MOSFET

Super Junction MOSFET in the SOT−223−3 Package

ROHM developed a Super Junction MOSFET product using a new SOT-223-3 package that replaces DPAK (TO-252 package), which has been used for many years in a variety of semiconductor devices. SOT-223-3 offers a package solution for downsizing and cost-effectiveness. However, downsizing a package poses challenges related to thermal characteristics. This application note explains the advantages of replacing DPAK with the SOT-223-3 package and how to overcome the challenges of the thermal design.

Comparison of external shapes

Figure 1 shows the outline drawings of DPAK and the SOT-223-3 package. In comparison with DPAK, SOT-223-3 is 31.1% smaller in area and 48.3% smaller.

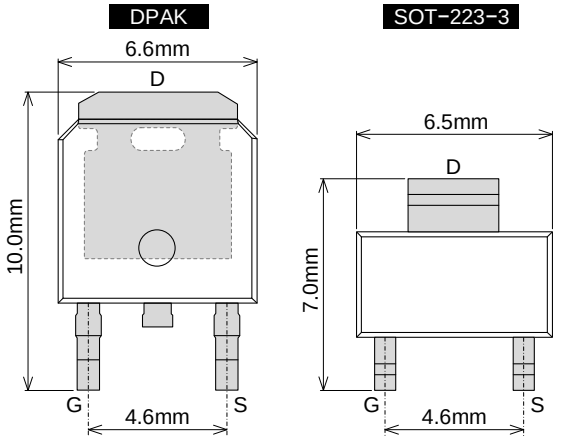


Figure 1. Outline drawings of DPAK and the SOT-223-3 package

Footprint compatibility

Figure 2 shows the footprints of DPAK and the SOT-223-3 package. Figure 3 shows the state of SOT-223-3 mounted on the footprint of DPAK. Since DPAK and SOT-223-3 are compatible in lead spacing, it is possible to mount SOT-223-3 in the place of DPAK as shown without modifying the footprint layout of DPAK.

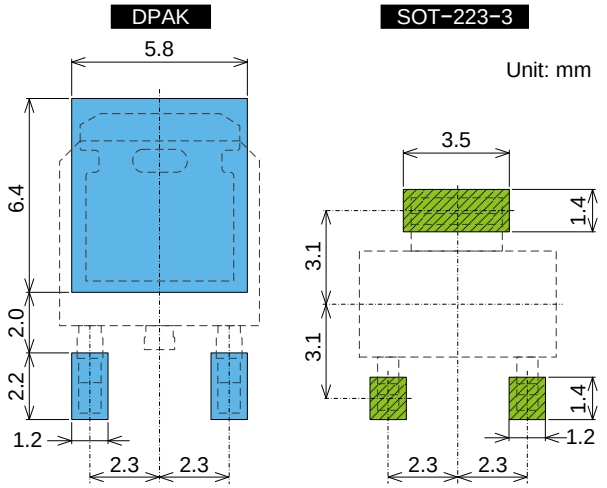


Figure 2. Footprints of DPAK and the SOT-223-3 package

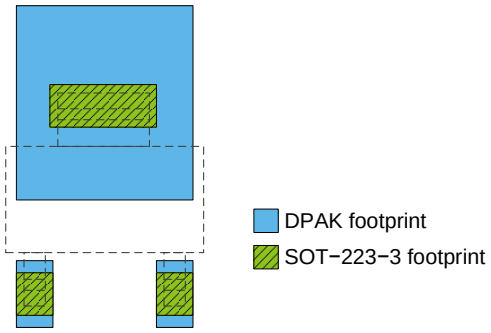


Figure 3. SOT-223-3 mounted on the footprint of DPAK

Challenges related to thermal characteristics

When surface mounted parts are mounted on a PCB, most of the heat is dissipated through heat dissipation paths to the PCB side due to the high thermal resistance of the air layer on the package surface. Figure 4 shows the main thermal conduction paths when DPAK is mounted on a PCB and when SOT-223-3 is mounted on a PCB. In DPAK, the lead frame directly below the chip (heat source) is exposed on the back surface of the plastic mold, which allows heat to be conducted to the copper foil and the PCB at the shortest distance. On the other hand, in SOT-223-3, the lead frame is not exposed on the back surface, so heat is transferred horizontally through the lead frame before being conducted to the copper foil and the PCB. Thus, SOT-223-3 has higher thermal resistance than DPAK.

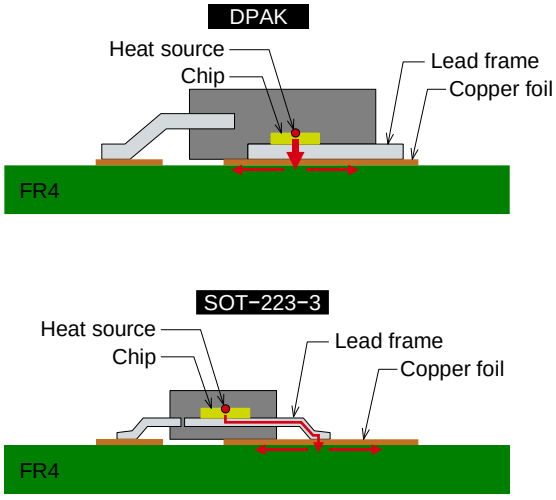


Figure 4. Main thermal conduction paths

Thermal design

Now, check to see how the PCB layout should be modified to obtain thermal characteristics equivalent to those of DPAK.

Figure 5 shows the simulation results when the copper foil area of the heat dissipation part is varied with each package mounted on the footprint of DPAK. Figure 6 shows an example of the heat dissipation part when the copper foil area is varied.

On the thermal resistance graph, the value at the left end of the curves represents the heat dissipation area of the reference footprint for DPAK, which is 37.1 mm^2 (= 5.8 mm × 6.4 mm). The thermal resistance at this point is 152.6°C/W for DPAK and 163.6°C/W for SOT-223-3, showing that SOT-223-3 is 11°C/W higher.

Next, determine the copper foil area required for SOT-223-3 to have the same thermal resistance as DPAK. Find the point on the graph at which the curve of SOT-223-3 crosses the DPAK's thermal resistance of 152.6°C/W. The X-axis value of the point of intersection represents the area required for heat dissipation. This value is 50.6 mm^2, which means that thermal resistance equivalent to that of DPAK can be obtained by increasing the original area by 13.5 mm^2.

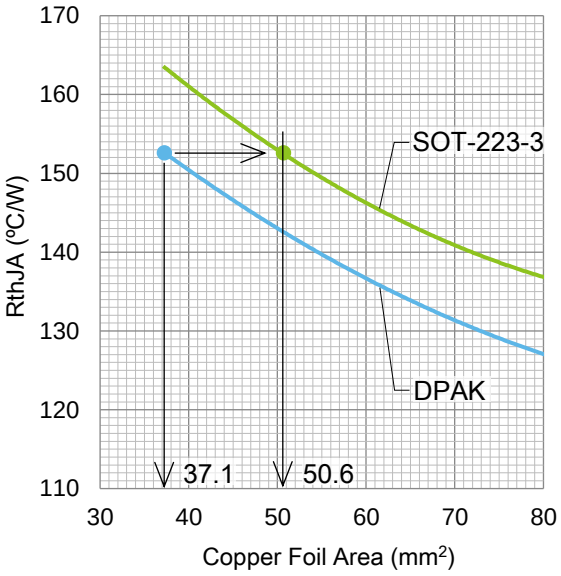


Figure 5. Thermal resistance with varied copper foil area
Each package mounted on the footprint of DPAK
Board specifications
- Board size: 100 mm × 100 mm, 1.6 mm thick
- Material: FR4
- Copper foil thickness: 35 µm

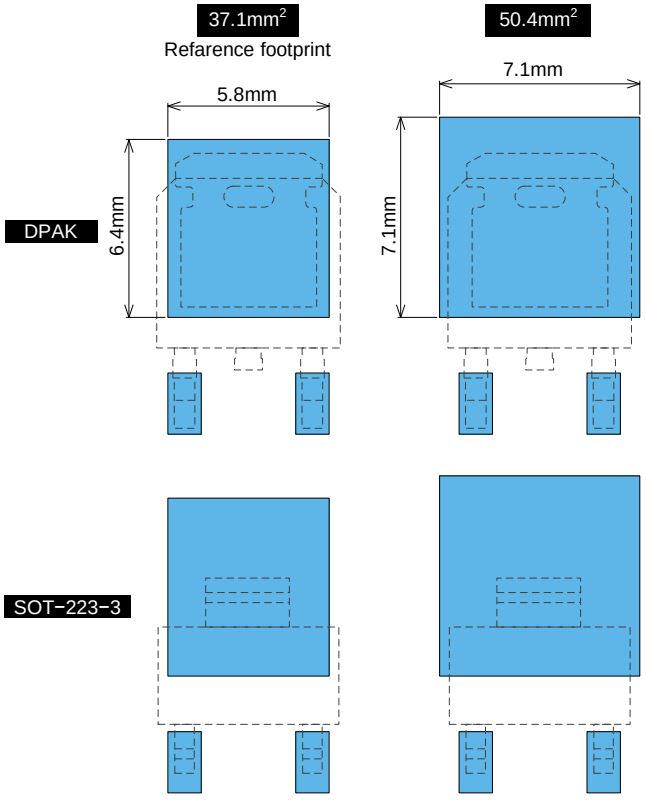


Figure 6. Example of the heat dissipation part with modified copper foil area
Each package mounted on the footprint of DPAK

Next, check the junction temperatures when the power dissipation is varied with each package mounted on the reference footprint for DPAK.

Figure 7 shows the simulation results. For example, when the power dissipation is 0.25 W, it is predicted that the temperature of SOT-223-3 will be 2.8°C higher than that of DPAK. Figure 8 shows the contour diagram for this case.

In applications where the temperature difference can be tolerated at each power dissipation value, SOT-223-3 can be used as an alternative to DPAK.

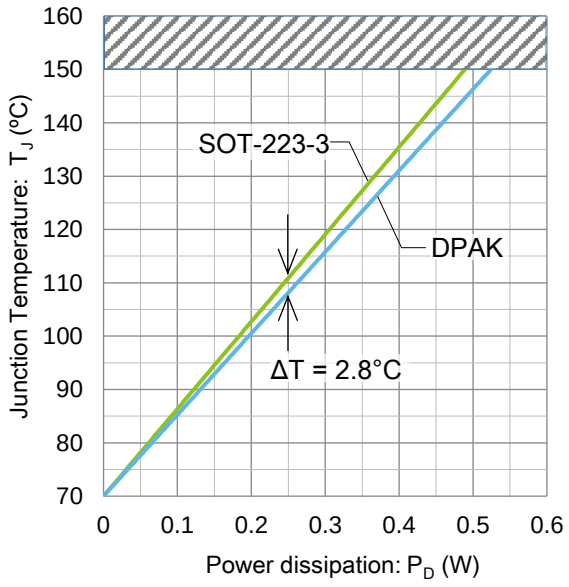
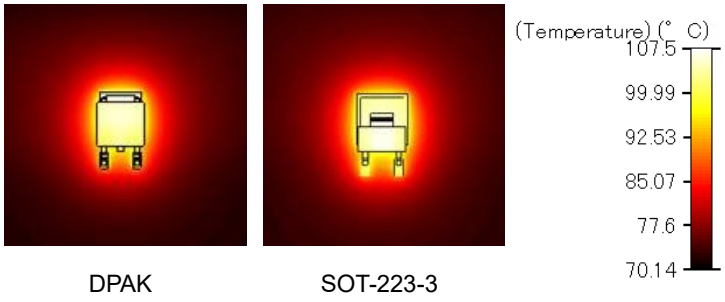


Figure 7. Junction temperatures with varied power dissipation
Each package mounted on the footprint of DPAK
Copper foil area 37.1 mm^2 (5.8 mm x 6.4 mm) at T_A = 70°C



DPAK SOT-223-3

Figure 8. Contour diagram

Summary

The following summarizes the advantages of the SOT-223-3 package and the thermal design data obtained from the thermal simulation.

Smaller package solution for cost-effectiveness

- 31.1% smaller in area and 48.3% smaller in volume than DPAK
- Compatible footprint that allows for pin-to-pin replacement of DPAK

Thermal characteristics equivalent to DPAK

- Equivalent thermal resistance can be obtained by increasing the copper foil area on the footprint of DPAK by 13.5 mm^2.
- The temperature will be a little less than 3°C higher than DPAK on the same footprint (at P_D = 0.25 W).

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