

# LCD Module Technical Specification

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Final Revision

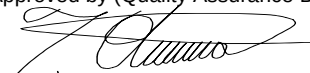
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Type No.

**T-51512D121J-FW-A-AC**



Approved by (Quality Assurance Division)



Checked by (ACI Engineering Division)



Prepared by (ACI Engineering Division)

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## 1. APPLICATION

This specification applies to color TFT-LCD module, T-51512D121J-FW-A-AC.

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OPTREX classifies the usage of the TFT-LCD module as follows. Please confirm the usage before using the product.

### (1) Standard Usage

Computers, office equipment, factory automation equipment, test and measurement equipment, communications, transportation equipment(automobiles, ships, trains, etc.), provided, however, that operation is not influenced by TFT-LCD directly.

### (2) Special Usage

Medical equipment, safety equipment, transportation equipment, provided, however, that TFT-LCD is necessary to its operation.

### (3) Specific Usage

Cockpit Equipment, military systems, aerospace equipment, nuclear reactor control systems, life support systems and any other equipment. OPTREX should make a contract that stipulate apportionment of responsibilities between OPTREX and our customer.

The product specified in this document is designed for “Standard Usage” unless otherwise specified in this document. If customers intend to use the product for applications other than those specified for “Standard Usage”, they should contact OPTREX sales representative in advance.

OPTREX has been making continuous effort to improve the reliability of its products. Customers should implement sufficient reliability design of their application equipments such as redundant system design, fail-safe functions, anti-failure features.

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Please contact and consult a OPTREX sales representative for any questions regarding this product.

## 2. OVERVIEW

T-51512D121J-FW-A-AC 12.1" color TFT-LCD (Thin Film Transistor Liquid Crystal Display) module composed of LCD panel, driver ICs, control circuit, and backlight unit.

By applying 6 bit digital data,  $800 \times 600$ , 260 K-color images are displayed on the 12.1" diagonal screen. Input power voltage is single 3.3V or 5.0V for LCD driving.

The type of data and control signals are digital and transmitted via CMOS interface per typ. 40MHz clock cycle.

Inverter for backlight is not included in this module. General specifications are summarized in the following table:

| ITEM                                  | SPECIFICATION                                        |
|---------------------------------------|------------------------------------------------------|
| Display Area (mm)                     | 246.0(H) $\times$ 184.5(V)<br>(12.106-inch diagonal) |
| Number of Dots                        | 800 $\times$ 3 (H) $\times$ 600 (V)                  |
| Pixel Pitch (mm)                      | 0.3075 (H) $\times$ 0.3075 (V)                       |
| Color Pixel Arrangement               | RGB vertical stripe                                  |
| Display Mode                          | Normally white TN                                    |
| Number of Color                       | 260 K                                                |
| Brightness (cd/m <sup>2</sup> )       | 400                                                  |
| Wide Viewing Angle Technology         | Optical compensation Film                            |
| Viewing Angle(CR $\geq$ 10)           | -65~65°(H) -75~45°(V)                                |
| Surface Treatment                     | Antireflection and hard-coating 2H                   |
| Electrical Interface                  | CMOS                                                 |
| Optimum Viewing Angle(Contrast ratio) | 6 o'clock                                            |
| Module Size (mm)                      | 280.0 (W) $\times$ 210.0 (H) $\times$ 12.0 (D)       |
| Module Mass (g)                       | 720                                                  |
| Backlight Unit                        | CCFL, 2-tubes, edge-light, replaceable               |

Characteristic value without any note is typical value.

### 3. ABSOLUTE MAXIMUM RATINGS

| ITEM                                                  | SYMBOL                    | MIN. | MAX  | UNIT              |
|-------------------------------------------------------|---------------------------|------|------|-------------------|
| Power Supply Voltage for LCD                          | VCC                       | 0    | 6.0  | V                 |
| Logic Input Voltage                                   | VI                        | -0.3 | 6.5  | V                 |
| Lamp Voltage                                          | VL                        | 0    | 2000 | V <sub>rms</sub>  |
| Lamp Current                                          | IL                        | 0    | 18   | mA <sub>rms</sub> |
| Lamp Frequency                                        | FL                        | --   | 80   | kHz               |
| Operation Temperature(Panel) <small>Note 1,2)</small> | T <sub>op</sub> (Panel)   | -20  | 70   | °C                |
| Operation Temperature(Ambient) <small>Note 2)</small> | T <sub>op</sub> (Ambient) | -20  | 70   | °C                |
| Storage Temperature <small>Note 2)</small>            | T <sub>stg</sub>          | -20  | 80   | °C                |

[Note]

1) Measured at the center of active area and at the center of panel back surface

2) Top, T<sub>stg</sub> ≤ 40°C : 90%RH max. without condensation

Top, T<sub>stg</sub> > 40°C : Absolute humidity shall be less than the value of 90%RH at 40°C without condensation.

### 4. ELECTRICAL CHARACTERISTICS

(1) TFT-LCD

Ambient temperature: Ta = 25°C

| ITEM                            |              | SYMBOL | MIN. | TYP. | MAX. | UNIT  | Remarks          |
|---------------------------------|--------------|--------|------|------|------|-------|------------------|
| Power Supply Voltage for LCD    | 3.3V powered | VCC    | 3.0  | 3.3  | 3.6  | V     | *1)              |
|                                 | 5.0V powered | VCC    | 4.75 | 5.0  | 5.25 | V     | *1)              |
| Power Supply Current for LCD    | 3.3V powered | ICC    | --   | 340  | 500  | mA    | *2)              |
|                                 | 5.0V powered | ICC    | --   | 220  | 340  | mA    | *2)              |
| Permissive Input Ripple Voltage |              | VRP    | --   | --   | 100  | mVp-p | VCC = +3.3V/5.0V |
| Logic Input Voltage             | High         | VIH    | 2.0  | --   | 5.25 | V     |                  |
|                                 | Low          | VIL    | 0    | --   | 0.8  | V     |                  |

\*1) Power and signals sequence:

$$t1 \leq 10 \text{ ms}$$

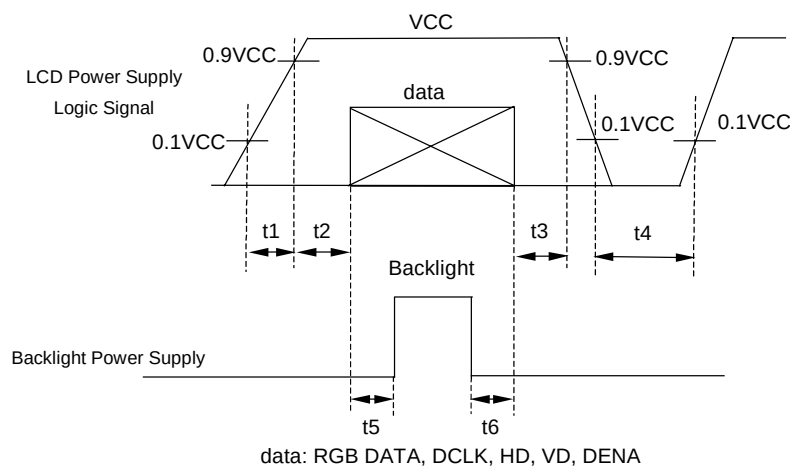
$$400 \text{ ms} \leq t4$$

$$0 < t2 \leq 50 \text{ ms}$$

$$200 \text{ ms} \leq t5$$

$$0 < t3 \leq 50 \text{ ms}$$

$$0 \leq t6$$



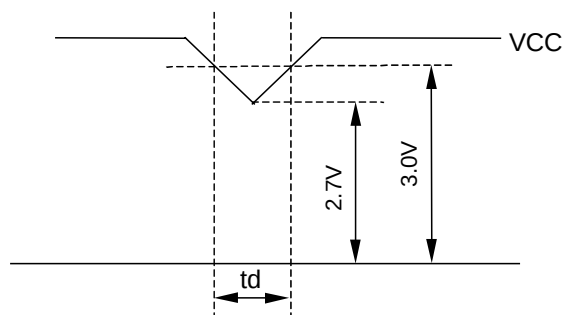
VCC-dip conditions:

(a) 3.3 V powered

1) When  $2.7\text{ V} \leq VCC < 3.0\text{ V}$ ,  $t_d \leq 10\text{ ms}$

2) When  $VCC < 2.7\text{ V}$

VCC-dip conditions should also follow the power and signals sequence.

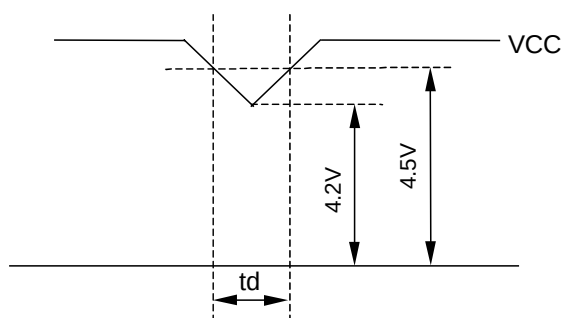


(b) 5.0V powered

1) When  $4.2\text{ V} \leq VCC < 4.5\text{ V}$ ,  $t_d \leq 10\text{ ms}$

2) When  $VCC < 4.2\text{ V}$

VCC-dip conditions should also follow the power and signals sequence.



B) Typical current condition:

64-gray-bar pattern

600 line mode

$VCC = +3.3\text{ V} / 5.0\text{ V}$ ,  $f_H=37.9\text{kHz}$ ,  $f_V=60.3\text{Hz}$ ,  $f_{CLK}= 40\text{MHz}$

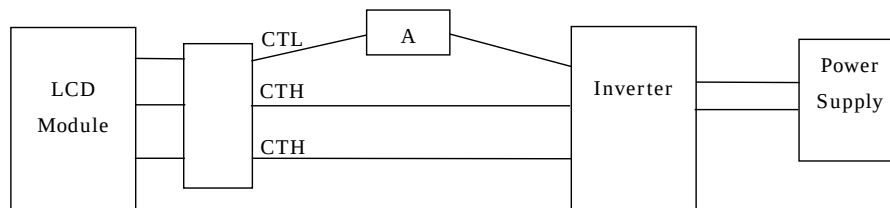
(2) Backlight

$T_a = 25^\circ\text{C}$

| ITEM                  | SYMBOL | MIN.   | TYP. | MAX. | UNIT  | Remarks                                         |
|-----------------------|--------|--------|------|------|-------|-------------------------------------------------|
| Lamp Voltage          | VL     | --     | 540  | --   | Vrms  | IL = 12.0 mArms                                 |
| Lamp Current          | IL     | 6.0    | 12.0 | 13.0 | mArms | *1), *5)                                        |
| Lamp Frequency        | FL     | 30     | --   | 60   | kHz   | *2)                                             |
| Starting Lamp Voltage | VS     | 1000   | --   | --   | Vrms  | $T_a = 25^\circ\text{C}$                        |
|                       |        | 1200   | --   | --   |       | $T_a = 0^\circ\text{C}$                         |
|                       |        | 1290   | --   | --   |       | $T_a = -20^\circ\text{C}$                       |
| Lamp Life Time        | LT     | 50,000 | --   | --   | h     | *3),*4)IL = 12.0 mArms,<br>Continuous operation |

[Note]

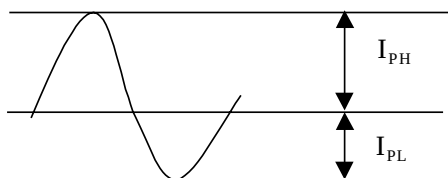
- 1) Lamp Current measurement method (The current meter is inserted in low voltage line.)



- 2) Lamp frequency of inverter may produce interference with horizontal synchronous frequency, and this may cause horizontal beat on the display. Therefore, please adjust lamp frequency, and keep inverter as far from module as possible or use electronic shielding between inverter and module to avoid the interference.
- 3) Lamp life time is defined as the time either when the brightness becomes 50% of the initial value, or when the starting lamp voltage does not meet the value specified in this table.
- 4) The life time of the backlight depends on the ambient temperature. The life time will decrease under low/high temperature.
- 5) Please use the inverter which has symmetrical current wave form as follows,

The degree of unbalance: less than 10%

The ratio of wave height: less than  $\sqrt{2} \pm 10\%$



$I_{PH}$ : High side peak

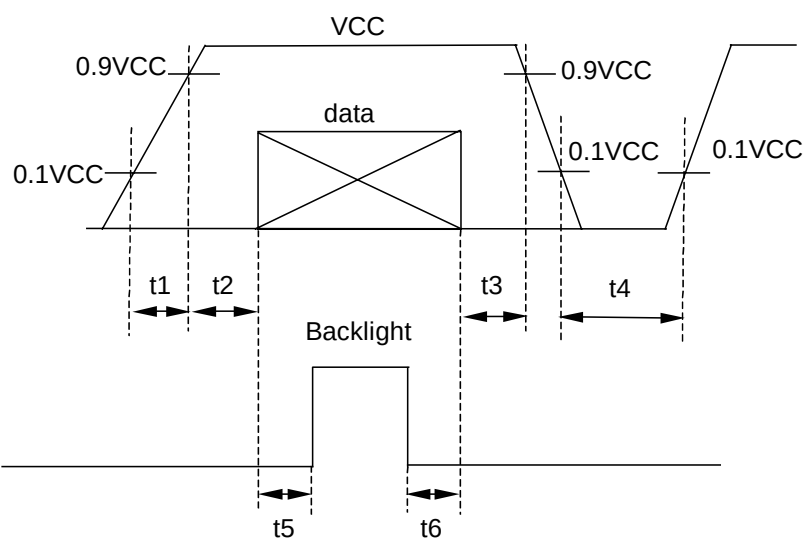
$I_{PL}$ : Low side peak

The degree of unbalance =  $|I_{PH} - I_{PL}| / I_{rms} \times 100(\%)$   
The ratio of wave height =  $I_{PH}(\text{or } I_{PL}) / I_{rms}$

## CURRENT WAVE FORM

### A) Power and signals sequence:

|                             |                          |
|-----------------------------|--------------------------|
| $t1 \leq 10 \text{ ms}$     | $400 \text{ ms} \leq t4$ |
| $0 < t2 \leq 50 \text{ ms}$ | $200 \text{ ms} \leq t5$ |
| $0 < t3 \leq 50 \text{ ms}$ | $0 \leq t6$              |



data: RGB DATA, DCLK, HD, VD, DENA

## 5. INTERFACE PIN CONNECTION

CN 1(INTERFACE SIGNAL)

Used connector: DF9B-41P-1V(Hirose)

Corresponding connector: DF9B-41S-1V(Hirose)

| Pin No. | Symbol | Function                                                  |
|---------|--------|-----------------------------------------------------------|
| 1       | GND    | Signal ground                                             |
| 2       | DCLK   | Clock signal for sampling catch data signal               |
| 3       | GND    | Signal ground                                             |
| 4       | HD     | Horizontal sync signal                                    |
| 5       | VD     | Vertical sync signal                                      |
| 6       | GND    | Signal ground                                             |
| 7       | GND    | Signal ground                                             |
| 8       | GND    | Signal ground                                             |
| 9       | R0     | RED data signal(LSB)                                      |
| 10      | R1     | RED data signal                                           |
| 11      | R2     | RED data signal                                           |
| 12      | GND    | Signal ground                                             |
| 13      | R3     | RED data signal                                           |
| 14      | R4     | RED data signal                                           |
| 15      | R5     | RED data signal(MSB)                                      |
| 16      | GND    | Signal ground                                             |
| 17      | GND    | Signal ground                                             |
| 18      | GND    | Signal ground                                             |
| 19      | G0     | GREEN data signal(LSB)                                    |
| 20      | G1     | GREEN data signal                                         |
| 21      | G2     | GREEN data signal                                         |
| 22      | GND    | Signal ground                                             |
| 23      | G3     | GREEN data signal                                         |
| 24      | G4     | GREEN data signal                                         |
| 25      | G5     | GREEN data signal(MSB)                                    |
| 26      | GND    | Signal ground                                             |
| 27      | GND    | Signal ground                                             |
| 28      | GND    | Signal ground                                             |
| 29      | B0     | BLUE data signal (LSB)                                    |
| 30      | B1     | Blue data signal                                          |
| 31      | B2     | BLUE data signal                                          |
| 32      | GND    | Signal ground                                             |
| 33      | B3     | BLUE data signal                                          |
| 34      | B4     | BLUE data signal                                          |
| 35      | B5     | BLUE data signal(MSB)                                     |
| 36      | GND    | Signal ground                                             |
| 37      | DENA   | Data enable signal(to settle the viewing area)            |
| 38      | NC     |                                                           |
| 39      | VCC    | +3.3 / 5.0 V Power supply                                 |
| 40      | VCC    | +3.3 / 5.0 V Power supply                                 |
| 41      | SC     | Scan direction control.(Low or Open:Normal, High:Reverse) |

\*)The shielding case is connected with GND.

## CN 2(BACKLIGHT)

Backlight-side connector: BHR-04VS-1 (JST)

Inverter-side connector: SM04(4.0)B-BHS-1(JST)

| Pin No. | Symbol | Function           |
|---------|--------|--------------------|
| 1, 2    | CTH    | VLH (High voltage) |
| 4       | CTL    | VL (Low voltage)   |

[Note]VLH - VL = VL



## 6. INTERFACE TIMING

### (1) Timing Specifications

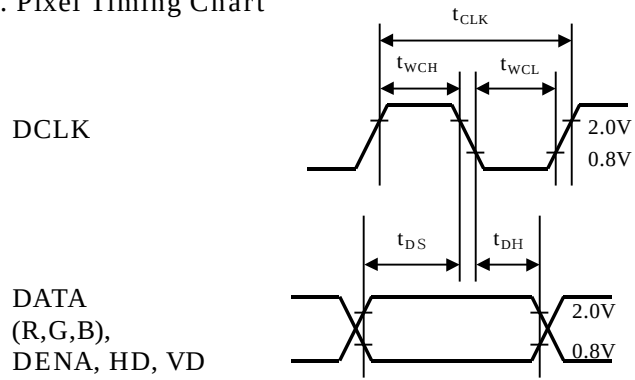
| ITEM                            |                        | SYMBOL           | MIN  | TYP  | MAX  | UNIT             |
|---------------------------------|------------------------|------------------|------|------|------|------------------|
| DCLK                            | Frequency              | f <sub>CLK</sub> | 35   | --   | 40   | MHz              |
|                                 | Period                 | t <sub>CLK</sub> | 25   | --   | 28.6 | ns               |
|                                 | Low Width              | t <sub>WCL</sub> | 10   | --   | --   | ns               |
|                                 | High Width             | t <sub>WCH</sub> | 10   | --   | --   | ns               |
| DATA<br>(R,G,B,DENA,<br>HD, VD) | Set up time            | t <sub>DS</sub>  | 4    | --   | --   | ns               |
|                                 | Hold time              | t <sub>DH</sub>  | 4    | --   | --   | ns               |
| DENA                            | Horizontal Active Time | t <sub>HA</sub>  | 800  | 800  | 800  | t <sub>CLK</sub> |
|                                 | Horizontal Front Porch | t <sub>HFP</sub> | 0    | --   | --   | t <sub>CLK</sub> |
|                                 | Horizontal Back Porch  | t <sub>HBP</sub> | 10   | --   | --   | t <sub>CLK</sub> |
|                                 | Vertical Active Time   | t <sub>VA</sub>  | 600  | 600  | 600  | t <sub>H</sub>   |
|                                 | Vertical Front Porch   | t <sub>VFP</sub> | 1    | --   | --   | t <sub>H</sub>   |
|                                 | Vertical Back Porch    | t <sub>VBP</sub> | 2    | --   | --   | t <sub>H</sub>   |
| HD                              | Frequency              | f <sub>H</sub>   | 35.2 | 37.9 | 39.2 | kHz              |
|                                 | Period                 | t <sub>H</sub>   | 25.5 | 26.4 | 28.4 | μs               |
|                                 | Low Width              | t <sub>WHL</sub> | 5    | --   | --   | t <sub>CLK</sub> |
| VD                              | Frequency              | f <sub>V</sub>   | 55   | 60.3 | 64.2 | Hz               |
|                                 | Period                 | t <sub>V</sub>   | 15.6 | 16.6 | 18.2 | ms               |
|                                 | Low Width              | t <sub>WVL</sub> | 1    | --   | --   | t <sub>H</sub>   |

[Note]

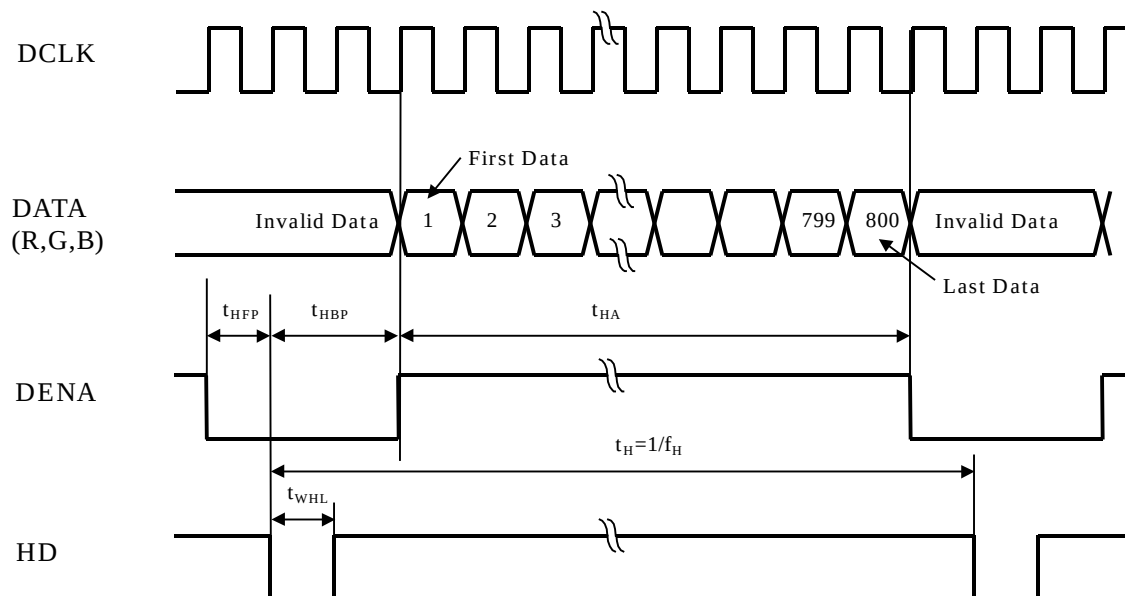
- 1) DATA is latched at fall edge of DCLK in this specification.
- 2) Polarities of HD and VD are negative in this specification.
- 3) DENA (Data Enable) should always be positive polarity as shown in the timing specification.
- 4) DCLK should appear during all invalid period, and HD should appear during invalid period of frame cycle.
- 5) t<sub>HFP</sub> + t<sub>HBP</sub> ≥ 20 t<sub>CLK</sub>

## (2) Timing Chart

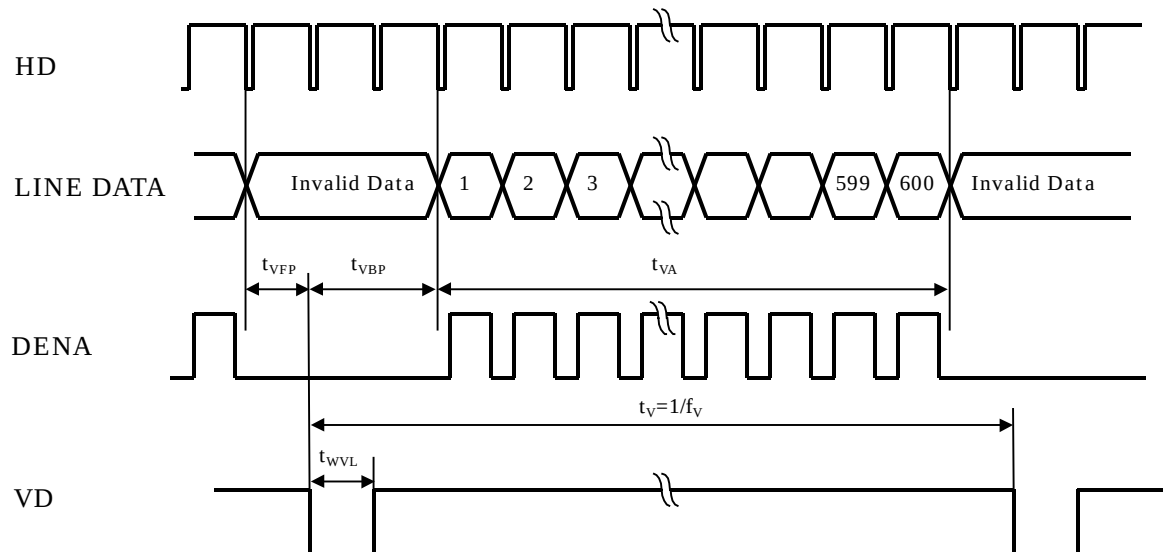
### a. Pixel Timing Chart



### b. Horizontal Timing Chart



### c. Vertical Timing Chart



### (3) Color Data Assignment

| COLOR          |           | INPUT DATA |    |    |    |    |     |        |    |    |    |    |     |        |    |    |    |    |     |
|----------------|-----------|------------|----|----|----|----|-----|--------|----|----|----|----|-----|--------|----|----|----|----|-----|
|                |           | R DATA     |    |    |    |    |     | G DATA |    |    |    |    |     | B DATA |    |    |    |    |     |
|                |           | R5         | R4 | R3 | R2 | R1 | R0  | G5     | G4 | G3 | G2 | G1 | G0  | B5     | B4 | B3 | B2 | B1 | B0  |
|                |           | MSB        |    |    |    |    | LSB | MSB    |    |    |    |    | LSB | MSB    |    |    |    |    | LSB |
| BASIC<br>COLOR | BLACK     | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
|                | RED(63)   | 1          | 1  | 1  | 1  | 1  | 1   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
|                | GREEN(63) | 0          | 0  | 0  | 0  | 0  | 0   | 1      | 1  | 1  | 1  | 1  | 1   | 0      | 0  | 0  | 0  | 0  | 0   |
|                | BLUE(63)  | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 1      | 1  | 1  | 1  | 1  | 1   |
|                | CYAN      | 0          | 0  | 0  | 0  | 0  | 0   | 1      | 1  | 1  | 1  | 1  | 1   | 1      | 1  | 1  | 1  | 1  | 1   |
|                | MAGENTA   | 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   |
| RED            | RED(1)    | 0          | 0  | 0  | 0  | 0  | 1   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
|                | RED(2)    | 0          | 0  | 0  | 0  | 1  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
|                |           |            |    |    |    |    |     |        |    |    |    |    |     |        |    |    |    |    |     |
|                |           |            |    |    |    |    |     |        |    |    |    |    |     |        |    |    |    |    |     |
|                | RED(62)   | 1          | 1  | 1  | 1  | 1  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
|                | RED(63)   | 1          | 1  | 1  | 1  | 1  | 1   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
| GREEN          | GREEN(1)  | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 1   | 0      | 0  | 0  | 0  | 0  | 0   |
|                | GREEN(2)  | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 1  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
|                |           |            |    |    |    |    |     |        |    |    |    |    |     |        |    |    |    |    |     |
|                |           |            |    |    |    |    |     |        |    |    |    |    |     |        |    |    |    |    |     |
|                | GREEN(62) | 0          | 0  | 0  | 0  | 0  | 0   | 1      | 1  | 1  | 1  | 1  | 0   | 0      | 0  | 0  | 0  | 0  | 0   |
|                | GREEN(63) | 0          | 0  | 0  | 0  | 0  | 0   | 1      | 1  | 1  | 1  | 1  | 1   | 0      | 0  | 0  | 0  | 0  | 0   |
| BLUE           | BLUE(1)   | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 1   |
|                | BLUE(2)   | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 1  | 0   |
|                |           |            |    |    |    |    |     |        |    |    |    |    |     |        |    |    |    |    |     |
|                |           |            |    |    |    |    |     |        |    |    |    |    |     |        |    |    |    |    |     |
|                | BLUE(62)  | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 1      | 1  | 1  | 1  | 1  | 0   |
|                | BLUE(63)  | 0          | 0  | 0  | 0  | 0  | 0   | 0      | 0  | 0  | 0  | 0  | 0   | 1      | 1  | 1  | 1  | 1  | 1   |

[Note]

1) Definition of gray scale

Color (n) --- n indicates gray scale level.

Higher n means brighter level.

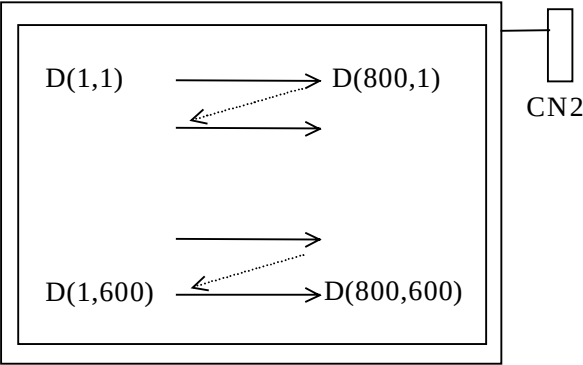
2) Data

1:High, 0: Low

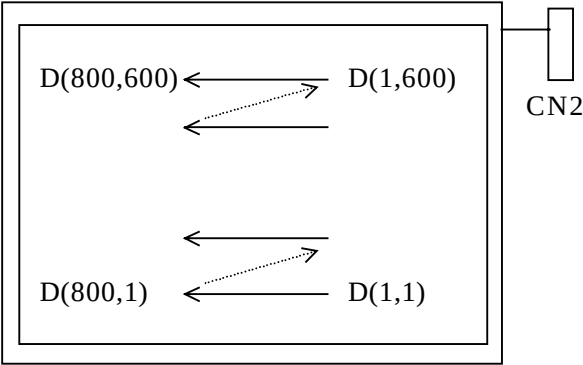
(4) Display Position and Scan Direction

D(X,Y) shows the data number of input signal for LCD panel signal processing PCB.

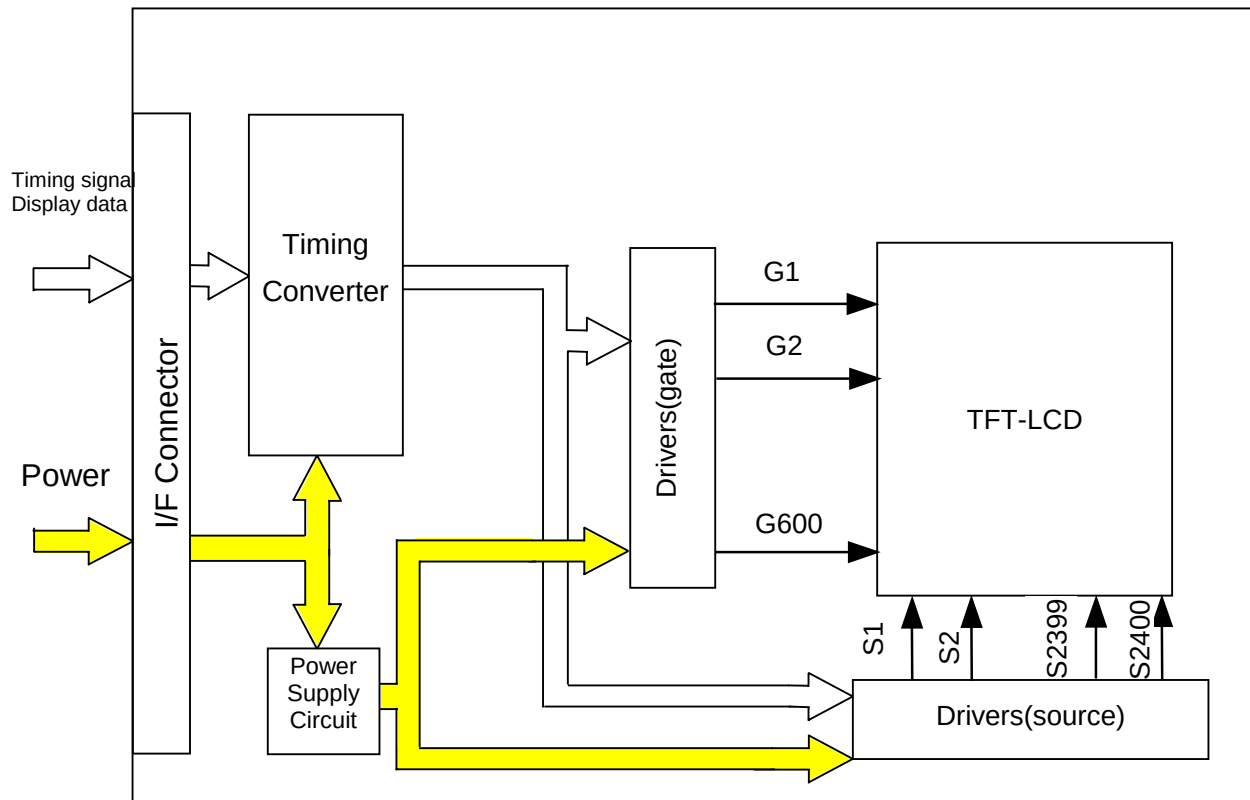
SC:Low or Open



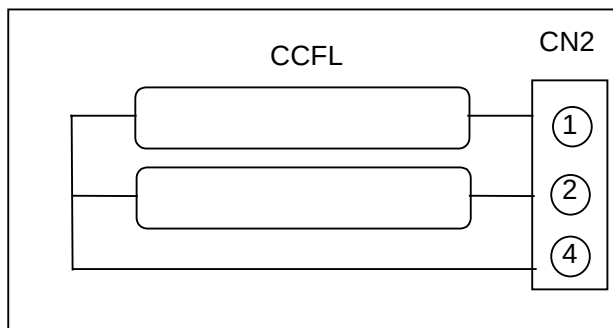
SC:High



## 7. BLOCK DIAGRAM

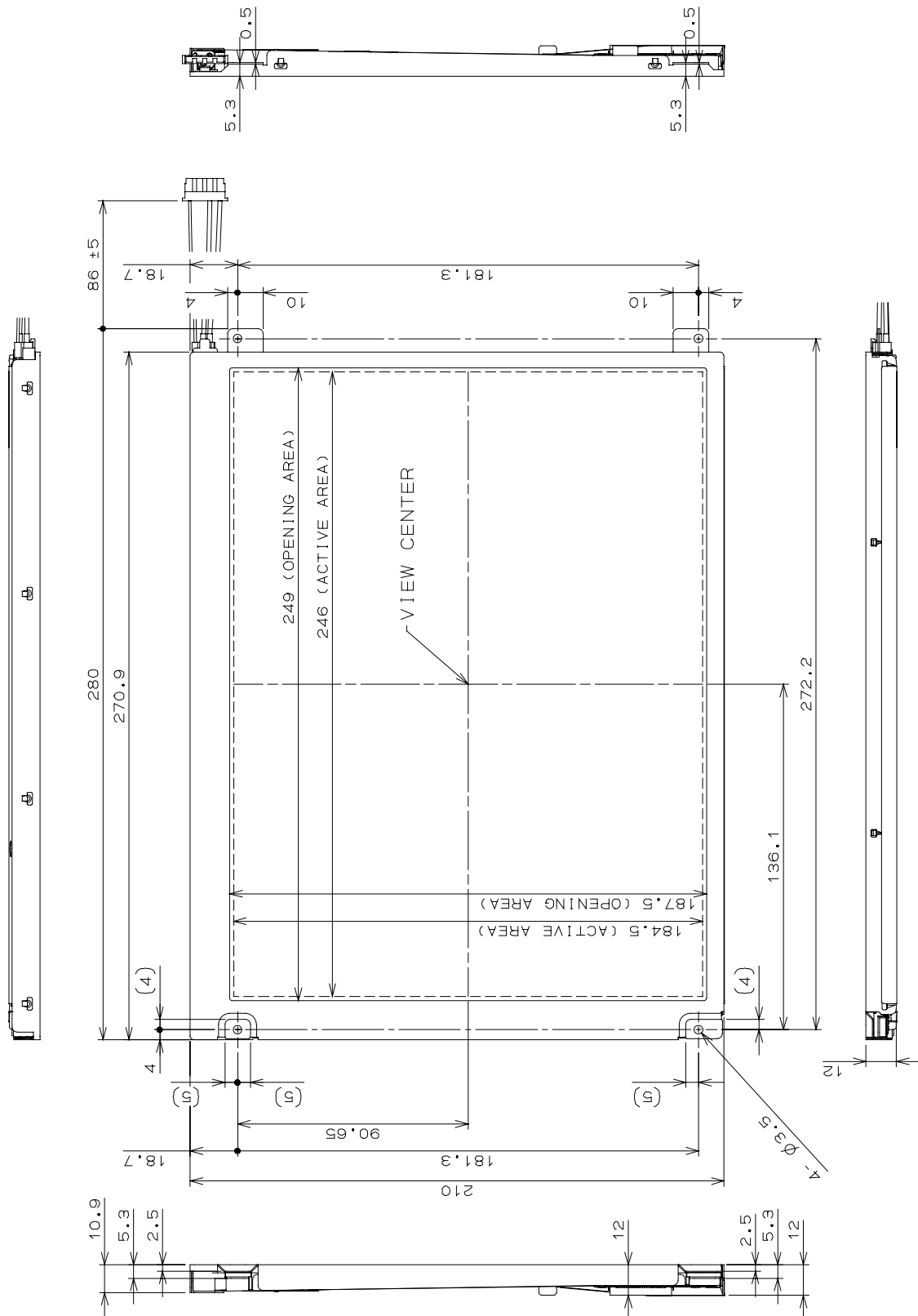


### BACKLIGHT



## 8. MECHANICAL SPECIFICATIONS

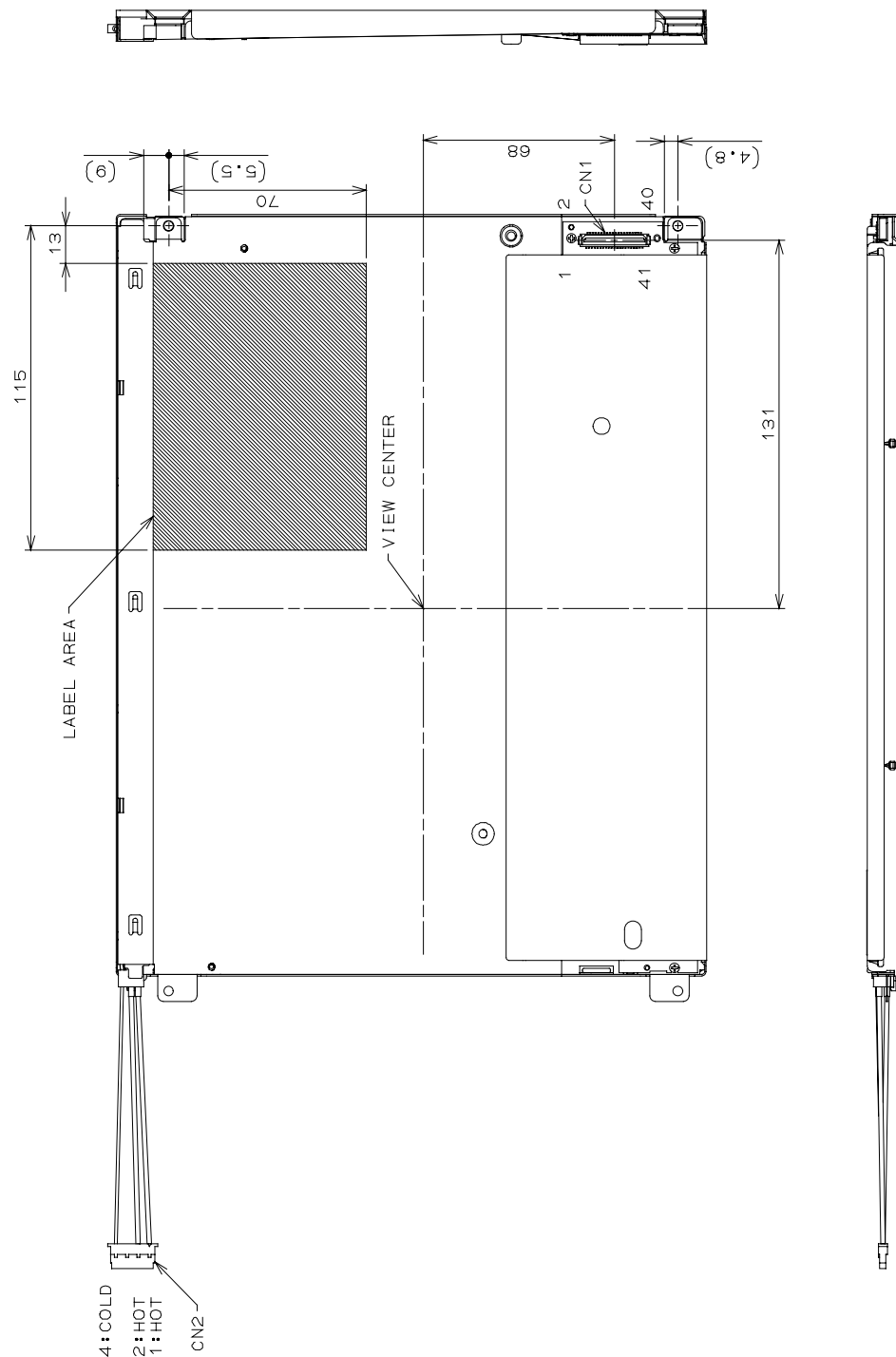
### (1) Front Side



UNDEFINED TOLERANCES TO BE  $\pm 0.5\text{mm}$ .  
EXCEPT FOR THICKNESS OF PET FILM.

(Unit: mm)

## (2) Rear Side



UNDEFINED TOLERANCES TO BE  $\pm 0.5\text{mm}$ .  
EXCEPT FOR THICKNESS OF PET FILM.

CN1:DF9B-41P-1V(HIROSE)  
CN2:BHR-04VS-1(JST)

(Unit:mm)

### [Note]

We recommend you referring to the detailed drawing for your design.  
Please contact our company sales representative when you need the detailed drawing.

## 9. OPTICAL CHARACTERISTICS

Ta=25°C, VCC=3.3V / 5.0V, Input Signals: Typ. Values shown in Section 6

| ITEM                 |            | SYMBOL      | CONDITION                 | MIN    | TYP    | MAX   | UNIT              | Remarks   |
|----------------------|------------|-------------|---------------------------|--------|--------|-------|-------------------|-----------|
| Contrast Ratio       |            | CR          | $\theta = \phi = 0^\circ$ | 350    | 500    | --    | --                | *1)*2)*6) |
| Luminance            |            | Lw          | $\theta = \phi = 0^\circ$ | 250    | 400    | --    | cd/m <sup>2</sup> | *1)*3)*6) |
| Luminance Uniformity |            | $\Delta Lw$ | $\theta = \phi = 0^\circ$ | --     | --     | 30    | %                 | *1)*4)*6) |
| Response Time        |            | tr          | $\theta = \phi = 0^\circ$ | --     | 10     | --    | ms                | *1)*5)*6) |
|                      |            | tf          | $\theta = \phi = 0^\circ$ | --     | 30     | --    | ms                | *1)*5)*6) |
| Viewing Angle        | Horizontal | $\phi$      | CR $\geq 10$              | -50~50 | -65~65 | --    | °                 | *1)*6)    |
|                      | Vertical   | $\theta$    |                           | -40~30 | -75~45 | --    | °                 | *1)*6)    |
|                      | Horizontal | $\phi$      | CR $\geq 5$               | -65~65 | -80~80 | --    | °                 | *1)*6)    |
|                      | Vertical   | $\theta$    |                           | -50~40 | -80~55 | --    | °                 | *1)*6)    |
| Image sticking       |            | tis         | 2 h                       | --     | --     | 2     | s                 | *7)       |
| Color Coordinates    | Red        | Rx          | $\theta = \phi = 0^\circ$ | 0.556  | 0.586  | 0.616 | --                | *1)*6)    |
|                      |            | Ry          |                           | 0.310  | 0.340  | 0.370 |                   |           |
|                      | Green      | Gx          |                           | 0.300  | 0.330  | 0.360 |                   |           |
|                      |            | Gy          |                           | 0.525  | 0.555  | 0.585 |                   |           |
|                      | Blue       | Bx          |                           | 0.138  | 0.168  | 0.198 |                   |           |
|                      |            | By          |                           | 0.167  | 0.197  | 0.227 |                   |           |
|                      | White      | Wx          |                           | 0.302  | 0.332  | 0.362 |                   |           |
|                      |            | Wy          |                           | 0.337  | 0.367  | 0.397 |                   |           |

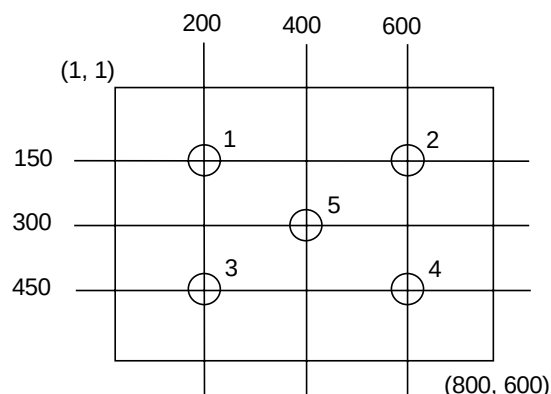
[Note]

These items are measured using CS1000(MINOLTA) for color coordinates, EZContrast(ELDIM) for viewing angle and CS1000 or BM-5A(TOPCON) for others under the dark room condition (no ambient light) after more than 30 minutes from turning on the lamp unless noted.

Condition: IL = 12.0 mArms, FL=55kHz

### \*1) Measurement Point

Contrast Ratio, Luminance, Response Time, Viewing Angle, Color Coordinates: Display Center  
Luminance Uniformity: point 1~5 shown in a figure below



### \*2) Definition of Contrast Ratio

CR=ON (White) Luminance / OFF(Black) Luminance

### \*3) Definition of Luminance

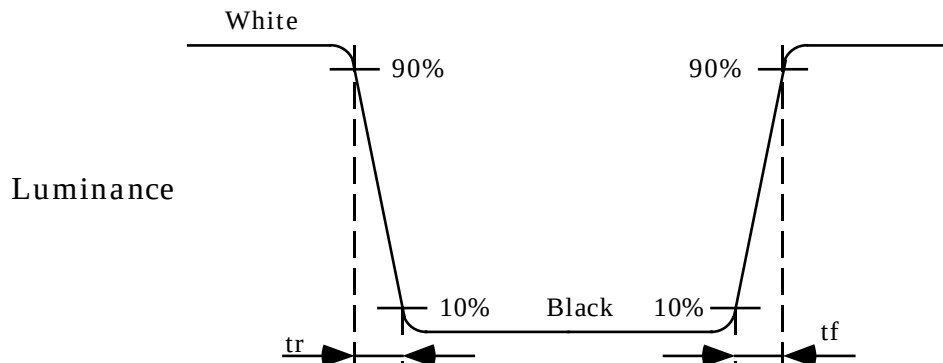
Lw= ON (White) Luminance



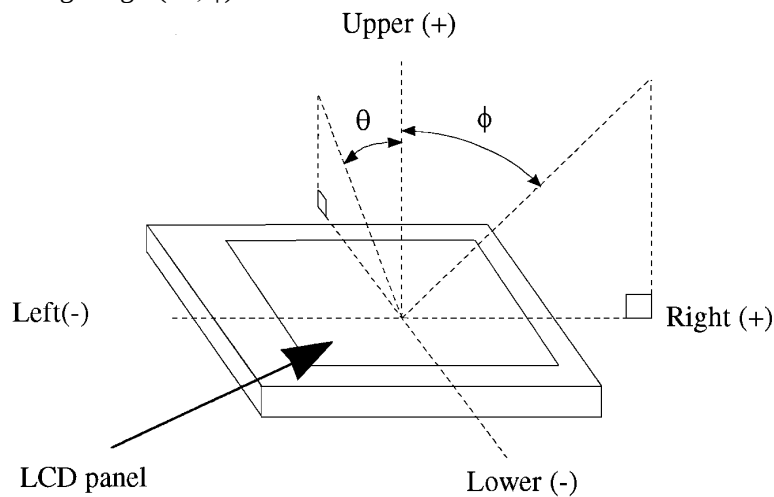
\*4) Definition of Luminance Uniformity

$$\Delta L_w = [L_w(\text{MAX})/L_w(\text{MIN}) - 1] \times 100$$

\*5) Definition of Response Time



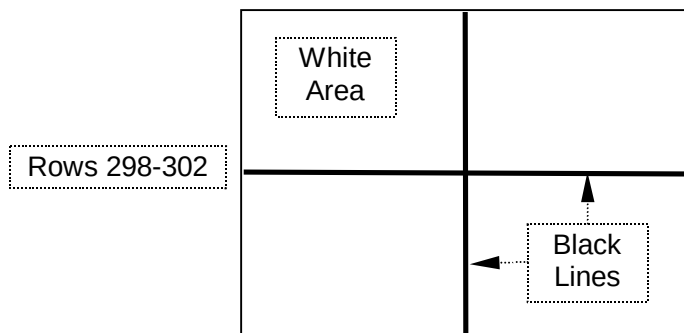
\*6) Definition of Viewing Angle(  $\theta$  ,  $\phi$  )



\*7) Image sticking:

Continuously display the test pattern shown in the figure below for two-hours. Then display a completely white screen. The previous image shall not persist more than two seconds at 25°C.

Cols 398-402



TEST PATTERN FOR IMAGE STICKING TEST

## 10. RELIABILITY TEST CONDITION

### (1) Temperature and Humidity

| TEST ITEM                                   | CONDITIONS                                     |
|---------------------------------------------|------------------------------------------------|
| HIGH TEMPERATURE<br>HIGH HUMIDITY OPERATION | 40°C, 90%RH, 240 h<br>(No condensation)        |
| HIGH TEMPERATURE STORAGE                    | 80°C, 240h                                     |
| LOW TEMPERATURE STORAGE                     | -20°C, 240 h                                   |
| THERMAL SHOCK                               | BETWEEN -20°C (1h) and 80°C(1h),<br>100 CYCLES |

### (2) Shock & Vibration

| ITEM                         | CONDITIONS                                                                                                                                                                                                                                                               |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SHOCK<br>(NON-OPERATION)     | Shock level: 1470m/s <sup>2</sup> (150G)<br>Waveform: half sinusoidal wave, 2ms<br>Number of shocks: one shock input in each direction of three mutually perpendicular axes for a total of six shock inputs                                                              |
| VIBRATION<br>(NON-OPERATION) | Vibration level: 9.8m/s <sup>2</sup> (1.0G)<br>Waveform: sinusoidal<br>Frequency range: 5 to 500Hz<br>Frequency sweep rate: 0.5 octave /min<br>Duration: one sweep from 5 to 500 Hz in each of three mutually perpendicular axis(each x,y,z axis: 1 hour, total 3 hours) |

### (3) Judgment standard

The judgment of the above tests should be made as follow:

Pass: Normal display image, no damage of the display function. (ex. no line defect)

Partial transformation of the module parts should be ignored.

Fail: No display image, damage of the display function. (ex. line defect)