Unison Industries Forced Air-Cooled Heat Sink

UNISON

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Introduction

- Unison Industries, LLC is a producer of aircraft electronic components.
- The heat source of interest is a full-bridge rectifier.
  - Rectification converts 3-phase power to DC.
  - Resistive losses occur due to resistance of components.
- Due to the First Law of Thermodynamics the power dissipates into heat.

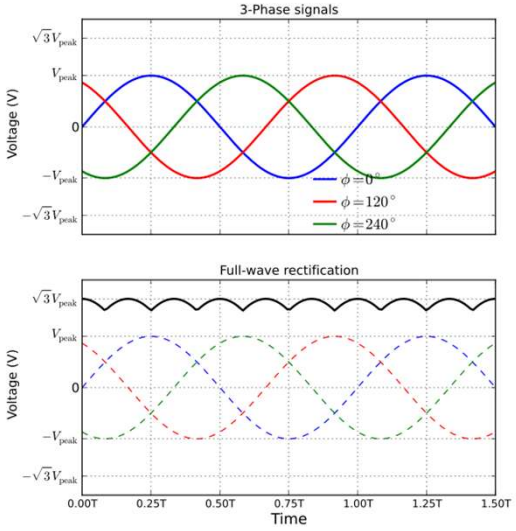

Figure 1: An example of full-wave rectification.

Figure 2: A similarly shaped electrical heat source.

Tyler Pilet

Background

- Heat Sink Types:
  - Natural Convection – Relies upon buoyant forces of air to dissipate heat.
  - Forced Convection – Air is mechanically forced through the fins.
- Heat transfer is directly related to fluid-solid interaction surface area.
- For heat sinks, surface area is related to:
  - Fin Number
  - Fin Length
- Thermal conductivity of the material influence heat sink effectiveness.

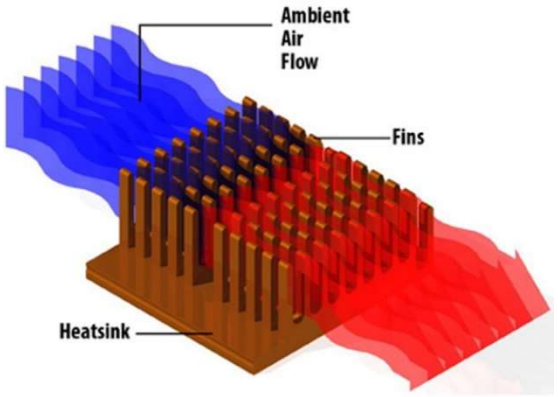

Figure 3: An example of a forced-air heat sink.

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Project Description and Key Goals

- We have been tasked with designing a heat sink for a small aircraft. The heatsink will be attached to an electronic component that dissipates 300 watts of heat, and needs to operate 135 degrees Celsius.

Goals:

1. Light Weight
2. Effectively Removes Heat
3. Small in Size

Primary and Secondary Markets

- Primary Markets
  - High power electronic component manufacturers
- Secondary Markets
  - Heat Exchanger Manufacturer
  - General Electronic Manufacturers
  - Aircraft Manufacturers
  - Hobbyists i.e. people building computers

Parker Harding

Assumptions and Stakeholders

- Assumptions
  - The heatsink will have a fan attached to aid in the cooling process
  - Mounting the heatsink to the electronic is out of our projects scope
  - Before prototyping we must use modeling software to prove our design is effective
  - Most of the components for our project will be ordered and later the team will assemble them
- Stakeholders
  - Unison Industries, LLC
  - Teams' Reputation
  - FAMU – FSU Department of Mechanical Engineering
  - Plane Passangers

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Customer Needs

Table 1: Customer Needs breakdown

What our sponsor said:	***Interpreted Need:***
This heatsink will be attached to a small aircraft	The heatsink must be small
	The heatsink must be lightweight
The heatsink must have a fan attached	The heatsink will use forced convection
The junction has a max operating temperature of 150°C, but has a normal operating temperature of 15°C below that	We need to design a heatsink to keep the electronic component operating at a steady state of 135°C, but lower than that can improve performance
We are using funding plan D	The budget for our project is $2,000
Once you provide data supporting your design we can move forward with building the prototype and testing	The product needs to be tested using computer software before we build

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Functional Decomposition

Heat Removal

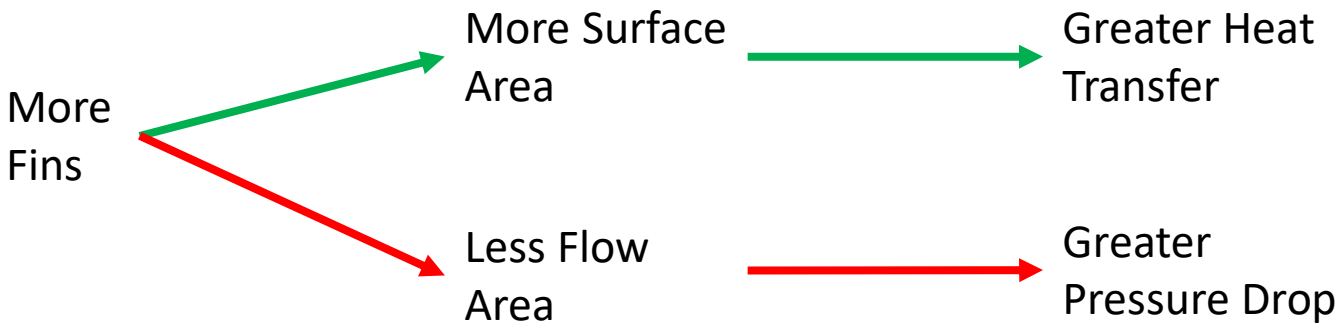
- Main function is to remove heat from circuitry
- Client has specified forced air heat sink design
- Circuit must operate at T=135C for optimal performance

Figure 4: Forced Air Heat Sink

Functional Decomposition

Optimization

- Determine relationships between variables
  - For example, fin number and pressure drop:



- Potentially make use of house of quality to keep track of relationships
- Minimized weight and size are desired due to application

Functional Decomposition

Uniform Heat Distribution

- Uniform heat distribution is desirable
- Tools such as R_theta can help test different configurations
- Different geometries affect distribution

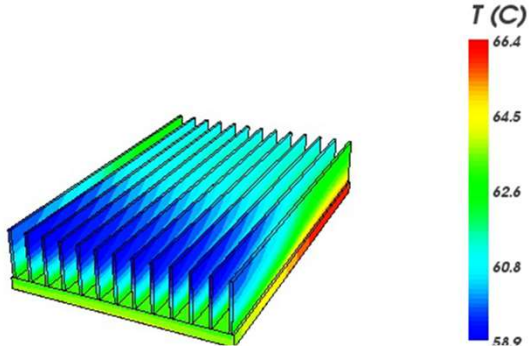


Figure 6: R_theta output

Figure 5: Straight Fin Array

Figure 7: Rotary Fin Array

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References

- What is a Heat Sink. (2014, July 1). Retrieved October 08, 2017, from http://www.sunpower-uk.com/glossary/what-is-a-heat-sink/

- Krishnavedala. (2011, July 8). File:3 phase rectification 2.svg. Retrieved October 08, 2017, from https://commons.wikimedia.org/wiki/File:3_phase_rectification_2.svg
- *TO-247PLUS Description of the packages and assembly guidelines* (p. 3, Tech.). (n.d.). Infineon. Retrieved October 8, 2017, from https://www.infineon.com/dgdl/Infineon-Application Note Discrete IGBT in TO-247PLUS-AN-v02_00-EN.pdf?fileId=5546d46249cd10140149e0c7fe9d56c7
- Kraus, A. D. (1996). *Design and Analysis of Heat Sinks*. John Wiley & Sons.
- *Future trends in heat sink design* (2001, February) . Retrieved October 12, 2017 https://www.electronics-cooling.com/2001/02/future-trends-in-heat-sink-design/
- Walker, Kevin.(2017) *Unison Capstone Kickoff Project* [PowerPoint Slides]