SPECIFICATION
FOR
APPROVAL

(●) Preliminary Specification
( ) Final Specification

Title	23" Full HD TFT LCD

BUYER	DELL
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LM230WF4
SUFFIX	TLA1

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

APPROVED BY	SIGNATURE DATE
/	
/	
/	

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

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H.Y. Kim / Engineer	

Products Engineering Dept.
LG. Display Co., Ltd

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RECORD OF REVISIONS

Revision No	Revision Date	Page	Description
0.1	Feb. 05. 2009	-	Preliminary
0.2	Feb. 16. 2009	17	Timing update
0.3	Mar. 06. 2009	28,29	Update drawings
0.4	Mar. 30. 2009	4	Power consumption update
		6	Electrical characteristic update
		17	Timing update
		21	Color specification update.
		25	Measurement distance update
		27	Max weight update
0.5	Apr. 08. 2009	28,29	Mechanical drawings update
0.6	Apr. 14. 2009	23	G to G explanation update
0.7	May. 13. 2009	9,11	Interface connection update : Insert MST option Enable and notes
		17	Signal timing notes update
		20	Power sequence update for optional signal
		21	Optical specification update
		29	Mechanical drawing update : Tcon board shift
		30	Reliability update : Insert operating altitude
		31	International standard update : Apply 2nd edition

1. General Description

LM230WF4 is a Color Active Matrix Liquid Crystal Display with an integral Cold Cathode Fluorescent Lamp (CCFL) backlight system. The matrix employs a-Si Thin Film Transistor as the active element.

It is a transmissive type display operating in the normally white mode. It has a 23-inch diagonally measured active display area with FHD resolution (1080 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 brightness of the sub-pixel color is determined with a 8-bit gray scale signal for each dot, thus, presenting a palette of more than 16.7M colors with A-FRC(Advanced Frame Rate Control). It is intended to support displays where high brightness, super wide viewing angle and high color saturation, etc.

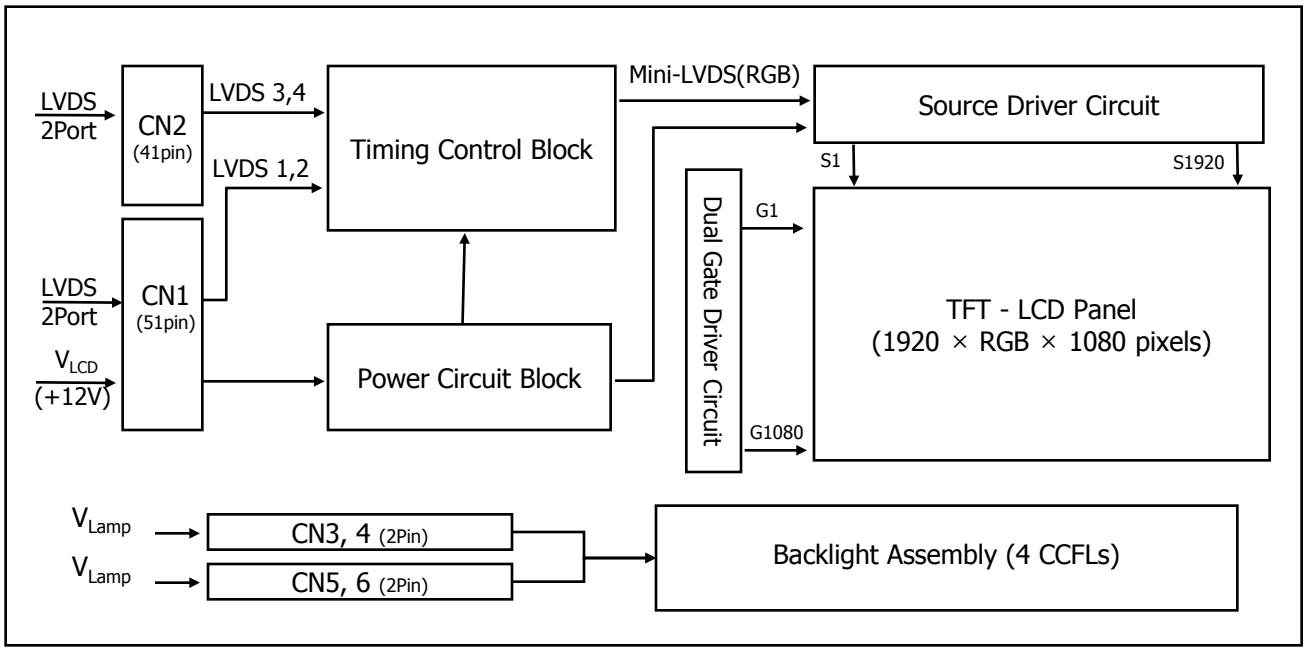


Figure 1. Block Diagram

General Features

Active Screen Size	23 inches (58.42cm) diagonal
Outline Dimension	533.2(H) x 312.0(V) x 20.0(D) mm (Typ.)
Pixel Pitch	0.0884(H) mm x RGB x 0.2652(V) mm
Pixel Format	1920 horizontal x 1080 vertical Pixels, RGB stripe arrangement
Color Depth	8-bit with A-FRC, 16.7M colors
Luminance, White	400 cd/m^2 (Center, 1 point)
Viewing Angle(CR>10)	R/L 170(Typ.), U/D 160(Typ.)
Power Consumption	Total 30.42 W (Typ.) (4.92 W @V_{LCD}, 25.50 W @ 400 cd/m^2)
Weight	2,600 g (Typ.)
Display Operating Mode	Transmissive mode, Normally White
Surface Treatment	Hard coating (3H) & Anti-Glare treatment of the front polarizer

2. Absolute Maximum Ratings

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

Table 1. Absolute Maximum Ratings

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Supply Input Voltage	V_{LCD}	-0.3	12.4	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.

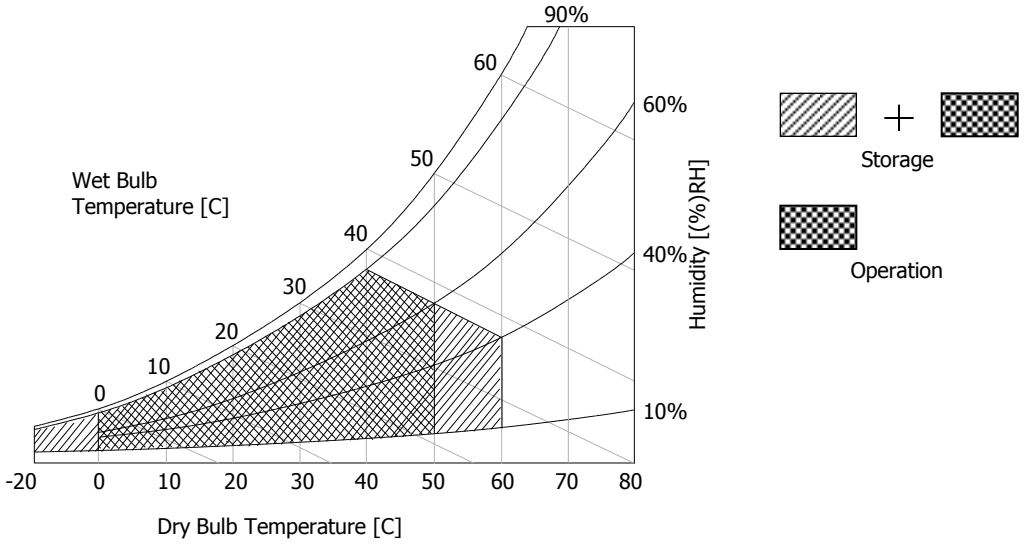


Figure 2. Temperature and Relative Humidity

3. Electrical Specifications

3-1. Electrical Characteristics

It requires two power inputs. One is employed to power the LCD electronics and to drive the TFT array and liquid crystal. The other input power for the CCFL is typically generated by an inverter. The inverter is an external unit to the LCDs.

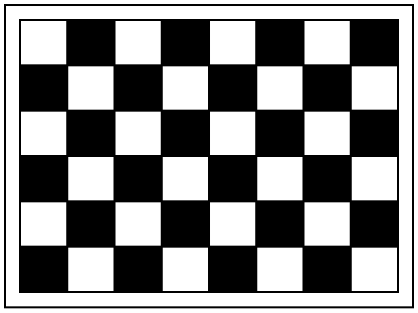
Table 2. Electrical Characteristics (Module)

Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input Voltage	V_{LCD}	11.6	12.0	12.4	Vdc	
Permissive Power Input Ripple	V_{dRF}			400	mVp-p	1
Differential Impedance	Z_m	90	100	110	Ohm	
Power Supply Input Current	$I_{LCD\text{-}MOSAIC\_60Hz}$	-	410	490	mA	2
	$I_{LCD\text{-}Black\_60Hz}$	-	480	580	mA	3
	$I_{LCD\text{-}MOSAIC\_120Hz}$		550	760	mA	
	$I_{LCD\text{-}Black\_120Hz}$		680	1080	mA	
Power Consumption	P_{LCD}	-	4.92	12.96	W	2
Rush current	I_{RUSH}	-	-	3.0	A	4

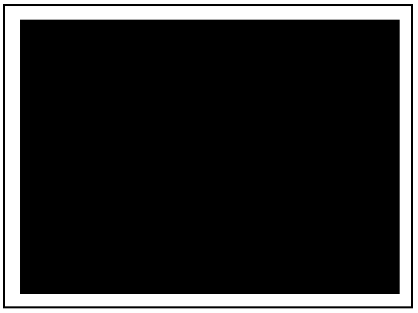
Note :

1. Permissive power ripple should be measured under V_{LCD}=12.0V, 25±2°C, f_V (frame frequency)= 120Hz condition and at that time, we recommend the bandwidth configuration of oscilloscope is to be under 20MHz.
2. The specified current and power consumption are under the V_{LCD} =12.0V, 25 ± 2°C, f_V = 60Hz condition whereas Mosaic pattern shown in the [Figure 3.] is displayed.
3. The specified current is measured at the Full black pattern.
4. The duration of rush current is about 5ms and measured under condition that the rising time of power input is 500us ± 20%.

Figure 3. Pattern for Electrical Characteristics



Mosaic Pattern(8 x 6)
White : 255Gray Black : 0Gray



Full Black Pattern

Table 3. Electrical Characteristics (Backlight System)

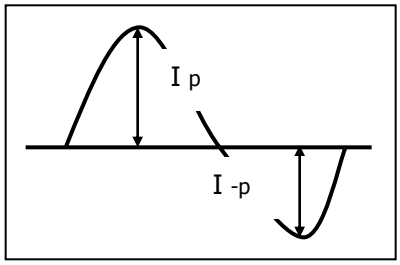
Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
LAMP :						
Operating Voltage	V_{BL}	830 (8.0mA)	850 (7.5mA)	1,000 (3.0mA)	V_{RMS}	1, 2
Operating Current	I_{BL}	3.0	7.5	8.0	mA_{RMS}	1
Established Starting Voltage	V_S					1, 3
at 25 °C				1,500	V_{RMS}	
at 0 °C				1,800	V_{RMS}	
Operating Frequency	f_{BL}	40	60	70	kHz	4
Discharge Stabilization Time	T_S			3	min	1, 5
Power Consumption	P_{BL}		25.5	28.1	W	6
Life Time		50,000			Hrs	1, 7

Note : The design of the inverter must have specifications for the lamp in LCD Assembly.
The performance of the Lamp in LCM, for example life time or brightness, is extremely influenced by the characteristics of the DC-AC inverter. So all the parameters of an inverter should be carefully designed so as not to produce too much leakage current from high-voltage output of the inverter.
When you design or order the inverter, please make sure unwanted lighting caused by the mismatch of the lamp and the inverter (no lighting, flicker, etc) never occurs. When you confirm it, the LCD - Assembly should be operated in the same condition as installed in you instrument.

※ Do not attach a conducting tape to lamp connecting wire.
If the lamp wire attach to a conducting tape, TFT-LCD Module has a low luminance and the inverter has abnormal action. Because leakage current is occurred between lamp wire and conducting tape.

1. Specified values are for a single lamp.
2. Operating voltage is measured at 25 ± 2°C. The variance of the voltage is ± 10%.
3. The voltage above V_S should be applied to the lamps for more than 1 second for start-up.
(Inverter open voltage must be more than lamp starting voltage.)
Otherwise, the lamps may not be turned on. The used lamp current is the lamp typical current.
4. Lamp frequency may produce interface with horizontal synchronous frequency and as a result this may cause beat on the display. Therefore lamp frequency shall be as far as possible from the horizontal synchronous frequency and from its harmonics in order to prevent interference.
5. Let's define the brightness of the lamp after being lighted for 5 minutes as 100%.
T_S is the time required for the brightness of the center of the lamp to be not less than 95%.
6. The lamp power consumption shown above does not include loss of external inverter.
The used lamp current is the lamp typical current. ($P_{BL} = V_{BL} \times I_{BL} \times N_{LAMP}$)
7. The life time is determined as the time at which brightness 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.

8. The output of the inverter must have symmetrical(negative and positive) voltage waveform and symmetrical current waveform (Unsymmetrical ratio is less than 10%). Please do not use the inverter which has unsymmetrical voltage and unsymmetrical current and spike wave.
   Requirements for a system inverter design, which is intended to have a better display performance, a better power efficiency and a more reliable lamp, are following.
   It shall help increase the lamp lifetime and reduce leakage current.
   a. The asymmetry rate of the inverter waveform should be less than 10%.
   b. The distortion rate of the waveform should be within $\sqrt{2}$ ±10%.
   * Inverter output waveform had better be more similar to ideal sine wave.



* Asymmetry rate:

$| I_p - I_{-p} | / I_{rms} \times 100\%$

* Distortion rate

I_p (or I_{-p}) / I_{rms}

9. The inverter which is combined with this LCM, is highly recommended to connect coupling(ballast) condenser at the high voltage output side. When you use the inverter which has not coupling(ballast) condenser, it may cause abnormal lamp lighting because of biased mercury as time goes.
10. In case of edge type backlight with over 4 parallel lamps, input current and voltage waveform should be synchronized

3-2. Interface Connections

This LCD module employs two kinds of interface connection, 51 pin connector and 41 pin connector are used for the module electronics.

3-2-1. LCD Module

Table 4. Module Connector (CN1) Pin Configuration

- LCD Connector(CN1): IS050-C51B-C39-A(manufactured by UJU) or compatible
- Mating Connector : FI-R51HL(JAE) or compatible

No	Symbol	Description
1	GND	Ground
2	MST	MST Option Enable
3	PWM_OUT	PWM Signal Output
4	NC	No Connection (SDA)
5	NC	No Connection (SCL)
6	NC	No Connection
7	NC	No Connection (DISM)
8	NC	No Connection
9	ODC_EN	ODC Enable
10	FPS_DET	H: High Frame rate, L: Legacy
11	GND	Ground
12	R1AN	1st LVDS Channel Signal (A-)
13	R1AP	1st LVDS Channel Signal (A+)
14	R1BN	1st LVDS Channel Signal (B-)
15	R1BP	1st LVDS Channel Signal (B+)
16	R1CN	1st LVDS Channel Signal (C-)
17	R1CP	1st LVDS Channel Signal (C+)
18	GND	Ground
19	R1CLKN	1st LVDS Channel Clock Signal(-)
20	R1CLKP	1st LVDS Channel Clock Signal(+)
21	GND	Ground
22	R1DN	1st LVDS Channel Signal (D-)
23	R1DP	1st LVDS Channel Signal (D+)
24	GND	Ground
25	NC	No Connection
26	NC	No Connection

No	Symbol	Description
27	NC	No Connection (BIT)
28	R2AN	2nd LVDS Channel Signal (A-)
29	R2AP	2nd LVDS Channel Signal (A+)
30	R2BN	2nd LVDS Channel Signal (B-)
31	R2BP	2nd LVDS Channel Signal (B+)
32	R2CN	2nd LVDS Channel Signal (C-)
33	R2CP	2nd LVDS Channel Signal (C+)
34	GND	Ground
35	R2CLKN	2nd LVDS Channel Clock Signal(-)
36	R2CLKP	2nd LVDS Channel Clock Signal(+)
37	GND	Ground
38	R2DN	2nd LVDS Channel Signal (D-)
39	R2DP	2nd LVDS Channel Signal (D+)
40	GND	Ground
41	NC	No connection
42	NC	No connection
43	GND	Ground
44	GND	Ground (AGP)
45	GND	Ground
46	NC	No connection
47	NC	No connection
48	VLCD	Power Supply +12.0V
49	VLCD	Power Supply +12.0V
50	VLCD	Power Supply +12.0V
51	VLCD	Power Supply +12.0V

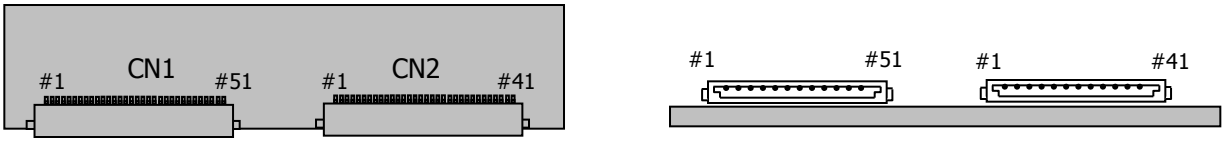
Table 5. Module Connector (CN2) Pin Configuration

- LCD Connector(CN2): IS050-C41B-C39-A(manufactured by UJU) or compatible
- Mating Connector : FI-RE41HL(JAE) or compatible

No	Symbol	Description
1	NC	No connection
2	NC	No connection
3	NC	No connection
4	NC	No connection
5	NC	No connection
6	NC	No connection
7	NC	No connection
8	NC	No connection
9	GND	Ground
10	RA3N	3rd LVDS Channel Signal (A-)
11	RA3P	3rd LVDS Channel Signal (A+)
12	RB3N	3rd LVDS Channel Signal (B-)
13	RB3P	3rd LVDS Channel Signal (B+)
14	RC3N	3rd LVDS Channel Signal (C-)
15	RC3P	3rd LVDS Channel Signal (C+)
16	GND	Ground
17	RCLK3N	3rd LVDS Channel Clock Signal(-)
18	RCLK3P	3rd LVDS Channel Clock Signal(+)
19	GND	Ground
20	RD3N	3rd LVDS Channel Signal (D-)
21	RD3P	3rd LVDS Channel Signal (D+)

No	Symbol	Description
22	GND	Ground
23	NC	No connection
24	NC	No connection
25	GND	Ground
26	RA4N	4th LVDS Channel Signal (A-)
27	RA4P	4th LVDS Channel Signal (A+)
28	RB4N	4th LVDS Channel Signal (B-)
29	RB4P	4th LVDS Channel Signal (B+)
30	RC4N	4th LVDS Channel Signal (C-)
31	RC4P	4th LVDS Channel Signal (C+)
32	GND	Ground
33	RCLK4N	4th LVDS Channel Clock Signal(-)
34	RCLK4P	4th LVDS Channel Clock Signal(+)
35	GND	Ground
36	RD4N	4th LVDS Channel Signal (D-)
37	RD4P	4th LVDS Channel Signal (D+)
38	GND	Ground
39	NC	No connection
40	GND	Ground
41	GND	Ground

Figure 4. Module Connector Diagram



[Rear view of LCM]

Note :

1. All GND (Ground) pins should be connected together to the LCD module's metal frame.
2. All V_{LCD} (power input) pins should be connected together.
3. All Input levels of LVDS signals are based on the EIA 664 Standard.
4. Always all LVDS signal and clock input should be 4 channels and synchronized.
5. Specific pins (CN1 pin No. 4~8, 27, 44) are used for internal process of the LCD module manufacturing. Leave these pins in condition that 'No Connection'.
6. MST : MST option enable (Input), 'L' : Disable, 'H' : Enable
   MST option : Left side image is applied to CN1, 1st & 2nd LVDS channel.
   Right side image is applied to CN2, 3rd & 4th LVDS channel.
   It should be tided up 'L' or 'H'.
7. PWM_OUT : Reference signal (Output) for synchronizing Vsync and Burst frequency of inverter to avoid wavy noise, flickering, etc.
8. ODC_EN : ODC enable (Input), 'L' : Disable, 'H' : Enable
9. FPS_DET : Frame rate detection (Input), 'L' : Under 50MHz, 'H': Over 50MHz.
   It should be tided up 'L' or 'H'.

3-2-2. Backlight system

Table 6. Lamp Connector Pin Configuration

- Lamp Connector(CN3,4,5,6): 35001HS-02LD (manufactured by Yeonho, Locking type)
- Mating Connector : 35001WR-02L (Yeonho) or compatible

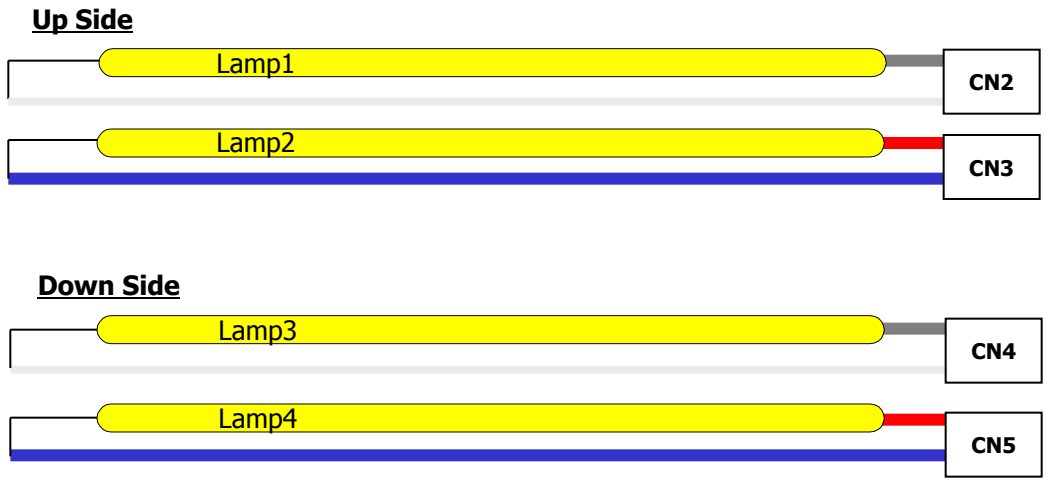
The pin configuration for the connector is shown in the table below.

Pin	Symbol	Description	Notes
1	HV	High Voltage for Lamp	1
2	LV	Low Voltage for Lamp	1, 2

Note :

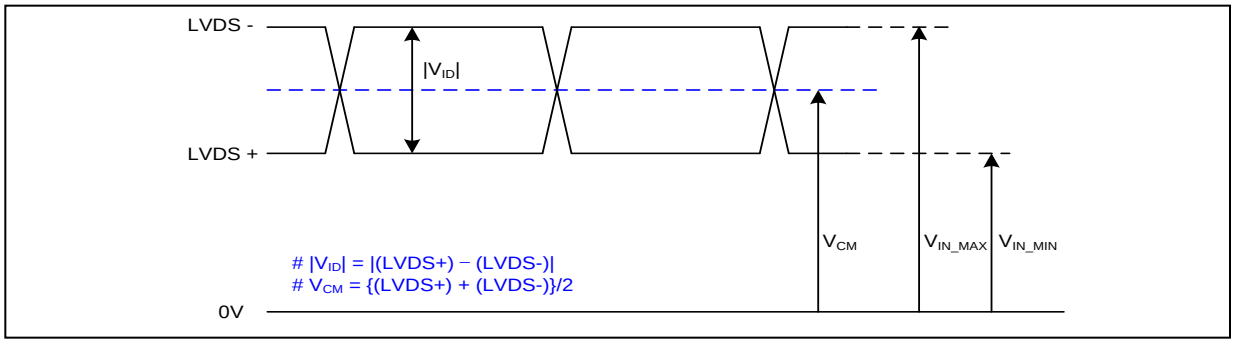
1. The high voltage power terminal is colored Gray, Red
   The low voltage pin color is White, Blue.
2. The backlight ground should be common with LCD metal frame.

Figure 5. Backlight connector diagram



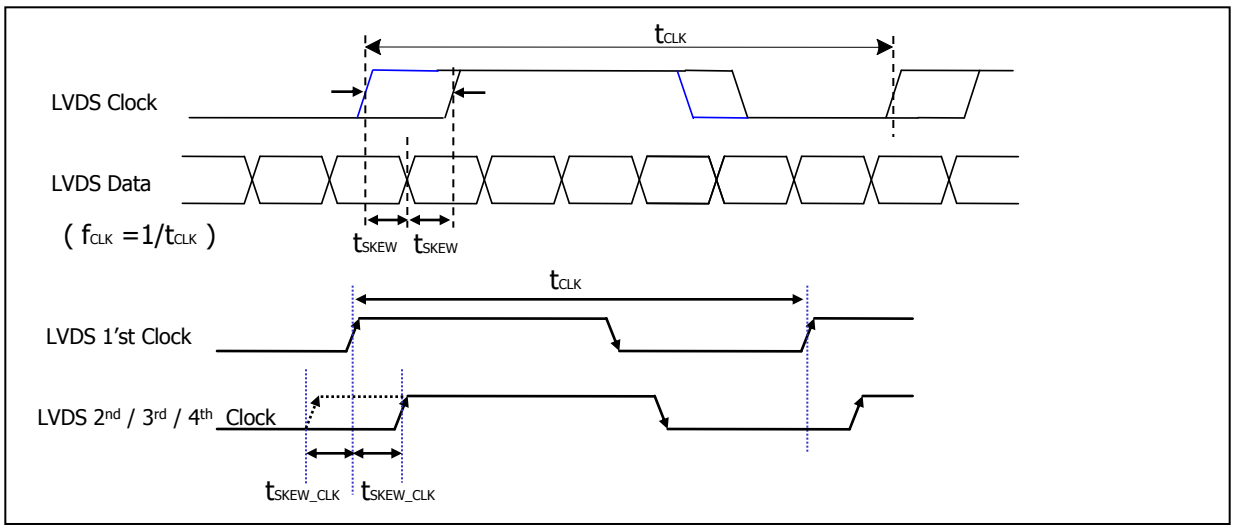
3-3. LVDS characteristics

3-3-1. DC Specification



Description	Symbol	Min	Max	Unit	Notes
LVDS Single end Voltage	$\|V_{ID}\|$	200	600	mV	-
LVDS Common mode Voltage	V_{CM}	1.1	1.4	V	-
LVDS Input Voltage Range	V_{IN}	0.8	1.6	V	-
Change in common mode Voltage	ΔV_{CM}	-	250	mV	-

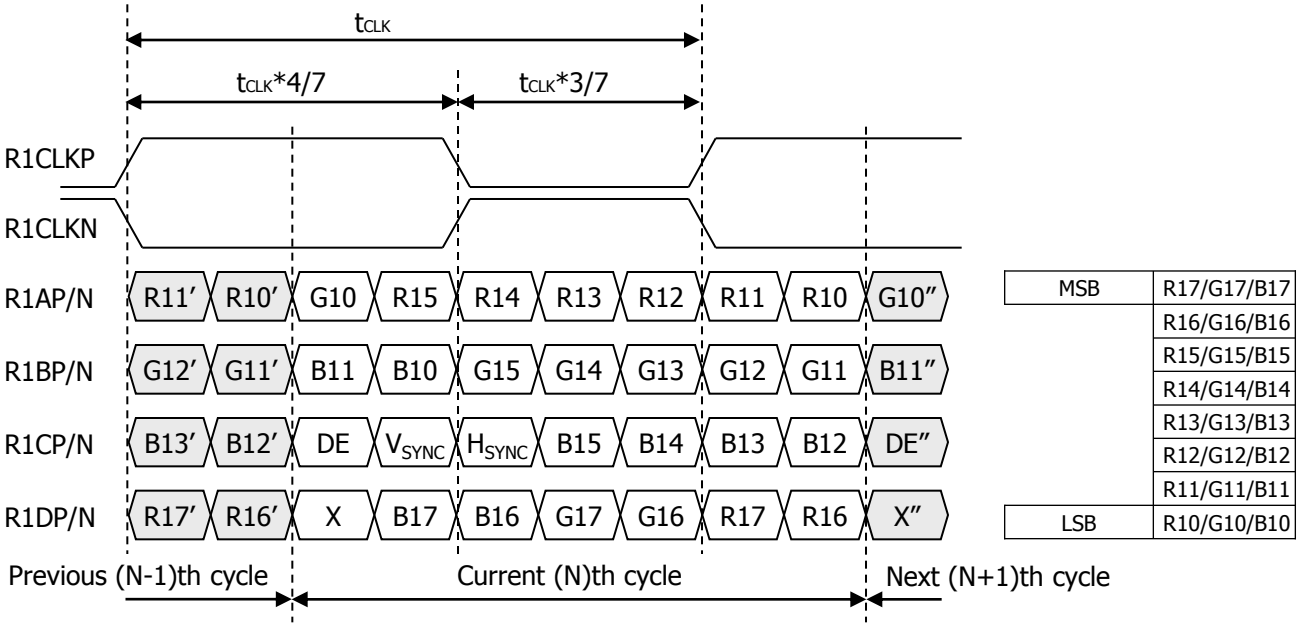
3-3-2. AC Specification



Description	Symbol	Min	Max	Unit	Notes
LVDS Clock to Data Skew Margin	t_{SKEW}	-1/7tc*(n+0.25)	1/7tc*(n+0.25)	ps	-
LVDS Clock to Clock Skew Margin	t_{SKEW_CLK}	- 1/7	+ 1/7	t_{CLK}	-

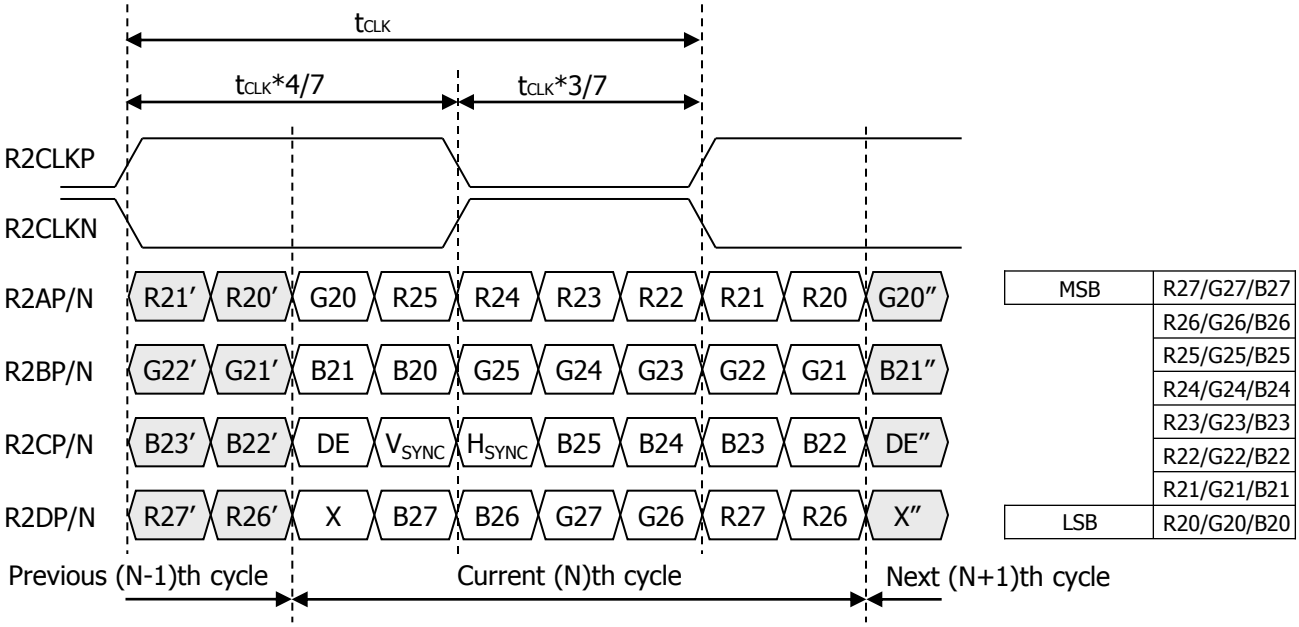
3-3-3. LVDS data format (8bit, VESA)

■ 1st LVDS Channel



MSB	R17/G17/B17
	R16/G16/B16
	R15/G15/B15
	R14/G14/B14
	R13/G13/B13
	R12/G12/B12
	R11/G11/B11
LSB	R10/G10/B10

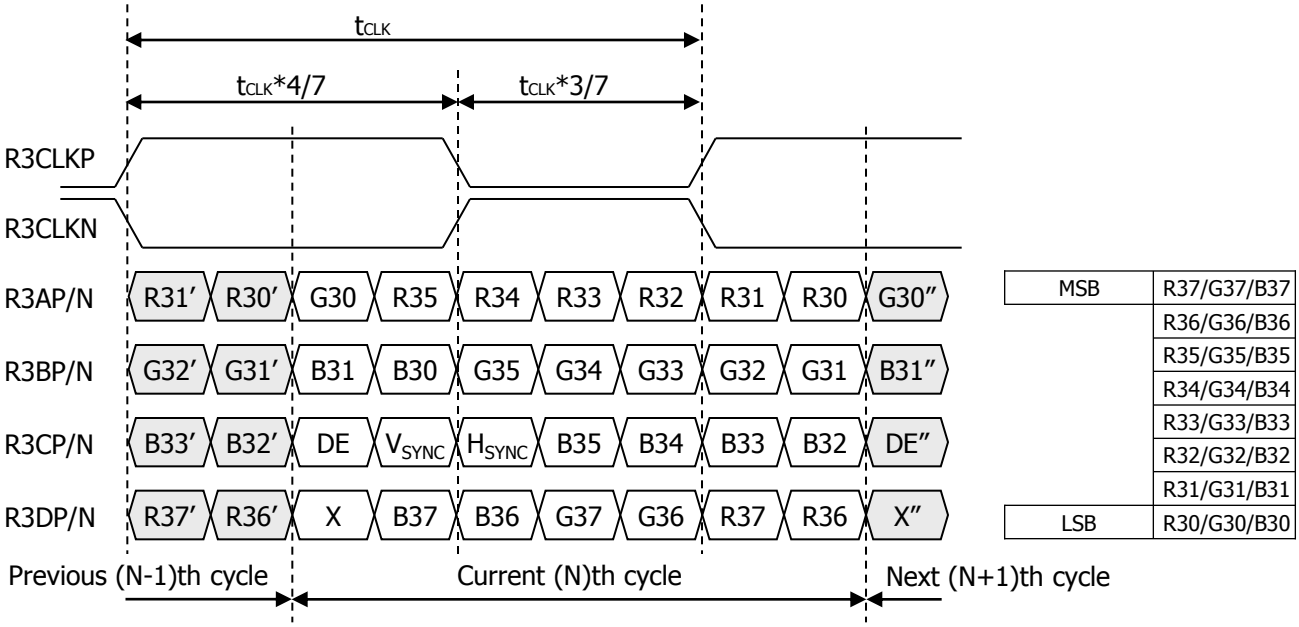
■ 2nd LVDS Channel



MSB	R27/G27/B27
	R26/G26/B26
	R25/G25/B25
	R24/G24/B24
	R23/G23/B23
	R22/G22/B22
	R21/G21/B21
LSB	R20/G20/B20

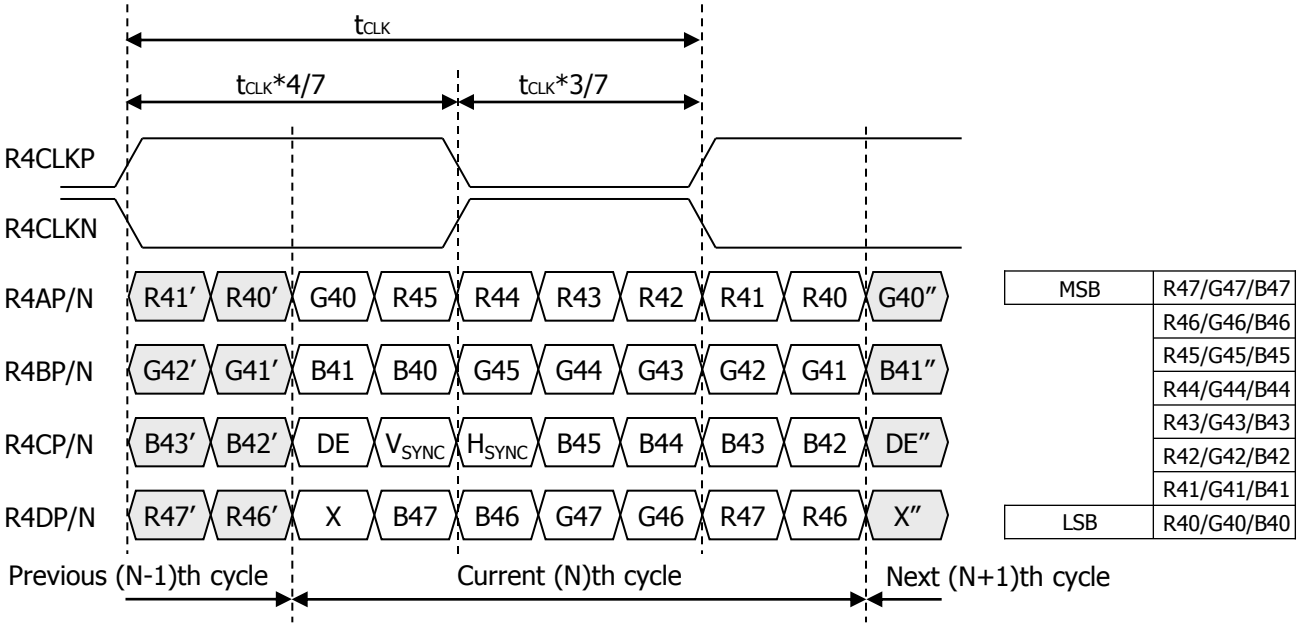
3-3-3. LVDS data format (8bit, VESA)

■ 3rd LVDS Channel



MSB	R37/G37/B37
	R36/G36/B36
	R35/G35/B35
	R34/G34/B34
	R33/G33/B33
	R32/G32/B32
	R31/G31/B31
LSB	R30/G30/B30

■ 4th LVDS Channel



MSB	R47/G47/B47
	R46/G46/B46
	R45/G45/B45
	R44/G44/B44
	R43/G43/B43
	R42/G42/B42
	R41/G41/B41
LSB	R40/G40/B40

Table 7. Required signal assignment for Flat Link(NS:DS90CF383) transmitter

Pin #	Pin Name	Require Signal	Pin #	Pin Name	Require Signal
1	VCC	Power Supply for TTL Input	29	GND	Ground pin for TTL
2	D5	TTL Input (R7)	30	D26	TTL Input (DE)
3	D6	TTL Input (R5)	31	T_X CLKIN	TTL Level clock Input
4	D7	TTL Input (G0)	32	PWR DWN	Power Down Input
5	GND	Ground pin for TTL	33	PLL GND	Ground pin for PLL
6	D8	TTL Input (G1)	34	PLL VCC	Power Supply for PLL
7	D9	TTL Input (G2)	35	PLL GND	Ground pin for PLL
8	D10	TTL Input (G6)	36	LVDS GND	Ground pin for LVDS
9	VCC	Power Supply for TTL Input	37	TxOUT3+	Positive LVDS differential data output 3
10	D11	TTL Input (G7)	38	TxOUT3−	Negative LVDS differential data output 3
11	D12	TTL Input (G3)	39	T_X CLKOUT+	Positive LVDS differential clock output
12	D13	TTL Input (G4)	40	T_X CLKOUT−	Negative LVDS differential clock output
13	GND	Ground pin for TTL	41	T_X OUT2+	Positive LVDS differential data output 2
14	D14	TTL Input (G5)	42	T_X OUT2−	Negative LVDS differential data output 2
15	D15	TTL Input (B0)	43	LVDS GND	Ground pin for LVDS
16	D16	TTL Input (B6)	44	LVDS VCC	Power Supply for LVDS
17	VCC	Power Supply for TTL Input	45	T_X OUT1+	Positive LVDS differential data output 1
18	D17	TTL Input (B7)	46	T_X OUT1−	Negative LVDS differential data output 1
19	D18	TTL Input (B1)	47	T_X OUT0+	Positive LVDS differential data output 0
20	D19	TTL Input (B2)	48	T_X OUT0−	Negative LVDS differential data output 0
21	GND	Ground pin for TTL Input	49	LVDS GND	Ground pin for LVDS
22	D20	TTL Input (B3)	50	D27	TTL Input (R6)
23	D21	TTL Input (B4)	51	D0	TTL Input (R0)
24	D22	TTL Input (B5)	52	D1	TTL Input (R1)
25	D23	TTL Input (RSVD)	53	GND	Ground pin for TTL
26	VCC	Power Supply for TTL Input	54	D2	TTL Input (R2)
27	D24	TTL Input (HSYNC)	55	D3	TTL Input (R3)
28	D25	TTL Input (VSYNC)	56	D4	TTL Input (R4)

Notes : Refer to LVDS Transmitter Data Sheet for detail descriptions.

3-4. Signal Timing Specifications

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

Table 8. Timing Table

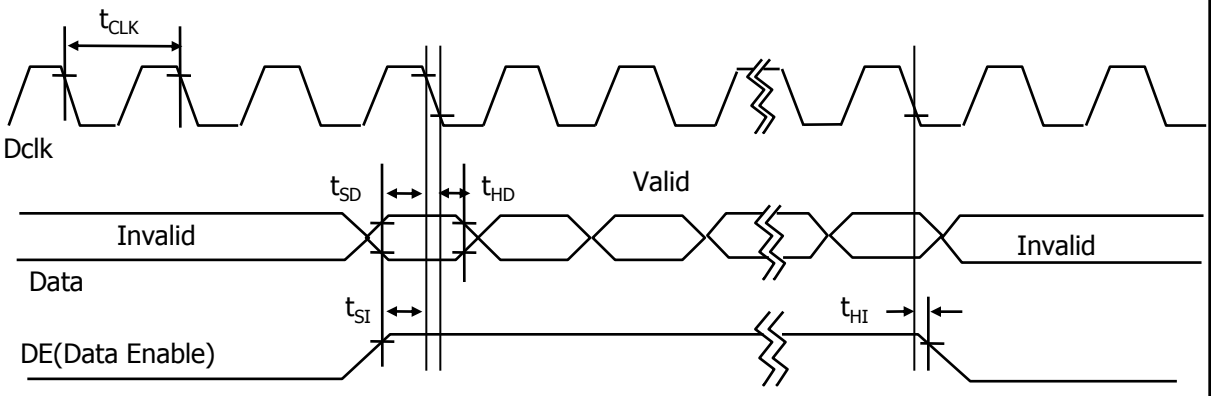
Parameter		Symbol	Min	Typ	Max	Unit	Notes
D_{CLK}	Period	t_{CLK}	10.0	27.8	33.3	ns	GUI typ. : 144MHz@60Hz
	Frequency	f_{CLK}	30	36	100	MHz	
Horizontal	Horizontal Valid	t_{HV}	480	480	480	t_{CLK}	
	H Period Total	t_{HP}	520	544	560		
	Hsync Frequency	f_H	64	66	192	kHz	
Vertical	Vertical Valid	t_{VV}	1080	1080	1080	t_{HP}	
	V Period Total	t_{VP}	1090	1100	1733		
	Vsync Frequency	f_V	50	60	122	Hz	
DE (Data Enable)	DE Setup Time	t_{SI}	4	-	-	ns	For D_{CLK}
	DE Hold Time	t_{HI}	4	-	-		
Data	Data Setup Time	t_{SD}	4	-	-	ns	For D_{CLK}
	Data Hold Time	t_{HD}	4	-	-		

Note:

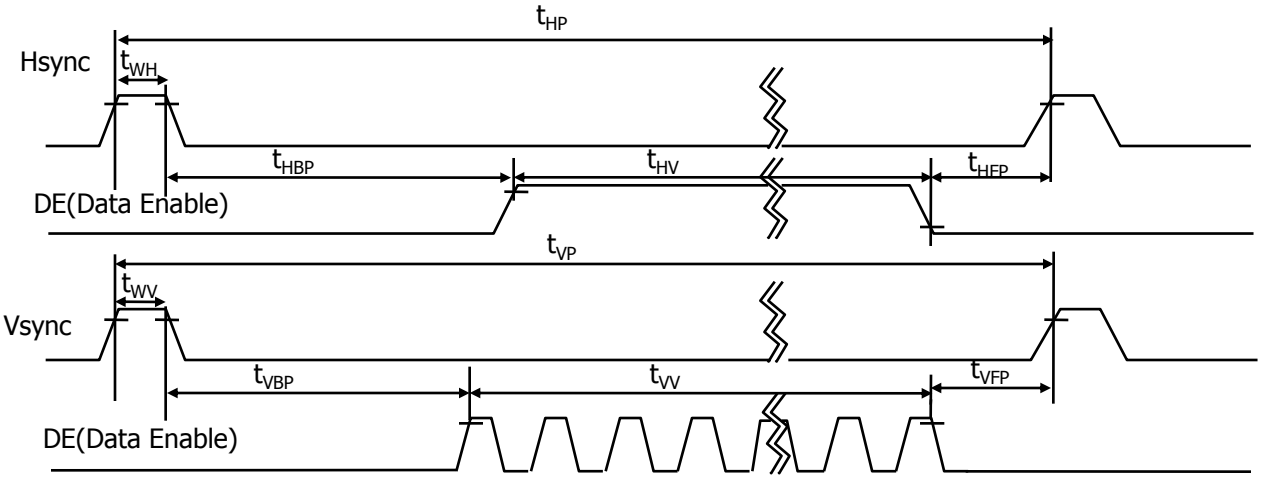
1. DE Only mode operation.
   The input of Hsync and Vsync signal does not effect on LCD normal operation.
2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
3. Horizontal period should be even.
4. Timing parameter's combination should be under D_{CLK} specification.

3-5. Signal Timing Waveforms

[DCLK , DE, DATA waveforms]



[Hsync, Vsync, DE waveforms]



3-6. 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 9. 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

3-7. Power Sequence

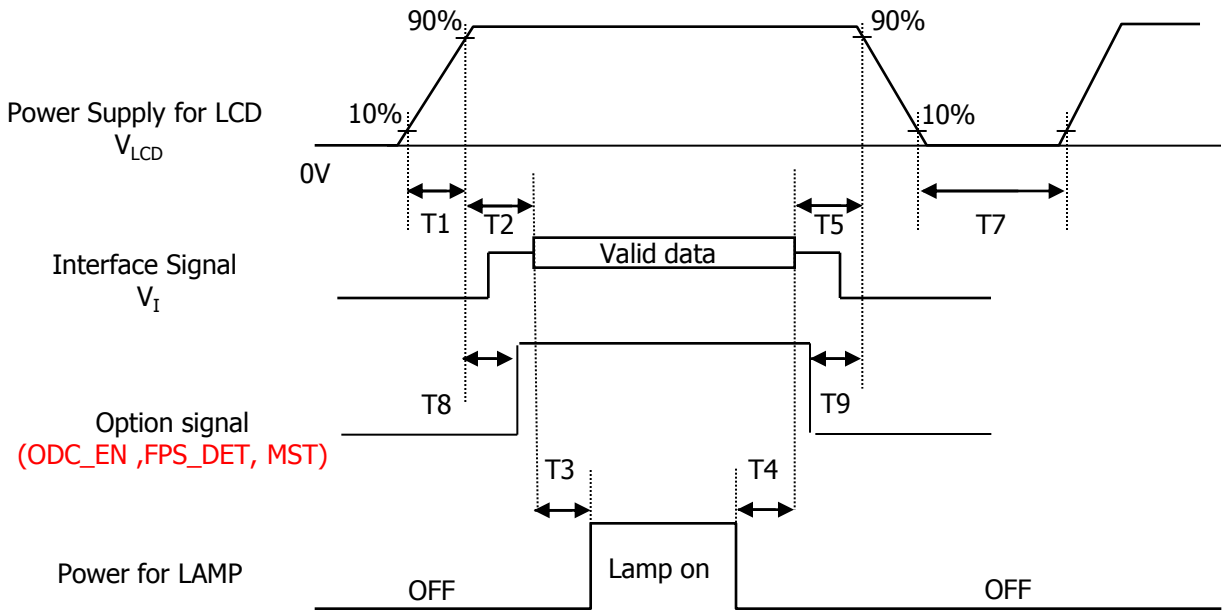


Table 10. Power Sequence

Parameter	Values			Units
	Min	Typ	Max	
T1	0.5	-	10	ms
T2	0.01	-	50	ms
T3	500	-	-	ms
T4	200	-	-	ms
T5	0.01	-	50	ms
T7	500		-	ms
T8	0 < T8 < T2			ms
T9	0 < T9 < T5			ms

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 V_{LCD} to 0V.
3. Lamp power must be turn on after power supply V_{LCD} and interface signal are valid.

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.
Figure. 6 presents additional information concerning the measurement equipment and method.

Figure. 6 Optical Characteristic Measurement Equipment and Method

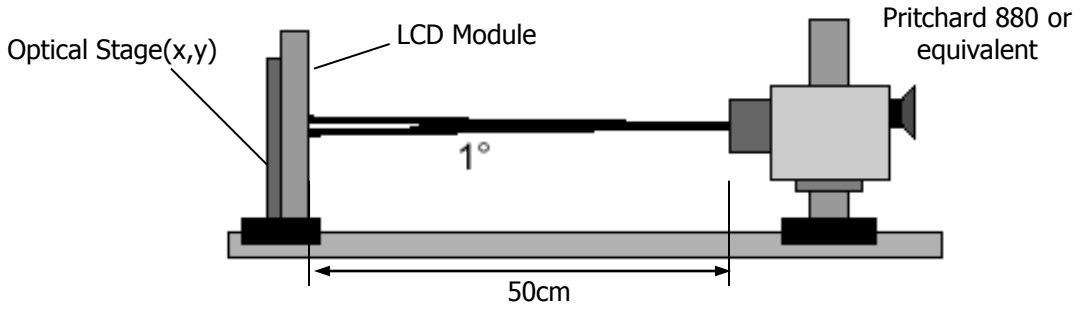


Table 11. Optical Characteristics (Ta=25 °C, V_{LCD}=12.0V, f_V=60Hz D_{CLK}=144MHz, I_{BL}=7.5mA)

Parameter		Symbol	Values			Units	Notes
			Min	Typ	Max		
Contrast Ratio		CR	700	1,000	-		1
Surface Luminance, white		L_{WHITE}	320	400	-	cd/m²	2
Luminance Variation		δ_{WHITE}	75	-	-	%	3
Response Time	Rise Time	Tr_R	-	1	4	ms	4
	Decay Time	Tr_D	-	4	8	ms	4
	Gray to Gray	T_{GTG}	-	3	6	ms	5
Color Gamut			-	72	-	%	
Color Coordinates [CIE1931]	RED	Rx	Typ -0.02	0.644	Typ +0.02		
		Ry		0.336			
	GREEN	Gx		0.295			
		Gy		0.614			
	BLUE	Bx		0.146			
		By		0.072			
	WHITE	Wx		0.313			
		Wy		0.329			
Viewing Angle (CR>10)							
	x axis, right(ϕ=0°)	θr	70	85	-	Degree	6
	x axis, left (ϕ=180°)	θl	70	85	-		
	y axis, up (ϕ=90°)	θu	60	75	-		
	y axis, down (ϕ=270°)	θd	70	85	-		
Gray Scale			-	2.2	-		7
Crosstalk			-	-	1.5	%	8
Luminance uniformity - Angular dependence		L_R	-	-	1.7		9
Color grayscale linearity		Δu'v'	-	0.01	-	-	10

Notes :

1. **Contrast ratio (CR)** is defined mathematically as :

   It is measured at center point (1)

$$\text{Contrast ratio} = \frac{\text{Surface luminance with all white pixels}}{\text{Surface luminance with all black pixels}}$$

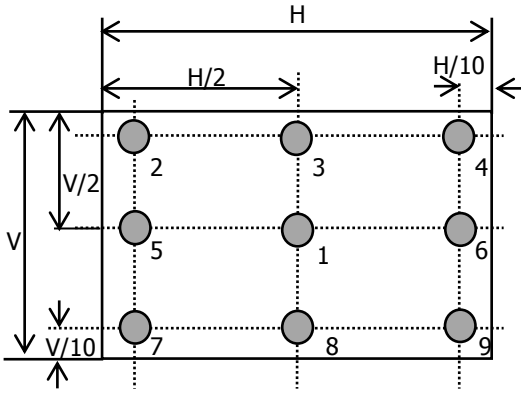
2. **Surface luminance** is the luminance value at center 1 point (1) across the LCD surface 50cm from the surface with all pixels displaying white.
   For more information see Figure 7.

3. The **variation in surface luminance** , δ_{WHITE} is defined as :

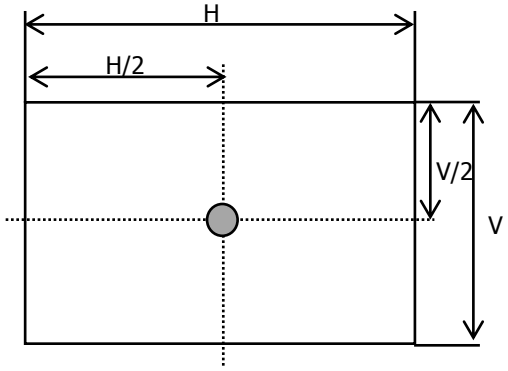
$$\delta_{WHITE} = \frac{\text{Minimum (P1,P2 .....P9)}}{\text{Maximum (P1,P2 .....P9)}} \times 100\ (\%)$$

   For more information see Figure 7.

Figure 7. Luminance measuring point



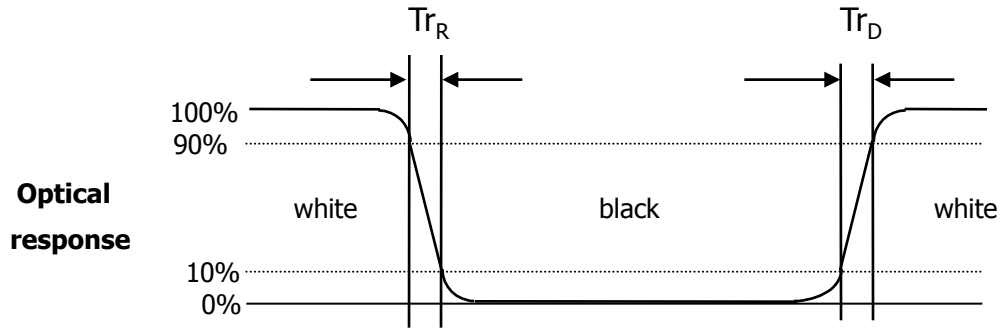
@ H,V : Active Area



<Measuring point for luminance variation> **<Measuring point for surface luminance>**

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 white to black (Rise Time, T**rR)** and from black to white (Decay Time, T**rD**).

Figure 8. Response Time



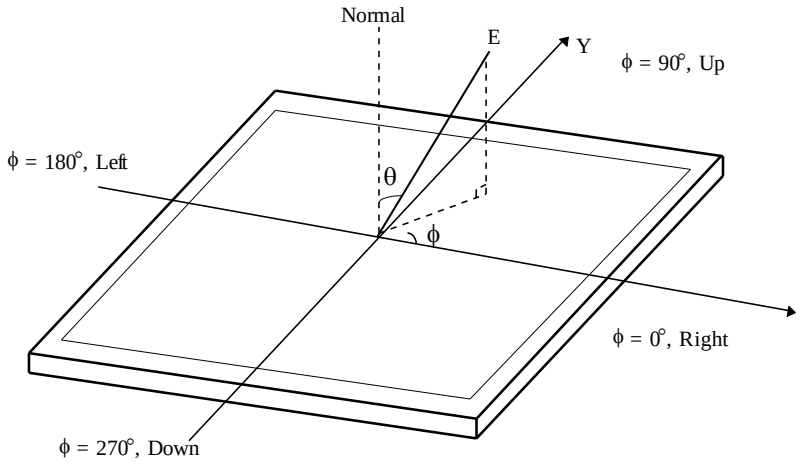
5. The **gray to gray response time** is defined as the following table and shall be measured by switching the input signal for "Gray To Gray".
   - Gray step : 5 step
   - $T_{GTG\ (Typ)}$ is the typical specification of total average time at rising time and falling time for 'Gray to Gray'.
   - $T_{GTG\ (Max)}$ is the maximum specification of total average time at rising time and falling time for 'Gray to Gray'.

Table 12. Gray to Gray Response time Table

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

6. **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 Figure 9 .

Figure 9. Viewing Angle



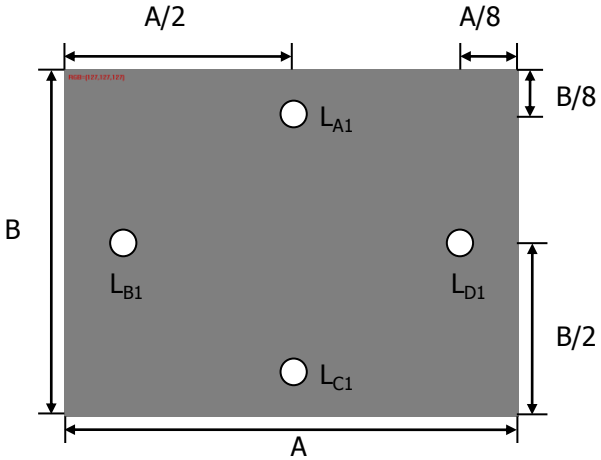
<Dimension of viewing angle range>

7. **Gray scale** specification
Gamma Value is approximately 2.2.

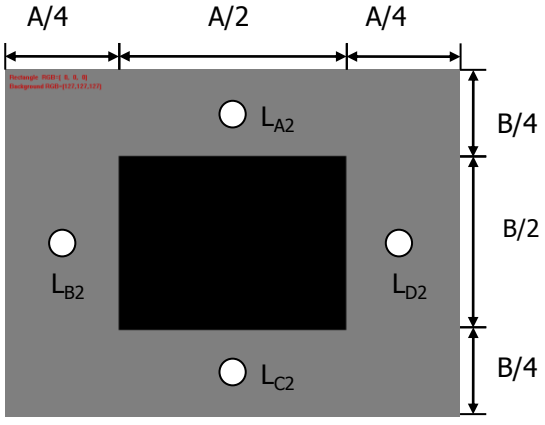
8. **Crosstalk** is defined as :

The equation of crosstalk : $(|L_{A[or\ C]2}-L_{A[or\ C]1}|/L_{A[or\ C]1}) \times 100(\%)$ [Vertical],
$(|L_{B[or\ D]2}-L_{B[or\ D]1}|/L_{B[or\ D]1}) \times 100(\%)$ [Horizontal]

Figure 10. Crosstalk



Pattern 1
(Half gray: gray 127)



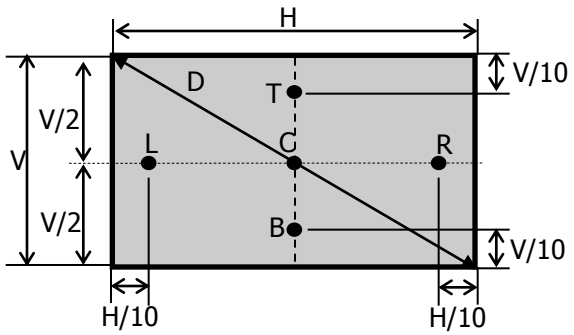
Pattern 2
(Background: gray 127, Rectangular: gray 0, gray255)

9. **Luminance Uniformity - angular – dependence** (L_R & T_B)

TCO '03 Luminance uniformity – angular dependence, is the capacity of the VDU to present the same Luminance level independently of the viewing direction.
The angular-dependent luminance uniformity is calculated as the ratio of maximum luminance to minimum luminance in the specified measurement areas.

- Test pattern : 80% white pattern
- Test point : 2-point
- Test distance : D x 1.5
- Test method : $L_R = ((L_{max.+30deg.} / L_{min.+30deg.}) + (L_{max.-30deg.} / L_{min.-30deg.})) / 2$
  $T_B = ((L_{max.+15deg.} / L_{min.+15deg.})$

Figure 11. Luminance Uniformity Angular Dependence



< Luminance uniformity - angular dependence measuring point >

10. **Color grayscale linearity** , Δu'v' is defined as :

$$\sqrt{(u'_A - u'_B)^2 + (v'_A - v'_B)^2}$$

Where indices A and B are the two gray levels found to have the largest color differences between them. i.e. get the largest Δu' and Δv' of each 6pairs of u' and v' and calculate Δu'v' .

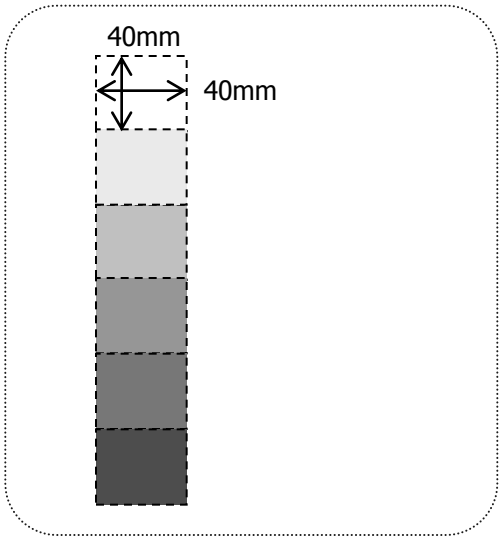
-Test pattern : 100% full white pattern with a test pattern as shown Figure 12.
Squares of 40mm by 40mm in size, filled with 255, 225, 195, 165, 135 and 105 grayscale steps should be arranged in the center of the screen.

-Test method

First gray step : move a square of 255 gray level should be moved into the center of the screen and measure luminance and u' and v' coordinates.

Next gray step : move a 255 gray square into the center and measure both luminance and u' and v' coordinates.
The same procedure shall then be repeated for gray steps 195, 165, 135 and 105.

Figure 12. Color grayscale linearity



5. Mechanical Characteristics

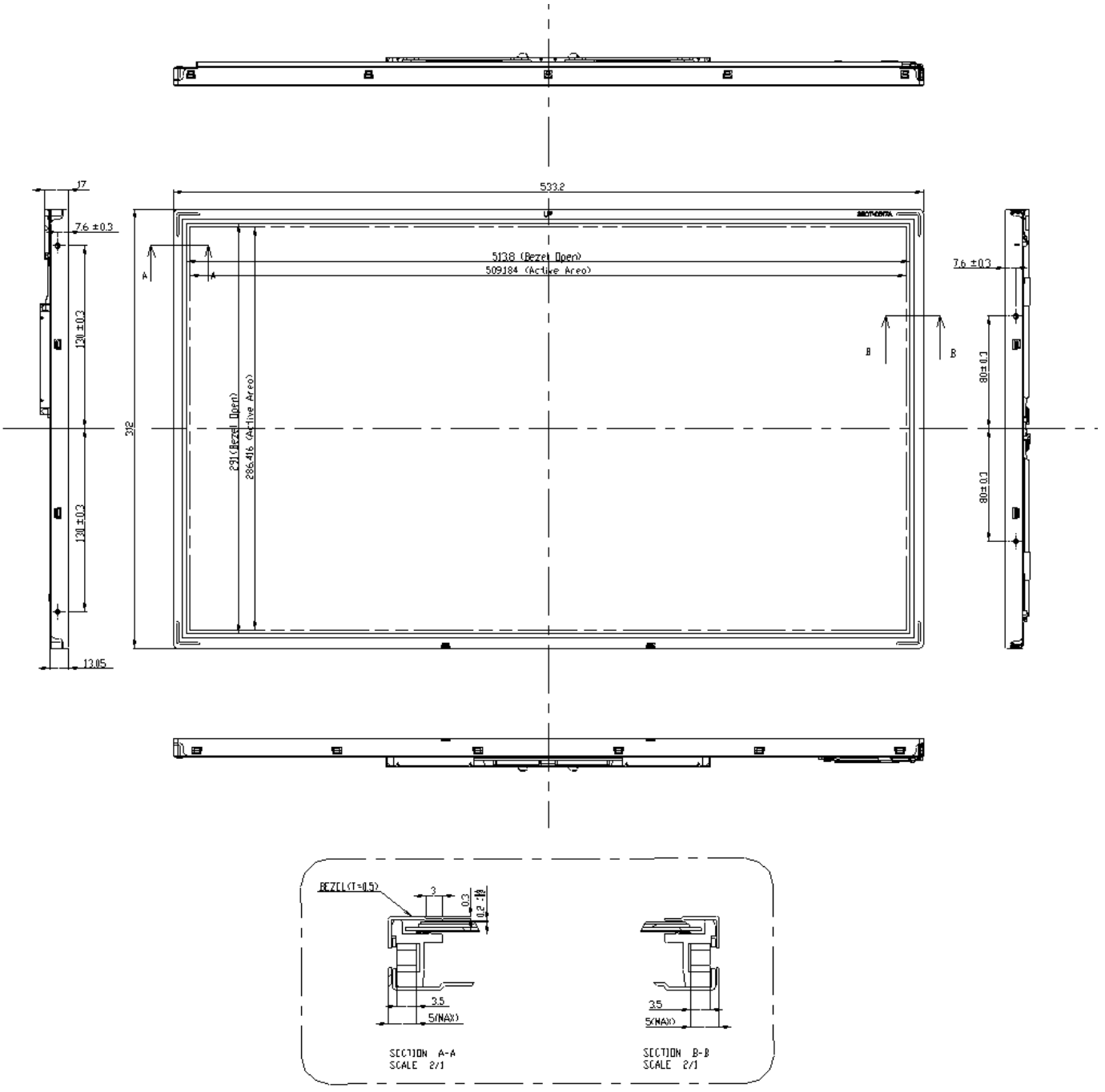
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

Table 13. Mechanical characteristics

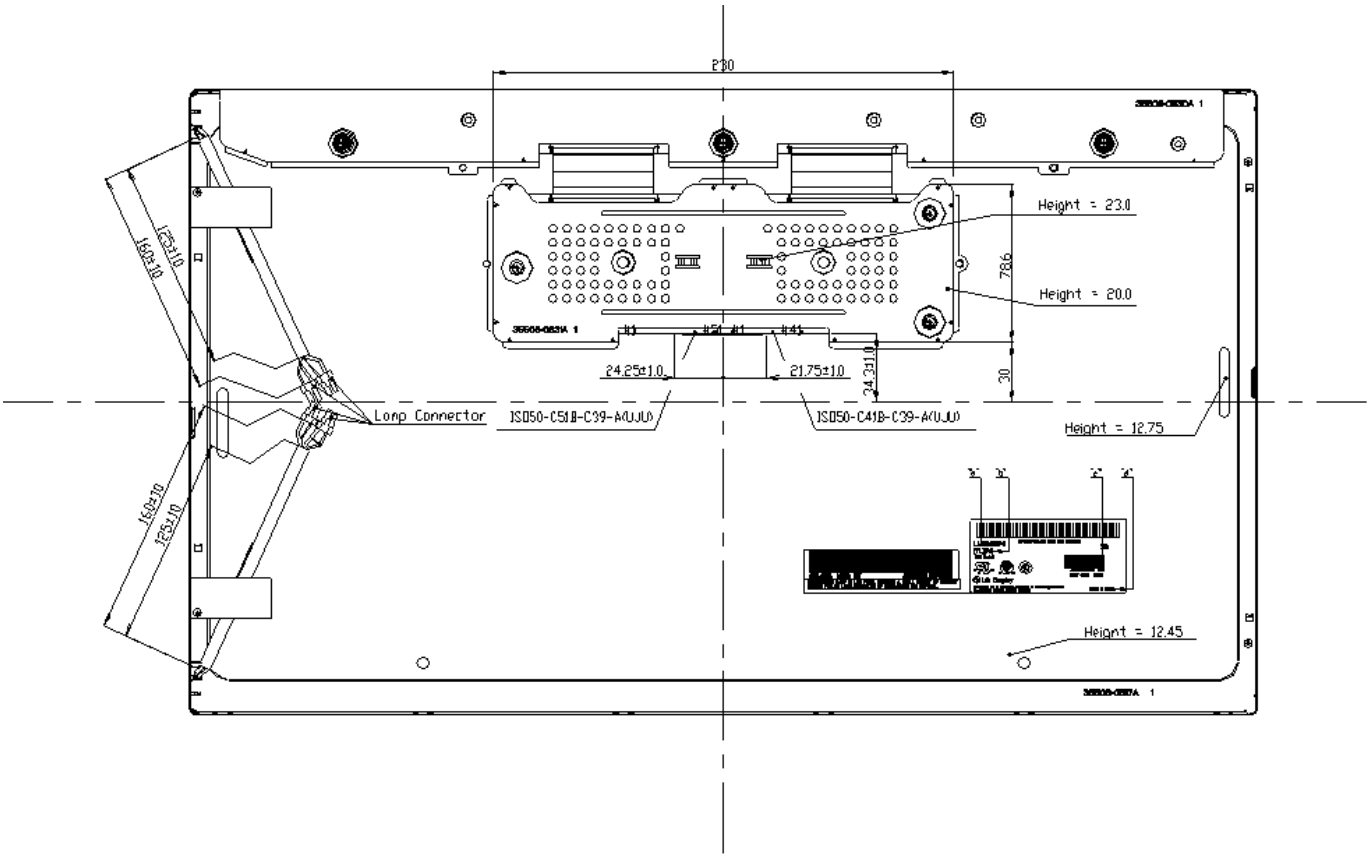
Outline Dimension	Horizontal	533.2mm
	Vertical	312.0mm
	Depth	20.0 mm
Bezel Area	Horizontal	513.784mm
	Vertical	291.016mm
Active Display Area	Horizontal	509.184mm
	Vertical	286.416mm
Weight	Typ. : 2,600g , Max : 2,730g	
Surface Treatment	Hard coating (3H) Anti-glare treatment of the front polarizer	

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

<FRONT VIEW>

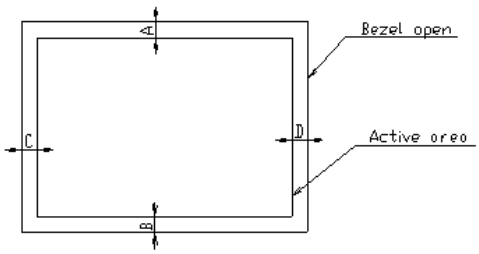

17
7.6 ±0.3
120 ±0.3
130 ±0.3
13.05
533.2
312
5138 (Bezel Open)
509184 (Active Area)
291(Bezel Open)
286.416 (Active Area)
A
A
B
B
7.6 ±0.3
80±0.3
80±0.3
BEZEL(T=0.5)
3
0.3
0.2 ±0.1
3.5
5(MAX)
SECTION A-A
SCALE 2/1
3.5
5(MAX)
SECTION B-B
SCALE 2/1

<REAR VIEW>



*Notes

1. Backlight : 4 Cold Cathode Fluorescent Lamps.
2. Screw Torque : 2.5~3.0kgf-cm
3. I/F Connector Specification : IS050-C51B-C39-A(UJU) & IS050-C41B-C39-A(UJU) or Equivalent
4. Tilt and partial disposition tole rance of display area as following
   (1) Y-Direction : |A-B| ≦ 1.4
   (2) X-Direction : |C-D| ≦ 1.4



5. Lamp(CCFL) No. is marked at back light connector
6. Do not wind conductive tape around the backlight wires
7. Unspecified tolerances to be ± 0.5mm

6. Reliability

Table 13. Environment test conditions

No	Test Item	Condition
1	High temperature storage test	Ta= 60°C 240hrs
2	Low temperature storage test	Ta= -20°C 240hrs
3	High temperature operation test	Ta= 50°C 50%RH 240hrs
4	Low temperature operation test	Ta= 0°C 240hrs
5	Vibration test (non-operating)	Wave form : random Vibration level : 1.0GRMS Bandwidth : 10-300Hz Duration : X,Y,Z, 20 min One time each direction
6	Shock test (non-operating)	Shock level : 120G Waveform : half sine wave, 2msec Direction : ±X, ±Y, ±Z One time each direction
7	Altitude operating storage / shipment	 0 - 16,400 feet(5,000m) 0 - 40,000 feet(12,192m)

[Result evaluation criteria]
There should be no change which might affect the practical display function when the display quality test is conducted under normal operating condition.

7. International Standards

7-1. Safety

a) UL 60950-1, Second Edition, Underwriters Laboratories Inc.
Information Technology Equipment - Safety - Part 1 : General Requirements.
b) CAN/CSA C22.2 No.60950-1-07, Second Edition, Canadian Standards Association.
Information Technology Equipment - Safety - Part 1 : General Requirements.
c) EN 60950-1:2006 + A11:2009, European Committee for Electrotechnical Standardization (CENELEC).
Information Technology Equipment - Safety - Part 1 : General Requirements.

7-2. EMC

a) ANSI C63.4 – 2003 "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz." American National Standards Institute (ANSI), 2003.
b) C.I.S.P.R. Pub. 22. Limits and methods of measurement of radio interference characteristics of information technology equipment." International Special Committee on Radio Interference (C.I.S.P.R.), 2005.
c) EN 55022 "Limits and methods of measurement of radio interference characteristics of information technology equipment." European Committee for Electrotechnical Standardization (CENELEC), 2006.

7-3. Environment

a) RoHS, Directive 2002/95/EC of the European Parliament and of the council of 27 January 2003

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)
E : MONTH
D : YEAR
F ~ M : SERIAL NO.

Note

1. YEAR

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Mark	1	2	3	4	5	6	7	8	9	0

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

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 : 7 pcs

b) Box Size : 424 x 328 x 603mm

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.