

# **LK460D3LZ19**

## **TFT-LCD Module**

Spec. Issue Date: December 28, 2006

No: LD-18Z32

|                         |                                                                                                                                                                                         |                                                         |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| PREPARED BY :      DATE | <h1 style="text-align: center;">SHARP</h1> <p style="text-align: center;">AVC Liquid Crystal Display GROUP<br/>SHARP CORPORATION</p> <h2 style="text-align: center;">SPECIFICATION</h2> | SPEC No. LD-18Z32                                       |
| APPROVED BY :      DATE |                                                                                                                                                                                         | FILE No.                                                |
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|                         |                                                                                                                                                                                         | APPLICABLE GROUP<br>AVC Liquid Crystal Display<br>Group |

DEVICE SPECIFICATION FOR

# TFT-LCD Module

MODEL No.

# LK460D3LZ19

☐ CUSTOMER'S APPROVAL

DATE \_\_\_\_\_

BY \_\_\_\_\_

PRESENTED

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AVC Liquid Crystal Display Group

SHARP CORPORATION

SPEC No. : LD-18Z32

[illegible]

## 1. Application

This specification applies to the color 46.0" TFT-LCD module LK460D3LZ19.

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## 2. Overview

This module is a color active matrix LCD module incorporating amorphous silicon TFT (Thin Film Transistor). It is composed of a color TFT-LCD panel, driver ICs, control circuit, power supply circuit, inverter circuit and back light system etc. Graphics and texts can be displayed on a 1920×RGB×1080 dots panel with 16,777,216 colors by using LVDS (Low Voltage Differential Signaling) to interface, +12V of DC supply voltages.

This module also includes the DC/AC inverter to drive the CCFT. (+24V of DC supply voltage)

And in order to improve the response time of LCD, this module applies the Over Shoot driving (O/S driving) technology for the control circuit. In the O/S driving technology, signals are being applied to the Liquid Crystal according to a pre-fixed process as an image signal of the present frame when a difference is found between image signal of the previous frame and that of the current frame after comparing them.

With these technologies, image signals can be set so that liquid crystal response completes within one frame. As a result, motion blur reduces and clearer display performance can be realized.

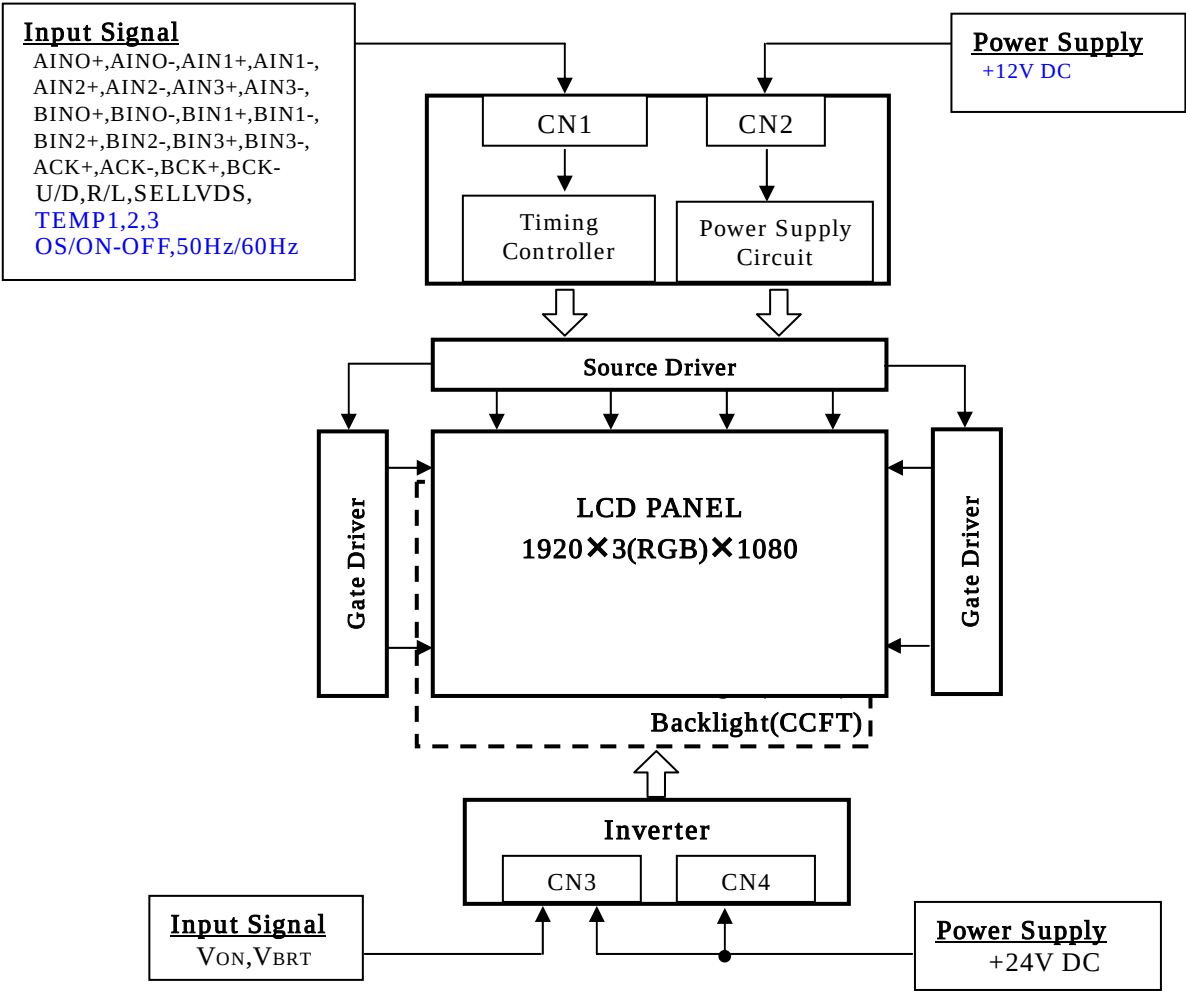
## 3. Mechanical Specifications

| Parameter                    | Specifications                                         | Unit  |
|------------------------------|--------------------------------------------------------|-------|
| Display size                 | 116.809 (Diagonal)                                     | cm    |
|                              | 46.0 (Diagonal)                                        | inch  |
| Active area                  | 1018.08(H) x 572.67(V)                                 | mm    |
| Pixel Format                 | 1920(H) x 1080(V)<br>(1pixel = R + G + B dot)          | pixel |
| Pixel pitch                  | 0.53025(H) x 0.53025(V)                                | mm    |
| Pixel configuration          | R, G, B vertical stripe                                |       |
| Display mode                 | Normally black                                         |       |
| Unit Outline Dimensions (*1) | 1083.0(W) x 627.0(H) x 65.7(D)                         | mm    |
| Mass                         | 17.1 ± 0.5                                             | kg    |
| Surface treatment            | Anti glare, low reflection coating<br>Hard coating: 2H |       |

(\*1) Outline dimensions are shown in Fig.1-1, Fig.1-2. (excluding protruding portion)

4. Input Terminals

4-1. Block Diagram



## 4-2. TFT panel driving

CN1 (Shown in Fig.1 : Outline dimensions)

Using connector : FI-RE41S-VF (Japan Aviation Electronics Ind. , Ltd.)

Mating connector : FI-RE41HL (Japan Aviation Electronics Ind. , Ltd.)

Mating LVDS transmitter : THC63LVDM83R(THine) or equivalent device

| Pin No. | Symbol    | Function                                          | Remark    |
|---------|-----------|---------------------------------------------------|-----------|
| 1       | GND       |                                                   |           |
| 2       | AIN0-     | Aport (-)LVDS CH0 differential data input         | LVDS      |
| 3       | AIN0+     | Aport (+)LVDS CH0 differential data input         | LVDS      |
| 4       | AIN1-     | Aport (-)LVDS CH1 differential data input         | LVDS      |
| 5       | AIN1+     | Aport (+)LVDS CH1 differential data input         | LVDS      |
| 6       | AIN2-     | Aport (-)LVDS CH2 differential data input         | LVDS      |
| 7       | AIN2+     | Aport (+)LVDS CH2 differential data input         | LVDS      |
| 8       | GND       |                                                   |           |
| 9       | ACK-      | Aport LVDS Clock signal(-)                        | LVDS      |
| 10      | ACK+      | Aport LVDS Clock signal(+)                        | LVDS      |
| 11      | AIN3-     | Aport (-)LVDS CH3 differential data input         | LVDS      |
| 12      | AIN3+     | Aport (+)LVDS CH3 differential data input         | LVDS      |
| 13      | GND       |                                                   |           |
| 14      | GND       |                                                   |           |
| 15      | GND       |                                                   |           |
| 16      | BIN0-     | Bport (-)LVDS CH0 differential data input         | LVDS      |
| 17      | BIN0+     | Bport (+)LVDS CH0 differential data input         | LVDS      |
| 18      | BIN1-     | Bport (-)LVDS CH1 differential data input         | LVDS      |
| 19      | BIN1+     | Bport (+)LVDS CH1 differential data input         | LVDS      |
| 20      | BIN2-     | Bport (-)LVDS CH2 differential data input         | LVDS      |
| 21      | BIN2+     | Bport (+)LVDS CH2 differential data input         | LVDS      |
| 22      | GND       |                                                   |           |
| 23      | BCK-      | Bport LVDS Clock signal(-)                        | LVDS      |
| 24      | BCK+      | Bport LVDS Clock signal(+)                        | LVDS      |
| 25      | BIN3-     | Bport (-)LVDS CH3 differential data input         | LVDS      |
| 26      | BIN3+     | Bport (+)LVDS CH3 differential data input         | LVDS      |
| 27      | GND       |                                                   |           |
| 28      | GND       |                                                   |           |
| 29      | GND       |                                                   |           |
| 30      | SELLVDS   | Select LVDS data order [Note1]                    | PULL UP   |
| 31      | R/L       | Horizontal shift direction [Note2]                | PULL DOWN |
| 32      | U/D       | Vertical shift direction [Note2]                  | PULL DOWN |
| 33      | NC        | It is required to set non-connection(OPEN)        |           |
| 34      | 50Hz/60Hz | Frame frequency setting H:60Hz, L:50Hz [Note3]    | PULL DOWN |
| 35      | NC        | It is required to set non-connection(OPEN)        |           |
| 36      | TEMP3     | Date3 of panel surface temperature [Note4]        | PULL UP   |
| 37      | TEMP2     | Date2 of panel surface temperature [Note4]        | PULL UP   |
| 38      | TEMP1     | Date1 of panel surface temperature [Note4]        | PULL UP   |
| 39      | NC        | It is required to set non-connection(OPEN)        |           |
| 40      | O/Sset    | O/S operation setting H:O/S_ON, L:O/S_OFF [Note4] | PULL UP   |
| 41      | NC        | It is required to set non-connection(OPEN)        |           |

[Note]GND of a liquid crystal panel drive part has connected with a module chassis.

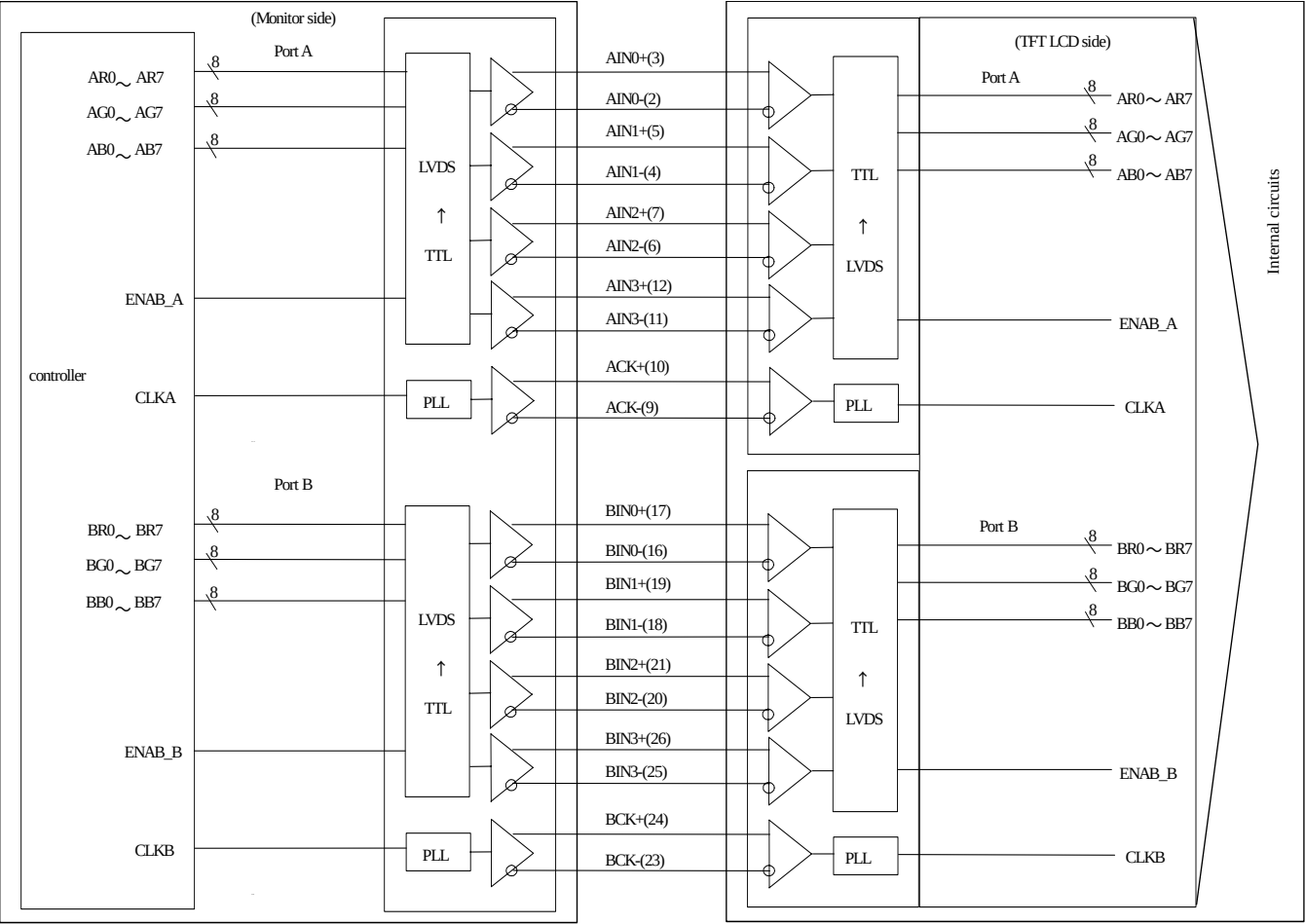
CN2 (Shown in Fig.1 Outline dimensions)

Using connector : BM20B-SHLDS-G-TFT (J.S.T. Mfg Co.,Ltd.)

Mating connector : SHLDP-20V-S-1(J.S.T. Mfg Co.,Ltd.)

| Pin No. | Symbol | Function                                   | Remark |
|---------|--------|--------------------------------------------|--------|
| 1       | Vcc    | +12V Power Supply                          |        |
| 2       | Vcc    | +12V Power Supply                          |        |
| 3       | Vcc    | +12V Power Supply                          |        |
| 4       | Vcc    | +12V Power Supply                          |        |
| 5       | Vcc    | +12V Power Supply                          |        |
| 6       | GND    | GND                                        |        |
| 7       | GND    | GND                                        |        |
| 8       | GND    | GND                                        |        |
| 9       | GND    | GND                                        |        |
| 10      | GND    | GND                                        |        |
| 11      | NC     | It is required to set non-connection(OPEN) |        |
| 12      | NC     | It is required to set non-connection(OPEN) |        |
| 13      | NC     | It is required to set non-connection(OPEN) |        |
| 14      | NC     | It is required to set non-connection(OPEN) |        |
| 15      | NC     | It is required to set non-connection(OPEN) |        |
| 16      | NC     | It is required to set non-connection(OPEN) |        |
| 17      | NC     | It is required to set non-connection(OPEN) |        |
| 18      | NC     | It is required to set non-connection(OPEN) |        |
| 19      | NC     | It is required to set non-connection(OPEN) |        |
| 20      | NC     | It is required to set non-connection(OPEN) |        |

• Interface block diagram  
Corresponding Transmitter: THC63LVDM83R (THine)





[Note 1]SELLVDS

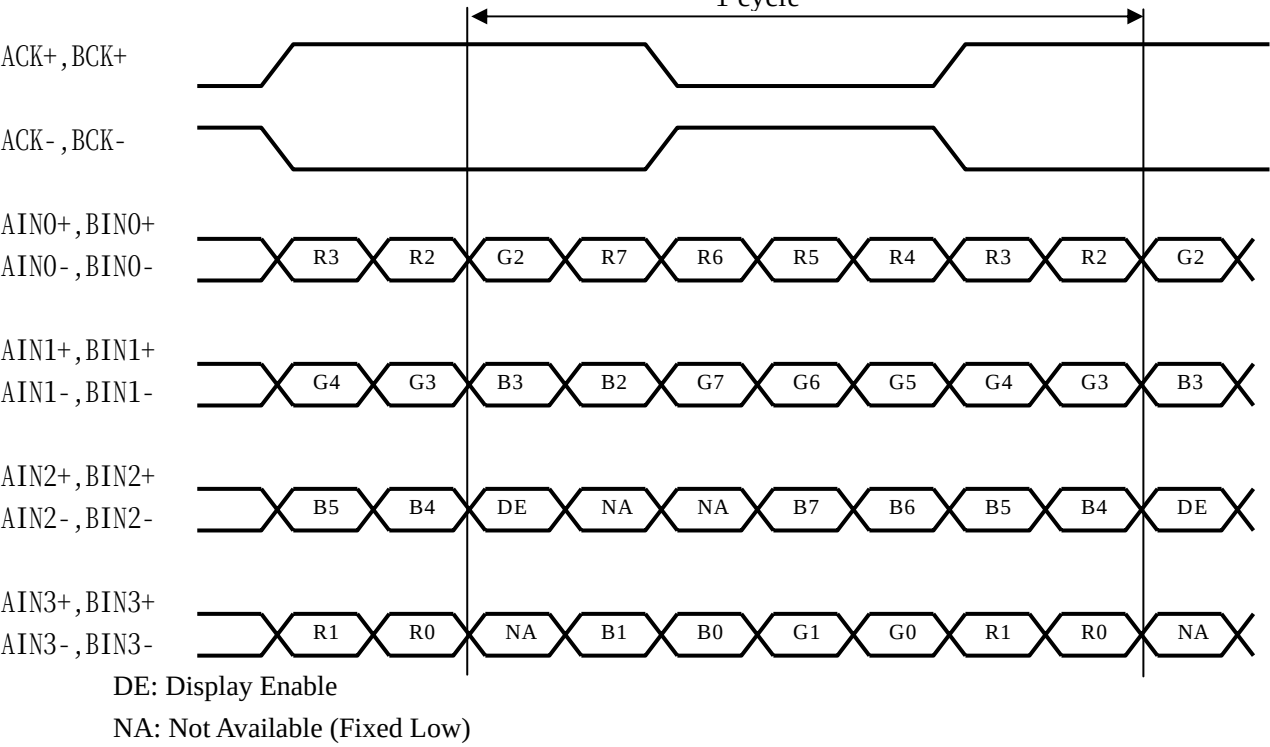
| Transmitter |      | SELLVDS |                  |
|-------------|------|---------|------------------|
| Pin No      | Data | =L(GND) | =H(3.3V) or Open |
| 51          | TA0  | R0(LSB) | R2               |
| 52          | TA1  | R1      | R3               |
| 54          | TA2  | R2      | R4               |
| 55          | TA3  | R3      | R5               |
| 56          | TA4  | R4      | R6               |
| 3           | TA5  | R5      | R7(MSB)          |
| 4           | TA6  | G0(LSB) | G2               |
| 6           | TB0  | G1      | G3               |
| 7           | TB1  | G2      | G4               |
| 11          | TB2  | G3      | G5               |
| 12          | TB3  | G4      | G6               |
| 14          | TB4  | G5      | G7(MSB)          |
| 15          | TB5  | B0(LSB) | B2               |
| 19          | TB6  | B1      | B3               |
| 20          | TC0  | B2      | B4               |
| 22          | TC1  | B3      | B5               |
| 23          | TC2  | B4      | B6               |
| 24          | TC3  | B5      | B7(MSB)          |
| 27          | TC4  | N A     | N A              |
| 28          | TC5  | N A     | N A              |
| 30          | TC6  | DE      | DE               |
| 50          | TD0  | R6      | R0(LSB)          |
| 2           | TD1  | R7(MSB) | R1               |
| 8           | TD2  | G6      | G0(LSB)          |
| 10          | TD3  | G7(MSB) | G1               |
| 16          | TD4  | B6      | B0(LSB)          |
| 18          | TD5  | B7(MSB) | B1               |
| 25          | TD6  | N A     | N A              |

NA: Not Available

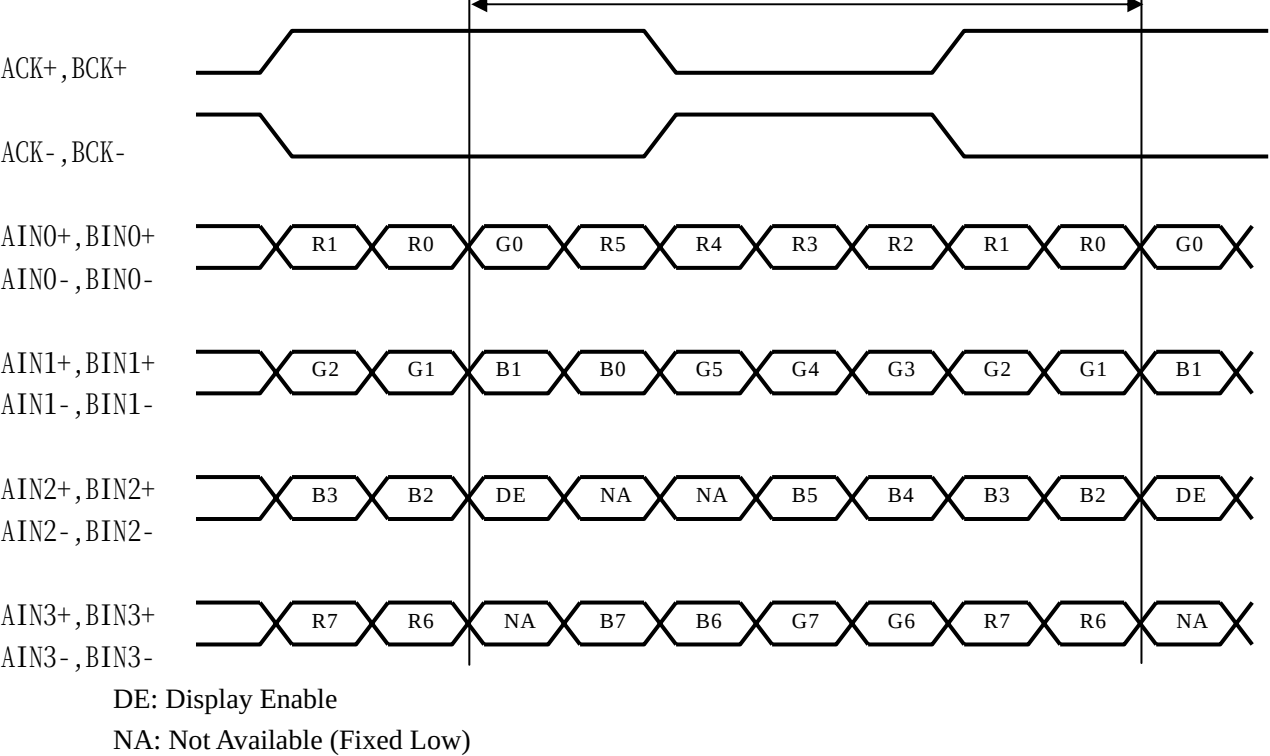
DE: Display Enable

(\*)Since the display position is prescribed by the rise of DE(Display Enable)signal, please do not fix DE signal during operation at “High”.

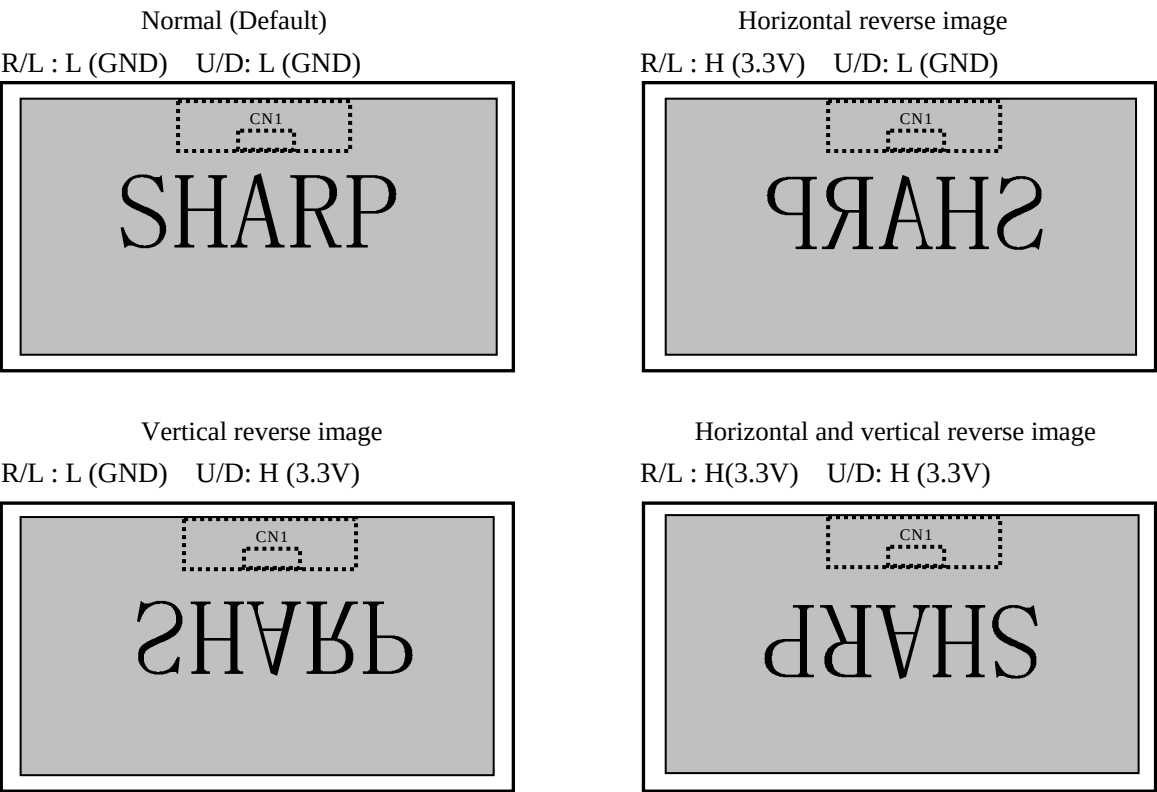
**SELLVDS= High (3.3V) or Open**



**SELLVDS= Low(GND)**



[Note 2] Display reversal function



[Note 3] Frame frequency setting                      \*L: Low level voltage (GND)    H: High level voltage(3.3V)

| Symbol    | Function                                  | Remark                |
|-----------|-------------------------------------------|-----------------------|
| 50Hz/60Hz | Frame frequency setting    H:60Hz, L:50Hz | Pull down 10kΩ: (GND) |

[Note 4] O/S control                                              \*L: Low level voltage (GND)    H: High level voltage(3.3V)

| Symbol    | Function                                   | Remark                      |
|-----------|--------------------------------------------|-----------------------------|
| OS/ON-OFF | O/S operating setting    H:OS_ON, L:OS_OFF | Pull up 10kΩ: (3.3V)    (*) |
| TEMP3     | Data3 of panel surface temperature         | Pull up 10kΩ: (3.3V)    (*) |
| TEMP2     | Data2 of panel surface temperature         | Pull up 10kΩ: (3.3V)    (*) |
| TEMP1     | Data1 of panel surface temperature         | Pull up 10kΩ: (3.3V)    (*) |

(\*) In case of OS/ON-OFF setting "L"(OS\_OFF), it should be set the TEMP1~3 to "L".

According as the surface temperature of the panel, enter the optimum 3 bit signal into pin No.4,5,6.  
Measuring the correlation between detected temperature by the sensor on PWB in users side and actual surface temperature of panel at center, convert the temperature detected by the sensor to the surface temperature of panel to enter the 3 bit temperature data.  
For overlapping temperatures (such as 5°C,10°C,15°C,20°C,25°C, 30°C,35°C) select the optimum parameter, judging from the actual picture image.

| Pin no. | Surface temperature of panel (assembled to the set) |        |         |         |         |         |         |                |
|---------|-----------------------------------------------------|--------|---------|---------|---------|---------|---------|----------------|
|         | 0-5°C                                               | 5-10°C | 10-15°C | 15-20°C | 20-25°C | 25-30°C | 30-35°C | 35°C and above |
| TEMP3   | 0                                                   | 0      | 0       | 0       | 1       | 1       | 1       | 1              |
| TEMP2   | 0                                                   | 0      | 1       | 1       | 0       | 0       | 1       | 1              |
| TEMP1   | 0                                                   | 1      | 0       | 1       | 0       | 1       | 0       | 1              |

\*0: Low level voltage (GND)    1: High level voltage(3.3V)

## 4-3. Backlight driving

CN3 (Inverter control and +24V DC power supply) (Shown in Fig.1 : Outline dimensions)

Using connector: S14B-PH-K-S (LF) (J.S.T. Mfg Co.,Ltd.)

Mating connector: PHR-14 (J.S.T. Mfg Co.,Ltd.)

| Pin No. | Symbol           | Function                                      | Remark   |
|---------|------------------|-----------------------------------------------|----------|
| 1       | V <sub>INV</sub> | 24V                                           |          |
| 2       | V <sub>INV</sub> | 24V                                           |          |
| 3       | V <sub>INV</sub> | 24V                                           |          |
| 4       | V <sub>INV</sub> | 24V                                           |          |
| 5       | V <sub>INV</sub> | 24V                                           |          |
| 6       | GND              | GND                                           |          |
| 7       | GND              | GND                                           |          |
| 8       | GND              | GND                                           |          |
| 9       | GND              | GND                                           |          |
| 10      | GND              | GND                                           |          |
| 11      | Reserved         | For LCD module internal usage, should be open |          |
| 12      | V <sub>ON</sub>  | Inverter ON/OFF                               | 【Note 1】 |
| 13      | V <sub>BRT</sub> | Brightness Control                            | 【Note 2】 |
| 14      | Reserved         | For LCD module internal usage, should be open |          |

\*GND of an inverter board is not connected to GND of a module chassis and a liquid crystal panel drive part.

CN4 (+24V DC power supply) (Shown in Fig.1 : Outline dimensions)

Using connector: S14B-PH-K-S (LF) (J.S.T. Mfg Co.,Ltd.)

Mating connector: PHR-14 (J.S.T. Mfg Co.,Ltd.)

| Pin No. | Symbol           | Function                                      | Remark |
|---------|------------------|-----------------------------------------------|--------|
| 1       | V <sub>INV</sub> | 24V                                           |        |
| 2       | V <sub>INV</sub> | 24V                                           |        |
| 3       | V <sub>INV</sub> | 24V                                           |        |
| 4       | V <sub>INV</sub> | 24V                                           |        |
| 5       | V <sub>INV</sub> | 24V                                           |        |
| 6       | GND              | GND                                           |        |
| 7       | GND              | GND                                           |        |
| 8       | GND              | GND                                           |        |
| 9       | GND              | GND                                           |        |
| 10      | GND              | GND                                           |        |
| 11      | Reserved         | For LCD module internal usage, should be open |        |
| 12      | Reserved         | For LCD module internal usage, should be open |        |
| 13      | Reserved         | For LCD module internal usage, should be open |        |
| 14      | Reserved         | For LCD module internal usage, should be open |        |

\*GND of an inverter board is not connected to GND of a module chassis and a liquid crystal panel drive part.

## 【Note 1】 Inverter ON/OFF

Pin No.12 is used for the control of the Inverter ON / OFF.

| Input voltage | Function       |
|---------------|----------------|
| 3.3V          | Inverter : ON  |
| 0V            | Inverter : OFF |

## 【Note 2】 Brightness control

PWM brightness control is regulated by analog input voltage (0V to 3.3V).

| Input voltage | Function                         |
|---------------|----------------------------------|
| 3.3V          | Brightness Maximum (Bright 100%) |
| 0V            | Brightness Minimum (Dark 20%)    |

## 4-4. The back light system characteristics

The back light system is direct type with 22 CCFTs (Cold Cathode Fluorescent Tube).

The characteristics of the lamp are shown in the following table.

The value mentioned below is at the case of one CCFT.

CCFC model : CFL3331A (Stanley Electric Co.,Ltd)

| Item      | Symbol         | Min. | Typ.  | Max. | Unit | Remarks |
|-----------|----------------|------|-------|------|------|---------|
| Life time | T <sub>L</sub> | -    | 60000 | -    | Hour | [Note]  |

[Note] • Lamp life time is defined as the time when brightness becomes 50% of the original value in the continuous operation under the condition of Ta=25°C.

- Above value is applicable when the long side of LCD module is placed horizontally (Landscape position).

## 5. Absolute Maximum Ratings

| Parameter                            | Symbol                              | Condition | Ratings    | Unit | Remark   |
|--------------------------------------|-------------------------------------|-----------|------------|------|----------|
| Input voltage<br>(for Control)       | V <sub>I</sub>                      | Ta=25 °C  | -0.3 ~ 3.6 | V    | [Note 1] |
| 12V supply voltage<br>(for Control)  | V <sub>CC</sub>                     | Ta=25 °C  | 0 ~ +14    | V    |          |
| Input voltage<br>(for Inverter)      | V <sub>BRT</sub><br>V <sub>ON</sub> | Ta=25 °C  | 0 ~ +6     | V    |          |
| 24V supply voltage<br>(for Inverter) | V <sub>INV</sub>                    | Ta=25 °C  | 0 ~ +29    | V    |          |
| Storage temperature                  | T <sub>stg</sub>                    | -         | -25 ~ +60  | °C   | [Note 2] |
| Operation temperature<br>(Ambient)   | T <sub>opa</sub>                    | -         | 0 ~ +50    | °C   |          |

[Note 1] SELLVDS, R/L, U/D, 50Hz/60Hz, OS/ON-OFF, TEMP3,2,1

[Note 2] Humidity 95%RH Max.(Ta≤40°C)

Maximum wet-bulb temperature at 39 °C or less.(Ta>40 °C)

No condensation.

## 6. Electrical Characteristics

## 6-1. Control circuit driving

Ta=25 °C

| Parameter                            |                | Symbol          | Min. | Typ. | Max. | Unit              | Remark                              |
|--------------------------------------|----------------|-----------------|------|------|------|-------------------|-------------------------------------|
| +12V supply voltage                  | Supply voltage | V <sub>CC</sub> | 11.4 | 12.0 | 12.6 | V                 | [Note 1]                            |
|                                      | Current        | I <sub>CC</sub> | -    | 0.85 | 1.8  | A                 | [Note 2]                            |
| Permissible input ripple voltage     |                | V <sub>RP</sub> | -    | -    | 100  | mV <sub>P-P</sub> | V <sub>CC</sub> = +12.0V            |
| Differential input threshold voltage | High           | V <sub>TH</sub> | -    | -    | 100  | mV                | V <sub>CM</sub> = +1.2V<br>[Note 6] |
|                                      | Low            | V <sub>TL</sub> | -100 | -    | -    | mV                |                                     |
| Input Low voltage                    |                | V <sub>IL</sub> | -    | -    | 0.8  | V                 | [Note 3]                            |
| Input High voltage                   |                | V <sub>IH</sub> | 2.0  | -    | 3.3  | V                 |                                     |
| Input leak current (Low)             |                | I <sub>IL</sub> | -    | -    | 400  | μA                | V <sub>I</sub> = 0V<br>[Note 4]     |
| Input leak current (High)            |                | I <sub>IH</sub> | -    | -    | 400  | μA                | V <sub>I</sub> = 3.3V<br>[Note 5]   |
| Terminal resistor                    |                | R <sub>T</sub>  | -    | 100  | -    | Ω                 | Differential input                  |

[Note] V<sub>CM</sub>: Common mode voltage of LVDS driver.

[Note 1]

Input voltage sequences

$$0 < t_1 \leq 10\text{ms}$$

$$10\text{ms} \leq t_{2-1} \leq 20\text{ms} \quad \text{Clock signal}$$

$$10\text{ms} \leq t_{2-2} \leq 1\text{s} \quad \text{Enable signal}$$

$$0 < t_3 \leq 1\text{s}$$

$$t_4 \geq 300\text{ms}$$

$$500\text{ms} \leq t_5$$

\*Please input data signals after clock confirmed.

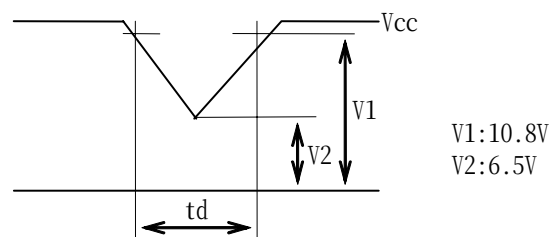
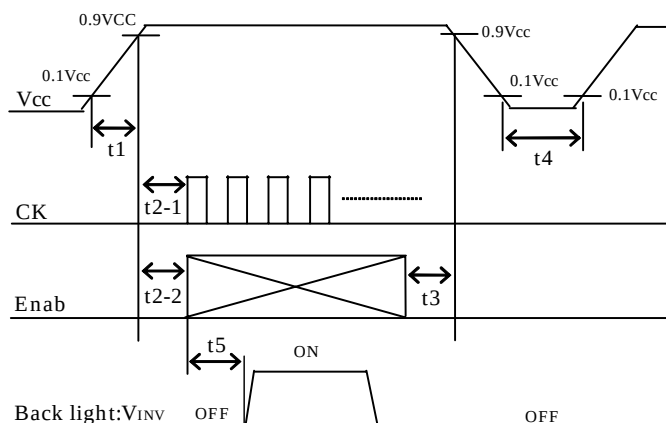
Dip conditions for supply voltage

$$\text{a) } 6.5\text{V} \leq V_{CC} < 10.8\text{V}$$

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

$$\text{b) } V_{CC} < 6.5\text{V}$$

Dip conditions for supply voltage is based on input voltage sequence.

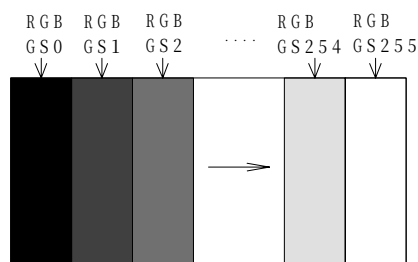


About the relation between data input and back light lighting, please base on the above-mentioned input sequence. When backlight is switched on before panel operation or after a panel operation stop, it may not display normally. But this phenomenon is not based on change of an incoming signal, and does not give damage to a liquid crystal display.

[Note 2] Maximum current situation: white (RGB GSS255)

Typical current situation: 256 gray-bar pattern

The explanation of RGB gray scale is seen in section 8.



$V_{CC} = 12.0\text{V}$   
 $CK = 74.25\text{MHz}$   
 $Th = 14.8\mu\text{s}$

[Note 3] R/L, U/D, SELLVDS, 50Hz/60Hz, OS/ON-OFF, TEMP3,2,1

[Note 4] SELLVDS,

[Note 5] R/L,U/D, 50Hz/60Hz, OS/ON-OFF, TEMP3,2,1

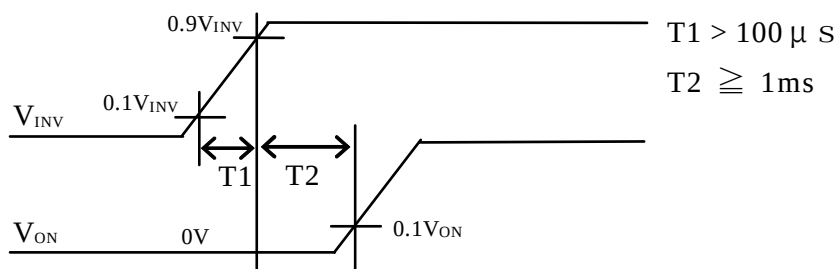
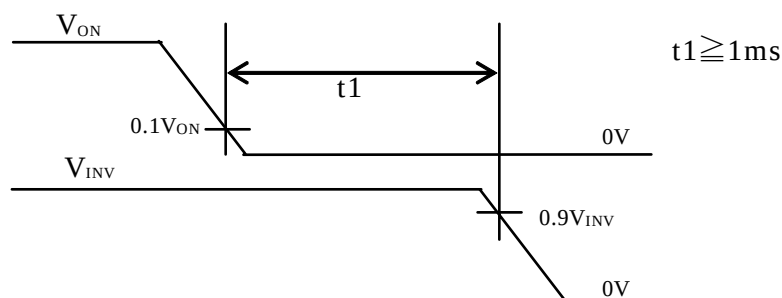
[Note 6]  $ACK \pm$ ,  $BCK \pm$ ,  $AIN0 \pm$ ,  $AIN1 \pm$ ,  $AIN2 \pm$ ,  $AIN3 \pm$ ,  $BIN0 \pm$ ,  $BIN1 \pm$ ,  $BIN2 \pm$ ,  $BIN3 \pm$

## 6-2. Inverter driving for back light

The back light system is direct type with 22 CCFTs (Cold Cathode Fluorescent Tube).

Ta=25°C

| Parameter                        | Symbol           | Min.              | Typ. | Max. | Unit | Remark                                                                                |
|----------------------------------|------------------|-------------------|------|------|------|---------------------------------------------------------------------------------------|
| +24V                             | Current 1        | I <sub>INV1</sub> | -    | 10.0 | A    | V <sub>INV</sub> = 24V<br>V <sub>BRT</sub> = 3.3V, V <sub>ON</sub> = 3.3V<br>【Note 4】 |
|                                  | Current 2        | I <sub>INV2</sub> | -    | 8.0  | A    |                                                                                       |
|                                  | Supply voltage   | V <sub>INV</sub>  | 22.8 | 24.0 | V    |                                                                                       |
| Permissible input ripple voltage | V <sub>RF</sub>  | -                 | -    | 200  | mV   | V <sub>INV</sub> = +24V                                                               |
| Input voltage (Low)              | V <sub>ONL</sub> | 0                 | -    | 1.0  | V    | 【Note 2】<br>impedance=2kΩ<br>(Min.)                                                   |
| Input voltage (High)             | V <sub>ONH</sub> | 3.0               | 3.3  | 5.0  | V    |                                                                                       |
| Input voltage                    | V <sub>BRT</sub> | 0                 | -    | 3.3  | V    | 【Note 3】<br>impedance=950kΩ<br>(Min.)                                                 |

【Note 1】 1)V<sub>INV</sub>(+24V) turn-on condition2) V<sub>INV</sub>(+24V) turn-off condition【Note 2】 V<sub>ON</sub>【Note 3】 V<sub>BRT</sub>

【Note 4】 Current1) Definition within 60 minutes after turn on. (Rush current is excluded.)

Current2) Definition more than 60 minutes after turn on.

【Note】 The inverter unit is driving at the following drive frequency.

\*The lamp drive frequency: 59kHz ± 2kHz

\*The burst Brightness control drive frequency: 275Hz ± 5Hz

The above drive frequency and the module drive frequency are cause and there is possibility Backlight display problem occurs. When setting the drive frequency of the module, The interference with the above frequency make not occur.



7. Timing characteristics of input signals

7-1. Timing characteristics

Timing diagrams of input signal are shown in Fig.2.

| Item                |                           | Symbol | Min  | Typ   | Max  | Unit  |
|---------------------|---------------------------|--------|------|-------|------|-------|
| DCLK                | Frequency                 | 1/Tc   | 55   | 74.25 | 80   | MHz   |
| DE<br>(Data Enable) | Horizontal total          | TH     | 1030 | 1100  | 1650 | CLOCK |
|                     |                           |        | 14.8 | 14.8  | -    | μs    |
|                     | Horizontal valid          | THd    | 960  | 960   | 960  | CLOCK |
|                     | Horizontal retrace period | TH-THd | 1.80 | 1.87  | -    | μs    |
|                     | Vertical total            | TV     | 1111 | 1125  | 1360 | LINE  |
|                     | Vertical valid            | TVd    | 1080 | 1080  | 1080 | LINE  |

- 【Note 1】 When vertical period is very long, flicker and etc. may occur.
- 【Note 2】 Please turn off the module after it shows the black screen.
- 【Note 3】 Please make sure that length of vertical period should become of an integral multiple of horizontal length of period. Otherwise, the screen may not display properly.

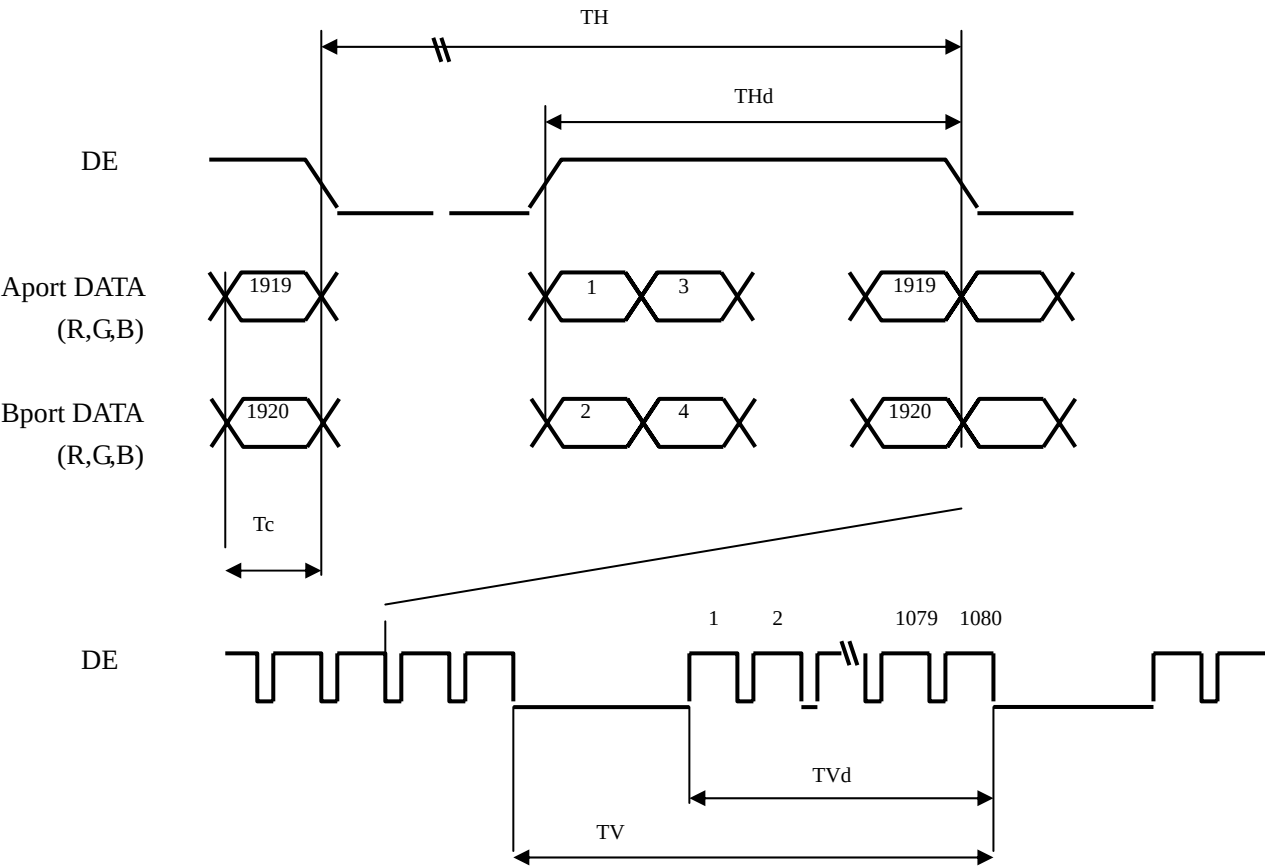
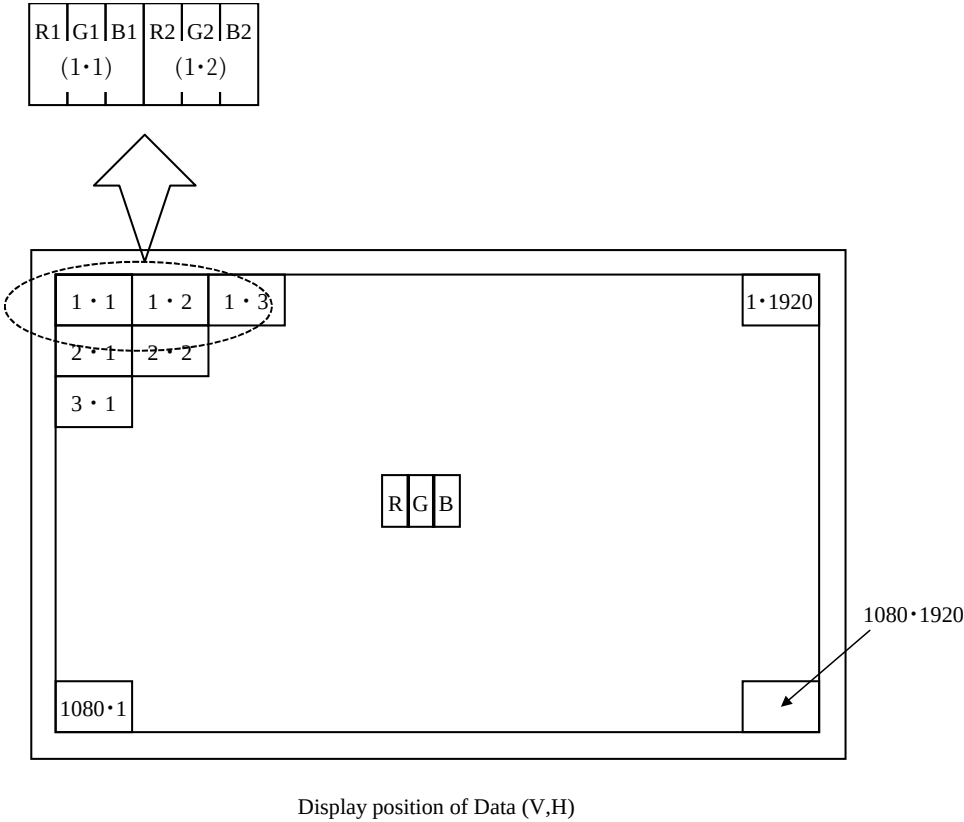


Fig.2 Timing characteristics of input signals

7-2. Input data signal and display position on the screen



## 8. Input Signal, Basic Display Colors and Gray Scale of Each Color

|                     | Colors &<br>Gray scale | Data signal   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |  |  |  |
|---------------------|------------------------|---------------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|--|--|--|
|                     |                        | Gray<br>Scale | R0 | R1 | R2 | R3 | R4 | R5 | R6 | R7 | G0 | G1 | G2 | G3 | G4 | G5 | G6 | G7 | B0 | B1 | B2 | B3 | B4 | B5 | B6 | B7 |  |  |  |
| 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  |  |  |  |
|                     | Blue                   | —             | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |  |  |  |
|                     | Green                  | —             | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | 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  |  |  |  |
|                     | Red                    | —             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | 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  |  |  |  |
| Gray Scale of Red   | Black                  | GS0           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↑                      | GS1           | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | Darker                 | GS2           | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↑                      | ↓             | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    |  |  |  |
|                     | ↓                      | ↓             | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    |  |  |  |
|                     | Brighter               | GS253         | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↓                      | GS254         | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | Red                    | GS255         | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
| Gray Scale of Green | Black                  | GS0           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↑                      | GS1           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | Darker                 | GS2           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↑                      | ↓             | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    |  |  |  |
|                     | ↓                      | ↓             | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    |  |  |  |
|                     | Brighter               | GS253         | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↓                      | GS254         | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | Green                  | GS255         | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
| Gray Scale of Blue  | Black                  | GS0           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↑                      | GS1           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | Darker                 | GS2           | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  |  |  |  |
|                     | ↑                      | ↓             | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    |  |  |  |
|                     | ↓                      | ↓             | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    | ↓  |    |    |    |    |    |    |    |  |  |  |
|                     | Brighter               | GS253         | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 1  | 1  | 1  | 1  | 1  | 1  |  |  |  |
|                     | ↓                      | GS254         | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |  |  |  |
|                     | Blue                   | GS255         | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |  |  |  |

0 : Low level voltage, 1 : High level voltage.

Each basic color can be displayed in 256 gray scales from 8 bit data signals. According to the combination of total 24 bit data signals, the 16-million-color display can be achieved on the screen.

## 9. Optical characteristics

Ta=25°C, V<sub>CC</sub> = 12.0V, V<sub>INV</sub> = 24.0V, V<sub>BRT</sub> = 3.3V

| Parameter            |            | Symbol           | Condition         | Min.  | Typ.  | Max.  | Unit              | Remark                        |
|----------------------|------------|------------------|-------------------|-------|-------|-------|-------------------|-------------------------------|
| Viewing angle range  | Vertical   | $\theta_{11,12}$ | $CR \geq 10$      | 80    | 88    | -     | Deg.              | [Note1,4]                     |
|                      | Horizontal | $\theta_{21,22}$ |                   | 80    | 88    | -     | Deg.              |                               |
| Contrast ratio       |            | CR               | $\theta = 0$ deg. | 900   | 1800  | -     |                   | [Note2,4]<br>$V_{BRT}=3.3V$   |
| Response time        |            | $\tau_d$         | $\theta = 0$ deg. | -     | 6     | -     | ms                | [Note3,4,5]<br>$V_{BRT}=3.3V$ |
|                      |            | $\tau_r$         |                   | -     | 6     | -     | ms                |                               |
| Chromaticity         | White      | $W_x$            | $\theta = 0$ deg. | 0.255 | 0.285 | 0.315 | -                 | [Note 4]<br>$V_{BRT}=3.3V$    |
|                      |            | $W_y$            |                   | 0.266 | 0.296 | 0.326 | -                 |                               |
|                      | Red        | $R_x$            | $\theta = 0$ deg. | 0.617 | 0.647 | 0.677 | -                 |                               |
|                      |            | $R_y$            |                   | 0.296 | 0.326 | 0.356 | -                 |                               |
|                      | Green      | $G_x$            | $\theta = 0$ deg. | 0.238 | 0.268 | 0.298 | -                 |                               |
|                      |            | $G_y$            |                   | 0.589 | 0.619 | 0.649 | -                 |                               |
|                      | Blue       | $B_x$            | $\theta = 0$ deg. | 0.110 | 0.140 | 0.170 | -                 |                               |
|                      |            | $B_y$            |                   | 0.051 | 0.081 | 0.111 | -                 |                               |
| Luminance of white   |            | $Y_L$            | $\theta = 0$ deg. | 360   | 450   | -     | cd/m <sup>2</sup> | [Note 4]<br>$V_{BRT}=3.3V$    |
| Luminance uniformity |            | $\delta_w$       | $\theta = 0$ deg. | -     | -     | 1.25  |                   | [Note 6]                      |

Measurement condition : Set the value of V<sub>BRT</sub> to maximum luminance of white.

\*The measurement shall be executed 60 minutes after lighting at rating.

【Note】 The optical characteristics are measured using the following equipment.

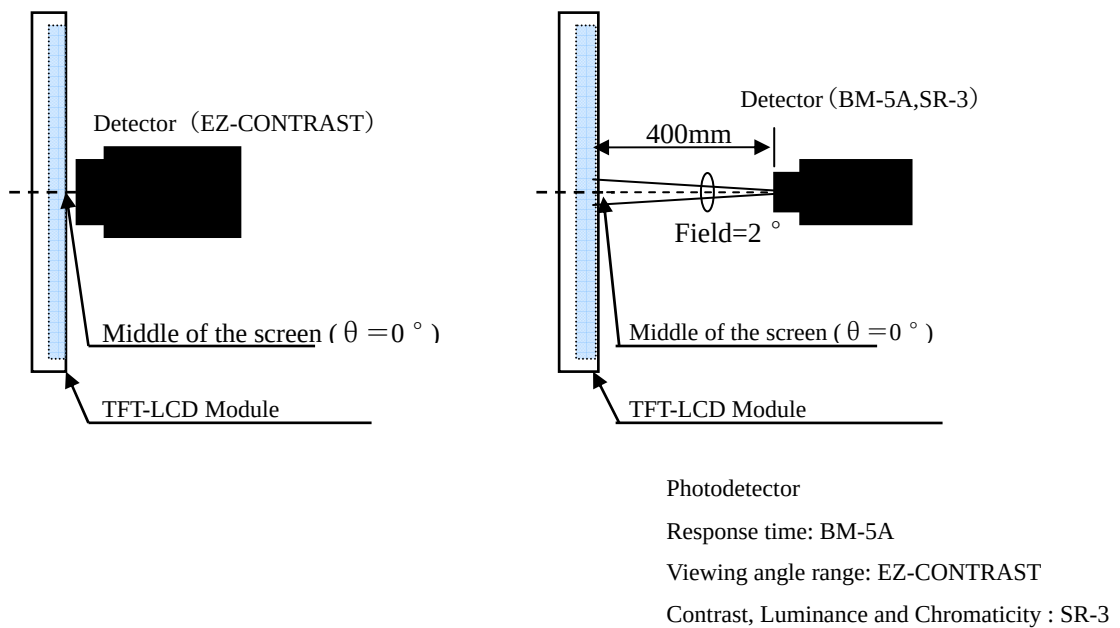
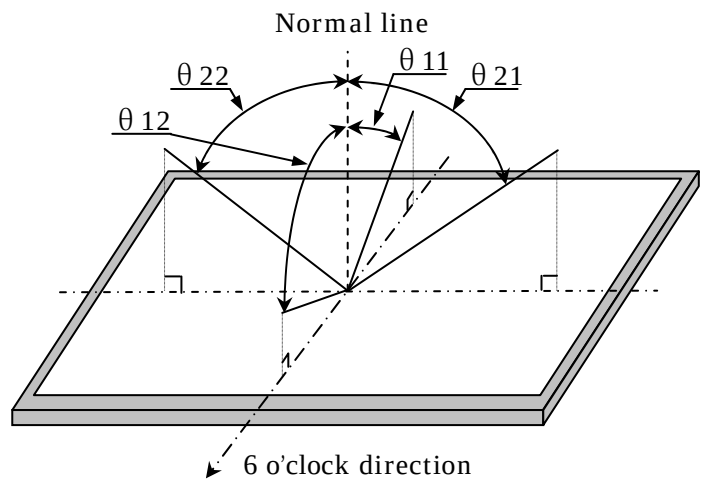


Fig3 Optical characteristics measurement

[Note 1]Definitions of viewing angle range :



[Note 2]Definition of contrast ratio :

The contrast ratio is defined as the following.

$$\text{Contrast Ratio} = \frac{\text{Luminance (brightness) with all pixels white}}{\text{Luminance (brightness) with all pixels black}}$$

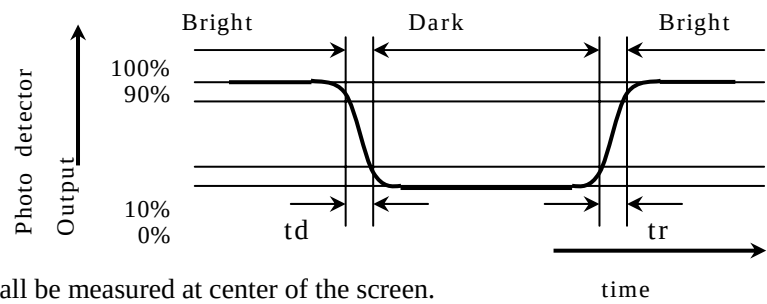
[Note 3]Definition of response time

The response time ( $\tau_d$  and  $\tau_r$ ) is defined as the following figure and shall be measured by switching the input signal for “any level of gray (0%, 25%, 50%, 75% and 100%)” and “any level of gray (0%, 25%, 50%, 75% and 100%)”.

|      | 0%          | 25%          | 50%          | 75%          | 100%         |
|------|-------------|--------------|--------------|--------------|--------------|
| 0%   |             | tr:0%-25%    | tr:0%-50%    | tr:0%-75%    | tr:0%-100%   |
| 25%  | td: 25%-0%  |              | tr: 25%-50%  | tr25%-75%    | tr: 25%-100% |
| 50%  | td: 50%-0%  | td: 50%-25%  |              | tr: 50%-75%  | tr: 50%-100% |
| 75%  | td: 75%-0%  | td: 75%-25%  | td: 75%-50%  |              | tr: 75%-100% |
| 100% | td: 100%-0% | td: 100%-25% | td: 100%-50% | td:10 0%-75% |              |

t\*:x-y...response time from level of gray(x) to level of gray(y)

$$\tau_r = \Sigma(\text{tr:x-y})/10, \tau_d = \Sigma(\text{td:x-y})/10$$



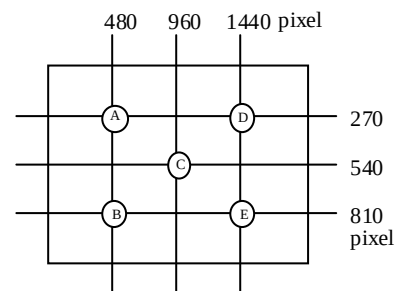
[Note 4] This shall be measured at center of the screen.

[Note 5] This value is valid when O/S driving is used at typical input time value.

[Note 6] Definition of white uniformity ;

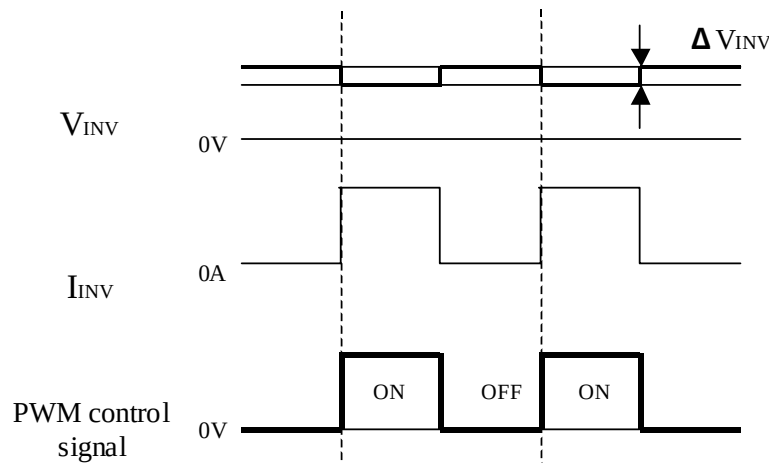
White uniformity is defined as the following with five measurements. (A~E)

$$\delta_w = \frac{\text{Maximum luminance of five points (brightness)}}{\text{Minimum luminance of five points (brightness)}}$$



## 10. Handling Precautions of the module

- Be sure to turn off the power supply when inserting or disconnecting the cable.
- This product is using the parts (inverter, CCFT etc), which generate the high voltage. Therefore, during operating, please don't touch these parts.
- Brightness control voltage is switched for "ON" and "OFF", as shown in Fig.4. Voltage difference generated by this switching,  $\Delta V_{INV}$ , may affect a sound output, etc. when the power supply is shared between the inverter and its surrounding circuit. So, separate the power supply of the inverter circuit with the one of its surrounding circuit.



- Be sure to design the cabinet so that the module can be installed without any extra stress such as warp or twist.
- Since the front polarizer is easily damaged, pay attention not to scratch it.
- Since long contact with water may cause discoloration or spots, wipe off water drop immediately.
- When the panel surface is soiled, wipe it with absorbent cotton or other soft cloth.
- Since the panel is made of glass, it may break or crack if dropped or bumped on hard surface. Handle with care.
- Since CMOS LSI is used in this module, take care of static electricity and take the human earth into consideration when handling.
- Please consider to minimize the influence of EMI and the exogenous noise before designing the grounding of LCD module.
- The module has some printed circuit boards (PCBs) and lamp cables on the back side, take care to keep them from any stress or pressure when handling or installing the module; otherwise some of electronic parts on the PCBs may be damaged.
- Observe all other precautionary requirements in handling components.

- m) When some pressure is added onto the module from rear side constantly, it causes display non-uniformity issue, functional defect, etc.. So, please avoid such design.
- n) When handling LCD modules and assembling them into cabinets, please be noted that long-term storage in the environment of oxidization or deoxidization gas and the use of such materials as reagent, solvent, adhesive, resin, etc. which generate these gasses, may cause corrosion and discoloration of the LCD modules.
- o) Lamps of the backlight are placed horizontally to the long side of LCD module. So make sure that the LCD module are placed horizontally (landscape position), as lifetime of backlight becomes shorter if placed at a tilt.
- p) Make sure that the LCD module is operated within specified temperature and humidity.  
Measures against dust, water, vibration, and heat radiation, etc. are required at the cabinet or equipment side.  
And image retention may occur if same fixed pattern is displayed for a long time. In some cases, it may not disappear. Please consider the design and operating environment.

## 11. Packing form

- a) Piling number of cartons : 2 maximum
- b) Packing quantity in one carton : 5 pcs.
- c) Carton size : 1186(W) × 572 (D) × 822 (H)
- d) Total mass of one carton filled with full modules : 100 kg (typ)
- e) Packing Form are shown in Fig.4

## 12. Reliability test item

| No. | Test item                                         | Condition                                                                                                                                                                                                                                                                                                    |        |
|-----|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| 1   | High temperature storage test                     | Ta=60°C 240h                                                                                                                                                                                                                                                                                                 |        |
| 2   | Low temperature storage test                      | Ta=-25°C 240h                                                                                                                                                                                                                                                                                                |        |
| 3   | High temperature and high humidity operation test | Ta=40°C ; 95%RH 240h<br>(No condensation)                                                                                                                                                                                                                                                                    |        |
| 4   | High temperature operation test                   | Ta=50°C 240h<br>(Panel surface temperature is below 60°C)                                                                                                                                                                                                                                                    |        |
| 5   | Low temperature operation test                    | Ta=0°C 240h                                                                                                                                                                                                                                                                                                  |        |
| 6   | Vibration test<br>(non-operation)                 | Frequency: 10~57Hz/Vibration width (one side): 0.075mm<br>: 58~500Hz/Acceleration: 9.8 m/ s <sup>2</sup><br>Sweep time: 11 minutes<br>Test period: 3 hours (1h for each direction of X, Y, Z)                                                                                                                | 【Note】 |
| 7   | Shock test<br>(non-operation)                     | Maximum acceleration: 490m/s <sup>2</sup><br>Pulse width: 11ms, sinusoidal half wave<br>Direction: ±X, ±Y, ±Z, once for each direction.                                                                                                                                                                      | 【Note】 |
| 8   | ESD                                               | * At the following conditions, it is a thing without incorrect operation and destruction.<br>(1)Non-operation: Contact electric discharge ±10kV<br>Non-contact electric discharge ±20kV<br>(2)Operation: Contact electric discharge ±8kV<br>Non-contact electric discharge ±15kV<br>Conditions: 150pF、330ohm |        |

【Note】 LCD panel misalignment is within tolerance levels after vibration and shock tests.

LCD module is supposed to be installed at the right position mentioned in the outline dimensions during vibration and shock tests.

【Result evaluation criteria】

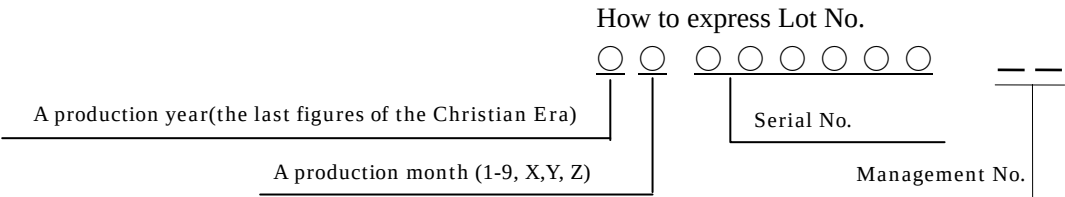
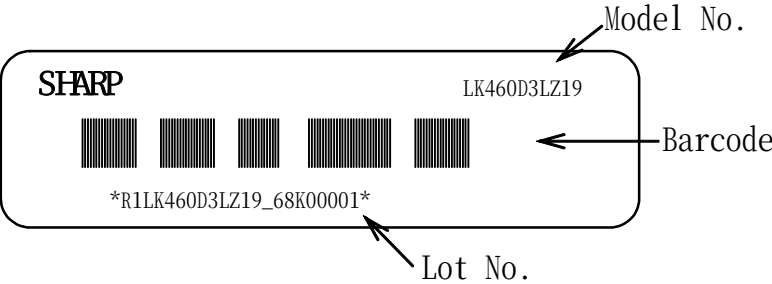
Under the display quality test condition with normal operation state, there shall be no change, which may affect practical display function.



13. Others

1) Lot No. Label:

The label that displays SHARP,product model(LK460D3LZ19),a product number is stuck on the back of the module.



2) Packing Label

社内品番 : ( 4 S ) LK460D3LZ19

Barcode

Lot NO. : ( 1 T ) 2006. \*. \*\* ( ② )

Barcode

Quantity : ( Q ) 5 pcs ( ③ )

Barcode

ユーザ品番 :

\*\*\*\*\*

シャープ物流用ラベルです。

- ① Management No. (LK460D3LZ19)
- ② Lot No. (Date)
- ③ Quantity

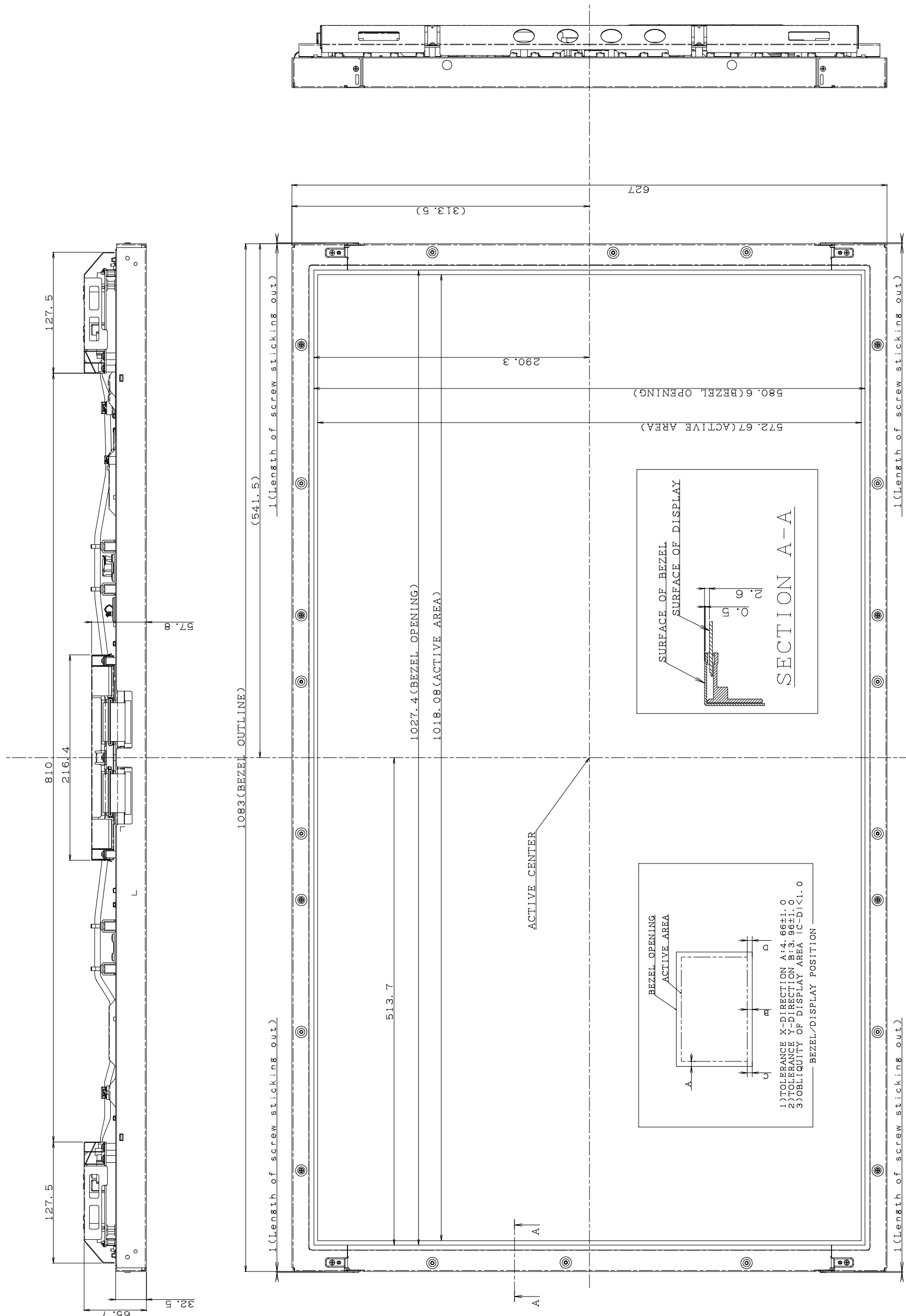
- 3) Adjusting volume have been set optimally before shipment, so do not change any adjusted value.  
If adjusted value is changed, the specification may not be satisfied.
- 4) Disassembling the module can cause permanent damage and should be strictly avoided.
- 5) Please be careful since image retention may occur when a fixed pattern is displayed for a long time.
- 6) Cold cathode fluorescent lamp in LCD PANEL contains a small amount of mercury. Please follow local ordinances or regulations for disposal. It is displaying the label in the module back.

COLD CATHODE FLUORESCENT LAMP IN LCD PANEL  
CONTAINS A SMALL AMOUNT OF MERCURY,PLEASE FOLLOW  
LOCAL ORDINANCES OR REGULATION FOR DISPOSAL  
当該液晶ディスプレイパネルは蛍光管が組み込まれていますので、地方自治体の条例、または、規則に従って廃棄ください。

- 7) Lead-free soldering is applied.
- 8) The chemical compound, which causes the destruction of ozone layer, is not being used.
- 9) Appearance quality and standard are referred to the outgoing incoming inspections.

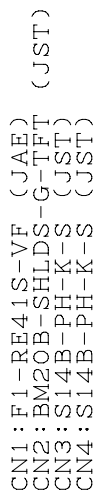
#### 14. Carton storage condition

|                     |                                                                                                                                                                                                                                                        |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Temperature         | 0°C to 40°C                                                                                                                                                                                                                                            |
| Humidity            | 95%RH or less                                                                                                                                                                                                                                          |
| Reference condition | : 20°C to 35°C , 85%RH or less (summer)<br>: 5°C to 15°C , 85%RH or less (winter)<br>• the total storage time (40°C,95%RH) : 240H or less                                                                                                              |
| Sunlight            | Be sure to shelter a product from the direct sunlight.                                                                                                                                                                                                 |
| Atmosphere          | Harmful gas, such as acid and alkali which bites electronic components and/or wires must not be detected.                                                                                                                                              |
| Notes               | Be sure to put cartons on palette or base, don't put it on floor, and store them with removing from wall<br>Please take care of ventilation in storehouse and around cartons, and control changing temperature is within limits of natural environment |
| Storage life        | 1 year                                                                                                                                                                                                                                                 |



UNSPECIFIED TOLERANCE TO BE  $\pm 1.0$   
UNIT: mm

# Fig 1-1. LK460D3LZ19 Outline dimensions (1/2)



UNSPECIFIED TOLERANCE TO BE  $\pm 1.0$   
UNIT: mm

THE 1-2-3-4-6-9-13-19-25-36-49-61-74-85-96-105-112-119-126-133-140-149-156-165-174-183-192-201-210-219-228-237-246-255-264-273-282-291-300-309-318-327-336-345-354-363-372-381-390-399-408-417-426-435-444-453-462-471-480-489-498-507-516-525-534-543-552-561-570-579-588-597-606-615-624-633-642-651-660-669-678-687-696-705-714-723-732-741-750-759-768-777-786-795-804-813-822-831-840-849-858-867-876-885-894-903-912-921-930-939-948-957-966-975-984-993-1002-1011-1020-1029-1038-1047-1056-1065-1074-1083-1092-1101-1110-1119-1128-1137-1146-1155-1164-1173-1182-1191-1200-1209-1218-1227-1236-1245-1254-1263-1272-1281-1290-1300-1309-1318-1327-1336-1345-1354-1363-1372-1381-1390-1400-1409-1418-1427-1436-1445-1454-1463-1472-1481-1490-1500-1509-1518-1527-1536-1545-1554-1563-1572-1581-1590-1600-1609-1618-1627-1636-1645-1654-1663-1672-1681-1690-1700-1709-1718-1727-1736-1745-1754-1763-1772-1781-1790-1800-1809-1818-1827-1836-1845-1854-1863-1872-1881-1890-1900-1909-1918-1927-1936-1945-1954-1963-1972-1981-1990-2000-2009-2018-2027-2036-2045-2054-2063-2072-2081-2090-2100-2109-2118-2127-2136-2145-2154-2163-2172-2181-2190-2200-2209-2218-2227-2236-2245-2254-2263-2272-2281-2290-2300-2309-2318-2327-2336-2345-2354-2363-2372-2381-2390-2400-2409-2418-2427-2436-2445-2454-2463-2472-2481-2490-2500-2509-2518-2527-2536-2545-2554-2563-2572-2581-2590-2600-2609-2618-2627-2636-2645-2654-2663-2672-2681-2690-2700-2709-2718-2727-2736-2745-2754-2763-2772-2781-2790-2800-2809-2818-2827-2836-2845-2854-2863-2872-2881-2890-2900-2909-2918-2927-2936-2945-2954-2963-2972-2981-2990-3000-3009-3018-3027-3036-3045-3054-3063-3072-3081-3090-3100-3109-3118-3127-3136-3145-3154-3163-3172-3181-3190-3200-3209-3218-3227-3236-3245-3254-3263-3272-3281-3290-3300-3309-3318-3327-3336-3345-3354-3363-3372-3381-3390-3400-3409-3418-3427-3436-3445-3454-3463-3472-3481-3490-3500-3509-3518-3527-3536-3545-3554-3563-3572-3581-3590-3600-3609-3618-3627-3636-3645-3654-3663-3672-3681-3690-3700-3709-3718-3727-3736-3745-3754-3763-3772-3781-3790-3800-3809-3818-3827-3836-3845-3854-3863-3872-3881-3890-3900-3909-3918-3927-3936-3945-3954-3963-3972-3981-3990-4000-4009-4018-4027-4036-4045-4054-4063-4072-4081-4090-4100-4109-4118-4127-4136-4145-4154-4163-4172-4181-4190-4200-4209-4218-4227-4236-4245-4254-4263-4272-4281-4290-4300-4309-4318-4327-4336-4345-4354-4363-4372-4381-4390-4400-4409-4418-4427-4436-4445-4454-4463-4472-4481-4490-4500-4509-4518-4527-4536-4545-4554-4563-4572-4581-4590-4600-4609-4618-4627-4636-4645-4654-4663-4672-4681-4690-4700-4709-4718-4727-4736-4745-4754-4763-4772-4781-4790-4800-4809-4818-4827-4836-4845-4854-4863-4872-4881-4890-4900-4909-4918-4927-4936-4945-4954-4963-4972-4981-4990-5000-5009-5018-5027-5036-5045-5054-5063-5072-5081-5090-5100-5109-5118-5127-5136-5145-5154-5163-5172-5181-5190-5200-5209-5218-5227-5236-5245-5254-5263-5272-5281-5290-5300-5309-5318-5327-5336-5345-5354-5363-5372-5381-5390-5400-5409-5418-5427-5436-5445-5454-5463-5472-5481-5490-5500-5509-5518-5527-5536-5545-5554-5563-5572-5581-5590-5600-5609-5618-5627-5636-5645-5654-5663-5672-5681-5690-5700-5709-5718-5727-5736-5745-5754-5763-5772-5781-5790-5800-5809-5818-5827-5836-5845-5854-5863-5872-5881-5890-5900-5909-5918-5927-5936-5945-5954-5963-5972-5981-5990-6000-6009-6018-6027-6036-6045-6054-6063-6072-6081-6090-6100-6109-6118-6127-6136-6145-6154-6163-6172-6181-6190-6200-6209-6218-6227-6236-6245-6254-6263-6272-6281-6290-6300-6309-6318-6327-6336-6345-6354-6363-6372-6381-6390-6400-6409-6418-6427-6436-6445-6454-6463-6472-6481-6490-6500-6509-6518-6527-6536-6545-6554-6563-6572-6581-6590-6600-6609-6618-6627-6636-6645-6654-6663-6672-6681-6690-6700-6709-6718-6727-6736-6745-6754-6763-6772-6781-6790-6800-6809-6818-6827-6836-6845-6854-6863-6872-6881-6890-6900-6909-6918-6927-6936-6945-6954-6963-6972-6981-6990-7000-7009-7018-7027-7036-7045-7054-7063-7072-7081-7090-7100-7109-7118-7127-7136-7145-7154-7163-7172-7181-7190-7200-7209-7218-7227-7236-7245-7254-7263-7272-7281-7290-7300-7309-7318-7327-7336-7345-7354-7363-7372-7381-7390-7400-7409-7418-7427-7436-7445-7454-7463-7472-7481-7490-7500-7509-7518-7527-7536-7545-7554-7563-7572-7581-7590-7600-7609-7618-7627

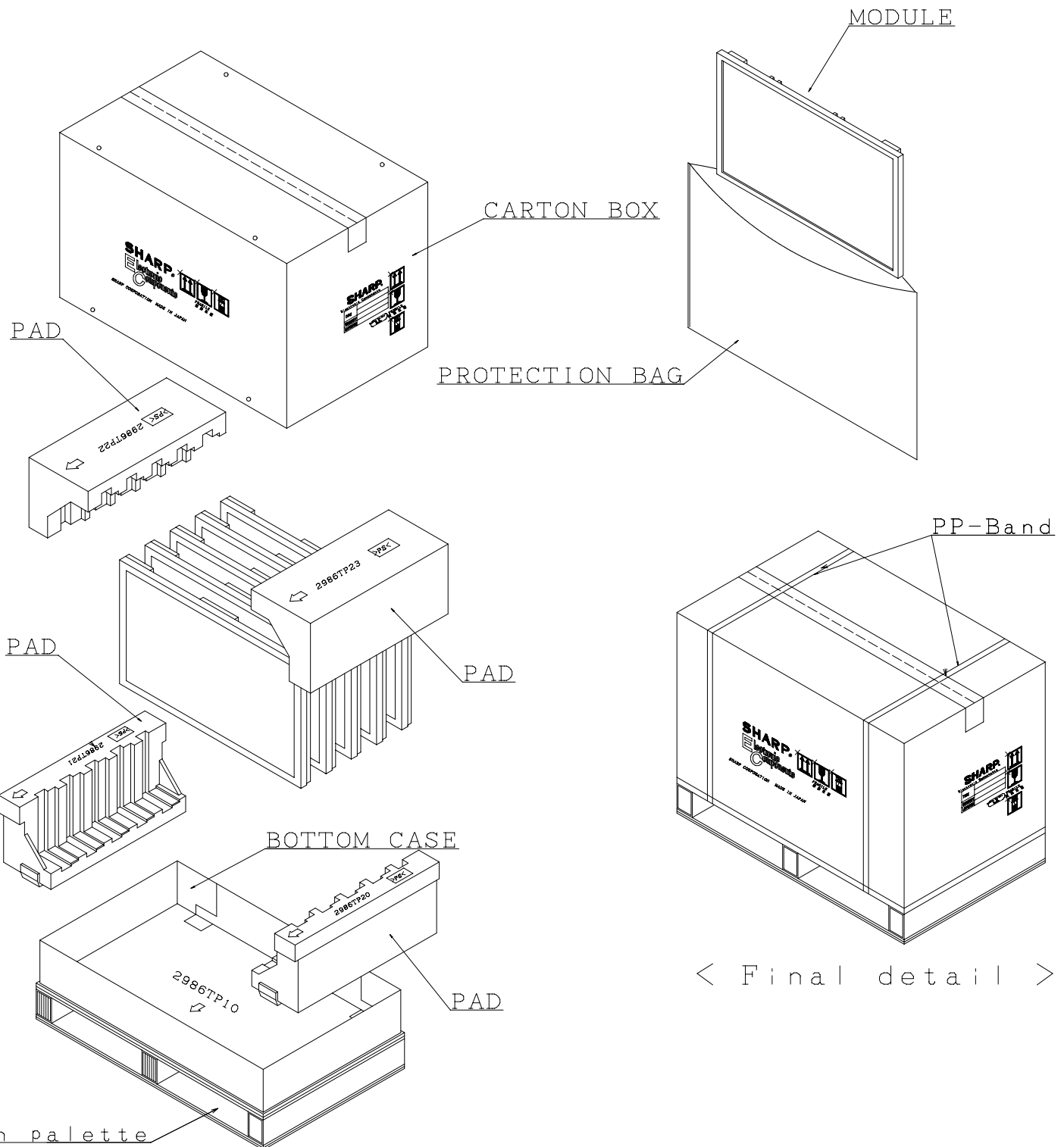


Fig 4. Module packing form

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