# LM129-08C351 - Sunlight Readable 8.4" LCD Module

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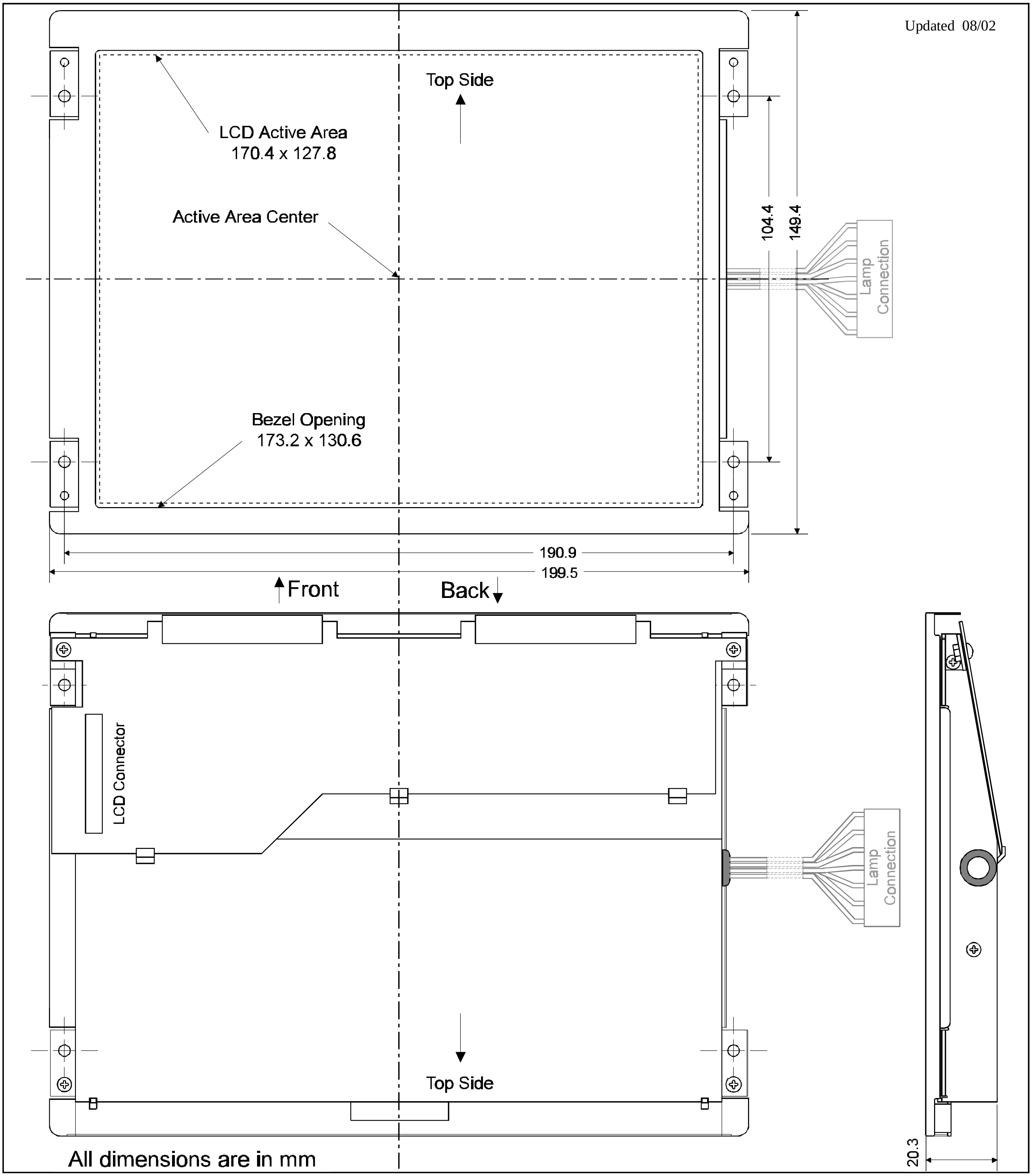


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# Introduction

LM129-08C351 is an 8.4" high efficiency sunlight readable LCD module. The module consists of a Toshiba LTM08C351 low temperature poly-silicon (LTPS) TFT color LCD with the original backlight replaced by a Landmark very high brightness (VHB) backlight. The module has the same foot print and uses the same mounting holes as the original LCD module.

At the maximum backlight power of 12 Watts, the LM129-08C351 module delivers 1,400 Cd/$m^2$ (nits) of LCD screen brightness. At this brightness level, the display is highly readable under direct sunlight. In addition, the color tone of the “White” displayed on the LCD screen closely matches the color of normal sunlight. With a wide dimming range inverter, the screen brightness can be adjusted down to less than 8 Cd/$m^2$.

The LM129-08C351 LCD module displays a superb color image at 800 x 600 resolution over ambient illumination levels ranging from total darkness to full bright sunshine, making it highly suitable for various outdoor applications.

## Characteristics (Note 1, 2)

| Parameters | Typical Value | Units | Conditions |
|---|---|---|---|
| LCD Screen Luminance | 1,400 | Cd/$m^2$ | White (LCD in OFF state) |
| Luminance Uniformity | 20% or better | | Note 3 |
| Backlight Power Consumption | 12 | Watts | Excluding inverter losses |
| Screen Dimming Ratio | 200:1 | | With LMT BI200A inverter |
| Typical LCD Contrast Ratio | 350 | | White vs. Black (measured in the dark at normal direction) |
| Typical Viewing Angles | | | |
| 3:00 to 9:00 direction | ± 60 (Note 4) | Degrees | Contrast ratio ≥ 5 |
| 6:00 to 12:00 direction | + 60, - 45 (Note 4) | Degrees | Contrast ratio ≥ 5 |
| 3:00 to 9:00 direction | ± 55 (Note 4) | Degrees | Screen brightness ≥ 250 Cd/$m^2$ |
| 6:00 to 12:00 direction | + 40, - 60 (Note 4) | Degrees | Screen brightness ≥ 250 Cd/$m^2$ |
| LCD Screen Chromaticity | | | |
| White | x = 0.345, y = 0.365 | | Measured at the normal direction |
| Red | x = 0.611, y = 0.346 | | Measured at the normal direction |
| Green | x = 0.317, y = 0.572 | | Measured at the normal direction |
| Blue | x = 0.148, y = 0.127 | | Measured at the normal direction |
| LCD Module Weight | 350 | Grams | |

Note 1: Please refer to the Toshiba LTM08C351 data sheet for detailed LCD electrical specifications and general precautions

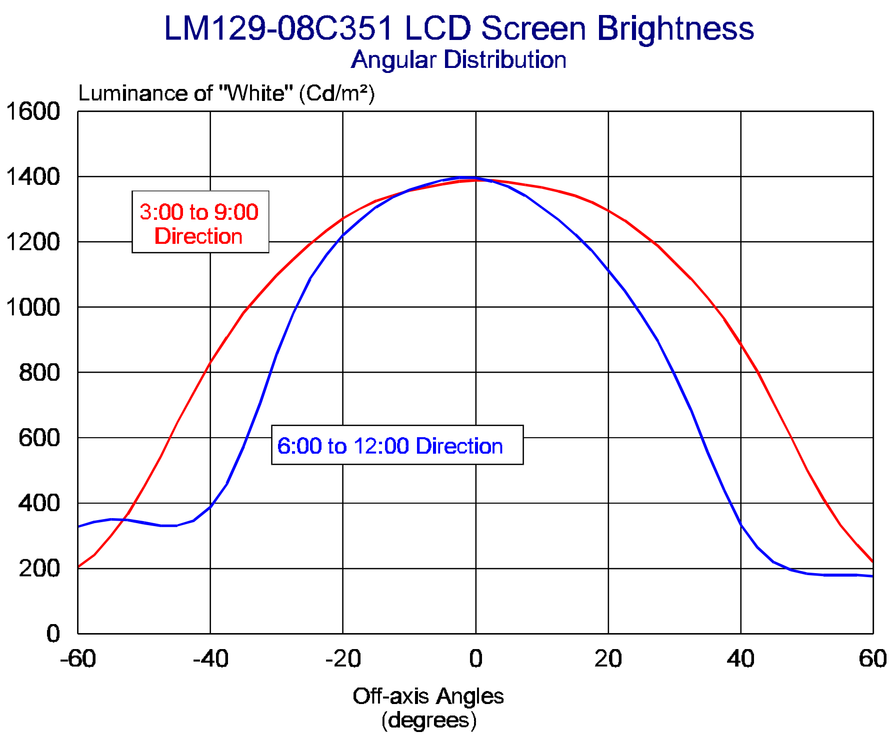
Note 2: All data is measured at 25$^o$ C ± 2$^o$C ambient temperature.

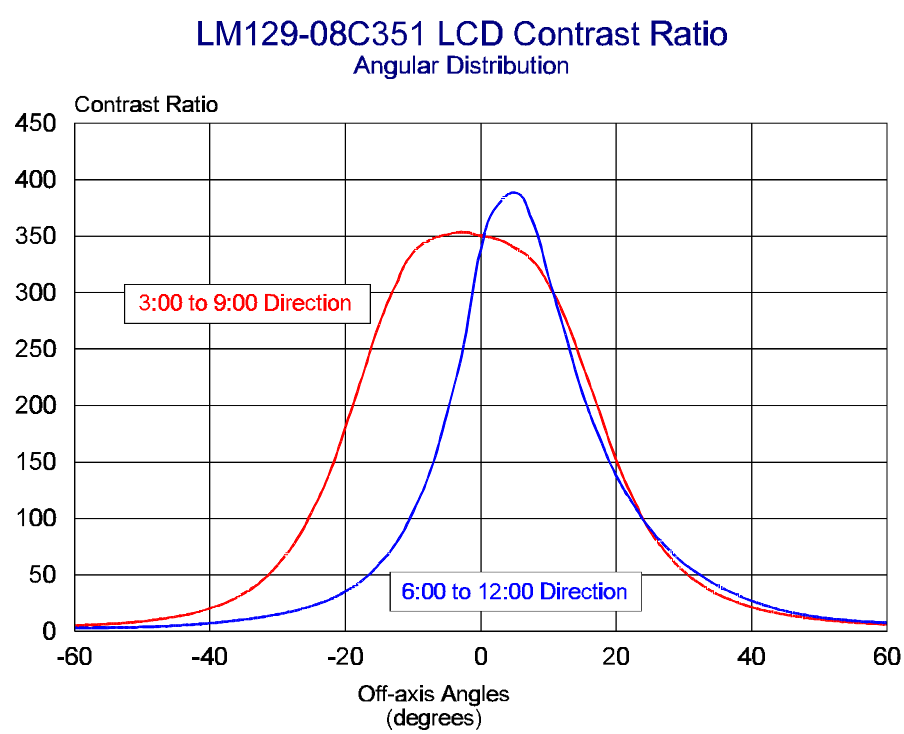
Note 3: Uniformity = ($L_{max}$ - $L_{min}$) / ($L_{max}$ + $L_{min}$) where $L_{max}$ ($L_{min}$) is the maximum (minimum) luminance measured using a 10 mm diameter meter aperture over the LCD active area, except the last 10 mm area from the edges.

Note 4: The positve angles are along the 6:00 & 3:00 directions and the negative angles are along the 12:00 & 9:00 directions

# LCD Module Optical Performances

The typical screen luminance and contrast ratio for the LM129-08C351 sunlight readable LCD module are shown in the figures below:



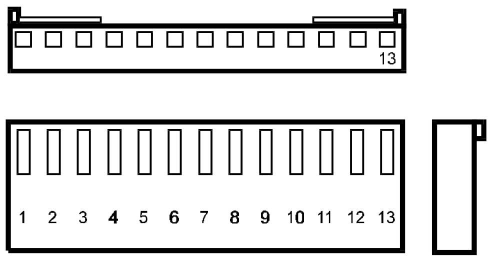




The LCD screen luminance is measured with the LCD in the "Off" state (i.e. the pixels are not energized). This is the "White" state that provides the maximum luminance. Very often, this "Off" state is brighter than the "White" color displayed on the screen when the LCD is turned on. This result may be caused by the LCD controller card or the video signal driving the display. When the LCD is properly driven, the difference between the luminance of the "Off" state and the "White" color should be less than 10%.

The inherent contrast ratio (CR) of the LCD is the luminance ratio between the "White" and the "Black" states measured in a dark room. In outdoor environments, the contrast ratio of the display drops significantly due to the reflections and glare caused by the ambient illumination at the front surface of the LCD and other layers, such as a touch screen or a protective window.

## Backlight Lamp Connections

The very high brightness (VHB) backlight in the LM129-08C351 module utilizes a total of 6 cold cathode fluorescent lamps to achieve the required luminance. The lamps are electrically connected in a parallel circuit: that is, they are connected at one side to a common lead.




Connector (Housing) Molex 22-01-3137

Mating Header: Molex 22-23-2131

**Connector Pinout**

| Pin # | To |
|---|---|
| 1 | Lamp Common |
| 2 | NC |
| 3 | Lamp #1 |
| 4 | NC |
| 5 | Lamp #2 |
| 6 | NC |
| 7 | Lamp #3 |
| 8 | NC |
| 9 | Lamp #4 |
| 10 | NC |
| 11 | Lamp #5 |
| 12 | NC |
| 13 | Lamp #6 |

The lamps are oriented in the horizontal direction with the #1 lamp at the top side of the LCD. The lead wires connecting the lamps are terminated with a 13-pin Molex connector. The figure on the left shows the connector pinout assignments. Customized lamp wire terminations with other connectors are available on request.

## Backlight Lamp Driving Specifications

It is recommended that an inverter with a 1200 to 1300 $V_{rms}$ starting voltage be used to run the VHB backlight on the LM129-08C351 module. At the maximum LCD screen luminance, the lamp voltage and current are listed below:

| | | |
|---|---|---|
| Operating Voltage | 330 | $V_{rms}$ |
| Lamp Current | 6 | $mA_{rms}$ |

At this driving condition, the backlight delivers about 1,400 $Cd/m^2$ LCD screen luminance with a power consumption of about 12 Watts. Since most inverters have an efficiency level between 70 - 80%, the total DC power input to the inverter is about 15 to 17 Watts. When the backlight is dimmed down, the power consumption decreases.

It is quite difficult to measure the lamp current accurately. As a result, if you intend to run the LM129-08C351 VHB backlight with your own inverter, please measure the screen brightness instead. Then use the brightness data to determine the correct driving condition. To do so, turn on the inverter to operate the backlight, but do not turn on the LCD. Make sure that the room temperature is about 25 °C and run the backlight for at least 30 minutes before measuring the screen brightness. If the measured screen brightness exceeds the specified value by a significant margin, for example, more than 10%, the lamps are over-driven. Over-driving the lamps can cause a significant reduction in backlight life.

## Thermal Management

The VHB backlight consumes a significant amount of power and as a result, the LCD temperature of a sunlight readable module will be higher than normal. In addition, the front surface of an LCD is a good sunlight absorber. Placing an LCD under strong direct sunlight can cause a very large temperature rise even without the backlight power.

The exact amount of temperature rise due to these two factors depends on how the LCD module is mounted and also on the heat dissipation design. For example, if the LCD is mounted vertically, a significant portion of the VHB backight heat will be dissipated into the air without heating up the LCD panel. As a result, the LCD temperature rise will be low. On the other hand, if the LCD module is mounted horizontally, then almost all of the backlight heat rises to warm the LCD panel. However, if a small fan or a heat sink is mounted onto the VHB backlight, the temperature rise of the LCD panel can be reduced significantly. With the LM129-08C351 module operating at its maximum brightness, the LCD temperature increase due to the VHB backlight is about 10 to 15 $^{O}$C. On the other hand, the absorption of direct sunlight by the LCD can heat up the LCD by more than 40 $^{O}$C in the extreme cases! Combining both heating effects, the LCD temperature may increase by more than 55$^{O}$C! Therefore, some forced cooling solution is needed to keep the LCD temperature within the specified range.

It is recommended that the LCD temperature be measured at full display brightness in your equipment under actual operating environments (for example, on a summer day with full sunshine). The cooling solution should then be designed accordingly. Please refer to the Toshiba LTM08C351 data sheet for LCD thermal specifications. Make sure that the specified maximum LCD temperature is not exceeded.

## Backlight Life

The backlight life is usually specified in half brightness life, which is the cummulative number of operating hours before the backlight luminance drops down to 50% of its initial value. The VHB backlight in the LM129-08C351 sunlight readable LCD module is rated at 25,000 hours when it is operated at maximum brightness. The backlight life is mainly determined by the lamp life. Lamp life depends strongly on the lamp current. If the lamps are operated at a reduced current, then the half brightness life of the VHB backlight can be extended far beyond the specified 25,000 hours.

In actual applications, a very bright sunlight readable display will most likely be dimmed down during dusk and at night. For example, if the screen brightness of the LCD module is dimmed down to 2/3 of its full level, the lamp current decreases to about 4 mA and the lamp life increases to about 40,000 hours. Therefore, the actual operating lifetime of the VHB backlight in the LCD module is expected to exceed 25,000 hours under most practical situations. For more detailed information on backlight life issues and actual test data on Landmark backlights, please refer to Technical Note TK801.