Designing & Testing Lightweight Heatsink for SiC PV Converter

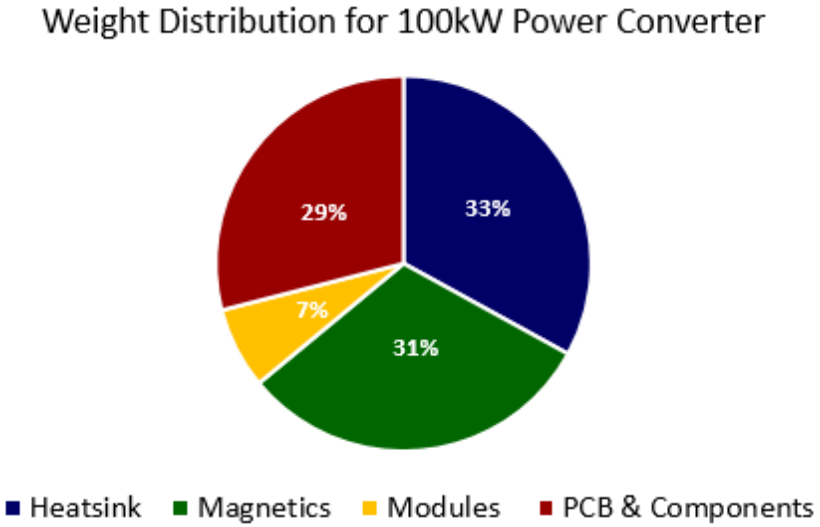
Team 13

Electrical Engineering
Melanie Gonzalez
Tianna Lentino

Mechanical Engineering
Leslie Dunn
James Hutchinson
Colleen Kidder

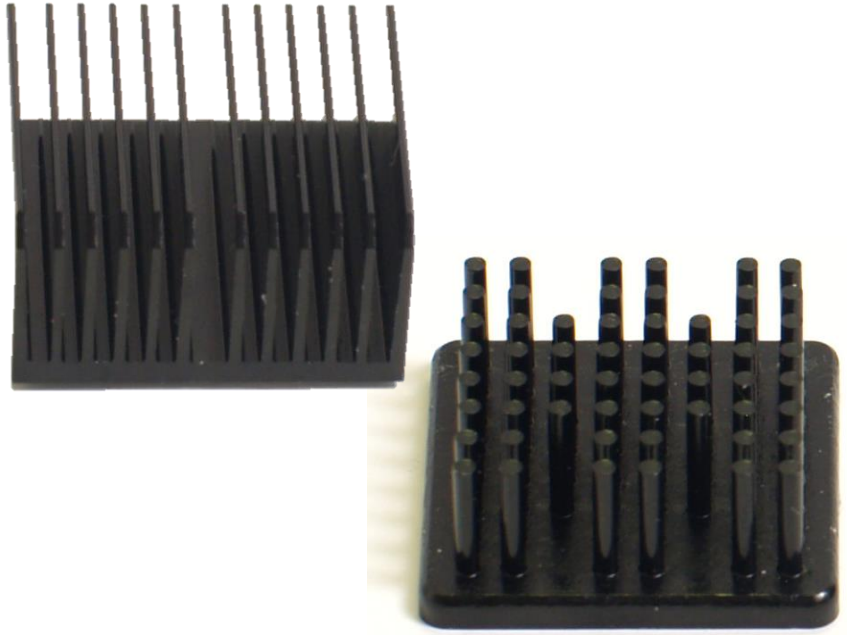
Project Statement

- By decreasing the weight of the heatsink, the power density of the converter can be increased
- Provide a heatsink design & test method for power converters that will allow for optimal system performance



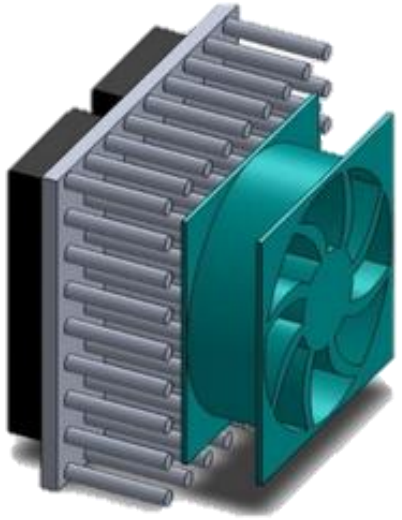
Project Scope

- Design an optimized thermal system for power converters to increase the power density
  - Plate fin vs. pin fin
- Implement a modular heatsink design to advance the current system



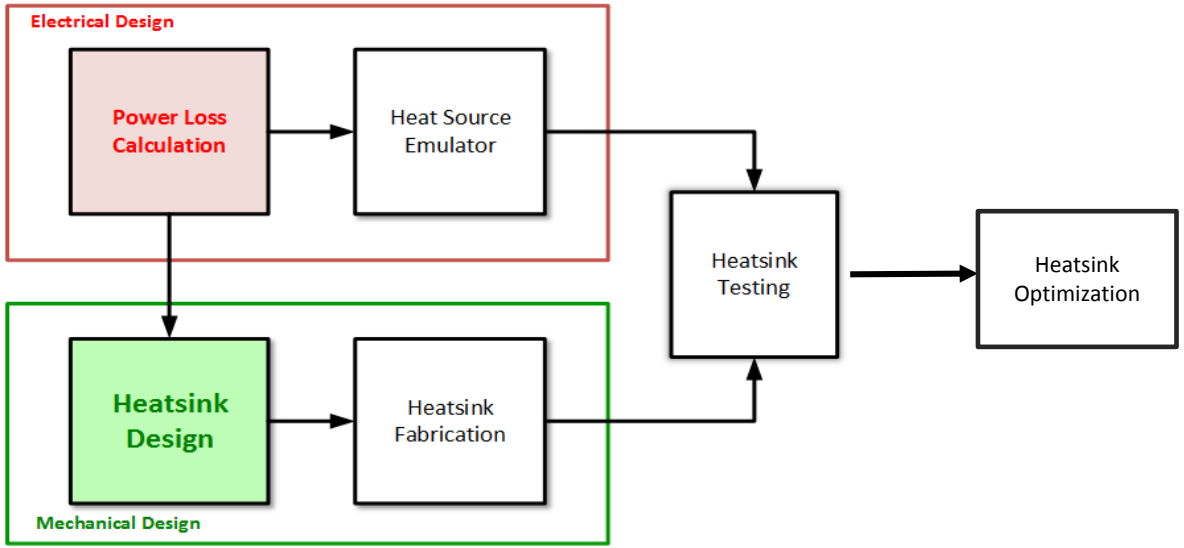
Project Objectives

- Increase the power density from 2.5 kW/kg
- Optimize design for pin fin heatsink
- Implement bi-modular design for a pin fin heatsink
- Select the appropriate fan size and speed



Plan & Methodology

- Through research & calculations, determine initial plate and pin fin modular heatsink designs
- Design & build heat source emulator for heatsink testing
- Verify calculations using both COMSOL simulations and experimental results
- Further improve design through optimized calculations



Heatsink Analysis

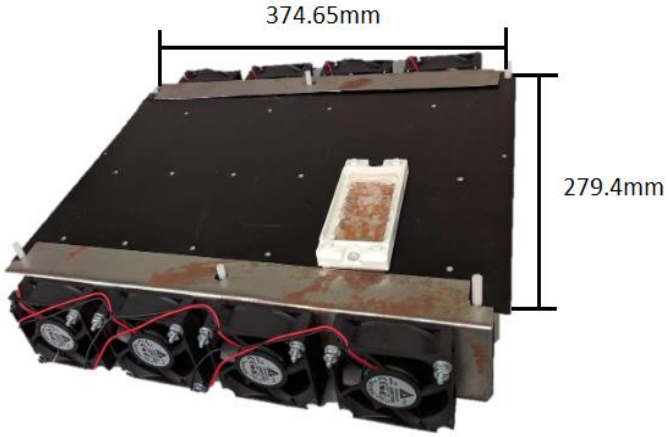
- Plate fin & Pin fin heatsink designs were analyzed using calculations and simulations assuming 120W heat source and an ambient temperature of 20°C

Heatsink Design	Plate Fin	Pin Fin
Size	127mm x 127mm x 69.2mm	113.7mm x 113.7mm x 17.8mm
Weight w/ fans	0.954 kg	0.553 kg
Fan Speed	1.73 m^3/min (x2)	3.03 m^3/min
Fan Orientation	Lateral	Axial
Junction Temperature	41°C	36°C

Weight Comparisons

- Original heatsink weighs 6.45 kg, supports 8 power modules

Heatsink Design	Plate Fin	Pin Fin
Weight (2 modules)	0.954 kg	0.553 kg
Weight (8 modules)	3.816 kg	2.212 kg
Weight Reduction %	40.8%	65.7%

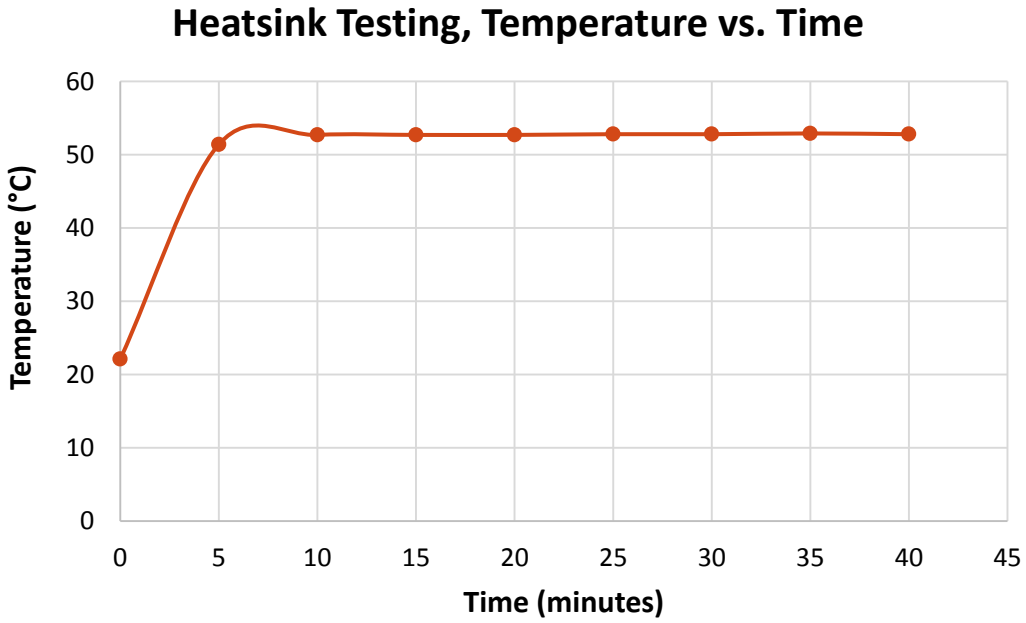


CAPS Original Heatsink

Preliminary Results: Plate Fin

- Plate fin tested using heat source emulators until steady state temperature was reached
- Fan power supply: 0.5A, 5.27V
- Power module power supply: 2.5A, 24.5V
- Junction Temperature = 52.8°C
- Thermal Resistance ≈ 0.257 K/W

$$R = \frac{T_{max} - T_{room}}{\dot{Q}}$$



PowerAmerica Conference

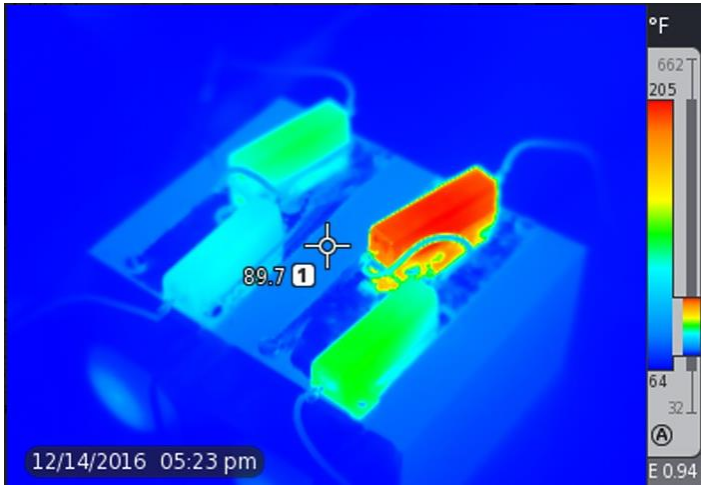
- Attended PowerAmerica Annual Meeting at North Carolina State University
- Presented project results to industry professionals & academic researchers
- Gained further incite into significance of thermal management for SiC PV converters

Challenges

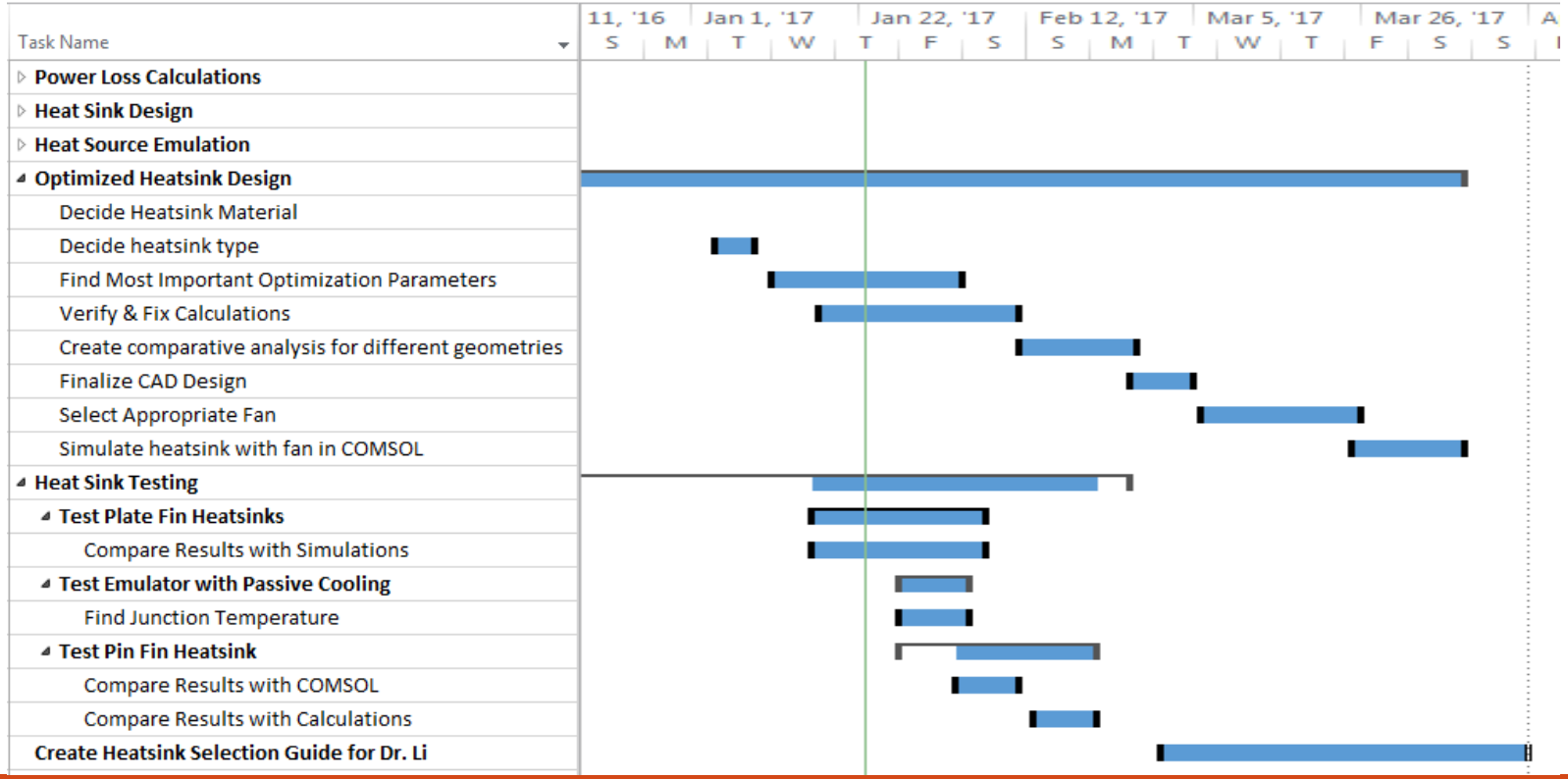
- Improvements have been made in COMSOL

- Testing:
  - One resistor had inconsistent thermal results
  - Power output of resistors in theory: 200 Watts
  - Power output of resistors in experiment: 120 Watts
  - Fan was not at max speed during first stage of testing

- Calculations: Significant error exists in the pin fin calculations
  - Current identified sources include
    1. Nusselt Number Equations
    2. Average Velocity of the air through the fins



Gantt Chart


Task Name
11, '16
Jan 1, '17
Jan 22, '17
Feb 12, '17
Mar 5, '17
Mar 26, '17
S M T W T F S S M T W T F S S
Power Loss Calculations
Heat Sink Design
Heat Source Emulation
Optimized Heatsink Design
Decide Heatsink Material
Decide heatsink type
Find Most Important Optimization Parameters
Verify & Fix Calculations
Create comparative analysis for different geometries
Finalize CAD Design
Select Appropriate Fan
Simulate heatsink with fan in COMSOL
Heat Sink Testing
Test Plate Fin Heatsinks
Compare Results with Simulations
Test Emulator with Passive Cooling
Find Junction Temperature
Test Pin Fin Heatsink
Compare Results with COMSOL
Compare Results with Calculations
Create Heatsink Selection Guide for Dr. Li

Summary

Provide a heatsink design & test method for power converters that will allow for optimal system performance. By decreasing the weight of the heatsink we can increase the power density of the converter.

- Continue testing to eliminate errors and perform comparison between simulations and test results
- Eliminate error generated from the pin fin calculations
- Optimize the Pin Fin Heatsink design
- Provide Dr. Li with a Heatsink Selection Guide