

LUXEON 3535L

Assembly and Handling Information



Introduction

This application brief addresses the recommended assembly and handling guidelines for LUXEON® 3535L emitters. These emitters deliver high efficacy and quality of light for distributed light source applications in a compact 3.5mm x 3.5mm package. Proper assembly, handling, and thermal management, as outlined in this application brief, ensure high optical output and reliability of these emitters.

Scope

The assembly and handling guidelines in this application brief apply to the following LUXEON product(s):

LUXEON 3535L (MXAx-PWxx)

In the remainder of this document the term LUXEON emitter refers to any product in the LUXEON series listed above.

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I. Component

I.1 Description

The LUXEON 3535L emitter (Figure 1) consists of a 3535 lead-frame package with an anode and a cathode. A small notch on the corner of the package marks the cathode side of the emitter package. The anode and cathode both serve as thermal pads for the emitter, with the majority of the heat being dissipated through the larger pad, corresponding to the cathode. The LUXEON emitter does not include any transient voltage suppressor (TVS) chip to protect the emitter against electrostatic discharges (ESD). Appropriate precautions should therefore be taken when handling this device (see Section 5.5).

I.2 Optical Center

The optical center coincides with the mechanical center of the LUXEON emitter. Optical rayset data for the LUXEON emitter are available on the Philips Lumileds website at www.philipslumileds.com.

I.3 Handling Precautions

The LUXEON emitter is designed to maximize light output and reliability. However, improper handling of the device may damage the silicone coating and affect the overall performance and reliability. In order to minimize the risk of damage to the silicone coating during handling, the LUXEON emitter should only be picked up from the side of the package.

I.4 Cleaning

The LUXEON emitter should not be exposed to dust and debris. Excessive dust and debris may cause a drastic decrease in optical output. In the event that a LUXEON emitter requires cleaning, first try a gentle swabbing using a lint-free swab. If needed, a lint-free swab and isopropyl alcohol (IPA) can be used to gently remove dirt from the silicone coating. Do not use other solvents as they may adversely react with the package of the LUXEON emitter. For more information regarding chemical compatibility, see Section 6.

I.5 Electrical Isolation

The LUXEON emitter has two electrodes, with a nominal spacing of 0.65mm, at the bottom of the package. In addition, the LUXEON emitter contains two tabs on the side of the package. These tabs are cut-off remnants of the lead-frame and are electrically connected to the anode and cathode, respectively. So it is important to keep sufficient distance between the LUXEON emitter package and any other objects or neighboring LUXEON emitters to prevent any accidental shorts.

In order to avoid any electrical shocks and/or damage to the LUXEON emitter, each design needs to comply with the appropriate standards of safety and isolation distances, known as clearance and creepage distances, respectively (e.g. IEC60950, clause 2.10.4).

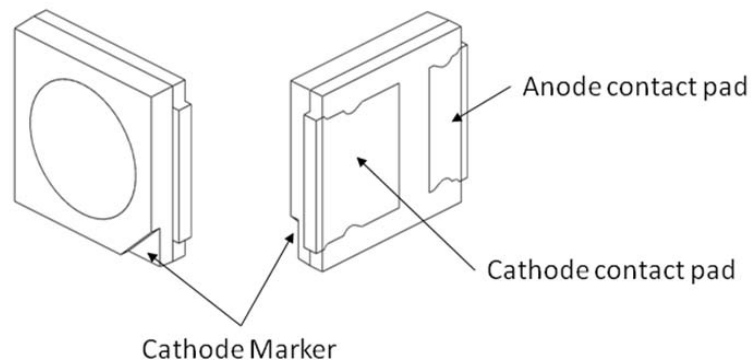


Figure 1. Package rendering of the LUXEON 3535L emitter.

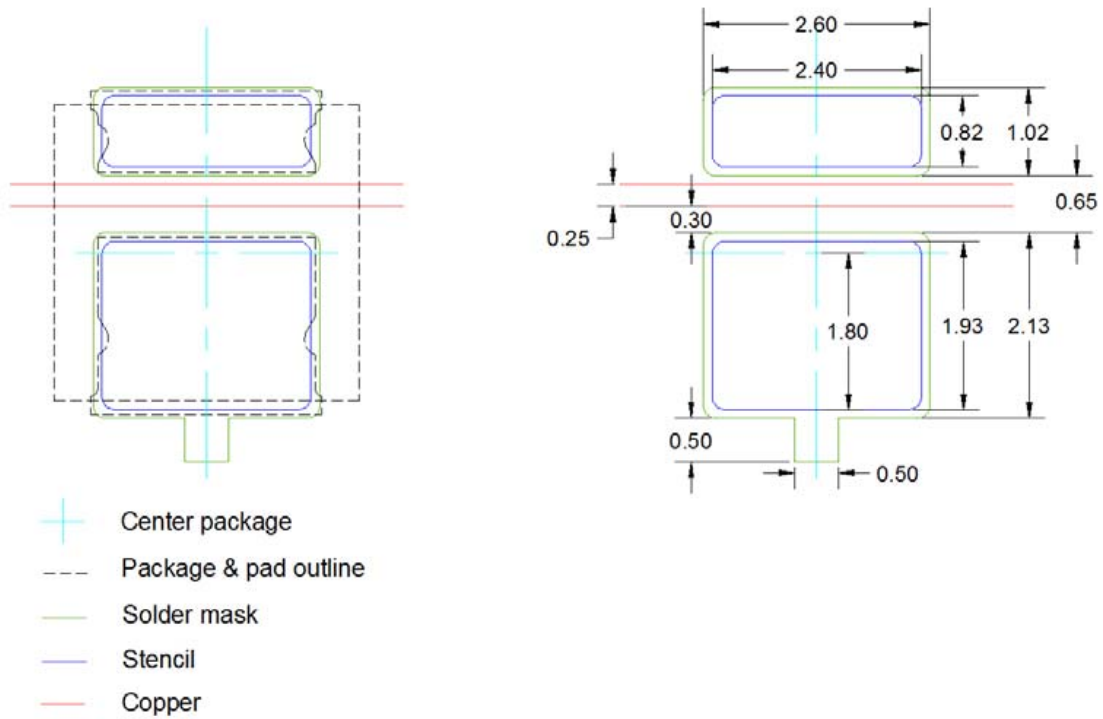


Figure 2. Recommended PCB footprint design for the LUXEON emitter. In order to ensure proper heat dissipation from the package electrodes to the PCB, it is best to extend the top copper layer of the PCB several millimeters beyond the package of the LUXEON emitter. All dimensions are in mm.

1.6 Mechanical Files

Mechanical drawings for the LUXEON emitter are available on the Philips Lumileds website at www.philipslumileds.com.

2. PCB Design Guidelines for the LUXEON Emitter

The LUXEON emitter is designed to be soldered onto a Printed Circuit Board (PCB). To ensure optimal operation, the PCB should be designed to minimize the overall thermal resistance between the LED package and the heat sink.

2.1 PCB Footprint and Land Pattern

The recommended PCB footprint design for the LUXEON emitter is shown in Figure 2. In order to ensure proper heat dissipation from the emitter electrodes to the PCB, it is best to extend the top copper layer of the PCB beyond the perimeter of the LUXEON emitter by 3mm – 4mm (see Section 3).

2.2 Surface Finishing

Philips Lumileds recommends using a high temperature organic solderability preservative (OSP) on the copper layer.

2.3 Minimum Spacing

Philips Lumileds recommends a minimum edge to edge spacing between LUXEON emitters of 0.5mm. Placing multiple LUXEON emitters too close to each other may adversely impact the ability of the PCB to dissipate the heat from the emitters and may cause accidental shorts between the metal stubs on the side of neighboring LUXEON emitters.

Example of maximized copper foil vs. minimum copper foot print used in evaluation.

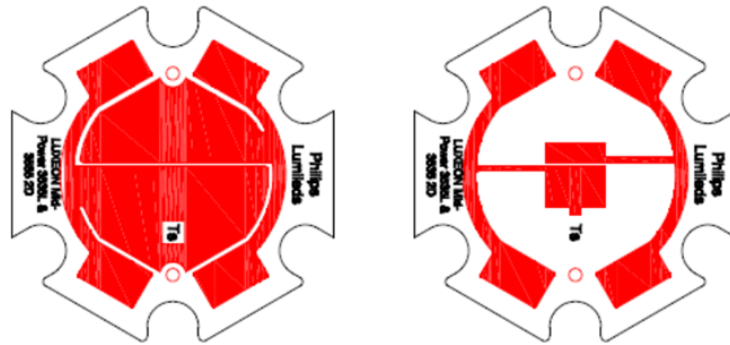


Figure 3. Maximum (left) and minimum (right) top side metallization on FR4 PCBs.

3. Thermal Management

The overall thermal resistance between a LUXEON emitter and the heat sink is strongly affected by the design and material of the PCB on which the emitter is soldered. Metal Core PCBs have been historically used in the LED industry for their low thermal resistance and rigidity. However, MCPCBs may not always offer the most economical solution. Multi-layer epoxy FR4 PCBs are commonly used in the electronics industry and can, if properly designed, yield an appropriate low-cost solution for various LED applications.

Philips Lumileds investigated the thermal performance of LUXEON emitters on a 1.0mm thick FR4 PCB with a top copper plating of 35µm. In order to quantify the impact of the PCB metallization on the overall thermal resistance between junction and heatsink, two different top side metallization configurations were considered (see Figure 3). Minimum top side metallization corresponds to copper pads which did not extend beyond the outline of the LUXEON emitter package. This configuration is representative for applications where multiple LEDs are placed in close proximity to each other. Maximum top size metallization corresponds to copper pads which extend several millimeters beyond the outline of the LUXEON emitter package. This situation is representative for distributed light applications where multiple LEDs are placed relatively far apart. Table I summarizes the typical results from these thermal experiments. This table also includes typical values for $R\theta_{j-s}$ (see Section 4). Similar experiments with FR4 PCBs, which had full metallization at the bottom as well, did not yield any noticeable improvements in $R\theta_{j-bottom PCB}$.

Table I. Typical thermal resistance values for FR4 PCBs with minimum and maximum top side metallization.

Top Side Metallization	Typical $R\theta_{j-bottom PCB}$ [K/W]	Typical $R\theta_{j-s}$ [K/W]
Minimum	100	28
Maximum	58	32

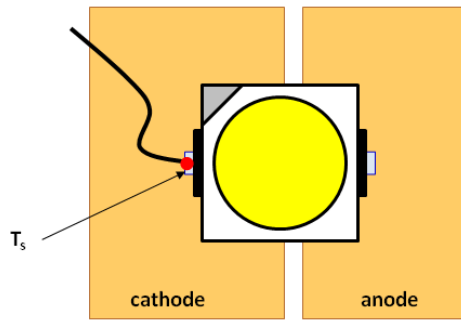


Figure 4. The recommended temperature measurement point T_s is located right next to the cathode of the LUXEON emitter on the PCB.

4. Thermal Measurement Guidelines

The typical thermal resistance $R\theta_{j-case}$ between the junction and the solder pads of the LUXEON emitter is provided in the datasheet. With this information, the junction temperature T_j can be determined according to the following equation:

$$T_j = T_{case} + R\theta_{j-case} \cdot P_{electrical}$$

In this equation T_{case} is the temperature at the bottom of the solder pads of the LUXEON emitter and $P_{electrical}$ is the electrical power going into the emitter. In typical applications it may be difficult, though, to measure the temperature T_{case} directly. Therefore, a practical way to determine the junction temperature of the LUXEON emitter is by measuring the temperature T_s of a predetermined sensor pad on the PCB with a thermocouple. The recommended location of the sensor pad is right next to the cathode of the LUXEON emitter on the PCB, as shown in Figure 4. To ensure accurate readings, the thermocouple must make direct contact with the copper of the PCB onto which the LUXEON emitter pads are soldered, i.e. any solder mask or other masking layer must be first removed before mounting the thermocouple onto the PCB. The thermal resistance $R\theta_{j-s}$ between the sensor pad and the LUXEON emitter junction was experimentally determined on FR4 PCBs with minimum and maximum metallization (see Table 1). The junction temperature can then be calculated as follows:

$$T_j = T_s + R\theta_{j-s} \cdot P_{electrical}$$

5. Assembly Process Guidelines

5.1 Stencil Design

The recommended solder stencil thickness is 125 μ m.

5.2 Solder Paste

Philips Lumileds recommends lead-free solder for the LUXEON emitter. Philips Lumileds tested SAC 305 solder paste from Alpha Metals (OM338 grade 3 and OM 325 grade 4) with satisfactory results. However, since application environments vary widely, Philips Lumileds recommends that customers perform their own solder paste evaluation in order to ensure it is suitable for the targeted application.

5.3 Solder Reflow Profile

The LUXEON emitter is compatible with standard surface-mount and lead-free reflow technologies. This greatly simplifies the manufacturing process by eliminating the need for adhesives and epoxies. The reflow step itself is the most critical step in the reflow soldering process and occurs when the boards move through the oven and the solder paste melts, forming the solder joints. To form good solder joints, the time and temperature profile throughout the reflow process must be well maintained.

A temperature profile consists of three primary phases:

1. Preheat: the board enters the reflow oven and is warmed up to a temperature lower than the melting point of the solder alloy.
2. Reflow: the board is heated to a peak temperature above the melting point of the solder, but below the temperature that would damage the components or the board.
3. Cool down: the board is cooled down rapidly, allowing the solder to freeze, before the board exits the oven.

As a point of reference, the melting temperature for SAC 305 is 217°C, and the minimum peak reflow temperature is 235°C.

5.4 Pick and Place

The LUXEON emitter is packaged and shipped in tape-and-reel which is compatible with standard automated pick-and-place equipment to ensure the best placement accuracy. Note that pick and place nozzles are customer specific and are typically machined to fit specific pick and place tools.

5.5 Electrostatic Discharge Protection

The LUXEON emitter does not include any transient voltage suppressor (TVS) chip to protect against electrostatic discharges (ESD). Therefore, Philips Lumileds recommends observing the following precautions when handling the LUXEON emitter:

- During manual handling always use a conductive wrist band or ankle straps when positioned on a grounded conductive mat.
- All equipment, machinery, work tables, and storage racks that may get in contact with the LUXEON emitter should be properly grounded.
- Use an ion blower to neutralize the static discharge that may build up on the surface and lens of the plastic housing of the LUXEON emitter during storage and handling.

LUXEON emitters which are damaged by ESD may not light up at low currents and/or may exhibit abnormal performance characteristics such as a high reverse leakage current, and a low forward voltage. To determine whether any device is damage by ESD, measure the light output and forward voltage of the emitter which is suspect. A forward voltage above 2.0V for a drive current of 0.1mA typically indicates that the LED is not damaged.

6. Packaging Considerations – Chemical Compatibility

The LUXEON emitter package contains a silicone overcoat to protect the LED chip and extract the maximum amount of light. As with most silicones used in LED optics, care must be taken to prevent any incompatible chemicals from directly or indirectly reacting with the silicone.

The silicone overcoat used in the LUXEON emitter is gas permeable. Consequently, oxygen and volatile organic compound (VOC) gas molecules can diffuse into the silicone overcoat. VOCs may originate from adhesives, solder fluxes, conformal coating materials, potting materials and even some of the inks that are used to print the PCBs.

Some VOCs and chemicals react with silicone and produce discoloration and surface damage. Other VOCs do not chemically react with the silicone material directly but diffuse into the silicone and oxidize during the presence of heat or light. Regardless of the physical mechanism, both cases may affect the total LED light output. Since silicone permeability increases with temperature, more VOCs may diffuse into and/or evaporate out from the silicone.

Careful consideration must be given to whether LUXEON emitters are enclosed in an “air tight” environment or not. In an “air tight” environment, some VOCs that were introduced during assembly may permeate and remain in the silicone. Under heat and “blue” light, VOCs captured inside the silicone may partially oxidize and create a silicone discoloration, particularly on the surface of the LED where the flux energy is the highest. In an air rich or “open” air environment, VOCs have a chance to leave the area (driven by the normal air flow). Transferring the devices which were discolored in the

enclosed environment back to “open” air may allow the oxidized VOCs to diffuse out of the silicone and may restore the original optical properties of the LED.

Determining suitable threshold limits for the presence of VOCs is very difficult since these limits depend on the type of enclosure used to house the LEDs and the operating temperatures. Also, some VOCs can photo-degrade over time.

Table 2 provides a list of commonly used chemicals that should be avoided as they may react with the silicone material. Note that Philips Lumileds does not warrant that this list is exhaustive since it is impossible to determine all chemicals that may affect LED performance.

The chemicals in Table 2 are typically not directly used in the final products that are built around LUXEON emitters. However, some of these chemicals may be used in intermediate manufacturing steps (e.g. cleaning agents). Consequently, trace amounts of these chemicals may remain on (sub)components, such as heat sinks. Philips Lumileds, therefore, recommends the following precautions when designing your application:

- When designing secondary lenses to be used over an LED, provide a sufficiently large air-pocket and allow for “ventilation” of this air away from the immediate vicinity of the LED.
- Use mechanical means of attaching lenses and circuit boards as much as possible. When using adhesives, potting compounds and coatings, carefully analyze its material composition and do thorough testing of the entire fixture under High Temperature over Life (HTOL) conditions.

Table 2. List of commonly used chemicals that will damage the silicone of the LUXEON emitter. Avoid using any of these chemicals in the housing that contains the LED package.

Chemical Name	Normally used as
hydrochloric acid	acid
sulfuric acid	acid
nitric acid	acid
acetic acid	acid
sodium hydroxide	alkali
potassium hydroxide	alkali
ammonia	alkali
MEK (Methyl Ethyl Ketone)	solvent
MIBK (Methyl Isobutyl Ketone)	solvent
Toluene	solvent
Xylene	solvent
Benzene	solvent
Gasoline	solvent
Mineral spirits	solvent
dichloromethane	solvent
tetrachlorometane	solvent
Castor oil	oil
lard	oil
linseed oil	oil
petroleum	oil
silicone oil	oil
halogenated hydrocarbons (containing F, Cl, Br elements)	misc
rosin flux	solder flux
acrylic tape	adhesive



Company Information

Philips Lumileds is a leading provider of LEDs for everyday lighting applications. The company's records for light output, efficacy and thermal management are direct results of the ongoing commitment to advancing solid-state lighting technology and enabling lighting solutions that are more environmentally friendly, help reduce CO2 emissions and reduce the need for power plant expansion. Philips Lumileds LUXEON® LEDs are enabling never before possible applications in outdoor lighting, shop lighting, home lighting, digital imaging, display and automotive lighting.

Philips Lumileds is a fully integrated supplier, producing core LED material in all three base colors, (Red, Green, Blue) and white. Philips Lumileds has R&D centers in San Jose, California and in the Netherlands, and production capabilities in San Jose, Singapore and Penang, Malaysia. Founded in 1999, Philips Lumileds is the high flux LED technology leader and is dedicated to bridging the gap between solid-state technology and the lighting world. More information about the company's LUXEON LED products and solid-state lighting technologies can be found at www.philipslumileds.com.

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