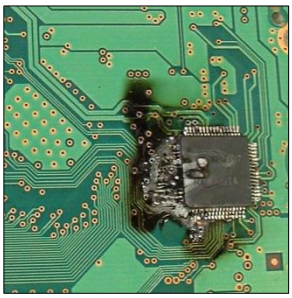
Thinking Ahead Thermally:
A Guide to Designing Your Board to Avoid Thermal Mistakes

Aavid has been designing and manufacturing thermal solutions for over 50 years and has worked with partners across the globe ranging from the largest corporations in the world to small local startups. In doing so, we have seen the havoc caused by thermal challenges that easily could have been prevented. Not planning for your thermal solution can cost time, money, and resources as well as cause a large amount of rework or even massive device failures.

Taking the time to properly consider your cooling needs can make a substantial difference to your device's success as well as save you from costly headaches further down the road. The factors outlined below should be considered for every electronic design in any industry.

What Can Happen When You Don't Think Ahead

The cost of not considering your thermal management early in the development process is more than money. Although the financial impact can be staggering, the consequences of an insufficient cooling solution include missed deadlines, product failures and recalls, costly redesign and rework, scrapped materials, safety concerns, and endless amounts of frustration.

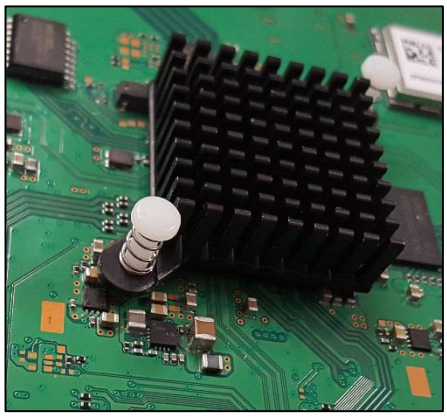


The repercussions of a subpar cooling solution include unfavorable product reviews, lower reliability, shorter product lifetime, noise issues, higher maintenance costs, and overall poor product performance. Additionally, it does not allow for forward compatibility. A poor solution cannot move forward into next generation products, but an optimized solution makes that next generation more likely.

In short, it is important that you take the time and effort to optimize your cooling and include it early in your design process.

How Your Thermal Solution Impacts Your Design – Board to Final Product

Designing your board with proper cooling in mind can change the entire layout of your board. It is a common occurrence for engineers to have their board designed and fabricated only to realize that there is no room for mounting their heat sink or that the solution required is simply too large for their final product.



Thermal Management is often an afterthought and many believe that they just find a heat sink with the correct footprint and simply stick it on top. The reality is that there are many factors to choosing the right heat sink and to designing your board to correctly accommodate it.

The location of your heat sources and other components impact the size and shape of our cooling solution. Conversely, looking at the system from another angle, the size and shape of your cooling solution influence where you should place your heat sources. Mounting holes will impact the routing of traces and may prevent mounting in certain locations. RAM location can be a deciding factor in heat sink size, but the size of your heat sink then impacts where you can place your RAM.

Throughout the entire process, you must be considering your final product. Touch temperature, air flow, direct ambient air contact are all important factors. The size and shape of the enclosure along with size and weight requirements of your product each affect your thermal management choices as well as your board layout.

Thermal Considerations While Designing Your Board

All too often, engineers design and spin their board with only the electronic function in mind. This can easily lead to forgetting that, in many cases, your thermal solution may end up being the largest component on your board or that it may require a flow path or ventilation holes. So, **before** you spin your board, plan to make space for your thermal management solution and consider your full board and packaging. While planning, be sure to ask yourself the following questions:

Board Level/ Layout

Does the final product prohibit the use of a heat sink due to volume or weight constraints (i.e. tablets)?

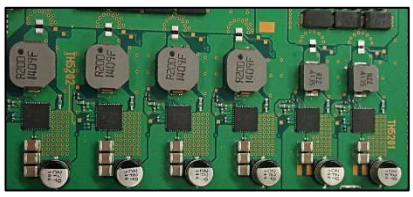
> If you cannot include a heat sink due to design constraints for your final product, consider utilizing thermal vias in your board. Thermal vias are conductive traces in your PCB that help spread heat away from your heat source.

Should you design a keep out area for your thermal solution to exist? Do you have vertical clearance to accommodate a relatively tall heat sink? Or do you have a large enough footprint to spread out a heat sink?

> Make sure there is enough volume available to place a heat sink. If you might require a heat sink larger than your heat source, you will want to ensure that there are no taller components nearby that would interfere with your heat sink placement. For example, don't put RAMs (vertical over the board) very close to a processor because it may need a heat sink.

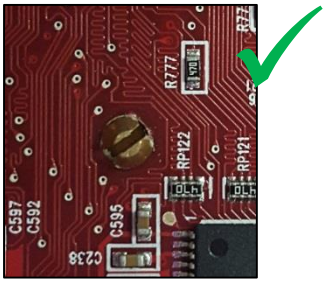
Can you heat sink multiple devices to a single base?

If you have multiple devices that require cooling, you may want to consider putting them close enough to be able to use one heat sink across multiple devices. This helps decrease product complexity and assembly time. Keep in mind that this only works up to a certain point. If the devices will be dissipating higher power, you will want to space them out on the board and ensure room for separate, larger heat sinks.



How will you be attaching your heat sink to the device or board?

If you will be using mounting hardware, be sure to route vias and other devices away from areas where you may need to place holes or solder hooks to accommodate larger heat sinks. Be aware that if you are using tape, it will not be as robust as physical hardware. Tape will not provide the same thermal performance as thin bond line interface material combined with a mechanical attachment method.



Airflow/ Final Product

Is there any air flow on your board? Will you be using a fan for forced convection or will you rely on natural convection to dissipate heat?

Whether or not you will need a fan is dependent on factors such as the power density, total power, and the availability of ambient air. Consider if your entire board needs to be cooled or just a single device. This will help determine your board layout and the placement of your fan.

How will your airflow affect the rest of your components?

Do not neglect the air pre-heating effect in both passive and active cooling. Keep the most temperature sensitive devices upstream of airflow. Try to stagger heat dissipation devices along the direction of airflow to minimize one heating another.

Will your board be in an enclosure?

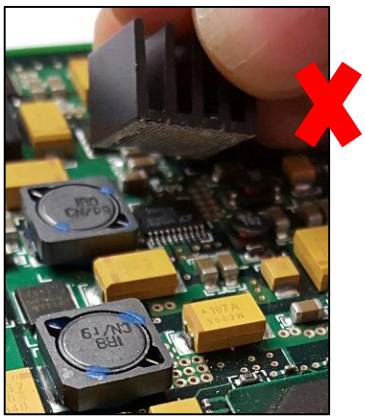
Your cooling solution becomes more complex when you need to dissipate heat through an enclosure or provide ventilation. You may need to consider external heat sinking or using your enclosure as your heat sink. Air to air heat exchangers are also a viable option.

If you're using natural convection, are your board and heat sink oriented to augment the chimney effect?

Your heat sink's fin pitch needs to be optimized to best take advantage of the chimney (or stack) effect. This is when the amount of heat generated combined with the orientation and spacing of your heat sink fins causes the heat to move more quickly from the heat source. Improper orientation will inhibit the thermal performance of your heat sink.

The 5 Most Common Thermal Mistakes When Designing Your Board

1. Not allowing enough room for a "Keep Out" area around the device to accommodate the heat sink.
2. Not considering the system level air flow and air mover placement. An example of this would be placing tall or bulky devices in the flow path, prohibiting air flow.
3. Routing circuitry in an area where mounting holes would need to go.
4. Sub-optimal RAM placement that hinders airflow, natural convection, or heat sink placement.
5. Not considering the back of the PCB. For example, not allowing space for push pins and mounting hardware.



What if it is Too Late? Potential Quick Fixes

- Adding a fan to a natural convection thermal solution will quickly boost its performance. Although this fix does come with its own considerations. These include power consumption, noise, and additional volume.
- Provide additional ventilation by cutting openings into your enclosure. Be aware that this option may impact IP ratings.
- Adding a small copper spreader, sometimes known as a "thermal band-aid", can help when you just need to increase your thermal performance slightly. These solutions work best for lower power, low profile applications.
- Switch out your current heat sink for one with a similar footprint but better thermal properties. Examples would include switching an aluminum heat sink for a copper one or replacing your heat sink with an advanced fin type solution to allow for more surface area. In this scenario, cost may be a limiting factor.

Final Thoughts

Treating thermal management as an afterthought can be disastrous. Although there are a number of enhancements that can be applied to "fix" your solution, nothing takes the place of designing your board with your cooling solution in mind. By thinking ahead you can avoid costly errors and ensure that your product is optimized for performance, reliability, and lifetime.

Aavid Design can help. Aavid offers engineering services as early on as concept development and as late as a full retrofit. Our engineers can provide continuous support throughout the entire product development cycle from concept to manufacturing and future generations. By bringing in Aavid at the beginning, not only can your team can avoid the consequences of insufficient thermal management, we can ensure that your product is fully optimized for success.

More About Aavid Design

Aavid employs over 300 engineers worldwide and maintains Design Centers in the US, Europe, India, and Asia. Aavid Design offers innovative, cost effective product design, testing, and prototyping services across all industries, with customers ranging from Fortune 500 companies to pioneering technology startups. Our engineers work to provide the best solution to fit your requirements. From finding the right current standard part to developing custom systems utilizing integrated design solutions, Aavid Design can help.

DESIGNING YOUR THERMAL SOLUTION

Aavid determines the needs of a customer based on the evaluation of six key factors affecting your product:

USABILITY
Surface Temperatures
Feature Set

MATERIAL SELECTION
Metals or Plastics
Manufacturing Processes

AESTHETICS
Texture
Finish
Venting
Perforations

PERFORMANCE
Acoustic
EMI/Radio
Power
Environment

COST
BOM Cost
Assembly Cost

FORM
Size
Weight
Architecture
Footprint

Based on your specific needs, Aavid Design will provide the best solution in one of three ways:

1. **SELECTING THE BEST EXISTING OPTION**
   from our catalog of standard thermal solutions
2. **DESIGNING A CUSTOM COMPONENT SOLUTION**
3. **DEVELOPING A CUSTOM SYSTEM UTILIZING AAVID'S INTEGRATED DESIGN SOLUTIONS**
   Thermal Design
   Mechanical Design
   Electrical Design
   Industrial Design
   Prototyping
   Testing & Verification

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AAVID DESIGN PROCESS

The Aavid Design Process is a proven model for engineering successful product designs. Our process is molded to each individual project based on our clients' requirements; the one constant is engineering innovation.

STEP 1 — CONCEPT

Can include but is not limited to:

- *Multidisciplinary Brainstorms*
- *Spreadsheets and Hand Calculations*
- *Thermal and Structural Simulations*
- *Hand Sketches and Renderings*
- *Technology and Ergonomic Studies*
- *Industrial Design Appearance Models*
- *Mechanical Scale Models of Mechanisms*
- *Electrical and Proof of Concept Breadboards*

STEP 2 — DESIGN

Can include but is not limited to:

- *Assembly and Manufacturability of Parts*
- *Materials, Finishes and Manufacturing Processes*
- *Off-the-Shelf Component Selection and Sourcing*
- *Functional Performance and Environmental Conditions*
- *Interoperability and Industry Standards and Regulations*
- *Installation, Maintenance, Interaction and Usability*
- *Disassembly and Recycling*

STEP 3 — PROTOTYPING & VALIDATION

Can include but is not limited to:

- *Stereolithography (SLA) and 3D Printing*
- *Precision Machining and Rapid Tooling*
- *Coating, Casting, Forming and Bonding*
- *Quick Turn Printed Circuit Board and Assembly*
- *Electromechanical Integration*
- *Post-Processing and Finishing*
- *Full Range of Performance and Reliability Testing utilizing state-of-the-art equipment*

STEP 4 — MANUFACTURING

Can include but is not limited to:

- *Tooling and Fixture Design*
- *Manufacturing Line Testing Plans*
- *Manufacturing Process Adjustments*
- *Material and Finish Adjustments*
- *Transferring Knowledge to Manufacturing*
- *First Article Inspections and Approvals*
- *Packaging Designs*

For Questions, Quotes, Or More information

Contact Aavid Design Now

About Aavid

Founded in 1964 as Aavid Engineering, Aavid Thermalloy is the oldest and largest design engineering and manufacturing corporation focused on thermal management solutions in the world. For over 50 years we have consistently brought the most innovative new cooling solutions to market while also improving the efficiency and availability of conventional cooling technologies. In doing so, we have developed the widest array of cooling products and services in the industry. Aavid provides thermal solutions across all industries and for any application on a global level. Decades of experience and expertise combined with an unwavering dedication to unique problem solving allows us to meet any requirements and resolve any thermal challenges.

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