

# Heat Dissipation Design

**CITILED**<sup>®</sup>  
The Light Engine

**CLL801 Series**



Heat dissipation design is a precondition in order to maximize the performance of the LED. In this document, the data that is deemed necessary in the detailed heat dissipation structure of the products and the heat dissipation design of the lighting apparatus is provided as a reference for the appropriate thermal design.

## CONTENTS

|   |     |
|---|-----|
| 1. Introduction                             | P.2 |
| 2. Package structure and thermal resistance | P.2 |
| 3. Thermal design outside the package       | P.3 |

**CITIZEN ELECTRONICS CO., LTD.**

1-23-1, Kamikurechi, Fujiyoshida-shi, Yamanashi, 403-0001, Japan Tel. +81-555-23-4121 <http://ce.citizen.co.jp>  
Copyright © 2010 CITIZEN ELECTRONICS CO., LTD. All Rights reserved.

Ref.CE-P2178 10/12



# Heat dissipation structure that can conduct heat radiated from LEDs efficiently

## 1. Introduction

### Significance of the heat dissipation structure

The light-emitting diode of an LED package radiates light and heat according to the input power. However, the surface area of an LED package is quite small, and the package itself is expected to release little heat into the atmosphere. An external radiator such as a heat sink is thus required. The heat dissipation structure up to the connection portion of the external radiator uses mainly heat conduction. Regarding LED packages, to control the junction temperature of the light-emitting diode  $T_j$  is important. The  $T_j$  must be kept from exceeding the absolute maximum rating in the specifications under any conditions. As direct measurement of the junction temperature of a light-emitting diode inside a package is difficult, the temperature of a particular part on

the external package ( the soldering temperature )  $T_s$  [°C] is normally measured.  $T_j$  [°C] is calculated using the thermal resistance between the junction and the case  $R_{j-s}$  [°C/W], and the emitted heat amount that is nearly equal to the input power  $P_d$  [W]. The heat generated at the light-emitting diode can be conducted to the external radiator efficiently because the package structure for the CLL801 series minimizes the thermal resistance  $R_{j-s}$ . This document describes the detailed heat dissipation structure of the CLL801 series and provides data necessary for thermal design of the lighting apparatus to maximize LED performance.

## 2. Package structure and thermal resistance

### Understanding the junction temperature

The cross-sectional structure example, where the package of the CLL801 series is connected to an external laminated circuit board, is shown in Figure-1 ( a ). The package has a laminated structure with a light-emitting diode mounted on a substrate, which has conductive copper foil patterns and through-holes.

A distinctive point is to be able to conduct the heat generated at the light-emitting diode via through-holes to the outside of the package efficiently.

The electrode section of the package outer shell is connected via solder to the electrode on the external circuit board that doubles as the heat sink for conductive connection. As described above, the heat generated in the junction section of the light-emitting diode is transferred using heat conduction mainly to the electrode on the external circuit board, which doubles as the heat sink, through the light-emitting diode to adhesive for die-mounting to through-holes to the

electrode of the outer shell to solder. The thermal resistance between the junction section of the light-emitting diode and the electrode side of the outer shell is  $R_{j-s}$  and the specific thermal resistance value of the package.

Therefore, the following formula is used:

$$T_j = R_{j-s} \cdot P_d + T_s$$

In addition, the thermal resistance of the solder outside the package is  $R_s$  [°C/W], the thermal resistance of the electrodes with the heat sink function is  $R_e$  [°C/W], and the ambient temperature is  $T_a$  [°C].

Figure-2 ( b ) indicates the equivalent thermal resistance along the cross-sectional diagram in Figure-2 ( a ). As indicated, the thermal resistances  $R_{j-s}$ ,  $R_s$ , and  $R_e$  are connected in series between the junction temperature  $T_j$  and the ambient temperature  $T_a$ . The thermal resistances outside the package  $R_s$  and  $R_e$  can be integrated into the thermal resistance  $R_{s-a}$  at this point. Thus, the following formula is also used:

$$T_j = ( R_{j-s} + R_{s-a} ) \cdot P_d + T_a$$

Figure-2 ( a ) Thermal Resistance Connection

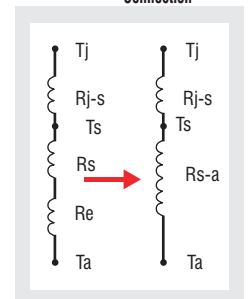
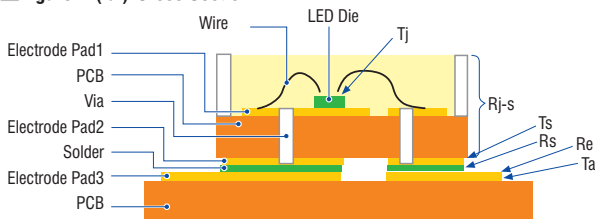


Figure-1 ( a ) Cross Section





# Considering the design outside the package based on ambient temperature and driving parameters.

## 3. Thermal design on the outside of the package

### Point of the external heat dissipation mechanism

The thermal resistance outside the package  $R_{s-a}$  [ $^{\circ}\text{C}/\text{W}$ ], which is the combination of the thermal resistance of the solder  $R_s$  [ $^{\circ}\text{C}/\text{W}$ ] and the thermal resistance of the electrodes with the heat sink function  $R_e$  [ $^{\circ}\text{C}/\text{W}$ ], is limited by the input power  $P_d$  [ $\text{W}$ ], the ambient temperature  $T_a$  [ $^{\circ}\text{C}$ ], and the thermal resistance of the package  $R_{j-s}$  [ $^{\circ}\text{C}/\text{W}$ ], i.e.,

$$T_j = (R_{j-s} + R_{s-a}) \cdot P_d + T_a \rightarrow R_{s-a} = (T_j - T_a) / P_d - R_{j-s}$$

$T_j$  function converted from the above formula is

$$R_{s-a} = -T_a / P_d + T_j / P_d - R_{j-s}$$

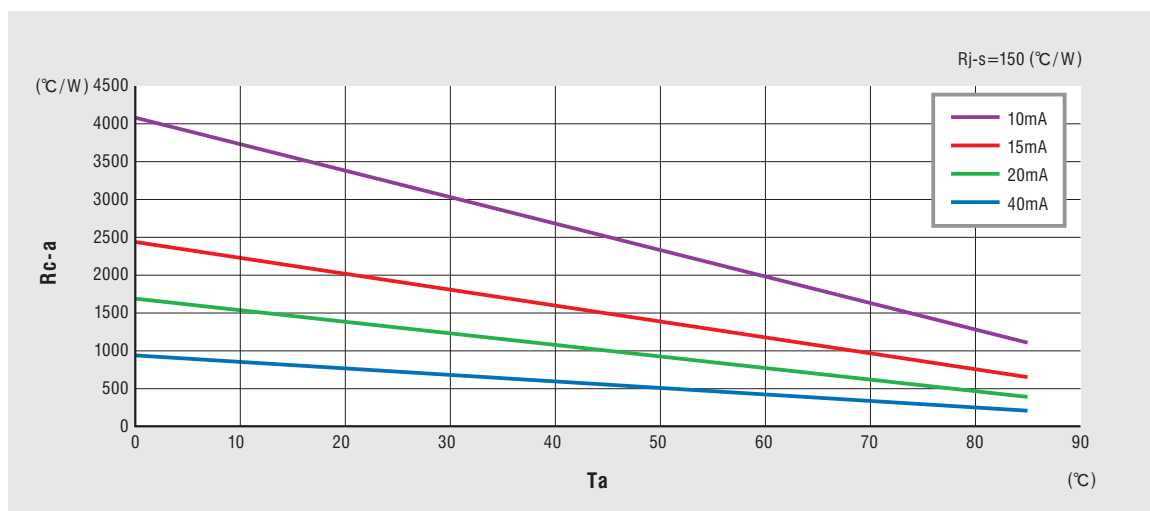
and it is a straight line with the slope of  $-1 / P_d$  and the intercept of  $T_j / P_d - R_{j-s}$ .

Figure-2 is the chart showing the relationship between the ambient temperature  $T_a$  and the thermal resistance

outside the package  $R_{s-a}$  indicated by driving current, where  $T_j$  is assumed to be  $120^{\circ}\text{C}$  - the absolute maximum rating value in the specifications for the CLL801 package.

The higher the ambient temperature  $T_a$  and the larger the driving current, the smaller the allowable thermal resistance outside the package  $R_{s-a} = R_s + R_e$ . In brief, the external heat dissipation mechanism with smaller thermal resistance ( this means better heat dissipation ) is required in order to keep  $T_j$  from exceeding  $120^{\circ}\text{C}$ , the absolute maximum rating in the specifications, if the ambient temperature becomes higher and/or the driving current is larger. Therefore, use Figure-2 as a guide when selecting the external heat dissipation parts, and ultimately conduct thermal verification on actual devices.

Figure-2  $T_a$ - $R_{s-a}$



- CITIZEN ELECTRONICS CO., LTD. shall not be liable for any disadvantages or damages resulting from the use of technical information or data included in this document or the impossibility of download and use, responsibility for the cause of lawsuit or any other damages or losses.
- This technical information or data shall be provided 'as is' to users and CITIZEN ELECTRONICS CO., LTD. does not guarantee the absence of error or other defects in this technical information or data, conformance of this technical information or data to specific purpose, this technical information or data or its use will not infringe the rights of users or third parties or any other content.
- CITIZEN ELECTRONICS CO., LTD. reserves the right to make changes to technical information or data without notification.

Information contained in this document such as sentences, photographs and images is subject to copyright, and is protected by law. Unless it is for "duplication for private use" or "quotation" under copyright law, any duplication or diversion of this information without permission of CITIZEN ELECTRONICS CO., LTD. is prohibited by law.



## **CITIZEN ELECTRONICS CO., LTD.**

1-23-1, Kamikurechi, Fujiyoshida-shi, Yamanashi, 403-0001, Japan  
Tel. +81-555-23-4121  
<http://ce.citizen.co.jp>

Requests / Inquiries  
[inquiry@ce.citizen.co.jp](mailto:inquiry@ce.citizen.co.jp)

Website for LEDs for lighting  
[http://ce.citizen.co.jp/lighting\\_led/jp/](http://ce.citizen.co.jp/lighting_led/jp/)