Thermal Measurement Report

DATE: 7/10/1998
Revised 7/31/98

Package Description:

Package: 480 37.5x37.5 mm TBGA 29 x 29 Array
Case: 1152-01
Frame: ASAT Drawing Nbr. E04480002-0-50
(DCDA37480-M014-001)
Cavity: 12.3 mm sq.
Die: C57D - 10.16 mm sq.
Die Orientation: Die Down
Die Attach: JMI 7100A - silver filled
Spreader: Copper Package Top
Glob Filler: Ciba R1004
Glob Dam: Hysol FP4451
Assembled: ASAT Hong Kong

Junction to Ambient Thermal Resistance or Theta JA ($R_{\theta JA}$) was measured per SEMI Test Method G38-87 at 3 watts in a horizontal configuration. The test board was designed to a draft JEDEC specification. There was one trace per ball on the outer perimeter of the package. The traces were designed to be 0.4 mm wide. Sample size: 5

Convection	Theta JA Average °C/watt	Standard Deviation °C/watt	Theta JA Ave + 3 Std. Dev. °C/watt
Natural	13.1	0.22	13.7
100 ft/min	10.7	0.16	11.2
200	9.6	0.14	10.0
400	8.2	0.23	8.9
800	6.4	0.14	6.8

"Thermal resistance" from junction to a thermocouple on top center of case, previously titled Theta J-Ref ($R_{\theta JR}$), was been renamed by the industry standard committee JEDEC JC15.1 as Ψ_{JT}. It is a useful value to use to estimate junction temperature in steady state customer environments.

Convection	Ψ_{JT} Average °C/watt	Standard Deviation °C/watt
Natural	0.38	0.02
100 ft/min	0.43	0.02
200	0.45	0.03
400	0.47	0.03
800	0.51	0.03

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Junction to ambient thermal resistance, Theta JA ($R_{\theta JA}$), was also measured with four different heat sinks. To properly evaluate the effect of the heat sink, the measurements were done with the single layer test board described above. Heat sink interface material was Wakefield 120 Thermal Grease. Two samples were measured at 5 watts. Average values are listed in the table.

Convection	Theta JA Heat Sink A °C/watt	Theta JA Heat Sink B °C/watt	Theta JA Heat Sink C °C/watt	Theta JA Heat Sink D °C/watt
Natural	9.01	8.62	6.45	6.45
100 ft/min	6.38	6.05	4.5	4.89
200	4.78	4.58	3.25	3.92
400	3.49	3.37	2.64	3.1
800	2.64	2.51	2.03	2.59

Heat Sink	Description
A	Thermalloy 2330B, 37.9x38.2x16.3 mm, cross cut extrusion pin fin
B	Thermalloy 2332B, 41.3x43.3x16.3 mm, cross cut extrusion pin fin
C	Wakefield 698100AB, 53.8x53.1x24.7 mm, cross cut extrusion pin fin
D	IERC 21426-ICB stamped and formed, base 35x35 mm, overall height 25 mm, overall width 58 mm square.

The Chip Cooler heat sinks had been previously measured with the 304 TBGA package. The Chip Cooler heat sinks are smaller and less effective than the ones measured here. Photographs have been attached at the end of the document.

Junction to case thermal resistance, Theta JC ($R_{\theta JC}$), was measured using the cold plate technique with the cold plate temperature used as the "case" temperature.

Theta JC Average °C/watt	Standard Deviation °C/watt	Theta JC Ave + 3 Std. Dev. °C/watt
1.08	0.03	1.2

Junction to board thermal resistance Theta JB ($R_{\theta JB}$) was measured using the cold plate technique. The board temperature was measured with a thermocouple soldered to a center trace on the top surface of the printed circuit board. The measurement was taken using 4 conductor layer printed circuit board.

Theta JB Average °C/watt	Standard Deviation °C/watt	Theta JB Ave + 3 Std. Dev. °C/watt
3.3	0.07	3.5

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Junction to Ambient Thermal Resistance or Theta JA ($R_{\theta JA}$) was measured on a 4 layer 4 x 4.5 inch thermal test board at 3 watts in a horizontal configuration. Do Not Report in the Data Book Without Footnotes indicating that the measurements were taken on test boards with two internal planes. Sample size: 5

Convection	Theta JA Average °C/watt	Standard Deviation °C/watt	Theta JA Ave + 3 Std. Dev. °C/watt
Natural	10.5	0.13	10.9
100 ft/min	8.6	0.14	9.0
200	7.8	0.15	8.2
400	6.9	0.09	7.2
800	5.5	0.1	5.8

The thermal performance of this TBGA package is closely coupled to the printed circuit board's thermal performance. It has been found that this effect can be described by relating the thermal performance to the printed circuit board temperature. The data in the Figure 1 was taken with a heater pad attached to the bottom of the board to simulate the effect of other heat sources on the board. The board temperature is determined using a thermocouple soldered to a trace on the top surface of the board next to the package. The observed junction temperature rise above ambient divided by package power (Theta JA) is plotted as a function of the board temperature rise above ambient divided by the power dissipated in the package.

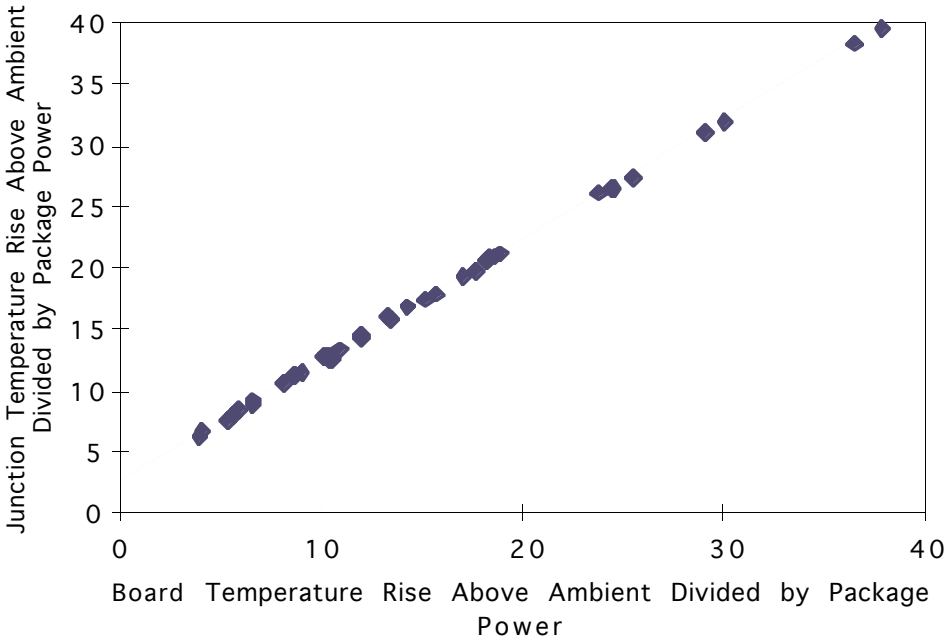

Figure 1. Effect of board temperature on the thermal performance.

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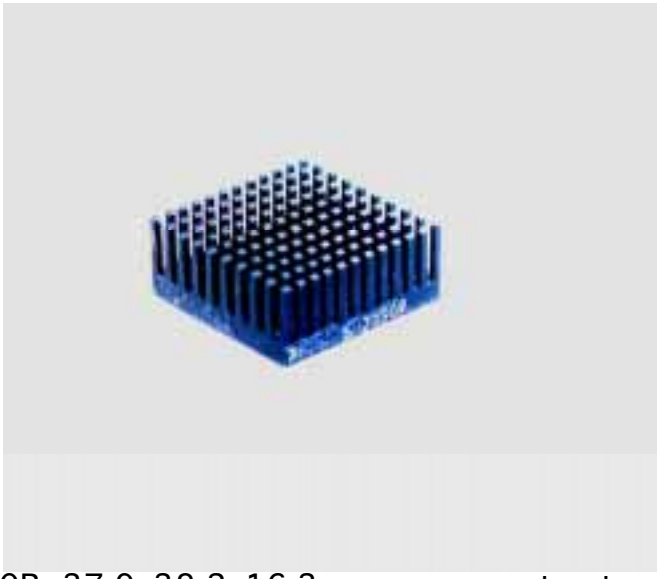
The data shown in Figure 1 was taken at 2 watt dissipation in the TBGA with 8 or 15 watts in the heater and at 3 watts in the package with 4 or 8 watts in the heater. All the data at those power settings in natural convection, 100, 200, 400, or 800 ft/min air flow can be plotted on a single straight line. The least squares fit to the line had an intercept of 2.8 °C/watt.

Heat Sink Photographs

All of the pin fin heat sinks used in this study were fabricated by cross cutting an aluminum extrusion; the heat sinks look similar, but are different sizes. There are many different heat sinks which could be used. These samples happened to be available and represent typical heat sinks which would be used for this package. Heat sink vendors should be contacted for adhesive, pressure sensitive adhesive (tape), or clip recommendations.



Thermalloy 2330B, 37.9x38.2x16.3 mm, cross cut extrusion pin fin

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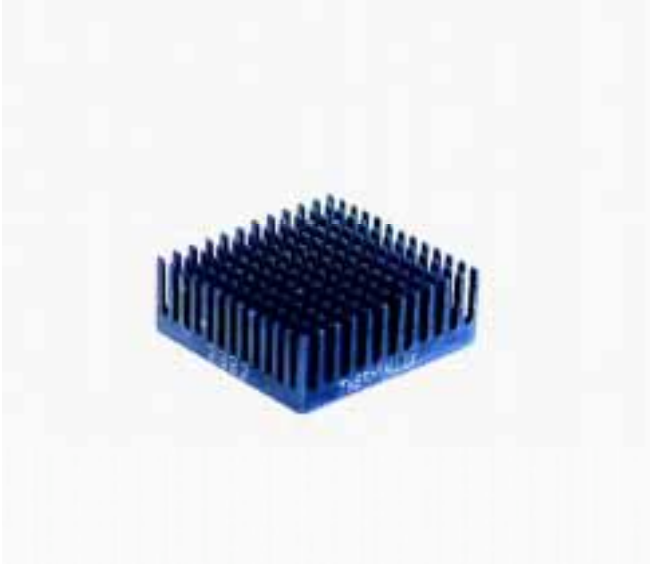
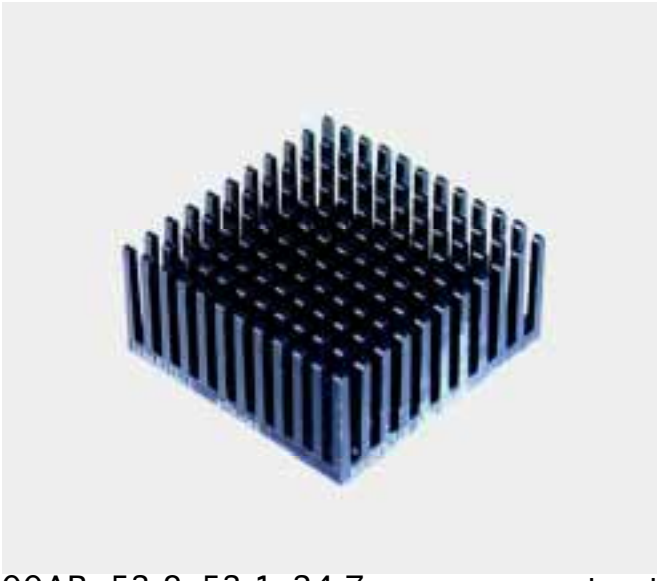


Thermalloy 2332B, 41.3x43.3x16.3 mm, cross cut extrusion pin fin



Wakefield 698100AB, 53.8x53.1x24.7 mm, cross cut extrusion pin fin

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IERC 21426-ICB stamped and formed, base 35x35 mm, overall height 25 mm, overall width 58 mm square. Clip was removed for clarity.

Heat Sink Vendors:

Aavid Engineering, Inc.
One Cool Path
P.O. Box 400
Laconia, NH 03247
(603) 528-3400

Internation Electronics Research Corporation (IERC)
135 W. Magnolia Blvd.
Burbank, CA 91502
(213) 849-2481

Thermalloy Inc.
P.O. Box 810839
Dallas, TX 75381-0839
(972) 243-4321

Wakefield Engineering, Inc.
60 Audubon Road
Wakefield, MA 01880
(617) 245-5900

Chip Coolers Inc
333 Strawberry Field Rd
Warwick, RI 02886
(800) 227-0254

Freescale Semiconductor, Inc.