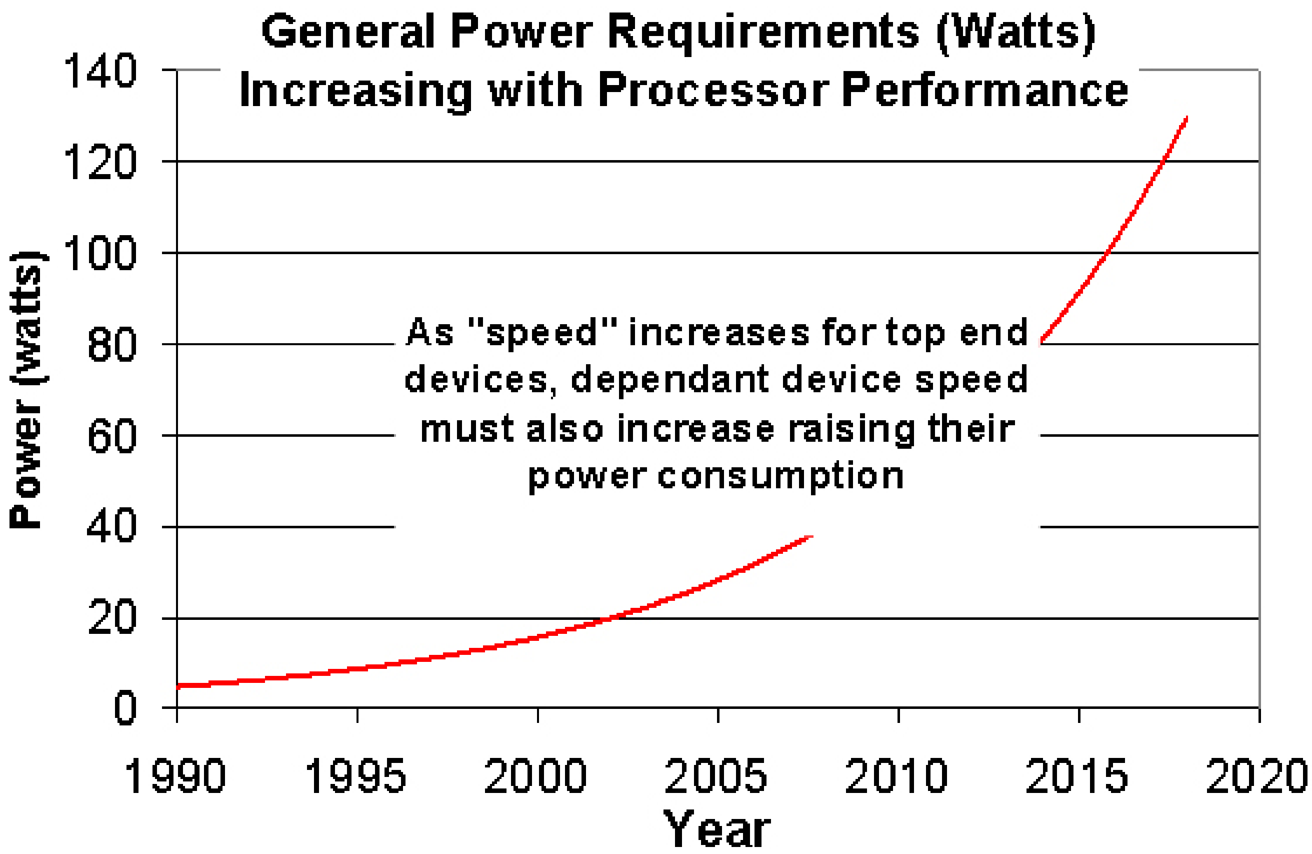
No More Silos Allowed for Thermal and EMI Engineers as Frequencies Rise

Jeff McCutcheon, Senior technical specialist, 3M Electronics

Are you a “Themimech” engineer? Rising frequencies of many applications are now forcing engineers to be aware of and plan for issues related to rising frequencies in electronic devices and systems and to participate in mutually supportive designs. A “Themimech” engineer is one who recognizes that due to ever increasing frequencies, the potential for thermal cooling will be needed: The “Th”. The engineer further recognizes that as frequencies rise, EMI issues become a great challenge to mitigate: The “emi”. And finally, all electronics are part of a system that must pass vibration, environmental and a robust integration design: The “mech”. The “themimech” engineer no longer works in their “silo”, rather works to provide an integrated solution required to meet the ever-increasing frequencies of design and the associated thermal and EMI design challenges.

(GRAPH 1: WATTS INCREASE FROM 1993 TO 2003)



An Emerging Issue for 70-80 Percent of All Devices

The increasing speed of expensive processors is forcing less expensive "associated board" or “dependant” devices to keep up. Consequently, thermal management and EMI are becoming issues for traditional lower frequency or power devices, such as Application Specific Integrated Circuits (ASICs), memory, power resistors, controller chips, LEDs, and other traditionally lower power devices that comprise 70 to 80 per cent of all devices.

As one begins a “Themimech” engineering assignment, good questions are the starting point to understanding potential solutions and their selection process:

• What is the speed and power level of the device and how hot will it get?
• What new EMI challenges exist ?
• Is the current EMI “Faraday cage” design robust ?
• Can I combine thermal and EMI solutions ?

The design challenges, however, are not as daunting as they may first appear with a good understanding of today’s thermal and EMI material options. EMI solutions are strongly frequency influenced, so even though an application may need an improved EMI solution, it often can use newer “off the shelf” EMI solutions. As a result, a greater number of thermal management and EMI options and cost/value alternatives are available to lower power device engineers.

Thermal Impact of Higher Frequencies

In these increasing “power/frequency” applications, the heat must be removed or the devices will be damaged. The thermal management for low power is basically the same as for higher power devices, but there are many more options for the lower power devices as the “power density” of “watts dissipated/surface area” is lower. All devices need to move the heat from the “hot” device to a cooler location. The primary purpose of the TIM is to improve thermal flow between these hot and cooler locations.

Lower Power Thermal Interface Material Options

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(CHART 1: COMPARING THERMAL INTERFACE OPTIONS PROS AND CONS)

Thermal Interface Options

Technology	Thermal conductivity vs air*	Pro	Con
Grease	20-185x	Thin, low cost. Thin = low impedance. Good wetting.	Messy. No adhesion, so mechanical attachment of heat sink is necessary. Silcone contamination.
Liquids	20-125x	Thin = low impedance. High bond strength Good wetting	Messy. Pot life of epoxy. Needs cure time and fixturing.
Phase change	20-125x	Good wet-out. Less messy than grease. Thin = low impedance.	No adhesion, so mechanical attachment of heat sink is necessary. Initial heat cycle.
Tapes	20-40x	Good wet-out. No mechanical fasteners. Ease of use.	Typically used in applications less than 20 watts.
Pads	35-500x	Greater thicknesses. Very soft, comfortable. Gap filling.	Light adhesion, so mechanical attachment is necessary. Cost due to thickness.
Solder, metal phase change materials	500-1,000x	Thin thickness. High conductivity. Gap filling.	Difficult to apply. Low viscosity when melted. High-cost materials.

* The thermal conductivity of air is 0.02 watts per meter-kelvin.

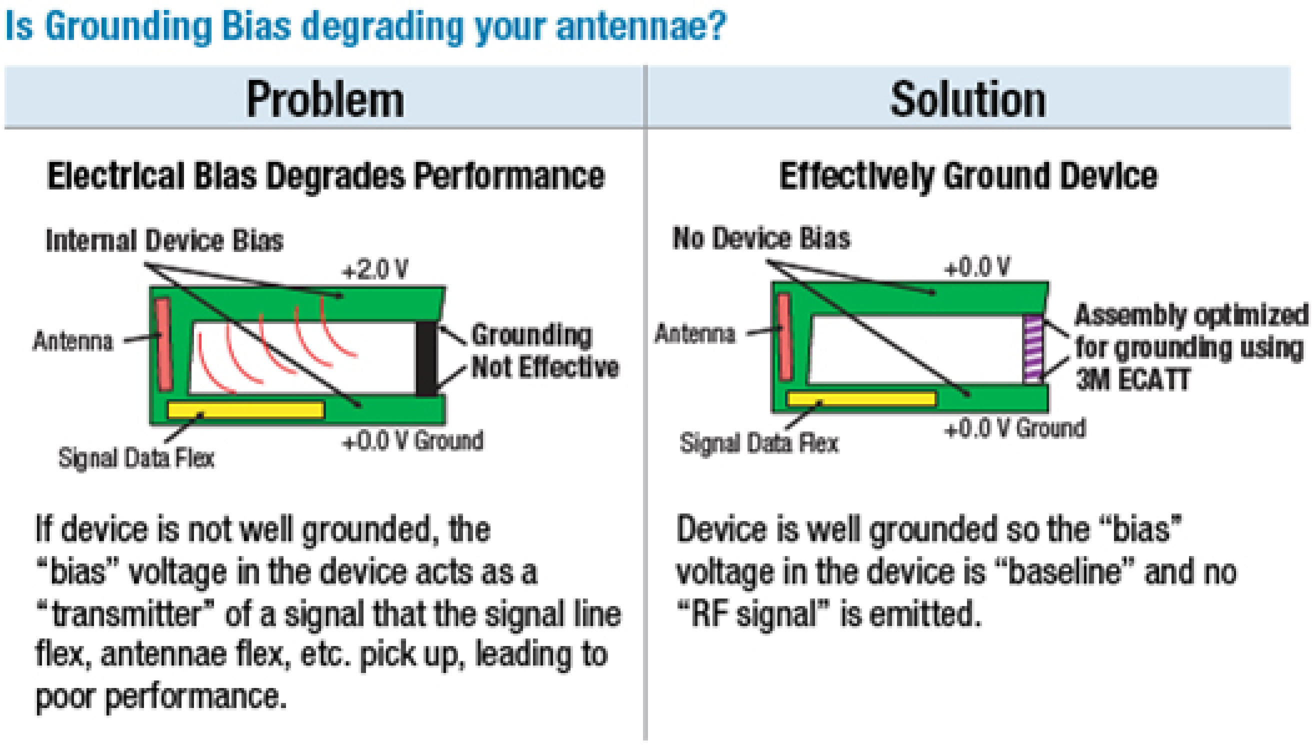
Only Buy the Thermal Performance Needed

Today’s adhesive vendors are engineering cost-effective alternatives with the necessary strength, conductivity, and reliability for lower power devices. The four tapes in 3M’s 8810 Series thermally conductive adhesive transfer tapes have a tacky pressure-sensitive adhesive without a carrier but with high cohesive strength. Specialized chemistry provides a next generation of performance in terms of conformability to non-flat surfaces, high adhesion and good thermal interface.

For low power applications where a gap filling solution is desired, thermally conductive acrylic thermal pads provide excellent thermal resistance, good thermal stability, good softness and a UL rating.

EMI Impact of Higher Frequencies
The higher frequencies can also lead to the need for improved EMI shielding solutions. New compact, low-profile designs with IC devices in closer proximity to each other and within a contained EMI environment require new and innovative EMI solutions as the EMI issues are often related to not just the electric field of EMI, but now the magnetic field associated with EMI that can become a greater concern in “near field” conditions that are geometry based.

The EMI shielding solutions are needed as the higher frequencies and compact designs lead to a more complex EMI noise environment. High frequencies imply the following logic and design implications:
a) Higher Frequencies are needed devices or flex circuits to support higher information data rates
b) Higher Frequencies lead to an inherent lower “Signal to Noise” (S/N) in the circuit.
c) A lower S/N ratio can lead to a higher error rate in transmitted data.
d) The Noise floor must be reduced to improve the S/N ratio.
e) A more robust S/N ratio is achieved by a reduced EMI environment accomplished by a lower resistance grounding design, less rising frequency bias, improved Faraday design, absorb EMI and circuit design layout.

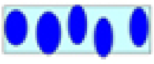
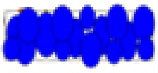


A lower EMI environment can be accomplished with improved EMI reflective shielding materials -- such as a Copper foil EMI tape, a Gold plated fabric or more economical solutions such as one that uses a lower cost Nickel plated fabric.

EMI “reflective” shielding solutions are now being complemented with EMI “absorbing” materials. EMI absorbing materials act like “acoustic absorber” sealing tiles or carpet in a room that is too loud acoustically. By adding acoustic sealing tiles or carpet in a room, the baseline noise level is reduced. By added EMI absorbing sheet and pad materials into an EMI environment, the EMI noise is absorbed and reduced, improving the system performance. With absorbers, it is best to establish their highest performance impact first (ie:AB-7000 using greatest thickness the application can use) as it may allow other design changes once a new EMI reduction as been demonstrated.

As frequencies rise, the need for improved assembly grounding may be needed to optimize the performance of the entire system. Lower contact resistance can improve the Faraday cage performance. Improved grounding can minimize RF signals generated on the system structures that radiate and can improve the S/N of the data transmitted via a flexible circuit or improve antenna S/N performance.

The 3M ECATT tapes 9705, 7772, 9709S and 9725 represent key design types found for grounding solutions. As the conductive portion of the ECATT affects adhesion, grounding resistance level, shock and vibration performance, reliability, EMI shielding in the bond line, and rework each application must be optimized for which ECATT product best meets the end user grounding and EMI shielding design goals.

ECATT Product	Pictoral Design	Thickness (um)	Z or XYZ Conductivity. (Based on 3M Test Method)	Features - Advantages - Benefits
9705		50	Z	Z-Axis, Standard Adhesion Acrylic Adhesive, Silver Conductive Filler, 9706 is the higher adhesion version of the 9705.
9709S		50	XYZ	XYZ, "Bond Line Gap/Slit" EMI Shielding for High Frequency , Low contact Resistance to Stainless Steel, Improved Contact R conformance. 9707 is the higher adhesion version of 9709S.
7772		66	XYZ	XYZ, Double Coated Aluminum foil, Medium Adhesion Acrylic Adhesive, Nickel Conductive Filler
9725		55	XYZ	XYZ, Non-woven Conductive Scrim, Low Contact Resistance to Stainless Steel, Higher Adhesion Acrylic Adhesive, 9723 next level higher adhesion acrylic adhesive.

Thermal and EMI Hybrid Solutions
Other products are available that offer a hybrid of thermal and EMI features, such as an EMI Shielding-Absorber which provides good heat transfer one that presents good grounding performance and thermal performance along with EMI shielding in the “bond line gap thickness”.

Conclusion
Thermal and EMI materials options can be judicially selected to implement the TIM and EMI performance needed to manage the higher power device. Design reviews should include the Hybrid Thermal/EMI solutions along with an understanding how new material can meet ever increasing frequencies.

To discuss thermal and EMI design solutions, contact Jeff McCutcheon (651-733-6199 or jeffmccutcheon@mmm.com [1]), 3M Electronic Markets Materials Division
USA: 800-362-3550; www.3M.com/electronics [2]

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