Handling and Assembly of LuxiGen™ LED Emitters

LED ENGIN

LZ Series

LED Engin offers 1-, 4-, 7-, 9-, 12-, 24- and 25-die LuxiGen™ LED emitters with the highest flux output in compact packages providing industry leading flux densities (lm/mm2). Emitters are available with red (R), deep red, far red, green (G), blue (B), amber (A), dental blue and white (W) sources in the visible range and ultra violet (UV) and infrared (IR) in the non-visible range. The multi-chip packages are also available with multi-color / -wavelength options such as RGB, RGBA or RGBW. All emitters are sold in 2 configurations - emitter only and emitter mounted on metal core PCB (MCPCB).

This application note provides recommendations for handling, as well as mechanical and electrical assembly of a LuxiGen emitter mounted on a MCPCB into a lighting system to ensure mechanically robust and thermally efficient contact between the emitter and the underlying heat sink. In the case where the customer purchases emitters only, they are also responsible for attaching the LuxiGen emitter to the application specific PCB and are expected to follow the guidelines provided by LED Engin for the system assembly.

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Assembly Overview

Light fixture or system manufacturers are responsible for sufficient thermal design based on the emitter attributes provided in the datasheet. When designing a lighting system using a LuxiGen LED emitter mounted on a MCPCB (hereafter referred to as *emitter on MCPCB*) the following functional requirements must be met:

- Provide sufficient thermally conductive path from the case (or back) of the MCPCB to the heat sink or lighting fixture body
- Ensure robust mechanical connection between the MCPCB and the heat sink
- Ensure good electrical connection between the LED driver and the solder pads on the MCPCB

Drawings of assembling typical emitter on MCPCB to a flat heat sink surface are shown below (Fig. 1a and 1b). Major components of the assembly include wires, solder, screws, plastic washers, heat sink, and a thermal interface material (TIM) in addition to the emitter on MCPCB. Secondary optics such as reflectors, collimators or other lens systems may be mounted on top of the MCPCB to shape the light beam. The mounting of secondary optics is not part of this note.

Recommended mounting of MCPCB with emitter on to heat sink includes:

- Thermal interface material (such as Gap Pads) between MCPCB and heat sink.
- High temperature (such as polycarbonate or glass-filled nylon) and rigid (like polycarbonate) plastic washers between pan-head screws and MCPCB.

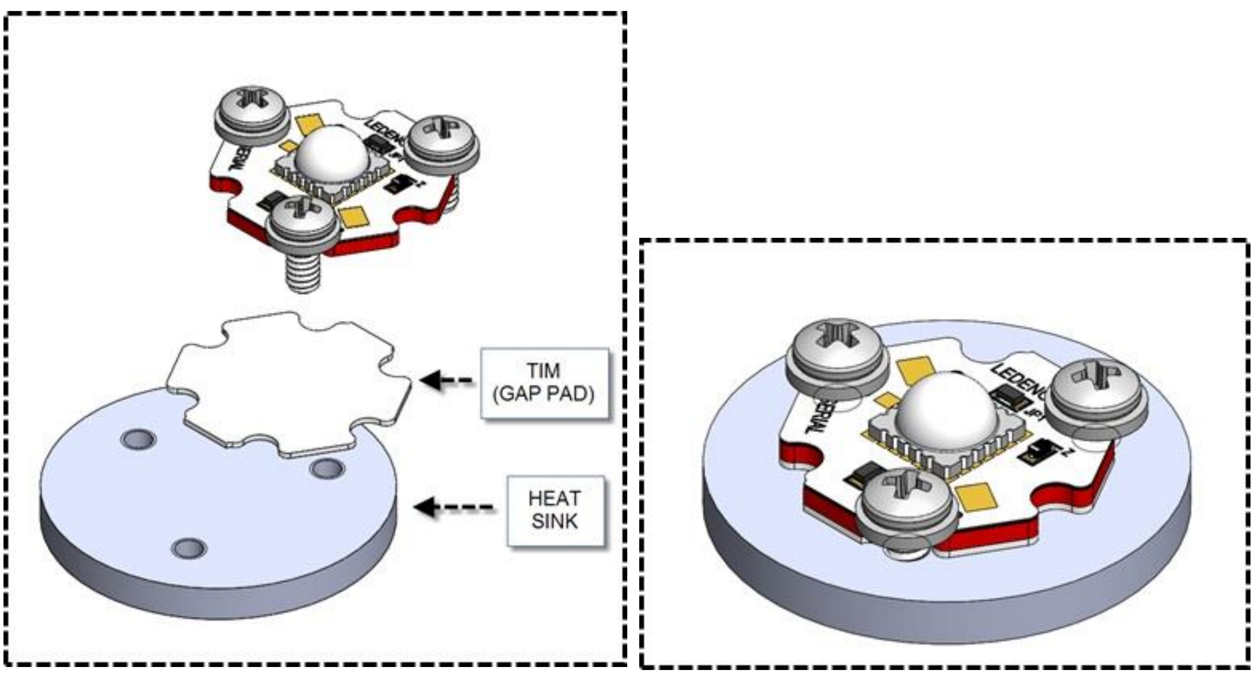

Fig. 1a: Reference assembly drawing of LZ9 and typical "star" shaped MCPCB

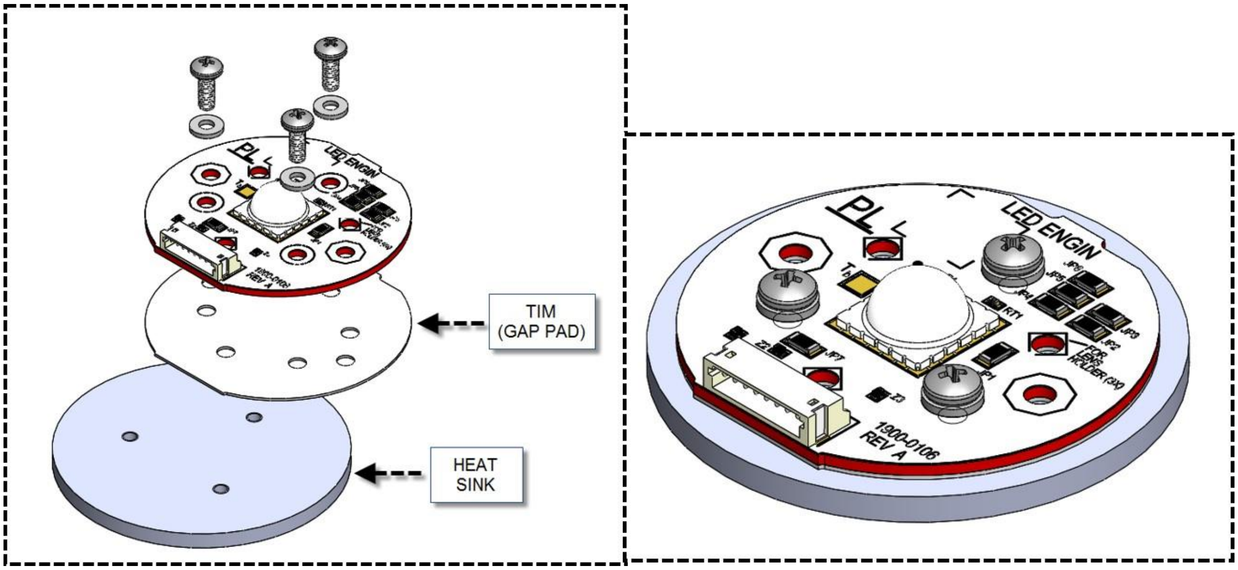

Fig. 1b: Reference assembly drawing of LZP and typical "round" MCPCB

Chemical Compatibility

Manufacturing processes and materials used in the assembly of the LuxiGen emitter into the lighting system affect the performance and reliability of the lighting system. Safe handling and use of appropriate material are therefore important. Chemicals used in the assembly process with the emitters should be evaluated for potential interactions and some chemicals should be avoided or carefully managed.

All LuxiGen emitters feature a glass dome or flat lens on top of the die. For emitters with glass dome lens, there is a silicone layer between the die and the domed lens. Since silicone is permeable to gas molecules like volatile organic compounds (VOCs), halogens and sulfur compounds, these chemicals can interact with silicone and the emitter encapsulation. This can cause degradation in the performance of the emitter. The rate and location of degradation in the emitter may vary depending on the type and concentration of the chemical, the temperature and duration of exposure. Silicone is also vulnerable to non-polar fluids. Solvents commonly used during cleaning, oil assisted drilling and other aspects of the manufacturing process of the lighting system can be sources of contaminants as well. Any process that allows the emitter to come in contact with such fluids or solvents should be minimized and controlled.

Materials used inside a luminaire with a potential to outgas should be identified and each component's chemical composition reviewed as part of the luminaire design process. This helps to create a non-reactive environment surrounding the emitter. Some sources of out-gassing contaminants are polymers present in glues, gaskets, paints and insufficiently-cured materials. IP rated or "sealed" luminaires that create an "air tight environment" can trap potentially damaging contaminants resulting in long term exposure of the emitter to these contaminants.

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Table 1: Commonly used chemicals not compatible with silicone

Classification	Chemical Name	Found In Some
Organic solvents	Ethers such as glycol ether	Cleaners, mineral spirits, petroleum, paint, gasoline
	Ketones such as MEK, MIBK	
	Aldehydes such as formaldehyde	
Organic acids	Acetic acid	RTV silicones, cutting fluids, degreasers, adhesives
Low Molecular Weight Organics (VOCs)	Acetates	Superglue, Loctite adhesives, thread lockers and activators, common glues, conformal coatings
	Acrylates	
	Aldehydes	
	Dienes	
Petroleum oils	Liquid hydrocarbons	Machine oil, lubricants
Non-petroleum oils	Siloxanes, fatty acids	Silicone oil, lard, linseed oil, castor oil
Aromatic solvents	Xylene	Cleaners
	Toluene	
	Benzene	
Acids	Hydrochloric acid	Cleaners, cutting fluids
	Sulfuric acid	
	Nitric acid	
	Phosphoric acid	
Bases	Sodium hydroxide	Detergents, cleaners
	Potassium hydroxide	
	Amines	
Oxidizers/Reducers	Sulfur compounds	Gaskets, paints, sealants, petroleum byproducts
Halogen compounds	Cl, F, or Br containing organic and inorganic compounds	Solder flux/paste, flame-retardants

Table 1 lists some common chemicals known to be harmful to silicone - the list is a guideline and not meant to be exhaustive. Lighting system manufacturers are responsible for understanding and managing the chemical compatibility of LuxiGen emitters in their design and assembly process.

Handling

Emitters on MCPCB are packaged for volume shipment in closed stackable trays (Fig. 2). LED Engin recommends wearing finger cots or gloves when manually removing the units from the trays to prevent dirt or other contaminants from adhering to the emitter's optical surface (Fig. 3). Parts may also be handled with tweezers. If handling the emitters with tweezers, select tweezers with rounded tips and grip the MCPCB by the edges away from the solder pads (Fig. 4).

Fig. 2: Emitters on MCPCB shipped in trays

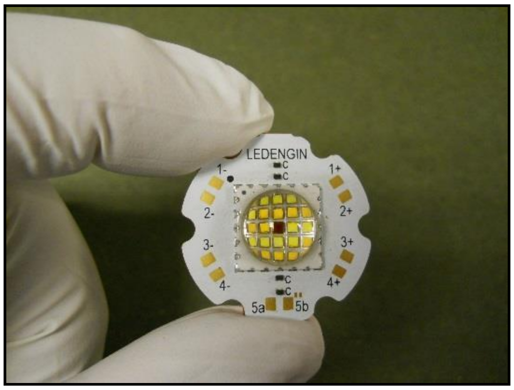

Fig. 3: Proper handling of emitter with gloves on

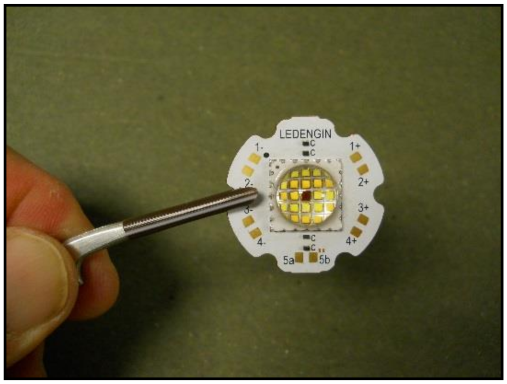

Fig. 4: Proper handling of emitter using tweezers

Although use of a clean room is not mandatory, the assembly environment should be free of dust and particulates. If debris contacts or adheres to the optical area, gently remove it using the tip of a cotton swap soaked in isopropyl alcohol (rubbing alcohol). LED Engin also recommends using appropriate ESD grounding procedures while handling the emitters and MCPCBs with emitters to prevent inadvertent ESD damages.

Emitters are optical devices. Applying too much stress to the optical area can result in damage to the emitter. If pick-and-place equipment is used for automated assembly, the vacuum collet should be designed to avoid contact with the optical area of the LED emitter. Secondary optics and reflectors must not be mounted in contact with or pressed against the emitter optical area. Secondary optical devices may be mounted on the top surface of the MCPCB outside of the LED ceramic substrate. The mechanical features such as MCPCB edges and mounting holes can be used to secure the optical device as needed.

Soldering Wires

Equipment and Materials

1. Soldering Iron

LED Engin recommends the use of a soldering iron with precision temperature control and flat solder tip, similar to the Weller WTCPT (60 Watt Temperature Controlled Soldering Station) or models with higher power than 60W. Many similar soldering systems are commercially available.

2. Solder Flux

Solder flux is typically applied using a flux applicator. The flux applicator may be a bottle with a thin needle tip, a thin brush, or a flux pen with a fine tip. Flux is a cleaning agent used to remove metal oxides from metal surfaces being soldered together. Using the flux as recommended by the solder manufacturer is essential. Water soluble or self-cleaning flux facilitates easy removal of excess flux after the soldering process by simply cleaning with water rather than other chemicals, which may be a source of contaminants. If a non-water-soluble or non-self-cleaning flux is used, cleaning with isopropyl alcohol and a lint free cotton swab is suggested.

3. Stranded Copper Wire

Wire gauge for each application is design dependent. Electrical designer is responsible for selecting the wire gauge that meets all codes and regulatory requirements for the lighting system. Typical considerations include selecting a suitable wire that enables specific voltage drop across the wire (driver operation related), temperature requirements (safety code related), insulating material requirements (safety code related), and flexibility requirements (wire routing related).

After wires are cut to size, they should be stripped to remove a few millimeters of insulating material at the ends for soldering. The stripping should be appropriately gauged to prevent bare wires from touching the copper MCPCB and inadvertently creating current paths (leading to shorting). The general rule of thumb is that the stripped wire dimension is no longer than the size of the solder pad on the MCPCB minus 1 to 2 mm.

4. Solder

The selection of solder is design dependent. Small diameter solder wires, 0.040 inch or 1mm, are easier to use, but larger diameter solder wires may be needed for thicker lead wires. LED Engin recommends using lead free solders (e.g. SnAg) for environmental protection, with high flux content. Solder selection is based on factors like reliability (thermal fatigue and corrosion), melting temperature (support solder profile in LED emitter datasheet), wettability, strength and reactivity with other components. Table 4 lists a sampling of solders and their melting temperatures.

Table 4: Solder types and associated melting points

Solder	Melting Point	RoHS Compliant
SnAg	217 to 220°C	YES
$SnBi_{58}$	138°C	YES
$SnIn_{52}$	118°C	YES

5. Temperature Controlled Hot Plate

Due to the very low thermal resistance of the emitter on MCPCB, heat is quickly dissipated from the solder pad during soldering. This implies that a longer solder iron contact time is needed. One way to do this is to place the emitter on MCPPCB on a temperature controlled hot plate. The temperature setting of the hot plate should always be kept substantially lower (20° to 30°C lower) than both the melting point of the solder and the pre-heating zone max temperature as listed in the solder reflow profile in the emitter datasheet (150°C for most of the LuxiGen emitters).

6. Flux Cleaner

If there is a need to clean the emitters to remove excess solder flux, LED Engin recommends using isopropyl alcohol or deionized water and a clean cotton swab.

Soldering Process

Safety and operating guidelines provided by the soldering station manufacturer should be strictly followed at all times.

1. Pre-tin the tip of the soldering iron and the tip of the wires with a small amount of solder. As noted in the emitter datasheet Reflow Soldering Profile section, the temperature of the tip of the soldering iron should not exceed the Peak Temperature in the Reflow Zone at all times, and the soldering iron maximum temperature should preferably be set at 20° to 30°C below.
2. Clean the emitter solder pads. If the solder pads are heavily oxidized due to improper storage, rub the oxidized pad with a pencil eraser to remove oxidation. Use isopropyl alcohol to remove non-polar compounds and other contamination.
3. If not already provided with pre-tinned solder pads, pre-tin the MCPCB solder pads. To pre-tin the solder pads use the following process:

    a. Place the emitter on MCPCB on a hot plate whose temperature is set to 20° to 30°C below the Reflow Zone max temp or the melting point of the solder selected whichever is lower (i.e. 120 – 130 °C for SnAg solder).
    b. Apply a small amount of flux onto the solder pads of the MCPCB (Fig. 8). Flux should be applied only to the solder pads and should not touch other parts of the MCPCB or emitter, especially the light emitting region.
    c. Hold the soldering iron tip on the solder pad, allowing the pad to reach the temperature at which the solder wets and flows.
    d. Apply solder to the solder pad and solder tip, allowing sufficient time for the solder to wet. The solder should form a domed shape on the solder pad.
    e. Allow the pre-tinned solder pad to cool.
    f. Remove excess flux from the solder pad using isopropyl alcohol, allow the pad to dry.

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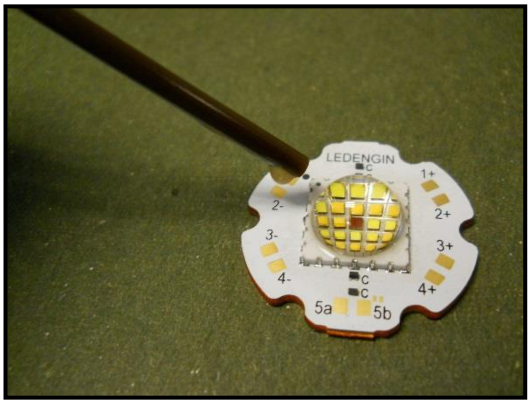

Fig. 8: Dispensing flux onto MCPCB solder pad

4. Solder the pre-tinned wires onto solder pads using the process below.

   a. Pre-tin the tip of the soldering iron.
   b. Pre-tin the striped wire tip
   c. Place the pre-tinned emitter on MCPCB on a hot plate which temperature is set to 20 - 30°C below the melting point of the selected solder or 150°C whichever is lower.
   d. Place the pre-tinned wire tip on the pre-tinned solder pad.
   e. Place the hot tip of the soldering iron on top of the wire tip. Bring the solder wire to the area just below the solder tip (Fig. 9). Only a small amount of solder is necessary to form a joint. After the solder melts and while holding the wire in place, quickly remove the soldering iron to prevent the formation of icicles. Signs of an overheated solder joint include solder spike formations and burnt flux residue. If these signs are observed, consider reducing the solder time or the soldering iron temperature. The process of soldering wires to the MCPCB should take just a few seconds. The maximum time that the soldering tip should contact the MCPCB solder pad and wire is 3 to 5 seconds.
   f. Allow the solder joint to cool.
   g. Remove excess flux from the MCPCB using Isopropyl Alcohol, allow to dry.
   h. A pull test on the wire can be used to ensure the integrity of the solder joint.

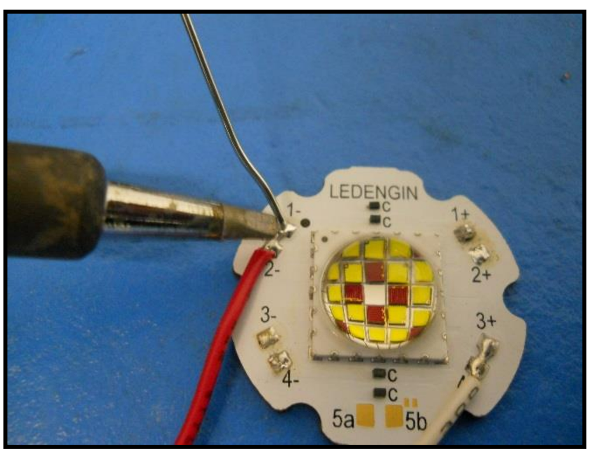

Fig. 9: Soldering a pre-tinned wire to a pre-tinned solder pad

Thermal Interface Material

A thermally conductive thermal interface material (TIM) is required when mounting the MCPCB on to the heat sink to properly transfer heat from LED emitter to heat sink. There are different types of such material such as thermal paste, thermal pads, phase change materials and thermal epoxies. Bergquist's Gap Pad 5000S35 and 3M's 5590H are some of the commercially available TIM recommended by LED Engin. In order to ensure an effective thermal interface between the TIM and the heat sink, LED Engin recommends that heat sink surfaces are specified to maintain a flatness tolerance of 0.1 mm and a surface roughness tolerance, Ra 125 μin (3.2 micron) or finer. Thermal management designer should verify the TIM's thermal resistance to be sufficient for the selected emitter on MCPCB and its operating conditions.

Phase Change materials may also be used as TIM, but users should pay attention to the feature of the material that the MCPCP may needed to be re-torque (loosen and re-tighten) after the first heat/thermal cycle or the thermal interface may not be properly set for optimal condition.

Thermal grease can also be another TIM technology employed, but do not use silicone oil based thermal grease as there are concerns about the grease drying out under long term high temperature operating conditions. And when applying thermal grease to the MCPCB, the thermal grease selected should be viscous enough to support at least a 5 mil thick bond line and flows well enough to cover the entire bottom face of the MCPCB.

Mechanical Assembly

LuxiGen emitter MCPCBs are provided with holes or slots to facilitate mounting with screws. A wide variety of screws are commercially available to meet design requirements. LED Engin recommends M3 or #4-40 (#4) pan head screws for all MCPCBs used. Typical screw head diameters range from 5.2 to 6.0 mm. When selecting a screw, consider one that has a low profile screw head. A low profile screw head has the advantage of blocking less of the light emitted from the emitter. Additionally, a low profile screw head allows more room for the optical components if a secondary optic is to be used in the application. Please refer to the mechanical drawings included in the emitter datasheet for additional information regarding the location of the slots and holes for mounting of secondary optics.

Mechanical mounting of MCPCB

MCPCB bending should be avoided as it will cause mechanical stress on the emitter, which could lead to substrate cracking and subsequently LED emitter failing.

To avoid MCPCB bending:
- Special attention needs to be paid to the flatness of the heat sink surface and the torque on the screws.
- Table 5 lists screw or slot diameter, required mounting screw size, and maximum torque based on MCPCB size and base material used.
- Care must be taken when securing the MCPCB to the heat sink. This can be done by tightening three M3 screws (or #4-40) in steps and not all the way through at once. Using fewer than three screws will increase the likelihood of board bending.
- Plastics washers are recommended in combinations with the three screws.
- If non-tapped holes are used with self-tapping screws, it is advised to back out the screws slightly after tightening (with controlled torque) and then re-tighten the screws again.

For hexagonal star MCPCBs, the recommended screw locations are illustrated in Figure 10. The recommended screw locations for all other products are the 3.2 mm diameter holes or the 3.2 mm wide slots indicated in the mechanical drawings section of the relevant product datasheet.

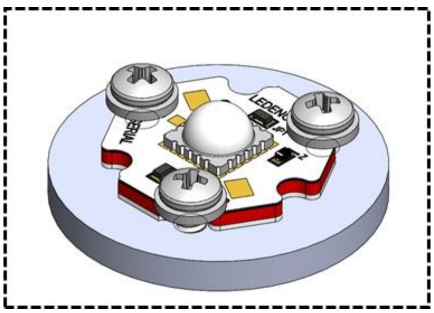

Fig. 10: Recommended screw locations for hexagonal star Emitters

When mounting the MCPCB to a heat sink, ensure that the proper torque is applied to the screws. The maximum torque that may be applied to mounting screws for each emitter on MCPCB is specified in the product datasheet. Excessive torque may result in damage to the emitter’s ceramic substrate. Torque required has to do with the choice of thermal pad material. The torque range recommended in the emitter product datasheets are based on thermal pad similar to Bergquist Gap Pad 5000S35 which are typically 10 to 20 mils thick, toughness rated 35 by Shore test method and stiffness rated to Young’s Modulus of 17.5psi. After assembly the bottom of the screw head should be parallel to the top surface of the MCPCB. It is the responsibility of the user to ensure that the recommended maximum torque values are not exceeded.

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Washers, Fasteners and Thread Sealants

To prevent loosening of screws during vibration or thermal cycling LED Engin recommends using lock washers, self-locking fasteners, or thread sealants (like Loctite's 222 or 243 thread lockers). Soft non-electrically conductive flat washers are recommended for use with all products. Non-conductive washers installed between the fastening screw and the MCPCB reduces the risk of electrical shorts (which can be caused by mounting screw electrically connecting the solder pads or traces in the MCPCB to the heat sink). The maximum outer diameter (OD) of washers that may be used with LuxiGen emitters on MCPCB is shown in Table 5.

In high temperature environments (heat sink temperature greater than 75°C/167°F but less than 100°C/212°F) use polycarbonate type washer. Example of polycarbonate washer (source: McMaster) for #4 screw is shown below.

Plastic Washers

These plastic washers are good electrical insulators.

Polycarbonate washers are more rigid than most plastic washers for high impact resistance. They have good moisture resistance and withstand oil, greases, and detergents.

CAD For technical drawings and 3-D models, click on a part number.

For Screw Size	ID	OD	Thick.	Temperature Range, °F Min.	Temperature Range, °F Max.	Hardness	Color	Pkg. Qty.	
Polycarbonate Plastic									
No. 4	0.115"	0.250"	0.027"-0.037"	Not Rated	212°	Rockwell R75	Clear	100	90940A005

In normal temperature environments (heat sink temperature less than 75°C/167°F) nylon washers are acceptable. Example of a nylon washer (source: McMaster) for #4 screw is shown below.

Plastic Washers

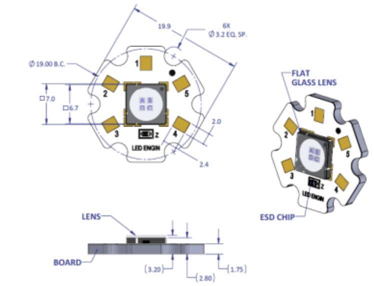
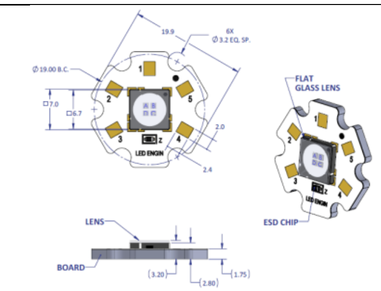
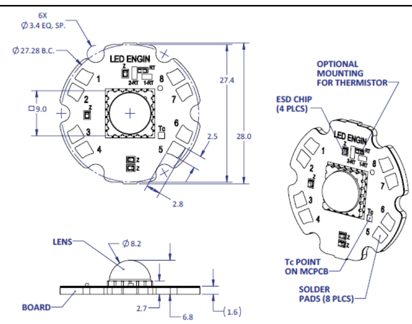
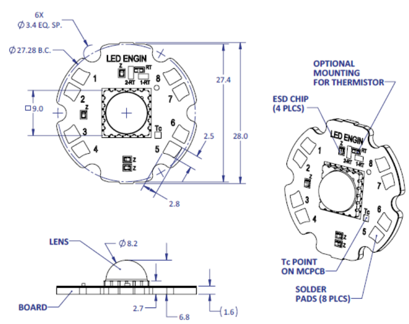
These plastic washers are good electrical insulators.

Nylon washers are stronger than polycarbonate and UHMW washers. Exposure to moisture may cause them to expand.

CAD For technical drawings and 3-D models, click on a part number.

For Screw Size	ID	OD	Thick.	Temperature Range, °F Min.	Temperature Range, °F Max.	Hardness	Choose a Color	Pkg. Qty.	
Nylon Plastic									
No. 4	0.115"	0.250"	0.057"-0.067"	-40°	180°	Rockwell R115	Black, Off-White	100	90295A345

Table 5: Screw sizes, washer sizes, and mounting screw hole tolerances

MCPCB Series (nominal dimensions)		**Slot or Screw Hole Diameter**	**Required Mounting Screw Size**[1]	**Recommended Torque** [2]
Standard Star Copper based MCPCB Series (19 - 20 mm dia)		3.2 mm	M3 or #4-40	20 to 25 oz-in (1.25 to 1.56 lbf-in or 0.14 to 0.18N-m) using Bergquist Gap Pad 5000S35
Standard Star Aluminum based MCPCB Series (19 -20 mm dia)		3.2 mm	M3 or #4-40	20 to 25 oz-in (1.25 to 1.56 lbf-in or 0.14 to 0.18N-m) using Bergquist Gap Pad 5000S35
Large Star Copper based MCPCB Series (27 - 28 mm dia)		3.4 mm	M3 or #4-40	20 to 25 oz-in (1.25 to 1.56 lbf-in or 0.14 to 0.18N-m) using Bergquist Gap Pad 5000S35
Large Star Aluminum based MCPCB Series (27 - 28 mm dia)		3.4 mm	M3 or #4-40	20 to 25 oz-in (1.25 to 1.56 lbf-in or 0.14 to 0.18N-m) using Bergquist Gap Pad 5000S35

Design Resources

Included below are some publicly available design resources that may be useful for manufacturing engineers working with LED emitters. These resources are not LED Engin approved or qualified. Designers should fully qualify and validate the selected components and assembly processes used in their lighting system design to meet all the regulatory and safety code requirements.

Wire Gauge Current Ratings

https://www.engineeringtoolbox.com/wire-gauges-d_419.html

Mounting Screws, Washers, Lock Washers, and Self Locking Fasteners

www.longloklocking.com/products

www.nord-lock.com

www.nylok.com

References for Soldering Processes and Procedures

Soldered Electrical and Electronic Assemblies

http://www.ipc.org/committee/drafts/5-22a_d_J-STD-001F-Feb2012.pdf

Solderability Tests

http://www.ipc.org/committee/drafts/5-23b_d_002d_Proposed_for_ballot.pdf

Requirements for Soldering Fluxes

http://www.ipc.org/toc/ipc-j-std-004b.pdf

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About LED Engin

LED Engin, an OSRAM business based in California's Silicon Valley, develops, manufactures, and sells advanced LED LED Engins, optics and light engines to create uncompromised lighting experiences for a wide range of entertainment, architectural, general lighting and specialty applications. LuxiGen™ multi-die LED Engin and secondary lens combinations reliably deliver industry-leading flux density, upwards of 5000 quality lumens to a target, in a wide spectrum of colors including whites, tunable whites, multi-color and UV LEDs in a unique patented compact ceramic package. Our LuxiTune™ series of tunable white lighting modules leverage our LuxiGen LED Engin and lenses to deliver quality, control, freedom and high density tunable white light solutions for a broad range of new recessed and down-lighting applications. The small size, yet remarkably powerful beam output and superior in-source color mixing, allows for a previously unobtainable freedom of design wherever high-flux density, directional light is required. LED Engin is committed to providing products that conserve natural resources and reduce greenhouse emissions.

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