SPECIFICATION
FOR
APPROVAL

(●) Preliminary Specification
( ) Final Specification

Title	3.54” (320XRGBX480) TFT LCD

BUYER	
MODEL	

SUPPLIER	LG Display Co., Ltd.
*MODEL	LH350H01
SUFFIX	FD01

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

SIGNATURE	DATE
/	
/	
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Please return 1 copy for your confirmation with your signature and comments.

APPROVED BY	DATE
REVIEWED BY	
PREPARED BY	

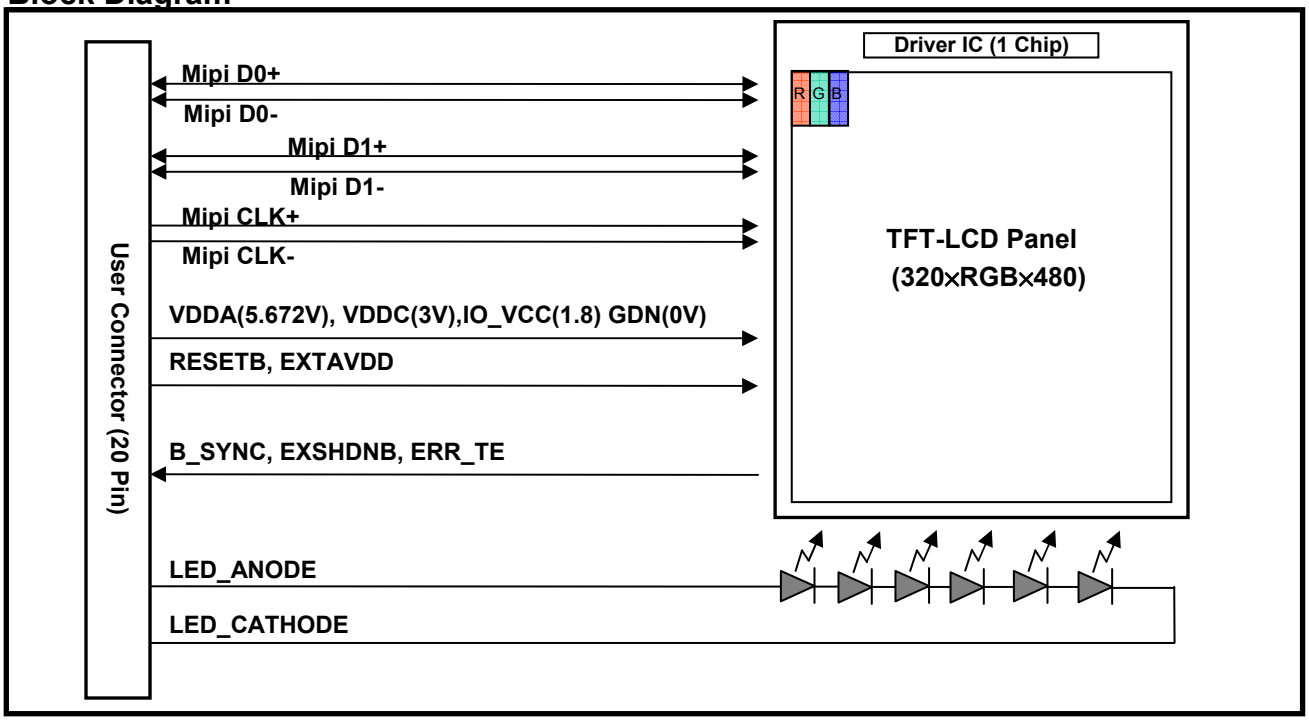
Product Engineering Dept.
LG Display Co., Ltd

Product Specification

1. GENERAL DESCRIPTION

The LH350H01 is a Color Active Matrix Liquid Crystal Display with Light Emission Diode(LED) backlight system. The matrix employs a-Si Thin Film Transistor as the active element.
It is transflective type display operating in the normally white mode. This TFT-LCD has 3.54 inch diagonally measured active display area with (320*RGB*480) resolution. Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arranged in vertical stripes.

Block Diagram



LCM Connector: JAE AA03-S020VA1

Fig 1.1 Block Diagram of TFT-LCD Module with LED Backlight Unit

General Features

Active screen size	3.54” diagonal
Outline Dimension	55.14 (H) x 82.84 (V) x 1.65 (T) Typ.
Pixel Pitch	0.156(H) × 0.156(V)
Pixel format	320(H) X 480 (V) (RGB Stripe)
Color depth	24-bits (R8, G8, B8)
Interface	MIPI 2-lane
Power Consumption	490mW (max. B/L on), 70mW (max. B/L off)
Luminance	450nit(typ.) @20mA
Viewing Direction	7:30 o’clock (Non-inversion)
LCD Driver	COG 1Chip

2. ABSOLUTE MAXIMUM RATINGS

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

Table 2.1 Absolute Maximum Ratings

Parameter	Symbol	Values		Units	Notes
		Min.	Max		
Power Supply Input	VDDC	-0.3	4.0	V	
Power Supply Input	VDDA	-0.3	6.4	V	
Power Supply Input	IO_VCC	-0.3	2.5	V	
LED Power Consumption	P_{LED}	-	120	mW	1
LED Current	I_{LED}	-	30	mA	1, 2

Notes:
1. Applies to each LED individually.
2. Allowable forward current is refer to Fig 2.1

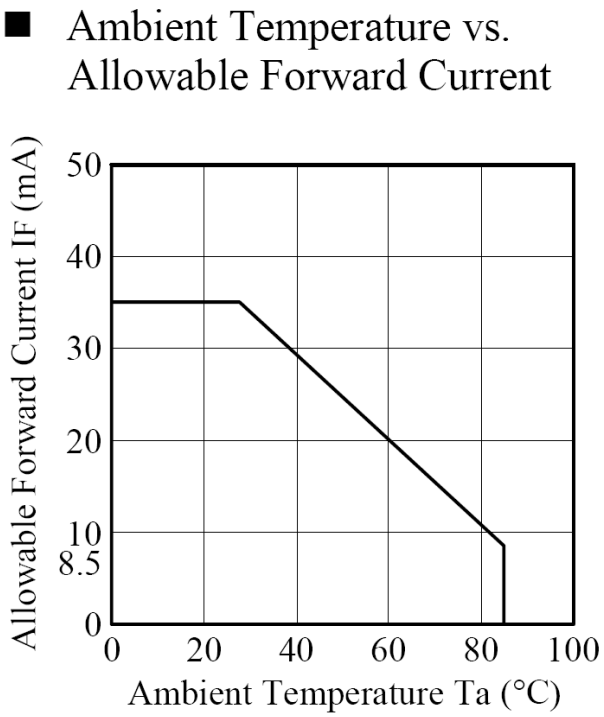


Fig 2.1 Ambient Temperature vs. Allowable Forward Current

3. ELECTRICAL SPECIFICATIONS

3-1. ELECTRICAL CHARACTERISTICS

Table 3.1 Electrical Characteristics Of TFT-LCD Module

Parameter	Symbol	Values			Units	Notes
		Min	Typ.	Max		
Power Supply Input	VDDC	2.85	3.0	3.15	V	
Power Supply Input	VDDA	-	5.672	-	V	
Power Supply Input	IO_VCC	1.65	1.8	1.95	V	
“H”Level Input Voltage	V_{IH}	0.8 V_{IO_VCC}	-	-	V	
“L”Level Input Voltage	V_{IL}	-	-	0.2 V_{IO_VCC}	V	
Current Consumption, Panel	P_B		60	70	mW	1

Notes:
1. Large black/white checker pattern(20 pixel blocks) at 60Hz

3-2. BACK LIGHT UNIT

The edge-lighting type of back light unit consists of 3 LEDs which is connected in serial.

Table 3.2 Electrical Characteristics Of Back Light Unit

Parameter	Symbol	Values			Units	Notes
		Min	Typ.	Max		
LED Current	I_{LED}	-	20	25	mA	
LED Forward Voltage	V_{LED}	-	-	-	V	
LED Power Consumption	P_{LED}	-	384	420	mW	

3-3. INTERFACE CONNECTIONS

The pin connections are provided in Table 3.3 The connector is JAE AA03-S020VA1.

Table 3.3 Module Connector Pin Configuration

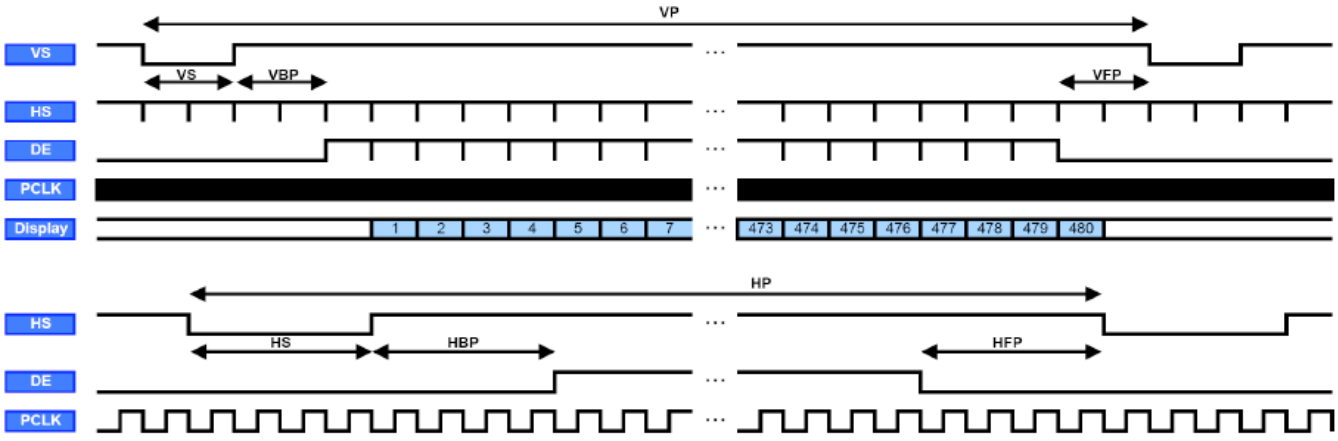
	Signal	I/O	Description	Comment
1	GND	-	Ground	
2	LED-	-	LED Cathode	
3	D0-	I/O	MIPI Data	
4	LED+	-	LED Anode	
5	D0+	I/O	MIPI Data	
6	VDDA	-	6V Switching Power Supply	
7	GND	-	Ground	
8	VDDC	-	3V LCD Power Supply	
9	CLK-	I	MIPI Clock	
10	IO_VCC	-	1.8V LCD Power Supply	
11	CLK+	I	MIPI Clock	
12	RESETB	I	Reset	
13	GND	-	Ground	
14	ERR_TE	O	Error Test	
15	D1-	I/O	MIPI Data	
16	B_SYNC	O	Blanking Sychronization Signal	
17	D1+	I/O	MIPI Data	
18	EXSHDNB	O	System PMU Control Enable	
19	GND	-	Ground	
20	EXTAVDD	I	PMU Configuration	

3-4. SIGNAL TIMING SPECIFICATIONS

Table 3.4 Timing Parameters

Item	Symbol	Timing	Unit	Notes
Vertical cycle	VP	500	Line	1
Vertical low pulse width	VS	8	Line	1
Vertical front porch	VFP	6	Line	1
Vertical back porch	VBP	6	Line	1
Vertical display area	VDISP	480	Line	1
Horizontal cycle	HP	380	clk	1
Horizontal low pulse width	HS	16	clk	1
Horizontal front porch	HFP	12	clk	1
Horizontal back porch	HBP	12	clk	1
Horizontal display area	HDISP	320	clk	1
Pixel Clock	fPCLK	10.80	MHz	1,2
	tPCLK	92.5925925	ns	1

Note 1: VDDC = 2.85~3.15V, IO_VCC = V_{EE}=1.65~1.95V
Note 2: Use 10.80MHz for Vcom & Gamma adjustment.



3-5. COLOR INPUT DATA REFERENCE

Colors & Gray Scale	Gray scale Levels	Data Signal																							
		R0	R1	R2	R3	R4	R5	R6	R7	G0	G1	G2	G3	G4	G5	G6	G7	B0	B1	B2	B3	B4	B5	B6	B7
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
Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
⇑ Darker ⇑ ⇓ Brighter ⇓	GS1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GS2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	↓						↓						↓							↓					
	↓						↓						↓							↓					
	GS61	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GS62	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red	GS63	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
⇑ Darker ⇑ ⇓ Brighter ⇓	GS1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	GS2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	↓						↓						↓							↓					
	↓						↓						↓							↓					
	GS61	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0
	GS62	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Green	GS63	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
Black	GS0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
⇑ Darker ⇑ ⇓ Brighter ⇓	GS1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	GS2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	↓						↓						↓							↓					
	↓						↓						↓							↓					
	GS61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	1
	GS62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Blue	GS63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1

3-6. Power On/off sequence

Power On Sequence

Power to VDDC is switched on after or simultaneously with Vdd.

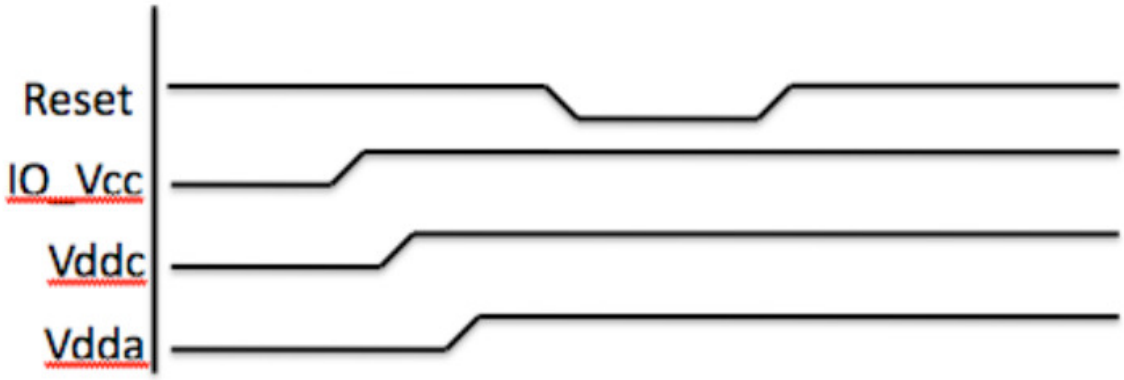


Fig 3.1 Power on Sequence

Power Off Sequence

Power to VDDC is removed.
In a normal power off sequence the commands and/or register settings are followed.

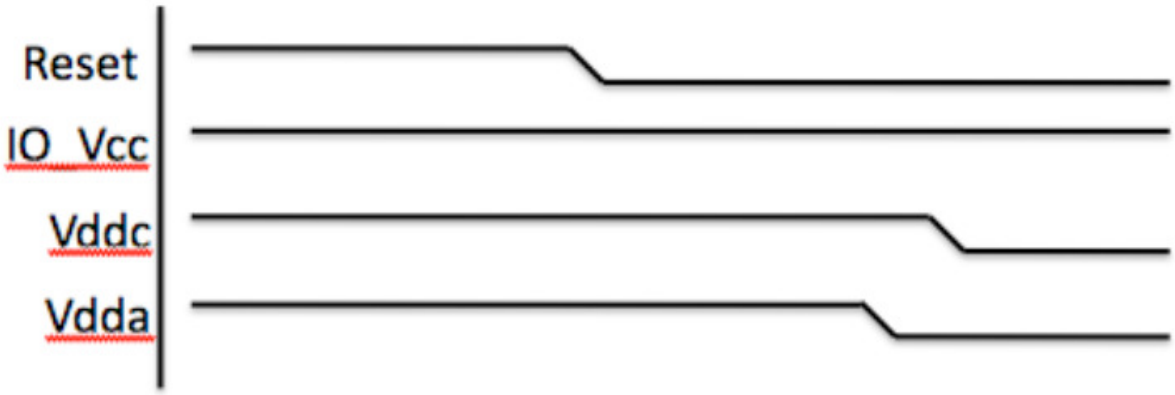


Fig 3.2 Power off Sequence

Hard Reset

Under a hard reset condition, power to VDDC and IO_VCC are cut simultaneously during display operation.

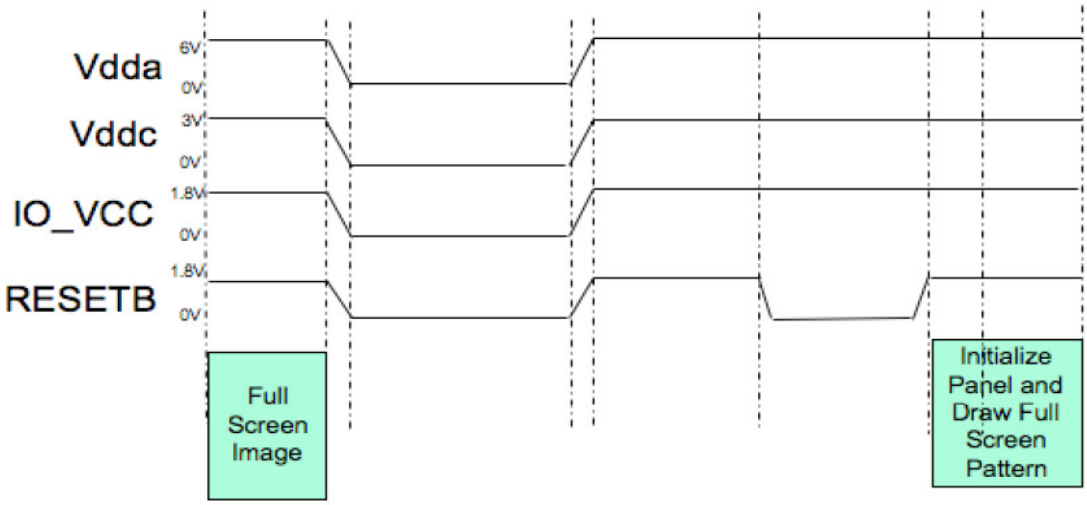


Fig 3.3 Hard Reset Sequence

3-7. Software Flow

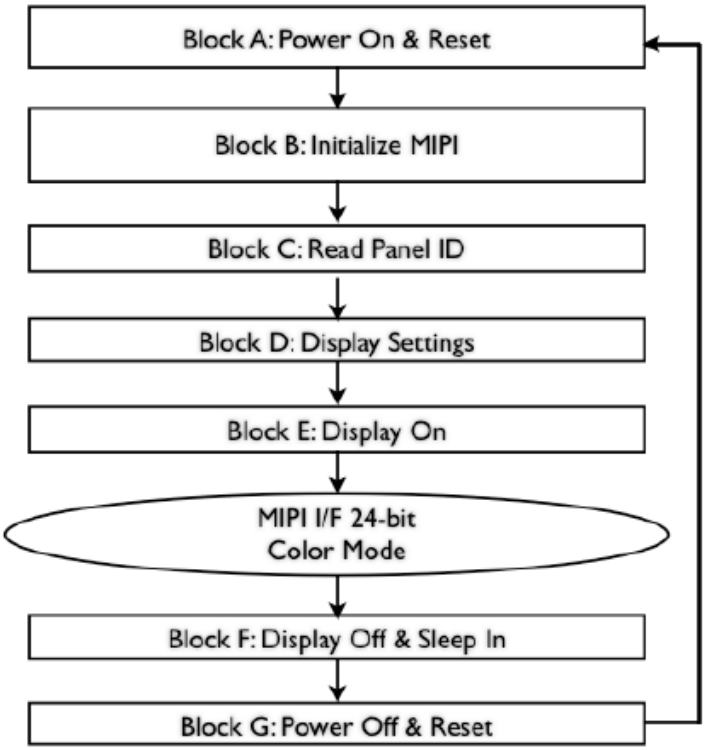


Fig 3.4 Software Flowchart

Table 3-5-1. Block A : Power off & Reset

Step	Operation
1	Apply IO_VCC
2	Apply VDDC/VDDA
3	Toggle Reset

Table 3-5-2. Block B : Initialize MIPI

Step	Register/ Command	Parameter/ Setting	Operation
1			Initialize SOC DSIM
2	0x00		Send MIPI NOP
3			Start MIPI Highspeed Clock

Table 3-5-3. Block C : Read Panel ID

Step	Register/ Command	Parameter/ Setting	Operation
1	0xB1	0x14	Read ID

Table 3-5-4. Block D : Display Setting

Step	Register/ Command	Parameter/ Setting	Operation
1	Optionally override EEPROM settings in supplier specific electrical specification		

Table 3-5-5. Block E : Sleep Out & Display On

Step	Register/ Command	Parameter/ Setting	Operation
1	0x11		Sleep Out
2	0x29		Display On

Table 3-5-6. Block F : Display Off & Sleep In

Step	Register/ Command	Parameter/ Setting	Operation
1			Draw White
2	0x28		Display Off
3	0x10		Sleep In

Table 3-5-7. Block G : Power Off & Reset

Step	Register/ Command	Parameter/ Setting	Operation
1	Power down simultaneously or IO_VCC logic first then VDDC supply.		

4. OPTICAL CHARACTERISTICS

4-1. Optical Characteristics – Backlight Off

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Remarks
Viewing angle range	ΘUP	CR ≥2	45		-	˚(degree)	Note 3
	ΘDOWN					˚(degree)	Note 3
	ΘLEFT		45		-	˚(degree)	Note 3
	ΘRIGHT					˚(degree)	Note 3
Contrast ratio	CR	Optimal	3	5	-		Note 2 (Spot light)
Reflectivity	R	Optimal	1.0	1.5	-	%	Note 1 (Diffuse light)
Response time	$\tau_f + \tau_r$	Θ =0 ˚ Ta =25 ˚C	-	40	60	ms	Note 4
White Chromaticity	Wx			0.309		CIE	Note 1 (Diffuse light)
	Wy			0.333		CIE	

1. Optical Test Equipment & method refer to Note1,2,3,4.

4-2. Optical Characteristics – Backlight On

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Remarks
Viewing angle range	ΘUP	CR ≥5	50	60		℃(degree)	Note 3
	ΘDOWN		40	45		℃(degree)	Note 3
	ΘLEFT		50	60		℃(degree)	Note 3
	ΘRIGHT		50	60		℃(degree)	Note 3
Contrast ratio	CR	Optimal	100	150		--	Note 2
Brightness	Y	I_{LED}= 20mA	350	450		cd/㎡	Note 1 [PR880]
Brightness Uniformity	Y	I_{LED}=20mA	80			%	Note 5 [PR880]
Response time	$\tau_f + \tau_r$	Θ =0 ° Ta =25 ℃		35	50	ms	Note 4
White Chromaticity	Wx	Θ =0 ° Ta =25 ℃		0.309			Note 1 [PR650]
	Wy			0.324			
Red Chromaticity	Rx			0.605			
	Ry			0.350			
Green Chromaticity	Gx			0.330			
	Gy			0.555			
Blue Chromaticity	Bx			0.150			
	By			0.120			
Color Gamut	NTSC			50		%	

1. Optical Test Equipment & method refer to Note1,2,3,4.

[Note 1] Optical Test Equipment Setup

Optical characteristics are determined after the unit has been 'ON' and stable for approximately 30 minutes in a dark environment at 25℃. The values specified are at an approximate distance 50cm from the LCD surface. In case of backlight on, measured on the center area of the panel by PHOTO RESEARCH photometer PR-880&PR650 or Equivalent.
In case of backlight off, measured on the center area of the panel by DMS-803

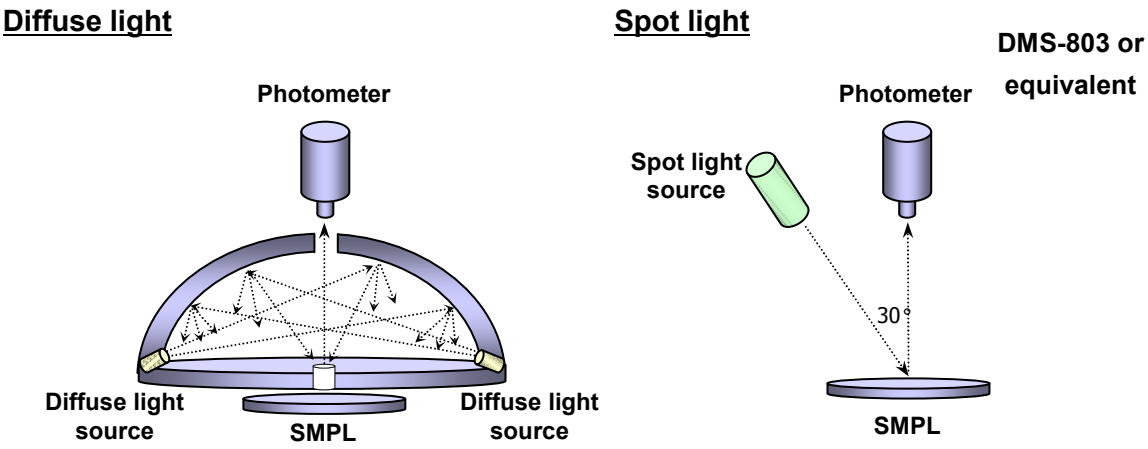


Fig 4.1 Backlight Off (Optical Characteristic Measurement Equipment and Method)

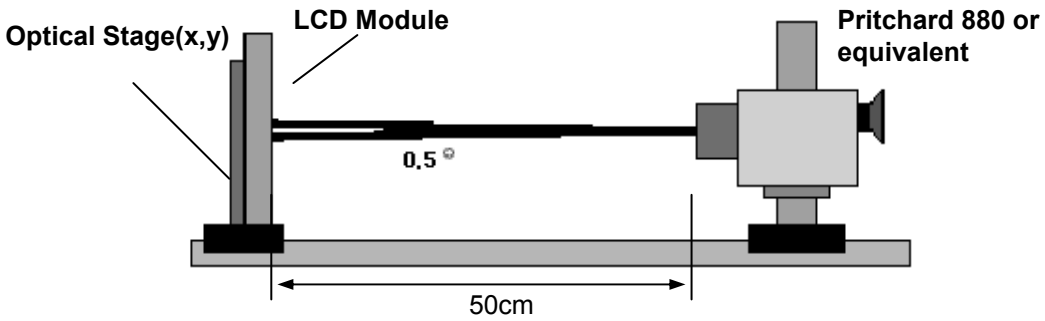


Fig 4.2 Backlight On (Optical Characteristic Measurement Equipment and Method)

[Note 2]

Contrast ratio is defined as follows ;

$$\text{Contrast Ratio(CR)} = \frac{\text{Photo detector output with LCD being “white”}}{\text{Photo detector output with LCD being “black”}}$$

[Note 3]

Viewing angle range is defined as follows;

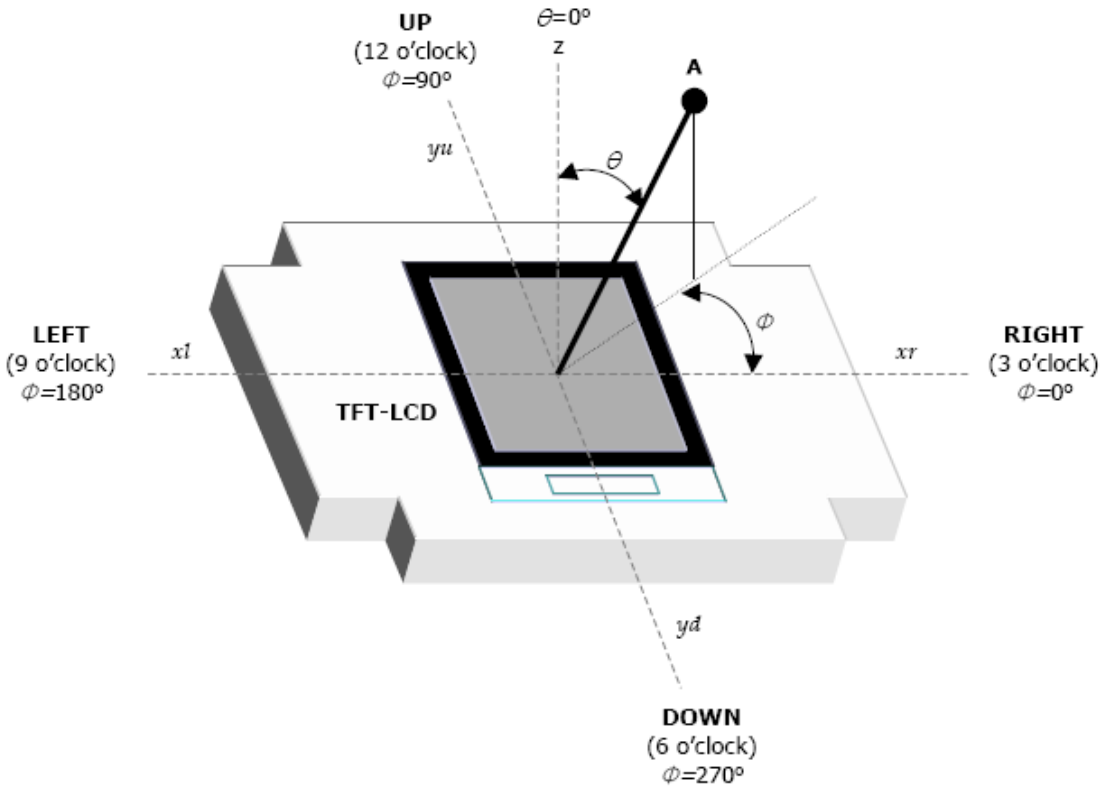


Fig 4.3 Viewing Angle Definitions

[Note 4]

Response time is obtained by measuring the transition time of photo detector output, when input signals are applied so as to make the area “black” to and from “white”.

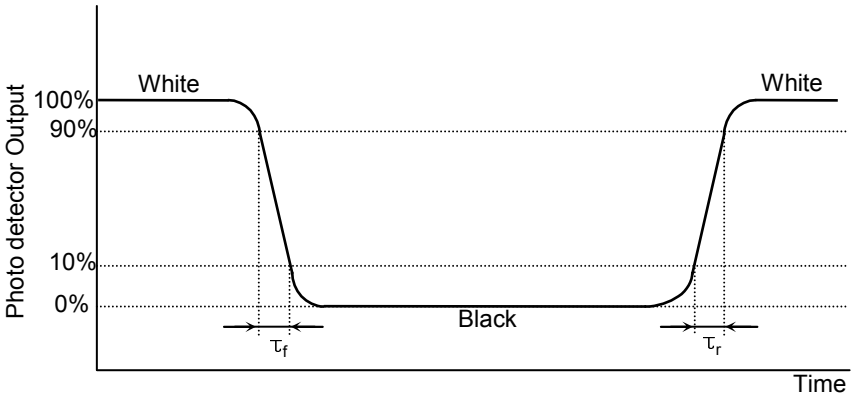


Fig 4.4 Response Time Definition

[Note 5]

The brightness measurement is taken at point B5.

$$\text{Brightness Uniformity} = \left(\frac{\text{Minimum Photo detector output for B1-B9 with all pixels white}}{\text{Maximum Photo detector output for B1-B9 with all pixels white}}\right) \times 100$$

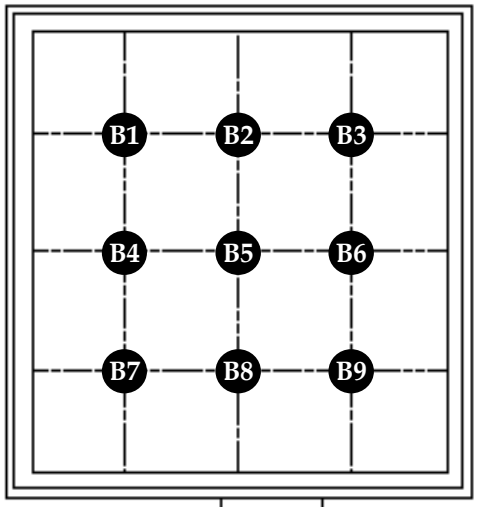


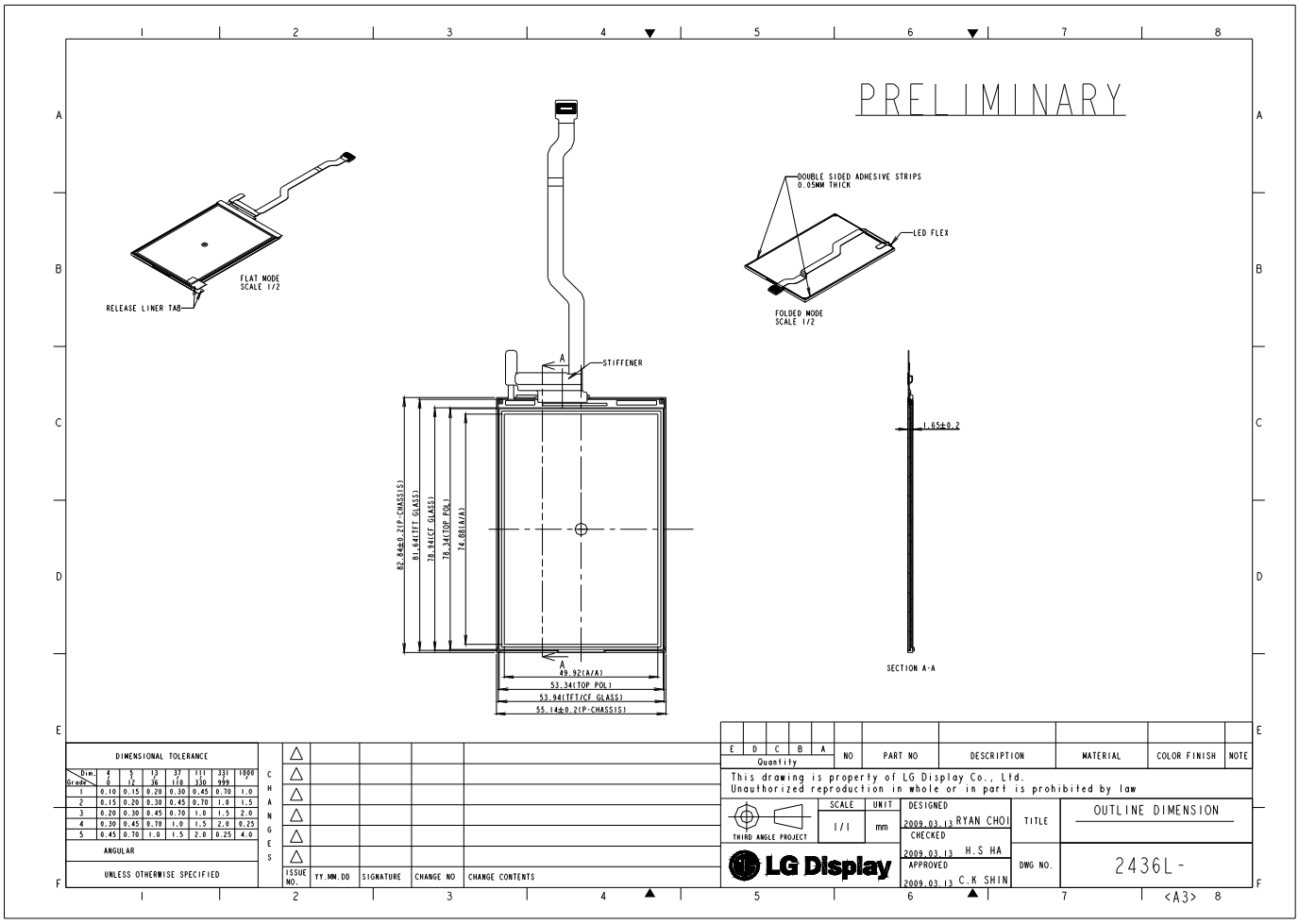
Fig 4.5 Brightness measurement points

5. MECHANICAL CHRACTERISTICS

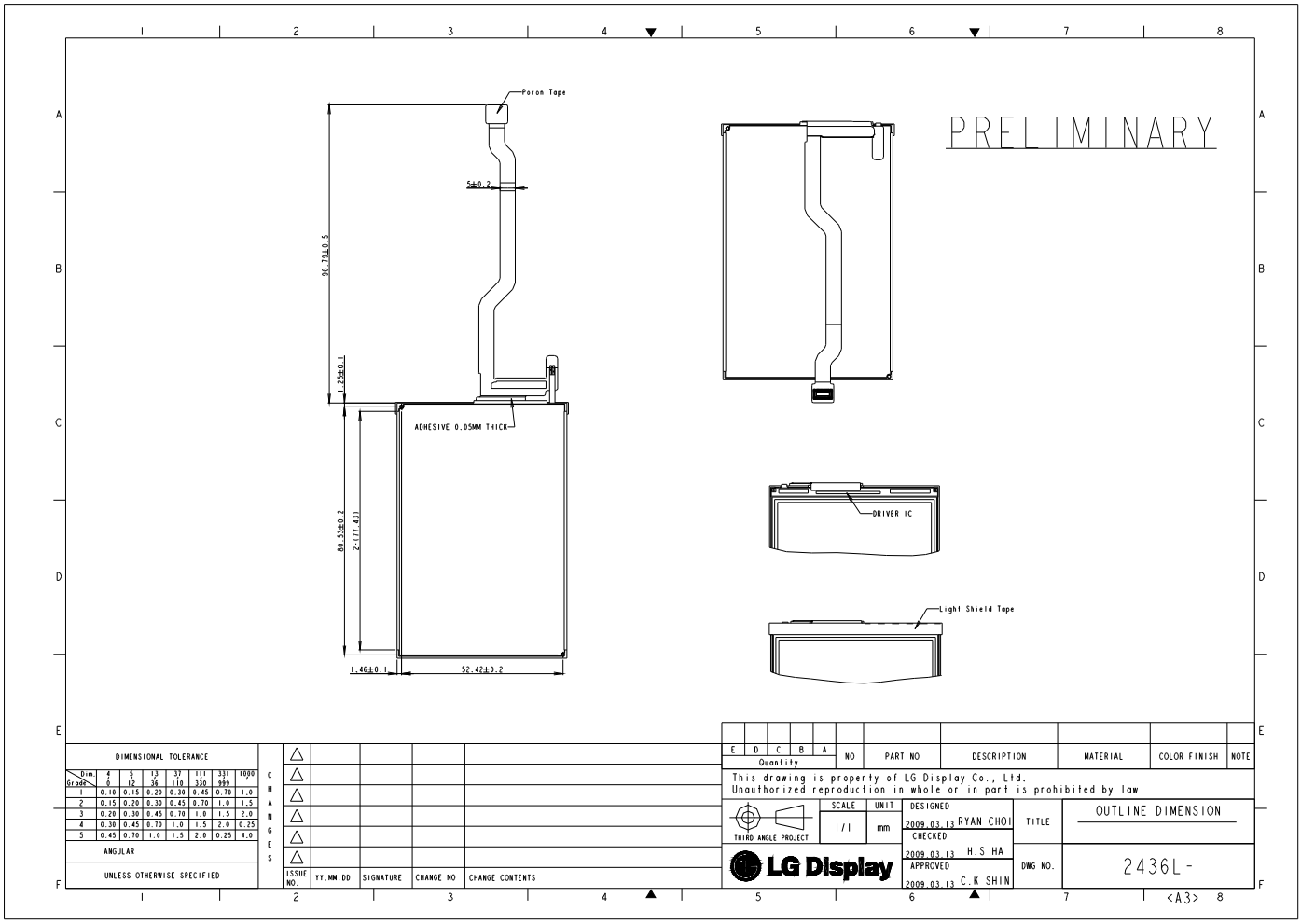
The contents provide general mechanical characteristics for the model.
In addition the figures in the next page are detailed mechanical drawing of the LCD.

DIMENSION	MIN	TYP	MAX	UNIT
HORIZONTAL (H)	-	55.14	-	MM
VERTICAL (V)	-	82.84	-	MM
THICKNESS (T)	-	1.65	-	MM

[Outline Dimension]

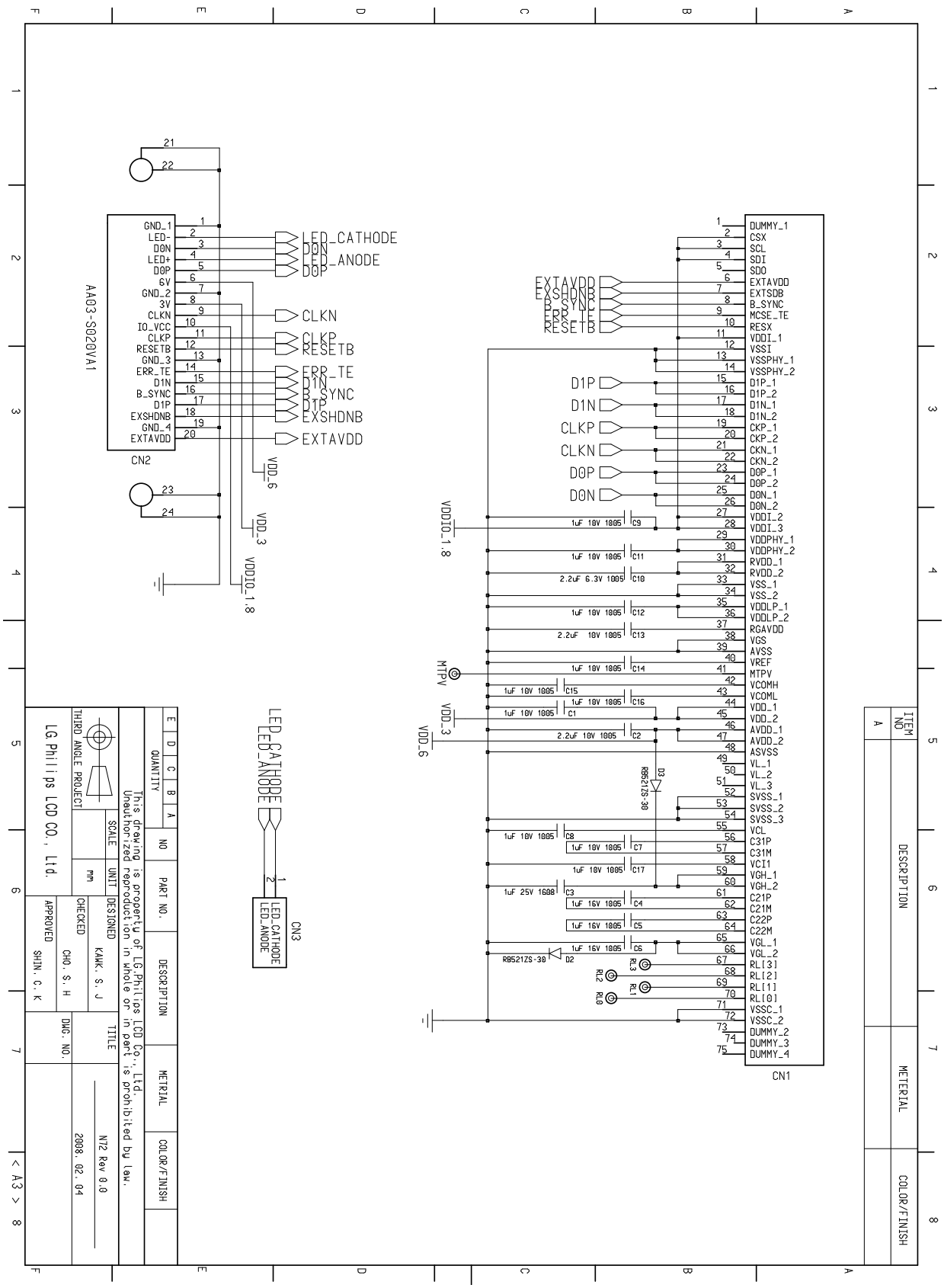


[Outline Dimension]



Product Specification

[FPC Schematic]



6. RELIABLITY TEST

6-1. RELIABLITY TEST

No.	Test Items	Test Condition	Remark
1	Low Temperature Storage	Ta=-30℃ 240hrs	
2	High Temperature Storage	Ta=70℃ 240hrs	
3	Low Temperature Operation	Ta=-10℃ 240hrs	
4	High Temperature Operation	Ta=60℃ 240hrs	
5	High Temperature and High Humidity Operation	Ta=40℃ 95%RH 240hrs	
6	High temperature and Humidity Storage	Ta=60℃ 90%RH 240hrs	
7	Low Pressure Non-operating	303hpa(40,000ft), RT, 48hrs	
8	Heat Shock	-30C to +70C, 10 cycles, 1.5h	
9	Shock Test	Half sine wave, 180G, 2ms, 1 time shock of X, Y, Z axis	
10	Vibration Test	- X, Y, Z : 1hr(axis, sweep) - Acceleration : 10mm/4.4G/2.5G the amplitude is 10mm - Sweep range: 5~15Hz/10mm P-P/ 16~30Hz/4.4G, 30~300Hz/2.5G	

{ Result Evaluation Criteria }
TFT-LCD Panel should be at room temperature for 2 hours after the reliability test is over.
There should be no particular change which might affect the practical display function
and the display quality should be conducted under normal operating condition.

9. PRECAUTIONS

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

9-1. ASSEMBLY PRECAUTIONS

(1) Please attach a transparent protective plate to the surface in order to protect the polarizer. Transparent protective plate should have sufficient strength in order to the resist external force.
(2) You should adopt radiation structure to satisfy the temperature specification.
(3) Acetic acid type and chlorine type materials for the cover case are not desirable because the former generates corrosive gas of attacking the polarizer at high temperature and the latter causes circuit break by electro-chemical reaction.
(4) Do not touch, push or rub the exposed polarizers with glass, tweezers or anything harder than HB pencil lead. And please do not rub with dust clothes with chemical treatment.
Do not touch the surface of polarizer for bare hand or greasy cloth.(Some cosmetics deteriorate the polarizer.)
(5) When the surface becomes dusty, please wipe gently with absorbent cotton or other soft materials like chamois soaks with petroleum benzine. Normal-hexane is recommended for cleaning the adhesives used to attach front / rear polarizers. Do not use acetone, toluene and alcohol because they cause chemical damage to the polarizer.
(6) Wipe off saliva or water drops as soon as possible. Their long time contact with polarizer causes deformations and color fading.
(7) Do not open the case because inside circuits do not have sufficient strength.
(8) The metal case of a module should be contacted to electrical ground of your system.

9-2. OPERATING PRECAUTIONS

(1) The spike noise causes the mis-operation of circuits. It should be lower than following voltage :
V=± 200mV(Over and under shoot voltage)
(2) Response time depends on the temperature.(In lower temperature, it becomes longer.)
(3) Brightness depends on the temperature. (In lower temperature, it becomes lower.)
And in lower temperature, response time(required time that brightness is stable after turned on) becomes longer.
(4) Be careful for condensation at sudden temperature change. Condensation makes damage to polarizer or electrical contacted parts. And after fading condensation, smear or spot will occur.
(5) When fixed patterns are displayed for a long time, remnant image is likely to occur.
(6) Module has high frequency circuits. Sufficient suppression to the electromagnetic interference shall be done by system manufacturers. Grounding and shielding methods may be important to minimized the interference.

9-3. ELECTROSTATIC DISCHARGE CONTROL

Since a module is composed of electronic circuits, it is not strong to electrostatic discharge. Make certain that treatment persons are connected to ground through wrist band etc. And don't touch interface pin directly.

9-4. PRECAUTIONS FOR STRONG LIGHT EXPOSURE

Strong light exposure causes degradation of polarizer and color filter.

9-5. STORAGE

When storing modules as spares for a long time, the following precautions are necessary.
(1) Store them in a dark place. Do not expose the module to sunlight or fluorescent light. Keep the temperature between 5℃ and 35℃ at normal humidity.
(2) The polarizer surface should not come in contact with any other object.
It is recommended that they be stored in the container in which they were shipped.

9-6. HANDLING PRECAUTIONS FOR PROTECTION FILM

(1) When the protection film is peeled off, static electricity is generated between the film and polarizer. This should be peeled off slowly and carefully by people who are electrically grounded and with well ion-blown equipment or in such a condition, etc.
(2) The protection film is attached to the polarizer with a small amount of glue. If some stress is applied to rub the protection film against the polarizer during the time you peel off the film, the glue is apt to remain on the polarizer.
Please carefully peel off the protection film without rubbing it against the polarizer.
(3) When the module with protection film attached is stored for a long time, sometimes there remains a very small amount of glue still on the polarizer after the protection film is peeled off.
(4) You can remove the glue easily. When the glue remains on the polarizer surface or its vestige is recognized, please wipe them off with absorbent cotton waste or other soft material like chamois soaked with normal-hexane.

10. International Standards

10-1. Safety

a) UL 60950-1:2003, First Edition, Underwriters Laboratories, Inc.,
Standard for Safety of Information Technology Equipment.

10-2. EMC

a) ANSI C63.4 “Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electrical Equipment in the Range of 9kHZ to 40GHz. “American National Standards Institute(ANSI), 1992
b) CISPR22 “Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment.“ International Special Committee on Radio Interference.
c) EN 55022 “Limits and Methods of Measurement of Radio Interface Characteristics of Information Technology Equipment.“ European Committee for Electrotechnical Standardization.(CENELEC), 1998
(Including A1: 2000)