

Thermal Design

Thermal resistance and thermal characterization parameter

Contents

1. Scope	1
2. Normative references	1
3. Terms and definitions.....	1
4. Test method environmental conditions (JESD51-2A)	2
5. Test board	3
6. Thermal measurement procedure	4

1. Scope

The definition and how to use thermal resistance and thermal characterization parameter of packages for ROHM's IC are described in this application note.

2. Normative references

The content of this application note complies with JEDEC standard JESD51.

3. Terms and definitions

3.1 T_A : Ambient temperature

3.2 T_J : Junction temperature

3.3 T_T : Top-center temperature on device package surface

3.4 θ_{JA} : Junction to ambient thermal resistance. Thermal radiation by plural paths.

3.5 Ψ_{JT} : Junction to top-center thermal characterization Parameter. This value varies depending on the heat radiation amount to other than the top center of the outside surface of the component package.

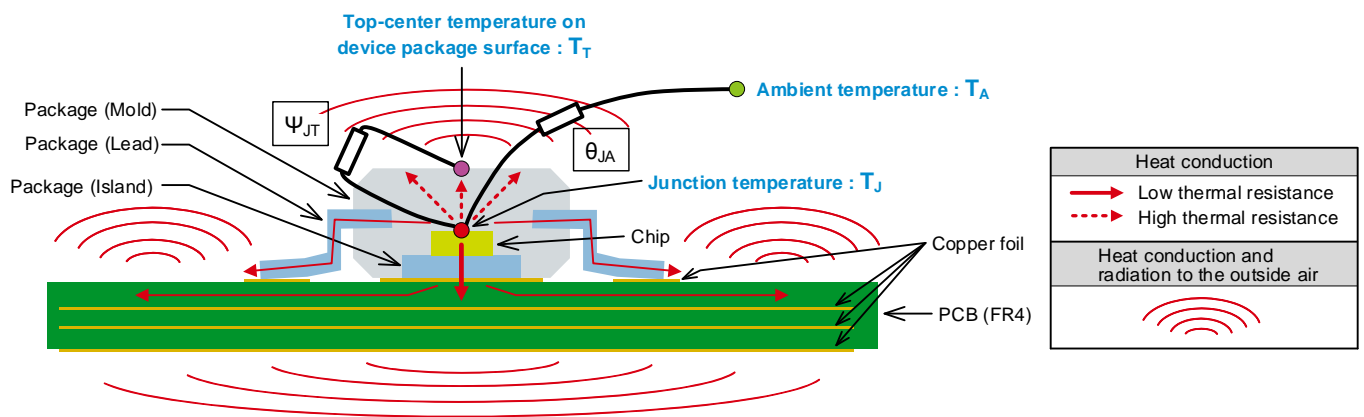


Figure1. The definition of thermal resistance θ_{JA} and thermal characterization parameter Ψ_{JT} (ex: HTSOP-J8)

● Thermal Resistance^(*)

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s ^{(*)3}	2s2p ^{(*)4}	
HTSOP-J8				
Junction to Ambient	θ_{JA}	130	34	°C/W
Junction to Top Characterization Parameter ^{(*)2}	Ψ_{JT}	15	7	°C/W
TO252-3				
Junction to Ambient	θ_{JA}	136	23	°C/W
Junction to Top Characterization Parameter ^{(*)2}	Ψ_{JT}	17	3	°C/W
SOT223-4(F)				
Junction to Ambient	θ_{JA}	164	71	°C/W
Junction to Top Characterization Parameter ^{(*)2}	Ψ_{JT}	20	14	°C/W

(*)1Based on JESD51-2A(Still-Air).

(*)2The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.

(*)3Using a PCB board based on JESD51-3.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3mm x 76.2mm x 1.57mm

Top	
Copper Pattern	Thickness
Footprints and Traces	70 μ m

(*)4Using a PCB board based on JESD51-5, 7.

Layer Number of Measurement Board	Material	Board Size	Thermal Via ^{(*)5}	
			Pitch	Diameter
4 Layers	FR-4	114.3mm x 76.2mm x 1.6mm	1.20mm	Φ 0.30mm

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70 μ m	74.2mm x 74.2mm	35 μ m	74.2mm x 74.2mm	70 μ m

Figure2. Data sheet description example

4. Test method environmental conditions (JESD51-2A)

Thermal test method environmental conditions comply with JESD51-2A (Still-Air) as below.

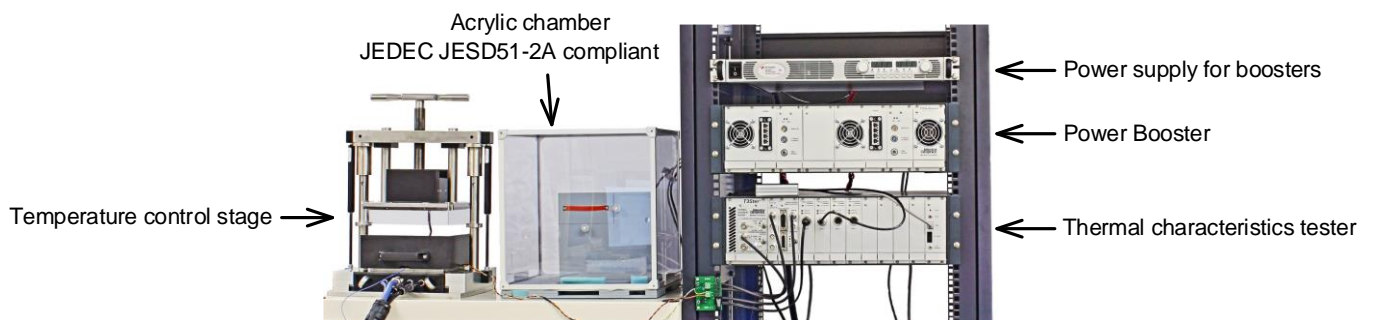


Figure3. Thermal test method environmental conditions

Table1. Measurement equipment for thermal resistance

Measurement equipment	Supplier	Type	Note
Thermal characteristics tester	Mentor Graphics	T3Ster	-
Temperature control stage	Keenus Design	PELNUS	-
Thermocouple (NOTE1)	Ninomiya Electric Wire	0.1x1P K-1-G-J1	Class 1 / Φ 0.1 mm

(NOTE1) By fixing the thermocouple to the top center of the outside surface of the component package, the temperature at the top center of the outside surface of the component package is measured.

5. Test board

Thermal test board complies with JESD51-3,5,7,9,10 as below.

Table2. Specified parameters and values used for PCB design. (Package size is specified by a maximum body length.)

Package type	PCB	Material	Board Size	Thermal via ^(NOTE1)		Through-hole via ^(NOTE2)
				Pitch	Diameter	Diameter
SMD (Package size < 27mm)	1s	FR-4	114.3mm x 76.2mm x 1.57mm	-	-	-
	2s2p		114.3mm x 76.2mm x 1.6mm	1.20mm	Φ 0.30mm	-
BGA, THD (Package size ≤ 40mm)	1s	FR-4	114.5mm x 101.5mm x 1.6mm	-	-	Φ 0.85mm
	2s2p			1.20mm	Φ 0.30mm	Φ 0.85mm

Package type	PCB	Component trace		Plane		Backside trace	
		Copper pattern	Thickness	Copper pattern	Thickness	Copper pattern	Thickness
SMD (Package size < 27mm)	1s	Component mounting and trace fan-out region	70μm	-	-	-	-
	2s2p			74.2x74.2mm	35μm	74.2x74.2mm	70μm
BGA, THD (Package size ≤ 40mm)	1s	Component mounting and trace fan-out region	70μm	-	-	-	-
	2s2p			99.5x99.5mm	35μm	99.5x99.5mm	70μm

(NOTE1) Thermal via: This is a penetrating via, connected to 1, 2 and 4 layers of copper foil. Placement conforms to the land pattern.

(NOTE2) Through-hole via: Through-hole vias for THD mounting, connected to the first layer of copper foil. Arrangement and dimensions conform to the land pattern.

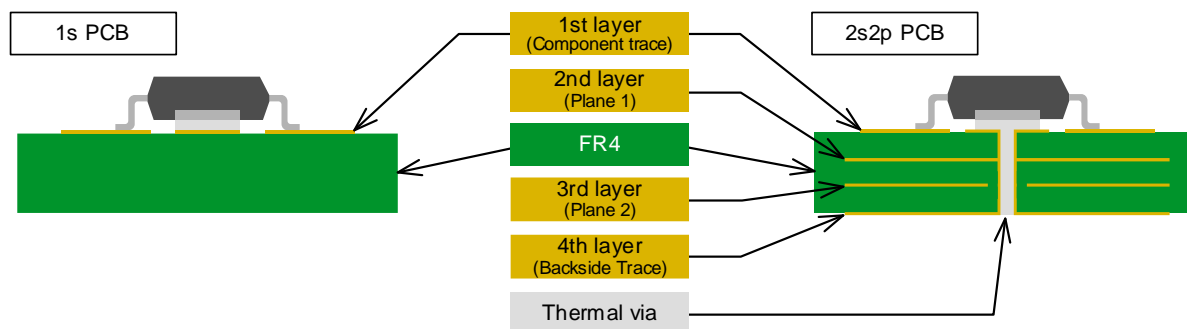


Figure4. Sectional view of the thermal test board (SMD with heat sink)

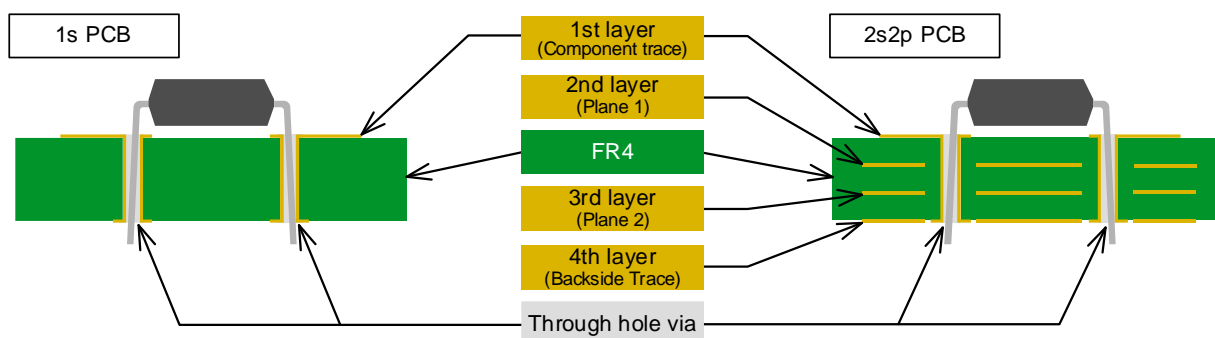


Figure5. Sectional view of the thermal test board (THD: DIP type)

6. Thermal measurement procedure

Below are two methods of thermal measurement for semiconductor.

- Thermal measurement at the surface of the package (connected measurement / unconnected measurement)
- Thermal measurement at the PN junction of the chip

The advantages and disadvantages of each method are written in the table below.

Table3. The advantages and disadvantages due to differences in measurement method

Measurement method	Advantages	Disadvantage
Thermal measurement at the surface of the package	Measurement is easy.	It is likely to contain some errors due to environment because it is not directly monitored.
Thermal measurement at the PN junction of the chip	Junction temperature is directly measured, resulting in a good accuracy.	The terminal for thermal measurement is needed for semiconductor.

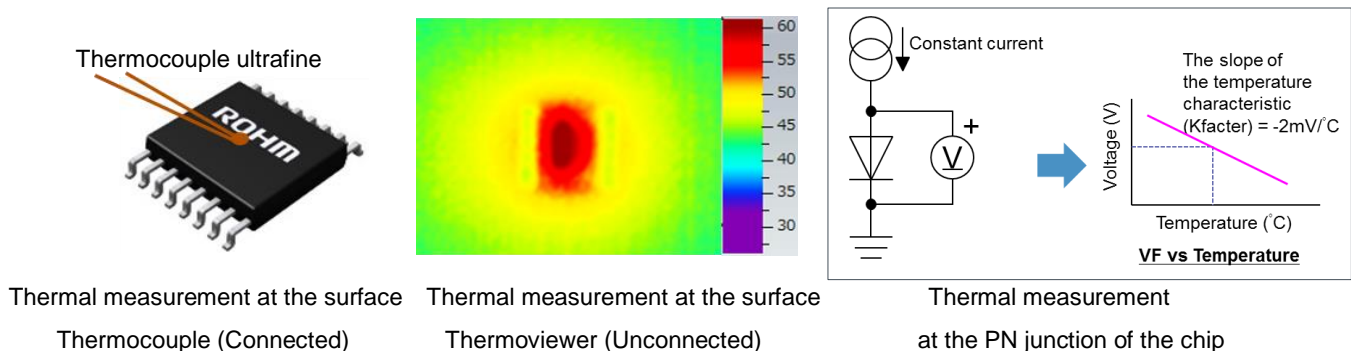


Figure6. Images of each measurement

If surface temperature measurement is used in performing the semiconductor temperature measurement, thermal characterization parameter Ψ_{JT} will be used for the calculation.

Ψ_{JT} is a parameter which defines the temperature difference between junction temperature T_J and the temperature at the top center of the outside surface of the component package T_T , and it is same as ROHM previously used notation θ_{JC} .

An accurate junction temperature can be calculated by using thermal characterization parameter if temperature T_T is measured while the thermocouple is firmly contacted with the top center of the package. However, it must be considered that thermal characterization parameter changes depending on heat dissipation performance of the board.

$$T_J = T_T + \Psi_{JT} \times P \quad (T_J: \text{Junction temperature}, T_T: \text{the temperature at the top center of the outside surface of the component package}, P: \text{Power consumption})$$

In addition, junction temperature can be easily calculated by using thermal resistance θ_{JA} . However, it is likely to be influenced by the difference with JEDEC environment rather than thermal characterization parameter

$$T_J = T_A + \theta_{JA} \times P \quad (T_J: \text{Junction temperature}, T_A: \text{Ambient temperature}, P: \text{Power consumption})$$

In case of checking the margin to the temperature limit from the package surface temperature, by assuming that $T_C \approx T_T$, maximum temperature $T_{C_{MAX}}$ at the top surface of the component package can be calculated as below.

$$T_{C_{MAX}} = T_{J_{MAX}} - \Psi_{JT} \times P \quad (T_{C_{MAX}}: \text{Maximum temperature at the top surface of the component package}, T_{J_{MAX}}: \text{Maximum junction temperature}, P: \text{Power consumption})$$

Notes

- 1) The information contained herein is subject to change without notice.
- 2) Before you use our Products, please contact our sales representative and verify the latest specifications :
- 3) Although ROHM is continuously working to improve product reliability and quality, semiconductors can break down and malfunction due to various factors.
Therefore, in order to prevent personal injury or fire arising from failure, please take safety measures such as complying with the derating characteristics, implementing redundant and fire prevention designs, and utilizing backups and fail-safe procedures. ROHM shall have no responsibility for any damages arising out of the use of our Products beyond the rating specified by ROHM.
- 4) Examples of application circuits, circuit constants and any other information contained herein are provided only to illustrate the standard usage and operations of the Products. The peripheral conditions must be taken into account when designing circuits for mass production.
- 5) The technical information specified herein is intended only to show the typical functions of and examples of application circuits for the Products. ROHM does not grant you, explicitly or implicitly, any license to use or exercise intellectual property or other rights held by ROHM or any other parties. ROHM shall have no responsibility whatsoever for any dispute arising out of the use of such technical information.
- 6) The Products specified in this document are not designed to be radiation tolerant.
- 7) For use of our Products in applications requiring a high degree of reliability (as exemplified below), please contact and consult with a ROHM representative : transportation equipment (i.e. cars, ships, trains), primary communication equipment, traffic lights, fire/crime prevention, safety equipment, medical systems, servers, solar cells, and power transmission systems.
- 8) Do not use our Products in applications requiring extremely high reliability, such as aerospace equipment, nuclear power control systems, and submarine repeaters.
- 9) ROHM shall have no responsibility for any damages or injury arising from non-compliance with the recommended usage conditions and specifications contained herein.
- 10) ROHM has used reasonable care to ensure the accuracy of the information contained in this document. However, ROHM does not warrants that such information is error-free, and ROHM shall have no responsibility for any damages arising from any inaccuracy or misprint of such information.
- 11) Please use the Products in accordance with any applicable environmental laws and regulations, such as the RoHS Directive. For more details, including RoHS compatibility, please contact a ROHM sales office. ROHM shall have no responsibility for any damages or losses resulting non-compliance with any applicable laws or regulations.
- 12) When providing our Products and technologies contained in this document to other countries, you must abide by the procedures and provisions stipulated in all applicable export laws and regulations, including without limitation the US Export Administration Regulations and the Foreign Exchange and Foreign Trade Act.
- 13) This document, in part or in whole, may not be reprinted or reproduced without prior consent of ROHM.



Thank you for your accessing to ROHM product informations.
More detail product informations and catalogs are available, please contact us.

ROHM Customer Support System

<http://www.rohm.com/contact/>