SPECIFICATION
FOR
APPROVAL

( ) Preliminary Specification
(●) Final Specification

Title	23" Full HD TFT LCD

BUYER	Mitsubishi
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LM230WF6
SUFFIX	SLA1

*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.

APPROVED BY	SIGNATURE DATE
J. H. Park / G.Manager	
REVIEWED BY	
J. G. Lee / Manager	
PREPARED BY	
K. H. Lee / Engineer	

Products Engineering Dept.
LG. Display Co., Ltd

CONTENTS

RECORD OF REVISIONS

Revision No	Revision Date	Page	Description
0.0	July. 6. 2010	-	Preliminary
0.1	July.16.2010	4	Correct typing errors (400 → 350cd/m^2)
			60Hz Timing change (H min blank 20→40)
0.2	Aug. 06.2010	4.6	Update logic power consumption.
		20	Update GTG specification and GTG MPRT measurement condition at 120Hz
0.3	Aug.20.2010	5	Add the notes 2 and 3
		26	Correct Table 11 (Gray scale specification)
0.4	Sep,16.2010	4	Update BL power consumption
		8	Update pin configuration.
		16	Timing specification change (60hz Timing is erased)
		19	Correct the miss printing from Lamp to LED
			Add the notes no4, and inversion select pin.
		20	Update the color coordination.
		26	Correct Table 11 (Gray scale specification)
		30	Table 13, Environment test condition is changed. Variation 20→10min, Shock 120→100G
		31	Change Safety standard.
1.0	Sep.27.2010		Final specifications
		6	Correct the miss printing from Lamp to LED
		7	Update BL max power consumption
1.1	Oct.14.2010	20	Change CR specification from 1000 to 900.

1. General Description

LM230WF6 is a Color Active Matrix Liquid Crystal Display Light Emitting Diode (White LED) backlight system without LED driver**.** 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(True) colors. It has been designed to apply the 8Bit 4 port LVDS interface. It is intended to support displays where high brightness, super wide viewing angle, high color saturation, and high color are important.

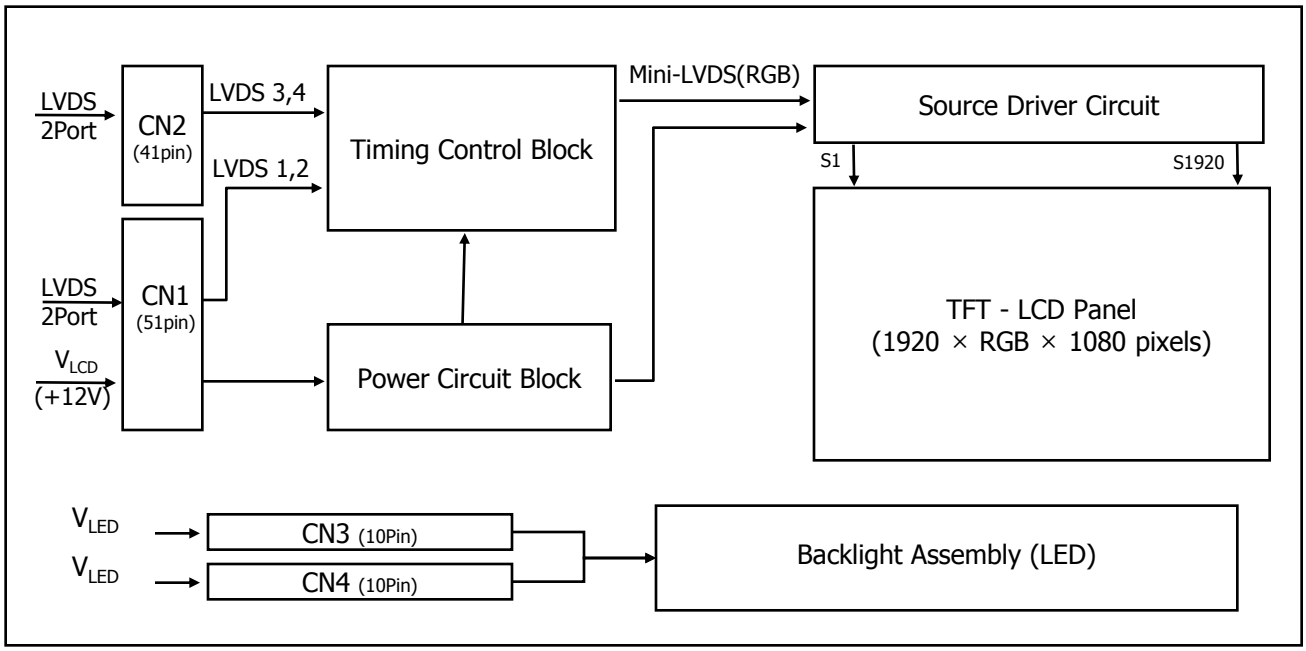


Figure 1. Block Diagram

General Features

Active Screen Size	23 inches (58.42cm) diagonal
Outline Dimension	533.2(H) x 312.0(V) x 11.9(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, 16,777,216 colors
Luminance, White	350 cd/m^2 (Center, 1 point)
Viewing Angle(CR>10)	View Angle Free (R/L 178(Typ.), U/D 178(Typ.))
Power Consumption	Total 20.59 W (Typ.) (7.92 W @V_{LCD}, 12.67 W @ 350 cd/m^2)
Weight	1,810 g (Typ.)
Display Operating Mode	Transmissive mode, Normally Black
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	13.0	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.
2. Maximum Storage Humidity is up to 40℃, 90% RH only for 4 corner light leakage Mura.
3. Storage condition is guaranteed under packing condition.

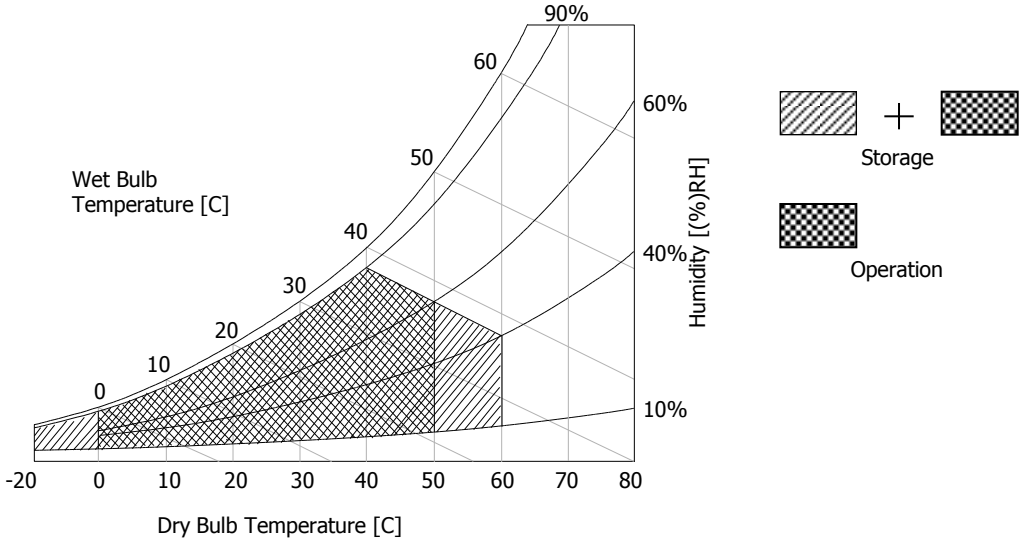


Figure 2. Temperature and Relative Humidity

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 LED/Backlight is typically generated by a LED Driver. The LED Driver. is an external unit to the LCDs.

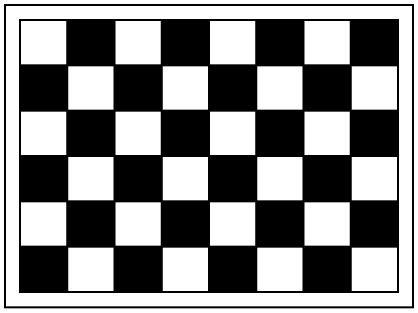
Table 2. Electrical Characteristics (Module)

Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input Voltage	V_{LCD}	11.4	12.0	12.6	Vdc	
Permissive Power Input Ripple	V_{dRF}			400	mVp-p	1
Differential Impedance	Z_m	90	100	110	Ohm	
Power Supply Input Current	$I_{LCD\text{-}MOSAIC\_60Hz}$	-	660	825	mA	2
	$I_{LCD\text{-}WHITE\_60Hz}$	-	580	725	mA	3
	$I_{LCD\text{-}MOSAIC\_120Hz}$		630	788	mA	
	$I_{LCD\text{-}WHITE\_120Hz}$		660	825	mA	
Power Consumption	P_{LCD}	-	7.92	9.9	W	2
Rush current	I_{RUSH}	-	-	3.0	A	4

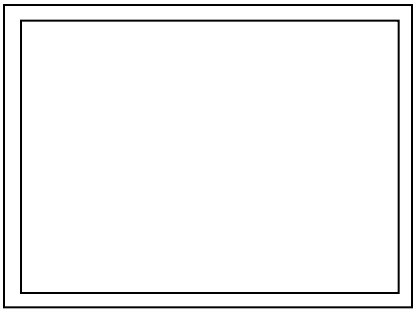
Note :

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 White 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	Condition	Values			Unit	Notes
			Min.	Typ.	Max.		
LED :							1,7
LED String Current	Is		-	110	120	mA	2,7
LED String Voltage	Vs		17.7	18.9	20.1	V	3,7
Power Consumption	P_{Bar}(1Bar)		11.68	12.47	13.27	Watt	4,6,7
LED Life Time	LED_LT		30,000	-	-	Hrs	5,7

LED driver design guide

: The design of the LED driver must have specifications for the LED in LCD Assembly**.**
The performance of the LED in LCM, for example life time or brightness, is extremely influenced by the characteristics of the LED driver.
So all the parameters of an LED driver should be carefully designed and output current should be Constant current control.
Please control feedback current of each string individually to compensate the current variation among the strings of LEDs.
When you design or order the LED driver, please make sure unwanted lighting caused by the mismatch of the LED and the LED driver (no lighting, flicker, etc) never occurs.
When you confirm it, the LCD module should be operated in the same condition as installed in your instrument.

1. Specified values are for a single LED bar.
2. The specified current is input LED chip 100% duty current.
3. The specified voltage is input LED string and Bar voltage at typical 110 mA 100% duty current.
4. The specified power consumption is input LED bar power consumption at typical 110 mA 100% duty current.
5. The life is determined as the time at which luminance of the LED is 50% compared to that of initial value at the typical LED current on condition of continuous operating at 25 ± 2°C.
6. The LED bar power consumption shown above does not include loss of external driver.
   The used LED bar current is the LED typical current.
   Min Power Consumption is calculated with PBar = Vs(Min.) x Is(Typ.) x Nstring
   Max Power Consumption is calculated with PBar = Vbar(Max.) x Is(Typ) x Nstring
7. LED operating DC Forward Current and Junction Temperature must not exceed LED Max Ratings at 25 ± 2°C.

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	NC	No Connection
3	PWM_OUT	PWM Signal For Scanning
4	NC	LGD internal use for I2C
5	NC	LGD internal use for I2C
6	NC	No Connection
7	NC	No Connection
8	**Inversion select**	**Inversion select** **'H':H2 dot, 'L': H1 dot**
9	ODC_EN	ODC on/off control 'H': on, 'L': off
10	Frame_DET	120, 60Hz frame detection & ODC selection 'H':120Hz, 'L' : 60Hz
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

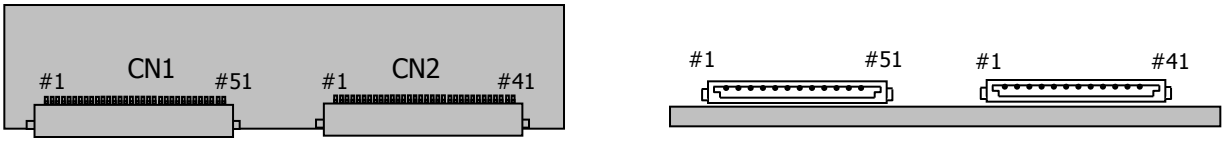
Table 5. Module Connector (CN2) Pin Configuration

- 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.

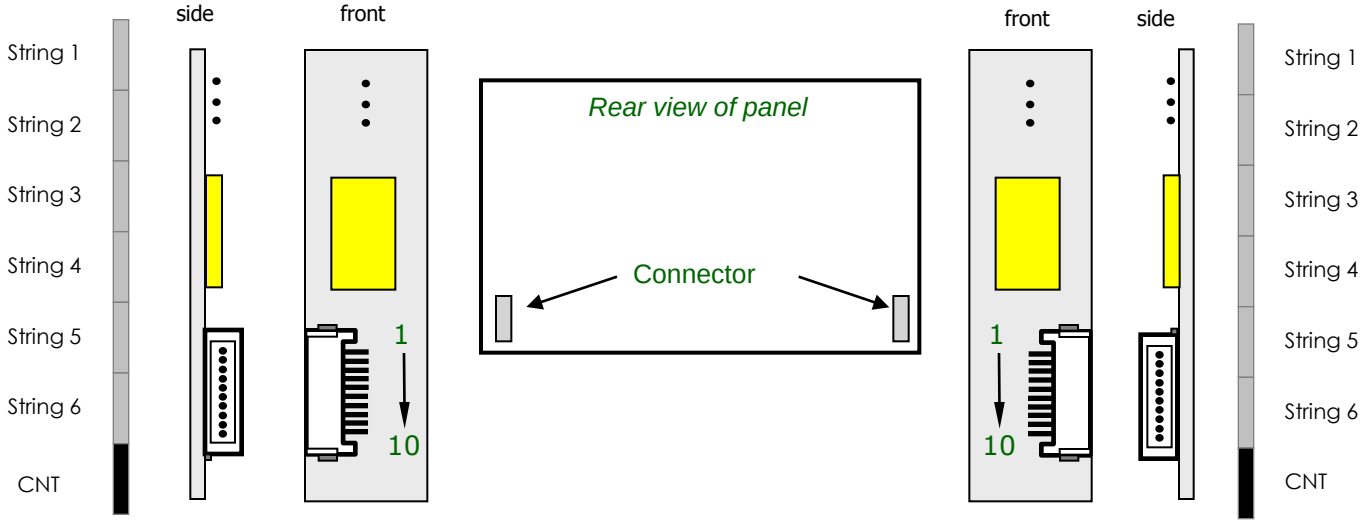
3-2-2. Backlight system

Table 6. BACKLIGHT CONNECTOR PIN CONFIGURATION(CN2)

The LED interface connector is a model 10FH-SM1-GAN-TB(LF)(SN) manufactured by JST.
The mating connector is a FFC/FPC specified in LED interface connector specification.
The pin configuration for the connector is shown in the table below.

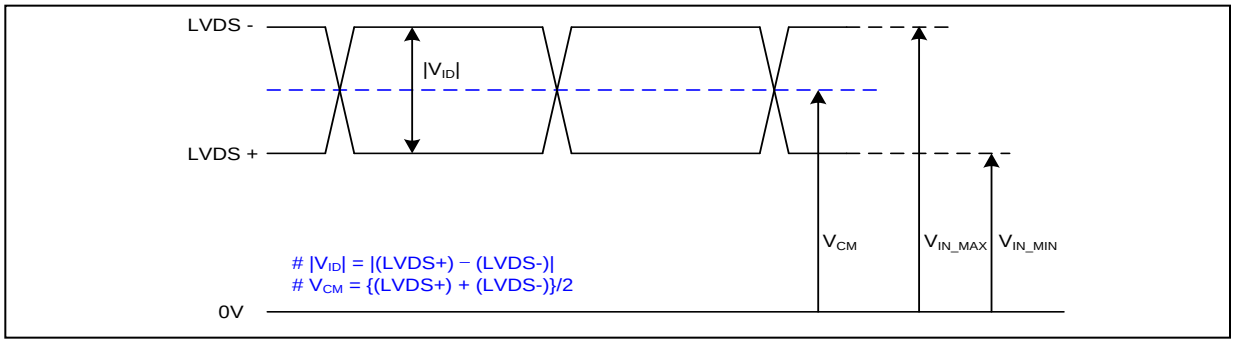
Pin	Symbol	Description	Notes
1	FB6	Channel6 Current Feedback	
2	FB5	Channel5 Current Feedback	
3	FB4	Channel4 Current Feedback	
4	VLED	LED Power Supply	
5	VLED	LED Power Supply	
6	VLED	LED Power Supply	
7	VLED	LED Power Supply	
8	FB3	Channel3 Current Feedback	
9	FB2	Channel2 Current Feedback	
10	FB1	Channel1 Current Feedback	

Figure 5. Backlight connector diagram



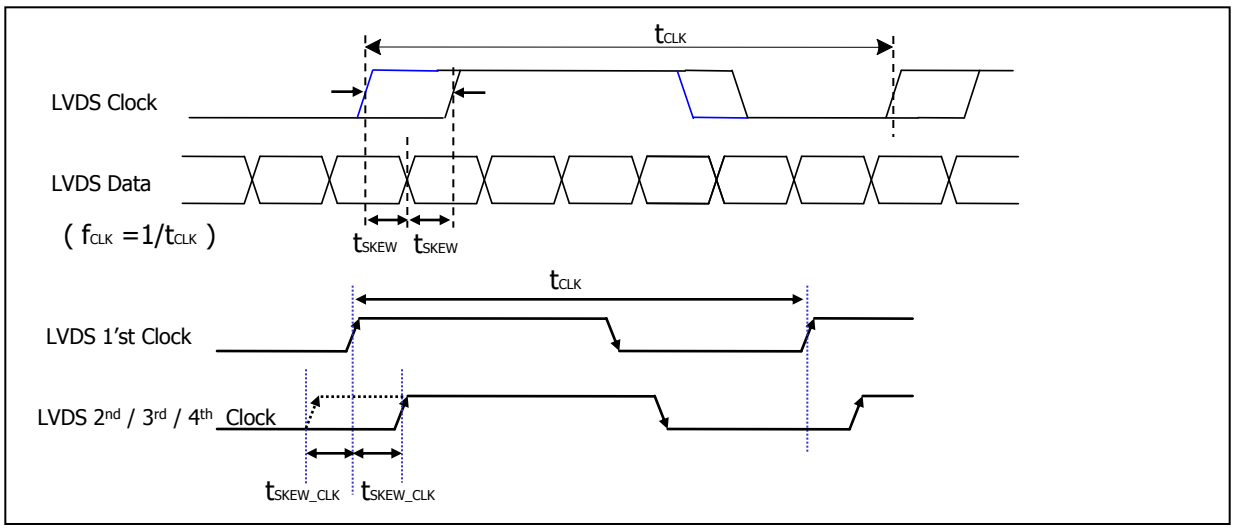
3-3. LVDS characteristics

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	-

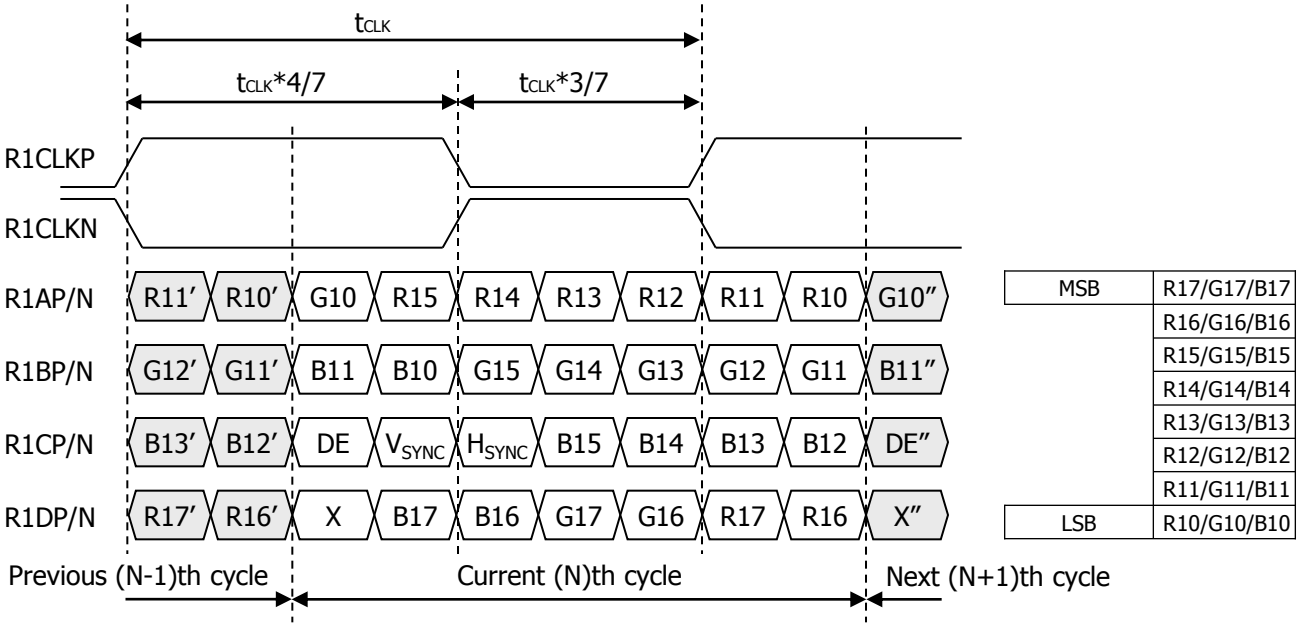
3-3-2. AC Specification



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}	-

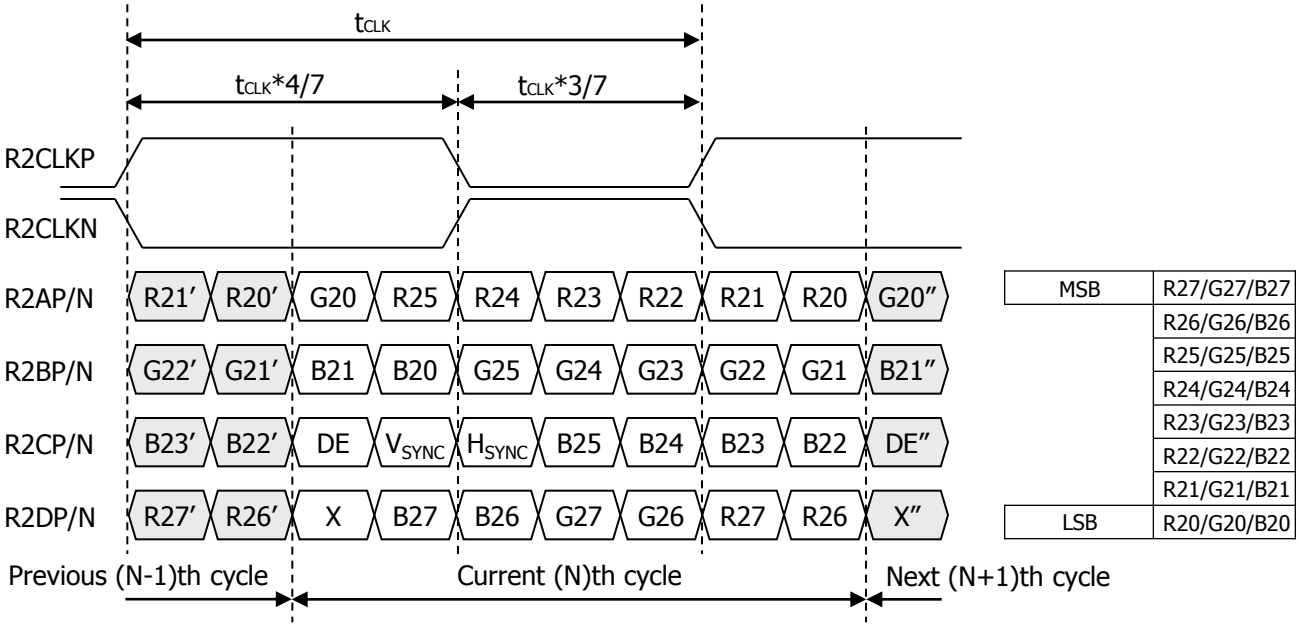
3-3-3. LVDS data format (8bit, VESA)

■ 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

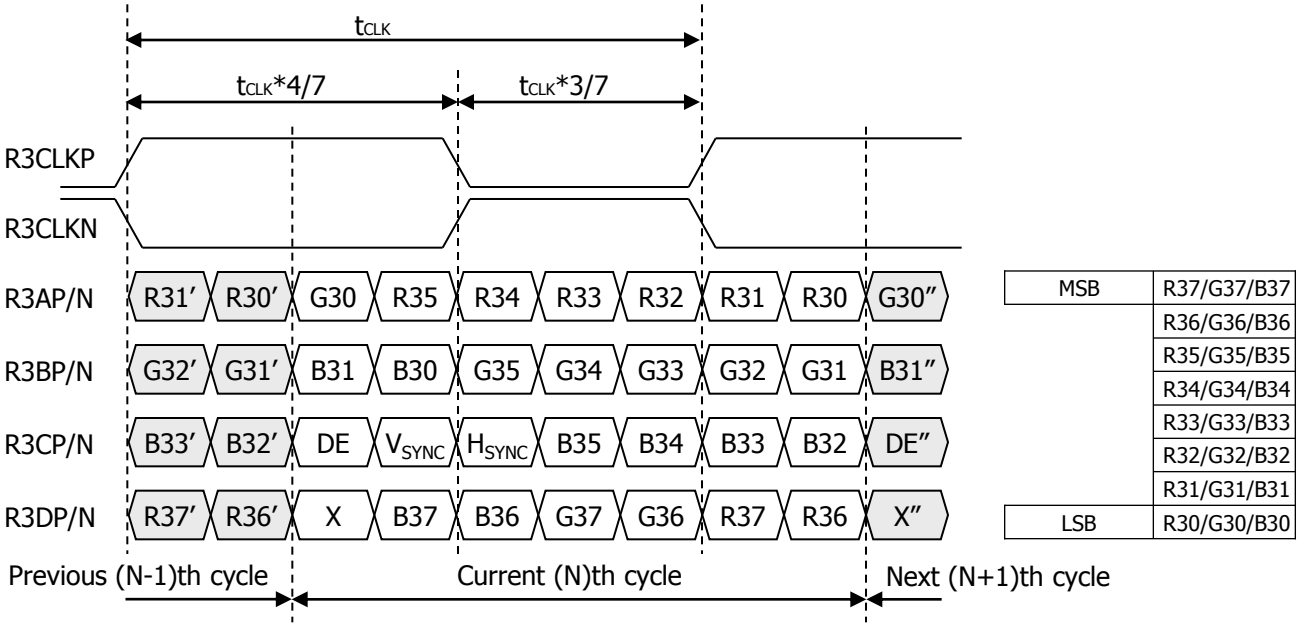
■ 2nd LVDS Channel



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

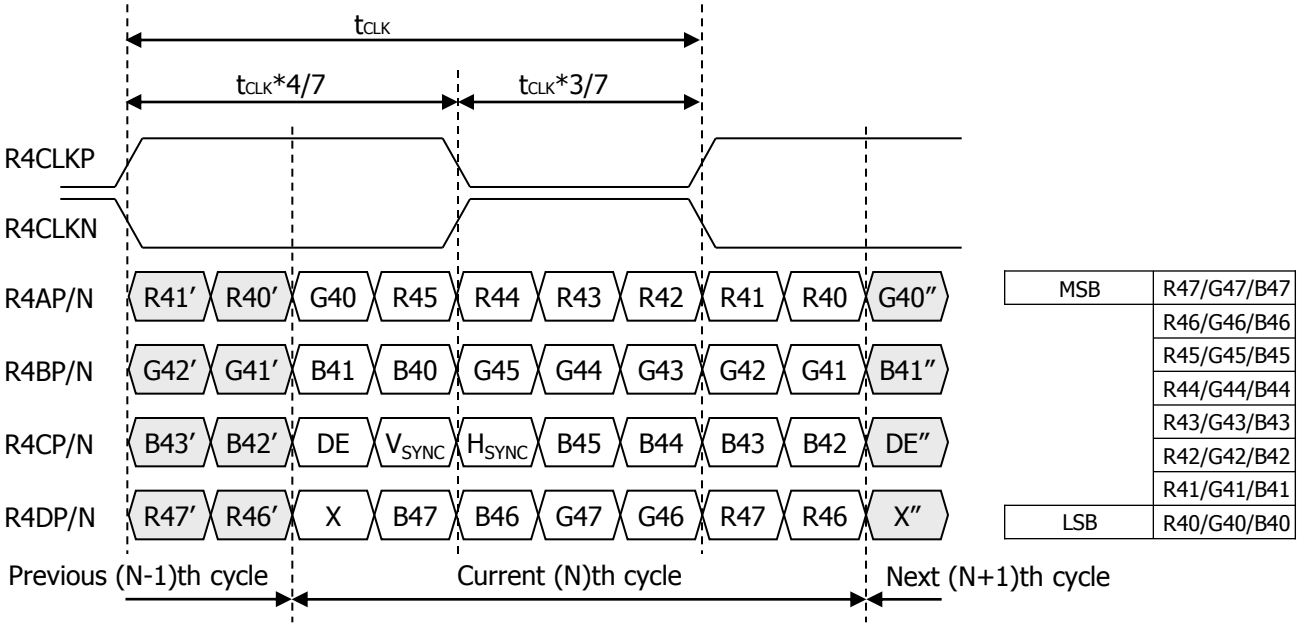
3-3-3. LVDS data format (8bit, VESA)

■ 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.

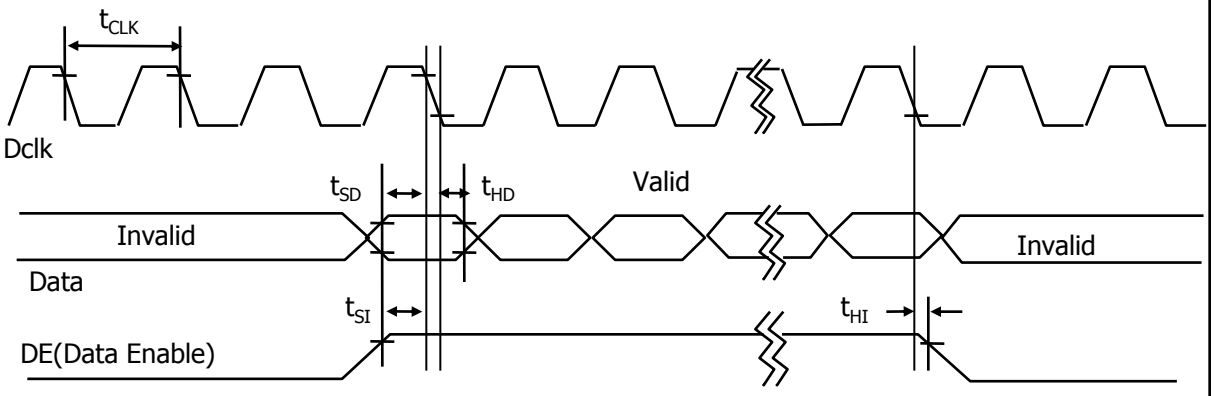
Table 8-1 120Hz Timing Table

ITEM		Symbol	Min	Typ	Max	Unit	Note
Horizontal	Display Period	tHV	480	480	480	tCLK	1920 / 4
	Blank	tHB	40	70	200	tCLK	1
	Total	tHP	520	550	680	tCLK	
Vertical	Display Period	tVV	1080	1080	1080	Lines	
	Blank	tVB	16	45	86	Lines	1
	Total	tVP	1096	1125	1166	Lines	
Frequency	DCLK	fCLK	66.97	74.25	78.00	MHz	
	Horizontal	fH	121.8	135	140	KHz	2
	Vertical	fV	108	120	122	Hz	2

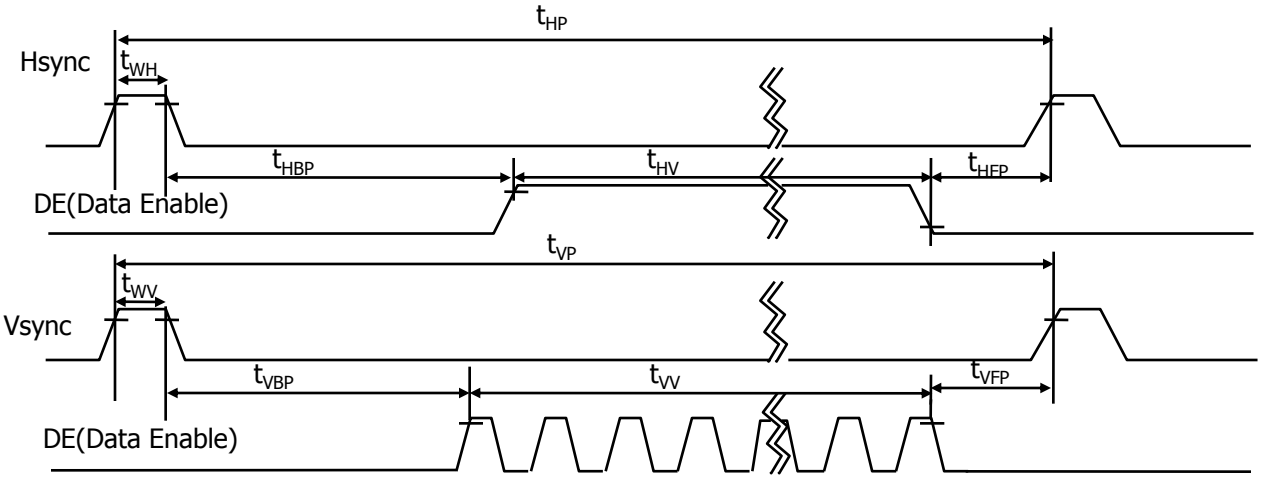
Note 1. The Input of HSYNC & VSYNC signal does not have an effect on normal operation (DE Only Mode). If you use spread spectrum for EMI, add some additional clock to minimum value for clock margin.
2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rate and the horizontal frequency.

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

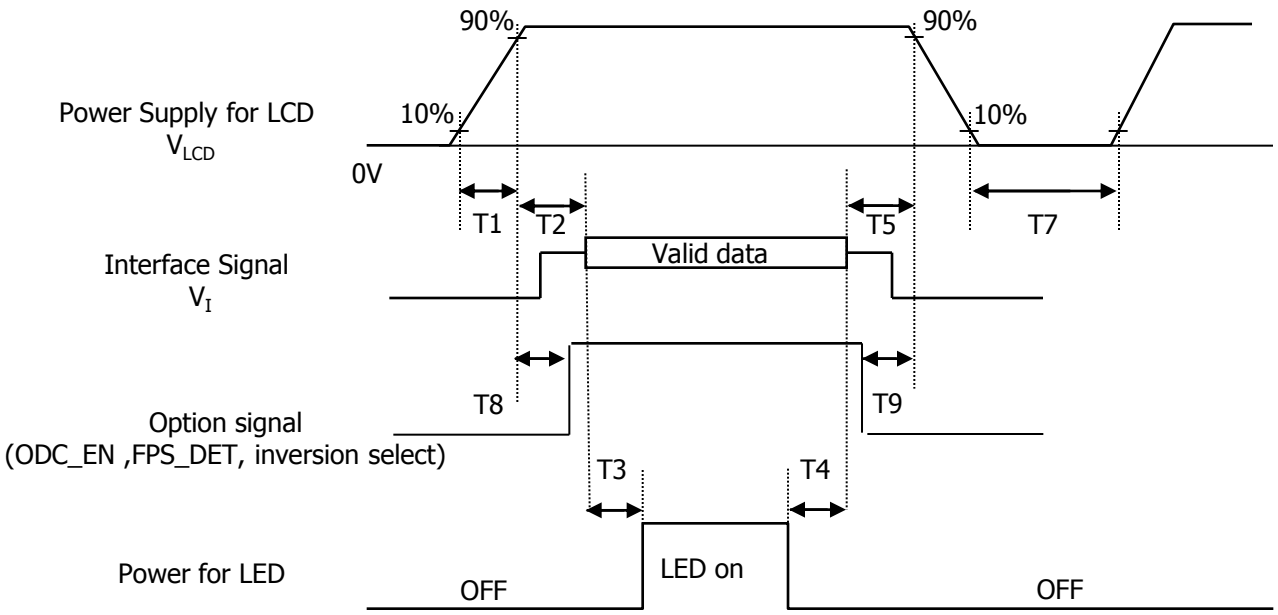


Table 10. Power Sequence

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. LED power must be turn on after power supply V_{LCD} and interface signal are valid.
4. If VLCD Power is Changed during on status, be sure to Pull down the LED Power on to 0V

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

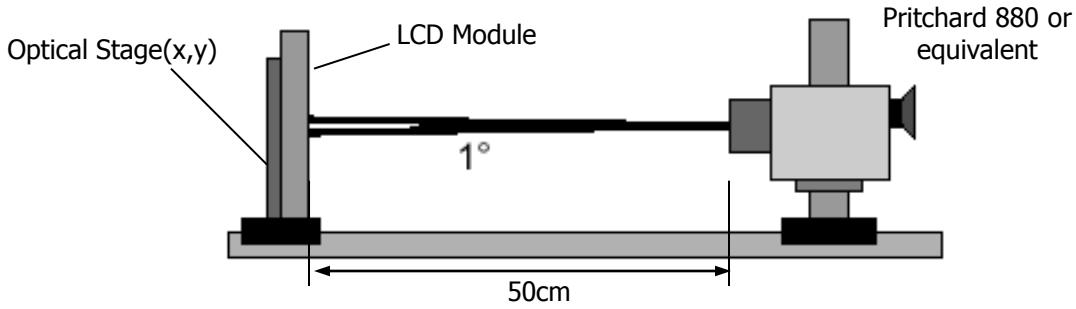


Table 11. Optical Characteristics (Ta=25 °C, V_{LCD}=12.0V, f_V=120Hz D_{CLK}=297MHz, Is=110mA)

Parameter		Symbol	Values			Units	Notes
			Min	Typ	Max		
Contrast Ratio		CR	630	900	-		1
Surface Luminance, white		L_{WHITE}	280	350	-	cd/m^2	2
Luminance Variation		δ_{WHITE}	75	-	-	%	3
Response Time [120Hz]	GTG	T_{GTG_AVR}	-	7	10	ms	4
	MPRT	T_{MPRT}		10	15	ms	5
Color Gamut			-	72	-	%	
Color Coordinates [CIE1931]	RED	Rx	Typ -0.03	0.638	Typ +0.03		
		Ry		0.331			
	GREEN	Gx		0.306			
		Gy		0.626			
	BLUE	Bx		0.153			
		By		0.071			
	WHITE	Wx		0.313			
		Wy		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	-		
GSR @ 60dgree (Gamma shift rate)	Horizontal	δ_{Gamma_H}	-	-	20	%	8
	Vertical	δ_{Gamma_V}	-	-	20		
Gray Scale			-	2.2	-		9

Notes :

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

   It is measured at center point (1)

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

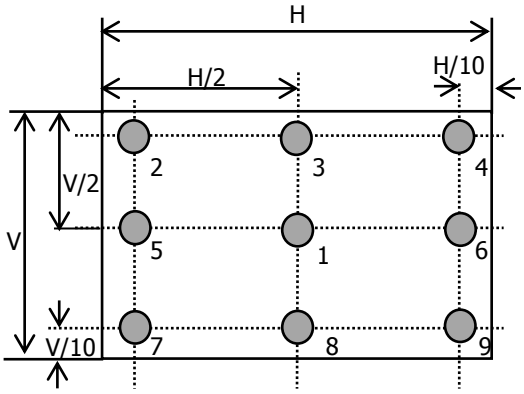
2. **Surface luminance** is the luminance value at center 1 point (1) across the LCD surface 50cm from the surface with all pixels displaying white.
   For more information see Figure 7.

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

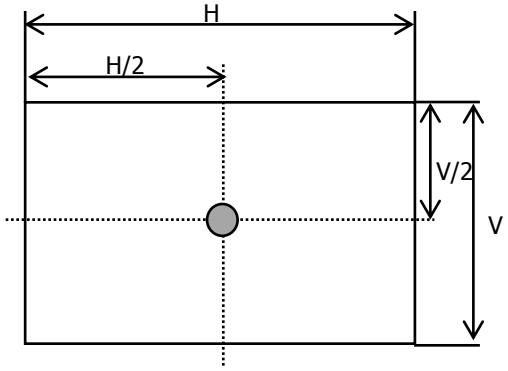
   $$\delta_{WHITE} = \frac{\text{Minimum (P1,P2 .....P9)}}{\text{Maximum (P1,P2 .....P9)}} \times 100\ (\%)$$

   For more information see Figure 7.

Figure 7. Luminance measuring point



@ H,V : Active Area



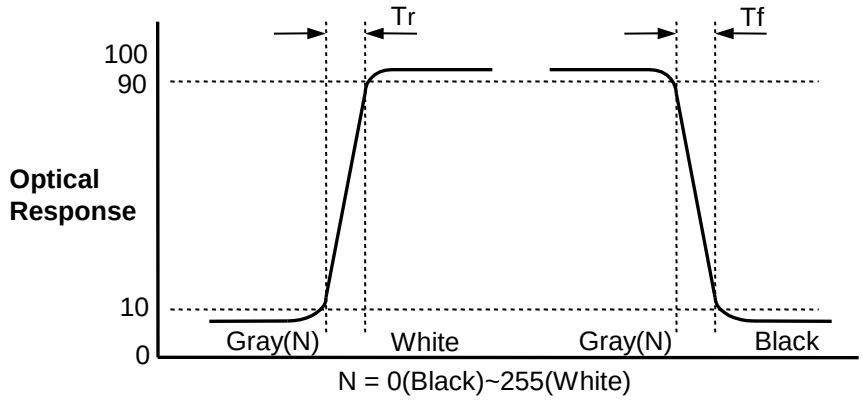
<Measuring point for luminance variation> **<Measuring point for surface luminance>**

4. The **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
   - TGTG_AVR is the total average time at rising time and falling time for "Gray To Gray ".
   - if system use ODC (Over Driving Circuit) function, Gray to Gary response time may be 5ms~8ms GtG
     * it depends on Overshoot rate.

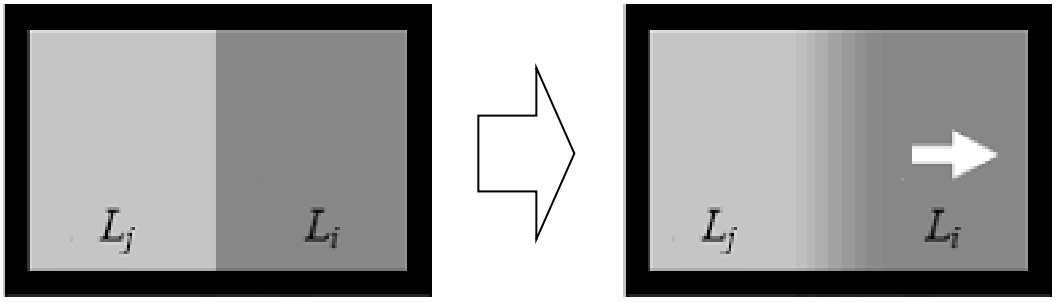
Table. 12 GTG Gray Table

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

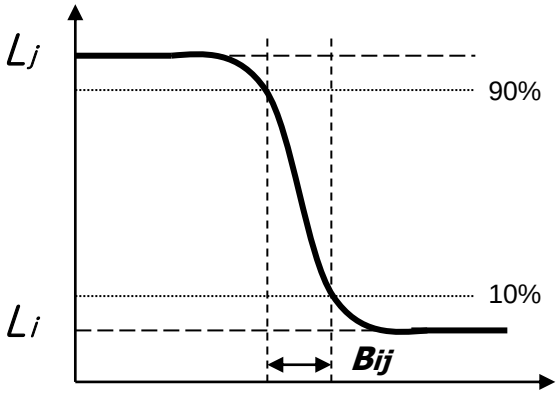
Response time is defined as the following figure and shall be measured by switching the input signal for "Gray(N)" and "Black or White".



5, The **MPRT** is defined as the 10% to 90% blur-edge with Bij(pixels) and scroll speed U(pixels/frame)at the moving picture.



$$M = \frac{1}{U} Bij \ (i \neq j)$$



Example) Bij = 12pixels, U = 10pixels / 120Hz

M = 12pixels / (10pixels / 120Hz)

= 12pixels / {10pixels / (1/120)s}

= 12 / 1,200 s

= 10 ms

Figure 9. MPRT

6. Color shift is the angle at which the average color difference for all Macbeth is lower than 0.02.
For more information see FIG.9 ***(By EZ Contrast)***
- Color difference (Δu'v')

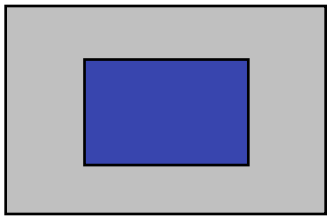
$$u' = \frac{4x}{-2x+12y+3} \qquad v' = \frac{9y}{-2x+12y+3} \qquad \Delta u'v' = \sqrt{(u'_1 - u'_2)^2 + (v'_1 - v'_2)^2}$$

$$Avg(\Delta u'v') = \frac{\sum_{i=1}^{24} (\Delta u'v')i}{24}$$

u'1, v'1 : u'v' value at viewing angle direction
u'2, v'2 : u'v' value at front (θ=0)
i : Macbeth chart number (Define 23 page)

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

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



25% Box size

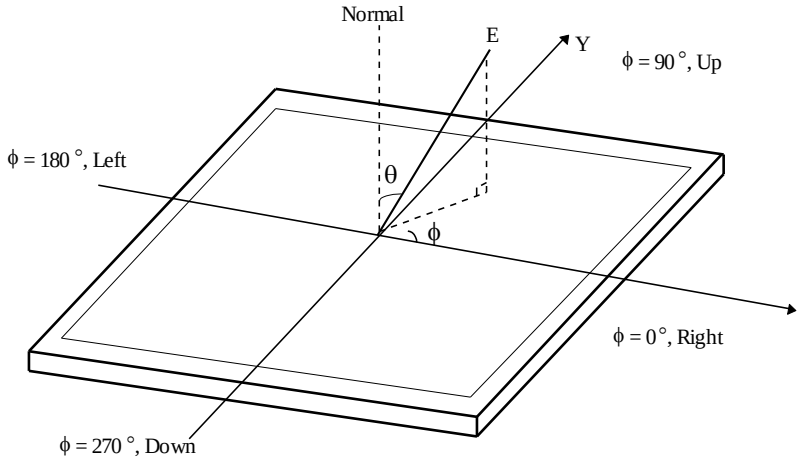
Figure 10. Color Shift Test Pattern

Average RGB values in Bruce RGB for Macbeth Chart

	Dark skin (i=1)	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

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 Figure 9 .

Figure 11. Viewing Angle



8. **GSR** is the rate of gamma shift at up, down, left and right 60 degree viewing angle compare with center gamma. For more information see FIG.11 and FIG.12 ***(By EZ Contrast)***

- GSR (δ Gamma) is defined as :

$$GSR = \left(1 - \frac{\text{View angle Gamma Value (Up, Down, Reft, Light 60 Degree)}}{\text{Center Gamma Value (0 Degree)}}\right) \times 100$$

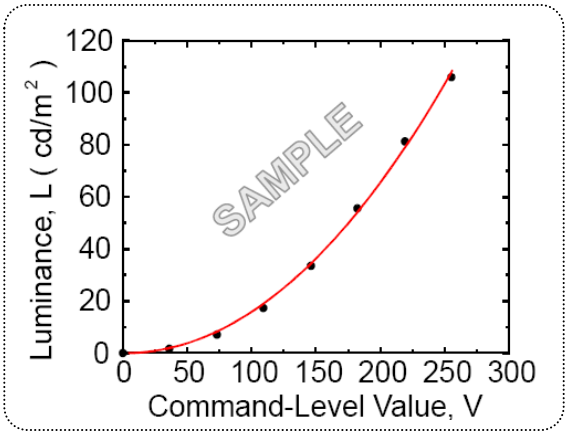


Figure.12 Sample Luminance vs. gray scale (using a 256 bit gray scale)

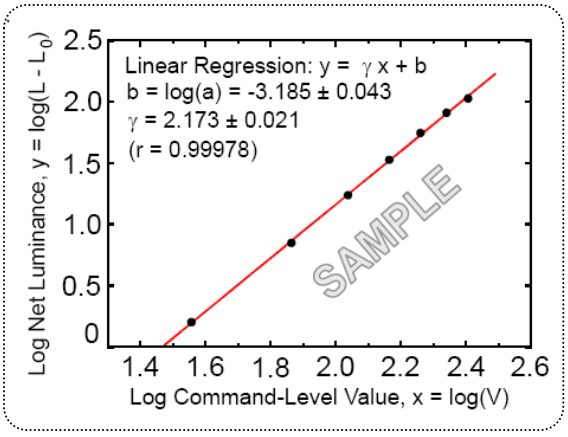


Figure.13 Sample Log-log plot of luminance vs. gray scale

$$L = aV^{r} + L_b$$

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

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.11)

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

Gray Level	Relative Luminance [%] (Typ.)
0	0.1
31	1.1
63	4.54
95	11.27
127	20.85
159	34.7
191	51.5
223	75.2
255	100

Table 11. Gray Scale Specification

5. Mechanical Characteristics

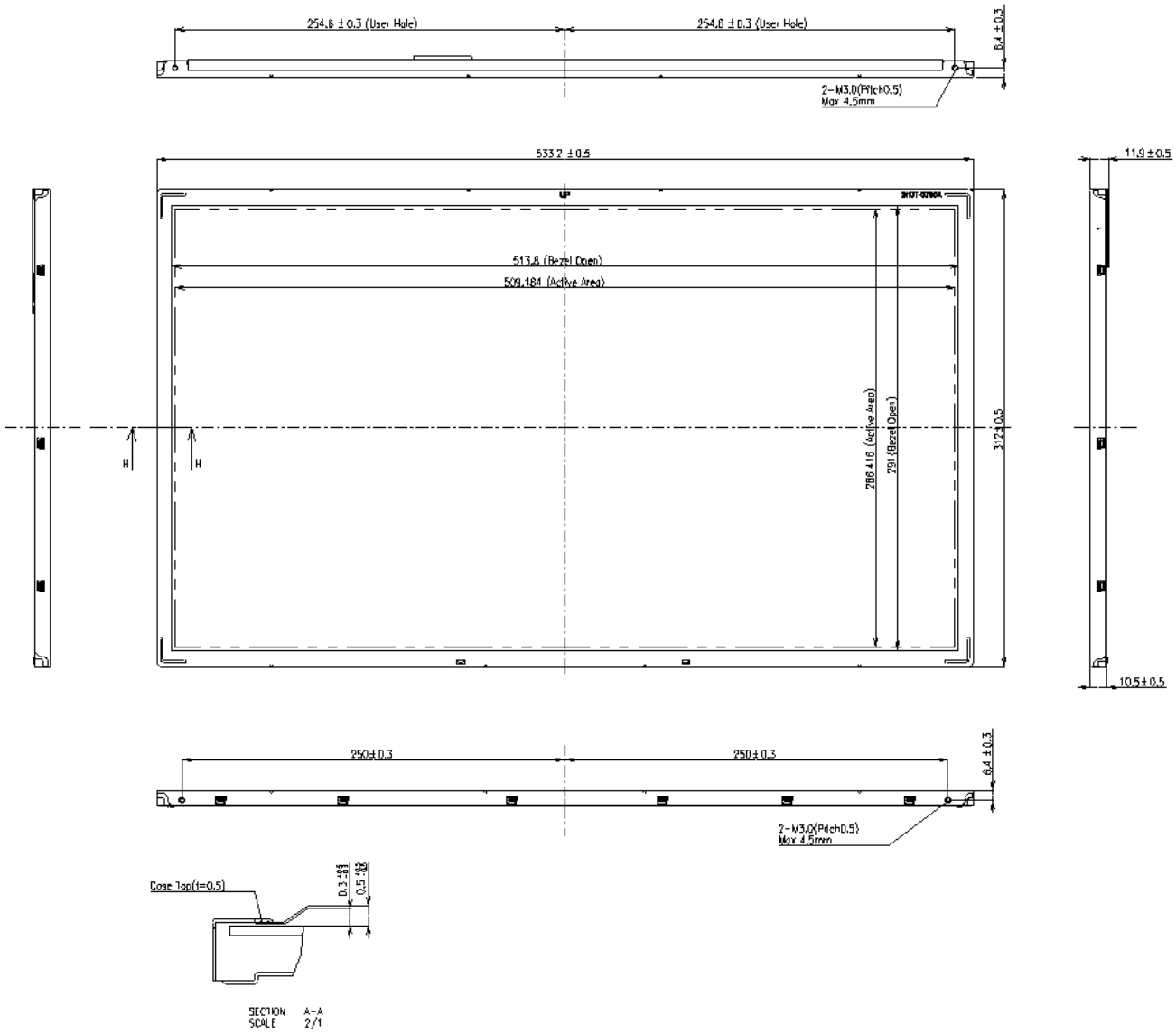
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

Table 13. Mechanical characteristics

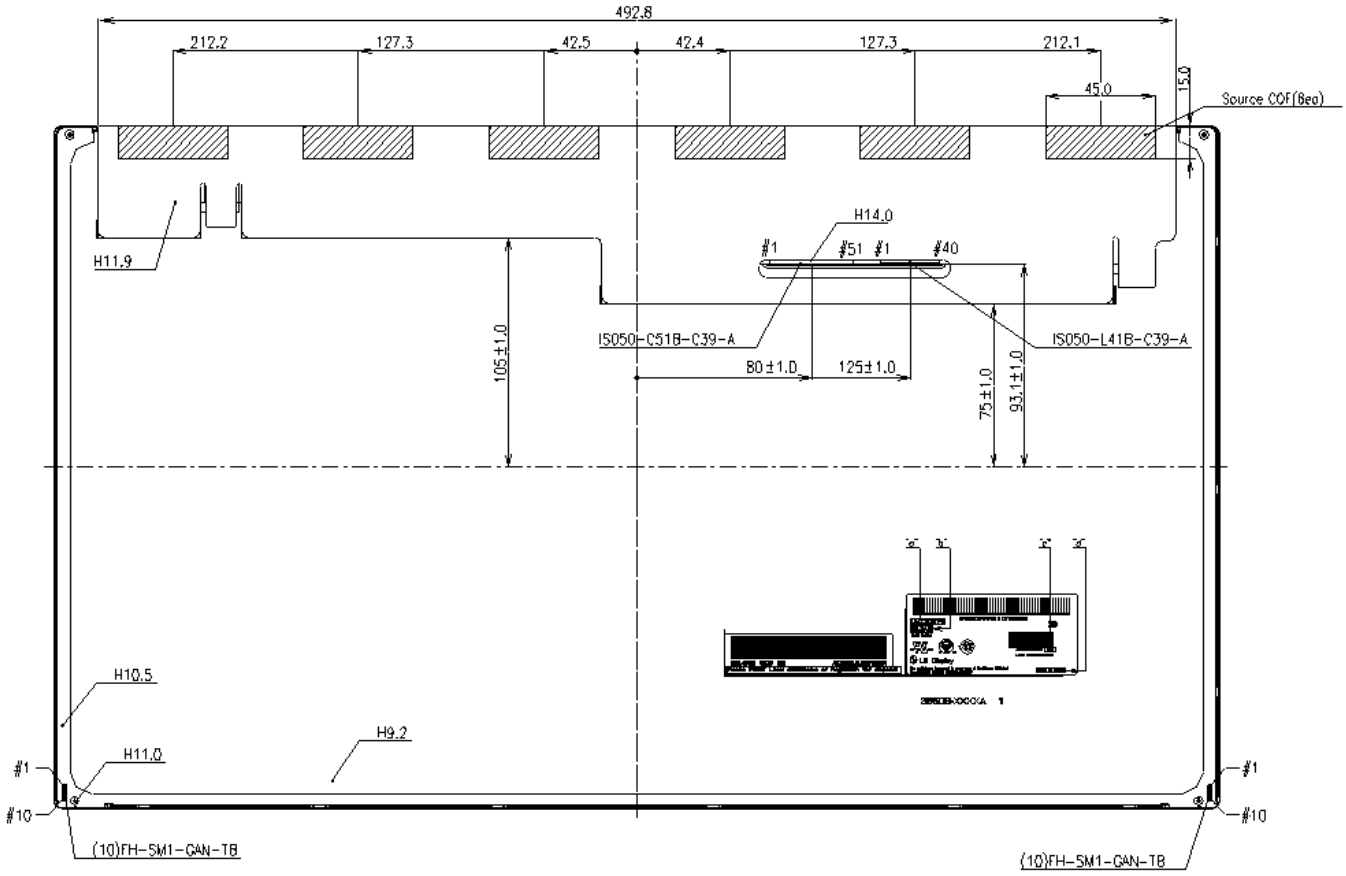
Outline Dimension	Horizontal	533.2mm
	Vertical	312.0mm
	Depth	11.9 mm
Bezel Area	Horizontal	513.8mm
	Vertical	291.0mm
Active Display Area	Horizontal	509.184mm
	Vertical	286.416mm
Weight	Typ. : 1,810g , Max : 1,900g	
Surface Treatment	Hard coating (3H) Anti-glare treatment of the front polarizer	

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

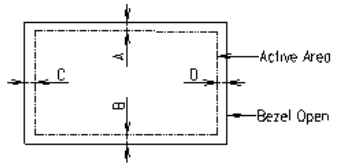
<FRONT VIEW>


254.6 ± 0.3 (User Hole)
254.6 ± 0.3 (User Hole)
6.4 ± 0.3
2-M3.0(Pitch0.5)
Max 4.5mm
533.2 ± 0.5
513.8 (Bezel Open)
509.184 (Active Area)
286.416 (Active Area)
291 (Bezel Open)
312.4 ± 0.5
H
H
11.9 ± 0.5
10.5 ± 0.5
250 ± 0.3
250 ± 0.3
6.4 ± 0.3
2-M3.0(Pitch0.5)
Max 4.5mm
Case Top(t=0.5)
0.3 ± 0.3
0.5 ± 0.3
SECTION A-A
SCALE 2/1

<REAR VIEW>



Notes
1. LVDS input connector specification : (a) ISO50-C51B-C39-A (UJU)
   (b) ISO50-L41B-C39-A (UJU)
2. LED connector specification : (10)FH-5M1-GAN-TB
3. Torque of user hole: 2.5~3.5kgf-cm.
4. Tilt and partial disposition tolerance of display area as following
   (1) Y-direction : IA-BI ≦ 1.4
   (2) X-direction : IC-DI ≦ 1.4



5. Unspecified tolerances to be ±0.5mm
6. The COF area is weak & sensive, so please don't press the COF area

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, 10 min One time each direction
6	Shock test (non-operating)	Shock level : 100G 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.

d) IEC 60950-1:2005, Second Edition, The International Electrotechnical Commission (IEC).
Information Technology Equipment - Safety - Part 1 : General Requirements.
(Including report of IEC60825-1:2001 clause 8 and clause 9)

Notes

1. Laser (LED Backlight) Information

Class 1M LED Product IEC60825-1 : 2001 Embedded LED Power (Class 1M)

2. Caution
: LED inside.
Class 1M laser (LEDs) radiation when open.
Do not open while operating.

7-2. EMC

a) ANSI C63.4 "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) CISPR 22 "Information technology equipment – Radio disturbance characteristics – Limit and methods of measurement." International Special Committee on Radio Interference (CISPR), 2005.

c) CISPR 13 "Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and method of measurement." International Special Committee on Radio Interference (CISPR), 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 : 10 pcs

b) Box Size : 418 x 365 x 618mm

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.