APPLICATION NOTE

Design Considerations for ChromaLit Contour A19 and A21 Reference Designs

Introduction: This document provides an introduction to the Intematix ChromaLit 360, Contour, remote phosphor products used in high performance A19 and A21 LED retrofit lamps at incandescent equivalents of 60W, 75W, 100W, and 150W. LED retrofit lamp reference design details are discussed along with performance metrics. Design considerations for possible modifications are also reviewed here.

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General Description

The Intematix ChromaLit Contour provides Energy Star capable A lamp retrofit sources for 60W, 75W, 100W, and 150W incandescent equivalent power levels. These products all use a patented thermal management system from Intematix in combination with unique patented remote phosphor architecture. The ChromaLit contour design provides a robust, high performance, precision color quality source for LED retrofit lamp applications up to 150W incandescent equivalent at significantly lower input power and at equal lumen level.

The product outlines are shown in Figure 1 below. The 75W is A19 configured and the 100W and 150W reference is A21 configured. All products can be operated in base down or base up orientations due to the unique patent pending convective airflow design.

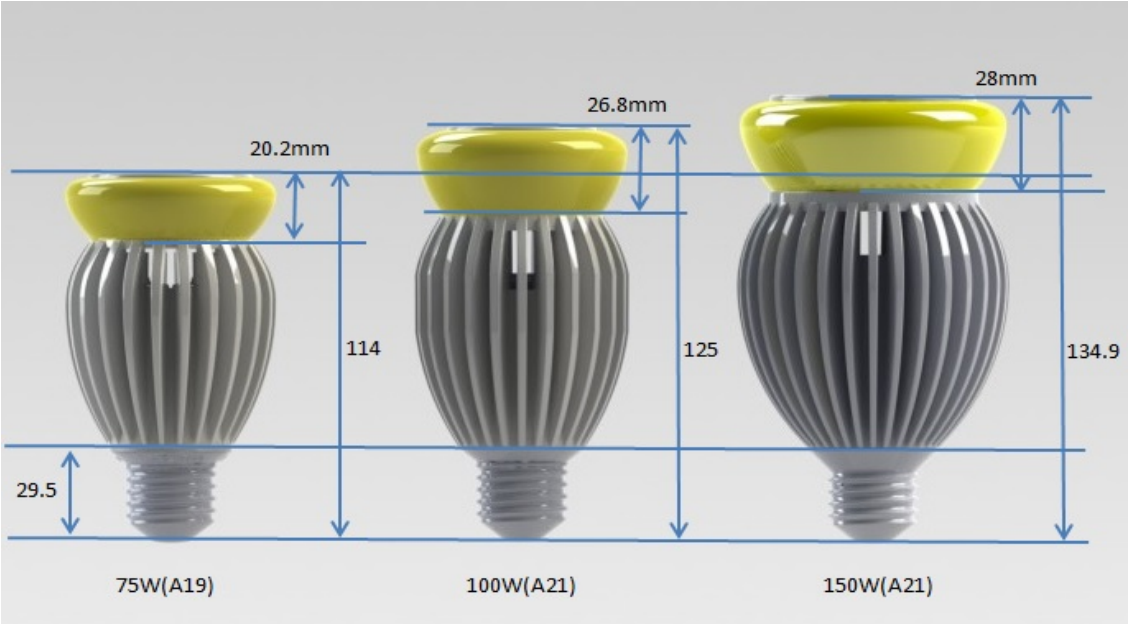


Figure 1 ChromaLit Contour Reference Design Outline Dimensions.

Design

Specifications

The specifications for the 3000K Contour lamp reference design are listed in Figure 2 below.

Wattage Equivalent	60W	75W	100W	150W
Bulb Shape	A19	A19	A21	A21
Minimum Lumen Output	>800	>1100	>1600	>2200
AC Wattage	11.5W	17W	25W	30W
Efficacy (Lm/W) min.	65	60	60	82
Min CRI	80	80	80	80
Dimmable	Yes	Yes	Yes	50/100/150 3-way

Figure 2 Contour reference design bulb performance specifications.

The standard color temperatures of ChromaLit Contour are 2700K, 3000K, and 5000K and the color point is within three SDCM (standard deviation of color matching) similar to all remote phosphor sources provided by Intematix. The table below shows the typical conversion efficacies for these three color temperatures in lumens per input LED blue watts.

For example, if the LED source produces 6.5 watts of blue optical power to the ChromaLit at 2700K/80CRI, the generated lumens would be a minimum of about 175x6.5=1138 lumens.

Product	CCT (K)	Color Consistency (SDCM)	Min CRI	Minimum Conversion Efficacy (lm/W_{rad}) at 25°C	Typical Conversion Efficacy (lm/W_{rad}) at 25°C
CL-827	2700	3	80	175	180
CL-927	2700	3	90	130	150
CL-830	3000	3	80	185	195
CL-930	3000	3	90	140	160
CL-850	5000	4	80	190	210

Figure 3 LED rays are shown in blue; down converted rays are shown in yellow

Thermal Management

The convective air flow and conductive heat flow patterns for ChromaLit Contour products are shown below. There are three main sources of heat generated in the reference design products. The driver, although highly efficient, will produce about 15-20% of its input AC power as heat. The LEDs, with about 50% WPE, will need to conduct approximately half of their input DC power in the form of conducted heat to the PCB and heat sinks. The ChromaLit remote phosphor generates heat through the down conversion process of the blue LED spectral output and the white light that is generated. This Stokes loss produces heat in the remote phosphor that must be cooled mainly through radiation and convection.

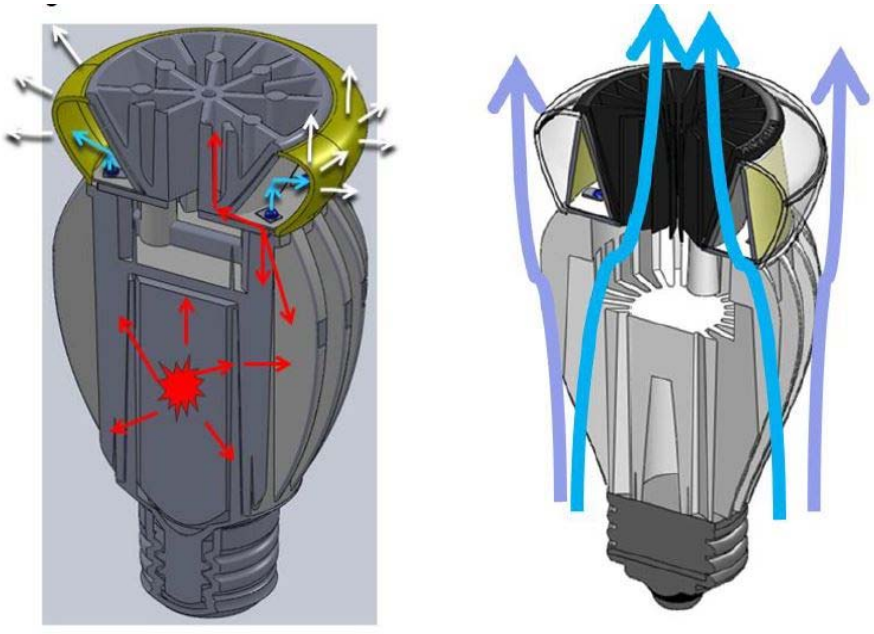


Figure 4 Heat and air flow patterns for the Contour design

Drivers

The driver used in the Contour 75W is the iWatt iW3612-03 series. The drivers are configured for 108-132VAC input and 24V output at 620ma. Power factor is above 0.7 and efficiencies are above 83%. The drivers are designed for a wide variety of dimmers using both leading and trailing edges. Please contact iWatt for further technical details for their driver reference designs if required.

The driver size is shown in Figure 5 below. The insulator shown in the exploded view Figure 8 has the internal volume to hold this driver, with side wall thickness of at least 1mm.

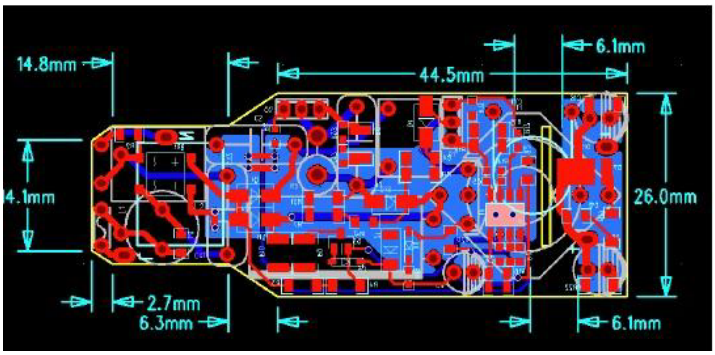


Figure 5 Driver dimensions

The insulator which houses the driver provides electrical isolation between the driver components and the electrically conductive heat sink. Further isolation is provided by the thermally conductive potting material described further below.

The insulator material chosen for the driver housing reference design is made by ProtoLab using their ABS/PC natural Cycoloy C2950-11 with color specified as bright white UN0005. The C2950 resin from Sabic is non-chlorinated, non-brominated flame retardant PC/ABS with a Vicat softening point of 112^{o}C per ASTM D1525 and relative temperature index (RTI) of 85^{o}C. The material has a flame rating of UL94-V0 at 1.49mm thick.

The driver is potted in the insulator housing using Sylgard 160 from Dow Corning. This is a material with moderately high thermal conductivity and excellent flow and cure properties. The material is UL tested and is flame retardant. It is a 2-part mix at 1:1 ratio and has an acceptable operating temperature range of -45^{o}C to 200^{o}C.

LED PCB

The Intematix Contour reference designs utilize a metal core PCB that is compression mounted to the heat sink when the top heat sink is torqued down. The PCB must have a suitable thermal interface material to reduce the thermal resistance between the LED PCB and heat sink.

26 gauge insulated lead wire is recommended for the driver to PCB connection and 24 gauge for driver to Edison screw base.

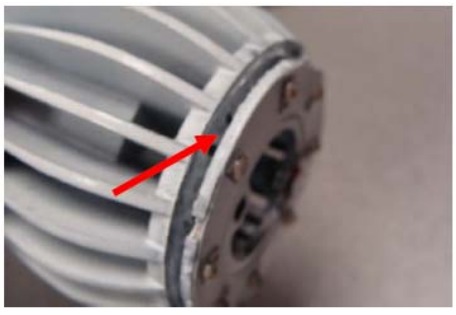


Figure 6 thermal interface materials

ChromaLit Flame Rating

It is important that the driver be isolated class 2 per UL1310, which the iWatt driver is. For this power class, there are no special flammability requirements on the remote phosphor per UL94. For non-isolated, non-class 2 drivers special UL94 flame rating is required.

Assembly and Handling

The bill of materials for the Intematix Contour reference design is shown below including thermal paste and adhesives required to assemble the ready to operate bulb.

QTY	ITEM
1	LED MCPCB Board
1	Top Heat Sink
1	Bottom Heat Sink
2	ChromaLit Contour
8	Lumileds LUXEON Rebel ES LED LXML-PR02 color bin 4/5 flux 1000mw min.
1	Top Reflector, Furukawa E3 with 3M VHB adhesive
1	Bottom Reflector, Furukawa E3 with 3M VHB adhesive
1	ABS/PC Insulator
1	Edison Base and Tab
A/R	Thermal Compound (LED PCB) 0.657 W/mK minimum
2	FHS 4-40 x5/16”
2	FHS 1-72 x 3/8”
1	Driver PCB, iWatt
A/R	Silicone Potting Material – Dow Corning Sylgard 160
A/R	Top Reflector Instant Adhesive, 3M Scotch Weld CA100

Figure 7 Bill of Materials

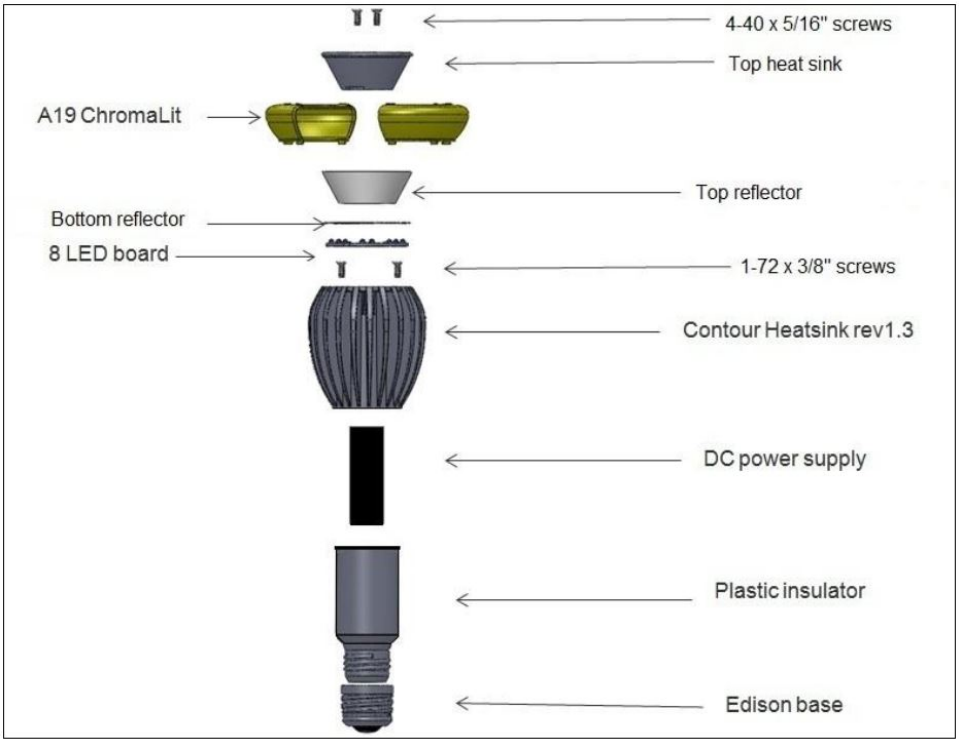


Figure 8 Exploded view of Contour 75W-equivalent lamp

The top heat sink is held in place using tow 4-40 x 5/16” screws. Recommended torque values for these

screws are 5.2 in-lb for 18-8 stainless and 5.5 for 316 stainless. The ChromaLit has small tabs that get sandwiched between the heat sink and the top cover as shown in the photographs below.

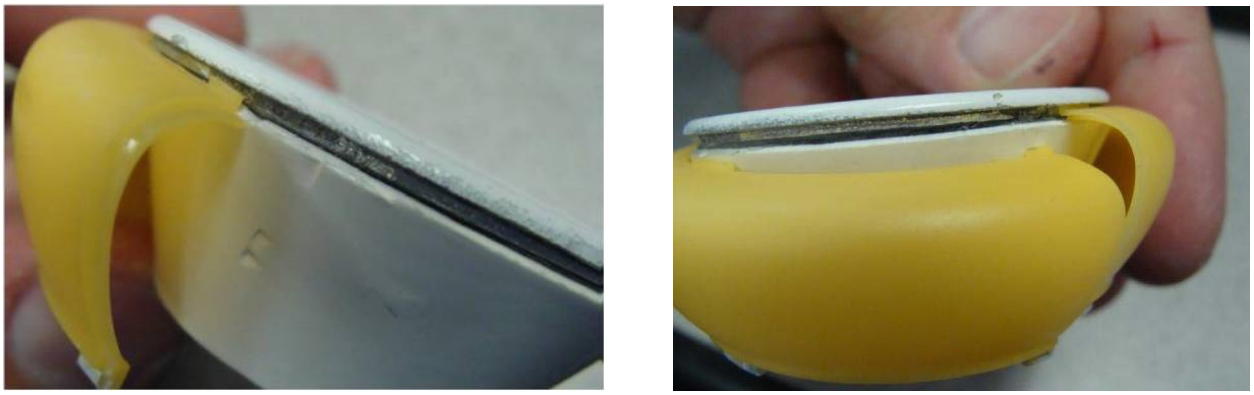


Figure 9 ChromaLit Contour tabs inserted into top cover groove

The top reflector show in Figure 9 is wrapped and bonded on the reference design from Intematix. However, a one-piece injection molded plastic or thermoform would be significantly easier for assembly. These one-piece designs although convenient can have reduced reflectivity if proper attention is not given to the thermoforming process. Any new reflector design should be fully tested and qualified at the system level for optical and thermal stability performance. Please see Intematix mixing chamber application note for materials recommended for these types of reflectors.

Figure 10 Bottom tabs on remote phosphor engage bottom slot in heat sink

The ChromaLit Contour is designed to be a robust assembly without the need for secondary adhesive bonding. However, if an application demands exceptional robustness beyond the standard level, the remote phosphor can be bonded to the heat sink using an adhesive such as 3M DP-460 (or equivalent). If an adhesive is implemented, however, the material must be kept away from any light emitting portions of the remote phosphor since the hardened material can impact performance if it is in a direct light path.

General Cleaning and Handling

The ChromaLit remote phosphor should be cleaned if needed using a damp, lint-free cloth, water and mild detergent or isopropyl alcohol, and then dried with compressed air or lint-free cloth.

Assembly

The ChromaLit Contour remote phosphor is made up of two pieces. The two pieces snap fit to one another as

well as to the bottom and top heat sink. The remote phosphor surrounds the blue light chamber, which consists of royal blue LEDs mounted on a metal core PCB. Reflective material covers the MCPCB and conical surface of the top heat sink and has appropriate cut-outs for the LED apertures.

Figure 11 ChromaLit Contour remote phosphor

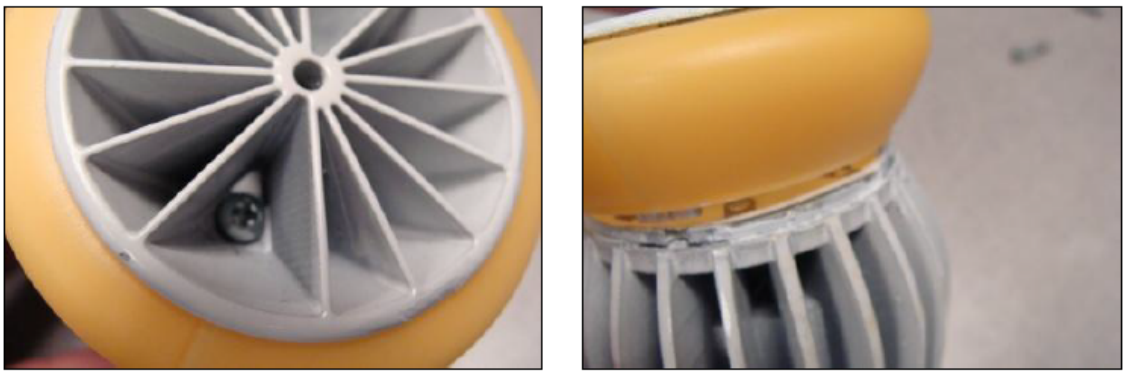
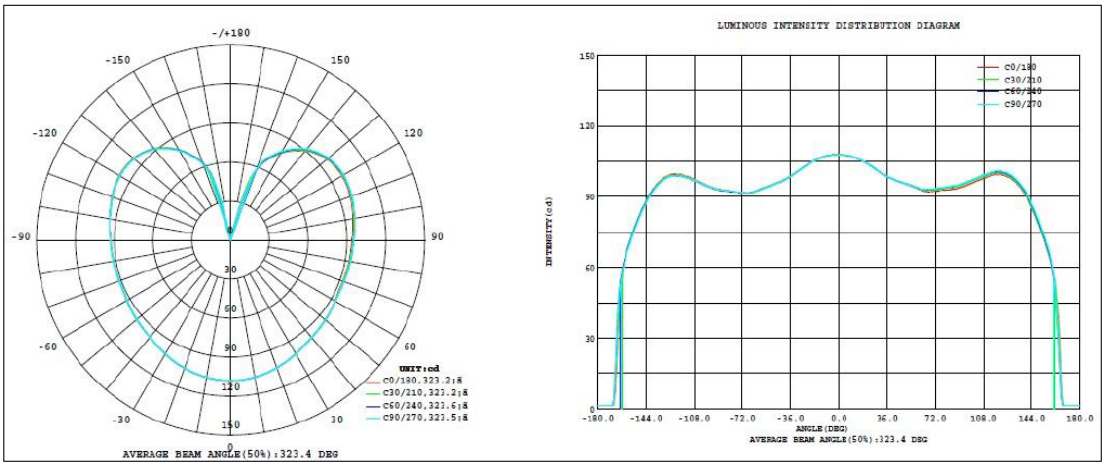


Figure 12 Remote phosphor snap fit into top heat sink (left) and bottom heat sink (right)

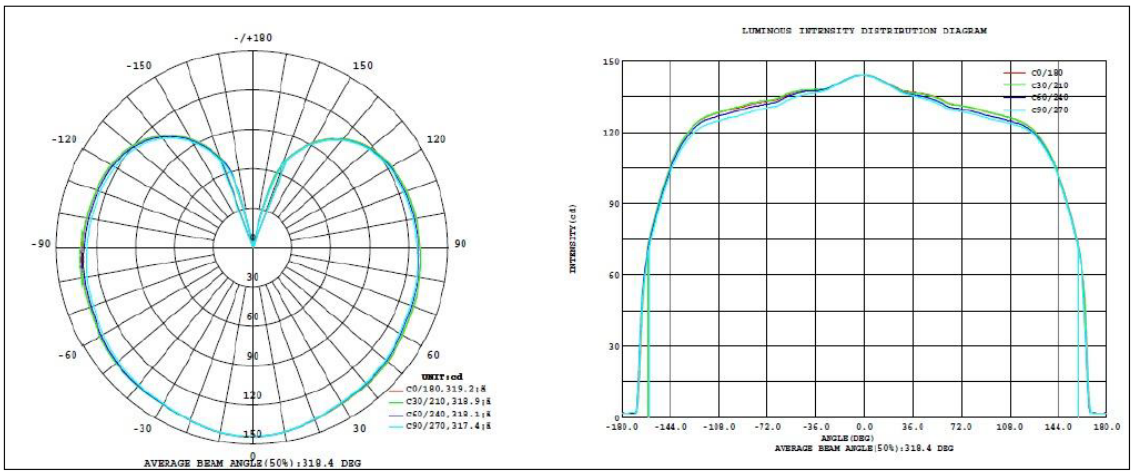
The LED apertures should be sufficiently large to prevent any blue light loss. The lower reflectance surfaces of the PCB and LED case should be covered to provide as much surface area as possible with high reflectance so that the blue light that is down converted and returned to this chamber area is efficiently recycled.

The current reflective material used in the Intematix reference design is Furukawa MC-PET grade E3 on the top heat sink surface and PCB. The Furukawa MC-PET is backed with 3M adhesive transfer tap 467 adhesive material. The reflector on the PCB has precision aperture cut-outs for the LED array that ensures that the extracted blue light from the LED is optimized. The Furukawa material on the top heat sink provides a light tight assembly by slightly overlapping the top edge of the remote phosphor. This material is also chosen for its high maximum operating temperatures (~120^{o}C), and its demonstrated stability under long term blue and white light exposure.

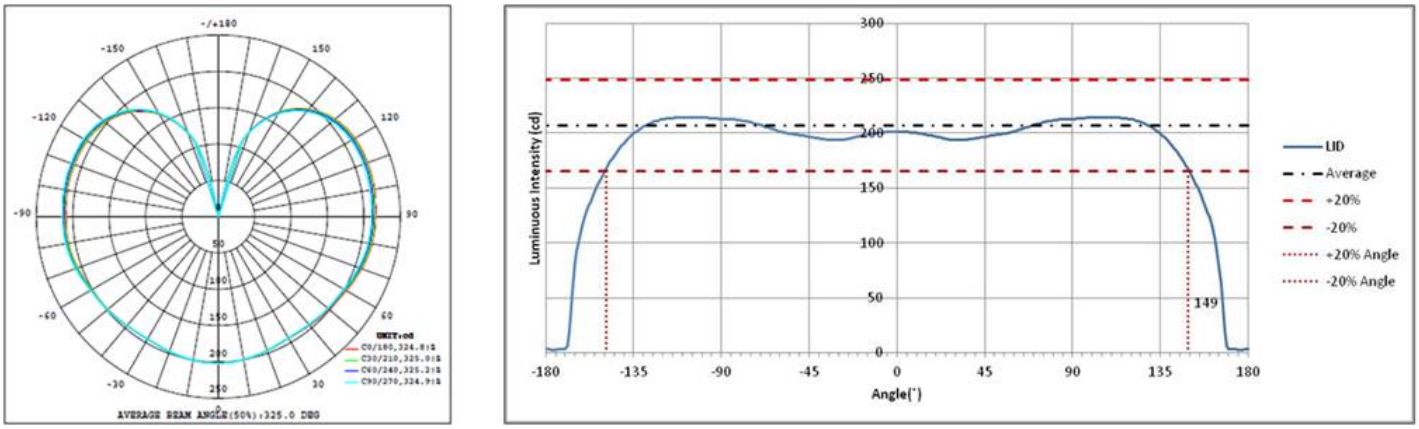
Energy Star Compliant Intensity Patterns for Contour LED Retrofit Lamps



Typical 60W and 75W Intensity Pattern



Typical 100W Intensity Pattern



Typical 150W Intensity Pattern

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Design Considerations for Customer Alterations

Item	Critical Function	Recommendations
ChromaLit Contour	Down conversion and spectrum. Light distribution pattern.	It is recommended to use the existing part without modifications.
LEDs	Source of 450-460nm dominant wavelength.	The blue LED ideally is centered close to 455nm dominant. The WPE (blue output power/dc input) should be 50% or higher at nominal spec current level. Choosing lower WPE or reducing LED count and over-driving can detrimentally impact the lamp thermals reducing reliability and life characteristics.
LED Placement	Light distribution and optimized efficacy. Recommend axial symmetry and located between reflector and ChromaLit	It is recommended to maintain distance of LED from inside reflector. The LEDs should also be located for maximum rotational symmetry.
Heat Sink Surface Area	The solid model files are available for the Contour reference designs.	Since warmer CCT and more enclosed environments put additional demands on the heat dissipation properties of the heat sinks, it is highly recommended to verify through thermal testing all heat sink configurations whether identical to Intematix reference design or modified version of it. Thermal conductivity of aluminum varies from about 121 W/mC for 2024 T4 to 180 W/mC for 6061 O. Intematix reference designs employ investment casted 356 T6 typically.
Heat Sink Shape	Reduction of Light Blockage balanced with thermal performance.	The shape of the top and bottom heat sinks are such that light is free to propagate throughout a wide angle from the top towards the base of the bulb. Heat sink shape that would absorb the light from the remote phosphor could result in failure to meet the Energy Star criteria.
PCB	Circuit path for LED current and thermal heat transfer of conducted LED to heat to bulb heat sink.	Alternative PCB or direct connect of LEDs to ceramic can be used as long as thermal resistance is low between LED case and heat sink.
Thermal Interface Material	Reduce thermal resistance between PCB and heat sink	Must choose material with high thermal conductivity and long operating life at operating temperatures.
Driver	Provide AC to DC conversion and deliver constant current to LEDs with dimming capability	Alternative drivers can be used but efficiency and reliability should be tested.
Reflector Top	Provides recycling of white light between top heat sink and remote phosphor	High reflectivity material with operating temperatures to 120^{o}C is recommended. Top and bottom reflector could be combined into one injection molded piece.
Reflector Bottom	Provides recycling of white light between LED PCB and remote phosphor	High reflectivity material with operating temperatures to 120^{o}C is recommended. Top and bottom reflector could be combined into one injection molded piece.
Insulator	Provide electrical isolation of driver	Non-thermally conductive material with UL94-V0 rating or better is recommended with 1mm wall thickness.
Top Heat Sink	Thermal conduction and convection of heat	The reference design uses cast aluminum heat sinks. Thermally conductive.
Heat Sink Paint	Cosmetic and high surface emissivity	Alternative pigments can be used. Intematix recommended high emissivity equivalent.
Edison Base	Electrical connection to driver	Currently, this is the standard connection method for A19/A21. Alternatives to suit the application are acceptable.

For more information on ChromaLit solutions please visit our website www.intematix.com/ChromaLit.