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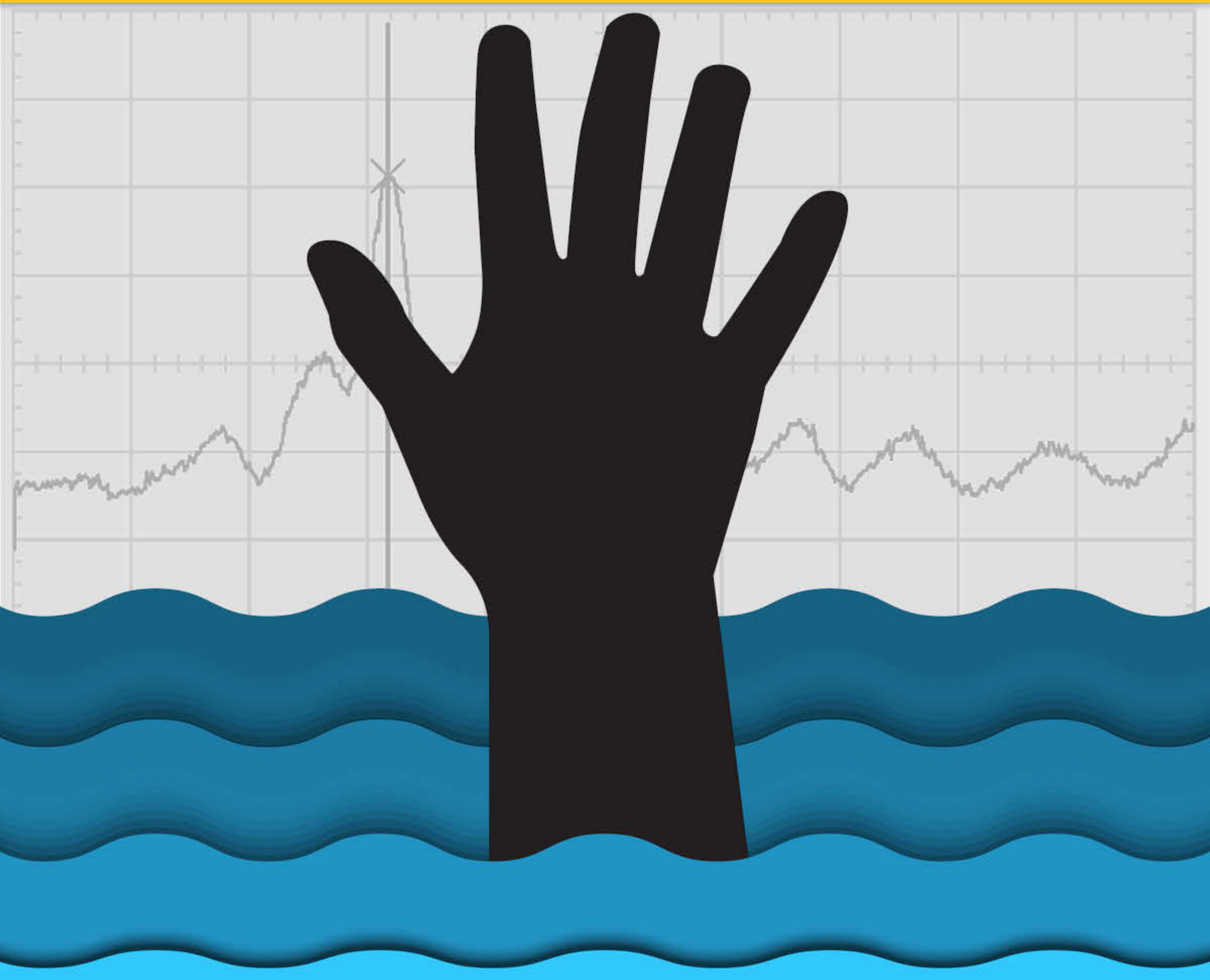
SIGNAL INTEGRITY



Sink or Swim at 28 Gbps

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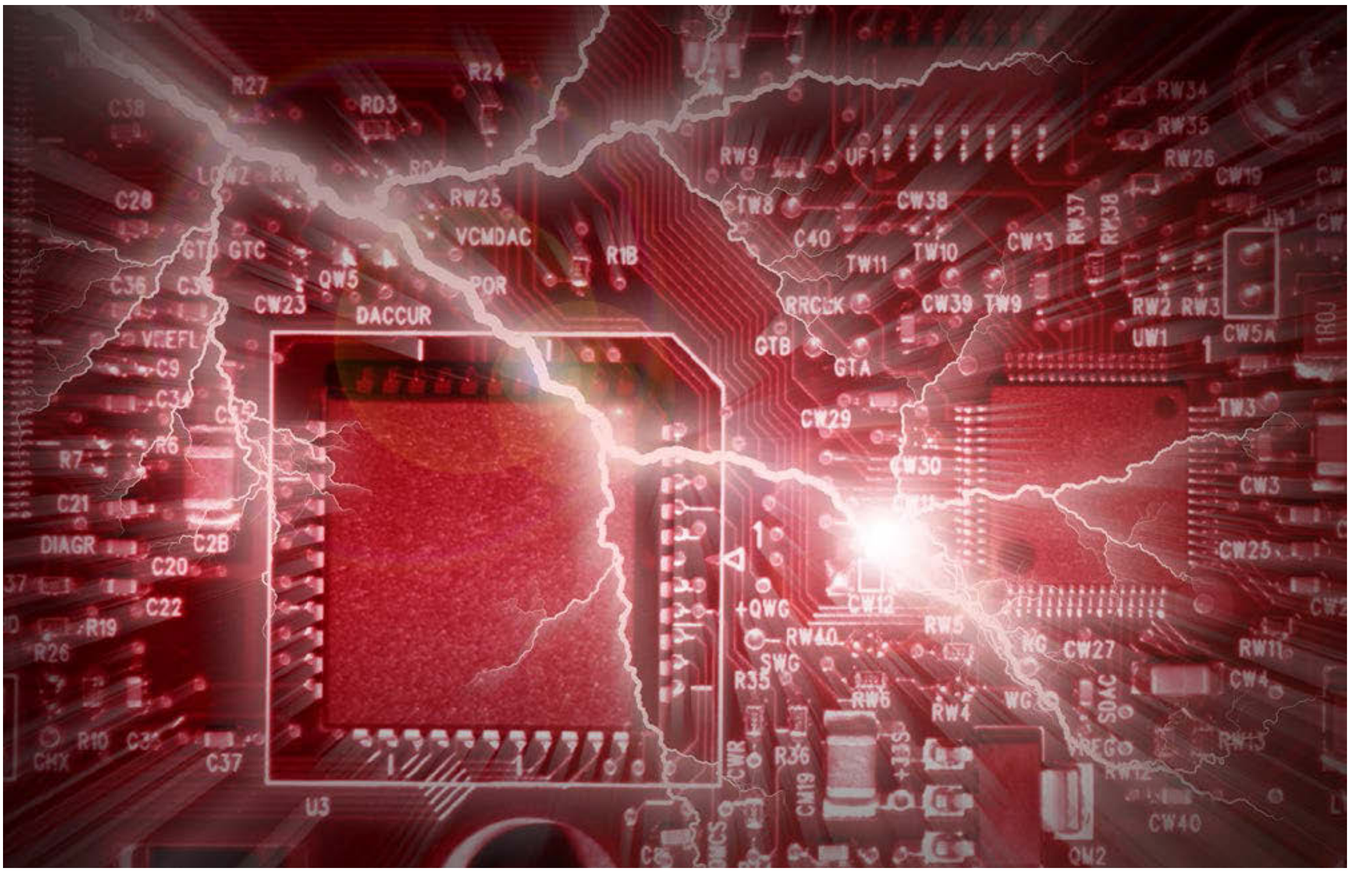
Chilling Out with Conductive Adhesives

by John Coonrod
ROGERS CORPORATION

Conductive adhesives have been around for many years. Some are electrically conductive, others are thermally conductive, and some have both properties. Additionally, the conductive adhesives can be a pressure-sensitive adhesive (PSA) or a thermoset adhesive. To narrow the scope of this month's column, only thermoset thermally and electrically conductive adhesive (TECA) will be discussed.

TECA is often used for heat sink attachment of PCB assemblies when thermal management is a concern. In the RF industry, power amplifiers often generate a lot of heat, and the PCB supporting the power amp is generally attached to a large metal heat sink. The attachment between the PCB and the heat sink is usually done by mechanical attachment with screws, sweat soldering or TECA. Each attachment method has its own set of capabilities and limits.

The mechanical attachment may have air gaps between the circuit and the heat sink, and if these are in critical areas they can make a less efficient heat flow path from the PCB to the heat sink. A less efficient heat flow path can cause the PCB assembly to have a higher temperature than desired and sweat soldering can have similar issues due to voiding. Air gaps are not an issue with TECA when parts are properly bonded using vendor supplied parameters. The drawback to TECA, compared to the other two technologies, is that TECA is usually not as thermally conductive as a metal-to-metal contact. And for RF applications, the heat sink is often used as the system ground and the electrical



	Room temp Insertion Loss				65° C Insertion Loss				RT vs. 65° C Difference			
	5 GHz	10 GHz	15 GHz	20 GHz	5 GHz	10 GHz	15 GHz	20 GHz	5 GHz	10 GHz	15 GHz	20 GHz
Bare circuit	1.869	3.218	4.479	5.651	1.941	3.355	4.697	5.941	0.072	0.137	0.218	0.29
Circuit laminated to Heat Sink	1.898	3.177	4.464	5.617	1.937	3.315	4.726	5.863	0.039	0.138	0.262	0.246

Figure 1: Test results for TECA films with 50 ohm microstrip transmission line circuits.

connection between the PCB, so the heat sink has to be very good for most RF applications.

The obvious critical material properties for TECA are thermal conductivity and electrical conductivity, but there are other concerns. As general statements, a TECA material with thermal conductivity of 3 W/m·K or more is considered good, and electrical conductivity with a volume resistance value of 0.0005 ohm·cm or less is considered good. Regarding other properties, TECA with good bond strength to different metals and robustness to lead-free solder reflow may be important.

Having TECA bond well to different metals is beneficial for bonding to heat sinks made with different metals and/or the different final plated finishes on a PCB, which will be bonded to the heat sink with the TECA. There have been TECA materials in the PCB industry which were not robust with lead-free soldering; they were still useful for heat sink attachment, but had special processing considerations.

Lastly, electrical performance will be more challenging for RF applications. The electrical conductivity of TECA will be important for DC or low-frequency applications, but is even more critical for RF applications. With RF applications, the ground plane of the PCB must be extremely well connected to the ground of the system, which can be through the heat sink. In these cases, at high frequencies, small anomalies in the grounding between the PCB and the heat sink can cause an increase in system noise and insertion loss. These small electrical anomalies may not be detected at lower frequencies or DC, but they can be very problematic for high-frequency systems. When using TECA in this manner, the surface treatment of the bond surfaces should be considered. A gold surface will provide the best electrical bond interface.

Another concern for TECA used in high-frequency applications is the possible variance of the ground return path due to the conductivity changing with a change in temperature. TECA uses conductive fillers to make the electrical connection through the volume of the material. When TECA is heated, it will expand and the fillers may move farther apart, causing less connection or less conductivity. This generally changes little with electrical conductivity, but with high-frequency applications it can be detectable. Knowing how much the electrical conductivity will change for TECA, a change in temperature should be understood for RF applications.

Laminate providers now offer TECA films. Rogers Corporation's COOLSPAN TECA Film has been tested for all of the concerns mentioned in this column. It is robust for lead-free soldering and bonds well to any metal evaluated thus far. High-frequency testing has been conducted using 50 ohm microstrip transmission line circuits and across a range of microwave frequencies. The table in Figure 1 shows a summary of these circuits, and it can be seen that there is no significant difference for insertion loss from room temperature to 65°C across the range of frequencies tested.

There are several options to attach heat sinks to PCBs, and TECA materials are being used more often. Even though the other options are usually higher in thermal conductive because they use metal or direct metal-to-metal interface, TECA is generally more consistent for heat flow path, relatively easy to apply, and comparable to the RF electrical performance of other options. **PCBDESIGN**

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