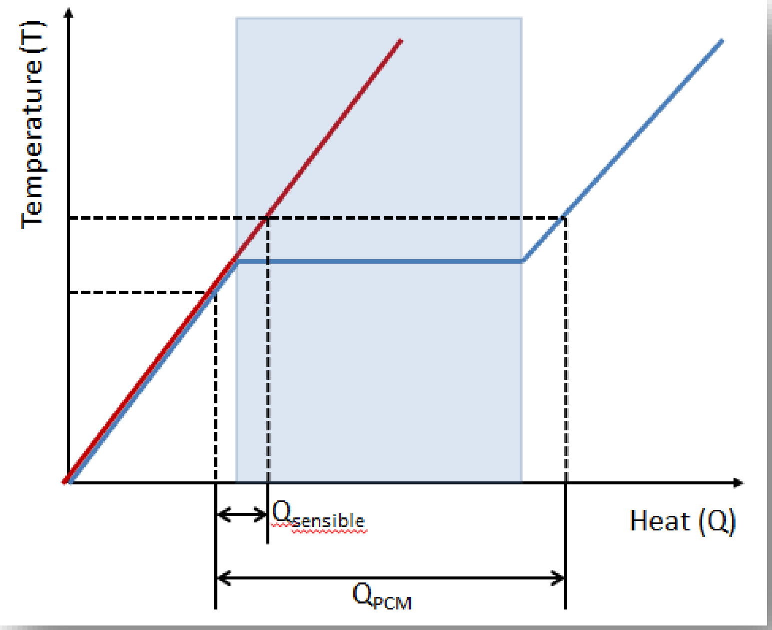
- **Challenges:**
  - Poor thermal conductivity of PCM creates gradients during the melt process
  - Minimize impact of voids at the critical component locations
- **Design Considerations:**
  - Reduce thermal gradients with proper fin design:
    - Fin Pitch
    - Fin Thickness
  - Trades between thermal gradient and PCM volume



PHASE CHANGE MATERIAL HEAT SINKS

- Phase Change Material (PCM) is any material that has a relatively high thermal capacity, or latent heat value
  - Latent heat of Fusion – Solid to Liquid
  - Latent heat of Vaporization – Liquid to Gas
- Things to keep in mind:
  - Melt range(s)
  - Compatibility with base metal
  - Type of PCM
  - Purity
  - Capacity
    - Driven by latent heat





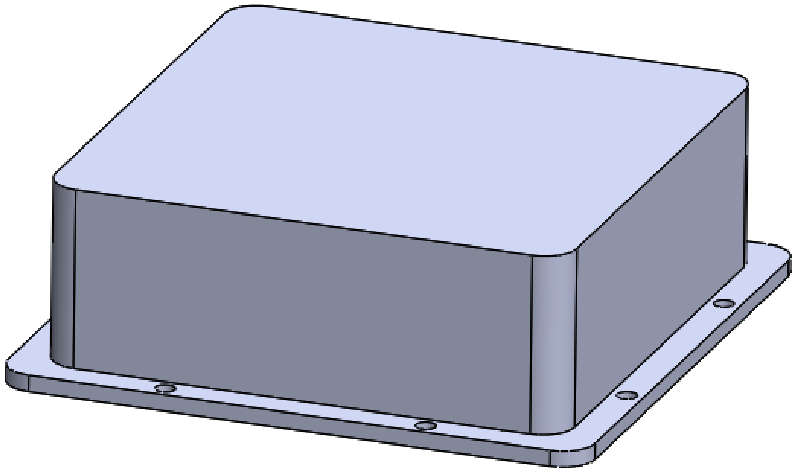
PHASE CHANGE MATERIAL HEAT SINKS

Property or Characteristic	Hydrated Salt	Metallics	Paraffin Wax
Heat of Fusion	High	Medium	High
Thermal Conductivity	High	Very High	Very Low
Melt Temperature °C	0 to 100+	150 to 800	-20 to 100+
Latent Heat (kJ/kg)	60 to 300	25 to 100	200 to 280
Volume Change During Melt	Small	Small	Small
Corrosive	Corrosive	Corrosive	Non-Corrosive
Economics	$ to $$	$$ to $$$	$ to $$
Thermal Cycling	Unstable over repeated thermal cycles	Stable	Stable
Weight	Light	Heavy	Medium

PHASE CHANGE MATERIAL CASE STUDY

Design Requirements:

- Heat load: 10W for 110 min
- Heated Area: 4” x 4”
- Starting Temp: 60°C
- Max Temp: 75°C



Possible PCM Materials	$C_{36}H_{74}$	$C_{32}H_{66}$	$C_{30}H_{62}$
$Density_{solid}$ (kg/m³)	857	809	810
Latent Heat (kJ/kg)	223	261	249
T_{melt} (°C)	72 to 76	66 to 70	59 to 66

PHASE CHANGE MATERIAL CASE STUDY

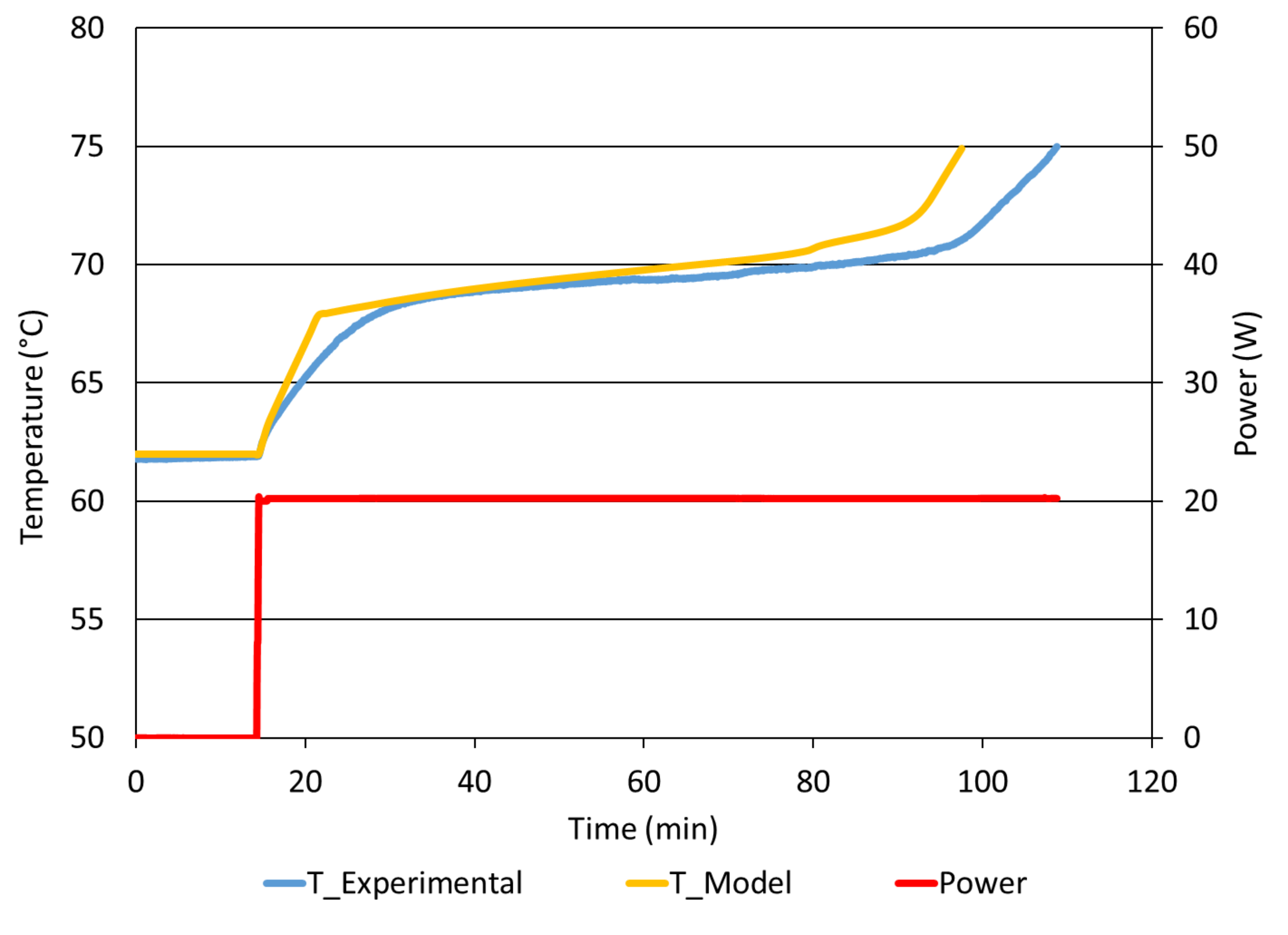
https://www.1-act.com/resources/pcm-calculator/

Parameters		
Initial Temp	60	°C
Final Temp	75	°C
Power	10	W
Time	110	min
Base Width	4	in
Base Length	4	in

COMPUTE PCM OPTIONS

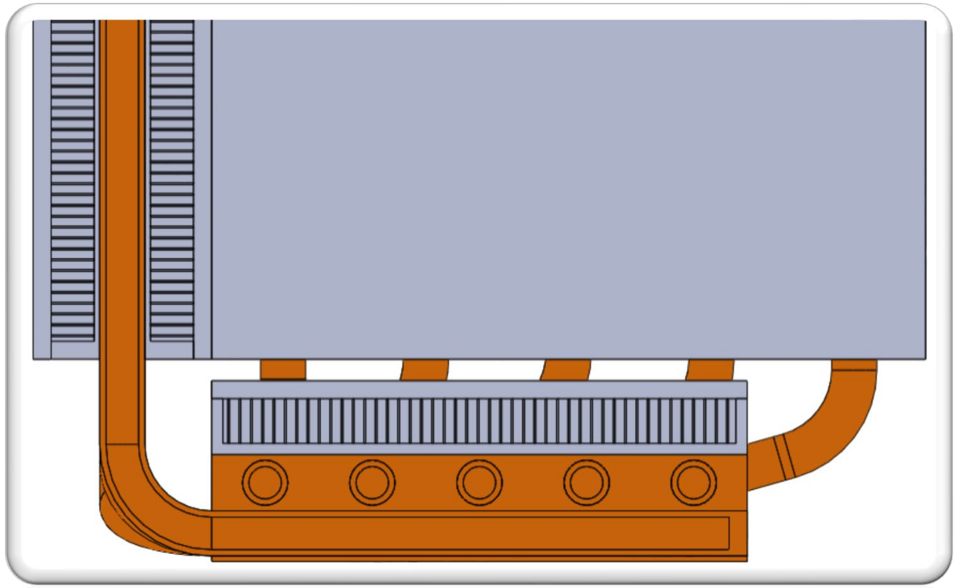
PHASE CHANGE MATERIAL CASE STUDY

PHASE CHANGE MATERIAL CASE STUDY



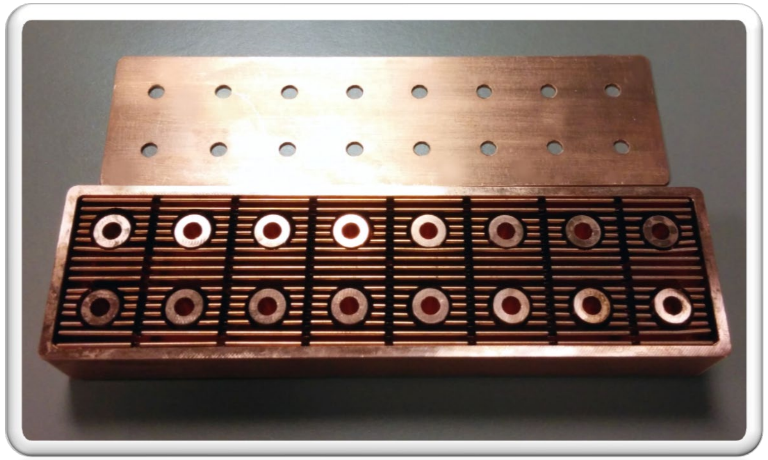
COMBINING TECHNOLOGIES

- Heat pipes and PCM combining for ultimate thermal management
- Concentrated source with height restriction; requiring significant xy spreading to allow for the appropriate PCM volume



TAKEAWAYS

- Understand your thermal requirements and technology options
  - HiK™
  - PCM
- Using passive two-phase can greatly improve thermal performance at card and chassis levels with minimal impact on design consideration.



QUESTION & ANSWER SEGMENT

- Enter your questions into the question panel to the right of your screen

INNOVATION – TEAMWORK – CUSTOMER CARE

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