

LCD Module Technical Specification

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Final Revision

Type No.

T-51863D150J-FW-A-AFN

OPTREX CORPORATION

Approved : Shigeo Suzuki

QUALITY ASSURANCE DIVISION _____

Checked : Noboru Wada

ACI ENGINEERING DIVISION _____

Prepared : Satoshi Sano

ACI ENGINEERING DIVISION _____

APPROVED

By _____

Signature :

Date :

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as having been accepted.

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Revision History

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1. APPLICATION

This specification applies to color TFT-LCD module, T-51863D150J-FW-A-AFN.

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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.

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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.

OPTREX assumes no responsibility for any damage resulting from the use of the product that does not comply with the instructions and the precautions specified in this document.

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

2. OVERVIEW

T-51863D150J-FW-A-AFN is 15.0" color TFT-LCD (Thin Film Transistor Liquid Crystal Display) modules composed of LCD panel, driver ICs, control circuit, and backlight unit.

By applying 6 bit or 8 bit digital data, 1024 × 768, 262K-color or 16.7M-color images are displayed on the 15.0" diagonal screen. Input power voltage is 3.3 V for LCD driving.

The type of data and control signals are digital and transmitted via LVDS interface per Typ. 65 MHz clock cycle.

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

| ITEM | SPECIFICATION |
|--|---|
| Display Area (mm) | 304.1 (H) × 228.1 (V) (15.0-inch diagonal) |
| Number of Dots | 1024 × 3 (H) × 768 (V) |
| Pixel Pitch (mm) | 0.297 (H) × 0.297 (V) |
| Color Pixel Arrangement | RGB vertical stripe |
| Display Mode | Normally white TN |
| Number of Color | 262K(6 bit/color)16.7M(8 bit/color) |
| Luminance (cd/m ²) | 800 |
| Wide Viewing Angle Technology | Optical Compensation Film |
| Viewing Angle (CR ≥ 10) | -75~75° (H) -60~50° (V) |
| Surface Treatment | Anti-glare and hard-coating 3H |
| Electrical Interface | LVDS(6 bit/8 bit) |
| Optimum Viewing Angle (Contrast ratio) | 6 o'clock |
| Module Size (mm) | 326.0 (W) × 255.0 (H) × 15.9 (D) |
| Module Mass (g) | 1350 |
| Backlight Unit | CCFL, 4-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 | 4.0 | V |
| Logic Input Voltage | VI | -0.3 | VCC+0.3 | V |
| Lamp Voltage | VL | 0 | 2500 | Vrms |
| Lamp Current | IL | 0 | 10.0 | mArms |
| Lamp Frequency | FL | -- | 100 | kHz |
| Operation Temperature (Panel) <small>Note 1,2)</small> | T _{op(Panel)} | -20 | 70 | °C |
| Operation Temperature (Ambient) <small>Note 2)</small> | T _{op(Ambient)} | -20 | 70 | °C |
| Storage Temperature <small>Note 2)</small> | T _{stg} | -20 | 80 | °C |

[Note]

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

2) Top, Tstg ≤ 40°C : 90%RH max. without condensation

Top, Tstg > 40°C : Absolute humidity shall be less than the value of 90%RH at 40°C without condensation.

4. ELECTRICAL CHARACTERISTICS

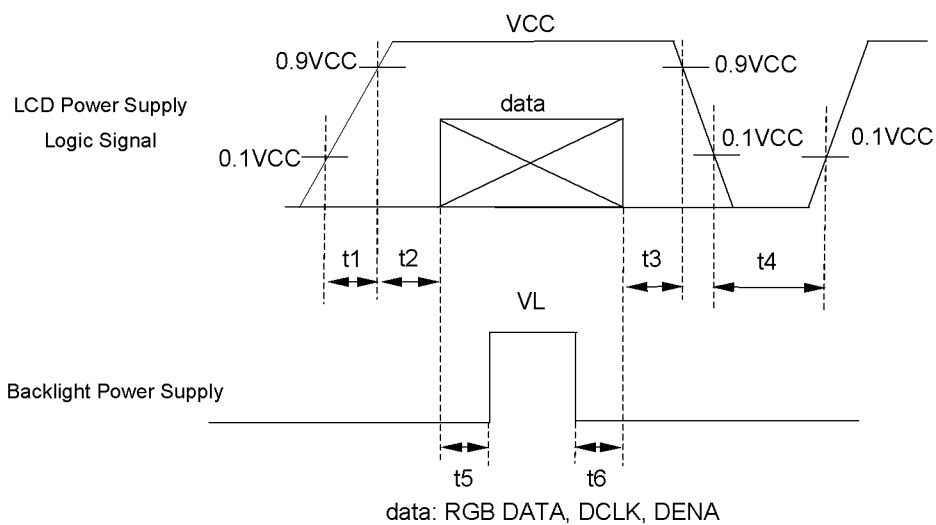
(1) TFT- LCD

Ambient Temperature : Ta = 25°C

| ITEM | SYMBOL | MIN. | TYP. | MAX. | UNIT | Remarks |
|---------------------------------|--------|------|------|------|---------|--------------|
| Power Supply Voltage for LCD | VCC | 3.0 | 3.3 | 3.6 | V | *1) |
| Power Supply Current for LCD | ICC | -- | 410 | 700 | mA | *2) |
| Permissive Input Ripple Voltage | VRP | -- | -- | 100 | mVp-p | VCC = +3.3 V |
| Logic Input Voltage | High | VIH | 2.0 | -- | VCC+0.3 | V |
| | Low | VIL | 0 | -- | 0.8 | V |

*1) Power and signals sequence:

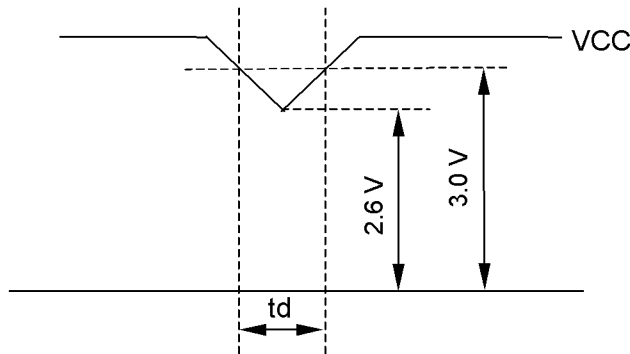
$$\begin{aligned}
 t1 &\leq 10 \text{ ms} & 200 \text{ ms} &\leq t4 \\
 0 < t2 &\leq 50 \text{ ms} & 200 \text{ ms} &\leq t5 \\
 0 < t3 &\leq 50 \text{ ms} & 0 &\leq t6
 \end{aligned}$$



VCC-dip conditions:

- 1) When $2.6\text{ V} \leq VCC < 3.0\text{ V}$, $t_d \leq 10\text{ ms}$
- 2) When $VCC < 2.6\text{ V}$

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



*2) Typical current condition:

- 64-gray-bar-pattern(6 bit)
- 256-gray-bar-pattern(8 bit)
- 768 line mode
- $VCC = +3.3\text{ V}$, $f_H = 48.4\text{ kHz}$, $f_V = 60\text{ Hz}$, $f_{CLK} = 65\text{ MHz}$

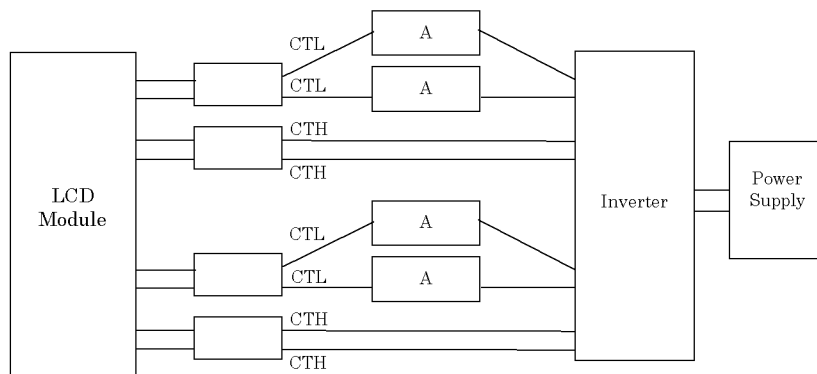
(2) Backlight

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

| ITEM | SYMBOL | MIN. | TYP. | MAX. | UNIT | Remarks |
|-----------------------|--------|-------|------|------|-------|--|
| Lamp Voltage | VL | -- | 620 | -- | Vrms | $I_L = 6.5\text{ mArms}$ |
| Lamp Current | IL | 3.5 | 6.5 | 8.0 | mArms | *2),*6) |
| Lamp Frequency | FL | 40 | -- | 70 | kHz | *3) |
| Starting Lamp Voltage | VS | 1300 | -- | -- | Vrms | $T_a = 25^\circ\text{C}$ |
| | | 1500 | -- | -- | Vrms | $T_a = 0^\circ\text{C}$ |
| | | 1650 | -- | -- | Vrms | $T_a = -20^\circ\text{C}$ |
| Lamp Life Time | LT | 50000 | -- | -- | h | *4),*5) $I_L = 6.5\text{ mArms}$, Continuous Operation |

*1) Please use synchronous inverter.

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

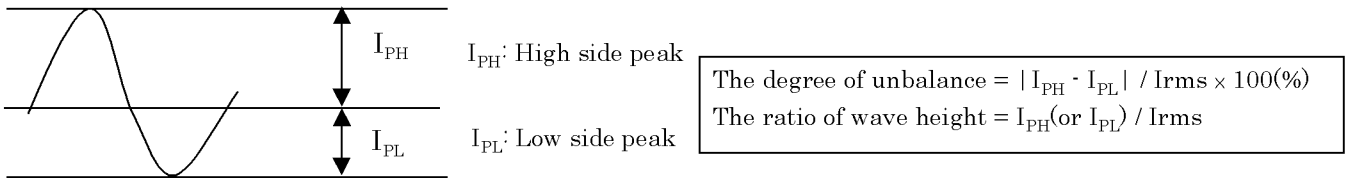


*3) Lamp frequency of inverter may produce interference with horizontal synchronous frequency, and this may cause horizontal beat on the display. Therefore, please adjust lamp frequency, and keep inverter as far from module as possible or use electronic shielding between inverter and module to avoid the interference.

- *4) 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.
- *5) The life time of the backlight depends on the ambient temperature. The life time will decrease under low/high temperature.
- *6) 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 $\sqrt{2} \pm 10\%$



CURRENT WAVE FORM

5. INTERFACE PIN CONNECTION

(1) CN 1(Interface Signal)

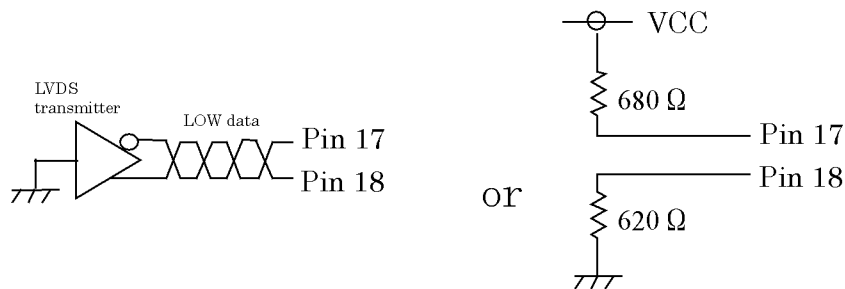
Used Connector: DF14H-20P-1.25H(56) (HIROSE)

Corresponding connector: DF14-20S-1.25C (HIROSE)

| Pin No. | Symbol | Function(ISP 6 bit compatibility mode) | | Function(ISP 8 bit compatibility mode) |
|---------|---------|--|----------------------------|--|
| | | 6 bit input | 8 bit input | |
| 1 | VCC | +3.3 V Power supply | | ← |
| 2 | VCC | +3.3 V Power supply | | ← |
| 3 | GND | GND | | ← |
| 4 | GND | GND | | ← |
| 5 | Link 0- | R0, R1, R2, R3, R4, R5, G0 | R2, R3, R4, R5, R6, R7, G2 | R0, R1, R2, R3, R4, R5, G0 |
| 6 | Link 0+ | R0, R1, R2, R3, R4, R5, G0 | R2, R3, R4, R5, R6, R7, G2 | R0, R1, R2, R3, R4, R5, G0 |
| 7 | GND | GND | | ← |
| 8 | Link 1- | G1, G2, G3, G4, G5, B0, B1 | G3, G4, G5, G6, G7, B2, B3 | G1, G2, G3, G4, G5, B0, B1 |
| 9 | Link 1+ | G1, G2, G3, G4, G5, B0, B1 | G3, G4, G5, G6, G7, B2, B3 | G1, G2, G3, G4, G5, B0, B1 |
| 10 | GND | GND | | ← |
| 11 | Link 2- | B2, B3, B4, B5, DENA | B4, B5, B6, B7, DENA | B2, B3, B4, B5, DENA |
| 12 | Link 2+ | B2, B3, B4, B5, DENA | B4, B5, B6, B7, DENA | B2, B3, B4, B5, DENA |
| 13 | GND | GND | | ← |
| 14 | CLKIN- | Clock - | | ← |
| 15 | CLKIN+ | Clock + | | ← |
| 16 | GND | GND | | ← |
| 17 | Link3- | See: *2) | R0, R1, G0, G1, B0, B1 | R6, R7, G6, G7, B6, B7 |
| 18 | Link3+ | See: *2) | R0, R1, G0, G1, B0, B1 | R6, R7, G6, G7, B6, B7 |
| 19 | MODE | Low=ISP 6 bit compatibility mode | | High=ISP 8 bit compatibility mode |
| 20 | SC | Scan direction control (Low = Normal , High = Reverse) | | ← |

*1) The shielding case is connected with GND

*2) Recommended wiring of Pin 17,18 (6 bit input)



(2) CN 2,4(Backlight)

Backlight-side connector: BHSR-02VS-1 (JST)

Inverter-side connector: SM02B-BHSS(LF)(SN) (JST)

| Pin No. | Symbol | Function |
|---------|--------|---------------------|
| 1, 2 | CTH | VBLH (High Voltage) |

[Note]

$$VBLH - VBLL = VL$$

(3) CN 3,5(Backlight)

Backlight-side connector: BHR-02VS-1 (JST)

Inverter-side connector: SM02(4.0)B-BHS(LF)(SN) (JST)

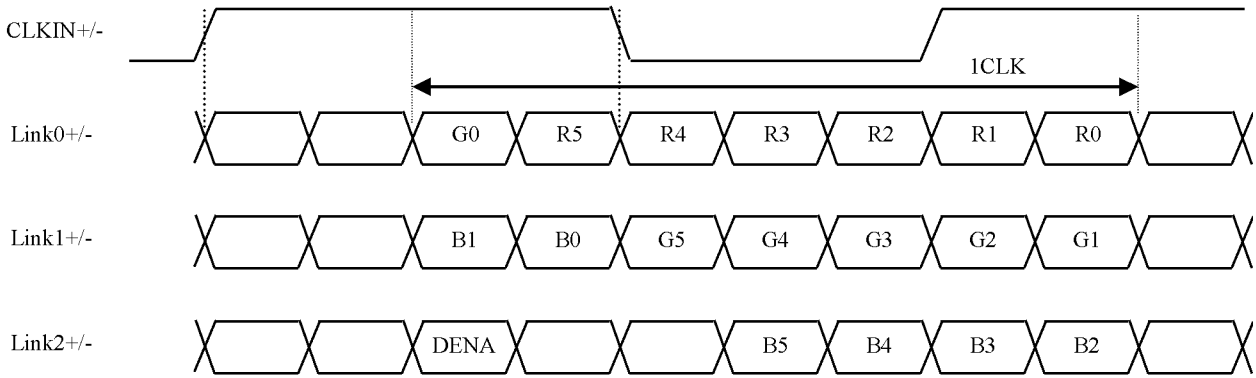
| Pin No. | Symbol | Function |
|---------|--------|--------------------|
| 1, 2 | CTL | VBLL (Low Voltage) |

[Note]

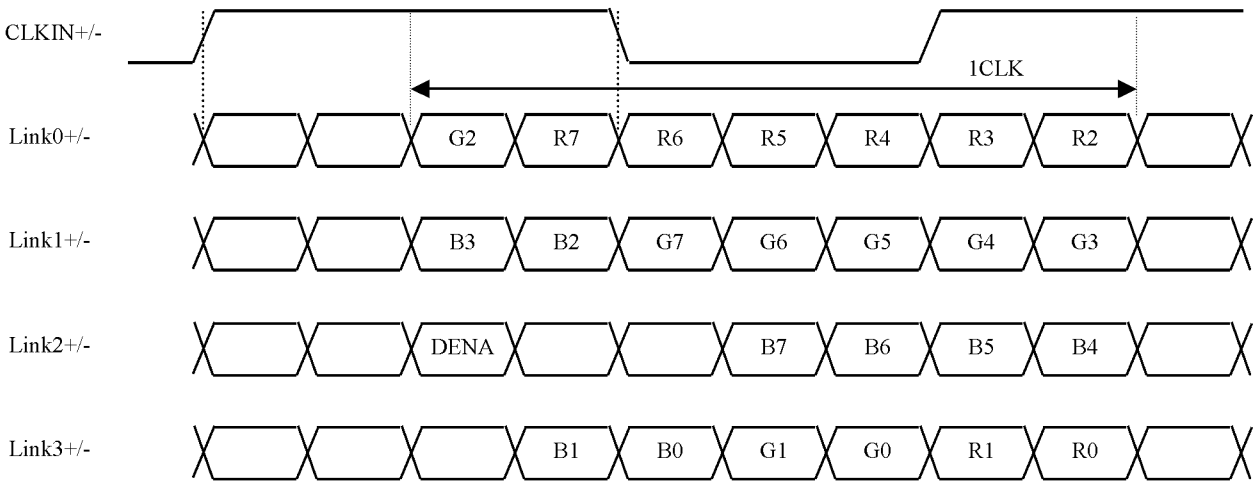
$VBLH - VBLL = VL$

(4) ISP data mapping

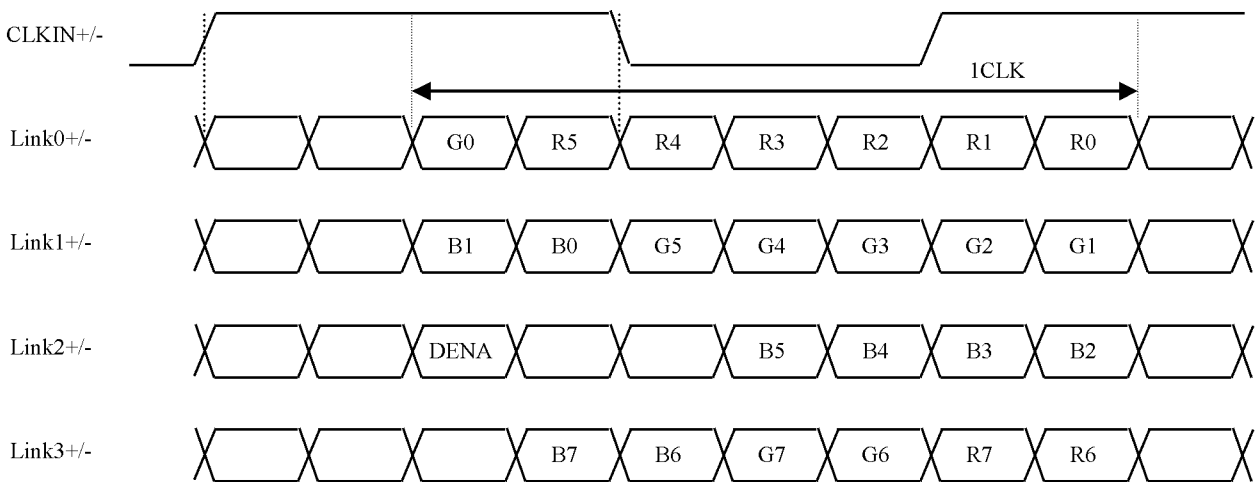
a. ISP 6 bit compatibility mode(6 bit input)



b. ISP 6 bit compatibility mode(8 bit input)



c. ISP 8 bit compatibility mode



6. INTERFACE TIMING

LVDS transmitter input signal

(1) Timing Specifications

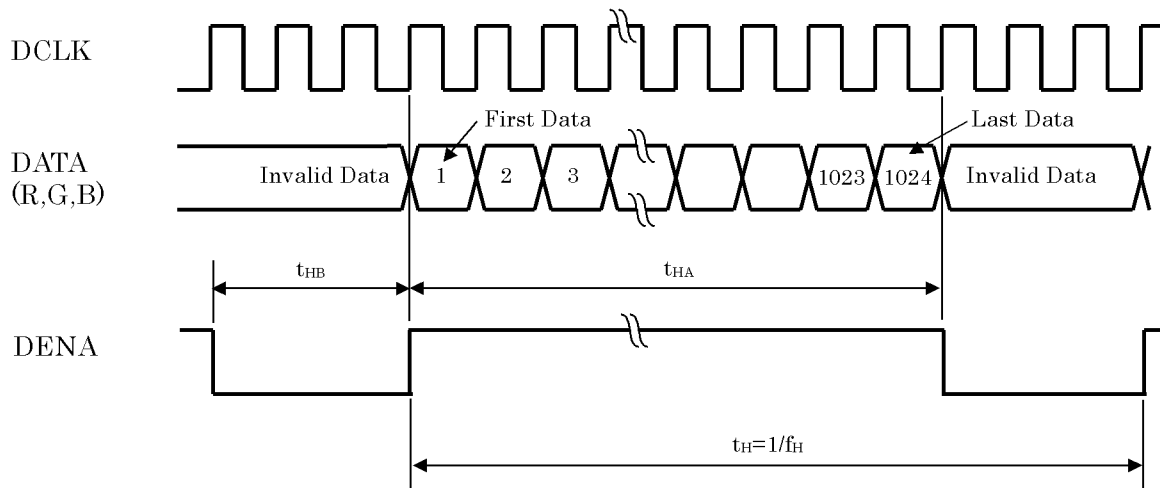
| ITEM | | SYMBOL | MIN. | TYP. | MAX. | UNIT | |
|------|------------|------------------|-----------------|------|------|------|------------------|
| DCLK | Frequency | f _{CLK} | 50 | 65 | 80 | MHz | |
| | Period | t _{CLK} | 12.5 | 15.4 | 20 | ns | |
| DENA | Horizontal | Active Time | t _{HA} | 1024 | 1024 | 1024 | t _{CLK} |
| | | Blanking Time | t _{HB} | 20 | 320 | 511 | t _{CLK} |
| | | Frequency | f _H | 42.4 | 48.4 | 60 | kHz |
| | | Period | t _H | 16.6 | 20.7 | 23.6 | μs |
| | Vertical | Active Time | t _{VA} | 768 | 768 | 768 | t _H |
| | | Blanking Time | t _{VB} | 3 | 38 | -- | t _H |
| | | Frequency | f _V | 55 | 60 | 75 | Hz |
| | | Period | t _V | 13.3 | 16.7 | 18.2 | ms |

[Note]

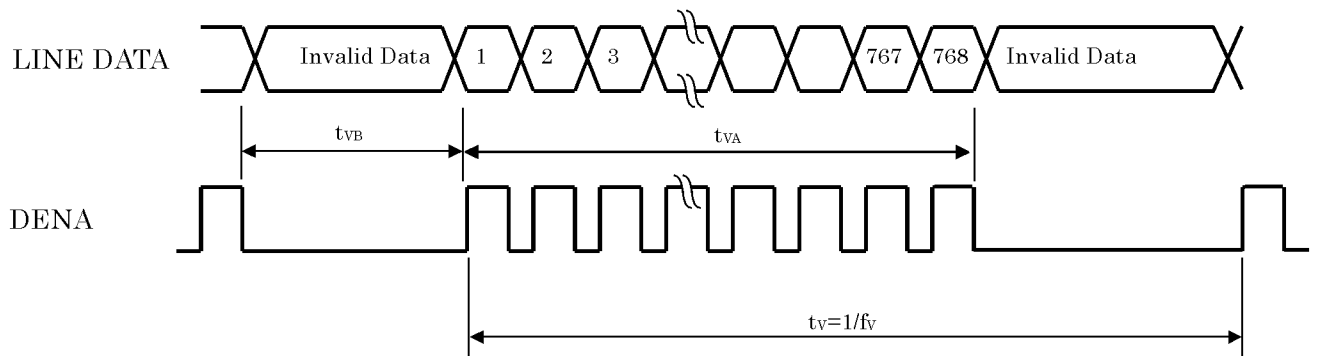
- 1) DENA (Data Enable) shall always be positive polarity as shown in the timing specification.
- 2) DCLK shall appear during all invalid period.
- 3) LVDS timing follows the timing specifications of LVDS receiver IC: THC63LVDF84B(Thine).
- 4) $t_{VA} + t_{VB} \leq 1024$

(2) Timing Chart

a. Horizontal Timing Chart



b. Vertical Timing Chart



(3) Color Data Assignment

a. 6 bit input

| 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 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

b. 8 bit input

| COLOR | | INPUT DATA | | | | | | | | | | | | | | | | | | | | | | | |
|----------------|------------|------------|----|----|----|-----|----|----|----|--------|----|----|----|-----|----|----|----|--------|----|----|----|-----|----|----|----|
| | | R DATA | | | | | | | | G DATA | | | | | | | | B DATA | | | | | | | |
| | | R7 | R6 | R5 | R4 | R3 | R2 | R1 | R0 | G7 | G6 | G5 | G4 | G3 | G2 | G1 | G0 | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 |
| | | MSB | | | | LSB | | | | MSB | | | | LSB | | | | MSB | | | | LSB | | | |
| BASIC COLOR | 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 |
| | RED(255) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GREEN(255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | BLUE(255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | CYAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | MAGENTA | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | YELLOW | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | WHITE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| RED | RED(1) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | RED(2) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | RED(255) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 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 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | GREEN(2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | GREEN(255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 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 | 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 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| | BLUE(255) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 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

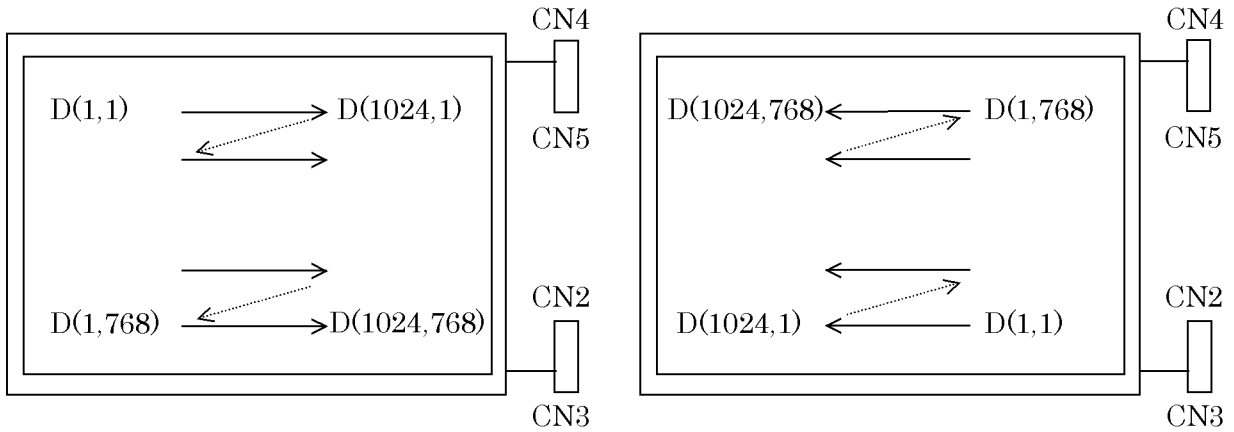
1:High, 0: Low

(4) Display Position and Scan Direction

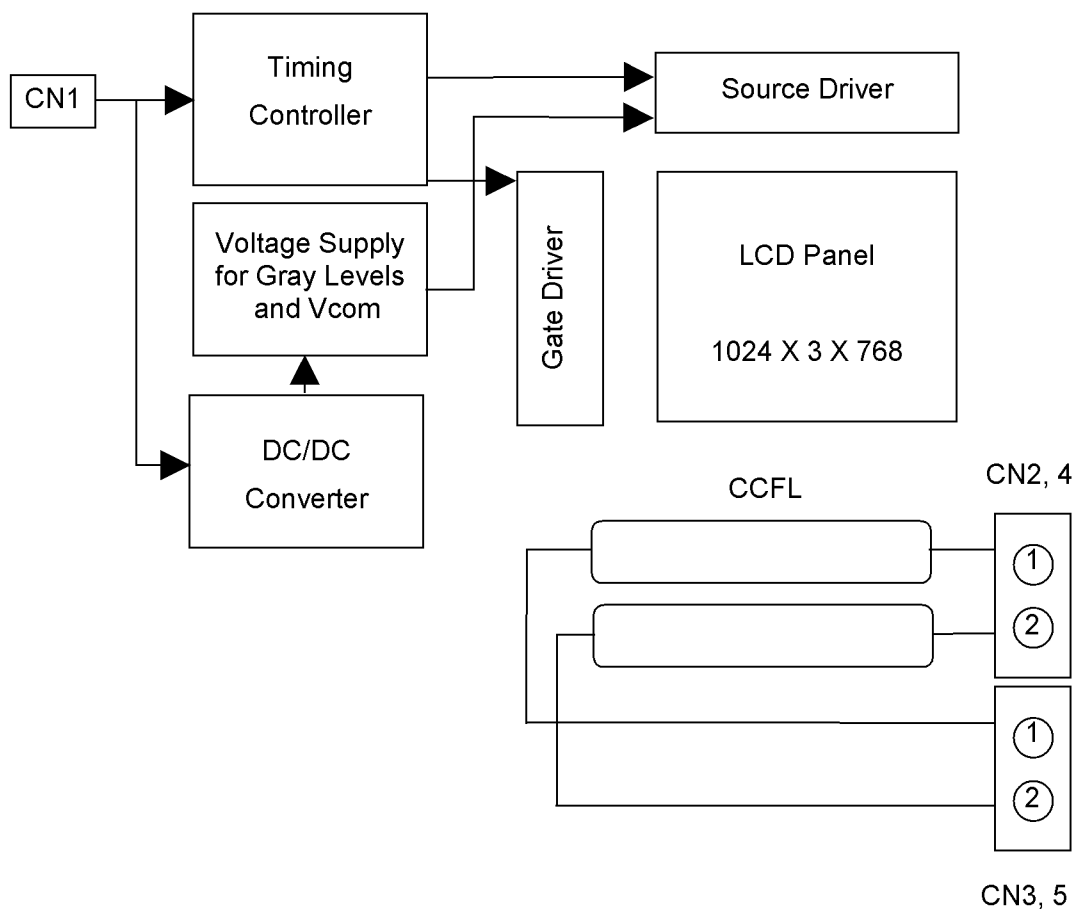
D(X,Y) shows the data number of input signal for LCD panel signal processing PCB.

SC: Low

SC: High

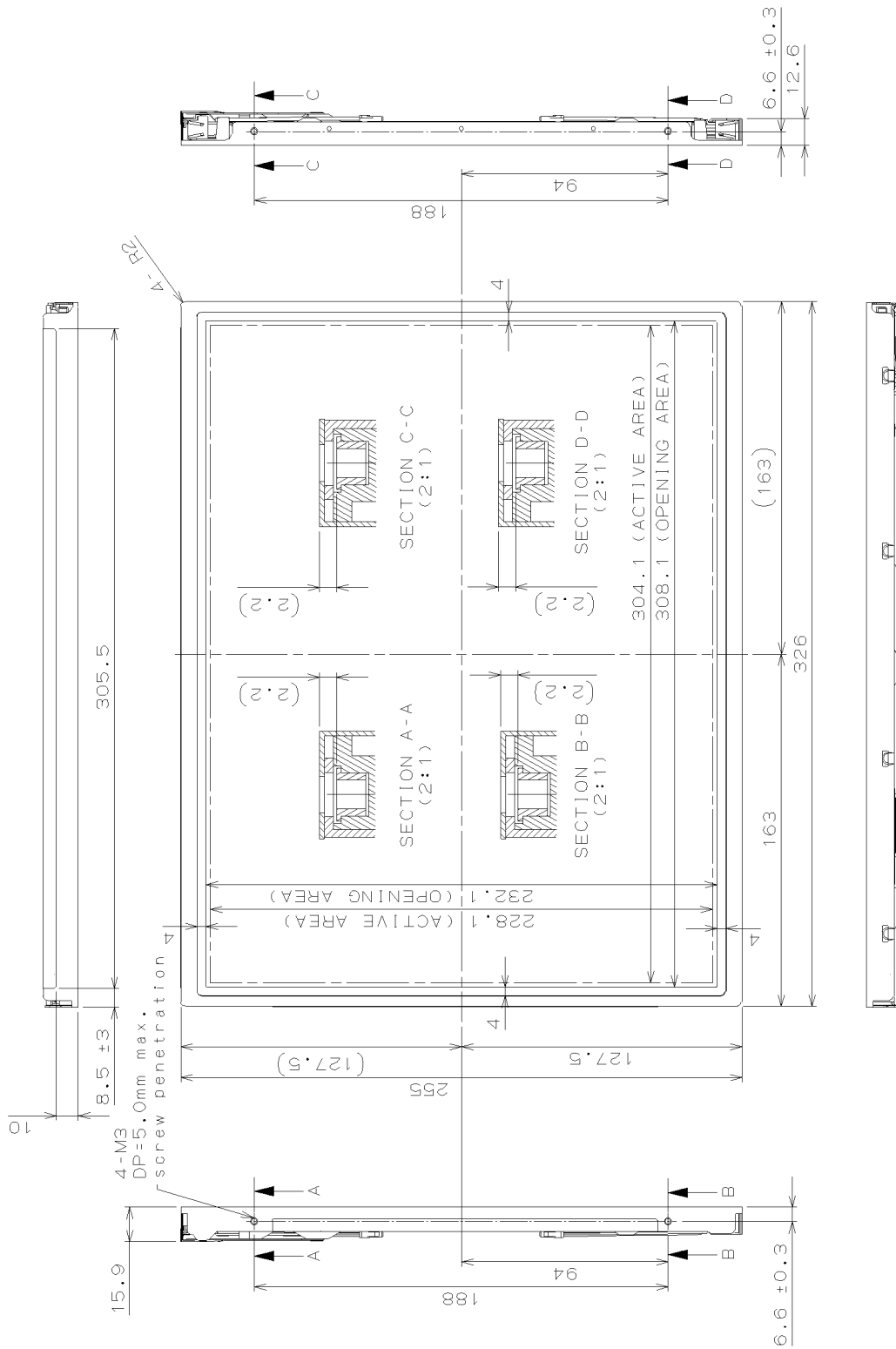


7. BLOCK DIAGRAM



8. MECHANICAL SPECIFICATIONS

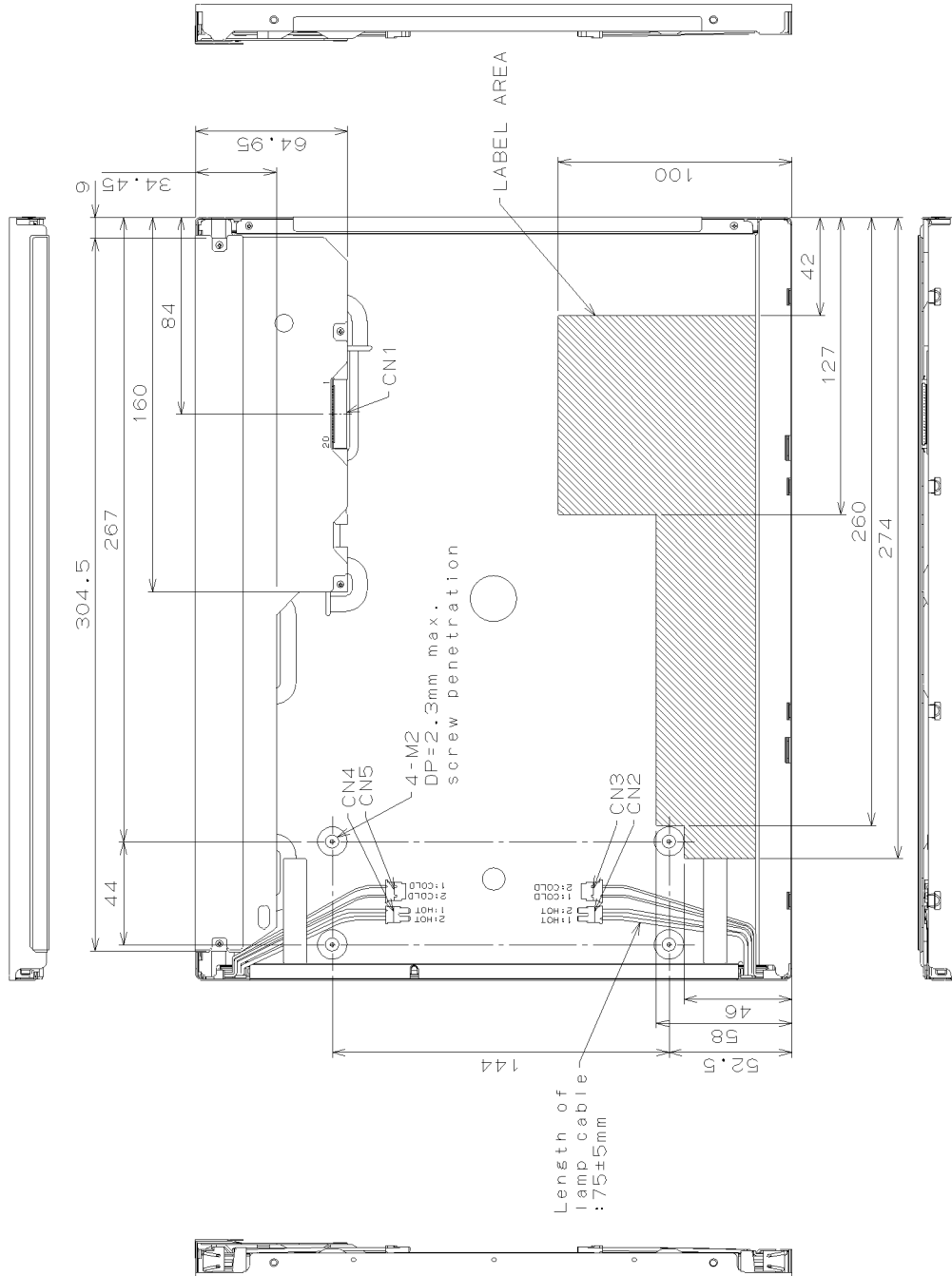
(1) Front side



- 1) Tolerance is ±0.5mm unless noted.
- 2) Except for thickness of PET film.

(Unit: mm)

(2) Rear side



CN1: DF14H-20P-1.25H(56) (HIROSE)
 CN2, 4: BHSR-02VS-1 (JST)
 CN3, 5: BHR-02VS-1 (JST)

1) Tolerance is ±0.5mm unless noted.
 2) Except for thickness of PET film.

(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 = 3.3 V, Input Signals: Typ. Values shown in Section 6

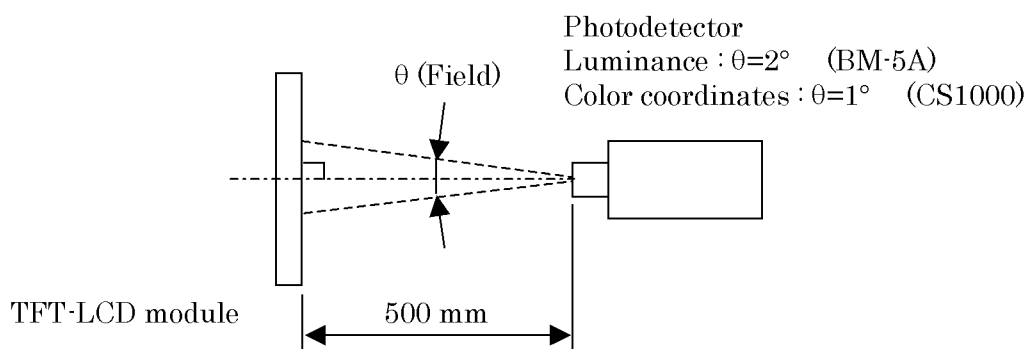
| ITEM | SYMBOL | CONDITION | MIN. | TYP. | MAX. | UNIT | Remarks | |
|----------------------|-------------|--------------------------------------|--------------------------------------|--------|--------|-------------------|-----------|---------|
| Contrast Ratio | CR | $\theta_V=0^\circ, \theta_H=0^\circ$ | 420 | 600 | -- | -- | *1)*2)*5) | |
| Luminance | Lw | $\theta_V=0^\circ, \theta_H=0^\circ$ | 640 | 800 | -- | cd/m ² | *1)*5) | |
| Luminance Uniformity | ΔLw | $\theta_V=0^\circ, \theta_H=0^\circ$ | -- | -- | 30 | % | *1)*3)*5) | |
| Response Time | tr | $\theta_V=0^\circ, \theta_H=0^\circ$ | -- | 6 | -- | ms | *1)*4)*5) | |
| | tf | $\theta_V=0^\circ, \theta_H=0^\circ$ | -- | 19 | -- | ms | *1)*4)*5) | |
| Viewing Angle | Horizontal | θ_H | CR \geq 10 | -65~65 | -75~75 | -- | ° | *1)*5) |
| | Vertical | θ_V | | -50~40 | -60~50 | -- | ° | *1)*5) |
| | Horizontal | θ_H | CR \geq 5 | -70~70 | -80~80 | -- | ° | *1)*5) |
| | Vertical | θ_V | | -70~60 | -80~70 | -- | ° | *1)*5) |
| Image Sticking | tis | 2 h | -- | -- | 2 | s | *6) | |
| Color Coordinates | Red | Rx | $\theta_V=0^\circ, \theta_H=0^\circ$ | 0.575 | 0.605 | 0.635 | -- | *1) *5) |
| | | Ry | | 0.310 | 0.340 | 0.370 | | |
| | Green | Gx | | 0.281 | 0.311 | 0.341 | | |
| | | Gy | | 0.535 | 0.565 | 0.595 | | |
| | Blue | Bx | | 0.124 | 0.154 | 0.184 | | |
| | | By | | 0.100 | 0.130 | 0.160 | | |
| | White | Wx | | 0.283 | 0.313 | 0.343 | | |
| | | Wy | | 0.299 | 0.329 | 0.359 | | |

[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 = 6.5 mArms, Inverter frequency: 50 kHz

Measurement method for luminance and color coordinates is as follows.

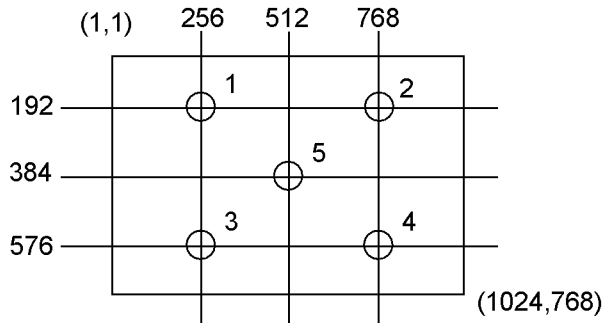


The luminance is measured according to FLAT PANEL DISPLAY MEASUREMENTS STANDARD (VESA Standard).

*1) Measurement Point

Contrast Ratio, Luminance, Response Time, Viewing Angle, Color Coordinates: Display Center

Luminance Uniformity: point 1~5 shown in a figure below



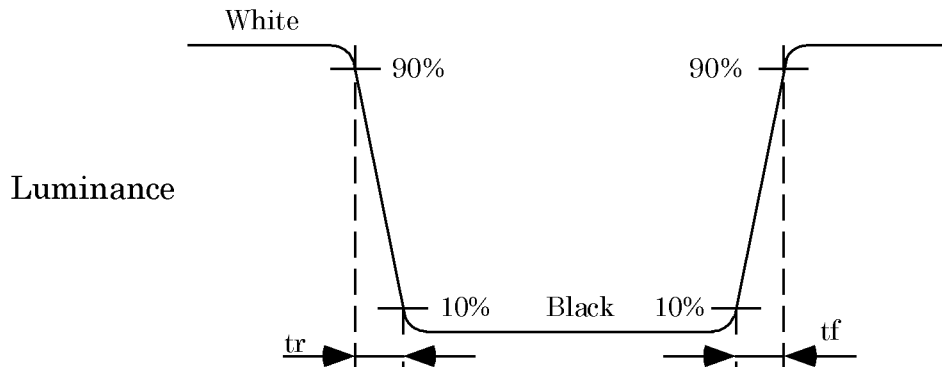
*2) Definition of Contrast Ratio

$CR = \text{Luminance with all white pixels} / \text{Luminance with all black pixels}$

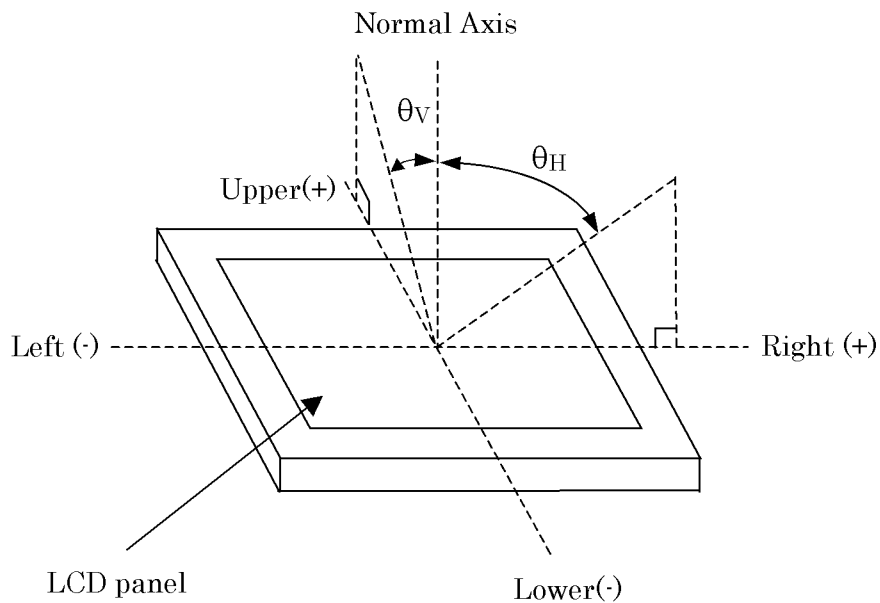
*3) Definition of Luminance Uniformity

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

*4) Definition of Response Time

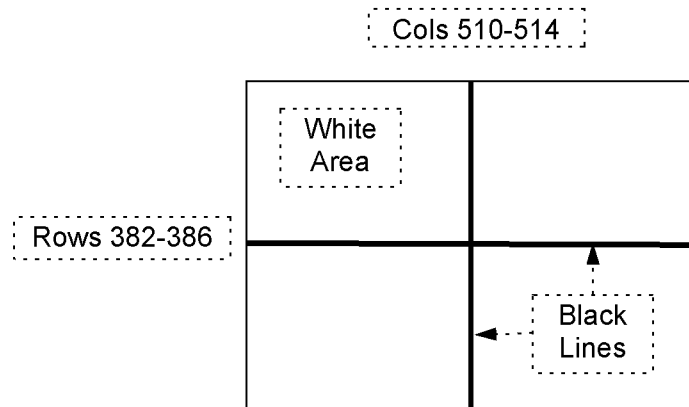


*5) Definition of Viewing Angle (θ_v, θ_H)



*6) 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.



TEST PATTERN FOR IMAGE STICKING TEST

10. RELIABILITY TEST CONDITION

(1) Temperature and Humidity

| ITEM | CONDITIONS |
|---|--|
| HIGH TEMPERATURE HIGH HUMIDITY OPERATION | 40°C, 90% RH, 240 h (No condensation) |
| HIGH TEMPERATURE OPERATION | 70°C, 240 h |
| LOW TEMPERATURE OPERATION | -20°C, 240 h |
| HIGH TEMPERATURE STORAGE | 80°C, 240 h |
| LOW TEMPERATURE STORAGE | -20°C, 240 h |
| THERMAL SHOCK (NON-OPERATION) | BETWEEN -20°C (1h) and 80°C(1h), 100 CYCLES |

(2) Shock & Vibration

| ITEM | CONDITIONS |
|------------------------------|---|
| SHOCK (NON-OPERATION) | Shock level: 980 m/s ² (100 G) Waveform: half sinusoidal wave, 2 ms Number of shocks: one shock input in each direction of three mutually Perpendicular axes for a total of six shock inputs |
| VIBRATION (NON-OPERATION) | Vibration level: 9.8 m/s ² (1.0 G) zero to peak Waveform: sinusoidal Frequency range: 5 to 500 Hz Frequency sweep rate: 0.5 octave /min 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)