LM146-121SL01 - 12.1"

Sunlight Readable LCD Module

Introduction

LM146-121SL01 is a 12.1" sunlight readable LCD module. The module consists of a Mitsubishi AA121SL01 TFT color LCD panel and a Landmark VHB (very high brightness) backlight. The module has the same foot print and uses the same mounting holes as the original AA121SL01 LCD.

At the maximum backlight power of 20 Watts, the LM146-121SL01 module delivers a screen luminance of about 1,850 Cd/m^2 (nits). At this brightness level, the display is highly readable under bright ambient lighting including direct outdoor sunlight. It is recommended that the Landmark BI200A inverter be used to operate the backlight in this LCD module. With this inverter, the LCD screen luminance can be adjusted down to 10 Cd/m^2 for night viewing.

Characteristics (Note 1, 2)

Parameters	Typical Value	Units	Conditions
LCD Screen Luminance	1,850	Cd/m^2	LCD in OFF state (normally White)
Luminance Uniformity	20% or better		Note 3
Backlight Power Consumption	20	Watts	Excluding inverter losses
Screen Luminance Dimming Ratio	200:1		With LMT BI200A inverter
Typical LCD Contrast Ratio	550:1		White vs. Black (measured in the dark along the normal direction)
Typical Viewing Angles			
3:00 direction	> 60	Degrees	Contrast ratio ≥ 10
9:00 direction	> 60	Degrees	Contrast ratio ≥ 10
6:00 direction	> 60	Degrees	Contrast ratio ≥ 10
12:00 direction	> 45	Degrees	Contrast ratio ≥ 10
LCD Screen Chromaticity (x, y)			
White	(0.354, 0.378)		Measured at the normal direction
Red	(0.603, 0.340)		Measured at the normal direction
Green	(0.337, 0.557)		Measured at the normal direction
Blue	(0.168, 0.207)		Measured at the normal direction
Response Speed			
Rise time	20	msec	White to Black, 10% - 90% transition
Fall time	30	msec	Black to White, 10% - 90% transition
LCD Module Weight	680	Grams	

Note 1: Please refer to Mitsubish AA121SL01 LCD Specification for detailed 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.

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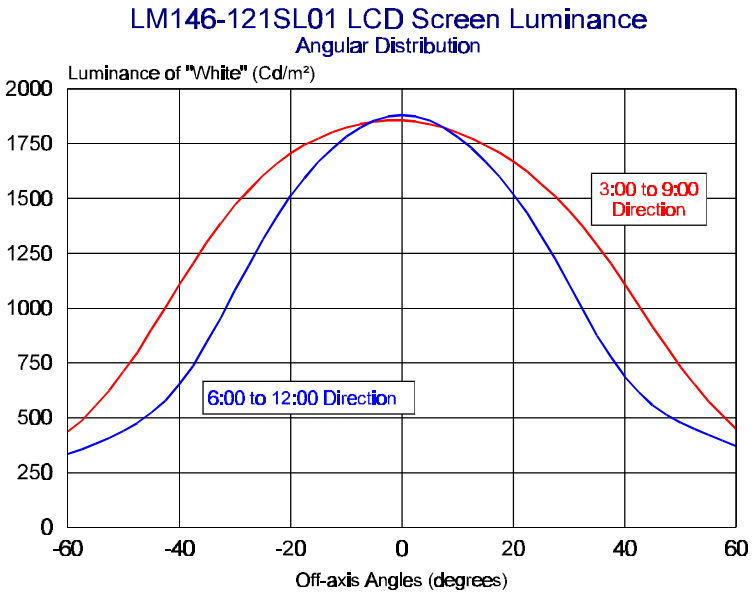
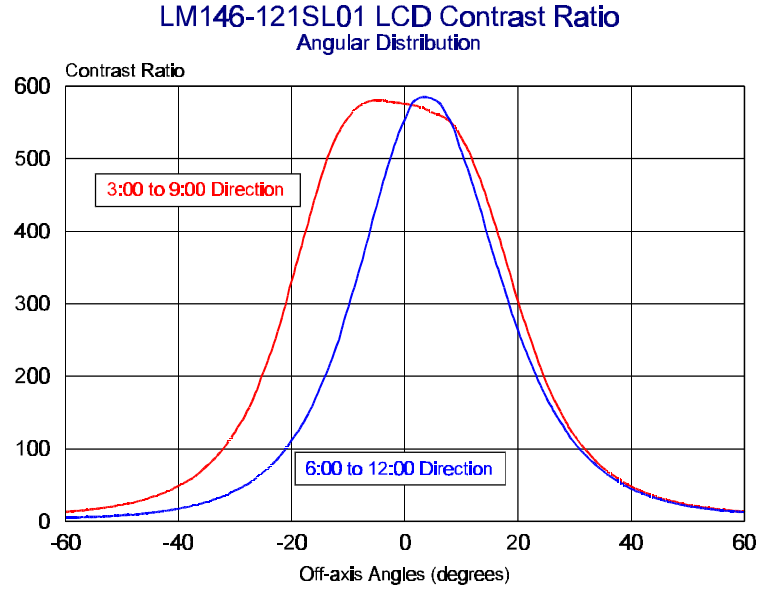
LCD Module Optical Performances

Luminance & Contrast Ratio

The typical LM146-121SL01 LCD module screen luminance and contrast ratio are shown in the figures below. At the best viewing direction, this module delivers a very high screen luminance of about 1,850 Cd/m^2. Since this module is a normally white LCD, the 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 possible luminance. The "white" color displayed on the screen when the video signal is applied may have a slightly lower luminance which can be caused by improper setting of the graphics card and/or the LCD controller. When the LCD is properly driven, the measured luminance of the "white" color displayed on the screen should be within 10% of the specified value.





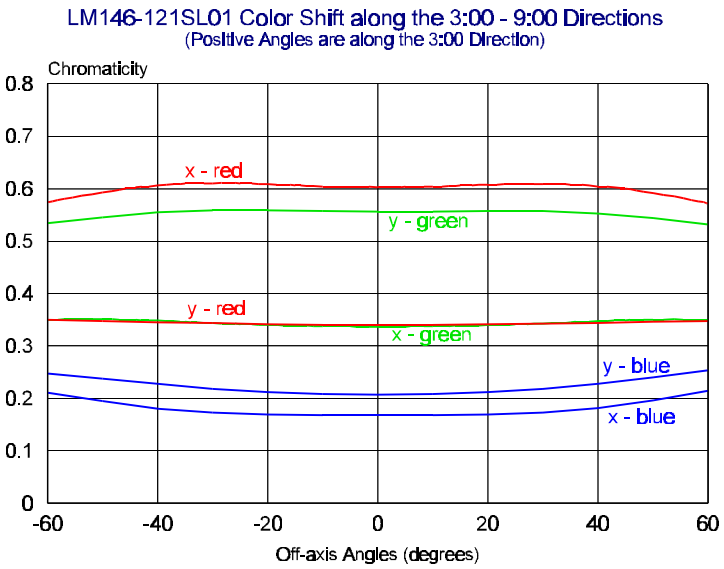
The LM146-121SL01 LCD module also has an exceptionally high contrast ratio (CR) of nearly 600:1. This is the inherent CR, which is the luminance ratio between the "White" and the "Black" states measured in a dark room. Under ambient lighting, particularly in bright outdoor environments, the CR value of the display drops significantly due to the reflection and glare caused by the strong ambient illumination.

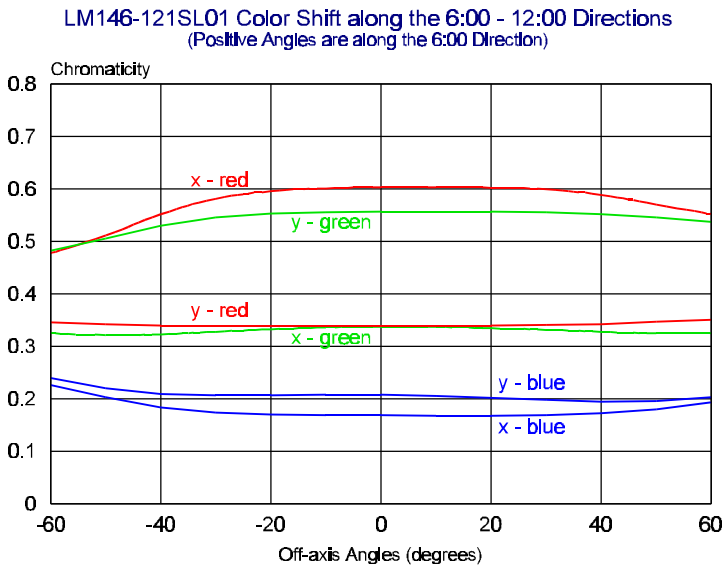
Chromaticity

The figures on the next page present the chromaticity (x, y) data of the R, G, B primary colors displayed on the screen.

Along the 3:00 to 9:00 (horizontal) directions, the chromaticity values of the R, G, B primary colors do not change significantly except at very large off-axis angles. Therefore, the color shift along the horizontal direction is small.

Along the 6:00 to 12:00 (vertical) directions, the chromaticity values do not change too much until the viewing angle reaches about 40^o and beyond, along the 12:00 direction. As a result, the color shift is only significant along the 12:00 direction at large off-axis viewing angles.





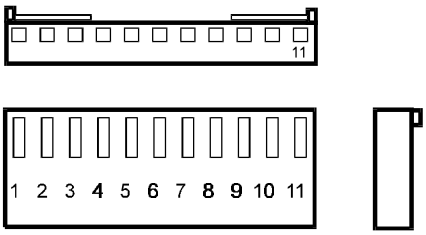
Backlight Lamp Driving Specifications

LM146-121SL01 VHB LCD has a VHB backlight with 8 cold cathode fluorescent lamps (CCFLs). The lamps are electrically connected into two groups through two 11-pin Molex connectors. The figure below shows the connector pin out assignments.

It is recommended that an inverter with a minimum of 1300 V_{rms} starting voltage be used to run the VHB backlight on the LM146-121SL01 module. The lamp voltage and current at full LCD screen luminance are listed below:

Lamp Voltage	470	V_{rms}
Lamp Current	5.4	mA_{rms}

At this driving condition, the backlight delivers 1,850 Cd/m^2 of LCD screen luminance with a power consumption of about 20 Watts.



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 #5
4	NC	4	NC
5	Lamp #2	5	Lamp #6
6	NC	6	NC
7	Lamp #3	7	Lamp #7
8	NC	8	NC
9	Lamp #4	9	Lamp #8
10	NC	10	NC
11	COMMON 1	11	COMMON 2

Since most inverters have an efficiency level between 75 - 80%, the DC power input to the inverter is about 25 to 27 Watts. When the LCD luminance is adjusted down, the power consumption decreases.

Landmark BI200A inverter is designed to drive the 8-CCFL backlight in the LM146-121SL01 module. The inverter has a PWM (pulse width modulation) circuit that provides a 200:1 screen luminance adjustment (i.e. from 1,850 to 9 Cd/m^2). For detailed information, please refer to the BI200A data sheet.

Backlight Life

When the lamps in the LM146-121SL01 backlight are operating at the recommended current for full LCD screen luminance, they are rated at 20,000 hours half brightness life. The half brightness life is the number of operating hours before the CCFL surface luminance drops down to 50% of its initial value.

In general, the luminance of a backlight decays slightly faster than that of a CCFL. This is due to the aging of other materials in the backlight. However, in actual applications, the luminance of a VHB display will likely be adjusted down in dimly lit environments. Since the half brightness life increases rapidly when lamps are operated at reduced current levels for lower LCD screen luminance, the actual operating lifetime of the backlight in this LCD module can be expected to reach beyond 20,000 hours. For detailed discriptions on backlight life issues and actual test data on Landmark Technology backlights, please refer to Technical Note TK801

Thermal Management

The backlight power consumption of the LM146-121SL01 LCD module is approximately 20 Watts at full brightness. As a result, the LCD screen temperature will be higher than normal. It is necessary to dissipate the backlight heat such that the LCD temperature stays within the temperature specifications of the Mitsubishi AA121SL01 LCD.

The exact increase in screen temperature depends on the installation of the LCD module in the equipment. For example, with the LM146-121SL01 operating at full brightness in open air with no air flow (still air), the average temperature of the LCD front surface is about 15 to 20 ^{o}C above the ambient air temperature. The highest temperature rise usually occurs if the LCD is placed horizontally. If the LCD is placed vertically, a portion of the heat may rise and dissipate into the air without heating up the LCD. When the LCD is mounted on a heat conducting bezel or a cooling fan is used, the screen temperature rise can be significantly reduced.

It is recommended that the LCD screen temperature be measured at full brightness in the equipment under actual operating environments. The cooling measure 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, it is possible to run the LM146-121SL01 module at a lower brightness to reduce the backlight power. For example, if the PWM dimming circuit of the BI200A inverter is set at a 65% duty cycle, the LCD screen luminance is about 1,200 nits and the backlight power will be reduced by about 40%. As a result, the thermal related issues are reduced proportionally.

LCD Module Mechanical Dimensions