LUXEON H

Assembly and Handling Information for High Voltage (100V and 200V) LEDs

Introduction

This application brief addresses the recommended assembly and handling procedures for LUXEON® H 100V and 200V emitters. The LUXEON H is a high voltage emitter, which delivers high efficacy in an easy-to-use, screw-down package. LUXEON H facilitates assembly in space-constrained applications such as GU10 or A19 retrofit bulbs, decorative and consumer luminaires, and high voltage track lighting. Proper assembly, handling, and thermal management, as outlined in this application brief, ensure high optical output and long lumen maintenance for LUXEON H emitters.

Scope

The assembly and handling guidelines in this application brief apply to the following LUXEON H products:

- LUXEON H 100V
  (LXV8-PWxx-0014)
- LUXEON H 200V
  (LXV8-PWxx-0024)

Any assembly or handling requirements that are specific to a subset of LUXEON H products is clearly marked. In the remainder of this document the term LUXEON H emitter refers to any product in the LUXEON H 100V and 200V product family.

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1. Component

1.1 Description

The LUXEON H emitter consists of a 2x2 array of high voltage LED chips mounted onto a ceramic substrate to facilitate assembly and handling. The ceramic substrate ensures a good thermal path between the LEDs and the heat sink on which the LUXEON H emitter is mechanically mounted. An electrical interconnect layer connects the LED chips to a cathode and anode on the top of the ceramic substrate (Figure 1). The ceramic substrate is overmolded with a silicone dome to enhance light extraction and to shield the chip array from the environment. The bottom of the ceramic substrate contains a serial number and a 2D barcode which is unique for each emitter. The LUXEON H emitter contains two circular fiducial marks.

The LUXEON H emitter comes in a 100V and 200V configuration to accommodate operation with 100V, 120V and 230V AC line voltages. The LUXEON H emitter does not include a transient voltage suppressor (TVS) to protect the emitter against electrostatic discharges (ESD). However, ESD test results indicate that the 100V and 200V LUXEON H configurations pass ±2kV HBM and ±4kV HBM ESD tests, respectively. In addition, ESD test results indicate that both LUXEON H configurations pass the ±400V MM ESD test.

1.2 Optical Center

The LUXEON H emitter contains two feature sets to locate the theoretical optical center:

1. Topside fiducials
   The fiducial marks on the ceramic frame of the LUXEON H emitter provide the most accurate methodology to locate the theoretical optical center. The theoretical optical center is in the middle of the virtual line going through the center of the fiducials (see Figure 2).
2. LED outline
   The theoretical optical center is located 7.25mm from the edge of the LUXEON H emitter.

Optical rayset data for LUXEON H is available on the Philips Lumileds website at www.philipslumileds.com and www.philipslumileds.cn.com.

1.3 Handling Precautions

The LUXEON H emitter is designed to maximize light output and reliability. However, improper handling of the emitter may damage the silicone overmold and affect the overall performance and reliability. In order to minimize the risk of damage to the silicone overmold during handling, LUXEON H emitters should only be picked up from the ceramic substrate with a pair of tweezers and not from the lens as shown in Figure 3.

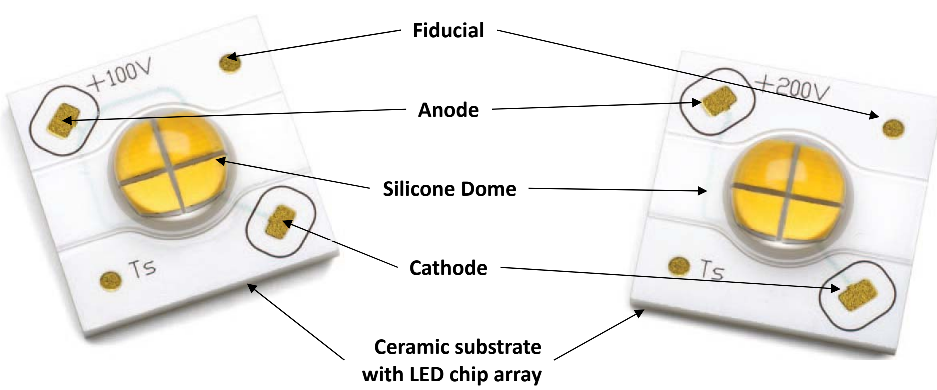

Figure 1. 3D rendering of LUXEON H emitter.

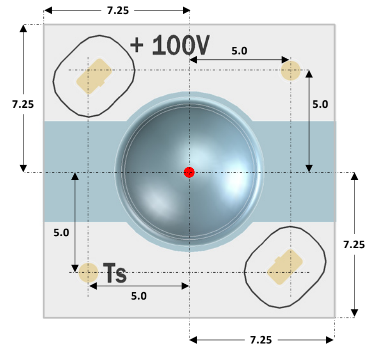

Figure 2. Fiducial marks on the top of the LUXEON H emitter provide the most accurate method to locate the theoretical optical center. The two corner cut-outs near the fiducials are designated for M3 screws to secure the LUXEON H emitter onto a heat sink. All dimensions in mm.

1.4 Cleaning

A LUXEON H 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 H 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 lens. Do not use other solvents as they may adversely react with the LED assembly. For more information regarding chemical compatibility, see Section 4.

1.5 Electrical Isolation

The ceramic substrate of the LUXEON H emitter electrically isolates the bottom of the emitter from the LED cathode and anode.

1.6 Mechanical Files

Mechanical drawings for LUXEON H (2D and 3D) are available on the Philips Lumileds website at www.philipslumileds.com and www.philipslumileds.cn.com.

1.7 Soldering

LUXEON H emitters are designed to be mechanically secured onto a heat sink. Electrical wires may have to be soldered onto the electrodes. For detailed assembly instructions, see Section 2.

2. LUXEON H Assembly Process

This section provides guidelines on how to assemble a LUXEON H emitter onto a heat sink and how to electrically connect to the LUXEON H emitter.

2.1 LUXEON H TE Connectivity LED Holder

LUXEON H emitters are designed to be directly mounted onto a heat sink, facilitating the design and assembly of fixtures

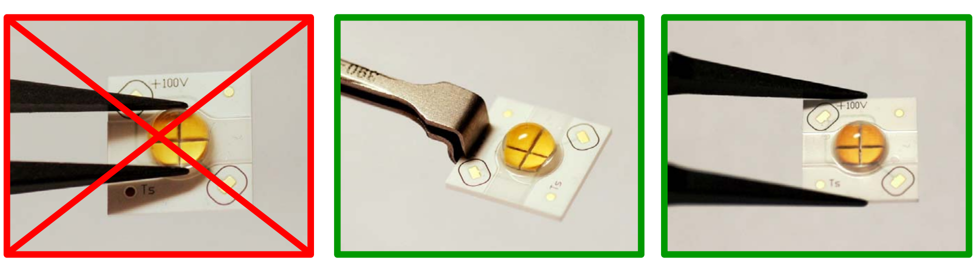

Figure 3. Incorrect handling (left) and correct handling (middle and right) of LUXEON H emitters.

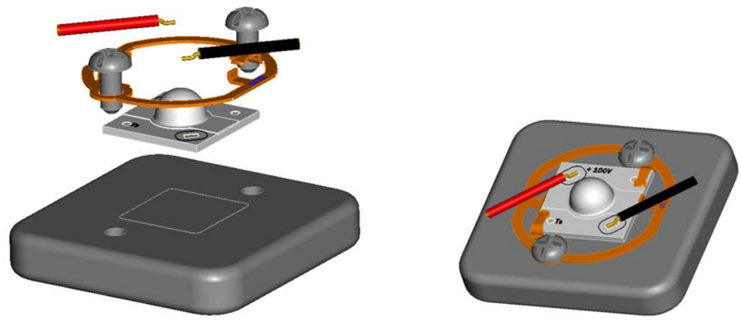

Figure 4. The LUXEON H emitter can be mechanically and thermally secured onto a heat sink with the TE Connectivity LED Holder, Type LH.

with the LUXEON H emitter. TE Connectivity[1] offers a special LUXEON H solderless LED Socket from, which can be used to electrically, mechanically and thermally secure a LUXEON H emitter onto a heat sink, see Figure 4. Using two screws, the TE holder secures the LUXEON H emitter to the heat sink thereby providing a thermal and mechanical connection to the LUXEON H. Figure 5 provides some relevant reference dimensions of the TE Connectivity LED Holder, Type LH. Figure 6 provides a reference layout and dimensions of the holes that need to be drilled into the heat sink to align and secure the LUXEON H emitter with the TE Connectivity LED Holder, Type LH. Basic performance information for the TE Connectivity LED Holder, Type LH is summarized in Table 1.

The Type LH holder is designed and manufactured by TE Connectivity and may be subject to change without notice. The assembly information for the Type LH holder discussed in this document is for reference only. For the latest up-to-date information on the Type LH holder, visit http://www.te.com/catalog/pn/en/2154821-1. Philips Lumileds provides no warranty of any kind with respect to the Type LH holder.

[1] TE Connectivity, TE Connectivity (logo) and TE (logo) are trademarks of the TE Connectivity Ltd family of companies.

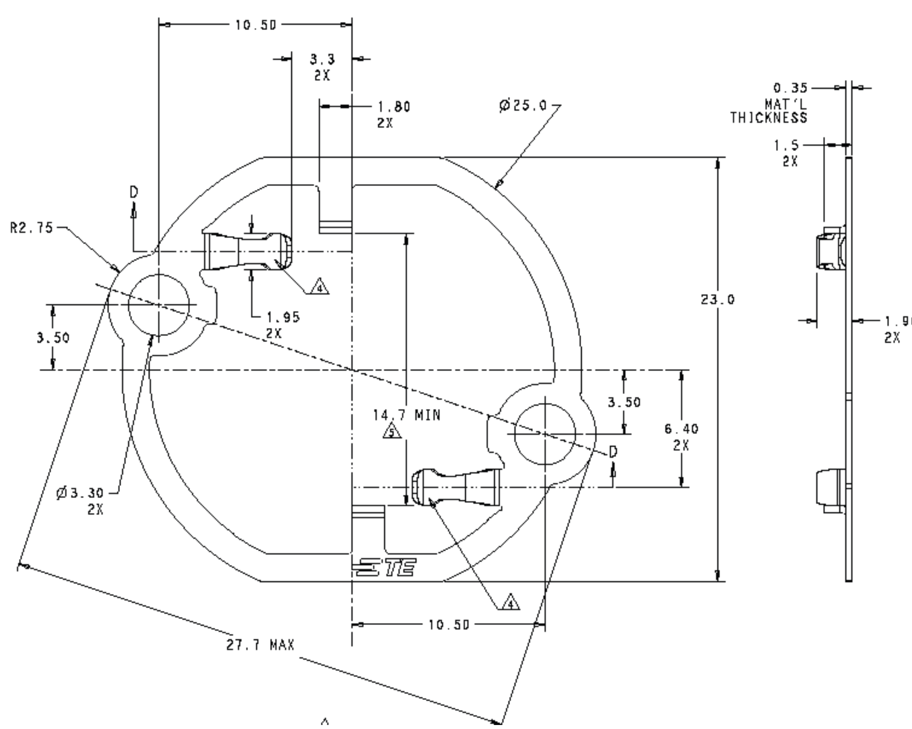

Figure 5. Reference dimensions for the TE Connectivity LED Holder, Type LH. All dimensions are in mm.

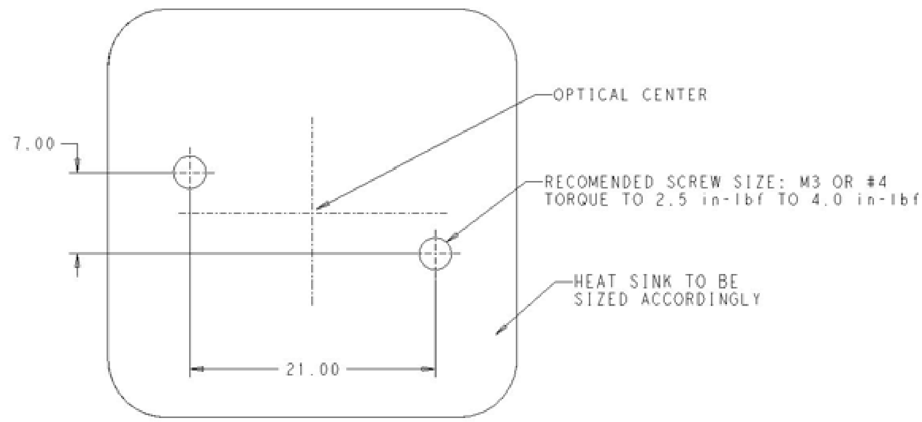

Figure 6. Reference layout and dimensions of the holes that need to be drilled into the heat sink to align and secure the LUXEON H emitter with the TE Connectivity LED Holder, Type LH. All dimensions are in mm.

Table 1. Basic performance for the TE Connectivity LED Holder, Type LH.

Operating Temperature Range	-40 to 110°C
Maximum thermal interface material thickness	0.25mm
Minimum LED clamping force	14.0N with a 0.13mm thick thermal pad
Mounting screw size	M3 or #4 screw with a 5.50mm head diameter
Recommended mounting screw torque	0.3 to 0.5 kgf-m
Material	Stainless steel
Environment Compliance	RoHS and REACH

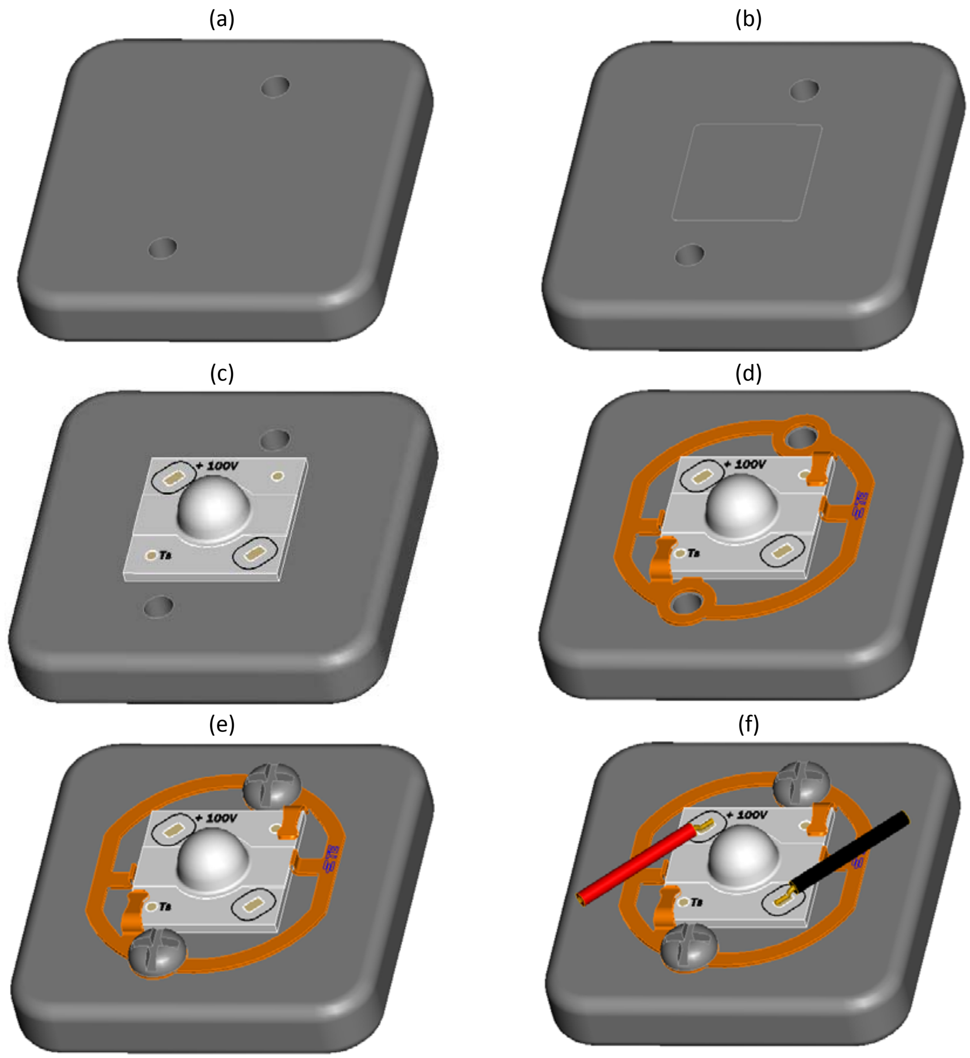

Figure 7. Assembly Guidelines for the LUXEON H emitter on a heat sink with the TE Connectivity LED Holder, Type LH.

2.2 Assembly Process

Follow these steps to mount the LUXEON H emitter on a heat sink with the TE Connectivity LED Holder, Type LH (see also Figure 7):

1. Prepare the heat sink
    a. Ensure that the heat sink surface is clean and flat (≤ 25um, with no crowns or peaks in the mounting area).
    b. Drill and tap the holes as per Figure 6 and wipe the heat sink surface clean with IPA (Figure 7a).
    c. Apply a thermal interface material (TIM) on the LED area (Figure 7b).
2. Place the LUXEON H on the heat sink, paying attention to the location of the electrical pads (Figure 7c).
3. Place the TE Connectivity LED Holder over the LUXEON H Emitter and heat sink mounting holes and align the screw holes in the LED Holder with the pre-drilled screw holes in the heat sink (Figure 7d).
4. Secure the LED Holder onto the heat sink with two M3 or #4 screws. The screw down torque should be in the range of 0.3 to 0.5 kgf-m (Figure 7e).
5. Solder wires to the electrical pads of the LUXEON H emitter, as discussed in Section 2.3 (Figure 7f). Note: Due to the high thermal conductivity of the LUXEON H substrate and/or the heat sink, it may be easier to solder wires onto the LUXEON H emitter before it is mounted onto the heat sink, depending on the final product configuration.

2.3 Soldering Process for Electrical Wires

The electrical pads of the LUXEON H emitter are gold plated to facilitate electrical contact through spring contacts in an electro-mechanical clamp. In the absence of an electro-mechanical clamp with spring contacts, wires can be directly soldered onto the LUXEON H emitter. The following supplies are needed to do so:

- Soldering iron, capable of reaching 350°C
- Stranded or solid copper wire – 24 gauge or larger
- Low-flux Sn96Ag4 solder wire
- Hot-plate, capable of reaching 100°C/212°F (optional)

Follow these steps to attach the electrical wires to the LUXEON H emitter:

1. Prepare the electrical wires:
   a. Cut the wires to size.
   b. Strip a few millimeters of insulating material from the ends of the wires.
   c. Pre-tin the wires with a small amount of solder.
2. Prepare the LUXEON H emitter:
   a. Clean the electrical pads of the LUXEON H emitter with a lint-free swab and IPA to remove any debris or particles.
   b. The ceramic substrate of the LUXEON H emitter is designed to dissipate heat quickly. This may make it difficult to get the temperature of the electrical pads to a point where the solder will reflow. Therefore it is important to place the LUXEON H emitter on a thermally insulating surface. Alternatively, place the LUXEON H emitter on a pre-heated hot plate set to 100°C/212°F.
   c. Place the tip of the soldering iron on the electrical pad, apply solder and allow it to wet the electrical pad. Do not place the soldering iron on the electrical pad for more than 3 seconds to prevent any damage to the LUXEON H emitter.
3. Solder the pre-tinned wires to the pre-tinned electrical pads:
   a. Place the pre-tinned LUXEON H emitter on a thermally insulating surface. Alternatively, place the LUXEON H emitter on a pre-heated hot plate set to 100°C/212°F.
   b. Place the pre-tinned wire on the pre-tinned electrical pad.
   c. Place the tip of the soldering iron on the electrical pad and allow the solder to reflow around the wire. Do not place the soldering iron on the electrical pad for more than 3 seconds to prevent any damage to the LUXEON H emitter. If a solder joint cannot be established within this time, allow the LUXEON H emitter to cool before reapplying the heat.
   d. Remove the soldering iron and allow the solder to joint to cool.

3. Thermal Management

3.1 Thermal Interface Materials (TIM) Selection

Due to the low thermal resistance of the LUXEON H emitter and its large thermal footprint, a variety of thermal interface materials can be used to thermally connect the emitter to the heat sink (e.g. phase change materials, thermal tapes, graphite sheets). However, TIM selection should be made with the following considerations:

1. Pump out—Some TIMs will move out of the thermal path during extreme temperature excursions and create voids in the thermal path. These materials should not be used.
2. TIM thickness—Excessive thickness of some TIMs will present an unacceptable thermal resistance even though the thermal conductivity may be high. Also, a thick TIM that doesn't completely cover the area of the LUXEON H ceramic substrate may cause a fulcrum, making the ceramic substrate subject to fracture stress. Therefore, it is best to minimize the thickness of the TIM to 5 mils or less.
3. Surface roughness—In order to fill the air gaps between adjacent surfaces, choose the appropriate TIM that minimizes the interfacial contact resistance.
4. Operating temperature—Some TIMs perform poorly at elevated temperatures. Care should be exercised to select a TIM that will perform well under the anticipated operating conditions.
5. Out-gassing—Out-gassing of some TIMs at design temperatures may produce undesirable optical or appearance qualities (e.g. fogging) in a sealed system. Special consideration must be given to limit this effect.
6. Clamping force—TIMs such as thermal tape or pads perform better when the right pressure is applied.

3.2 Thermal Measurement Guidelines

The typical thermal resistance $R\theta_{j\text{-}case}$ between the junction and the bottom of the LUXEON H emitter is 2.8K/W. With this information, the junction temperature T_j can be calculated according to the following equation:

$$T_j = T_{case} + 2.8 \bullet P_{electrical}$$

In this equation T_{case} is the temperature of the bottom of the LUXEON H ceramic substrate and $P_{electrical}$ is the electrical power going into the LUXEON H emitter.

In typical applications it may be difficult, though, to accurately measure the case temperature T_{case} directly. Therefore, a practical way to determine the junction temperature of the LUXEON H emitter is by measuring the temperature of the T_s point which is clearly marked on the ceramic substrate of the LUXEON H emitter (see Figure 1).

The thermal resistance $R\theta_{j\text{-}s}$ between the circular fiducial and the junction of the LUXEON H emitter was experimentally determined to be 2.6K/W. The junction temperature can then be calculated as follows:

$$T_j = T_s + 2.6 \bullet P_{electrical}$$

3.3 Thermocouple Attachment Guidelines

This section describes in detail how to mount a thermocouple onto the LUXEON H emitter in order to determine the junction temperature T_j.

Supplies and Equipment

Below is a list of supplies and equipment that is needed for T_j measurements:

- Type T precision fine wire (0.003" gauge diameter) thermal couple from Omega Engineering Inc. (part number: 5SRTC-TT-T-40-36)

- Eccobond one component, low temperature curing, thermal conductive epoxy adhesive from Emerson and Cuming (part number: E 3503-1) or Arctic Alumina Thermal Adhesive compound from Arctic Silver Inc. (part number: AATA-5G)
- Disposable 3CC barrel syringe from EFD Inc. (part number 5109LL-B)
- Disposable 0.016" inner diameter fine needle tip from EFC Inc. (part number:5122-B)
- Kapton tape
- Convection oven (for curing of Eccobond epoxy)
- Thermometer
- Magnifying glass or low power microscope (e.g. 5x to 30x)

Thermocouple Mounting Procedure

1. Familiarize yourself with the manufacturer's Material Safety Data Sheet (MSDS) and preparation procedures for the epoxy or adhesive compound.
2. Place the thermocouple tip on one of the two circular fiducials of the LUXEON H emitter. The thermocouple must touch the substrate of the LUXEON H emitter to ensure an accurate reading.
3. Use Kapton tape to secure the thermocouple wire onto the LUXEON H emitter.
4. Follow step a or b below depending on the compound or adhesive that is used to thermally connect the thermocouple to the LUXEON H emitter.
   a. Eccobond Thermal Adhesive Epoxy
      i. Thaw the thermal conductive epoxy per manufacturer's recommendations.
      ii. Dispense sufficient epoxy into the 3CC barrel syringe with the fine needle tip. Store the balance per manufacturer's recommendations.
      iii. Drop a small amount of thermal conductive epoxy just enough to cover the thermocouple tip.
      iv. Cure the epoxy per the manufacturer's recommendations. Make sure that the oven temperature does not exceed the maximum rated temperature of the LUXEON H emitter.
      v. Let the board cool down to room temperature before starting any measurements.
   b. Arctic Alumina Thermal Adhesive compound
      i. Since this is a two part epoxy system with an approximate pot-life at room temperature after mixing of 3-4 minutes, make sure that proper setup is done to ensure that the epoxy can be dispensed within the pot-life span.
      ii. After mixing, put the epoxy immediately into the 3CC barrel syringe with the fine needle tip and dispense onto the thermocouple tip. Close to the end of the pot-life, it becomes difficult to dispense.
      iii. Alternatively, you can dip the fine needle tip into the epoxy mix and then "touch" the thermocouple tip to dispense the epoxy via surface tension.
      iv. Cure the epoxy at room temperature (25°C) for at least two hours.
5. Once the epoxy/compound has hardened, the LUXEON H emitter can be mechanically mounted onto the heat sink as explained in Section 2.
6. Plug in the thermocouple connector to the thermometer. The thermocouple now measures the temperature T_s.
7. Connect the power supply to the LUXEON H emitter and power up the emitter with a drive current that corresponds to normal operating conditions. If possible, attach all fixtures (e.g. heat sink, lens and any cover) to closely simulate the actual application environment.
8. Record the temperature T_s once the LUXEON H emitter stabilizes. This may take several minutes or more depending on the overall design and thermal mass.
9. The junction temperature can then be estimated as explained in Section 3.2.

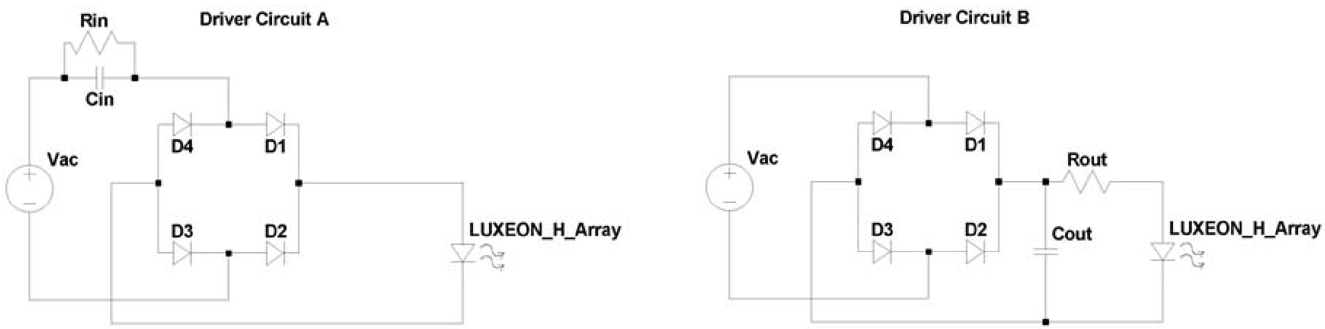

Figure 9. Two driver configurations for LUXEON H Array, each with passive components only.

4. LUXEON H Driver Configurations

4.1 Introduction

High brightness LEDs are typically powered by a driver which regulates the current. However, certain illumination applications (e.g. candle bulbs, GU10) are too space- and/or cost-constrained to accommodate a fixed-current driver. In those applications it can be desirable to use a very compact driver circuit with passive components only which can be plugged directly into the standard AC power line. Due to its high operating voltage, the LUXEON H is well suited for these space-constrained lighting applications which can only accommodate simple driver electronics. This section discusses several voltage regulated driving schemes for LUXEON H that can be directly powered with standard 120V and 230V AC line voltages.

4.2 Dimensioning Guidelines

To help with the design-in of LUXEON H emitters, two driver circuits, each containing only passive components, were simulated and dimensioned in SPICE[2]. Figure 9 shows the topology of the two driver circuits. The bridge rectifier prevents any reverse bias over the LUXEON H while the resistor and capacitor are used to limit the current through the LUXEON H. Driver Circuit A uses a capacitor C_{in} and a resistor R_{in} in parallel before the bridge rectifier while Driver Circuit B uses a capacitor C_{out} and a resistor R_{out} in parallel and in series, respectively, with the LUXEON H. Depending on the nominal voltage of the LUXEON H, the circuit is powered by a 120V 60Hz or a 230V 50Hz AC line voltage. The objective of this simulation study is to assess the following performance characteristics as function of the capacitor and resistor values used in the circuit:

1. RMS current through the LUXEON H (I_{rms})
2. Average LED power consumption (P_{LED})
3. Electrical efficiency of the driver circuit $\left(\frac{P_{LED}}{P_{electrical}}\right)$
4. Power Factor $\left(\frac{P_{electrical}}{I_{rms} \cdot V_{rms}}\right)$
5. Electrical Ripple $\left(\frac{I_{fmax} - I_{fmin}}{I_{rms}}\right)$

[2] SPICE (Simulation Program with Integrated Circuit Emphasis) is a general-purpose analog circuit simulation program. An LED SPICE model provides a compactly describtion of the typical relationship between the drive current I_f and the forward voltage V_f of an LED.

Figure 10 - Figure 13 show the simulated performance characteristics for Driver Circuits A and B, each in combination with a 100V or 200V LUXEON H emitter. The simulation results in these figures are based on typical I_f-V_f performance curves for LUXEON H at T_j = 85°C. Actual performance may vary for individual LUXEON H LEDs.

Each figure contains five two-dimensional graphs, corresponding to the five performance metrics specified above. Each individual graph shows the expected performance as function of the resistor value (horizontal axis, in kΩ) and capacitor value (vertical axis, in μF) used in the circuit. It is important to note that different combinations of capacitor and resistor values may yield the same performance metrics. For example, the top left graph of Figure 10 shows the simulated RMS drive current through a 100V LUXEON H emitter when combined with Driver Circuit A. Reading from the graph, an RMS drive current of ~ 50 mA can be obtained with many different combinations (R_{in} , C_{in}), including (R_{in} = 1kΩ, C_{in} = 1.5μF) or (R_{in} = 5kΩ, C_{in} = 1.9μF). Once a suitable (R_{in}, C_{in}) combination is selected, one can read the other (simulated) performance metrics from the remaining graphs. Continuing the previous example, (R_{in} = 1kΩ, C_{in} = 1.5μF) is expected to yield a driver efficiency of ~ 68% while (R_{in} = 5kΩ, C_{in} = 1.9μF) is expected to yield a driver efficiency of ~ 83%.

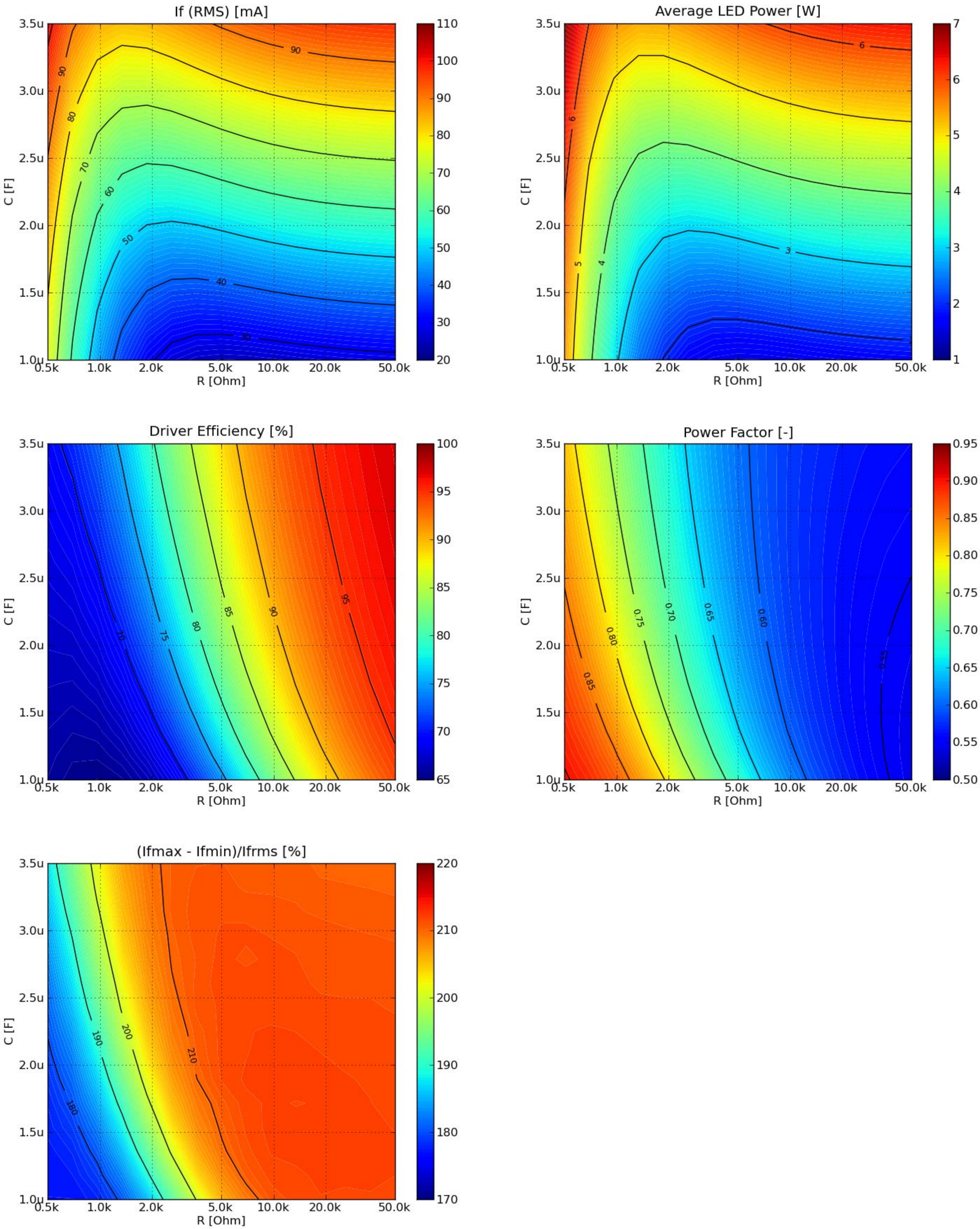

Figure 10. Simulated performance metrics for LUXEON H 100V in Driver Circuit A as function of R_{in} and C_{in} (V_{ac} = 120V, 60Hz).

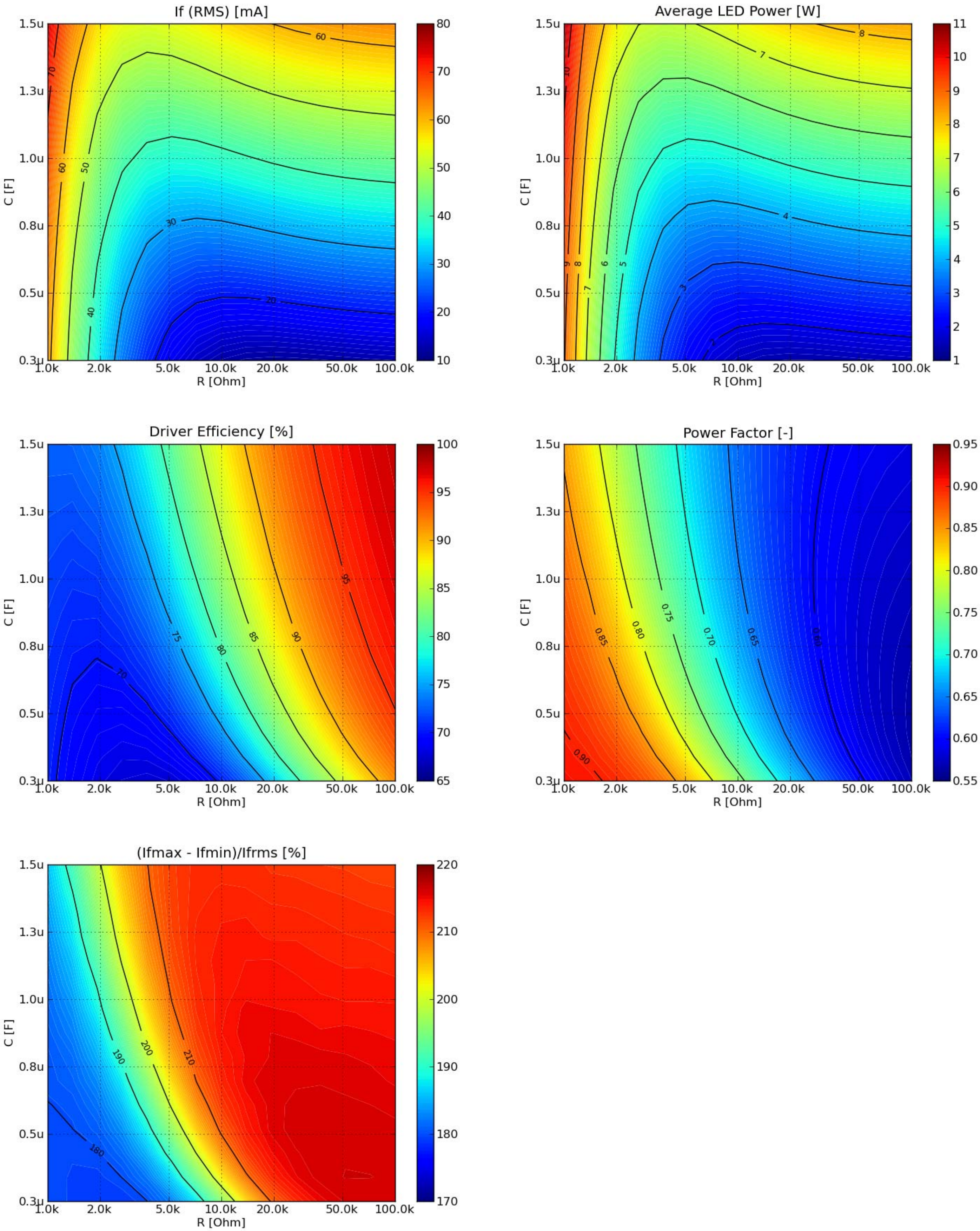

Figure 11. Simulated performance metrics for LUXEON H 200V in Driver Circuit A as function of R_{in} and C_{in} (V_{ac} = 230V, 50Hz).

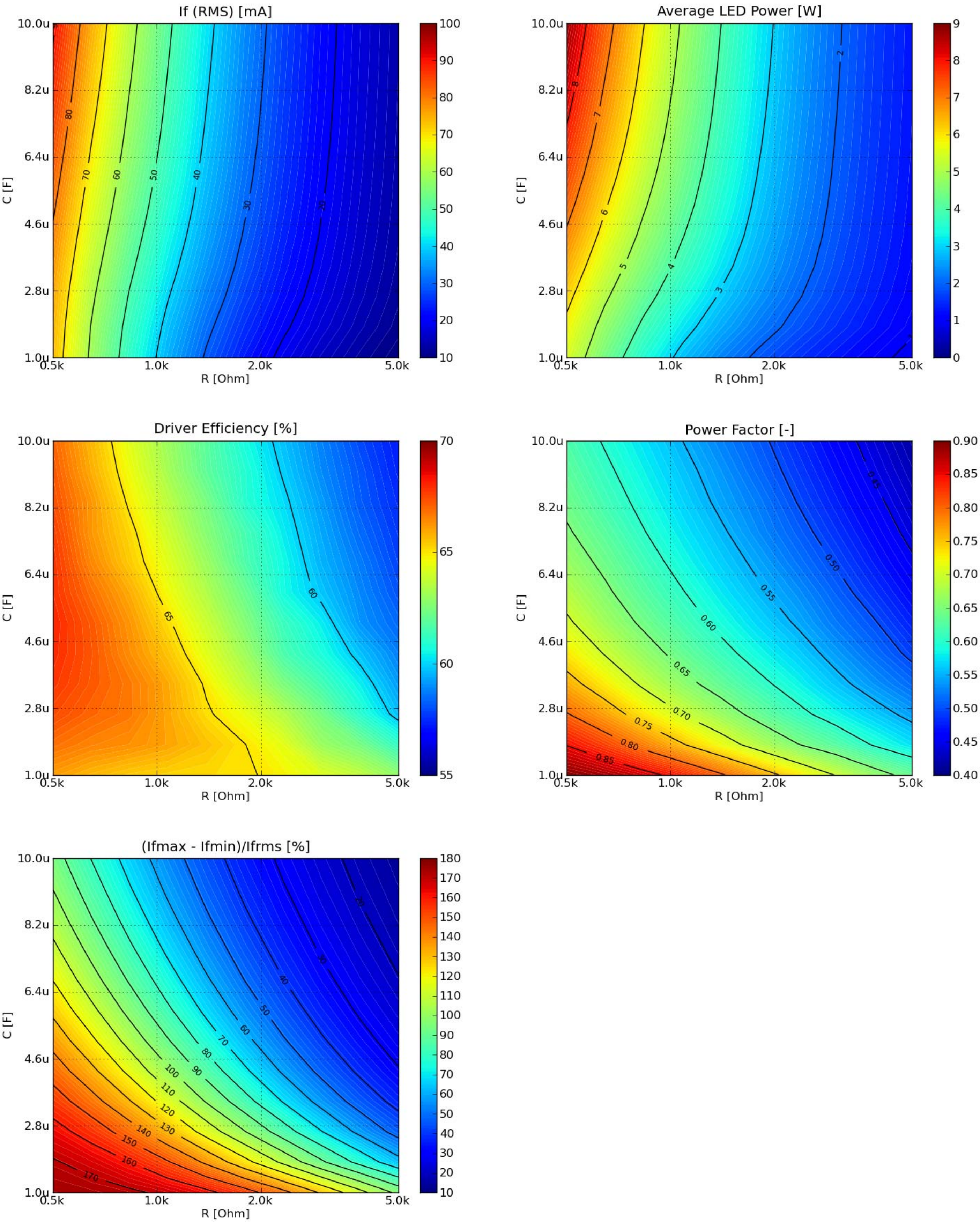

Figure 12. Simulated performance metrics for LUXEON H 100V in Driver Circuit B as function of R_{out} and C_{out} (V_{ac} = 120V, 60Hz).

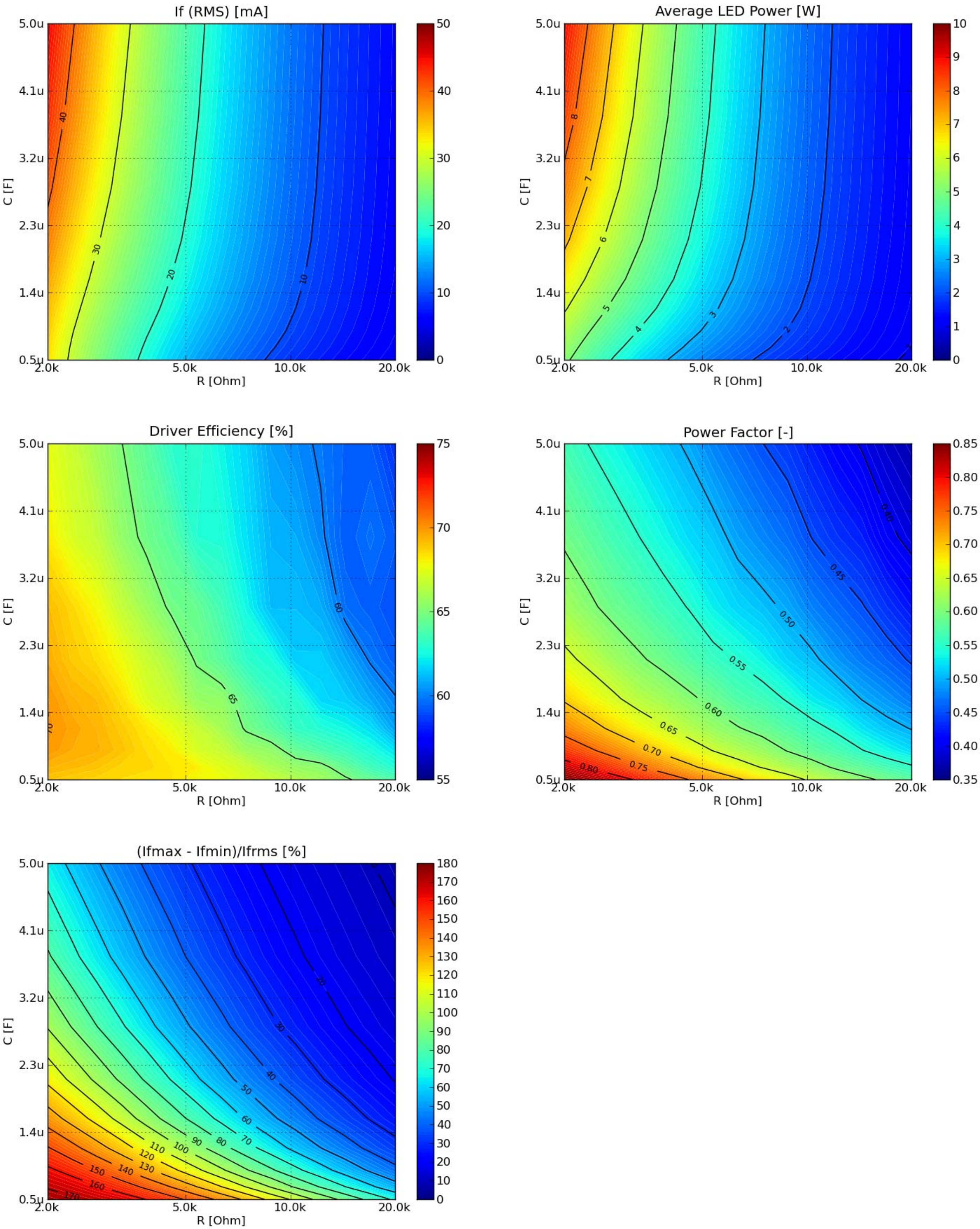

Figure 13. Simulated performance metrics for LUXEON H 200V in Driver Circuit B as function of R_{out} and C_{out} (V_{ac} = 230V, 50Hz).

5. Product Packaging Considerations – Chemical Compatibility

The LUXEON H emitter contains a silicone overcoat and dome to protect the LED chips 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 in LUXEON H 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 H 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 dome. Under heat and "blue" light, the VOCs inside the dome 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 dome 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 H LEDs. 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 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 dome of the LUXEON H 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
tetracholorometane	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

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Who We Are

Philips Lumileds focuses on one goal: Creating the world's highest performing LEDs. The company pioneered the use of solid-state lighting in breakthrough products such as the first LED backlit TV, the first LED flash in camera phones, and the first LED daytime running lights for cars. Today we offer the most comprehensive portfolio of high quality LEDs and uncompromising service.

Philips Lumileds brings LED's qualities of energy efficiency, digital control and long life to spotlights, downlights, high bay and low bay lighting, indoor area lighting, architectural and specialty lighting as well as retrofit lamps. Our products are engineered for optimal light quality and unprecedented efficacy at the lowest overall cost. By offering LEDs in chip, packaged and module form, we deliver supply chain flexibility to the inventors of next generation illumination.

Philips Lumileds understands that solid state lighting is not just about energy efficiency. It is about elegant design. Reinventing form. Engineering new materials. Pioneering markets and simplifying the supply chain. It's about a shared vision. Learn more about our comprehensive portfolio of LEDs at www.philipslumileds.com.

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