CITIZEN
Micro HumanTech

Heat Dissipation Design

CITILED®
The Light Engine

CL-824 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

CITIZEN ELECTRONICS CO., LTD.

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

Ref.CE-P966 01/11

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 Tj is important. The Tj 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) Ts [°C] is normally measured. Tj [°C] is calculated using the thermal resistance between the junction and the case Rj-s [°C/W], and the emitted heat amount that is nearly equal to the input power Pd [W]. The heat generated at the light-emitting diode can be conducted to the external radiator efficiently because the package structure for the CL-824 series minimizes the thermal resistance Rj-s.

This document describes the detailed heat dissipation structure of the CL-824 series and provides data necessary for thermal design of the lighting apparatus to maximize LED performance.

2. Package structure and thermal resistance

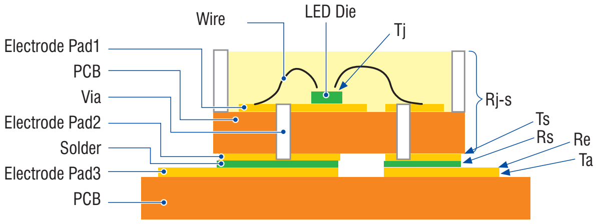
Understanding the junction temperature

The cross-sectional structure example, where the package of the CL-824 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 Rj-s and the specific thermal resistance value of the package.

■Figure-1 (a) Cross Section



Therefore, the following formula is used:

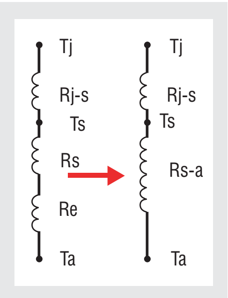
$$Tj = Rj\text{-}s \cdot Pd + Ts$$

In addition, the thermal resistance of the solder outside the package is Rs [°C/W], the thermal resistance of the electrodes with the heat sink function is Re [°C/W], and the ambient temperature is Ta [°C].

Figure-2 (b) indicates the equivalent thermal resistance along the cross-sectional diagram in Figure-2 (a). As indicated, the thermal resistances Rj-s, Rs, and Re are connected in series between the junction temperature Tj and the ambient temperature Ta. The thermal resistances outside the package Rs and Re can be integrated into the thermal resistance Rs-a at this point. Thus, the following formula is also used:

$$Tj = (Rj\text{-}s + Rs\text{-}a) \cdot Pd + Ta$$

■Figure-2 (a) Thermal Resistance Connection



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

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 Rs-a [°C/W], which is the combination of the thermal resistance of the solder Rs [°C/W] and the thermal resistance of the electrodes with the heat sink function Re [°C/W], is limited by the input power Pd [W], the ambient temperature Ta [°C], and the thermal resistance of the package Rj-s [°C/W], i.e.,

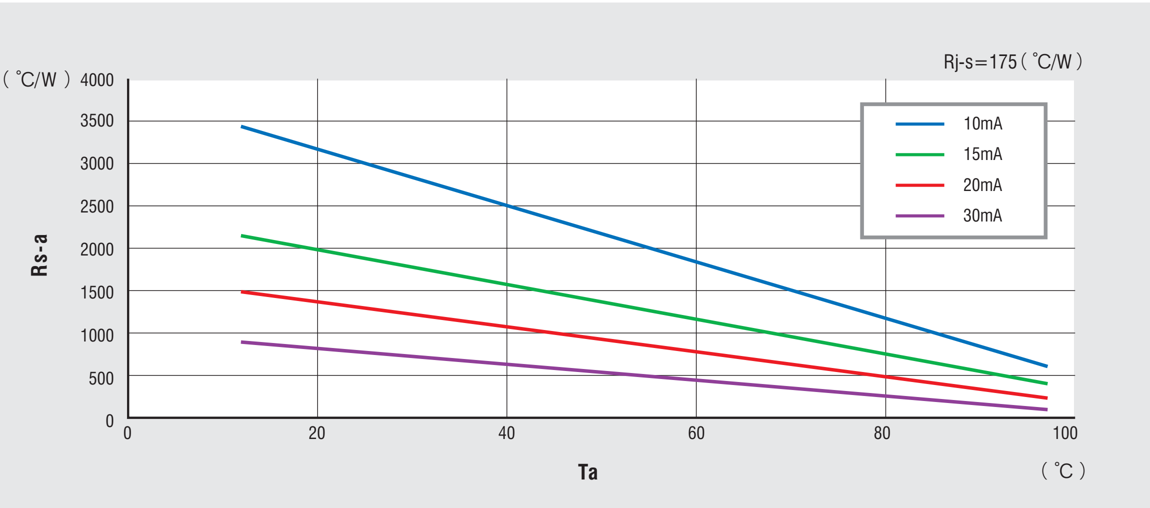
Tj = (Rj-s + Rs-a)・Pd + Ta ➡ Rs-a =(Tj - Ta) / Pd - Rj-s

Tj function converted from the above formula is

Rs-a = -Ta / Pd + Tj / Pd - Rj-s

and it is a straight line with the slope of -1 / Pd and the intercept of Tj / Pd - Rj-s.
Figure-2 is the chart showing the relationship between the ambient temperature Ta and the thermal resistance outside the package Rs-a indicated by driving current, where Tj is assumed to be 120°C - the absolute maximum rating value in the specifications for the CL-824-U1 package.
The higher the ambient temperature Ta and the larger the driving current, the smaller the allowable thermal resistance outside the package Rs-a = Rs + Re.
In brief, the external heat dissipation mechanism with smaller thermal resistance (this means better heat dissipation) is required in order to keep Tj from exceeding 120°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 Ta-Rs-a



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

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

Website for LEDs for lighting
http://ce.citizen.co.jp/lighting_led/jp/

Ref.CE-P966 01/11