SPECIFICATION
FOR
APPROVAL

( ) Preliminary Specification
(◆) Final Specification

Title	23.0" FHD TFT LCD

BUYER	General
MODEL	

SUPPLIER	L&T Display Technology (Fujian) Limited.
*MODEL	LM230WF5
SUFFIX	TRA1

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

SIGNATURE	DATE
/	
/	
/	

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

APPROVED BY	DATE
J.D. Park / Director	
REVIEWED BY	
K.H. HWANG / Manager [EE]	
H.J. CHO / Manager [ME]	
Kent.Zhuang / Manager [PM]	

R&D LCM Dept.
L&T Display Technology (Fujian) Limited.

Contents

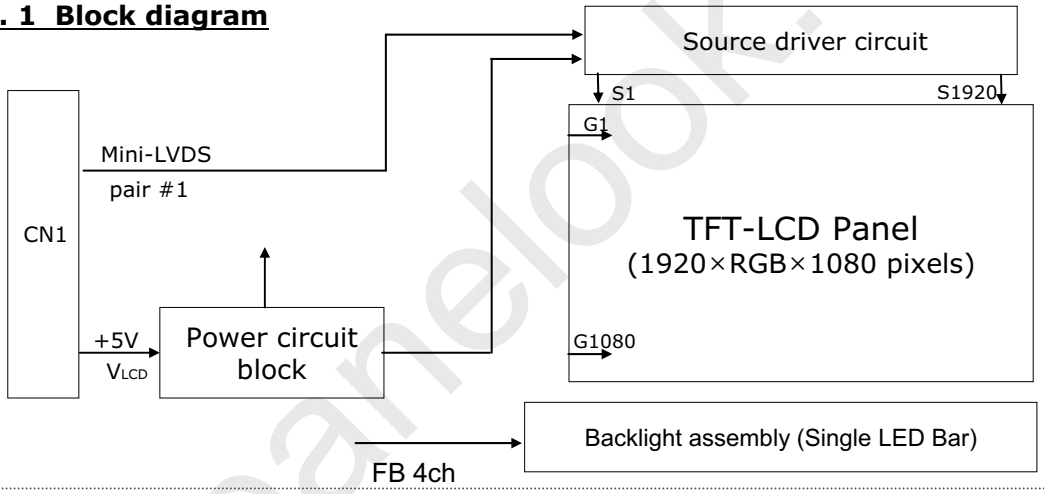
Record of revisions

Revision No	Date	Page	Description
Ver 0.1	Apr.,23,2010	-	Preliminary Specifications
Ver 0.2	Jun.,06,2010	18 20 29	Modify Power Sequence Change RGB color coordinate spec Add Precautions
Ver 0.3	Jun.,12,2010	27	Updated mechanical drawing sheet
Ver 0.4	Jul.,12,2010	11 4	Add Mini-LVDS min. frequency Add Color Gamut
Ver 0.5	Oct.,25,2010	7	Delete Notes 8.

1. General description

LM230WF5-TRA1 is a Color Active Matrix Liquid Crystal Display with an integral Light Emitting Diode (LED) 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 23.0 inch diagonally measured active display area with Full HD 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 6-bit gray scale signal for each dot, thus, presenting a palette of more than 16,7M colors in case of using 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 mini-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 LM230WF5-TRA1 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
Outline Dimension	533.2(H) x 312.0(V) x 8.3(D) mm(Typ.)
Pixel Pitch	0.0883*RGB(H)mm x 0.265(V)mm
Pixel Format	1920 horiz. By 1080 vert. Pixels RGB stripes arrangement
Interface	Mini-LVDS 1Port
Color depth	16.7M colors (When use Advanced FRC)
Luminance, white	250 cd/m2 (Center 1Point, typ)
Viewing Angle (CR>10)	R/L 170(Typ.), U/D 160(Typ.)
Power Consumption	Total 19.2 W(Typ.), (5.4 W@VLCD , 13.8 W@W/O Driver)
Weight	1490 g (Typ.)
Display operating mode	Transmissive mode, Normally White
Surface treatments	Hard coating (3H), Anti-glare treatment of the front polarizer
Color Gamut	68%(Typ.) CIE 1931

2. Absolute maximum ratings

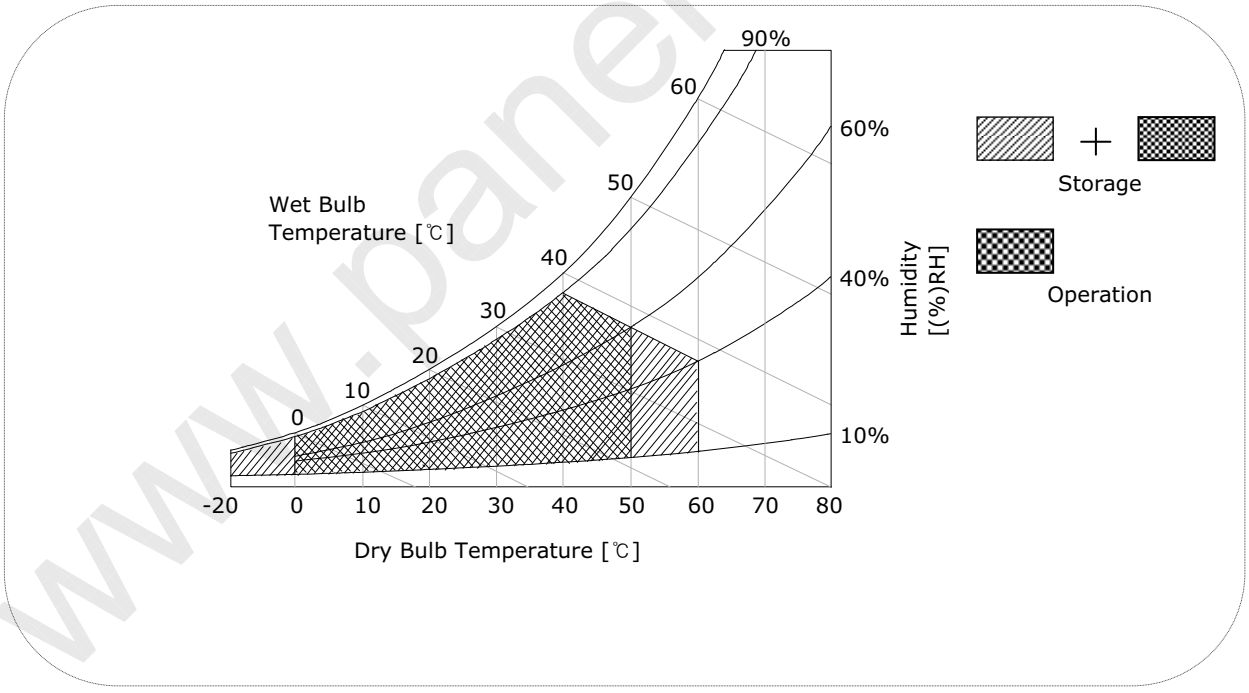
The following are maximum values which, if exceeded, may cause faulty operation or damage to the unit.

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	℃	1
Storage Temperature	T_{ST}	-20	60	℃	
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.

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 an 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}	-	-	0.3	V	3
Power Supply Input Current	$I_{LCD-MOSAIC}$(60Hz)	-	1080	1410	mA	1
	$I_{LCD-BLACK}$(60Hz)	-	1300	1690	mA	2
	$I_{LCD-BLACK}$(75Hz)		-	1960	mA	
Power Consumption	P_{LCD}	-	5.4	7.15	Watt	1
Inrush current	I_{RUSH}	-	-	3.0	A	4

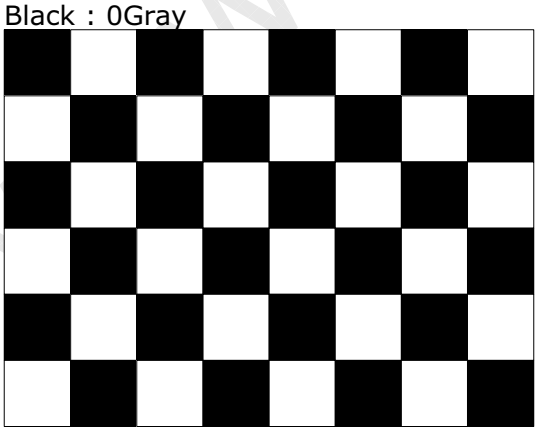
Note :

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 of Black pattern is specified under the V_{LCD}=5.0V, 25 ± 2°C,f_V=60Hz condition.
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 5ms 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		-	60	65	mA	2,7
LED String Voltage	Vs		-	57.6	59.9	V	3,7
Power Consumption	PBar		-	13.8	14.4	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 60 mA 100% duty current.
4. The specified power consumption is input LED bar power consumption at typical 60 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 = Vs(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.

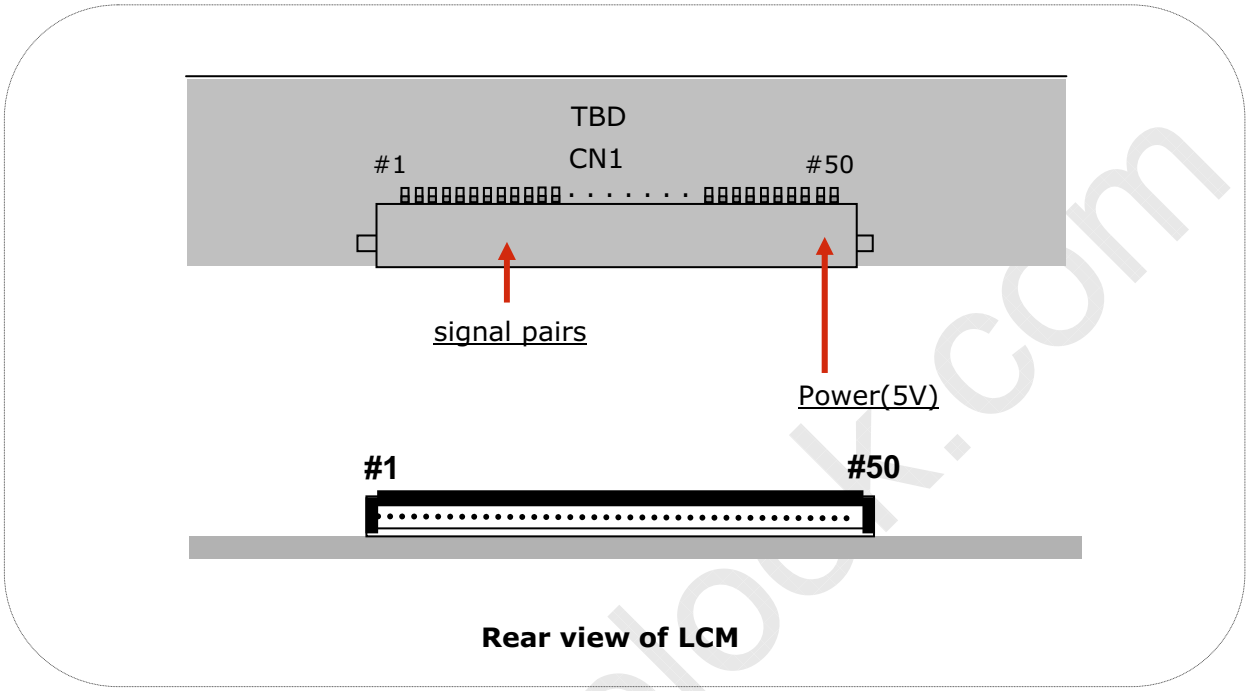
3-2. Interface connections

LCD connector(CN1) : TF19L-50S-0.5SH(Hirose) or Equivalent
Mating connector : 50pin FFC locking Cable

Table 4. Module connector(CN1) pin configuration

NO.	Symbol	Description	NO.	Symbol	Description
1	GND	Ground	26	POL	Polarity Control Signal
2	GND	Ground	27	CSC	Charge Share mode Control Signal
3	LV5-	Mini LVDS Receiver Signal(5-)	28	H2DOT	Horizontal 2 Inversion Signal
4	LV5+	Mini LVDS Receiver Signal(5+)	29	GND	Ground
5	GND	Ground	30	ICLK_RESET	Vertical Start Pulse
6	LV4-	Mini LVDS Receiver Signal(4-)	31	ICLK1	GIP GATE Clock 1
7	LV4+	Mini LVDS Receiver Signal(4+)	32	ICLK2	GIP GATE Clock 2
8	GND	Ground	33	ICLK3	GIP GATE Clock 3
9	LV3-	Mini LVDS Receiver Signal(3-)	34	ICLK4	GIP GATE Clock 4
10	LV3+	Mini LVDS Receiver Signal(3+)	35	IVDD-O	GIP Panel VDD for Odd GATE TFT
11	GND	Ground	36	IVDD-E	GIP Panel VDD for Even GATE TFT
12	LVCLK-	Mini LVDS Receiver Clock Signal(-)	37	FLK2	GPM Control Clock
13	LVCLK+	Mini LVDS Receiver Clock Signal(+)	38	FLK1	GPM Control Clock
14	GND	Ground	39	GND	Ground
15	LV2-	Mini LVDS Receiver Signal(2-)	40	SDA	I2C Data
16	LV2+	Mini LVDS Receiver Signal(2+)	41	SCL	I2C Clock
17	GND	Ground	42	GND	Ground
18	LV1-	Mini LVDS Receiver Signal(1-)	43	VIN	Input Voltage
19	LV1+	Mini LVDS Receiver Signal(1+)	44	VIN	Input Voltage
20	GND	Ground	45	VIN	Input Voltage
21	LV0-	Mini LVDS Receiver Signal(0-)	46	VIN	Input Voltage
22	LV0+	Mini LVDS Receiver Signal(0+)	47	VIN	Input Voltage
23	GND	Ground	48	VIN	Input Voltage
24	SOE	Source Output Enable SIGNAL	49	GND	Ground
25	POL2	Polarity Control Signal	50	GND	Ground

FIG. 4 Connector diagram



Rear view of LCM

Note:

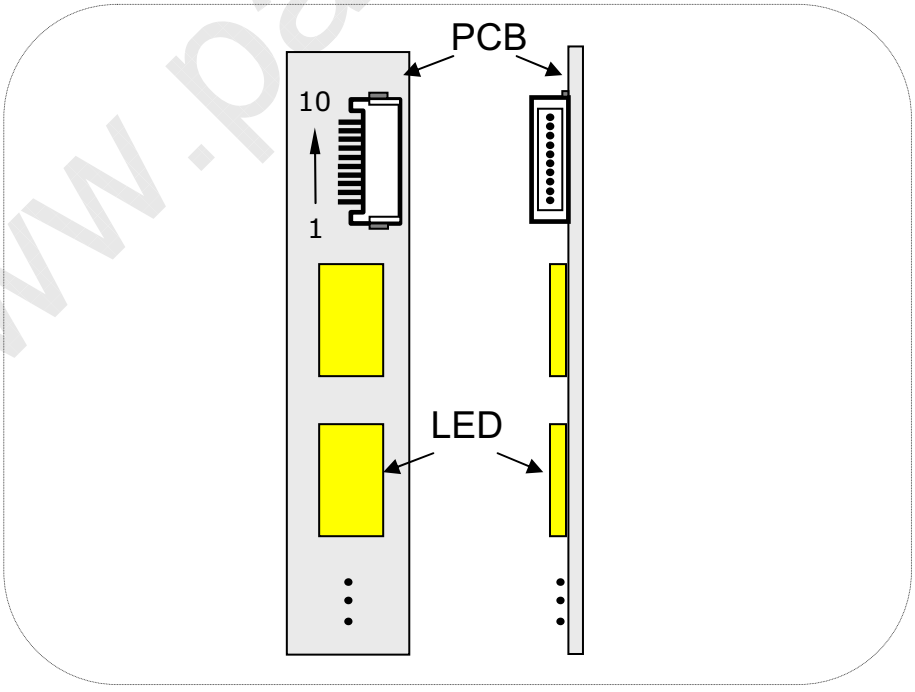
1. NC: No Connection.
2. All GND(ground) pins should be connected together and to Vss which should also be connected to the LCD's metal frame.
3. All V_{LCD} (power input) pins should be connected together.
4. Input Level of Mini-LVDS signal is based on the Source D-IC Spec

The LED interface connector is a model 10FH-SM1-GAN-TB 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.

Table 5. LED connector pin configuration

Pin No.	Symbol	Description	Notes
1	FB1	Channel1 Current Feed Back	
2	FB2	Channel2 Current Feed Back	
3	X	N/C	
4	X	N/C	
5	Vled	LED Power Supply (Common Input)	
6	Vled	LED Power Supply (Common Input)	
7	X	N/C	
8	X	N/C	
9	FB3	Channel3 Current Feed Back	
10	FB4	Channel4 Current Feed Back	

FIG. 5 Backlight connector view



3-3. Mini-LVDS characteristics

3-3-1. Signal Timing Specifications

Table 6. ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Condition	MIN	TYP	MAX	Unit	Note
Mini-LVDS Clock frequency	CLK	3.0V≤VCC ≤3.6V	160		290	MHz	
mini-LVDS input Voltage (Center)	V_{IB}	Mini-LVDS Clock and Data	0.9		(VCC-1.2) − VID / 2	V	5
mini-LVDS input Voltage Distortion (Center)	ΔV_{IB}				0.8	V	
mini-LVDS differential Voltage range	V_{ID}		0.2		0.7	V	
mini-LVDS differential Voltage range Dip	ΔV_{ID}		0.025		0.7	V	

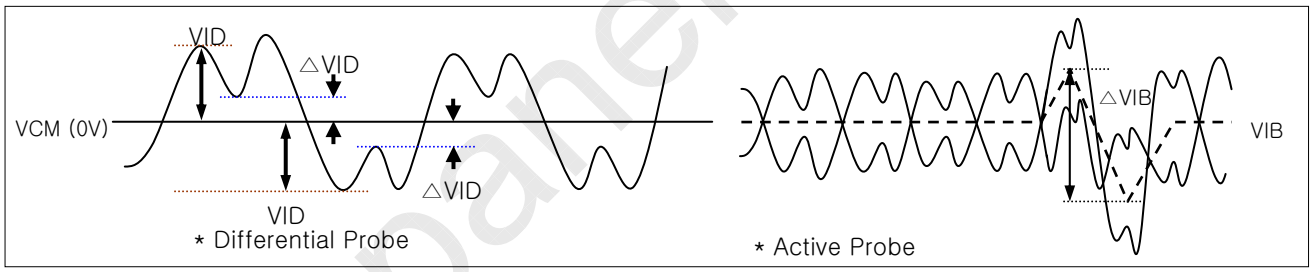


FIG. 6 Description of VID, ΔVIB, ΔVID

3-3-1. Signal Timing Specifications

Table 7. Timing Requirements

Parameter	Symbol	Condition	Min	Typ	Max	Unit	Note
Mini Clock pulse period	T_1		3.45	-		ns	1
Mini Clock pulse low period	T_2		1.6	-	-	ns	
Mini Clock pulse high period	T_3		1.6	-	-	ns	
Mini Data setup time	T_6		0.7	-	-	ns	
Mini Data hold time	T_7		0.7	-	-	ns	
Reset low to SOE rising time	T_8		0	-	-	ns	
SOE to Reset input time	T_9		200	-	-	ns	
Receiver off to SOE timing	T_{10}		5	-	-	CLK cycle	
POL signal to SOE setup time	T_{11}		-5	-	-	ns	
POL signal to SOE hold time	T_{12}		6	-	-	ns	
Reset High Period	T_{13}		3			CLK cycle	
SOE signal Pulse Width	T_{14}		200			ns	

Note : 1. 290 MHz Clock Frequency @ 3.0<VCC<3.6,
2. Setup time and hold time couldn't be satisfied at the same time

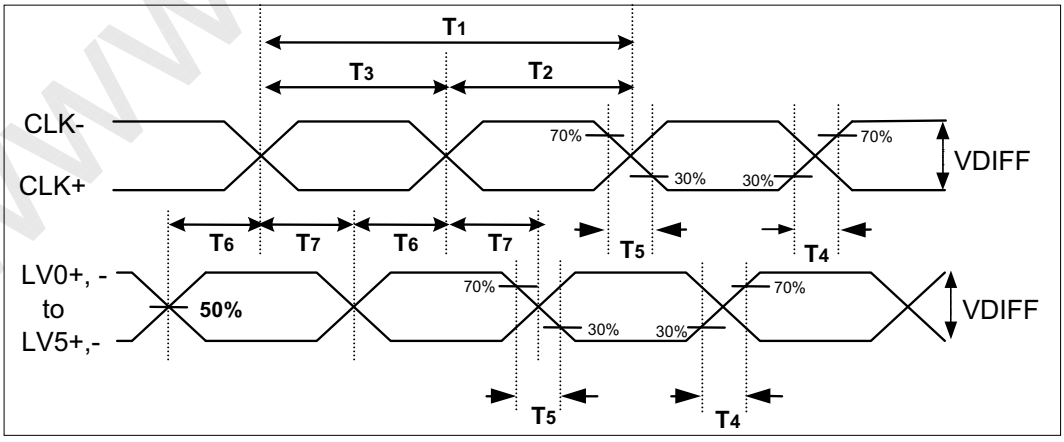


FIG. 7 Source D-IC Input Data Latch Timing Waveform

3-3-1. Signal Timing Specifications

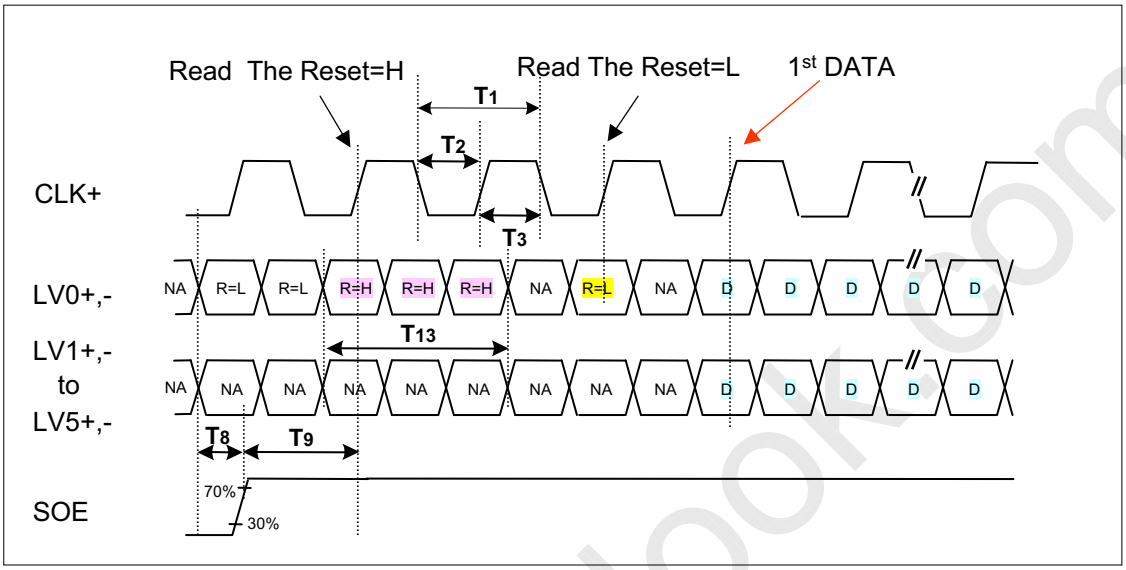


FIG. 8 Input Data Timing for 1st Source D-IC Chip

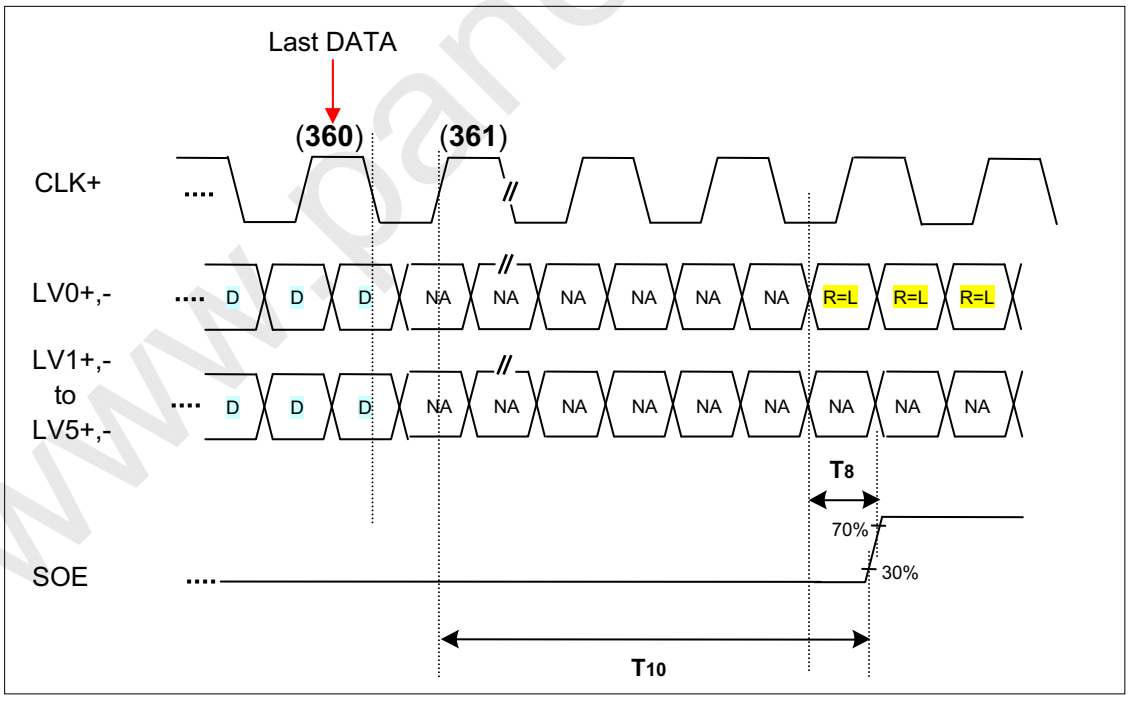


FIG. 9 Last Data Latch to SOE Timing

3-3-1. Signal Timing Specifications

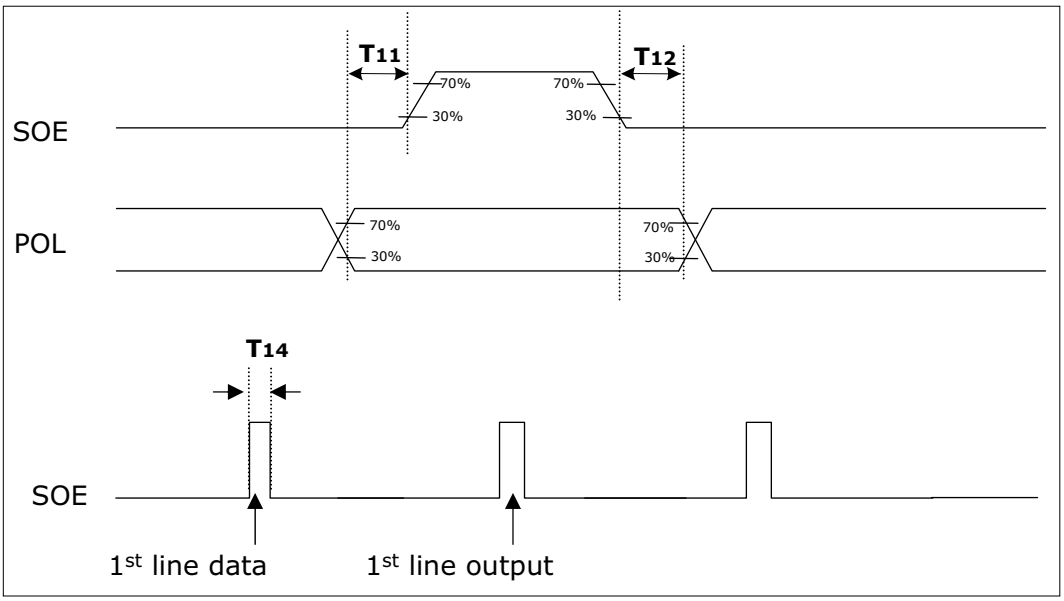


FIG. 10 POL and SOE Timing Waveform

3-3-2. Data Mapping and Timing

Display data and control signal (RESET) are input to LV0 to LV5.

1) Control signal input mode

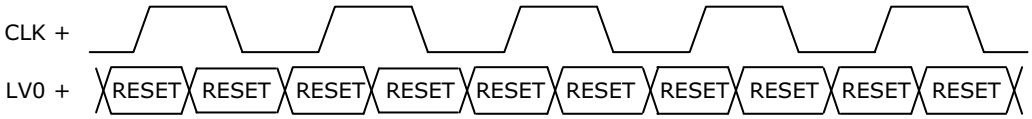


FIG. 11 Mini-LVDS Data

2) Display data input mode

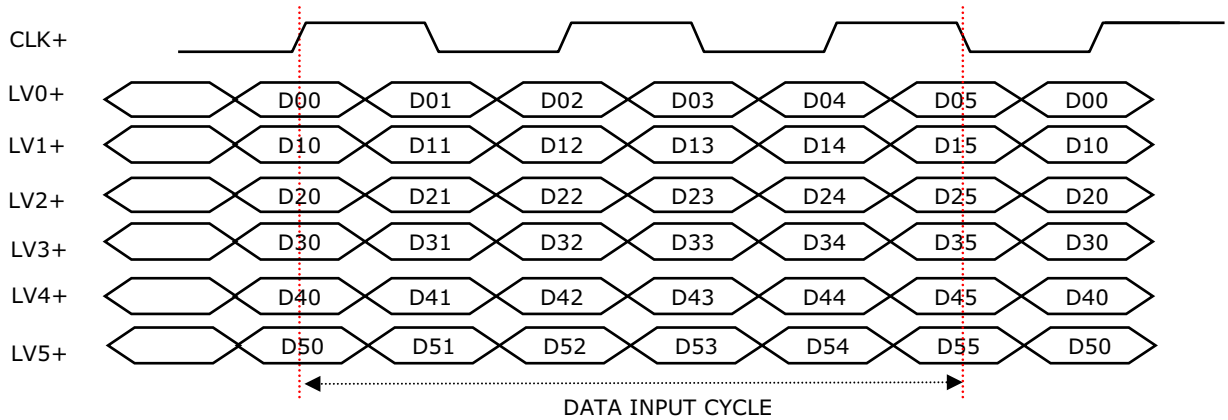


FIG 12. Mini-LVDS Data

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.

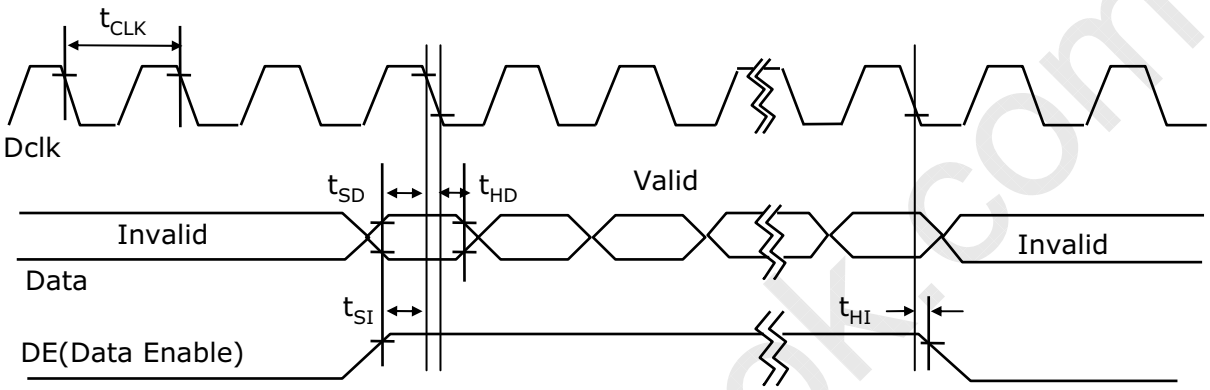
Table 8. Timing table

Parameter		Symbol	Min.	Typ.	Max.	Unit	Notes
D_{CLK}	Period	t_{CLK}	11.43	13.89	16.7	ns	Pixel frequency : Typ.144MHz
	Frequency	f_{CLK}	60	72	87.5	MHz	
Horizontal	Horizontal Valid	t_{HV}	960	960	960	t_{CLK}	
	H Period Total	t_{HP}	1024	1088	1120		
	Hsync Frequency	f_H	64	66	83	kHz	
Vertical	Vertical Valid	t_{VV}	1080	1080	1080	t_{HP}	
	V Period Total	t_{VP}	1090	1100	1160		For D_{CLK}
	Vsync Frequency	f_V	50	60	75	Hz	
DE (Data Enable)	DE Setup Time	t_{SI}	4	-	-	ns	
	DE Hold Time	t_{HI}	4	-	-		
Data	Data Setup Time	t_{SD}	4	-	-	ns	For D_{CLK}
	Data Hold Time	t_{HD}	4	-	-		

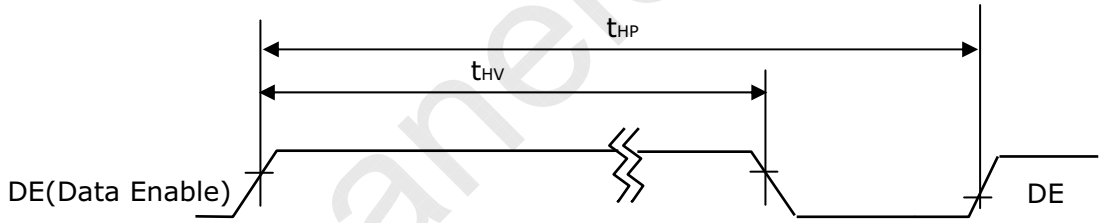
Note:
1. DE Only mode operation. The input of Hsync & Vsync signal does not have an effect on LCD normal operation.
2. The performance of the electro-optical characteristics may be influenced by variance of the vertical refresh rates.
3. Horizontal period should be even.

3-5. Signal timing waveforms

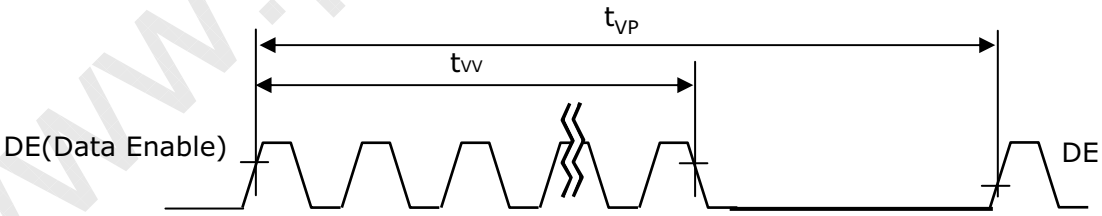
1. DCLK , DE, DATA waveforms



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 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(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
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	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
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	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
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	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

3-7. LCD Driving circuit

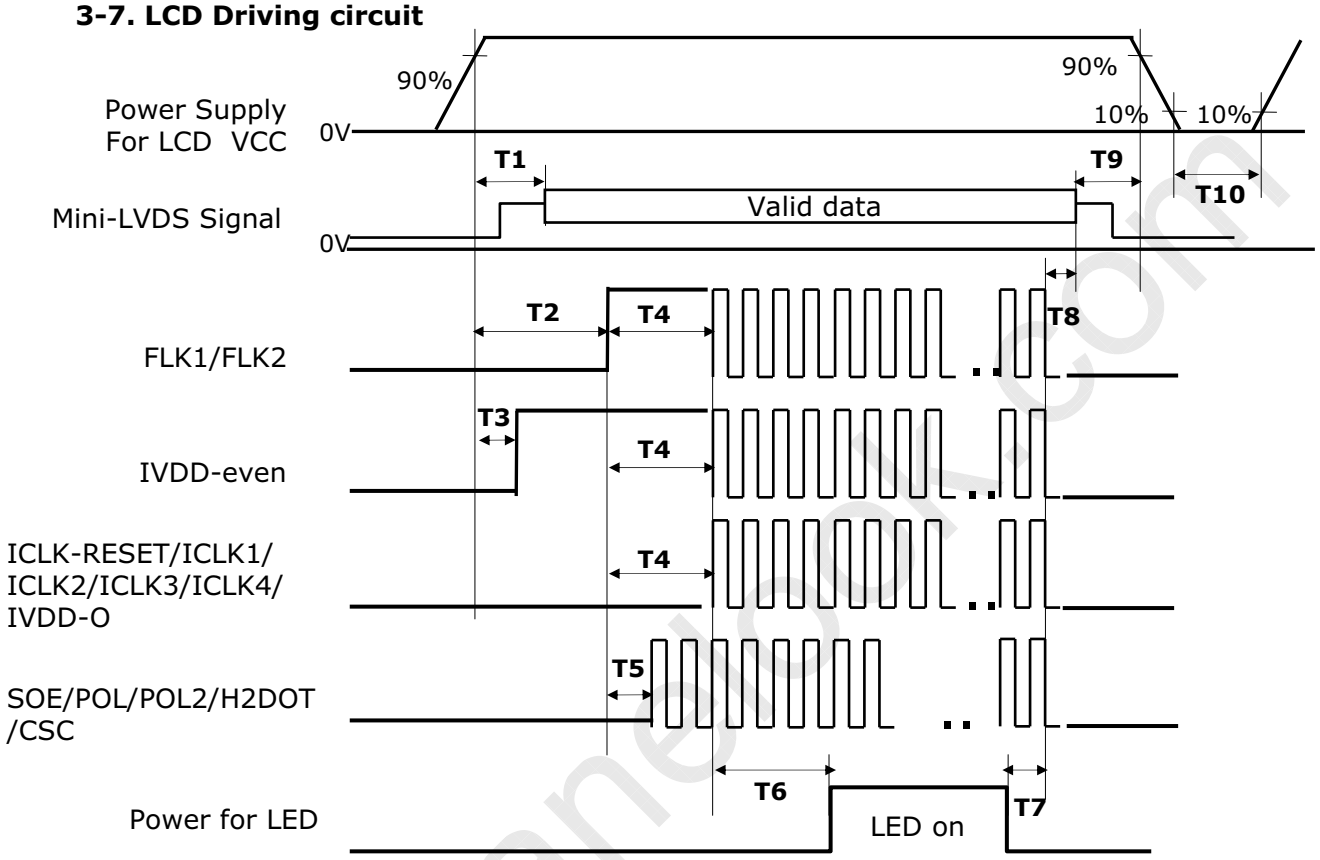


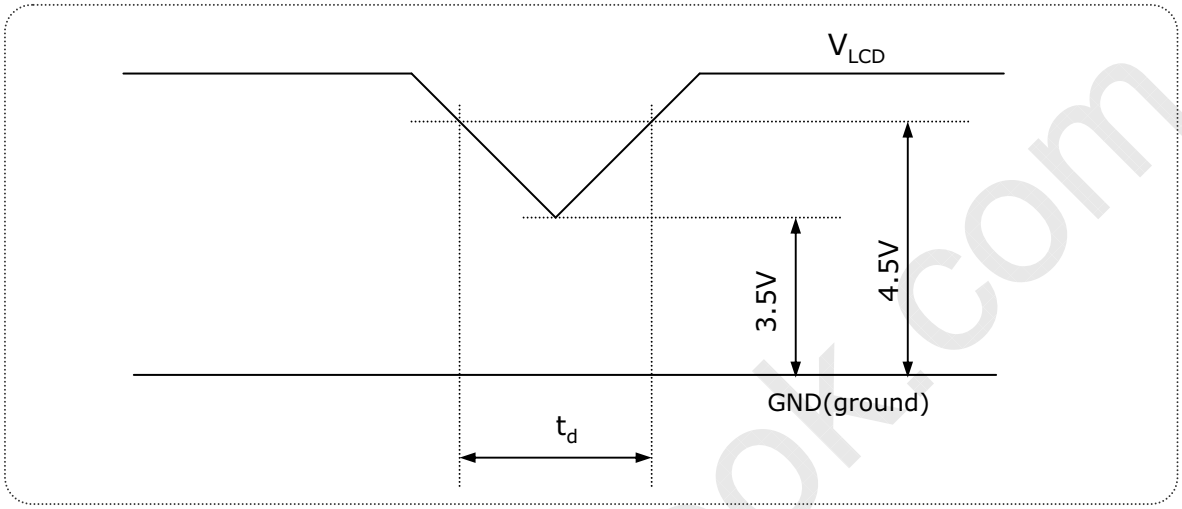
Table 10. POWER SEQUENCE

Parameter	Value			Unit	Notes
	Min	Typ	Max		
T1	0	-	500	ms	
T2	30	-	500	ms	
T3	0	-	30	ms	
T4	60	-	-	ms	
T5	0	-	60	ms	
T6	500	-	-	ms	
T7	200	-	-	ms	
T8	0.01	-	-	s	
T9	0.01	-	-	s	
T10	1	-	-	s	

Note : 1. The Source D-IC power on sequence must be VCC, logic input, VDD, Gamma ref.
2. IVDD Even signal should be started "High" status.
3. IVDD even & odd can not be "High at the same time.
4. ICLK On Sequence : ICLK1 → ICLK2 → ICLK3 → ICLK4
5. Power Off Sequence order is reverse of Power On Condition including Source D-IC and ILCK.

3-8. V_{LCD} Power dip condition

FIG. 13 Power dip condition



1) Dip condition

3.5V ≤VLCD < 4.5V , td≤20ms

2) VLCD < 3.5V

VLCD-dip conditions should also follow the Power On/Off conditions for supply voltage.

4. Optical specification

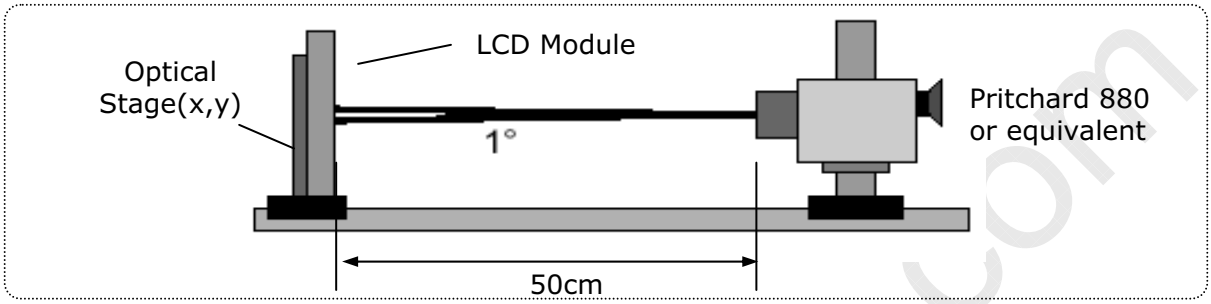
Optical characteristics are determined after the unit has been 'ON' for 30 minutes in a dark environment at 25°C.

Table 11. Optical characteristics Ta=25 °C, V_{LCD}=5.0V, f_V=60Hz, D_{CLK}=72MHz, Is=60mA

Parameter		Symbol	Values Min	Values Typ	Values Max	Units	Notes
Contrast Ratio		CR	700	1000	-		1 (PR-880)
Surface Luminance, white		L_{WH}	200	250	-	cd/m²	2 (PR-880)
Luminance Variation		δ_{WHITE} 9P	75	-	-	%	3 (PR-880)
Response Time	Rise Time	Tr_R	-	1.3	2.6	ms	4 (RD80S)
	Decay Time	Tr_D	-	3.7	7.4	ms	
Color Coordinates [CIE1931]	RED	Rx	Typ -0.03	0.627	Typ +0.03		(PR-650)
		Ry		0.347			
	GREEN	Gx		0.338			
		Gy		0.620			
	BLUE	Bx		0.155			
		By		0.049			
	WHITE	Wx		0.313			
		Wy		0.329			
Viewing Angle (CR>5)							6 (PR-880)
	x axis, right(?=0°)	?r	75	88		Degree	
	x axis, left (?=180°)	?l	75	88			
	y axis, up (?=90°)	?u	70	85			
	y axis, down (?=270°)	?d	70	85			
Viewing Angle (CR>10)							
	x axis, right(?=0°)	?r	70	85		Degree	
	x axis, left (?=180°)	?l	70	85			
	y axis, up (?=90°)	?u	60	75			
	y axis, down (?=270°)	?d	70	85			
Crosstalk					1.5	%	7 (PR880)
Luminance uniformity - Angular dependence (TCO'03)		LR	-	-	1.7		8 (PR880)
Color grayscale linearity		Δu'v'		0.018			10 (PR-650)

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. 14 presents additional information concerning the measurement equipment and method.

FIG. 14 Optical characteristic measurement equipment and method



Notes :

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

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

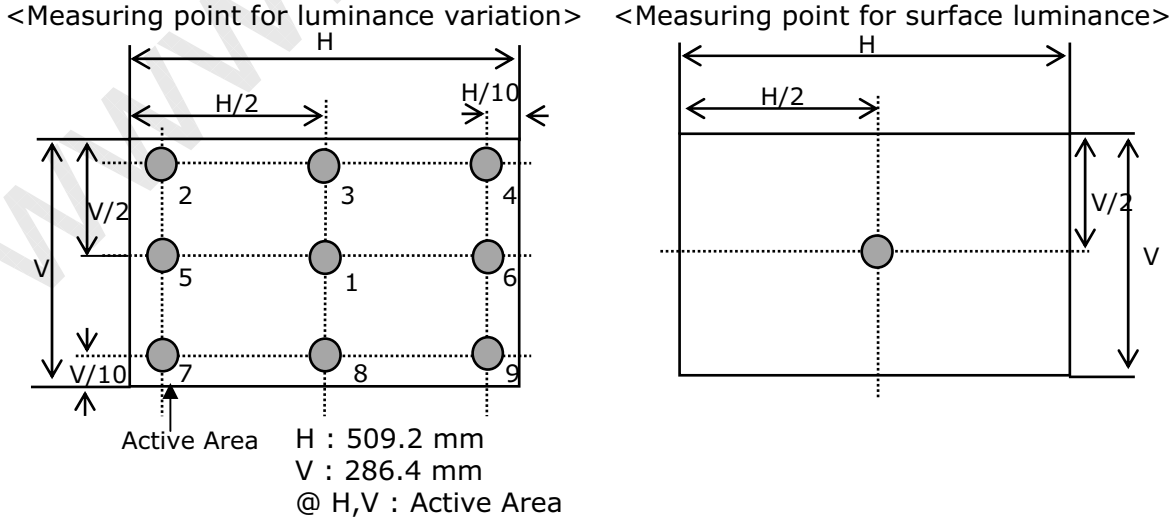
2. Surface luminance is the luminance value at center 1 point(1) across the LCD surface 50cm from the surface with all pixels displaying white. For more information see FIG 15.

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. 15 Luminance measuring point

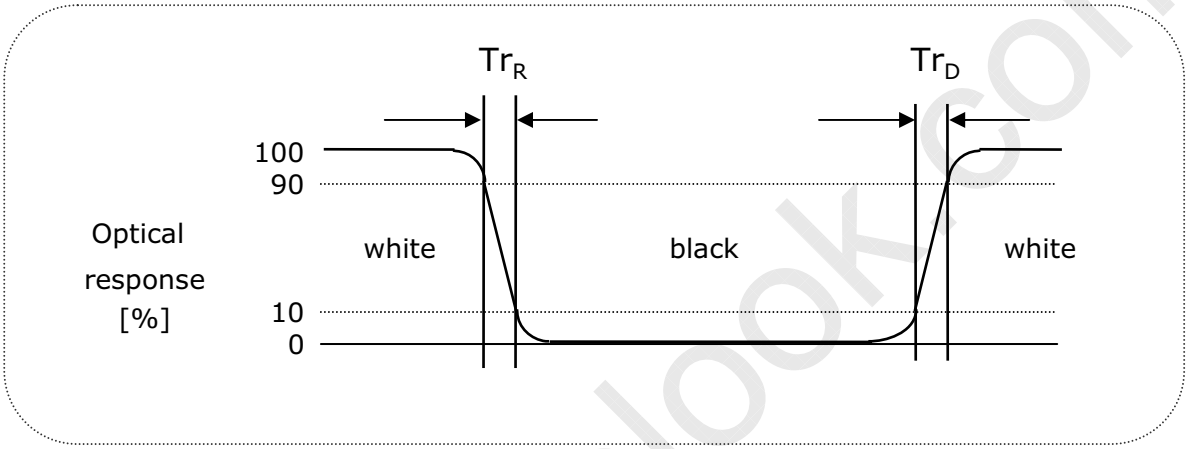


Notes :

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. 16.

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

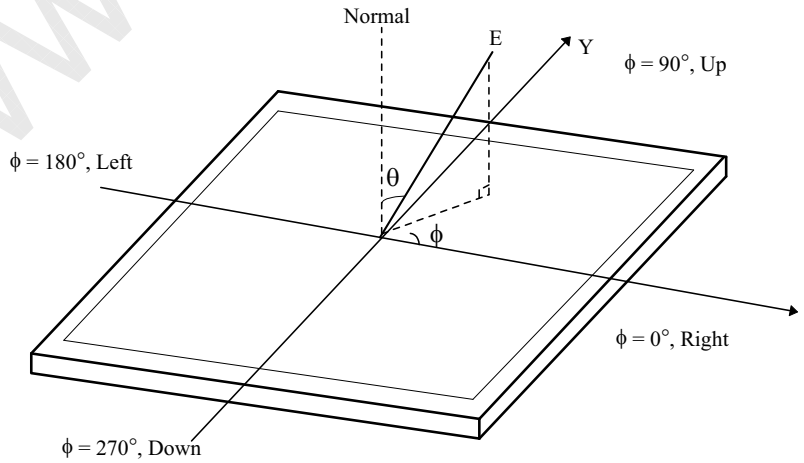
FIG. 16 Response time



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. 17.

FIG. 17 Viewing angle

<Dimension of viewing angle range>



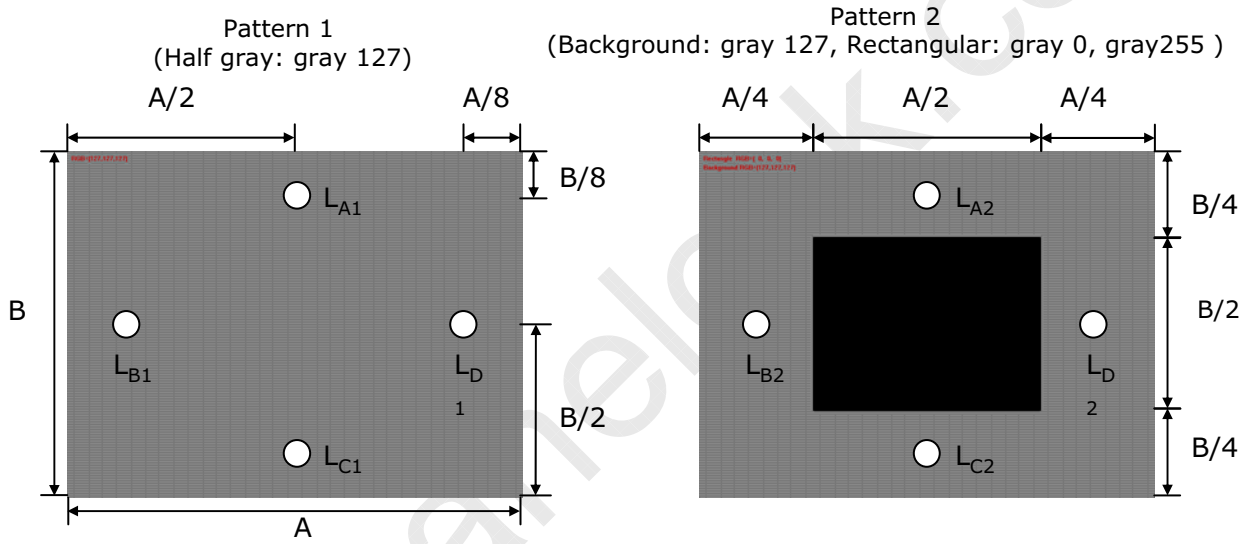
Notes :

6. 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]

For more information see Figure 18.

FIG. 18 Crosstalk measuring point



Notes :

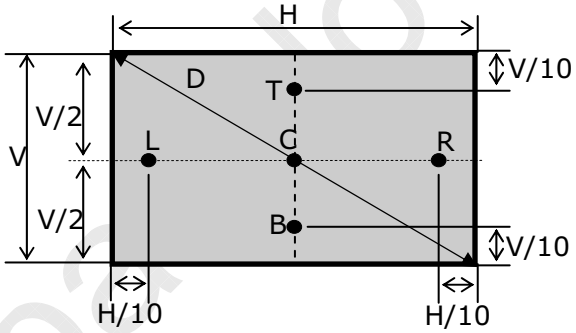
7. Luminance Uniformity - angular – dependence (LR& TB)

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 * 1.5 = 87.63
- Test method : LR = ((Lmax.+30deg. / Lmin. +30deg.) + (Lmax. -30deg. / Lmin. -30deg.)) / 2
  TB = ((Lmax.+15deg. / Lmin. +15deg.)

FIG. 19 Luminance Uniformity angular dependence

< Luminance uniformity - angular dependence measuring point >



8. Gray scale specification

Table 12. Gray scale

Gray level	Luminance [%] (Typ)
L0	0.1
L31	1.23
L63	4.98
L95	12.30
L127	23.58
L159	40.03
L191	61.30
L223	84.03
L255	100

Notes :

9. Color grayscale linearity , ∆u'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 ∆u' and ∆v' of each 6pairs of u' and v' and calculate ∆u'v' .

-Test pattern :

100% full white pattern with a test pattern as shown FIG.20
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 :

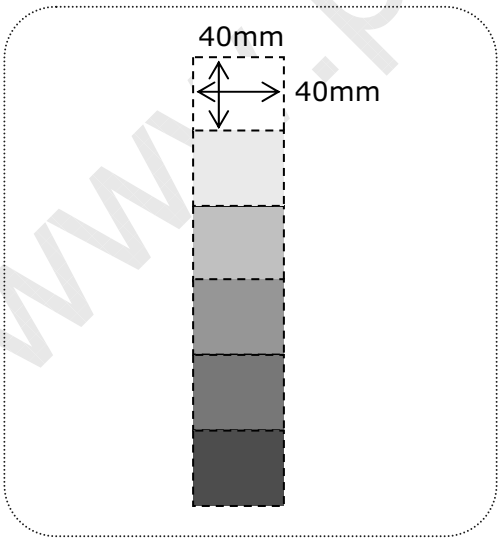
First gray step :

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.

FIG. 20 Color grayscale linearity



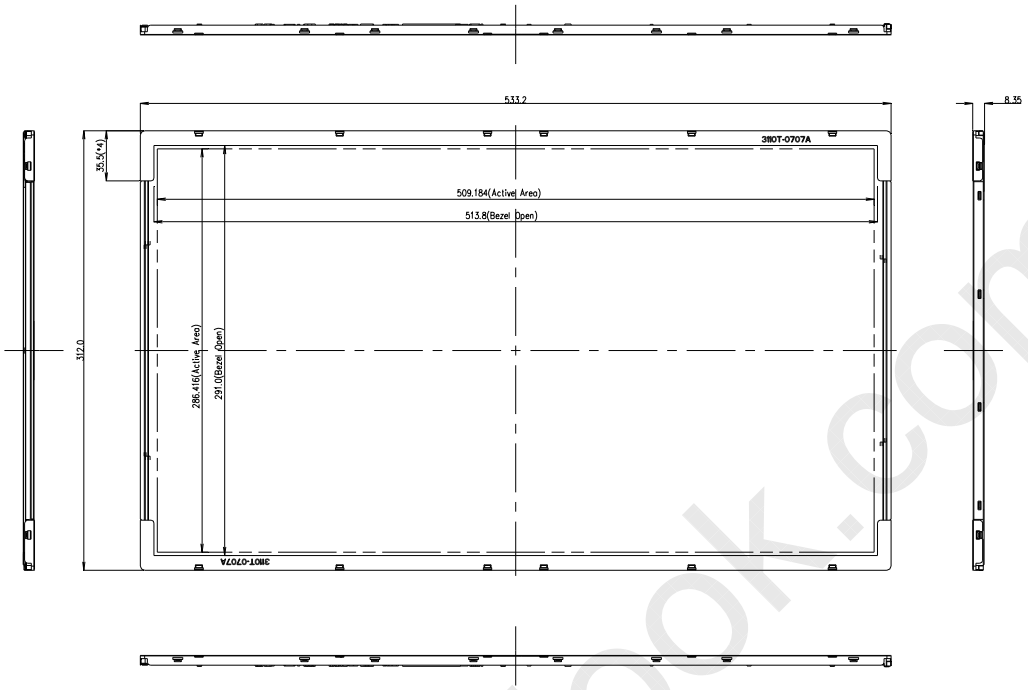
5. Mechanical characteristics

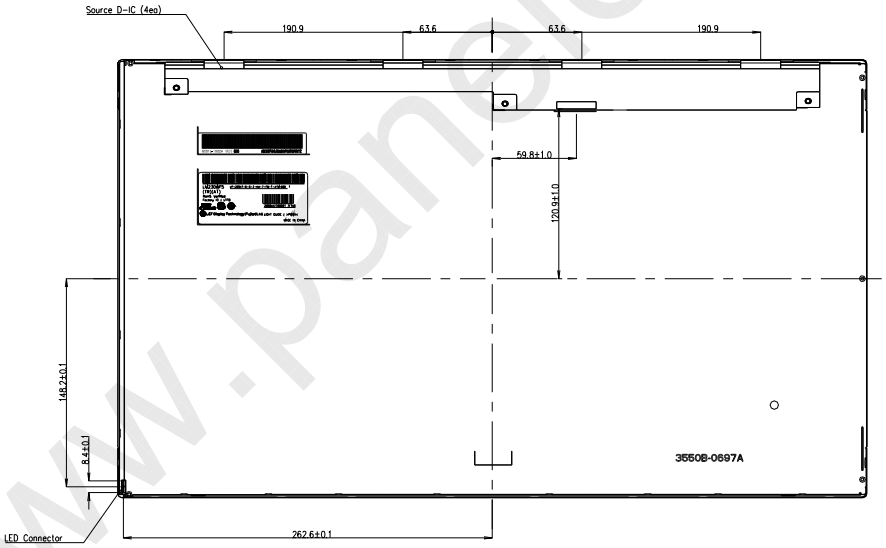
The contents provide general mechanical characteristics. In addition the figures in the next page are detailed mechanical drawing of the LCD.

Table 13. Mechanical characteristics

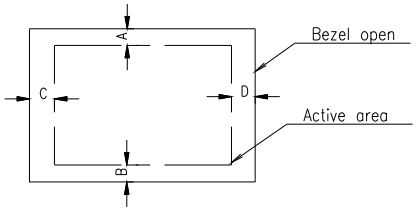
Outline dimension	Horizontal	533.2 mm
	Vertical	312 mm
	Depth	8.3 mm
Bezel area	Horizontal	513.8 mm
	Vertical	291 mm
Active display area	Horizontal	509.2mm
	Vertical	286.4mm
Weight	1490 g (Typ.) 1565g (Max.)	
Surface treatment	Hard coating(3H) Anti-glare treatment of the front polarizer	

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





Notes
1. Backlight : 1 LED Array ass'y
2. I/F Connector Specification : TF19L-50S-0.5SH (HIROSE) or Equivalent
3. LED Connector Specification : FH-SM1-GAN_10PIN (JST)
4. Tilt and partial disposition tolerance of display area as following
   (1) Y-Direction : IA-BI ≤ 1.0
   (2) X-Direction : IC-DI ≤ 1.0



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

6. International Standards

6-1. 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.

6-2. 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.

6-3. Environment

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

7. Precautions

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

7-1. 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.

7-2. 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 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.

7-3. 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.

7-4. Precautions for strong light exposure

Strong light exposure causes degradation of polarizer and color filter.

7-5. 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.

7-6. 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.