SPECIFICATION
FOR
APPROVAL

( ) Preliminary Specification
(●) Final Specification

Title	23.0" WUXGA TFT LCD

BUYER	HP
MODEL	

SUPPLIER	LG.Philips LCD Co., Ltd.
*MODEL	LM230W02
Suffix	A2

*When you obtain standard approval,
please use the above model name without suffix

SIGNATURE	DATE
/	
/	
/	

Please return 1 copy for your confirmation with your signature and comments.

SIGNATURE	DATE
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MNT Products Engineering Dept.
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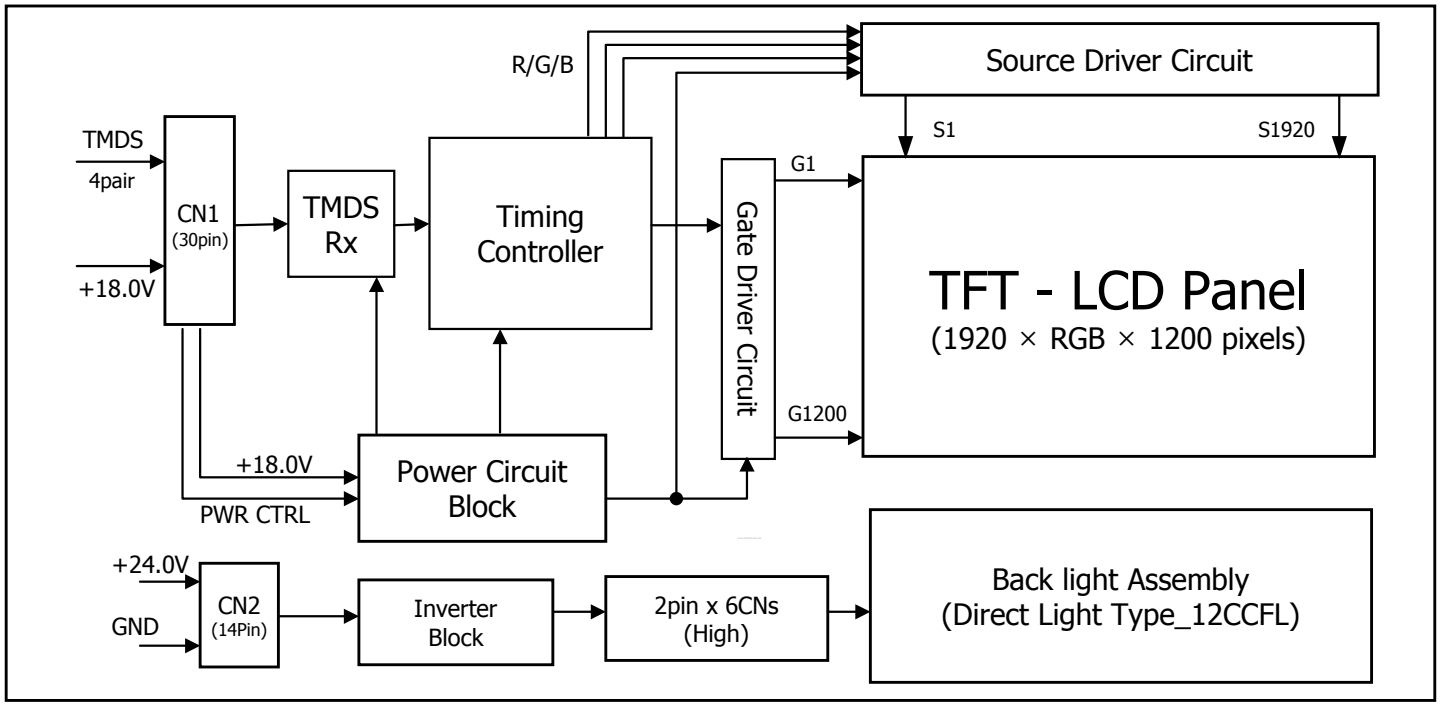
RECORD OF REVISIONS

Revision No	Revision Date	Page	Description
0.0	July. 27. 2003	-	First Draft(Preliminary)
0.1	Aug. 05. 2003	All	Table & Paragraph Arranged from side to side. Table style reversion
		21	User Connector position changed (vertically 1.2mm moved)
0.2	Aug. 18. 2003	7	Updated Inverter Electrical Characteristics (Table 2-2)
0.3	Oct. 09. 2003	4	Updated Power consumption
		7	Changed Inverter Electrical Characteristics (Table 2-2)
		8	Put in the equivalent connector part name
		15	Updated Table 9.
		21	Changed Mechanical Drawing (Add Bead)
1.0	Oct. 21. 2003	-	Final Specification
		4	Added Contrast Ratio value
		15	Updated Table 9. (Add crosstalk and TCO spec)
1.1	April. 06. 2004	15-19	Changed the Optical characteristic (Added the Gray-to-gray response time, Color shift, Effective viewing angle and Luminance uniformity)
		22-23	Changed Mechanical Drawing

1. General Description

The LM230W02 LCD is a Color Active Matrix Liquid Crystal Display with an integral Cold Cathode Fluorescent Lamp(CCFL) back light system. The matrix employs a-Si Thin Film Transistor as the active element. It is a transmissive type display operating in the normally black mode. This TFT-LCD has a 23.0 inch diagonally measured active display area with WUXGA resolution(1200 vertical by 1920 horizontal pixel array). Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arranged in vertical stripes. Gray scale or the luminance of the sub-pixel color is determined with a 8-bit gray scale signal for each dot, thus, presenting a palette of more than 16,777,216 colors.
The LM230W02 has been designed to apply the TMDS™(Transition Minimized Differential Signaling) interface.



General Features

Active Screen Size	23.0 inches(58.4cm) diagonal
Outline Dimension	523.4(H) x 335.6(V) x 41.0(D) mm(Typ.)
Active Area	495.36[mm] × 309.6[mm]
Pixel Pitch	0.258 mm x 0.258mm
Pixel Format	1920 horiz. By 1200 vert. Pixels RGB stripes arrangement
Color Depth	8-bit, 16,777,216 colors
Luminance, CR	250 cd/m^2 , 500:1
Viewing Angle(CR>10)	View Angle Free (R/L 176(Typ.), U/D 176(Typ.))
Power Consumption	Total 56 Watt (Typ.) (Logic=5.6 W, Lamp=50.4 W)
Weight	2,870g(typ.)
Display Operating Mode	Transmissive mode, normally black
Surface Treatment	Hard coating(3H), Anti-glare treatment of the front polarizer
Interface	TMDS

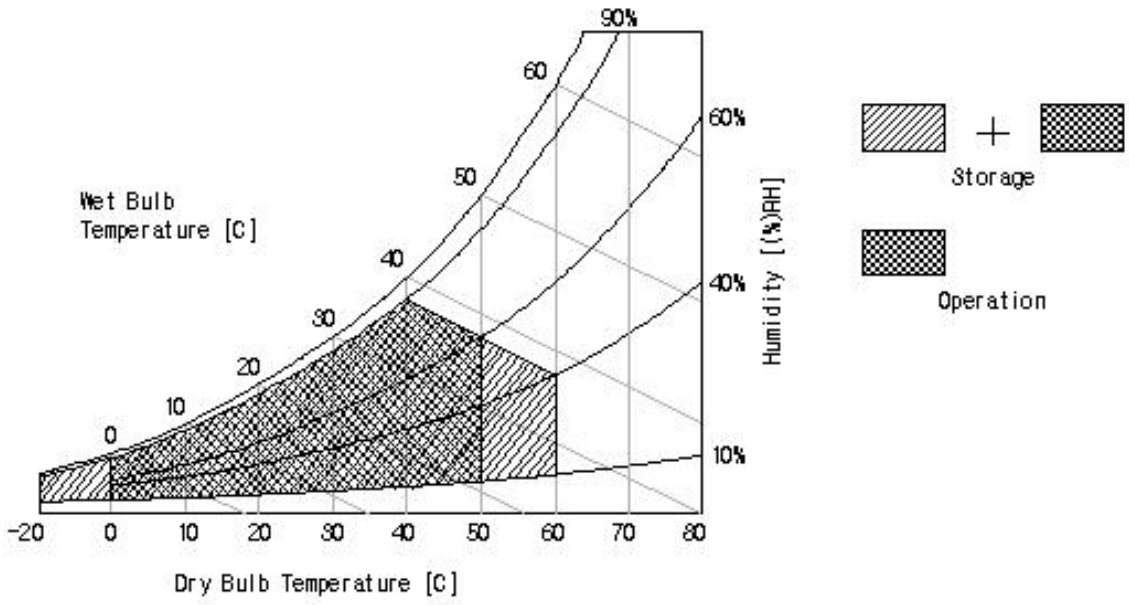
2. Absolute Maximum Ratings

The following are maximum values which, if exceeded, may cause operation or damage to the unit.

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Input Voltage	VLCD	-0.3	21	Vdc	at 25 ± 2°C
Operating Temperature	TOP	0	50	°C	1
Storage Temperature	TST	-20	60	°C	
Operating Ambient Humidity	HOP	10	90	%RH	
Storage Humidity	HST	10	90	%RH	

Note : 1. Temperature and relative humidity range are shown in the figure below.
Wet bulb temperature should be 39 °C Max, and no condensation of water.



3. Electrical Specifications

3-1. Electrical Characteristics

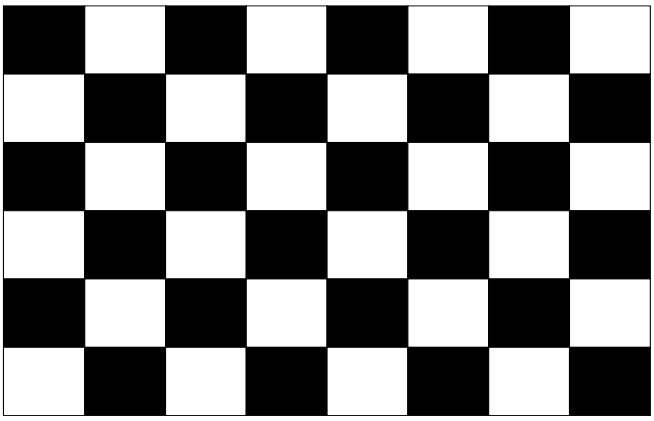
The LM230W02 requires two power inputs. One input is employed to power the LCD electronics and to drive the TFT array and liquid crystal. And the second input power for the CCFL / Backlight is to power the inverter.

Table 2-1. ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input Voltage	V_{LCD}	17.0	18.0	19.0	Vdc	
Power Supply Input Current	I_{LCD}	-	310	357	A	1
		-	470	610	A	2
Power Consumption	P_{LCD}	-	5.60	6.44	Watt	1
Rush current	I_{RUSH}	-	-	3.0	A	3

Note :
1. The specified current and power consumption are under the V_{LCD}=18.0V, 25 ± 2°C,f_V=60Hz condition whereas mosaic pattern(8 x 6) is displayed and f_V is the frame frequency.
2. The current is specified at the maximum current pattern.
3. The duration of rush current is about 2ms and rising time of power Input is 1ms(min.).

White : 255Gray
Black : 0Gray



Mosaic Pattern(8X6)

Table 2-2. INVERTER ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Condition	Values			Unit	Notes
			Min.	Typ.	Max.		
Inverter :							
Input Voltage	V_{DDB}		22.0	24.0	26.0	V	1
Input Current	I_{DDB}	V_{BR} = 3.3V	1.8	2.1	2.4	A	2
Input Power	PB	V_{BR} = 3.3V	43.2	50.4	57.6	Watt	2
B/L on/off control	VON/OFF	Lamp ON = High	4.0	-	5.0	V	
		Lamp OFF =Low	0.0	-	0.8	V	
Brightness Adj	VBR		0	-	3.3	V	
LAMP :							
Life time			50,000			Hrs	3

Notes :

1. The input voltage ripple is limited below 400mVp-p.
2. The specified current and power consumption are under the typical supply Input voltage, 24V.
3. The life is determined as the time at which luminance of the lamp is 50% compared to that of initial value at the typical lamp current on condition of continuous operating at 25 ± 2°C.
4. Electrical characteristics are determined after the unit has been 'ON' and stable for approximately 30min in a dark environment at 25 °C± 2°C.
5. The lamp must be turned on in condition of 0℃ temperature.

3-2. Interface Connections

This LCD employs Two interface connections, a 30 pin connector is used for the module electronics and a 14Pin Connector is used for the integral backlight system.

3-2-1. LCD Module

- LCD Connector(CN1):FI-XB30SL-HF, FI-XB30SSL-HF15 (Manufactured by JAE) or Equivalent
- Mating Connector : FI-X30C2L (Manufactured by JAE) or Equivalent
- Interface chips(LCD) : PTFP 403 PZP (TI)

Table 3 MODULE CONNECTOR(CN1) PIN CONFIGURATION

No	Symbol	Description	No	Symbol	Symbol
1	GND	Ground	16	OPEN	NC
2	SHLD2	Shield for TMDS channel 2	17	OPEN	NC
3	RX2+	TMDS Differential Output(+) (CH 2)	18	OPEN	NC
4	RX2-	TMDS Differential Output(-) (CH 2)	19	GND	Ground
5	SHLD1	Shield for TMDS channel 1	20	GND	Ground
6	RX1+	TMDS Differential Output(+) (CH 1)	21	GND	Ground
7	RX1-	TMDS Differential Output(-) (CH 1)	22	V_{LCD}	Supply voltage for LCD
8	SHLD0	Shield for TMDS channel 0	23	V_{LCD}	Supply voltage for LCD
9	RX0+	TMDS Differential Output(+) (CH 0)	24	V_{LCD}	Supply voltage for LCD
10	RX0-	TMDS Differential Output(-) (CH 0)	25	PWR_ON	Power ON control signal input 3.3V(H:90%,L:10%)
11	SHLDC	Shield for TMDS channel C	26	HS_OUT	Hsync Output
12	RXC+	TMDS Differential Output(+) (CH C)	27	VS_OUT	Vsync Output
13	RXC-	TMDS Differential Output(-) (CH C)	28	GND	Ground
14	GND	Ground	29	OPEN	DDC –Clk(HDCP) for future use
15	OPEN	NC	30	OPEN	DDC –Data(HDCP) for future use

Notes: 1. All GND(ground) pins should be connected together and should also be connected to the LCD's metal frame.
2. All V_{LCD}(power input) pins should be connected together.
3. Input Level of TMDS signal is based on the Digital Visual Interface (DVI 1.0) Standard.

Rear view of LCM

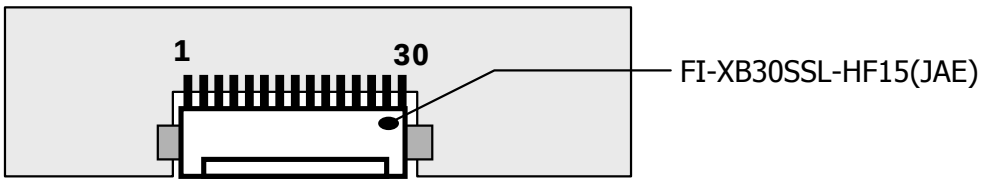


Table 4 REQUIRED SIGNAL ASSIGNMENT FOR TMDS TRANSMITTER

Graphics Controller		PanelLink		Flat Panel Controller	
24-bits	18-bits	Sil160	Sil161	18-bits	24-bits
B0 - 0		DIE0	QE0		B0 - 0
B1 - 0		DIE1	QE1		B1 - 0
B2 - 0	B0 - 0	DIE2	QE2	B0 - 0	B2 - 0
B3 - 0	B1 - 0	DIE3	QE3	B1 - 0	B3 - 0
B4 - 0	B2 - 0	DIE4	QE4	B2 - 0	B4 - 0
B5 - 0	B3 - 0	DIE5	QE5	B3 - 0	B5 - 0
B6 - 0	B4 - 0	DIE6	QE6	B4 - 0	B6 - 0
B7 - 0	B5 - 0	DIE7	QE7	B5 - 0	B7 - 0
G0 - 0		DIE8	QE8		G0 - 0
G1 - 0		DIE9	QE9		G1 - 0
G2 - 0	G0 - 0	DIE10	QE10	G0 - 0	G2 - 0
G3 - 0	G1 - 0	DIE11	QE11	G1 - 0	G3 - 0
G4 - 0	G2 - 0	DIE12	QE12	G2 - 0	G4 - 0
G5 - 0	G3 - 0	DIE13	QE13	G3 - 0	G5 - 0
G6 - 0	G4 - 0	DIE14	QE14	G4 - 0	G6 - 0
G7 - 0	G5 - 0	DIE15	QE15	G5 - 0	G7 - 0
R0 - 0		DIE16	QE16		R0 - 0
R1 - 0		DIE17	QE17		R1 - 0
R2 - 0	R0 - 0	DIE18	QE18	R0 - 0	R2 - 0
R3 - 0	R1 - 0	DIE19	QE19	R1 - 0	R3 - 0
R4 - 0	R2 - 0	DIE20	QE20	R2 - 0	R4 - 0
R5 - 0	R3 - 0	DIE21	QE21	R3 - 0	R5 - 0
R6 - 0	R4 - 0	DIE22	QE22	R4 - 0	R6 - 0
R7 - 0	R5 - 0	DIE23	QE23	R5 - 0	R7 - 0
B0 - 1		DIO0	QO0		B0 - 1
B1 - 1		DIO1	QO1		B1 - 1
B2 - 1	B0 - 1	DIO2	QO2	B0 - 1	B2 - 1
B3 - 1	B1 - 1	DIO3	QO3	B1 - 1	B3 - 1
B4 - 1	B2 - 1	DIO4	QO4	B2 - 1	B4 - 1
B5 - 1	B3 - 1	DIO5	QO5	B3 - 1	B5 - 1
B6 - 1	B4 - 1	DIO6	QO6	B4 - 1	B6 - 1
B7 - 1	B5 - 1	DIO7	QO7	B5 - 1	B7 - 1
G0 - 1		DIO8	QO8		G0 - 1
G1 - 1		DIO9	QO9		G1 - 1
G2 - 1	G0 - 1	DIO10	QO10	G0 - 1	G2 - 1
G3 - 1	G1 - 1	DIO11	QO11	G1 - 1	G3 - 1
G4 - 1	G2 - 1	DIO12	QO12	G2 - 1	G4 - 1
G5 - 1	G3 - 1	DIO13	QO13	G3 - 1	G5 - 1
G6 - 1	G4 - 1	DIO14	QO14	G4 - 1	G6 - 1
G7 - 1	G5 - 1	DIO15	QO15	G5 - 1	G7 - 1
R0 - 1		DIO16	QO16		R0 - 1
R1 - 1		DIO17	QO17		R1 - 1
R2 - 1	R0 - 1	DIO18	QO18	R0 - 1	R2 - 1
R3 - 1	R1 - 1	DIO19	QO19	R1 - 1	R3 - 1
R4 - 1	R2 - 1	DIO20	QO20	R2 - 1	R4 - 1
R5 - 1	R3 - 1	DIO21	QO21	R3 - 1	R5 - 1
R6 - 1	R4 - 1	DIO22	QO22	R4 - 1	R6 - 1
R7 - 1	R5 - 1	DIO23	QO23	R5 - 1	R7 - 1
Shift CLK	Shift CLK	IDCK	ODCK	Shift CLK	Shift CLK
VSYNC	VSYNC	VSYNC	VSYNC	VSYNC	VSYNC
HSYNC	HSYNC	HSYNC	HSYNC	HSYNC	HSYNC
DE	DE	DE	DE	DE	DE

3-2-2. Backlight Interface

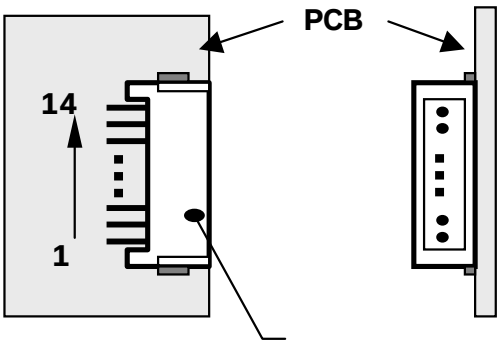
- Inverter Connector : S14B-PH-SM3 Side entry type (Manufactured by JST) or Equivalent
- Mating Connector : PHR-14(Manufactured by JST) or Equivalent

Table 5. INVERTER CONNECTOR PIN CONFIGULATION

Pin No	Symbol	Description	Remarks
1	VDDB	Power Supply +24.0V (Back light)	
2	VDDB	Power Supply +24.0V (Back light)	
3	VDDB	Power Supply +24.0V (Back light)	
4	VDDB	Power Supply +24.0V (Back light)	
5	VDDB	Power Supply +24.0V (Back light)	
6	GND	Power Ground (Back light)	Note 1
7	GND	Power Ground (Back light)	
8	GND	Power Ground (Back light)	
9	GND	Power Ground (Back light)	
10	GND	Power Ground (Back light)	
11	OPEN	NC	
12	VON/OFF	Backlight On/off Signal	(On :4.0V~5V/Off :0.0~0.8V)
13	VBR	Brightness Adjustable Voltage	(Max :3.3V / Min :0.0V)
14	OPEN	NC	

Notes : 1. GND is connected to the LCD's metal frame.

Rear view of LCM



S14B-PH-SM3-TB
(JST : Japan Solderless Terminal Co.,Ltd.)

3-3. Signal Timing Specifications

This is signal timing required at the input of the TMDS transmitter. All of the interface signal timing should be satisfied with the following specifications for it's proper operation.

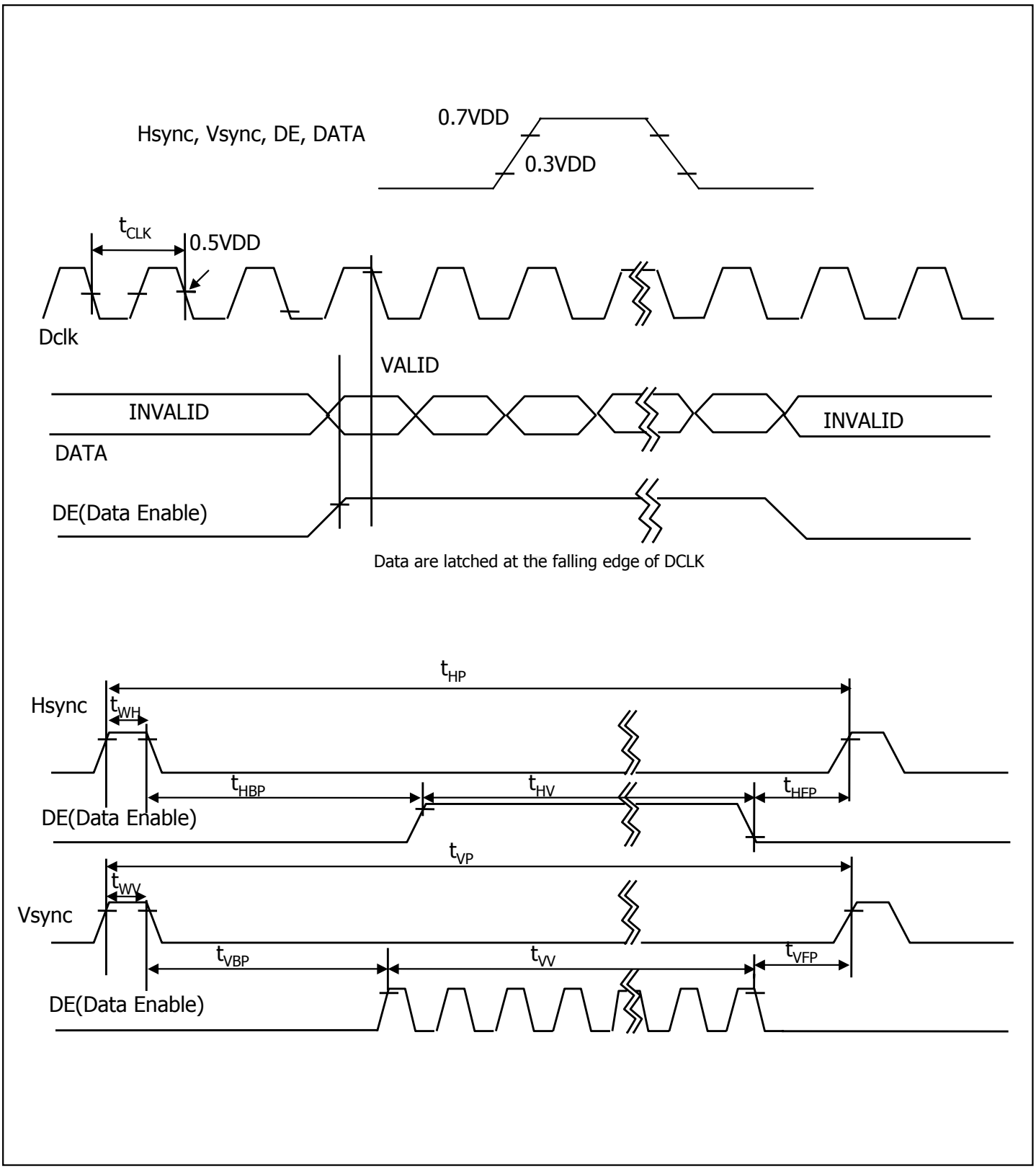
Table 6. TIMING TABLE

ITEM		SYMBOL	Min	Typ	Max	Unit	Note
DCLK	Period	t_{CLK}	6.49	6.41	6.33	ns	
	Frequency	f_{CLK}	154	156	158	MHz	
Hsync	Period	t_{HP}	1984	2144	-	t_{CLK}	
	Width-Active	t_{WH}	32	32	32		
Vsync	Period	t_{VP}	1206	1212	-	t_{HP}	
	Frequency	f_V	56	60	64	Hz	
	Width-Active	t_{WV}	2	3	-	t_{HP}	
Data Enable	Horizontal Valid	t_{HV}	1920	1920	1920	t_{CLK}	
	Horizontal Back Porch	t_{HBP}	16	128	-		
	Horizontal Front Porch	t_{HFP}	16	64	-		
	Horizontal Blank	-	64	224	-		t_{WH}+ t_{HBP}+ t_{HFP}
	Vertical Valid	t_{VV}	1200	1200	1200	t_{HP}	
	Vertical Back Porch	t_{VBP}	3	6	-		
	Vertical Front Porch	t_{VFP}	1	3	-		
	Vertical Blank	-	6	12	-		t_{WV}+ t_{VBP}+ t_{VFP}

Note: Hsync period and Hsync width-active should be even number times of t_{CLK}. If the value is odd number times of t_{CLK}, display control signal can be asynchronous. In order to operate this LCM a Hsync, Vsyn, and DE(data enable) signals should be used.

1. : The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
2. Vsync and Hsync should be keep the above specification.
3. Hsync Period, Hsync Width, and Horizontal Back Porch should be any times of of character number(8).

3-4. Signal Timing Waveforms



3-5. Color Data Reference

The luminance of each primary color(red,green,blue) is based on the 8-bit gray scale data input for the color; the higher the binary input, the brighter the color. The table below provides a reference for color versus data input.

Table 7. COLOR DATA REFERENCE

Color		Input Color Data																							
		RED								GREEN								BLUE							
		MSB							LSB	MSB							LSB	MSB							LSB
		R7	R6	R5	R4	R3	R2	R1	R0	G7	G6	G5	G4	G3	G2	G1	G0	B7	B6	B5	B4	B3	B2	B1	B0
Basic Color	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
	Red (255)	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Green (255)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	Blue (255)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	Cyan	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Magenta	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	Yellow	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	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	1	1	1	1	1	1
RED	RED (000) Dark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RED (001)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	...				...								...								...				
	RED (254)	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	RED (255)	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GREEN	GREEN (000) Dark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GREEN (001)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	...				...								...								...				
	GREEN (254)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
	GREEN (255)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
BLUE	BLUE (000) Dark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	BLUE (001)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	...				...								...								...				
	BLUE (254)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
	BLUE (255)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

Note : Users should be input true 8 Bit data streams via TMDS transmitter.

3-6. Power Sequence

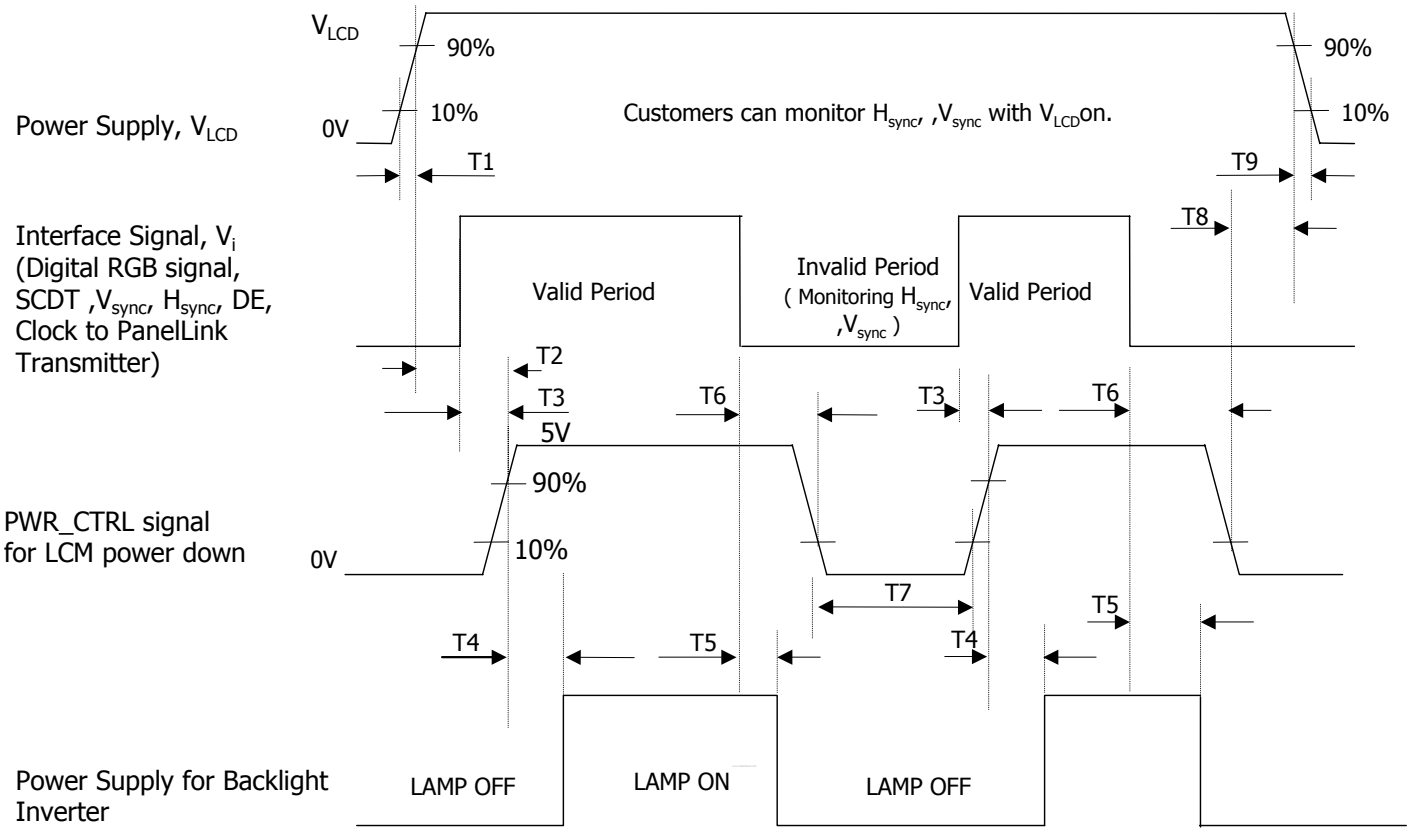


Table 8. POWER SEQUENCE

Parameter	Values			Units
	Min	Typ	Max	
T1	-	-	10	ms
T2	-	-	50	ms
T3	-	-	50	ms
T4	100	-	-	ms
T5	-	-	50	ms
T6	-	-	80	ms
T7	400	-	-	ms
T8	50	-	-	
T9	-		10	

Notes : 1. Please avoid floating state of interface signal at invalid period.
2. When the interface signal is invalid, be sure to pull down the power supply for LCD $V_{LCD}$to 0V.
3. Lamp power must be turn on after power supply for LCD and interface signal are valid.
4. When connector is hot-plug and plug,T2 & T8 min spec can be 0ms.

4. Optical Specifications

Optical characteristics are determined after the unit has been 'ON' for approximately 30 minutes in a dark environment at 25±2°C. The values specified are at an approximate distance 50cm from the LCD surface at a viewing angle of Φ and θ equal to 0 ° and aperture 1 degree.

FIG. 1 presents additional information concerning the measurement equipment and method.

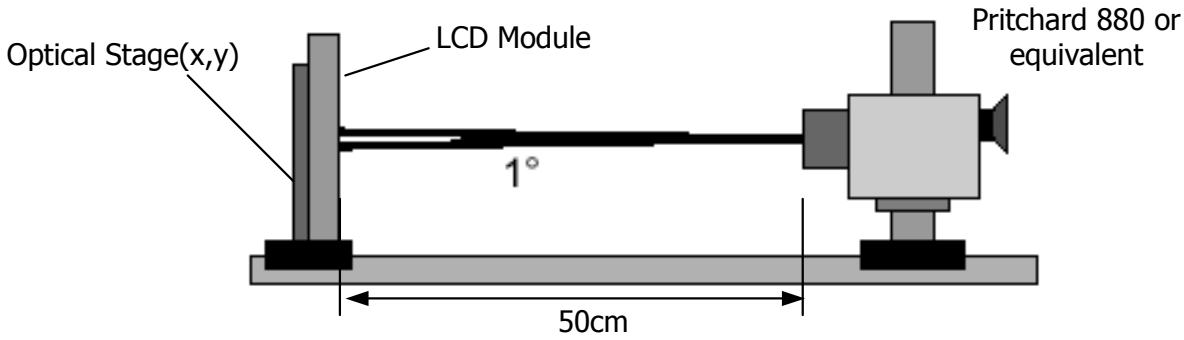


FIG. 1 Optical Characteristic Measurement Equipment and Method

Table 9. OPTICAL CHARACTERISTICS (Ta=25 °C, V_{LCD}=18.0V, f_V=60Hz Dclk=156MHz, V_{BR}=3.3V)

Parameter		Symbol	Values			Units	Notes
			Min	Typ	Max		
Contrast Ratio		CR	350	500			1
Surface Luminance, white		L_{WH}	200	250		cd/m^2	2
Luminance Variation		δ_{WHITE}			1.3		3
Response Time	Rise Time	Tr_R	-	8.5	15	ms	4
	Decay Time	Tr_D	-	7.5	15	ms	4
	Gray to Gray	T_{GTG_AVR}	-	12		ms	5
		T_{GTG_MAX}	-	18		ms	5
Color Coordinates [CIE1931]	RED	Rx	Typ -0.03	0.640	Typ +0.03		
		Ry		0.332			
	GREEN	Gx		0.288			
		Gy		0.601			
	BLUE	Bx		0.146			
		By		0.065			
	WHITE	Wx		0.313			
		Wy		0.329			
Color Shift	Horizontal	θ_{CST_H}	-	176	-	Degree	6
	Vertical	θ_{CST_V}	-	176	-		
Viewing Angle (CR>10)							
General	Horizontal	θ_H	170	176	-	Degree	7
	Vertical	θ_V	170	176	-		
Effective	Horizontal	θ_{GMA_H}		176	-	Degree	8
	Vertical	θ_{GMA_V}		176	-		
Gray Scale				2.2			9
Crosstalk					1.8	%	FIG.8
Luminance Uniformity (TCO'99)		L_R			1.7		FIG.9

Notes 1. Contrast Ratio(CR) is defined mathematically as :

$$\text{Contrast Ratio} = \frac{\text{Surface Luminance with all white pixels}}{\text{Surface Luminance with all black pixels}}$$

It is measured at center point(Location P1)

2. Surface luminance(L_{WH})is luminance value at center point(P1) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG 2.

3. The variation in surface luminance , δ WHITE is defined as :

$$\delta_{WHITE} = \frac{\text{Maximum}(L_{P1}, L_{P2}, \ldots, L_{P5})}{\text{Minimum}(L_{P1}, L_{P2}, \ldots, L_{P5})}$$

Where P1 to P5 are the luminance with all pixels displaying white at 5 locations.
For more information see FIG 2.

4. Response time is the time required for the display to transition from black to white (Rise Time, Tr_R) and from white to black (Decay Time, Tr_D). For additional information see FIG 3.

5. Gray to gray response time is the time required for the display to transition from gray to gray. For additional information see Table 10.

6. Color shift is the angle at which the color difference is lower than 0.04.
For more information see FIG 4.
- Color difference (Δu'v')

$$u' = \frac{4x}{-2x+12y+3} \qquad v' = \frac{9y}{-2x+12y+3}$$

$$\Delta u'v' = \sqrt{(u'_1 - u'_2)^2 + (v'_1 - v'_2)^2}$$

u'1, v'1 : u'v' value at viewing angle direction
u'2, v'2 : u'v' value at front (θ=0)

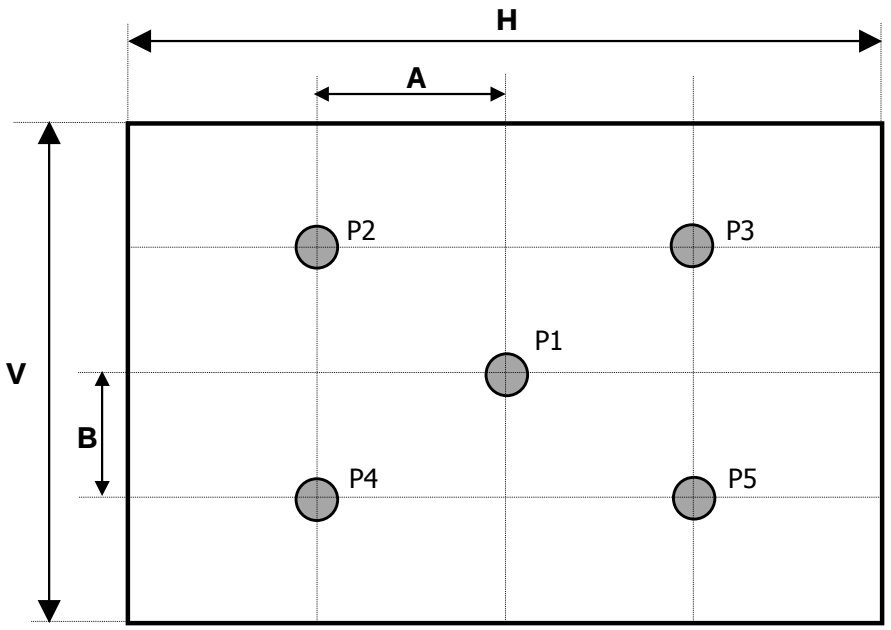
- Pattern size : 25% Box size
- Viewing angle direction of color shift : Horizontal, Vertical

7. Viewing angle is the angle at which the contrast ratio is greater than 10. The angles are determined for the horizontal or x axis and the vertical or y axis with respect to the z axis which is normal to the LCD surface. For more information see FIG 5.

8. Effective viewing angle is the angle at which the gamma shift of gray scale is lower than 0.3.
For more information see FIG 6 and FIG 7.

9. Gray scale specification
Gamma Value is approximately 2.2. For more information see Table 11.

Measuring point for surface luminance & measuring point for luminance variation.



A : H / 4 mm
B : V / 4 mm
H : 495.36 mm
V : 309.60 mm
@ H,V : Active Area

FIG. 2 Measure Point for Luminance

The response time is defined as the following figure and shall be measured by switching the input signal for "black" and "white".

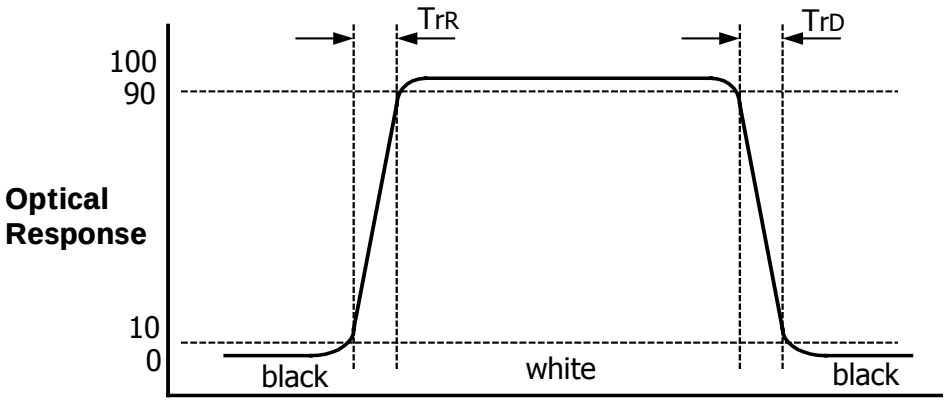


FIG. 3 Response Time

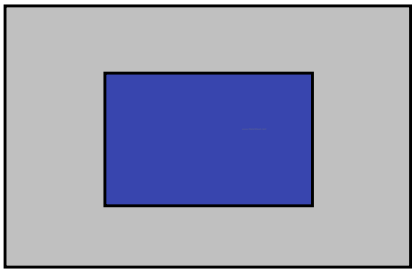
The gray to gray response time is defined as the following figure and shall be measured by switching the input signal for "Gray To Gray".

- Gray step : 5 step
- T_{GTG_AVR} is the total average time at rising time and falling time for "Gray To Gray".
- T_{GTG_MAX} is the max time at rising time or falling time for "Gray To Gray".

Table 10. Gray to gray response time table

Gray to Gray		Rising Time				
		G255	G191	G127	G63	G0
Falling Time	G255					
	G191					
	G127					
	G63					
	G0					

Color shift is defined as the following test pattern and color.



25% Box size

FIG. 4 Test Pattern

Average RGB values in Bruce RGB for Macbeth Chart

	Dark skin	Light skin	Blue sky	Foliage	Blue flower	Bluish green
R	98	206	85	77	129	114
G	56	142	112	102	118	199
B	45	123	161	46	185	178
	Orange	Purplish blue	Moderate red	Purple	Yellow green	Orange yellow
R	219	56	211	76	160	230
G	104	69	67	39	193	162
B	24	174	87	86	58	29
	Blue	Green	Red	Yellow	Magenta	cyan
R	26	72	197	241	207	35
G	32	148	27	212	62	126
B	145	65	37	36	151	172
	White	Neutral 8	Neutral 6.5	Neutral 5	Neutral 3.5	black
R	240	206	155	110	63	22
G	240	206	155	110	63	22
B	240	206	155	110	63	22

Dimension of viewing angle range.

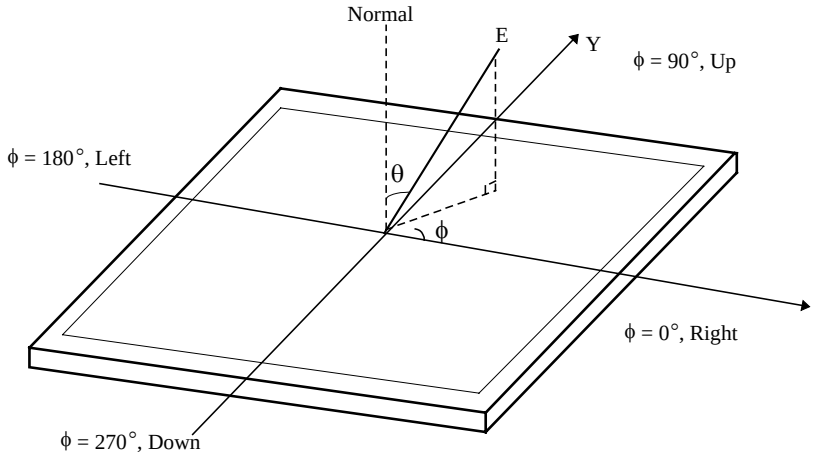


FIG. 5 Viewing angle

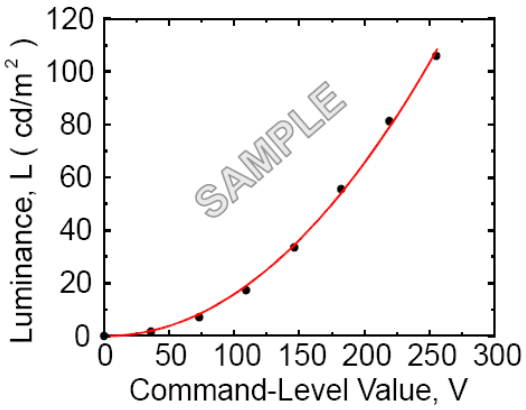


FIG. 6 Sample Luminance vs. gray scale (using a 256 bit gray scale)

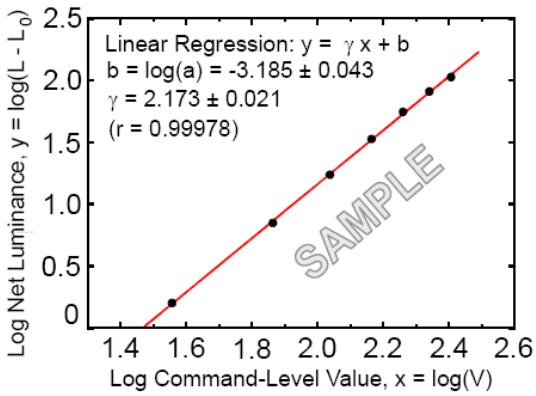


FIG. 7 Sample Log-log plot of luminance vs. gray scale

$$L = aV^r + L_b$$

$$\log(L - L_b) = r\log(V) + \log(a)$$

Here the Parameter α and γ relate the signal level V to the luminance L.

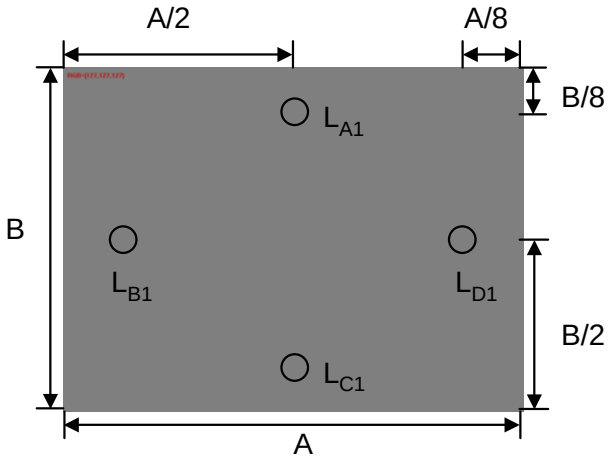
The GAMMA we calculate from the log-log representation (FIG. 7)

Table 11. Gray Scale Specification

Gray Level	Relative Luminance [%] (Typ.)
0	0.3
31	1.2
63	4.7
95	11.7
127	21.2
159	35.2
191	53.0
223	75.4
255	100

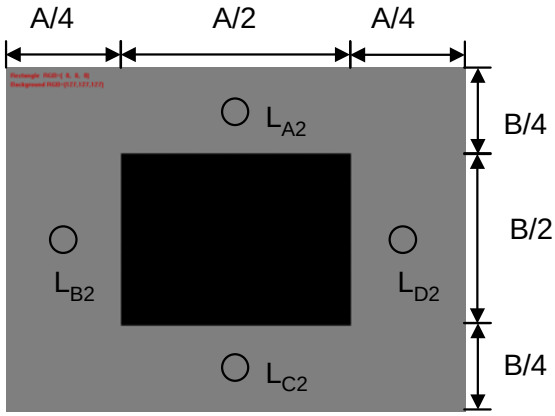
Crosstalk is defined as

Crosstalk : ($|L_{A[or\ C]2}-L_{A[or\ C]1}|/L_{A[or\ C]1}$) ×100(%)[Vertical],
($|L_{B[or\ D]2}-L_{B[or\ D]1}|/L_{B[or\ D]1}$) ×100(%)[Horizontal]



Pattern 1

- Half Gray: Gray 127



Pattern 2

- Background :Gray 127
- Window :Gray 0/255

FIG. 8 Crosstalk

Luminance Uniformity - angular – dependent (L_R)

TCO '99 Certification requirements and test methods for environmental labelling of Display [Flat] report No.2 (Luminance uniformity- angular – dependent)

- Test pattern : White pattern when the DUT luminance is 125 cd/㎡
- Test point : 2-point
- Test distance : 87.63 ㎝
- Test method : $L_R = ((L_{max.+30deg.} / L_{min.+30deg.}) + (L_{max.-30deg.} / L_{min.-30deg.})) / 2$

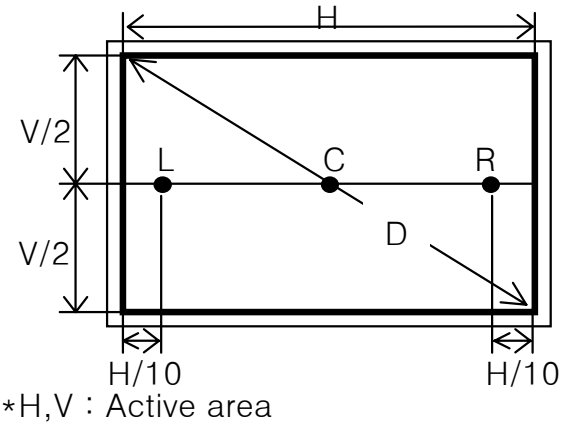


FIG. 9 Luminance Uniformity-Angular dependent

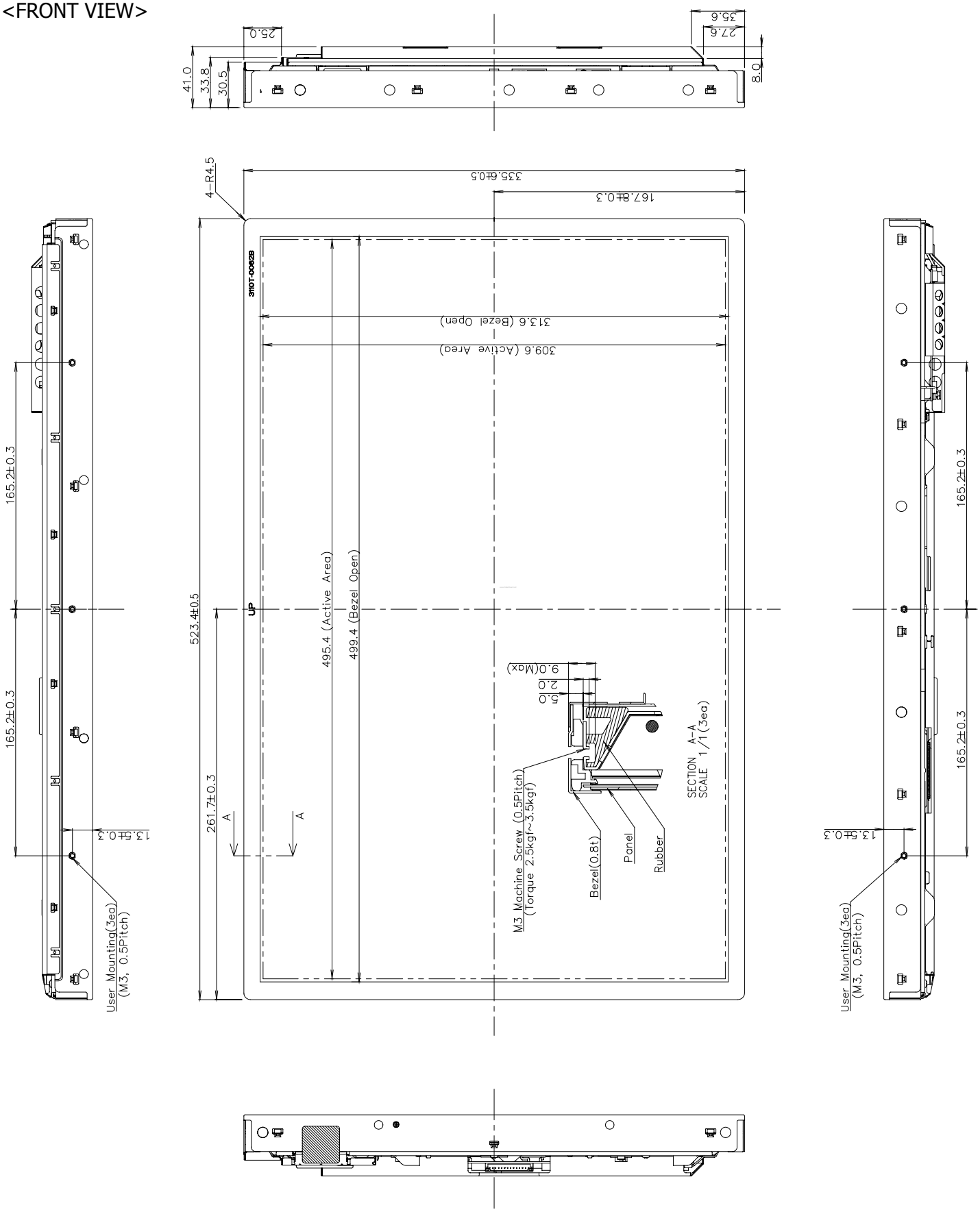
5. Mechanical Characteristics

The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

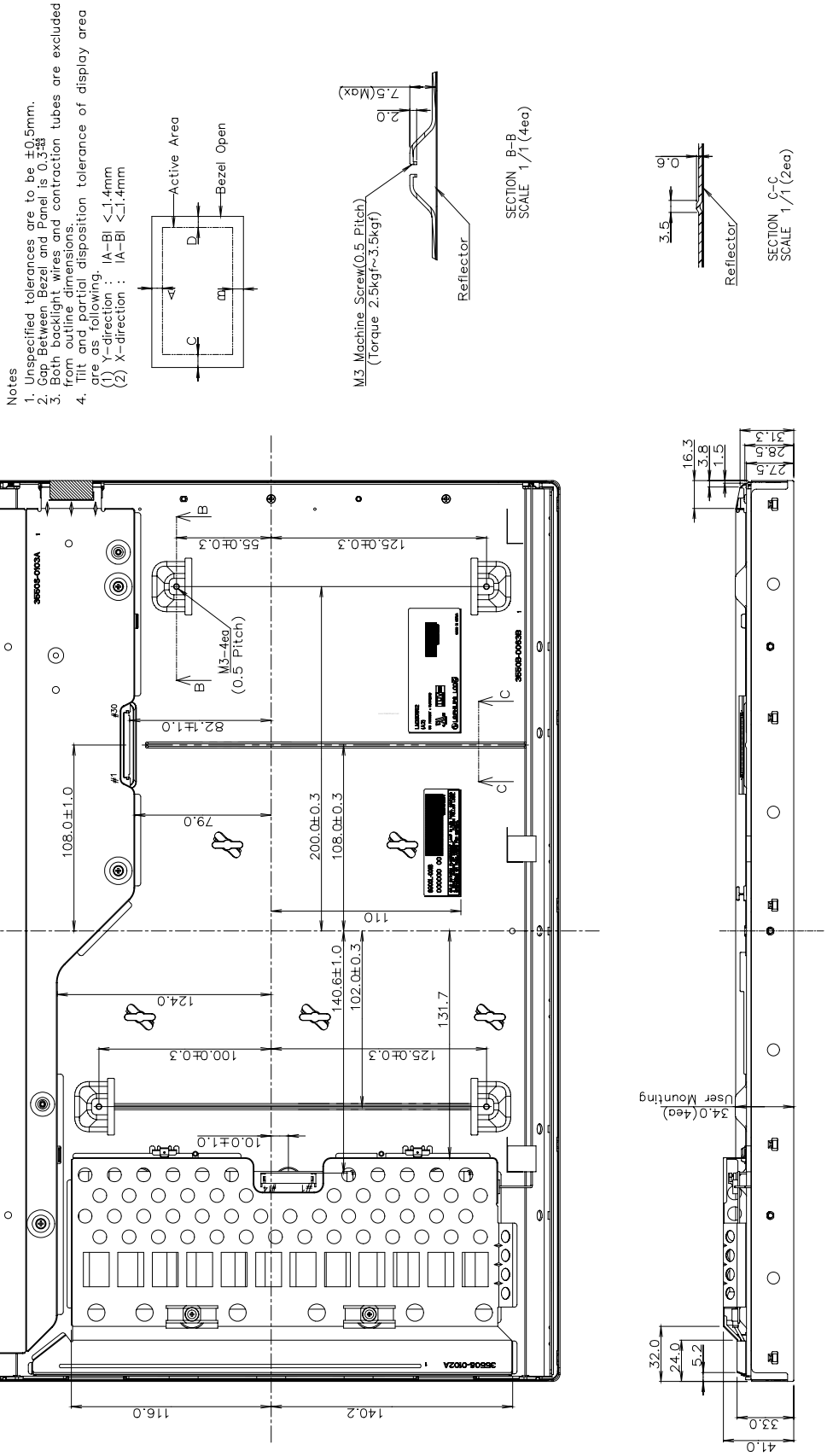
Outline Dimension	Horizontal	523.4mm
	Vertical	335.6mm
	Depth	41mm
Bezel Area	Horizontal	499.4mm
	Vertical	313.6mm
Active Display Area	Horizontal	495.36mm
	Vertical	309.6mm
Weight	2870g (Typ.)	
Surface Treatment	Hard coating(3H) Anti-glare(13%) treatment of the front polarizer	

Notes : Please refer to a mechanic drawing in terms of tolerance at the next page.

<FRONT VIEW>


25.0
35.6
27.6
41.0
33.8
30.5
8.0
4-R4.5
335.6±0.5
167.8±0.3
313.6 (Bezel Open)
309.6 (Active Area)
495.4 (Active Area)
499.4 (Bezel Open)
523.4±0.5
261.7±0.3
165.2±0.3
165.2±0.3
165.2±0.3
165.2±0.3
13.5±0.3
13.5±0.3
User Mounting(3ea)
(M3, 0.5Pitch)
User Mounting(3ea)
(M3, 0.5Pitch)
UP
A
A
9.0(Max)
2.0
5.0
M3 Machine Screw (0.5Pitch)
(Torque 2.5kgf~3.5kgf)
Bezel(0.8t)
Panel
Rubber
SECTION A-A
SCALE 1/1(3ea)

<REAR VIEW>


Notes
1. Unspecified tolerances are to be ±0.5mm.
2. Gap Between Bezel and Panel is 0.3+0.3 -0.3
3. Both backlight wires and contraction tubes are excluded from outline dimensions.
4. Tilt and partial disposition tolerance of display area are as following.
(1) Y-direction : IA-BI <1.4mm
(2) X-direction : IA-BI <1.4mm
Active Area
Bezel Open
M3 Machine Screw(0.5 Pitch)
(Torque 2.5kgf~3.5kgf)
Reflector
SECTION B-B
SCALE 1/1 (4ea)
Reflector
SECTION C-C
SCALE 1/1 (2ea)
M3-4ea
(0.5 Pitch)
User Mounting
34.0(4ea)

6. Reliability

Environment test condition

No	Test Item	Condition
1	High temperature storage test	Ta= 60°C 240h
2	Low temperature storage test	Ta= -20°C 240h
3	High temperature operation test	Ta= 50°C 50%RH 240h
4	Low temperature operation test	Ta= 0°C 240h
5	Vibration test (non-operating)	Wave form : random Vibration level : 1.0G RMS Bandwidth : 10-500Hz Duration : X,Y,Z, 10 min One time each direction
6	Shock test (non-operating)	Shock level : 100Grms Waveform : half sine wave, 2ms Direction : ±X, ±Y, ±Z One time each direction
7	Humidity condition Operation	Ta= 40 °C ,90%RH
8	Altitude storage / shipment	0 - 40,000 feet(12192m)

7. International Standards

7-1. Safety

a) UL 60950, Third Edition, Underwriters Laboratories, Inc., Dated Dec. 11, 2000.
Standard for Safety of Information Technology Equipment, Including Electrical Business Equipment.
b) CAN/CSA C22.2, No. 60950, Third Edition, Canadian Standards Association, Dec. 1, 2000.
Standard for Safety of Information Technology Equipment, Including Electrical Business Equipment.
c) EN 60950 : 2000, Third Edition
IEC 60950 : 1999, Third Edition
European Committee for Electrotechnical Standardization(CENELEC)
EUROPEAN STANDARD for Safety of Information Technology Equipment Including Electrical Business Equipment.

7-2. EMC

a) ANSI C63.4 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electrical Equipment in the Range of 9kHZ to 40GHz. "American National Standards Institute(ANSI), 1992
b) C.I.S.P.R "Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment." International Special Committee on Radio Interference.
c) EN 55022 "Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment." European Committee for Electrotechnical Standardization.(CENELEC), 1998
(Including A1: 2000)

8. Packing

8-1. Designation of Lot Mark

a) Lot Mark

A	B	C	D	E	F	G	H	I	J	K	L	M

A,B,C : SIZE(INCH)
D : YEAR
E : MONTH
F : PANEL CODE
G : FACTORY CODE
H : ASSEMBLY CODE
I,J,K,L,M : SERIAL NO.

Note

1. YEAR

Year	97	98	99	2000	2001	2002	2003	2004	2005	2006	2007
Mark	7	8	9	0	1	2	3	4	5	6	7

2. MONTH

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mark	1	2	3	4	5	6	7	8	9	A	B	C

3. PANEL CODE

Panel Code	P1 Factory	P2 Factory	P3 Factory	P4 Factory	P5 Factory	Hydis Panel
Mark	1	2	3	4	5	H

4. FACTORY CODE

Factory Code	LPL Gumi	LPL Nanjing
Mark	K	C

5. SERIAL NO.

Year	1 ~ 99999	100000 ~
Mark	00001 ~ 99999	A0001 ~ A9999, ... , Z9999

b) Location of Lot Mark

Serial NO. is printed on the label. The label is attached to the backside of the LCD module.
This is subject to change without prior notice.

8-2. Packing Form

a) Package quantity in one box : 4PCS

b) Box Size : 434 X 334 X 666

9. PRECAUTIONS

Please pay attention to the followings when you use this TFT LCD module.

9-1. MOUNTING PRECAUTIONS

(1) You must mount a module using holes arranged in four corners or four sides.
(2) You should consider the mounting structure so that uneven force (ex. Twisted stress) is not applied to the module. And the case on which a module is mounted should have sufficient strength so that external force is not transmitted directly to the module.
(3) Please attach the surface transparent protective plate to the surface in order to protect the polarizer. Transparent protective plate should have sufficient strength in order to the resist external force.
(4) You should adopt radiation structure to satisfy the temperature specification.
(5) Acetic acid type and chlorine type materials for the cover case are not desirable because the former generates corrosive gas of attacking the polarizer at high temperature and the latter causes circuit break by electro-chemical reaction.
(6) Do not touch, push or rub the exposed polarizers with glass, tweezers or anything harder than HB pencil lead. And please do not rub with dust clothes with chemical treatment.
Do not touch the surface of polarizer for bare hand or greasy cloth.(Some cosmetics are detrimental to the polarizer.)
(7) When the surface becomes dusty, please wipe gently with absorbent cotton or other soft materials like chamois soaks with petroleum benzene. Normal-hexane is recommended for cleaning the adhesives used to attach front / rear polarizers. Do not use acetone, toluene and alcohol because they cause chemical damage to the polarizer.
(8) Wipe off saliva or water drops as soon as possible. Their long time contact with polarizer causes deformations and color fading.
(9) Do not open the case because inside circuits do not have sufficient strength.

9-2. OPERATING PRECAUTIONS

(1) The spike noise causes the mis-operation of circuits. It should be lower than following voltage :
V=±200mV(Over and under shoot voltage)
(2) Response time depends on the temperature.(In lower temperature, it becomes longer.)
(3) Brightness depends on the temperature. (In lower temperature, it becomes lower.)
And in lower temperature, response time(required time that brightness is stable after turned on) becomes longer.
(4) Be careful for condensation at sudden temperature change. Condensation makes damage to polarizer or electrical contacted parts. And after fading condensation, smear or spot will occur.
(5) When fixed patterns are displayed for a long time, remnant image is likely to occur.
(6) Module has high frequency circuits. Sufficient suppression to the electromagnetic interference shall be done by system manufacturers. Grounding and shielding methods may be important to minimized the interference.
(7) Please do not give any mechanical and/or acoustical impact to LCM. Otherwise, LCM can't be operated its full characteristics perfectly.
(8) A screw which is fastened up the steels should be a machine screw.
(if not, it causes metallic foreign material and deal LCM a fatal blow)
(9) Please do not set LCD on its edge.

9-3. ELECTROSTATIC DISCHARGE CONTROL

Since a module is composed of electronic circuits, it is not strong to electrostatic discharge. Make certain that treatment persons are connected to ground through wrist band etc. And don't touch interface pin directly.

9-4. PRECAUTIONS FOR STRONG LIGHT EXPOSURE

Strong light exposure causes degradation of polarizer and color filter.

9-5. STORAGE

When storing modules as spares for a long time, the following precautions are necessary.

(1) Store them in a dark place. Do not expose the module to sunlight or fluorescent light. Keep the temperature between 5°C and 35°C at normal humidity.
(2) The polarizer surface should not come in contact with any other object.
It is recommended that they be stored in the container in which they were shipped.

9-6. HANDLING PRECAUTIONS FOR PROTECTION FILM

(1) The protection film is attached to the bezel with a small masking tape.
When the protection film is peeled off, static electricity is generated between the film and polarizer.
This should be peeled off slowly and carefully by people who are electrically grounded and with well ion-blown equipment or in such a condition, etc.
(2) When the module with protection film attached is stored for a long time, sometimes there remains a very small amount of glue still on the bezel after the protection film is peeled off.
(3) You can remove the glue easily. When the glue remains on the bezel surface or its vestige is recognized, please wipe them off with absorbent cotton waste or other soft material like chamois soaked with normal-hexane.