

INNOLUX DISPLAY CORPORATION

LCD MODULE

SPECIFICATION

Customer: _____

Model Name: CT028TN03 (Puma-T1)

Spec. No.: C028-03-TT-01

Date: 2008/01/02

Version: 1.0

- Preliminary Specification**
- Final Specification**

For Customer's Acceptance

Approved by	Comment

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1. General Specifications

1.1 Description

The CT028TN03 is a color active matrix Thin Film Transistor (TFT) Liquid Crystal Display (LCD) that uses amorphous silicon (a-Si) TFT as a switching device. This model is composed of a single 2.8 inches transmissive type main TFT-LCD panel and a resistive touch screen display. The resolution of the panel is 240x320 pixels and can display up to 65K/262K color.

1.2 Features

- TM type for main TFT-LCD panel
- Resistive type touch panel
- One backlight with 4 white LEDs
- 80-system 18/16/8-bit parallel bus
- Full, Still, Partial & Standby modes are available

1.3 Application

- Display terminals for cellular phone

1.4 General Specification

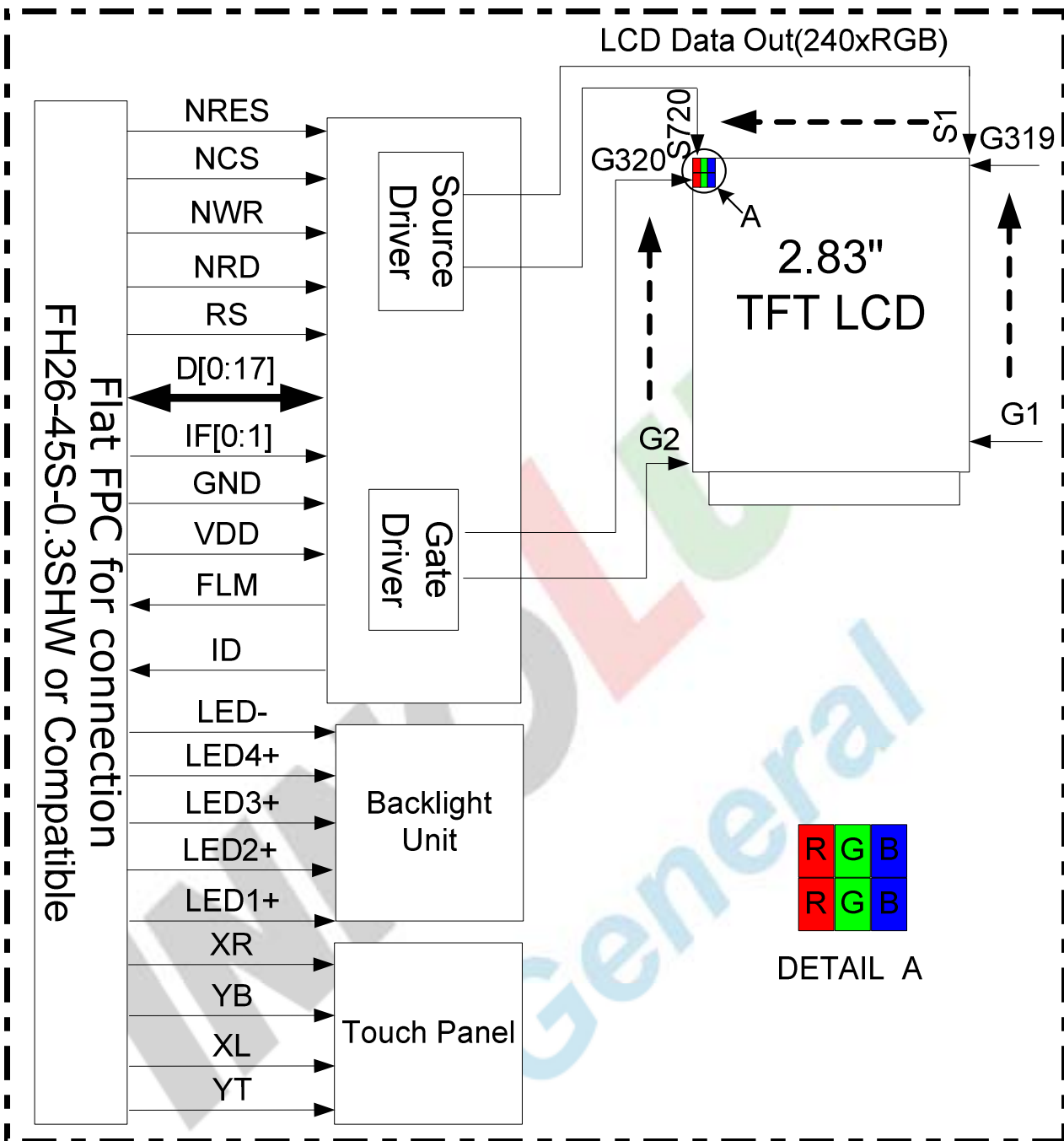
No.	Item	Specification	Unit	Remark
1	LCD Size	2.83	inch	-
2	Panel Type	a-Si TFT active matrix	-	-
3	Touch Panel Type	4-wire Analog Resistive	-	-
4	Resolution	240 x RGB x 320	pixel	-
5	Display Mode	Normally white, Transmissive	-	-
6	Display Number of Colors	65K/262K	-	-
7	Viewing Direction	12 o'clock	-	Note 1
8	Contrast Ratio	500	-	-
9	Luminance	250	cd/m ²	Note 2
10	Module Size	50.20(W) x 69.30(L) x 3.65 (T)	mm	Note 1
11	Panel Active Area	43.20(W) x 57.60(L)	mm	Note 1
12	Touch Panel Active Area	44.20(W) x 62.50(L)	mm	Note 1
13	Touch Panel View Area	44.80(W) x 63.10(L)	mm	Note 1
14	Pixel Pitch	0.180(W) x 0.180(L)	mm	-
15	Weight	TBD	g	-
16	Driver IC	HX8347	-	-
17	Driver IC RAM Size	240 x 18 x 320	bit	-
18	Light Source	4 white LEDs in Parallel	-	-
19	Interface	80-system 18/16/8-bit parallel bus	-	-
20	Operating Temperature	-20~70	°C	-
21	Storage Temperature	-30~80	°C	-

Note 1: Please refer to the mechanical drawing.

Note 2: Luminance is measured with touch panel attached.

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2. Block Diagram



3. Pin Assignments

Pin No.	Symbol	I/O	Function	Remark
1	FLM	O	Connect to TE(Tearing Effect) Pin	-
2	GND	P	Ground	-
3	YB	-	Touch panel signal	-
4	XR	-	Touch panel signal	-
5	YT	-	Touch panel signal	-
6	XL	-	Touch panel signal	-
7	GND	P	Ground	-
8	IF0	I	Interface select signal	Note 2
9	IF1	I	Interface select signal	Note 2
10	VDD	P	Analog/Logic supply voltage	Note 1
11	VDD	P	Analog/Logic supply voltage	Note 1
12	VDD	P	Analog/Logic supply voltage	Note 1
13	NC	-	Dummy Pin	-
14	D17	I/O	Data bus (Bit 17)	-
15	D16	I/O	Data bus (Bit 16)	-
16	D15	I/O	Data bus (Bit 15)	-
17	D14	I/O	Data bus (Bit 14)	-
18	D13	I/O	Data bus (Bit 13)	-
19	D12	I/O	Data bus (Bit 12)	-
20	D11	I/O	Data bus (Bit 11)	-
21	D10	I/O	Data bus (Bit 10)	-
22	D9	I/O	Data bus (Bit 9)	-
23	D8	I/O	Data bus (Bit 8)	-
24	D7	I/O	Data bus (Bit 7)	-
25	D6	I/O	Data bus (Bit 6)	-
26	D5	I/O	Data bus (Bit 5)	-
27	D4	I/O	Data bus (Bit 4)	-
28	D3	I/O	Data bus (Bit 3)	-
29	D2	I/O	Data bus (Bit 2)	-

30	D1	I/O	Data bus (Bit 1)	-
31	D0	I/O	Data bus (Bit 0)	-
32	NRES	I	Reset signal (Low: active)	-
33	NRD	I	Read signal (Low: active)	-
34	NWR	I	Write signal (Low: active)	-
35	RS	I	Register select signal	-
36	NCS	I	Chip select signal (Low: active)	-
37	GND	P	Ground	-
38	LED1+	-	LED anode	-
39	LED2+	-	LED anode	-
40	LED3+	-	LED anode	-
41	LED4+	-	LED anode	-
42	NC	-	Dummy Pin	-
43	NC	-	Dummy Pin	-
44	LED-	-	LED cathode	-
45	ID	O	Connect to VDD by a 120KΩ resistor	-

Note 1: There is only one power VDD input to combine digital power and analog power.

Note 2: Interface Selection

IF0	IF1	Bus Width	Bit Number in a pixel	Data Bus
0	0	16-bit parallel	16-bit (65K)	D15~D0
0	1	18-bit parallel	18-bit (262K)	D17~D0
1	1	8-bit parallel	18-bit (262K)	D7~D0

4. Electrical Specifications

4.1 Absolute Maximum Rating

($T_a=+25^{\circ}\text{C}$)

Item	Symbol	Values		Unit	Remark	
		Min.	Max.			
TFT Module	Analog/Logic Supply Voltage	VDD	-0.3	+4.6	V	Note 1
Backlight Unit	Current	I_B	-	120	mA	Note 2
	Power Consumption	P_{BL}	-	480	mW	Note 2

Note1: Permanent damage to the device may occur if maximum values are exceeded or reverse voltage is applied.

Note2: Without LED driver IC, please refer to 4.3.

4.2 Typical Operation Conditions

4.2.1 DC Characteristics

($T_a=+25^{\circ}\text{C}$)

Item	Symbol	Values			Unit	Remark
		Min.	Typ.	Max.		
Analog/ Logic Supply Voltage	VDD	2.7	2.8	3.0	V	Note
Input High Voltage	V_{IH}	0.8 VDD	-	VDD	V	
Input Low Voltage	V_{IL}	0	-	0.2VDD	V	
Output Low Voltage	V_{OL}	0	-	0.2VDD	V	
Output High Voltage	V_{OH}	0.8 VDD	-	VDD	V	
Frame Frequency	f_{FRAME}	-	80	-	Hz	

Note: To prevent IC latch up or DC operation in LCD panel, the power on/off sequence should follow the driver IC specification.

4.2.2 Current Consumption

Item	Symbol	Values		Unit	Remark
		Typ.	Max.		
MCU Interface (80-system 18/16/8-bit parallel bus)					
Still Mode	VDD	TBD	TBD	mA	Note1
Standby Mode	VDD	TBD	TBD	uA	Note1, Note2

Note1: Test Condition

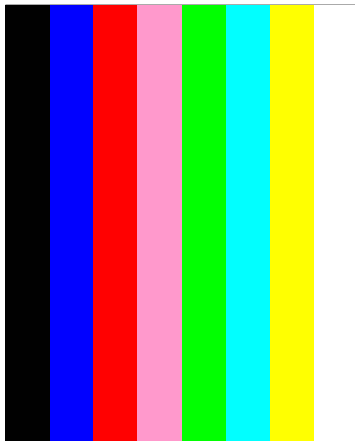
Typ: VDD=2.8V

Display Pattern: 8 Color Bar

Frame Rate=80Hz at Line Inversion

Operating Temperature: 25°C

Typ. current check pattern:



8-Color Bar

Max: VDD=3.0V

Display Pattern: All Pixel Black

Frame Rate=80Hz at Line Inversion

Operating Temperature: 25°C

Max. current check pattern:

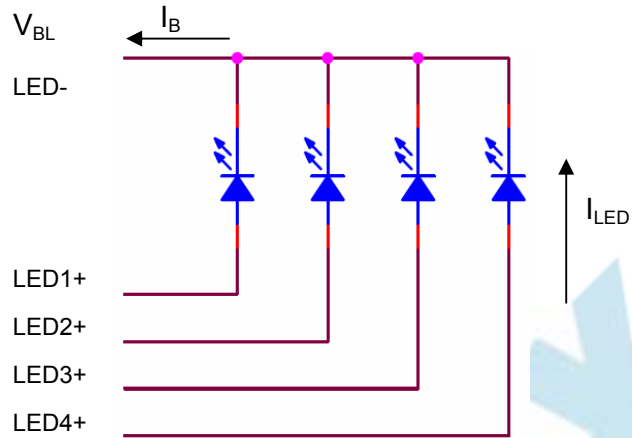


Black

Note2: In the standby mode, all the internal display operations are suspended including the internal R-C oscillator.

4.3 Backlight Unit

The backlight system is an edge lighting type with 4 white LEDs.



($T_a=+25^{\circ}\text{C}$)

Item	Symbol	Values			Unit	Remark
		Min.	Typ.	Max.		
Current	I_B	-	80	-	mA	Note 1
Power Consumption	P_{BL}	-	270	-	mW	Note 2

Note1: 4 LEDs are connected in parallel; each LED's current consumption is 20mA.

Note2: Where $I_B=80\text{mA}$, $P_{BL} = I_B \times V_{BL}$, V_{BL} is backlight forward voltage.

4.4 Instruction Setting Flow

4.4.1 Initial Setting Sequence
TBD

4.4.2. Standby In/Out Sequence
TBD

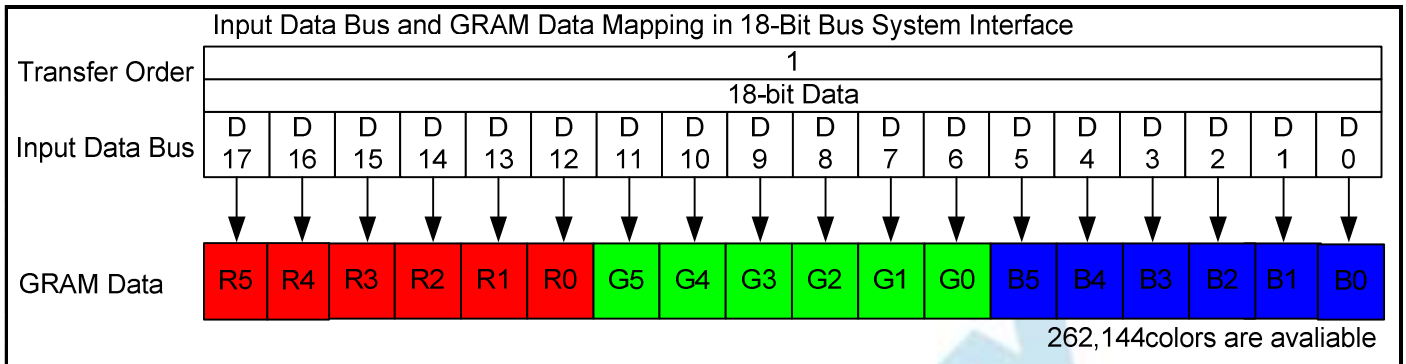
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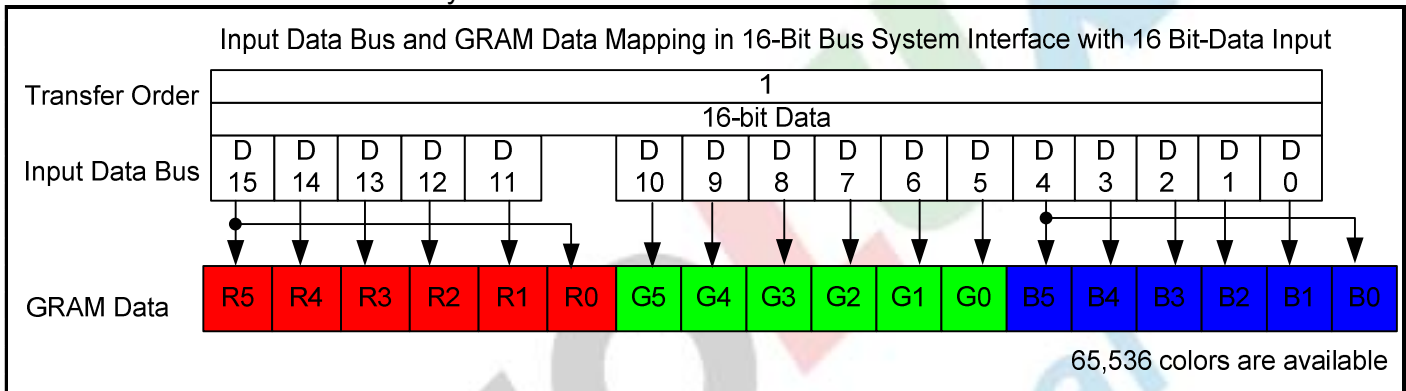
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4.5 Display RAM Data Format and Input Bus

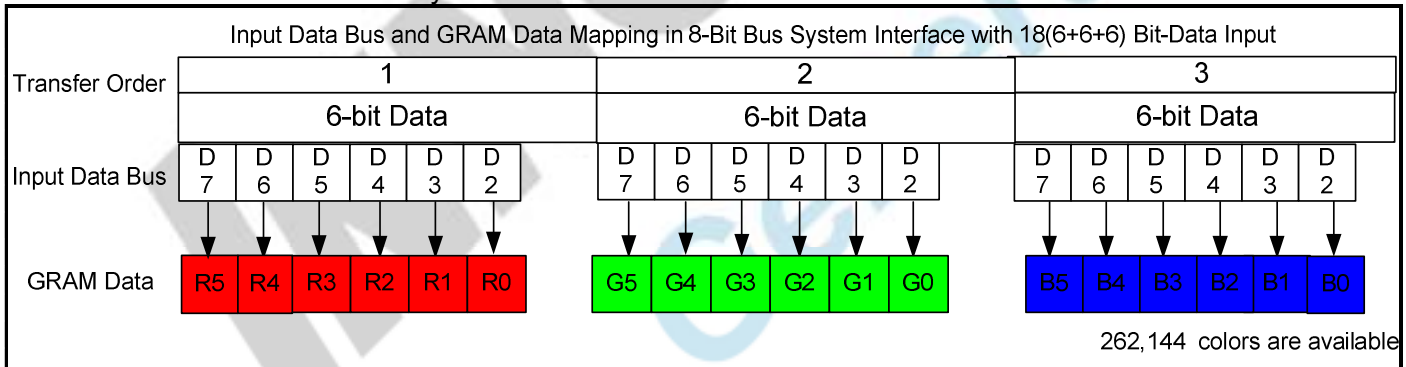
4.5.1 18-bit Parallel Bus System Interface



4.5.2 16-bit Parallel Bus System Interface

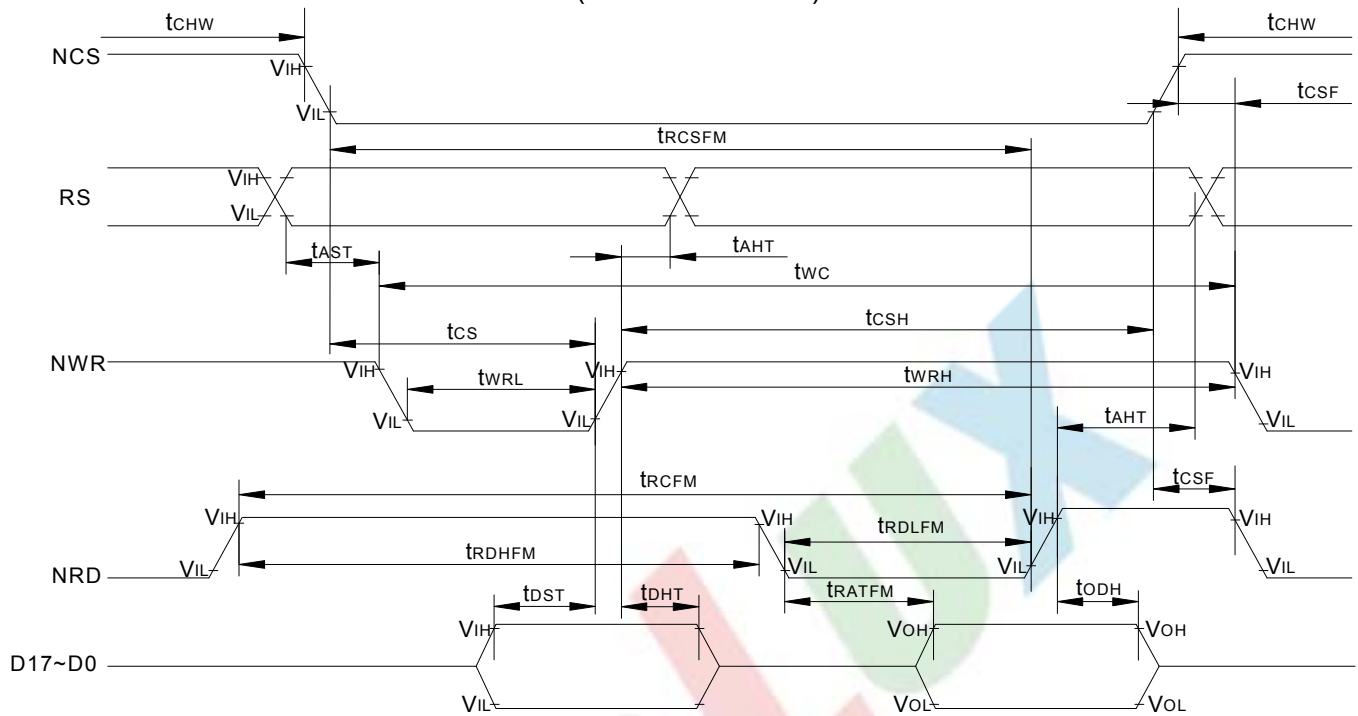


4.5.3 8-bit Parallel Bus System Interface



4.6 Timing Characteristic

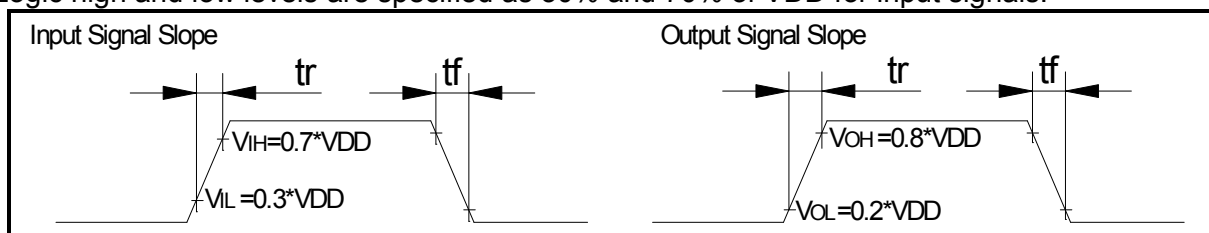
4.6.1 Parallel Interface Characteristics (8080-series MPU)



(VDD=2.7 to 3.0V, Ta=25°C)

Signal	Symbol	Parameter	Min.	Max	Unit	Description
RS	t_{AST}	Address setup time	10	-	ns	-
	t_{AHT}	Address hold time (Write/Read)	10	-	ns	-
NCS	t_{CHW}	Chip select "H" pulse width	0	-	-	-
	t_{CS}	Chip select setup time (Write)	35	-	-	-
	t_{RCSFM}	Chip select setup time	180	-	ns	-
	t_{CSF}	Chip select wait time (Write/Read)	10	-	-	-
NWR	t_{CSH}	Chip select hold time	10	-	-	-
	t_{WC}	Write cycle	100	-	-	-
	t_{WRH} t_{WRL}	Control pulse "H" duration Control pulse "L" duration	15 20	- -	ns -	-
NRD	t_{RDFM}	Read cycle	250	-	-	-
	t_{RDHFM} t_{RDLFM}	Control pulse "H" duration Control pulse "L" duration	15 180	- -	ns -	When read from GRAM
	t_{DST} t_{DHT} t_{RATFM} t_{ODH}	Data setup time Data hold time Read access time Output disable time	10 10 - 20	- - 180 80	ns	For maximum $C_L=30pF$ For minimum $C_L=8pF$

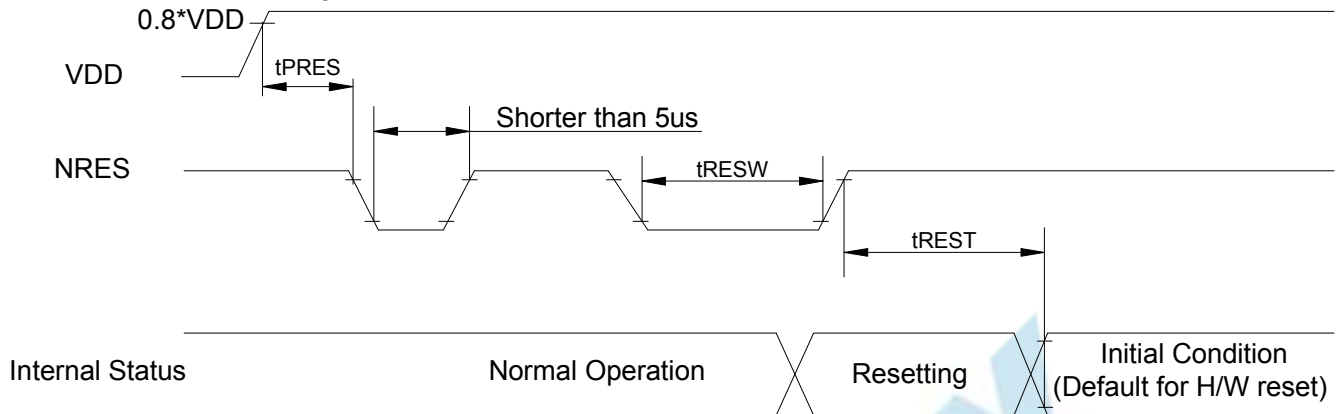
Note: The input signal rise time and fall time (t_r , t_f) is specified at 15ns or less.
Logic high and low levels are specified as 30% and 70% of VDD for input signals.



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4.6.2 Reset Input Timing

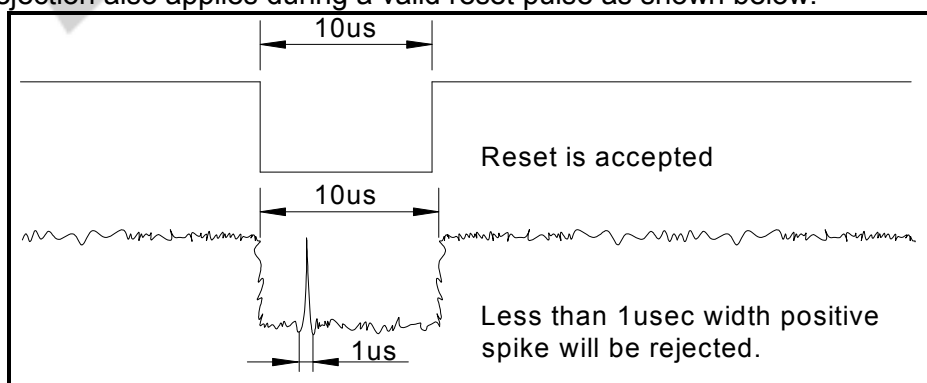


Symbol	Parameter	Related Pins	Min.	Typ.	Max.	Note	Unit
tRESW	Reset low pulse width ⁽¹⁾	NRES	10	-	-	-	µs
tREST	Reset complete time ⁽²⁾	-	-	-	5	When reset applied during STB mode	ms
		-	-	-	120	When reset applied during STB mode	ms
tPRES	Reset goes high level after Power on time	NRES & VDD	1	-	-	Reset goes high level after Power on	ms

Note: (1) Spike due to an electrostatic discharge on NRES line does not cause irregular system reset according to the table below.

NRES Pulse	Action
Shorter than 5µs	Reset Rejected
Longer than 10µs	Reset
Between 5µs and 10µs	Reset Start

- (2) During the resetting period, the display will be blanked (The display is entering blanking sequence, which maximum time is 120 ms, when Reset Starts in STB Out-mode, the display remains the blank state in STB-mode) and then return to Default condition for H/W reset.
- (3) During Reset Complete Time, ID2 and VCOMOF value in OTP will be latched to internal register during this period. This loading is done every time when there is H/W reset complete time (tREST) within 5ms after a rising edge of NRES.
- (4) Spike Rejection also applies during a valid reset pulse as shown below:



- (5) It is necessary to wait 5msec after releasing NRES before sending commands. Also STB Out command cannot be sent for 120msec.

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5 Touch Panel Specifications

5.1 Electrical Characteristics

Item	Value			Unit	Remark
	Min.	Typ.	Max.		
Linearity	-1.5	-	1.5	%	Note 3
Terminal Resistance	180	-	560	Ω	X
	270	-	760	Ω	Y
Insulation resistance	25	-	-	M Ω	DC 25V
Operating Voltage	-	5	-	V	DC

5.2 Optical Characteristics

Item	Value			Unit	Remark
	Min.	Typ.	Max.		
Response Time	-	-	10	ms	100k Ω pull-up
Light Transparency	80	-	-	%	-

5.3 Mechanical Characteristics

Item	Value			Unit	Remark
	Min.	Typ.	Max.		
Active Force	-	-	80	gf	Note 1
Surface Hardness	3	-	-	H	-
Pen Sliding Durability	100,000	-	-	time	Note 2, 4
Hitting Durability	1,000,000	-	-	time	Note 2, 5

Note 1: Do not operate it with a stylus other than a polyacetal pen (tip R0.8mm or less) or a finger, especially those with hard or sharp tips such as a ball point pen or a mechanical pencil.

Note 2: Test Condition:

End shape: R0.8mm and R8.0mm,

Resistance between X and Y axis must be equal or lower than $2K\Omega$, the test voltage =DC5V.

Note 3: Measurement For Linearity. (After environment and life test)

-Load: 150g with End shape R0.8 mm Polyacetal resin.

-Measuring area: 1.0mm inside the edge of touch panel active area, pitch 5mm. (Fig. 1)

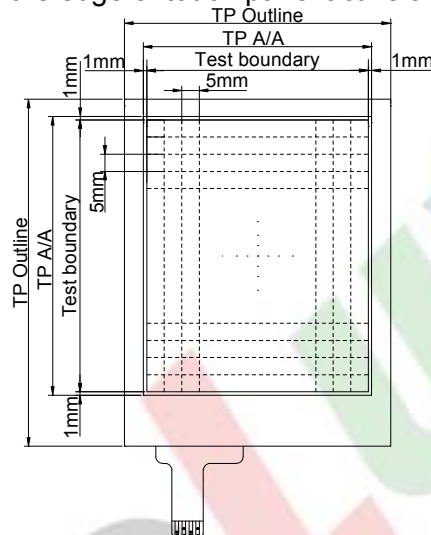


Fig. 1 Measuring area for Linearity

Note 4: Measurement for surface area.

-Scratch 100,000 times of straight line on the screen with a stylus which is changed every 20,000 times. One time is defined in one direction, strike one time, and then in the reverse direction strike one time that defined 2nd time.

-Force: 150gf.

-Speed: 150mm/sec.

-Writing Length: 35mm.

-Stylus: R0.8 polyacetal tip.

-Measuring area: 2.0mm inside the edge of touch panel active area, any line. (Fig. 2)

-Result: the SPEC of Electrical Characteristics pass.

Note 5: Hit 1,000,000 times on the screen with a R0.8mm Polyacetal resin By stylus tapping at same points.

-Force: 250gf.

-Speed: 5times/sec.

-Measuring area: 2.0mm inside the edge of touch panel active area, any point. (Fig. 2)

-Result: The SPEC of Electrical Characteristics pass.

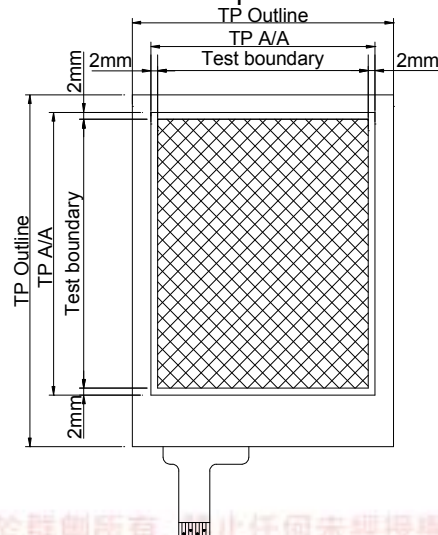
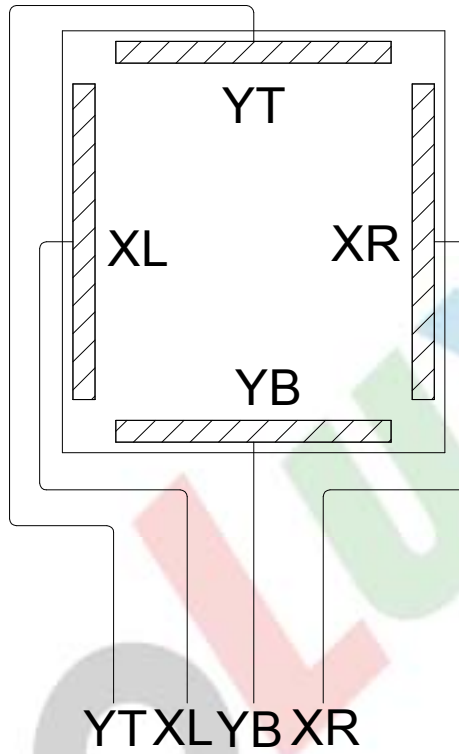


Fig. 2 Measuring area for Pen Sliding & Hitting Durability

5.4 Touch Panel Circuit Block

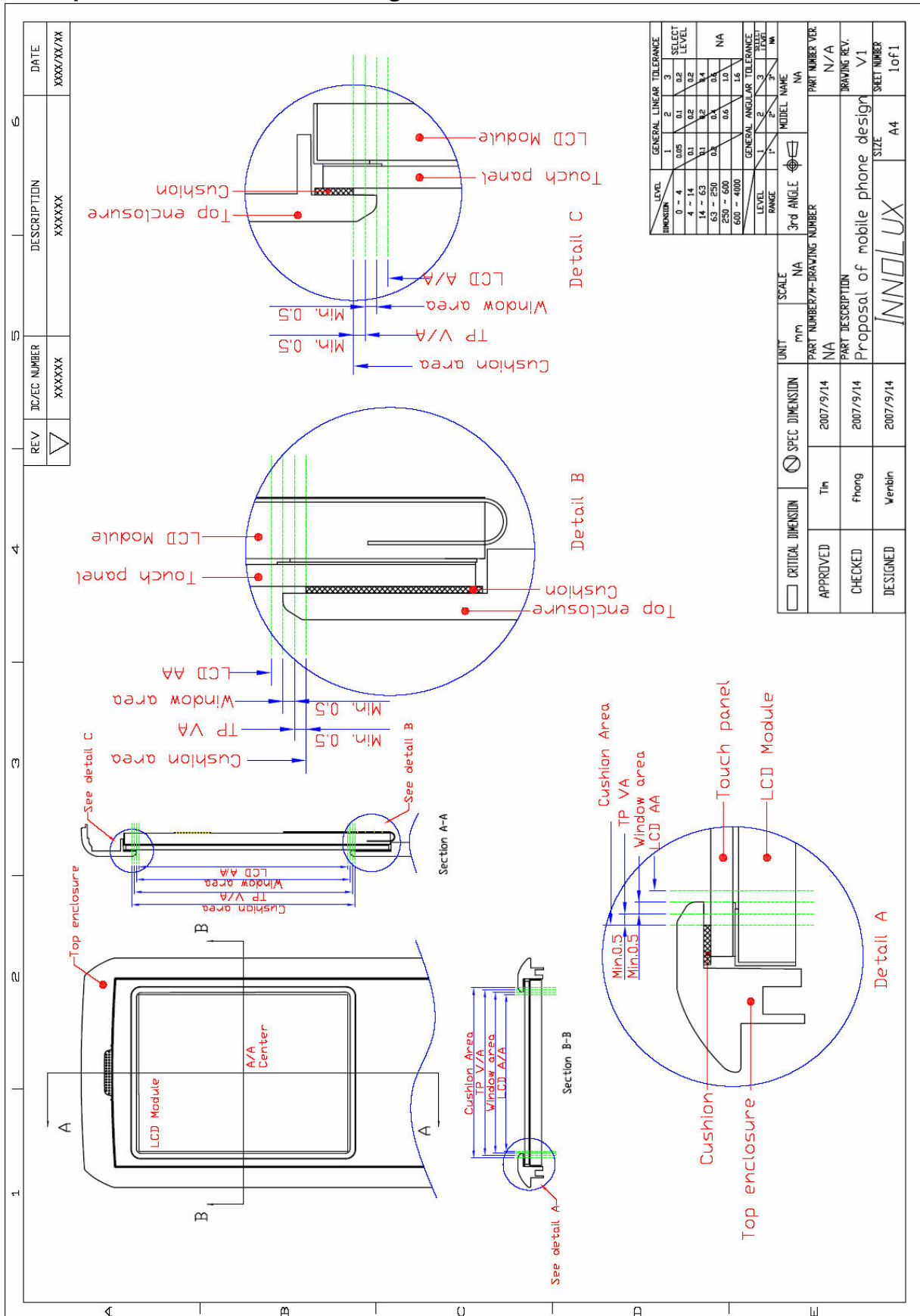


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5.5 Proposal of Mobile Phone Design



Note 1: "Top enclosure" is the top case of mobile phone.

Note 2: "Window Area" is the opening area of top enclosure of the mobile phone, we suggest customers design it following the drawing and there should be no defect in the LCD module within the area.

Note 3: "Cushion Area" is the cushion customer use between top enclosure and LCM, we suggest customers design it following the drawing and the cushion should not press the TP V/A.

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6 Optical Specifications

(Ta=+25°C, VDD=+2.8V, I_B=80mA)

Item	Symbol	Condition	Values			Unit	Remark	
			Min.	Typ.	Max.			
Viewing Angle Range	Left	θ_L	CR \geq 10	-	65	-	degree	Note 1,2
	Right	θ_R		-	65	-		
	Top	θ_T		-	65	-		
	Bottom	θ_B		-	55	-		
Response Time	T _{on} +T _{off}	Normal $\theta=\phi=0^\circ$	-	25	-	ms	Note 2,3	
Contrast Ratio	CR	Normal $\theta=\phi=0^\circ$	350	500	-	-	Note 2,4	
Luminance	L	Normal $\theta=\phi=0^\circ$	-	250	-	cd/m ²	Note 2,5	
Color Chromaticity (CIE1931)	White	W _x	Normal $\theta=\phi=0^\circ$	-	0.28	-	-	Note 2,6
		W _y		-	0.29	-		
	Red	R _x		-	0.59	-		
		R _y		-	0.34	-		
	Green	G _x		-	0.34	-		
		G _y		-	0.58	-		
	Blue	B _x		-	0.14	-		
		B _y		-	0.06	-		
Color Gamut	NTSC	CIE1931	-	55	-	%	-	
Luminance Uniformity	U _L	Normal $\theta=\phi=0^\circ$	75	80	-	%	Note 2,7	
Flicker	-	-	No Visible			-	Note 8	
Crosstalk	-	-	No Visible			-	Note 9	

Note 1: Definition of viewing angle

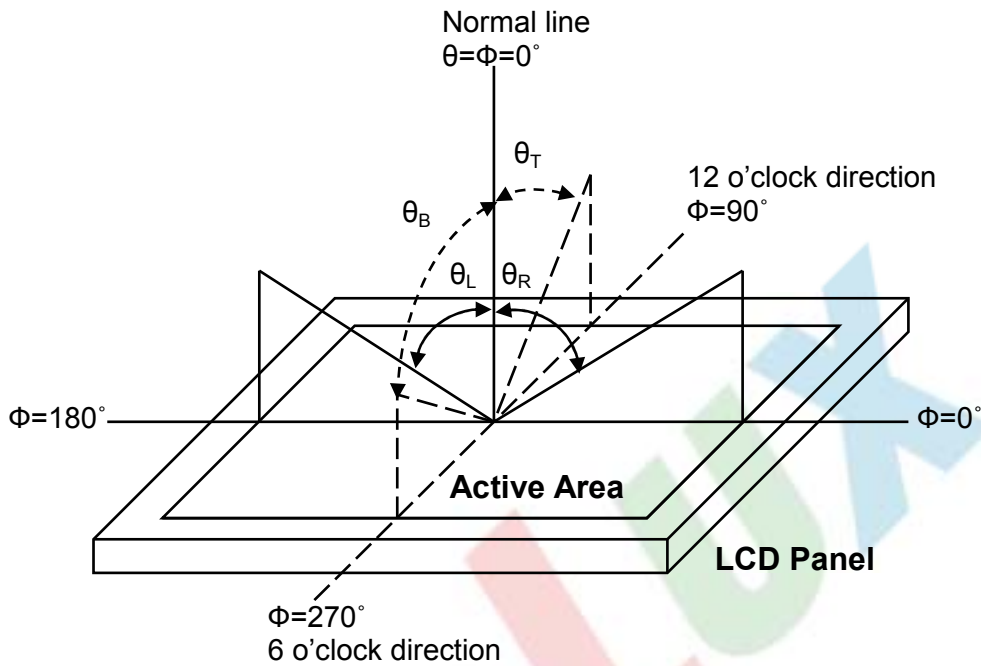


Fig. 1 Definition of viewing angle

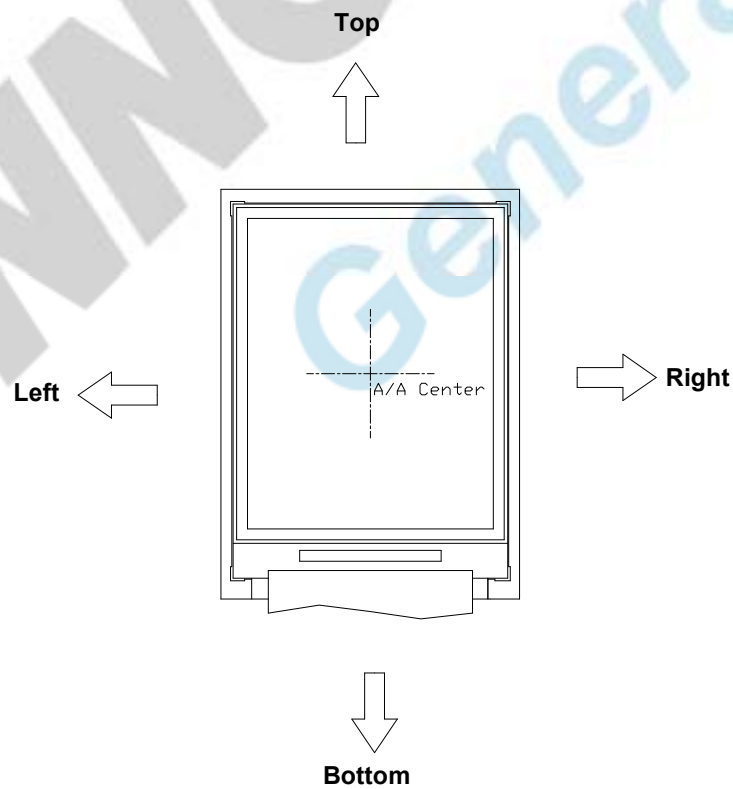


Fig. 2 Definition of viewing angle for display

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Note 2: Definition of optical measurement system

The optical characteristics should be measured in a dark room with ambient temperature $T_a = +25^\circ\text{C}$. The optical properties are measured at the center point of the LCD screen after 5 minutes operation. (Equipment: Photo detector TOPCON BM-5A or BM-7 /Field of view: 1° /Height: 500mm.)

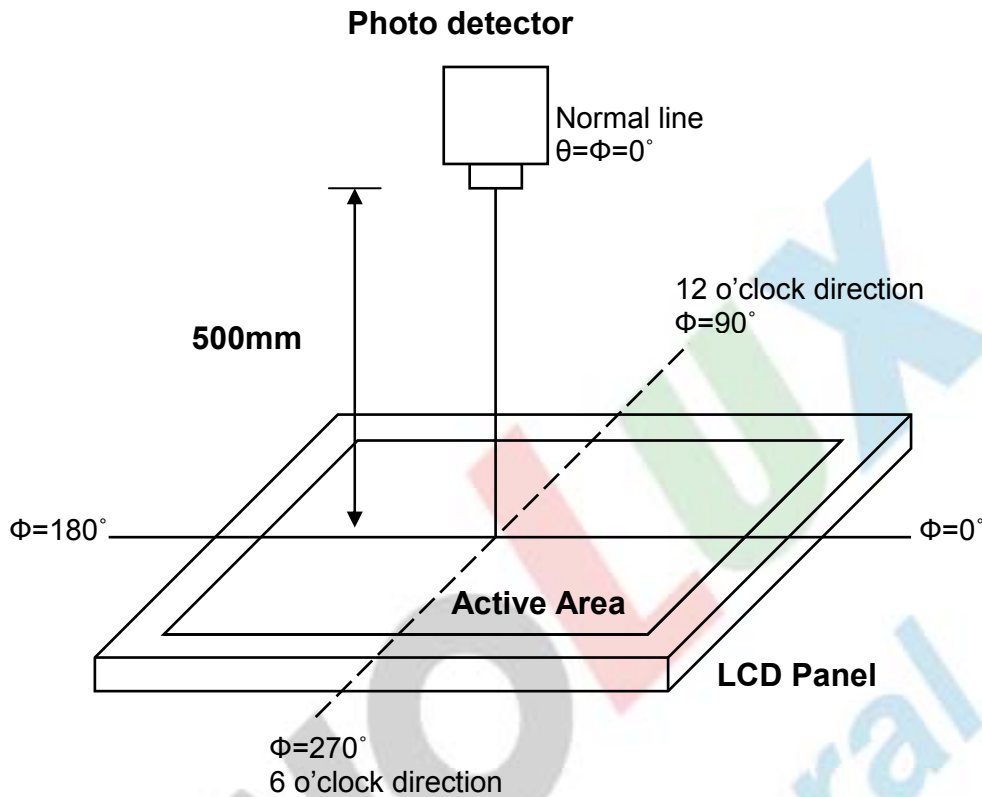


Fig. 3 Optical measurement system setup

Note 3: Definition of response time

The response time is defined as the LCD optical switching time interval between "White" state and "Black" state. Rise time (T_{on}) is the time between photo detector output intensity changed from 90% to 10%, and fall time (T_{off}) is the time between photo detector output intensity changed from 10% to 90%.

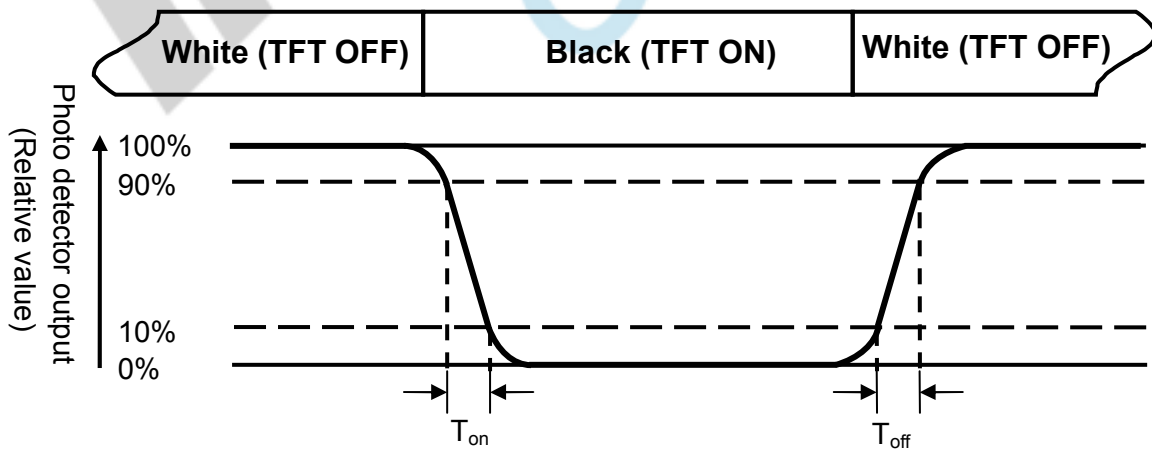


Fig. 4 Definition of response time

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Note 4: Definition of contrast ratio

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

Note 5: Definition of luminance

Measured at the center area of the panel when LCD panel is driven at "white" state.

Note 6: Definition of color chromaticity (CIE1931)

Color coordinates measured at the center point of LCD when panel is driven at "White", "Red", "Green" and "Blue" state respectively.

Note 7: Definition of luminance uniformity

To test for uniformity, the tested area is divided into 3 rows and 3 columns. The measurement spot is placed at the center of each circle as below.

$$\text{Luminance Uniformity (U}_L\text{)} = \frac{L_{\min}}{L_{\max}}$$

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

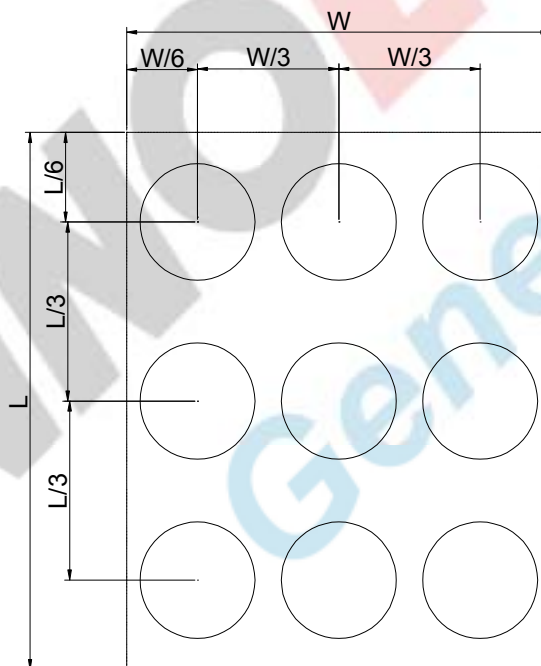


Fig. 5 Definition of luminance uniformity

L_{\max} : The measured maximum luminance of all measurement position.

L_{\min} : The measured minimum luminance of all measurement position.

Note 8: Definition of Flicker

Flicker is the pattern usually used to describe the visual sensation produced by a rapidly varying light intensity. There should be no visible flicker in normal direction of the display when the following figure is loaded.

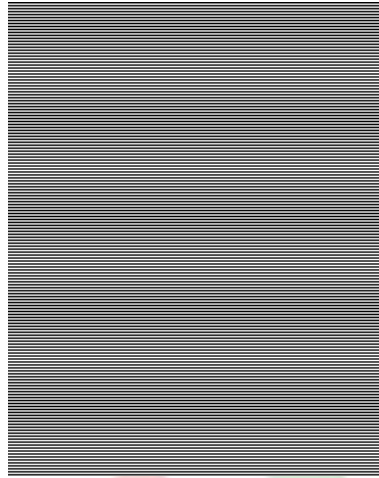


Fig.6 Flicker checker pattern

Note9: Definition of crosstalk

There should be no visible in normal direction of the display when the following figures are loaded.

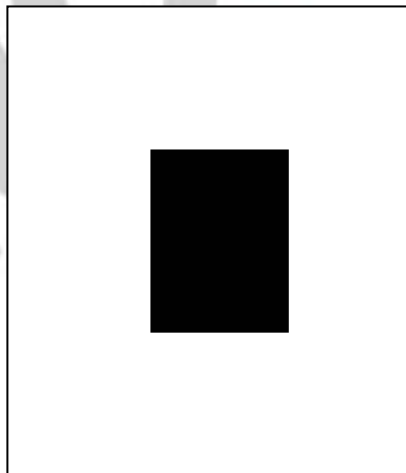


Fig.7 Crosstalk checker pattern

7 Reliability Test Items

Test Items	Test Conditions	Remark
High Temperature Storage	+80°C±3°C for 240 hours	-
Low Temperature Storage	-30°C±3°C for 240 hours	-
High Temperature Operation	+70°C±3°C for 240 hours	-
Low Temperature Operation	-20°C±3°C for 240 hours	-
High Temperature and Humidity Operation	+60°C±3°C, 90%±3%RH max. for 240 hours	-
Thermal Shock	-30°C/0.5h ~ +80°C/0.5h for a total 100 cycles, Start with cold temp and end with high temp	-
Vibration Test	Frequency range:10~55Hz Stoke:1.5mm Sweep:10Hz~55Hz~10Hz 2 hours for each direction of X. Y. Z. (6 hours for total)	-
Mechanical Shock	100G 6ms,±X, ±Y, ±Z 3 times for each direction	-
Package Vibration Test	Random Vibration : 0.015G ² /Hz from 5-200Hz, -6dB/Octave from 200-500Hz 1 hour for each direction of X. Y. Z. (3 hours for total)	-
Package Drop Test	Height :72cm(Weight ≤ 10kg); 60cm(Weight > 10kg) 1 corner, 3 edges, 6 surfaces	-
Electro Static Discharge	± 2KV, Human Body Mode, 100pF/1500Ω	-

Note1: During the display practical test under normal operation condition, there shall be not change or effect to the display function.

Note2: Before function check, the test sample requires 2 hours storage at room temperature.

Before test the function of TP, the sample must be placed in room temperature for 24hrs after RA test.

8 Handling Precautions

8.1. Safety

- 8.1.1 The liquid crystal in the LCD is poisonous. **DO NOT** put it in your mouth. If the liquid crystal touches your skin or clothes, wash it off immediately using soap and water.

8.2. Handling

- 8.2.1 The LCD and touch panel is made of plate glass. **DO NOT** subject the panel to mechanical shock or to excessive force on its surface.
- 8.2.2 Do not handle the product by holding the flexible pattern portion in order to assure the reliability
- 8.2.3 Transparency is an important factor for the touch panel. Please wear clear finger sacks, gloves and mask to protect the touch panel from finger print or stain and also hold the portion outside the view area when handling the touch panel.
- 8.2.4 Provide a space so that the panel does not come into contact with other components.
- 8.2.5 To protect the product from external force, put a covering lens (acrylic board or similar board) and keep an appropriate gap between them.
- 8.2.6 Transparent electrodes may be disconnected if the panel is used under environmental conditions where dew condensation occurs.
- 8.2.7 Property of semiconductor devices may be affected when they are exposed to light, possibly resulting in IC malfunctions.
- 8.2.8 To prevent such IC malfunctions, your design and mounting layout shall be done in the way that the IC is not exposed to light in actual use.

8.3. Static Electricity

- 8.3.1 Ground soldering iron tips, tools and testers when they are in operation.
- 8.3.2 Ground your body when handling the products.
- 8.3.3 Power on the LCD module **BEFORE** applying the voltage to the input terminals.
- 8.3.4 **DO NOT** apply voltage which exceeds the absolute maximum rating.
- 8.3.5 Store the products in an anti-electrostatic bag or container.

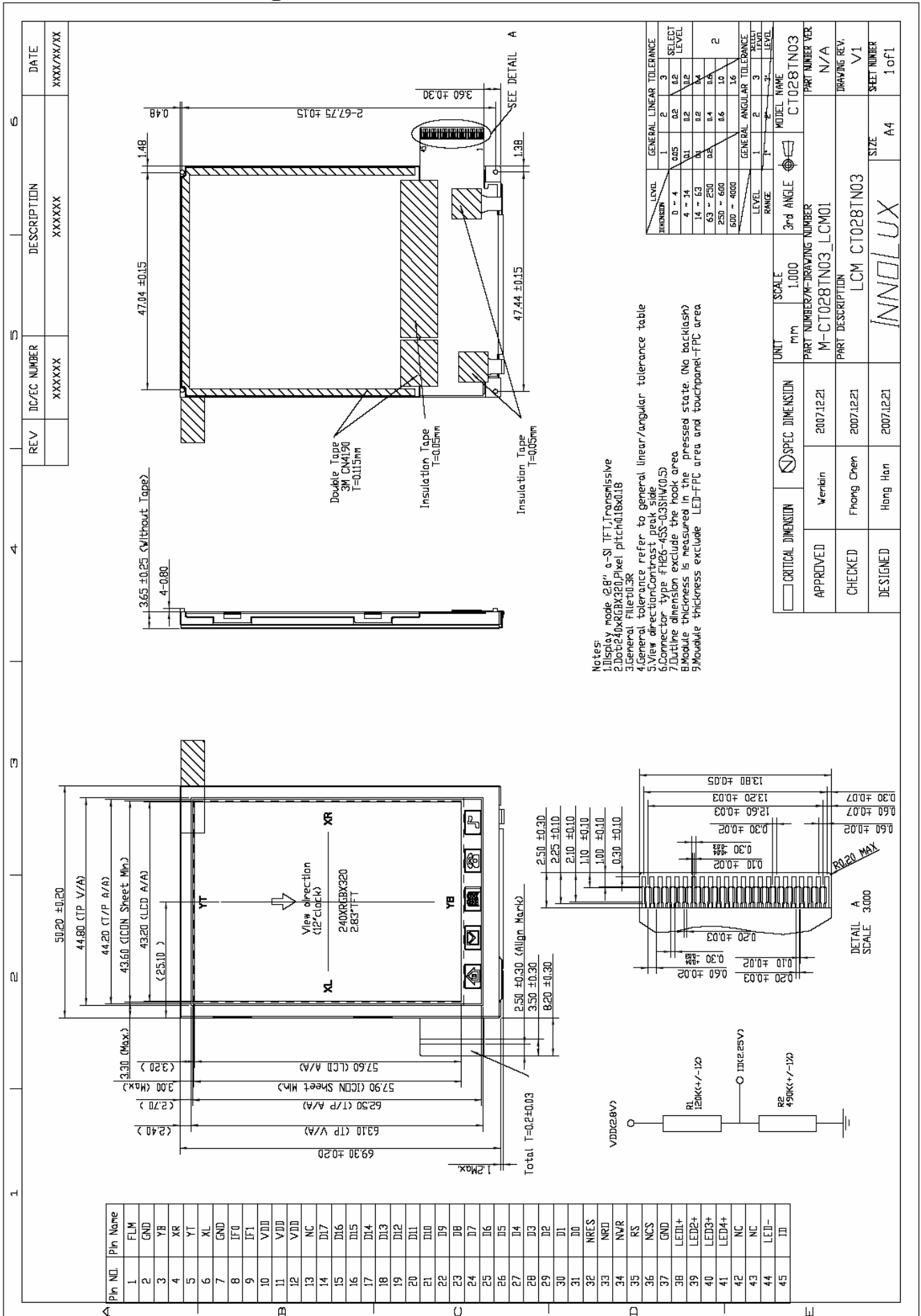
8.4. Storage

- 8.4.1 Store the products in a dark place at $+25^{\circ}\text{C} \pm 10^{\circ}\text{C}$ with low humidity (65%RH or less).
- 8.4.2 **DO NOT** store the products in an atmosphere containing organic solvents or corrosive gas.

8.5. Cleaning

- 8.5.1 **DO NOT** wipe the touch panel with dry cloth, as it may cause scratch.
- 8.5.2 Wipe off the stain on the product by using soft cloth moistened with ethanol. **DO Not** allow ethanol to get in between the upper film and the bottom glass. It may cause peeling issue or defective operation. **Do not** use any organic solvent or detergent other than ethanol.

9 Mechanical Drawing



- Notes:
1. Display mode: 28", a-SI TFT, Transmissive
 2. Dot: 240xRGBx320 Pixel pitch: 0.18x0.18
 3. General: File: 10.3R
 4. General: tolerance refer to general linear/angular tolerance table
 5. View direction: Contrast peak side
 6. Connector type: FH26-45S-0.3SHW(0.5)
 7. Outline dimension exclude the hook area
 8. Module thickness is measured in the pressed state. (No backlash)
 9. Module thickness exclude LED-FPC area and touchpanel-FPC area

LEVEL	GENERAL LINEAR TOLERANCE	GENERAL ANGULAR TOLERANCE	SELECT LEVEL
1	0.05	0.2	0.2
2	0.1	0.4	0.4
3	0.15	0.6	0.6
4	0.2	1.0	1.0
5	0.3	1.5	1.5
6	0.4	2.0	2.0
7	0.5	3.0	3.0
8	0.6	4.0	4.0
9	0.8	6.0	6.0
10	1.0	8.0	8.0
11	1.2	10.0	10.0
12	1.5	12.0	12.0
13	2.0	15.0	15.0
14	2.5	20.0	20.0
15	3.0	25.0	25.0
16	4.0	30.0	30.0
17	5.0	40.0	40.0
18	6.0	50.0	50.0
19	8.0	60.0	60.0
20	10.0	80.0	80.0
21	12.0	100.0	100.0
22	15.0	120.0	120.0
23	20.0	150.0	150.0
24	25.0	200.0	200.0
25	30.0	250.0	250.0
26	40.0	300.0	300.0
27	50.0	400.0	400.0
28	60.0	500.0	500.0
29	80.0	600.0	600.0
30	100.0	800.0	800.0
31	120.0	1000.0	1000.0
32	150.0	1200.0	1200.0
33	200.0	1500.0	1500.0
34	250.0	2000.0	2000.0
35	300.0	2500.0	2500.0
36	400.0	3000.0	3000.0
37	500.0	4000.0	4000.0
38	600.0	5000.0	5000.0
39	800.0	6000.0	6000.0
40	1000.0	8000.0	8000.0
41	1200.0	10000.0	10000.0
42	1500.0	12000.0	12000.0
43	2000.0	15000.0	15000.0
44	2500.0	20000.0	20000.0
45	3000.0	25000.0	25000.0

CRITICAL DIMENSION	SPEC DIMENSION	UNIT	SCALE	MODEL NAME
APPROVED	2007.12.21	M/M	1:000	CT028TN03
CHECKED	Phong Chen	M-CT028TN03_DRAWING NUMBER		PART NUMBER VAR
DESIGNED	Hong Han	PART DESCRIPTION		N/A
				DRAWING REV. V1
				SHEET NUMBER 1 of 1
				SIZE A4
				INNO LUX

10. Package Drawing

10.1. Packing Material Per Carton

TBD

10.2. Packing Specification and Quantity

TBD

10.3. Illustration

TBD

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General

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