Mechanical Techniques for maximizing PCB space and reducing system size and weight

Jeff Davis

TennMax

7500 NE St. Johns Road
Vancouver WA 98665, USA

Traditionally high frequency applications have used metal multi-cavity clamshell shields screwed down to the PCB. In order to minimize the gaps, they would either place screws a few centimeters apart, or place an extruded gasket on the walls and move the screws farther apart. Both solutions require a wide PCB trace and excessive bosses which increase the weight of the metal and requires an excessive amount of PCB space. There are techniques that can reduce the amount of screws needed, while thinning the walls, thus providing both weight reduction and decreasing the width of the PCB traces (as low as 0.5mm).

Another key item for reducing overall system size and weight is the removal of heat. Metal is the only reasonable method for removing heat, but by using design techniques such as heat pipes or vapor chambers, you can increase the efficiency of the heat transfer. These techniques will allow you to reduce the overall fin and metal size. You can also potentially add the gaskets to the bottom of the thermal module to provide a single part for both heat and shielding in the same part.

In the beginning, TennMax identified itself as an EMI and Thermal Management company, but the reality is, most of our most our material and technical development is focused on assisting our customer to reduce weight and size from their systems. Instrumentation companies are trying to fit more technology into existing formats such as PXI while Aerospace, SATCOM, Automotive, Military and even consumer products are all trying to find ways to put more technology into the same or smaller packages.

Historically, metal has been the main tool used for shielding and heat management and while that is still the case, recent technology efforts have been focused on removing the amount of metal used. The use of robotically place conductive silicone gaskets (FIP) on thinner metal walls can have a significant impact on the amount of metal required and decrease the number of screws by over half. This technique will also decrease the trace area required on the PCB to provide more room for other components. For applications that are in harsher environments or need chemical resistance, dispensable Fluorosilicone is also available.

Fig 1. Form-In-Place conductive gasket

Another technique for reducing weight is to replace traditional Aluminium shields with Magnesium or metalized plastic using Physical Vapor Deposition. For designs that have an external plastic housing, it is sometime possible to eliminate the shield altogether and add the cavity walls to the housing then metallize the inside. Doing this can reduce both the overall size of the system and the weight.

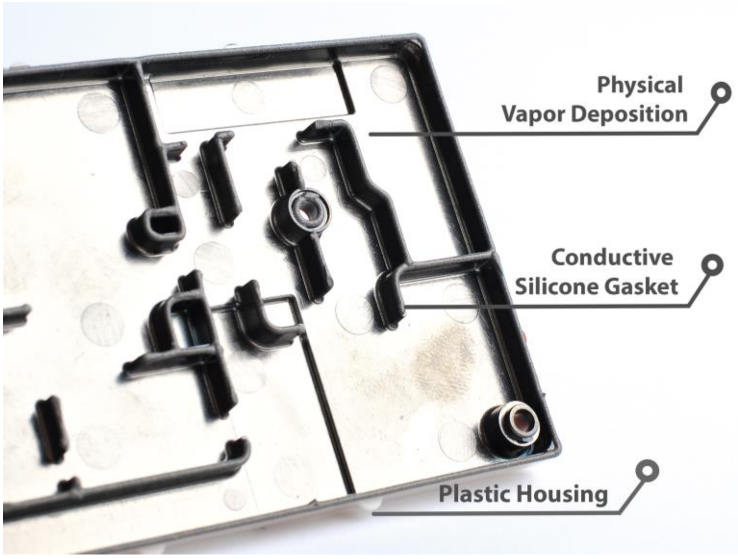

Fig 2. Metallized Plastic Shield

With higher power RF systems, the bulk of the weight is typically found in the heatsink. Traditional designs will use either machined or extruded Aluminium. Metal only sinks do not efficiently spread the heat over a wide area and the only way to increase performance is to add more metal or provide additional airflow. An alternative option would be to use Heat Pipes or Vapor Chambers that can expand the heat over a larger part of the sink which would allow you to either increased thermal dissipation or similar performance but with smaller fins and or metal plate. Some of the new higher W/mk thermal materials can also help increase heat transfer efficiency as well.

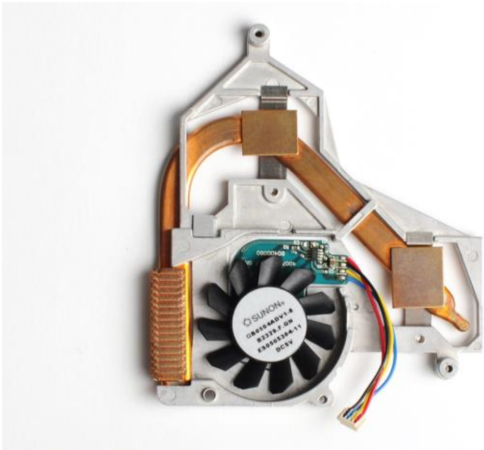

Fig 3. Heat Pipe

A more efficient thermal design can be beneficial for both active and passive cooled systems. Another advantage for an active cooled system is the potential to lower fan speeds to reduce system noise. Some of the major hurdles implementing these types of designs are lack of internal expertise and/or simulation software and finding a qualified source willing to manufacture lower volumes. That is why TennMax has put together a thermal design group to work with customers and structured our manufacturing to support low volume prototypes as well as low to medium volume production.

Along with optimizing the thermal module, it is also important to be using the correct thermal transfer material. The most commonly used is the standard thermal pad, but in the last few years the use of thermal gel has been increasing. Compression force, tolerance stack, rework ability and area covered can impact the selection. There are several performance levels, everything from 1 W/m-k to 11 W/m-k, the main difference is performance vs. cost, so it is important to find the correct material for your application. Some other items that can impact performance is material thickness and hardness.

It is extremely critical that you make sure your material maintains its performance. Thermal pads are commonly made from impregnated silicone, if it is not crosslinked correctly, there can be significant issues with oil leakage and outgassing. This will not only create system issues, it will also decrease the performance over time as the material will start to flake and harden. Not all silicone materials are the same, there are some materials that can withstand temperature cycling and others that will break down. Another potential failure mechanism is over compression, please consult with the material manufacture to make sure that you are within suggested guidelines for maximum compression. We generally recommend between 25 to 40%, but this can vary depending on pad thickness.

TYPICAL PROPERTIES	GP1000	GP2000	GP3000	GP5000	GP7000	GP8000	GPE000	GP-CP5000
Form	Thermal Conductive Gap Filler Pad							Thermal & Electrical Conductive Pad
Color	Light Gray	Blue	Gray	Light Blue	Cyan	Light Gray	Light Gray	Light Gray
Thickness Range	0.13 - 10mm				0.25 - 10mm			0.15, 0.25, 0.50, 0.75, 1.00mm
Specific Gravity	2.00 g/cm³	2.20 g/cm³	2.60 g/cm³	2.90 g/cm³	3.00 g/cm³	2.50 g/cm³	2.45 g/cm³	2.54 g/cm³
Thermal Conductivity	1.0 W/m-K	1.5 W/m-K	2.0 W/m-K	3.0 W/m-K	5.0 W/m-K	7.8 W/m-K	11.0 W/m-K	1.5 W/m-K
Multilayer Capable	0.5mm up							N/A
Insulation Properties	High	High	High	High	High	Low	Low	Conductive, DC Through Resistance <0.5 ohm
Flammability Rating	UL 94V-0							UL 94V-0
Operating Temp. Range	-55 to 200°C							-55 to 200°C
Standard Hardness (H1)	46 Shore OO	46 Shore OO						25 Shore A
Ultrasoft Hardness (H0)	N/A	36 Shore OO						N/A
Ubersoft Hardness (HU)	N/A	26 Shore OO						N/A

Fig 4. Thermal Pad Selection Guide

Many Engineers struggle to try to make their system work by using traditional EMI and Thermal solutions and they adjust their design function to work with their existing solutions. As market pressures increase the need for smaller and lighter systems, this may not be feasible anymore. whether you are portable instrument, 5G products, or a high-powered amplifier, it is important to remember that there are other options available that would allow you to design a shield or thermal module to fit your system, rather that the other way around.

REFERENCES

1. Visit www.tennmaxusa.com