WHITE PAPER

CW Operation of QFN-Packaged Pulsed GaN Power Amplifiers

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Executive Summary

This paper addresses thermal issues with using QFN-packaged GaN power amplifiers, originally designed for pulsed operation, in CW mode. Consideration need to be made for component mounting to provide a low thermal impedance path to the system heat sink for optimum operation and reliability, using the TGA2307-SM as an example.

Introduction

GaN amplifiers at microwave frequencies have presented system engineers with the opportunity to generate higher output power levels in smaller physical systems. Along with this improvement in system capability, however, is the need to provide sufficient thermal management of these GaN devices. Furthermore, many high powered small packaged (e.g., QFN) GaN devices, which were originally envisioned for pulsed applications, are increasingly desired for use in high power CW systems due to their small size and weight. Thermal management of these GaN devices is complicated by the smaller package thermal footprint and the interface of the package to the remaining components of the system heatsink.

Example: TGA2307-SM

One example is the Qorvo TGA2307-SM, a 5-6 GHz 50 Watt GaN power amplifier, fabricated using Qorvo’s QGaN25 production process. The TGA2307-SM is packaged in a 6 mm x 6 mm 40-pin plastic overmolded QFN package. Originally developed primarily for pulsed applications, the TGA2307-SM dissipates 6.2-8.0 Watts average power with a 100 us pulse width and 10% duty cycle. Sufficient thermal management at this power level is obtained by employing PCB mounting with copper-filled thermal vias under the main center pad of the package (Figure 1), as used on the evaluation board (EVB).

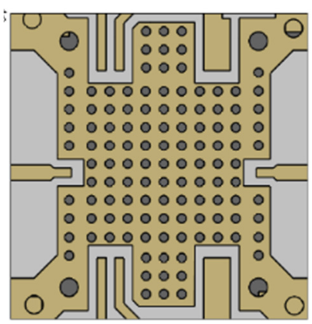

Figure 1. Mounting detail for the TGA2307-SM EVB PCB.

Average power dissipation increases as the duty cycle increases, until at CW operating conditions the dissipated power is now in the > 60 watt range. Prior experience has shown that power levels above 10-15 watts average cannot be adequately handled using this thermal management approach. PCBs with openings for heat sinks with machined pedestals and coined PCBs offer the capability of handling higher power dissipation by providing much lower thermal resistance from the package through the PCB to the eventual system heat sink.

In order to determine the possibility of using the TGA2307-SM in CW mode, three material stack-up environments were simulated:

1. 8 mil filled thermal vias with the PCB epoxy attached to heat sink (baseline EVB configuration)
2. 20 mil coined PCB with the PCB epoxy attached to heat sink
3. 20 mil coined PCB with the PCB soldered to heat sink using SAC-305

The results of the thermal simulations are shown in Figure 2. A schematic of the material stack-up of the thermal analysis problem is shown in Figure 3.

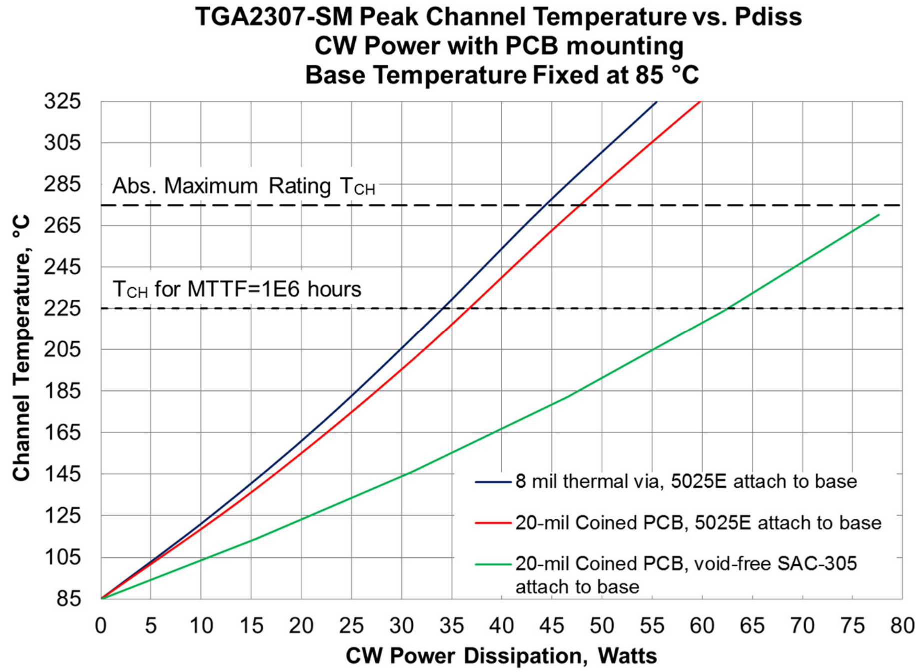

Figure 2. Thermal modeling results for various PCB thermal management implementations.

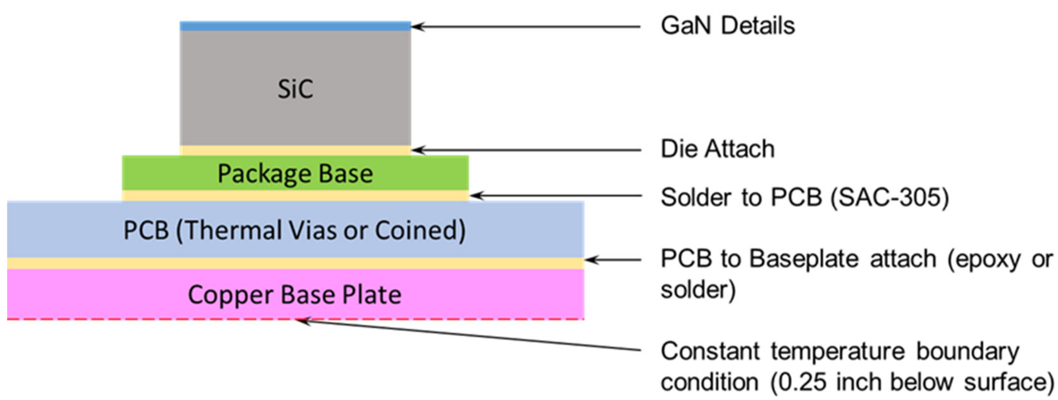

Figure 3. Thermal Model Stack-up for TGA2307-SM EVB.

As the CW dissipation for the TGA2307-SM under CW conditions is at or greater than 60 watts, the provided plot shows that for cases (1) and (2), both using PCB epoxy attach to the heat sink, the channel temperature exceeds 325 ℃, even with a coined PCB (!). As the thermal conductivity properties of the various materials above 325 ℃ start to degrade, and the part lifetime with a MTTF at this point decreases substantially, operating under these conditions is certainly not recommended.

It should be noted that all cases, even for case (3), PCB solder attach to the heat sink, assume a void-free uniform solder interface between the TGA2307-SM package base and the coin, and void-free uniform epoxy-or-solder interface between the coin and the heat sink. This will be difficult to accomplish in a prototype environment, and even more so in production.

Also, the user needs to be aware that this model assumes a fixed 85 °C backside temperature 0.25 inch under the surface of the heat sink (the evaluation board has a hole for mounting a thermocouple at this location). This implies that whatever the package/coin is mounted to should be able to sink whatever heat flux is dumped into it while maintaining this temperature. This is good for modeling purposes, as it allows a consistent boundary condition for model comparison, as well as providing temperature values to use during testing, but discounts the rest of the customer's thermal management system, which may or may not be able to perform this level of heat sinking.

Summary

CW operation of the TGA2307-SM is possible, providing that the part is mounted using a coined PCB with an excellent solder interface between the package and the coin, and likewise an excellent thermal interface between the coin and the heat sink, along with a system thermal management approach that can sink the requisite heat flux to maintain a sufficiently low package backside temperature. At this point, it is a judgement call for the customer to use this part in this way.

A thermal analysis similar to that shown above should be performed with any high power GaN amplifier in a QFN-style package to determine the thermal management requirements to obtain best RF performance while maintaining a long component lifetime.