Working With PolarPAK®
In-Lab Soldering and Re-Working Recommendations

By Kandarp Pandya

INTRODUCTION

PolarPAK®, a new-generation Vishay Siliconix power MOSFET package, offers double-sided cooling with a metal surface on both the top and bottom sides. As it is leadless, extra care is needed while working with the package in an engineering laboratory environment. The conventional approach for this package is to employ sophisticated soldering stations like the Metcal APR5000, which offers optical alignment for accurate part placement on the printed circuit board (PCB) and runs a predefined reflow profile to solder or de-solder the part using temperature controlled airflow. However, due to its high cost, such a facility is not commonly available. Alternatively, using a standard soldering station often leads to common mistakes. Heating the top metal surface by touching it with the tip of the soldering iron is one of the most detrimental mistakes, resulting in catastrophic damage to the MOSFET. This application note, one of a series of support documents for PolarPAK, describes inexpensive, in-lab recommended soldering procedures closely matching the production reflow profile, while in turn insuring a reliable solder joint even on the lab bench top. The solder joint quality is evaluated by means of X-rays, and the electrical functionality of the part is verified after both soldering and re-works procedures.

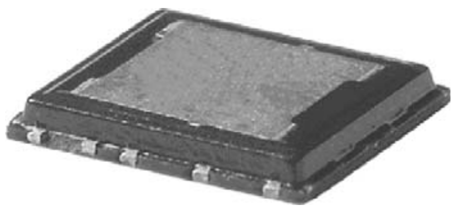

Figure 1a. PolarPAK top side

Figure 1b. PolarPAK bottom side

ENGINEERING LAB SET-UP

The set-up is comprised of the following materials and equipment:

(1) Samples of Vishay Siliconix SiE802DF PolarPAK MOSFETs (Figures 1a, 1b, 1c, and 1d).

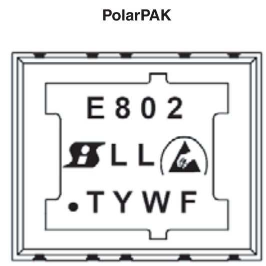

Figure 1c. Part Marking

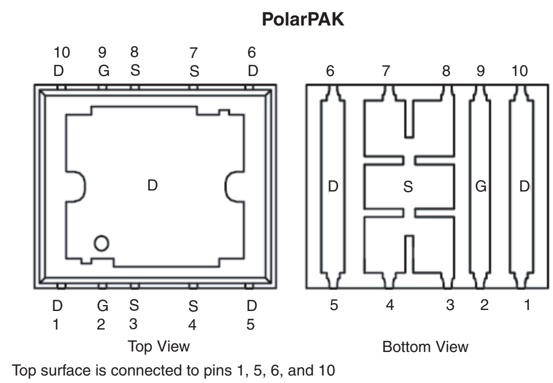

Figure 1d. Pin Configuration

(2) Test PCB used for this experiment (Figure 2). See Appendix A for details.

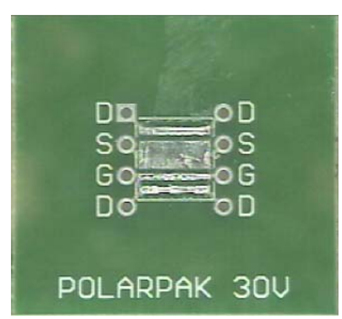

Figure 2. 1" x 1" PCB

(3) Steinel Heat Gun with Digital Display, Model HG3002LCD (Figures 3, 4a, 4b, 4c, and 4d). See Appendix B for details.

Figure 3. Steinel Heat Gun Model HG3002LCD

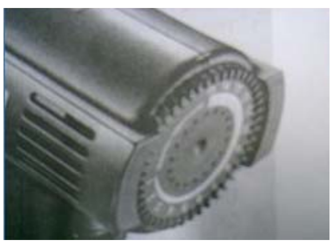

Figure 4a. Temperature Setting Wheel

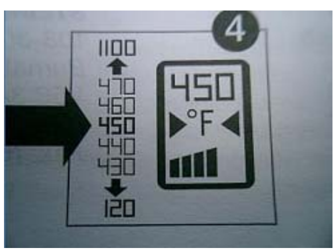

Figure 4b. LCD Display for temperature and air Flow

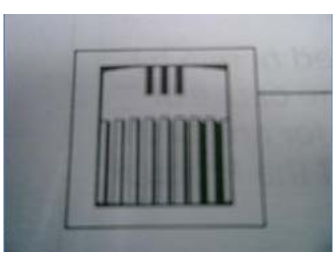

Figure 4c. Air Flow Control

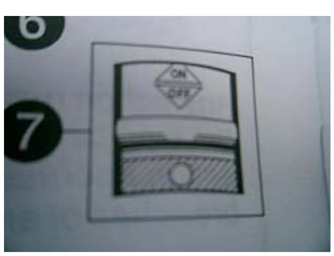

Figure 4d. On/Off Switch

(4) Stencil (with applicator) set for PolarPAK (Figures 5a, 5b, and 6).

Figure 5a. Stencil with Clamp and Applicator

Figure 5b. Stencil

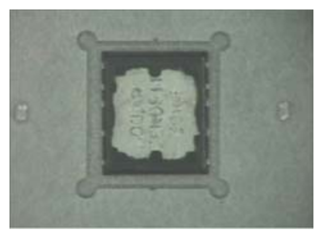

Figure 6. Stencil with Part

(5) Mechanical fixture to hold the heat gun (Figure 7).

Figure 7. Mechanical fixture to hold the heat gun

(6) No-clean variety of solder paste, Kester Puremark 202, type sn63/pb37.

(7) Electronic lab tools, measuring instruments, thermo-couples with temperature indicator, and soldering material.

SET-UP DESCRIPTION:

(1) Part Preparation

A sample SiE802DF PolarPAK device was taken. Gate-source, gate drain, and drain-source resistance values were measured by means of multimeter to verify that the part sample was electrically good.

Using the stencil shown in Figure 5, the part sample was held on the stencil, Figure 6. An even layer of solder paste was applied by swiping the applicator over the stencil surface. The stencil was unclamped gently to release the part for placement on the PCB pads.

(2) PCB Assembly Preparation

Carefully, the part was placed on the PCB pads using the best visual judgment to align the pads and pins while maintaining the polarity of drain, gate, and source. Refer to Figures 1c and 1d for part making and details of polarity. Minor miss-matches are bound to occur; however, the part generally aligns with the PCB pads due to surface tension when the solder paste melts.

(3) Heat Gun and Mechanical Fixture Assembly

The Steinel Heat Gun, Model HG3002LCD, shown in Figure 3, is a calibrated heat gun which has all the features required to work with PolarPAK in the laboratory environment. The temperature setting wheel (Figure 4a) enables setting the temperature of the air blown by the heat gun. The set temperature is displayed on an LCD panel (Figure 4b), which also displays vertical bars to indicate airflow. Airflow can be set with the airflow control knob as shown in Figure 4c. The on/off control switch in Figure 4d enables heat gun operation with controlled airflow at a preset temperature.

The mechanical fixture can be a simple vertical clamp that can hold the heat gun upright over the PCB assembly at a desired distance. Figure 7 shows our lab arrangement, which uses a Metcal soldering station capable of providing X-Y-Z movement to hold the heat gun in its upper head. The air nozzle of the gun can be lowered over the PCB to keep at any distance.

REFLOW PROFILE DEFINITION AND DEVELOPMENT

The Vishay reliability manual, available online at http://www.vishay.com/docs/80126/80126.pdf, covers the recommended basic reflow profile definitions. Graphical representations of the recommended reflow profile in degrees Celsius and in Fahrenheit are shown in Figure 8a and 8b respectively. The temperature values in red trace show the maximum values and those in blue traces show the minimum values.

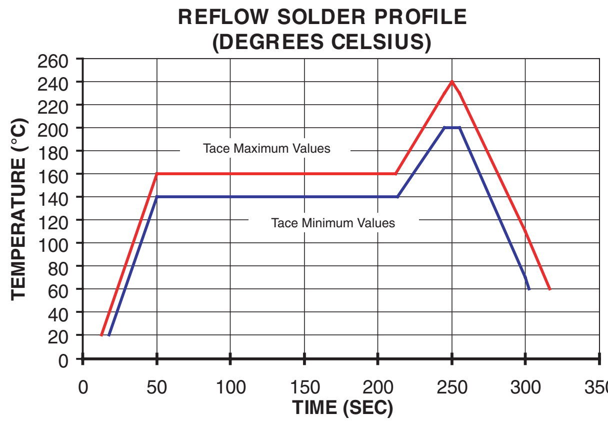

Figure 8a. Recommended reflow profile in Celsius
(Red Trace Maximum Values, Blue Trace Minimum Values)

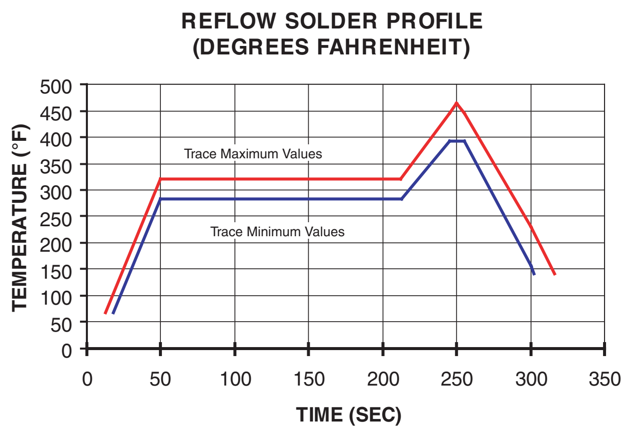

Figure 8b. Recommended reflow profile in Fahrenheit
(Red Trace Maximum Values, Blue Trace Minimum Values)

During the initial profile development, the computerized setup of the Metcal AR5000 facilitates temperature monitoring. One thermo-couple is placed on top of the part, another on the part lead, and a third on the bottom surface to monitor the actual temperature of the part. The temperature profile can be monitored on the computer screen and documented; however, even simple temperature measuring instruments can serve this purpose.

Developing or following the profile is a task in itself, requiring an operator's experience and skill. There are four interdependent parameters, two of which are the settings of the calibrated heat gun: the temperature and airflow settings. The third parameter is the distance of the air nozzle from the component/PCB assembly. The fourth parameter is the time duration for a given temperature setting. Temperature settings and time durations are controlled dynamically by the operator.

After a number of trials, the following setting produced the desired results.

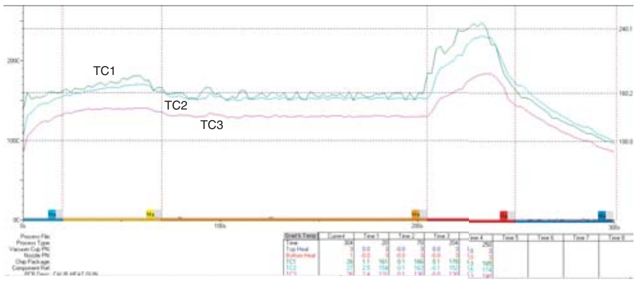

Figure 9. Reflow profile generated by using heat gun
Thermo-couple Placement:
TC1 -- Green Trace - Top of Component
TC2 - Blue Green - Close to lead frame on PCB
TC3 - Pink Trace - Bottom of PCB

Observe the temperature reflow profile in Figure 9, which matches the recommendations in Figure 8a:

a) Air nozzle distance from component: 1" (25.4 mm)

b) Air flow setting: medium

c) Temperature settings and time steps:

(1) 370 °F (180 °C) for 200 seconds - pre-heat period

(2) 700 °F (240 °C) for 25 to 40 seconds - reflow period

(3) 0 °F (0 °C) for 100 to 150 seconds - cool-down period

It should be noted that higher temperature settings are required for the heat gun to get the desired temperature on the component and PCB surfaces. This is due to the distance between the air nozzle and the component. The airflow setting also contributes to this difference in the temperature settings.

Also take note that this profile is developed for soldering a part on a 1 in. x 1 in. (25.4 mm x 25.4 mm) PCB as defined in Appendix A. Different temperature settings and air speeds may be required for different PCBs. However, such changes are easily made by an experienced laboratory technician.

SOLDER JOINT AND POLARPAK PART

A PCB assembly with the SiE802DF PolarPAK device is shown in Figures 10a and 10b.

Figure 10a. Assembled SiE802DF

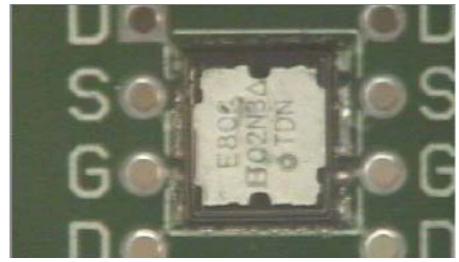

Figure 10b. Assembled SiE802DF Zoom-in

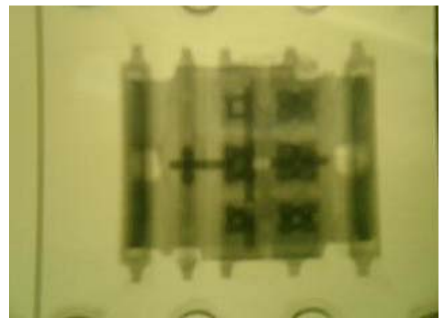

Figure 10c. X-ray of assembled SiE802DF

An X-ray of the assembly shown in Figure 10c verifies that an acceptable solder joint has been obtained, with voids observed on the source pad being less than 20 %.

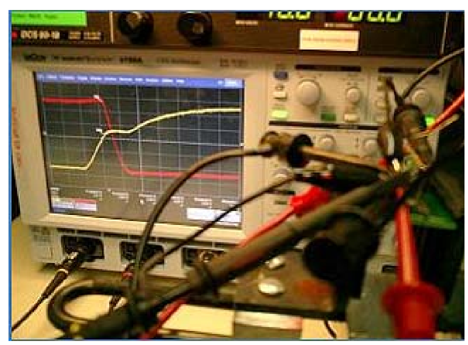

Figure 10d. Functionality test for assembled SiE802DF

Figure 10d shows waveforms of the part on the PCB assembly under functionality tests. The part was tested to be fully functional after the reflow assembly.

RE-WORK PROFILE DEFINITION AND DEVELOPMENT

To remove a part from the PCB assembly, the same settings are used. The only difference is that after 25 to 40 seconds in step 2 of the temperature settings, the solder under the part needs to be checked to see if it is soft enough so that the part can be picked away. Figure 11 shows a removed part with the PCB. The part was tested with multimeter for its electrical functionality.

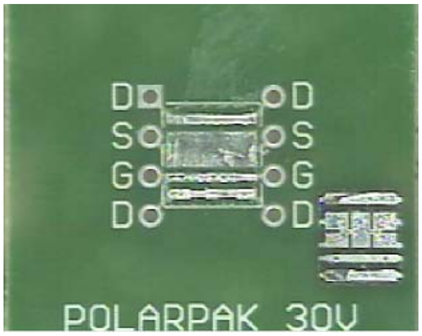

Figure 11. Removed part and PCB

SUMMARY

Working with PolarPAK in a laboratory environment is made simple with:

- A calibrated heat gun such as a Steinel Heat Gun mounted on a vertical clamp. A clamping facility with x-y-z movement can be of additional help, although it is not a requirement.
- Satisfactory soldering and re-work has been demonstrated with the following recommended soldering and re-work settings:
  a) Air nozzle distance from component: 1" (25.4 mm)
  b) Air flow: medium
  c) Temperature settings and time steps:
    (1) 370 °F (180 °C) for 200 seconds - pre-heat period
    (2) 700 °F (240 °C) for 25 to 40 seconds - reflow period
    (3) 0 °F (0 °C) for 100 to 150 seconds - cool-down period
- Experimental adjustments for distance, temperature settings, and airflow might be necessary when working with different board varieties.
- A solder paste applicator stencil (preferred) achieves an even layer of solder paste on the part.
- Temperature monitoring set-up can be of great help while changing the profile for different PCB assemblies.

ACKNOWLEDGEMENTS:

The author wishes to acknowledge the contribution by Dwight Kraus for his debuts in this experiment.

APPENDIX A

Standard PCB used for MOSFET soldering/re-work:

a. Dimensions: 1 in. x 1 in. x 0.062 in. (25.4 mm x 25.4 mm x 1.575 mm)
b. Material: FR4
c. Number of copper layers: 2
d. Copper thickness on both sides: 2 oz. (0.076 mm)
e. Area covered by copper on top side: 20 %
f. Area covered by copper on top side: 100 %

APPENDIX B

STEINEL HG3002LCD HEAT GUN SPECIFICATIONS

TECHNICAL SPECIFICATIONS	
Voltage	120 V AC
Output	1500 V
Temperature, Step 1	120 °F
Temperature, Step 2	120 °F - 1100 °F
Indicator range display	120 °F - 1100 °F
Blower	Continuously variable
Air flow	Min. 7 cfm, Max. 17.6 cfm
Weight	31 oz. with cord and plug

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