

# ***Thermal Measurement Services***

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***TEA***

# Topics

- Introduction
- Thermal Measurement Standards
- Thermal Measurement Procedure
- Customer Supplied Input
- Thermal Measurement Cost Info
- Thermal Measurement Schedule
- About TEA
- Customer List
- Reference Information
- Summary

# Introduction

As the importance of understanding of semiconductor thermal properties has grown, the need for making proper thermal measurements following a standardized approach has become paramount.

There are two approaches to thermal measurements –standards-oriented or applications-oriented. Both of approaches make use of a temperature sensitive parameter of the Device-Under-Test (DUT) to measure junction temperature (TJ) but differ primarily in the thermal environment surrounding the DUT and the measurement electrical conditions.

The standards-oriented approach primarily focuses on the JEDEC JESD51 group of standards for the measurement of semiconductor devices – currently limited to integrated circuits – and the US Military Standards under Mil-Spec 750 and 833. The latter lists a number of test methods for many discrete (i.e., BJT, MOSFET, IGBT, JFET, Diode, Zener, SCR, TRIAC, etc.) semiconductor devices.

The applications-oriented approach generally follows the same electrical measurement approach with slight modification to tailor the measurement to the application requirements. However, the thermal environment surrounding the DUT may be distinctly different. An example of environmental difference is making a thermal measurement when DUT is mounted in an application environment (i.e., mounted in a socket on a printed circuit assembly with a specific heat sink attached using a specified thermal interface material).

# Thermal Measurement Standards

## JEDEC

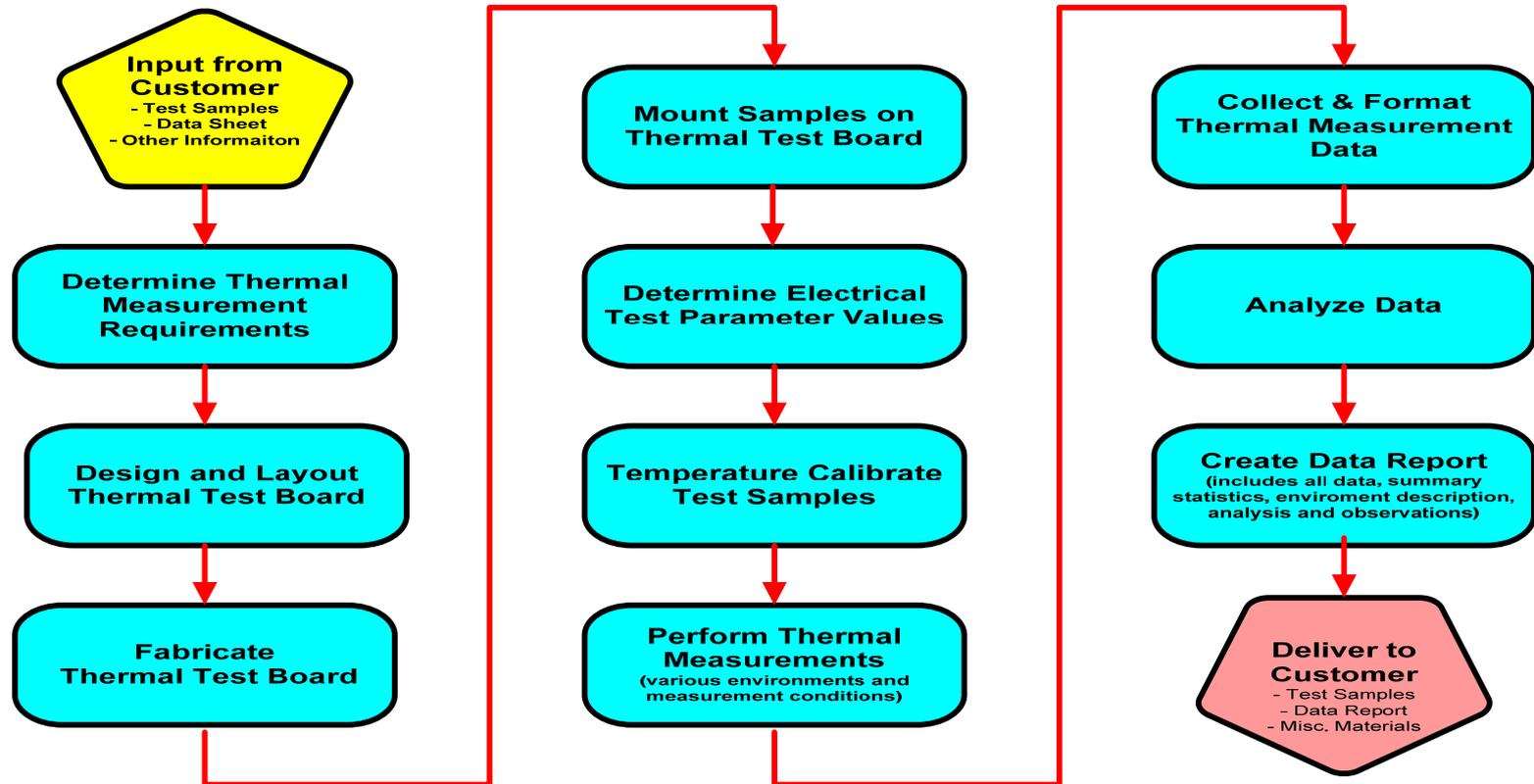
<a href="#"><u>JESD51</u></a>	Methodology for the Thermal Measurement of Component Packages (Single Semiconductor Device)
<a href="#"><u>JESD51-1</u></a>	Integrated Circuit Thermal Measurement Method - Electrical Test Method (Single Semiconductor Device)
<a href="#"><u>JESD51-2</u></a>	Integrated Circuits Thermal Test Method Environmental Conditions - Natural Convection (Still Air)
<a href="#"><u>JESD51-3</u></a>	Low Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages
<a href="#"><u>JESD51-4</u></a>	Thermal Test Chip Guidelines (Wire Bond-type Chip)
<a href="#"><u>JESD51-5</u></a>	Extension of Thermal Test Board Standards for Packages with Direct Thermal Attachment Mechanisms
<a href="#"><u>JESD51-6</u></a>	Integrated Circuit Thermal Test Method Environmental Conditions - Forced Convection (Moving Air)
<a href="#"><u>JESD51-7</u></a>	High Effective Thermal Conductivity Test Board for Leaded Surface Mount Packages
<a href="#"><u>JESD51-8</u></a>	Integrated Circuit Thermal Test Method Environmental Conditions - Junction-to-Board
<a href="#"><u>JESD51-9</u></a>	Test Boards for Area Array Surface Mount Package Thermal Measurements
<a href="#"><u>JESD51-10</u></a>	Test Boards for Through-Hole Perimeter Leaded Package Thermal Measurements
<a href="#"><u>JESD51-11</u></a>	Test Boards for Through-Hole Area Array Leaded Package Thermal Measurements
<a href="#"><u>JESD51-12</u></a>	Guidelines for Reporting and Using Electronic Package Thermal Information
<a href="#"><u>JESD51-13</u></a>	Glossary of Thermal Measurement Terms and Definitions
<a href="#"><u>JESD51-14</u></a>	Transient Dual Interface Test Method for the Measurement of the Thermal Resistance Junction to Case of Semiconductor Devices with Heat Flow Through a Single Path
<a href="#"><u>JESD15</u></a>	THERMAL MODELING OVERVIEW
<a href="#"><u>JESD15-1</u></a>	COMPACT THERMAL MODEL OVERVIEW
<a href="#"><u>JESD15-3</u></a>	TWO-RESISTOR COMPACT THERMAL MODEL GUIDELINE
<a href="#"><u>JESD15-4</u></a>	DELPHI COMPACT THERMAL MODEL GUIDELINE

# Thermal Measurement Standards

## US Military Standards

<b>Mil Std 750</b> <a href="#">Method 3101</a>	<b>Thermal Impedance (Response) Testing of Diodes</b>
<b>Mil Std 750</b> <a href="#">Method 3103</a>	<b>Thermal impedance measurements of Insulated Gate Bipolar Transistors</b>
<b>Mil Std 750</b> <a href="#">Method 3104</a>	<b>Thermal impedance measurements of GaAs MESFETs</b>
<b>Mil Std 750</b> <a href="#">Method 3131</a>	<b>Thermal resistance measurements of Bipolar Junction Transistors (emitter to base forward voltage, emitter-only switching method)</b>
<b>Mil Std 750</b> <a href="#">Method 3161</a>	<b>Thermal impedance measurements for vertical power MOSFETs (delta source-drain voltage method)</b>
<b>Mil Std 883</b> <a href="#">Method 1012</a>	<b>Thermal characteristics of Integrated Circuits (See JEDEC JESD51 for more up to date standard)</b>

# Thermal Measurement Procedure



# Customer-supplied Input

*The first two items below are required in order to initiate a formal quotation for thermal measurement services. The third item is required if TEA is selected to provide the thermal measurements.*

- Complete the **COMPONENT THERMAL TESTING QUESTIONNAIRE** available at the TEA website or by clicking on the link above.
- DUT datasheet or development specifications, including pinout and package mechanical information
- A minimum of 6 test samples; all will be mounted on Thermal Test boards but only 5 will be used in the thermal measurements

# Thermal Measurement Cost Info

*The information presented below is for budgetary purposes only. A formal quotation will be submitted in response to a request accompanied with specific measurement requirements including appropriate device datasheets and package mechanical drawings.*

- **Thermal Test Board Design, Layout and Fabrication**
  - Price range is \$375 to \$550, depending on package attributes such as lead/ball/pad size and pitch, escapement routing,
  - TTB cost is dependent on the type:
    - JEDEC 2s (copper both sides): \$1,500 min lot, 10 pcs
    - JEDEC 2s2 (copper both sides, two internal planes): \$2,500 min lot, 10 pcs
- **Test Sample mounting on TTB**
  - Price range is \$150 to \$1,000 per lot, depending on package type, mounting material, and whether a solder paste stencil is required
- **Thermal Measurements**
  - Price range is \$1,975 to \$3,500, depending on thermal parameters required, number of different power levels, and the number of air velocities required
  - Includes Data Report in electronic form

# Thermal Measurement Schedule

*The schedule information provided below is based on typical times for standards-oriented measurements. Times for application-oriented testing dependent on required environmental conditions and test matrix; this is quoted on an individual basis.*

- Thermal Test Board design and layout takes 5 to 7 work days
- The customer is then asked to review and approve the layout; assumption is a 2-day review cycle.
- Thermal Test Board fabrication usually takes 7 to 10 work days
- Test sample mounting on the TTB takes 2 to 5 days, depending on whether a solder paste stencil is required.
- Thermal measurements takes 10 to 20 days, depending on the test matrix required and the environmental conditions.

**Total elapsed time is roughly 5 to 9 weeks from receipt of order, electrical and mechanical information, and test samples. Shorter time is possible for additional cost.**

# About TEA

- TEA provides a broad range of products and services for the thermal design and measurement requirements of the electronics industry.
- Founded in 1999 by Bernie Siegal, a world recognized leader in the field of semiconductor thermal measurements
- Mr. Siegal was a key participant, including principal author, in the development of many of the thermal measurement standards that currently are in wide use within the electronics industry
- TEA has served over 100 customers located throughout the world with products and services.

# Customer List

A partial list of thermal measurement customers includes:

- National Semi
- Toshiba Electronics
- Analog Devices
- UTAC
- AMD
- iWatt
- Philips Semi
- Lumileds
- Emcore
- Skyline
- Teradyne
- Vishay
- Agilent
- AMCC
- Apple
- US Navy
- ATI/AMD
- Bridgelux
- Dallas Semi
- Hi/fn

# Reference Information

The TEA website ([www.thermengr.com](http://www.thermengr.com)) has a comprehensive collection of technical information for site visitors wanting to learn the details of semiconductor measurements.

- [www.thermengr.net/html/tech\\_briefs.html](http://www.thermengr.net/html/tech_briefs.html) contains short technical briefs on specific measurement and device subjects.
- [www.thermengr.net/html/standards\\_status.html](http://www.thermengr.net/html/standards_status.html) provides a listing of, and access to, thermal measurement standards from JEDEC, US Military, and SEMI
- [www.thermengr.net/html/hot\\_links.html](http://www.thermengr.net/html/hot_links.html) lists technical papers, handbooks, and material data files related to semiconductor thermal measurements

# Summary

- **TEA is uniquely qualified to provide thermal measurements on a wide variety of semiconductor devices and packages.**
- **TEA has one of the best equipped thermal measurements laboratories in the world**
- **Under Bernie Siegal's supervision, the company has a well established track record for providing accurate and completed thermal measurement results in a timely fashion**
- **All thermal testing services are offered on a quotation basis after receipt and review of test sample datasheet, package information, and completed test services questionnaire.**
- **The company's collection of associates can address applications-oriented thermal measurements in a complete and timely manner.**