# TITLE ：NV156FHM-N4V

## Customer: DELL

## Product Specification

## Rev. P1

## ( DELL DPN :2GMF6 )



**Chongqing BOE Optoelectronics CO., LTD**

## REVISION HISTORY

(√ )Preliminary Specification

( )Final Specification

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# 1.0 GENERAL DESCRIPTION

## 1.1 Introduction

NV156FHM-N4V is a color active matrix TFT LCD module using amorphous silicon TFT's (Thin Film Transistors) as an active switching devices. This module has a 15.6 inch diagonally measured active area with Full-HD resolutions (1920 horizontal by 1080 vertical pixel array). Each pixel is divided into RED, GREEN, BLUE dots which are arranged in vertical stripe and this module can display 262K(Round down)(6bit) colors and color gamut 45%. The TFT-LCD panel used for this module is a low reflection and higher color type. Therefore, this module is suitable for Notebook PC. The LED driver for back-light driving is built in this model.

All input signals are eDP1.2 interface compatible.

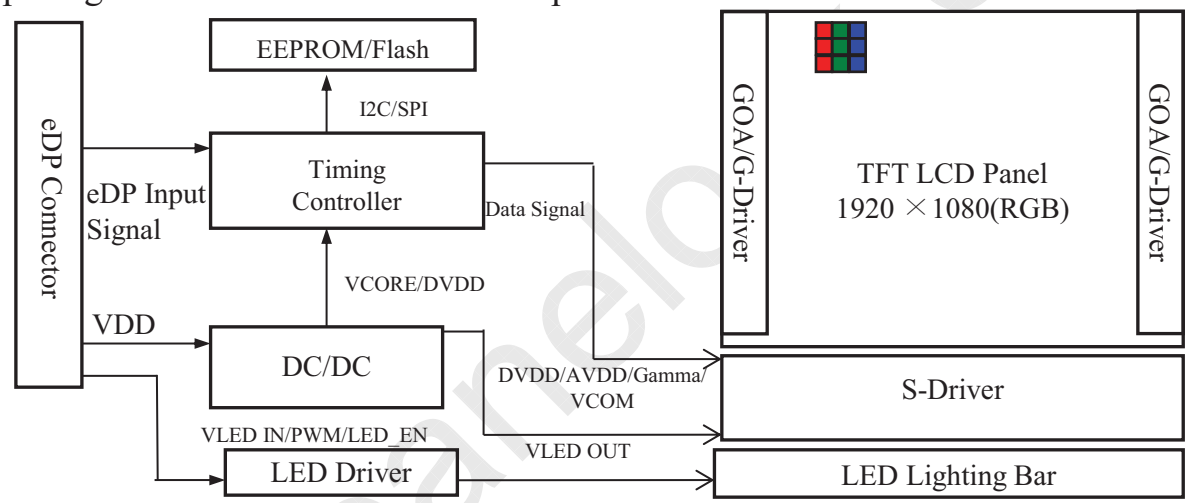



Figure 1. Drive Architecture

## 1.2 Features

- 2 lane eDP1.2 interface with 2.7Gbps link rates
- Thin and light weight
- 262K(Round down)(6bit) color depth, color gamut 45%
- Single LED lighting bar (Bottom side/Horizontal Direction)
- Data enable signal mode
- Side mounting frame
- Green product (RoHS & Halogen free product)
- On board LED driving circuit
- Low driving voltage and low power consumption
- On board EDID chip
- DPCD Version 1.1
- Function： CABC/BIST

### 1.3 Application

- Notebook PC (Wide type)

### 1.4 General Specification

The followings are general specifications at the model NV156FHM-N4V. (listed in Table 1)

<Table 1. General Specifications>

| Parameter | Specification | Unit | Remarks |
|---|---|---|---|
| Active area | 344.16(H) ×193.59(V) | mm | |
| Number of pixels | 1920 (H) ×1080 (V) | pixels | |
| Pixel pitch | 179.25(H) ×179.25(V) | um | |
| Pixel arrangement | RGB Vertical stripe | | |
| Display colors | 262K(6bit) | | Round down |
| Color gamut | 45% | | |
| Display mode | Normally Black | | |
| Dimensional outline | 350.66±0.3(H)×205.69±0.3(V)×1.6 Max for FPC(V)×3.0±0.15(W/O PCB)<br>350.66±0.3(H)×205.69±0.3(V)×1.6 Max for FPC(V)×5.4(Max)(W PCB) | mm | |
| Weight | 380(Max.) | g | |
| Surface treatment | Fine AG | | |
| Surface hardness | 3H | | |
| Back-light | Bottom edge side, 1-LED lighting bar type | | Note 1 |
| Power consumption | $P_D$ : 0.88(Max) | W | @Mosaic |
| | $P_{BL}$ : 2.95(Max.) | W | @12V input |
| | $P_{Total}$ : 3.83(Max.) | W | @Mosaic |

Notes : 1. LED Lighting Bar (40*LED Array)

## 2.0 ABSOLUTE MAXIMUM RATINGS

The followings are maximum values which, if exceed, may cause faulty operation or damage to the unit. The operational and non-operational maximum voltage and current values are listed in Table 2.

< Table 2. Absolute Maximum Ratings>

Ta=25+/-2˚C

| Parameter | Symbol | Min. | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Power Supply Voltage | $V_{DD}$ | -0.3 | 4.0 | V | Note 1 |
| eDP input Voltage | $V_{eDP}$ | 0 | 2.0 | V | |
| Logic Supply Voltage | $V_{IN}$ | $V_{SS}$-0.3 | $V_{DD}$+0.3 | V | |
| Operating Temperature | $T_{OP}$ | 0 | +50 | ˚C | Note 2 |
| Storage Temperature | $T_{ST}$ | -20 | +60 | ˚C | |

Notes :
1. Permanent damage to the device may occur if maximum values are exceeded functional operation should be restricted to the condition described under normal operating conditions.
2. Temperature and relative humidity range are shown in the figure below.
95 % RH Max. ( 40 ˚C ≥ Ta) Maximum wet-bulb temperature at 39˚C or less.(Ta >40˚C)No condensation.

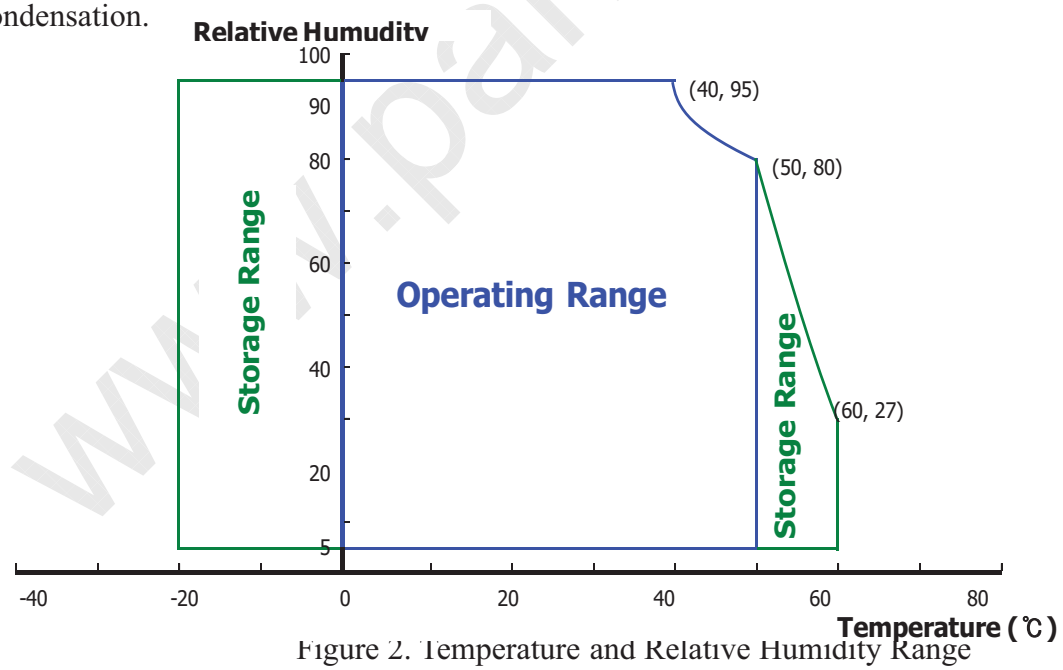



Figure 2. Temperature and Relative Humidity Range

## 3.0 ELECTRICAL SPECIFICATIONS

### 3.1 Electrical Specifications

< Table 3. Electrical Specifications > Ta=25+/-2°C

| Parameter | | | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| Power Supply Voltage | | $V_{DD}$ | 3.0 | 3.3 | 3.6 | V | Note 1 |
| Permissible Input Ripple Voltage | | $V_{RF}$ | -10% VDD | - | +10% VDD | V | Note 4 |
| CABC Control Level | | High Level | 2 | 2.5 | 3.6 | V | Note 5 |
| | | Low Level | 0 | - | 0.8 | V | |
| BIST Control Level | | High Level | 2 | 2.5 | 3.6 | V | |
| | | Low Level | 0 | - | 0.8 | V | |
| Power Supply Inrush Current | | Inrush | - | - | 2 | A | Note3 |
| Power Supply Current | Mosaic | $I_{DD}$ | - | - | 267 | mA | |
| | Red | | - | - | 485 | mA | |
| | Green | | - | - | 485 | mA | |
| | Blue | | - | - | 485 | mA | |
| Power Consumption | Mosaic | $P_M$ | - | - | 0.88 | W | |
| | Red | $P_R$ | - | - | 1.6 | W | |
| | Green | $P_G$ | - | - | 1.6 | W | |
| | Blue | $P_B$ | - | - | 1.6 | W | |
| | BLU | $P_{BL}$ | - | - | 3 | W | Note 2 |
| | Total | $P_{Total}$ | - | - | 4.6 | W | Note 1 |

# 3.0 ELECTRICAL SPECIFICATIONS

## 3.1 Electrical Specifications

Notes :

1. The supply voltage is measured and specified at the interface connector of LCM.
   The current draw and power consumption specified is for 3.3V at 25 ˚C.(Typ. value for reference)
   a) Mosaic pattern 8*8
   b) R/G/B patterns

(a) (b)

Figure 3. Power Measure Patterns

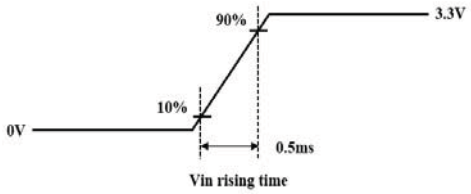



Figure 4. Inrush Measure Condition

2. Calculated value for reference ($V_{LED} \times I_{LED}$) , The power consumption with LED Driver are under the VLED = 12.0V , 25℃, PWM Duty 100% .
3. Measure condition (Figure 4)
4. Input voltage range:3.0~3.6V.Test condition: Oscilloscope bandwidth 20MHz, AC coupling
5. CABC&BIST setting

| Pin No | Define | Enable | Disable |
|---|---|---|---|
| 1 | CABC | Pull High | Pull Low/Floating |
| 14 | BIST | Pull High | Pull Low/Floating |

### 3.2 Backlight Unit

< Table 4. LED Driving Guideline Specifications > Ta=25+/-2˚C

| Parameter | | | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| LED Forward Voltage | | $V_F$ | - | - | 2.9 | V | |
| LED Forward Current | | $I_F$ | - | 21.3 | - | mA | |
| LED Power Input Voltage | | $V_{LED}$ | 5 | 12 | 21 | V | |
| LED Power Input Current | | $I_{LED}$ | - | - | 245 | mA | Note 1 |
| LED Power Consumption | | $P_{LED}$ | - | - | 2.95 | W | |
| Power Supply Voltage for LED Driver Inrush | | Iled inrush | - | - | 2 | A | |
| LED Life-Time | | N/A | 15,000 | - | - | Hour | IF = 21.3 mA Note 2 |
| EN Control Level | Backlight On | $V_{BL\_EN}$ | 2.5 | - | 5.0 | V | Note 4 |
| | Backlight Off | | 0 | - | 0.3 | V | |
| PWM Control Level | High Level | $V_{BL\_PWM}$ | 2.5 | - | 3.6 | V | |
| | Low Level | | 0 | - | 0.3 | V | |
| PWM Control Frequency | | $F_{PWM}$ | 200 | - | 2,000 | Hz | |
| Duty Ratio | | | 5 | - | 100 | % | Note 3 |

Notes :
1. The current and power consumption with LED Driver are under the VLED = 12.0V , 25℃, PWM Duty 100% .
2. The LED life-time define as the estimated time to 50% degradation of initial luminous.
3. Measure condition (Figure 5).
4.LED_EN&PWM setting

| Pin No | Define | Enable | Disable |
|---|---|---|---|
| 22 | LED_EN | Pull High | Pull Low/Floating |
| 23 | PWM | Pull High | Pull Low/Floating |

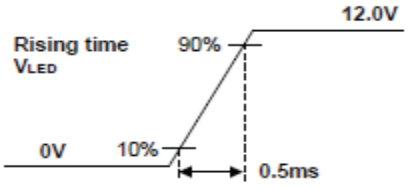



Figure 5. Inrush Measure Condition

### 3.3 LED Structure

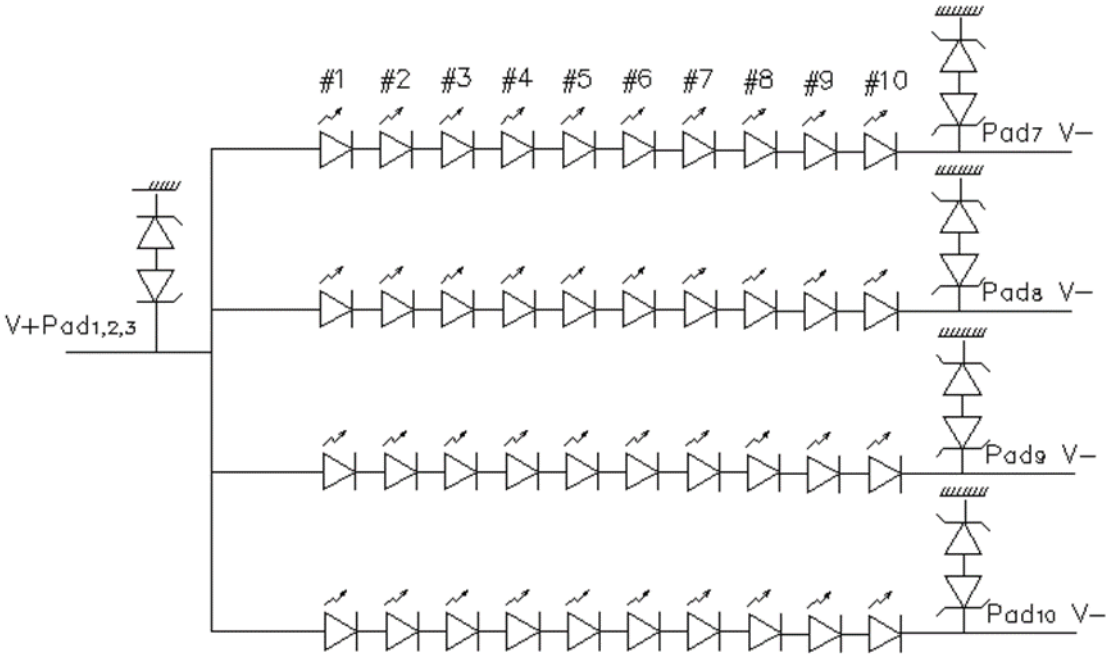



Figure 6. LED Structure

# 4.0 OPTICAL SPECIFICATION

## 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 (PR730&PR810) 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°. We refer to θØ=0 (=θ3 ) as the 3 o'clock direction (the "right"), θØ=90 (= θ12 ) as the 12 o'clock direction ("upward"), θØ=180 (= θ9 ) as the 9 o'clock direction ("left") and θØ=270(= θ6 ) as the 6 o'clock direction ("bottom"). While scanning θand/or Ø, the center of the measuring spot on the display surface shall stay fixed. The backlight should be operating for 30 minutes prior to measurement. VDD shall be 3.3+/- 0.3V at 25°C.

## 4.2 Optical Specifications

<Table 5. Optical Specifications>

| Parameter | | Symbol | Condition | Min. | Typ. | Max. | Unit | Remark |
|---|---|---|---|---|---|---|---|---|
| Viewing Angle Range | Horizontal | $\Theta_3$ | CR > 10 | 80 | 89 | - | Deg. | Note 1 |
| | | $\Theta_9$ | | 80 | 89 | - | Deg. | |
| | Vertical | $\Theta_{12}$ | | 80 | 89 | - | Deg. | |
| | | $\Theta_6$ | | 80 | 89 | - | Deg. | |
| Luminance Contrast Ratio | | CR | Θ = 0° | 600 | 700 | - | | Note 2 |
| Luminance of White | 5 Points | $Y_w$ | Θ = 0° $I_{LED}$ = 21.3mA | 212 | 250 | - | cd/m² | Note 3 |
| White Luminance Uniformity | 5 Points | ΔY5 | | 80 | - | - | | Note 4 |
| | 13 Points | ΔY13 | | 65 | - | - | | |
| White Chromaticity | | $W_x$ | Θ = 0° | 0.283 | 0.313 | 0.343 | | Note 5 |
| | | $W_y$ | | 0.299 | 0.329 | 0.359 | | |
| Reproduction of Color | Red | $R_x$ | Θ = 0° | Typ.-0.03 | 0.585 | Typ.+0.03 | | |
| | | $R_y$ | | | 0.364 | | | |
| | Green | $G_x$ | | | 0.350 | | | |
| | | $G_y$ | | | 0.568 | | | |
| | Blue | $B_x$ | | | 0.163 | | | |
| | | $B_y$ | | | 0.124 | | | |
| Color Gamut | | | | 43 | 45 | - | % | NTSC |
| Response Time (Rising + Falling) | | $T_{RT}$ | Ta= 25℃ Θ = 0° | - | 30 | 35 | ms | Note 6 |
| Cross Talk | | CT | Θ = 0° | - | - | 2.0 | % | Note 7 |
| Gamma | | - | - | 1.7 | 2.2 | 2.7 | | |

Notes :

1. Viewing angle is the angle at which the contrast ratio is greater than 10. The viewing angles 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 Figure 7).

2. Contrast measurements shall be made at viewing angle of $\Theta = 0$ 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 Figure 7) Luminance Contrast Ratio (CR) is defined mathematically.

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

3. Center Luminance of white is defined as luminance values of 5 point average across the LCD surface. Luminance shall be measured with all pixels in the view field set first to white. This measurement shall be taken at the locations shown in Figure 8 for a total of the measurements per display.

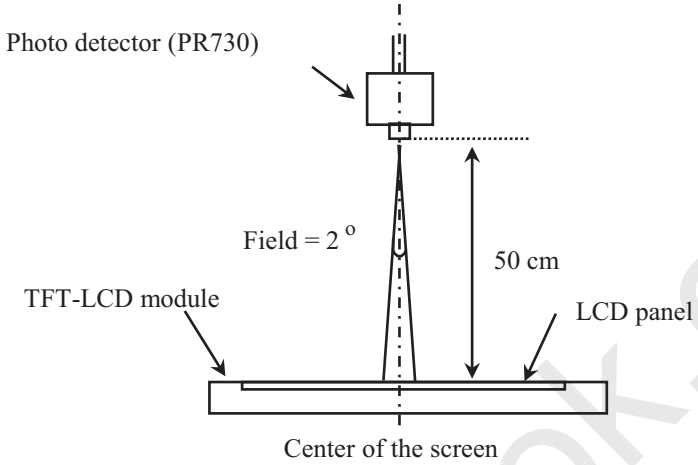
4. The White luminance uniformity on LCD surface is then expressed as : $\Delta Y$ =Minimum Luminance of 5(or 13) points / Maximum Luminance of 5(or 13) points.(see Figure 8 and Figure 9).

5. The color chromaticity coordinates specified in Table 5 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 panel.

6. The electro-optical response time measurements shall be made as Figure 10 by switching the "data" input signal ON and OFF. The times needed for the luminance to change from 10% to 90% is $T_r$, and 90% to 10% is $T_f$.

7. Cross-Talk of one area of the LCD surface by another shall be measured by comparing the luminance ($Y_A$) of a 25mm diameter area, with all display pixels set to a gray level, to the luminance ($Y_B$) of that same area when any adjacent area is driven dark. (See Figure 11).

### 4.3 Optical Measurements




Optical characteristics measurement setup

Figure 7. Measurement Set Up

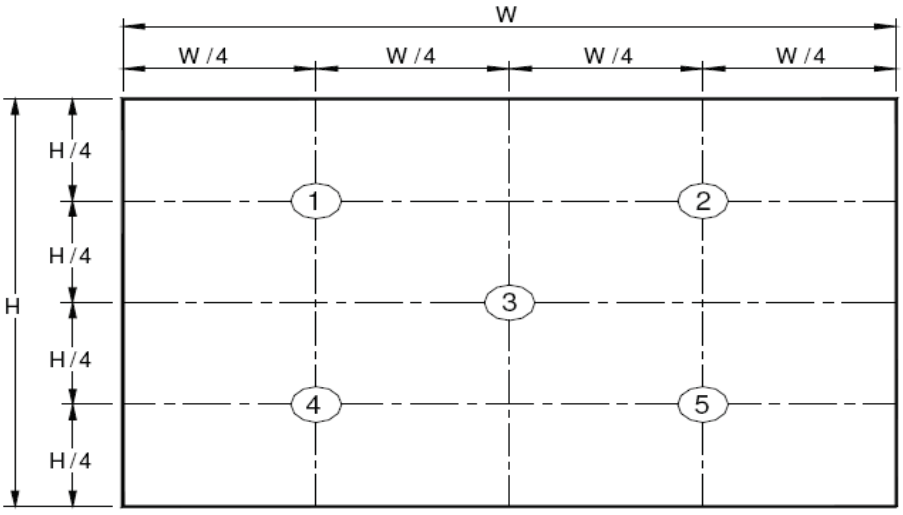



Figure 8. White Luminance and Uniformity Measurement Locations (5 points)

Center Luminance of white is defined as luminance values of center 5 points across the LCD surface. Luminance shall be measured with all pixels in the view field set first to white. This measurement shall be taken at the locations shown in Figure 7 for a total of the measurements per display.

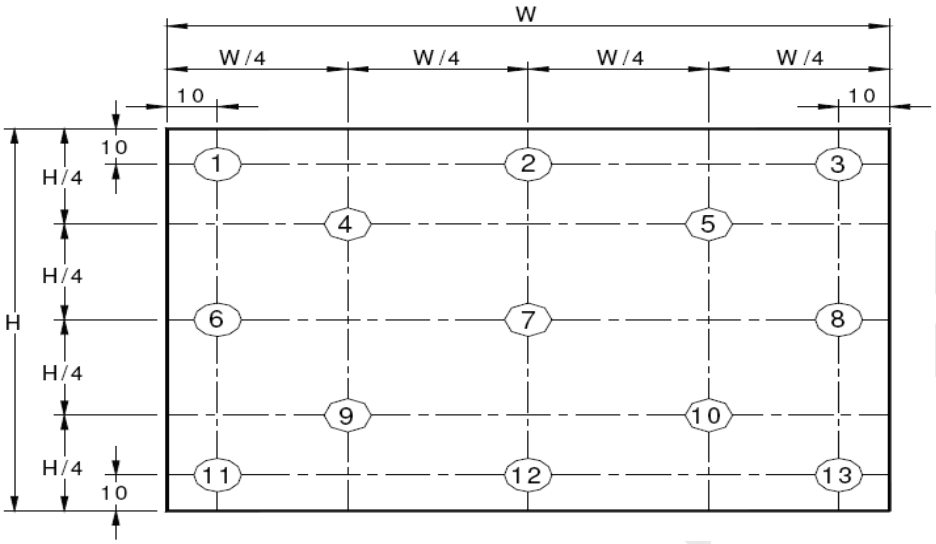



Figure 9. Uniformity Measurement Locations (13 points)

The White luminance uniformity on LCD surface is then expressed as : ΔY5 = Minimum Luminance of five points / Maximum Luminance of five points (see Figure 8) , ΔY13 = Minimum Luminance of 13 points /Maximum Luminance of 13 points (see Figure 9).

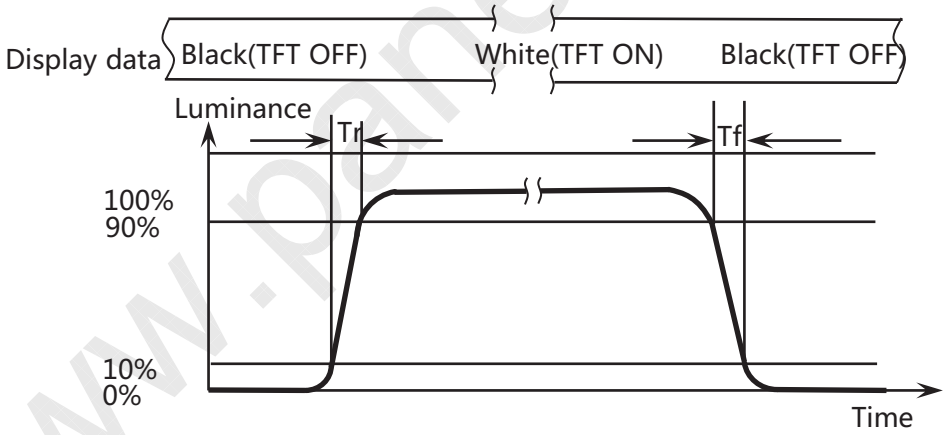
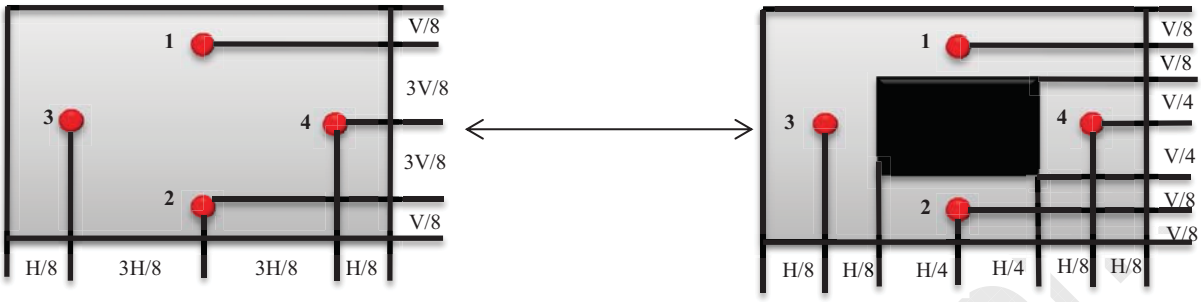



Figure 10. Response Time Testing

The electro-optical response time measurements shall be made as shown in Figure 10 by switching the "data" input signal ON and OFF. Tr: The luminance to change from 10% to 90% ,Tf: The luminance to change from 90% to 10% .

The test system : LMS PR810




$$\text{Cross Talk (\%)} = \left| \frac{Y_B - Y_A}{Y_A} \right| \times 100$$

Figure 11. Cross Talk Modulation Test Description

Where:

$Y_A$ = Initial luminance of measured area (cd/m$^2$)

$Y_B$ = Subsequent luminance of measured area (cd/m$^2$)

The location 1/2/3/4 measured will be exactly the same in both patterns. The test background gray is from L64 to L192.Take the largest data as the result.

Cross Talk of one area of the LCD surface by another shall be measured by comparing the luminance (YA) of a 25mm diameter area, with all display pixels set to a gray level, to the luminance (YB) of that same area when any adjacent area is driven dark.(Refer to Figure 11)

The test system: PR730

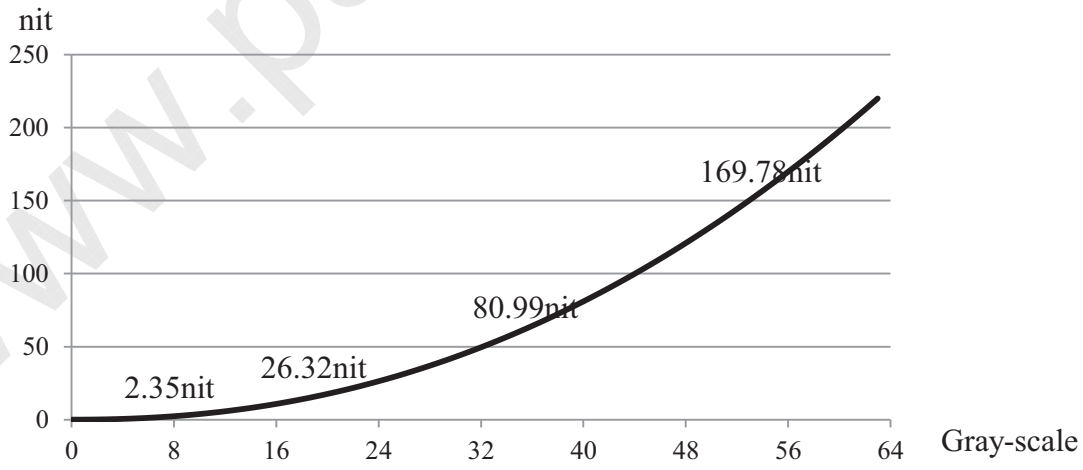



Figure 12. Brightness and Gray-scale Contrast

# 5.0 INTERFACE CONNECTION

## 5.1 Electrical Interface Connection

The electronics interface connector is STM MSAK24025P30G.
The connector interface pin assignments are listed in Table 6.

<Table 6. Pin Assignments for the Interface Connector>

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | CABC_EN | CABC_Function Reserved |
| 2 | H_GND | Ground |
| 3 | LANE1_N | eDP RX Channel 1 Negative |
| 4 | LANE1_P | eDP RX Channel 1 Positive |
| 5 | H_GND | Ground |
| 6 | LANE0_N | eDP RX Channel 0 Negative |
| 7 | LANE0_P | eDP RX Channel 0 Positive |
| 8 | H_GND | Ground |
| 9 | AUX_CH_P | eDP AUX CH Positive |
| 10 | AUX_CH_N | eDP AUX CH Negative |
| 11 | H_GND | Ground |
| 12 | LCD_VCC | Power Supply, 3.3V (typ.) |
| 13 | LCD_VCC | Power Supply, 3.3V (typ.) |
| 14 | BIST | Panel Self Test Enable |
| 15 | H_GND | Ground |
| 16 | H_GND | Ground |
| 17 | HPD | Hot Plug Detect Output |
| 18 | BL_GND | LED Ground |
| 19 | BL_GND | LED Ground |
| 20 | BL_GND | LED Ground |
| 21 | BL_GND | LED Ground |
| 22 | BL_ENABLE | LED Enable Pin(+3.3V Input) |
| 23 | BL_PWM | System PWM Signal Input |
| 24 | NC | No Connection |
| 25 | NC | No Connection |
| 26 | BL_POWER | LED Power Supply 5V-21V |
| 27 | BL_POWER | LED Power Supply 5V-21V |
| 28 | BL_POWER | LED Power Supply 5V-21V |
| 29 | BL_POWER | LED Power Supply 5V-21V |
| 30 | NC | No Connection |

### 5.2 eDP Interface

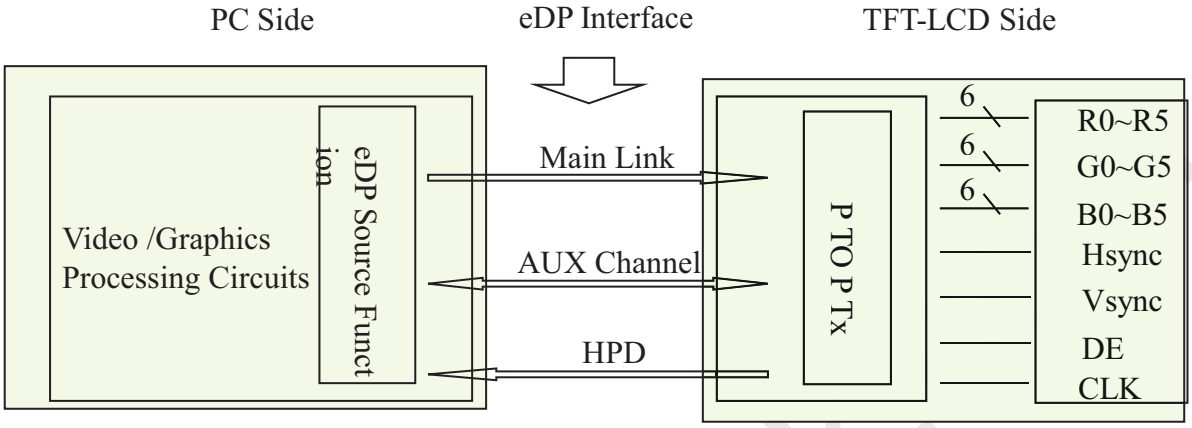



Figure 13. eDP Interface Architecture

Note:
Transmitter : Parade DP501 or equivalent.
Transmitter is not contained in module.

### 5.3 Data Input Format

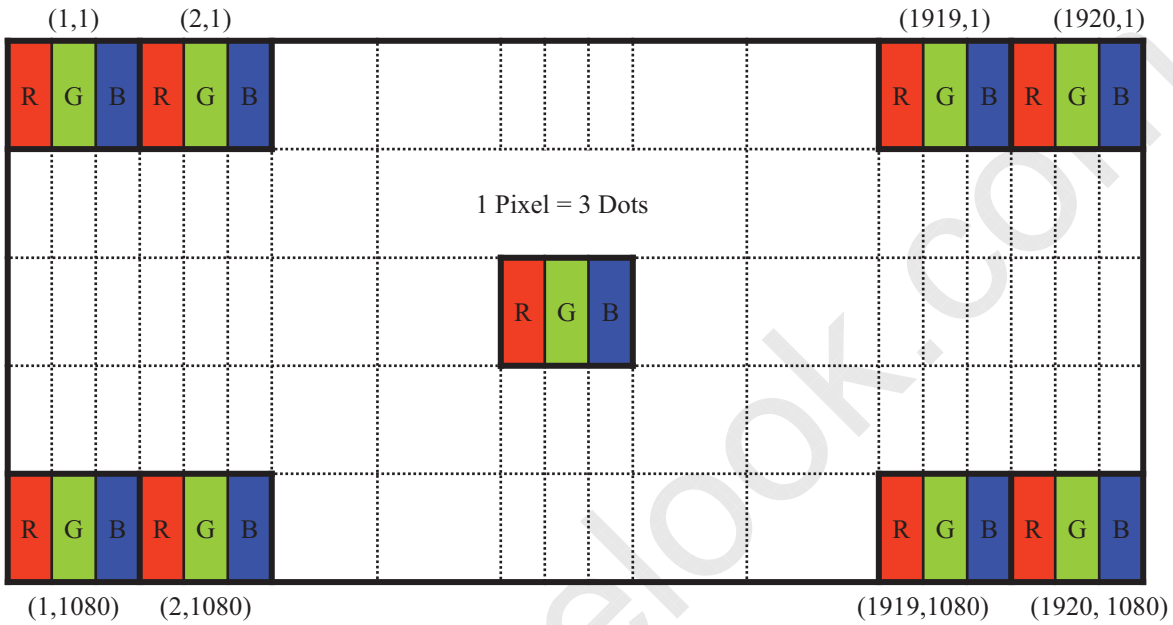



Figure 14. Display Position of Input Data (V-H)

### 5.4 Back-light & LCM Interface Connection

BLU Interface Connector: STM MSAK24022P10.

<Table 7. Pin Assignments for the BLU Connector>

| Pin No. | Symbol | Description | Pin No. | Symbol | Description |
|---|---|---|---|---|---|
| 1 | Vout | LED anode connection | 6 | NC | No Connection |
| 2 | Vout | LED anode connection | 7 | LED | LED cathode connection |
| 3 | Vout | LED anode connection | 8 | LED | LED cathode connection |
| 4 | NC | No Connection | 9 | LED | LED cathode connection |
| 5 | GND | Ground | 10 | LED | LED cathode connection |

## 6.0 SIGNAL TIMING SPECIFICATION

### 6.1 The NV156FHM-N4V Is Operated By The DE Only

< Table 8. Signal Timing Specification >

| Item | | Symbols | Min | Typ | Max |
|---|---|---|---|---|---|
| Clock | Frequency | 1/Tc | 145.1 | 152.5 | 156.6 |
| Frame Period | | Tv | 1120 | 1140 | 1160 |
| | | | - | 60 | - |
| | | | - | 16.7 | - |
| Vertical Display Period | | Tvd | - | 1080 | - |
| One line Scanning Period | | Th | 2160 | 2230 | 2250 |
| Horizontal Display Period | | Thd | - | 1920 | - |

Note : The above is as optimized setting.

### 6.2 eDP Rx Interface Timing Parameter

The specification of the eDP Rx interface timing parameter is shown in Table 9.

<Table 9. eDP Main-Link RX TP4 Package Pin Parameters>

| Item | Symbol | Min | Typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|
| Spread spectrum clock (Link clock down-spreading) | SSC | 0 | - | 0.5 | % | |
| Differential peak-to-peak input voltage at package pins | $V_{RX-DIFFp-p}$ | 100 | - | 1320 | mV | |
| Rx input DC common mode voltage | $V_{RX\_DC\_CM}$ | 0 | - | 2 | V | |
| Differential termination resistance | $R_{RX-DIFF}$ | 80 | - | 120 | Ω | |
| Single-ended termination resistance | $R_{RX-SE}$ | 40 | - | 60 | Ω | |
| Rx short circuit current limit | $I_{RX\_SHORT}$ | - | - | 50 | mA | |
| Intra-pair skew at Rx package pins (HBR) RX intra-pair skew tolerance at HBR | $L_{RX\_SKEW\_INTRA\_PAIR}$ | - | - | 60 | ps | |
| AC Coupling Capacitor | $C_{SOURCE\_ML}$ | 0 | - | 0.5 | nF | Source side |

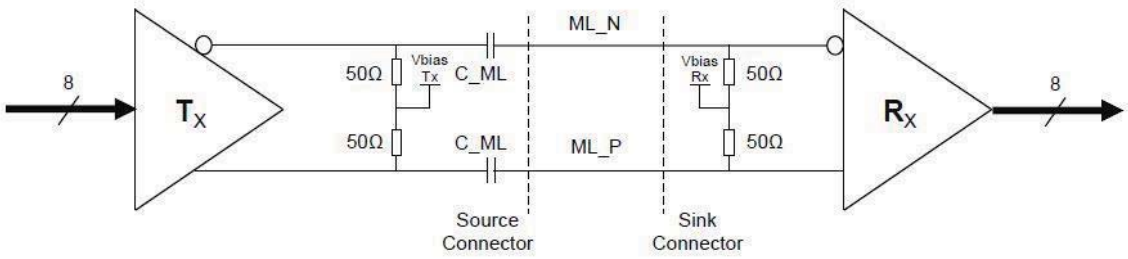



Figure 15. Main link differential pair

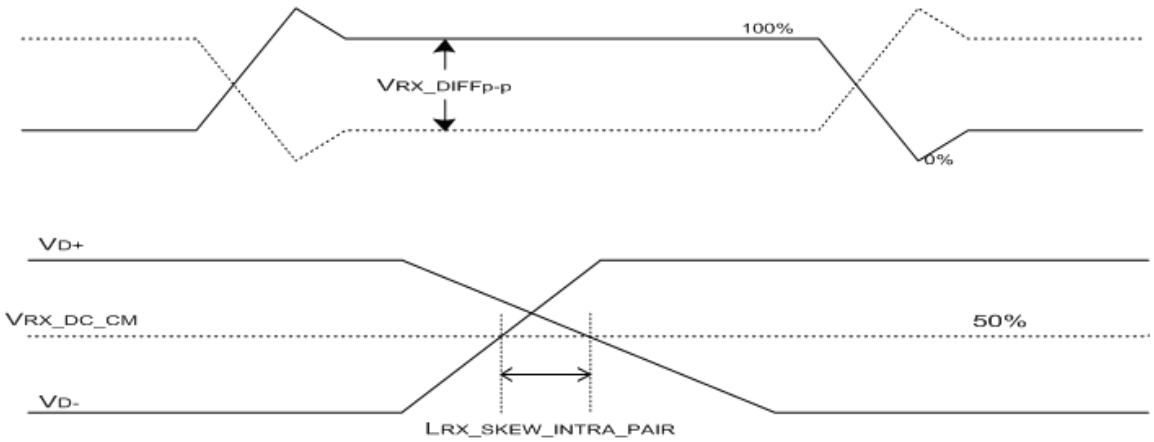



Figure 16. VRX-DIFFp-p & LRX_SKEW_INTRA_PAIR

<Table 10. HPD Characteristics>

| Item | Symbol | Min | Typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|
| HPD voltage | $V_{HPD}$ | 2.25 | - | 3.6 | V | Sink side |
| Hot Plug Detection Threshold | - | 2.0 | - | - | V | Source side |
| Hot Unplug Detection Threshold | - | - | - | 0.8V | V | |
| HPD_IRQ Pulse Width | HPD_IRQ | 0.5 | - | 1 | ms | |
| HPD_TimeOut | - | 2.0 | - | - | ms | |

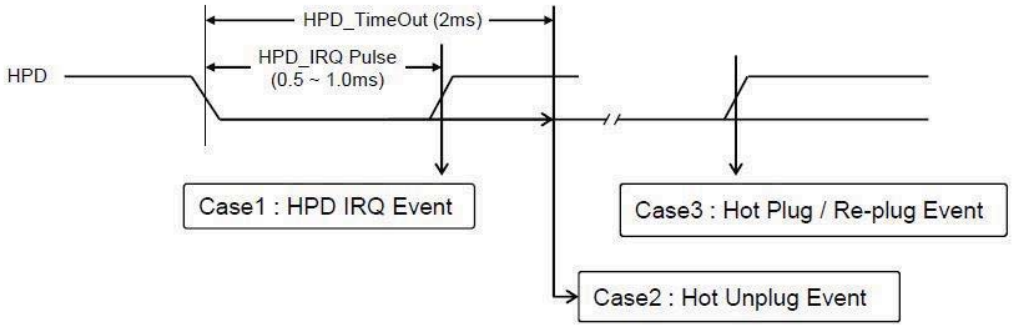



Figure 17. HPD Events

<Table 11. AUX Characteristics>

| Item | Symbol | Min | Typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|
| AUX unit interval | $U_{IAUX}$ | 0.4 | 0.5 | 0.6 | Us | |
| AUX peak-to-peak input differential voltage | $V_{AUX-RX-DIFFp-p}$ | 0.29 | - | 1.38 | V | Sink Side Connector Pin |
| AUX CH termination DC resistance | $R_{AUX-TERM}$ | 80 | 100 | 120 | Ohm | |
| AUX DC common mode voltage | $V_{AUX-DC-CM}$ | 0 | - | 2 | V | |
| AUX turn around common mode voltage | $V_{AUX-TURN-CM}$ | | | 0.3 | V | |
| AUX short circuit current limit | $I_{AUX-SHORT}$ | - | - | 90 | mA | |
| AUX AC Coupling Capacitor | $C_{SOURCE-AUX}$ | 75 | | 200 | nF | Source side |

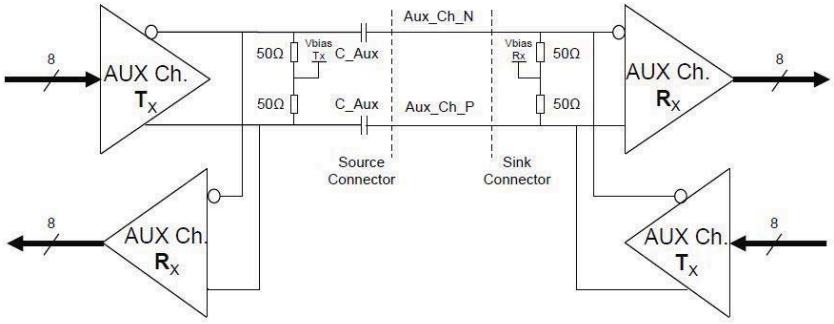



Figure 18. AUX differential pair

## 7.0 INPUT SIGNALS, BASIC DISPLAY COLORS & GRAY SCALE OF COLORS

<Table 12. Input Signal & Basic Display Colors & Gray Scale of Colors >

| | Colors & Gray scale | Data signal | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R0 | R1 | R2 | R3 | R4 | R5 | G0 | G1 | G2 | G3 | G4 | G5 | B0 | B1 | B2 | B3 | B4 | B5 |
| Basic colors | Black | 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 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Green | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Light Blue | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Red | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Purple | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Yellow | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 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 |
| Gray scale of Red | Black | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | △ | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Darker | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | △ ▽ | ↑ ↓ | | | | | | ↑ ↓ | | | | | | ↑ ↓ | | | | | |
| | Brighter | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ▽ | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Red | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gray scale of Green | Black | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | △ | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Darker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | △ ▽ | ↑ ↓ | | | | | | ↑ ↓ | | | | | | ↑ ↓ | | | | | |
| | Brighter | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ▽ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Green | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gray scale of Blue | Black | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | △ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Darker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | △ ▽ | ↑ ↓ | | | | | | ↓ ↓ | | | | | | ↑ ↓ | | | | | |
| | Brighter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| | ▽ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | Blue | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Gray scale of White & Black | Black | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | △ | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Darker | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | △ ▽ | ↑ ↓ | | | | | | ↑ ↓ | | | | | | ↑ ↓ | | | | | |
| | Brighter | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| | ▽ | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| | White | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

## 8.0 POWER SEQUENCE

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

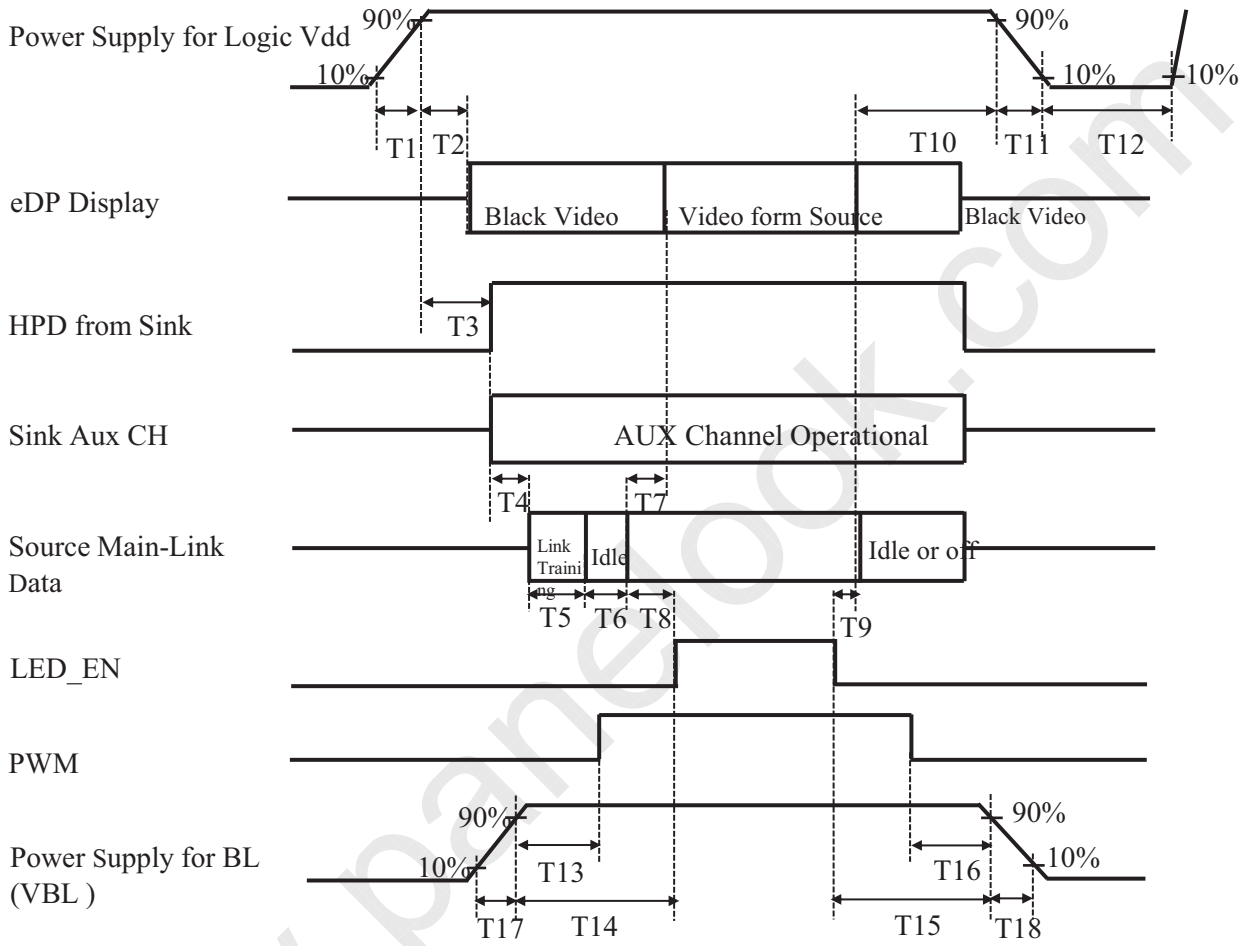



Figure 19. Power Sequence

- 0.5ms ≤ T1 ≤ 10 ms
- 0ms < T2 ≤ 200 ms
- 0ms < T3 ≤ 200 ms
- T4+T5+T6+T8>80ms
- 0ms < T7 ≤ 50ms
- 50ms < T8
- 0ms < T9
- 0ms < T10 < 500 ms
- 0.5ms ≤ T11 ≤ 10 ms
- 500ms ≤ T12
- 0ms < T13
- 0ms < T14
- 0ms < T15
- 0ms < T16
- 0.5ms ≤ T17
- 0.5ms ≤ T18

Notes:

1. When the power supply VDD is 0V, keep the level of input signals on the low or keep high impedance.
2. Do not keep the interface signal high impedance when power is on. Back Light must be turn on after power for logic and interface signal are valid.

## 9.0 Connector Description

Physical interface is described as for the connector on LCM.
These connectors are capable of accommodating the following signals and will be following components.

### 9.1 TFT LCD Module

< Table 13. Signal Connector >

| Connector Name /Description | For Signal Connector |
|---|---|
| Manufacturer | STM |
| Type/ Part Number | MSAK24025P30G |
| Mating Housing/ Part Number | I-PEX 20454-030T or Compatible |

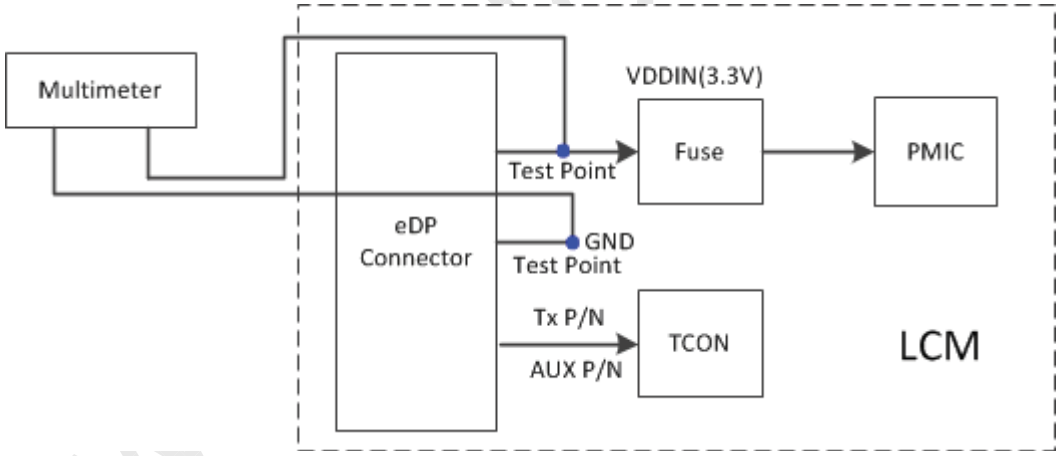
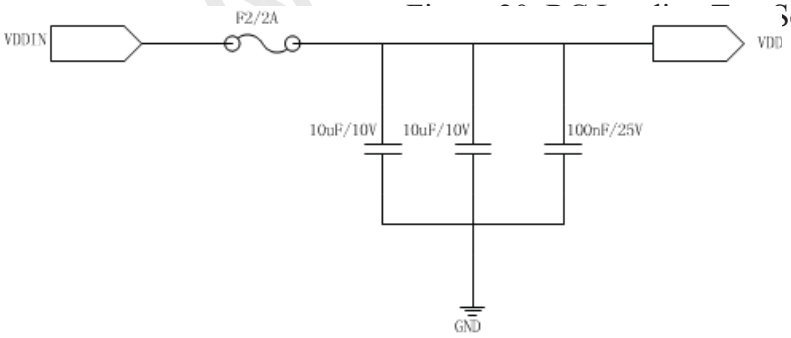



Figure 20. BOE Loading Type Schematic Diagram




| Item | RC Loading | |
|---|---|---|
| 2GMF6 | R | C |
| | 27.87kΩ | 16.5uF |

Figure 21. VCC Loop R/C Loading Parameter

# 10.0 MECHANICAL CHARACTERISTICS

## 10.1 Dimensional Requirements

Figure 26 shows mechanical outlines for the model NV156FHM-N4V.
Other parameters are shown in Table 14.

<Table 14. Dimensional Parameters>

| Parameter | Specification | Unit |
|---|---|---|
| Active Area | 344.16(H) ×193.59(V) | mm |
| Number of pixels | 1920 (H) X 1080 (V) (1 pixel = R + G + B dots) | pixels |
| Pixel pitch | 179.25(H) ×179.25(V) | um |
| Pixel arrangement | RGB Vertical stripe | |
| Display colors | 6bit | |
| Display mode | Normally Black | |
| Dimensional outline | 350.66±0.3(H)×205.69±0.3(V)×1.6 Max for FPC(V)×3.0±0.15(W/O PCB)<br>350.66±0.3(H)×205.69±0.3(V)×1.6 Max for FPC(V)×5.4(Max)(W PCB) | mm |
| Weight | 380 (Max.) | g |

## 10.2 Mounting

See Figure 26.

## 10.3 Anti-Glare and Polarizer Hardness.

The surface of the LCD has an Anti-Glare coating to minimize reflection and a coating to reduce scratching. The Polarizer Hardness is 3H.

## 10.4 Light Leakage

There shall not be visible light from the back-lighting system around the edges of the screen as seen from a distance 50cm from the screen with an overhead light level of 350lux.

## 11.0 RELIABILITY TEST

The reliability test items and its conditions are shown in below.

<Table 15. Reliability Test>

| No | Test Items | Conditions | Remark |
|---|---|---|---|
| 1 | High temperature storage test | Ta = 60˚C , 60%RH, 240 hrs | |
| 2 | Low temperature storage test | Ta = -20˚C , 240 hrs | |
| 3 | High temperature & high humidity operation test | Ta = 50˚C , 80%RH, 240 hrs | |
| 4 | High temperature operation test | Ta = 50˚C , 60%RH, 240 hrs | |
| 5 | Low temperature operation test | Ta = 0˚C , 240 hrs | |
| 6 | Thermal shock | Ta = -20 ˚C ↔ 60 ˚C (0.5 hr), 60%±3%RH, 100 cycle | |
| 7 | Vibration test (non-operating) | Ta = 25˚C , 60%RH, 1.5G, 10~500Hz, Sine X,Y,Z / Sweep rate : 1 hour | Note 1 |
| 8 | Shock test (non-operating) | Ta = 25˚C , 60%RH, 220G, Half Sine Wave 2msec ± X, ± Y, ± Z Once for each direction | Note 1 |
| 9 | Electro-static discharge test (operating) | Air : 150 pF, 330Ω, ±15 KV<br>Contact : 150 pF, 330Ω, ±8 KV<br>Ta = 25˚C , 60%RH, | Note 2 |

Notes :

1. The fixture must be hard enough , so that the module would not be twisted or bent.
2. Self- recovery and restart recovery is allowed. No hardware failures.

## 12.0 HANDLING & CAUTIONS

(1) Cautions when taking out the module
- Pick the pouch only, when taking out module from a shipping package.

(2) Cautions for handling the module
- As the electrostatic discharges may break the LCD module, handle the LCD module with care. Peel a protection sheet off from the LCD panel surface as slowly as possible.
- As the LCD panel and back - light element are made from fragile glass material, impulse and pressure to the LCD module should be avoided.
- As the surface of the polarizer is very soft and easily scratched, use a soft dry cloth without chemicals for cleaning.
- Do not pull the interface connector in or out while the LCD module is operating.
- Put the module display side down on a flat horizontal plane.
- Handle connectors and cables with care.

(3) Cautions for the operation
- When the module is operating, do not lose CLK, ENAB signals. If any one of these signals is lost, the LCD panel would be damaged.
- Obey the supply voltage sequence. If wrong sequence is applied, the module would be damaged.

(4) Cautions for the atmosphere
- Dew drop atmosphere should be avoided.
- Do not store and/or operate the LCD module in a high temperature and/or humidity atmosphere. Storage in an electro-conductive polymer packing pouch and under relatively low temperature atmosphere is recommended.

(5) Cautions for the module characteristics
- Do not apply fixed pattern data signal to the LCD module at product aging.
- Applying fixed pattern for a long time may cause image sticking.

(6) Other cautions
- Do not disassemble and/or re-assemble LCD module.
- Do not re-adjust variable resistor or switch etc.
- When returning the module for repair or etc. Please pack the module not to be broken. We recommend to use the original shipping packages.

## 13.0 LABEL

(1) Product Label

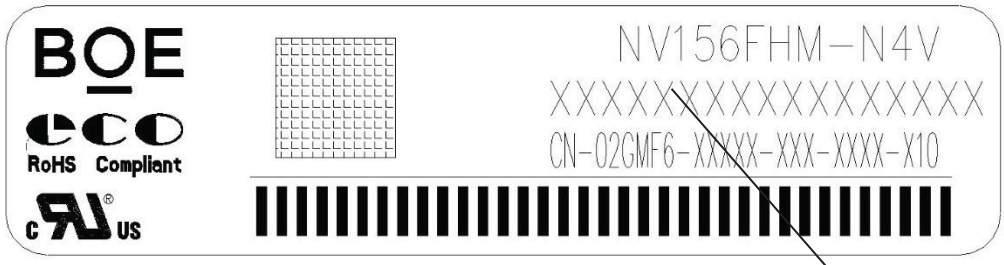



Figure 22. Product Label

Module ID Naming Rule:

<Table 16. Module ID Naming Rule>

| Digit / Code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | B | 9 | A | F | 1 | 7 | 8 | 8 | D | 3 | 1 | 0 | 0 | 0 | 0 | 6 | 8 |
| Description | Product Name | | Product Grade | B8 | Year | | Month | Model Extension Code (Last 4 Digits of FG CODE) | | | | Serial No. 00001-ZZZZZZ | | | | | |

(2) High voltage caution label

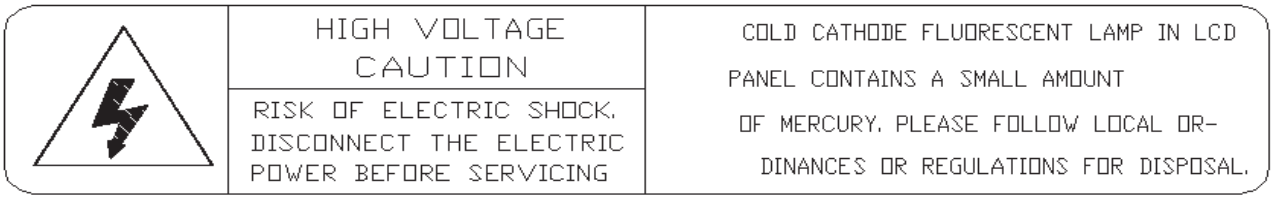



Figure 23. High Voltage Caution Label

(3) Box label

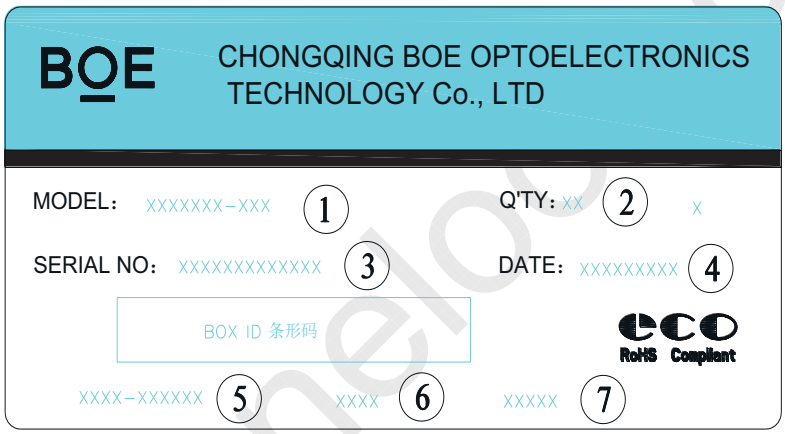



Figure 24. Box Label

Serial number marked part needs to print, show as follows:

1. FG-CODE(Before 12 bit)
2. Product quantity
3. Box ID
4. Date
5. The client section material number(The client)
6. FG-Code After four
7. The supplier code

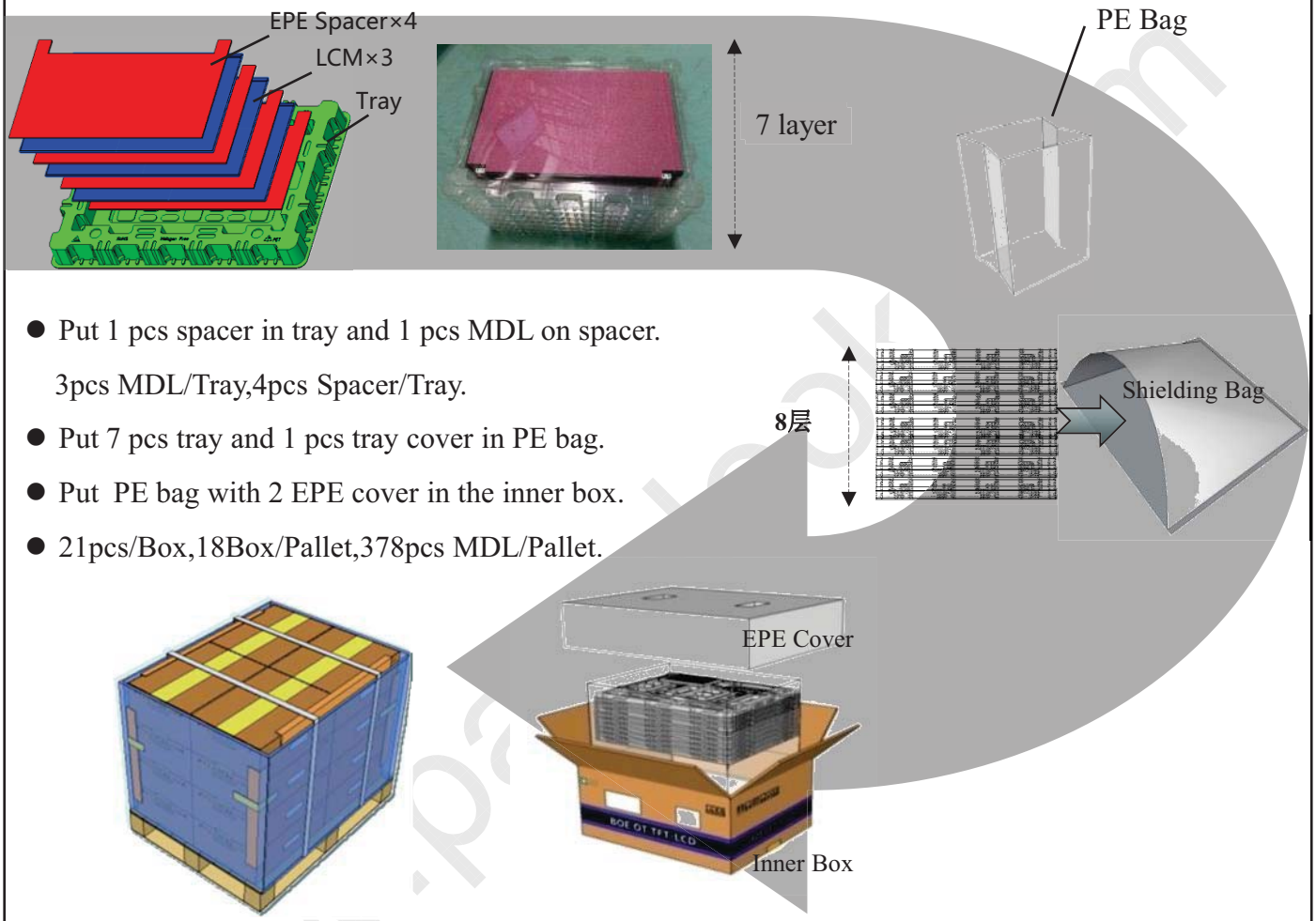
Total Size:100×50mm

<Table 17. Box Label Naming Rule >

| Digit / Code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | B | 9 | A | F | 1 | 7 | 8 | N | 0 | 0 | 3 | 2 | 7 |
| Description | Product Name | | Product Grade | B8 | Year | | Month | Revision | BOX Serial Number | | | | |

## 14.0 PACKING INFORMATION

### 14.1 Packing Order




- Put 1 pcs spacer in tray and 1 pcs MDL on spacer.
  3pcs MDL/Tray,4pcs Spacer/Tray.
- Put 7 pcs tray and 1 pcs tray cover in PE bag.
- Put PE bag with 2 EPE cover in the inner box.
- 21pcs/Box,18Box/Pallet,378pcs MDL/Pallet.

Figure 25. Packing Order

### 14.2 Note

- Box dimension: 480mm*350mm*285mm
- Package quantity in one box: 21pcs
- Total weight: 10.56kg/Box

## 15.0 MECHANICAL OUTLINE DIMENSION

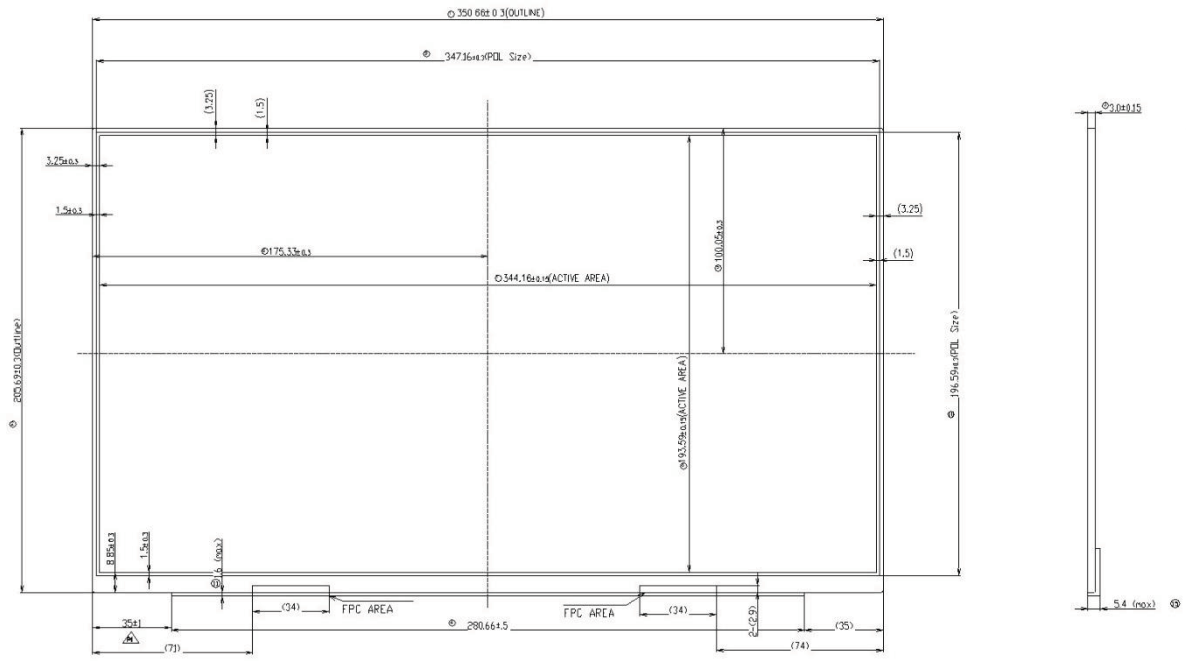



Figure 26. TFT-LCD Module Outline Dimension (Front View)

NOTES:
1.WARPAGE AND DEFORMATION SPEC.: 0.5mm MAX.
2.EDP CONNECTOR IS MEASURED AT PIN 1 AND MATING LINE
3.UNSPECIFIED TOLERANCE REFER TO +/- 0.3mm
4.TOP POLARIZER IS THE HIGHEST PORTION.
5.THE MEASUREMENT METHOD FOR THE DIMENSION OF MODULE, PLEASE REFRE TO PRODUCT SPEC.
BUT THE MEASUREMENT METHOD FOR OUTLINE W/PCB IS 3D COORDINATE MEASURING MACHINE.
6.CRITICAL DIMENSION: 1-15
CPK: 1-3
7. "()" REFER TO REFERENCE.

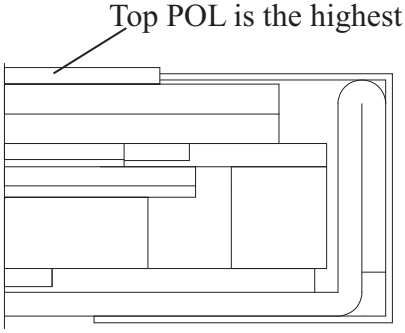



Figure 27. Highest Point Position

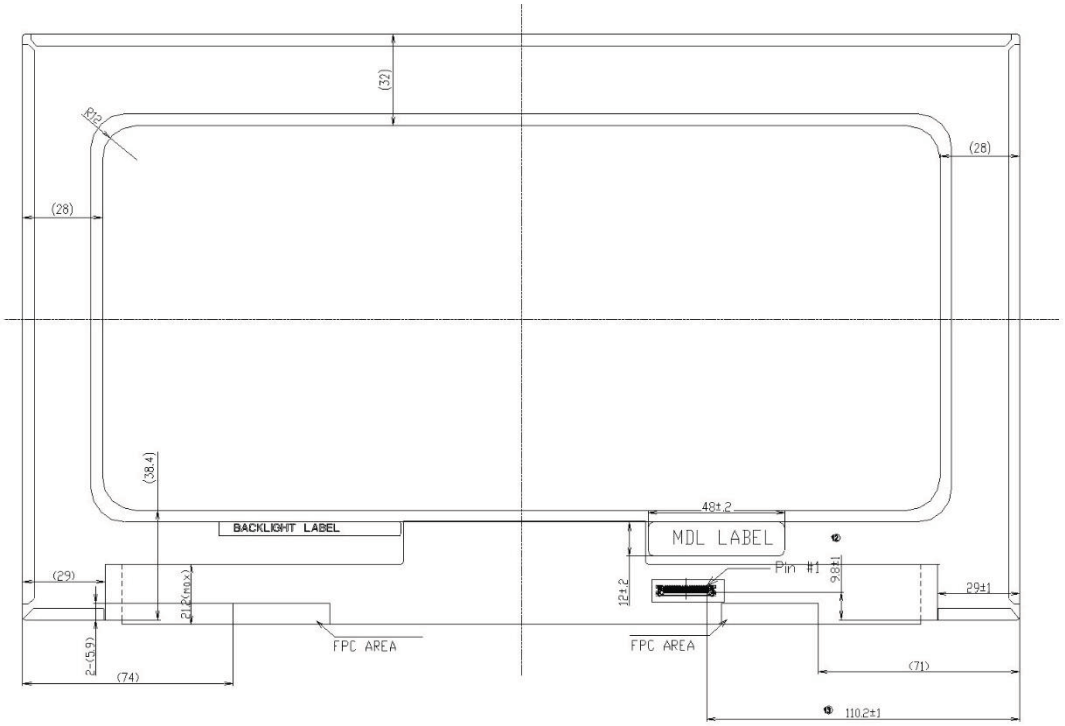



Figure 28. TFT-LCD Module Outline Dimensions (Rear view)

NOTES:
1.WARPAGE AND DEFORMATION SPEC.: 0.5mm MAX.
2.EDP CONNECTOR IS MEASURED AT PIN 1 AND MATING LINE
3.UNSPECIFIED TOLERANCE REFER TO +/- 0.3mm
4.TOP POLARIZER IS THE HIGHEST PORTION.
5.THE MEASUREMENT METHOD FOR THE DIMENSION OF MODULE, PLEASE REFRE TO PRODUCT SPEC. BUT THE MEASUREMENT METHOD FOR OUTLINE W/PCB IS 3D COORDINATE MEASURING MACHINE.
6.CRITICAL DIMENSION: 1-15
CPK: 1-3
7. "()" REFER TO REFERENCE.

## 16.0 EDID Table

| Address (HEX) | Function | Hex | Dec | crc | Input values. | Notes |
|---|---|---|---|---|---|---|
| 00 | Header | 00 | 0 | | 0 | EDID Header |
| 01 | | FF | 255 | | 255 | |
| 02 | | FF | 255 | | 255 | |
| 03 | | FF | 255 | | 255 | |
| 04 | | FF | 255 | | 255 | |
| 05 | | FF | 255 | | 255 | |
| 06 | | FF | 255 | | 255 | |
| 07 | | 00 | 0 | | 0 | |
| 08 | ID Manufacturer Name | 09 | 9 | | BOE | ID = BOE |
| 09 | | E5 | 229 | | | |
| 0A | ID Product Code | 28 | 40 | | 2344 | ID = 2344 |
| 0B | | 09 | 9 | | | |
| 0C | 32-bit serial No. | 00 | 0 | | 0 | |
| 0D | | 00 | 0 | | 0 | |
| 0E | | 00 | 0 | | 0 | |
| 0F | | 00 | 0 | | 0 | |
| 10 | Week of manufacture | 0B | 11 | | 11 | |
| 11 | Year of Manufacture | 1E | 30 | | 2020 | Manufactured in 2020 |
| 12 | EDID Structure Ver. | 01 | 1 | | 1 | EDID Ver 1.0 |
| 13 | EDID revision # | 04 | 4 | | 4 | EDID Rev. 0.4 |
| 14 | Video input definition | 95 | 149 | | - | Refer to right table |
| 15 | Max H image size | 22 | 34 | | 34 | 34 cm (Approx) |
| 16 | Max V image size | 13 | 19 | | 19 | 19 cm (Approx) |
| 17 | Display Gamma | 78 | 120 | | 2.2 | Gamma curve = 2.2 |
| 18 | Feature support | 02 | 2 | | - | Refer to right table |
| 19 | Red/Green low bits | C9 | 201 | | - | Red / Green Low Bits |
| 1A | Blue/White low bits | A0 | 160 | | - | Blue / White Low Bits |
| 1B | Red x high bits | 95 | 149 | 599 | 0.585 | Red (x) = 10010101 (0.585) |
| 1C | Red y high bits | 5D | 93 | 372 | 0.364 | Red (y) = 01011101 (0.364) |
| 1D | Green x high bits | 59 | 89 | 358 | 0.350 | Green (x) = 01011001 (0.35) |
| 1E | Green y high bits | 91 | 145 | 581 | 0.568 | Green (y) = 10010001 (0.568) |
| 1F | Blue x high bits | 29 | 41 | 166 | 0.163 | Blue (x) = 00101001 (0.163) |
| 20 | BLue y high bits | 1F | 31 | 126 | 0.124 | Blue (y) = 00011111 (0.124) |
| 21 | White x high bits | 50 | 80 | 320 | 0.313 | White (x) = 01010000 (0.313) |
| 22 | White y high bits | 54 | 84 | 336 | 0.329 | White (y) = 01010100 (0.329) |
| 23 | Established timing 1 | 00 | 0 | | - | Refer to right table |
| 24 | Established timing 2 | 00 | 0 | | - | |
| 25 | Established timing 3 | 00 | 0 | | - | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 26 | Standard timing #1 | 01 | 1 | | | Not Used |
| 27 | | 01 | 1 | | | |
| 28 | Standard timing #2 | 01 | 1 | | | Not Used |
| 29 | | 01 | 1 | | | |
| 2A | Standard timing #3 | 01 | 1 | | | Not Used |
| 2B | | 01 | 1 | | | |
| 2C | Standard timing #4 | 01 | 1 | | | Not Used |
| 2D | | 01 | 1 | | | |
| 2E | Standard timing #5 | 01 | 1 | | | Not Used |
| 2F | | 01 | 1 | | | |
| 30 | Standard timing #6 | 01 | 1 | | | Not Used |
| 31 | | 01 | 1 | | | |
| 32 | Standard timing #7 | 01 | 1 | | | Not Used |
| 33 | | 01 | 1 | | | |
| 34 | Standard timing #8 | 01 | 1 | | | Not Used |
| 35 | | 01 | 1 | | | |
| 36 | Detailed timing/monitor descriptor #1 | 95 | 149 | | 152.5 | 152.532MHz Main clock |
| 37 | | 3B | 59 | | | |
| 38 | | 80 | 128 | | 1920 | Hor Active = 1920 |
| 39 | | 36 | 54 | | 310 | Hor Blanking = 310 |
| 3A | | 71 | 113 | | - | 4 bits of Hor. Active + 4 bits of Hor. Blanking |
| 3B | | 38 | 56 | | 1080 | Ver Active = 1080 |
| 3C | | 3C | 60 | | 60 | Ver Blanking = 60 |
| 3D | | 40 | 64 | | - | 4 bits of Ver. Active + 4 bits of Ver. Blanking |
| 3E | | 30 | 48 | | 48 | Hor Sync Offset = 48 |
| 3F | | 20 | 32 | | 32 | H Sync Pulse Width = 32 |
| 40 | | 36 | 54 | | 3 | V sync Offset = 3 line |
| 41 | | 00 | 0 | | 6 | V Sync Pulse width : 6 line |
| 42 | | 58 | 88 | | 344 | Horizontal Image Size = 344 mm (Low 8 bits) |
| 43 | | C2 | 194 | | 194 | Vertical Image Size = 194 mm (Low 8 bits) |
| 44 | | 10 | 16 | | - | 4 bits of Hor Image Size + 4 bits of Ver Image Size |
| 45 | | 00 | 0 | | 0 | Hor Border (pixels) |
| 46 | | 00 | 0 | | 0 | Vertical Border (Lines) |
| 47 | | 1A | 26 | | - | Refer to right table |

| | | | | | | |
|---|---|---|---|---|---|---|
| 48 | Detailed timing/monitor descriptor #2 | FD | 253 | | 117.7 | 117.7344MHz Main clock |
| 49 | | 2D | 45 | | | |
| 4A | | 80 | 128 | | 1920 | Hor Active = 1920 |
| 4B | | 0E | 14 | | 270 | Hor Blanking = 270 |
| 4C | | 71 | 113 | | - | 4 bits of Hor. Active + 4 bits of Hor. Blanking |
| 4D | | 38 | 56 | | 1080 | Ver Active = 1080 |
| 4E | | 28 | 40 | | 40 | Ver Blanking = 40 |
| 4F | | 40 | 64 | | - | 4 bits of Ver. Active + 4 bits of Ver. Blanking |
| 50 | | 30 | 48 | | 48 | Hor Sync Offset = 48 |
| 51 | | 20 | 32 | | 32 | H Sync Pulse Width = 32 |
| 52 | | 36 | 54 | | 3 | V sync Offset = 3 line |
| 53 | | 00 | 0 | | 6 | V Sync Pulse width : 6 line |
| 54 | | 58 | 88 | | 344 | Horizontal Image Size = 344 mm (Low 8 bits) |
| 55 | | C2 | 194 | | 194 | Vertical Image Size = 194 mm (Low 8 bits) |
| 56 | | 10 | 16 | | - | 4 bits of Hor Image Size + 4 bits of Ver Image Size |
| 57 | | 00 | 0 | | 0 | Hor Border (pixels) |
| 58 | | 00 | 0 | | 0 | Vertical Border (Lines) |
| 59 | | 1A | 26 | | - | Refer to right above table |
| 5A | Detailed timing/monitor descriptor #3 | 00 | 0 | | | ASCII Data Sting Tag |
| 5B | | 00 | 0 | | | |
| 5C | | 00 | 0 | | | |
| 5D | | FE | 254 | | | |
| 5E | | 00 | 0 | | | |
| 5F | | 32 | 50 | | 2 | Dell P/N:2GMF6 |
| 60 | | 47 | 71 | | G | |
| 61 | | 4D | 77 | | M | |
| 62 | | 46 | 70 | | F | |
| 63 | | 36 | 54 | | 6 | |
| 64 | | 00 | 0 | | 00000000 | EDID Revison:X10 |
| 65 | | 4E | 78 | | N | BOE PN |
| 66 | | 56 | 86 | | V | |
| 67 | | 31 | 49 | | 1 | |
| 68 | | 35 | 53 | | 5 | |
| 69 | | 4E | 78 | | N | |
| 6A | | 34 | 52 | | 4 | |
| 6B | | 56 | 86 | | V | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6C | Detailed timing/monitor descriptor #4 | 00 | 0 | | | Flag |
| 6D | | 00 | 0 | | | |
| 6E | | 00 | 0 | | | |
| 6F | | 00 | 0 | | | Data Type Tag: Manufacturer Specified Data 00 |
| 70 | | 00 | 0 | | | Flag |
| 71 | | 00 | 0 | | - | 6-bit Color Depth & no FRC |
| 72 | | 41 | 65 | | - | WLED & singal light bar & one light bar |
| 73 | | 21 | 33 | | - | Frame rate 40Hz~65Hz |
| 74 | | 96 | 150 | | - | Light Controller:PWM & Max. Luminance220 |
| 75 | | 00 | 0 | | - | Front Surface:Anti-Glare & RGB v-stripe |
| 76 | | 10 | 16 | | - | with DBC |
| 77 | | 00 | 0 | | - | no Motion Blur & no Active Gamma |
| 78 | | 00 | 0 | | - | no Wireless Enhancement & no In-Cell Scanner |
| 79 | | 0A | 10 | | - | 2 Lane edp |
| 7A | | 01 | 1 | | - | Built-In Self Test |
| 7B | | 0A | 10 | | | Format：<br>terminate with ASCII code 0Ah<br>and pad field with ASCII code 20h |
| 7C | | 20 | 32 | | | |
| 7D | | 20 | 32 | | | |
| 7E | Extension flag | 00 | 0 | | 1 | 0：1個EDID；N-1：N个EDID |
| 7F | Checksum | **A3** | **163** | **163** | - | |

# 17.0 GENERAL PRECAUTIONS

## 17.1 HANDLING

(1) When the module is assembled, It should be attached to the system firmly using every mounting holes. Be careful not to twist or bend the modules.

(2) Refrain from strong mechanical shock or any force to the module. Otherwise, it may cause improper operation or damage to the module.

(3) Note that polarizers are very fragile and could be easily damaged. Do not press or scratch the surface harder than 1 HB pencil lead.

(4) Wipe off water droplets or oil immediately. If you leave the droplets for a long time, Staining and discoloration may occur.

(5) If the surface of the polarizer is dirty, clean it using some absorbent cotton or soft cloth.

(6) The desirable cleaners are water, IPA (Isopropyl Alcohol) or Hexane. Do not use Ketone type materials(ex. Acetone), Ethyl alcohol, Toluene, Ethyl acid or Methyl chloride. It might permanently damage to the polarizer due to chemical reaction.

(7) If the liquid crystal material leaks from the panel, it should be kept away from the eyes or mouth .In case of contact with hands, legs or clothes, it must be washed away thoroughly with soap.

(8) Protect the module from static , it may cause damage to the module.

(9) Use fingerstalls with soft gloves to keep display clean during the incoming inspection and assembly process.

(10) Do not disassemble the module.

(11) Do not pull or fold the LED FPC.

(l2) Do not touch any component which is located on the back side.

(13) Protection film for polarizer on the module shall be slowly peeled off just before use so that the electrostatic charge can be minimized.

(14) Pins of connector shall not be touched directly with bare hands.

## 17.2 STORAGE

(1) Do not leave the module in high temperature, and high humidity for a long time. It is highly recommended to store the module with temperature from 0 to 35℃ and relative humidity of less than 70%.

(2) Do not store the TFT-LCD module in direct sunlight.

(3) The module shall be stored in a dark place. It is prohibited to apply sunlight or fluorescent light during the store.

## 17.3 OPERATION

(1) Do not connect, disconnect the module in the " Power On" condition.

(2) Power supply should always be turned on/off by following item 8.0 " Power on/off sequence ".

(3) 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 minimize the interference.

(4) The standard limited warranty is only applicable when the module is used for general notebook applications. If used for purposes other than as specified, BOE is not to be held reliable for the defective operations. It is strongly recommended to contact BOE to find out fitness for a particular purpose.

## 17.4 OTHERS

(1) Avoid condensation of water. It may result in improper operation or disconnection of electrode.

(2) Do not exceed the absolute maximum rating value. ( the supply voltage variation, input voltage variation, Variation in part contents and environmental temperature, so on) Otherwise the module may be damaged.

(3) If the module displays the same pattern continuously for a long period of time, it can be the situation when The " image sticks" to the screen.

(4) This module has its circuitry PCB's on the rear or bottom side and should be handled carefully to avoid being stressed.

Appendix A

Caliper:

Thickness of Outline (Without/With PCB)

Coordinate Measuring Machine:

a. Length of Outline (Without Tape Wrinkle or Bulged)
b. Width of Outline (Without PCB) (Without Tape Wrinkle or Bulged)
c. Width of Outline (With PCB)
d. CF Polarizer Size
e. Active Area (Or AA_BM) Size
f. Active Area to Outline (Without Tape Wrinkle or Bulged)
g. Active Area to CF Polarizer
h. The Distance of Bracket Holes
i. P-Cover to Outline (Without Tape Wrinkle or Bulged)
j. Length of P-Cover
k. Connector Pin 1 to Outline (Without Tape Wrinkle or Bulged)

Height Gauge: The Different Height of Root and Top on the Bracket

(Need to Calculate From Bracket Angle Spec.)

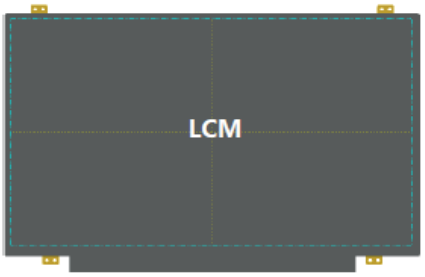
Feeler Gauge: The Warpage Spec. of Module

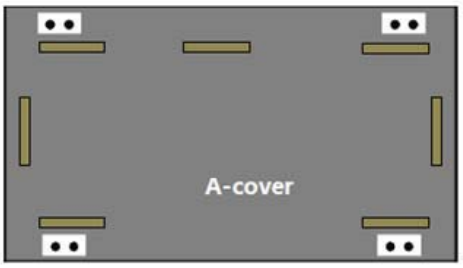
Notes:

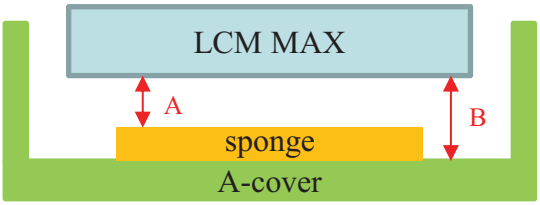
Except the Critical Dimensions as Above, Other Dimensions are Measured by Coordinate Measuring Machine If Necessary.

Appendix B

## LCM to A-Cover / sponges z-gap



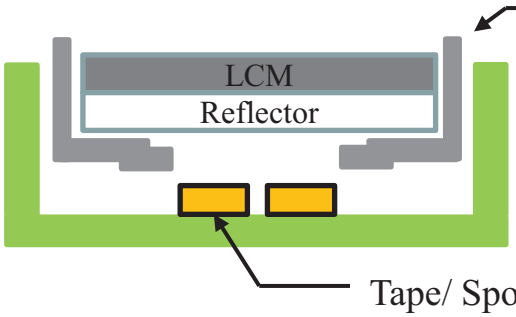

| | Plastic Cover (LCM Thickness: Max) | Metal Cover (LCM Thickness: Max) |
|---|---|---|
| A | >0mm | >0mm |
| B | Min: 1.0mm | Min: 0.8mm |
| Without the open area of back cover | | |

| | |
|---|---|
| Purpose | The reflector area is very sensitive, we suggest that design enough z-gap to decrease the risk of water ripple, white spot and other abnormal display |

Appendix B

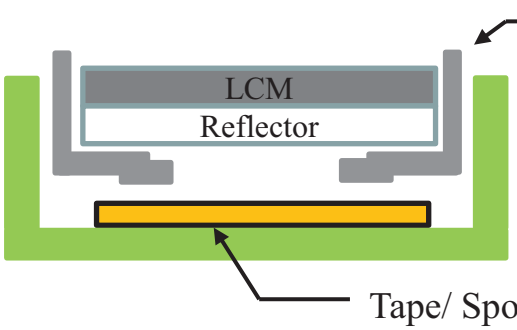
## LCM to A-Cover / sponges z-gap

a




NG

b

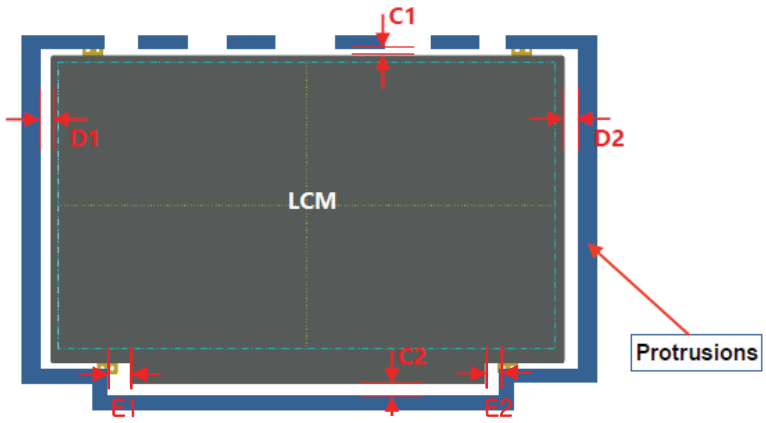



OK

| | |
|---|---|
| Purpose | If attach sponges or rubbers which correspond to white reflector area, it may cause white spot, pooling or other relate issues. We suggest that attach wide range sponges / rubbers which can cover the LCM back-bezel opening |

Appendix B

## LCM to side wall / protrusions




| | Normal border | Narrow border |
|---|---|---|
| D1/D2 | Min: 0.45mm | Min: 0.35mm |
| C1 | Min: 0.50mm | |
| C2 | Min: 0.50mm | |
| E1/E2 | Min: 0.55mm | |

| | |
|---|---|
| Purpose | We suggest that design enough gap around LCM to prevent shock test failure, or interference, cell crack, abnormal display...etc. in the reliability test |

Appendix B

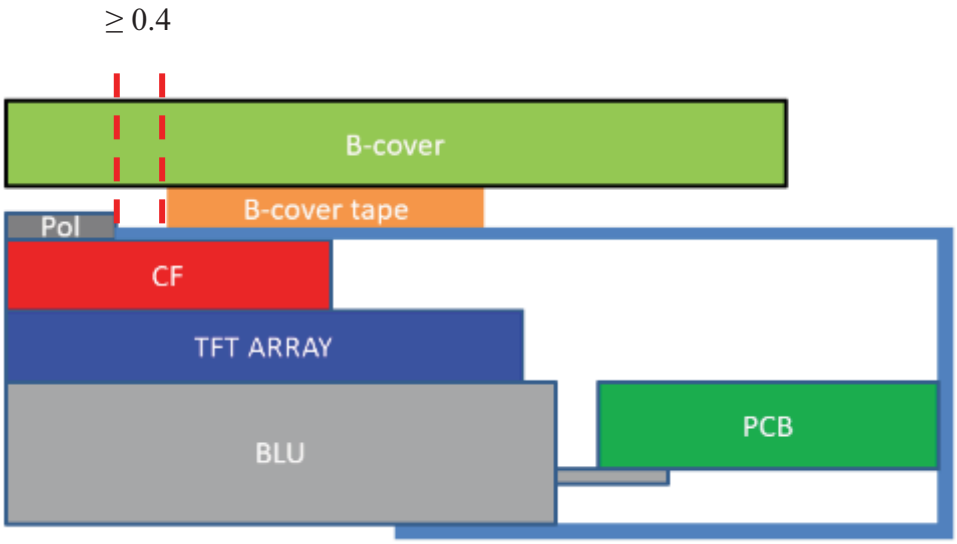
## LCM to B-cover z-gap


| B-cover Tape | Gap |
|---|---|
| Without | 0.15 ~ 0.25mm |
| With | 0.15 ~ 0.20mm |

| | |
|---|---|
| Purpose | Too less z-gap between system B-cover and LCM top pol has high risk to cause cell crack, pooling, light leakage and other issues |

Appendix B

## B-cover tape to top pol edge

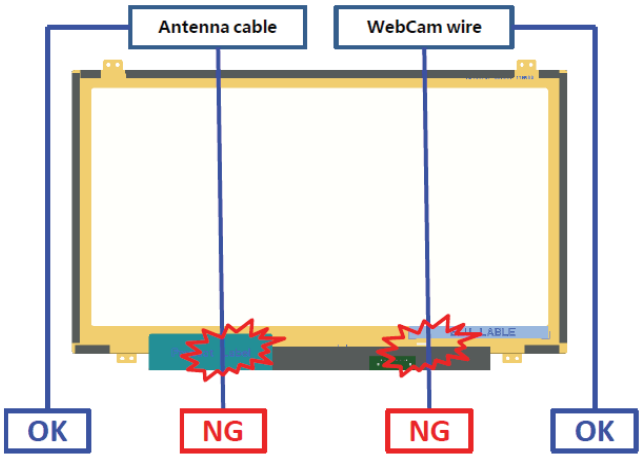


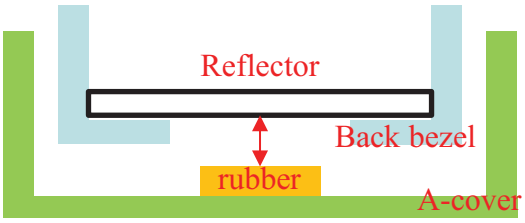

If attach b-cover and LCM with tapes,
Please let tapes to be located out of top pol edges 0.4mm away on 4 sides

| | |
|---|---|
| Purpose | To avoid the B-cover tape override top pol and cause pooling or light leakage issue |

Appendix B

## Antenna Cable & Webcam wire



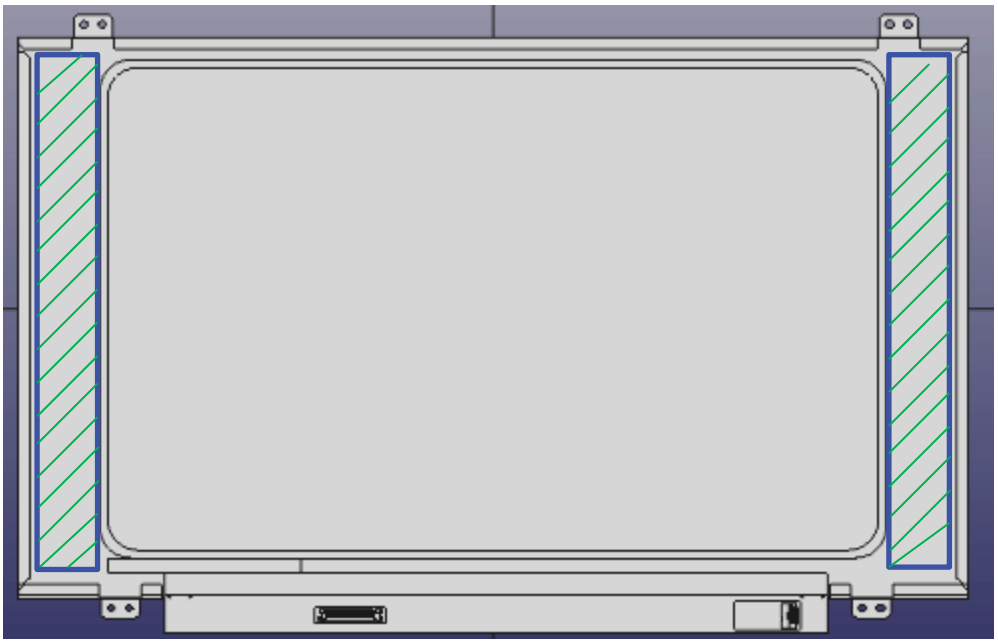




If sponge within the reflector area is necessary, we suggest that the gap between reflector and sponge is more than 0.5mm

| | |
|---|---|
| Purpose | 1. We suggest that do not set Antenna or WebCam cable / wire go behind LCM to avoid backpack test, hinge test ,twist test or pogo test with abnormal display<br>2. If the cable / wire is necessary to go behind LCM, please make a groove with rounds or chamfers to protect the cable / wire, or attach with higher sponge / rubbers adjacent to the cable / wire route<br>3. Suggest that attach the cable / wire with tapes to A-cover<br>4. Do not attach anything with LCM reflector area. If attach cable / wire with LCM reflector area, it may cause pooling, white spot, light leakage and other related issues |

Appendix B

## LCM paste area

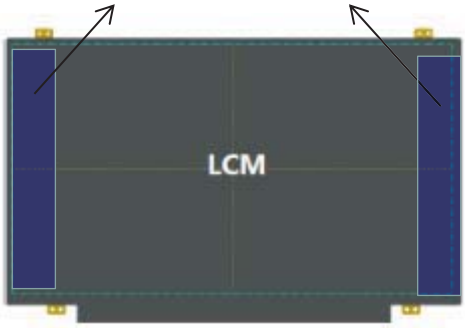


Attachment area

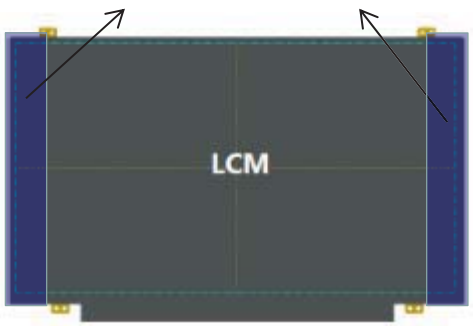
| | |
|---|---|
| Purpose | If use the stretch remove tapes to fix LCM with A-cover, please set the stretch remove tapes correspond to the LCM back-bezel and do not let the tapes override the back-bezel's level step of opening |

Appendix B

## LCM pressable area




NG

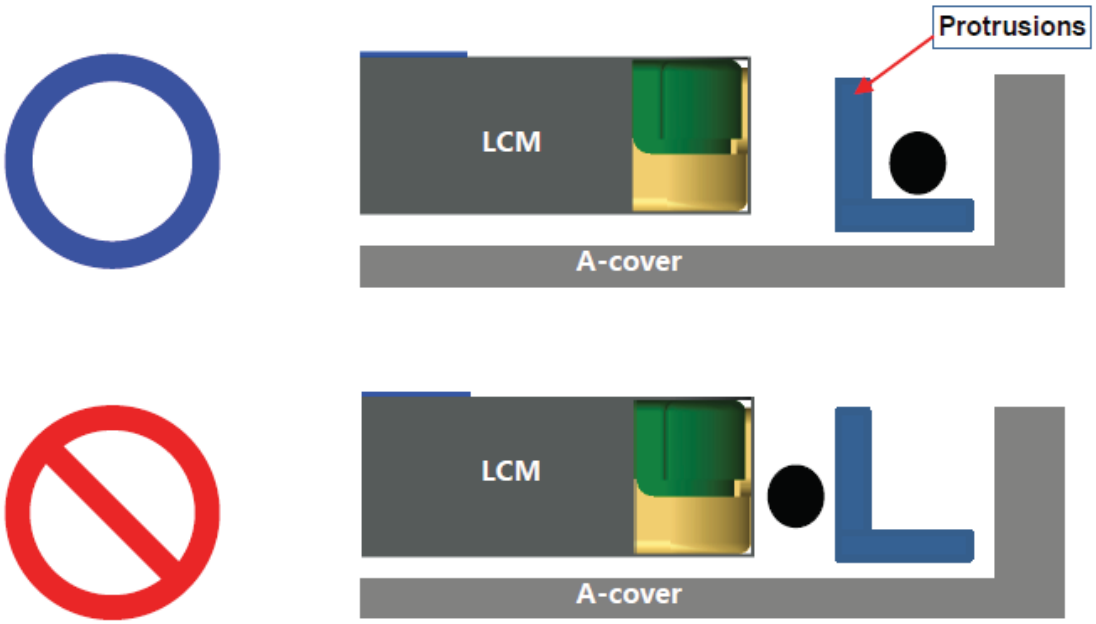



OK

| | |
|---|---|
| Purpose | 1. LCM is fixed on A-cover by double-sided tap which can stick LCM after using the press jig stress LCM during assembling.<br>2. To avoid panel broken the design of pressure head of press jig can not only pin on cell panel. The pressure head needs to pin on the LCM frame, which the LCM frame can share the pressure of the pressing head. |

Appendix B

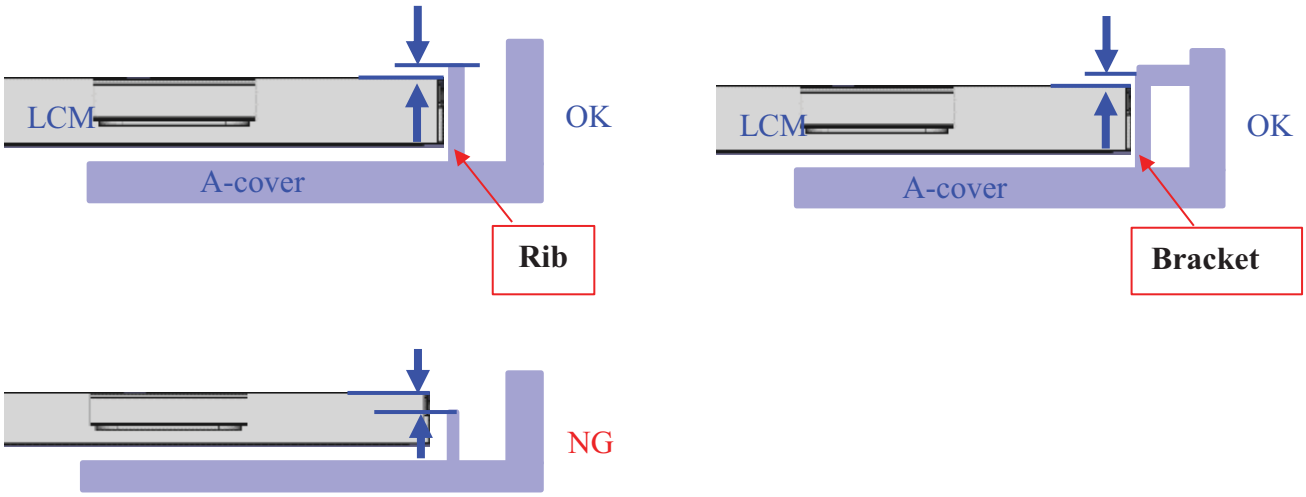
## Wire setting




| | |
|---|---|
| Purpose | Wire should be placed between Protrusions and A-cover. If place the wire between LCM and Protrusions, it may interfere with LCM when assembling B-covers, or even cause LCM breakage in reliability test. |

Appendix B

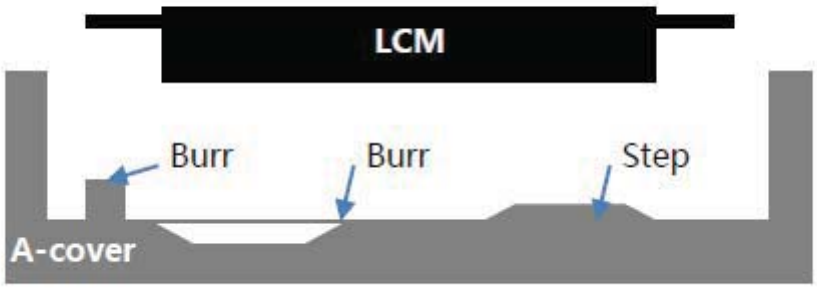
## A-cover strength




| Purpose | 1. It is recommended that Rib height is higher than LCM, in order to avoiding press on LCM edge panels.<br>2. As for LCM is more stronger than Rib, the L Bracket is be recommended. |
|---|---|

Appendix B

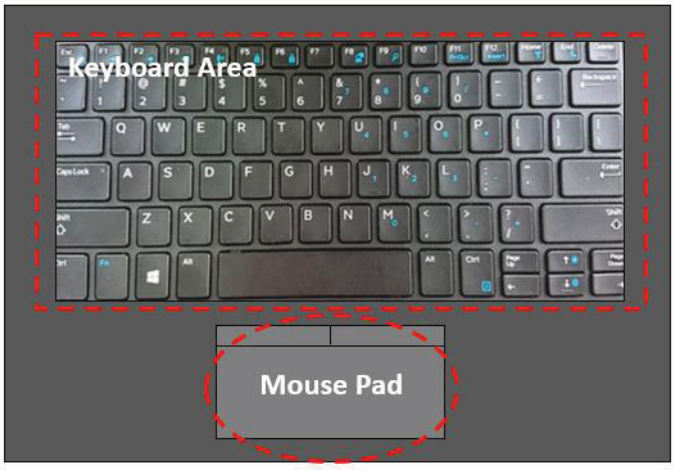
## System A-cover Inner Surface

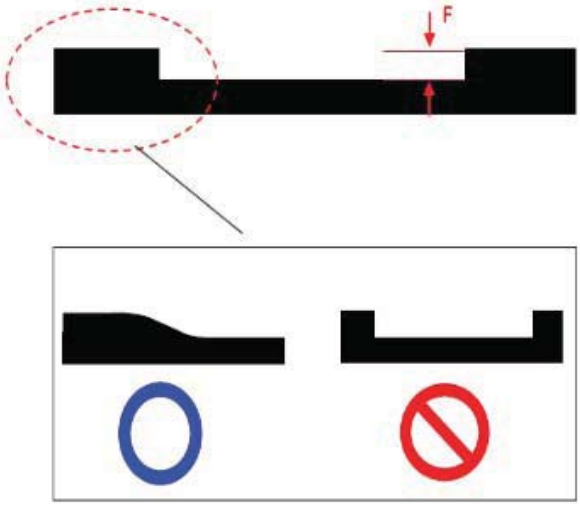



| | |
|---|---|
| Purpose | There should not exist any burr, segment gap or protrusions beside Logo, which would cause White Spot or Glass Broken by stress concentration. |

Appendix B

## Keyboard area & Mouse pad



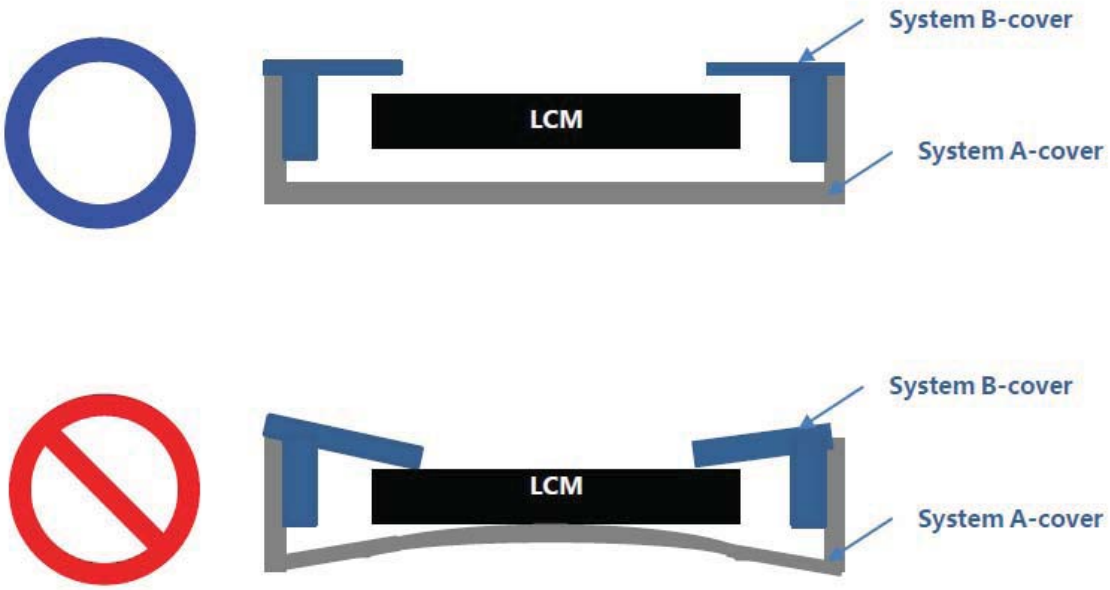




- F: max 0.3mm

| | |
|---|---|
| Purpose | In order to avoiding LCM fragments in reliability test, the step surface of Keyboard and Mouse pad transmits smoothly, and should not be right-angle. For example, when Pogo testing, if the broken hole is done in this location, it is easy to produce fragments. |

Appendix B

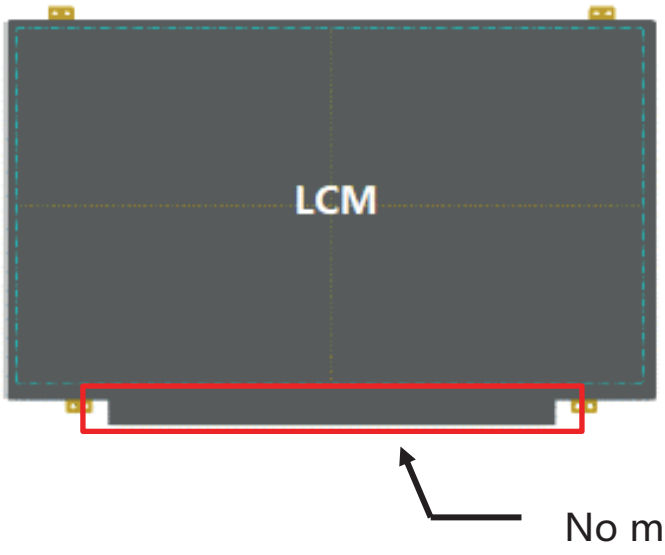
## System cover reliability




| | |
|---|---|
| Purpose | The permanent deformation part of System cover after the reliability test, including sponge and other structures or components, can not touch LCM. |

Appendix B

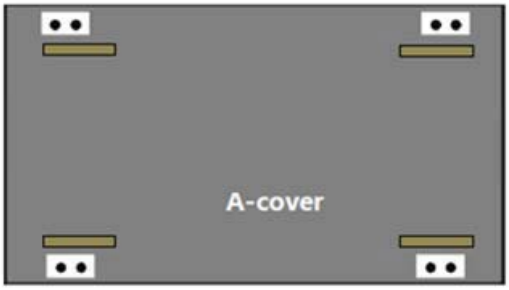
## A/B-cover near LCD PCBA

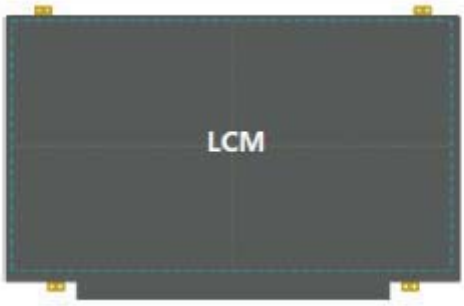



| | |
|---|---|
| Purpose | There should not have magnet object near LCM PCBA, which is prone to cause physical or electricity noise issue |

Appendix B

## A-cover add sponges on Boss side wall

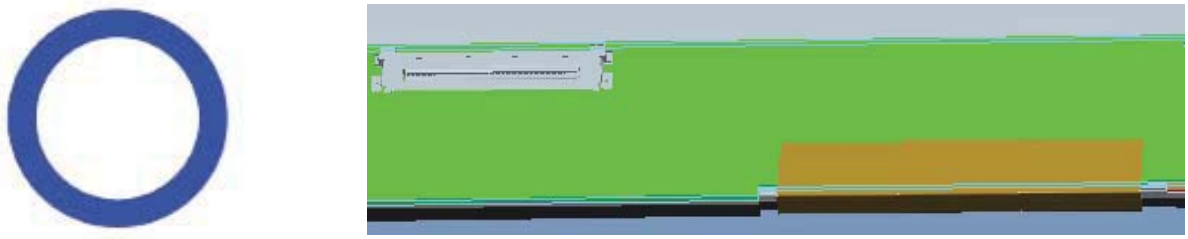


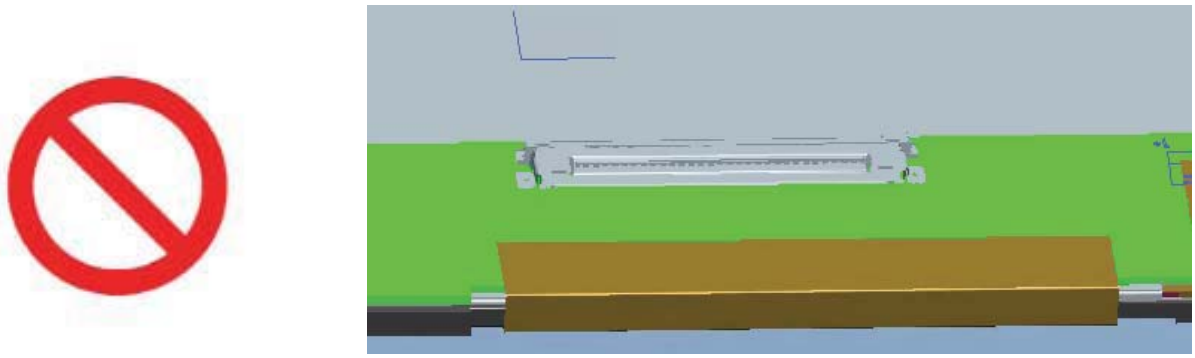




| | |
|---|---|
| Purpose | We suggest to attach Sponges to the side of the Boss column of A-cover to reduce the panel broken possibility in assembly. It is recommended to this design synchronously. |

Appendix B

## LCM to A-Cover / sponges z-gap

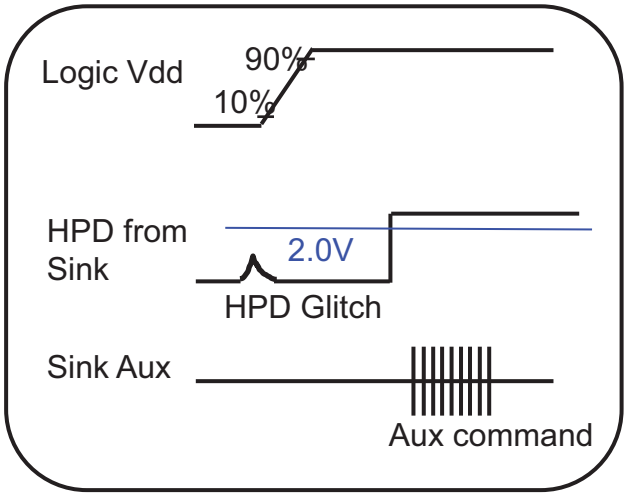




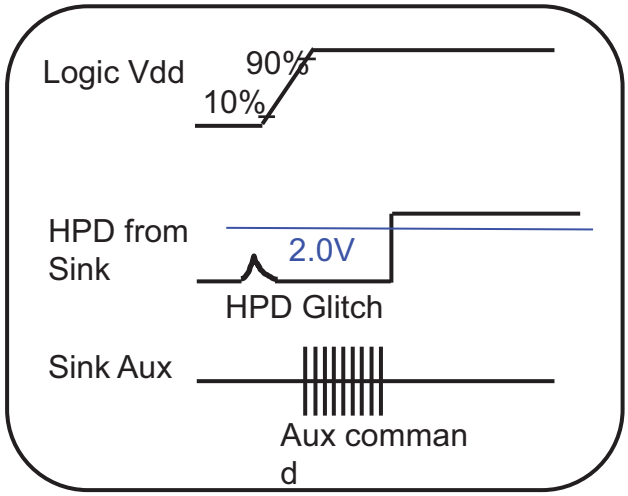
| | |
|---|---|
| Purpose | Bent product: The position of system connector and FPC should be staggered in X direction. Otherwise, when testing, the system Cable line extrudes FPC, leading to FPC Crack; (Panel FPC Bonding location is related to Mask and can not be changed easily) |

Appendix C

## HPD Signal recognition




Normal Signal (Ignore HPD Glitch)

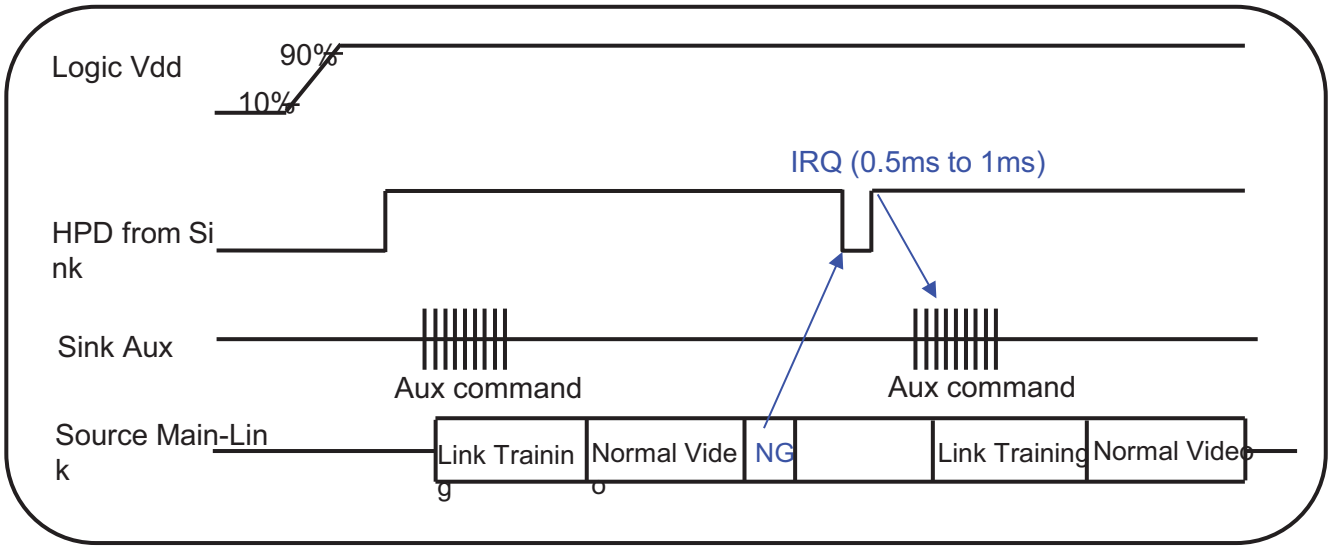



Abnormal Signal

| Purpose | When HPD glitch of source device minimum is 2.0(V). |
|---|---|

Appendix C

## HPD Signal Definition IRQ (Interrupt Request)




| | |
|---|---|
| Purpose | When HPD signal low than 0.5ms to 1ms, the source device should check sink status field from the DPCD and take link training again. |

Appendix C

## Main link eye diagram of TP3

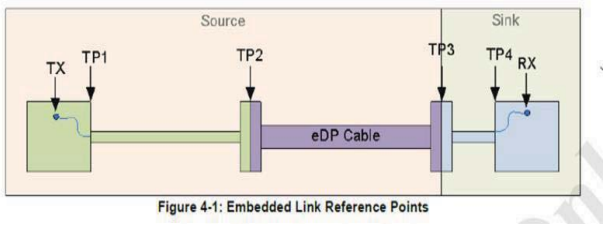
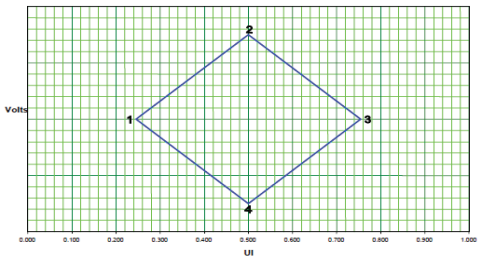


Figure 4-1: Embedded Link Reference Points

Measured TP3 on LCM connector.




Downstream Device Mask at TP3

| | UI | Voltage |
|---|---|---|
| 1 | 0.246 | 0 |
| 2 | 0.5 | 0.075 |
| 3 | 0.755 | 0 |
| 4 | 0.5 | -0.075 |

Eye for TP3 at HBR

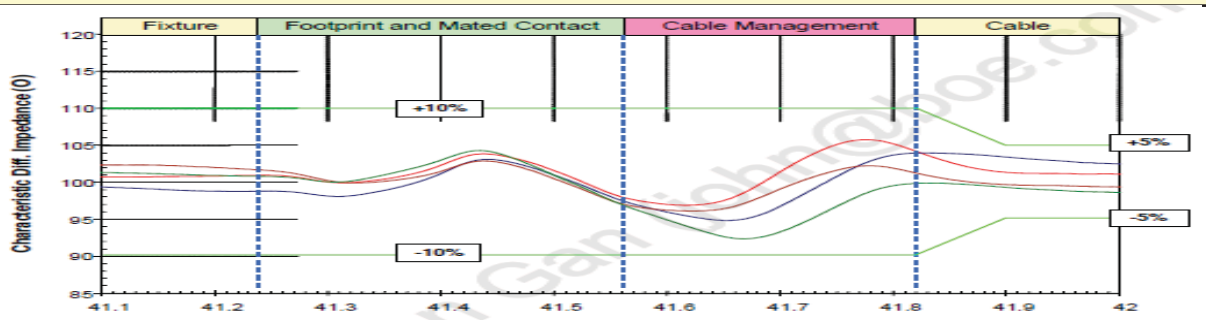
| | UI | Voltage |
|---|---|---|
| 1 | 0.375 | 0 |
| 2 | 0.5 | 0.023 |
| 3 | 0.625 | 0 |
| 4 | 0.5 | -0.023 |

Eye for TP3 at RBR

| Purpose | 1. Main Link EYE Diagram should meet TP3 point of VESA.<br>2. The measure method is through access fixture. |
|---|---|

Appendix C

## Impedance Profile through a DP Connector




Differential Impedance Profile Measurement Data Example

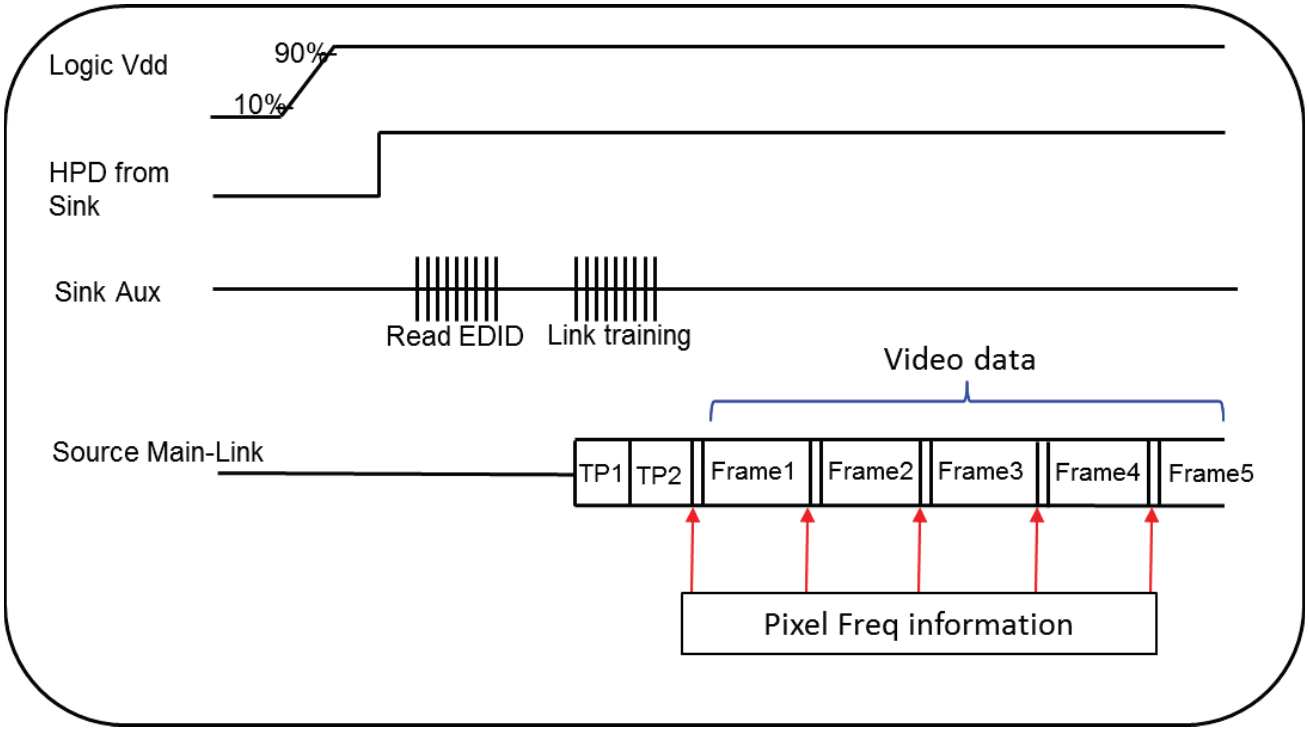
| Segment | Differential Impedance Value | Maximum Tolerance |
|---|---|---|
| Fixture | 100Ω/85Ω VESA | ±10% |
| Connector | 100Ω/85Ω VESA | ±10% |
| Wire management | 100Ω/85Ω VESA | ±10% |
| Cable | 100Ω/85Ω VESA | ±5% |

Impedance Profile Values for Cable Assembly

| | |
|---|---|
| Purpose | Cable Impedance Profile 100ohm for Cable Assembly |

Appendix C

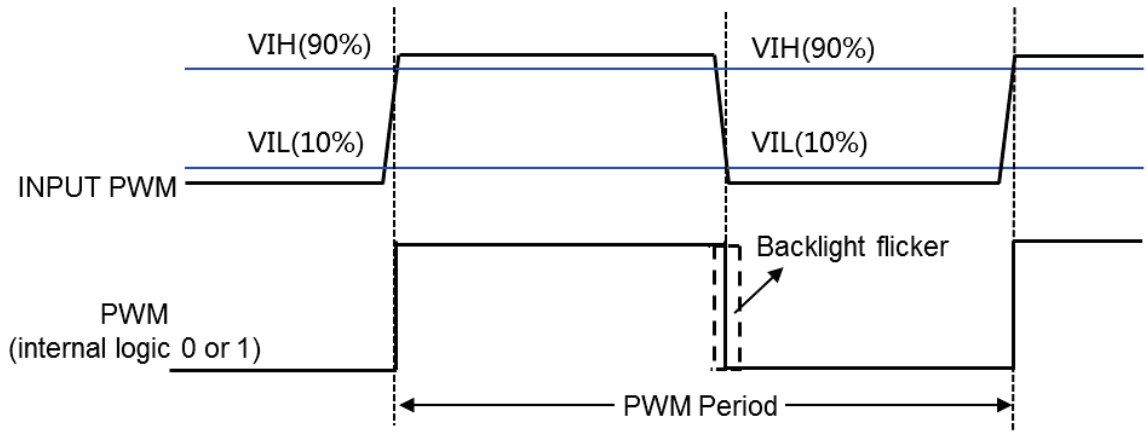
## Main Link Pixel Freq information value of MSA data




| | |
|---|---|
| Purpose | 1. It need to fix pixel freq information value of MSA data output to prevent the initial abnormal pixel freq information value from incoming after power on.<br>2. BOE can read DPCD to check this value. Ex: BIOS is 1.62G , but into windows is 2.7G. |

Appendix C

## Main Link Pixel Freq information value of MSA data




Example:

| Freq | Cycle Time | PWM Rising Time | PWM Falling Time |
|---|---|---|---|
| 200Hz | 5ms | ≤1us | ≤1us |
| 1KHz | 1ms | ≤200ns | ≤200ns |

| | |
|---|---|
| Purpose | 1. LED driver need to calculate the duty cycle of input PWM signal.<br>2. To avoid backlight flicker visible on LCD, system input PWM suggest :<br>PWM rising ≤ 200ppm*cycle time ; PWM falling ≤ 200ppm*cycle time. |