Surface Mount ChipLEDs

Design Guide

Introduction

An industry leader in high brightness LED technology, Avago Technologies offers a wide range of high quality ChipLED products to meet customer demand for various surface mount lighting requirements.

High brightness LED technology offers better efficiency, lower driving current and a smaller number of LEDs. Avago's ChipLED products have the lowest profile in the industry, and are positioned to support high volume, cost effective solutions.

The ChipLED footprint is an industry standard with top mount, reverse mount and right angle mount packaging options. The low profile products integrate well into designs where space is limited.

ChipLED products are used in a variety of applications including LCD and push button backlighting for cellular phones, white goods and appliances, industrial measurement and control systems, and for symbol lighting and status indication in computer peripherals and consumer goods.

Low power consumption, small size and easy assembly make the ChipLED ideal for backlighting handsets as well as backlighting industrial displays.

Features

- Small size, space saving
- Wide viewing angle, well suited for backlighting applications
- Intensity and color bin uniformity, can be closely mounted without any intensity variations
- Variety of packages and mounting options (top, reverse and right angle auto mountable)
- Industry standard footprint (requires no change in existing board layout)

Typical Applications

- Telecommunications
  - Keypad and LCD backlighting for mobile phones, pagers and cordless phones
- Industrial
  - Status and symbol indicator
  - Keypad and LCD backlighting
- Consumer
  - White goods and appliances
- Computer Peripherals
  - Status indicator

Typical Datasheet Information

The datasheet typically contains three tables of data. Usually for ChipLED devices the first table is titled Device Selection Guide, followed by the Absolute Maximum Ratings and the Electrical / Optical Characteristics table.

The Absolute Maximum Ratings at T_A = 25°C consists of the maximum peak and DC forward current, power dissipation, LED junction temperature, operating and storage temperature. These are the maximum allowed operating conditions for all the devices in the datasheet.

The Electrical / Optical Characteristics at T_A = 25°C contains the electrical data and optical data that are used to determine the operating conditions for the device. The forward voltage, V_F, and device thermal resistance $R\theta_{J\text{-}PIN}$, used in operating condition calculations are listed in this table.

The graphs used to determine operational conditions are:

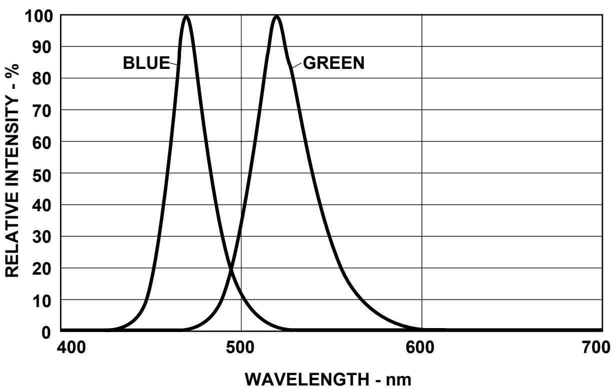

Figure 1. Relative Intensity vs. Wavelength.

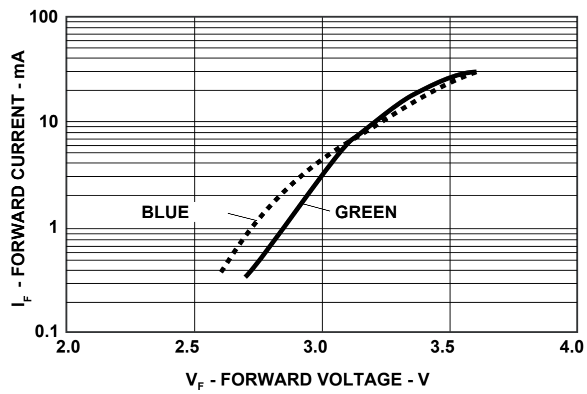

Figure 2. Forward Current vs. Forward Voltage.

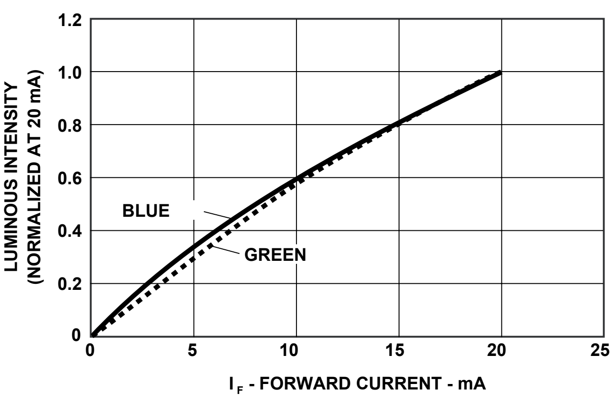

Figure 3. Relative Luminous Intensity vs. DC Forward Current.

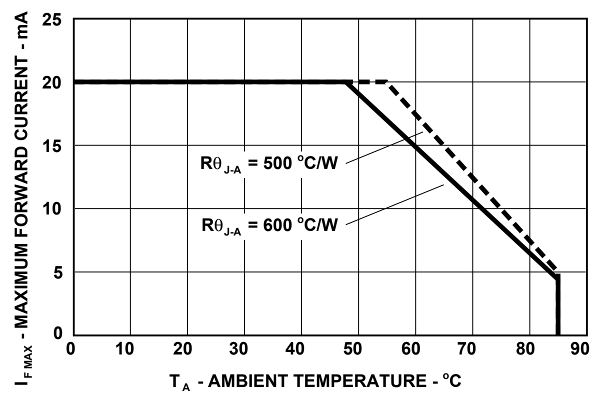

Figure 4. Maximum DC Forward Current vs. Ambient Temperature.

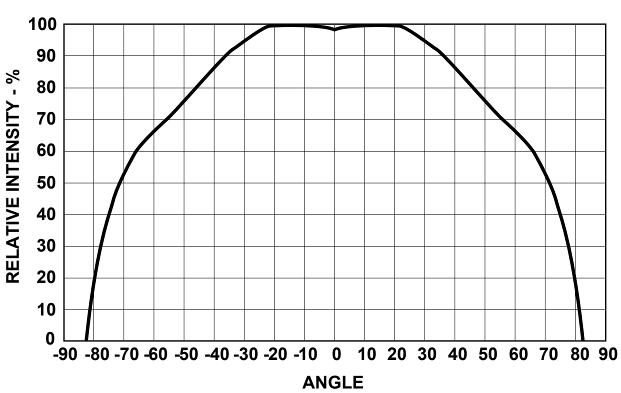

Figure 5. Relative Luminous Intensity vs. Angular Displacement.

Electrical Design Criteria

The two criteria that establish the operating limits are the maximum drive currents and the absolute maximum LED junction temperature, T_JMAX. The maximum drive currents have been established to ensure long operating life. The absolute maximum LED junction temperature is a device package limitation that must not be exceeded.

Thermal Resistance

The LED junction temperature, T_J(°C), is the sum of the ambient temperature, T_A(°C) and the temperature rise of the LED junction above ambient, ΔT_J(°C), which is the product of the power dissipated within the LED junction, PD(W), and the thermal resistance LED junction-to-ambient, $R\theta_{J\text{-}A}$(°C/W).

$$T_J = T_A + \Delta T_J$$

$$T_J = T_A + P_D \times R\theta_{J\text{-}A}$$

The cathode leads (terminal) of a typical LED device are the primary thermal paths for heat dissipation from the LED junction to the surrounding environment. The exceptions are AlGaAs devices that use flip chip technology (anode die attach), where the anode lead is the primary thermal path. The datasheet lists the thermal resistance LED junction-to-pin, $R\theta_{J\text{-}P}$(°C/W), for each device type listed. This device thermal resistance is added to the pc board mounting assembly thermal resistance-to-ambient, $R\theta_{PC\text{-}A}$(°C/W), to obtain the overall thermal resistance LED junction-to-ambient, $R\theta_{J\text{-}A}$(°C/W).

$$R\theta_{J\text{-}A} = R\theta_{J\text{-}PIN} + R\theta_{PC\text{-}A}$$

For reliable operation, it is recommended that the value of $R\theta_{PC\text{-}A}$ be designed low enough to achieve the lowest possible $R\theta_{J\text{-}A}$ to ensure the LED junction temperature does not exceed the absolute maximum value when the device is operated in the maximum surrounding ambient temperature.

Maximum Power Calculation

The maximum allowed power that may be dissipated within an LED junction, P_{MAX}, is determined by multiplying the maximum rated DC current by the forward voltage for that current, determined from Figure 2.

$$P_{MAX} = I_{DC}MAX \times V_F$$

Derating vs. Temperature

The derating curve, Figure 4, is a function of drive current, TJMAX andRθJ-A. Typically derating curves are given from two thermal resistance junction-to-ambient conditions, $R\theta_{J\text{-}A}$ = 500°C/W (dashed line) and $R\theta_{J\text{-}A}$ = 600°C/W (solid line). These values are based on the different PCB materials as the thermal resistance pc-to-ambient will be different. The derating curves are lines of T_JMAX with slopes equal to the specific maximum $R\theta_{J\text{-}A}$ values indicated, intersecting the temperature axis at the maximum LED junction temperature point with zero current. Operation of the LED device at a particular drive current should be at or below a derating curve with a thermal resistance-to-ambient at or less than the maximum value indicated for that curve.

Current Limiting

An LED is a current operated device, and therefore requires some kind of current limiting incorporated into the drive circuit. This current limiting typically takes the form of a current limiter resistor, R, placed in series with the LED. The forward voltage characteristic of Figure 2 is used to calculate the value of the series current limiter resistor.

$$R = V_{CC} - V_{SAT} - V_F / I_{DC}$$

Where:

V_{CC} = Power supply voltage

V_{SAT} = Saturation voltage of driver transistor(s)

V_F = Forward voltage of the LED at I_{DC}

I_{DC} = The DC forward current through the LED

Design Steps

In order to determine the derated drive conditions from the datasheet for an elevated ambient temperature, the value for $R\theta_{J\text{-}A}$ must be determined. Once the value for $R\theta_{J\text{-}A}$ has been established, the required current derating can be determined for safe operation at the elevated temperature directly from Figure 4. The basic design steps are:

1. Determine $R\theta_{J\text{-}A}$.
2. Calculate the required value for $R\theta_{PC\text{-}A}$ for the pc board mounting configuration.
3. Determine the maximum allowable dc drive current for the operating ambient temperature.
4. Calculate the LED chip power dissipation to be sure it will not cause T_J to exceed the absolute maximum value.
5. Calculate the value of the current limiting resistor.
6. Determine the luminous intensity at 25°C and at the elevated ambient temperature.

The example calculations in this design guide use representative data typically contained in ChipLED datasheets. The objective of the calculations is to ensure reliable operation of the ChipLED when operated at an elevated ambient temperature. For the following example, a ChipLED InGaN Blue device, HSMR-C191 is used with the datasheet parameters as below:

Typical Luminous Intensity at 20mA, Iv(25°C) = 55 mcd

Maximum DC Forward Current = 20mA

Maximum LED Junction Temperature = 95°C

Thermal Resistance Junction-to-Pin $R\theta_{J\text{-}PIN}$ = 300°C/W

DC Design Example

In this example, the operating ambient temperature is assumed to be T_A = 60°C.

Step 1: For this example, the value for (symbol here)$R\theta_{J\text{-}A}$ has been established to be 500°C/W.

Step 2: From equation $R\theta_{J\text{-}A} = R\theta_{J\text{-}PIN} + R\theta_{PC\text{-}A}$,

$R\theta_{PC\text{-}A}$ = (500 – 300)°C/W

$R\theta_{PC\text{-}A}$ = 200°C/W

The pc board mounting assembly should be designed to provide this value of thermal resistance to ambient, or less, for reliable operation of the LED device.

Step 3: From Figure 4, the maximum allowable DC forward current at T_A (60°C) is 17mA.

Step 4: Calculate the power dissipation for 17mA drive current using equation ($P_{MAX} = I_{DC}MAX \times V_F$).

From Figure 2, V_F(17 mA) = 3.35V

P = (0.017) (3.35) = 0.057 W

P = 57 mW

Using equation ($T_J = T_A + PD \times R\theta_{J\text{-}A}$) for LED junction temperature:

T_J = 60°C + (0.057W) (500°C/W)

T_J = 88.5°C, less than the maximum allowable 95°C.

Step 5: Equation ($R = V_{CC} - V_{SAT}\text{-}V_F / I_{DC}$) is used to calculate the value of the current limiting resistor. A 5V power supply and a switching transistor with a saturation of 0.1V is used to drive the LED.

R = (5.0 V – 0.1 V – 3.35 V) / (0.017 A)

R = 91.18Ω (Calculated limiting resistor)

R = 100 Ω (Nearest higher rated resistor)

Resistor power rating should be 2x the actual power dissipation.

P_R = I2 x R = (0.017 A)2 x 100

P_R = 0.03 W

Thus use a ¼ watt 100 Ω resistor.

Step 6: The luminous intensity at T_A = 25°C is determined from Figure 3.

From Figure 3, the relative luminous intensity factor at 17mA is 0.9.

Iv (25°C) = (55 mcd) (0.9)

Iv (25°C) = 49.5 mcd

At the operating temperature of 60°C, the luminous intensity is calculated using the below equation and the appropriate k factor value. For this example, k = -0.034 / °C (for reference only).

Iv (TA) = Iv (25°C)e[k(T_A - 25°C)]

Iv (60°C) = Iv (25°C) e[k(60 – 25°C)]

Iv (60°C) = (49.5 mcd) $e^{-0.034/°C\ (60\text{-}25°C)}$

Iv (60°C) = (49.5 mcd) (0.304)

Iv (60°C) = 15 mcd

DC Parameter Summary:

$T_A = 25°C$

$R\theta_{PC-A} = 200°C/W$

I_F (DC) = 17mA

$T_J = 88.5°C$

R = 100 Ω, 1/4 W

Iv (25°C) = 49.5 mcd

Iv (60°C) = 15 mcd

Ensuring Good Brightness and Color Uniformity

In the design of a drive circuit, it is very important to choose the right product for its intended application. The characteristics and performance capabilities of each LED device are presented in the product datasheet. The datasheet contains tabular data and graphs that describe the optical and electrical characteristics of the LED, and Absolute Maximum Rating which are the maximum operating capabilities of the device. A thorough understanding of how to use this information is the basis for achieving an optimum design.

Avago LEDs are current-driven devices and are therefore tested and binned by their forward currents typically of 5mA and 20mA. The characteristics and performance of the LED will shift according to the forward current. The further away the LED is driven from the test current the more shift in the characteristics of the LED is expected.

Example:

Avago InGaN Blue ChipLED is available in 5mA and 20mA test currents. Normally the drive current for mobile phone keypad backlighting applications require only very low currents, around 2mA to 4mA. The correct decision would be to choose a 5mA test current LED. If a 20mA test current LED were to be chosen in this case, uneven brightness and color would be expected between the LEDs. The Iv-IF relationship between a 5mA and 20mA device is different as shown in Figures 6 & 7 below.

Land Pattern Design Criteria

Good design of the land pattern or soldering pads is important to ensure good alignment and solderability to the SMT assembly board. Placing an SMT ChipLED component on the pc board so its axis is orientated perpendicular to the long dimension side of the board, as shown in Figure 8, will tend to reduce stress on the device during reflow soldering. Placing the axis of an SMT ChipLED component parallel to the long dimension side of the pc board will increase the probability of defects.

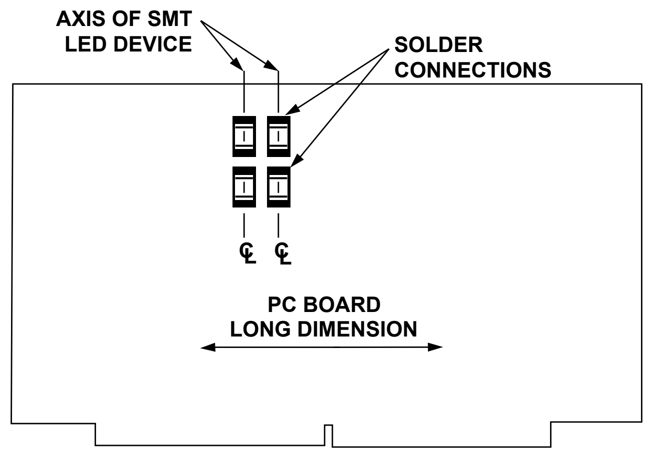

Figure 8. Recommended Orientation of ChipLED components on PC Boards for Minimum Stress.

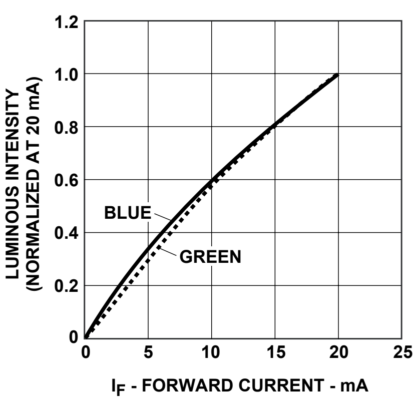

Figure 6. Luminous Intensity vs. Forward Current (20mA)

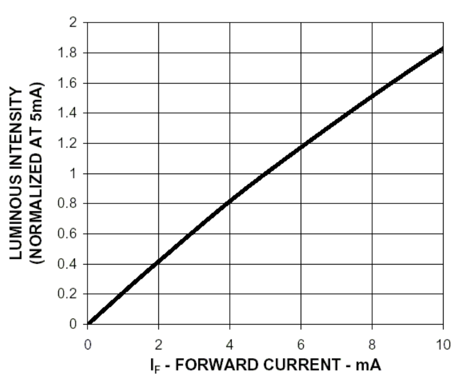

Figure 7. Luminous Intensity vs. Forward Current (5mA)

The proper design of soldering pads, as illustrated in Figure 9, will increase the probability of proper solder joint formations. Pad size should not exceed the recommended pad dimensions by more than 0.25mm (0.010 in.). Accurate placement of the SMT ChipLED components onto the soldering pads is also crucial to ensures proper alignment and good solder joint formation. When the soldering pads are of the correct size in relation to the termination of the ChipLEDs, the component will realign itself with respect to the pads, assisted by the capillary attraction (wetting forces) of the molten solder.

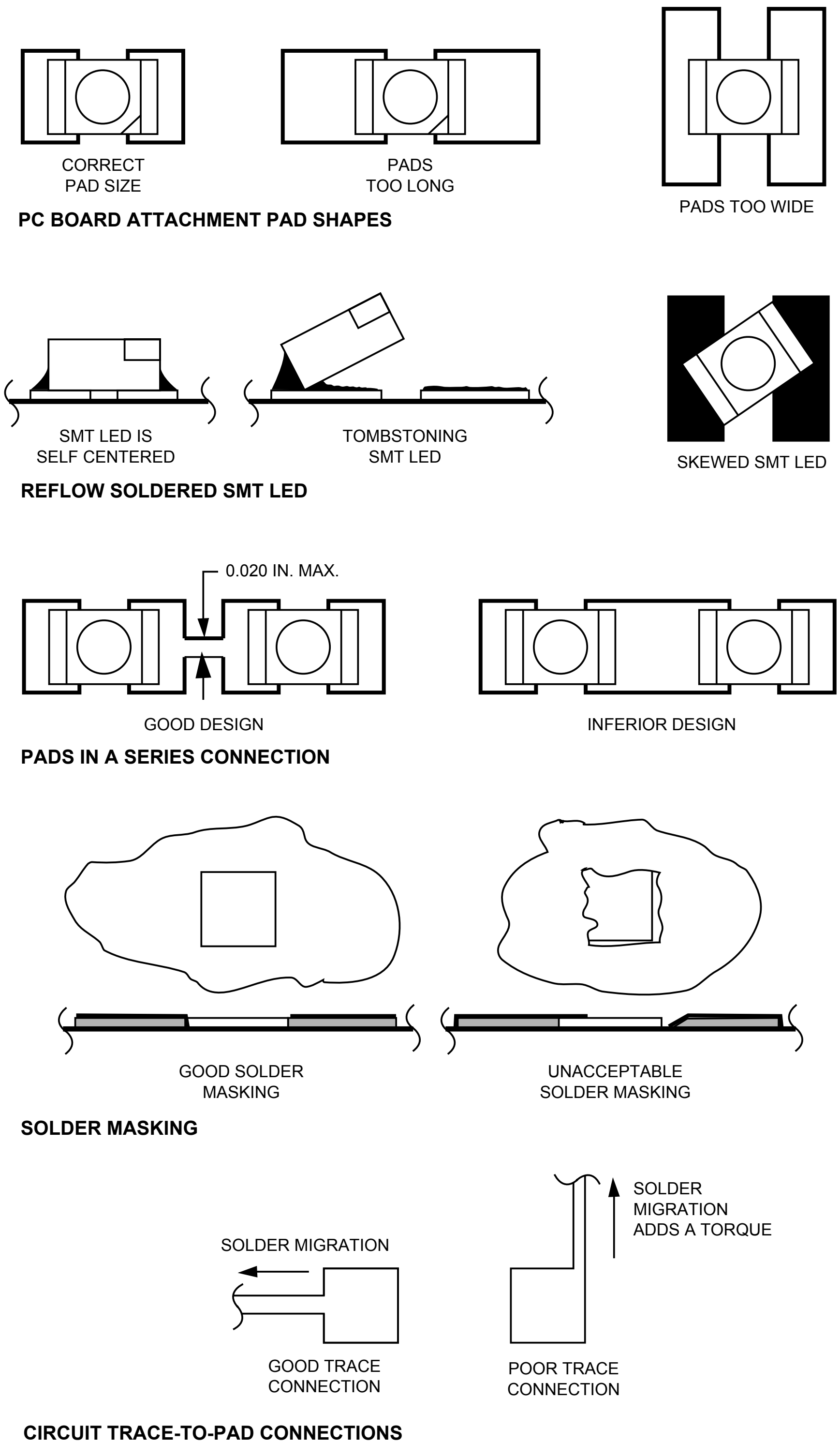

Figure 9. Soldering Land Pattern Considerations for SMT ChipLED Components.

PC board traces should connect to the center of each soldering pad. Traces that connect to the outer edges of the pads impart a torque to the SMT ChipLED components which contribute to skewing and off centering problems. Adjacent soldering pads for SMT ChipLED components electrically connected in series should be connected with a trace that is a maximum of 0.20 inches wide. Solder resist masking should be well defined around the perimeter of the soldering pads, without voids or smears over the pads that will inhibit the formation of good solder connections.

The recommended land pattern design for every ChipLED component is illustrated in their respective datasheets. Figure 10 shows some of these recommended land pattern designs.

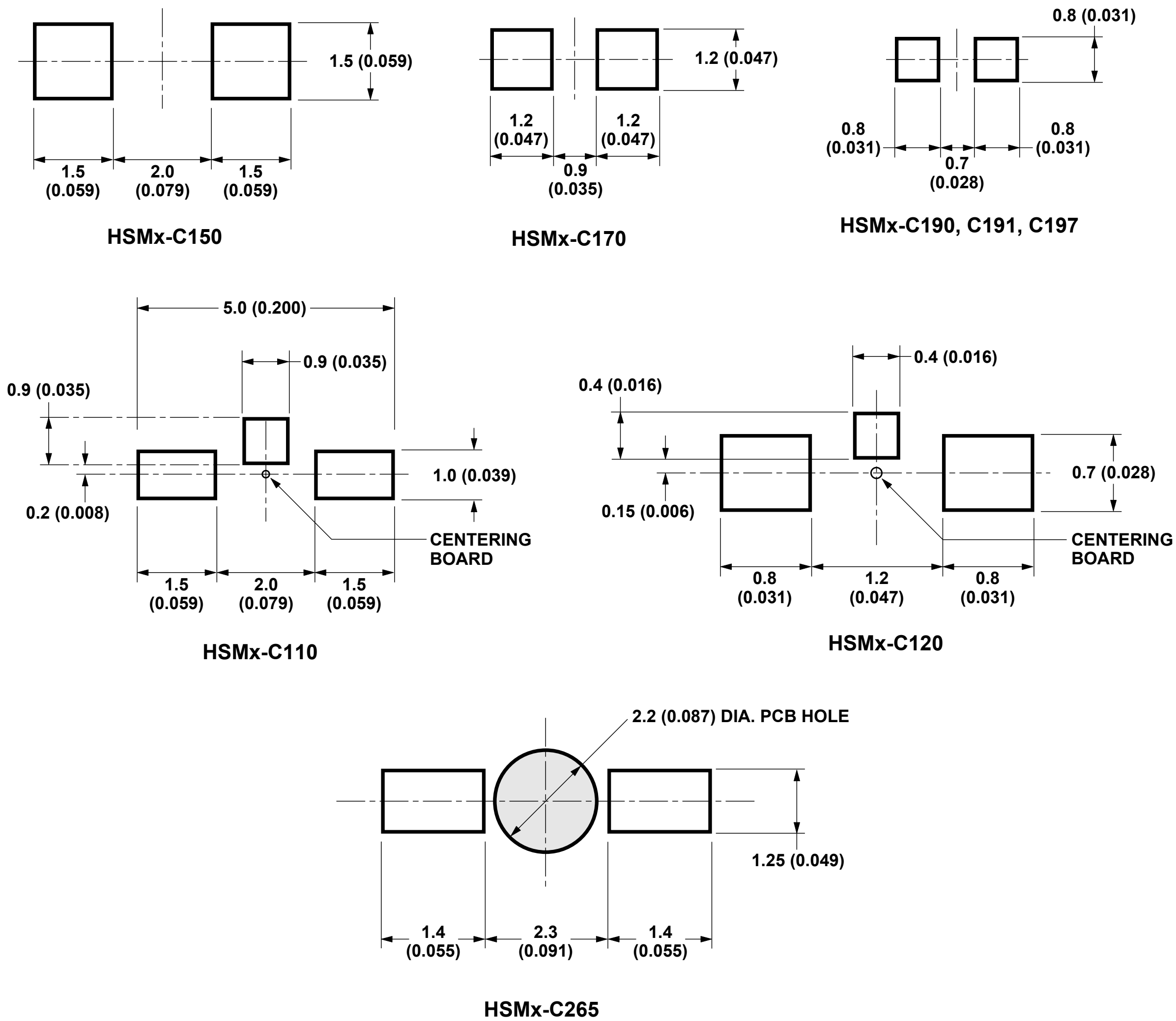

Figure 10. Recommended Soldering Land Pattern Design for ChipLEDs.

Land Pattern Design Considerations for Avago Side-Firing ChipLEDs

This series of right angle mount ChipLEDs is designed with the smallest footprint to achieve high density of components on board. They are designed to have the industry standard footprint. This makes them very suitable for cellular phone and mobile equipment back-lighting and indication application where space is a constraint.

The LED's design is unique in the sense that the it is right angle mounted to facilitate the side light emitting direction. Below is an illustration showing the light emitting direction and the recommended soldering land pattern of the side-firing ChipLEDs.

Avago recommended design for side-firing ChipLEDs have an additional center pad to assist in the alignment of the unit to the soldering pads. The center pad will hold the unit in place and prevent movement during the molten stage of the solder. Without this center pad, the units are able to shift during the molten stage of the solder which may lead to alignment and other solderability issues. Figure 13 is an illustration showing the possible scenarios of the unit shifting during reflow soldering.

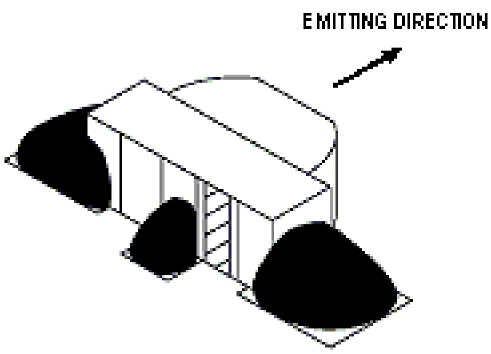

Figure 11. Package Outlook and Light Emitting Direction.

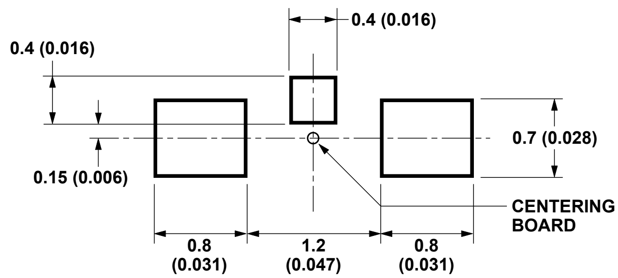

Figure 12. Recommended Soldering Land Pattern.

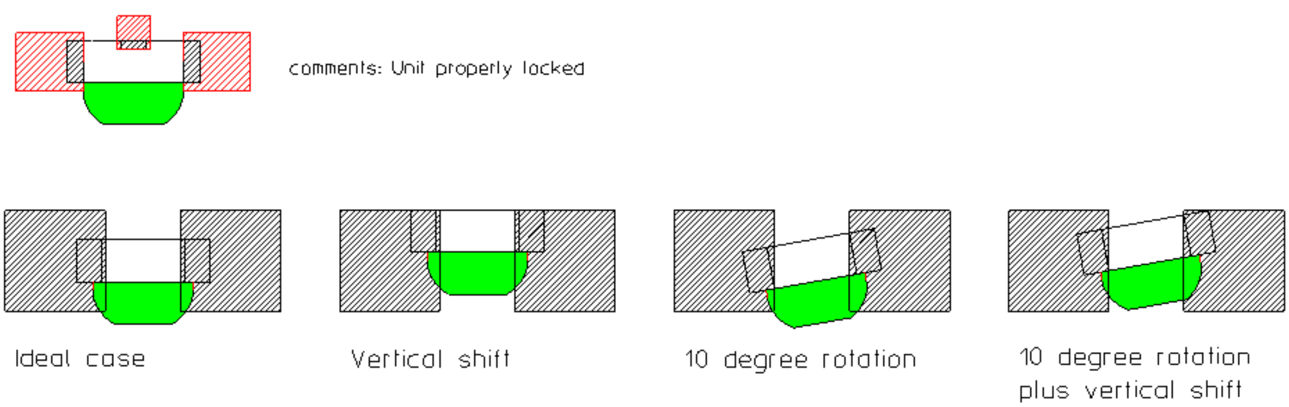

Figure 13. Soldering Pad Designed with Center Pad (Above) and Without Center Pad (Bottom).

AV02-0376EN - May 9, 2007

Компания «ЭлектроПласт» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits,General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.

Как с нами связаться

Телефон: 8 (812) 309 58 32 (многоканальный)
Факс: 8 (812) 320-02-42
Электронная почта: org@eplast1.ru
Адрес: 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.