KOE

JDI Group

Kaohsiung Opto-Electronics Inc.

FOR MESSRS : _____ DATE : Mar. 26th ,2020

# CUSTOMER'S ACCEPTANCE SPECIFICATIONS

# TX09D200VM0BAA

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ACCEPTED BY : _____ PROPOSED BY : Oblack Tsai

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# 3. GENERAL DATA

## 3.1 DISPLAY FEATURES

This module is a 3.5” QVGA of 3:4 format amorphous silicon TFT. The pixel format is vertical stripe and sub pixels are arranged as R(red), G(green), B(blue) sequentially. This display is RoHS compliant, and COG (chip on glass) technology and LED backlight are applied on this display

| | |
|---|---|
| Part Name | TX09D200VM0BAA |
| Module Dimensions | 65.68(W) mm x 88.8(H) mm x 9.95(D) mm |
| LCD Active Area | 53.28(W) mm x 71.04(H) mm |
| Pixel Pitch | 0.222(W) mm x 0.222(H) mm |
| Resolution | 240 x 3(RGB)(W) x 320(H) dots |
| Color Pixel Arrangement | R, G, B Vertical stripe |
| LCD Type | Transmissive Color TFT; Normally Black |
| Display Type | Active Matrix |
| Number of Colors | 16.7M Colors (8-bit RGB) |
| Backlight | Light Emitting Diode (LED) |
| Weight | 72g |
| Interface | C-MOS; 50 pins |
| Power Supply Voltage | 3.3V for LCD ; 12V for Backlight |
| Power Consumption | 82.5mW for LCD; 1020mW for B/L |
| Viewing Direction | Super Wide Version (In Plane Switching) |

# 4. ABSOLUTE MAXIMUM RATINGS

| Item | Symbol | Min. | Max. | Unit | Remarks |
|---|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | -0.3 | 4.0 | V | - |
| Input Voltage of Logic | $V_I$ | -0.3 | $V_{DD}$ +0.3 | V | Note 1 |
| Operating Temperature | Top | -40 | 85 | °C | Note 2 |
| Storage Temperature | Tst | -40 | 90 | °C | Note 2 |

Note 1: The rating is defined for the signal voltages of the interface such as Hsync, Vsync, DE, DCLK and RGB data bus.

Note 2: The maximum rating is defined as above based on the chamber temperature, which might be different from ambient temperature after assembling the panel into the application. Moreover, some temperature-related phenomenon as below needed to be noticed:

- Background color, contrast and response time would be different in temperatures other than 25°C.
- Operating under high temperature will shorten LED lifetime.

# 5. ELECTRICAL CHARACTERISTICS

## 5.1 LCD CHARACTERISTICS

$T_a = 25\ ^\circ C,\ \text{Vss} = 0\text{V}$

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| Power Supply Voltage | $V_{DD}$ | - | 3.0 | 3.3 | 3.6 | V | - |
| Input Voltage of Logic | $V_I$ | "H" level | $0.7V_{DD}$ | - | $V_{DD}$ | V | Note 1 |
| | | "L" level | $V_{SS}$ | - | $0.3V_{DD}$ | | |
| Power Supply Current | $I_{DD}$ | $V_{DD}$-$V_{SS}$ =3.3V | - | 25 | 40 | mA | Note 2,3 |
| Frame Frequency | $f_{Frame}$ | - | - | 60 | 66 | Hz | - |
| CLK Frequency | $f_{CLK}$ | - | 6.0 | 6.5 | 7.0 | MHz | |

Note 1: The rating is defined for the signal voltages of the interface such as Hsync, Vsync, DE, DCLK and RGB data bus.

Note 2: An all white check pattern is used when measuring $I_{DD}$, $f_{Frame}$ is set to 60 Hz.

Note 3: 0.32A fuse is applied in the module for $I_{DD}$. For display activation and protection purpose, power supply is recommended larger than 0.8A to start the display and break fuse once any short circuit occurred.

## 5.2 BACKLIGHT CHARACTERISTICS

$T_a = 25\ ^\circ C$

| Item | Symbol | Condition | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|---|
| LED Input Voltage | $V_{LED}$ | - | 11.5 | 12.0 | 12.5 | V | Note1 |
| LED Forward Current | $I_{LED}$ | 0V; 0% duty | 65 | 85 | 100 | mA | Note 2 |
| | | 3.3VDC; 100% duty | 10 | 18 | 25 | | |
| LED lifetime | - | $I_{LED}$=85 mA | - | 70K | - | hrs | Note 3 |

Note 1: As Fig. 5.1 shown, LED current is constant, 85 mA, controlled by the LED driver when applying 12V $V_{LED}$.

Note 2: Dimming function can be obtained by applying DC voltage or PWM signal from the display interface CN1. The recommended PWM signal is 1K ~ 10K Hz with 3.3V amplitude.

Note 3: The estimated lifetime is specified as the time to reduce 50% brightness by applying 85 mA at 25 °C.

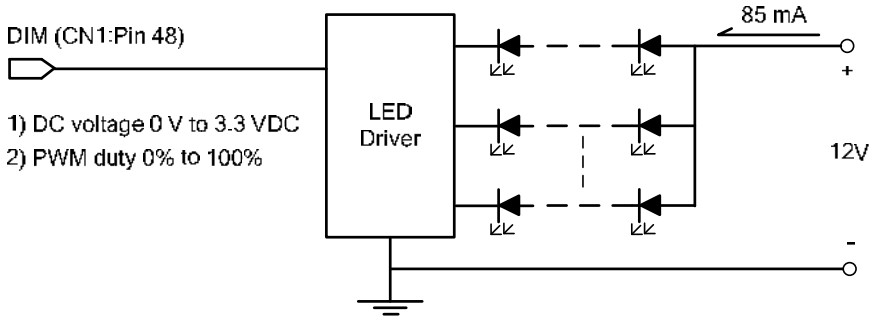



Fig 5.1

# 6. OPTICAL CHARACTERISTICS

The optical characteristics are measured based on the conditions as below:

- Supplying the signals and voltages defined in the section of electrical characteristics.
- The backlight unit needs to be turned on for 30 minutes.
- The ambient temperature is 25°C.
- In the dark room less than 100 lx, the equipment has been set for the measurements as shown in Fig 6.1.

$T_a = 25\ ^{\circ}C$, $f_{Frame} = 60$ Hz, $V_{DD} = 3.3V$

| Item | | Symbol | Condition | Min. | Typ. | Max. | Unit | Remarks |
|---|---|---|---|---|---|---|---|---|
| Brightness of White | | - | $\phi = 0^{\circ}, \theta = 0^{\circ}$, $I_{LED}$= 85mA | 480 | 600 | - | $cd/m^2$ | Note 1 |
| Brightness Uniformity | | - | | 75 | - | - | % | Note 2 |
| Contrast Ratio | | CR | | 720 | 900 | - | - | Note 3 |
| Response Time | | | $\phi = 0^{\circ}, \theta = 0^{\circ}$ | - | - | 53 | ms | - |
| NTSC Ratio | | - | $\phi = 0^{\circ}, \theta = 0^{\circ}$ | - | 65 | - | % | - |
| Viewing Angle | | $\theta$ x | $\phi = 0^{\circ}$, CR ≥ 10 | - | 85 | - | Degree | Note 5 |
| | | $\theta$ x′ | $\phi = 180^{\circ}$, CR ≥ 10 | - | 85 | - | | |
| | | $\theta$ y | $\phi = 90^{\circ}$, CR ≥ 10 | - | 85 | - | | |
| | | $\theta$ y′ | $\phi = 270^{\circ}$, CR ≥ 10 | - | 85 | - | | |
| Color Chromaticity | Red | X | $\phi = 0^{\circ}, \theta = 0^{\circ}$ | 0.60 | 0.65 | 0.70 | - | Note 6 |
| | | Y | | 0.27 | 0.32 | 0.37 | | |
| | Green | X | | 0.29 | 0.34 | 0.39 | | |
| | | Y | | 0.55 | 0.60 | 0.65 | | |
| | Blue | X | | 0.10 | 0.15 | 0.20 | | |
| | | Y | | 0.04 | 0.09 | 0.14 | | |
| | White | X | | 0.27 | 0.32 | 0.37 | | |
| | | Y | | 0.30 | 0.35 | 0.40 | | |

Note 1: The brightness is measured from the panel center point, P5 in Fig. 6.2, for the typical value.

Note 2: The brightness uniformity is calculated by the equation as below:

$$\text{Brightness uniformity} = \frac{\text{Min. Brightness}}{\text{Max. Brightness}} \times 100\%$$

which is based on the brightness values of the 9 points in active area measured by BM-5 as shown in Fig. 6.2.

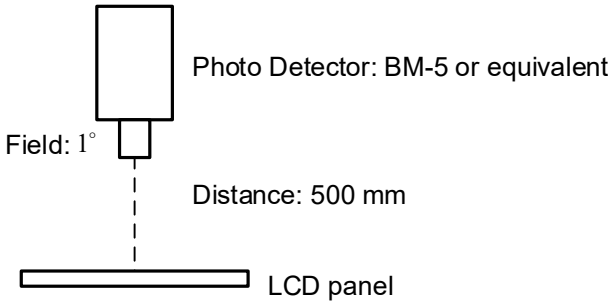



Fig 6.1

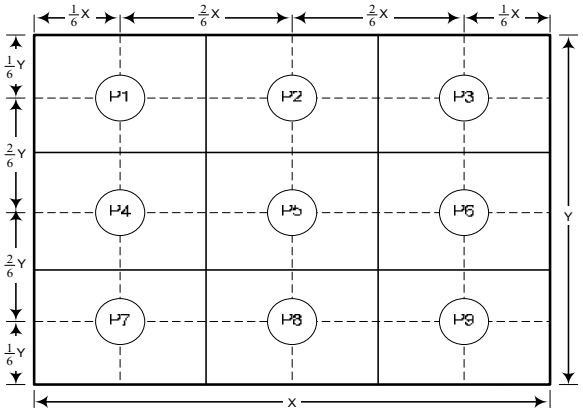



Fig 6.2

Note 3: The Contrast Ratio is measured from the center point of the panel, P5, and defined as the following equation:

$$CR = \frac{\text{Brightness of White}}{\text{Brightness of Black}}$$

Note 4: The definition of response time is shown in Fig. 6.3. The rising time is the period from 10% brightness to 90% brightness when the data is from black to white. Oppositely, Falling time is the period from 90% brightness rising to 10% brightness.

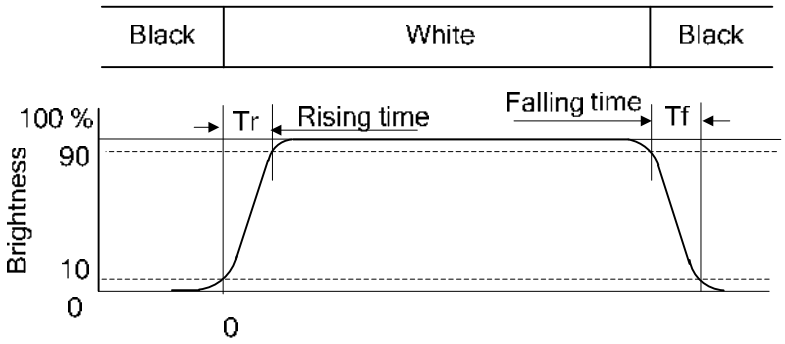



Fig 6.3

Note 5: The definition of viewing angle is shown in Fig. 6.4. Angle $\phi$ is used to represent viewing directions, for instance, $\phi = 270^\circ$ means 6 o'clock, and $\phi = 0^\circ$ means 3 o'clock. Moreover, angle $\theta$ is used to represent viewing angles from axis Z toward plane XY.

The display is super wide viewing angle version; 85° viewing angle can be obtained from each viewing direction.

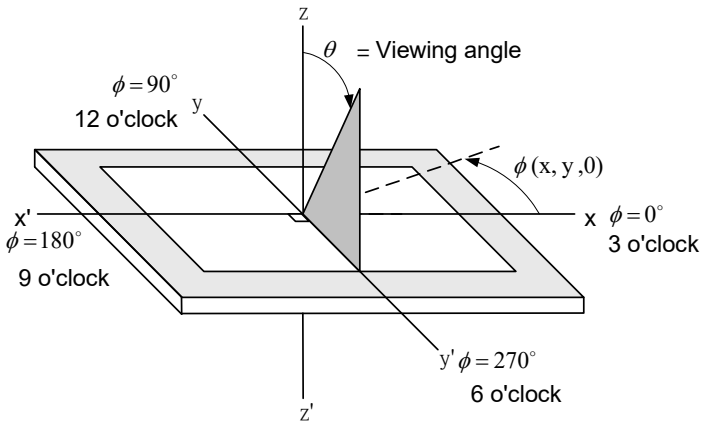
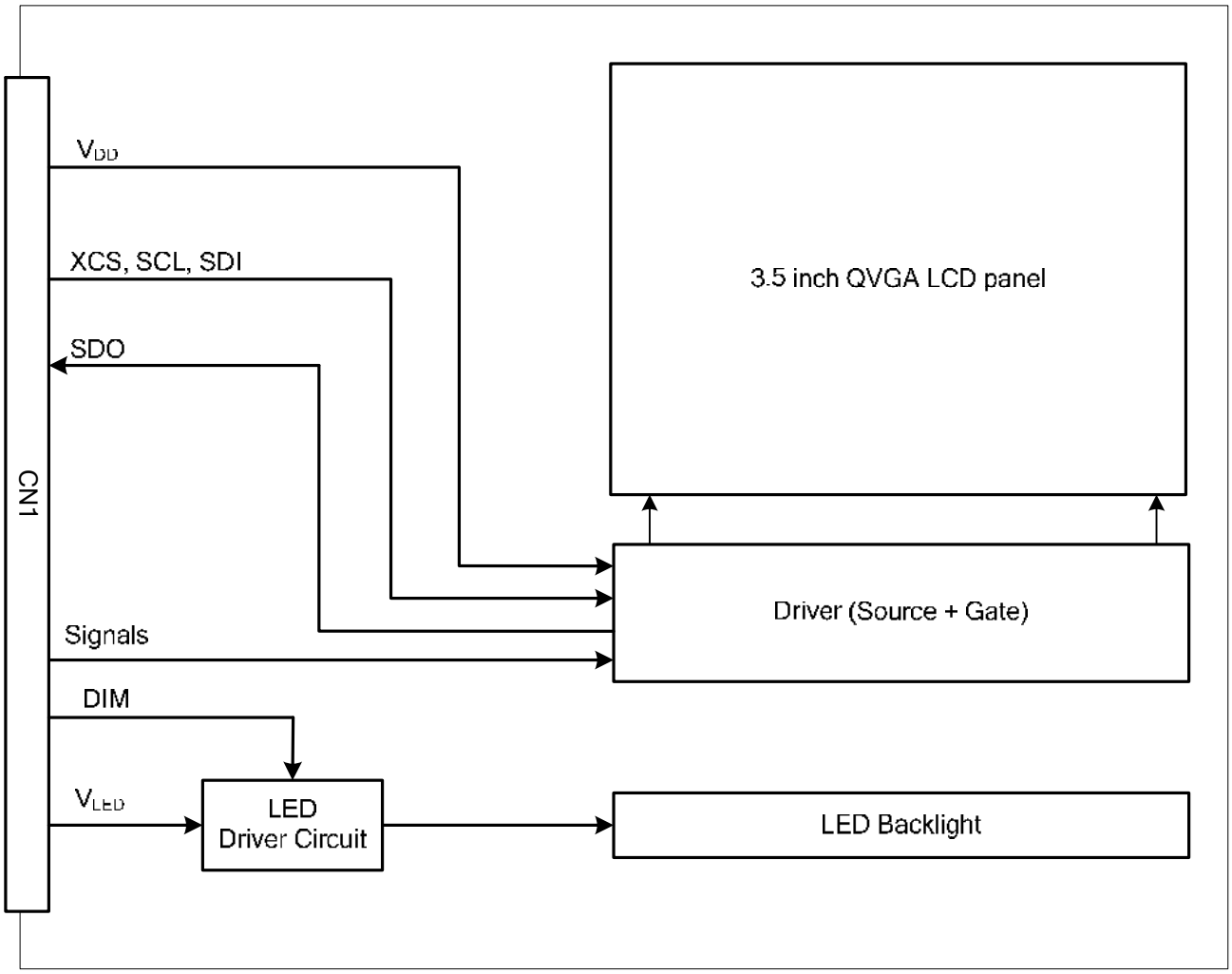



Fig 6.4

Note 6: The color chromaticity is measured from the center point of the panel, P5, as shown in Fig. 6.2.

# 7. BLOCK DIAGRAM




Note 1: Signals are DCLK, Vsync, Hsync, DE and RGB data bus.

# 8. RELIABILITY TESTS

| Test Item | Condition | |
|---|---|---|
| High Temperature | 1) Operating<br>2) 85℃ | 500 hrs |
| Low Temperature | 1) Operating<br>2) -40℃ | 500 hrs |
| High Temperature | 1) Storage<br>2) 90℃ | 500 hrs |
| Low Temperature | 1) Storage<br>2) -40℃ | 500 hrs |
| Heat Cycle | 1) Operating<br>2) –40℃~85℃<br>3) 3hrs~1hr~3hrs | 500 hrs |
| Thermal Shock | 1) Non-Operating<br>2) -40℃ ↔ 85℃<br>3) 0.5 hr ↔ 0.5 hr | 500 hrs |
| High Temperature & Humidity | 1) Operating<br>2) 40℃& 85%RH<br>3) Without condensation | 500 hrs<br>(Note 3) |
| Vibration | 1) Non-Operating<br>2) 10～200 Hz<br>3) 5G<br>4) X, Y, and Z directions | 1 hr for each direction |
| Mechanical Shock | 1) Non-Operating<br>2) 10 ms<br>3) 80G<br>4) ±X, ± Y and ±Z directions | Once for each direction |
| ESD | 1) Operating<br>2) Tip: 150 pF, 330 Ω<br>3) Air discharge for glass: ± 12KV<br>4) Contact discharge for metal frame: ± 15KV | 1) Glass: 9 points<br>2) Metal frame: 8 points<br>(Note 4) |

Note 1: Display functionalities are inspected under the conditions defined in the specification after the reliability tests.

Note 2: The display is not guaranteed for use in corrosive gas environments.

Note 3: Under the condition of high temperature & humidity, if the temperature is higher than 40℃, the humidity needs to be reduced as Fig. 8.1 shown.

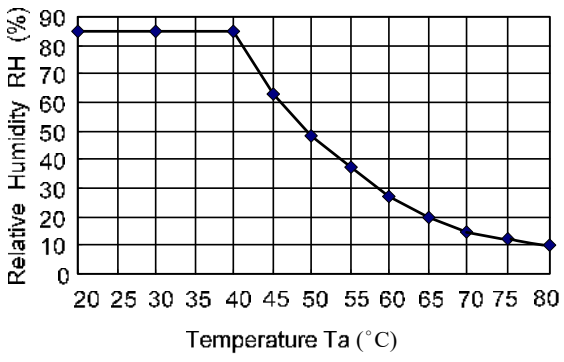



Fig. 8.1

Note 4: All pins of LCD interface (CN1) have been tested by ± 100V contact discharge of ESD under non-operating condition.

# 9. LCD INTERFACE

## 9.1 INTERFACE PIN CONNECTIONS

The display interface connector is FA5S050HP1 made by JAE (Thickness: 0.3 ± 0.05mm; Pitch: 0.5 ± 0.05mm) and more details of the connector are shown in the section of outline dimension.

Pin assignment of LCD interface is as below:

| Pin No. | Signal | Function | Pin No. | Signal | Function |
|---|---|---|---|---|---|
| 1 | $V_{DD}$ | Power Supply for Logic | 26 | G2 | Green Data |
| 2 | $V_{DD}$ | | 27 | G1 | |
| 3 | $V_{SS}$ | GND | 28 | G0 | |
| 4 | $V_{SS}$ | | 29 | $V_{SS}$ | GND |
| 5 | Vsync | Vertical Synchronous Signal | 30 | B7 | Blue Data |
| 6 | DE | Timing Signal for Data | 31 | B6 | |
| 7 | $V_{SS}$ | GND | 32 | B5 | |
| 8 | DCLK | Dot Clock | 33 | B4 | |
| 9 | $V_{SS}$ | GND | 34 | B3 | |
| 10 | Hsync | Horizontal Synchronous Signal | 35 | B2 | |
| 11 | $V_{SS}$ | GND | 36 | B1 | |
| 12 | R7 | Red Data | 37 | B0 | |
| 13 | R6 | | 38 | $V_{SS}$ | GND |
| 14 | R5 | | 39 | XCS | Chip Select Signal |
| 15 | R4 | | 40 | SCL | Serial Clock |
| 16 | R3 | | 41 | SDI | Serial Data input |
| 17 | R2 | | 42 | SDO | Serial Data output |
| 18 | R1 | | 43 | $V_{SS}$ | GND |
| 19 | R0 | | 44 | $V_{LED}$+ | 12 VDC |
| 20 | $V_{SS}$ | GND | 45 | $V_{LED}$+ | |
| 21 | G7 | Green Data | 46 | $V_{LED}$- | GND |
| 22 | G6 | | 47 | $V_{LED}$- | |
| 23 | G5 | | 48 | DIM | Brightness Control ; Note1 |
| 24 | G4 | | 49 | NC | No Connection |
| 25 | G3 | | 50 | NC | |

Note 1: Normal brightness: 0V or 0% PWM duty; Brightness control: 0V to 3.3V DC or 0% to 100% PWM duty.

## 9.2 FUNCTIONS

This LCD module is equipped with two kind of interface used for transferring of command data and pixel data.

1) MPU serial interface

Serial bus with MPU control for transferring of command data and parameter data.

2) RGB interface

RGB data (R: 8bit, G: 8bit, B: 8bit) and Hsync, Vsync, DCLK and DE for transferring of display-content.

MPU serial interface

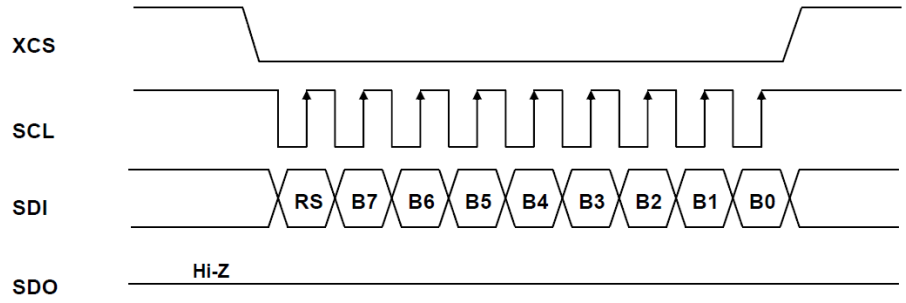
MPU serial interface is performed by four signal lines

| | |
|---|---|
| XCS | Chip select signal |
| SCL | Serial transfer clock signal |
| SDI | Serial input data signal (latched by rising edge of SCL) |
| SDO | Serial output data signal (data output during SCL = L) |

Command data and parameter data are possible by using the following four pins: XCS, SCL, SDI, SDO.

<Data Write Method>

It is necessary to keep XCS=L during data transferring operation. After 9bit data transferred, then XCS need pull high.

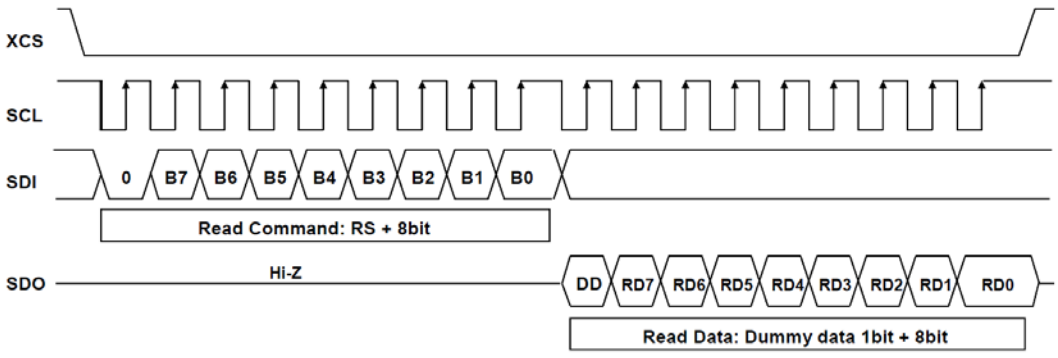



| RS | B[7:0] |
|---|---|
| 0 | Command data |
| 1 | Parameter data |

<Data Read Method>

A dummy clock is required before valid data reading as described in the following chart.

It is necessary to keep XCS = L during data reading operation. After all data received, XCS need pull high.



Command List

| No. | Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Function | Parameter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | NOP | 00h | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No operation | No |
| 2 | SWRESET | 01h | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Software reset | No |
| 3 | SLPIN | 10h | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | Sleep in | No |
| 4 | SLPOUT | 11h | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | Sleep out | No |
| 5 | DISINOFF | 20h | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | Grayscale inversion off | No |
| 6 | INVON | 21h | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | Grayscale inversion on | No |
| 7 | GAMSET | 26h | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | Select gamma curve | Yes (1Byte) |
| 8 | DISOFF | 28h | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | Display off | No |
| 9 | DISON | 29h | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | Display on | No |
| 10 | COLMOD | 3Ah | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | Select color depth | Yes (1Byte) |
| 11 | MADCTL | 36h | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | Address control | Yes (1Byte) |
| 12 | RDDID1 | DAh | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | Read ID1 data | Read data 1Byte |

(1) NOP

Command: 1 Parameter: 0

This command does not affect the operation or other effect to the LCD module (visual).

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| NOP | 00h | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | No operation |

(2) SWRESET

Command: 1 Parameter: 0

This command resets TFTLCD module by software. This command should by entered at SPLIN state.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| SWRESET | 01h | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Software reset |

(3) SLPIN

Command: 1 Parameter: 0

This command is used to TFTLCD module to the sleep state. When in sleep state, the oscillating circuit and the power circuit are suspended. After using this command, the power supply voltage ($V_{DD}$) must be maintained for more than 200ms.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| SLPIN | 10h | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | Sleep in |

The default setting SLPIN state.

(4) SLPOUT

Command: 1 Parameter: 0

This command is used to set TFTLCD module to quit the sleep state. By entering this command, the oscillating circuit and the power circuit start to operation. Output voltages of the power circuit are stabilized after 120ms or less from this command. After using this command, it is necessary to wait more than 10ms until entering next command.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| SLPOUT | 11h | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | Sleep out |

The default setting is SLPIN state.

(5) DISINOFF

Command: 1 Parameter: 0

This command allows inversion off display.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| DISINOFF | 20h | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | Grayscale inversion off |

The default setting is DISINOFF state.

(6) INVON

Command: 1 Parameter: 0

This command allows inverse the display without having to update the content.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| INVON | 21h | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | Grayscale inversion on |

The default setting is DISINOFF state.

(7) GAMSET

Command: 1 Parameter: 1

This command and the subsequent parameter are used to select the gamma curve.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| GAMSET | 26h | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | Grayscale inversion on |
| P1 | 00h | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

(8) DISOFF

Command: 1 Parameter: 0

This command makes the display a blank.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| DISOFF | 28h | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | Display off |

The default setting is DISOFF state.

(9) DISON

Command: 1 Parameter: 0

This command turns on the display.

As for the command input order, please refer to Recommended Sequence.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| DISON | 29h | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | Display on |

The default setting is DISOFF state.

(10) COLMOD

Command: 1 Parameter: 1

This command and the subsequent parameter are used to select the color depth.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| COLMOD | 3Ah | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | Select color depth |
| P1 | 70h | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | |

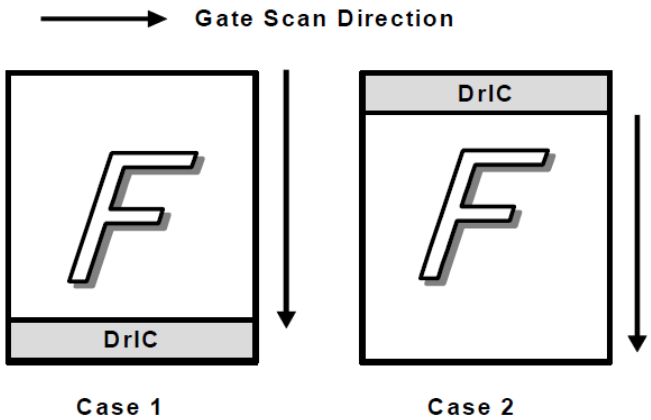
(11) MADCTL

Command: 1 Parameter: 1

This command and the subsequent parameter are used to settle the display direction.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| MADCTL | 36h | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | Address control |
| P1 | | P17 | P16 | 0 | 0 | 0 | 0 | 0 | 0 | |

| P17 | P16 | Display Direction |
|---|---|---|
| 0 | 0 | Case 1 |
| 1 | 1 | Case 2 |



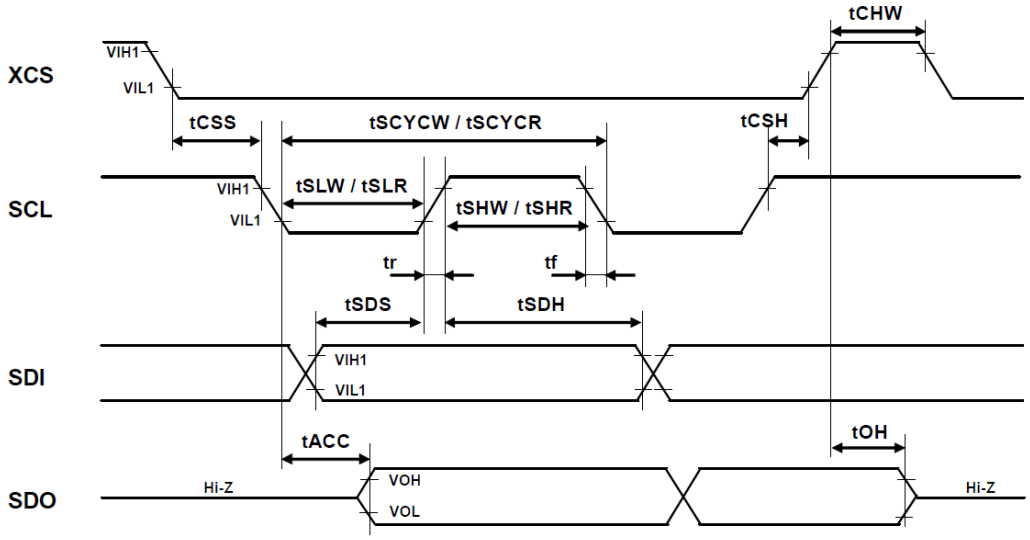
(12) RDDID1

Command: 1 Parameter: 1

This command is used to read the ID1 data that is written into the internal ROM.

| Command | Hex | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| RDDID1 | DAh | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | Read ID1 data |
| RD[7:0] | | RD7 | RD6 | RD5 | RD4 | RD3 | RD2 | RD1 | RD0 | ID1 data = 00h |

AC CHARACTERISTICS of MPU Serial interface




| Signal | Symbol | Parameter | Min. | Max. | Unit | Description |
|---|---|---|---|---|---|---|
| XCS | tCSS | Chip select signal set up time | 40 | - | ns | *1, *2 |
| | tCSH | Chip select signal hold time | 80 | - | ns | |
| | tCHW | Chip select signal high pulse width | 40 | - | ns | |
| SCL (Write) | tSCYCW | Write clock cycle time (tr, tf =100ns) | 400 | - | ns | |
| | tSHW | Write clock high pulse width | 100 | - | ns | |
| | tSLW | Write clock low pulse width | 100 | - | ns | |
| SCL (Read) | tSCYCR | Read clock cycle time (tr, tf =100ns) | 450 | - | ns | |
| | tSHR | Read clock high pulse width | 125 | - | ns | |
| | tSLR | Read clock low pulse width | 125 | - | ns | |
| SDI | tSDS | Data set up time | 40 | - | ns | |
| | tSDH | Data hold time | 40 | - | ns | |
| SDO | tACC | Read data access time | - | 120 | ns | *3, *4 |
| | tOH | Read data disable time | 15 | - | ns | |

Voltage of $V_{DD}$ is in range of 5.1 LCD CHARACTERISTICS ambient temperature is in a range of operating temperature.

*1: The rise and fall times of all input signals (tr, tf) are equal or less than 100ns.

*2: For timing of all input signals, they are using 30% and 70% of $V_{DD}$ as the base reference.

*3: For timing of all output signals, they are set using 20% and 80% of $V_{DD}$ as the base reference.

*4: Measurement condition CL = 100pF.

Recommended Sequence

Design a command sequence and intervals

Power on sequence

| Command | | Hex Data |
|---|---|---|
| Power-ON ($V_{DD}$) | | |
| Wait more than 2ms | | |
| Start to input control signals<br>(Vsync, Hsync, DE, DCLK, Red[7:0] , Green[7:0], Blue[7:0]) | | |
| Wait more than 0ms | | |
| COLMOD | CMD | 3Ah |
| | P1 | 70h |
| GAMSET | CMD | 26h |
| | P1 | 00h |
| MADCTL | CMD | 36h |
| | P1 | C0h |
| SLPOUT | CMD | 11h |
| Wait more than 120ms | | |
| DISON | CMD | 29h |

Power off sequence

| Command | | Hex Data |
|---|---|---|
| SLPIN | CMD | 10h |
| Wait more than 200ms | | |
| Stop the control signals<br>(Vsync, Hsync, DE, DCLK, Red[7:0] , Green[7:0], Blue[7:0]) | | |
| Wait more than 0ms | | |
| Wait more than 0ms | | |
| Power-OFF ($V_{DD}$) | | |

Refresh sequence

This sequence should be implemented continuously in order to recover the display error due to noise etc.

| Command | | Hex Data |
|---|---|---|
| COLMOD | CMD | 3Ah |
| | P1 | 70h |
| GAMSET | CMD | 26h |
| | P1 | 00h |
| MADCTL | CMD | 36h |
| | P1 | C0h |
| DISINOFF | CMD | 20h |
| DISON | CMD | 29h |
| SLPOUT | CMD | 11h |
| Wait more than 10ms<br>until entering next command | | |

## 9.3 TIMING CHART

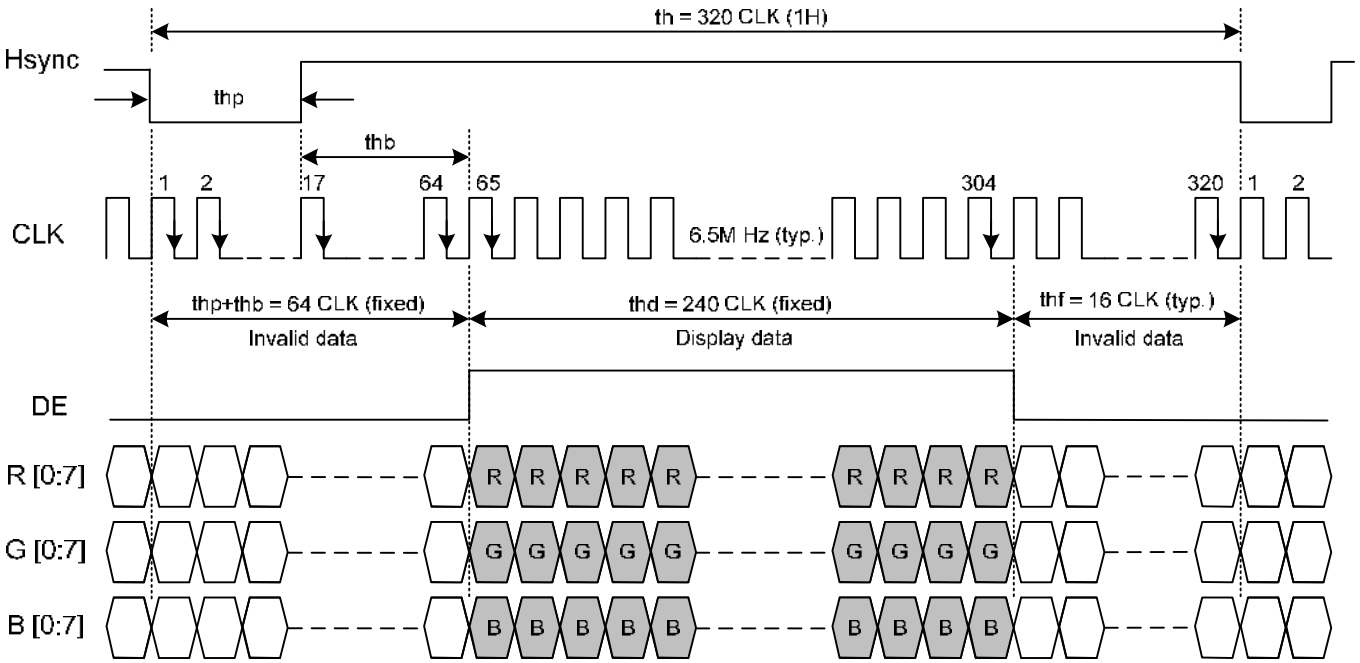



Fig. 9.1 Horizontal Timing of Synchronous Mode

Note 1: CLK's falling edge is the time to latch data and count (thp + thb), therefore, data sending and Hsync's falling edge should start when CLK's rise edge.

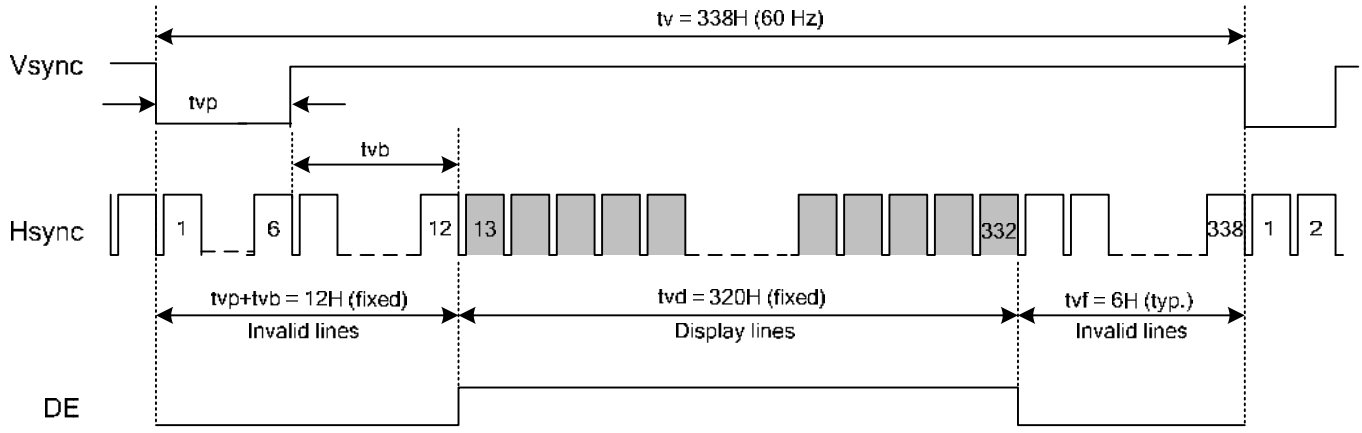



Fig. 9.2 Vertical Timing of Synchronous Mode

Note 2: Vsync's falling edge needs to start with Hsync's falling edge simultaneously to count (tvp + tvb).

## 9.4 TIME TABLE

The column of timing sets including minimum, typical, and maximum as below are based on the best optical performance, frame frequency (Vsync) = 60 Hz to define. If 60 Hz is not the aim to set, 54~66 Hz for Vsync is recommended to apply for better performance by other parameter combination as the definitions in section 5.1.

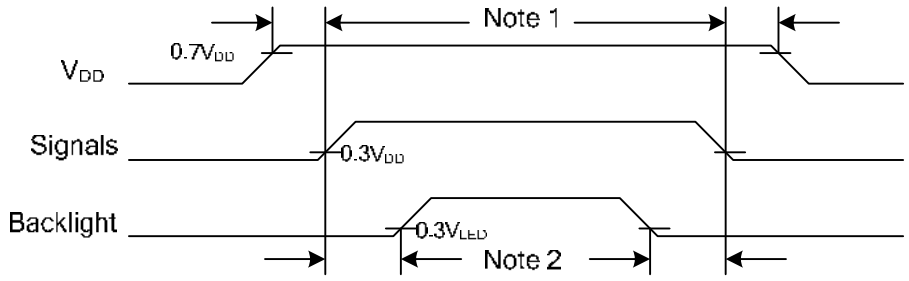
A. SYNCHRONOUS MODE

| Item | | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Hsync | CLK Frequency | fclk | 6.0 | 6.5 | 7.0 | M Hz |
| | Display Data | thd | 240 | 240 | 240 | CLK |
| | Cycle Time | th | 296 | 320 | 346 | |
| | Pulse Width | thp | 16 | 16 | 16 | |
| | Pulse Width and Back Porch | thp + thb | 40 | 64 | 90 | |
| | Front Porch | thf | 16 | 16 | 16 | |
| Vsync | Display Line | tvd | 320 | 320 | 320 | H |
| | Cycle Time | tv | 338 | 338 | 338 | |
| | Pulse Width | tvp | 6 | 6 | 6 | |
| | Pulse Width and Back Porch | tvp + tvb | 12 | 12 | 12 | |
| | Front Porch | tvf | 6 | 6 | 6 | |

B. CLOCK AND DATA INPUT TIMING

| Item | | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| CLK | Duty | Tcwh | 45 | 50 | 55 | % |
| | Cycle Time | Tcph | 143 | 154 | 166 | ns |
| Vsync | Setup Time | Tvsu | 15 | - | - | |
| | Hold Time | Tvhd | 15 | - | - | |
| Hsync | Setup Time | Thsu | 15 | - | - | |
| | Hold Time | Thhd | 15 | - | - | |
| Data | Setup Time | Tdsu | 15 | - | - | |
| | Hold Time | Tdhd | 15 | - | - | |

## 9.5 POWER SEQUENCE




Note 1: In order to avoid any damages, $V_{DD}$ has to be applied before all other signals. The opposite is true for power Off where $V_{DD}$ has to be remained on until all other signals have been switch off. The recommended time period is 1 second. Hot plugging might cause display damage due to incorrect power sequence, please pay attention on interface connecting before power on.

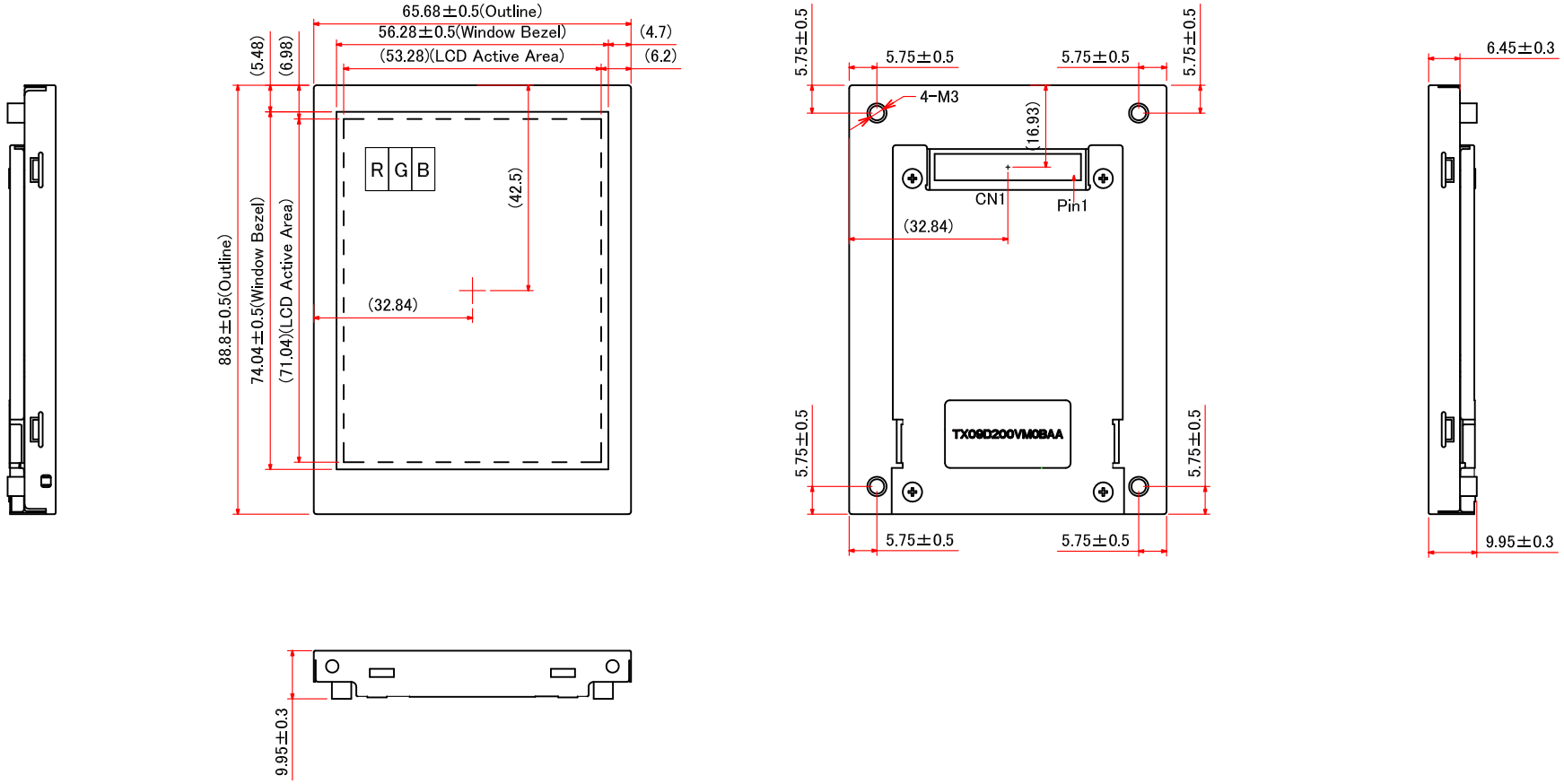
Note 2: In order to avoid showing uncompleted patterns in transient state. It is recommended that switching the backlight on is delayed for 1 second after the signals have been applied. The opposite is true for power Off where the backlight has to be switched off 1 second before the signals are removed.

## 9.6 DATA INPUT for DISPLAY COLOR

| Input color | | Red Data | | | | | | | | Green Data | | | | | | | | Blue 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 | 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(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(253) | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Red(254) | 1 | 1 | 1 | 1 | 1 | 1 | 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 | 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 |
| | 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(253) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Green(254) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 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 | 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(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(253) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | Blue(254) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 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 |

# 10. OUTLINE DIMENSIONS

## 10.1 FRONT VIEW AND REAR VIEW




General Tolerance:±0.5mm
Scale : NTS
Unit : mm

| KAOHSIUNG OPTO-ELECTRONICS INC. | SHEET No. | 7B64PS 2710-TX09D200VM0BAA-4 | PAGE | 10-1/1 |
|---|---|---|---|---|

# 11. APPEARANCE STANDARD

The appearance inspection is performed in a room around 500~1000 lx based on the conditions as below:

- The distance between inspector's eyes and display is 30 cm.
- The viewing zone is defined with angle $\theta$ shown in Fig.11.1 The inspection should be performed within $45^\circ$ when display is shut down. The inspection should be performed within $5^\circ$ when display is power on.

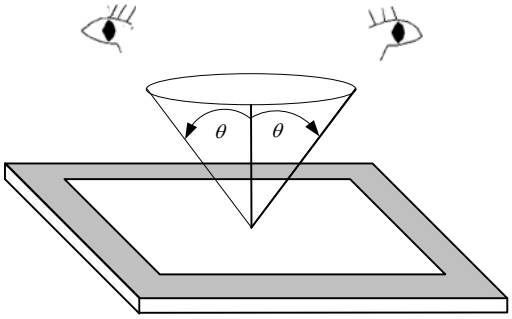



Fig. 11.1

## 11.1 THE DEFINITION OF LCD ZONE

LCD panel is divided into 2 areas as shown in Fig.11.2 for appearance specification in next section. A zone is the LCD active area (dot area); B zone is the area between A zone and metal frame.

In terms of housing design, B zone is the recommended window area customers' housing should be located in.

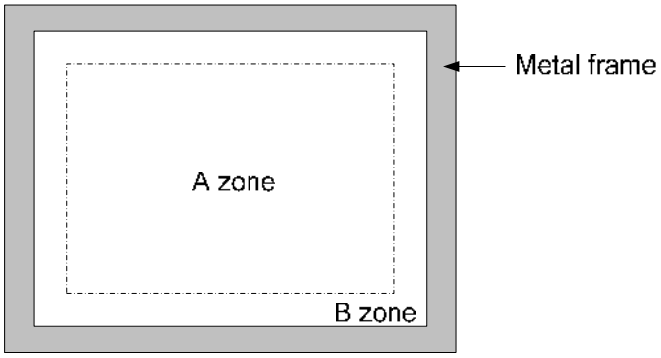



Fig. 11.2

## 11.2 LCD APPEARANCE SPECIFICATION

The specification as below is defined as the amount of unexpected phenomenon or material in different zones of LCD panel. The definitions of length, width and average diameter using in the table are shown in Fig.11.3 and Fig.11.4.

<table>
<tr><th>Item</th><th colspan="3">Criteria</th><th>Applied zone</th></tr>
<tr><td rowspan="4">Scratches</td><td>Length / L(mm)</td><td>Width / W(mm)</td><td>Maximum number Acceptable</td><td rowspan="4">A,B</td></tr>
<tr><td>L≦2.0</td><td>W≦0.03</td><td>Ignored</td></tr>
<tr><td>L≦2.0</td><td>0.03＜W≦0.05</td><td>4</td></tr>
<tr><td>L＞2.0</td><td>0.05＜W</td><td>None</td></tr>
<tr><td>Dent</td><td colspan="3">Serious one is not allowed.</td><td>A</td></tr>
<tr><td>Wrinkles in Polarizer</td><td colspan="3">Serious one is not allowed.</td><td>A</td></tr>
<tr><td rowspan="4">Bubbles on Polarizer</td><td colspan="2">Average diameter / D(mm)</td><td>Maximum number Acceptable</td><td rowspan="3">A</td></tr>
<tr><td colspan="2">D≦0.3</td><td>2</td></tr>
<tr><td colspan="2">0.3＜D</td><td>None</td></tr>
<tr><td rowspan="13">1) Stains<br>2) Foreign Materials<br>3) Dark Spot</td><td colspan="3">Filamentous (Line shape)</td><td rowspan="4">A,B</td></tr>
<tr><td>Length / L(mm)</td><td>Width / W(mm)</td><td>Maximum number Acceptable</td></tr>
<tr><td>L＜2.0</td><td>W≦0.05</td><td>4</td></tr>
<tr><td>L≦1.0</td><td>0.05＜W≦0.1</td><td>2</td></tr>
<tr><td colspan="3">Round (Dot shape)</td><td rowspan="7">A,B</td></tr>
<tr><td colspan="2">Average diameter / D(mm)</td><td>Maximum number acceptable</td></tr>
<tr><td colspan="2">D≦0.15</td><td>6</td></tr>
<tr><td colspan="2">0.15＜D≦0.2</td><td>4</td></tr>
<tr><td colspan="2">0.2＜D</td><td>None</td></tr>
<tr><td colspan="2">In total</td><td>Filamentous + Round=9</td></tr>
<tr><td colspan="3">Those wiped out easily are acceptable.</td></tr>
<tr><td rowspan="6">Dot-Defect<br>(Note 1)</td><td colspan="2">Type</td><td>Maximum number acceptable</td><td rowspan="6">A,B</td></tr>
<tr><td>Bright dot-defect</td><td>1 dot</td><td>0</td></tr>
<tr><td rowspan="3">Dark dot-defect</td><td>1 dot</td><td>4</td></tr>
<tr><td>2 dots</td><td>1(sets)</td></tr>
<tr><td>In total</td><td>4</td></tr>
<tr><td colspan="2">In total</td><td>4</td></tr>
</table>

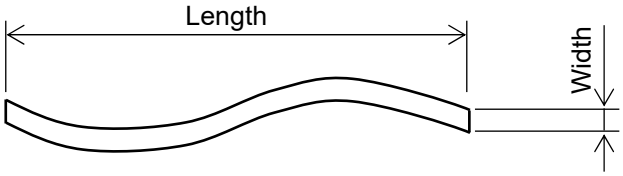
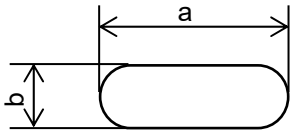



Fig.11.3




Average diameter = $\frac{a+b}{2}$

Fig.11.4

Note 1: The definitions of dot defect are as below:

- For bright dot-defect, showing black pattern, visible with 5% ND filter is defined.
- For dark dot-defect, showing white pattern, defect size over 1/2 dot area is defined.
- The definition of 1-dot-defect is the defect-dot, which is isolated and no adjacent defect-dot.
- The definition of adjacent dot is shown as Fig. 11.5.
- The density of dot defect is defined in the area within diameter $\phi$ =10mm.

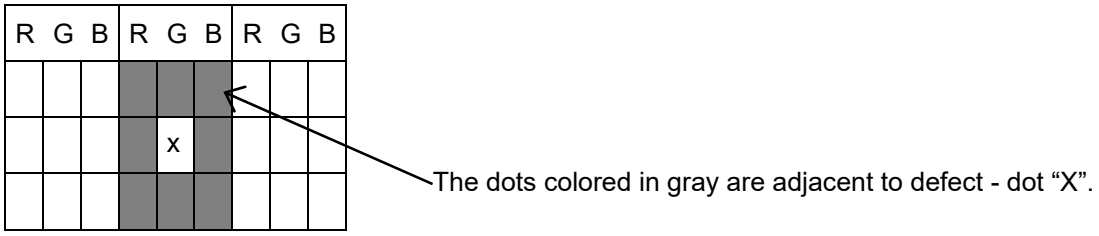



Fig 11.5

# 12. PRECAUTIONS

## 12.1 PRECAUTIONS of ESD

1) Before handling the display, please ensure your body has been connected to ground to avoid any damages by ESD. Also, do not touch display's interface directly when assembling.

2) Please remove the protection film very slowly before turning on the display to avoid generating ESD.

## 12.2 PRECAUTIONS of HANDLING

1) In order to keep the appearance of display in good condition, please do not rub any surfaces of the displays by using sharp tools harder than 3H, especially touch panel, metal frame and polarizer.

2) Please do not stack the displays as this may damage the surface. In order to avoid any injuries, please avoid touching the edge of the glass or metal frame and wore gloves during handling.

3) Touching the polarizer or terminal pins with bare hand should be avoided to prevent staining and poor electrical contact.

4) Do not use any harmful chemicals such as acetone, toluene, and isopropyl alcohol to clean display's surfaces.

5) Please use soft cloth or absorbent cotton with ethanol to clean the display by gently wiping. Moreover, when wiping the display, please wipe it by horizontal or vertical direction instead of circling to prevent leaving scars on the display's surface, especially polarizer.

6) Please wipe any unknown liquids immediately such as saliva, water or dew on the display to avoid color fading or any permanent damages.

7) Maximum pressure to the surface of the display must be less than $1{,}96 \times 10^4$ Pa. If the area of applied pressure is less than 1 $cm^2$, the maximum pressure must be less than 1.96N.

## 12.3 PRECAUTIONS OF OPERATING

1) Please input signals and voltages to the displays according to the values defined in the section of electrical characteristics to obtain the best performance. Any voltages over than absolute maximum rating will cause permanent damages to this display. Also, any timing of the signals out of this specification would cause unexpected performance.

2) When the display is operating at significant low temperature, the response time will be slower than it at 25 $C^\circ$. In high temperature, the color will be slightly dark and blue compared to original pattern. However, these are temperature-related phenomenon of LCD and it will not cause permanent damages to the display when used within the operating temperature.

3) The use of screen saver or sleep mode is recommended when static images are likely for long periods of time. This is to avoid the possibility of image sticking.

4) Spike noise can cause malfunction of the circuit. The recommended limitation of spike noise is no bigger than $\pm$ 100 mV.

## 12.4 PRECAUTIONS of STORAGE

If the displays are going to be stored for years, please be aware the following notices.

1) Please store the displays in a dark room to avoid any damages from sunlight and other sources of UV light.
2) The recommended long term storage temperature is between 10℃~35℃ and 55%~75% humidity to avoid causing bubbles between polarizer and LCD glasses, and polarizer peeling from LCD glasses.
3) It would be better to keep the displays in the container, which is shipped from KOE, and do not unpack it.
4) Please do not stick any labels on the display surface for a long time, especially on the polarizer.

# 13. DESIGNATION of LOT MARK

1) The lot mark is showing in Fig.13.1. First 4 digits are used to represent production lot, T represented made in Taiwan, and the last 6 digits are the serial number.

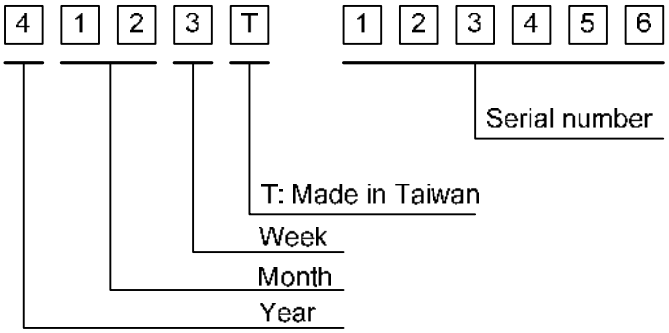



Fig. 13.1

2) The tables as below are showing what the first 4 digits of lot mark are shorted for.

| Year | Lot Mark |
|---|---|
| 2014 | 4 |
| 2015 | 5 |
| 2016 | 6 |
| 2017 | 7 |
| 2018 | 8 |

| Month | Lot Mark | Month | Lot Mark |
|---|---|---|---|
| Jan. | 01 | Jul. | 07 |
| Feb. | 02 | Aug. | 08 |
| Mar. | 03 | Sep. | 09 |
| Apr. | 04 | Oct. | 10 |
| May | 05 | Nov. | 11 |
| Jun. | 06 | Dec. | 12 |

| Week | Lot Mark |
|---|---|
| 1~7 days | 1 |
| 8~14 days | 2 |
| 15~21 days | 3 |
| 22~28 days | 4 |
| 29~31 days | 5 |

3) Except letters I and O, revision number will be shown on lot mark and following letters A to Z.

4) The location of the lot mark is on the back of the display shown in Fig. 13.2.

Label example :

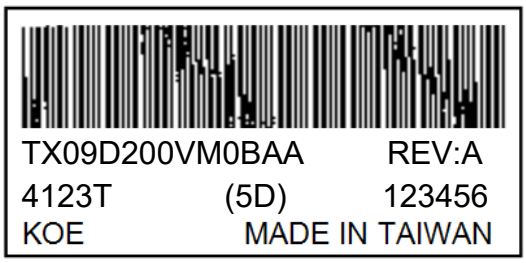



Fig. 13.2