SPECIFICATION

[◉] Preliminary Specification
[ ] Final Specification

Description **12.1” 800xRGBx600 TFT-LCD Module**

Part Number **P1210SVF1ME00**

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* This cover page is for your Comments and Signatures back to TIANMA.

Rev	Date	Page	Revision Items	Editor
1.0	2024/01/17	All	Preliminary Specification release	Hongwei Liu
1.1	2024/11/05	1	Add power consumption	Hongwei Liu
1.1	2024/11/05	2	Correct the description of PIN 19	Hongwei Liu
1.1	2024/11/05	4&5	Add data of panel & backlight driving	Hongwei Liu
1.1	2024/11/05	12	Correct the figure of input tining	Hongwei Liu
1.1	2024/11/05	13	Add data of chromaticity	Hongwei Liu

CONTENTS

1. Summary

1.1 General Description

This is a 12.1 inch a-Si TFT-LCD module with Normal- Black technology. It is composed of a TFT-LCD panel, a driver circuit, PCB, and a LED backlight unit.

1.2 Features

- Ultra-wide viewing angle
- Interface: 1port LVDS, 6/8bit selectable
- LED driver integrated
- Surface treatment: Anti-Glare

- Compliant with the European RoHS Directive (2011/65/EU) and Delegated Directive (2015/863/EU, Amending Annex II of 2011/65/EU)

2. General Specifications

Feature		Spec	Unit
Display Spec	Size	12.1 inches	
	Resolution	800(RGB)x600	
	Pixel Pitch	0.3075(H) × 0.3075(V)	mm
	TFT Active Area	246.0 (H) × 184.5 (V)	mm
	Technology Type	a-Si	
	Pixel Configuration	R.G.B Vertical Stripe	
	Display Mode	SFT, Normally Black	
	Surface Treatment	Anti-Glare	
	Viewing Direction	ALL	
Mechanical Characteristics	LCM (W x H x D)	279.0 (H) ×209.0 (V) ×9.0 (D)	mm
	Weight	TBD	g
Optical Characteristics	Luminance	350	cd/m^2
	Contrast Ratio	1000	
	NTSC	72	%
	Viewing Angle	88/88/88/88	degree
Electrical Characteristics	Interface	1port LVDS, 6/8bit selectable （DE mode only）	
	Color Depth	16.7M/262K	color
	Power Consumption	LCD:1006.5 Backlight: 4500	mW

Table 2.1 General TFT Specifications

3. Input / Output Terminals

3.1 CN1 Pin assignment (LCD Interface)

Connector Information	
LCD Module connector	CN1: MSB240420HE (Produced by STM) or equivalent.
Matching connector	P240420H Terminal: 2404PS-00

Table 3.1.1 Connector information

No	Symbol	I/O	Description	Comment
1	VCC	P	3.3V Power Supply	
2	VCC	P	3.3V Power Supply	
3	GND	P	Ground	
4	6-8Bit SET	I	Select 6 or 8 Bits LVDS Input (VCC/NC:8Bits ; GND: 6Bits)	
5	RIN0-	I	Negative(-) LVDS differential data input	
6	RIN0+	I	Positive(+) LVDS differential data input	
7	GND	P	Ground	
8	RIN1-	I	Negative(-) LVDS differential data input	
9	RIN1+	I	Positive(+) LVDS differential data input	
10	GND	P	Ground	
11	RIN2-	I	Negative(-) LVDS differential data input	
12	RIN2+	I	Positive(+) LVDS differential data input	
13	GND	P	Ground	
14	CLKIN-	I	Clock Signal(-)	
15	CLKIN+	I	Clock Signal(+)	
16	GND	P	Ground	
17	RIN3-	I	Negative(-) LVDS differential data input (Used for 8Bits LVDS Input; GND for 6Bits)	
18	RIN3+	I	Positive(+) LVDS differential data input (Used for 8Bits LVDS Input; GND for 6Bits)	
19	REVERSE	I	Display Reversed Function (VCC: Display Reverse; GND/NC: Normal Display)	
20	NC/GND	/	Test Function Pin(Do not set this pin to High)	

Table 3.1.2 Pin Assignment for LCD Interface

Note1: I/O definition: I---Input, O---Output, P---Power/Ground, N---No connection

Note2: All of the GND pins should be connected to the system ground.

Note3: This LCD module supports SYNC-DE & DE mode, the pin setting is different from each other. Please refer to the descriptions.

3.2 CN2 Pin assignment (Back Light)

Connector Information	
LCD Module connector	MSB24038P5 (Produced by STM) or equivalent.
Matching connector	P24038P5 Terminal: 24038PS-00

Table 3.2.1 Connector information

No	Symbol	I/O	Description	Remark
1	VDD	P	12V	
2	GND	P	GND	
3	Enable	I	5V-On / 0V-Off	
4	Dimming	I	PWM Dimming	
5	NC	/	NC	

Table 3.2.2 Pin Assignment for Back Light Interface

Note1: I/O definition: I---Input, O---Output, P---Power/Ground, N---No connection
Note2: All of the GND pins should be connected to the system ground.

4. Absolute Maximum Ratings

Item	Symbol	MIN	MAX	Unit	Remark
Power Voltage	VCC	-0.5	5.0	V	Note1
Input voltage	V_{IN}	-0.5	5.0	V	
Digital input voltage	-	-0.3	VCC+0.3	V	Note1
Backlight Power Voltage	VDD	-0.3	33	V	
Backlight Input Voltage	V_{IN_BL}	-0.3	5.5	V	Note1
Operating Temperature	Top	-20	70	℃	
Storage Temperature	Tst	-30	80	℃	
Relative Humidity Note2	RH	--	≤95	%	Ta≤40℃
		--	≤85	%	40℃＜Ta≤50℃
		--	≤55	%	50℃＜Ta≤60℃
		--	≤36	%	60℃＜Ta≤70℃
		--	≤24	%	70℃＜Ta≤80℃
Absolute Humidity	AH	--	≤70	g/m³	Ta＞70℃

Table 4.1 Absolute Maximum Ratings

Note1: Input voltage include all input data., Including RINn±&CLKIN± & Including 6-8Bit SET & REVERSE.
Note2: Ta means the ambient temperature. It is necessary to limit the relative humidity to the specified temperature range. Condensation on the module is not allowed.
Note3: The absolute maximum rating values of this product are not allowed to be exceeded at any times. A module should be used with any of the absolute maximum ratings exceeded, the characteristics of the module may not be recovered, or in an extreme condition, the module may be permanently destroyed

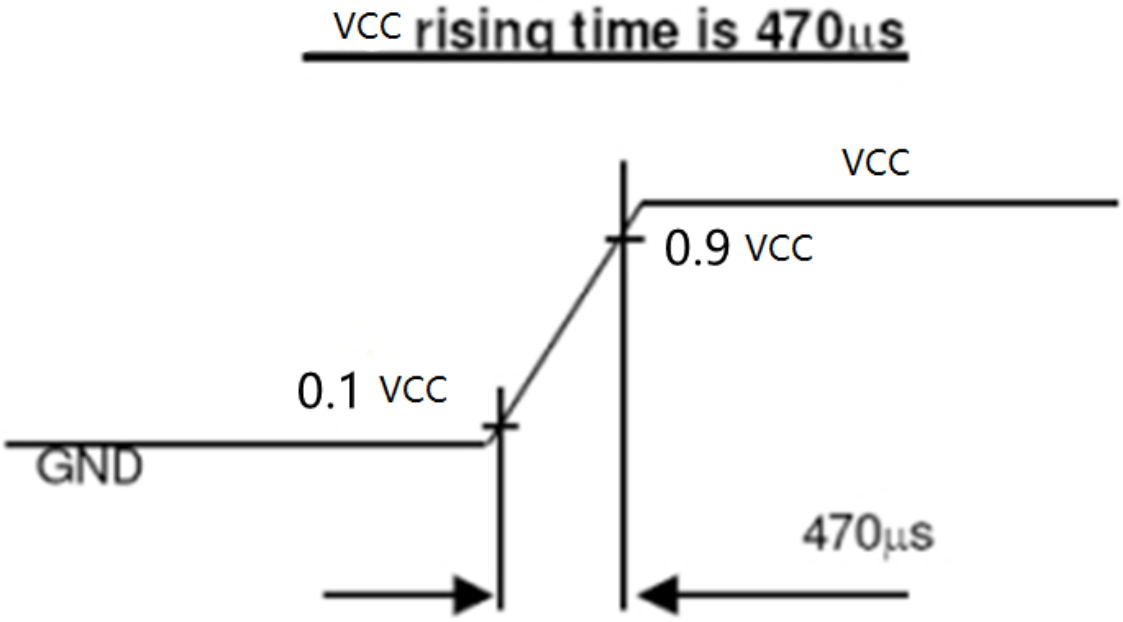
5. Electrical Characteristics

5.1 DC Characteristics for Panel Driving

Item		Symbol	MIN	TYP	MAX	Unit	Remark
Power Supply Voltage		VDD	3.0	3.3	3.6	V	
Power supply current		ICC	-	305	457.5	mA	at VCC = 3.3V Note 1
Input Signal Voltage	Low Level	VIL	DGND	--	0.3×VDD	V	
	High Level	VIH	0.7×VDD	--	VDD	V	
Output Signal Voltage	Low Level	VOL	DGND	--	DGND+0.4	V	
	High Level	VOH	VDD-0.4	--	VDD	V	
Permissible ripple voltage	VRP			200		mV	Permissible ripple voltage
LCD Power Consumption	60Hz	P	--	1006.5	1647	mW	White pattern

Table 5.1.1 Operating Voltages

Note 1: Indicated the subsequent version may be updated.
Note 2: Measurement Conditions:



5.2 DC Characteristics for Backlight Driving

Item		Symbol	Min	Typ	Max	Unit	Remark
Backlight power supply voltage		VDD	11.2	12	12.8	11.2	
Backlight power supply current		I_Total	-	375		-	Note1
Backlight power consumption		P_Total	-	4.5		-	
Input voltage for Dimming	High level	1.6	-	5	1.6	V	Input voltage for Dimming
	Low level	-	-	0.8	-	V	
Input voltage for Enable	High level	1.6	-	5	1.6	V	Input voltage for Enable
	Low level	-	-	0.8	-	V	
Dimming frequency		Fpwm	100	-	8K	100	
Dimming duty		D	1	-	100	1	Note2
PWM pulse width		-	5	-	-	us	
Inrush current		Inrush	-	0.71	1.2	A	Note5
LED Life Time		-	-	30000	-	H	Note6

Table 5.2.1 LED Backlight Characteristics

Note 1: I_Total is the power supply current of LED driver, P_Total is the power consumption of LED driver and backlight.

Note 2: According to LED driver IC characteristics, the minimum value of VBR duty may vary with VBR frequency, higher the frequency, bigger the duty.

Note 3: Optical performance should be evaluated at Ta=70℃ only with 100%PWM.

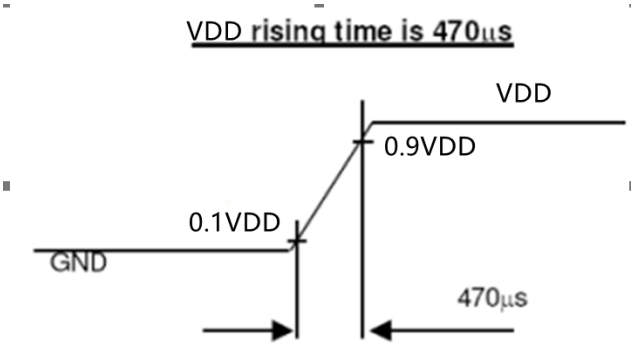
If LED is driven by high current, high ambient temperature & humidity condition. The life time of LED will be reduced.

Operating life means brightness goes down to 50% of initial brightness.

Operating life time is estimated data.

Note 4: Ta=25℃ only with 100%PWM, the other condition should follow Note3.

Note 5: In-rush current test conditions:



Note6: Optical performance should be evaluated at Ta=25℃.Only If LED is driven by high current, high ambient temperature & humidity condition. The life time of LED will be reduced. Operating life means brightness goes down to 50% of initial brightness. Typical operating life time is an estimated data.

5.3 Recommended Power ON/OFF Sequence

Item	Symbol	MIN	Typ	MAX	Unit	Remark
VCC on to VCC stable	Tp1	0.5	-	3	ms	
VCC stable to signal on	Tp2	20	-	100	ms	
Signal stable to ENABLE(BL_EN) on	Tp3	200	-	-	ms	
Dimming(BL_ PWM) on to ENABLE(BL_EN) on	Tp4	0	-	200	ms	
VDD to Dimming(BL_ PWM) on	Tp5	10	-	-	ms	
VDD on to VDD stable	Tp6	0.5	-	10	ms	
VCC off time	Tp7	0.5	-	10	ms	
VCC off to next VCC on	Tp8	500	-	-	ms	
Signal off before VCC off	Tp9	123	-	500	ms	
ENABLE(BL_EN) off before signal off	Tp10	200	-	-	ms	
ENABLE(BL_EN) off before Dimming(BL_ PWM) off	Tp11	0	-	200	ms	
Dimming(BL_ PWM)off before VDD off	Tp12	10	-	-	ms	

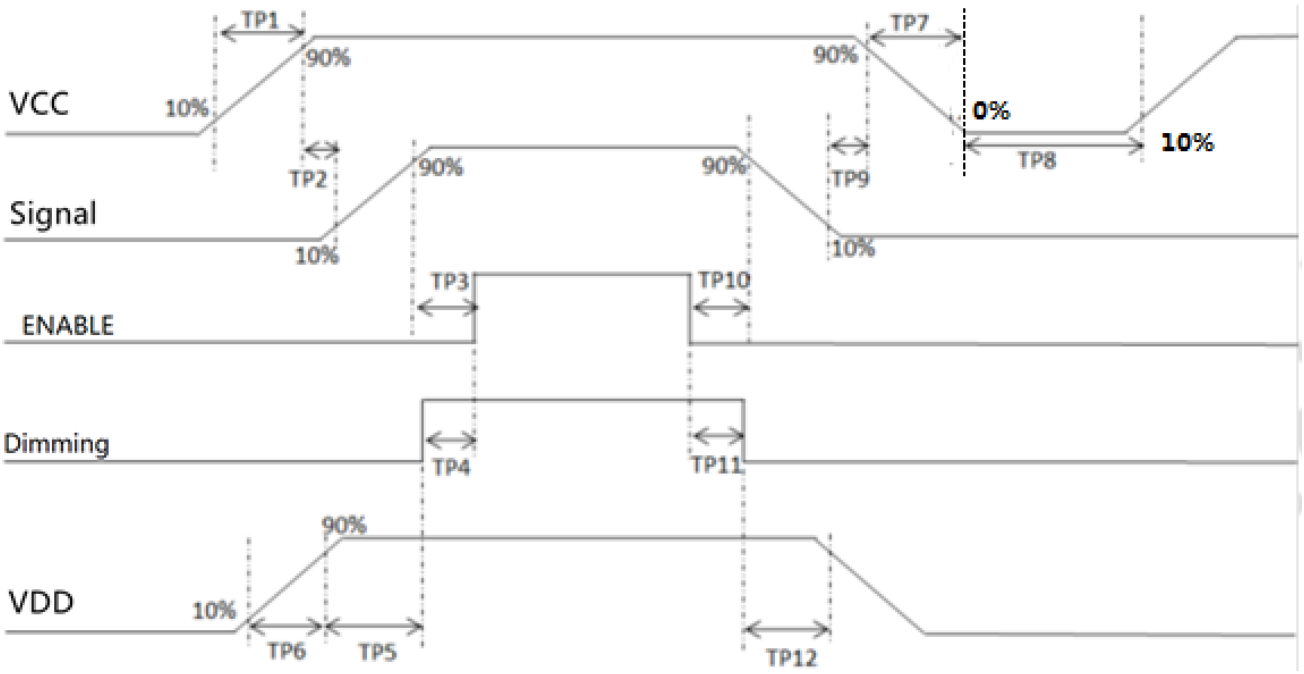


Figure 5.3.1 interface power on/off sequence

Note1: T1< T2.
Note2: The low level of these signals and analog powers are GND level.
Note3: All of the power and signals should be kept at GND level before power on. If there are residual voltages on them, the LCD might not work properly.
Note4: The power on/off sequence is the first version. It will be updated when the design is fixed.
Note5: BL is the voltage applied to backlight. Keep it turned off until the display has stabilized.

5.4 LCD Module Block Diagram

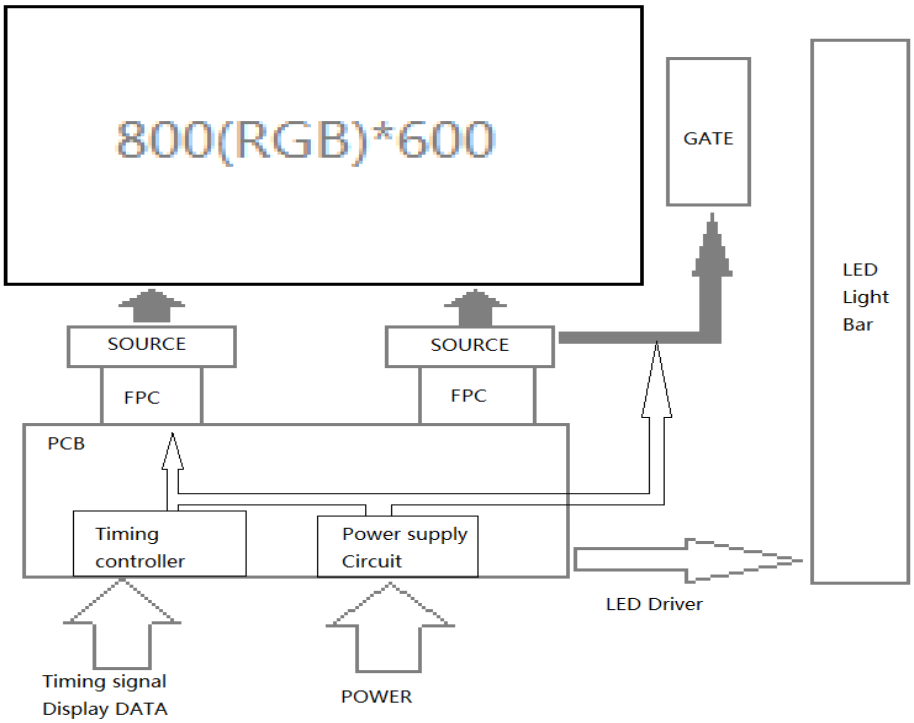


Figure 5.4.1 LCD Module Block Diagram

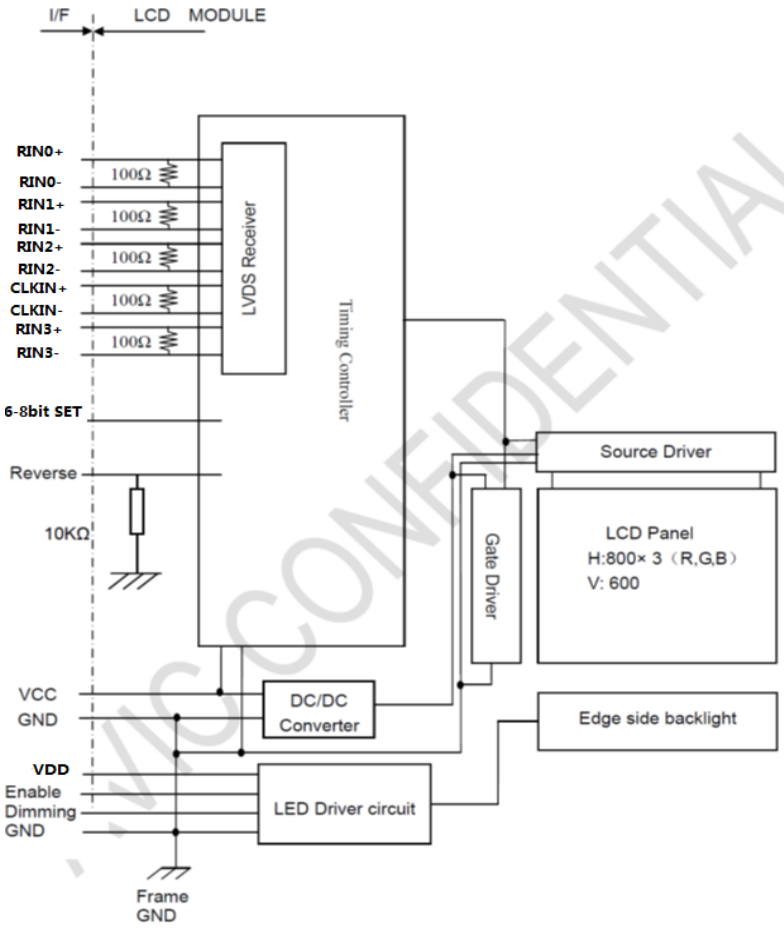


Figure 5.4.2 LCD Module Electrical Characteristics

6. Display colors and input data signals

This product can display in equivalent to 16.7M colors in 256 scales. Also the relation between display colors and input data signals is as the following table.

Display colors		Data signal (0:Low level , 1:High Level)																							
		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
	Blue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	Red	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	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
	Green	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	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
	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 grayscale	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
	Dark	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	↑	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		:								:								:							
	↓	:								:								:							
	Bright	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	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		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 grayscale	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
	Dark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	↑	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		:								:								:							
	↓	:								:								:							
	Bright	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	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
		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 grayscale	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
	Dark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	↑	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
		:								:								:							
	↓	:								:								:							
	Bright	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

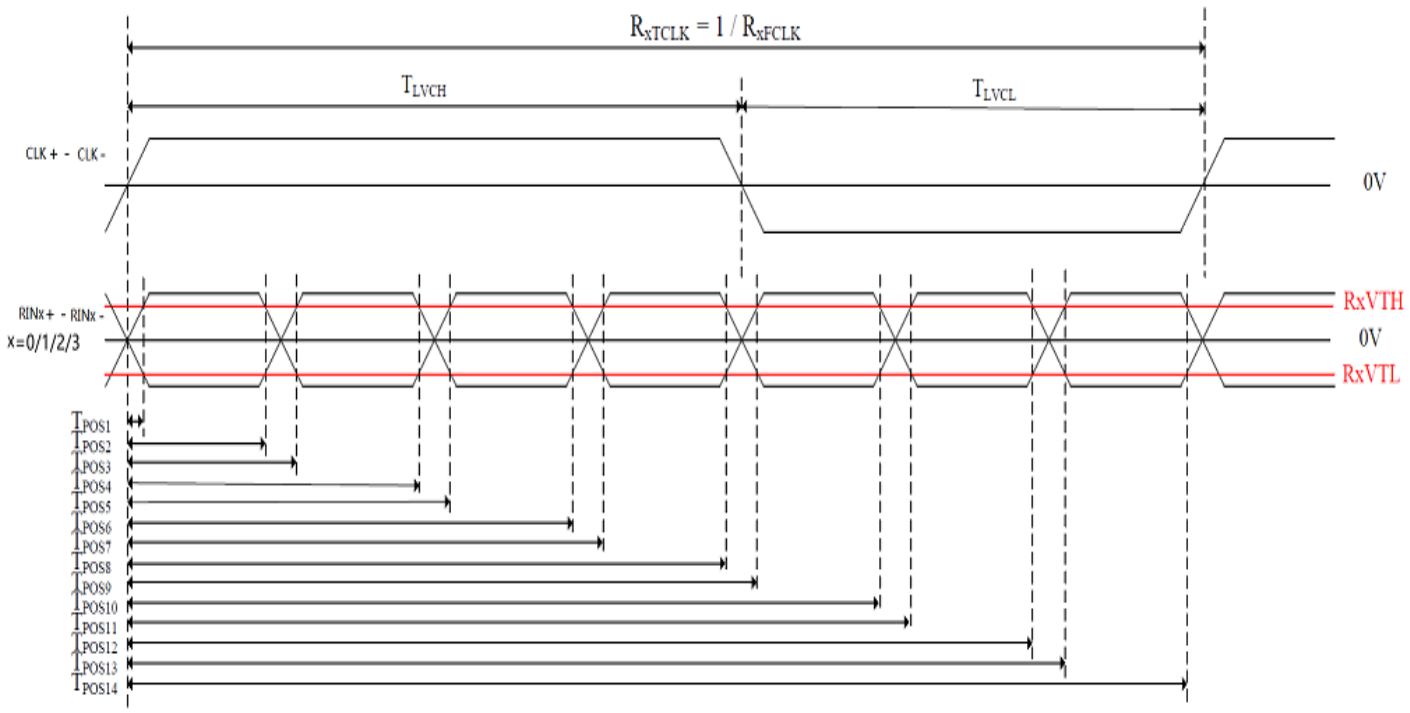
7. Timing Characteristics

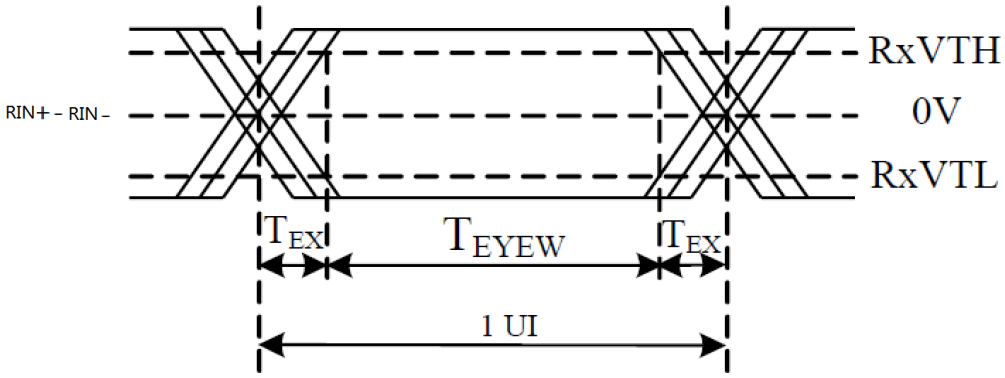
7.1 DC Characteristics

Parameter	Symbol	Min	Typ.	Max.	Unit	Conditions
Input leakage current	ILEAK	-	-	+/-1	uA	CMOS I/F digital circuit
Pull low/high resistor	RPULL	180K	250K	320K	ohm	For the digital input pin @VCC=3.3V

7.2 LVDS AC Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Conditions
Clock Frequency	R_{xFCLK}	20		80	MHz	
Clock Period	R_{xTCLK}	12.5		50	ns	
1 data bit time	UI	-	1/7	-	R_{xTCLK}	
Clock high time	T_{LVCH}		4		UI	
Clock low time	T_{LVCL}		3		UI	
Position 1	T_{POS1}	-0.25	0	0.25	UI	
Position 2	T_{POS2}	0.75	-	1.25	UI	
Position 3	T_{POS3}	0.75	1	1.25	UI	
Position 4	T_{POS4}	1.75	-	2.25	UI	
Position 5	T_{POS5}	1.75	2	2.25	UI	
Position 6	T_{POS6}	2.75	-	3.25	UI	
Position 7	T_{POS7}	2.75	3	3.25	UI	
Position 8	T_{POS8}	3.75	-	4.25	UI	
Position 9	T_{POS9}	3.75	4	4.25	UI	
Position 10	T_{POS10}	4.75	-	5.25	UI	
Position 11	T_{POS11}	4.75	5	5.25	UI	
Position 12	T_{POS12}	5.75	-	6.25	UI	
Position 13	T_{POS13}	5.75	6	6.25	UI	
Position 14	T_{POS14}	6.75	-	7.25	UI	
Input eye width	T_{EYEW}	0.5	-	-	UI	
Input eye border	T_{EX}	-	-	0.25	UI	

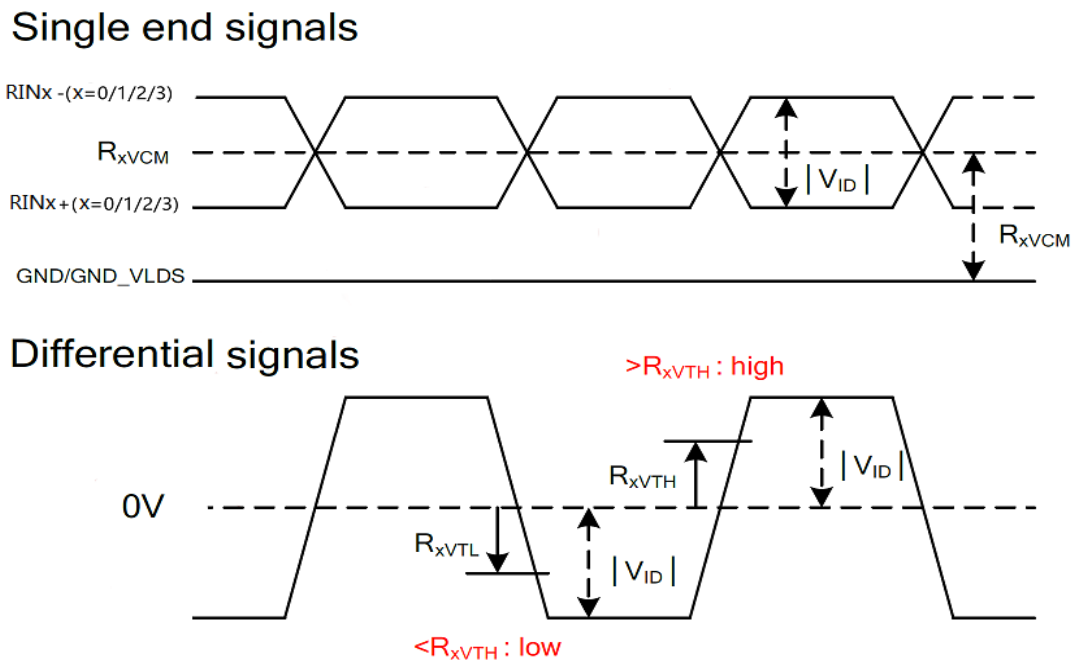




7.3 LVDS DC Electrical Characteristics

VCC=3.3V, GND=0V, Ta=25℃

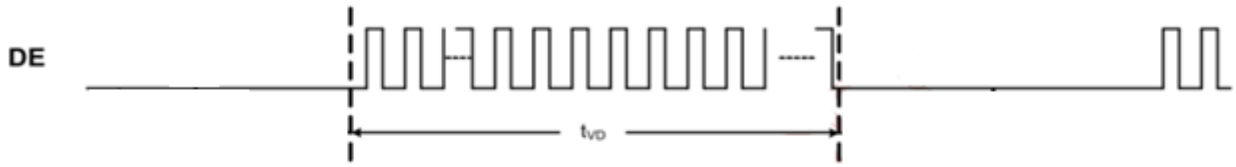
Parameter	Symbol	Min.	Typ.	Max.	Unit	Remark
Differential input high Threshold voltage	R_{XVTH}			0.1	V	
Differential input Low Threshold voltage	R_{XVTL}	-0.1			V	
Input voltage range(single-end)	R_{XVIN}	0		VCC-1.0	V	
Differential input common Mode voltage	R_{XVCM}	0.6	1.2	2.4-|VID|/2	V	
Differential input voltage	$\|V_{ID}\|$	0.2	0.4	0.6	V	
Differential input leakage current	RVxliz	-10		10	uA	



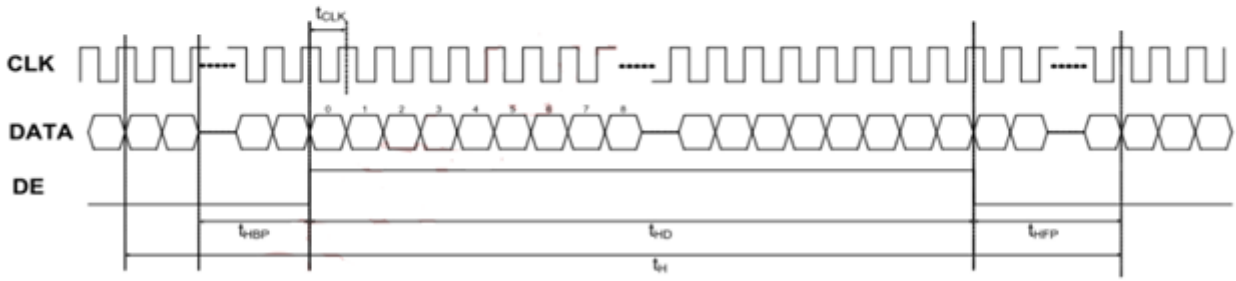
7.4 Input timing

Parameter	Symbol	MIN	Typ	MAX	Unit	Remark
CLK frequency	tclk	30.38	31.63	40.27	MHz	
Horizontal display area	thd		800		tclk	
Horizontal pulse width	thpw	2	2	8	tclk	
Horizontal back porch	thbp	8	16	40	tclk	
Horizontal front porch	thfp	16	16	100	tclk	
HSYNC period	th	826	834	948	tclk	
Vertical display area	tvd		600		th	
Vertical plus width	tvpw	2	2	8	th	
Vertical back porch	tvbp	3	10	40	th	
Vertical front porch	tvfp	8	20	60	th	
VSD period	tv	613	632	708	th	
Frame rate	FR		60		Hz	

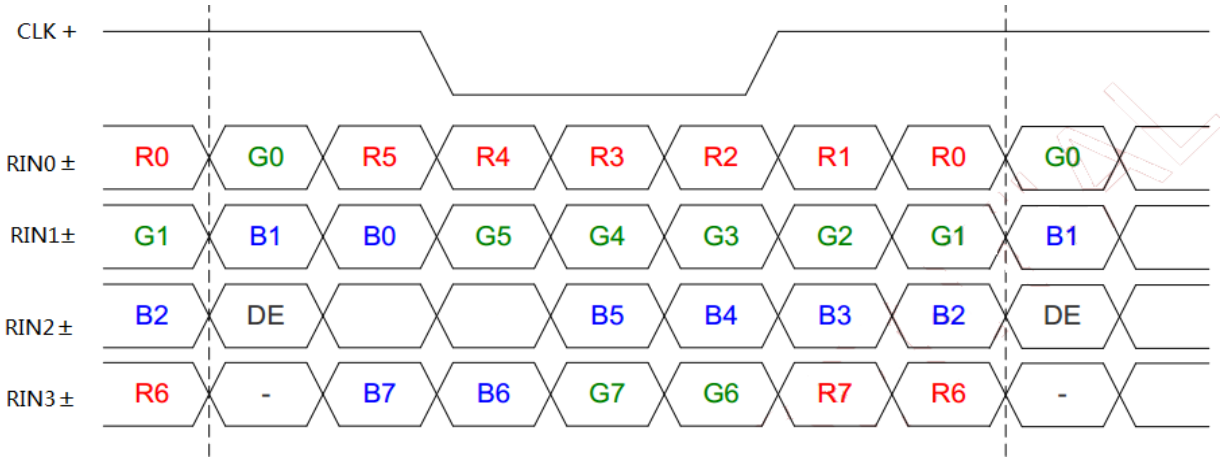
Vertical input timing



Horizontal input timing



7.5 Data Input Format VESA Data Mapping



8. Optical Characteristics

Item		Symbol	Condition	Min	Typ	Max	Unit	Remark
View Angles		θT	CR≧10	80	88		degree	Note2,3
		θB		80	88			
		θL		80	88			
		θR		80	88			
Contrast Ratio		CR	θ=0°	500	750			Note 3
Response Time		T_{ON}	25℃		25	35	ms	Note 4
		T_{OFF}						
Chromaticity	**White**	x	Backlight is on	0.245	0.295	0.345		Note 1,5
		y		0.281	0.331	0.381		
	Red	x		0.583	0.633	0.683		Note 1,5
		y		0.285	0.335	0.385		
	Green	x		0.229	0.279	0.329		Note 1,5
		y		0.570	0.620	0.670		
	Blue	x		0.102	0.152	0.202		Note 1,5
		y		0.012	0.062	0.112		
Uniformity		U		70	80		%	Note 6
NTSC		-		65	72		%	Note 5
Luminance		L			350		cd/m^2	Note 7

Table 7.1 Optical Parameters

Test Conditions:

1. The ambient temperature is 25℃. VDD= 3.3V, VCC=12V, 100% brightness,
2. The test systems refer to Note1 and Note2.

Note1: Definition of optical measurement system.

The optical characteristics should be measured in dark room. After 5 Minutes operation, the optical characteristics are measured at the center point of the LCD screen.

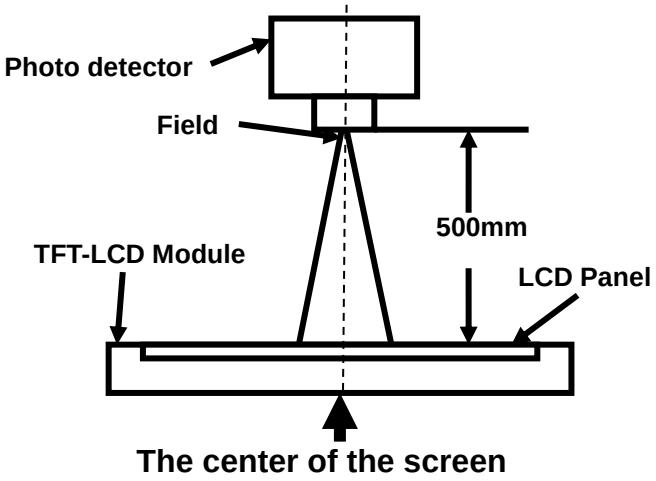


Fig1. Measurement Set Up

Note2: Definition of viewing angle range and measurement system. Viewing angle is measured at the center point of the LCD 。

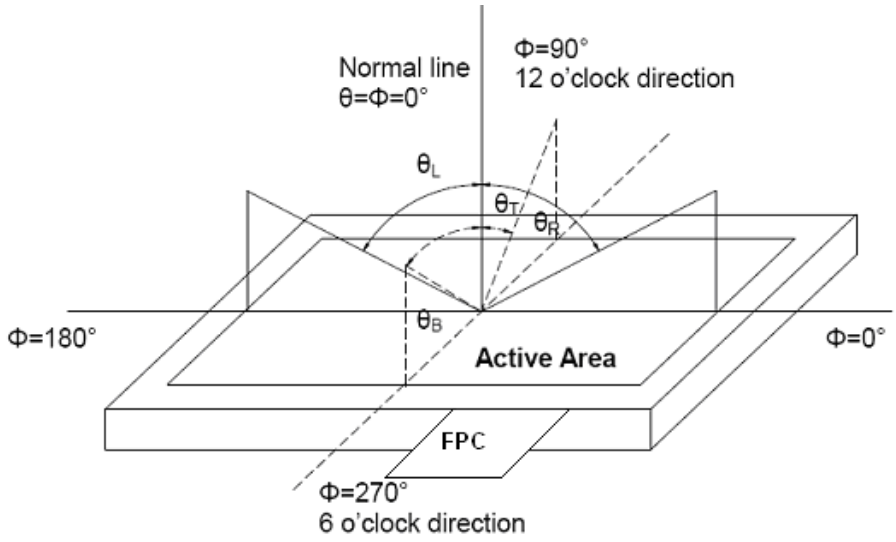


Fig2. Measurement viewing angle

Note3: Definition of contrast ratio

$$\text{Contrast ratio (CR)} = \frac{\text{Luminance measured when LCD is on the "White" state}}{\text{Luminance measured when LCD is on the "Black" state}}$$

Note4: Definition of Response time

For SFT LCM, the response time is defined as the LCD optical switching time interval between “White” state and “Black” state. Rise time (T_r) is the time between photo detector output intensity changed from 10% to 90%. And fall time (T_f) is the time between photo detector output intensity changed from 90% to 10%.

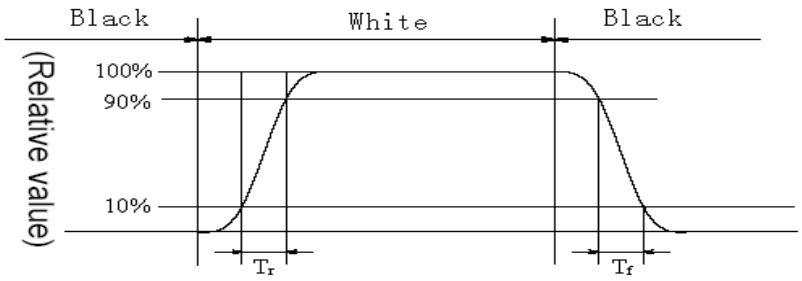


Fig3. Response Time Testing(SFT)

Note5: Definition of color chromaticity (CIE1931)

Color coordinates measured at center point of LCD.

Note6: Definition of Luminance Uniformity

Active area is divided into 9 measuring areas (Refer Fig.5). Every measuring point is placed at the center of each measuring area.

Luminance Uniformity (U) = Lmin/ Lmax

Lmax: The measured Maximum luminance of all measurement position.

Lmin: The measured Minimum luminance of all measurement position.

L-------Active area length; W----- Active area width

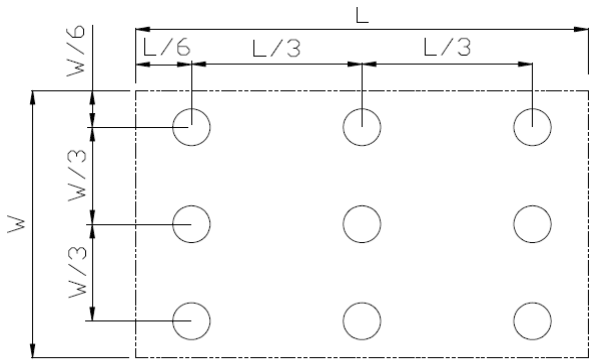


Fig5. Luminance Uniformity Measurement Locations(9 points)

Note7: Definition of Luminance:

Measure the luminance of white state at center point.

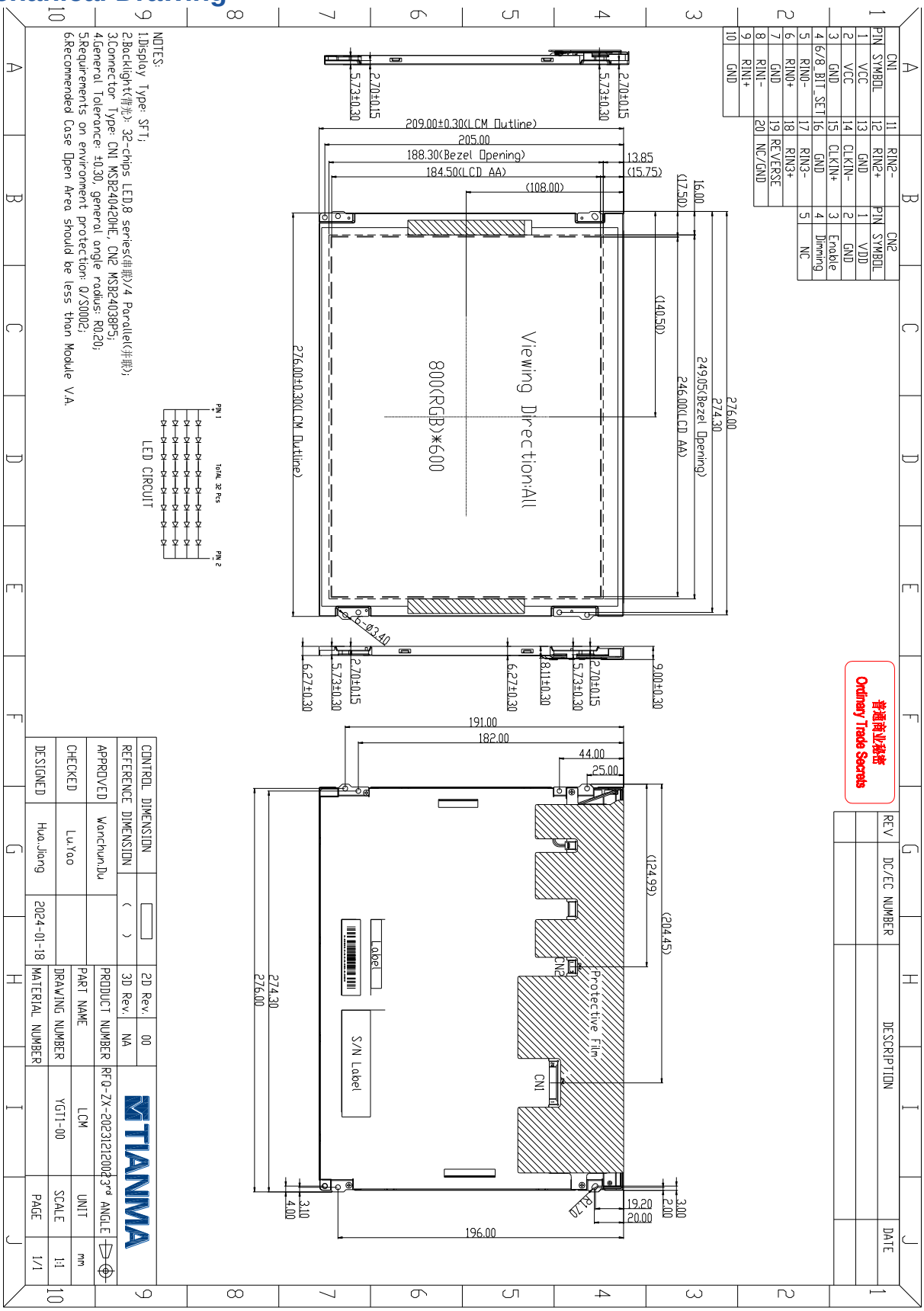
9. Reliability Test

No	Test Item	Condition	Remarks
1	High Temperature & High Humidity Operation	60℃，90%RH，240hrs	IEC60068-2-78 GB/T2423.3
2	High Temperature Storage	+80℃, 240hrs	IEC60068-2-2 GB2423.2
3	Low Temperature Storage	-30℃, 240hrs	EC60068-2-1 GB2423.1
4	High Temperature Operation	+70℃， 240hrs	IEC60068-2-2,GB2423.2
5	Low Temperature Operation	-20℃， 240hrs	IEC60068-2-1 GB2423.1
6	Thermal Shock (Non-operation)	-30℃,30min;80℃,30min;1H/cycle, Change time:5min, 100 Cycles	Start with cold temperature nd with high temperature, EC60068-2-14,GB2423.22
7	Vibration	10~55HZ Stroke:1.5mm Sweep:10HZ~55HZ~10HZ 2H For X\Y\Z	IEC60068-2-6 GB/T2423.10
8	Package condition	5-20 -200HZ， PSD ：0.01-0.01 -0.001 Total:0.781g2/HZ, x/y/z every direction every direction 30min	GB/T 4857.23
9	ESD	C=150pF,R=330Ω； Air:±15kV,9points,25times/point； Contact:±8kV,9points,25times/point	IEC61000-4-2 GB/T17626.2

Table 8.1 RA test condition

Note1: Temperature is the ambient temperature of sample
Note2: Before cosmetic and function test, the product must have enough recovery time, at least 2 hours at room temperature.
Note3: In the standard condition, there shall be no practical problem that may affect the display function. After the reliability test, the product's function only be guaranteed, but not for all of the cosmetic specification.

10. Mechanical Drawing



11. Packing Instruction

TBD

12. Precautions for Use of LCD Modules

11.1 Handling Precautions

(1) The display panel is made of glass. Do not subject it to mechanical shock by dropping it, etc.
(2) If the display panel is damaged and the liquid crystal fluid inside it leaks out be sure not to get any in your mouth. If the fluid comes into contact with your skin or clothes promptly wash it off using soap and water.
(3) Do not apply excessive force to the display surface or the bezel since this may cause the color tone to vary.
(4) The polarizer covering the display surface of the LCD module is soft and easily scratched. Handle the polarizer carefully.
(5) If the display surface is contaminated, breathe on the surface and gently wipe it with a soft dry cloth. If it is still not completely clear use a moist cloth with one of the following solvents:
- Isopropyl alcohol
- Ethyl alcohol

Solvents other than those mentioned above may damage the polarizer. Specifically, do not use the following:
- Water
- Ketone
- Aromatic solvents

(6) Do not disassemble the LCD Module.
(7) If powered off, do not apply the input signals.
(8) To prevent destruction of the module by static electricity, be careful to maintain an optimum work environment.
(9) Be sure to ground your body when handling the LCD Modules.
(10) Tools used for assembly, must be properly grounded.
(11) To reduce the amount of static electricity generated, do not conduct assembly or other work under very low humidity conditions.
(12) The LCD Module is covered with a film to protect the display surface, remove film slowly under the ionizer.

11.2 Storage precautions

(1) When storing the LCD modules avoid exposure to direct sunlight or to the light of fluorescent lamps.
(2) The LCD modules should be stored within the rated storage temperature range. The recommend condition is: Temperature: 0 ~ 35 ℃ at normal humidity.
(3) The LCD modules should be stored in a room without acid, alkali or other harmful gas.

11.3 Transportation Precautions

The LCD modules should not be dropped or subject to violent mechanical shock during transportation. Also they should avoid excessive pressure, water, high humidity and direct sunlight.

11.4 Screen saver Precautions

Not display the fixed pattern for a long time. Use a screen saver, if the fixed pattern is displayed on the screen

11.5 Safety Precautions

(1) When you waste damaged or unnecessary LCDs, it is recommended to crush LCDs into pieces and wash them off with solvents such as acetone and ethanol, which should later be burned
(2) Be sure to turn off the power supply when inserting or disconnecting the LED backlight cable.
(3) LED driver should be designed to limit or stop its function when over current is detected on the LED.