PRODUCT SPECIFICATION

CDTECH Model: **S121IWX07EP-FC18**

CUSTOMER Model: -

Description: **12.1 ” TFT-LCD Module with CTP**

Version: **1.0**

CDTECH	PREPARED BY	CHECKED BY	APPROVED BY
SIGNATURE			
DATE	2025.1.7	2025.1.7	2025.1.7

	SIGNATURE	DATE
CUSTOMER APPROVAL		

Record of Revisions

Version	Revise Date	Description	Page
1.0	2024-11-26	First Release	-
	2025-1-7	Update backlight driver current	5

Contents

1. General Specifications

1.1 LCM General Information

Item	Specification	Unit
LCD Size	12.1	inch
Number of Pixels	1280 (H) RGB x 800 (V)	pixels
Display Mode	Normally Black	-
Viewing Direction	Free	-
Interface	LVDS	-
Display Colors	16.7M	colors
Outline Dimension	312.12 (H) x 204.2 (V) x 8.71 (D)	mm
Active Area	260.35 (H) x 162.72 (V)	mm
Pixel Pitch	0.2034 (H) x 0.2034 (V)	mm
Driver IC	-	-
Operation Temperature	-20~70	℃
Storage Temperature	-30~80	℃

1.2 Touch Panel Information

Item	Specification
Touch Structure	G+G
Bonding Type with LCM	OCA Optical Bonding
Driver IC	ILI2511
Interface	I²C&USB
Touch Count Max	10 Points
Surface treatment	-
Surface hardness	6H
I2C slave address	0x82
Origin of coordinate	Top Left Corner

Note1:Requirements on environmental protection RoHS compliant.

2. Absolute Maximum Ratings

Item	Symbol	MIN.	MAX.	Unit	Note
Analog Supply voltage	VDD	-0.3	5.0	V	Note 1

Note 1:Permanent damage may occur to the LCD module if beyond this specification.
Functional operation should be restricted to the conditions described under normal operating conditions.

3. Elecrical Characteristics

3.1 Recommended Operating Condition for TFT LCD

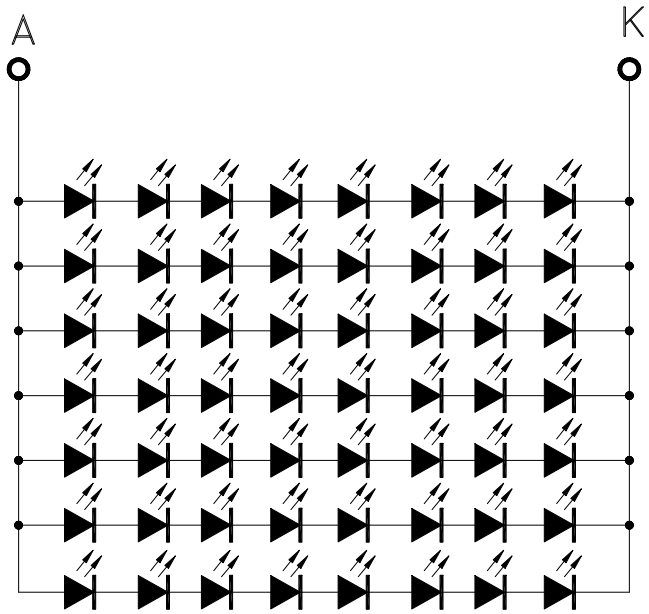
Item	Symbol	Min.	Typ.	Max.	Unit	Note
Analog Supply voltage	VDD+3.3V	3.0	3.3	3.6	V	
Analog supply current	$I_{VDD+3.3V}$	130	230	300	mA	VDD+3.3V=3.3V (Blue picture)
Logic input voltage	VIH	0.7*VDD+3.3V	-	VDD+3.3V	V	
	VIL	GND	-	0.3*VDD+3.3V	V	

3.2 Recommended Driving Condition for Backlight

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Driving Current	I_F	-	380	-	mA	
Driving Voltage	V_F	21.6	-	27.2	V	
Power consumption	W_{BL}	8.208	-	10.336	W	
LED Life-Time	N/A	-	30,000	-	Hours	Ta=25℃ Note 1

Note 1:LED lifetime is defined as the module brightness decay 50% of original brightness at Ta=25 degree, typical current.

Note 2:LED circuit :



3.3 Touch Panel(I2C)

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Power Supply voltage	I2C_VDD	-	3.3	-	V	
Analog supply current	I_{I2C_VDD}	-	100	-	mA	I2C_VDD=3.3V
Input high-level voltage	VIH	0.7*I2C_VDD	-	I2C_VDD	V	
Input low -level voltage	VIL	GND	-	0.3*I2C_VDD	V	

3.4 Touch Panel(USB)

Item	Symbol	Min.	Typ.	Max.	Unit	Note
Power Supply voltage	USB_VDD	-	5.0	-	V	
Analog supply current	I_{USB_VDD}	-	100	-	mA	USB_VDD=5.0V
Input high-level voltage	VIH	0.7*USB_VDD	-	USB_VDD	V	
Input low -level voltage	VIL	GND	-	0.3*USB_VDD	V	

4. Interface Pin Assignment

4.1 LCM Pin Assignment

No.	Symbol	Description
1	NC	No connection
2	VDD+3.3V	Power Supply For LCD,VDD=3.3V
3	VDD+3.3V	Power Supply For LCD,VDD=3.3V
4	VDD+3.3V	Power Supply For LCD,VDD=3.3V
5	NC	No connection
6	GND	Ground
7	GND	Ground
8	RIN0-	LVDS Data differential signal input pins.
9	RIN0+	LVDS Data differential signal input pins.
10	GND	Ground
11	RIN1-	LVDS Data differential signal input pins.
12	RIN1+	LVDS Data differential signal input pins.
13	GND	Ground
14	RIN2-	LVDS Data differential signal input pins.
15	RIN2+	LVDS Data differential signal input pins.
16	GND	Ground
17	LVDS-CLK-	LVDS CLOCK differential signal input pins.
18	LVDS-CLK+	LVDS CLOCK differential signal input pins.
19	GND	Ground
20	RIN3-	LVDS Data differential signal input pins.
21	RIN3+	LVDS Data differential signal input pins.
22	GND	Ground
23	NC	No connection
24	NC	No connection
25	GND	Ground
26	SDA	Serial data input/output for I2C Interface.
27	SCL	Clock Input for I2C interface.
28	GND	Ground
29	NC	No connection
30	NC	No connection
31	GND	Ground
32	GND	Ground
33	GND	Ground
34	NC	No connection
35	PWM/NC	No connection
36	LED-EN/NC	No connection

37	NC	No connection
38	VLED/NC	No connection
39	VLED/NC	No connection
40	VLED/NC	No connection

4.2 Touch FPC Pin Assignment

No.	Symbol	Description
1	USB_GND	Ground
2	USB_VDD(5.0V)	Power supply for CTP(5.0V)
3	USB_D-	Data- input
4	USB_D+	Data+ input
5	I2C_GND	Ground
6	I2C_VDD(3.3V)	Power supply for CTP(3.3V)
7	I2C_RST	Reset Pin for CTP
8	I2C_SCL	I2C clock input for CTP
9	I2C_INT	Interrupt signal for CTP
10	I2C_SDA	I2C data input and output for CTP

4.3 CN1 PIN Assignment

No.	Symbol	Description
1	USB_VDD(5.0V)	Power supply for CTP(5.0V)
2	USB_D-	Data- input
3	USB_D+	Data+ input
4	USB_GND	Ground

4.4 CN2 PIN Assignment

No.	Symbol	Description
1	I2C_GND	Ground
2	I2C_VDD(3.3V)	Power supply for CTP(3.3V)
3	I2C_RST	Reset Pin for CTP
4	I2C_SCL	I2C clock input for CTP
5	I2C_INT	Interrupt signal for CTP
6	I2C_SDA	I2C data input and output for CTP

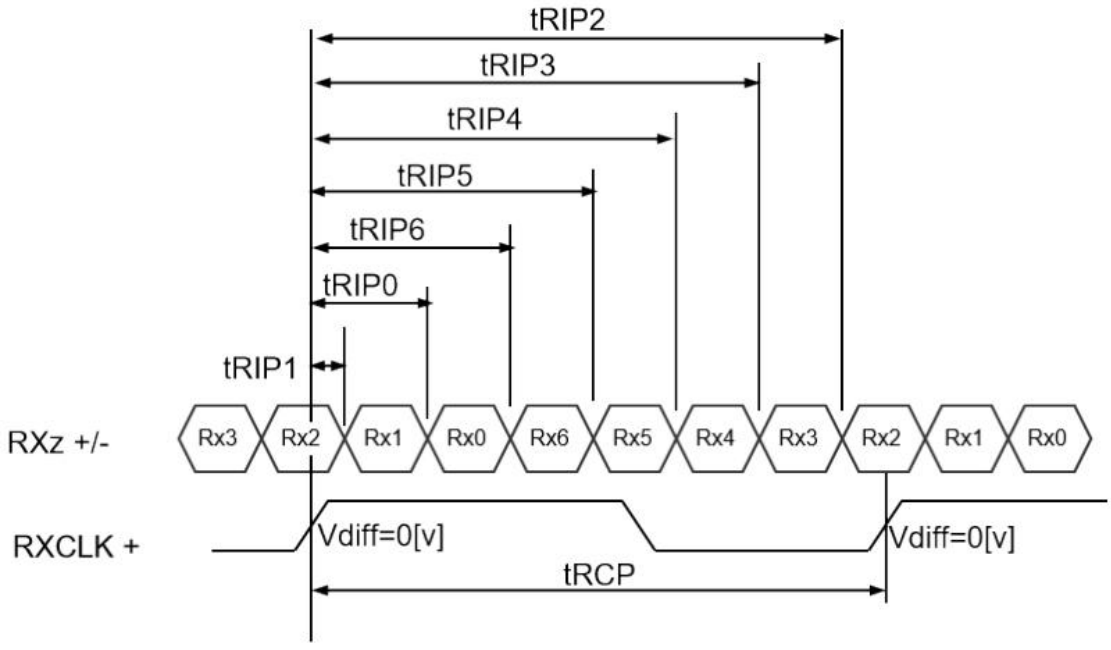
5. Interface Characteristics

5.1 LVDS Rx InterfaceTiming Parameter

The specification of the LVDS Rx interface timing parameter is shown inTable8.

<Table8.LVDS Rx InterfaceTimingSpecification>

Item	Symbol	Min	Typ	Max	Unit	Remark
CLKIN Period	tRCP	10	T	40	nsec	
Receiver Data Input Margin	tRMG	-0.45	-	+0.45	nsec	fCLKIN=80.9MHz
		-0.60	-	+0.60	nsec	fCLKIN=75MHz
Input Data 0	tRIP1	- | tRMG |	0.0	| tRMG |	Clock	
Input Data 1	tRIP0	T/7- | tRMG |	T/7	T/7+ | tRMG |	Clock	
Input Data 2	tRIP6	2 T/7- | tRMG |	2T/7	2T/7+ | tRMG |	Clock	
Input Data 3	tRIP5	3T/7- | tRMG |	3T/7	3T/7+ | tRMG |	Clock	
Input Data 4	tRIP4	4T/7- | tRMG |	4T/7	4T/7+ | tRMG |	Clock	
Input Data 5	tRIP3	5T/7- | tRMG |	5T/7	5T/7+ | tRMG |	Clock	
Input Data 6	tRIP2	6T/7- | tRMG |	6T/7	6T/7+ | tRMG |	Clock	

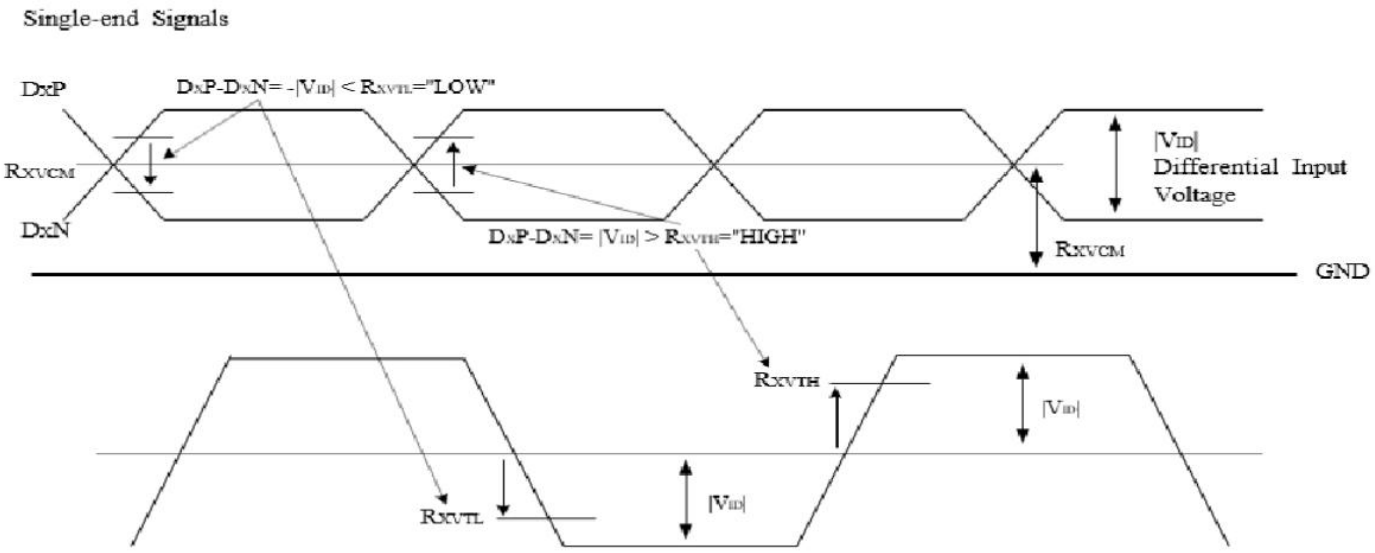


* Vdiff = (RXz+)-(RXz-),…. ,(RXCLK+)-(RXCLK-)

5.2 DC Specification

LVDS Receiver Differential Input(DCCharacteristics)
<Table9-1.LVDS Rx DC Characteristics>

Parameter	Symbol	Min	Typ	Max	Unit	Notes
Differential Input High Threshold Voltage	VTH	-	-	+100	mV	VCM=1.2V
Differential Input Low Threshold Voltage	VTL	-100	-	-	mV	
Differential Input Common Mode Voltage	VCM	1	1.2	1.4	V	
Differential Input Voltage	| VID |	200	-	600	mV	

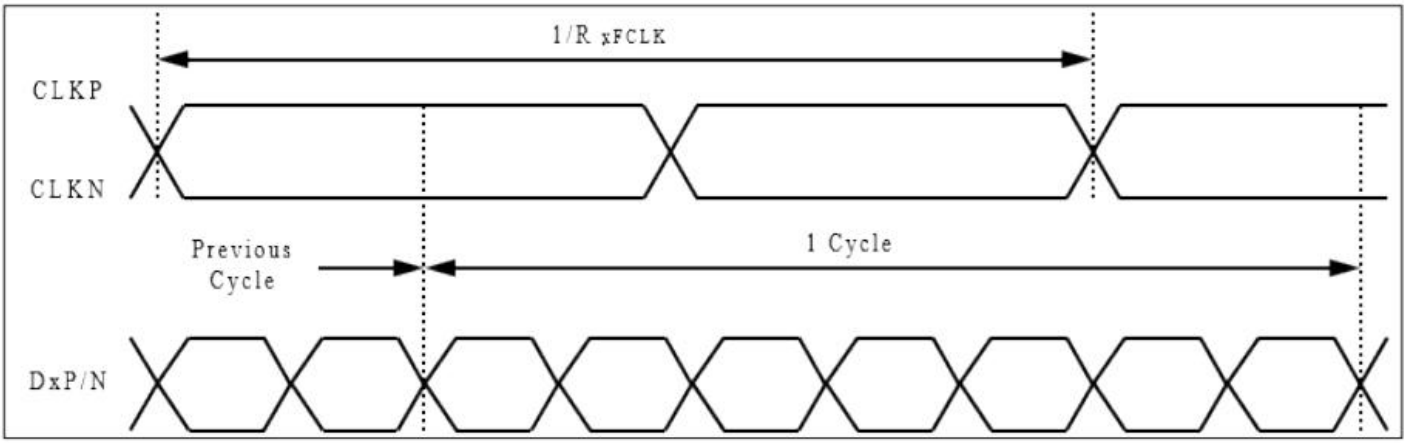


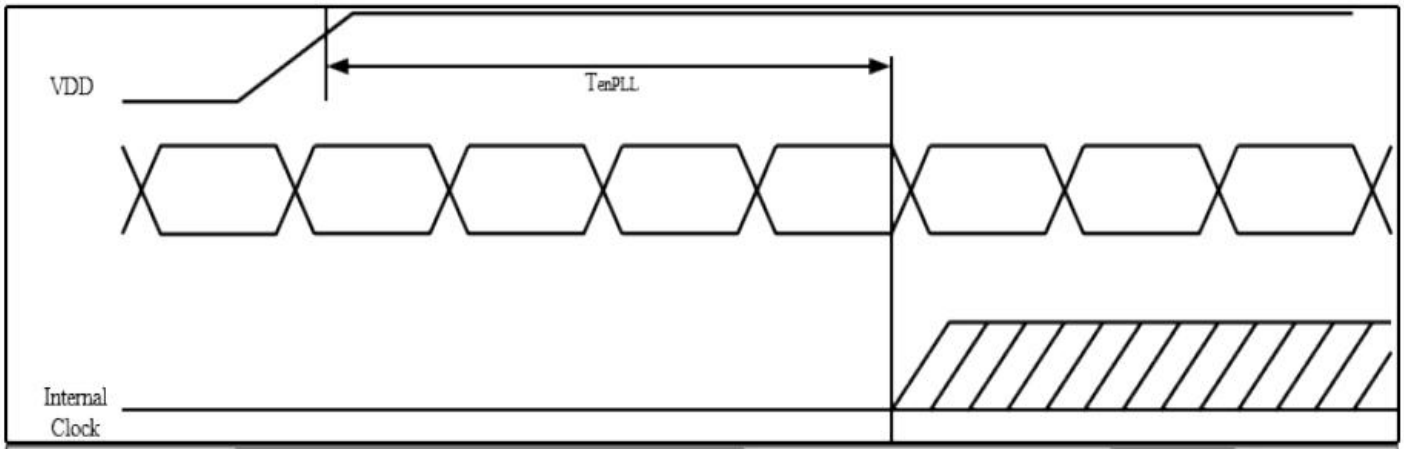
5.3 AC Specification

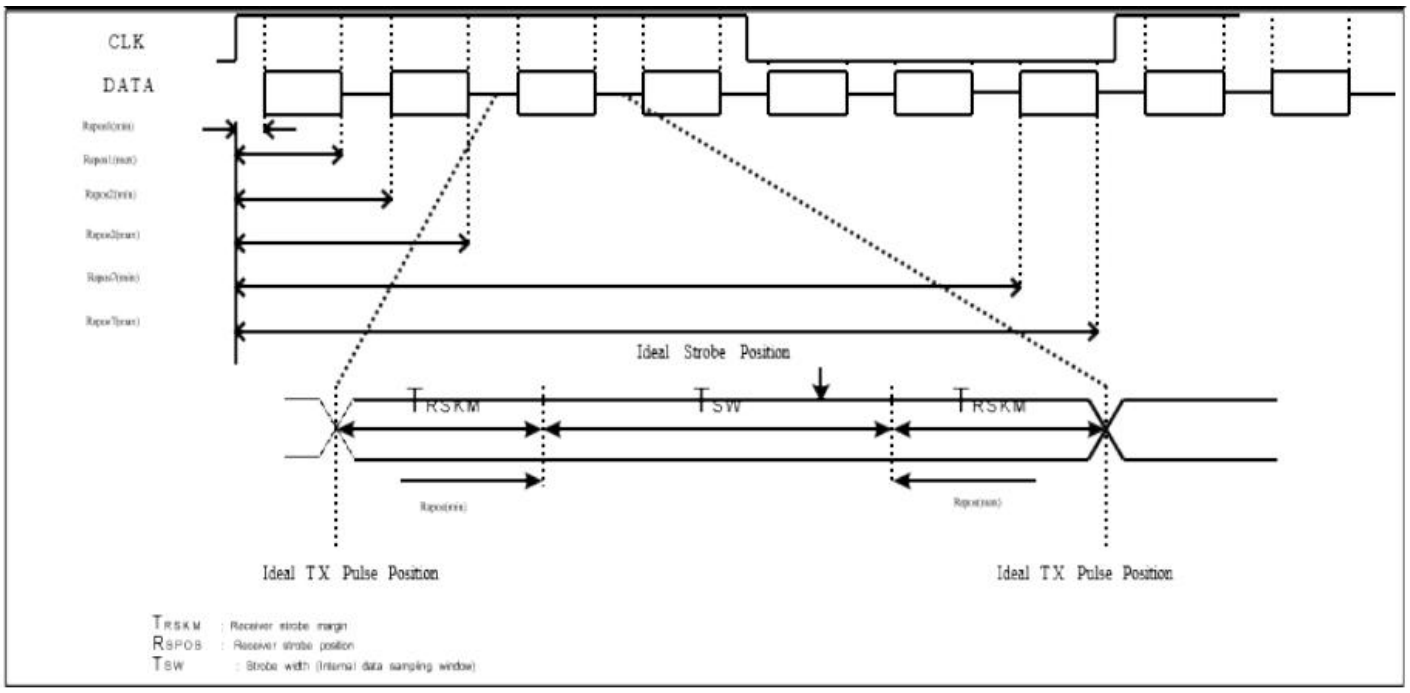
-LVDS Receiver Differential Input(ACCharacteristics)

<Table9-2.LVDS Rx AC Characteristics>

Parameter	Symbol	Min	Typ	Max	Unit	Notes
LVDS Strobe Width	tSW	200	-	-	ps	Vcm=1.2V VID = 200mV @81MHz
LVDS Receiver Skew Margin	tRSM	500	-	-	ps	







5.4 Interface timing Parameter

5.4.1 Timing Parameters(DEonlymode)

<Table7.Timing Parameter>

For 1280RGBx800

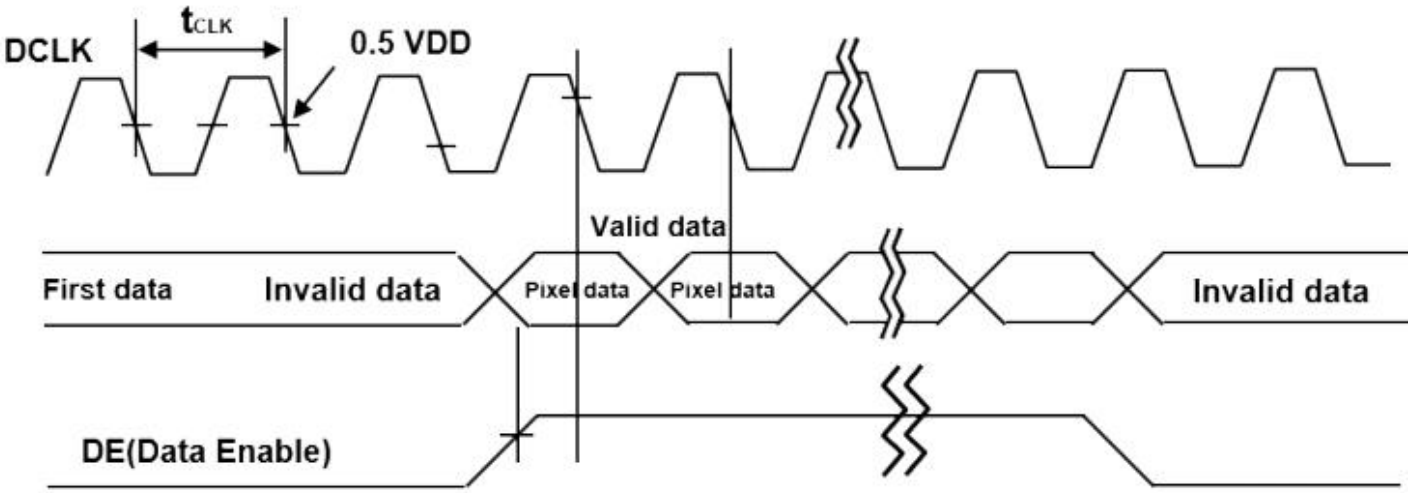
Parameter		Symbol	Value			Unit
			Min.	Typ.	Max.	
DCLK frequency @Frame rate=60Hz (LVDS)		F_{DCLK}	66.3	72.4	78.9	MHz
HSYNC period time		T_H	1380	1440	1500	DCLK
Horizontal display area		T_{HD}		1280		DCLK
HSYNC pulse width	Min.	T_{HPW}		2		
	Typ.			-		
	Max.			40		
HSYNC back porch(with pulse width)		T_{HBP}	88	88	88	DCLK
HSYNC front porch		T_{HFP}	12	72	132	DCLK
VSYNC period time		T_V	824	838	872	H
Vertical display area		T_{VD}		800		H
VSYNC pulse width	Min.	T_{VPW}		2		H
	Typ.			-		
	Max.			20		
VSYNC back porch(with pulse width)		T_{VBP}	23	23	23	H
VSYNC front porch		T_{VFP}	1	15	49	H

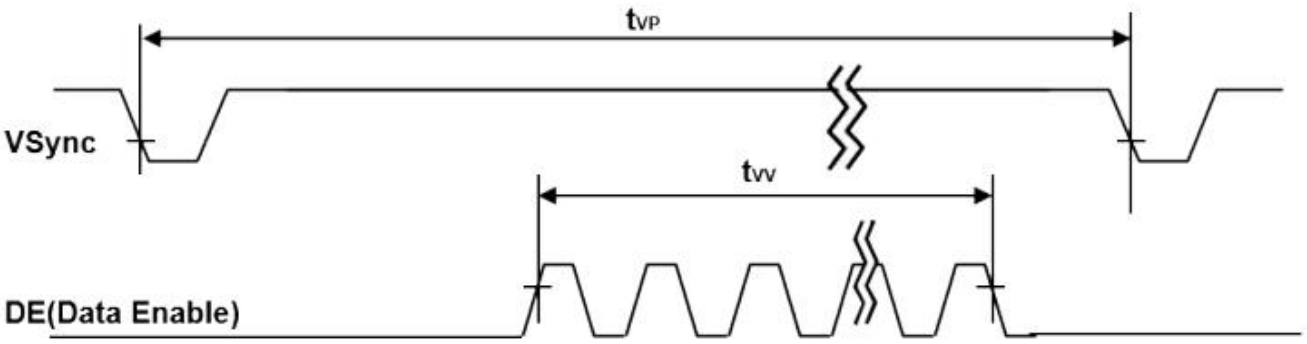
For 1280RGBx800 DE mode

Parameter	Symbol	Value			Unit
		Min.	Typ.	Max.	
DCLK frequency @Frame rate=60Hz (LVDS)	F_{DCLK}	69.7	75	80.9	MHz
Horizontal display area	T_{HD}		1280		DCLK
HSYNC period time	T_H	1380	1440	1500	DCLK
HSYNC blanking	$T_{HBP}+T_{HFP}$	100	160	220	DCLK
Vertical display area	T_{VD}		800		H
VSYNC period time	T_V	842	838	872	H
VSYNC blanking	$T_{VBP}+T_{VFP}$	24	38	72	H

1.DE Only Mode，While operation,DE signal should be have the same cycle.The input of HSYNC &VSYNC signal does not have an effect on normal operation.
2.Best operation clock frequency is75Mhz.
3.Frequency]=[HTotal]*[VTotal]*[verticalFramerate]
H Total,V Total and Frame rate]should operate with in the range between Frequency_Minand Frequency_Max.
4.Except Best operation clock frequency,FOS(Flicker&Brightness&Crosstalk,Etc.) are not guaranteed.
5.Main frequency Max is 80.9MhzMHz without spread spectrum.

5.4.2 Signal Timing Waveform





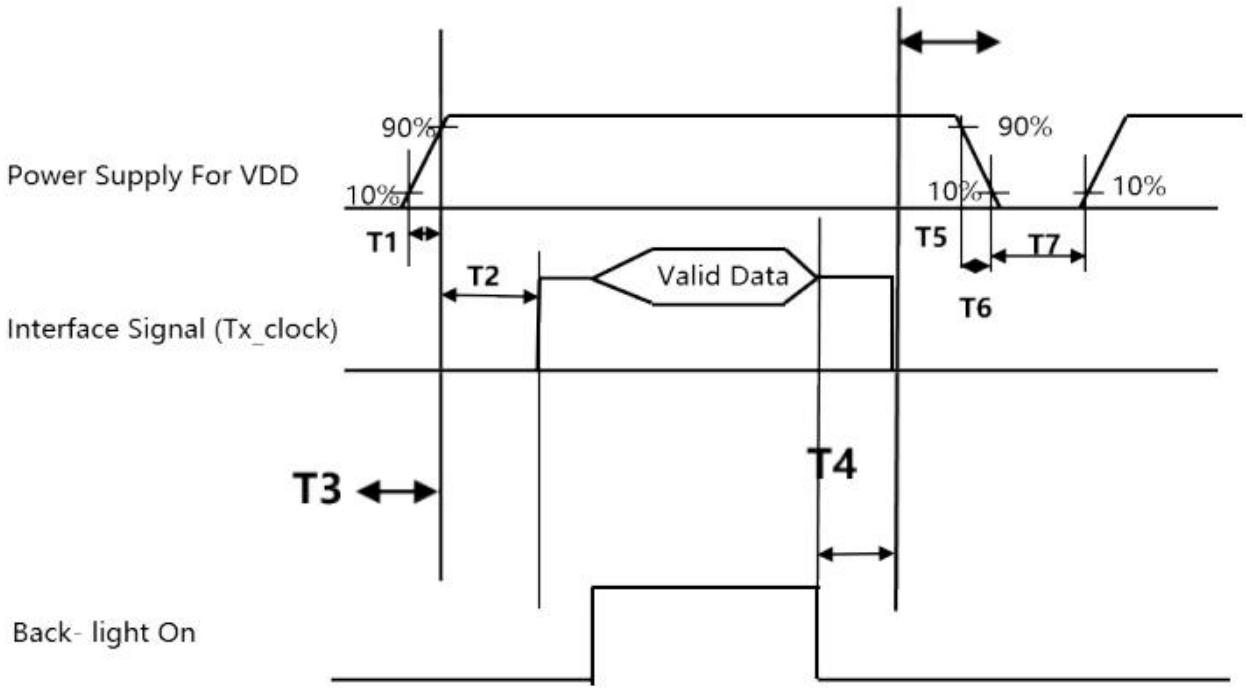
5.4.3 Input Signals,Basic Display Colors and Gray Scale of Colors

<Table12.Input Signal and Display Color Table>

Color & Gray Scale		Input Data Signal																							
		Red Data								Green Data								Blue Data							
		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 Colors	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
	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
	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
	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
Gray Scale of Red	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
	△	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Darker	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	△	↑								↑								↑							
	▽	↓								↓								↓							
	Brighter	1	1	1	1	1	1	0	1	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
	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
Gray Scale of Green	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
	△	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Darker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	△	↑								↑								↑							
	▽	↓								↓								↓							
	Brighter	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	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
	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
Gray Scale of Blue	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
	△	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Darker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	△	↑								↑								↑							
	▽	↓								↓								↓							
	Brighter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1
	▽	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	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
Gray Scale of White	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
	△	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
	Darker	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
	△	↑								↑								↑							
	▽	↓								↓								↓							
	Brighter	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1
	▽	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	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

5.5 POWER SEQUENC

To prevent a latch-up or DC operation of the Open Cell,the power on/off sequence shall be as shown in below.



Parameter	Values			Units
	Min	Typ	Max	
T1	0.1	-	10	ms
T2	0.1	-	50	ms
T3	300	-	-	ms
T4	200	-	-	ms
T5	0.1	-	50	s
T6	0.1	-	10	ms
T7	500	-	-	ms

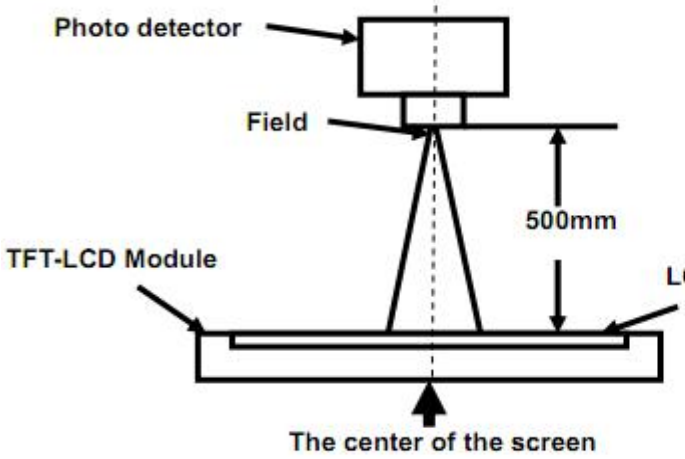
Note 1: Even though T1 is over the specified value, there is no problem if the rush current is within Spec.
Note 2: When the power supply VDD is 0V, keep the level of input signals on the low or high impedance;
※ Please avoid floating state of interface signal at invalid period.
※ When the power supply for LCD (VDD) is off, be sure to pull down the valid and invalid data to 0V.
Note 3: The T3 / T4 is recommended value, the case when failed to meet a minimum specification, abnormal display would be shown. There is no reliability problem.
Note 4: T6: Voltage of VDD must decay smoothly after power-off , there should be none re-bounding voltage. (customer system decide this value)
Note 5: T7 should be measured after the Module has been fully discharged between power off and on period

6. Optical Specifications

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Viewing Angle (CR≥10) B/L ON	θ_T	Φ=90°(12 o'clock)	80	85	-	deg	Note2
	θ_B	Φ=270°(6 o'clock)	80	85	-	deg	Note2
	θ_L	Φ=180°(9 o'clock)	80	85	-	deg	Note2
	θ_R	Φ=0°(3 o'clock)	80	85	-	deg	Note2
Response Time	T_{ON}	Normal θ=Φ=0°	-	15	17	msec	Note4
	T_{OFF}		-	15	17	msec	Note4
Contrast Ratio	CR		1000	1200	-	-	Note1 Note3
Color Chromaticity	W_X		0.2785	0.3085	0.3385	-	Note1 Note5
	W_Y		0.3265	0.3565	0.3865	-	Note1 Note5
Luminance	L		650	800	-	cd/m²	Note1 Note7
Luminance Uniformity	Y_U		70	80	-	%	Note1 Note6
NTSC	-		68	75	-	%	-

Note 1:Definition of optical measurement system

The optical characteristics should be measured in dark room. After 5 minutes operation, the optical properties are measured at the center point of the LCD screen. All input terminals LCD panel must be ground when measuring the center area of the panel.



Item	Photo detector	Field
Contrast Ratio	SR-3A	1°
Luminance		
Chromaticity		
Lum Uniformity		
Response Time	BM-7A	2°

Fig 1

Note 2: Definition of viewing angle range and measurement system.
viewing angle is measured at the center point of the LCD by CONOSCOPE(ergo-80).

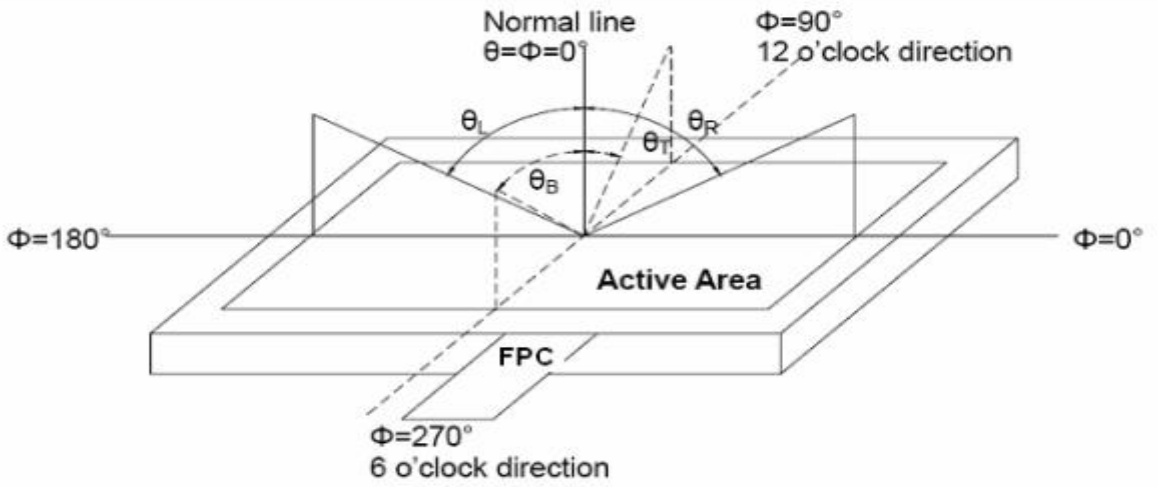


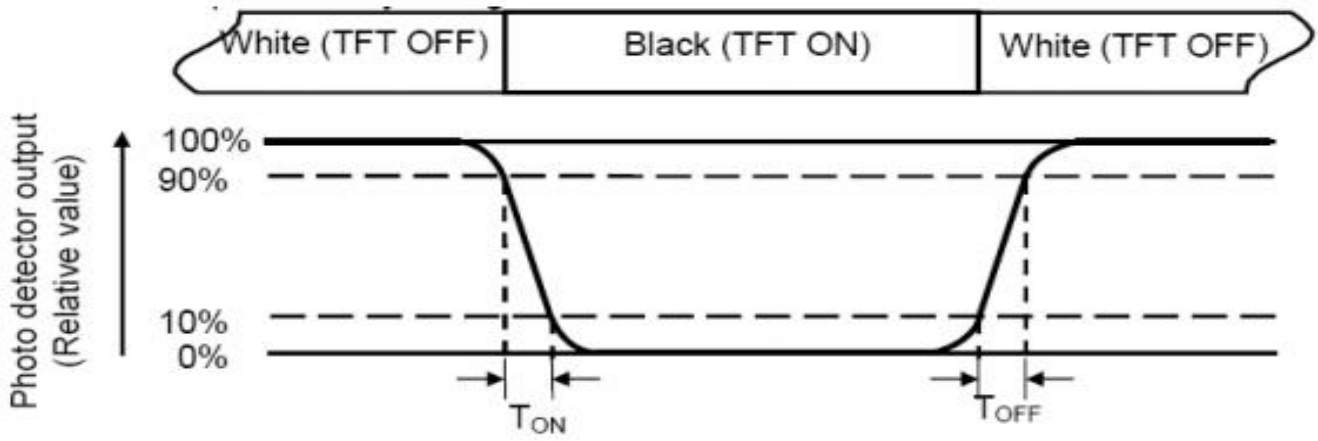
Fig 2 Definition of viewing angle

Note 3: Definition of contrast ratio

$$CR = \frac{\text{Luminance with all pixels white}}{\text{Luminance with all pixels black}}$$

Note 4: Definition of Response time

The response time is defined as the LCD optical switching time interval between “White” state and “Black” state. Rise time (TON) is the time between photo detector output intensity changed from 90% to 10%. And fall time (TOFF) is the time between photo detector output intensity changed from 10% to 90%.



Note 5: Definition of color chromaticity (CIE1931)

Color coordinates measured at center point of LCD.

Note 6: Definition of Luminance Uniformity

The luminance uniformity in surface luminance is determined by measuring luminance at each test position 1 through n, and then dividing the maximum luminance of n points luminance by minimum luminance of n points luminance.For more information see FIG.3-a/b

Note 7:Surface luminance is the luminance with all pixels displaying white.

Lv = Average Surface Luminance with all white pixels(P1,P2,P3, ...,Pn)

For more information see FIG.3-a/b

Note 8:Size : S≤5”(see Figure a) H,V : Active area
Light spot size ⌀ =5mm(BM-5) or ∅=7.7mm (BM-7)50cm distance or test spot position : see Figure a.
measurement instrument : TOPCON’s luminance meter SR-3A or BM-7 or compatible (see Figure 1).

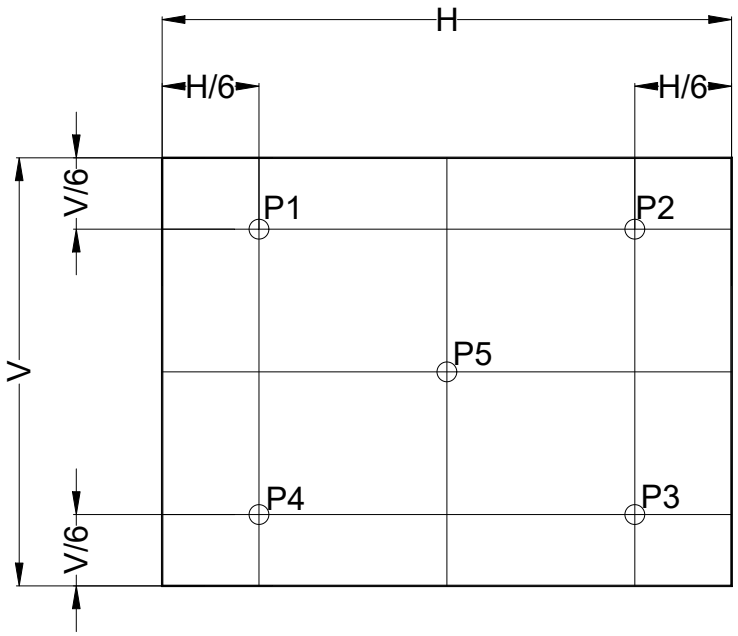


Fig. 3-a Definition of points

5”＜S≤12.3”(see Figure b) . H,V : Active area
Light spot size ∅=5mm(BM-5) or ∅=7.7mm (BM-7)50cm distance or compatible distance from the LCD surface to detector lens. test spot position : see Figure b.
measurement instrument : TOPCON’s luminance meter SR-3A or BM-7 or compatible (see Figure 1).

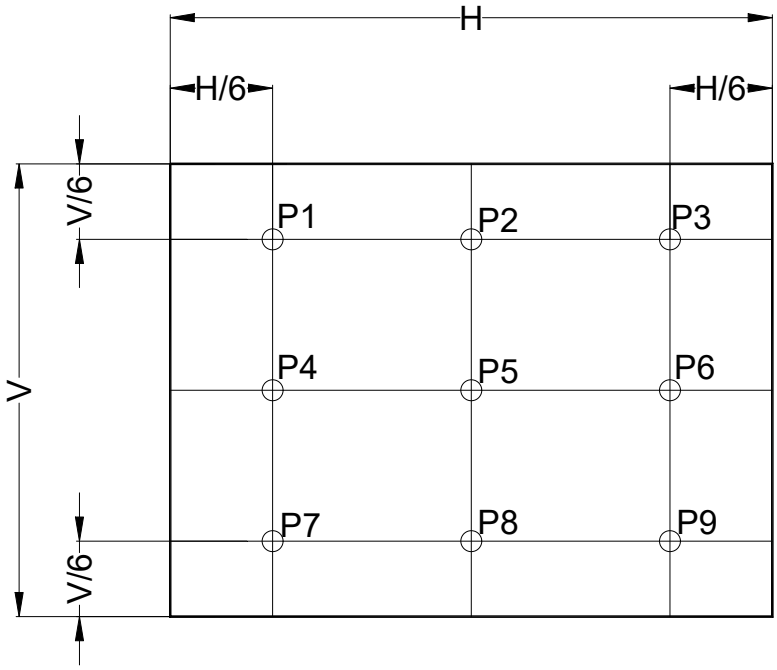


Fig. 3-b Definition of points

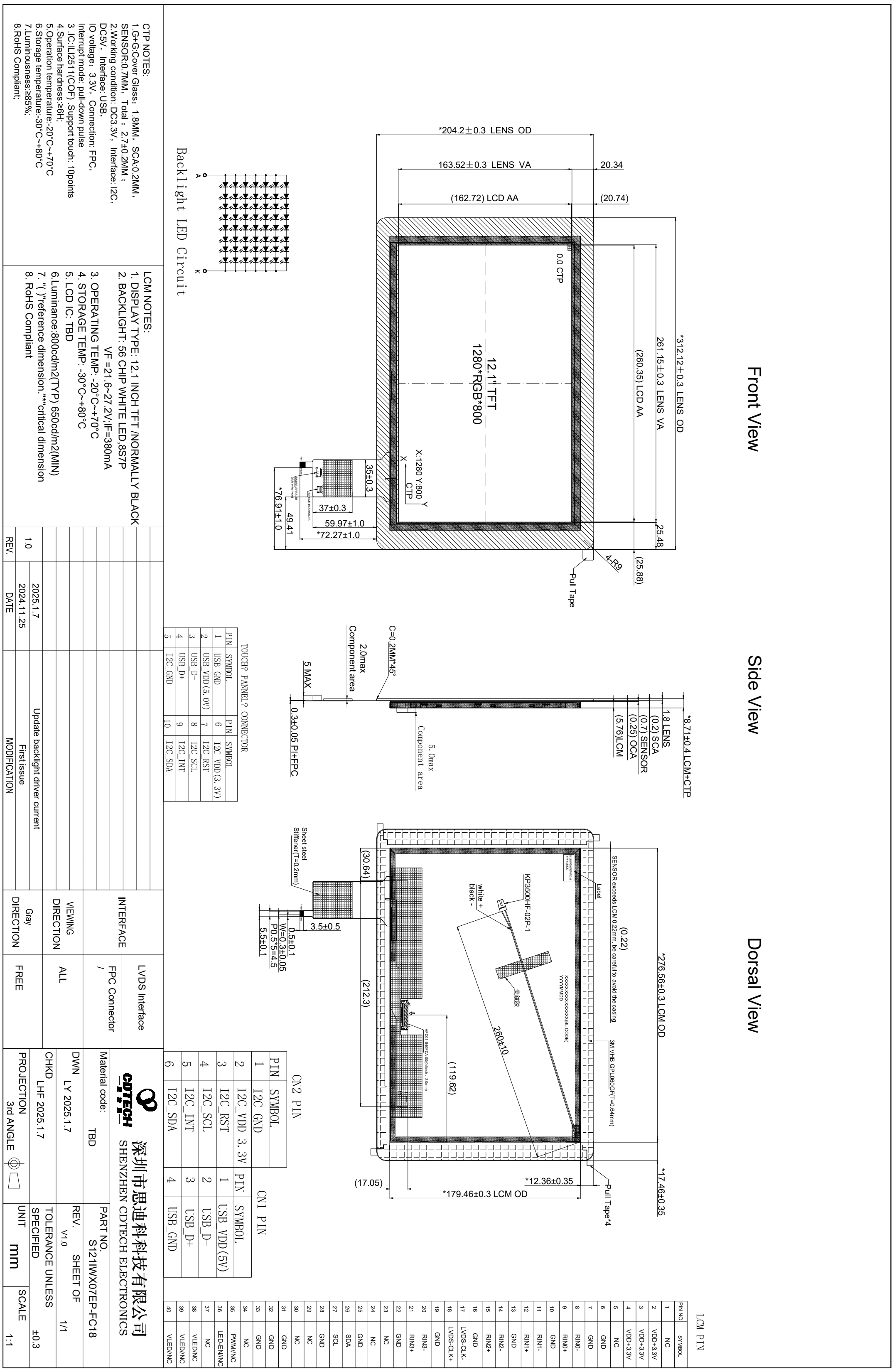
7. Reliability Test Items

Test Item	Test Conditions	
High Temperature Storage	Ta= +80℃	96hrs
Low Temperature Storage	Ta= -30℃	96hrs
High Temperature Operation	Ta= +70℃	96hrs
Low Temperature Operation	Ta= -20℃	96hrs
High Temperature and Humidity Storage	Ta= +60℃, 90% RH	96hrs
Thermal Shock (Non-operation)	-30℃/30 min ~ +80℃/30 min for 20 cycles Start with cold temperature end with high temperature	
Electro Static Discharge	Contact = ± 4 kV, class B Air = ± 8 kV, class B R=330Ω,C=150pF	
Vibration	Sweep: 10Hz~55Hz~10Hz Stroke: 1.5mm 2 hrs for each direction of X .Y. Z.	
Mechanical Shock	60G 6ms,±X,±Y,±Z 3 times for each direction	
Package Drop Test	Height: 60 cm 1 corner, 3 edges, 6 surfaces	

Notes: The test result shall be evaluated after the sample has been left at room temperature and humidity for 2 hours without load. No condensation shall be accepted. The sample will not be accepted if appear these defects:

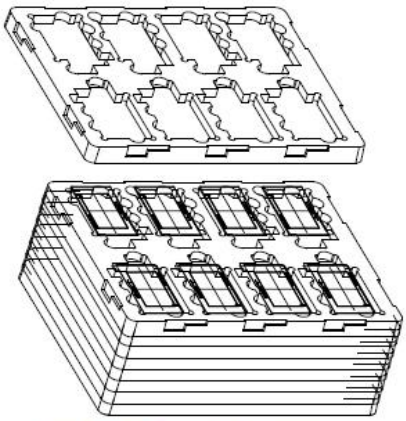
1). Air bubble in the LCD
2). Seal leak or Glass crack
3). Non display or abnormal display
4). Brightness reduction >50%

8. Mechanical Drawing

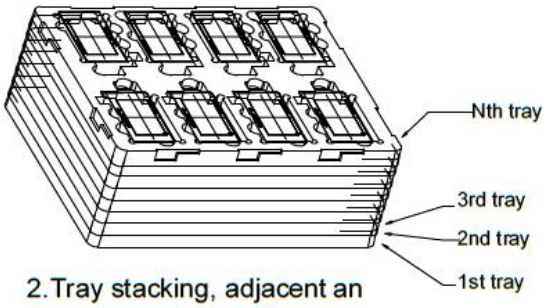


9. Packing

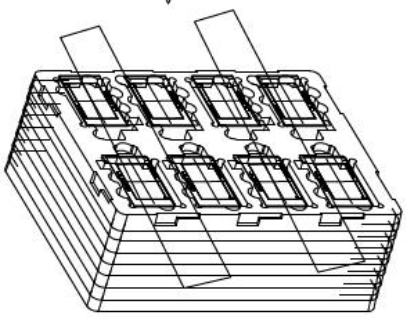
Packing Method



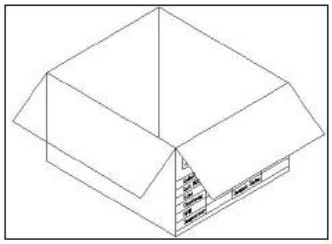
1.Put LCD module into tray cavity



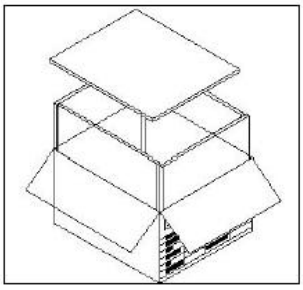
2.Tray stacking, adjacent an upper lower layer with a 180-degree rotation



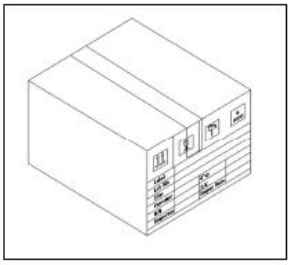
3.Medium Carton: Fix the tray stack with stretch film
Large Carton： Fix the tray stack with stretch film, then place it into a transparent PE antistatic bag



4. put the tray stack into carton



5. 6 sides of white foams inside the box



6. Carton sealing with adhesive tape

10. Precautions for Use of LCD modules

10.1 Handling Precautions

10.1.1. The display panel is made of glass. Do not subject it to a mechanical shock by dropping it from a high place, etc.

10.1.2. If the display panel is damaged and the liquid crystal substance inside it leaks out, be sure not to get any in your mouth, if the substance comes into contact with your skin or clothes, promptly wash it off using soap and water.

10.1.3. Do not apply excessive force to the display surface or the adjoining areas since this may cause the color tone to vary.

10.1.4. The polarizer covering the display surface of the LCD module is soft and easily scratched. Handle this polarizer carefully.

10.1.5. If the display surface is contaminated, breathe on the surface and gently wipe it with a soft dry cloth. If still not completely clear, moisten cloth with one of the following solvents:

- Isopropyl alcohol
- Ethyl alcohol

Solvents other than those mentioned above may damage the polarizer. Especially, do not use the following:

- Water
- Ketene
- Aromatic solvents

10.1.6. Do not attempt to disassemble the LCD Module.

10.1.7. If the logic circuit power is off, do not apply the input signals.

10.1.8. To prevent destruction of the elements by static electricity, be careful to maintain an optimum work environment.

10.1.8.1. Be sure to ground the body when handling the LCD Modules.

10.1.8.2. Tools required for assembly, such as soldering irons, must be properly ground.

10.1.8.3. To reduce the amount of static electricity generated, do not conduct assembly and other work under dry conditions.

10.1.8.4. The LCD Module is coated with a film to protect the display surface. Be care when peeling off this protective film since static electricity may be generated.

10.2 Storage Precautions

10.2.1.When storing the LCD modules,avoid exposure to direct sunlight or to the light of fluorescent lamps.

10.2.2.The LCD modules should be stored under the storage temperature range if the LCD modules will be stored for a long time,the recommend condition is :

Temperature : 0℃ ~40℃ Relatively humidity: ≤80%

10.2.3.The LCD modules should be stored in the room without acid, alkali and harmful gas.

10.3 Transportation Precautions

The LCD modules should be no falling and violent shocking during transportation, and also should avoid excessive press, water, damp and sunshine.

10.4 Packaging instructions

when the customers using trays, they have to stack the adjacent trays in a 180° staggered to prevent pressure that could cause product damage.