# JEDEC STANDARD

## Overview of Methodologies for the Thermal Measurement of Single- and Multi-Chip, Single- and Multi-PN-Junction Light-Emitting Diodes (LEDs)

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# OVERVIEW OF METHODOLOGIES FOR THE THERMAL MEASUREMENT OF SINGLE- AND MULTI-CHIP, SINGLE- AND MULTI-PN-JUNCTION LIGHT-EMITTING DIODES (LEDS)

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## Foreword

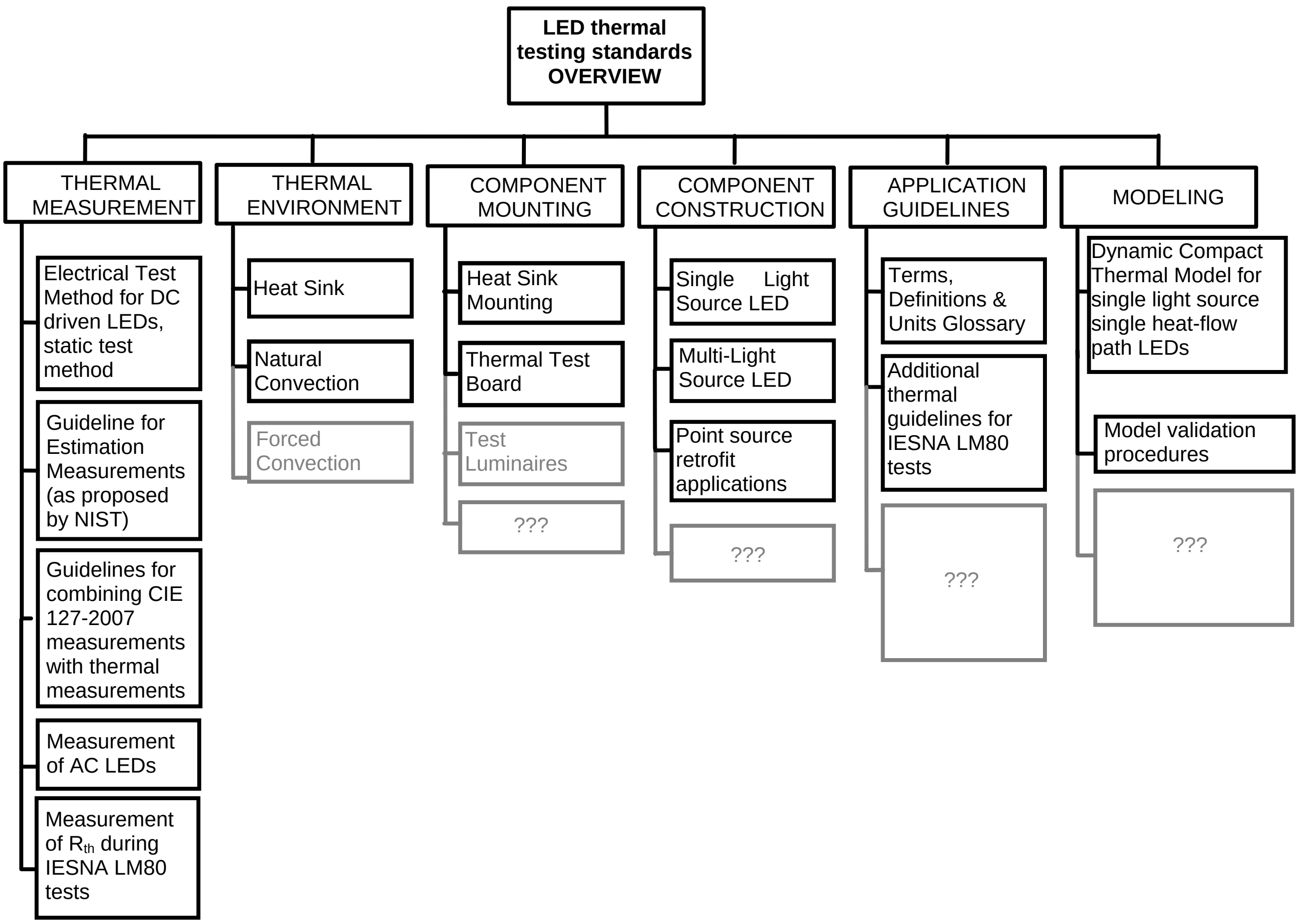
This document provides an overview of the methodology necessary for making meaningful thermal measurements on high-power light-emitting diodes (LEDs) built on single or multiple chips with one or more pn-junctions per chip. The actual methodology components are contained in separate detailed documents.

# OVERVIEW OF METHODOLOGIES FOR THE THERMAL MEASUREMENT OF SINGLE- AND MULTI-CHIP, SINGLE- AND MULTI-PN-JUNCTION LIGHT-EMITTING DIODES (LEDS)

(From JEDEC Board Ballot JCB-12-07, formulated under the cognizance of the JC-15 Committee on Thermal Characterization.)

## 1 Scope

The measurement methodology described herein is distributed among several documents so that the appropriate combination of documents can be selected to meet specific thermal measurement requirements. This document provides the OVERVIEW; the rest of the documents are grouped as shown below:




Each group will have one or more applicable documents to reflect different thermal measurement requirements. Because environmental conditions, component mounting approaches and device construction techniques and processes will change as technology changes, additional documents will be added to these groups as the needs arise and standards established. As appropriate, each of these documents will contain terminology and symbolic definitions that are specific to the material covered by the individual document; this information will also be included in a single document to make for easy access.

## 2 Rationale

The junction temperature of a semiconductor device greatly influences the performance, reliability, quality, and cost of the device. This document and the subsequent documents that it calls on, provide a standard for thermal measurements that, if followed fully, will provide correct and meaningful data that will allow for determination of junction temperature for specific conditions, e.g., device environment, mounting and construction. The data can be used for package design evaluation, device (i.e., chip/package combination) characterization, reliability predictions, etc.

## 3 Purpose

Two key standard thermal parameters for any semiconductor device are junction temperature ($T_J$) and thermal resistance ($R_{\theta JX}$, $R_{thJX}$ or $\Theta_{JX}$). The former is the prime parameter while the latter is a vehicle for determining the former. Since $T_J$ usually can not be measured directly, the following approach is used:

$$T_J = T_{J0} + \Delta T_J \tag{1}$$

where

$T_{J0}$ is the junction temperature before application of dissipation (heating power), also known as the adiabatic temperature (measured in [$^{o}$C]);
$\Delta T_J$ is the change of junction temperature as a response to the change in the dissipated power [$^{o}$C].

Under carefully defined conditions for a specific environment, the change in junction temperature can be determined as follows:

$$T_J = P_H \cdot R_{\theta JX} + T_X \tag{2}$$

resulting in

$$[\Delta T_J]_X = T_J - T_X = P_H \cdot R_{\theta JX} = P_H \cdot \Theta_{JX} \tag{3}$$

where

$P_H$ is the dissipated power in the device (measured in [W]);
$R_{\theta JX}$ is the thermal resistance from the device junction to the specific environment $X$ (measured in [K/W]).

In the case of LEDs in which a significant portion of the applied electrical power is converted to optical power output, the power dissipation is defined as

$$P_H = P_{el} - P_{opt} = I_F \cdot V_F - P_{opt} \tag{4}$$

where

$P_{el}$ is the applied electrical power to the device [W] (calculated as the product of the forward current and the forward voltage);
$P_{opt}$ is the device's emitted optical power [W] (also known as $\Phi_e$, the total radiant flux) when $I_F$, forward current, is applied when the device is in an environment at a reference temperature of $T_X$.

## 3 Purpose (cont'd)

The thermal resistance term ($R_{\theta JX}$) is highly dependent on the environment surrounding the device. The two most common environments, infinite heat sink and natural convection, usually define the practical limits of thermal resistance, but may not represent typical component environments. The Environmental and Component Mounting documents that accompany this document provide alternatives that approach to those found in actual semiconductor applications.

The thermal resistance symbol (either $R_{\theta JX}$, $R_{thJX}$ or $\Theta_{JX}$) is only applicable when the thermal measurements are performed in a manner that strictly conforms to the standards that define and control the heat flow from the junction to the thermal test environment. For those situations that have non-standard heat flow environments in which there is only a partial heat flow towards environment $X$, a thermal characterization parameter ($\Psi_{JX}$) is the appropriate choice for specifying thermal performance.

## 4 Data presentation

Thermal data are not meaningful unless all the pertinent test condition information is provided with the actual thermal data. Because the test conditions and data will vary with the type of thermal test being performed, the documents for each of the measurement areas listed below in Table 1 state the thermal information necessary for a complete description of the data.

**Table 1 — Thermal measurement test condition and data parameter summary**

| Measurement Area | Condition Parameter(s) | Data Parameter(s) |
|---|---|---|
| Thermal Measurement | Refer to appropriate document | Refer to appropriate document |
| Environmental | Refer to appropriate document | Refer to appropriate document |
| Component Mounting | Refer to appropriate document | Refer to appropriate document |
| Device Construction | Refer to appropriate document | Refer to appropriate document |

Environmental conditions, component mounting approaches and device construction techniques and processes will change as technology and applications change, thus necessitating continual additions to each of the measurement area groups listed in Table 1.

## Standard Improvement Form

**JEDEC JESD51-50**

The purpose of this form is to provide the Technical Committees of JEDEC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to JEDEC. All comments will be collected and dispersed to the appropriate committee(s).

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1. I recommend changes to the following:
   - [ ] Requirement, clause number __________
   - [ ] Test method number __________ Clause number __________

   The referenced clause number has proven to be:
   - [ ] Unclear [ ] Too Rigid [ ] In Error
   - [ ] Other __________

2. Recommendations for correction:

3. Other suggestions for document improvement:

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