DISPLAY MODULE

SPECIFICATION

Module Size： ***1.39inch 454RGB*454***

Date： ***2020-05-29***

Version： ***Ver A***

Revision History

Version	Revise Date	Page	Content	Prepared by

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1 General Specification

1.1 Features

General Specification-- AMOLED
--MIPI
--COF
-- Board to Board Connection
--Outline & AA are round

1.2 Application

Display terminals for *Round Watch.*

1.3 General Specification

Table 1 General Specification

No.	Item	Specification	Unit	Remark
1	Display Size	1.39	Inch	
2	Array Technology Type	LTPS		
3	Display Type	AMOLED		
4	Resolution	454RGB*454（Real RGB or equivalent ）		
5	Color Depth	16.7M		
6	Viewing Direction	All direction		Note 1
7	Contrast Ratio	100000:1		Min
8	Luminance	450cd/m2	cd/m2	Typ
9	Panel Size	39.41(H)+39.61(V)+0.654(T)	Mm	Note 1
10	Panel Maximum Thickness	0.733（MDL）	Mm	Note 1
11	Module Outline	<=ϕ42	Mm	Include COF bending dimension
12	Panel Active Area	∅35.412	Mm	Diameter

13	Pixel Size	78*78	Mm	
14	Pixel Pitch	78	Mm	
15	Pixel Aspect Ratio	1：1		
16	Driver IC	RM69330		
17	Driver IC RAM Size	Full RAM or1/2 RAM		
18	Light Source	OLED		
19	Interface	MIPI/SPI		
20	Operation Temperature	-20~70	degC	
21	Storage Temperature	-30~80	degC	
22	Weight	2.48(MDL)	Gram	±15%
23	Pixel Per Inch	326	PPI	
24	Environmental Protection Requirement	RoHS & REACH must be executed		
25	Connection Method	BM28U-24DP/2-0.35V(86)		
26	Gamma Correction	R/G/B separation		
27	Polarizer Type	Hard coat treating	3H	
		Glare		
28	Panel gate scan direction	Pad to pad Opposite		Note 2
29	Warpage	Front side warpage value < 0.1mm； Rear side warpage value(w/o foam) < 0.1mm		Note 3
30	GSM TDMA Noise	Input support 500mV drop		Note4
31	Antenna Interference	AMOLED can not interference Antenna		

Note1: Please Refer to the mechanical drawing.

Note2: Some GOP panel can not support gate bidirectional scanning , or even some gate bidirectional scanning GOP panel are abnormal working when the gate scanning direction set to be reversed.

Note3: Warpage inspected by Manual height/ flatness test instrument.(4 points position is defined

Note4: TDMA Frame（4.615ms）Includes 8 time slots（1 time slot=577us），1 TDMA Frame has 1 time slot 577us drop 500mV, AMOLED can not display abnormal.

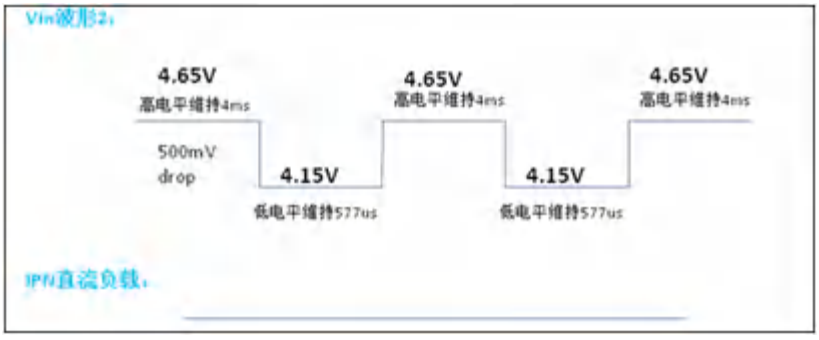


Fig 1 TDMA Frame

2 Pin Assignments

Table 2 PIN Assignments

Pin No.	Symbol	I/O	Function
1	XRES	I	Device reset signal (0 : enable ; 1 : Disable)
2	VCI_EN	I	VCI enable signal
3	NC（MTP）	-	Floating
4	GND	Power	Ground
5	TE	O	Synchronous signal output from panel to avoid tearing effect
6	DSI_D0N	I/O	MIPI data negative signal
7	AM_SPI_CSX	I	SPI interface
8	DSI_D0P	I/O	MIPI data positive signal
9	AM_SPI_SCL	I	SPI interface
10	GND	Power	Ground
11	AM_SPI_DCX	I	SPI interface
12	DSI_CLKN	I	MIPI strobe negative signal
13	AM_SPI_SDI	I/O	SPI interface
14	DSI_CLKP	I	MIPI strobe positive signal
15	AM_SPI_SDO	I/O	SPI interface
16	GND	Power	Ground
17	NC	-	Floating
18	VDDIO	Power	Power supply for interface system except MIPI interface
19	VBAT	Power	AMOLED power
20	VDDIO	Power	Power supply for interface system except MIPI interface
21	VBAT	Power	AMOLED power
22	VBAT	Power	AMOLED power
23	VBAT	Power	AMOLED power
24	VBAT	Power	AMOLED power

Note ID: This pin definition needs to confirm with hardware engineer before AMOLED FPC fixed.

3 Schematic Circuit Diagram

3.1 MIPI Reference Circuit

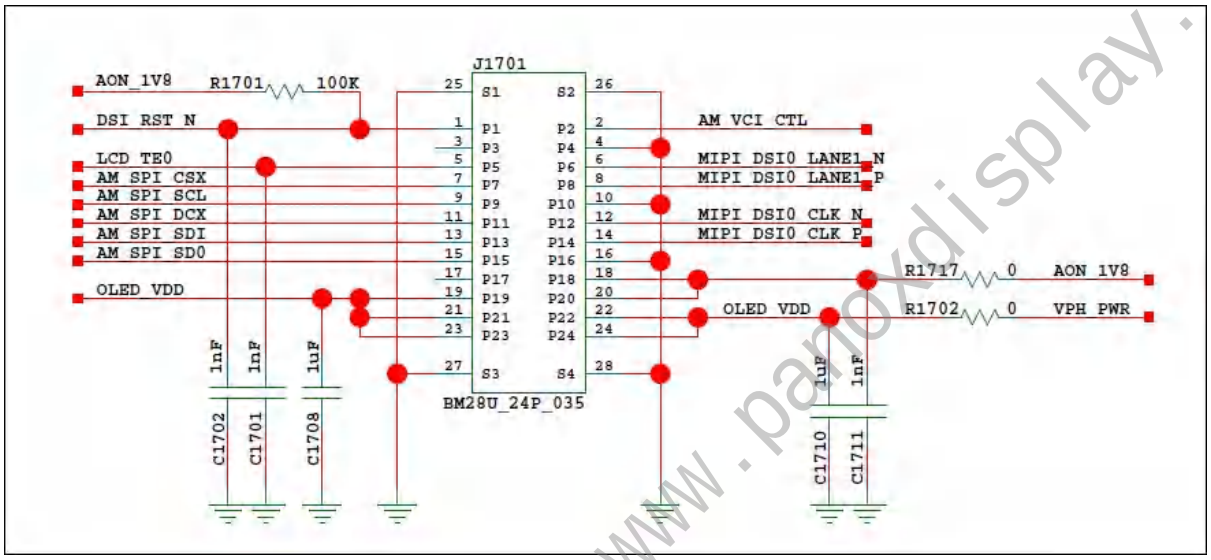


Fig 2 MIPI Reference Circuit

4 Register &Pixel Data Format

4.1 MIPI 24 bit Data Format

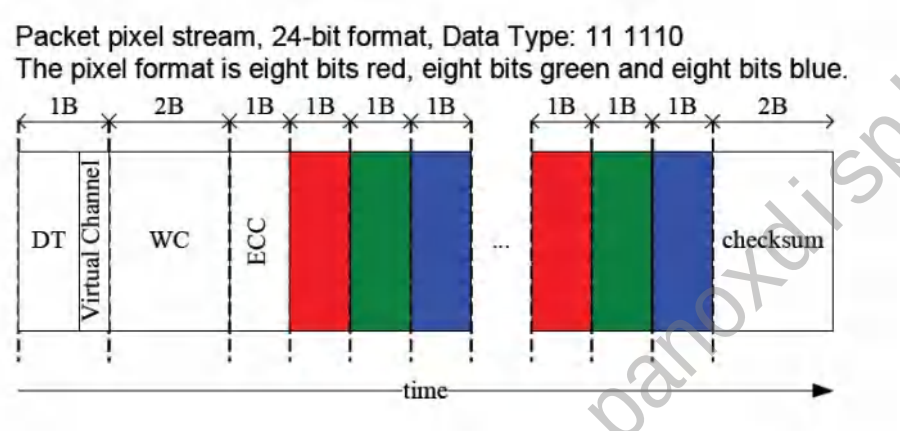


Fig3 MIPI 24 Bit Data Format

4.2 Graphic memory writing direction

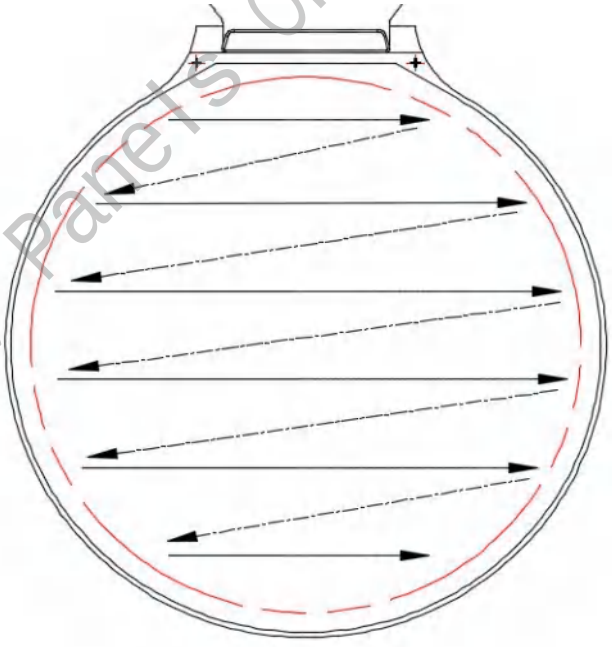


Fig 4 Graphic Memory Writing Direction

5 Timing Characteristics

5.1 MIPI Interface Characteristics

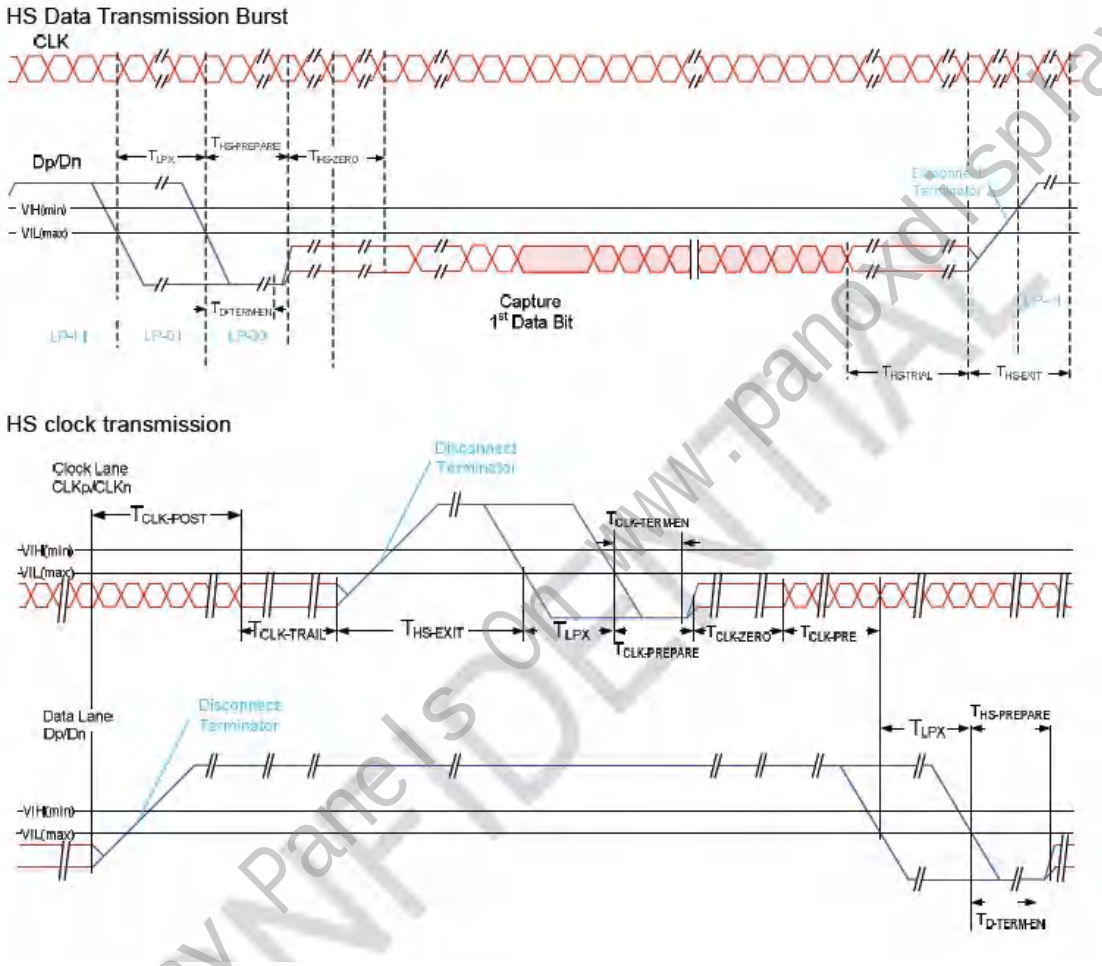
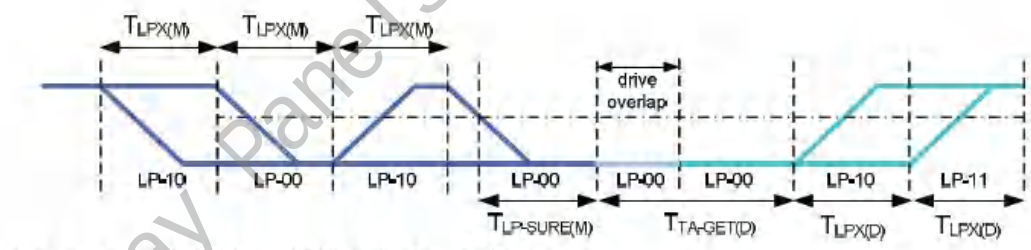


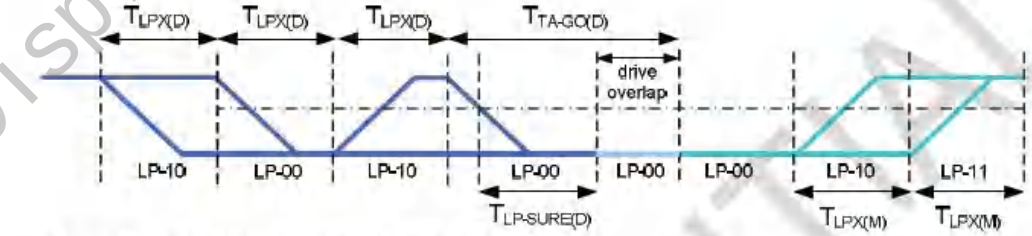
Fig 5 MIPI Interface Characteristics

Timing Parameters:

Parameter	Description	Min	Typ	Max	Unit
$T_{CLK-POST}$	Time that the transmitter continues to send HS clock after the last associated Data Lane has transitioned to LP Mode. Interval is defined as the period from the end of $T_{HS-TRAIL}$ to the beginning of $T_{CLK-TRAIL}$.	60ns + 52*UI			ns
$T_{CLK-TRAIL}$	Time that the transmitter drives the HS-0 state after the last payload clock bit of a HS transmission burst.	60			ns
$T_{HS-EXIT}$	Time that the transmitter drives LP-11 following a HS burst.	**300**			ns
$T_{CLK-TERM-EN}$	Time for the Clock Lane receiver to enable the HS line termination, starting from the time point when Dn crosses $V_{IL,MAX}$.	Time for Dn to reach $V_{TERM-EN}$		38	ns
$T_{CLK-PREPARE}$	Time that the transmitter drives the Clock Lane LP-00 Line state immediately before the HS-0 Line state starting the HS transmission.	38		95	ns
$T_{CLK-PRE}$	Time that the HS clock shall be driven by the transmitter prior to any associated Data Lane beginning the transition from LP to HS mode.	8			UI
$T_{CLK-PREPARE}$ + $T_{CLK-ZERO}$	$T_{CLK-PREPARE}$ + time that the transmitter drives the HS-0 state prior to starting the Clock.	300			ns
$T_{D-TERM-EN}$	Time for the Data Lane receiver to enable the HS line termination, starting from the time point when Dn crosses $V_{IL,MAX}$.	Time for Dn to reach $V_{TERM-EN}$		35 ns +4*UI	
$T_{HS-PREPARE}$	Time that the transmitter drives the Data Lane LP-00 Line state immediately before the HS-0 Line state starting the HS transmission	40ns + 4*UI		85 ns + 6*UI	ns
$T_{HS-PREPARE}$ + $T_{HS-ZERO}$	**$T_{HS-PREPARE}$ + time that the transmitter drives the HS-0 state prior to transmitting the Sync sequence.**	**145ns + 10*UI**			**ns**
$T_{HS-TRAIL}$	Time that the transmitter drives the flipped differential state after last payload data bit of a HS transmission burst	60ns + 4*UI			ns



Bus turnaround (BAT) from MPU to display module timing



Bus turnaround (BAT) from display module to MPU timing

Low Power Mode :

Parameter	Description	Min	Typ	Max	Unit	Notes
$T_{LPX(M)}$	Transmitted length of any Low-Power state period of MCU to display module	50		**150**	ns	1,2
$T_{TA-SURE(M)}$	Time that the display module waits after the LP-10 state before transmitting the Bridge state (LP-00) during a Link Turnaround.	$T_{LPX(M)}$		$2*T_{LPX(M)}$	ns	2
$T_{LPX(D)}$	Transmitted length of any Low-Power state period of display module to MCU	50		**150**	ns	1,2
$T_{TA-GET(D)}$	Time that the display module drives the Bridge state (LP-00) after accepting control during a Link Turnaround.		$5*T_{LPX(D)}$		ns	2
$T_{TA-GO(D)}$	Time that the display module drives the Bridge state (LP-00) before releasing control during a Link Turnaround.		$4*T_{LPX(D)}$		ns	2
$T_{TA-SURE(D)}$	Time that the MPU waits after the LP-10 state before transmitting the Bridge state (LP-00) during a Link Turnaround.	$T_{LPX(D)}$		$2*T_{LPX(D)}$	ns	2

NOTE:
1. T_{LPX} is an internal state machine timing reference. Externally measured values may differ slightly from the specified values due to asymmetrical rise and fall times.
2. Transmitter-specific paramete

6 Electrical Specifications

6.1 DC Characteristics Requirements

Table 3 DC Characteristics Requirements

Item	Symbol	Values			Unit	Remark
		Min	Typ	Max		
I/O Supply Voltage	VDDIO	1.65	1.8	1.95	V	
Battery power Voltage	V_{bat}	2.9	3.7	4.8	V	
Input High Voltage	V_{IH}	0.8*VDDIO	--	VDDIO	V	
Input Low Voltage	V_{IL}	0	--	0.2*VDDIO	V	
Output High Voltage	V_{OH}	0.8*VDDIO	--	VDDIO	V	
Output Low Voltage	V_{OL}	0	--	0.2*VDDIO	V	
Frame Frequency1	F_{FRAME}	43	45	47	HZ	

6.2 Power Consumption of Panel

Power Supply: VDDIO=1.8V Vbat=3.7V

Table 4 Power Consumption of Panel

Display Mode	Item	Typ	Max	Remark
		Power (mW)	Power (mW)	
100% Pixel On,450nits,45Hz	Normal mode		260	
All Pixel Off,0nits,45Hz	Normal mode		38	
All Pixel Off,0nits/Vci on/Vddio on	Standby mode		1.2	
All Pixel Off,0nits/ Vci off/Vddio on	Standby mode		<50μW	
10% Pixel On,50nits,15Hz	Idle mode		TBD	
100% Pixel On,800nits,45Hz	Boost mode		TBD	

Note: Selecting different display mode supported by software setting.

7 Optical Specifications

Test condition：VDDIO=1.8V , Vbat=3.7V ,Ta=25℃

Table 5 Optical Specifications

Item		Symbol	Condition	Min	Typ	Max	Unit	Note
Luminance		Bp	θ=0° ϕ=0°	TBD	450	TBD	cd/m^2	CPK>1.33 Note8
		Boost Bp	θ=0° ϕ=0°	TBD	800	TBD	cd/m^2	
Uniformity		ΔBp		85	--	--	%	Note9
Viewing Angle2	Left	θ_L	Cr≥10	80	--	--	deg	Note 10
	Right	θ_R		80	--	--		
	Top	ψ_T		80	--	--		
	Bottom	ψ_B		80	--	--		
Contrast Ratio		Cr	θ=0° ϕ=0°		100000:1	--	-	Note 11
Response Time		T_r		--	2	3	ms	Note 12
		T_f		--	2	3	ms	
		T_{gray}		-	2	3	ms	
Color Coordinate of CIE1931	Red	x	θ=0° ϕ=0°	0.64	0.67	0.70	-	Note 13
		y		0.290	0.329	0.350		
	Green	x		0.186	0.226	0.266		
		y		0.675	0.715	0.755		
	Blue	x		0.123	0.138	0.163		
		y		0.035	0.055	0.075		
	White	x		0.28	0.3	0.32		
		y		0.29	0.31	0.33		
NTSC Ratio		NTSC	CIE1931	85	100	--	%	Note 14
Flicker		amount	-	-	--	-30	dB	Note 15
Gamma		-	-	1.9	2.2	2.5		Note 16
Crosstalk		ΔCT	-	-	--	1.1		Note 17
Reflectance		Rf	@550nm	--	TBD	--	%	Note 18
Polarization direction of front polarizer		PdF		--	135	--	deg	Note 19
Luminance decrease ratio of full white			θL=30°		35	40	%	Note 20
			θR=30°		35	40	%	
			ψT=30°		35	40	%	
			ψB=30°		35	40	%	

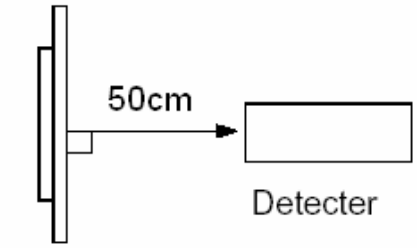
Color Shift		θL=30°	---		5	JNCD	Note 21
		θR=30°	---		5	JNCD	
		ψT=30°	--		5	JNCD	
		ψB=30°	--		5	JNCD	
OLED lifetime	1.39* (TYP brightness)	At25℃,with white color pattern		150		hrs	
Image sticking		With 8*8 black-white chess board test image, lighting on with maximum luminance for 12H	Light off or gray display for 3 minutes, normal performance after the test, without image sticking.	Level 1(450nit，127)			
White color uniformity				B 标：Max Δu'v'-A ≤0.014； Max Δu'v'-B） ≤0.007			Note 22

Note 8: Luminance measurement

The test condition is at 25℃ and measured on the surface of OLED module.

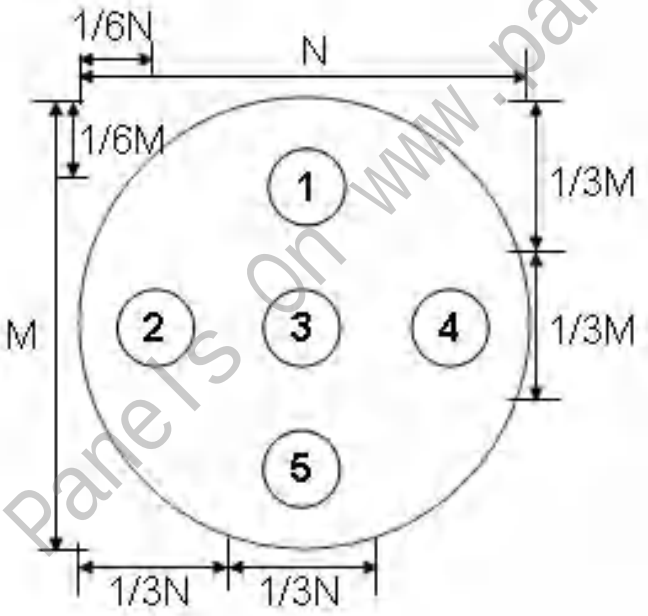
The data are measured after OLEDs are lighted on for more than 5 minutes and displays are fully white. The brightness is the average value of 5 measured spots. Measurement equipment CS2000 or similar equipments (Field of view:1deg,Distance:50cm)

- Measuring surroundings: Dark room.
- Measuring temperature: Ta=25℃.
- Adjust operating voltage to get optimum contrast at the center of the display.
- Measured value at the center point of panel must be after more than 5 minutes while backlight turning on.



Note 9: Uniformity

- The test condition is at 25℃ and measured on the surface of display module.
- Measurement equipment: CS2000 or similar equipments.
- The luminance uniformity is calculated by using following formula:
- ΔBp = Bp (Min.) / Bp (Max.)×100 (%)
- Bp (Max.) = Maximum brightness in 5 measured spots
- Bp (Min.) = Minimum brightness in 5 measured spots.



Note 10: **The definition of Viewing Angle**

Refer to the graph below marked by ϑ and Φ

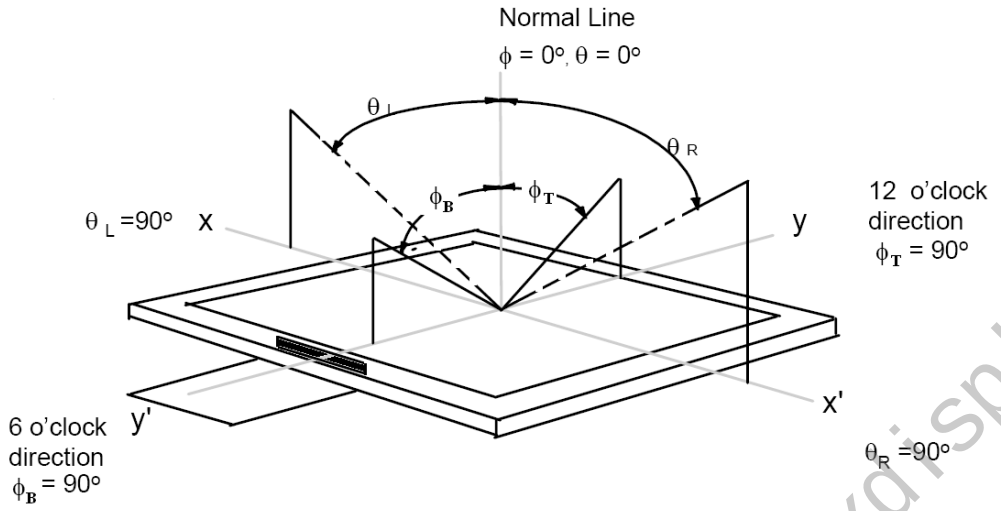


Fig 6 The definition of Viewing Angle

Note 11: **The definition of Contrast Ratio**

(Test OLED using CS2000 or similar equipments):

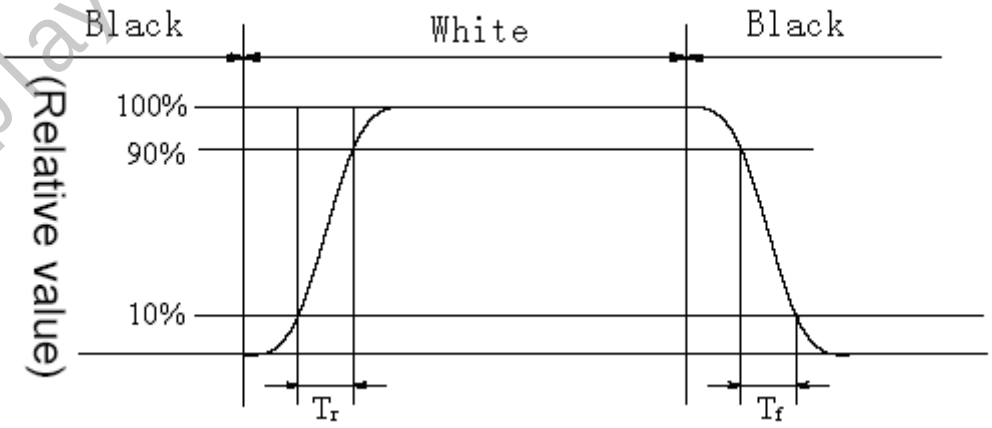
$$\text{Contrast Ratio(CR)} = \frac{\text{Luminance When OLED is at "White" state}}{\text{Luminance When OLED is at "Black" state}}$$

(Contrast Ratio is measured in optimum common electrode voltage. Black state display pure black color and luminance<0.003nits.)

Note 12: **Definition of Response time.**

(Test OLED using DMS501 or similar equipments):

The output signals of photo detector are measured when the input signals are changed from "black" to "white"(Voltage falling time) and from "white" to "black"(Voltage rising time), respectively. The response time is defined as the time interval between the 10% and 90% of amplitudes. Refer to figure as below.



Response time of gray to gray:（In 8 grays, neighboring gray-scale intensity can not capture, substitute with the brightness of the between level1 ~ level2）

- Measurement equipment: DMS501 or similar equipments.
- Test method :we define 8 grays L0-L7, the grays of L0-L7 were defined as:0,36,73, 109, 146, 182, 219, 255. The output signals of photo detector are measured when the input signals are changed from “Lx” to “Ly”, x, y= [0, 7]. The response time is defined as the time interval between the 10% and 90% of amplitudes. The result of the test can be noted as below:

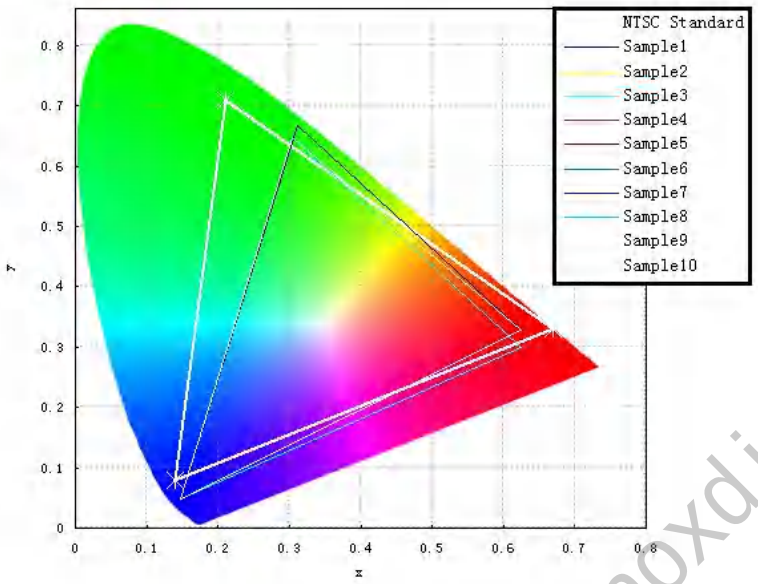
	L0	L1	L2	L3	L4	L5	L6	L7
L0	■							
L1		■						
L2			■					
L3				■				
L4					■			
L5						■		
L6							■	
L7								■

Note 13: Color Coordinates of CIE 1931

- The test condition is at 25℃ and measured on the surface of display module.
- Measurement equipment: CS2000 or similar equipments.
- The Color Coordinate (CIE 1931) is the measurement of the center of the display shown in below figure.

Note 14: **Definition of Color of CIE Coordinate and NTSC Ratio.**

$$S\% = \frac{\text{area of RGB triangle}}{\text{area of NTSC triangle}} \times 100\%$$



Note 15: **Flicker**

- Measurement equipment :CA-210 or similar equipments
- Measuring temperature: Ta=25℃.
- Test method: JEITA method
- Test pattern : Refer to below(Test Pattern should be full-fill of display screen)

1 L127　　2 row　　3 cloumn　　4 white

The point should be marked is, for line and frame inversion, the background of Flicker Test Pattern-"gray " are defined as middle gray scale .For example, RGB 24bit "gray" defined as below:

For Dot inversion, the RGB data for first pixel is (127, 0, 127), the RGB data for the second pixel is (0, 127, 0).

- Frame Frequency Requirement：45HZ.
- Measurement Point: the center of display active area.
- Conversion of Flicker ratio:

  Flicker[dB] = 10xlog[Px/P0]

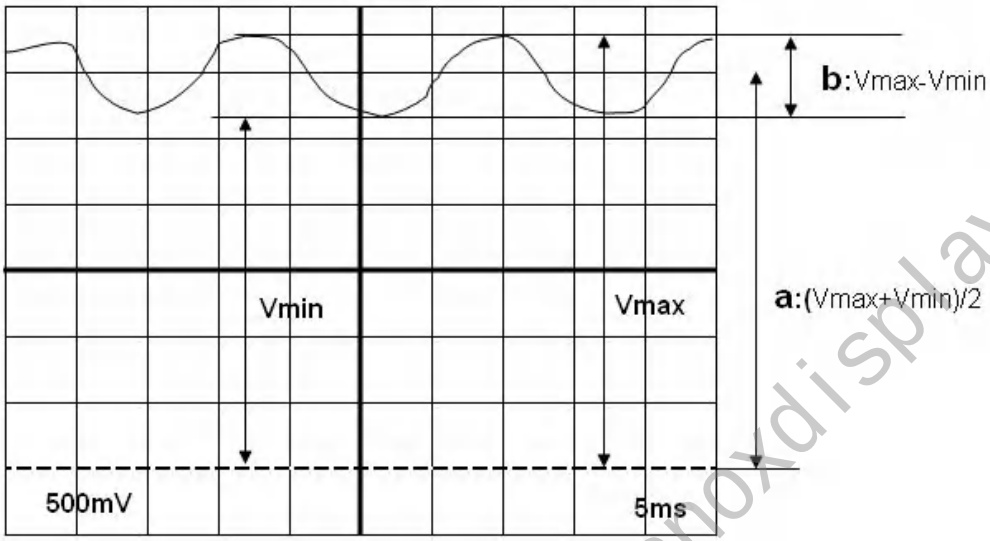
  Where

  Px: Maximum power spectrum of AC component after passing through integrator

  P0:Power spectrum of DC component after passing through integrator

  AC component=b (Refer to below diagram)

  DC component=a (Refer to below diagram)



Note 16: Gamma Curve Control

- For gamma curve control, request as below:
- 1,the whole curve's tolerance must control within +/-0.3, will test the gray scale below:
  0, 8, 16, 25, 33, 41, 49, 58, 66, 74, 82, 90, 99, 107, 115, 123, 132, 140, 148, 156, 165, 173, 181, 189, 197,206, 214, 222, 230, 239, 247, 255

Note 17: **Crosstalk**

- There should be no visible cross-talk in normal direction of the display when the two "Cross-talk Test Patterns " below are loaded.
- Measurement equipment: CS2000 or similar equipments
- The point should be marked is, the background of Cross-talk Test Pattern-"gray " are defined as middle gray scale . For example, RGB 24bit "gray" defined as below:

1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

- ΔBpn = Bpn (gray) / Bpn (white)
  Which n means the dot No. In the Cross-talk Test Pattern ;
  Bpn (gray) means the brightness of the No.n spots in Cross-talk Test Pattern;
  Bpn (white) means the brightness of the No.n spots in Full white Test Pattern;
- ΔBp (Max.) = Maximum value in ΔBp1~ΔBp4.
- ΔBp (Min.) = Minimum value in ΔBp1~ΔBp4.
- ΔCT=ΔBp (Max.)/ ΔBp(Min.).
- ΔCT must be less than 1.10

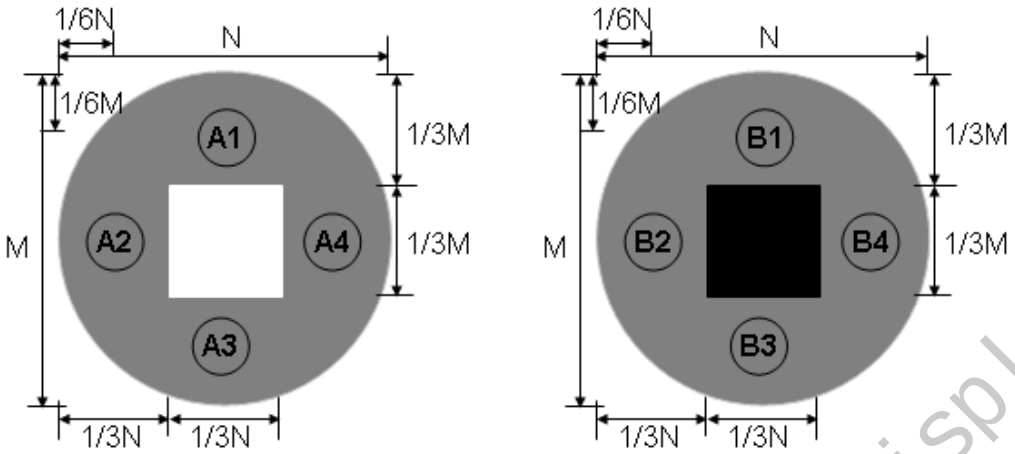


Fig 7 Cross-talk Test Pattern

Note 18:Reflectance Ratio

- Measurement equipment : X-rite SP64
- Measurement parameter： Reflectance Ratio @550nm

Note 19: Polarization Direction Definition

- Viewing direction is normal user viewing direction which is vertical to the display surface
- The polarizer which is closer to viewer is defined as Front Polarizer
- The polarizer which is on the rear side of viewer is defined as Rear Polarizer
- The X axis is defined as parallel line to top&bottom sidelines of the Active Area
- PdF which is marked in blue arrow is polarization degree of Front polarizer
- The polarization degree parameter must be indicated in range of 0deg to 180deg according to above definition
-

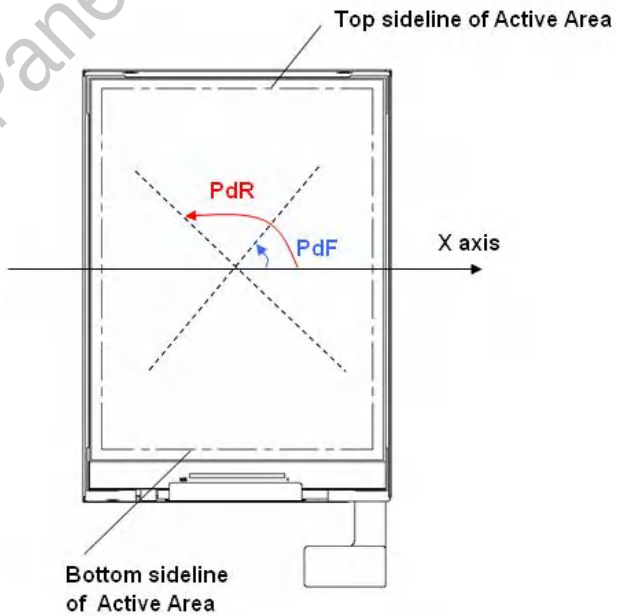


Fig 8 Absorption axis Definition

Note 20: **Definition of Luminance Decrease Ratio**

- Refer to the graph of note 9.
- Test pattern : Full White
- The luminance decrease ratio is calculated by using following formula:

$$\text{Luminance decrease Ratio} = 1 - \frac{\text{Luminance test at } \theta_L/\theta_R/\psi_T/\psi_B=30°}{\text{Luminance test at } \theta_L/\theta_R/\psi_T/\psi_B=0°}$$

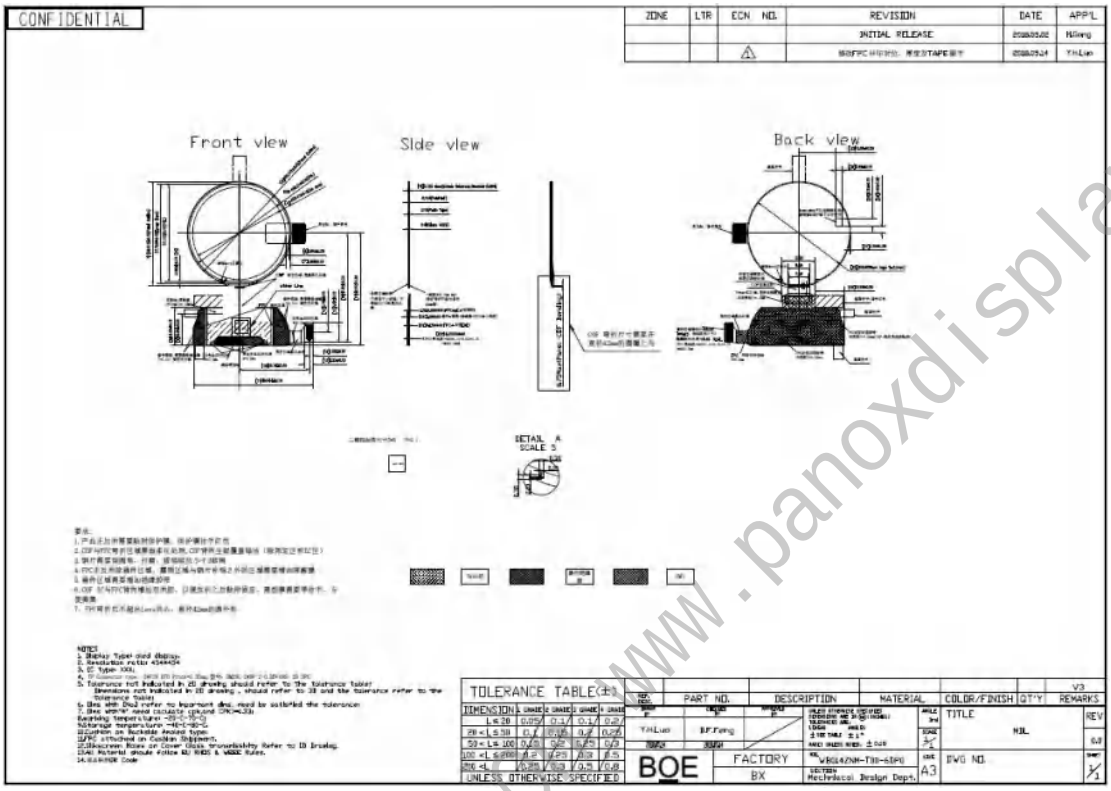
Note 21: Color Shift JNCD

- For JNCD measure:
- Fix on one pattern like white pattern,
- On the condition θ=0 F=0°, we can get the color coordinate (u1', v1') and onθL=30° we can get another color coordinate (u2', v2')
- Delta = Square Root((u2' - u1')^2 + (v2' - v1')^2)
- JNCD stands for "Just Noticeable Color Difference"
- For the (u', v') color space JNCD=0.0040.
- 2JNCD means Delta u'v'<0.0080
- For color shift we need to measure white/red/green/blue pattern.
- This Requirement is from our customer and we have test some of our phone display and the result is OK.

Note 22: White Color Uniformity

- The test condition is at 25℃ and measured on the surface of display module, The test location is same with uniformity
- Measurement equipment: CS2000 or similar equipments.
- The luminance uniformity is calculated by using following formula:
- All measurements are color between any two points：Δ u'v'-A=sqrt(（um-un）2+（vm-vn）2)
- All measurements are color between any two adjacent points：Δ u'v'-B=sqrt(（ui-uj）2+（vi-vj）2)

8 Mechanical Drawing——PDF



9 Reliability Requirement

9.1 General Reliability Requirement

Table 6 General Reliability Requirement

Test item	Test condition	No. of failures /No. of examinations
Vibration test	Amplitude 1.5mm,f=10 to 55 Hz, 2 hours each in the X,Y and Z direction	0/3
Packing shock test	Apply 1g for operation time 6ms, 3 times each in X,Y and Z direction	0/3
Packing vibration-proof test	2g, f=10->55->10Hz apply in each of X, Y, and Z direction for 30 min	0/3
Packing drop test	Drop the packing from 75cm height, 3 times for 6-faces, 3-edges and 1-corner	--