SPECIFICATION
FOR
APPROVAL

(●) **Preliminary Specification**
( ) **Final Specification**

Title	**23” Full HD TFT LCD**

BUYER	General
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LM230WF8
SUFFIX	TLA2

*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	
H.Y Kim / Manager	
PREPARED BY	
S.W Yoo / Engineer	

MNT Products Engineering Dept.
LG Display Co., Ltd

Contents

No		ITEM	Page
		COVER	1
		CONTENTS	2
		RECORD OF REVISIONS	3
1		GENERAL DESCRIPTION	4
2		ABSOLUTE MAXIMUM RATINGS	5
3		ELECTRICAL SPECIFICATIONS	6
	1)	ELECTRICAL CHARACTERISTICS	6
	2)	INTERFACE CONNECTIONS	8
	3)	LVDS characteristics	11
	4)	SIGNAL TIMING SPECIFICATIONS	14
	5)	SIGNAL TIMING WAVEFORMS	15
	6)	COLOR INPUT DATA REFERNECE	16
	7)	POWER SEQUENCE	17
	8)	POWER DIP CONDITION	18
4		OPTICAL SPECIFICATIONS	19
5		MECHANICAL CHARACTERISTICS	25
6		RELIABILITY	28
7		INTERNATIONAL STANDARDS	29
	1)	SAFETY	29
	2)	EMC	29
8		PACKING	30
	1)	DESIGNATION OF LOT MARK	30
	2)	PACKING FORM	30
9		PRECAUTIONS	31
	1)	MOUNTING PRECAUTIONS	31
	2)	OPERATING PRECAUTIONS	31
	3)	ELECTROSTATIC DISCHARGE CONTROL	32
	4)	PRECAUTIONS FOR STRONG LIGHT EXPOSURE	32
	5)	STROAGE	32
	6)	HANDLING PRECAUTIONS FOR PROTECTION FILM	32

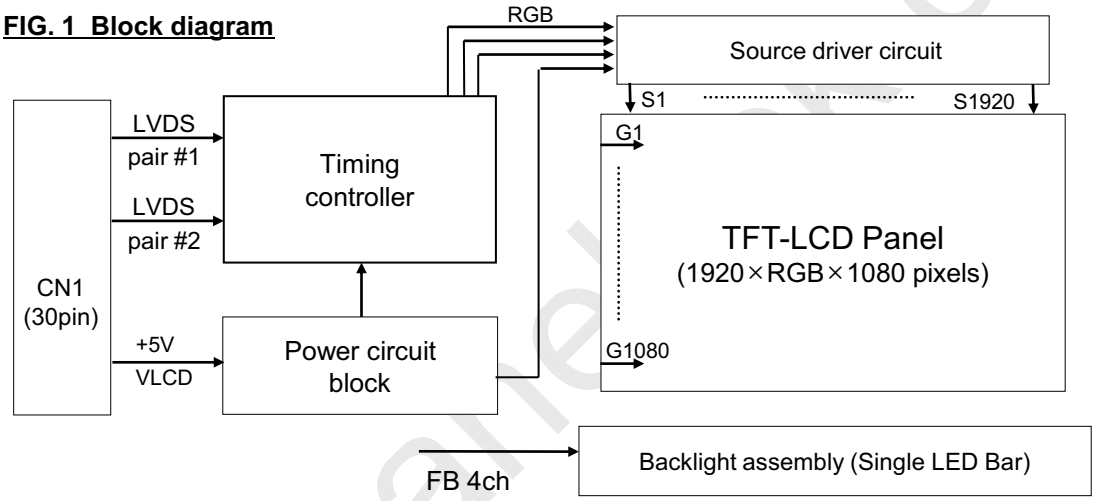
Record of revisions

Revision No	Date	Page	Description
Ver. 0.1	Apr. 25, 2011	-	First Draft, **Preliminary Specifications.**

1. General description

LM230WF8-TLA2 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 colors with Advanced-FRC(Frame Rate Control). It has been designed to apply the interface method that enables low power, high speed, low EMI. FPD Link or compatible must be used as a LVDS(Low Voltage Differential Signaling) chip. It is intended to support applications where thin thickness, wide viewing angle, low power are critical factors and graphic displays are important. In combination with the vertical arrangement of the sub-pixels, the LM230WF8-TLA2 characteristics provide an excellent flat panel display for office automation products such as monitors.

FIG. 1 Block diagram



General features

Active screen size	23 inches(58.42cm) diagonal(Aspect ratio 16:9)
Outline Dimension	533.2(H) x 312.0(V) x 10.7(D) mm (Typ.)
Pixel Pitch	0.265mm x 0.265mm
Pixel Format	1920 horizontal By 1080 vertical Pixels. RGB stripe arrangement
Interface	LVDS 2Port
Color depth	16.7M colors
Luminance, white	250 cd/m^2 (Center 1Point, typ)
Viewing Angle (CR>10)	R/L 170(Typ.), U/D 160(Typ.)
3D Viewing Angle(3DCT<10)	R/L 40/40 (Typ.), U/D 12 (Typ.)
Power Consumption	Total 27.12 W (Typ.), (6.0 W@V_{LCD} , 21.12 W@W/O_Driver)
Weight	1,700 g (Typ.)
Display operating mode	Transmissive mode, normally White
Surface treatments	Anti Glare

2. Absolute maximum ratings

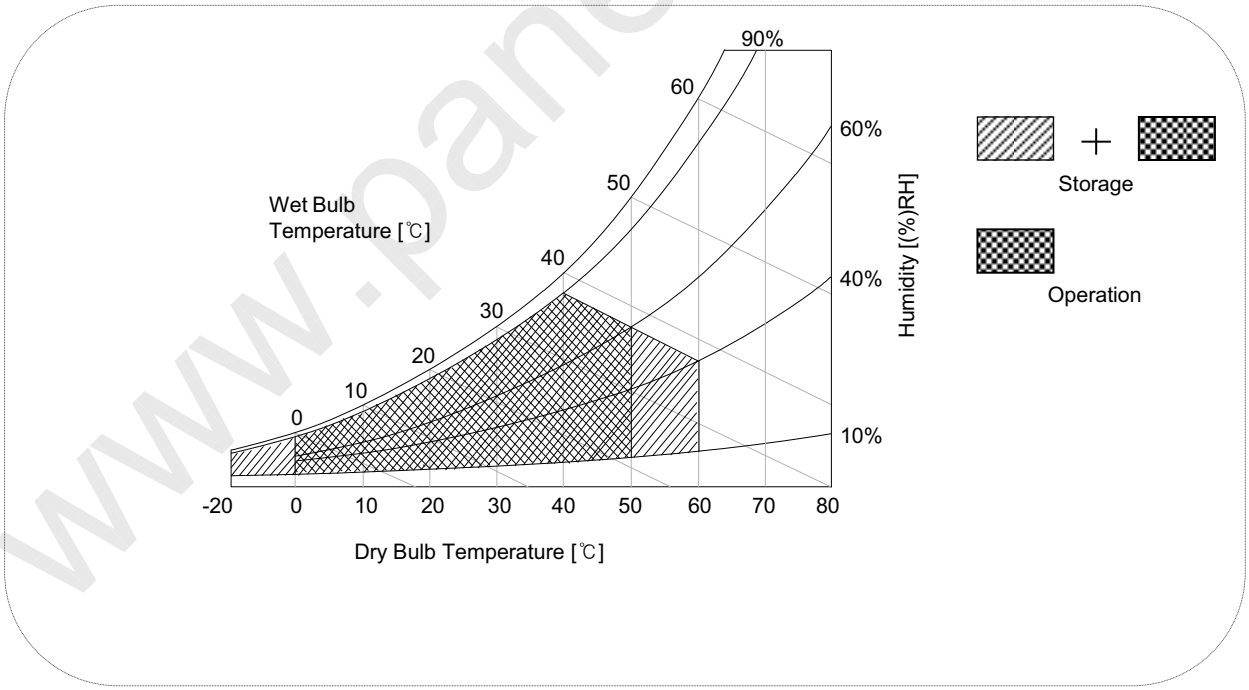
The following are maximum values which, if exceeded, may cause faulty operation or damage to the unit.

Table 1. Absolute maximum ratings

Parameter	Symbol	Values		Units	Notes
		Min	Max		
Power Supply Input Voltage	V_{LCD}	-0.3	+6.0	Vdc	At 25℃
Operating Temperature	T_{OP}	0	50	°C	1,2,3
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℃, 70% RH only for 4 corner light leakage Mura.
3. Storage condition is guaranteed under packing condition.

FIG. 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 second 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

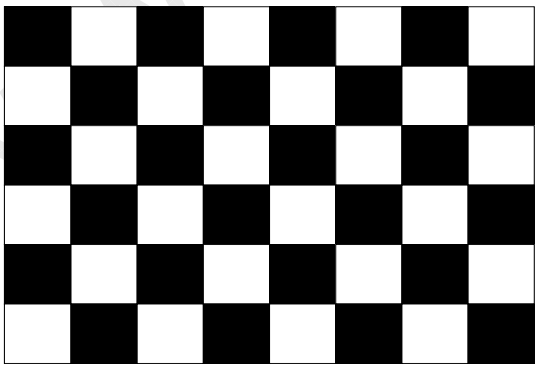
Parameter	Symbol	Values			Unit	Notes
		Min	Typ	Max		
MODULE :						
Power Supply Input Voltage	V_{LCD}	4.5	5.0	5.5	Vdc	
Permissive Power Input Ripple	V_{LCD}	-	-	0.4	V	3
Power Supply Input Current	$I_{LCD-MOSAIC}$	-	1200	1350	mA	1
	$I_{LCD-BLACK}$	-	1400	1600	mA	2
Power Consumption	P_{LCD}	-	6.0	6.90	Watt	1
	$P_{LCD-BLACK}$	-	7.0	8.0	Watt	
Inrush current	I_{RUSH}	-	-	3.5	A	3

Note :
1. The specified current and power consumption are under the V_{LCD}=5.0V, 25 ± 2°C,f_V=60Hz condition whereas mosaic pattern(8 x 6) is displayed and f_V is the frame frequency.
2. The current is specified at the maximum current pattern.
3. Permissive power ripple should be measured under VCC=5.0V, 25°C, f_V (frame frequency)=75Hz condition and At that time, we recommend the bandwidth configuration of oscilloscope is to be under 20MHz.
4. The duration of rush current is about 2ms and rising time of power Input is 500us ± 20%.

FIG.3 pattern for Electrical characteristics

power consumption measurement

White : 255Gray
Black : 0Gray



Mosaic Pattern(8 x 6)

power input ripple

Full Black Pattern

Table 3. LED bar Electrical characteristics

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		45	48	51	V	3,7
Power Consumption	P_{Bar}		19.80	21.12	22.44	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

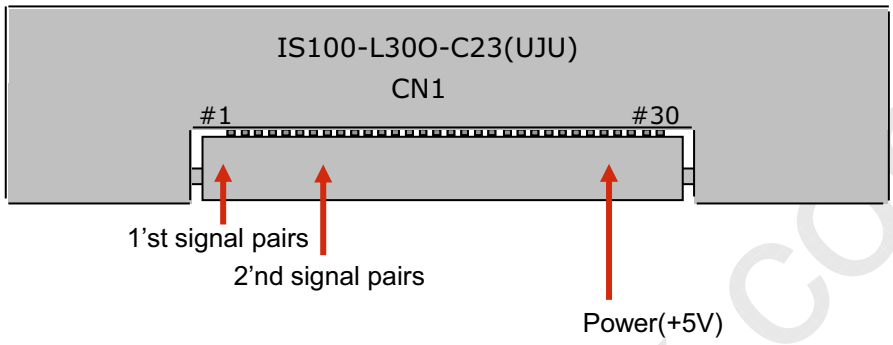
LCD connector(CN1) : IS100-L30O-C23(UJU), GT103-30S-H15 (LSM)

Mating connector : FI-X30H and FI-X30HL (JAE) or Equivalent

Table 4. Module connector(CN1) pin configuration

Pin No	Symbol	Description	
1	RXO0-	Minus signal of 1st channel 0 (LVDS)	First Pixel data
2	RXO0+	Plus signal of 1st channel 0 (LVDS)	
3	RXO1-	Minus signal of 1st channel 1 (LVDS)	
4	RXO1+	Plus signal of 1st channel 1 (LVDS)	
5	RXO2-	Minus signal of 1st channel 2 (LVDS)	
6	RXO2+	Plus signal of 1st channel 2 (LVDS)	
7	GND	Ground	
8	RXOC-	Minus signal of 1st clock channel (LVDS)	
9	RXOC+	Plus signal of 1st clock channel (LVDS)	
10	RXO3-	Minus signal of 1st channel 3 (LVDS)	
11	RXO3+	Plus signal of 1st channel 3 (LVDS)	
12	RXE0-	Minus signal of 2nd channel 0 (LVDS)	Second Pixel data
13	RXE0+	Plus signal of 2nd channel 0 (LVDS)	
14	GND	Ground	
15	RXE1-	Minus signal of 2nd channel 1 (LVDS)	
16	RXE1+	Plus signal of 2nd channel 1 (LVDS)	
17	GND	Ground	
18	RXE2-	Minus signal of 2nd channel 2 (LVDS)	
19	RXE2+	Plus signal of 2nd channel 2 (LVDS)	
20	RXEC-	Minus signal of 2nd clock channel (LVDS)	
21	RXEC+	Plus signal of 2nd clock channel (LVDS)	
22	RXE3-	Minus signal of 2nd channel 3 (LVDS)	
23	RXE3+	Plus signal of 2nd channel 3 (LVDS)	
24	GND	Ground	
25	NC	No Connection (For LCD internal use only.)	
26	NC	No Connection (For LCD internal use only.)	
27	NC	No Connection (For LCD internal use only.)	
28	V_{LCD}	Power Supply (5.0V)	
29	V_{LCD}	Power Supply (5.0V)	
30	V_{LCD}	Power Supply (5.0V)	

FIG. 4 Connector diagram



Rear view of LCM

Note:

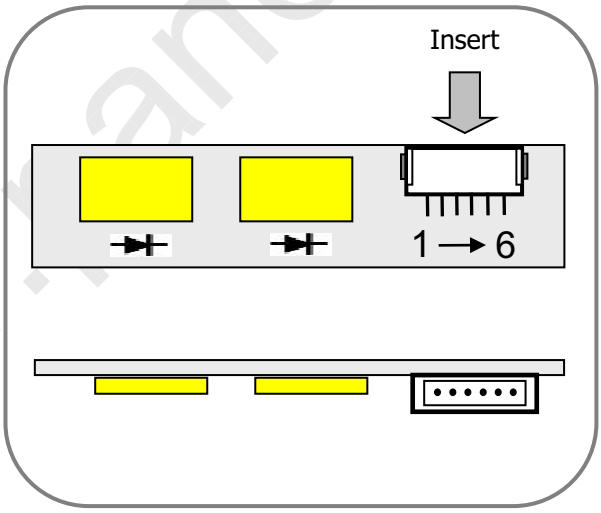
1. NC: No Connection.
2. All GND (ground) pins should be connected together and to Vss which should also be connected to the LCD's metal frame.
3. All V_{LCD} (power input) pins should be connected together.
4. Input Level of LVDS signal is based on the IEA 664 Standard.

The LED interface connector is a model 10019HR-H06B manufactured by YEONHO.
The pin configuration for the connector is shown in the table below.

Table 5. LED connector pin configuration

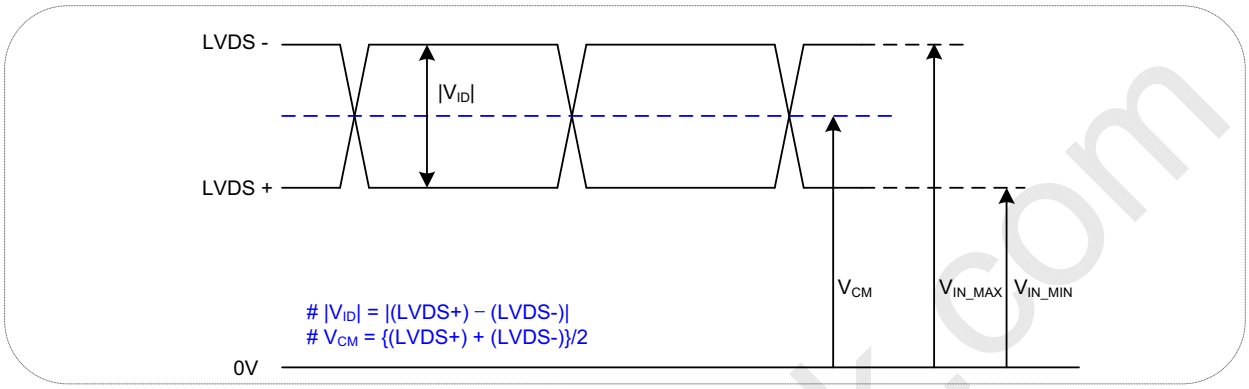
Pin	Symbol	Description	Notes
1	FB1	Channel1 Current Feedback	
2	FB2	Channel2 Current Feedback	
3	VLED	LED Power Supply	
4	VLED	LED Power Supply	
5	FB3	Channel3 Current Feedback	
6	FB4	Channel4 Current Feedback	

FIG. 5 Backlight connector view



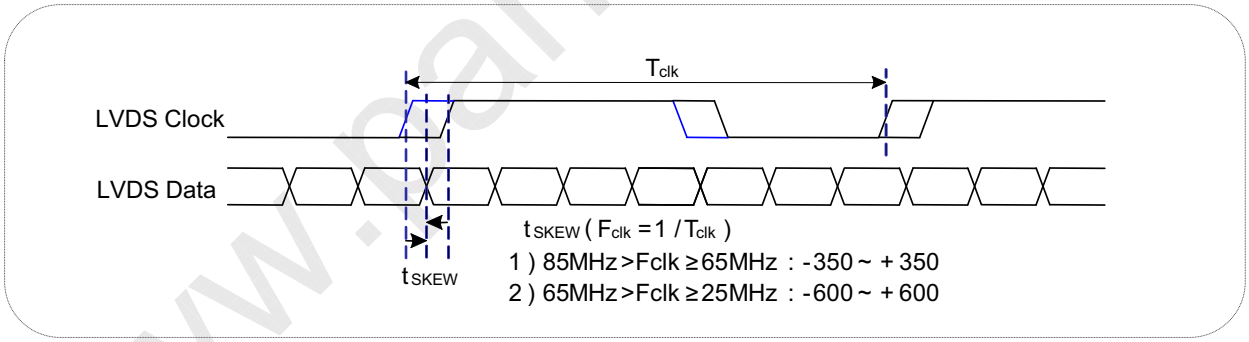
3-3. LVDS characteristics

3-3-1. DC Specification

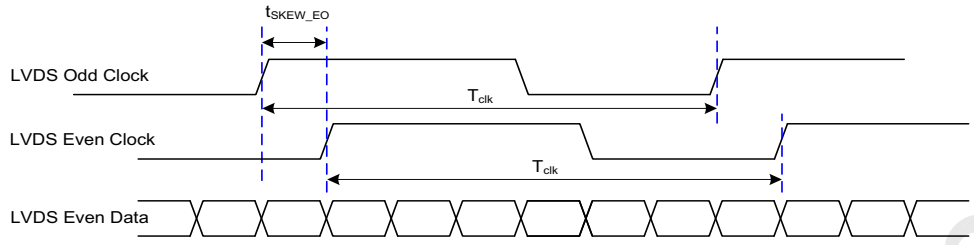


Description	Symbol	Min	Max	Unit	Notes
LVDS Differential Voltage	$\|V_{ID}\|$	200	600	mV	-
LVDS Common mode Voltage	V_{CM}	0.6	1.8	V	-
LVDS Input Voltage Range	V_{IN}	0.3	2.1	V	-

3-3-2. AC Specification

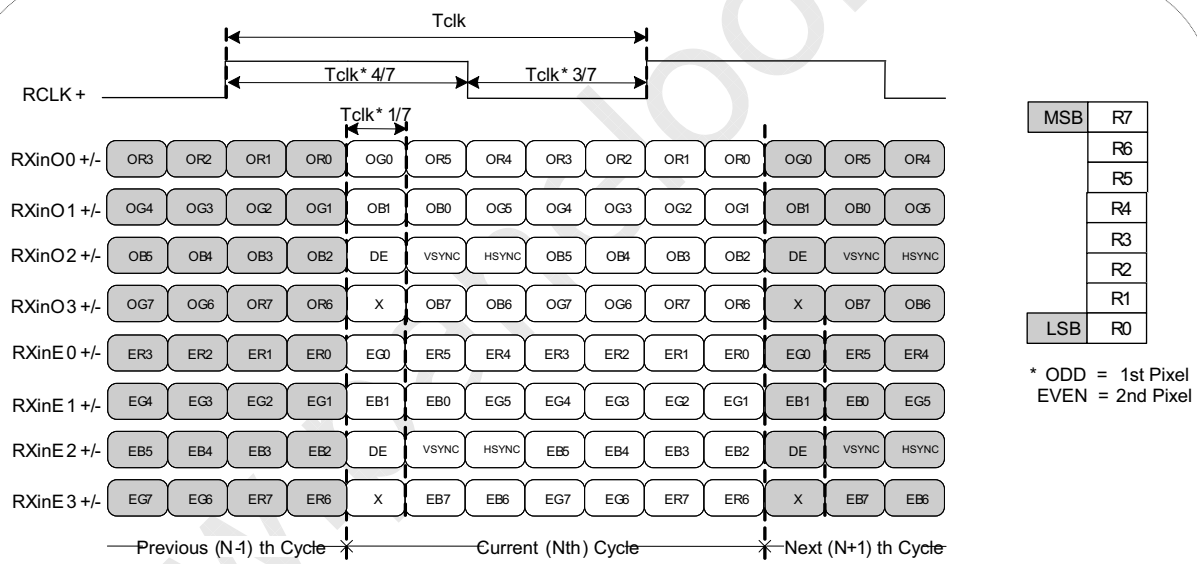


Description	Symbol	Min	Max	Unit	Notes
LVDS Clock to Data Skew Margin	t_{SKEW}	- 350	+ 350	ps	85MHz > Fclk ≥ 65MHz
	t_{SKEW}	- 600	+ 600	ps	65MHz > Fclk ≥ 25MHz
LVDS Clock to Clock Skew Margin (Even to Odd)	t_{SKEW_EO}	- 1/7	+ 1/7	T_{clk}	-



< Clock skew margin between channel >

3-3-3. LVDS Data format



< LVDS Data Format >

Table 6. 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 : 1. Refer to LVDS Transmitter Data Sheet for detail descriptions.
2. 7 means MSB and 0 means LSB at R,G,B pixel data

3-4. Signal timing specifications

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

Table 7. Timing table

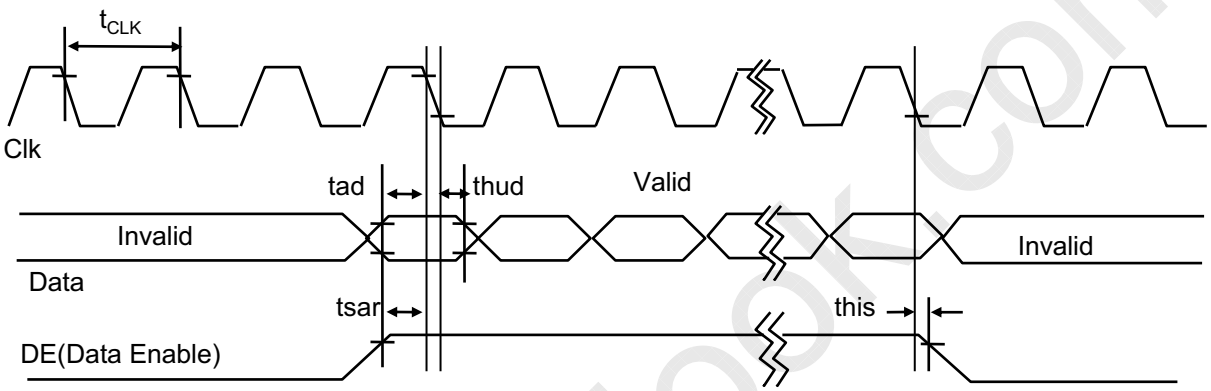
ITEM	Symbol		Min	Typ	Max	Unit	Note
DCLK	Period	tCLK	11.43	13.89	16.7	ns	
	Frequency	-	60	72	87.5	MHz	5
Hsync	Period	tHP	1024	1088	1120	tCLK	
	Horizontal Valid	tHV	960	960	960	tCLK	
	Horizontal Blank	tHB	64	128	160		
	Frequency	fH	64	66	83	KHz	
	Width	tWH	16	32	48	tCLK	
	Horizontal Back Porch	tHBP	32	48	64		
	Horizontal Front Porch	tHFP	16	48	48		
Vsync	Period	tVP	1090	1100	1160	tHP	
	Vertical Valid	tVV	1080	1080	1080	tHP	
	Vertical Blank	tVB	10	20	80	tHP	
	Frequency	fV	50	60	75	Hz	
	Width	tWV	2	4	16	tHP	
	Vertical Back Porch	tVBP	5	8	32		
	Vertical Front Porch	tVFP	3	8	32		

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, Vsyn, and DE(data enable) signals should be used.

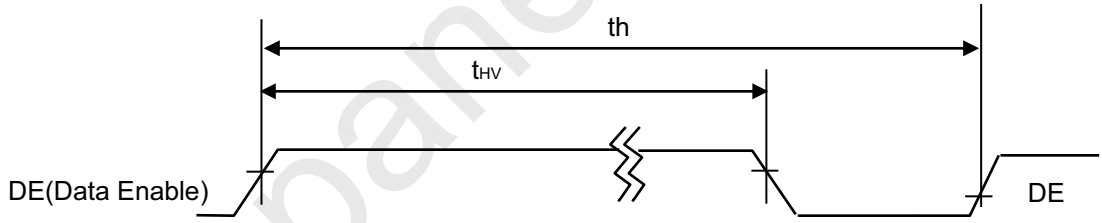
1. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
2. Vsync and Hsync should be keep the above specification.
3. Hsync Period, Hsync Width, and Horizontal Back Porch should be any times of of character number(4).
4. The polarity of Hsync, Vsync is not restricted.
5. The Max frequency of 1920X1080 resolution is 82.5Mhz

3-5. Signal timing waveforms

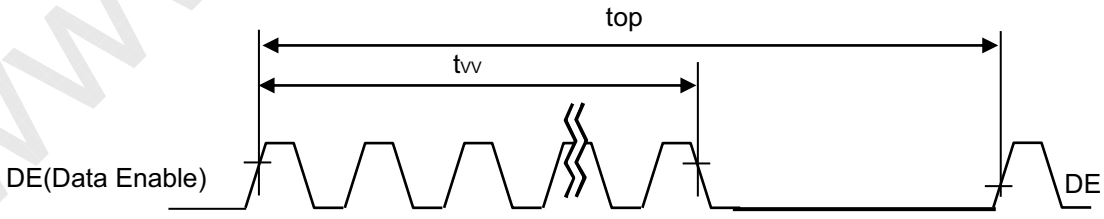
1. DCLK , DE, DATA waveforms



2. Horizontal waveform



3. Vertical waveform



3-6. Color input data reference

The brightness of each primary color (red,green and blue) is based on the 8bit 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 8. Color data reference

Color		Input Color Data																							
		Red MSB							LSB	Green MSB							LSB	Blue 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(002)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	- - - - - - - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	- - - - - - - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Red(253)	1	1	1	1	1	1	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) Bright	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(002)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	- - - - - - - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	- - - - - - - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Green(253)	0	0	0	0	0	0	0	0	1	1	1	1	1	1	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)Bright	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(002)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	- - - - - - - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	- - - - - - - - -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Blue(253)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	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) Bright	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

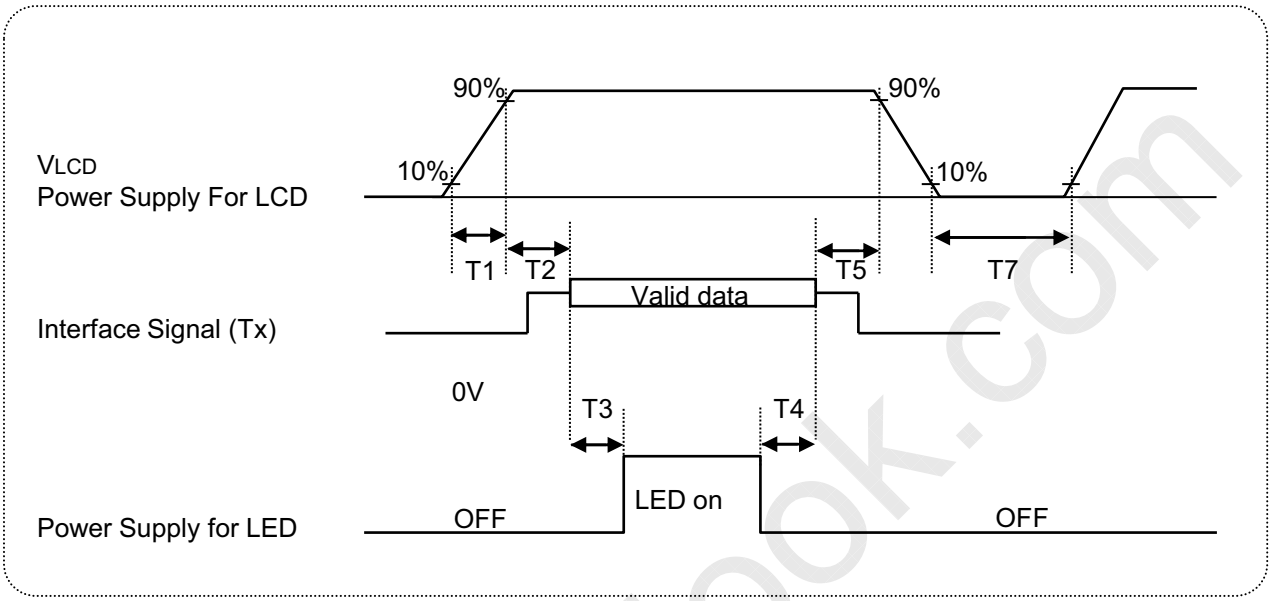


Table 9. Power sequence

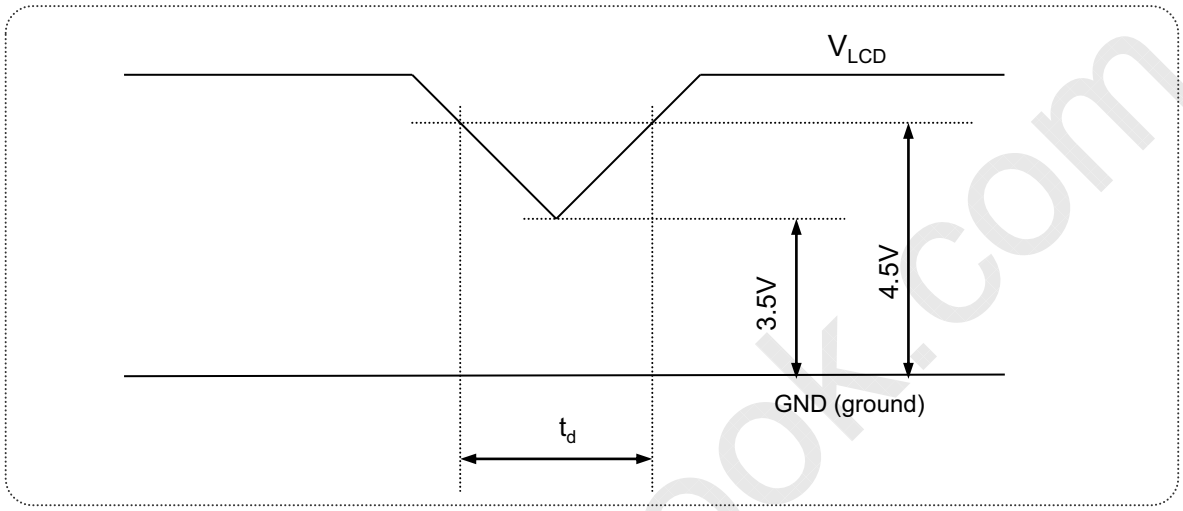
Parameter	Values			Units
	Min	Typ	Max	
T1	0.5	-	10	ms
T2	0.01	-	50	ms
T3	500	-	-	ms
T4	200	-	-	ms
T5	0.01	-	50	ms
T7	1	-	-	s

Notes :

1. Please V_{LCD} power on only after connecting interface cable to LCD.
2. Please avoid floating state of interface signal at invalid period.
3. When the interface signal is invalid, be sure to pull down the power supply for LCD V_{LCD} to 0V.
4. LED power must be turn on after power supply for LCD an interface signal are valid.

3-8. V_{LCD} Power dip condition

FIG. 6 Power dip condition



1) Dip condition

$3.5V \leq V_{LCD} < 4.5V$, $t_d \leq 20ms$

2) $V_{LCD} < 3.5V$

V_{LCD}-dip conditions should also follow the Power On/Off conditions for supply voltage.

4. Optical specification

Optical characteristics are determined after the unit has been 'ON' for 30 minutes in a dark environment at 25°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 °.
FIG. 7 presents additional information concerning the measurement equipment and method.

FIG. 7 Optical characteristic measurement equipment and method

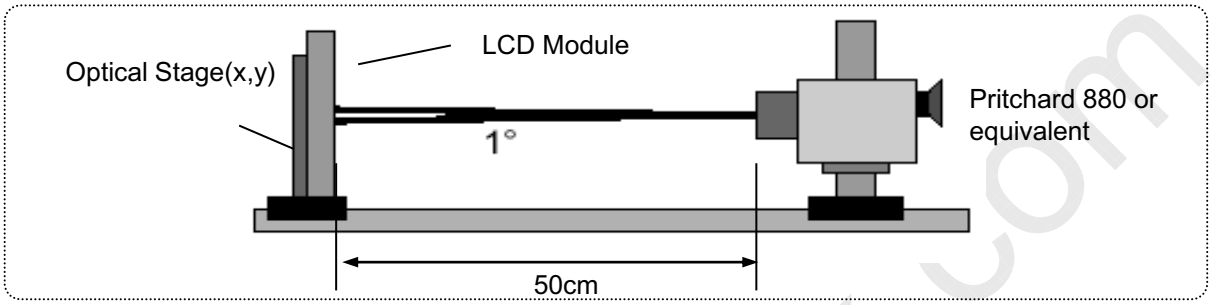


Table 10. Optical characteristics

Ta= 25°C, V_{LCD}=5.0V, fv=60Hz f_{CLK}=119MHz, I_{BL} = 110mA

Parameter		Symbol	Values			Units	Notes
			Min	Typ	Max		
Contrast Ratio		CR	700	1000	-		1
Surface Luminance, white		L_{WH}	200	250	-	cd/m²	2
Luminance Variation		δ_{WHITE} 9P	75			%	3
Response Time	Rise Time	Tr_R	-	1.3	2.6	ms	4
	Decay Time	Tr_D	-	3.7	7.4	ms	4
Color Coordinates [CIE1931]	RED	Rx	Typ -0.03	0.636	Typ +0.03		
		Ry		0.333			
	GREEN	Gx		0.303			
		Gy		0.626			
	BLUE	Bx		0.153			
		By		0.070			
	WHITE	Wx		0.313			
		Wy		0.329			
Color Gamut		-	-	72	-	%	
Viewing Angle (CR>5)							
	x axis, right(ϕ=0°)	θr	75	88		Degree	5
	x axis, left (ϕ=180°)	θl	75	88			
	y axis, up (ϕ=90°)	θu	70	85			
	y axis, down (ϕ=270°)	θd	70	85			
Viewing Angle (CR>10)							
	x axis, right(ϕ=0°)	θr	70	85		Degree	5
	x axis, left (ϕ=180°)	θl	70	85			
	y axis, up (ϕ=90°)	θu	60	75			
	y axis, down (ϕ=270°)	θd	70	85			
3D Viewing Angle (3DCT < 10%)				**12**		Degree	5
Crosstalk					1.5	%	6
3D Crosstalk (min.)				**1.8**	**5.0**	%	5

Notes :

1. Contrast ratio(CR) is defined mathematically as :It is measured at center point(1)

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

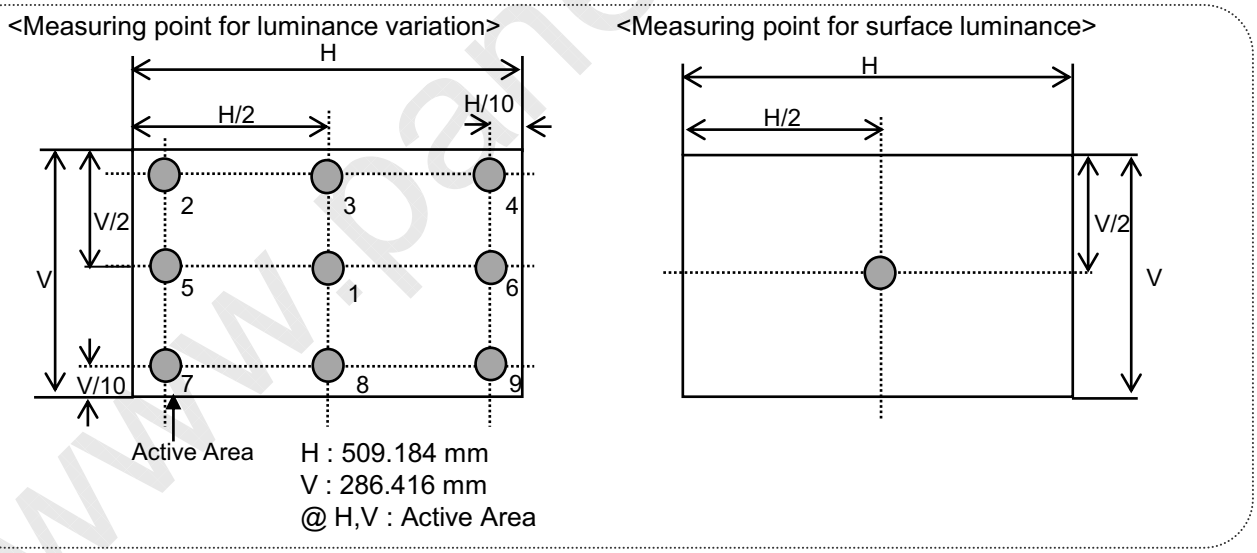
2. Surface luminance is the luminance value at center 1 point(1) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG 8.

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

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

For more information see Figure 8.

FIG. 8 Luminance measuring point

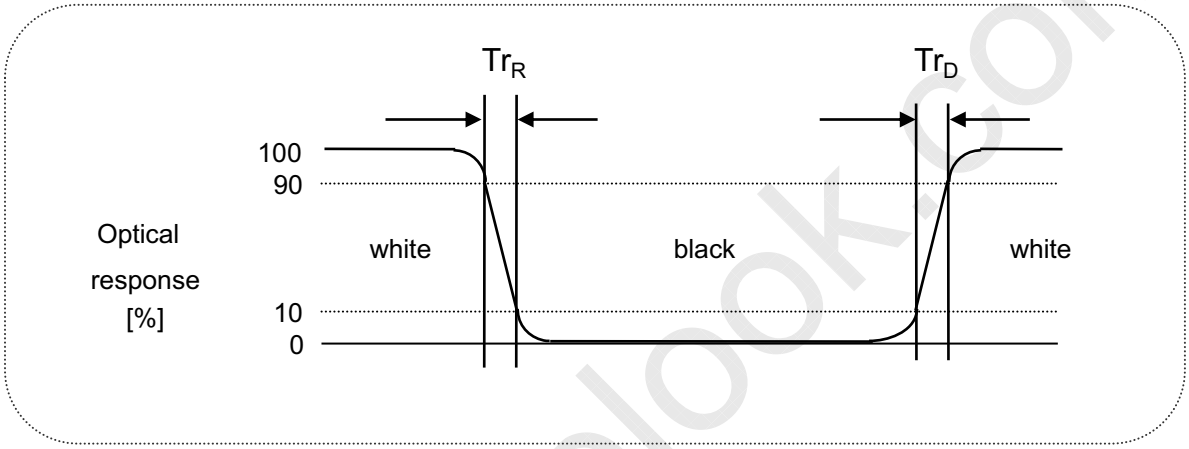


Notes :

4. Response time is the time required for the display to transition from black to white (Decay Time, Tr_D) and from white to black (Rise Time, Tr_R)
The sampling rate is 2,500 sample/sec. For additional information see FIG. 9.

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

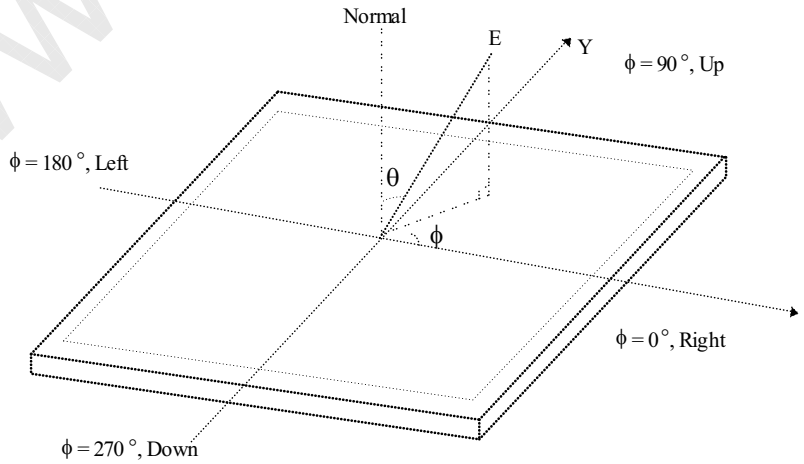
FIG. 9 Response time

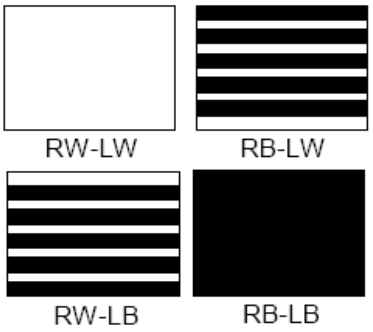


5. Viewing angle is the angle at which the contrast ratio is greater than 10 or 5. The angles are determined for the horizontal or x axis and the vertical or y axis with respect to the z axis which is normal to the LCD surface. For more information see FIG. 10 .

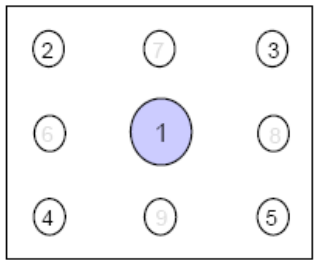
FIG. 10 Viewing angle

<Dimension of viewing angle range>

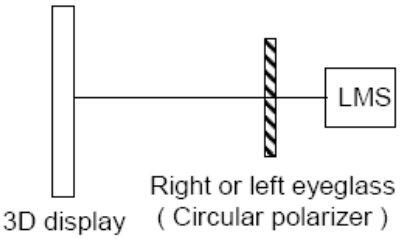




(a) Test pattern image

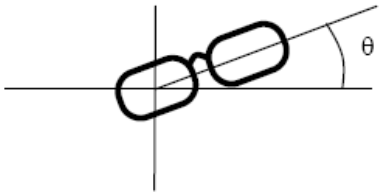


(b) Measurement position

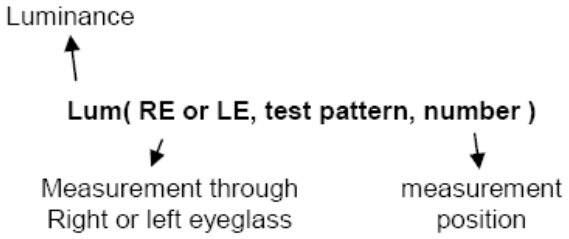


(c) Setup

< Figure 6. Measurement configuration>



< Figure 7. Positioning eyeglass >



< Figure 8. notation of luminance measurement >

In order to measure 3D viewing angle (**distance 50cm**), it need to be prepared as below;

1) Measurement configuration
4-Test pattern images. Refer to FIG 8.
-. RW-LW : White for right and left eye
-. RW-LB : White for right eye and Black for left eye
-. RB-LW : Black for right eye and white for left eye
-. RB-LB : Black for right eye and left eye
Image files where black and white lines are displayed on even or odd lines.
Luminance measurement system (LMS) with narrow FOV (field of view) is used. Refer to FIG 1.

2) Positioning Eyeglass
Find angle of minimum transmittance.
This value would be provided beforehand or measured by the following steps;

(i) Test image (RB-LW) is displayed.
(ii) Right eyeglass are placed in front of LMS and luminance is measured,
rotating right eyeglass such as FIG 7. The notation for luminance measurement is “Lum(RE, RB-LW,1)”.
(iii) Find the angle where luminance is minimum.

* Following measurements should be performed at the angle of minimum transmittance of eyeglass.

3) 3D cross talk and 3D viewing angle
(i) Test image (RB-LW, RW-LB and RB-LB) is displayed.
(ii) Right or left eyeglass are placed in front of LMS successively and luminance is measured for position 1 (position 2,3 : optional) with rotating LMS or sample vertically. (horizontal: optional)

The value of 3D cross talk is

$$\frac{\text{Lum(LE, RW-LB,1) - Lum(LE, RB-LB,1)}}{\text{Lum(LE, RB-LW,1) - Lum(LE, RB-LB,1)}}$$

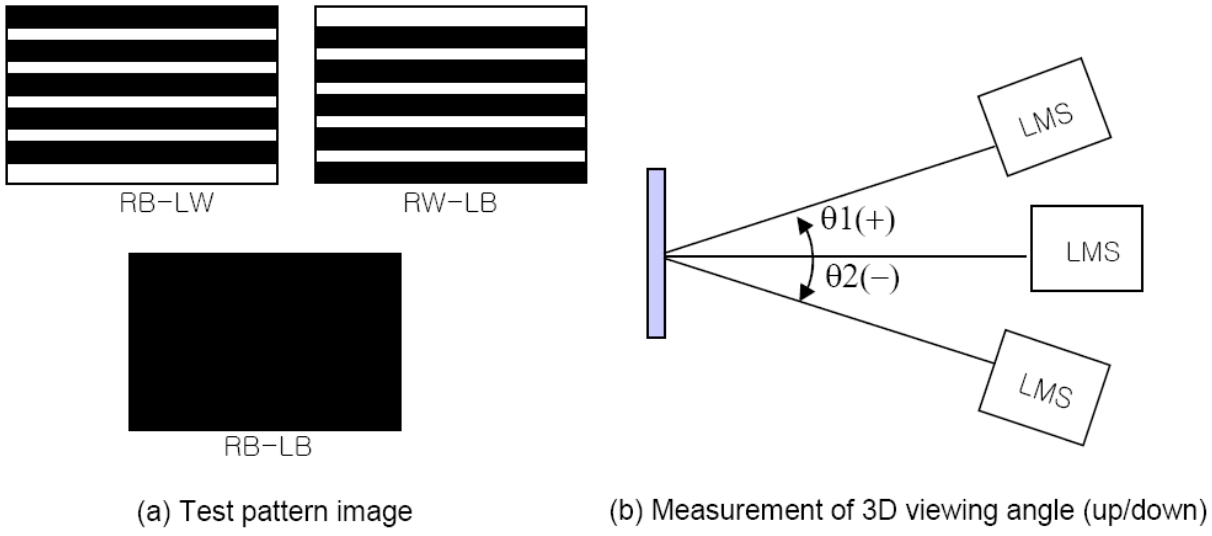
or

$$\frac{\text{Lum(RE, RB-LW,1) - Lum(RE, RB-LB,1)}}{\text{Lum(RE, RW-LB,1) - Lum(RE, RB-LB,1)}}$$

The 3D crosstalk (min.) is minimum 3D crosstalk within viewing angle.

3D perceiving angular range, or 3D viewing angle, is defined as angular range that 3D crosstalk is below 10%.

The typical center of U/D viewing angle is 2°(Θ1) direction.



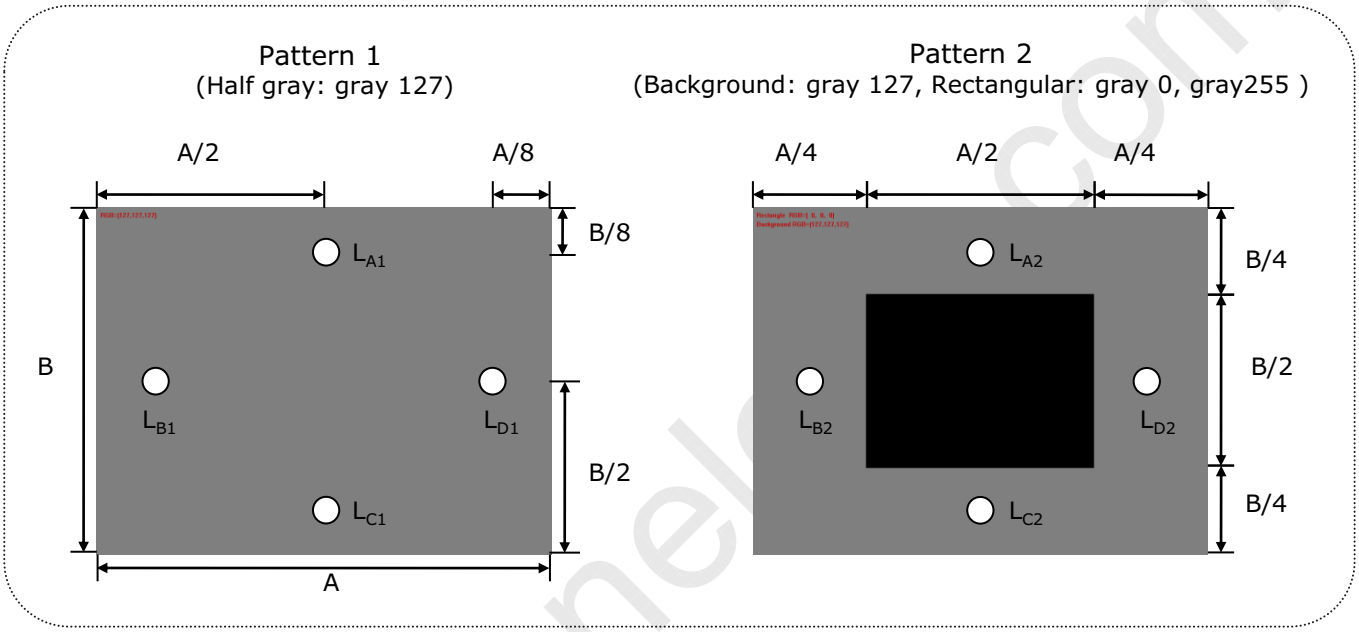
(a) Test pattern image (b) Measurement of 3D viewing angle (up/down)

< Figure 9. Measurement of 3D crosstalk and 3D viewing angle >

Notes :

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

FIG. 11 Crosstalk



7. Gray scale specification

Table 11. Gray scale

Gray level	Luminance [%] (Typ)
L0	0.1
L31	1.10
L63	4.83
L95	12.25
L127	23.45
L159	37.30
L191	54.55
L223	76.00
L255	100

5. Mechanical characteristics

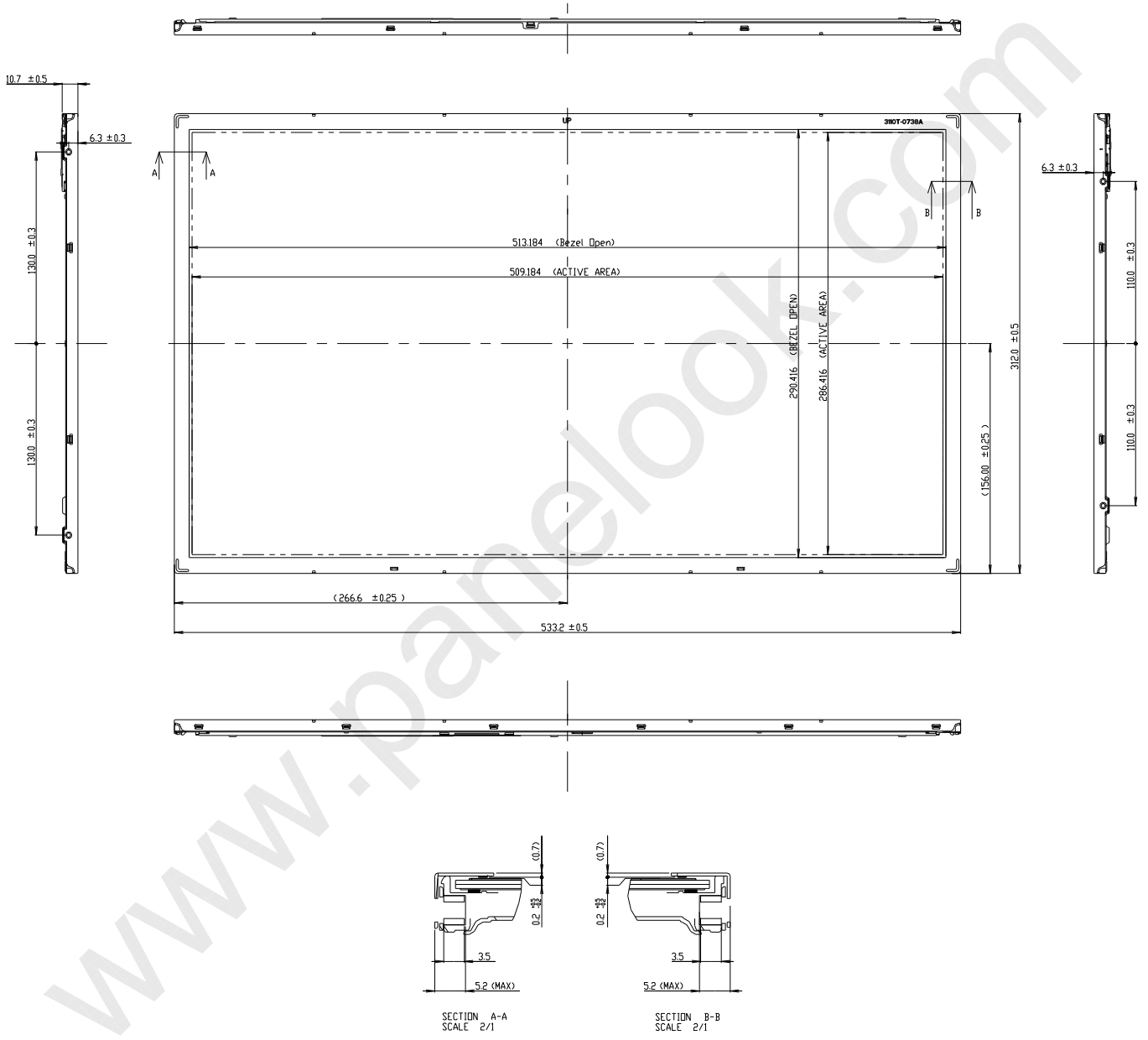
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

Table 12. Mechanical characteristics

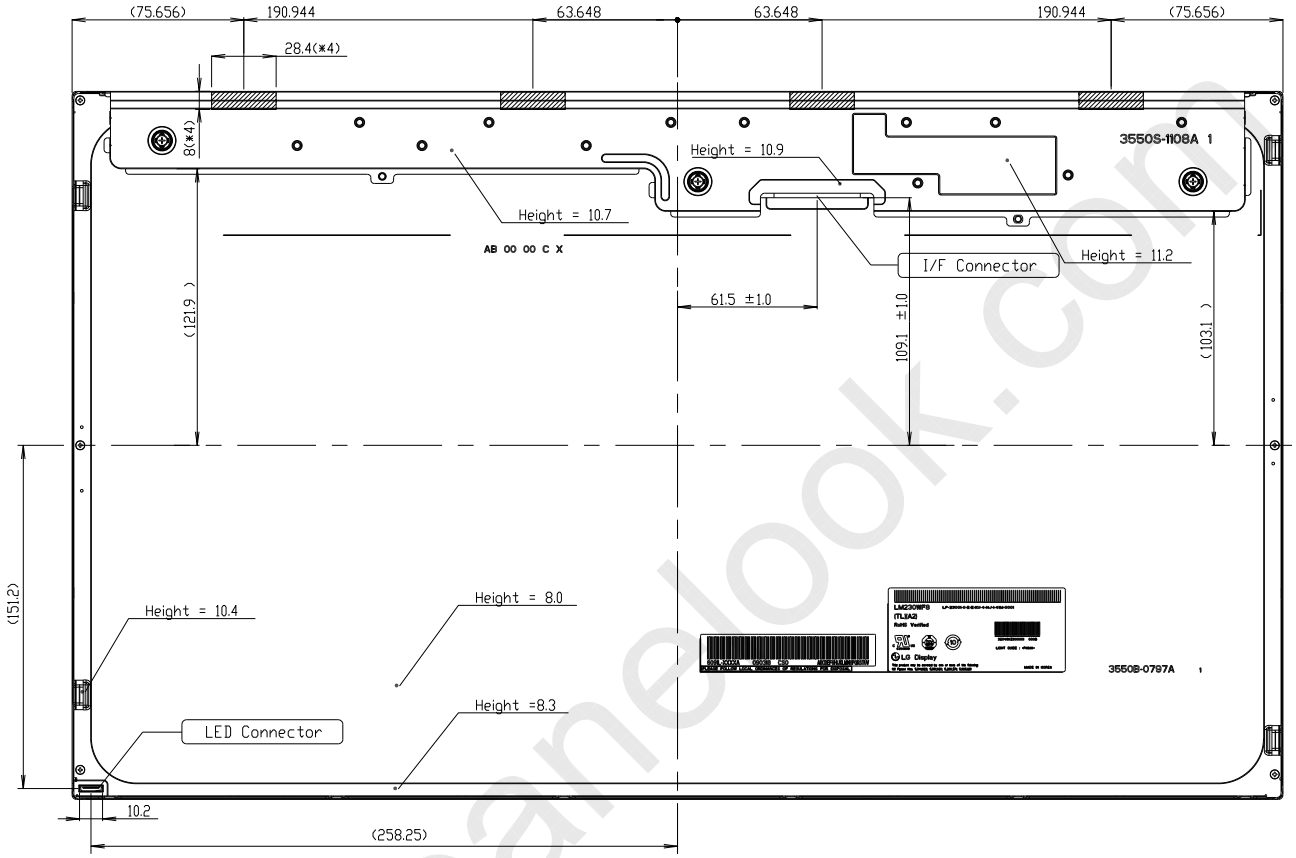
Outline dimension	Horizontal	**533.2mm**
	Vertical	**312.0mm**
	Depth	**10.7 mm**
Bezel area	Horizontal	**513.184mm**
	Vertical	**290.416mm**
Active display area	Horizontal	**509.184mm**
	Vertical	**286.416mm**
Weight	1,700 g (Typ.) 1,830 g (Max.)	
Surface treatment	Anti Glare	

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

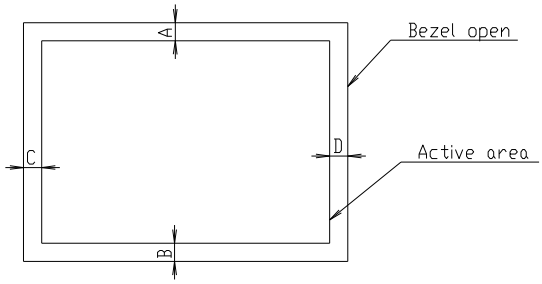
< FRONT VIEW >



< REAR VIEW >



Notes
1. Backlight has 1 LED PKG ASS'Y.
2. I/F Connector Specification
   - GT103-30S-H15 (LSM), IS100-L30□-C23 (UJU).
3. LED Connector Specification
   - 10019HR-H06B (Yeonho)
4. Torque of user hole : 3.0~3.5 kgf-cm
5. 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



6. Unspecified tolerances to be ± 0.5mm
7. The D-IC area is weak & sensitive, so, please don't press the D-IC 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, 20 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 - 10,000 feet(3,048m) 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)
D : YEAR
E : MONTH
F ~ M : SERIAL NO.

Note

1. YEAR

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Mark	A	B	C	D	E	F	G	H	J	K

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 : 11 pcs (The modules are individually packed in AL bag)

b) Box size : 355 X 408 X 600

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 higher.) 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 not be operated its full characteristics perfectly.
(8) A screw which is fastened up the steels should be a machine screw (if not, it causes metal 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.