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# Design, Development and Thermal Analysis of Heat Sink for Unidirectional Lighting Fixture

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## ABSTRACT
The project "Design, Development and thermal analysis of heat sink for unidirectional lighting fixture " specifically deals withunidirectinallighting.current lighting practice uses multiple light source technologies and fixture to achieve the requierd illumination for the various tasks.With the evalution of LED as attractive source of light the lighting fixture design has been changed drastically. The older design were based on the traditional light sources such asincandensent bulbs, hylogen light, metal halide, CFL, etc. All these light sources are emitting light in 3600 and the fixture have been deigned to reflect the maximum light in the desired direction unidirectional or task lighting fixture design prominantly involved the design of reflectors most common shape in parabolic reflectors LEDs emit light in the beem of 1200 hence the maximum light is emitted in the forward direction most of the lighting requirements are satisfied due to that type of emmission in the applications where concentrated light or desired pattern of light is needed external optics are available and can be used.here an attempt is made to design a new LED lighting fixture to cater the needs of commercial establishment like shopping mall, jewellary showroom, artgallaries etc.

## Keywords
Lighting fixture (unidirectional),design software (Pro-E),Modeling , analysis software ,

## 1. INTRODUCTION
LED (light emitting diode) are now a days replacing all commercial lighting fixture due to their inherent property is low power maximum lights commercial establishments consume maximum power in lighting. Most commonly used conventional lights include PAR lights ,zoom lights, etc.

These fixture used high power light sources such as CDMT, halogen CFL, sodium vapour metal halides all the light sources are very high power consuming with low efficacy and low life the major drawback is they generate large amount of heat while emitting light. LEDs lightwith proper external optics can replace all such conventional lights with very low power cons umps since the luminous efficacy LED sources have been studied their comparative analysis is made and bent source have been selected the major area of concern in LED design in fixture and heat sink design . in LED lights the fixtures can be developed intelligently so that the fixture itself can work as heat sinks and proper thermal management can be done. The paper reveals the proposed work to be done in the form of CAD design of aluminum fixture heat sink external optics electronic designs and the thermal analysis of heat sink any ways.

### 1.1 Design requirement
The design goals can be based either on an existing fixture or on the applications lighting requirement

Specify any other goals that will influence the design such asspecial optical or environmental requirements.

A desirable task light is low in power consumptions and efficiently illuminates the area where it is installed.

**Table 1 Design Criteria**

| Importance | Characteristics | units |
|---|---|---|
| Critical | Luminous flux<br>Luminance/ illuminance<br>Electrical power<br>Meet safety standards<br>Price<br>Lifetime | Lumens(lm)<br>Candela/m2 or lux<br>Watts(W)<br>Agency listing/mark<br>$<br>hours |
| Important | Correlated color temperature(CCT)<br>Color Rendering index(CRI)<br>Manufacturability<br>Ease of installation<br>Comply W/Energy star<br>Compatible W/controls<br>End of life disposition | Kelvin<br><br>100ponit scale<br><br>$<br>Time=$<br>Has lable<br>Yes/ NO<br>Cost to recycle |

**Table 2 General Energy Star Requirements**

| Characteristics | Requirements |
|---|---|
| CCT | The luminaire must have one of the following designated ccts and fall within the 7 step chromaticity quadrangles as defined 2007k |
| Color angular uniformity | The variation of cromaticity shall be within 0.004 from the weighted average |
| Color maintenance | The change of chromaticity over the first 6,000 hours of luminaire operation shall be within 0.007 |
| CRI | Indoor luminaire shall have a minimum CRI of 80 |
| Off state power | Luminaire will not draw power in the off state |
| Lumen maintenance requirement | L70>25000 hours |
| Power factor | Total luminaire input power >0.9 |
| Operating frequency | >120Hz |
| Zonal lumen density | Minimum of 60% of total lumens within 0.600 zone<br>Minimum of 12.5% of total lumens within 60-900 zone |
| Minimum luminaire efficiency | 100 /W |

## 1.2 Design Goals

The principle for this design was to meet energy star guideline and provide an off the self design that can be used immediately or easily modified to meet specific requirements.

**Table 3 Specific Requirement Of Lighting**

| Characteristic | unit | Minimum goal | Target goal |
|---|---|---|---|
| Luminaire light output | Lm | 200 | 300 |
| Illuminance (luminance profile) | Lux | | |
| System power | W | 24 | 20 |
| Luminaire efficiency | Lm/w | 100 | 120 |
| Life time | hours | 40,000 | 50000 |
| CCT | K | 3000 | 2700 |
| CRI | | 80 | 85 |
| Maximum ambient temperature | 0c | 460 | 490 |

# 2. CONCEPT DESIGN & DRAWING

Design a linear lighting fixture that exceeds linear fluorescent performance is cost competitive and exceeds energy star performance criteria requires a design approach

- Four system level elements
- LED selection
- External /secondary optics
- Selection of electronics driver and
- Thermal management

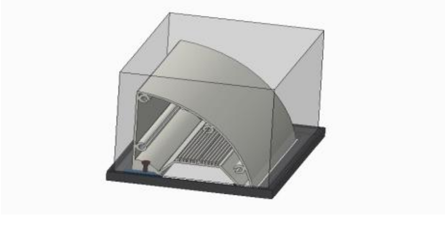


**Figure 1. Lighting Fixture**

## 2.1 Selection of light source

A linear light fixture is expected to provide uniform light transmission color temperature and in the case of a dimmable LED based fixture maintain color temperature while dimming.

This design shows that the comparison lighting data of the various company like, SAMSUNG ELECTRONICS – LH3512, SEOUL SEMICONDUCTOR 525M2_WX_XX, SEMILEDS.C3535L.C3535 M_XXLI, CREE_XLAMP XP_GLEDs.the target for the application and much higher current producing more light within the fixture if requirement dictate. LEDs placement within the fixture is also critical linear fluorescent lamps have uniform light transmission and are unidirectional .this gives a nice lighting profile when looking directly at the fixture penalty in the constrained space of under cabinet design since SSL laminaires are point source careful consideration of LED placement within the fixture is vital.

**Table 4 Comparision Lighting Data Of Luminous Flux**

| MAKE , , | PARAMETER | | ILLUMINATION (FLUX) | | | JUNCTION TEMPERATURE | OPERATING TEMPERATURE |
|---|---|---|---|---|---|---|---|
| | Fv | If | 300 mA | 700 mA | 1000mA | | |
| SAMSUNG ELECTRONICS-LH351Z | 2.7 | 3.0 | 136 | 238 | 307 | 150 | 85 |
| Seoul semiconductor-SZ5-M2-WX-XX | 1.5 | 2.0 | 130 | 236 | 315 | 150 | 125 |
| SEMILEDs – C3535L.C3535 M-XXL1 | 2.0 | 3.0 | 139 | 235 | - | 150 | 85 |
| CREE – X LAMP XP-G LEDs | 3.75 | 1.5 | 107 | 180 | 250 | 150 | 125 |

## 2.2 Selection of external optics

The diffuser in the comparison lighting fixture traps as much as 50% of the light produced by the LEDs tube. This has a huge negative impact on total efficacy of the fixture. a linear diffuser was designed and optimized for this application. This allowed for almost 85% of the light generated by the LEDs to be transmitted through the diffuser and onto the work surface

**Table 5 Selection Of Optics**

| Light | Luminous flux | CCT | CRI |
|---|---|---|---|
| SSL without diffuser | 307 lm | 4051 | 85 |
| SSL with diffuser | 261 lm | 4033 | 85 |

To eliminate shadowing and produce light uniformity, the LED-to-diffuser distance had to be tailored so the point-source LEDs are essentially invisible. The original design placed the LEDs 0.75 in. behind the diffuser. Though Bright View worked to optimize the diffuser, the distance between the LEDs and from the LEDs to the diffuser produced a suboptimal result, with the individual LEDs clearly visible and corresponding shadowing apparent.

With reference by the LEDlink, khatod, LED ial

## 2.3 Selection of electronics drivers

It is highly likely that a user will come in contact with the fixture, so a safe topology that isolates the user from the AC mains is required

We selected the fly back topology for this design, providing the maximum safety available in an SSL fixture. Driver efficiency is critical, and this design achieves 80% efficiency at full load, as shown in Figure 7 and Figure 8. Figure 9 shows the power factor. The curves in these figures are for three drivers tested under identical conditions. Differences in the curves are due to variances in the driver performance based on manufacturing/component spreads in the driver assemblies

## 2.4 Calculation Of Heat Generation And Thermal Management

Thermal management is critical in SSL luminaires. Ensuring the recommended maximum LED junction temperature is not exceeded is critical to long life and color point stability of the LEDs. We designed an aluminum housing, increasing the housing cost by 30% over a sheet metal version. This increased cost was offset by improved thermal performance without the necessity of an additional heat sink. An aluminum housing allows the LED assembly to be produced with standard FR-4 PCB material A simple one-layer MCPCB is comprised of a solder mask, copper circuit layer, thermally conductive dielectric layer, and metal core base layer, as shown below in Figure 3. These three layers are laminated and bonded together, providing a path for the heat to dissipate. Often the metal substrate is aluminum, though steel and copper can also be used.

Using the thermal conductivity values in Table 3 below, the one-dimensional through-plane thermal resistance for a 1.6-mm-thick star board of approximately 270 mm2 is roughly 0.2 ºC/W. If a smaller heat source size is considered, the resulting thermal resistance is 5.3 ºC/W. In this case, the limiting factor is the PCB dielectric.

| Layer material | Thickness(µm) | Thermal conductivity(W/mk) |
|---|---|---|
| SnAgcu solder | 75 | 58 |
| Top layer copper | 70 | 398 |
| PCB dielectric | 100 | 2.2 |
| Al. plate | 1588 | 150 |

**Table 6. Material and thermal conductivity**

# 3. DESIGN OF HEAT SINK

In this document we give you a simple straight forward approach how you can determine the current LED sink for your new LED lighting design .fixture consisting of a flat round aluminum heat sink and a high-power LED. The front of the heat sink was exposed tothe ambient air, and the back was enclosed by the recessed can. The fixture was cooled by natural convection, radiation,and conduction. In the figure, $T_{bc}$ and Ta are boundary temperature and ambient temperature, respectively the thermal resistance network, $R_{\Theta j\text{-}b}$ is the thermal resistance of the LED package between junction and board, which is determined by the specific LED type; Rc is the contact thermal resistance between the LED board and heat sink, which is dependent on the attachment method the heat sink design; Rcond ,i and Rcond , c are the conduction thermal resistances of the insulation and ceiling, respectively, which are determined by the insulation and ceiling materials. Since only Rconv ,$h_{s\text{-}f,}$Rrad ,$h_{S\text{-}F}$ , Rconv , con , and Rrad , can (Figure 1 dashed rectangle) are affected by the heat sink design, in later analysis these thermal resistances are calculated according to the equations below to explain the contribution of different heat transfer mechanisms to each heat sink design.

$$R_{conv.}h_s\text{-}f = \frac{T_{hs}-T_a}{Q\ conv}, \qquad R_{rad.}h_s\text{-}f = \frac{T_{hs}-T_a}{Q\ rad.}$$

$$R_{conv.con} = \frac{T_{hs}-T_a}{Q.\ conv.} \qquad R_{rad.con} = \frac{T_{hs}-T_a}{Q\ rad}$$

T j is the maximum LED junction temperature, Tb is the LED board temperature, $T_{hs}$ is the maximum temperature of the heat sink, Ta is the ambient temperature, and $T_{bc}$ is the temperature on the boundary of the insulation material and ceiling. In the experiment, $T_{bc}$ is a controlled equal to Ta , and $T_{hs}$ was measured and used to validate imulation results because T j cannot be measured directly.

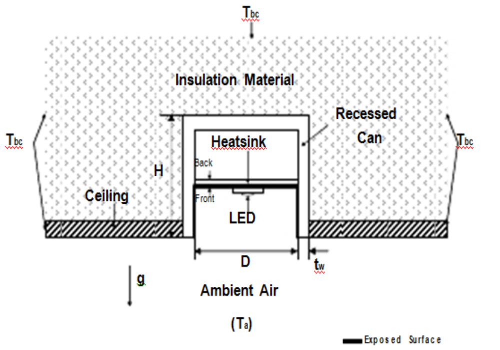



**Figure 2**

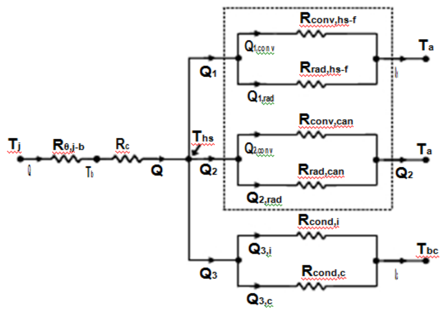



**Figure 3**

Final design of heat sink along with fixtureDesign parameters
Each led lighting design has its own specific parameters.

**Define expected ambient temperature**

Open air mounted spot light : 30°CRecessed ceiling downlighte : 50-55°CAutomotive lighting : 45°C (design point only)Tlife = -40°C up to +85°C

**Define LED parameters**

LED COB module from the CitizenForward current If 360mA – forward voltage Vf 40.9Vdc – power 14.7W Luminous flux 1210lm – CCT 3000K Maximum case temperature Tc 100°C - Maximum junction temperature Tj

150°CThermal resistance of the COB module Rj-c 2.6°C/W Citizen guarantees for this module a 50.000hr life time (conditional,0% of remaining flux) like 25°C ambient temperature We calculate with 90% reliability on these for the maximum junction temperature we want in our design – example below Ifa B10,L70 curve is available, we suggest you determine your required lifetime and read out the maximum junction temperature Tj related In this case we want to keep our junction temperature below 90% of the Tj max =>Tj required < 150°C x 90% < 135°C

## 4. CALCULATE THE REQUIRED LED HEAT SINK

The basics to do that is to understand the scheme at the right Each part of the design adds up some heat due to individual thermal resistances of each material – the adding up can be calculated as T = Pd x Rth In this case we have the thermal resistance of the Citizen LED COB module (Rj-c), the thermal resistance of a gap filler (thermal pad or grease) we want to place between the COB module and the heat sink (Rb), and the thermal resistance from our heat sink (Rh) which has to make that the total design stays below the maximum required junction temperature Tj

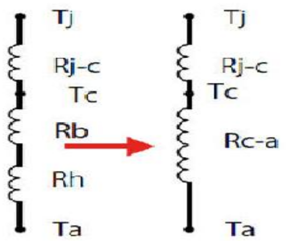
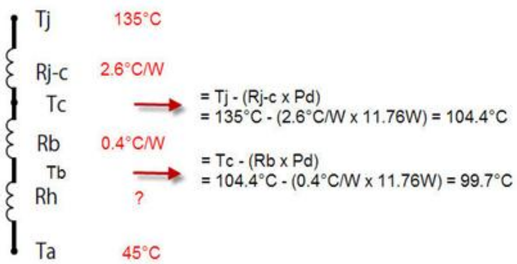
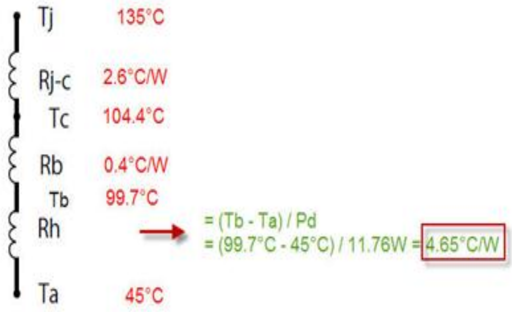



**Figure 4**

Ifourledlightisinarecessedenvironment Iwanttocalculatewith anambient temperature Ta of 45°CMeans the maximum temperature added in the total design is Tj – Ta = 135°C – 45°C = 90°CThe total power to dissipate is of course lower than the total power the LED consumesSome part of the power becomes light – the more efficient your LED module, the bigger part of the total power will be transferred in to light, easy to verify if you compare the luminous flux to the power As a fist rule we use 80% of the total power to be dissipated (Pd)Pd = 14.7W x 80% = 11.76WNow we just define mathematically what would be the maximum thermal resistance our heat sink should have or define the maximum rise in temperature our heat sink will create when dissipatingPd 11.76W Suppose we will use a phase change gap filler thickness 0.18mm (thermal pad which becomes fluid on first heating cycle) with a thermal resistance of 0.4°C/w




Choose a heat sink with an Rth value of<4.65°COR(see notesbe low) Choose a heat sink which guarantees less than (99.7°C– 45°C) = 54.7°C heating at a dissipated power Pd of 11.76W

## 5. . VERIFY THE DESIGN

After applying the thermal pad and the heat sink, verify the design Some LED COB module manufacturers for see a thermal measurement point at the caseRemember for this Citizen COB module Tc measurement max was 100°C Since we designed with some safety margins should measure a temperature around 87-92°C

## 6. CONCLUSION

As per the design the total number of LED have been selected the total heat generated due to all these LED have been successfully transfer connection between the LED MCPCB and heat sink. It is observed that the maximum temperature of heat sink was thedeign of heat sink the guaranteed the maximum temperature rise assure the smooth transfer of heat sink. Due to which the life time performance of the LED have been assured this design will be validated through actual manufacturing of the model and its temperature rise will be tested on thermal emending second part of the project and present separately

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