

Specification

Module No. : GEA-156E01-DC9521-G020
Client Name : _____
Client Ref. : _____
Version No. : A1

| Client Confirmation | Approved by | Prepared by |
|---------------------|-------------|-------------|
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Issue History

| Version | History | Date | Remarks |
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1. Purpose

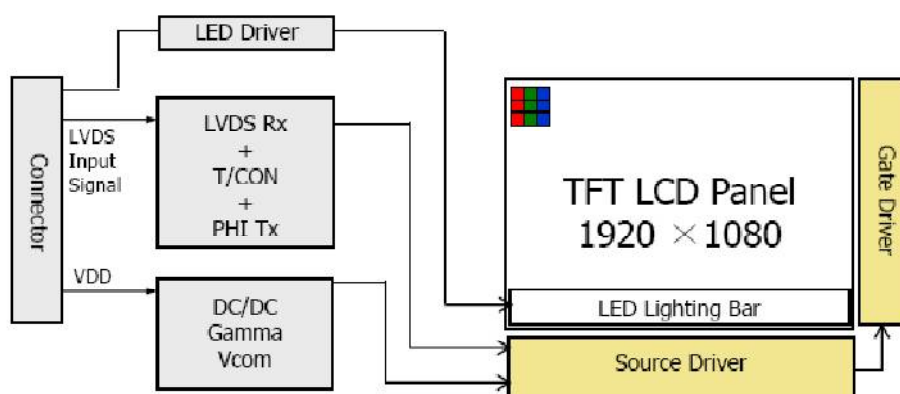
This specification document is issued for the 15.6" TFT Liquid Crystal Display bonded with Capacitive-Type Touch Panel delivered by General Electrical Touch Co., Limited. This document defined the general provisions (including structure, performance, characteristics and quality guarantee) for the specific module listed at the front page of this document. In the event of conflict between this document and other documents, this document including the attachments and drawing, is highest-level specification for this products.

2. Feature

2.1 Overview

The touch part is a 15.6 inch DITO glass Capacitive-Type Touch Panel. It uses a SIS9521 touch controller and with USB & I²C communication.

The display part BOE EV156FHM-N11 which 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 FHD 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 16.7M colors.



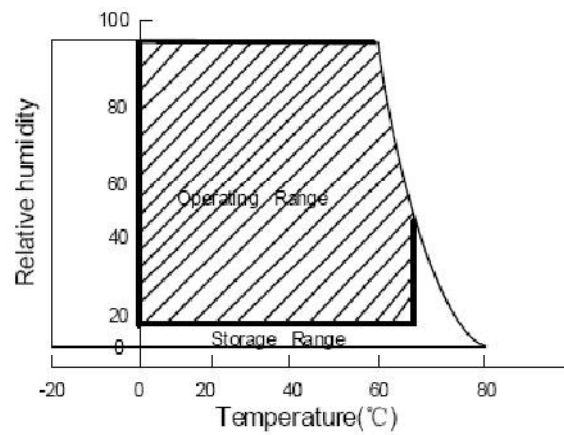
2.2 Absolute Maximum Ratings

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

| Parameter | Symbol | Min. | Max. | Unit | Remarks |
|-----------------------|----------|--------------|--------------|------|---------|
| Power Supply Voltage | V_{DD} | -0.3 | 4.0 | V | Note 1 |
| Logic Supply Voltage | V_{IN} | $V_{SS}-0.3$ | $V_{DD}+0.3$ | V | |
| Operating Temperature | T_{OP} | 0 | +70 | °C | Note 2 |
| Storage Temperature | T_{ST} | -20 | +80 | °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. ($T_a \leq 40^\circ\text{C}$) Maximum wet-bulb temperature at 39°C or less.
($T_a > 40^\circ\text{C}$) No condensation.



2.3 Module Structure

| Main Component | Materials | Remarks |
|------------------|---------------------------------|---------------------|
| Cover Glass | 2mm chemical strengthened glass | black printed board |
| Adhesive | SCA | Thickness: 0.25 mm |
| Touch Sensor | DITO glass | 0.70mm, 60~90Ω/□ |
| Air Bonding Tape | 3M 4905 | Thickness: 0.5 mm |
| Display | TFT LCD | BOE EV156FHM-N11 |

2.4 Physical Specifications

| Item | Specifications | Remark |
|----------------------|---|--------|
| TFT Active Area | 344.16(H)*193.59(V) mm | |
| Touch Visible Area | 346.20(H)*195.50(V) mm | |
| Number Of Pixels | 1920(H)×1080(V) | |
| Pixel Pitch | 0.05975(H)×0.17925(V) mm | |
| Pixel Arrangement | Pixels RGB stripe arrangement | |
| Display Colors | 16.7M(6bits+Hi FRC) | |
| Display Mode | Normally Black | |
| Surface Treatment | AG25 | |
| Contrast Ratio | 1200:1(Typ) | |
| Viewing Angle(CR>10) | 89/89/89/89(Typ) deg. | |
| Response Time | 25(Typ) ms | |
| Color Gamut | 72%(Min)/78%(Typ) | NTSC |
| Brightness | 425(Min)/500(Typ) cd/m ² | |
| Power Consumption | LCD: 2.8W(Typ) BLU: 8.7W(Max) | |
| Touch Activation | Multi-finger touch | |
| Touch Resolution | 36X, 63Y | |
| Touch Controller | SIS9521 | |
| Bonding Method | CG to touch sensor: optical bonding TP module to display: tape bonding | |
| Outline Dimension | 392.2(H)*241.5(V)*13.1(Typ) mm | |
| Weight | 1.4 KG | |

3. Electrical Specifications

3.1 Display Electrical Specifications

3.1.1 TFT LCD Module

<LCD Module Electrical Specifications>

[Ta=25±2℃]

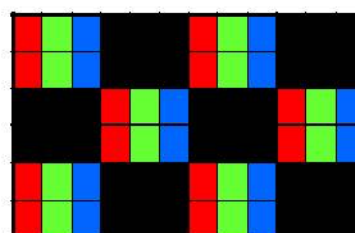
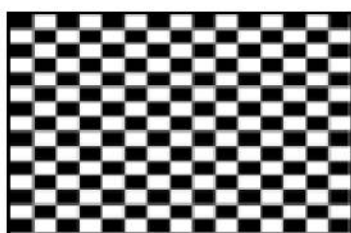
| Parameter | | Min. | Typ. | Max. | Unit | Remarks |
|--|-------------|------|------|------|------|----------------------|
| Power Supply Voltage | V_{DD} | 3.0 | 3.3 | 3.6 | V | Note 1 |
| Permissible Input Ripple Voltage | V_{RF} | - | - | 100 | mV | At $V_{DD} = 3.3V$ |
| Power Supply Current | I_{DD} | - | 900 | - | mA | Note 1 |
| Positive-going Input Threshold Voltage | V_{IT+} | - | - | 100 | mV | $V_{cm} = 1.2V$ typ. |
| Negative-going Input Threshold Voltage | V_{IT-} | -100 | - | - | mV | |
| Differential Input Voltage | V_{ID} | 200 | - | 600 | mV | |
| Power Consumption | P_D | - | - | 4.5 | W | Note 1 |
| | P_{BL} | - | - | 8.8 | W | Note 2 |
| | P_{total} | - | - | 13.3 | W | |

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℃.

a) Typ: Mosaic Pattern

b) Max: R/G/B Pattern



2. Calculated value for reference ($V_{LED} \times I_{LED}$).

3.1.2 Back-Light Unit

<LED Driver Electrical Specifications>

[Ta=25±2℃]

| Parameter | | Min. | Typ. | Max. | Unit | Remarks |
|-------------------------------------|----------------|-----------|------|------|--------|--------------|
| LED Forward Voltage | V_F | - | 3.0 | 3.3 | V | - |
| LED Forward Current | I_F | - | 60 | | mA | - |
| LED Power Consumption | P_{LED} | | 7.8 | 8.8 | W | Note 1 |
| LED Life-Time | N/A | 50,000 | - | - | Hour | $I_F = 60mA$ |
| Power supply voltage for LED Driver | | V_{LED} | 10.8 | 12 | 13.2 | V |
| EN Control Level | Backlight on | | 2.5 | | 5.0 | V |
| | Backlight off | | 0 | | 0.8 | V |
| PWM Control Level | PWM High Level | | 2.5 | | 5.0 | V |
| | PWM Low Level | | 0 | | 0.8 | V |
| PWM Control Frequency | | F_{PWM} | 180 | - | 10,000 | Hz |
| Duty Ratio | | - | 10 | - | 100 | % |

Notes: 1. $P_{LED} = V_{LED} \times I_{LED}$ (Without LED converter transfer efficiency).

2. The life time of LED, 50,000Hrs, is determined as the time at which luminance of the LED is 50% compared to that of initial value at the typical LED current on condition of continuous operating at 25±2℃.

3.1.3 Electrical Interface Connection

The electronics interface connector is I-PEX 20455-040E-66 or Compatible. The connector interface pin assignments are listed in below table.

| Pin No. | Symbol | Description |
|---------|----------|--|
| 1 | BL POWER | +12V Vi power supply |
| 2 | BL POWER | +12V Vi power supply |
| 3 | BL POWER | +12V Vi power supply |
| 4 | BL POWER | +12V Vi power supply |
| 5 | GND | Ground |
| 6 | GND | Ground |
| 7 | GND | Ground |
| 8 | GND | Ground |
| 9 | LED_EN | Enable pin |
| 10 | LED_PWM | Backlight Adjust |
| 11 | LCD_VCC | LCD Power 3.3V |
| 12 | LCD_VCC | LCD Power 3.3V |
| 13 | LCD_VCC | LCD Power 3.3V |
| 14 | NC | Not Connection , this pin should be open |
| 15 | NC | Not Connection , this pin should be open |
| 16 | NC | Not Connection , this pin should be open |
| 17 | LCD_GND | LCD Ground |
| 18 | RXO_0- | Negative LVDS differential data input Channel O0(Odd) |
| 19 | RXO_0+ | Positive LVDS differential data input Channel O0(Odd) |
| 20 | RXO_1- | Negative LVDS differential data input Channel O1(Odd) |
| 21 | RXO_1+ | Positive LVDS differential data input Channel O1(Odd) |
| 22 | RXO_2- | Negative LVDS differential data input Channel O2(Odd) |
| 23 | RXO_2+ | Positive LVDS differential data input Channel O2(Odd) |
| 24 | LCD_GND | LCD Ground |
| 25 | RXO_C- | Negative LVDS differential clock input(Odd) |
| 26 | RXO_C+ | Positive LVDS differential clock input (Odd) |
| 27 | LCD_GND | LCD Ground |
| 28 | RXO_3- | Negative LVDS differential data input Channel O3(Odd) |
| 29 | RXO_3+ | Positive LVDS differential data input Channel O3(Odd) |
| 30 | RXE_0- | Negative LVDS differential data input Channel E0(Even) |
| 31 | RXE_0+ | Positive LVDS differential data input Channel E0(Even) |
| 32 | RXE_1- | Negative LVDS differential data input Channel E1(Even) |
| 33 | RXE_1+ | Positive LVDS differential data input Channel E1(Even) |
| 34 | LCD_GND | LCD Ground |
| 35 | RXE_2- | Negative LVDS differential data input Channel E2(Even) |
| 36 | RXE_2+ | Positive LVDS differential data input Channel E2(Even) |
| 37 | RXE_C- | Negative LVDS differential clock input(Even) |
| 38 | RXE_C+ | Positive LVDS differential clock input (Even) |
| 39 | RXE_3- | Negative LVDS differential data input Channel E3(Even) |
| 40 | RXE_3+ | Positive LVDS differential data input Channel E3(Even) |

3.1.4 LVDS Interface

| | Input Signal | Transmitter | | Interface | | HR230WU-400 (CN11) | Remark |
|------------------|--------------|-------------|----------|----------------------|----------------------|--------------------|--------|
| | | Pin No. | Pin No. | System (Tx) | TFT-LCD (Rx) | Pin No. | |
| L V D S | OR0 | 51 | 48 47 | OUT0- OUT0+ | RXO0- RXO0+ | 1 2 | |
| | OR1 | 52 | | | | | |
| | OR2 | 54 | | | | | |
| | OR3 | 55 | | | | | |
| | OR4 | 56 | | | | | |
| | OR5 | 3 | | | | | |
| | OG0 | 4 | 46 45 | OUT1- OUT1+ | RXO1- RXO1+ | 3 4 | |
| | OG1 | 6 | | | | | |
| | OG2 | 7 | | | | | |
| | OG3 | 11 | | | | | |
| | OG4 | 12 | | | | | |
| | OG5 | 14 | | | | | |
| | OB0 | 15 | 42 41 | OUT2- OUT2+ | RXO2- RXO2+ | 5 6 | |
| | OB1 | 19 | | | | | |
| | OB2 | 20 | | | | | |
| | OB3 | 22 | | | | | |
| | OB4 | 23 | | | | | |
| | OB5 | 24 | | | | | |
| | Hsync | 27 | 40 39 | CLK OUT- CLK OUT+ | RXO CLK- RXO CLK+ | 8 9 | |
| | Vsync | 28 | | | | | |
| | DE | 30 | | | | | |
| | MCLK | 31 | | | | | |
| | OR6 | 50 | 38 37 | OUT3- OUT3+ | RXO3- RXO3+ | 10 11 | |
| | OR7 | 2 | | | | | |
| | OG6 | 8 | | | | | |
| | OG7 | 10 | | | | | |
| | OB6 | 16 | | | | | |
| | OB7 | 18 | | | | | |
| | RSVD | 25 | | | | | |

3.1.5 Signal Timing Specification

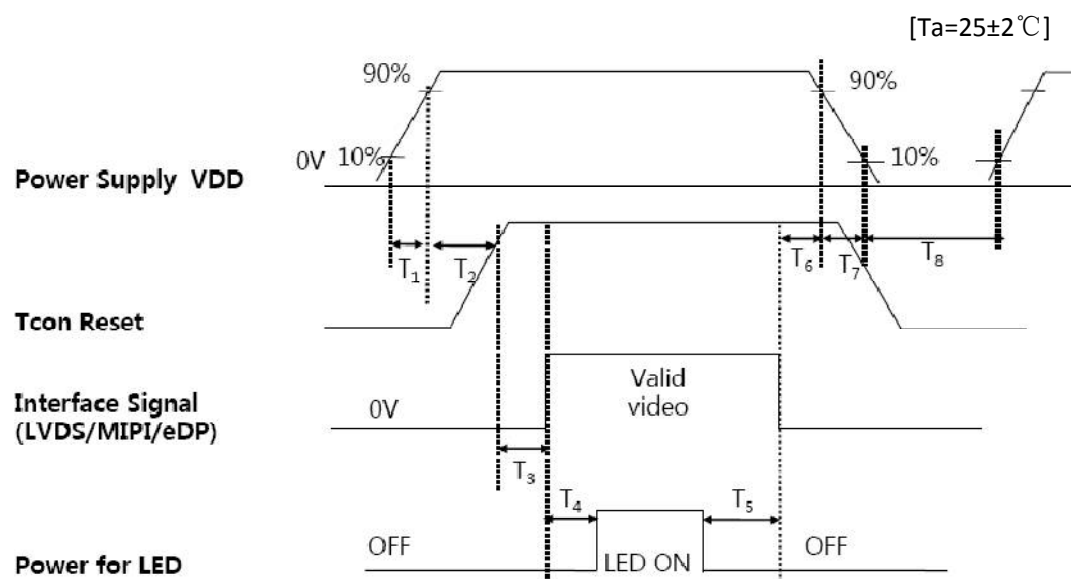
The EV156FHM-N11 is operated by the DE only.

| Item | | Symbols | Min | Typ | Max | Unit |
|---------------------------|-----------|---------|------|-------|-------|--------|
| Clock | Frequency | 1/Tc | 100 | 147.8 | 160 | MHz |
| | High Time | Tch | - | 4/7Tc | - | Tc |
| | Low Time | Tcl | - | 4/7Tc | - | Tc |
| Frame Period | | Tv | 1112 | 1125 | 1238 | lines |
| | | | 40 | 60 | 66 | Hz |
| | | | 25 | 16.67 | 15.15 | ms |
| Vertical Display Period | | Tvd | - | 1080 | - | lines |
| One line Scanning Period | | Th | 2080 | 2200 | 2400 | clocks |
| Horizontal Display Period | | Thd | - | 1920 | - | clocks |

3.1.6 Input Signals, Basic Display & 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 |
| | Blue | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | Green | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Light Blue | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Red | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Purple | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| | Yellow | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | White | 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 |
| | △ | 1 | 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 |
| | △ | ↑ | | | | | ↑ | | | | | ↑ | | | | |
| | ▽ | ↓ | | | | | ↓ | | | | | ↓ | | | | |
| | Brighter | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | ▽ | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Red | 1 | 1 | 1 | 1 | 1 | 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 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Darker | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | △ | ↑ | | | | | ↑ | | | | | ↑ | | | | |
| | ▽ | ↓ | | | | | ↓ | | | | | ↓ | | | | |
| | Brighter | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | ▽ | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| | Green | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 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 | 1 | 0 | 0 | 0 | 0 |
| | Darker | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | △ | ↑ | | | | | ↑ | | | | | ↑ | | | | |
| | ▽ | ↓ | | | | | ↓ | | | | | ↓ | | | | |
| | Brighter | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| | ▽ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | Blue | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 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 |
| | △ | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | Darker | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| | △ | ↑ | | | | | ↑ | | | | | ↑ | | | | |
| | ▽ | ↓ | | | | | ↓ | | | | | ↓ | | | | |
| | Brighter | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| | ▽ | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| | White | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

3.1.7 Power Sequence



<Sequence Table>

| Parameter | Value | | | Units |
|-----------|-------|------|------|-------|
| | Min. | Typ. | Max. | |
| T1 | 0.1 | - | 5 | (ms) |
| T2 | 10 | - | 30 | (ms) |
| T3 | 5 | - | 100 | (ms) |
| T4 | 200 | - | - | (ms) |
| T5 | 200 | - | - | (ms) |
| T6 | 0 | - | 50 | (ms) |
| T7 | 0 | - | 10 | (ms) |
| T8 | 500 | - | - | (ms) |

3.2 Touch Panel Electrical Specifications

3.2.1 Interface Connection

| Item | Specification | Remarks |
|---------------|--------------------------|---------------|
| FPC type | COF | |
| Connector | USB-MINI-B | |
| | Molex 53261-1071 | or compatible |
| Communication | USB and I ² C | |

3.2.2 Connector Pins Definition

<Molex 53261-1071 Pins Definition>

| Pin | Definition | Description |
|-----|---------------|---------------------------------------|
| 1 | Vcc | 5V |
| 2 | USB Data+ | |
| 3 | USB Data- | |
| 4 | SDA | I ² C serial data |
| 5 | SCL | I ² C serial clock |
| 6 | INT | Interrupt pin sending request to HOST |
| 7 | Reset | Low active power on reset signal |
| 8 | GPIO0 | |
| 9 | GND | |
| 10 | GND-Shielding | |

3.2.3 I²C Interface

| | |
|------------------------|---------------------------------------|
| Slaver address | 0x5c(7-bits addressing, programmable) |
| Clock rate | @400 kHz(fast mode) |
| Interrupt mode | Default active low, level trigger |
| _CID | PNP0C50 |
| _DSM | 3CDF6F7-4267-4555-AD05-B30A3D8938DE |
| HID Descriptor address | 0x0000 |

4. Optical Specifications

4.1 Display Optical Specifications

4.1.1 Overview

The test of Optical specifications shall be measured in a dark room (ambient luminance ≤ 1 lux and temperature $= 25 \pm 2^\circ\text{C}$) with the equipment of Luminance meter system (Goniometer system and TOPCONE BM-5) 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 $\theta\phi=0$ ($=\theta_3$) as the 3 o'clock direction (the "right"), $\theta\phi=90$ ($=\theta_{12}$) as the 12 o'clock direction ("upward"), $\theta\phi=180$ ($=\theta_9$) as the 9 o'clock direction ("left") and $\theta\phi=270$ ($=\theta_6$) as the 6 o'clock direction ("bottom"). While scanning θ and/or ϕ , the center of the measuring spot on the Display surface shall stay fixed. The measurement shall be executed after 30 minutes warm-up period. VDD shall be $3.3 \pm 0.3\text{V}$ at 25°C . Optimum viewing angle direction is 6 o'clock.

4.1.2 Optical Specifications

[VDD = 3.3V, Frame rate = 60Hz, Clock = 74.25MHz, IBL = 240mA, Ta = $25 \pm 2^\circ\text{C}$]

| Parameter | | Symbol | Condition | Min. | Typ. | Max. | Unit | Remark |
|----------------------------|------------|---------------|--|-------|-------|-------|-------------------|--------|
| Viewing Angle range | Horizontal | Θ_3 | CR > 10 | 80 | 89 | - | Deg. | Note 1 |
| | | Θ_9 | | 80 | 89 | - | Deg. | |
| | Vertical | Θ_{12} | | 80 | 89 | - | Deg. | |
| | | Θ_6 | | 80 | 89 | - | Deg. | |
| Luminance Contrast ratio | | CR | $\Theta = 0^{\circ}$ (Center) Normal Viewing Angle | 1000 | 1200 | | | Note 2 |
| Luminance of White | | Y_w | | 425 | 500 | | cd/m ² | Note 3 |
| White luminance uniformity | | ΔY | | 75 | 80 | | % | Note 4 |
| Reproduction of color | White | W_x | | 0.283 | 0.313 | 0.343 | - | Note 5 |
| | | W_y | | 0.299 | 0.329 | 0.359 | - | |
| | Red | R_x | | 0.622 | 0.652 | 0.682 | - | |
| | | R_y | | 0.299 | 0.329 | 0.359 | - | |
| | Green | G_x | | 0.265 | 0.295 | 0.325 | - | |
| | | G_y | | 0.605 | 0.635 | 0.665 | - | |
| | Blue | B_x | | 0.118 | 0.148 | 0.178 | - | |
| | | B_y | | 0.035 | 0.065 | 0.095 | - | |
| Response Time | GTG | T_g | | 25 | 30 | ms | Note 6 | |
| Cross Talk | | CT | | - | - | 2.0 | % | Note 7 |

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.

2. Contrast measurements shall be made at viewing angle of $\theta = 0^\circ$ 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 1 shown in Appendix) 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 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 2 for a total of the measurements per display.

4. The White luminance uniformity on LCD surface is then expressed as : $\Delta Y = (\text{Minimum Luminance of 9points} / \text{Maximum Luminance of 9points}) * 100$ (See FIGURE 2 shown in Appendix).

5. The color chromaticity coordinates specified in the table above. 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. Response time T_g is the average time required for display transition by switching the input signal as below table and is based on Frame rate $f_v = 60\text{Hz}$ to optimize. Each time in below table is defined as Figure 3 and shall be measured by switching the input signal for "any level of gray(bright)" and "any level of gray(dark)". (See FIGURE 3 shown in Appendix).

7. 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. (See FIGURE 4 shown in Appendix).

Figure 1. Measurement Set Up

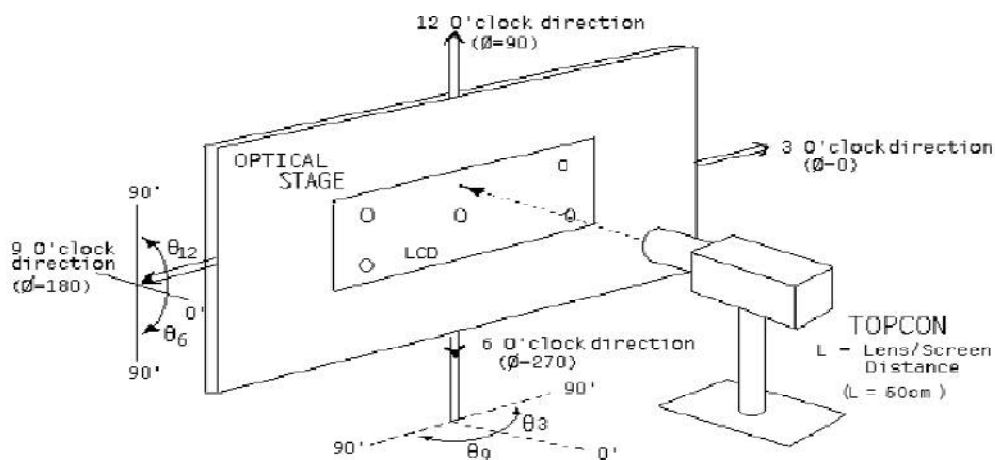


Figure 2. White Luminance and Uniformity Measurement Locations (9 points)

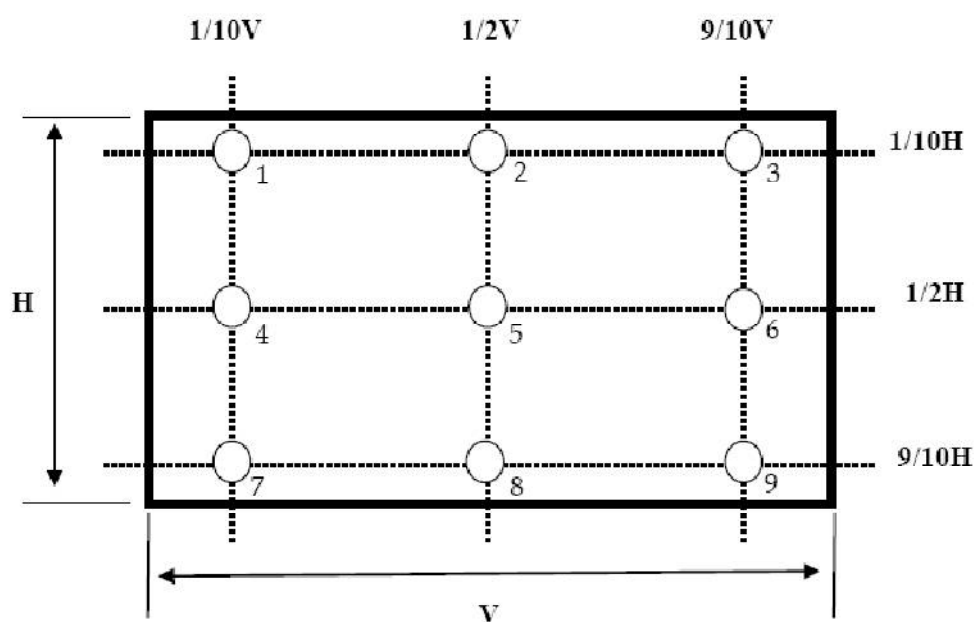
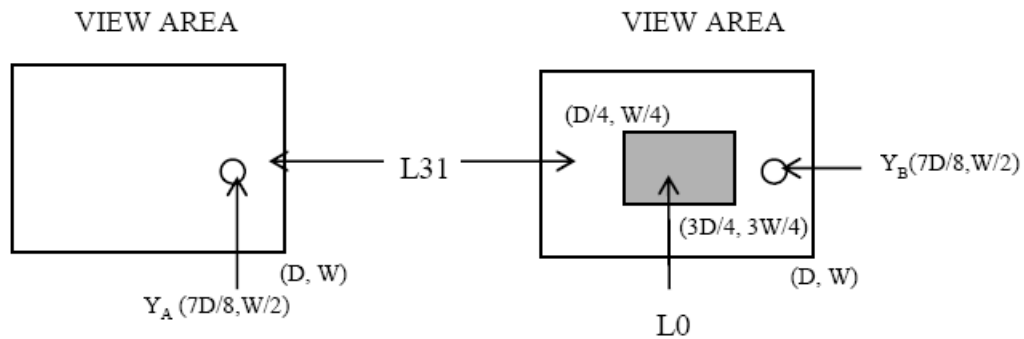


Figure 3. Response Time Testing

| Measured Response Time | Target | | | | | | | | | | | | | | | |
|------------------------|--------|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | 0 | 15 | 31 | 47 | 62 | 79 | 95 | 111 | 127 | 143 | 159 | 175 | 191 | 207 | 223 | 239 |
| Start | 0 | | | | | | | | | | | | | | | |
| | 15 | | | | | | | | | | | | | | | |
| | 31 | | | | | | | | | | | | | | | |
| | 47 | | | | | | | | | | | | | | | |
| | 62 | | | | | | | | | | | | | | | |
| | 79 | | | | | | | | | | | | | | | |
| | 95 | | | | | | | | | | | | | | | |
| | 111 | | | | | | | | | | | | | | | |
| | 127 | | | | | | | | | | | | | | | |
| | 143 | | | | | | | | | | | | | | | |
| | 159 | | | | | | | | | | | | | | | |
| | 175 | | | | | | | | | | | | | | | |
| | 191 | | | | | | | | | | | | | | | |
| | 207 | | | | | | | | | | | | | | | |
| | 223 | | | | | | | | | | | | | | | |
| | 239 | | | | | | | | | | | | | | | |
| | 255 | | | | | | | | | | | | | | | |

Figure 4. Cross Modulation Test Description



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

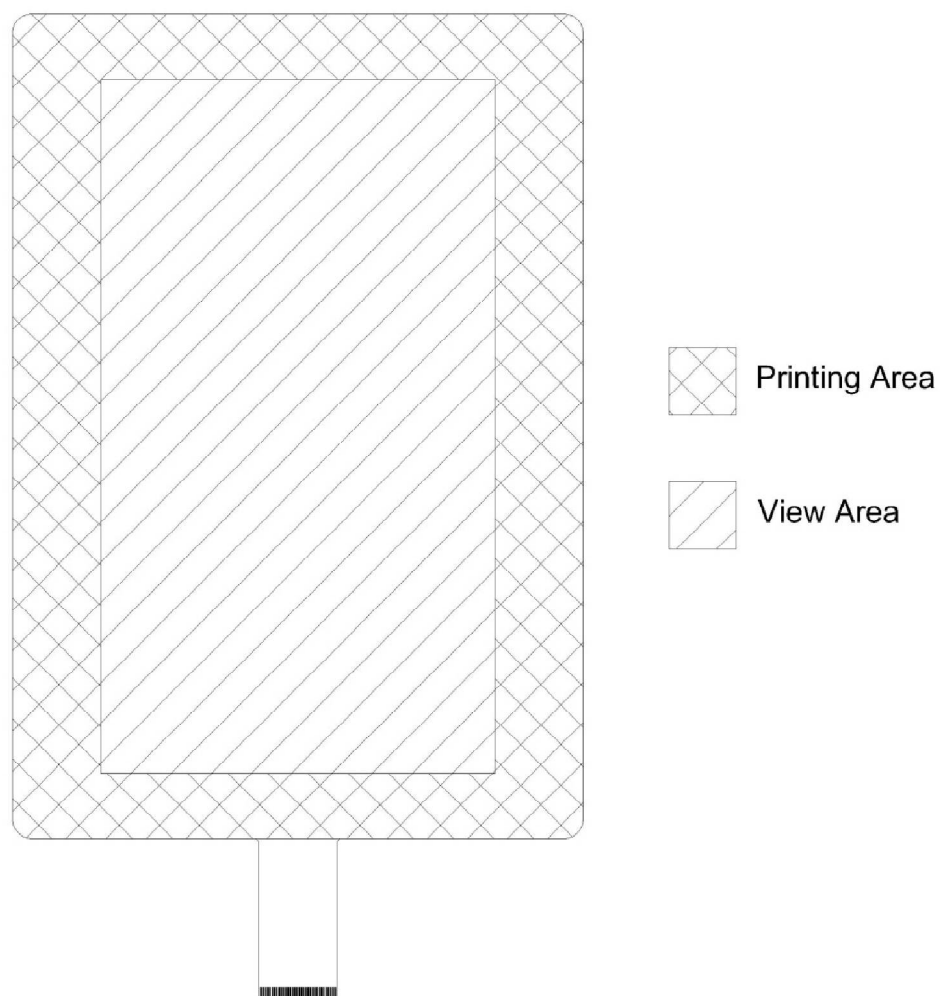
Where: Y_A = Initial luminance of measured area (cd/m^2)

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

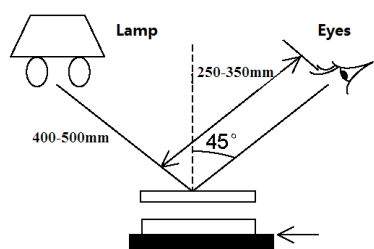
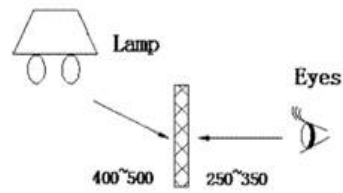
The location measured will be exactly the same in both patterns.

4.2 Appearance Specifications

4.2.1 Terms Definition



4.2.2 Inspection Conditions

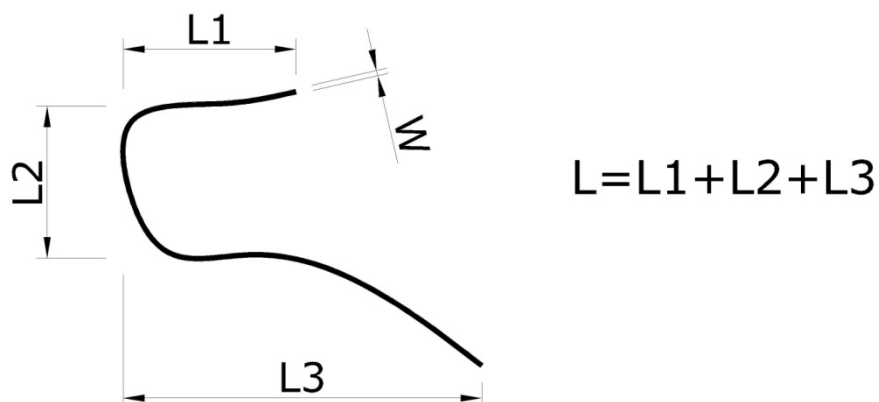
| Items | Conditions | Remarks |
|---------------------------------------|---|---|
| Inspection Lamp | Florescent Cool White Lamp, 1000~1200Lux | |
| Inspection with Reflect Light (RL) | <ul style="list-style-type: none"> *Normal eyes level 1.0 (with Glasses accepted); *Distance between Lamp and product:40-50cm; *Distance between Eyes and Product:25-35cm; *Angle of view: 45°; *Black background; *Inspection time no more than 10s. |  |
| Inspection with Through Light (TL) | <ul style="list-style-type: none"> *Normal eyes level 1.0 (with Glasses accepted); *Distance between Lamp and Product: 40-50cm; *Distance between Eyes and Product: 25-35cm; *Angle of view: 45°; *Black background; *Inspection time no more than 10s. |  |

4.2.3 Printing Area Appearance Inspection Criteria

| Items | Conditions | Inspection Criteria | Method |
|--------------------------------------|------------|--|--------------------------|
| Light Transparent Hole/Light Leakage | TL | Not Allowed (Repaired with black marker pen at the back side can be accepted.) | Eye view |
| Ink Off | TL | Not Allowed | Eye view |
| Stain and Dirty Mark | RL | *Stain and dirty mark refer to visible sheet contamination; the non-cleanable stain should be inspected as "Dot-like Defects". *Contamination cannot be cleaned by soft cloth and alcohol, Not Allowed; *Contamination can be cleaned by soft cloth and alcohol, Accept; but if the ratio of such contamination defected products is more than 10% of all the inspected products, Not Allowed; | Eye view |
| Liner-like Defects | RL | Refer to 4.2.4 Liner-like Defects. | Eye view, dot/wire gauge |
| Dot-like Defects | RL | Refer to 4.2.4 Dot-like Defects. | Eye view, dot/wire gauge |
| Logo/ Letter | RL | *Logo Break; Not Allowed *within a shaping printing < 120 mm: ± 0.10 ≥ 120 mm < 400 mm: ± 0.15 ≥ 400 mm: ± 0.25 *between shaping printing(offset to 2nd, 3rd, etc. color) < 400 mm: ± 0.30 ≥ 400 mm: ± 0.50 | Eye view, dot/wire gauge |

4.2.4 View Area Appearance Inspection Criteria

(W=Width, L=Length)



<Liner-like Defects>

| Condition | Width(mm) | Length(mm) | Criteria |
|-----------|---|-------------|---|
| RL | $W \leq 0.03$ | Not limited | *Accept QTY: not limited. |
| | $0.03 < W \leq 0.06$ | $L \leq 10$ | *Accept QTY: not more than 6; *Not allowed if the distance between 2 objects is less than 20 mm. |
| | $0.06 < W \leq 0.10$ | $L \leq 10$ | *Accept QTY: not more than 4; *Not allowed if the distance between 2 objects is less than 20 mm. |
| | $W > 0.10$ | $L > 10$ | *Not allowed. |
| | Liner-like Defects including: Liner Foreign Object/Scratch. | | |

< Dot-like Defects>

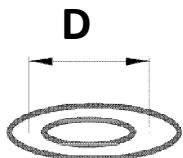
(D=Diameter)

| Condition | Average Diameter(mm) | Criteria |
|-----------|---|---|
| RL | $D \leq 0.20$ | *Not limited. |
| | $0.20 < D \leq 0.30$ | *Accept Qty: not more than 10; *Not allowed if the distance between 2 defects is less than 20mm. |
| | $0.30 < D \leq 0.40$ | *Accept Qty: not more than 5; *Not allowed if the distance between 2 defects is less than 20mm. |
| | $D > 0.40$ | *Not allowed. |
| | Dot-like Defects including: Foreign Objects/Stab. | |

< Stain and Dirty Mark>

| Condition | Criteria |
|-----------|--|
| RL | <p>* Stain and Dirty Mark refer to the visible contamination in mass, Dot-like contamination should be inspect as "Dot-like Defects";</p> <p>*Contamination cannot be clean by soft cloth and alcohol, Not Allowed;</p> <p>*Contamination can be clean by soft cloth and alcohol, Accept; but if the ratio of such defected products are more than 10% of all the inspected products, Not Allowed.</p> |

< Surface Fisheye>

| Condition | Average Diameter(mm) | Criteria | Remarks |
|-----------|----------------------|---|--|
| RL | $D \leq 0.15$ | <p>*Accept QTY: not more than 3;</p> <p>* Not allowed if the distance between 2 objects is less than 50 mm.</p> |  |
| | $0.15 < D \leq 0.30$ | <p>*Accept Qty: not more than 2;</p> <p>* Not allowed if the distance between 2 objects is less than 50 mm.</p> | |
| | $0.30 < D \leq 0.50$ | *Accept Qty: not more than 1. | |
| | $D > 0.50$ | *Not allowed. | |

Defects of back side, locates outside the View Area

The Appearance defects, such as Scratch, Foreign Object, Stain and Dirty-mark, on the backside of Module not lead to the performance failure, Accept;

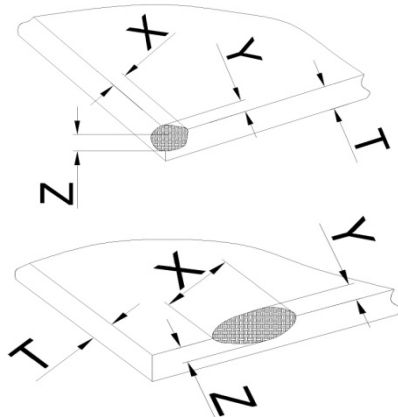
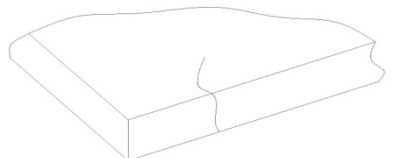
FPC and sensor pin bonding migration not more than pin width 1/2, Accept;

Scratches on bonding area on PS, Not Allowed;

Mechanical damages on FPC(dent/kink), Not Allowed;

Glue residue, broken and oxidation on gold finger, Not Allowed.

4.2.5 Glass Breakage

| Items | Criteria | Remarks |
|-----------------------------|---|--|
| Corner/ Edge Breakage | $*(X+Y)/2 < 0.3 \text{ mm}$, $Z < 1/3T \text{ mm}$; distance between 2 defects more than 5 mm; *Accept QTY: not more than 3. |  |
| Crack | Not Allowed. |  |

5. Reliability Test

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

| No | Test Items | Conditions |
|----|---|--|
| 1 | High temperature storage test | Ta = 80℃, 240 hrs |
| 2 | Low temperature storage test | Ta = -20℃, 240 hrs |
| 3 | High temperature & high humidity operation test | Ta = 50℃, 80%RH, 240hrs |
| 4 | High temperature operation test | Ta = 70℃, 240hrs |
| 5 | Low temperature operation test | Ta = 0℃, 240hrs |
| 6 | Thermal shock | Ta = -20℃ ↔ 60℃ (0.5hr), 100 cycle |
| 7 | Vibration test (non-operating) | Frequency 10 ~ 500 Hz, half sine Gravity / AMP 1.5 Grms Period X, Y, Z / Sweep rate: 1hour |
| 8 | Shock test (non-operating) | Gravity 220G |
| | | Pulse width Half sine wave 2m sec |
| | | Direction ±X, ±Y, ±Z Once for each |
| 9 | Electro-static discharge test (non-operating) | Air: 150 pF, 330Ω, 15KV Contact: 150 pF, 330Ω, 8KV |
| 10 | Impact Resistance | Steel ball: 64 g Height: 30 cm |

6. General Precaution

6.1 Mounting Method

- The panel of the LCD consists of two thin glasses with polarizer which easily get damaged. So extreme care should be taken when handling the LCD.
- Excessive stress or pressure on the glass of the LCD should be avoided. Care must be taken to insure that no torsional or compressive forces are applied to the LCD unit when it is mounted.
- If the customer's set presses the main parts of the LCD, the LCD may show the abnormal display. But this phenomenon does not mean the malfunction of the LCD 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 LCD module with the specified mounting parts.

6.2 Caution of LCD Handling and Cleaning

- Since the LCD 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 may be 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 LCD's surface with wipe lightly.
-IPA(Isopropyl Alcohol), Ethyl Alcohol, Trichlorotrifluoroethane.
- Do not wipe the LCD's surface with dry or hard materials that will damage the polarizer and others. Do not use the following solvent.
-Water, Ketone, Aromatics.
- It is recommended that the LCD be handled with soft gloves during assembly, etc. The polarizer on the LCD's surface are vulnerable to scratch and thus to be damaged by sharp particles.
- Do not drop water or any chemicals onto the LCD's surface.
- A protective film is supplied on the LCD and should be left in place until the LCD 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 the ITO corrosion, customers are recommended that the ITO area would be covered by UV or silicon.

6.3 Caution Against Static Charge

- The LCD modules use C-MOS 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 LCD, wear non-charged material gloves. And the conducting wrist to the earth and the conducting shoes to the earth are necessary.

6.4 Caution For Operation

- It is indispensable to drive the LCD within the specified voltage limit since the higher Voltage than the limit causes the shorter LCD's life. An electro-chemical reaction due to DC causes undesirable deterioration of the LCD so that the use of DC drive should avoid.
- Do not connect or disconnect the LCD to or from the system when power is on.
- Never use the LCD under abnormal conditions of high temperature and high humidity.
- When expose to drastic fluctuation of temperature (hot to cold or cold to hot) ,the LCD may be affected; Specifically, drastic temperature fluctuation from cold to hot ,produces dew on the LCD's surface which may affect the operation of the polarizer and the LCD.
- Response time will be extremely delayed at lower temperature than the operating temperature range and on the other hand at higher temperature LCD may turn black at temperature above its operational range. However those phenomena do not mean malfunction or out of order with the LCD. The LCD 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 LCD structure. If the screen is displayed with fixed pattern, use a screen saver.

6.5 Packaging

- Modules use LCD 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.

6.6 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 LCD'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 LCD near organic solvents or corrosive gasses.
- Keep the LCD safe from vibration, shock and pressure.
- Black or white air-bubbles may be produced if the LCD is stored for long time in the lower temperature or mechanical shocks are applied onto the LCD.
- 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 LCD in the packaging situation LCD when it was delivered.

6.7 Safety

- For the crash damaged or unnecessary LCD, it is recommended to wash off liquid crystal by either of solvents such as acetone and ethanol and should be burned up later.
- In the case the LCD 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 should 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.

7. Packing

TBD

8. Mechanical Drawing

