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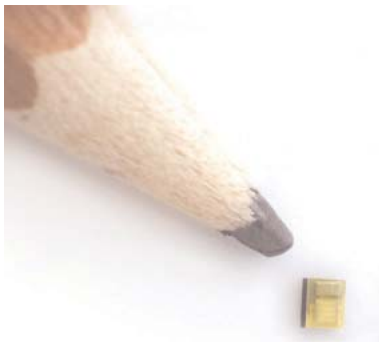
Luxeon Flash for Cell Phone Camera, PDA and DSC Applications

Introduction

The following reference design outlines the key considerations in the construction of a solid-state, high performance flash solution utilizing Luxeon® LED technology. This design integrates Lumileds high power Luxeon Flash product with a cost effective lens solution to provide the necessary light output and illumination pattern suited to digital still camera (DSC) and cell phone camera flash applications. An example of a Luxeon Flash implementation is described and the expected practical output performance is summarized.

Additional recommendations considering the mechanical design, thermal management and electronic drive circuitry are provided to assist rapid design and development of a functional camera flash solution for space-constrained applications such as cell phones and PDAs. Finally, the light output color spectrum of the Luxeon Flash is compared to requirements for expected use in combination with CMOS and CCD image sensors.



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Lumileds Lighting offers the Luxeon Flash for camera phone, PDA and DSC flash applications: Please consult the datasheet "DS49—Luxeon Flash" or Lumileds technical team for details and diagrams of this emitter type. The total design depth required for the Luxeon Flash System is less than 2.6mm in combination with the secondary lens. In this configuration Luxeon Flash produces significantly more light than conventional LED sources.

Mechanical Dimensions

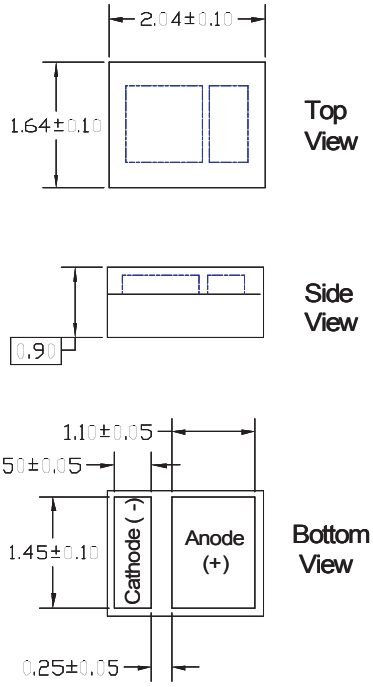


Figure 1. Luxeon Flash

Thermal Considerations

Luxeon Flash can perform the dual function of a camera flash and a continually operated torch/flashlight/view finding light. In order to ensure appropriate thermal design, each of these applications should be viewed separately.

Flash

To maximize the achievable distance and the light output for a flash application, Lumileds Lighting recommends pulsing the Luxeon Flash with DC current. The current peak pulse should not exceed 2000 mA. High current pulses of longer duration require thermal design to manage the heat produced. Table 1 describes the safe drive current and timing combinations practicable with the copper clad layout described in Figure 2.

Torch / Flashlight / View finding light

For Torch/Flashlight/View finding light applications, it is possible to operate the Luxeon Flash with a continuous DC current. Good thermal design practice ensures that the junction temperature does not exceed the maximum value (Luxeon Flash: $T_{j,max}$=150°C). Lumileds provides a general description of thermal management in Application Brief "AB05—Thermal Design using Luxeon Power Light Sources". Nonetheless, with the thermal design described in Figure 2, torch can be operated at 150mA maximum in steady state.

Table 1. Summary of Practical Pulsing Configurations with Typical Thermal Management.

	Flash Pulse Current			
Flash Pulse Duration	0.35A	0.6A	1A	2A
50 ms	OK	OK	OK	OK
100ms	OK	OK	OK	
200ms	OK	OK		
300 ms	OK			

OK — Signifies a transient temperature change of less than 40°C.

Temperature change > 40°C, may require additional thermal management

Assembly Considerations

Luxeon Flash is mounted on substrate by standard SMD processing. Because the available space inside a mobile device is highly constrained, Lumileds recommends mounting the Luxeon Flash directly to a FR4 or flex-circuit PCB. See Lumileds application brief on assembly considerations for Luxeon Flash parts. In order to minimize large variations in board temperature, Lumileds recommends placing a copper pad underneath the Luxeon Flash. This interface will help conduct and distribute any excess heat generated.

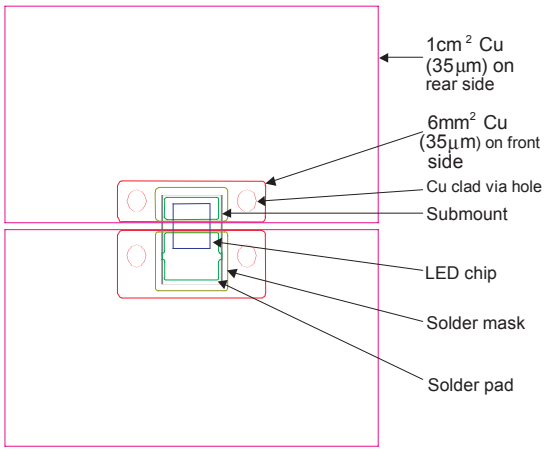


Figure 2. Suggested Typical Thermal Design Copper clad structure on PCB or Flex Circuit spreads heat from Luxeon Flash.

Electrical Considerations

The voltage supplied by a typical cell phone battery ranges from about 3V when discharged up to 4.2V when fully charged. However, the required forward voltage of Luxeon Flash can range from 3.2V to 4.8V at $T_{junction}$ = 25° and a pulse current of 1A.

Furthermore, during operation, this range can extend in both directions. Assuming the minimum Junction Temperature will be -40°C and the maximum +120°C during operation, the required forward voltage will range from 2.78V to 5.14V with a pulse current of 1A.

This chart illustrates that the battery voltage does not completely cover the required voltage range of the Luxeon. A regulating circuit is required to power the Luxeon Flash. Luxeon devices are current driven devices and their light output is proportional to the input current. The regulating circuit therefore needs to be a current source. The regulating circuit must perform as follows: it needs to drive the Luxeon with a defined current from the battery, which is a voltage source, and second it needs to regulate the voltage required by the Luxeon based on the desired current drive level and the charge level of the battery.

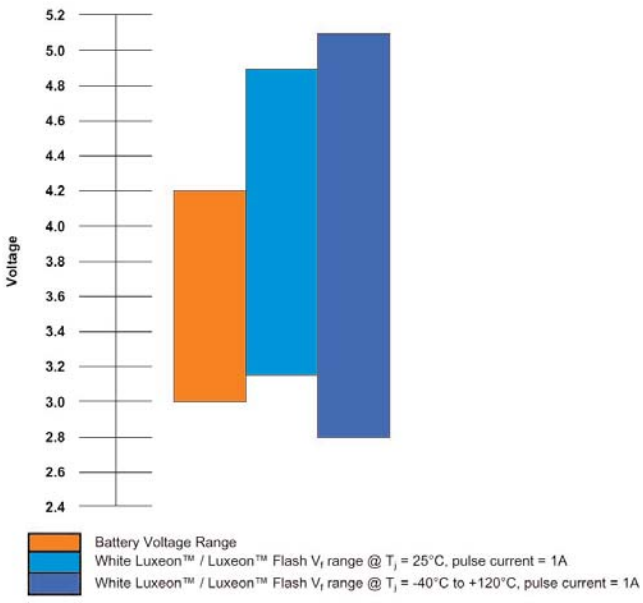


Chart 1. Battery Voltage vs. Luxeon Forward Voltage.

Following are two examples of feasible regulating circuit topologies to power the Luxeon in a flash application:

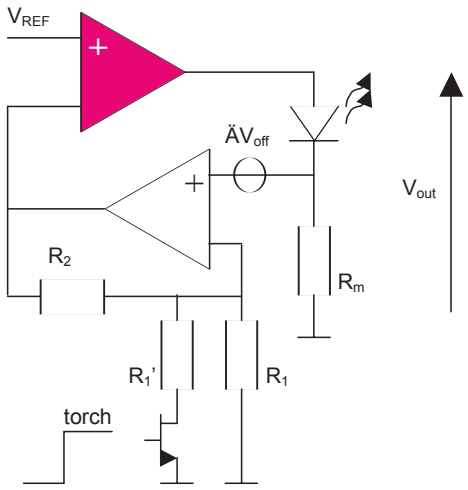


Figure 3. Buck / Boost Circuit Topology
This circuit topology contains the optimum functionality to power and control the Luxeon. It has Buck-Boost capability, a very high efficiency and a high level of accuracy determined by Voff.

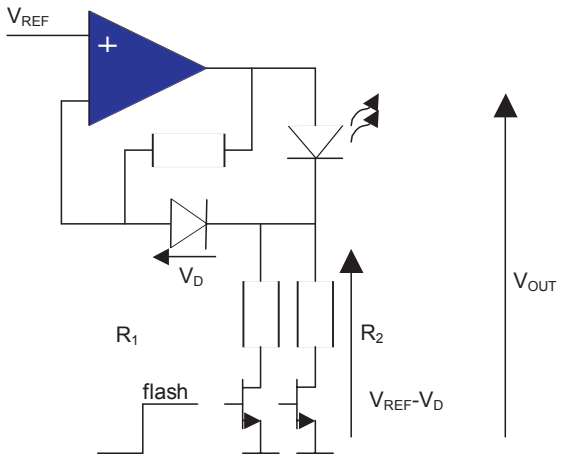


Figure 4. Boost Circuit Topology
This circuit topology provides good functionality to power and control the Luxeon. The efficiency of this circuit is lower than the Buck-Boost equivalent but it requires only one Operation Amplifier. However, because this is a Boost only circuit, the circuit has to contain features to ensure proper operation if the forward voltage of the Luxeon is below the battery voltage.

The two circuits above are examples of Luxeon Flash drive circuits. Many IC suppliers are developing new products to fit the required needs for this kind of application. This includes charge-pump topologies to reduce the size of the circuit and to eliminate Electro Magnetic Interference (EMI) issues. Please consult application brief "AB28 - *Driver Integrated Circuits for Luxeon Flash Applications*" for up-to-date recommendations.

Chart 2. Operating Voltage of the Luxeon Flash at $T_{junction}$=25°C

Operating Voltage of the Luxeon Flash			
Current (mA)	Volts Min.	Volts Typ.	Volts Max
200	2.8	3.3	3.8
350	2.8	3.4	4.0
700	3.0	3.7	4.4
1000	3.2	3.8	4.8

Optical Considerations (Radiation Pattern & Optical Secondary Lens)

In order to enhance the optical performance of the Luxeon Flash for camera phone applications, a secondary optic is required. Specifically, by placing a Fresnel lens in front of the Luxeon Flash, most of the generated light can be captured and redirected onto the camera image plane.

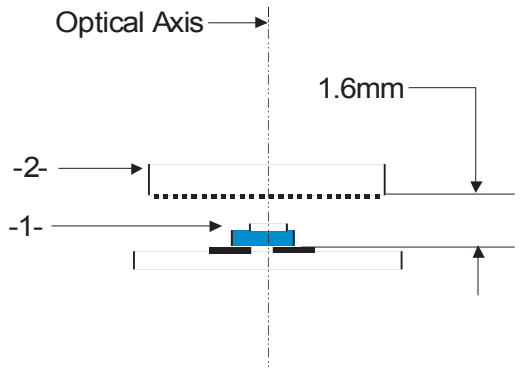
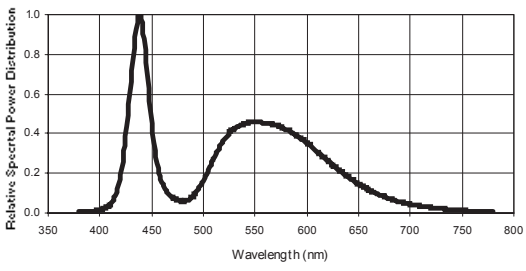


Figure 5. Optical system cross-section for Luxeon Flash with lens.

Image Sensor Requirements

In order to appropriately render the image in low ambient light, the image sensor must sense light from all visible wavelengths (approximately 380nm to 780nm). This is accomplished by using a light source (flash) with a comprehensive spectral distribution. If the light source has significant gaps in its spectral distribution, the result will be an image of poor color rendering.

The graph below depicts the spectral distribution of a white Luxeon Flash Device. As the diagram shows, Luxeon devices emit a comprehensive spectral distribution and therefore will enable image capturing with high color rendering in low ambient light.



Performance Results

Due to the refractive action of the Fresnel optic fixed in front of the Luxeon Flash, the structure described can focus a considerable fraction of the total light emitted into a total beam angle of 60 degrees.

The result, by powering Luxeon Flash at pulse current of 1000mA for 200ms, is that the lighting design illuminates up to 53 lux at a distance of one meter as shown below for a typical Luxeon Flash with lens.

Chart 3.

Measured Output of the Luxeon Flash Reference Design						
Part Number	Current (mA)	Light Output within 60° (lm)	Distance (m)	Peak Illuminance (lux)	Peak Intensity (cd)	Peak Beam Candle Power Seconds, BCPS (cds), (60° total viewing angle, 200ms pulse)
LXCL-PWF1	700	34	0.5 1.0 1.5 2.0	164 41 18 10	41	8.2
LXCL-PWF1	1000	43	0.5 1.0 1.5 2.0	211 53 24 13	53	10.6

The combination of the Luxeon Flash with the secondary optic Fresnel lens not only creates high illuminance values, but also a uniform illuminance distribution throughout the image field of the camera. The typical camera module has a viewing angle of about 56° x 44° that defines an image field of about 1.0m x 0.8m at a distance of 1.0m. Figure 6 shows how the Luxeon Flash Reference Design illuminates the image field uniformly. By shifting the lens closer to the Luxeon flash, more uniformity is obtained but the peak illuminance will be lower.

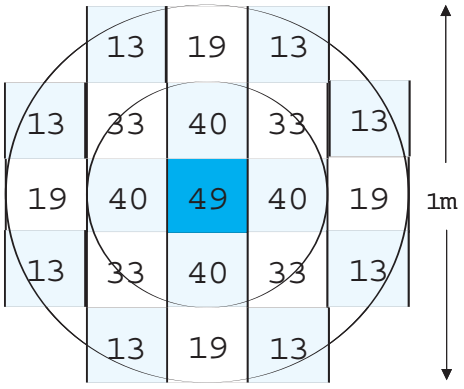


Figure 6. Average Distribution of Illuminance on Image Field.

Typical Illuminance Distribution of Luxeon Flash Reference Design at 1 meter distance. (1A pulse drive current)

The following parts compose the reference design discussed here.

Chart 4. Parts List (BOM)

Parts List (BOM)				
No.	Part Number	Part Description	Supplier	Contact
1	LXCL-PWF1	Luxeon Flash, Power LED light source	Lumileds Lighting	www.lumileds.com info@lumileds.com
2	IFX450-90	Fresnel lens, 8mm diameter, 1mm thickness	Philips Electronics (High Tech Plastics)	www.htp/philips.com
3		FR4 or Flex Printed Circuit Board	various	

Summary

Luxeon Flash Emitters, especially when coupled with a Fresnel optic, are practical for use as a light source for camera phones and digital cameras. The small overall size and the high light output capability, make the design (described in this document) unsurpassed compared to conventional LEDs when used as the flash source in combination with CMOS and CCD image sensors in a variety of products.

Luxeon sources also have significant flexibility compared to conventional camera flash sources. The Luxeon devices can be turned on and off in less than 1 microsecond intervals and precisely adjusted for specific durations offering the ultimate flexibility for optimizing sensor capabilities.

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Company Information

Luxeon is developed, manufactured and marketed by Lumileds Lighting, U.S., LLC. Lumileds is a world-class supplier of Light Emitting Diodes (LEDs) producing billions of LEDs annually. Lumileds is a fully integrated supplier, producing core LED material in all three base colors (Red, Green, Blue) and White. Lumileds has R&D development centers in San Jose, California and Best, The Netherlands and production capabilities in San Jose, California and Malaysia. Lumileds Lighting is a joint venture of Agilent Technologies and Philips Lighting and was founded in 1999. Lumileds is pioneering the high-flux LED technology and bridging the gap between solid-state LED technology and the lighting world. Lumileds is absolutely dedicated to bringing the best and brightest LED technology to enable new applications and markets in the Lighting world.

Lumileds may make process or materials changes affecting the performance or other characteristics of our products. These products supplied after such changes will continue to meet published specifications, but may not be identical to products supplied as samples or under prior orders.

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