intel®

82546 EB/GB Gigabit Ethernet Controller Thermal Properties with External Heat Sink

Application Note (AP-458)

Revision History

Date	Revision	Description
Dec 2003	0.5	Initial Releasez

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Contents

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1.0 Introduction

This report presents the thermal measurement results of PBGA 364 in terms of junction-to-ambient thermal resistance (θ_{JA}), junction-to-case thermal resistance (θ_{JC}). The measurement included the component and the HS evaluation.

2.0 Result Summaries

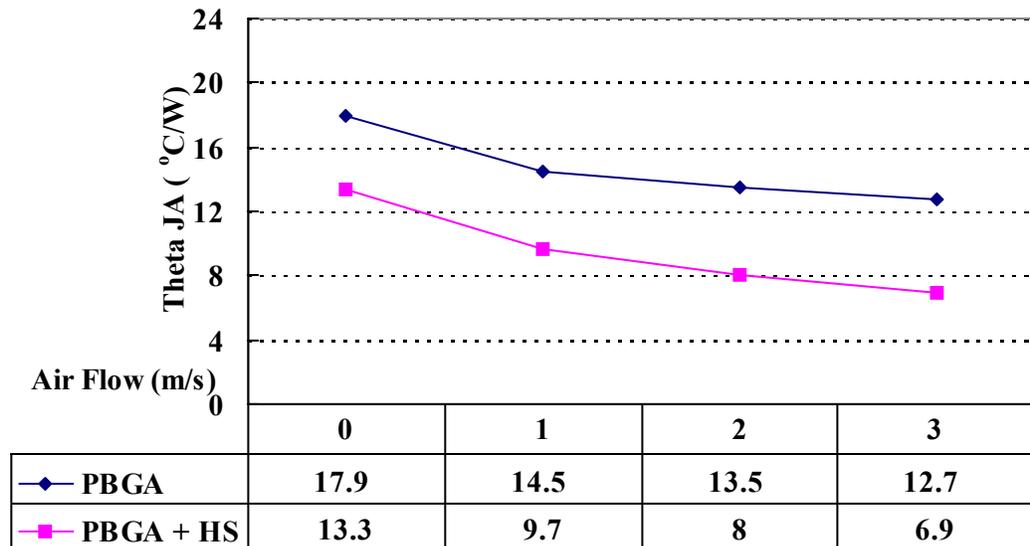| Air Flow (m/s)	0	1	2	3
◆ PBGA	17.9	14.5	13.5	12.7
■ PBGA + HS	13.3	9.7	8	6.9

Figure 1. Thermal Performance of PBGA 364 under Forced Convection
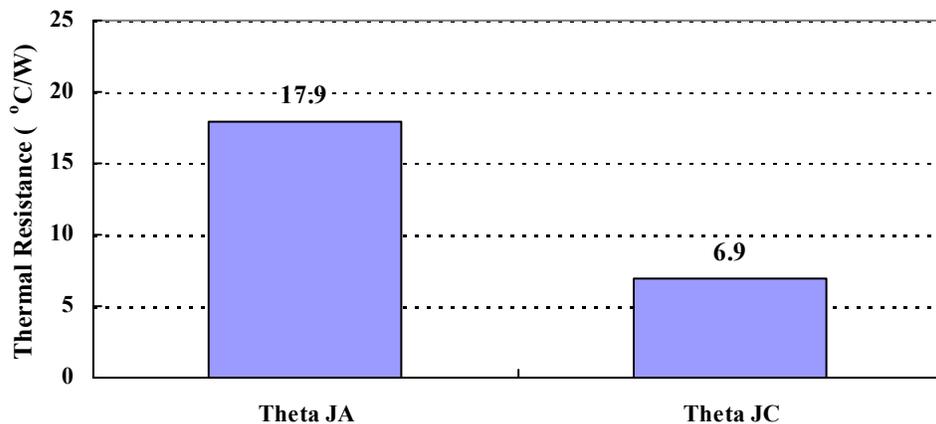

Figure 2. Thermal Resistance of PBGA364 under Natural Convection

3.0   Conclusion

From the measurement results, we can obtain the q_{JA}. Assuming applicable ambient temperature of 65°C and maximum junction temperature of 125°C, we can predict the power dissipation capability of this package as below table.

Air Flow (LFPM)		0	100	200	300
Power Dissipation (watt)	STD	3.35	4.13	4.44	4.72
	with Passive HS	4.51	6.18	7.5	8.69

4.0   Methodology

4.1   Junction Temperature Measurement

In this measurement the packages were built using standard practice with 300 mil thermal die.

4.2   Test Condition

Packages were mounted on 4-layer test boards and are measured for thermal resistance under forced convection. The tests were conducted inside a closed-loop wind tunnel system which controls temperature from 18° C to 65° C and wind speed from less than 0 m/s to 5 m/s. The measured temperature data will be taken by a data acquisition system. In forced convection, airflow is applied from 0 m/s to 3 m/s which the heating power for packages is fixed at 3.5 W and the surrounding temperature is $22 \pm 1°$ C. Samples are measured and the average thermal resistances are calculated. The test conditions summaries are shown below.

Condition	Setting
Heating Power	3.5 watts
Test Board	4-layer
Control Condition	Air Speed = 0, 1, 2, 3 m/s
Ambient Temp.	22±1°C
Test Samples	3 pieces

5.0 Package Information

5.1 Package Description

Type	364-Pin PBGA
Drawing NO	I-1244 (4L)
Dimension (L x W)	21 x 21 mm
Package Thickness	2.23 mm (including solder ball)
Chip Size	7.77 x7.77 mm (300 x 300 mil)
Die Thickness	0.3048 mm
Ball pitch / Ball Diameter	1.0 mm / 0.6 mm
Number of Cu Layer	4-layer (2oz)
Thermal Ball	40
Thermal Via	51

5.2 Passive Heat Sink Description

Type	AAVID 335314
Dimension	

5.3 Test Board Description

Material	FR-4
Dimension (L x W)	4" x 4.5"
Thickness	1.6 mm
Number of Cu Layer	4-layer (2S2P) (Inner layer Cu coverage 40%)
Part Number	BA-20-10-04

5.4 Assembly Material

Component	Material	Thermal Conductivity (w/m-k)
Die	Silicon	147
Substrate	BT	0.2
Silver Paste	8360	2.9
Mold Compound	SMT-B-1	0.71
PCB	FR4	0.2
	Cu	396
Solder Balls	63Sn/37Pb	50
Drop-in H/S	Cu	396

Appendix A Terminology

The major thermal dissipation paths can be illustrated as following

T_J**:** the maximum junction temperature;
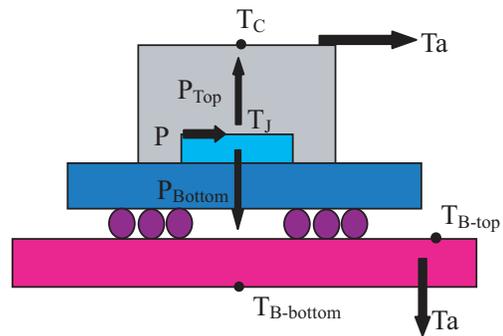
T_A: the ambient or environment temperature;

T_C: the center of top compound surface temperature;

P: total input power

Junction to ambient thermal resistance, θ_{JA}, defined as:

1. Junction to ambient thermal resistance, θ_{JA}, defined as:

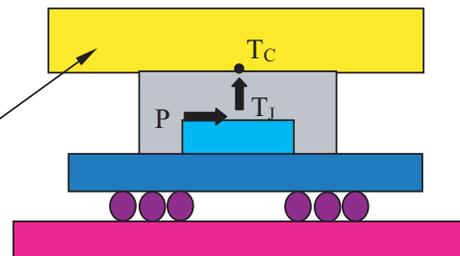$$\theta_{JA} = \frac{T_J - T_A}{P} \; ; \qquad (1)$$

Thermal Dissipation of BGA

2. Junction to case thermal resistance, θ_{JC}, defined as:

$$\theta_{JC} = \frac{T_J - T_C}{P} \; ; \qquad (1)$$

Attach a block with constant
temperature onto package

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