Power Systems Design EUROPE

Power Control Intelligent Motion

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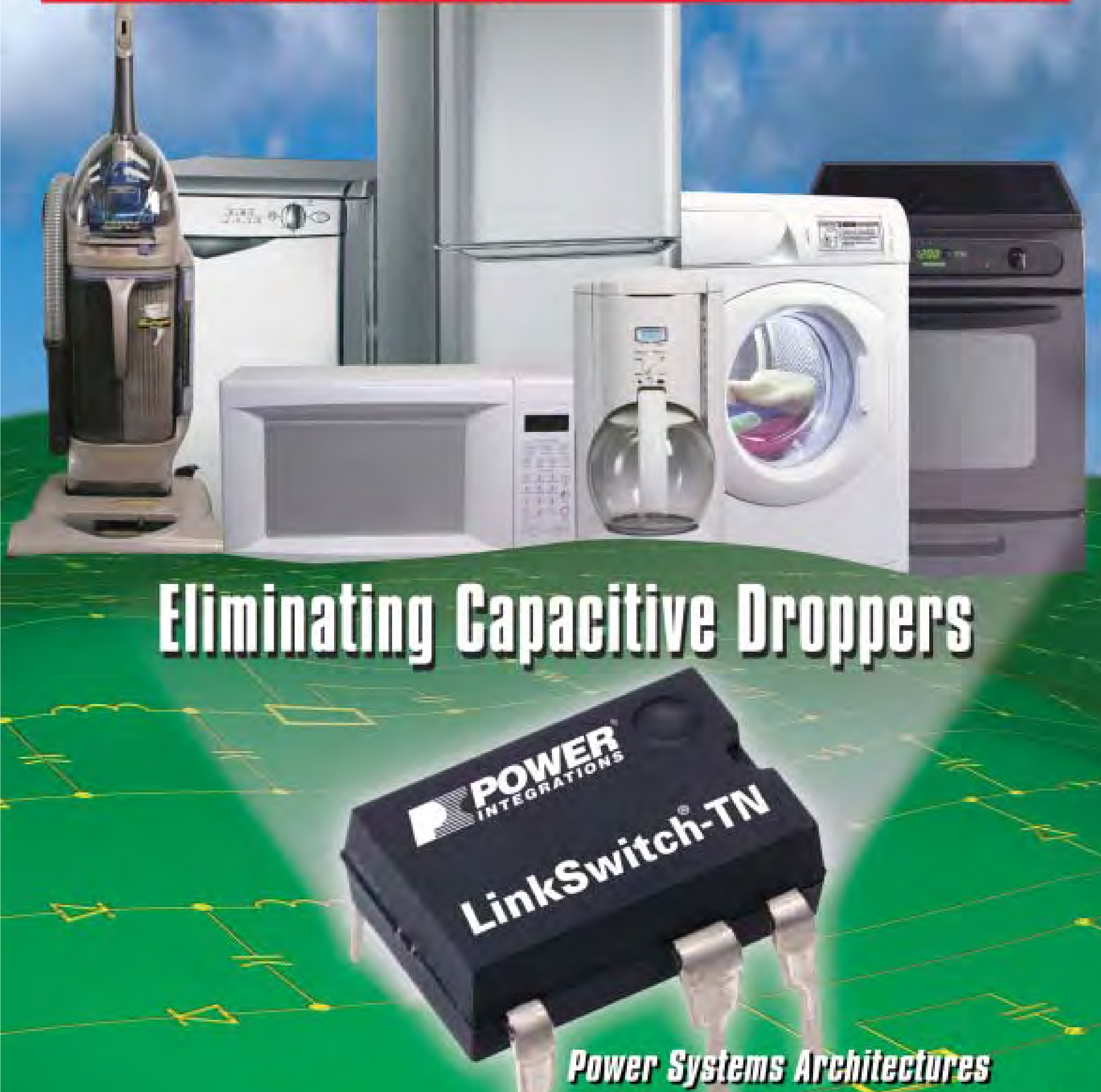

Eliminating Capacitive Droppers

Power Systems Architectures

Programmable Power Management

Acoustic Evaluation

Subscriber Line Protection

ISSN number: in progress

DESIGN AND SIMULATION

Acoustic evaluation of heat sink attachment

Ensure the integrity of the heat sink function

Many electronic devices employ some type of heat sink to remove heat and prevent the device from failing. Low-power integrated circuits (ICs) often depend on the conduction of heat through a die attach layer onto the die paddle.

By Tom Adams, consultant, Sonoscan, Inc

Since the thermal efficiency required in low-power systems is not generally very high, defects such as voids may be present in the die attach layer without having a significant impact on the heat sink function.

In high-power devices, the subtraction of heat from the device is much more critical, and the thermal efficiency required from the heat sink system is much greater. For example, the die attach layer between a very low-power IC and its die paddle might contain voids (trapped air bubbles) over as much as 40% of the area of the die attach without causing device failure from overheating. In a high-power device, the presence of any voids might be enough to lead to thermally-caused failure.

How ultrasound images heat sink attachment

To ensure the integrity of the heat sink function, acoustic micro imaging can be used to image the attachment layer between the heat sink and the device. In many devices, this layer consists of solder, but it may also consist of a thermal grease or another type of adhesive. If the attachment layer is homogeneous and without anomalies, the acoustic image of the layer will show no features. But if the attachment layer includes a void (or any other type of gap), this anomaly will show up distinctly in the acoustic image.

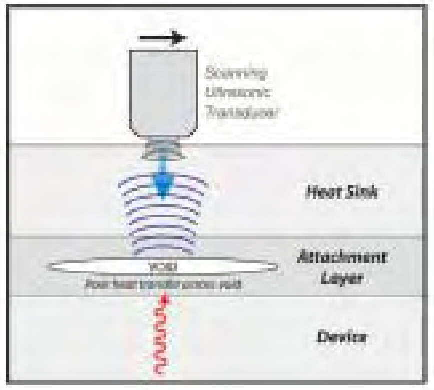

Figure 1: Acoustic image through a heat sink attached to the back of a PC board. The transducer scanned the surface of the heat sink, and the return echoes were gated at the attach layer depth. Two components are visible because cutouts through the board attach them directly to the heat sink. The numerous red areas are voids in the solder attach layer.

Acoustic micro imaging uses a scanning transducer to pulse ultrasound into the heat sink and to collect the return echoes (Figure 1). Pulsing and signal collection both take place several thousand times a second as the transducer scans the heat sink. Each return echo becomes a single pixel in the completed acoustic image. The velocity of ultrasound through most production materials is quite high, and the elapsed time for the pulse-echo round trip is usually on the order of a few nanoseconds.

Despite the high speed of transmission of ultrasound, return echoes from various depths arrive back at the transducer at slightly different times. It is the usual practice to gate the return echoes via a time window, with the result that only those echoes from a desired depth are used to assemble the acoustic image. In the case of heat sinks, this depth is usually the attachment layer between the heat sink and the device itself. Ultrasound is reflected only from the interfaces between materials, and the heat sink itself is presumed to be structurally homogeneous and therefore lacking in acoustic features.

Finding voids in heat sink attachment

Figure 2 is the acoustic image made through a large-area heat sink that has been applied to the back side of a PC board. This is a low-power application, but one that demonstrates nicely the acoustic imaging of heat sink integrity. The return echo signals were gated on the solder layer attaching the metal heat sink to the PC board. The weave pattern of the board is visible, as are irregularities in the heat sink attach layer. The outlines of two active components are visible because cutouts were made in the PC board in order to attach these components directly to the heat sink.

The key features in Figure 2 are the red regions, which are voids in the solder layer attaching the heat sink to the PC board. Their bright color corresponds (in the color map used here) to high amplitude in the ultrasonic echo signals. The voids are numerous, and will to some extent compromise the intended heat sink function. Note that there are even small voids along the edges of the two components attached directly to the heat sink.

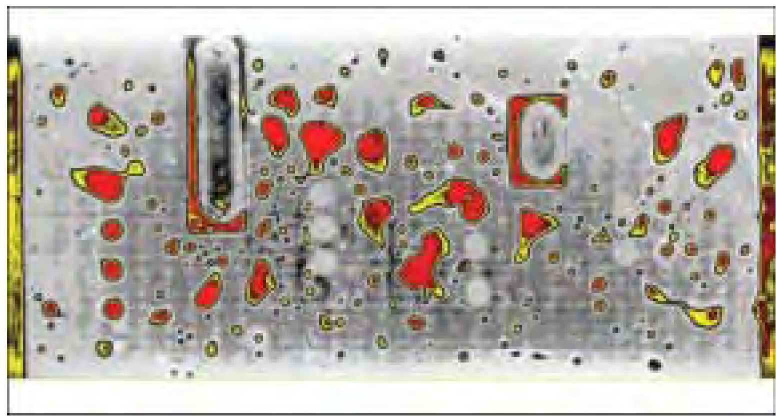

Figure 2: Thermally, a void acts as an insulator and prevents heat dissipation. Acoustically, the great differences in density and in acoustic velocity between the air-filled void and adjacent solid material causes the void to reflect ultrasound at high amplitude.

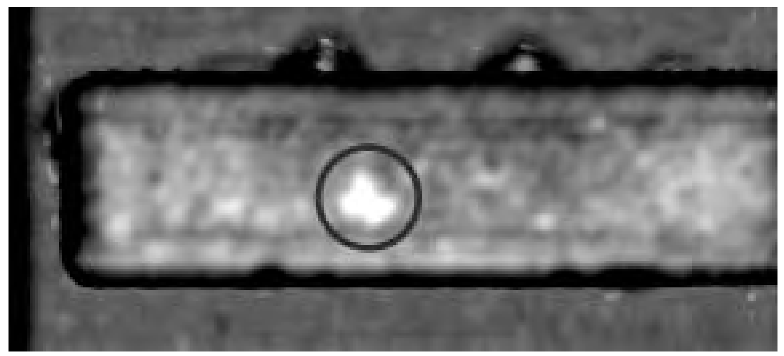

Figure 3: A critical application: the acoustic image of the attachment of a laser diode to its heat sink. The white area (circle) is a heat-blocking void.

Figure 4: The attachment of a thermo-electric cooler, whose vertical vanes (white in this image) enhance heat dissipation. Black rectangles are areas where the cooler is bonded to the substrate, but these areas contain many small white voids. The diagram at bottom shows a side view.

Reflection of ultrasound from internal interfaces

Ultrasound pulsed into a sample is reflected only from material interfaces, and not from the bulk of a material. Most internal interfaces involve two solid materials, but the presence of a void means that the arriving ultrasound encounters an interface where one of the materials is air. Air (or any gas) differs so sharply in its density and in its acoustic velocity from the overlying solid material that the return echo signal from this point has very high amplitude.

The relatively low acoustic reflection from a well bonded interface between two solids means that much of the ultrasound crosses the interface and travels deeper—and this is why an acoustic micro imaging system can “reach down” through several layers of material to image a single interface of interest. A void or other gap-type defect reflects ultrasound so efficiently that essentially no ultrasound penetrates through the gap to reach deeper layers.

The vertical dimension of the void is relatively unimportant for acoustic reflection. Recent tests show that gaps whose vertical dimension is on the order of 100Å to 1000Å reflect ultrasound with about the same efficiency as much thicker gaps.

Heat sinks in high-power applications

Figure 3 is the acoustic image of a thermally critical application—the attach of a very thin laser diode to its heat sink substrate. Because of the high thermal output of the diode, no voids can be tolerated in the attachment layer. The bright spot (circle) in Figure 3 is a void, conspicuous because of the high amplitude of the echo signals being reflected from the void.

Because laser diodes are themselves very thin (typically between 75 and 100 microns), earlier acoustic imaging systems could not easily gate on the very restricted depth represented by the attachment layer. This problem was solved by the development of higher acoustic frequencies (230 MHz, 300 MHz) that make such precision a routine matter.

Figure 4 is the acoustic image of a thermo-electric cooler. Although the structure of the thermo-electric cooler is more complex than the structure of most heat sinks, the basic principle is the same, and voids at the attachment layer will cause a reduction in heat subtraction function. The black rectangles in Figure 4 are the solder attach of the vertical cooling vanes that increase the surface area. Small white areas are present within the outline of the solder bonds. These features correspond to voids and show the same reflection level as the non-bonded areas between the vane bonds.

Measuring the thickness of the attachment layer

In some applications the absence of voids in the attachment layer is not in itself enough to ensure efficient heat removal. The precise thickness of the attachment layer from one side of the heat sink to the other is also important. If the attachment layer is too thick or too thin, the device may fail, even if no voids are present.

A method developed at Sonoscan (www.sonoscan.com) uses acoustic micro imaging techniques to measure the thickness of the attachment layer nondestructively and with great precision. Measurements are performed at Sonoscan's applications laboratory, and are useful in establishing process parameters for the successful attach of a heat sink to a device under development.

Variations in the thickness of the attach layer can also be demonstrated graphically. At each pixel point, the time difference across the thickness of the attach layer is measured, and colors are assigned to various thicknesses.

Figure 5 shows the thickness profile of the solder attach layer of a direct bond copper substrate to its heat sink. Thickness corresponds to the color map at the left, where red indicates the thinnest attach layer. The thickest regions of the attach layer (green) are at the center because the substrate was slightly warped. There are also numerous voids of various sizes in the attach layer. Although the substrate is warped, the voids are all at the same level and therefore all have the same color.

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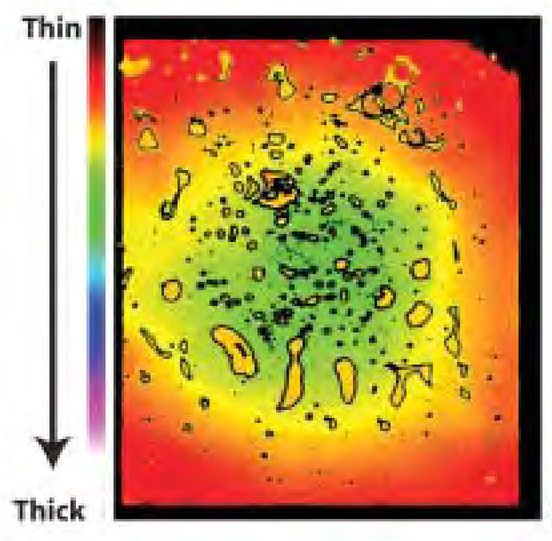

Figure 5: Color visualization of the thickness of the attachment layer. In this acoustic image of the attachment of a direct bond copper substrate to its heat sink, red areas are thinner, and green areas thicker.

Rectifier Bridge

The Easy1 housing offers a well suited module concept for a compact and cost-effective integration of power semiconductors with a footprint of only 33 x 45 mm.

The Easy module series devices demonstrate excellent performance which was now transmitted into a new topology. This newest available topology, called EasyBRIDGE1, extends the existing Easy family with an uncontrolled three phase bridge rectifier including an integrated brake arm. Such a topology provides best adaptation to EasyPACK modules and even Econo modules, due to the common height.

The product range for EasyBRIDGE modules covers the voltage range VRRM (repetitive peak reverse voltage) for 800V and 1600V at an output current for I_d = 50A resp. 40A.

Further addressed to market requirements, EasyBRIDGE modules will be available additionally in versions with improved surge forward current of approx. 60%.

With these extensions, the product portfolio of Easy modules, realizing input rectifier, brake chopper and inverter, are applicable for motor ratings up to 5,5kW.

www.eupec.com

Power Quality Analyser

LEM has introduced an “Advanced function” for its MEMOBOX Power Quality Analyser family. With this enhancement, all aspects of PQ analysis, network optimisation and disturbance analysis (previously only available in separate instruments) are covered in a single instrument. The new version now covers all measuring tasks needed for the operation and maintenance of an electricity supply network for a utility or in large industrial facilities.

The new function enables the user to measure and store 500 relevant parameters simultaneously over a period of up to four weeks. The MEMOBOX can be used in low- and medium-voltage networks up to 830 V peak-to-peak and captures up to four currents. Its compact size allows it to be installed into the smallest cabinets. The isolated case and accessories provide reliable protection against electrical shock.

The MEMOBOX analyses supply quality fully in accordance with EN 50160, including voltage and current harmonics up to the 50th. For analysis, the package includes the new Version 4.0 "Codam plus" software, which is accepted as the leading PQ software providing the user with clear conclusions without extensive training.

www.lem.com

Smallest 100-V Half-Bridge Driver ICs

Intersil announced that the very popular HIP2100 and HIP2101 high-voltage half-bridge MOSFET driver ICs are now available in new space-saving and thermally efficient packages. The new 8-lead exposed-pad (EP or E-pad) SOIC package offers enhanced thermal efficiency and the 4 X 4 mm dual flat no-lead (DFN) package yields the world’s smallest 100-V half-bridge MOSFET driver. Applications for these thermally enhanced drivers include, but are not limited to, telecom and datacom power supplies, avionics DC/DC converters, two-switch forward converters and active-clamp forward converters.

Intersil’s exposed-pad device package is a thermally enhanced eight-lead small-outline integrated circuit (EPSOIC) that enables power supplies to run cooler and more efficiently. This enhanced package features a copper pad connection to the printed circuit board ground, which serves as a heat sink. Transferring heat from the MOSFET driver integrated circuit (IC) through the copper pad reduces thermal resistance by up to 50 percent and enables the MOSFET driver to operate cooler and more efficiently.

The 4 X 4 mm DFN version is sampling to customers now and will be released to full production in about sixteen weeks. It is the smallest 100-V half-bridge MOSFET driver available that allows engineers to ad here to IPC-2221 design standards for printed circuit board layout. The guidelines call for 0.6 mm of spacing between high voltage nodes in order to assure long-term system reliability.

http://www.intersil.com/HIP210X