Application Note

Quickly setup your LED Lighting solution with

Cree® XLamp® MC-E series Star Board

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This application note describes how to select Cree XLamp MC-E star board series and covers the complete lighting solution include selection of driver, optics and heatsink. At the end would like to focus on some design tips and demo setup.

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1. Introduction of Cree® XLamp® MC-E High Power LED

The XLamp MC-E LED is a lighting-class, multi-chip LED that provides high lumen output in a small footprint package. Compared to discrete LEDs, XLamp MC-E LEDs reduce the distance between LED die, creating a small optical source for excellent optical control and efficient color mixing. XLamp MC-E LEDs can reduce LED system complexity by reducing the number of components required.

Cree Xlamp LEDs bring high performance and quality of light to a wide range of lighting applications, including color-changing lighting, portable and personal lighting, outdoor lighting, indoor directional lighting, and entertainment lighting.
FEATURES

- Available in white (2600 K – 10,000 K CCT), EasyWhite™, or color (RGBW)
- ANSI-compatible neutral and warm white chromaticity bins
- Individually addressable LEDs
- Maximum drive current: 700 mA per LED die
- Reflow solderable – JEDEC J-STD-020
- Electrically neutral thermal path
- RoHS and REACH-compliant

2. Cree® Star board with major features and parameters

FEATURES

- 430 lm @ 350mA
- 700mA - Max Drive Current
- 12.8V - Typ. Forward Voltage @ 350mA (For series configuration)
- 13.6V - Typ. Forward Voltage @ 700mA (For series configuration)
- 4-Chip In Series and parallel Circuit
- 4-Chip Individually Addressable
- Star board available in single color – Cool white, Neutral white and Warm white
- no need of reflow

Below table shows different types of Star board LED configuration, depending on requirement customer can choose series, parallel or individual configuration. As an example we have selected 3 LED in different configuration.

<table>
<thead>
<tr>
<th>Part No</th>
<th>BRD</th>
<th>Circuit</th>
<th>BRD Thickness</th>
<th>LED Color</th>
<th>Bins code</th>
<th>Flux code</th>
<th>Lumen (Min)</th>
<th>Each LED VF(typ) @350mA</th>
<th>Viewing Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCE4WT-A2-0000-00M02-STARIND</td>
<td>star</td>
<td>Individual (Figure3)</td>
<td>2mm</td>
<td>Cool White</td>
<td>WC, WD, WG, WF</td>
<td>M</td>
<td>430</td>
<td>3.2V</td>
<td>110deg</td>
</tr>
<tr>
<td>MCE4WT-A2-0000-00K02-STARSR</td>
<td>star</td>
<td>Series (Figure1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>370</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCE4WT-A2-0000-00M02-STARP</td>
<td>star</td>
<td>Parallel (Figure2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>430</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1
STAR MCPCB In series
White mask Gold letter

Figure 2
STAR MCPCB In parallel
White mask Gold letter

Figure 3
STAR MCPCB In Individual
White mask Gold letter
3. How to select Star board based on the system requirement

LED is available in single die or multi die, depending on its application and lux requirement either of them can be selected. Example, Cree MCE series having 4 die in a single chip means you will get more lumens output in a small footprint package so you can use for microscope illumination, high end strobe light like applications.

While selecting LED Module please check below parameters as per your application requirement.

- Configuration – Series, parallel and Individual
- Lumen output
- Output current
- Maximum output power
- Size and dimension
- Efficiency
- When you selecting LED module please select radiation pattern Lamberlain, batwing and side emitting which matches to your application. If the LED is not available in this pattern, then you can use optics to get the required output.

Please also ensure whether for your application required binned LED or full distribution, for this example we are not using bin LED as application is not demanding. Depending on application you can select which bin you require like – forward voltage, color, and flux bin.

Explained below with an example how to select MC-E star module as per system requirement

**Example - High Strobe lighting**

**Specification**-

✔️ 1 meter @ 5000 lux.

To get 5000 lux at 1 meter, need almost 330lm source. Here we consider height 1meter, viewing angle 14° and overall efficiency 70%.

To get 330 lm source atleast need to use 3-4 LED and optics for each led, but with the use of MC-E LED the number of optics, size of MCPCB and manufacturing hours in assembling will reduce to bring down total system cost. Same explained in below picture.

Part Number selected for design,

Cree MC-E LED - MCE4WT-A2-0000-00K02-STARS
Fraen lens - FRC-N1-MCE-0R
Find the central spot “on-axis intensity” value from Fraen datasheet. Narrow Beam (Part Number: FRC-N1-MCE-0R), value is 14.

If the Fraen narrow reflector FRC-N1-MCE-0R is used on a cool white MC-E LED at 350 mA, the typical luminous flux of the “Group K” LED is 370 lumens.

The calculation is:

\[(14 \text{ candela/lumen}) \times (370 \text{ lumens}) = 5180 \text{ candela peak on-axis.}\]

1 candela at 1-meter distance produces 1 Lux. This means the peak intensity at 1 meter will be 5180 lux.

The intensity decreases as a function of the distance squared, so at 2 meters the peak intensity will be \(5180 \div (2^2) = 1295\) lux. At 3 meters distance, the peak intensity will be \(5180 \div (3^2) = 575\) lux.

<table>
<thead>
<tr>
<th>Lux Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
</tr>
<tr>
<td>Illuminance</td>
</tr>
</tbody>
</table>

With the help of effective reflector can achieve long beam distances (example- 200 meter).

**Beam photographs**

Once you complete the testing and get required output, then you can paste star board with adhesive to heatsink. Then finally this assembly can be fixed with enclosure as a finished product.

4. **Suppliers recommendation for Driver**

If the power consumption of an LED module is higher than the power of a single LED driver when designing, we can use several LED drivers or an external MOSFET to drive the module.

LED drivers may need to work with various power supply voltages in illumination circuits, and it may therefore, be better to select an LED drivers that support a wide range of input voltage in order to mitigate any voltage fluctuation problems.

Several suppliers including National Semiconductor, Maxim, Zetex and in driver module LI GHTECH and Lumidrives can offer relevant solutions to meet different applications requirements.

Cree LED Array Vout, Iout, and Power driver requirements as below.

<table>
<thead>
<tr>
<th>Array PN</th>
<th>Vout</th>
<th>Iout (max)</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCE4WT-A2-0000-00K02-STARS R</td>
<td>13.6V</td>
<td>700mA</td>
<td>9.52W</td>
</tr>
</tbody>
</table>
LED Driver Selection consideration

- Voltage and Current rating of driver to be selected as per LED’s configuration whether array configuration in Serial, parallel and Individual combination.
- Efficiency
- Depends on input LED driver topology to be selected
  - Dc Input - Buck, Boost, Buck-Boost,
  - AC Input – Flyback, forward, LLC.

Depending on the input voltage and output power the choice can be made for LED driver, can be buck type, boost type, buck/boost type, and also charge-pump type. For power line driven system the buck type is chosen, for the single cell battery operated devices the boost type is chosen, for the system which run on both powerline and battery the buck/boost is chosen. Charge pump type is preferred if the output power is less and EMI and other noise issues.

Table below show lists of drivers that meet Cree LED Array’s output voltage, output constant current, and power requirements.

### LED Driver Selection Guide (Iout = 700mA)

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Device</th>
<th>Device Description</th>
<th>Input Voltage Range</th>
<th>Iout</th>
<th>Output Voltage Range/ Max</th>
<th>Topology</th>
<th>NOC</th>
<th>FOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Semiconductor</td>
<td>LM3407MY/NOPB</td>
<td>350 mA, Constant Current Output Floating Buck Switching Converter for High Power LEDs from the PowerWise® Family</td>
<td>4.5V to 30V</td>
<td>350mA</td>
<td>0.45V to 27V</td>
<td>Buck</td>
<td>78M7735</td>
<td>1555100</td>
</tr>
<tr>
<td>Zetex</td>
<td>ZXLD1350ET5</td>
<td>350mA LED driver with internal switch</td>
<td>7V to 30V</td>
<td>350mA</td>
<td>30V</td>
<td>Buck</td>
<td>05M2175</td>
<td>1226470</td>
</tr>
<tr>
<td>Maxim</td>
<td>MAX16803ATE+</td>
<td>2MHz, High-Brightness LED Drivers with Integrated MOSFET and High-Side Current Sense</td>
<td>6.5V to 65V</td>
<td>700mA</td>
<td>63</td>
<td>Buck</td>
<td>89K3247</td>
<td>1552873</td>
</tr>
<tr>
<td>*LIGHTECH</td>
<td>901010700P</td>
<td>LED 10W driver</td>
<td>120-240Vac</td>
<td>700mA</td>
<td>15V</td>
<td>Module</td>
<td>73R3502</td>
<td>1797597</td>
</tr>
<tr>
<td>* Lumidrives</td>
<td>MDU9-SC-3570</td>
<td>LED Driver Power Supply</td>
<td>110-240Vac</td>
<td>350/700mA</td>
<td>4-32V</td>
<td>Module</td>
<td>20M5601</td>
<td>1712028</td>
</tr>
</tbody>
</table>

* Note- Highlighted parts are LED module

5. Suppliers recommendation for Optics

Secondary optics is used to modify the output beam of the LED such that the output beam of the finished lamp will efficiently meet the desired photometric specification.

How to select the optics

- What is viewing angle required.
- Select beam ( narrow, medium, wide)
- Select radiation pattern ( Batwing, Lambertian, side emitting)
- If you know Illuminance + distance then you can calculate what is angle you need to select for lens
Table below show lists of lens that suit with Cree MC-E LED.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Device</th>
<th>Device Description</th>
<th>Viewing angle (FWHM)</th>
<th>NOC</th>
<th>FOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ledil</td>
<td>FA10613_LM1-RS</td>
<td>LENS, REAL SPOT, CREE MCE</td>
<td>±10.5°</td>
<td>79R6300</td>
<td>1817542</td>
</tr>
<tr>
<td>Fraen</td>
<td>FRC-N1-MCE-0R</td>
<td>FRC Series 35mm Diameter Reflector</td>
<td>14°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ledil</td>
<td>FA10680_CMC-O</td>
<td>LENS, OVAL, CREE MCE</td>
<td>±21° x ±10°</td>
<td>79R6321</td>
<td>1817549</td>
</tr>
<tr>
<td>Ledil</td>
<td>C10686_EVA-MC-W</td>
<td>LENS, WIDE, CREE MCE</td>
<td>±18.2°</td>
<td>79R6139</td>
<td>1817560</td>
</tr>
</tbody>
</table>

6. Suppliers recommendation for Heatsink

Thermal resistance is a measure of the ability of the package to conduct heat from the chip to the environment.

**How to select the Heatsink**

- Heatsink thermal resistance value should be equal or lower than calculated value of thermal resistance of board to ambient i.e. \( R_{th(b-a)} \). The lower the value, the higher the thermal performance.
- Heat sinks should be designed to have a large surface area, use large number of fine fins.
- Material selection - Aluminium is the most common material used as a heat sink.

Table below show lists of Heatsinks that equal or less than to Cree MC-E LED thermal resistance.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Device</th>
<th>Device Description</th>
<th>Thermal Resistance</th>
<th>NOC</th>
<th>FOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>COOLIANCE</td>
<td>CML8001-52-10-101</td>
<td>LED HEAT SINK</td>
<td>3°C/W</td>
<td>99R4723</td>
<td>1847664</td>
</tr>
<tr>
<td>WAKEFIELD SOLUTIONS</td>
<td>882-100AB</td>
<td>LED HEAT SINK</td>
<td>2.88°C/W</td>
<td>96M8765</td>
<td>-</td>
</tr>
</tbody>
</table>

Heatsink can be customized as per end product design requirement.

7. Design and Application tips

- In order to determine LED systems reliability the system designer must consider the possible failure modes for each component. It is generally known that one of the weakest parts of an LED system is the LED driver due to the number and types of components they contains and so covered below point which effect LED drivers reliability.
An LED drivers’ reliability depends upon:

- The number and quality of components used within the driver design
- Rated wattage of the driver.
- The maximum operating temperature of the electrolytic capacitors used in the driver.
- The overall efficiency of the AC-DC and DC-DC stages of the driver.
- Good driver design where component placement is determined by safety, EMC and thermal considerations.
- A suitable thermal management system for the driver such as an aluminium case or forced air cooling fan if appropriate.

- The maximum LED junction temperature (Tj) provided in the data sheet, example Tj-150°C, so at certain ambient temperature you may need to back off the current so that you don’t exceed the maximum Tj, always refer d-rating curve graph to know what is the value of ambient and current on particular thermal value.

- LED drivers are typically constant current drivers that provide stable current for a single LED or LED array. LEDs used in the applications described are usually high-power LEDs of 1W or greater. These high power LEDs can produce a considerable amount of heat in operation. This heat, if unmanaged, can degrade the lifetime, light output, forward voltage and most importantly dominant wavelength, which shifts with temperature and therefore it is advisable to consider this and incorporate sufficient thermal management into the design. Some of the Drivers work in conjunction with temperature sensors to achieve the thermal protection and management so as to improve the performance of LEDs in a variety of applications.

8. Demo Setup

Below set up done for MC-E series star board.

To complete the set up need:

- Power supply source ( used 24V,1A rating)
- Constant Current LED Driver ( used LM3404 driver)
- Cree Star Board ( used MCE4WT-A2-0000-00K02-STARSR LED array )
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