LC640.480.21-065

HIGH PERFORMANCE 6.5" COLOR TFT AMLCD

PLANAR®

The Definition of Quality

Revision Control

Date	Description
September 2000	Document number OM610-00

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LC640.480.21-065 Display

The LC640.480.21-065 is a 6.5-inch diagonal VGA active matrix liquid crystal display (AMLCD) designed to meet the demanding SAE specifications for the transportation industry. This display is ideal for a variety of industrial applications, such as point-of-sale and outdoor kiosks. With a typical brightness of 1000 nits, this sunlight-readable display offers high contrast in bright environments along with a wide dimming range for nighttime operation. With its modular design, this display is perfect for mobile computing and rugged applications where a high-performance embedded display is required.

AMLCD Panel: The panel is a color active matrix LCD module incorporating amorphous silicon TFT (thin film transistor) technology with wide viewing angle characteristics. The video interface is digital, 6-bits per color, which allows up to 262,144 different colors.

Backlight Module: The backlight assembly contains six high-efficiency cold cathode fluorescent lamps (CCFL), temperature sensors, and lamp heaters. All the components are mounted to a single circuit board. The CCFLs are heated at low temperatures to increase their luminance and extend their life. Located in front of the backlight module are several diffusing and brightness-enhancement films.

Inverter Module: This assembly contains the backlight inverter electronics, microprocessor, heater control circuitry, and input/output connectors. All the components are mounted to a single circuit board. The microprocessor controls the inverter, heater, and dimming functions. The dimming functions include manual analog and automatic control based upon ambient light.

Ambient Light Sensor: The ambient light sensor can remain attached to the display or mounted remotely using a cable.

Video Interface: Standard VGA TFT interface is digital 6-bit RGB.

Features and Benefits

- 1000 cd/m^2 typical luminance for sunlight-readability
- 3:1 contrast @ 100K Lux ambient for outdoor daylight use
- Wide +35/-45° vertical / ±50° horizontal viewing angle
- 300:1 digital dimming for efficient control over a wide range of ambient light
- 18-bit (6 bits per color) video interface for wide color range (262,144 colors)
- 30,000 hours MTBF for long service-free operating life
- Durable and lightweight for rugged conditions
- Convection cooling for operation without cooling fans
- Modular design for easy field replacement of backlight and inverter
- Automatic thermal management at low and high temperature extremes

Installation and Handling

Do not drop, bend, or flex the display. Do not allow objects to strike the surface of the display.

Mounting the Display

To maximize shock and vibration performance, the display must be properly mounted using all four mounting hole locations. There are two recommended mounting configurations. Appropriate changes to these mounting configurations may be needed to meet specific requirements or applications. Table 1 below lists the recommended mounting hardware.

Table 1. Mounting Hardware.

Screw	M2.5 SS phillips-head or #4 SS phillips-head
Washer	Lockwasher, split type
Tightening torque	4 oz-in \ $2.8x10^5$ dyne – cm

Mounting Display Face Down

Standoff spacers or bosses with a minimum height of 3.0 mm must be used at all four mounting locations to prevent binding and deflection of the display.

Mounting Display Face Up

Standoff spacers or bosses with a minimum height of 33.0 mm must be used at all four mounting locations to prevent binding and deflection of the display.

Thermal Control

Several thermal sensors located on the backlight module allow the display to operate safely at temperature extremes. At low ambient temperatures, heaters on the backlight module warm the lamps to a safe temperature before energizing the lamps. This cold-start routine extends the life of the lamps and increases the luminance at low temperatures. During the warm up period, pin 39 on the input connector is set low.

At high ambient temperatures, the luminance will gradually be reduced to maintain acceptable temperatures on the inverter module. If the temperatures remain above the acceptable level after the luminance has been totally reduced, then the inverter will shut down. During the luminance reduction period, pin 40 on the input connector (J1) is set to low.

Isolation and Air Gap

The display generates high voltage AC to drive the CCFL tubes. High voltage is present at numerous points on the backlight and inverter module that forms the rear surface of the display, so your application should not place metal too near the module. In the interests of both high voltage isolation and airflow for cooling, it is recommended that an air gap of .197" (5 mm) or greater be maintained behind the display.

Ambient Light Sensor Clearance

Two backlight dimming modes utilize automatic brightness control. If the display is to be operated in either of these modes, the ambient light sensor located on the front bezel must be unobstructed. If the sensor is placed behind the same protective window as the display active (viewing) area, the sensor operation may be affected due to light scattering and reflections from display-generated light coupling to the sensor via the window.

Cable Length

Due to the high frequencies present on the video interface, unterminated video cable lengths of more than 12 inches (300 mm) are discouraged.

Cleaning

Care should be taken to minimize scratching. Clean the display front with a dry, soft cloth such as a professional photographic lens cleaner. Disposable cleaning cloths are recommended to minimize the risk of inadvertently scratching the display with particles embedded in a re-used cloth. Particular care should be taken when cleaning displays with polarizers or anti-glare and anti-reflective films. These films may delaminate if exposed to certain chemicals.

Avoiding Image Retention

Image retention may occur when a fixed pattern is displayed for a long time. Use a screen saver or image inversion to avoid image retention on the display.

Specifications

Performance characteristics are guaranteed with the display at room temperature (25 °C) and with the operating voltage within specifications, unless otherwise specified. Optical performance is referenced to screen center at normal incidence with a full white screen display and the backlight at maximum luminance, 60Hz LCD frame rate, unless otherwise specified.

Environmental Characteristics

Table 2. Environmental Characteristics.

Temperature	
Operating	-20 to +71 °C (-40 to +71°C with cell heater/version -01)
Operating survival	-40 to +85 °C, 2 hrs. maximum
Storage	-45 to +90 °C, 24 hrs. maximum
Humidity	
Operating	93% RH @ 40 °C, non-condensing, 10 days per IEC 68-2-3
Non-operating	0 to 95% RH @ 25-55 ºC, 6 days per IEC 68-2-30
Altitude	
Operating	0 to 10k ft. per IEC 68-2-13
Non-operating	0 to 40k ft. per IEC 68-2-13
Vibration (random)	
Operating/Non-operating	0.02 g^2/Hz, 5-500 Hz, 30 min. ea. axis, per IEC 68-2-34 Specific profiles for each axis, SAE J1455, section 4.9
Shock	
Operating/Non-operating	100 g, 6 ms, half sine wave, 3 shocks per surface, per IEC 68-2-27

Safety and EMI Certifications

The display will not inhibit the end product from compliance with UL1950, CSA22.2, and IEC950. When housed in a suitable enclosure, the display will not inhibit the end product from complying with FCC Part 15, Subpart J Class B, EN55022 Class B, or SAE-J-1113.

Reliability and Backlight Life

The demonstrated system MTBF is to be greater than 30,000 hours with a 90% confidence level at 25 °C. Refer to Table 3 for backlight life.

Table 3. Backlight Life.

Usage	**Backlight life** (typical to 50% of initial luminance)
Continuous at full luminance	20K hours
Continuous at half luminance	60K hours
Typical use using CBM*	50K hours @ 700 cd/m^2
* Controlled luminance mode	

Mechanical Characteristics

Refer to mechanical outline drawing in Figure 23 on page 33. All size measurements shown in Table 3 are in millimeters (inches).

Table 4. Mechanical Characteristics.

Display External Dimensions	
width	178.8 (7.04) nominal
height	126.8 (4.99) nominal
depth	38.3 (1.51) nominal
Weight (normal)	
	470 g (1.05 lbs.)
Display Active Area	
width	132.48 (5.22) nominal
height	99.36 (3.91) nominal
diagonal	165.10 (6.5)
Pixel Pitch	
width	.207 (0.008) nominal
height	.207 (0.008) nominal

Optical Characteristics

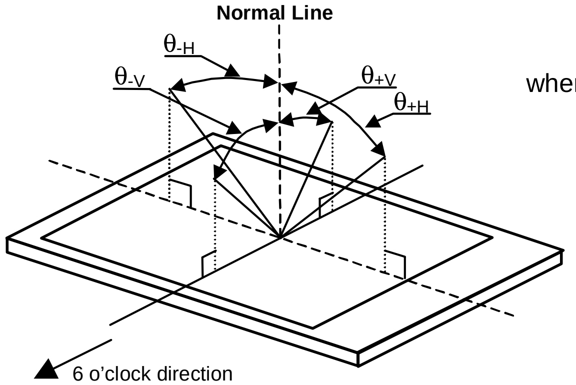
Table 5. Optical Characteristics.

Luminance (at screen center)	
Standard (typical)	3 cd/m^2 minimum, 1000 cd/m^2 maximum (initial)
[1]Controlled (typical)	3 cd/m^2 minimum, 700 cd/m^2 maximum
Contrast Ratio	
Dark room ambient	150: 1 typical, 80:1 minimum
500 Lux ambient	92:1 typical
5K Lux ambient	12:1 typical
20K Lux ambient	4:1 typical
Color Coordinates	
White field	x = .362 typical; y = .370 typical
Luminance Non-uniformity	
25% maximum	With a white screen, max difference between any 2 of 5 points is defined as follows: Lnu (%) = (1- (Lmin/Lmax)) x 100%
Luminance Control (typical))	
Dimming range	50:1 initial, 300:1 stabilized (Lmax after > 15 minutes at max. lum., then Lmin at min. lum; dimming range = Lmax/Lmin)
Ambient Light Sensor	
Response	Visible light filtered ~420 to 675nm @ 50% pts.
Field of view	±50 degrees typical to half sensitivity
Dynamic range	0 to 3000 Lux typ.; assumes 18% scene reflectance
Viewing Angles	
Horizontal	±50 degrees typ., White/black CR ≥ 10
Vertical	+35/-45 degrees typ., White/black CR ≥ 10
(See Figure 1)	

[1] The contrast brightness mode regulates backlight luminance via feedback over the life of the lamps. The lamp and luminance life will vary depending on the chosen controlled luminance level. For more information, see "Backlight Dimming" on page 20.

Viewing Angles

Figure 1. Viewing Angles.



where: θ_{+H} +Horizontal angle (+50)

θ_{-H} -Horizontal angle (-50)

θ_{+V} +Vertical angle (+35)

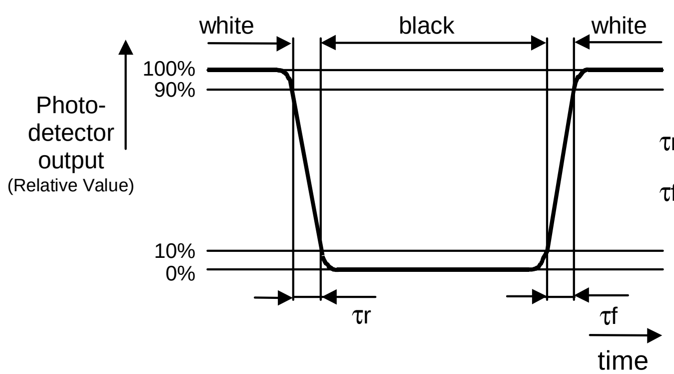
θ_{-V} -Vertical angle (-45)

and R/L and U/D = default

Response Times

As shown in Figure 2, the rise response time (from white to black) is 40 ms typical and the fall response time (from black to white) is 50 ms typical.

Figure 2. Response Times.



τr = Rise (wht to blk): 40 ms typ

τf = Fall (blk to wht): 50 ms typ

Interfacing and Operation

Control Basics

Power Requirements

The LC640.480.21-065 display requires two power supplies: +5 Vdc for the LCD logic and +12 Vdc for the backlight. In Table 6 below, the backlight current and power are referenced to maximum luminance, 25 °C ambient temperature.

Table 6. Input Power

	Symbol	Min	Typ	Max	Units
Panel					
Panel voltage (nominal = 5.0V)	V_{CC}	4.75	5.0	5.25	Vdc
Absolute max. V_{CC}	V_{CC}	-0.3	–	6.5	Vdc
I_{CC} (V_{CC} = 5.0V)	I_{CC}	–	470	640	mAdc
Inverter					
Inverter voltage (nominal = +12.0V)	V_{INV}	8.0	12.0	18.0	Vdc
Absolute max. voltage	V_{INV}	–	–	20.0	Vdc
Current (V_{INV} = 8.0V, max. luminance)	I_{INV}	–	1.6	1.8	Adc
Backlight					
Backlight heater voltage	V_{LH}	8.0	12.0	18.0	Vdc
Backlight heater current	I_{LH}	–	2.0	3.0	Adc
Cell heater voltage	V_{LH}	8.0	12.0	18.0	Vdc
Cell heater current	I_{LH}	–	1.0	1.5	Adc

CAUTION: Absolute maximum ratings are those values beyond which damage to the device may occur.

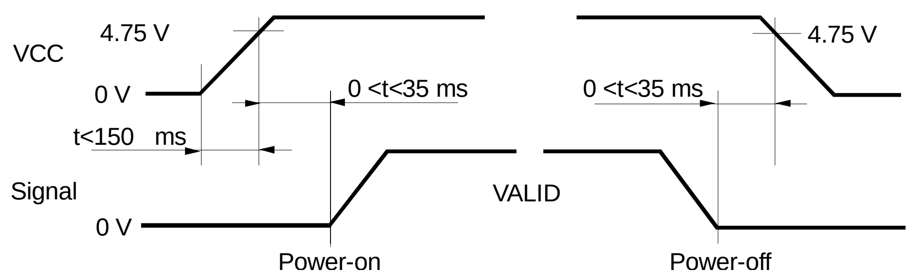
Power Sequencing (LCD)

When performing power sequencing:

- Ensure the supply voltage for input signals is the same as for VCC.
- Apply VCC within the LCD operation period. When the backlight turns on before LCD operation or the LCD operation turns off before the backlight turns off, the display may momentarily become white.
- When the power is off, keep whole signals (Hsync, Vsync, CLK, DE, and DATA) low level or high impedance.

Figure 3. Power Sequencing.

SUPPLY VOLTAGE SEQUENCE



***1 The supply voltage for input signals should be the same as VCC.**

***2 Apply VDD within the LCD operation period. When the backlight turns on before LCD operation or the LCD operation turns off before the backlight turns off, the display may momentarily become white.**

***3 When the power is off, please keep whole signals (Hsync, Vsync, CLK, DE, and DATA) low level or high impedance.**

Video Signals

Video Signal Characteristics

Video signal inputs on J1 are digital inputs and are compatible with CMOS logic.

Table 7. Video Signal DC Characteristics.

Description	Symbol	Minimum	Maximum	Units
Absolute maximum input voltage	V_{Imax}	-0.3	6.5	Vdc
Low-level input voltage	V_{IL}	0	0.8	Vdc
High-level input voltage	V_{IH}	2.2	5.25	Vdc

Signal Timing

Video signal timing diagrams are shown in Figures 2 through 4 on the following pages. Table 8 refers to these diagrams.

Table 8. Video Signal Timing.

Parameter		Symbol	Min.	Typ.	Max.	Unit
CLK	Frequency[1]	1/tc	21.0	25.175	29.0	MHz
	Duty	t ch/ t c	0.4	0.5	0.6	–
	Rise, fall	t crf	–	–	10	ns
Hsync	Period[2]	t h	30.0	31.778	33.6	μs
			–	800	–	CLK
	Display period	t hd	640		CLK	
	Front-porch	t hf	2	16	–	CLK
	Pulse width	t hp	10	96	–	CLK
	Back-porch	t hb	5	48	–	CLK
		*) t hp + t hb	64	144	–	CLK
	CLK-Hsync timing	t hch	12	–	–	ns
	Hsync-CLK timing	t hcx	8	–	–	ns
	Hsync-Vsync timing	t vh	15	–	–	ns
	Vsync-Hsync timing	t vs	15	–	–	ns
	Rise, fall	t hrf	–	–	10	ns
Vsync	Period[3]	t v	16.1	16.683	17.2	ms
			–	525	–	H
	Display period	t vd	480			H
	Front-porch	t vf	1	12	–	H
	Pulse width	t vp	2	2	–	H
	Back-porch	t vb	4	31	–	H
		*) t vp + t vb	6	33	–	H
	Rise, fall	–	–	–	10	ns
DATA R0-R5 G0-G5 B0-B5	CLK-DATA timing	t ds	8	–	–	ns
	DATA-CLK timing	t dh	12	–	–	ns
	Rise, fall	t drf	–	–	10	ns
DE	DE-CLK timing	t es	8	–	–	ns
	CLK-DE timing	t eh	12	–	–	ns
	Rise, fall	t erf	–	–	10	ns

[1] 39.722 ns (Typ.) [2] 31.468 kHz (Typ.) [3] 59.94 Hz (Typ.)

Note: Keep all parameters within the specified range. Do not operate the LCD module without an input DE signal.

Figure 4. Timing Diagram.

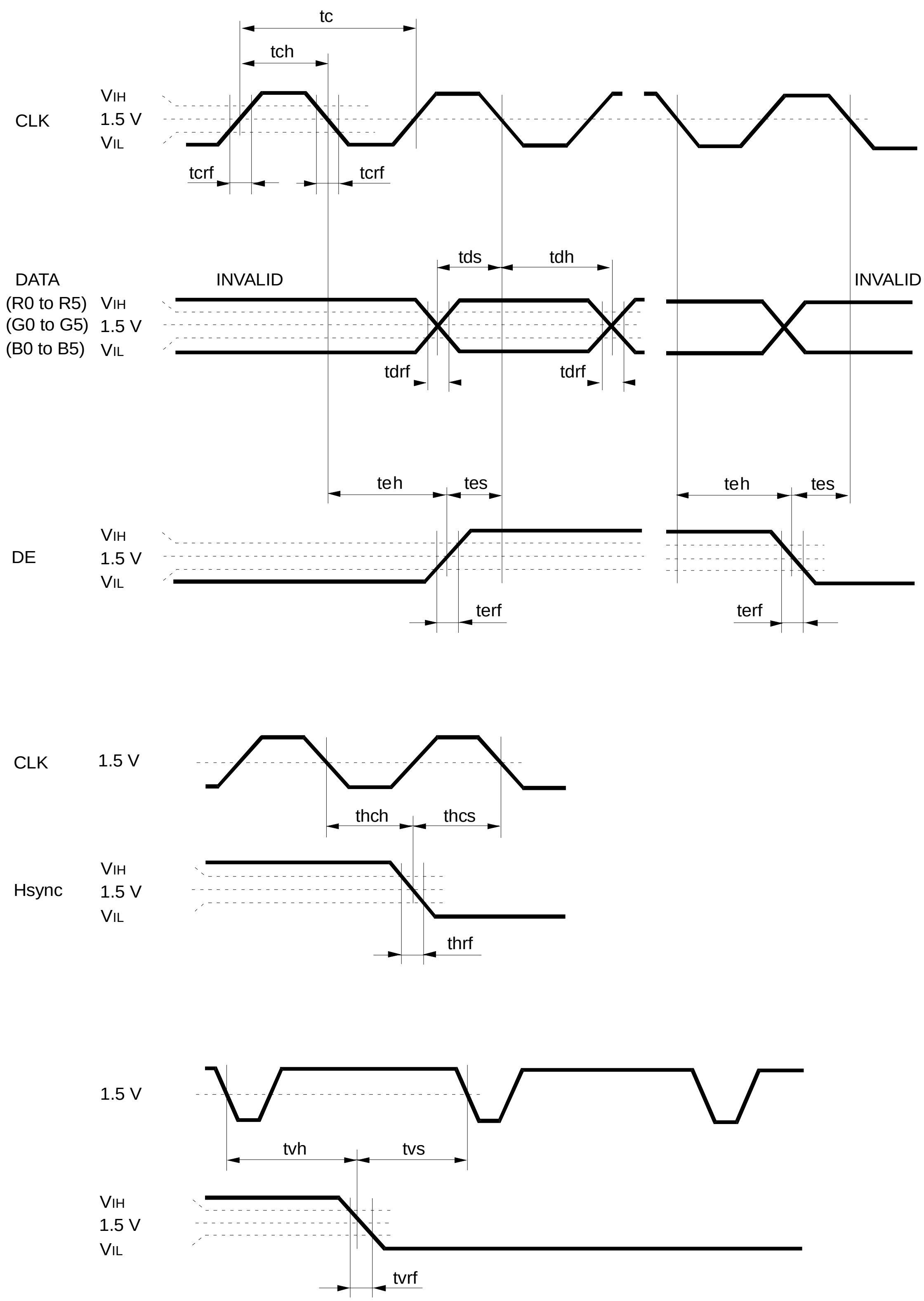
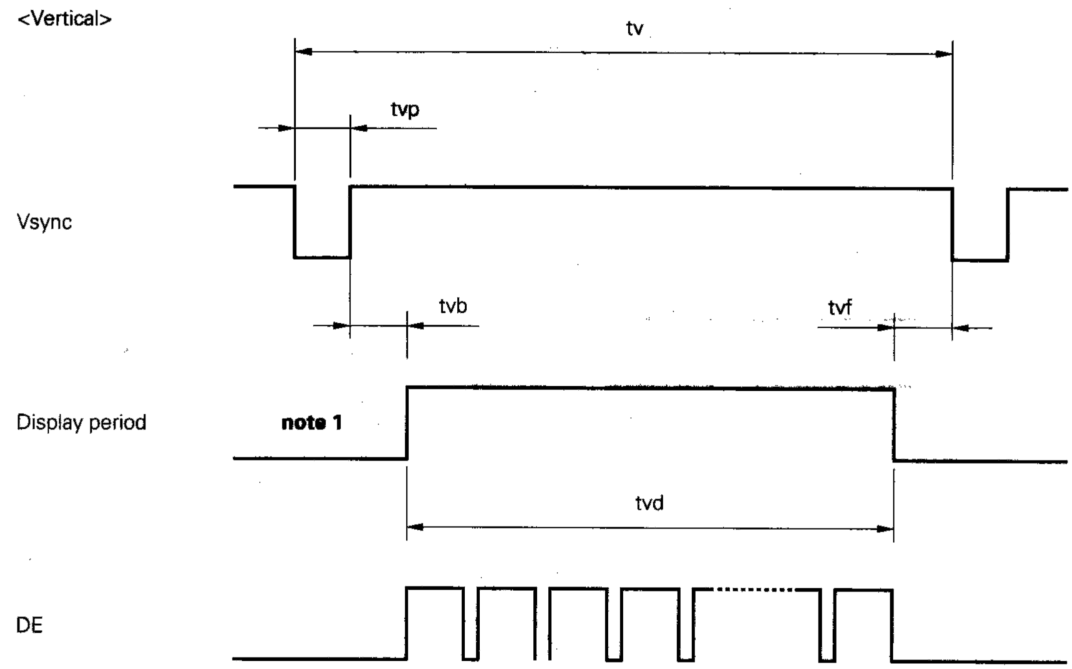
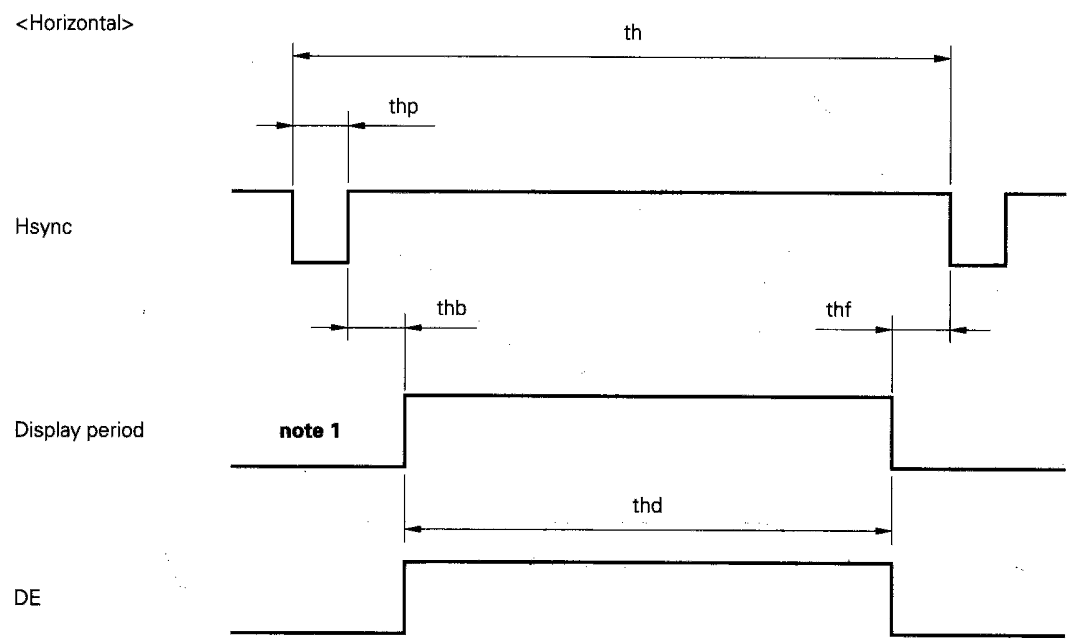


Figure 5. Timing Diagram.

(2) Definition of input signal timing

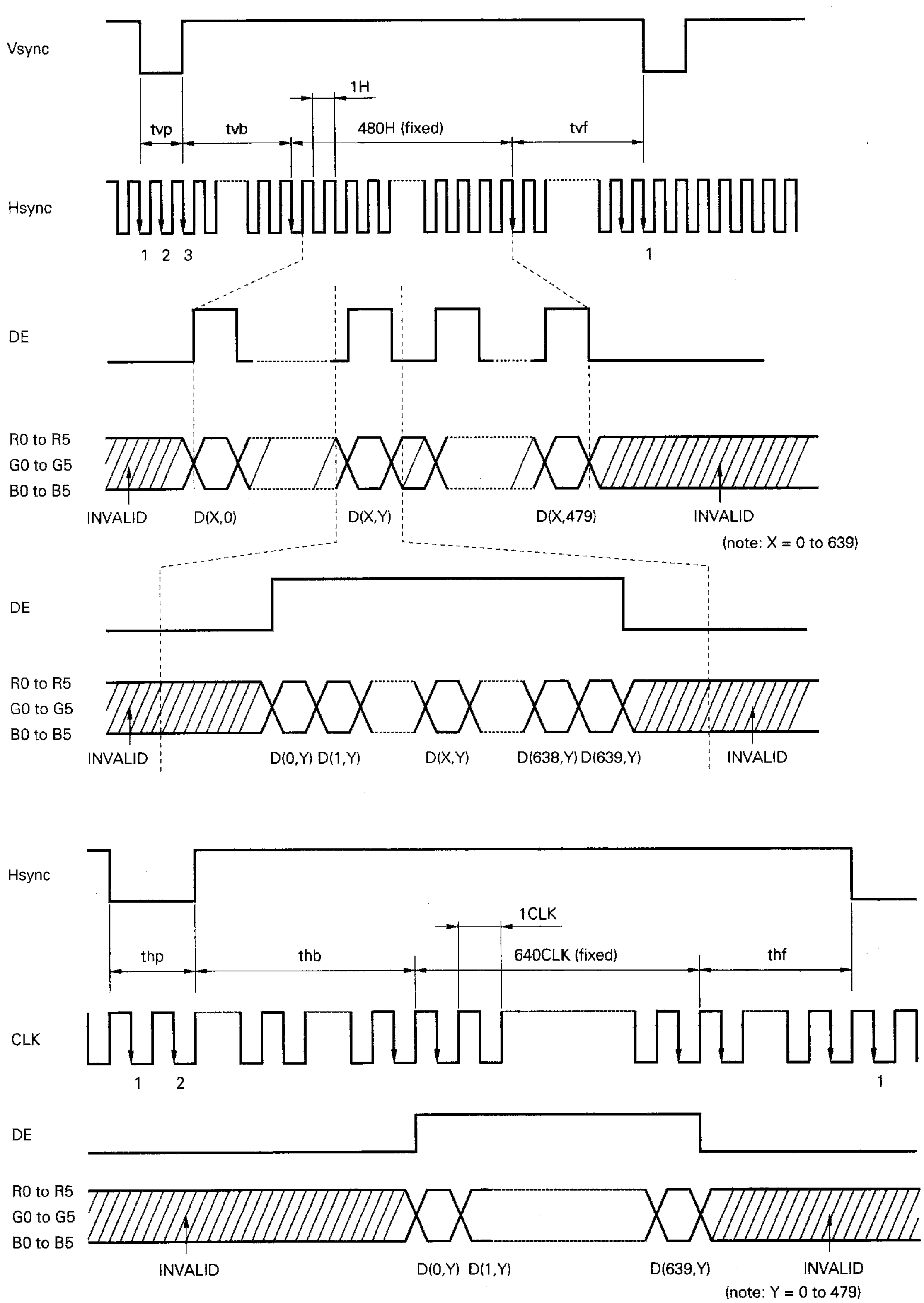




note 1 : Display period does not exist as signals.
note 2 : Set the total of thp + thb and tvp + tvb as the table of input signal timing, otherwise display position is shifted to right or left side, or to up or down side.
note 3 : Do not operate LCD module without input DE signal.

Figure 6. Timing Diagram.

(3) Input signal timing chart



Video Characteristics

Colors are developed in combination with 6-bit signals (64 steps in grayscale) of each primary red, green, and blue color. This process can result in up to 262,144 (64x64x64) colors. The mapping of the eighteen video data inputs is shown in Table 9.

Table 9. Video Data Color and Grayscale Map.

Display colors		Data signal (0: Low level, 1: High level)		
		R5 R4 R3 R2 R1 R0	G5 G4 G3 G2 G1 G0	B5 B4 B3 B2 B1 B0
Basic colors	Black	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0
	Blue	0 0 0 0 0 0	0 0 0 0 0 0	1 1 1 1 1 1
	Red	1 1 1 1 1 1	0 0 0 0 0 0	0 0 0 0 0 0
	Magenta	1 1 1 1 1 1	0 0 0 0 0 0	1 1 1 1 1 1
	Green	0 0 0 0 0 0	1 1 1 1 1 1	0 0 0 0 0 0
	Cyan	0 0 0 0 0 0	1 1 1 1 1 1	1 1 1 1 1 1
	Yellow	1 1 1 1 1 1	1 1 1 1 1 1	0 0 0 0 0 0
	White	1 1 1 1 1 1	1 1 1 1 1 1	1 1 1 1 1 1
Red grayscale	Black	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0
		0 0 0 0 0 1	0 0 0 0 0 0	0 0 0 0 0 0
	dark	0 0 0 0 1 0	0 0 0 0 0 0	0 0 0 0 0 0
	↑	↑	↑	↑
	↓	↓	↓	↓
	bright	1 1 1 1 0 1	0 0 0 0 0 0	0 0 0 0 0 0
		1 1 1 1 1 0	0 0 0 0 0 0	0 0 0 0 0 0
	Red	1 1 1 1 1 1	0 0 0 0 0 0	0 0 0 0 0 0
Green grayscale	Black	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0
		0 0 0 0 0 0	0 0 0 0 0 1	0 0 0 0 0 0
	dark	0 0 0 0 0 0	0 0 0 0 1 0	0 0 0 0 0 0
	↑	↑	↑	↑
	↓	↓	↓	↓
	bright	0 0 0 0 0 0	1 1 1 1 0 1	0 0 0 0 0 0
		0 0 0 0 0 0	1 1 1 1 1 0	0 0 0 0 0 0
	Green	0 0 0 0 0 0	1 1 1 1 1 1	0 0 0 0 0 0
Blue grayscale	Black	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0
		0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 1
	dark	0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 1 0
	↑	↑	↑	↑
	↓	↓	↓	↓
	bright	0 0 0 0 0 0	0 0 0 0 0 0	1 1 1 1 0 1
		0 0 0 0 0 0	0 0 0 0 0 0	1 1 1 1 1 0
	Blue	0 0 0 0 0 0	0 0 0 0 0 0	1 1 1 1 1 1

Pixel Position

The position of pixel data, relative to the color filter orientation and scan direction inputs is shown in Figure 7 below. Refer to Table 10 to see the relations between the scan direction and the viewing direction.

Table 10. Display Positions.

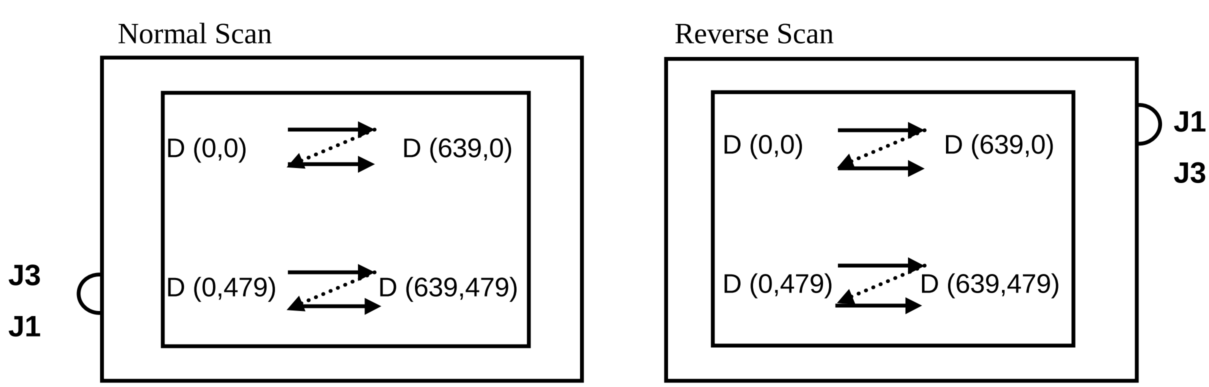
Normal scan: DPS = "L" or "OPEN"

D (0,0)	D (1,0)	—	D (X,0)	—	D (638,0)	D (639,0)
D (0,1)	D (1,1)	—	D (X,1)	—	D (638,1)	D (639,1)
│	│	┼	──┼──	┼	│	│
(D 0,Y)	D (1,Y)	—	D (X,Y)	—	D (638,Y)	D (639,Y)
│	│	┼	──┼──	┼	│	│
D (0,478)	D (1,478)	—	D (X,478)	—	D (638,478)	D (639,478)
D (0,479)	D (1,479)	—	D (X,479)	—	D (638,479)	D (639,479)

Reverse scan: DPS = "H"

D (639,479)	D (638,479)	—	D (X,479)	—	D (1,479)	D (0,479)
D (639,478)	D (638,478)	—	D (X,478)	—	D (1,478)	D (0,478)
│	│	┼	──┼──	┼	│	│
D (639,Y)	D (638,Y)	—	D (X,Y)	—	D (1,Y)	(D 0,Y)
│	│	┼	──┼──	┼	│	│
D (639,1)	D (638,1)	—	D (X,1)	—	D (1,1)	D (0,1)
D (639,0)	D (638,0)	—	D (X,0)	—	D (1,0)	D (0,0)

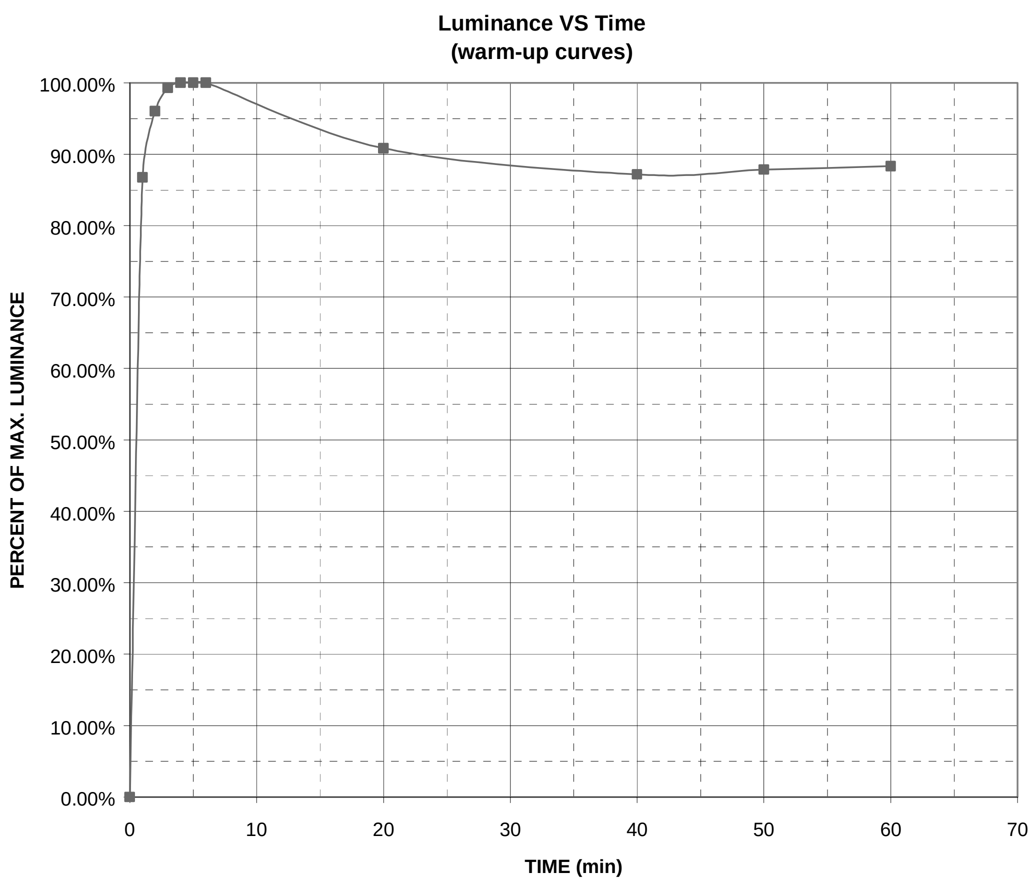
Figure 7. Pixel Position of Input Data.



Warmup Characteristic

Some time after startup is required to allow the CCFL tubes to reach their normal operating temperature. The graph in Figure 8 shows the typical room temperature warmup curve for the LC640.480.21-065 when set to maximum luminance.

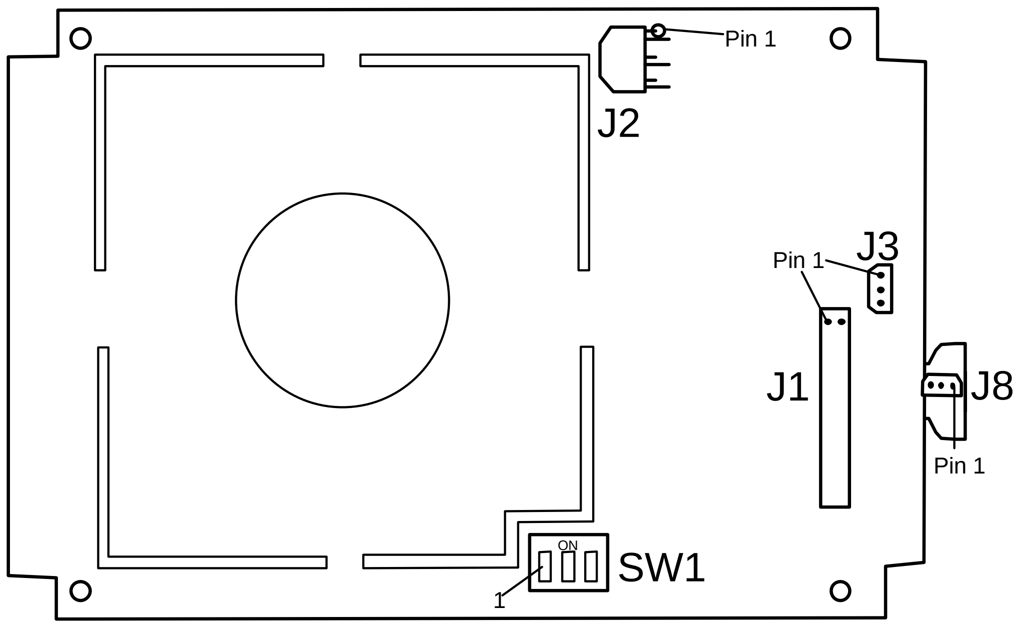
Figure 8. Warmup Curve.



Connectors

The LC640.480.21-065 display has four connectors on the back near one side of the display. J1 is the video input and backlight control connector, J2 is the backlight inverter and heater connector, and J3 and J8 are the connectors for tethering the ambient light sensor.

Figure 9. Connector Locations.



Video Input and Backlight Control Connector (J1)

The video input and backlight control signals are connected to the display through a 40-pin, dual-row, 1.27 mm pitch, square pin, locking connector (Samtec FTSH-120-01-L-DV-EJ-A). The mating connector is available through Samtec as a cable assembly (FFSD series). Consult your Samtec representative (1-800-SAMTEC) for cable and connector options. Table 11 on the following page lists the pin assignments for the J1 connector.

Table 11. Video Input and Backlight Connector (J1) Pinouts.

Pin	Signal	Description	Pin	Signal	Description
1	GND	Ground	2	CLK	Video clock
3	HSync	Horiz. sync	4	VSync	Vert. sync
5	GND	Ground	6	R0	Red data (LSB)
7	R1	Red data	8	R2	Red data
9	R3	Red data	10	R4	Red data
11	R5	Red data (MSB)	12	GND	Ground
13	G0	Green data (LSB)	14	G1	Green data
15	G2	Green data	16	G3	Green data
17	G4	Green data	18	G5	Green data (MSB)
19	GND	Ground	20	B0	Blue data (LSB)
21	B1	Blue data	22	B2	Blue data
23	B3	Blue data	24	B4	Blue data
25	B5	Blue data (MSB)	26	GND	Ground
27	DE	Data Enable	28	V_{CC}	AMLCD power
29	V_{CC}	AMLCD and fan power	30	GND	Ground
31	DPS	Display scan select	32	/CBM	Controlled luminance
33	DIM	Analog dimming control	34	DIMREF	Dim reference
35	INV	Inverter control	36	GND	Ground
37	ALS	Ambient light sensor	38	TS1	Temperature sensor
39	/HT	Heater indicator	40	/OHT	Overtemp indicator

Signal	I/O	Description
CLK	I	Video Clock
HSync	I	Horizontal Sync
Vsync	I	Vertical Sync
R0-R5	I	Red Data
G0-G5	I	Green Data
B0-B5	I	Blue Data
GND	I	Ground – Signal return for logic and power supplies. Isolated from the display metal bezel.
DE	I	Data Enable
DPS	I	Display Scan - Low or open = normal; High = image upside down
V_{CC}	I	AMLCD power supply: +5 Vdc
INV	I	Inverter - High or open = enable; Low = disable (backlight off)
/CBM	I	Controlled Luminance Mode - High or open = normal; Low = enabled
DIM	I	Analog Dimming Control - 0 to +5 Vdc; +5 Vdc is maximum luminance
DIMREF	O	Dimming Reference - +5 Vdc reference for analog dimming
ALS	O	Ambient Light Sensor - signal to microprocessor: 0 to +5 Vdc; +5 Vdc is lowest ambient light level
TSI	O	Temperature Sensor (no. 1) - signal to microprocessor: 0 to +5 Vdc, with 0C = 0.5 Vdc, and 10 mv/°C
/HT	O	Heating Indicator - Low = display is heating and backlight is turned off
/OHT	O	Over-temp Indicator - Low = display temperature is at maximum and luminance is reduced

Backlight Inverter and Heater Connector (J2)

This connector supplies 12 Vdc nominal to the inverter to operate the backlight inverter and backlight heater. The connector is a Molex Micro-Fit 3.0 Wire-to-Board Header (# 43045-0600). The mating connector is a Molex Micro-Fit 3.0 Wire-to-Wire Receptacle (#43025-0600, crimp # 43030-0007).

Table 12. Backlight Inverter and Heater Connector (J2) Pinouts.

Pin	Function
1	VDD, inverter
2	Inverter ground
3	VLH, backlight heater
4	Backlight heater ground
5	VCH, cell heater
6	Cell heater ground

Ambient Light Sensor (Tethered Option) (J3 and J8)

This connector is used when the ambient light sensor is tethered. The connector is a 3-pin Molex part number 22-03-5035. The mating connector is Molex part number 50-37-5033 with 5263 crimps (Molex # 08-70-1040).

Table 13. Ambient Light Sensor (J3 and J8) Pinouts.

Pin	Symbol	Function
1	PDANODE	Photo diode anode
2	PDCATH	Photo diode cathode
3	GND	Power ground

Tethering the Light Sensor

The protruding circuit board area containing the light sensor is designed so it can be snapped off and removed from the main interface board. Once the ambient sensor is removed it will require the addition of a cable between J3 and J8 in order to function. With the cable installed the sensor can be remotely positioned. The sensor may be discarded if the ambient sensing capability is not required.

To remove the light sensor, place the thumb of your right and left hand on the corresponding front surfaces of the sensor circuit board. Place the index fingers of both hands on the display's rear circuit board just above the sensor. With a firm quick action, push the sensor circuit board back. This will cause the circuit board to snap along the perforation. Now rock the sensor circuit board back and forth several times until it is free from the main interface board.

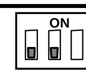
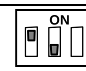
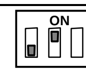
Connect a cable from J8 on the rear of the sensor circuit board to J3 on the rear of the display. The ambient light sensor should now function normally.

Luminance Features

Backlight Dimming

Control for backlight dimming is performed by several methods depending on how the switches on switch block SW1 (see Figure 9) are set as shown in Table 14 below. These selections are available for both standard and controlled luminance mode.

Table 14. Backlight Dimming Control.

Luminance Control	Switch 1	Switch 2	Switch 3	
Manual control	off	off	–	
Automatic control with ambient light sensor	on	off	–	
Automatic control with manual offset and ambient light sensor	off	on	–	
Note: Because Switch 3 is not used, its position has no effect.				

Manual Dimming

This mode allows the user to adjust the luminance by varying the input from 0 to +5 Vdc on pin 33 (DIM) of the video input connector (J1). See Figures 10 and 11.

Table 15. Manual Dimming Specifications.

Description	Specification
Dimming range	Approximately 300:1
Analog voltage input (DIM)	Compatible with voltage and potentiometer (3 terminal) No connection results in maximum luminance Voltage range: 0 to +5V (+5V equals maximum luminance)
Dimming method	Pulse width modulation (period = 100 millisecond, 256 discrete steps, linear)
Recommended pot value	10K ohm
DIM REF	High side pot reference output provided, short-circuit protected
SWI Setting	Switch 1 = OFF, Switch 2 = OFF

Figure 10. Dimming Voltage Input on J1 (DIM).

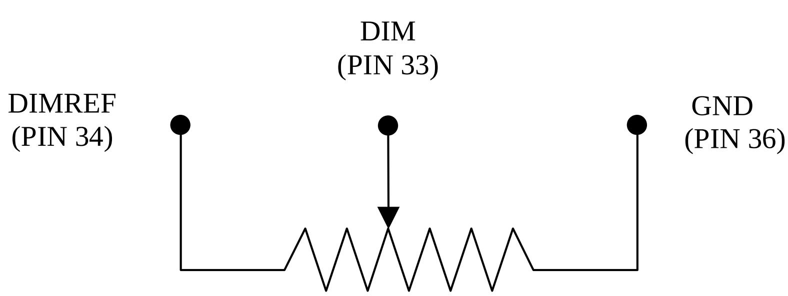
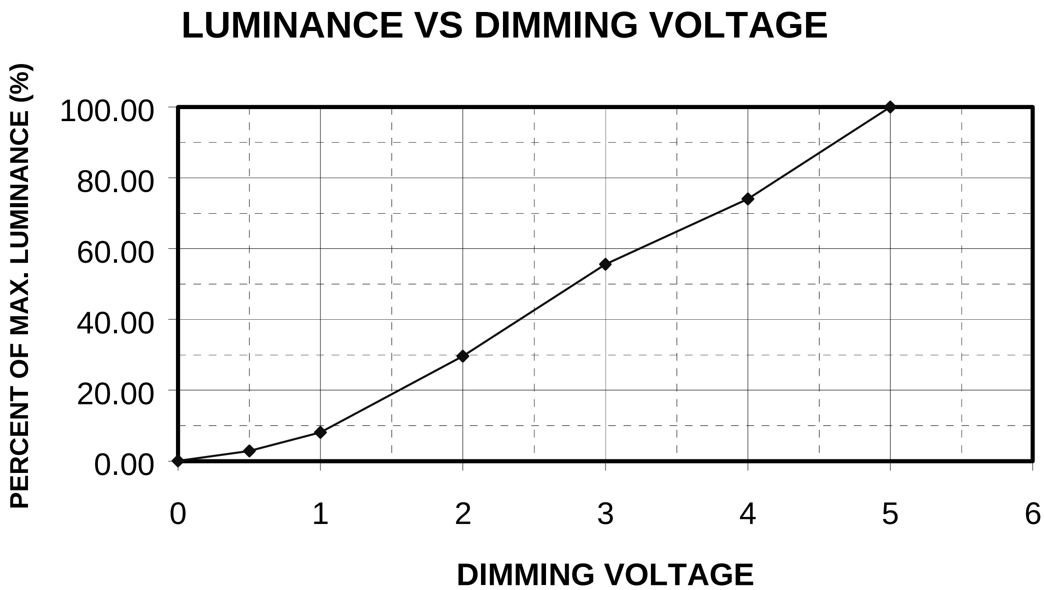


Figure 11. Luminance vs. Dimming Voltage: Manual Dimming.



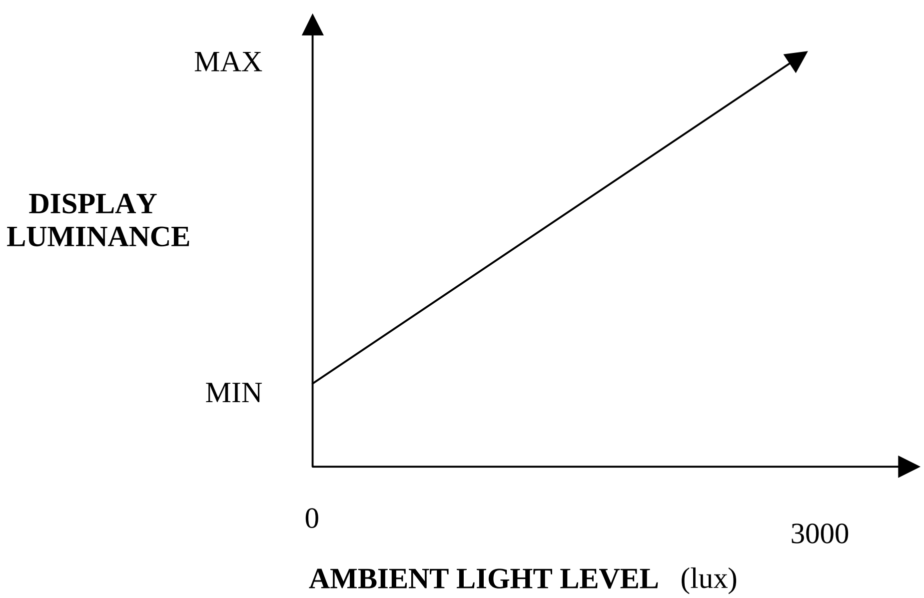
Automatic Dimming (Ambient Light Sensor)

Lamp luminance varies depending on ambient light levels. An off-board light sensor is used to determine the level. See Figure 12 below.

Table 16. Automatic Dimming (Ambient Light Sensor) Specifications.

Description	Specification
Sensor type	Photodiode, visible light filtered
Sensor sensitivity	10 nA/lux
Dynamic range	3000 lux ambient = maximum display luminance 0 lux ambient = minimum display luminance
Ambient to display luminance	Approximately linear relationship 1 second averaging
Field of view	± 50 degrees typical to half sensitivity
Response	Visible light filtered, 420 to 675 nm @ 50% points
SWI Setting	Switch 1 = ON, Switch 2 = OFF

Figure 12. Luminance Levels: Automatic Dimming (Ambient Light Sensor).



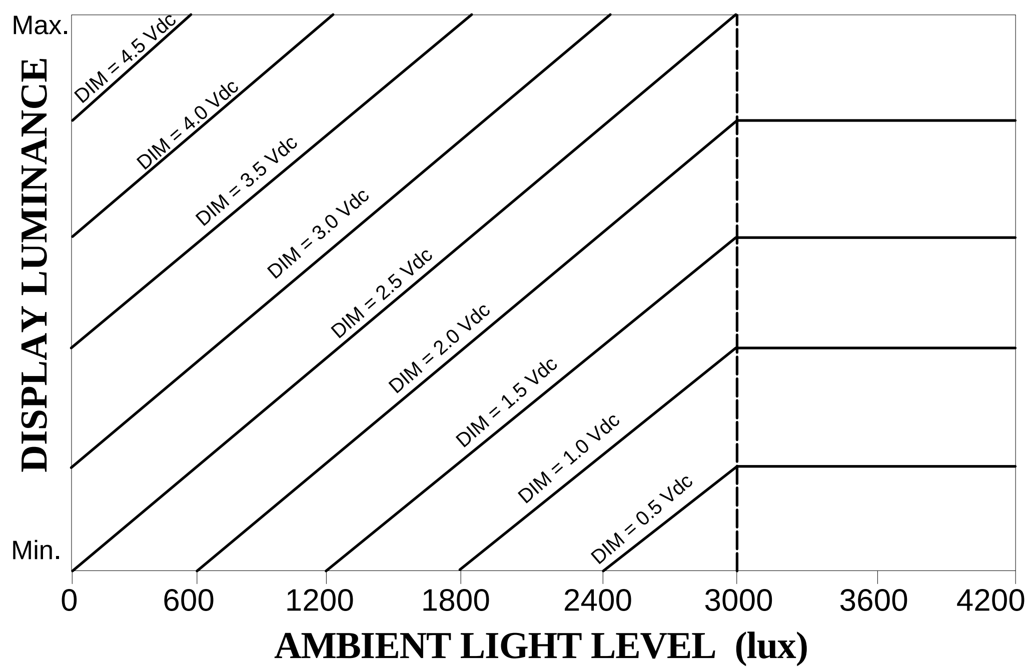
Automatic Dimming (Manual Offset)

Lamp luminance varies depending on ambient light levels. An off-board light sensor is used to determine the level. The user can adjust the luminance offset by varying the input from 0 to 5 Vdc on pin 33 (DIM) of the video input connector (J1). See Figure 13 below.

Table 17. Automatic Dimming (Manual Offset) Specifications.

Description	Specification
DIM function	0 Vdc = max. negative offset (display always at min. luminance) +2.5 Vdc = no offset +5 Vdc = max. positive offset (display always at max. luminance)
DIM voltage to offset %	Linear relationship
SWI Setting	Switch 1 = OFF, Switch 2 = ON

Figure 13. Luminance Levels: Automatic Dimming (Manual Offset).



Controlled Luminance Mode

This function compensates for the luminance degradation of the lamps over time and constrains the maximum display luminance to approximately 700 cd/m^2. Using a light sensor that measures the lamp luminance inside the light box, the microcontroller adjusts the lamp current to maintain constant luminance at the desired luminance level. For example, if DIM = 2.5V (corresponding to a 50% luminance level) in analog dimming mode, then the display luminance will be maintained at approximately 350 cd/m^2. The controlled luminance mode is enabled when pin 32 (/CBM) on J1 is low.

Backlight Enable

The INV input on pin 35 of the backlight control connector (J1) directly shuts down the inverter output.

Table 18. Backlight Enable Specifications.

Description	Specification
Input characteristic	CMOS logic-compatible; open circuit defaults to high state
State definition	INV low state turns backlight off

Temperature Considerations

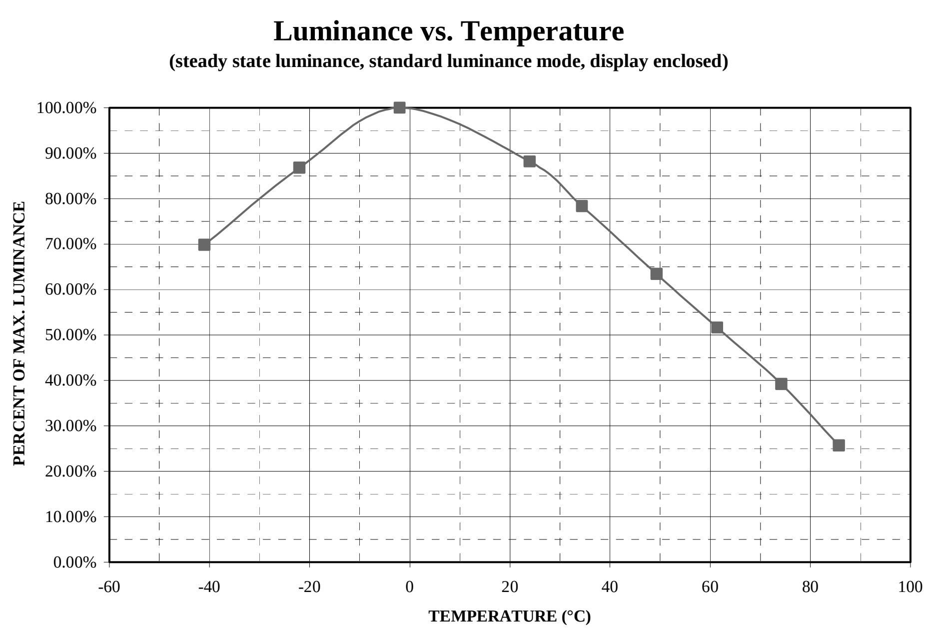
The LC640.480.21-065 display is designed to operate over a wide temperature range. To accomplish this, the display must be heated at low temperatures and the power level reduced at high temperatures. At low temperatures, the lamps are heated using nichrome wires. At high temperatures, the internal temperature is lowered by reducing the backlight luminance. Two sensors located on the lamp circuit board monitor the internal temperature. The 996-0406-01 product incorporates a cell heater to warm the AMLCD cell at cold temperatures.

Luminance Variation Due to Ambient Temperature

Although the inverter features regulated lamp current drive, luminance will vary across the temperature range due to the characteristics of the CCFL tubes. Lamp luminance decreases at low temperatures as the mercury condenses out of the gas and it decreases again at high temperatures as the tube phosphors become less efficient. The LC640.480.21-065 has been designed to provide peak luminance at normal room temperatures without using a heater, and at low temperatures with a heater for the CCFL tubes.

Backlight power consumption decreases as temperatures climb and the working voltage of the CCFL tubes decreases. The graph in Figure 14 indicates typical performance across temperatures.

Figure 14. Backlight Power Consumption.



Temperature Sensors

The temperature sensors are located at opposite corners of the backlight module, just outside the active area of the display. The output of the sensors are sent to the microprocessor on the inverter module through a board-to-board connector.

Heater Operation and Over Heat Status Lines

There are two situations when the inverter controller will override the external control of the backlight:

1. At cold temperatures, the backlight will not turn on until it is warmed up.
2. At high temperatures, the luminance will be reduced until the temperature drops to a safe level.

Two digital status signals notify the user computer of these conditions. These CMOS-level outputs sink up to 20 mA to accommodate an LED load.

Table 19. Heater Operation and Over Heat Status Line Parameters.

Parameter	Value	Units
Heater status (/HT, pin 39, J1)	0 = heating, +5 = normal	Vdc
Over heat status (/OHT, pin 40, J1)	0 = over heat, +5 = normal	Vdc

Backlight Heater

The backlight heater consists of nichrome wire wrapped around each lamp. The purpose of the heater is to vaporize the mercury at low temperatures providing proper lamp emission color and extending lamp life.

When the inverter is first powered up it checks the backlight cavity temperature. If the temperature is below +10° C, the lamp heaters are turned on at 100% duty cycle and the inverter is disabled for a specific time period as shown in Figure 15 on page 26. After the time delay, the inverter is enabled and the heater duty cycle is set to the value shown in Figure 16 on page 27. The heater continues to operate until the sensor temperature reaches +10° C. See Figure 17 on page 27 for actual display warm-up performance.

Table 20. Backlight Heater Parameters.

Parameter	Value
Type	Resistive wire (nichrome: NiCrA – 80% Ni 20% Cr, 39 AWG, 53 ohms/foot)
Length/Lamp	~ 200 mm (7.87 inches)/lamp, 8 revolutions around each lamp, resistance/wire = 36 ohms, total heater resistance = 6 ohms
Active temperature sensor	Monitor temperature sensor with the highest reading
Control	Duty cycle and maximum power time delay are stepped as shown in Figures 15 and 16
Inverter enable	Inverter is enabled as shown in Figure 15. If the temperature is below +10°C, inverter is turned off until the lamps are heated.
Status indicator	Set the status indicator when the inverter is disabled. See "Heater Operation and Over Heat Status Lines." On page 25.
Hysteresis	3.0 °C
Heater voltage	8-18 Vdc
Power	10.6 W (@ 8 V), 54W (@18 V)

Figure 15. Sensor Temperature vs. Lamp Heater (Inverter Startup Time Delay)

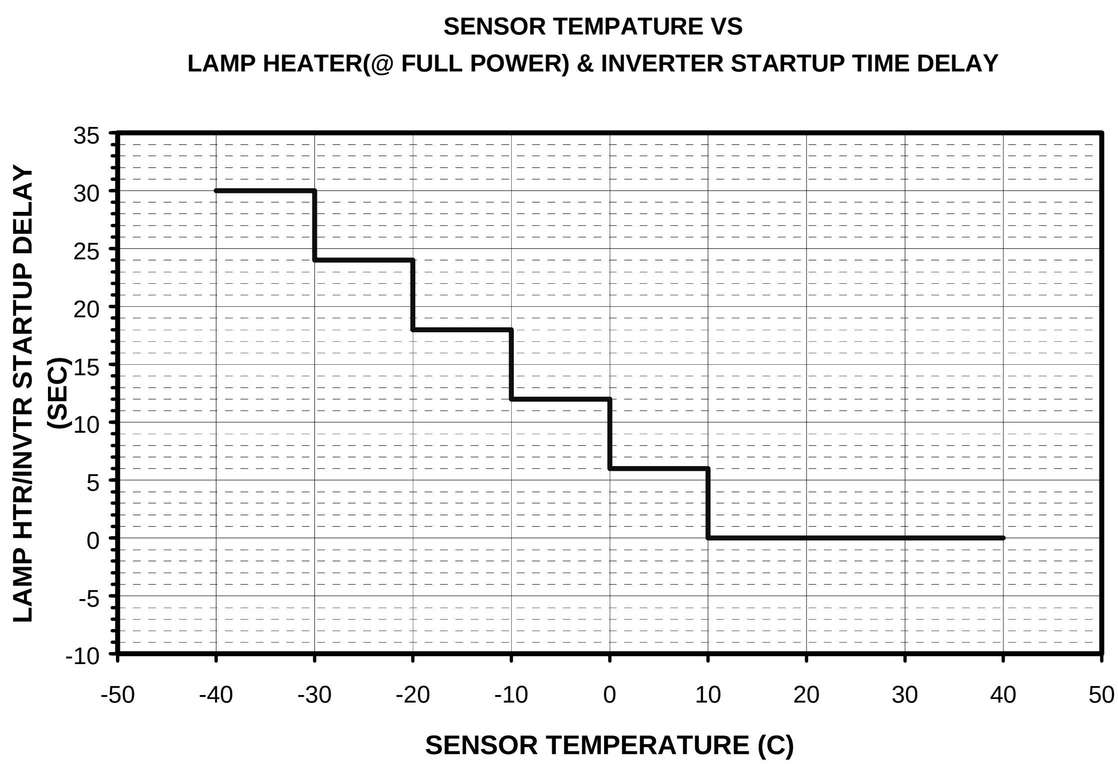


Figure 16. Sensor Temperature vs. Lamp Heater Duty Cycle

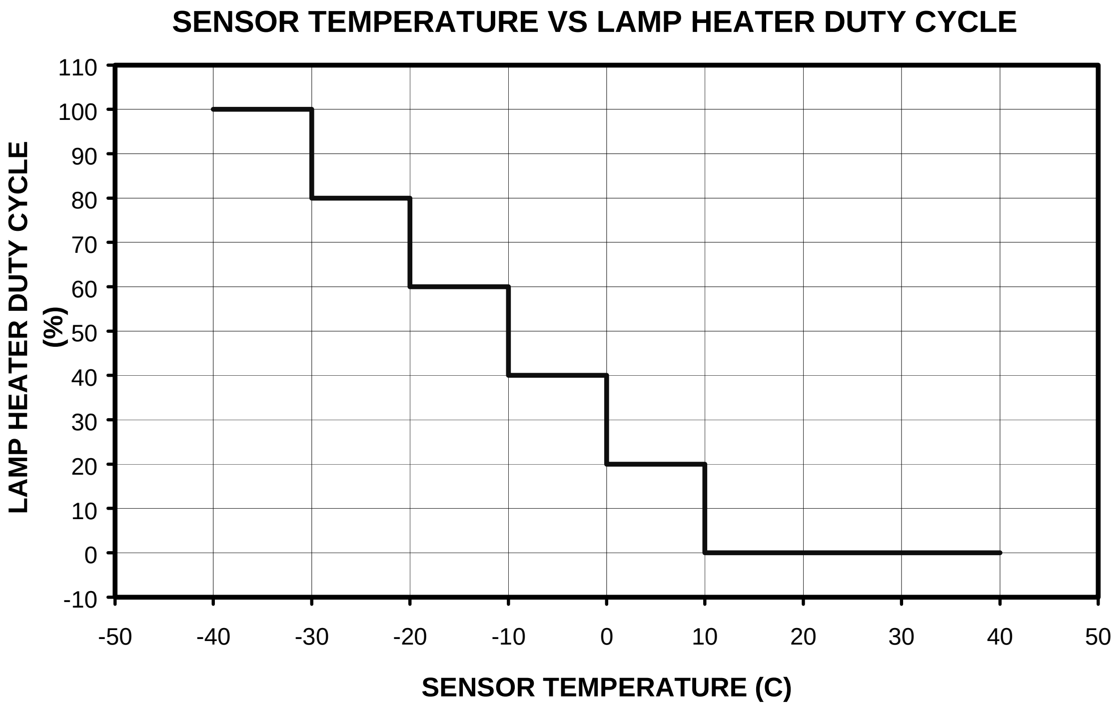
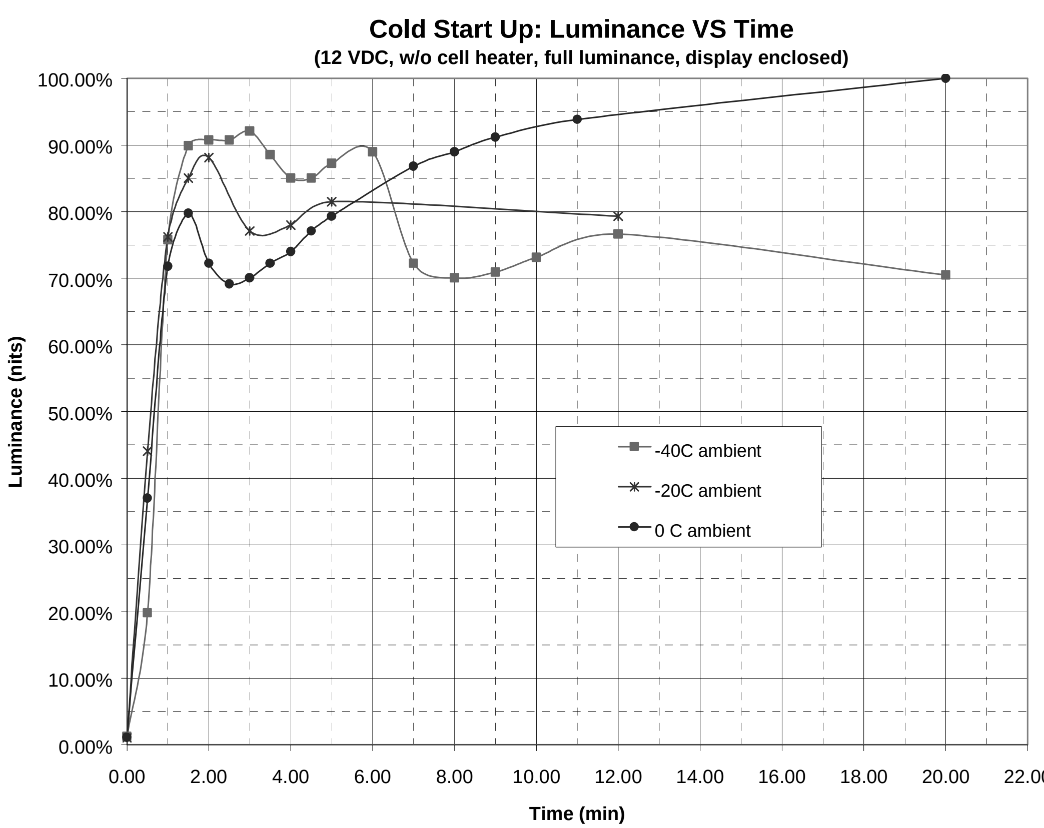


Figure 17. Display Warmup Performance.



Cell Heater (Optional version 996-0406-01)

The cell heater consists of a glass panel with an ITO coating on one side. There are bus bars along each side of the panel. The heater decreases the response time of the AMLCD cell at low temperatures by heating the liquid crystal material in the cell. Figure 18 shows the response time performance at different heater voltages.

If the temperature is below +10° C, the ITO heater is turned on at 100% duty cycle for the time shown in Figure 19 on page 29. The heater duty cycle is then set as shown in Figure 20 on page 29.

Table 21. Cell Heater Parameters.

Parameter	Value	Units
Type	Resistive: ITO on glass (~ 7.5 ohms/square) Total resistance ~ 12 ohms	None
Active temperature sensor	Monitor temperature sensor with the highest reading	None
Control	Duty cycle is stepped as shown in Figure 21	%
Trip point	Not applicable	C
Hysteresis	3.0	C
Heater voltage	8-18	Vdc
Power	5.3 (@ 8 V), 27 (@18V)	Watts

Figure 18. Cell Heater Response Time Performance.

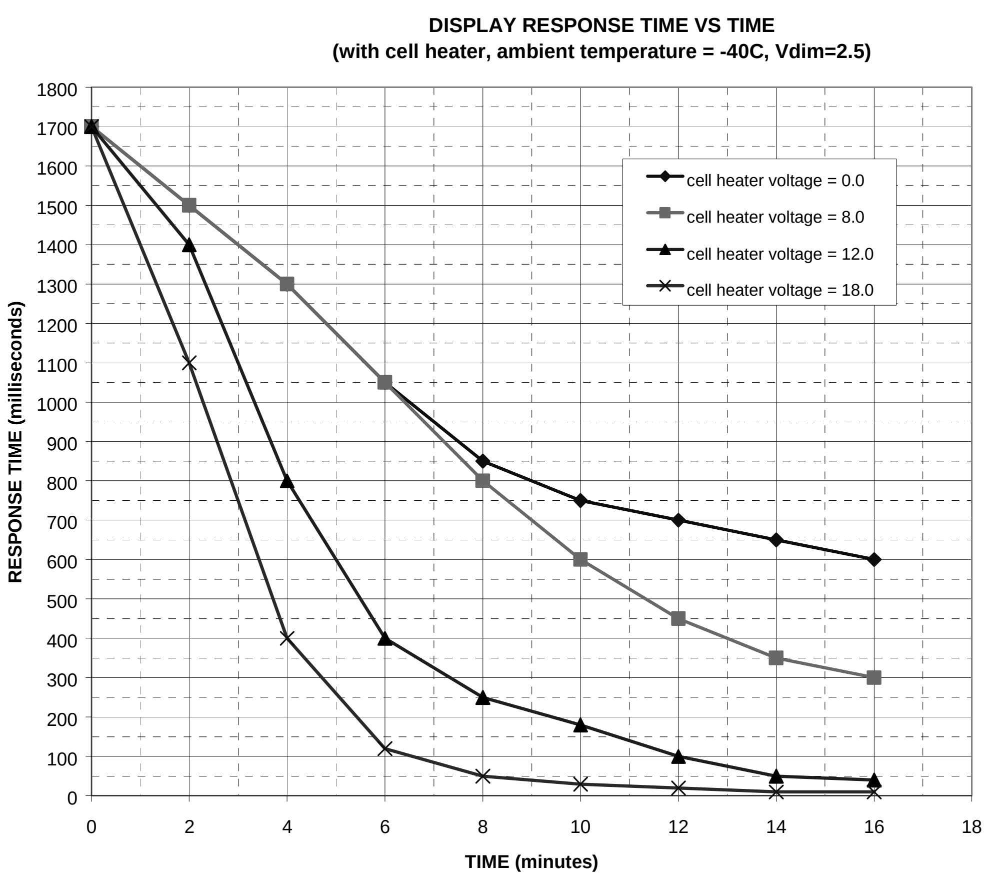


Figure 19. Cell Heater Maximum Power Time.

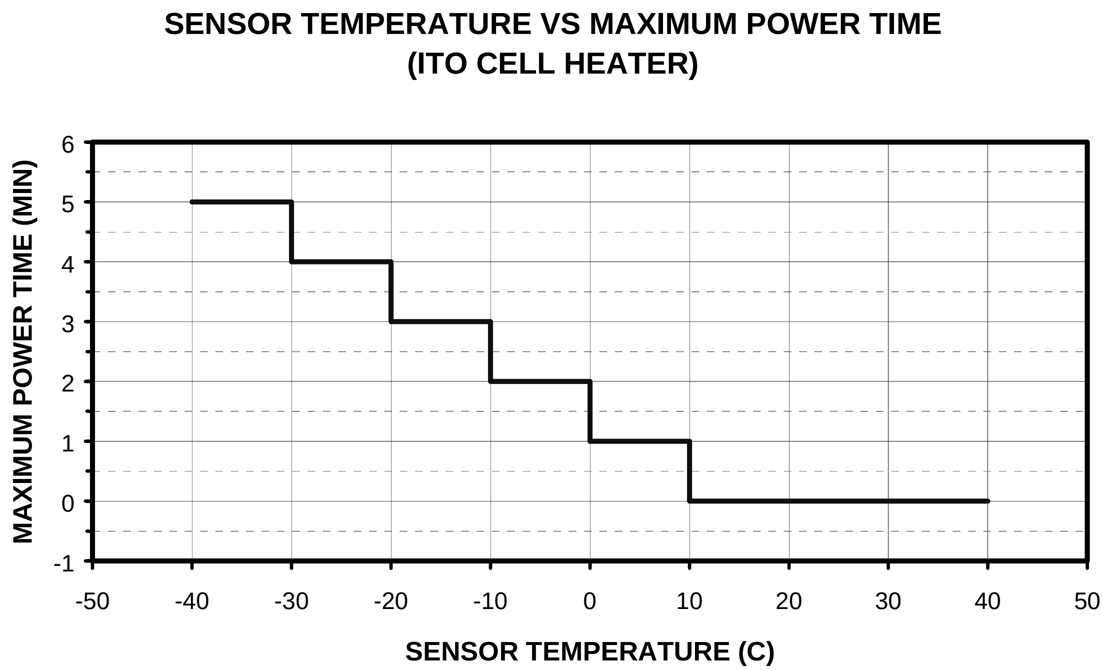
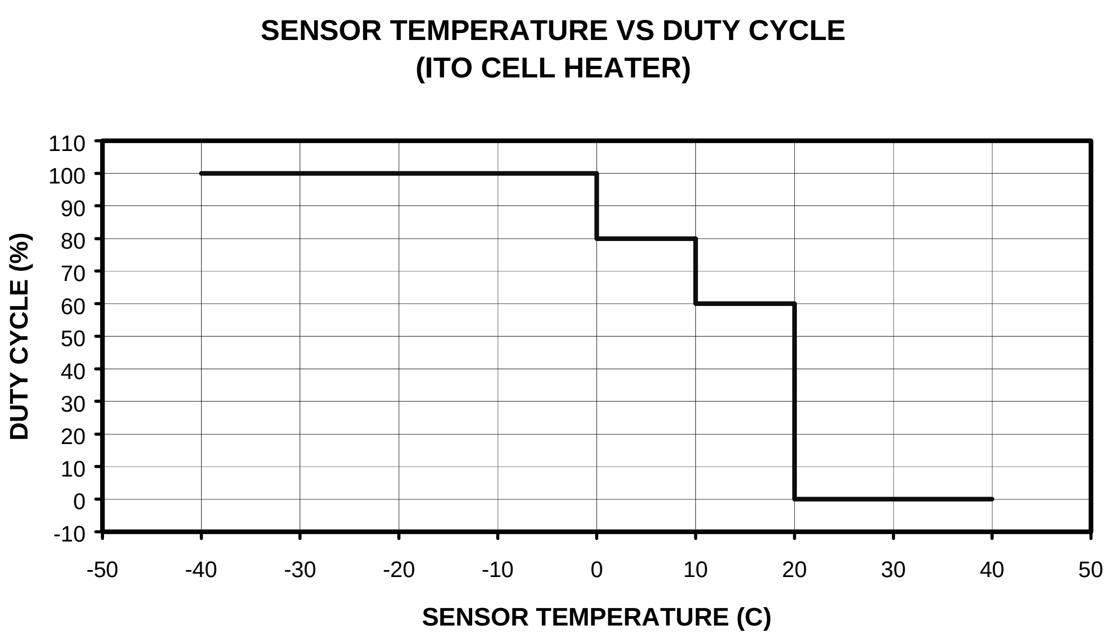


Figure 20. Cell Heater Duty Cycle.



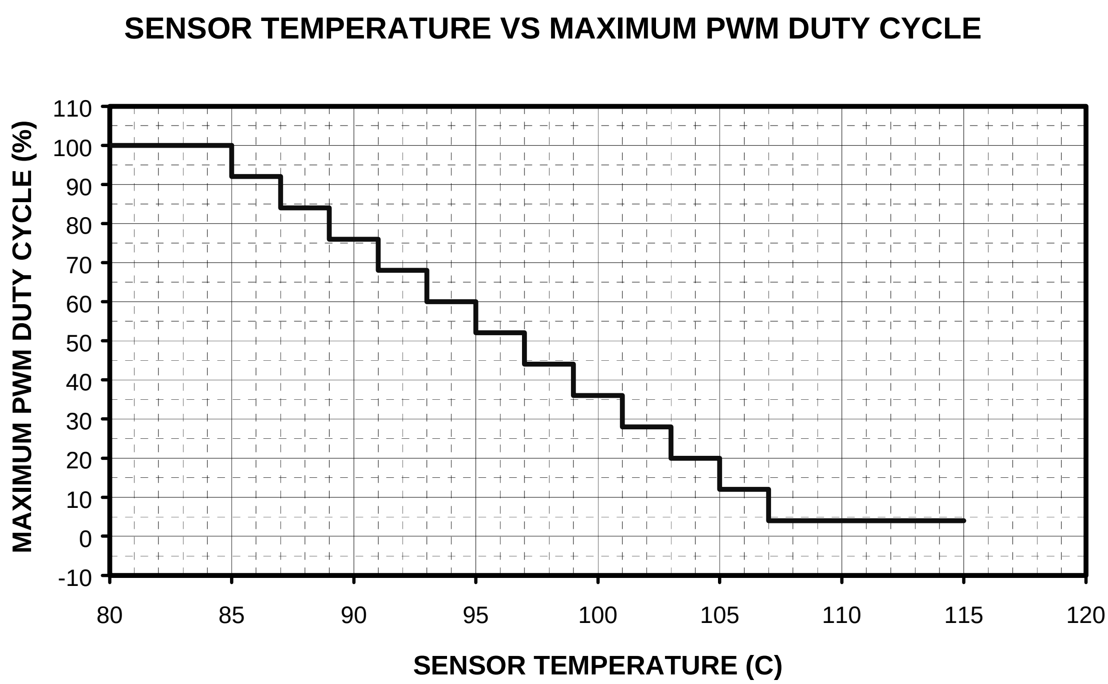
High Temperature Control

At high temperatures, thermal control is performed by decreasing the maximum duty cycle of the backlight inverter. See Table 22 and Figure 21 below.

Table 22. High Temperature Control Parameters.

Parameter	Value	Units
Active temperature sensor	Monitor temperature sensor with the highest reading	None
Control	Maximum duty cycle is stepped as shown in Figure 21	%
Hysteresis	3.0	C

Figure 21. Temperature Control: Maximum Pulse Width Modulation Duty Cycle.



Defects

Emissive Defects

Table 23. Emissive Defects.

Item	Specification	
Line Defect	Not allowed	
Luminous Dots		
Color	Red, Green, Blue	
	Distance between same color dot defects	**Quantity**
Brightness: F + H[1]	–	R + G + B ≤ 15
Brightness: F[1]	≤ 6.5 mm	≤ 6 pairs, each color[4]
	Adjacent two dots	≤ 6 pairs, each color
	Adjacent three or more dots	≤ 0 pair, each color
Dark Dots [2] [3]		
Color	Red, Green, Blue	
	Distance between same color dot defects	**Quantity**
	–	≤ 8, each color[5]
	Adjacent three or more dots	≤ 0 pair, each color

[1] "F" means full-luminous dot(s), bright point independent from viewing angle.
"H" means half-luminous dot(s), bright point dependent on viewing angle.
[2] Dark dots are counted while the screen is illuminated with Red, Green, or Blue dots only.
[3] Adjacency is considered separately for each color; adjacency among Red, Green, and Blue is not considered as adjacent.
[4] When the distance between two pairs is ≤ 10 mm, this situation is not allowed. If distance is ≤ 10 mm, the quantity is 0 pair.
[5] Adjacent two dark dots is counted as one point.

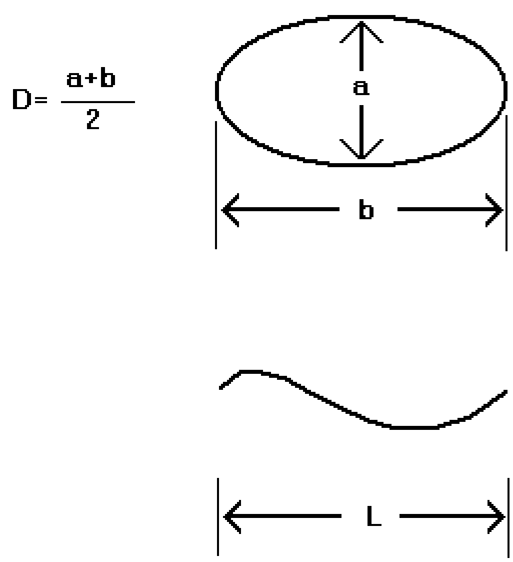
Cosmetic Defects

Table 24. Cosmetic Defects.

Item	Measurement Criteria		Quantity
Polarizer scratch	Remarkable scratches		0 points
Polarizer bubbles, wrinkles, or dent	Average diameter	D ≤ 0.5 mm	≤ 3 points
Other objects or dust between polarizer and glass	Width ≤ 0.05 mm	–	All allowed
	0.05 mm ≤ Width ≤ 0.1 mm	L < 0.7 mm 0.7 mm ≤ L ≤ 1.0 mm 1.0 mm < L	All allowed ≤ 5 points 0 point
	0.1 mm < Width	–	0 point
	Average diameter	D ≤ 0.2 mm 0.2 mm < D < 0.3 mm* 0.3 mm ≤ D ≤ 0.5 mm* 0.5 mm < D	All allowed ≤ 11 points ≤ 4 points 0 points

* The distance between each defect is larger than 6.5 mm.

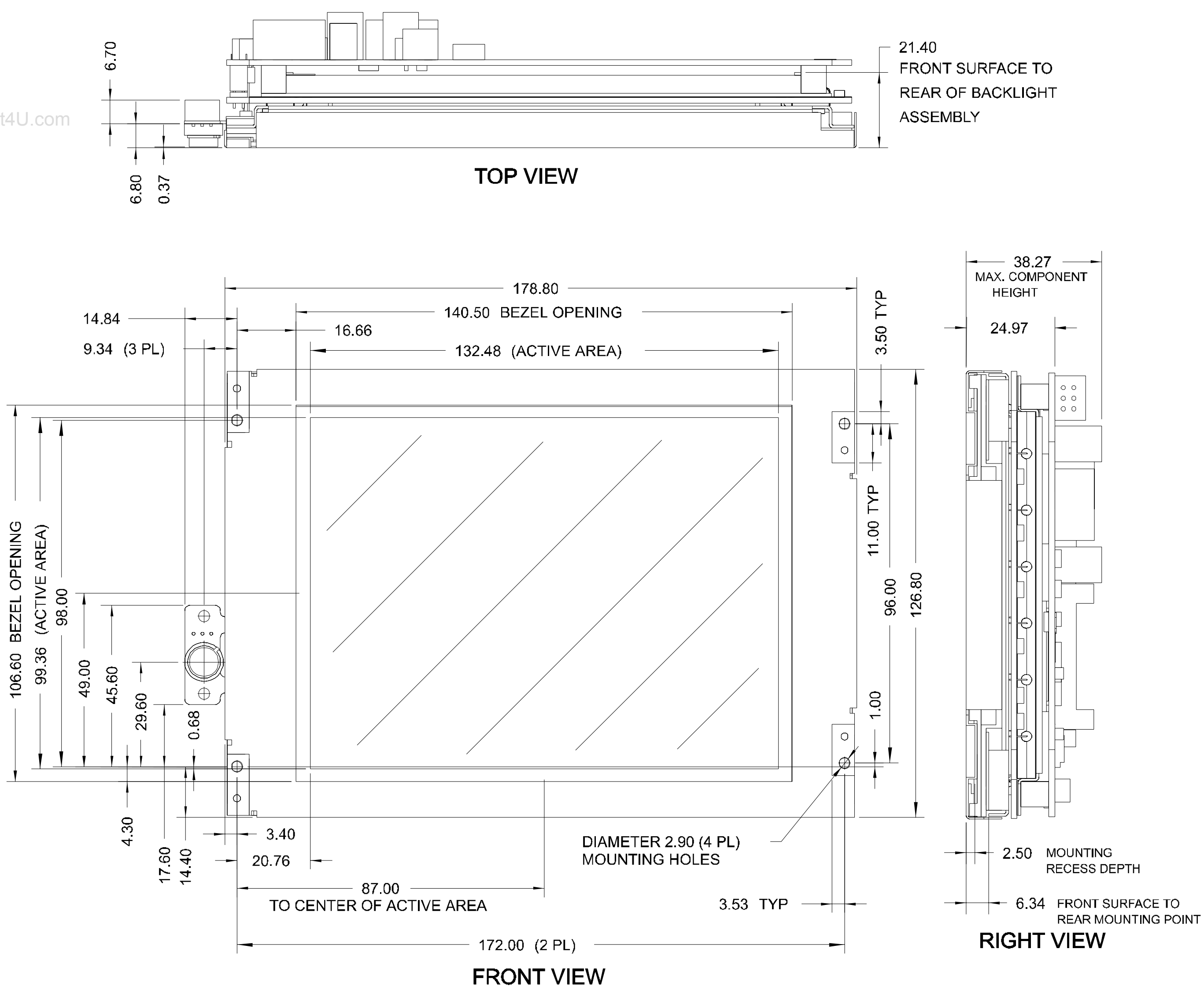
Figure 22. Diameter Calculation.



Display Dimensions

The recommended clearance shown in Figure 23 indicates the distance behind the display module that should be left to provide free-flow of air for convection cooling. In Figure 23, dimensions are in millimeters.

Figure 23. Display Dimensions.



Unless specified, tolerances are:

.x = ±0.50
.xx = ±0.25

Note: The dimensions in this drawing are approximate. Please contact Planar Applications Engineering to request the actual drawing prior to beginning your design.

Description of Warranty

This description is not the full warranty, and should not be construed as a substitute for the full warranty. A copy of the full warranty is available upon request.

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The goods Planar sells are warranted for a period of one year unless otherwise agreed to by Planar and the Buyer. The Buyer must return the defective or non-conforming goods, upon request, to Planar not later than 30 days after Planar's receipt of notice of the alleged defect or non-compliance. Buyer shall prepay transportation charges, and Planar shall pay for return of the goods to the Buyer. No goods are to be returned to Planar without prior permission.

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Ordering Information

Product	Part Number	Description
LC640.480.21-065	996-0406-00	Standard
LC640.480.21-065 HTR	996-0406-01	Cell heater, conformal coating
LC640.480.21-065 CC	996-0406-02	Conformal coating

Design and specifications are subject to change without notice.

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