Dissipating Heat From RF Circuit Boards

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The integration of heat removal systems in the structure of circuit boards is a proven and reliable technique, and ideally suited for high frequency (HF) circuit boards. In addition to using conductive adhesive films to bond cool elements to HF circuit boards, new methods have been developed to integrate local heat removal systems in the form of Copper coins. These techniques give the circuit designer flexibility in terms of board design and choice of materials. The models presented below are already being used for various HF components in base stations for mobile telephony networks and WiMax services.

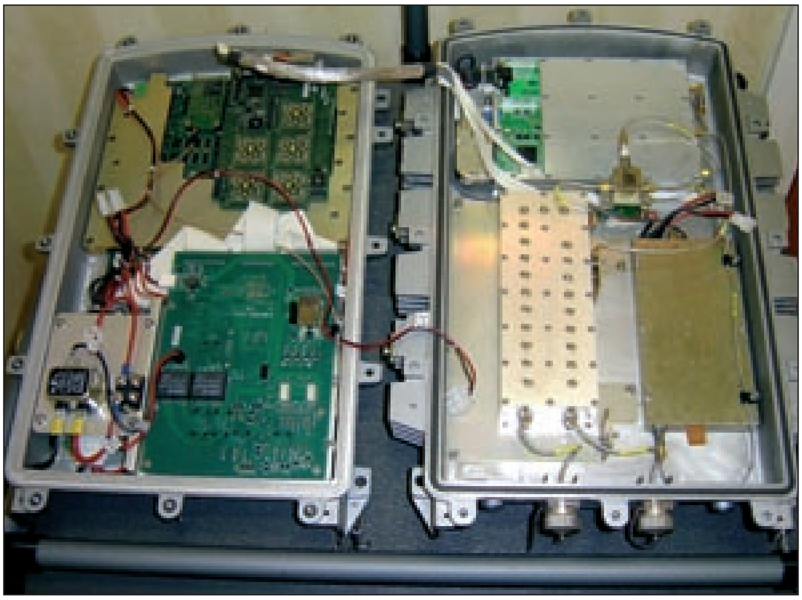


Figure 1 - WiMax HF amplifier

Large quantities of heat are generated when signals are processed in high-frequency applications, and particularly in the amplification of HF signals. This heat needs to be removed quickly and efficiently from the components. HF circuits are very often built into special shielding housings (Figure 1). This makes it difficult to mount a simple cooling element on the component needing to be cooled, or heat removal by the element is inadequate.

In HF technology, the heat from power transistors is normally dissipated via the base of the component to the heat sink, e.g. the housing, for which materials with a high thermal capacity are used. This principle allows the heat dissipation system to be integrated into the mechanical construction of HF circuit boards.

For heat dissipation, the whole circuit board is very often mounted on a thick metal plate. Various methods are available. Bare boards, for example, can be "sweat soldered" to the cooling element. Or they are simply screwed to a cooling element after circuit board assembly.

We know from experience that such methods involve a lot of time and effort on the part of our customers, especially when large numbers of pieces are processed and high quality standards need to be met. For that reason, methods and models have been developed that make it possible to integrate the cooling element, or other local elements for heat dissipation, into the structure of the HF circuit board during the production stage.

Pre-bonded or post-bonded

Several material manufacturers offer HF materials that have already been laminated to a flat metal plate for heat dissipation. The HF substrate is located direct on a thick layer of metal, with no interlayer. Materials used for the metal plate are Copper, Aluminium or brass. Because this composite structure is obtained as such from the material manufacturer, the method has become known as the "pre-bonded" technique.

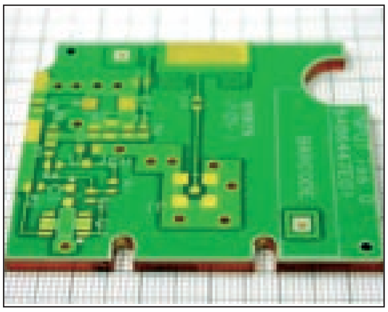


Figure 2 - Metal-backed HF substrate

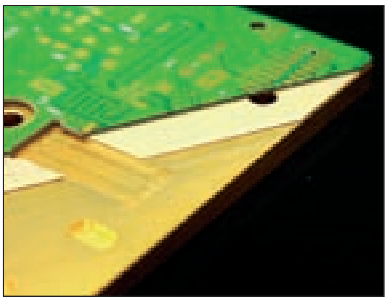


Figure 3 - HF circuit board with cooling element

Figure 2 shows a pre-bonded HF substrate with a thick metal backing of Copper. For circuit boards, this base material is processed in the same way as a double-sided circuit board.

Plated-through holes in the form of blind holes or through-holes can be made. The circuit board features a conductive pattern on one side only. However, the processing of such metal-backed accessories, typically 1 mm to 3 mm thick, is time-consuming in circuit board production.

The starting material for the pre-bonded version is a composite material consisting of a relatively soft HF substrate and a thick metal plate. The optimum parameters for mechanically processing these materials differ widely. For that reason, compromises have to be made in production, or special machine equipment or configurations have to be used. The metals to choose from have very different plating properties. Usually, Copper and brass can be through-plated without difficulty. However, Aluminium requires special pretreatments and coatings before Copper plating. The same applies to the surface finish.

The base material in the pre-bonded construction is normally more expensive than when the materials are procured singly.

In the post-bonded method, the finished HF circuit board is bonded by means of an adhesive film to a separately made cooling element. The adhesive film can be selected according to requirements; electrically conductive, thermally conductive and non-conductive films are available. Electrically and thermally conductive adhesive films are normally used for HF power amplifiers. Since the adhesive film is electrically conductive, the cooling element is conductively connected to the earthing of the HF circuit board. With approx. 1 mW, the electrical transfer resistance is very low.

Figure 3 shows a segment of an HF circuit board with electrically and thermally conductive adhesive film and cooling element. The cooling element contains a cavity in which an HF power transistor with flange is mounted. The bond between circuit board and cooling element must be of very high quality. There should be no voids so as to rule out hot spots. After lamination, the thickness of the adhesive film must be very uniform. Appropriate process management will ensure that these requirements are met.

The post-bonded method has considerable advantages over the pre-bonded method in terms of both the design and production of circuit boards. The HF circuit board can be of any design. There is no limit to the number of conductive pattern layers nor to the choice of HF substrates. Equally, the cooling element can be of any shape and design. In production, the three components are manufactured separately in optimally geared processes. After completion, the single parts are joined by laminating. Any defective parts can be rejected before assembly.

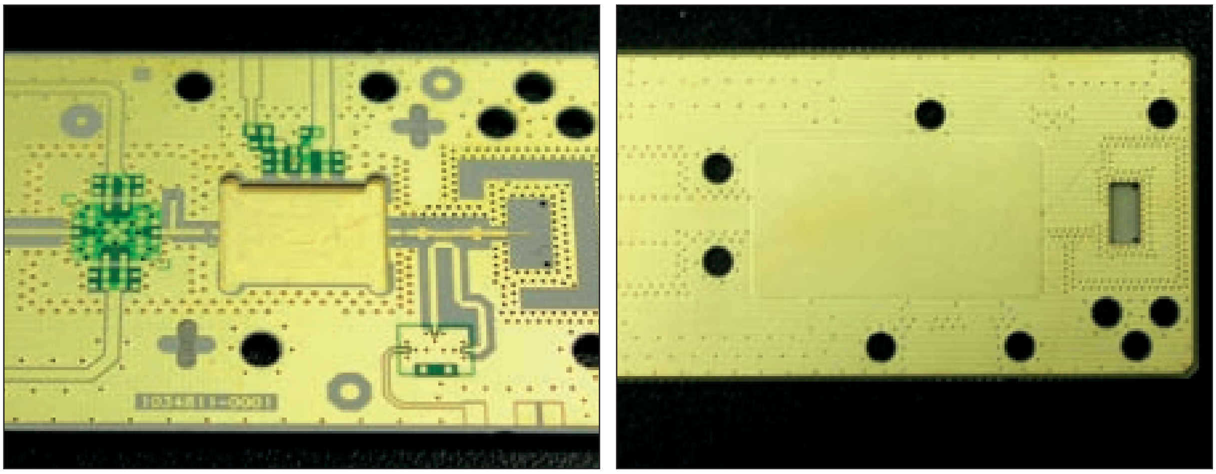
Local heat dissipation by Copper coins

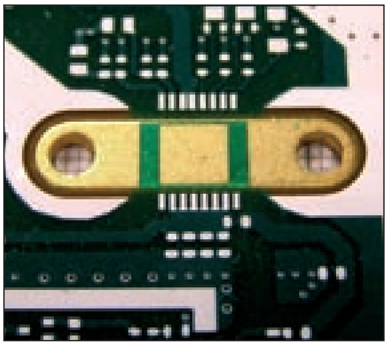
In many cases, mounting of a cooling element over the full board area is not necessary or practical, for example, when the HF circuit board has yet to be mounted on a metal holder or in a metal housing. A local heat sink integrated in the HF circuit board will then suffice to transfer heat away from the component to the underside of the circuit board and then to an external heat sink. Thus, for example, areas with thermal vias can dissipate the heat through the circuit board. If their thermal conductivity is not high enough, pieces of solid Copper (Cu coins) are inserted in the circuit board. For this purpose Ruwel has developed various methods. Copper has high electrical and thermal conductivity properties and can be readily integrated into circuit board designs.

One method is to embed the Copper pieces in an HF multilayer circuit board. High-frequency circuits are often stacked up to form a so-called hybrid design. An HF substrate is bonded to a laminate of a different material. Before the complete composite construction is laminated, the Cu coins are placed in an opening in the second substrate. The Cu coins can be connected by plated-through holes and the metallic coating of the circuit board to the frame potential of the circuit board (Figure 4).

As shown on the right in Figure 4, the Cu coin lies flush with the plane on the rear side of the circuit board. However, the method also allows the Cu coin to finish flush with both surfaces of the circuit

Figure 4 - HF circuit board with embedded Cu coin





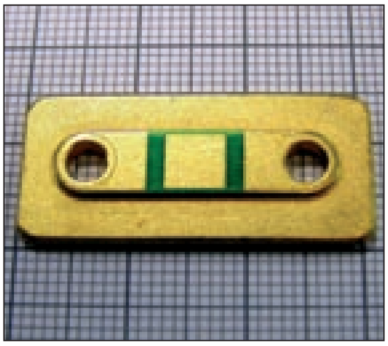


Figure 5 - HF circuit board with bonded Cu coin

board. This design then allows the use of SMT versions of HF power transistors.

Another method is to bond the Cu coins after the HF circuit board has been completed. For this purpose the HF circuit board contains cavities to hold prefabricated Cu coins in place with a conductive adhesive. The adhesive can be thermally and electrically conductive (Figure 5).

The adhesive strength of the bonded Cu coins depends on the adhesive used, the type of surfaces, and also on the size and geometry of the cemented area. In the configuration shown, a vertical peel force of 600 N is attained.

Cu coins in press-fit technique

The insertion of Cu coins in circuit boards by means of the press-fit method is a fairly recent method that is practised on circuit boards for motor controls in the automotive industry.

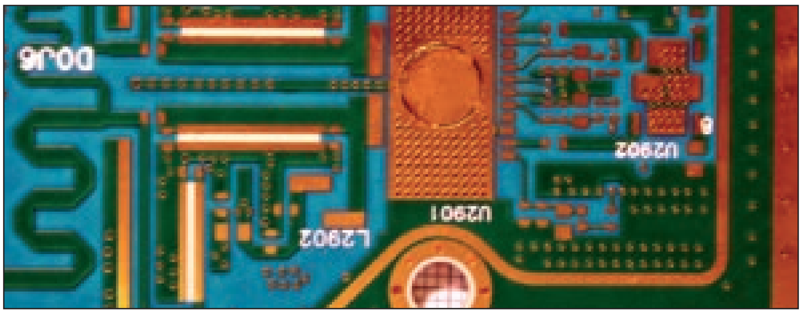


Figure 6 - HF circuit board with press-fitted Cu coin

This method can also be used for HF circuit boards. Round or rectangular Cu coins are pressed into appropriate openings in the HF circuit boards. The Cu coins can be press-fitted into plated or non-plated openings. Copper plating of the circuit board after the coins have been press-fitted is just as possible as is the application of the usual surface finishes.

Figure 6 shows a segment of an HF circuit board with press-fitted Cu coins. Additionally, the coins are surrounded by thermal vias to boost heat dissipation. However, they are not absolutely necessary and in this instance were only fitted because space was available. The thermal conductivity of Cu coins is far higher than that of thermal vias.

Professional Legend Printing For PCB Prototypes

According to LPKF, the company's new ProLegend is a fast and easy to use system designed to create professional legend print on PCB prototypes. The environmentally friendly solution does not require screen printing and comes with all the necessary tools and consumables. Furthermore, ProLegend requires very little training; a user with no previous knowledge can learn to operate the system effectively very quickly.

By enabling in-house legend printing, the system increases security of confidential design information and helps reduce product time to market. The ProLegend is the final step of LPKF's in-house soldering system.

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