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Halogen Desk Lamp Conversion to LEDs

White Paper: Halogen Desk Lamp Conversion to LEDs

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It is estimated by the International Energy Agency that more than 19% of electrical energy demand globally is used for lighting so there is a significant impact in replacing inefficient light sources such as incandescent lamps with more energy efficient solutions. Much of the focus in reducing this demand has been on encouraging the adoption of compact fluorescent lamps (CFL). The choice of using CFLs is not without consequence; each bulb contains mercury which, when not disposed of properly, ends up in landfills. In addition, the form factor is not ideal for all applications. An alternative that have been gaining significant attention is phosphor converted white LEDs. LED efficacy – the measure of lumen output versus input power - and lumen output continues to make significant progress year over year. Moreover power LEDs can have lifetimes of greater than 50,000 hours when properly designed and operated.

An off-the-shelf halogen desk lamp was used as the basis for a demonstration of the real world performance of today's latest production LED light sources. A Cree XLAMP® MC-E LED was used as the light source. This product houses 4 LEDs in a single compact package which is ideal for directed light applications such as MR-16 and Portable Task Lamps. The original lamp was characterized before and after modification to highlight the real world performance differences.

Figure 1: Off-the-shelf 50 W Halogen Portable Desk Lamp

Figure 2: 50 W Bulb with protective glass removed

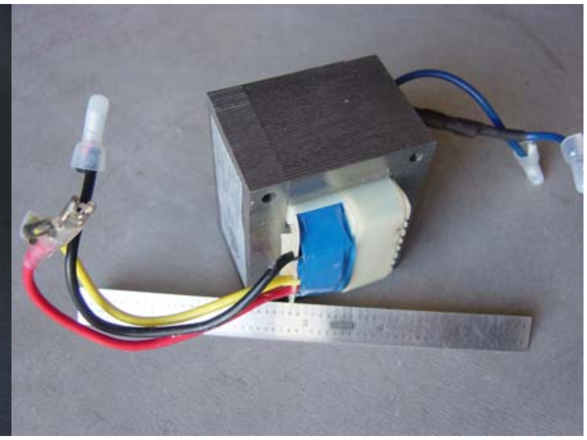

Figure 3: 60 Hz iron-core transformer, 2.4 pounds

Halogen incandescent bulbs operate at extremely high temperatures and, as such, luminaires must provide safeguards for users. In this case, a glass cover plate restricts access to the bulb to protect the user from burns and a plastic shell provides a thermal shield on the top. Moreover, the glass acts as a UV filter. Halogen bulbs must operate at a high temperature ranging from 250-600 ºC for proper operation. A typical 12 V halogen bulb used in these desk lamps can have efficacies ranging from 14-18 lm/W. Note this is only the rated efficacy of the bulb and does not include the losses in the power conversion transformer such as illustrated in Figure 3 or fixture losses.

High Brightness LEDs display significantly higher light conversion efficiency and therefore produce less waste heat for a given light output. Less waste heat means the lamp assembly operates much cooler and does not expose the user to extremely high temperatures. The bulb assembly was redesigned with a heatsink (figure 4) for the Cree MC-E LED lamp that fit within the existing plastic housing of the bulb fixture. The cast aluminum insert shown below was installed in the lamp shell. A neutral color white Cree MC-E was mounted on a metal core PCB sub-mount to aid in assembly. The LED was used without any secondary optics.

Figure 4: Custom Heatsink for Lamp Shell

Figure 5: Cree MC-E mounted on sub-mount and connected to heatsink

The LED assembly is powered with an ON Semiconductor [NCP1014: 360 mA 24 V LED Driver evaluation board](). This high efficiency driver provides the required isolated drive current to power the LED assembly. In addition, it has a universal input power range from 90-265 Vac which allows one design to be used in multiple regions with only a cabling change for the wall plug. This is not the case with the existing halogen iron-core transformer as it is designed specifically for one range of line voltage. The evaluation board was modified to allow three different LED current settings via a switch mounted on the lamp base. Current setting resistors are switched to provide a range of fixed nominal currents of 620 mA, 350 mA, or 140 mA to the LED assembly. The 620 mA maximum current was chosen to stay safely below the 700 mA maximum operating current of the Cree MC-E.

Shown below (figure 6) is the LED driver board mounted in the base of the desk lamp. Note that a ballast weight was required to stabilize the lamp since the original transformer, which provided a counterbalance, was removed from the base. In a portable desk lamp design optimized specifically for LEDs, the LED heatsink design would be optimized for minimal weight and the base would be designed to be wider and flatter to stabilize the lamp assembly without the need for added weight.

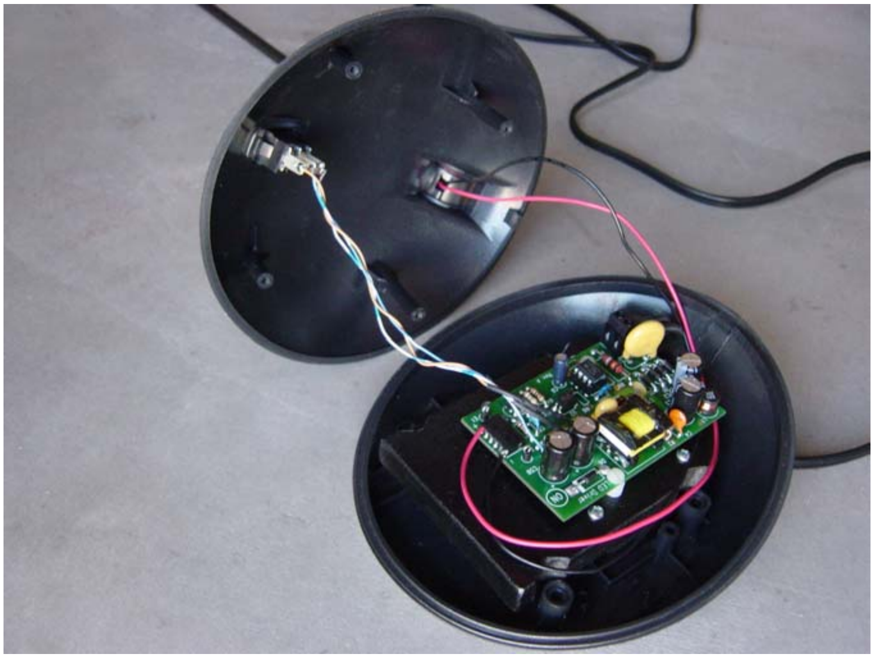

Figure 6: NCP1014 Constant Current Driver Board mounted in Base of Desk lamp

Data shown below was collected on the desk lamp with the original halogen bulb and after conversion to the LED source. Illuminance (expressed in foot-candles or in lux) is the measurement of total luminous flux on a surface at a specific distance.

Table1: Before and After Comparison

Lamp	**Setting**	**Input Power (Watts)**	**Illuminance**	
			Foot-Candles	**Lux**
Halogen	Normal	44.2	65.7	707
Halogen	High	60.1	126.6	1362
MC-E	Low (140 mA)	2.36	35.6	383
MC-E	Normal (350 mA)	6.02	75.1	808
MC-E	High (620 mA)	12.0	111.1	1195

While a comparison of the illuminance directly below the light source is important, even distribution of light on the surface is also important so other test points were selected at a 25 cm offset from the center to see what the distribution of the light was under normal operation conditions.

Table 2: Light Distribution Pattern

Lamp	Setting	Illuminance at 25 cm Offset (lux)				
		Left	Right	Front	Mean	Sigma
Halogen	Normal	408	401	328	379	44
LED	Normal	448	448	456	451	5

In this example, the converted LED desk lamp produced 14% greater illuminance in the normal setting as the halogen bulb yet consumed 85% less electricity. Interestingly, after reviewing the performance of the magnetic transformer alone in the original desk lamp, it had approximately 9.7 W of loss which is more than 60% greater than the complete power consumption of the LED equipped desk lamp using the NCP1014 350 mA Driver at the normal setting. In the high setting, the illuminance was within 15% of the halogen bulb yet the input power was 80% less. In addition, at the highest current setting, the temperature of the substrate that the LED was mounted on had a temperature of 71.8 °C. Since this was a retrofit, the existing plastic housing for the halogen bulb was re-used, which had no venting. With the plastic cover removed, the LED sub-mount temperature dropped to less than 63 °C; if the product was optimized for LED operation, the thermal environment would improve further as the non vented cover could be redesigned or removed depending on the end product design considerations. Note as well, under normal drive conditions (350mA), the LED sub-mount temperature with the cover on was 49 °C.

The benefits in energy consumption are clear. The higher efficiency, smaller size and weight, and lower LED power dissipation open the door for innovative luminaire designs which have historically been constrained by the limitations of halogen bulbs. Effective solutions are possible when coupled with an appropriate LED driver circuit to simplify the product design so that, with only minor changes, the same product could be sold in all regions of the world. Moreover, manufacturers can easily incorporate additional current settings levels to allow the user to further optimize the light output for their specific environmental needs instead of the one or two light levels of a traditional halogen based desk lamp.

In addition, a driver optimized for universal AC input of 90-265 Vac would allow a manufacturer to have one basic luminaire design for all markets and the only item that would need to be changed by region would be the power cable. Clearly luminaires based around state-of-the-art LEDs such as the Cree XLAMP MC-E and driven by high efficiency constant current source drivers will allow the introduction of new energy saving general lighting products.

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