

Product Specification
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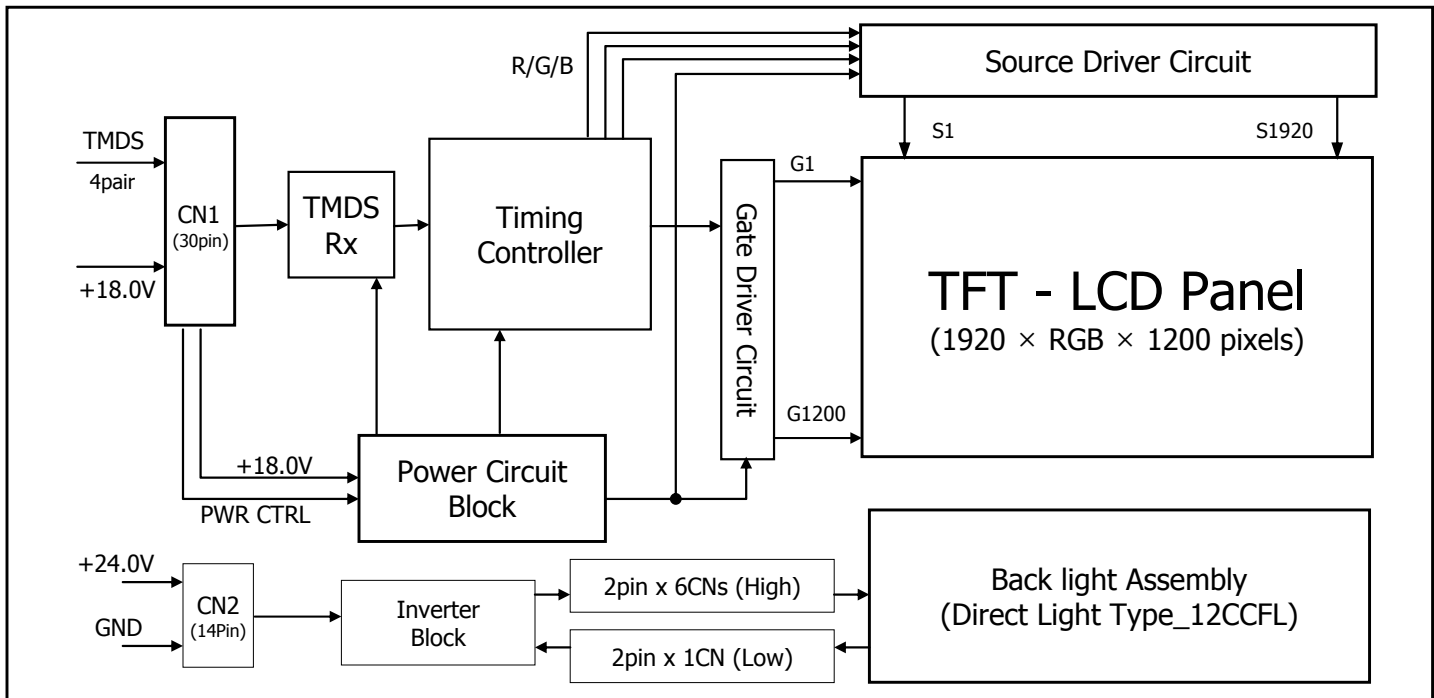
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Product Specification

1. General Description

The LM230WU3 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 TMDSTM(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 36.9(D) mm(Typ.)
Pixel Pitch	0.258 mm x 0.258 mm
Pixel Format	1920 horiz. By 1200 vert. Pixels RGB stripes arrangement
Color Depth	8-bit, 16,777,216 colors
Luminance, White	400 cd/m ² (5 points Avg.)
Viewing Angle(CR>10)	View Angle Free (R/L 178(Typ.), U/D 178(Typ.))
Power Consumption	Total 61.1 Watt (Typ.) (8.1 Watt @V _{LCD} , 53 Watt @400cd)
Weight	2,790g(typ.)
Display Operating Mode	Transmissive mode, normally black
Surface Treatment	Hard coating(3H), Anti-glare treatment of the front polarizer

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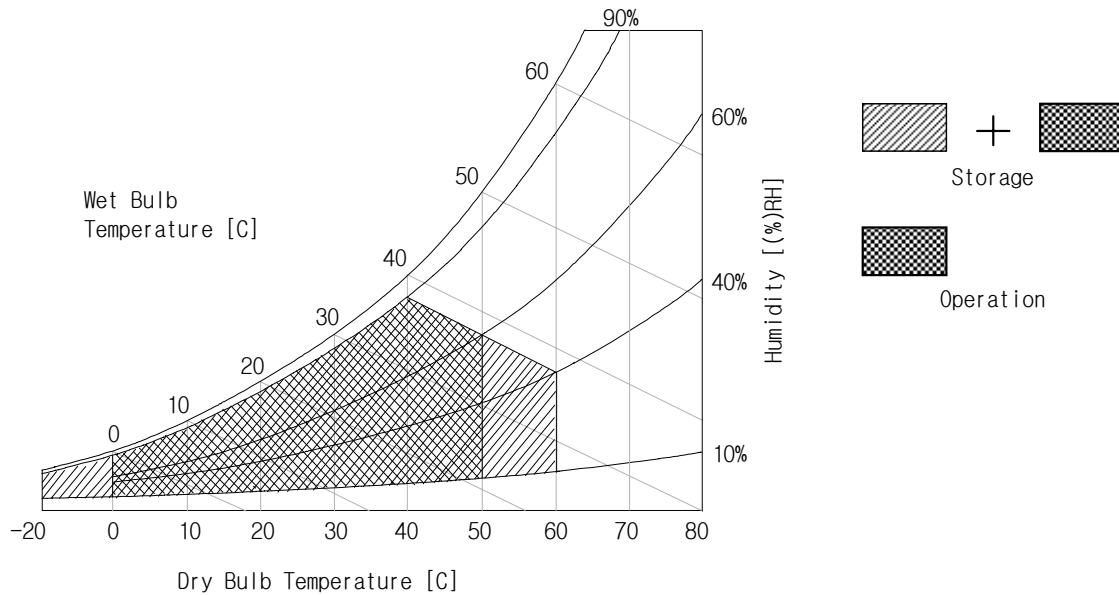
2. Absolute Maximum Ratings

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

Table 1. ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Input Voltage	V _{LCD}	-0.3	21	Vdc	at 25 ± 2°C
Operating Temperature	T _{OP}	0	50	°C	1
Storage Temperature	T _{ST}	-20	60	°C	
Operating Ambient Humidity	H _{OP}	10	90	%RH	
Storage Humidity	H _{ST}	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.



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3-2-2. Backlight Interface

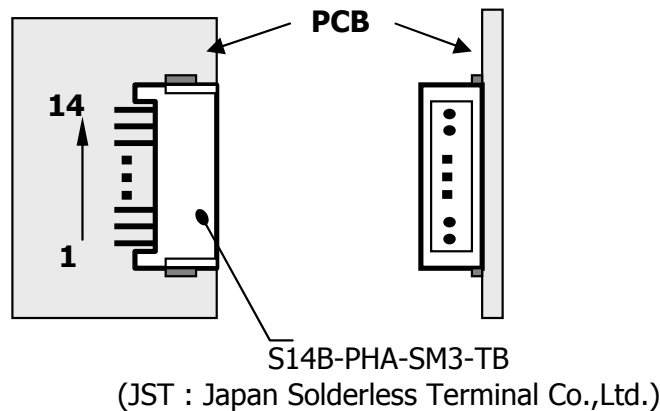
- Inverter Connector : S14B-PHA-SM3 Side entry type (Manufactured by JST) or Equivalent
- Mating Connector : PHR-14(Manufactured by JST) or Equivalent

Table 4. INVERTER CONNECTOR PIN CONFIGURATION

Pin No	Symbol	Description	Remarks
1	VBL	Power Supply +24.0V	
2	VBL	Power Supply +24.0V	
3	VBL	Power Supply +24.0V	
4	VBL	Power Supply +24.0V	
5	VBL	Power Supply +24.0V	
6	GND	Power Ground	Note 1
7	GND	Power Ground	
8	GND	Power Ground	
9	GND	Power Ground	
10	GND	Power Ground	
11	OPEN	NC	
12	VON	Backlight On/off Signal	(On :2.0V~5V/Off :0.0~0.8V)
13	VBR	Brightness Adjustable Voltage	(Max :3.3V / Min :0.0V)
14	Status	Lamp Operating Status	Normal=0~0.8V Abnormal=3.0~5.0V

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

Rear view of LCM



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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 5. TIMING TABLE (VESA COORDINATED VIDEO TIMING)

ITEM		SYMBOL	Min	Typ	Max	Unit	Note
DCLK	Period	tCLK	6.49	6.49	6.49	ns	
	Frequency	fCLK	154	154	154	MHz	
Hsync	Period	tHP	2080	2080	2080	tCLK	
	Width-Active	tWH	32	32	32		
Vsync	Period	tVP	1235	1235	1235	tHP	
	Frequency	fV	59.95	59.95	59.95	Hz	
	Width-Active	tWV	6	6	6	tHP	
Data Enable	Horizontal Valid	tHV	1920	1920	1920	tCLK	
	Horizontal Back Porch	tHBP	80	80	80		
	Horizontal Front Porch	tHFP	48	48	48		
	Horizontal Blank	-	160	160	160		tWH+ tHBP+ tHFP
	Vertical Valid	tVv	1200	1200	1200	tHP	
	Vertical Back Porch	tVBP	26	26	26		
	Vertical Front Porch	tVFP	3	3	3		
Vertical Blank	-	35	35	35	tWV+ tVBP+ tVFP		

Note: Hsync period and Hsync width-active should be even number times of tCLK. If the value is odd number times of tCLK, display control signal can be asynchronous. In order to operate this LCM a Hsync, Vsync, 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).
4. The polarity of Hsync, Vsync is not restricted.

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Table 5-1. TIMING TABLE 2

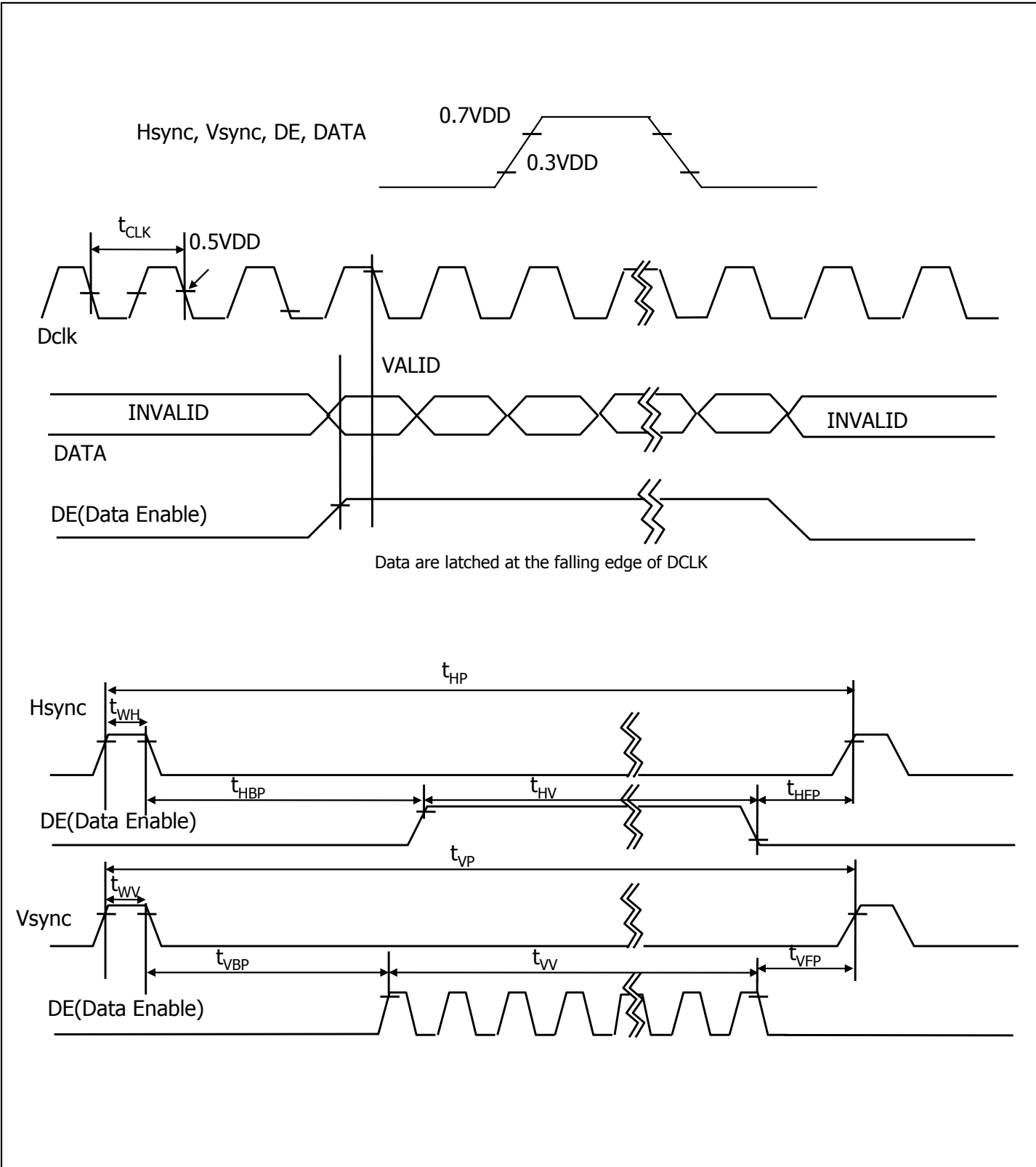
ITEM		SYMBOL	Min	Typ	Max	Unit	Note
DCLK	Period	tCLK	8.16	8.16	8.16	ns	
	Frequency	fCLK	122.5	122.5	122.5	MHz	
Hsync	Period	tHP	2080	2080	2080	tCLK	
	Width-Active	tWH	32	32	32		
Vsync	Period	tVP	1228	1228	1228	tHP	
	Frequency	fV	47.96	47.96	47.96	Hz	
	Width-Active	tWV	6	6	6	tHP	
Data Enable	Horizontal Valid	tHV	1920	1920	1920	tCLK	
	Horizontal Back Porch	tHBP	80	80	80		
	Horizontal Front Porch	tHFP	48	48	48		
	Horizontal Blank	-	160	160	160		tWH+ tHBP+ tHFP
	Vertical Valid	tVv	1200	1200	1200	tHP	
	Vertical Back Porch	tVBP	19	19	19		
	Vertical Front Porch	tVFP	3	3	3		
	Vertical Blank	-	28	28	28		tWV+ tVBP+ tVFP

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

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3-4. Signal Timing Waveforms



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3-5. Color Data Reference

The Brightness 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 6. COLOR DATA REFERENCE

Color		Input Color Data																							
		RED								GREEN								BLUE							
		MSB		RED				LSB		MSB		GREEN				LSB		MSB		BLUE				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

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3-6. Power Sequence

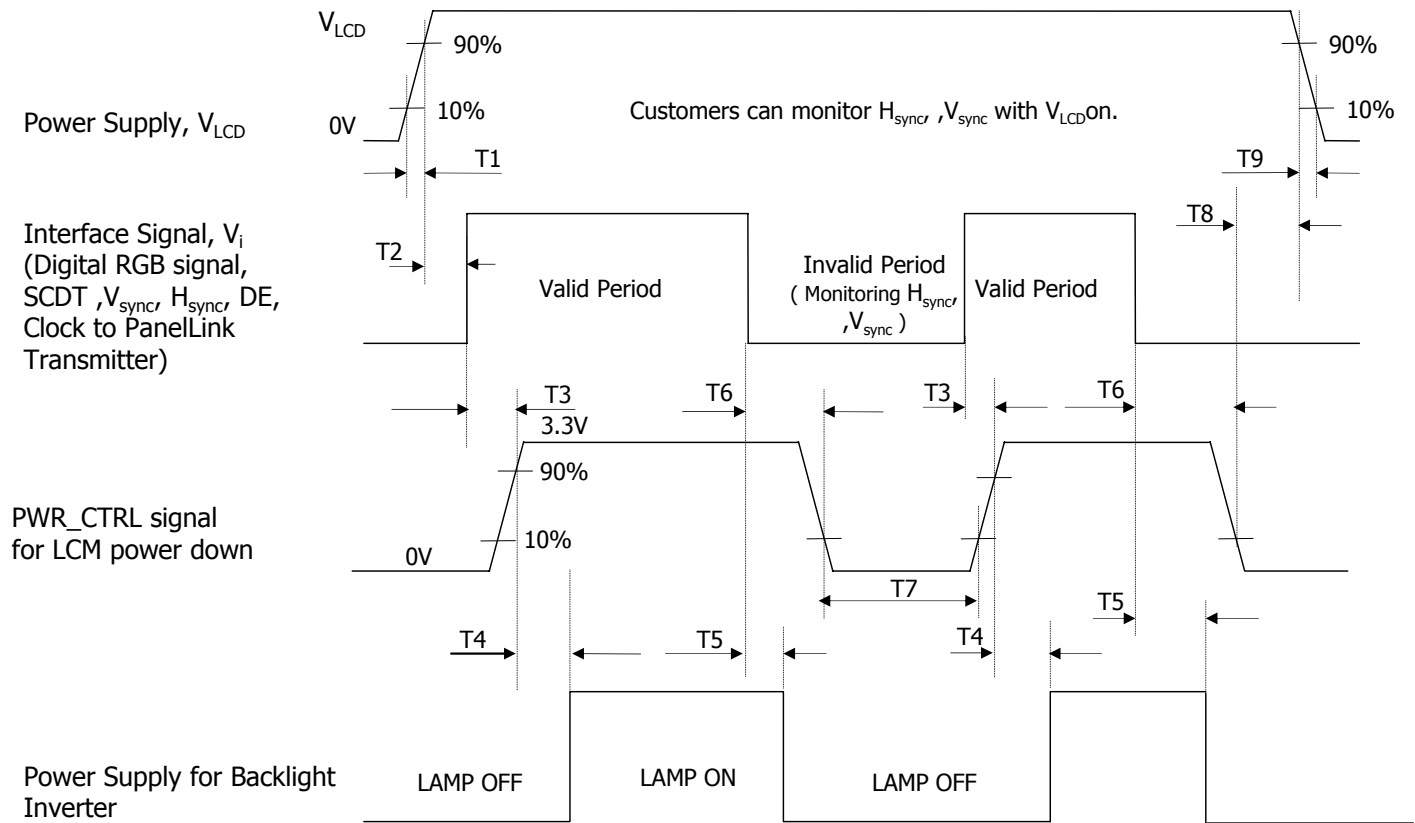


Table 7. POWER SEQUENCE

Parameter	Values			Units
	Min	Typ	Max	
T1	1	-	30	ms
T2	-	-	-	ms
T3	-	-	300	ms
T4	100	-	-	ms
T5	-	-	80	ms
T6	-	-	80	ms
T7	400	-	-	
T8	50	-	-	ms
T9	-	-	200	

- 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.

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3-7. Power Sequence for Inverter

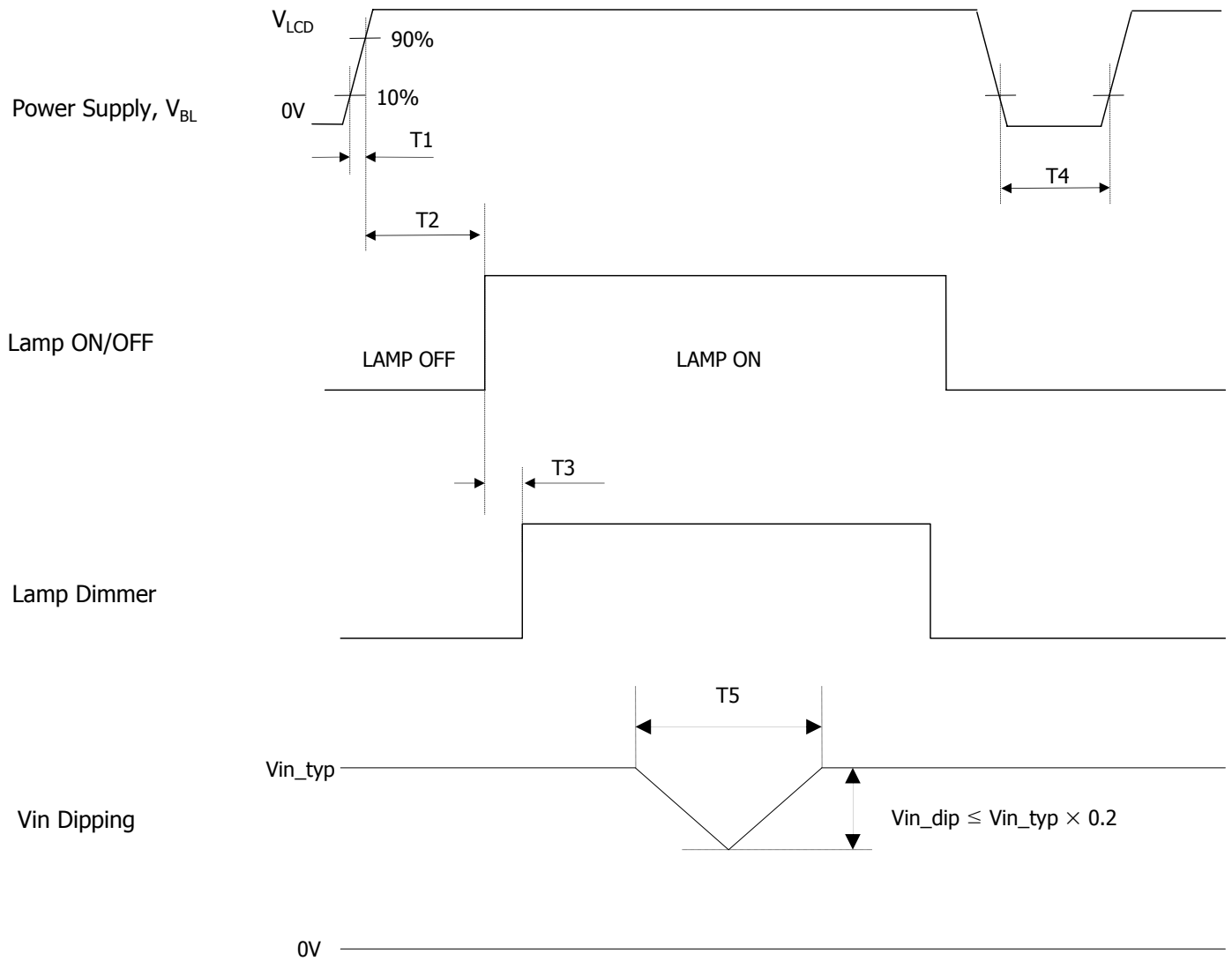


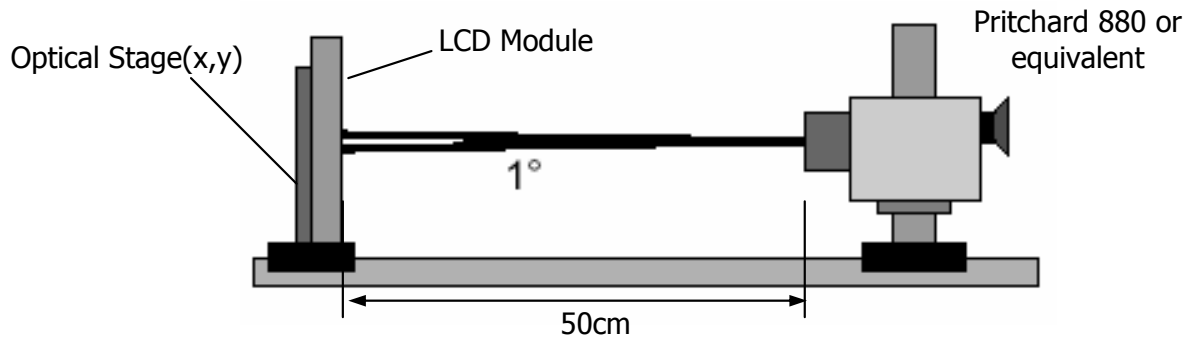
Table 8. POWER SEQUENCE

Parameter	Values			Units
	Min	Typ	Max	
T1	1	-	30	ms
T2	200	-	-	ms
T3	-	-	50	ms
T4	500	-	-	ms
T5	-	-	10	ms

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4. Optical Specifications

Optical characteristics are determined after the unit has been 'ON' for approximately 30 minutes in a dark environment at $25 \pm 2^\circ\text{C}$. 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

($T_a=25^\circ\text{C}$, $V_{LCD}=18.0\text{V}$, $f_v=60\text{Hz}$ Dclk=154MHz, $V_{BR}=3.3\text{V}$)

Parameter	Symbol	Values			Units	Notes	
		Min	Typ	Max			
Contrast Ratio	CR	450	700			1	
Surface Luminance, white	L_{WH}	300	400		cd/m ²	2	
Luminance Variation	δ_{WHITE}			35	%	3	
Response Time	Rise Time	T_{R}	-	5.5	12	ms	4
	Decay Time	T_{D}	-	6.5	12	ms	4
	Gray to Gray	T_{GTG_AVR}	-	10		ms	5
		T_{GTG_MAX}	-	20		ms	5
Color Coordinates [CIE1931]	RED	R_x	Typ -0.03	0.640	Typ +0.03		
		R_y		0.343			
	GREEN	G_x		0.292			
		G_y		0.618			
	BLUE	B_x		0.146			
		B_y		0.074			
	WHITE	W_x		0.313			
	W_y	0.329					
Color Shift	Horizontal	θ_{CST_H}	-	178	-	Degree	6
	Vertical	θ_{CST_V}	-	178	-		
Viewing Angle (CR>10)							
General	Horizontal	θ_H	170	178	-	Degree	7
	Vertical	θ_V	170	178	-		
Effective	Horizontal	θ_{GMA_H}		178	-	Degree	8
	Vertical	θ_{GMA_V}		178	-		
Gray Scale				2.2			9

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4. The response time is defined as the following figure and shall be measured by switching the input signal for "black" and "white".
 Response time is the time required for the display to transition from black to white (Rise Time, T_{rR}) and from white to black (Decay Time, T_{rD}).

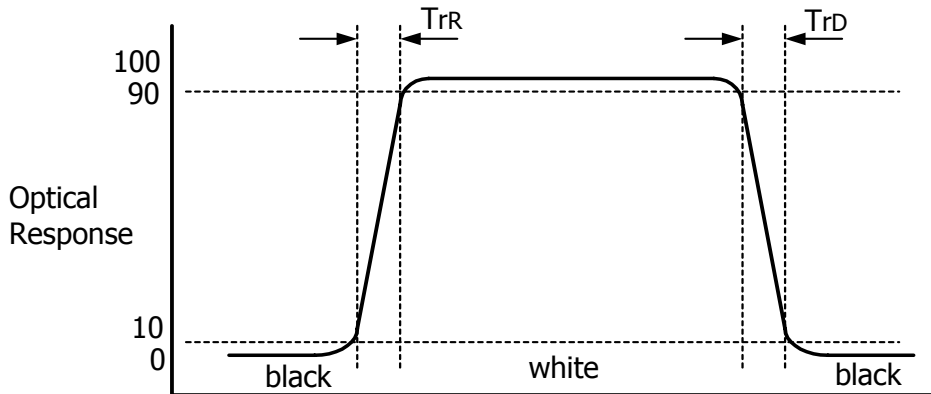


FIG. 3 Response Time

5. 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".

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

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6. Color shift is the angle at which the color difference is lower than 0.04.

- Color difference($\Delta u'v'$)

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

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

u'_1, v'_1 : $u'v'$ value at viewing angle direction
 u'_2, v'_2 : $u'v'$ value at front($\theta=0$)

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

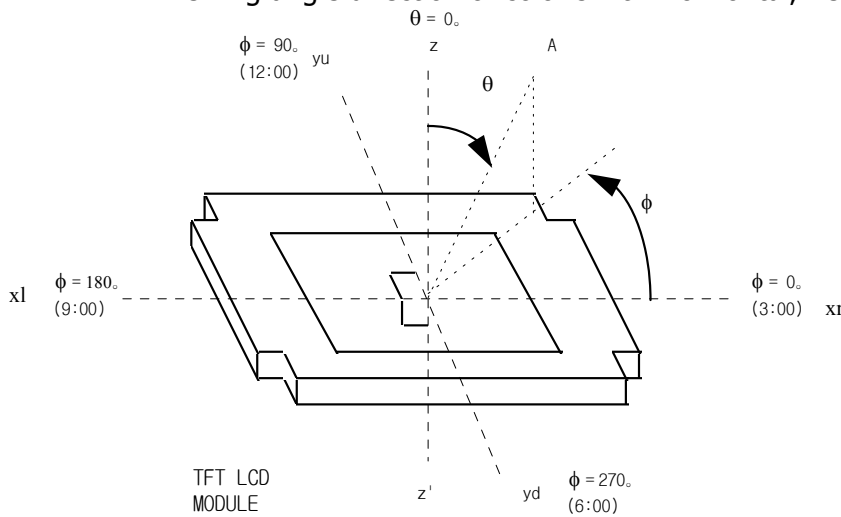


FIG. 4 Viewing angle direction

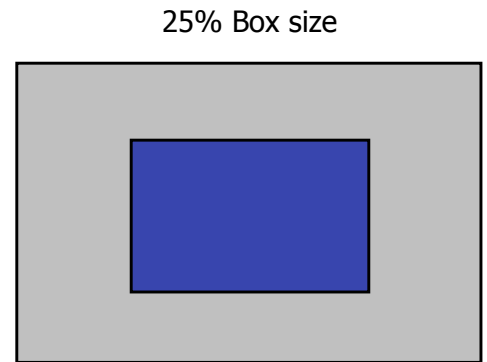


FIG. 5 Color shift test pattern

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

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7. Viewing angle(general) is the angle at which the contrast ratio is greater than 10.

8. Effective viewing angle is the angle at which the gamma shift of gray scale is lower than 0.3.

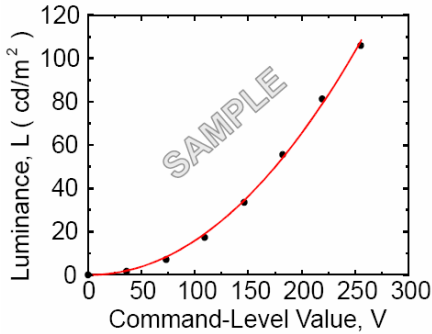


FIG. 6 Sample Luminance vs. gray scale (using a 256 bit gray scale)

$$L = aV^r + L_b$$

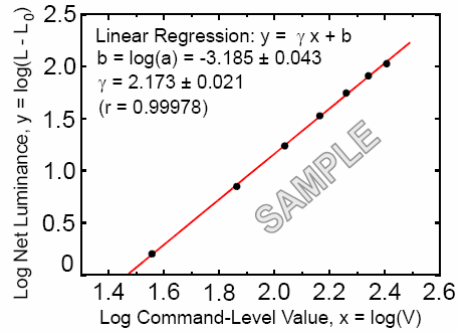


FIG. 7 Sample Log-log plot of luminance vs. gray scale

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

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)

9. Gray scale specification

Gamma Value is approximately 2.2. For more information see Table 10.

Table 10. 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

10. TCO '03 item regarding display characteristic is satisfied.

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5. Mechanical Characteristics

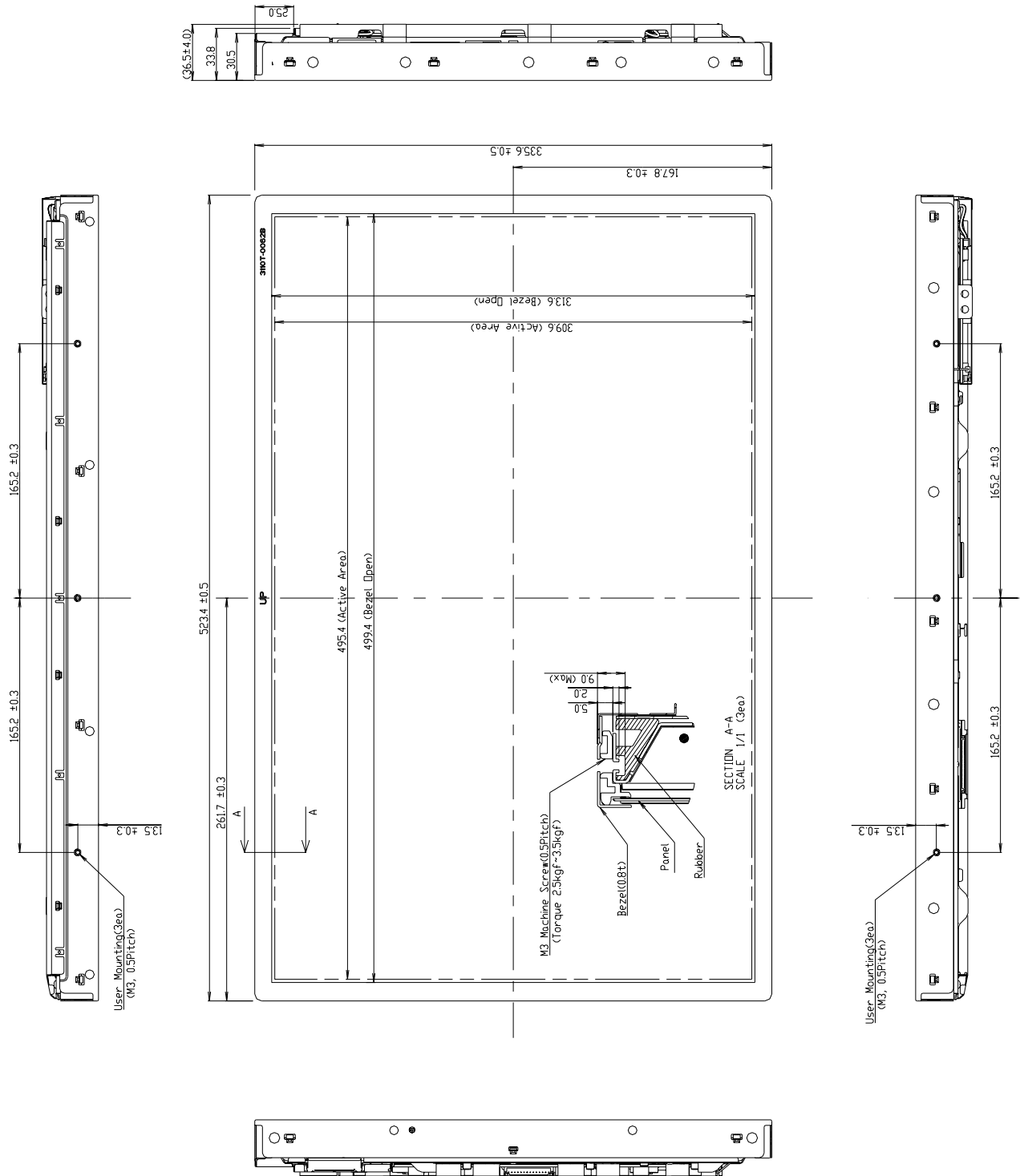
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

Outline Dimension	Horizontal	523.4mm
	Vertical	335.6mm
	Depth	36.9mm
Bezel Area	Horizontal	499.4mm
	Vertical	313.6mm
Active Display Area	Horizontal	495.36mm
	Vertical	309.6mm
Weight	2,790g (Typ.) / 2,930g (Max.)	
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.

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<FRONT VIEW>



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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 : 100G Waveform : half sine wave, 2ms Direction : ±X, ±Y, ±Z One time each direction
7	Altitude operating storage / shipment	0 - 10,000 feet(3048m) 0 - 40,000 feet(12,192m)

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7. International Standards

7-1. Safety

- a) UL 60950-1:2003, First Edition, Underwriters Laboratories, Inc.,
Standard for Safety of Information Technology Equipment.
- b) CAN/CSA C22.2, No. 60950-1-03 1st Ed. April 1, 2003, Canadian Standards Association,
Standard for Safety of Information Technology Equipment.
- c) EN 60950-1:2001, First Edition,
European Committee for Electrotechnical Standardization(CENELEC)
European Standard for Safety of Information Technology 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)

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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 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 :
 $V = \pm 200\text{mV}$ (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.

Product Specification

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.