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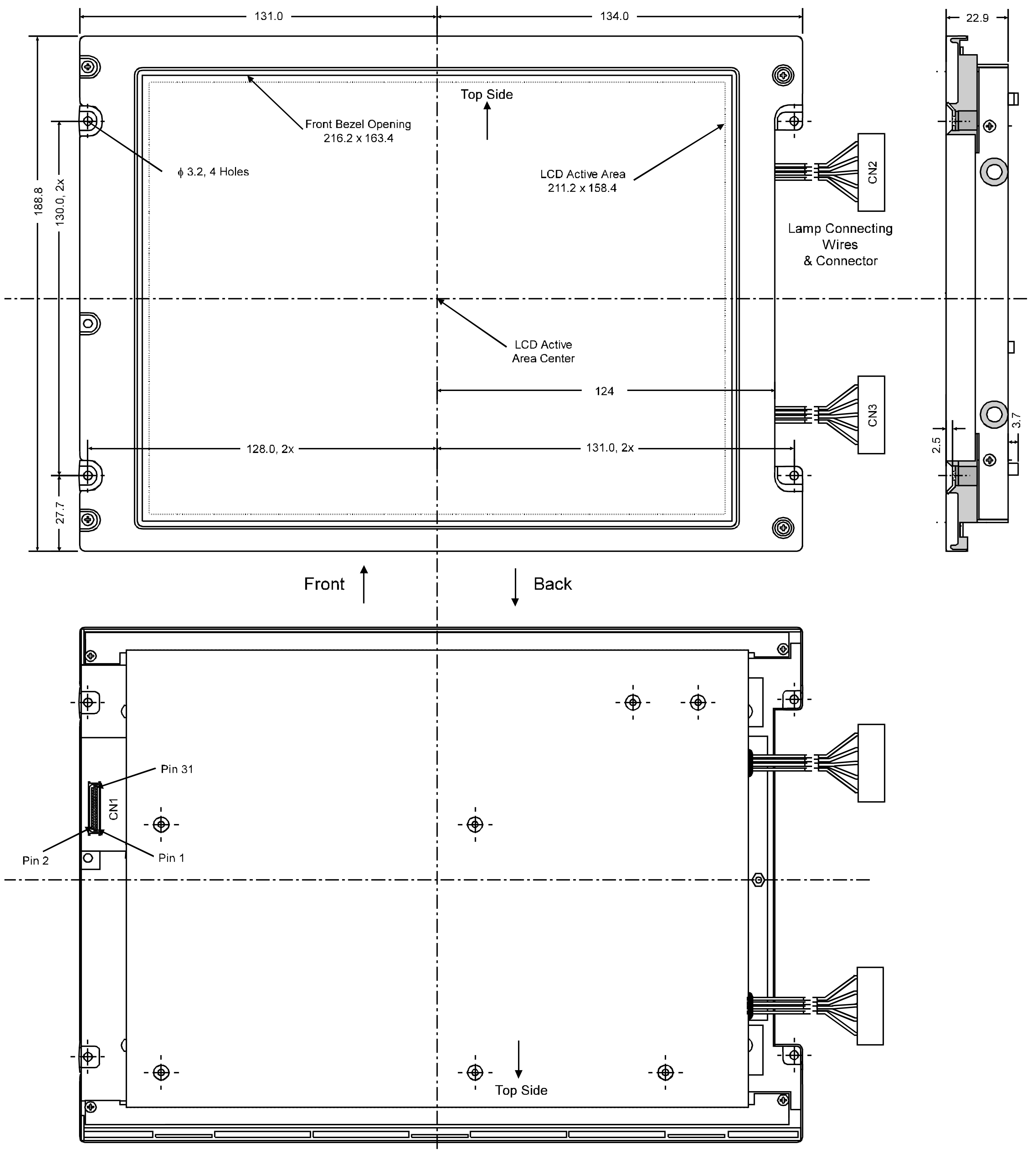
LM089C-104L - Sunlight Readable 10.4" LCD Module



All dimensions are in mm

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Introduction

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LM089C-104 is a 10.4" high efficiency sunlight readable LCD module. The module consists of an active matrix thin film transistor (AM TFT) addressed color LCD and a very high brightness (VHB) backlight for extremely high screen luminance.

At the maximum backlight power of 21 Watts, the LM089C-1104 module delivers 1,500 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 LM089-104 LCD module displays an excellent color image at 640 x 480 resolution with 6 bits color depth for up to 262,144 colors. Coupled with its high screen luminance, the display is highly suitable for various outdoor applications.

Characteristics (Note 1, 2)

Parameters	Typical Value	Units	Conditions
LCD Screen Luminance	1,500	Cd/m^2	White (LCD in OFF state)
Luminance Uniformity	20% or better		Note 3
Backlight Power Consumption	19	Watts	Excluding inverter losses
Screen Dimming Ratio	200:1		With LMT BI200A inverter
Typical LCD Contrast Ratio	300		White vs. Black (measured in the dark at normal direction)
Typical Viewing Angles			
3:00 to 9:00 direction	± 55	Degrees	Contrast ratio ? 5
6:00 to 12:00 direction	-25 to +50	Degrees	Contrast ratio ? 5
3:00 to 9:00 direction	± 55	Degrees	Screen brightness ? 250 Cd/m^2
6:00 to 12:00 direction	± 40	Degrees	Screen brightness ? 250 Cd/m^2
LCD Screen Chromaticity			
White	x = 0.342, y = 0.365		Measured at the normal direction
Red	x = 0.557, y = 0.359		Measured at the normal direction
Green	x = 0.314, y = 0.556		Measured at the normal direction
Blue	x = 0.155, y = 0.155		Measured at the normal direction
LCD Module Weight	710	Grams	
LCD Module Dimensions	See P. 1		

Note 1: Please refer to Landmark Document LM089C Specification for detailed LCD electrical specifications and general precautions

Note 2: All data are 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 with a 10 mm diameter meter aperture over the LCD active area except the last 10 mm area from the edges.

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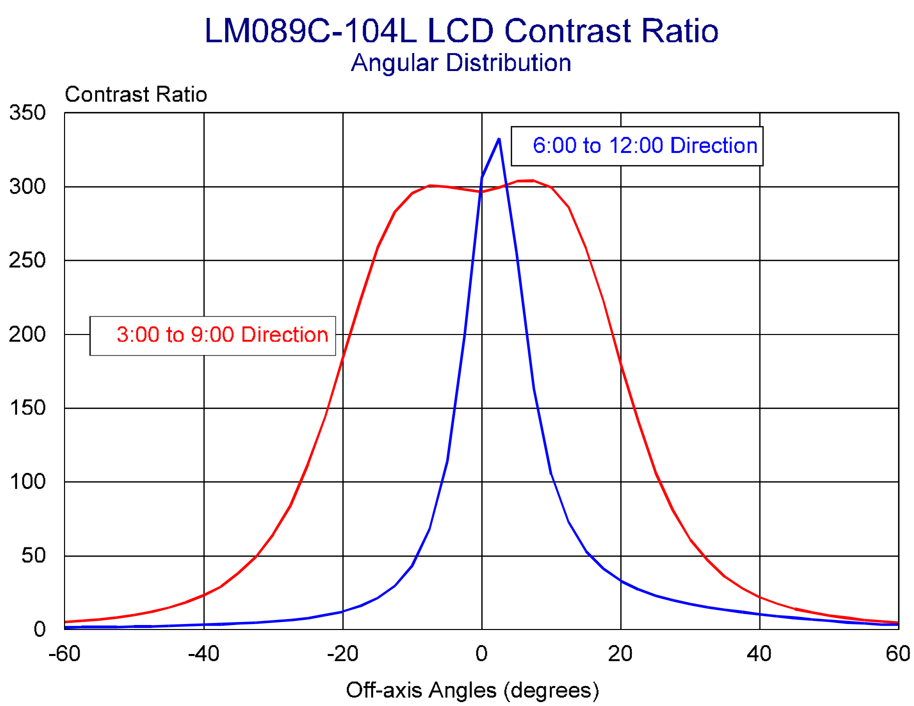
LCD Module Optical Performances

The typical screen luminance and contrast ratio for the LM089C-104L 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 with maximum luminance. Very often, this "Off" state is brighter than the "White" color displayed on the screen when the LCD is turned on. This difference may be caused by the graphics card and/or the controller card driving the display. When the LCD is properly driven, the difference between 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 reflection 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).



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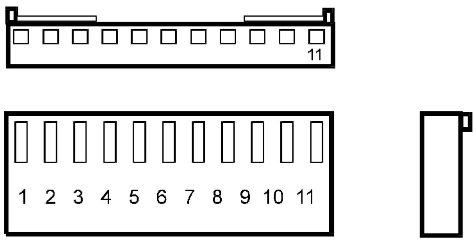
Backlight Lamp Connections

The very high brightness (VHB) backlight in the LM089C-104L module utilizes a total of 8 cold cathode fluorescent lamps to achieve the required luminance. The lamps are electrically connected in two separate groups. Group 1 contains lamps #1, #3, #5, and #7, and group 2 contains lamps #2, #4, #6, and #8. 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 two Molex connectors. The figure on the left shows the connector pin out assignments.



Connector (Housing): Molex 22-01-3117, Two connectors per backlight

Mating Header: Molex 22-23-2111

Group 1 Connector		Group 2 Connector	
Pin #	To	Pin #	To
1	NC	1	NC
2	NC	2	NC
3	Lamp #1	3	Lamp #2
4	NC	4	NC
5	Lamp #3	5	Lamp #4
6	NC	6	NC
7	Lamp #5	7	Lamp #6
8	NC	8	NC
9	Lamp #7	9	Lamp #8
10	NC	10	NC
11	COMMON 1	11	COMMON 2

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 LM123-12DG31 module. At the maximum LCD screen luminance, the lamp voltage and current are listed below:

Operating Voltage	400 V_{rms}
Lamp Current	6 mA_{rms} (each lamp)

At this driving condition, the backlight delivers the specified 1,500 Cd/m^2 LCD screen luminance with a power consumption of about 19 Watts. Since most inverters have an efficiency between 75 - 80%, the total DC power input to the inverter is about 23.8 to 25.3 Watts. When the backlight is dimmed down, the power consumption decreases.

For most efficient operation, the CCFLs should be driven with an AC current between 40 to 70 KHz.

It is quite difficult to measure the lamp current accurately. As a result, if you intend to run the LM089C-104L 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 15%, the lamps are over-driven. Over-driving the lamps can cause a significant reduction in backlight life.

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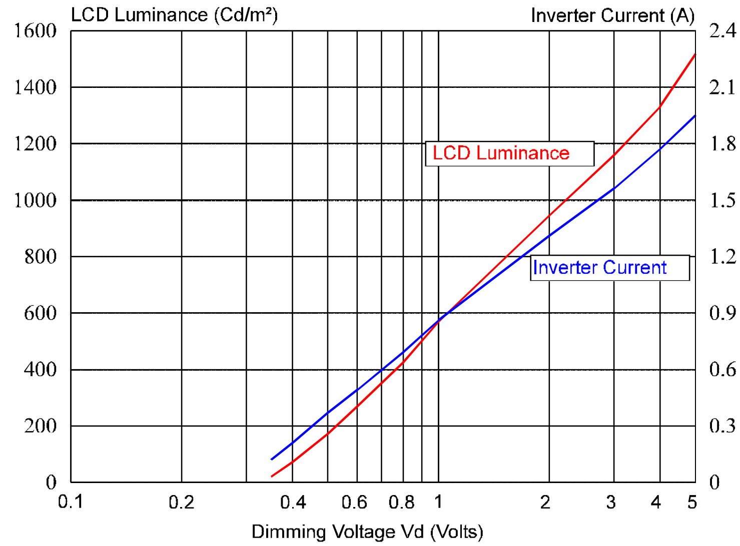
Operating the VHB Backlight with the Landmark BI200A Inverter

The Landmark BI200A is an inverter specially tuned to operate the VHB backlight in all 10.4" and 12.1" sunlight readable LCD module. The inverter has an on-board pulse width modulation (PWM) dimming circuit to provide an extremely wide range of luminance adjustments. Over the entire dimming range, there is no noticeable lamp flickering and the uniformity of the backlight is well maintained.

The BI200A inverter operates at a 12V DC input. The nominal lamp starting voltage is 1200 V_{rms}. The inverter also has a regulated +5V output serving as a voltage source for the dimming control circuit.

The figure on the right shows the typical LCD screen luminance as a function of the dimming voltage (Vd) input. The dimming characteristics are quite linear with the Vd scale in logarithm. Thus, in order to achieve a nearly linear luminance control, a logarithmic dimming voltage generation circuit should be used.

Typical Dimming Characteristics
LM089C-104L Sunlight Readable LCD Module with BI200A Inverter



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 significant 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 depends 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, and as a result, the LCD temperature rise will be low. However, if the LCD module is mounted horizontally, then almost all of the backlight heat rises to warm the LCD panel. 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 LM089C-104L module operating at its maximum brightness, the LCD temperature increase due to the VHB backlight is about 12 to 16 ^{O}C. The absorption of direct sunlight, in extreme cases, can heat up the LCD by more than 40 ^{O}C! Therefore, it is recommended that the LCD temperature be measured at full display brightness in the installed equipment under actual operating environments (for example, on a summer day with full sunshine). The cooling solution should then be designed accordingly. Please make sure that the specified maximum LCD temperature is not exceeded.

If the thermal issue becomes difficult to resolve, Landmark recommends an “S-mode” operation. By limiting the backlight luminance to 2/3 of its full level or lower, the power consumption of the backlight is proportionally reduced and, consequently, the thermal issue is somewhat relaxed. In the meantime, the LCD screen luminance is reduced but may still be adequate for your application. Please refer to Technical Note TK1205 for further details.

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Backlight Life

The backlight life is usually specified in half brightness life, which is the cummulative numbr of operating hours before the backlight luminance drops down to 50% of its initial value. The VHB backlight in the LM089C-104L sunlight readable LCD module is rated at 20,000 hours when it is operated at the 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 20,000 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 half of its full level, the lamp current decreases to about 3 mA and the lamp life increases to about 63,000 hours. Therefore, the actual operating lifetime of the VHB backlight in an LM089C-104L LCD module is expected to exceed 20,000 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.

The “S-mode” operation recommended to alleviate the thermal management issue has the extra benefit of resulting in a longer backlight life. By limiting the backlight luminance to about 2/3 of its full level, the maximum lamp current is reduced to about 4 mA and the backlight life is extended to about 40,000 hours.

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