Specification
For
Approval

■ Preliminary specification
□ Final specification

Title	1.54 320*320 ADS TFT-LCD (Module)

Buyer	
Model	

Supplier	Cheng Du BOE Optoelectronics Technology CO., LTD
Model	1.54 320*320

TITLE/SIGNATURE	DATE
_____	_____
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Please return one copy confirmation with signature and your comments

ITEM	SIGNATURE/DATE
Approved	_____
Reviewed	_____
Reviewed	_____
Prepared	_____

BOE CHENG DU
Optoelectronics Technology CO., LTD

CONTENT LIST

Record of Revisions				
Revision	Date	Page	Description	Released by
Pre.0	2014.03.20		Initial Released	Huangli

1.0 GENERAL DESCRIPTION

1.1 Introduction

1.54 320*320 is a color active matrix TFT-LCD Model using amorphous silicon TFT's (Thin Film Transistors) as an active switching devices. This model is composed of a TFT-LCD Panel, a driving circuit and a back light system. It is a transmissive type display operating in the normal black. This TFT-LCD has a 1.54 inch diagonally measured active area with 320 horizontal by 320 vertical pixel array. Each pixel is divided into Red, Green, Blue dots which are arranged in vertical stripe and this panel can display 16.7M colors.

1.2 Features

- 0.36 t Glass
- Thin and light weight
- Low Power consumption, High trans, High CR, Wide view angle
- Module Design
- RoHS Compliant

1.3 Application

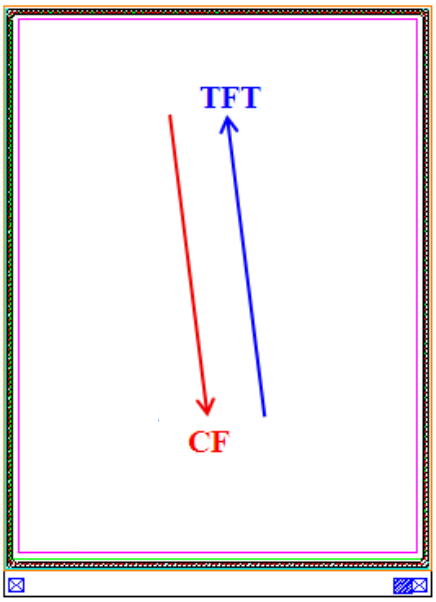
- Smart watch

1.4 General Specifications (H: horizontal length, V: vertical length**)**

Parameter	Specification	Unit	Remark
Active Area	27.744(H) × 27.744(V)	mm	
Number of Pixels	320(H) RGB × 320(V)	pixels	
Pixel Pitch	0.0867(H) × 0.0867(V)	mm	
Pixel Arrangement	RGB Vertical Stripe		
Display Colors	16.7M(Dithering)	colors	
Color Gamut	50% (typ.)		
Display Mode	Normally Black, Transmissive mode		
Dimensional Outline	31.82(H) × 33.72(V) × 1.147(D)	mm	Module
Polarizer Surface treatment	AR		
Viewing Direction (Human Eye)	80/80/80/80		Note 1,2
D-IC	ILI9488		
Weight	TBD	gram	

Note:

1. At the U/D/L/R direction, the viewing angle is same;
2. The TFT and CF Rubbing Direction;



2.0 ELECTRICAL SPECIFICATION

2.1 Absolute Maximum Ratings

The absolute maximum ratings are list on table as follows. When used out of the absolute maximum ratings, the LSI may be permanently damaged. Using the LSI within the following electrical characteristics limit is strongly recommended for normal operation. If these electrical characteristic conditions are exceeded during normal operation, the LSI will malfunction and cause poor reliability.

Item	Symbol	Unit	Value
Supply voltage(Analog)	VCI ~ DGND	V	-0.3 ~ +3.3
Supply voltage (I/O)	IOVCC ~ DGND	V	-0.3 ~ +3.3
OTP Supply voltage	DDVDH ~ DGND	V	-0.3 ~ +7.0
Supply voltage	DDVDH ~ DGND	V	-0.3 ~ +6.0
Supply voltage	DDVDL ~ DGND	V	0.3 ~ -6.0
Supply voltage	VGH ~ DGND	V	-0.3 ~ +25
Supply voltage	VGL ~ DGND	V	0.3 ~ -16
Driver supply voltage	VCI - VCL	V	≦ 6.0V
Driver supply voltage	VGH-VGL	V	≦ 32.0V
Input voltage	VIN	V	-0.3 ~ IOVCC + 0.3
HS Input voltage	VHSIN	V	-0.3 ~ + 1.65
Operating temperature	Topr	℃	-30 ~ +70
Storage temperature	Tstg	℃	-55 ~ +110

Note:

If the absolute maximum rating of even is one of the above parameters is exceeded even momentarily, the quality of the product may be degraded. Absolute maximum ratings, therefore, specify the values exceeding which the product may be physically damaged. Be sure to use the product within the range of the absolute maximum ratings

2.2 DC characteristics

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Note
Power & Operation Voltage							
Analog operating voltage	VCI	-	2.5	2.8	3.3	V	
Logic operating voltage	IOVCC	-	1.65	1.8	3.3	V	Note 1, 2
OTP Supply voltage	DDVDH	-	-	7	-	V	Note 1
Logic High level input voltage	V_{IH}	-	0.7*IOVCC		IOVCC	V	Note 1
Logic Low level input voltage	V_{IL}	-	-0.3		0.3*IOVCC	V	Note 1
Logic High level output voltage TE, SDO (SDA) , CABC_PWM	V_{OH}	IOH = -1.0mA	0.8*IOVCC		IOVCC	V	Note 1
Logic Low level output voltage TE, SDO (SDA) , CABC_PWM	V_{OL}	IOL = +1.0mA	0		0.2*IOVCC	V	Note 1
Gate Driver High Voltage	VGH	-	10.0	-	20	V	
Gate Driver Low Voltage	VGL	-	-15.0	-	-6.0	V	
Driver Supply Voltage	-	|VGH-VGL|	16	-	32	V	
Input and Output							
Logic High Level Input Voltage	VIH	-	0.7*IOVCC	-	IOVCC	V	
Logic Low Level Input Voltage	VIL	-	DGND	-	0.3*IOVCC	V	

Notes:

1. Ta = -30 to 70 ℃ (no damage up to 85℃ (at maximum)), IOVCC=1.65V to 3.3V, VCI=2.5V to 3.3V, DGND=0V.
2. Supply the digital IOVCC voltage equal to or less than the analog VCI voltage.
3. Source channel loading = 10KΩ,30pF/channel
4. The maximum value is between 10KΩ,30pF/channel and Gamma setting value.

2.3 Backlight Driving Conditions

Parameter	Symbol	Min	Typ	Max	Unit	Remark
LED Forward Voltage	V_F		3.2		V	-
LED Forward Current	I_F		40		mA	-
LED Power Consumption	PLED		TBD		W	Note 1

Notes:

1. Calculator Value for reference ILED×VLED×LED Quantity = PLED
2. The LED Life-time define as the estimated time to 50% degradation of initial luminous.

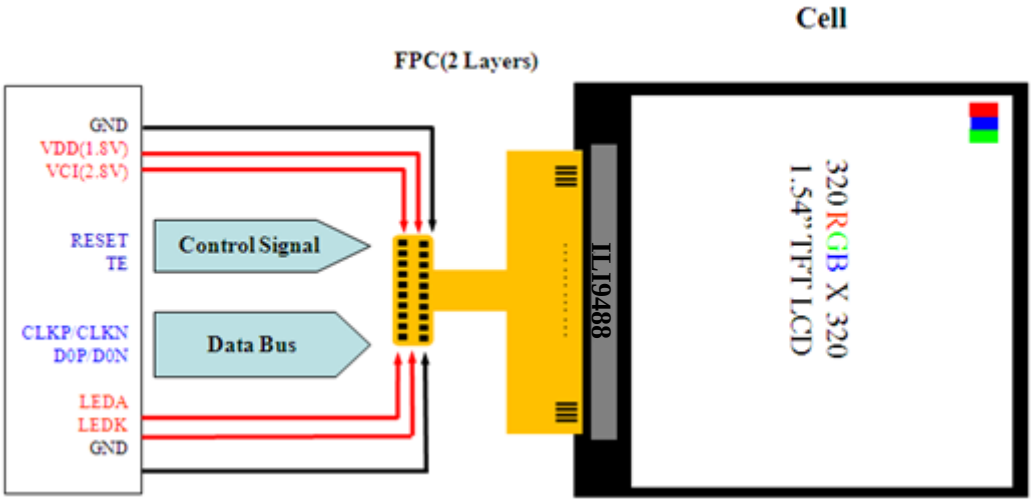
2.4 Power Consumption

Parameter	Symbol	Typ	Max	Unit	Remark
Normal mode	I_{VDDI}+ I_{VCI}	8.5	10	mA	Note
Sleep mode	I_{VDDI}+ I_{VCI}	30	50	uA	

Note:

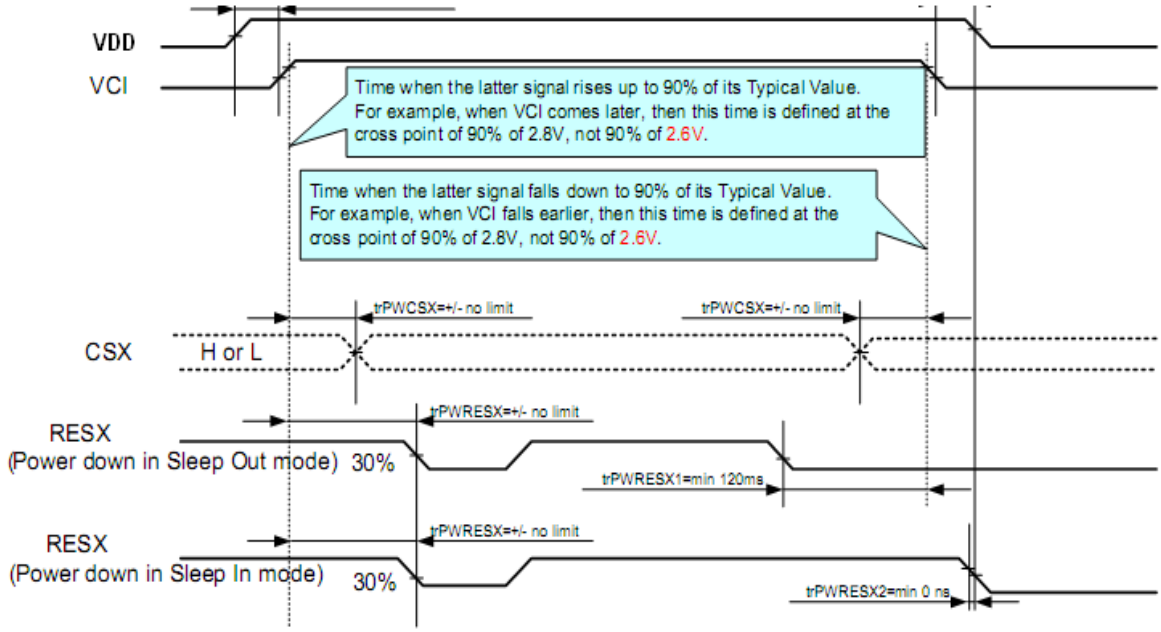
Frame rate=60HZ, Color bar pattern, 25℃.

2.5 Block Diagram



2.6 Power ON/OFF Sequence

The power supply ON/OFF setting sequences is illustrated in figure below.



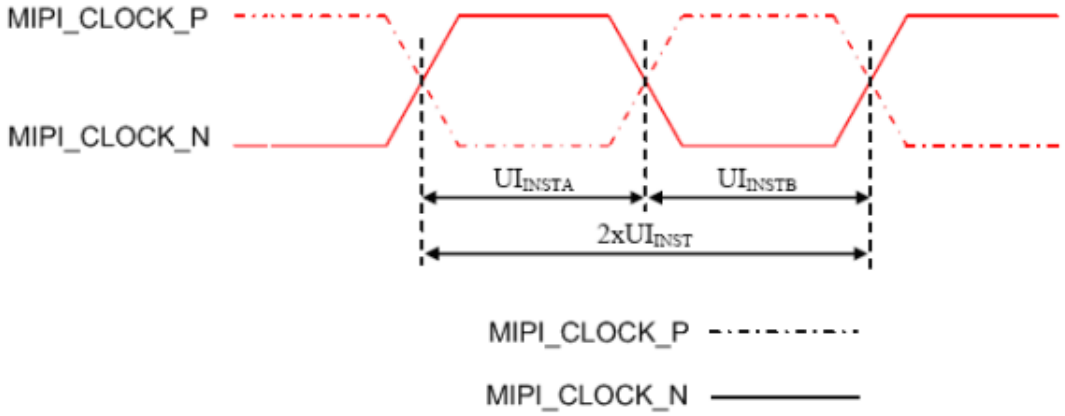
2.7 Connector Pin Assignment

Pin No.	Signal	I/O	Description
1	CLKP	I/O	MIPI clock
2	VCI	P	2.8 power supply
3	CLKN	I/O	MIPI clock
4	VDD	P	1.8V power supply
5	GND	P	Ground
6	TE	O	Synchronization Signal
7	D0P	I/O	MIPI Data
8	Resx	I	Reset(Active low)
9	D0N	I/O	MIPI Data
10	LED+	P	LED Cathode
11	GND	P	Ground
12	LED-	P	LED Anode

3.0 SIGNAL TIMING SPECIFICATION

3.1 High speed mode Timing Characteristics of the DSI

3.1.1 High Speed Mode – Clock Channel Timing



DSI Clock Channel Timing

DSI Clock Channel Timing

Signal	Symbol	Parameter	Min	Max	Unit
MIPI_CLOCK_P/N	$2xUI_{INST}$	Double UI instantaneous	4	25	ns
MIPI_CLOCK_P/N	UI_{INSTA}, UI_{INSTB} (Note 1)	UI instantaneous Half	2 (Note 2)	12.5	ns

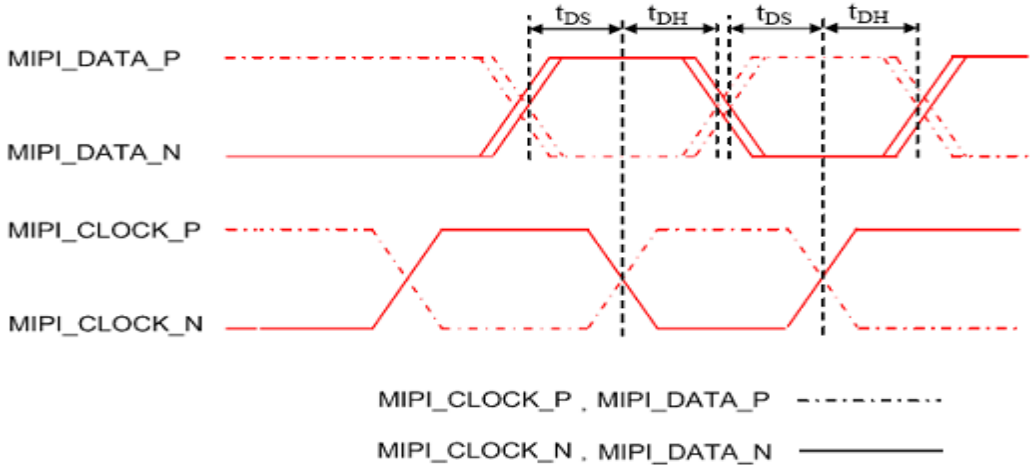
Notes:

1. UI = UIINSTA = UIINSTB
2. See Table 45 for the minimum value of 24 UI per Pixel.

Clock Channel Speed Limited

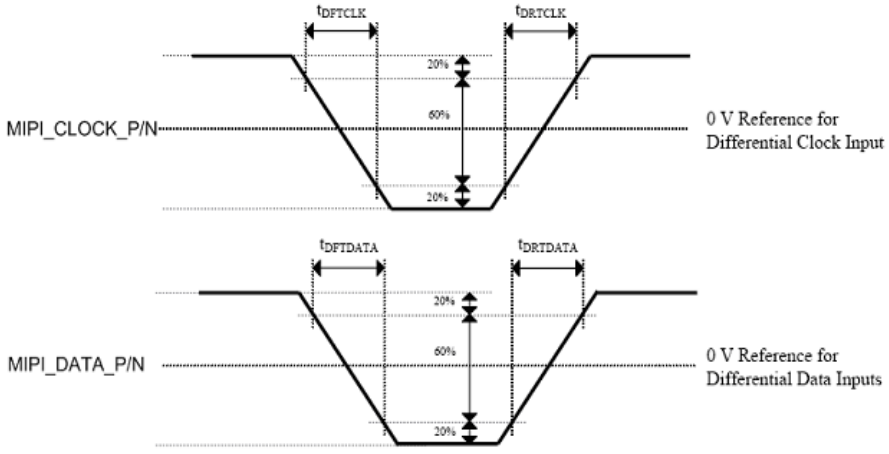
Data type	One Lanes speed	Unit
Data Type = 00 1110 (0Eh), RGB 565, 16 UI per Pixel	500M	bps
Data Type = 01 1110 (1Eh), RGB 666, 18 UI per Pixel	500M	bps
Data Type = 10 1110 (2Eh), RGB 666 Loosely, 24 UI per Pixel	500M	bps
Data Type = 11 1110 (3Eh), RGB 888, 24 UI per Pixel	500M	bps

3.1.2 High Speed Mode – Data Clock Channel Timing



Signal	Symbol	Parameter	Min	Max	Unit
MIPI_DATA_P/N	t_{DS}	Data to Clock Setup time	0.15xUI	-	ps
MIPI_DATA_P/N	t_{DH}	Clock to Data Hold Time	0.15xUI	-	ps

3.1.3 High Speed Mode – Rising and Falling Timings



Rising and Falling Timings on Clock and Data Channels

Rising and Falling Timings on Clock and Data Channels

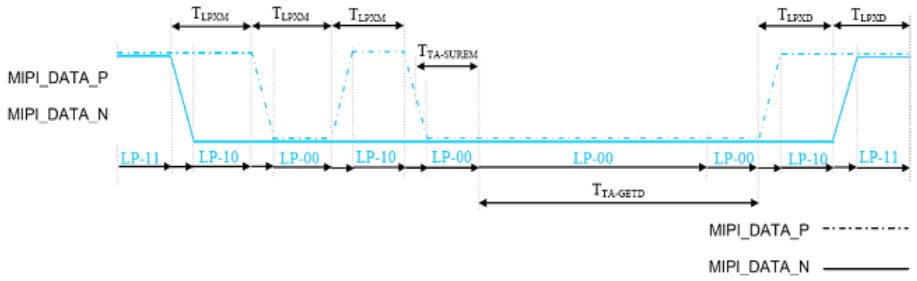
Parameter	Symbol	Condition	Specification			
			Min	Typ	Max	Unit
Differential Rise Time for Clock	t_{DRTCLK}	MIPI_CLOCK_P/N	-	-	900	ps
Differential Rise Time for Data	$t_{DRTDATA}$	MIPI_DATA_P/N	-	-	900	ps
Differential Fall Time for Clock	t_{DFTCLK}	MIPI_CLOCK_P/N	-	-	900	ps
Differential Fall Time for Data	$t_{DFTDATA}$	MIPI_DATA_P/N	-	-	900	ps

Note: The display module has to meet timing requirements, which are defined for the transmitter (MCU) on MIPI D-Phy standard.

3.2 Low power mode Timing Characteristics of the DSI

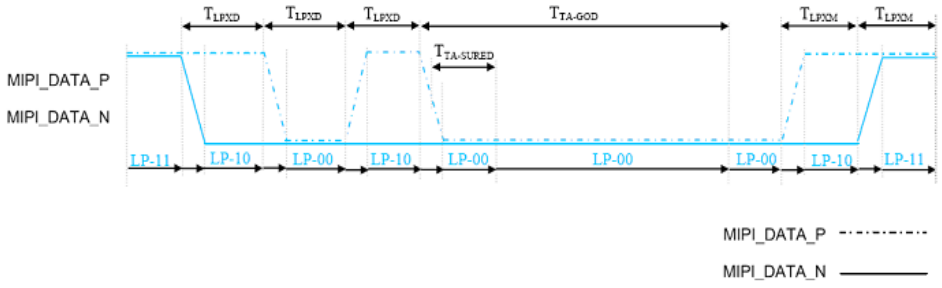
3.2.1 Low Power Mode – Bus Turnaround

Low Power Mode and its State Periods on the Bus Turnaround (BTA) from the MCU to the display module (ILI9488) sequence are illustrated below for reference purpose.



BTA from the MCU to the Display Module

Low Power Mode and its State Periods on the Bus Turnaround (BTA) from the display module (ILI9488) to the MCU sequence are illustrated below for reference purpose.



BTA from the Display Module to the MCU

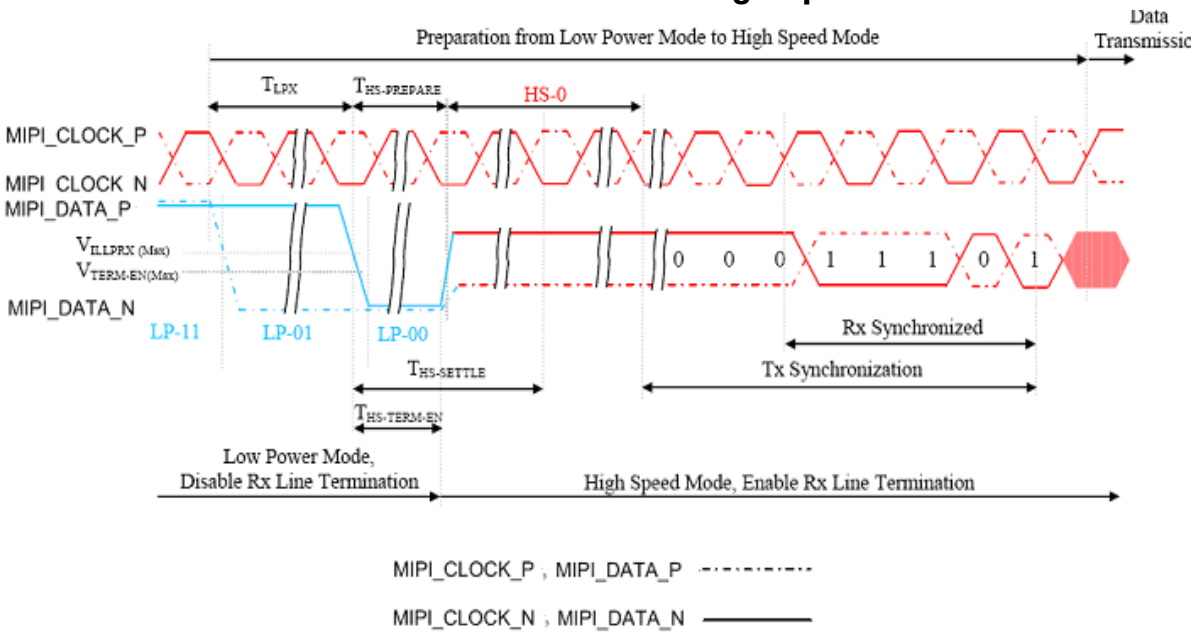
Low Power State Period Timings – A

Signal	Symbol	Description	Min	Max	Unit
Input (MIPI_DATA_P/N)	T_{LPXM}	Length of LP-00, LP-01, LP-10 or LP-11 periods MCU → Display Module (ILI9488)	50	75	ns
Output (MIPI_DATA_P/N)	T_{LPXD}	Length of LP-00, LP-01, LP-10 or LP-11 periods Display Module (ILI9488_ → MCU)	50	75	ns
Input (MIPI_DATA_P/N)	$T_{TA-SUREM}$	Time-out before the ILI9488 starts driving	T_{LPXM}	$2xT_{LPXM}$	ns
Output (MIPI_DATA_P/N)	$T_{TA-SURED}$	Time-out before the MCU starts driving	T_{LPXD}	$2xT_{LPXD}$	ns

Low Power State Period Timings – B

Signal	Symbol	Description	Time	Unit
Input (MIPI_DATA_P/N)	$T_{TA-GETD}$	Time to drive LP-00 by the ILI9488	$5xT_{LPXD}$	ns
Output (MIPI_DATA_P/N)	T_{TA-GOD}	Time to drive LP-00 after turnaround request – MCU	$4xT_{LPXD}$	ns

3.2.2 Data Lanes from Low Power Mode to High Speed Mode

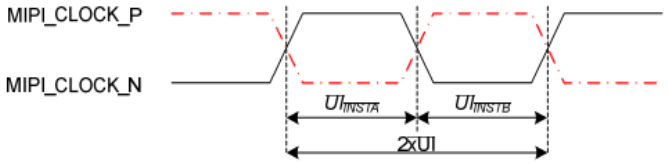


Data Lanes – Low Power Mode to High Speed Mode Timings

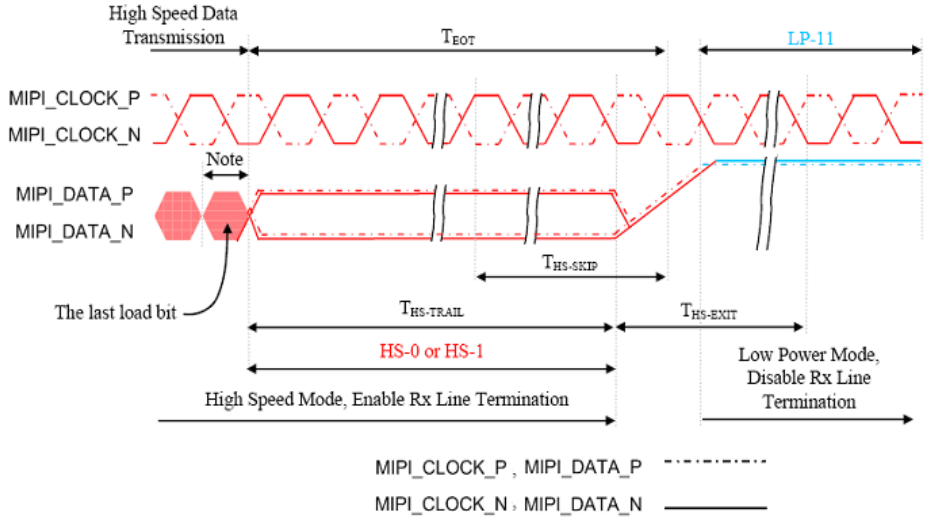
Data Lanes – Low Power Mode High Speed Mode Timings

Signal	Symbol	Description	Min	Max	Unit
Input (MIPI_DATA_P/N)	T_{LPX}	Length of any Low Power State Period	50	-	ns
Input (MIPI_DATA_P/N)	$T_{HS-PREPARE}$	Time to Drive LP-00 to prepare for HS Transmission	40+4xUI	85+6xUI	ns
Input (MIPI_DATA_P/N)	$T_{HS-TERM-EN}$	Time to enable Data Lane Receiver line termination measured from when D_n crosses V_{LMAX}	-	35+4xUI	ns

Note: $UI = UI_{INSTA} = UI_{INSTB}$



3.2.3 Data Lanes from High Speed Mode to Low Power Mode



Note:
If the last load bit is HS-1, the transmitter changes from HS-1 to HS-0.
If the last load bit is HS-0, the transmitter changes from HS-0 to HS-1.

Data Lanes – High Speed Mode to Low Power Mode Timings

Data Lanes – High Speed Mode to Low Power Timings

Signal	Symbol	Description	Min	Max	Unit
Input (MIPI_DATA_P/N)	$T_{HS-SKIP}$	Time-out at the ILI9488 to Ignore Transition Period of EoT	40	50+4xUI	ns
Input (MIPI_DATA_P/N)	$T_{HS-EXIT}$	Time to Driver LP-11 after HS burst	100	-	ns

4.0 OPTICAL SPECIFICATIONS

4.1 Overview

The test of Optical specifications shall be measured in a dark room(ambient luminance≤ 1 lux and temperature = 25±2℃) with the equipment of Luminance meter system (Topcon SR-UL1R and Westar TRD-100A) and test unit shall be located at an approximate distance 50cm from the LCD surface at a viewing angle of θ and Φ equal to 0°.The center of the measuring spot on the Display surface shall stay fixed.

The backlight should be operating for 30 minutes prior to measurement.

4.2 Optical Specifications

Parameter		Symbol	Condition	Min.	Typ.	Max.	Unit	Remark
Threshold Voltage		Vsat		4.1	4.3	4.5	V	Fig.1
		Vth		1.6	1.8	2.0	V	
Viewing Angle	Horizontal	Θ3	CR>10		80		°	Note 1
		Θ9			80		°	
	Vertical	Θ12			80		°	
		Θ6			80		°	
Contrast Ratio		CR	Θ= 0°		900			Note 2
Luminance		cd/m2	Θ= 0°		400		lm	Note 3
Uniformity		%	Θ= 0°					Note 4
NTSC		%	Θ= 0°		50			
Reproduction Of color	Red	Rx	Θ= 0°		TBD			Note 4 *Module
		Ry			TBD			
	Green	Gx			TBD			
		Gy			TBD			
	Blue	Bx			TBD			
		By			TBD			
White		Wx	Θ= 0°		TBD			
		Wy			TBD			
Response Time		Tr+Tf	Θ= 0°		35	50	ms	Note 5

Note:

1. Viewing angle is the angle at which the contrast ratio is greater than 10. The viewing are determined for the horizontal or 3, 9 o'clock direction and the vertical or 6, 12 o'clock direction with respect to the optical axis which is normal to the LCD surface (See FIG.1).
2. Contrast measurements shall be made at viewing angle of Θ= 0° and at the center of the LCD surface. Luminance shall be measured with all pixels in the view field set first to white, then to the dark (black) state. (See FIG. 1) Luminance Contrast Ratio (CR) is defined mathematically.

$$CR = \frac{\text{Luminance when displaying a white raster}}{\text{Luminance when displaying a black raster}}$$

3. Surface luminance is the center point across the LCD surface 50cm from the surface with all pixels displaying white. This measurement shall be taken at the locations shown in FIG. 2.

4. Uniformity measurement shall be taken at the locations shown in FIG. 2&3, for a total of the measurements per display, measure surface luminance of these nine points across the LCD surface 50cm from the surface with all pixels displaying white.

$$\text{Uniformity} = \frac{\text{Min Luminance of 9 points}}{\text{Max Luminance of 9 points}} \times 100\%$$

5. The color chromaticity coordinates specified in Table1 shall be calculated from The spectral data measured with all pixels first in red, green, blue and white. Measurements shall be made at the center of the Module.

6. The electro-optical response time measurements shall be made as FIG.4 by switching the "data" input signal ON and OFF.

The times needed for the luminance to change from 10% to 90% is Tr and 90% to 10% is Tf.

Figure 1. The definition of Vth & Vsat

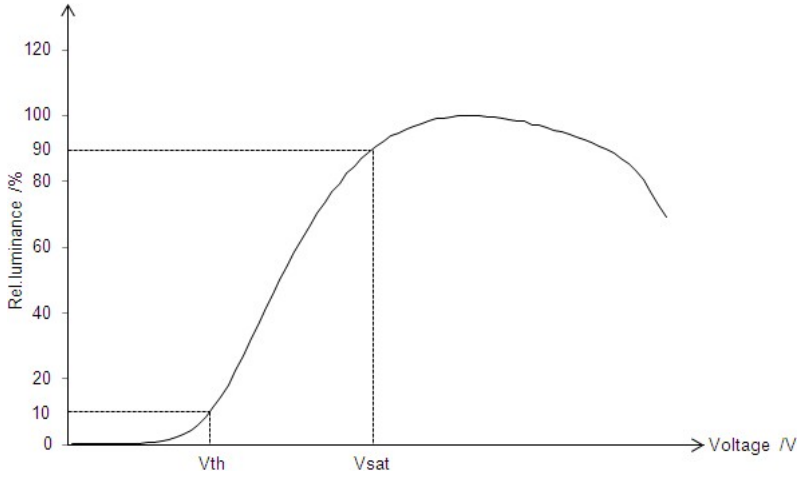


Figure 2. Measurement Set Up

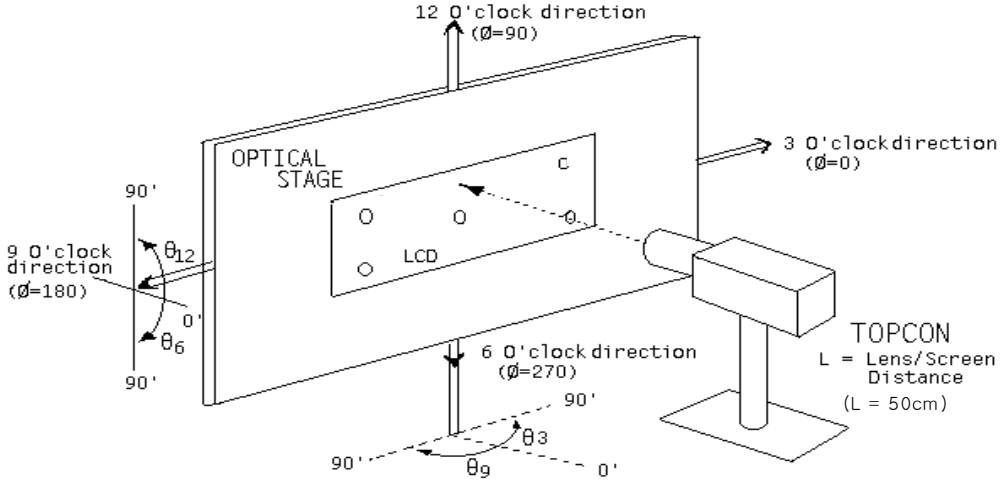


Figure 3. Uniformity Measurement Locations

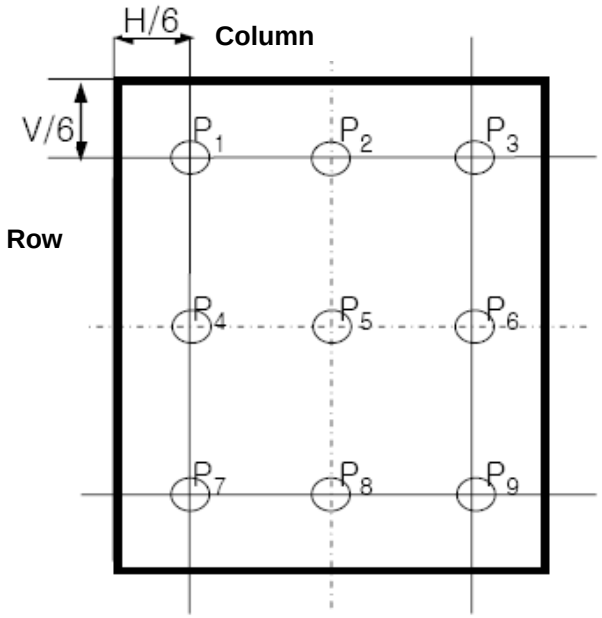
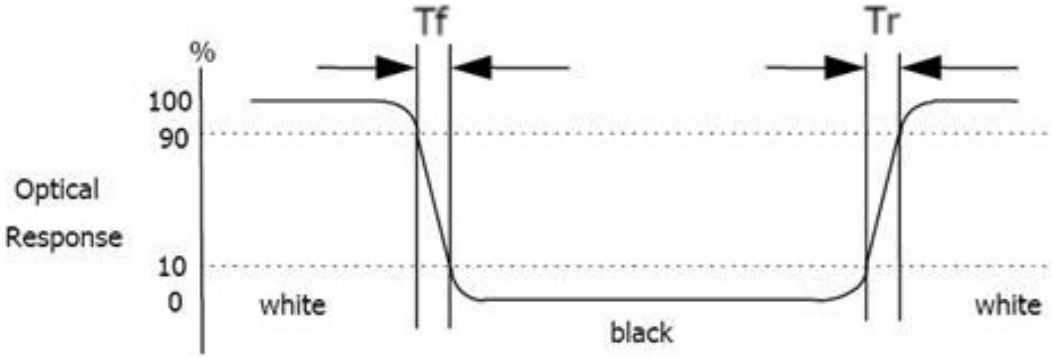


Figure 4. Response Time Testing



5.0 MECHANICAL CHARACTERISTICS

5.1 Dimension Requirements

Mechanical outlines for the panel **(**H: horizontal length, V: Vertical length**)**

Parameter	Specification	Unit	Remark
Panel size	30.12(H) × 33.12(V)	mm	
CF size	30.12(H) × 30.644(V)	mm	
Active area	27.744(H) × 27.744(V)	mm	
Number of pixels	320(H)RGB × 320(V)	pixels	
	(1 pixel = R + G + B dots)		
Pixel pitch	0.0867(H) × 0.0867(V)	mm	
Pixel arrangement	RGB Vertical Stripe		
Panel ID	0.8 × 0.8	mm	
COG pad area	2.476	mm	
D-IC to FPC distance	0.439	mm	Note
D-IC width	0.758	mm	
D-IC to CF edge	0.5	mm	
FPC to Glass edge	0.129	mm	
FPC width	0.65	mm	
Seal Area (U/D/L/R)	1.0/1.9/1.188/1.188	mm	
Dimensional outline	31.82(H) × 33.72(V) × 1.147(D)	mm	Module
Display mode	Normally Black		

Note:

The size specified is calculated by IC–driver ILI9488, the size maybe changed if customer use other IC.

Figure 5. LCM Outline Dimension (unit:mm)

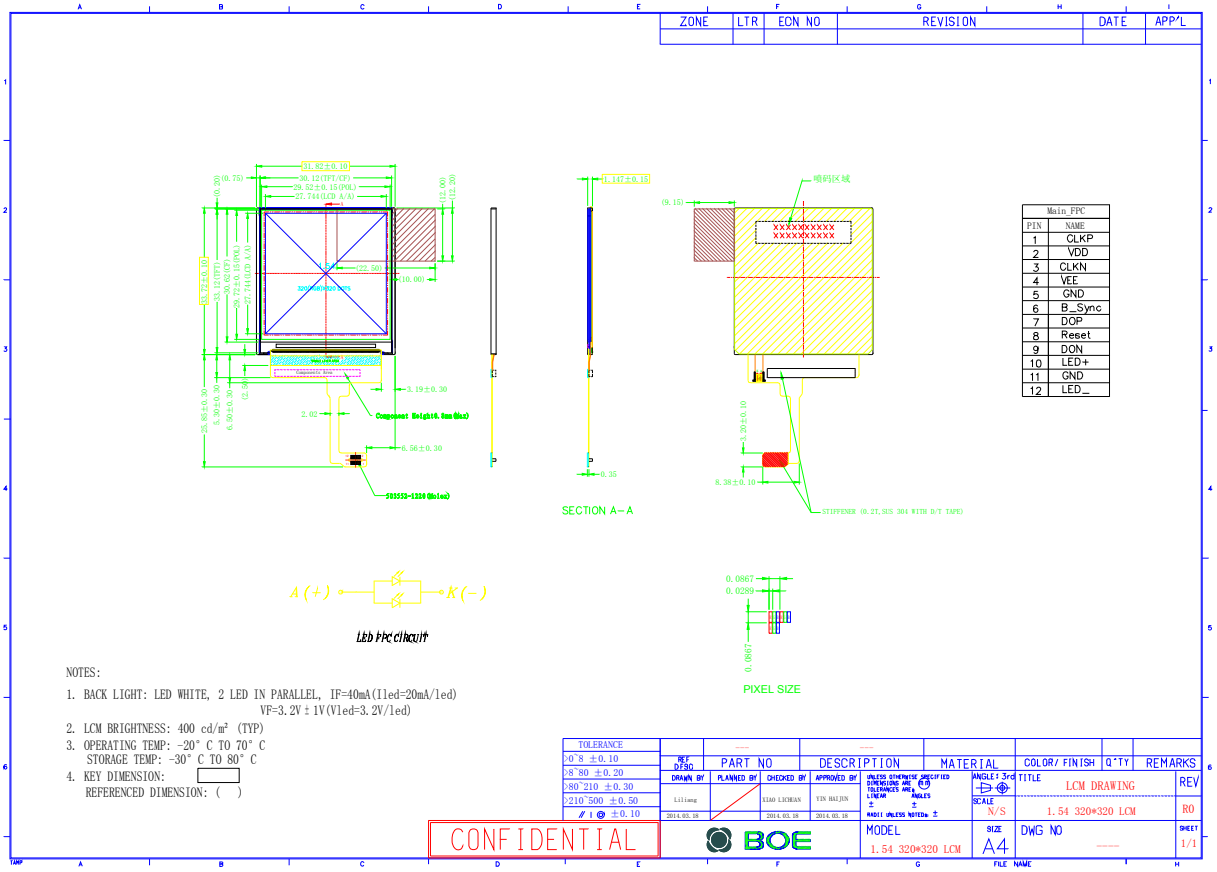


Figure 6. BLU Outline Dimension (unit:mm)

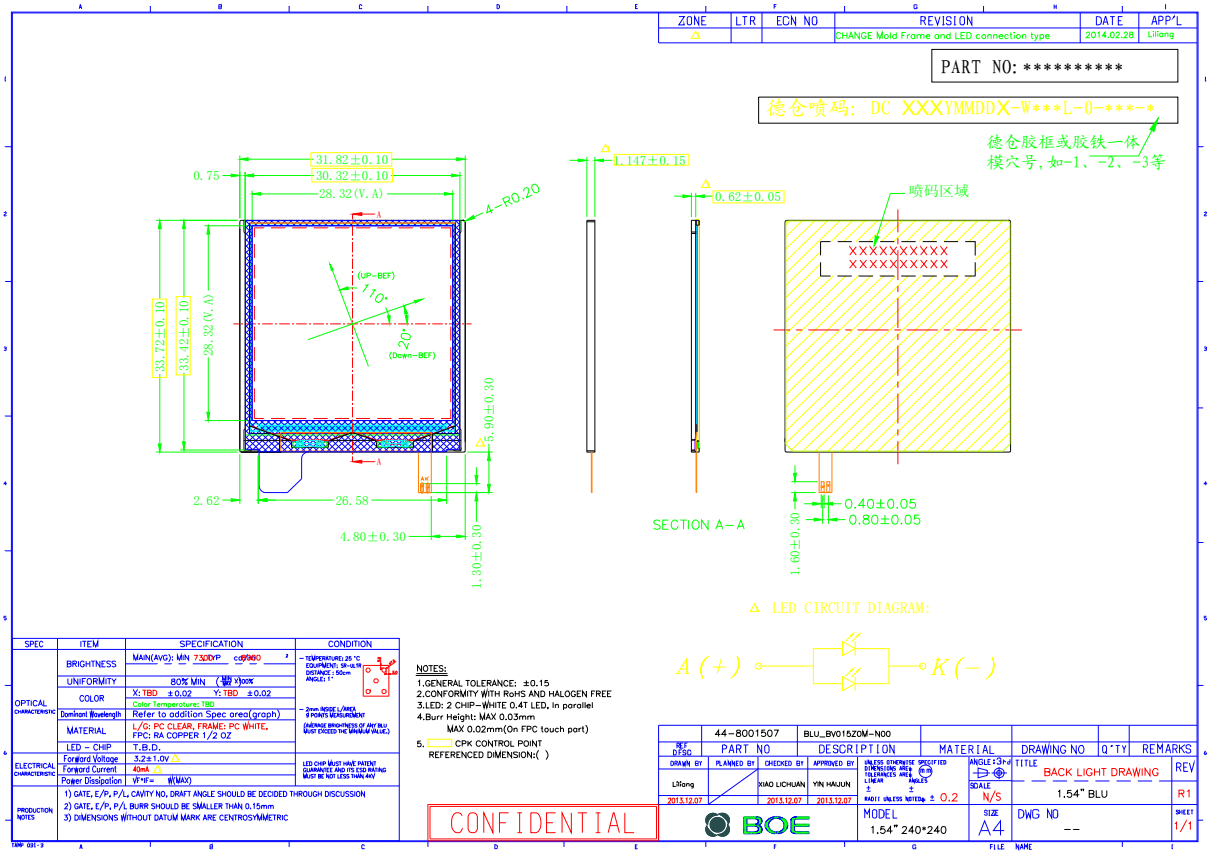
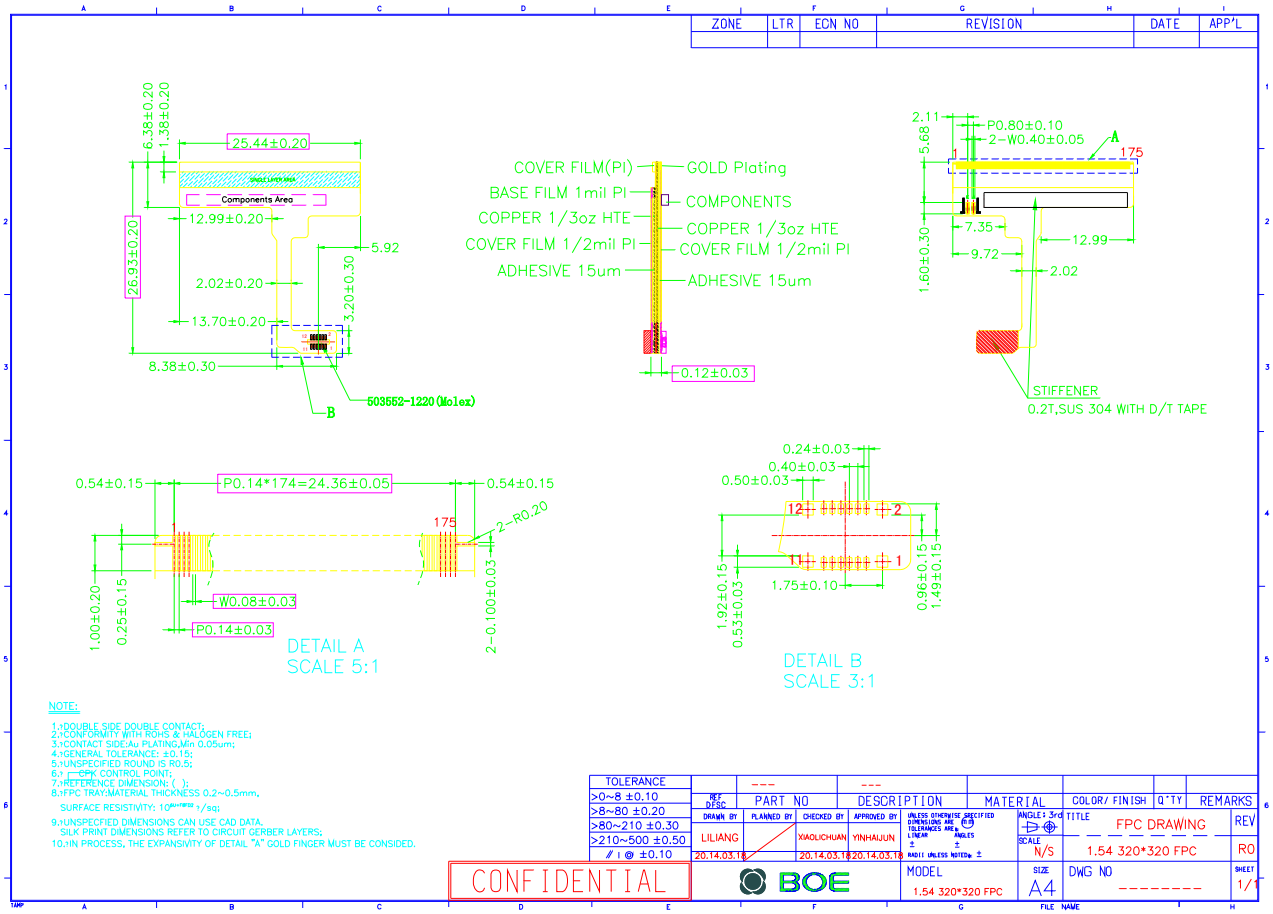


Figure 7. FPC main structure (unit:mm)



6.0 RELIABILITY TEST

TBD

7.0 PACKING METHOD

TBD

8.0 PRODUCT ID RULE

B V 015 Z2 M – N 0 0

1 2 3 4 5 6 7 8

1 <Company>

Code	Description
B	Mobile
N	Notebook
S	Special display

2 <Mode>

Code	Description
V	ADS-a Si
T	TN-a Si
S	ADS-LTPS

3 <Size>

Code	Description
015	1.54”
055	5.5”
060	6.0”

4 <Resolution>

Code	Description
Z2	Special resolution
FH	FHD
WH	WQHD

5 <Production type>

Code	Description
M	Module
Q	Q-Panel
E	Cell

6 <Product state>

Code	Description
N	Normal
E	In Cell Touch
A	Add On Touch

7 <Product Rev>

Code	Description
0	First Mode
1	Second Mode
2	Third Mode

8 <Product Rev>

Code	Description
0	First Mode
1	Second Mode
2	Third Mode

9.0 HANDDLING & CAUTIONS

9.1 Mounting Method

- The panel of the LCM consists of two thin glasses with polarizer which easily get damaged. So extreme care should be taken when handling the LCM.
- Excessive stress or pressure on the glass of the LCM should be avoided. Care must be taken to insure that no torsional or compressive forces are applied to the LCM unit when it is mounted.
- If the customer's set presses the main parts of the LCM, the LCM may show the abnormal display. But this phenomenon does not mean the malfunction of the LCM and should be pressed by the way of mutual agreement.
- To determine the optimum mounting angle, refer to the viewing angle range in the specification for each model.
- Mount a LCM with the specified mounting parts.

9.2 Caution of LCM Handling and Cleaning

- Since the LCM is made of glass, do not apply strong mechanical impact or static load onto it. Handling with care since shock, vibration, and careless handling may seriously affect the product. If it falls from a high place or receives a strong shock, the glass maybe broken.
- The polarizer on the surface of panel are made from organic substances. Be very careful for chemicals not to touch the polarizer or it leads the polarizer to be deteriorated.
- If the use of a chemical is unavoidable, use soft cloth with solvent recommended below to clean the LCM's surface with wipe lightly.

-IPA (Isopropyl Alcohol), Ethyl Alcohol, Tri-chloro, tri-florothane.

- Do not wipe the LCM's surface with dry or hard materials that will damage the polarizer and others. Do not use the following solvent—Water, acetone, Aromatics.
- It is recommended that the LCM be handled with soft gloves during assembly, etc.

The polarizer on the LCM's surface are vulnerable to scratch and thus to be damaged by shape particles.

- Do not drop water or any chemicals onto the LCM's surface.
- A protective film is supplied on the LCM and should be left in place until the LCM is required for operation.
- The ITO pad area needs special careful caution because it could be easily corroded. Do not contact the ITO pad area with HCFC, Soldering flux, Chlorine, Sulfur, saliva or fingerprint. To prevent from the ITO corrosion, customers are recommended that the ITO area would be covered by UV or silicon.
- Please clean the LCD without ultrasonic to avoid line open.

9.3 Caution Against Static Charge

- The LCM use C-MOS LSI drivers, so customers are recommended that any unused input terminal would be connected to Vdd or Vss, do not input any signals before power is turn on, and ground you body, work/assembly area, assembly equipments to protect against static electricity.
- Remove the protective film slowly, keeping the removing direction approximate 30-degree not vertical from panel surface, if possible, under ESD control device like ion blower, and the humidity of working room should be kept over 50%RH to reduce the risk of static charge.
- Avoid the use work clothing made of synthetic fibers. We recommend cotton clothing or other conductivity-treated fibers.
- In handling the LCM, wear non-charged material gloves. And the conducting wrist to the earth and the conducting shoes to the earth are necessary.

9.4 Caution For Operation

- It is indispensable to drive the LCM within the specified voltage limit since the higher voltage than the limit causes LCM's life shorter. An electro-chemical reaction due to DC causes undesirable deterioration of the LCM so that the use of DC drive should avoid.
- Do not connect or disconnect the LCM to or from the system when power is on.
- Never use the LCM under abnormal conditions of high temperature and high humidity.
- When expose to drastic fluctuation of temperature(hot to cold or cold to hot), the LCM may be affected; specifically, drastic temperature fluctuation from cold to hot, produces dew on the LCM's surface which may affect the operation of the polarizer on the LCM.
- Response time will be extremely delay at lower temperature than the operating temperature range and on the other hand LCM may turn black at temperature above its operational range. However those phenomenon do not mean malfunction or out of order with the LCM. The LCM will revert to normal operation once the temperature returns to the recommended temperature range for normal operation.
- Do not display the fixed pattern for a long time because it may develop image sticking due to the LCM structure. If the screen is displayed with fixed pattern, use a screen saver.
- Do not disassemble and/or re-assemble LCM module

9.5 Packaging

- Modules use LCM element, and must be treated as such.

-Avoid intense shock and falls from a height.

-To prevent modules from degradation, do not operate or store them exposed directly to sunshine or high temperature/humidity for long periods.

9.6 Storage

- A slight dew depositing on terminals is a cause for electro-chemical reaction resulting in terminal open circuit. Relative humidity of the environment should therefore be kept below 60%RH.
- Original protective film should be used on LCM's surface (polarizer). Adhesive type protective film should be avoided, because it may change color and/or properties of the polarizer.
- Do not store the LCM near organic solvents or corrosive gasses.
- Keep the LCM safe from vibration, shock and pressure.
- Black or white air-bubbles may be produced if the LCM is stored for long time in the lower temperature or mechanical shocks are applied onto the LCM.
- In the case of storing for a long period of time for the purpose or replacement use, the following ways are recommended.

-Store in a polyethylene bag with sealed so as not to enter fresh air outside in it.
-Store in a dark place where neither exposure to direct sunlight nor light is.
-Keep temperature in the specified storage temperature range.
-Store with no touch on polarizer surface by the anything else. If possible, store the LCM in the packaging situation when it was delivered.

9.7 Safety

- For the crash damaged or unnecessary LCM, it is recommended to wash off liquid crystal by either of solvents such as acetone and ethanol an should be burned up later.
- In the case of LCM is broken, watch out whether liquid crystal leaks out or not. If your hands touch the liquid crystal, wash your hands cleanly with water and soap as soon as possible.
- If you should swallow the liquid crystal, first, wash your mouth thoroughly with water, then drink a lot of water and induce vomiting, and then, consult a physician.
- If the liquid crystal get in your eyes, flush your eyes with running water for at least fifteen minutes.
- If the liquid crystal touches your skin or clothes, remove it and wash the affected part of your skin or clothes with soap and running water.

10.0 Applicable Scope

- This product specification only applies to the products manufactured and sold by our company.
- Any specification, quality etc. about other parts mentioned in this product spec are no concern of our company.