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## TFT Display Module

Part Number

E28RG12432LW2M450-R

### Overview:

- 2.8-inch TFT: 240x320 (50.5x69.7)
- 3/4SPI+16/18-bit RGB
- 8/9/16/18-bit MCU
- 4-wire Resistive Touch Screen
- White LED back-light
- Transmissive
- Wide Temp
- 450 NITS
- Controller: ST7789V
- RoHS Compliant

## Description

This is a color active matrix TFT (Thin Film Transistor) LCD (Liquid Crystal Display) that uses amorphous silicon TFT as a switching device. This model is composed of a transmissive type TFT-LCD Panel, driver circuit and a backlight unit. The resolution of the 2.8" TFT-LCD contains 240(RGB)x320 pixels and can display up to 262k colors.

## TFT Features

Low Input Voltage: 3.3V

Display Colors: 65k/262k colors

TFT Interfaces: 8/9/16/18-bit MCU

3/4SPI+16/18-bit RGB

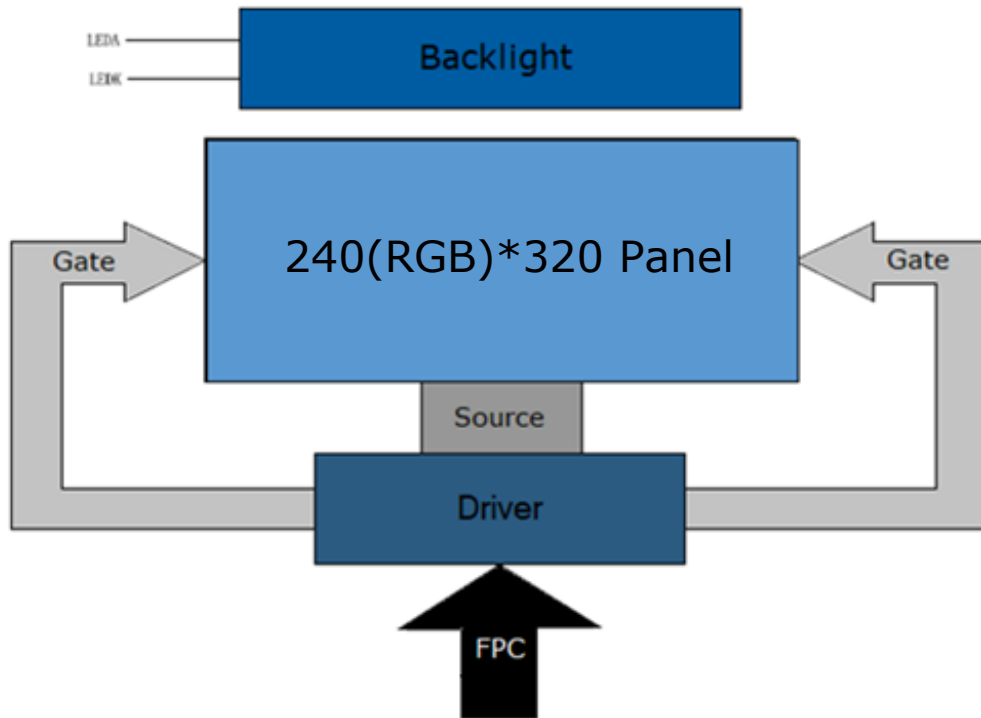
3-line/4-line Serial

| General Information Items | Specification                    | Unit    | Note |
|---------------------------|----------------------------------|---------|------|
|                           | Main Panel                       |         |      |
| TFT Display area (AA)     | 43.20 (H) x 57.60 (V) (2.8 inch) | mm      | -    |
| Driver element            | TFT active matrix                | -       | -    |
| Display colors            | 65k/262k                         | colors  | -    |
| Number of pixels          | 240(RGB)x320                     | dots    | -    |
| TFT Pixel arrangement     | RGB vertical stripe              | -       | -    |
| Pixel pitch               | 0.18 (H) x 0.18 (V)              | mm      | -    |
| Viewing angle             | 12:00                            | o'clock | -    |
| TFT Controller IC         | ST7789V                          | -       | -    |
| LCM Interface             | 4-Lane LVDS                      | -       | -    |
| Display mode              | Transmissive/ Normally White     | -       | -    |
| Operating temperature     | -20~+70                          | °C      | -    |
| Storage temperature       | -30~+80                          | °C      | -    |

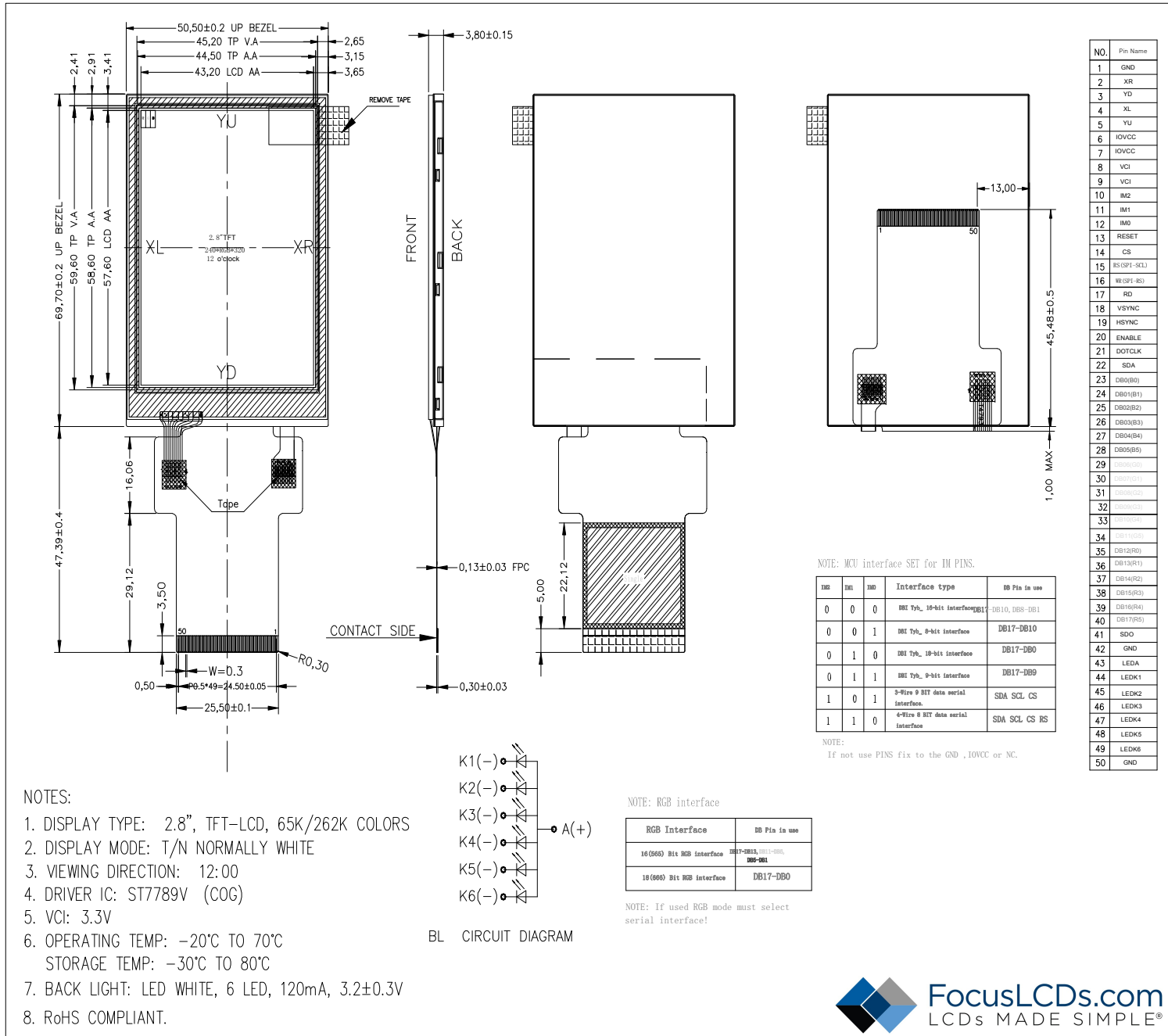
## Mechanical Information

| Item        |              | Min | Typ.  | Max | Unit | Note |
|-------------|--------------|-----|-------|-----|------|------|
| Module size | Height (H)   |     | 50.50 |     | mm   | -    |
|             | Vertical (V) |     | 69.70 |     | mm   | -    |
|             | Depth (D)    |     | 3.80  |     | mm   | -    |

## 1. Block Diagram



## 2. Outline Dimensions



### 3. Input Terminal Pin Assignment

Recommended TFT Connector: FH12S-50S-0.5SH(55)

Recommended RTP Connector: FH33-4S-1SH(10)

| NO.   | Symbol      | Description  | I/O |
|-------|-------------|--|-----|
| 1     | GND         | Ground   |     |
| 2     | XR          | Touch panel right glass terminal   |     |
| 3     | YD          | Touch panel bottom film terminal   |     |
| 4     | XL          | Touch panel left glass terminal  |     |
| 5     | YU          | Touch panel top film terminal  |     |
| 6     | IOVCC       | Supply voltage for IO (1.8-3.3V)   |     |
| 7     | IOVCC       | Supply voltage for IO (1.8-3.3V)   |     |
| 8     | VCI         | Supply voltage (3.3V)  |     |
| 9     | VCI         | Supply voltage (3.3V)  |     |
| 10    | IM2         | MPU parallel interface bus and serial interface select. If using RGB interface, you must select which serial interface. Fix to IOVCC and GND.                      |     |
| 11    | IM1         |  |     |
| 12    | IM0         |  |     |
| 13    | RESET       | Reset signal of the device. Must be applied to initialize chip.  |     |
| 14    | CS          | Chip select input pin. Low enabled. Fix to IOVCC and GND when not in use.  |     |
| 15    | RS(SPI_SCL) | Data or command pin in parallel interface. D/CX=1, data is selected. When D/CX=0, command is selected. In the serial interface this pin is used as the data clock. |     |
| 16    | WR(SPI_RS)  | Write signal in parallel interface. In serial interface it is a data pin. Data is applied at the rising edge of the SCL signal. Fix to IOVCC or GND when not used. |     |
| 17    | RD          | Read signal for parallel interface and MCU read data at the rising edge. Fix to IOVCC or GND when not in use.  |     |
| 18    | VSYNC       | Frame synchronizing signal for RGB interface. Fix to IOVCC or GND when not used.   |     |
| 19    | HSYNC       | Line synchronizing signal for RGB interface. Fix to IOVCC or GND when not used.  |     |
| 20    | ENABLE      | Data enable signal for RGB interface. Fix to IOVCC or GND when not used.   |     |
| 21    | DOTCLK      | Dot clock signal for RGB interface. Fix to IOVCC or GND when not used.   |     |
| 22    | SDA         | Serial input signal. The data is applied at the rising edge of the SCL signal. Fix to IOVCC or GND when not used.  |     |
| 23-40 | DB0-DB17    | 18-bit data bus. If not used please fix these pins to GND.   |     |
| 41    | SDO         | SPI interface output pin. The data is output on the falling edge of the SCL signal. Leave this pin open if not used.   |     |
| 42    | GND         | Ground   |     |
| 43    | LEDA        | Anode pin of the backlight   |     |
| 44    | LEDK1       | Cathode pin of the backlight   |     |
| 45    | LEDK2       | Cathode pin of the backlight   |     |
| 46    | LEDK3       | Cathode pin of the backlight   |     |
| 47    | LEDK4       | Cathode pin of the backlight   |     |
| 48    | LEDK5       | Cathode pin of the backlight   |     |
| 49    | LEDK6       | Cathode pin of the backlight   |     |
| 50    | GND         | Ground   |     |

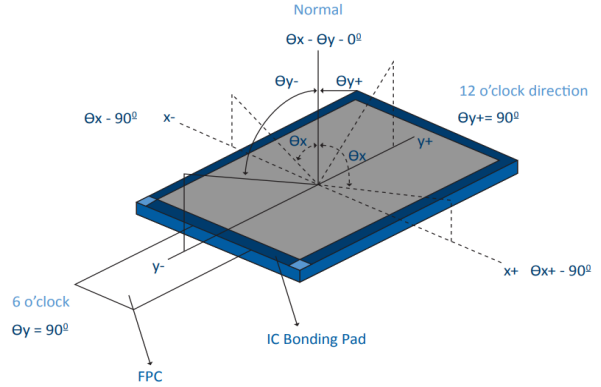
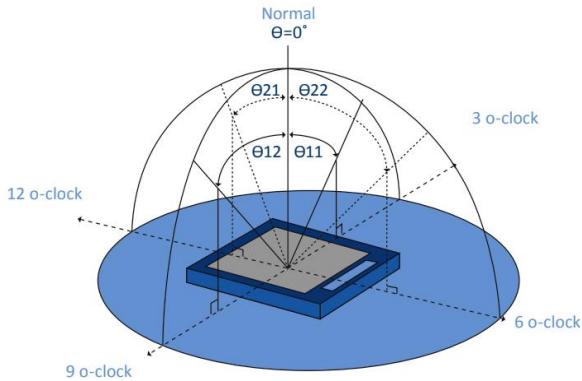
## 4. LCD Optical Characteristics

### 4.1 Optical Specifications

| Item                      | Symbol  | Condition      | Min                            | Typ.  | Max   | Unit  | Note   |
|---------------------------|---------|----------------|--------------------------------|-------|-------|-------|--------|
| Transmittance             | T%      |                | --                             | 17.3  | --    | %     |        |
| Contrast Ratio            | CR      |                | 400                            | 500   | --    | %     | (2)    |
| Response Time             | Rising  | TR             | --                             | 4     | 8     | ms    |        |
|                           | Falling | TF             | --                             | 12    | 24    | ms    |        |
| Color Filter Chromaticity | White   | W <sub>x</sub> | θ=0<br>Normal viewing<br>angle | 0.283 | 0.303 | 0.323 | (5)(6) |
|                           |         | W <sub>y</sub> |                                | 0.305 | 0.325 | 0.345 |        |
|                           | Red     | R <sub>x</sub> |                                | 0.606 | 0.626 | 0.646 |        |
|                           |         | R <sub>y</sub> |                                | 0.314 | 0.334 | 0.354 |        |
|                           | Green   | G <sub>x</sub> |                                | 0.257 | 0.277 | 0.297 |        |
|                           |         | G <sub>y</sub> |                                | 0.529 | 0.549 | 0.569 |        |
|                           | Blue    | B <sub>x</sub> |                                | 0.122 | 0.142 | 0.162 |        |
|                           |         | B <sub>y</sub> |                                | 0.102 | 0.122 | 0.142 |        |
| Viewing Angle             | Hor.    | Θ <sub>L</sub> | CR≥10                          | 35    | 45    | --    | degree |
|                           |         | Θ <sub>R</sub> |                                | 35    | 45    | --    |        |
|                           | Ver.    | Θ <sub>T</sub> |                                | 40    | 50    | --    |        |
|                           |         | Θ <sub>B</sub> |                                | 10    | 20    | --    |        |
| Option View Direction     |         |                | 12:00                          |       |       |       | (1)    |

**Optical Specification Reference Notes:**

(1) Definition of Viewing Angle: The viewing angle is the angle at which the contrast ratio is greater than 10. The viewing angles are determined for the horizontal or 3,9 o'clock direction and the vertical or 6,12 o'clock direction with respect to the optical axis which is normal to the LCD surface.

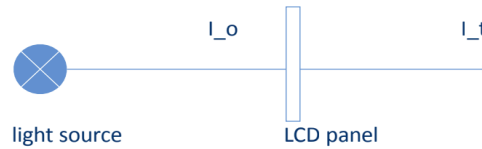


(2) Definition of Contrast Ratio (Cr): measured at the center point of panel. The contrast ratio (Cr) measured on a module, is the ratio between the luminance (Lw) in a full white area (R=G=B=1) and the luminance (Ld) in a dark area (R=G=B=0).

$$Cr = \frac{Lw}{Ld}$$

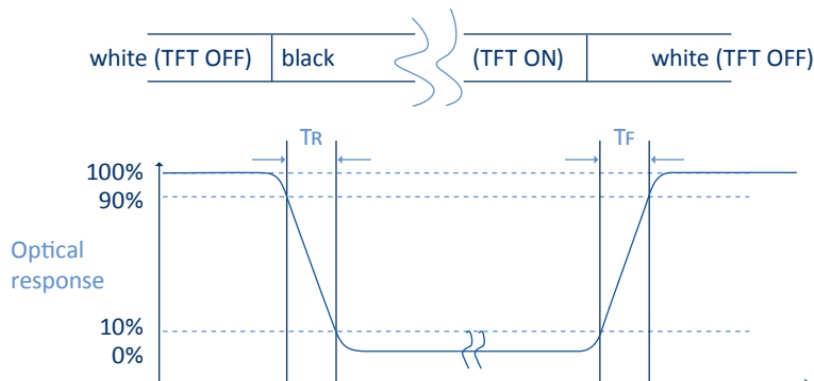
(3) Definition of transmittance (T%): The transmittance of the panel including the polarizers is measured with electrical driving. The equation for transmittance Tr is:

$$Tr = \frac{It}{Io} \times 100\%$$



Io = the brightness of the light source.  
It = the brightness after panel transmission

(4) Definition of Response Time (Tr, Tf): The rise time 'Tr' is defined as the time for luminance to change from 90% to 10% as a result of a change of the electrical condition. The fall time 'Tf' is defined as the time for luminance to change from 10% to 90% as a result of a change of the electrical condition.



(5) Definition of Color Gamut:

Measuring machine CFT-01. NTSC's Primaries: R(x,y,Y), G(x,y,Y), B(x,y,Y). FPM520 of Westar Display Technologies, INC., which utilized SR-3 for Chromaticity and BM-5A for other optical characteristics. The color chromaticity shall be calculated from the spectral data measured with all pixels first in red, green, blue and white. Measurements shall be made at the center of the panel.

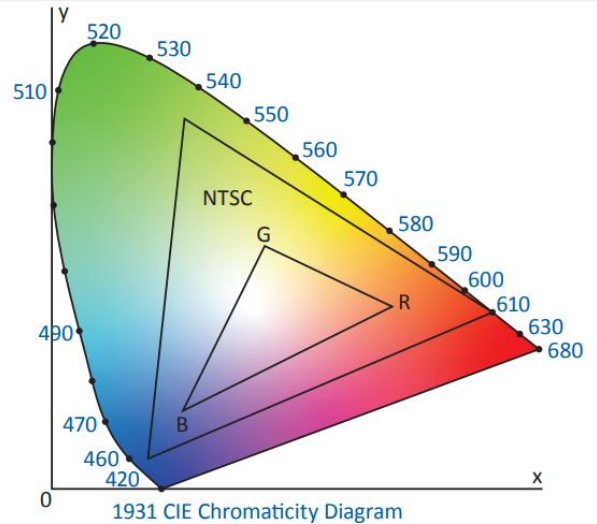
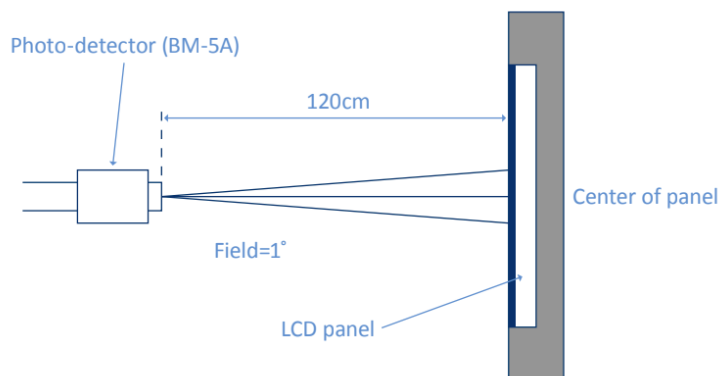
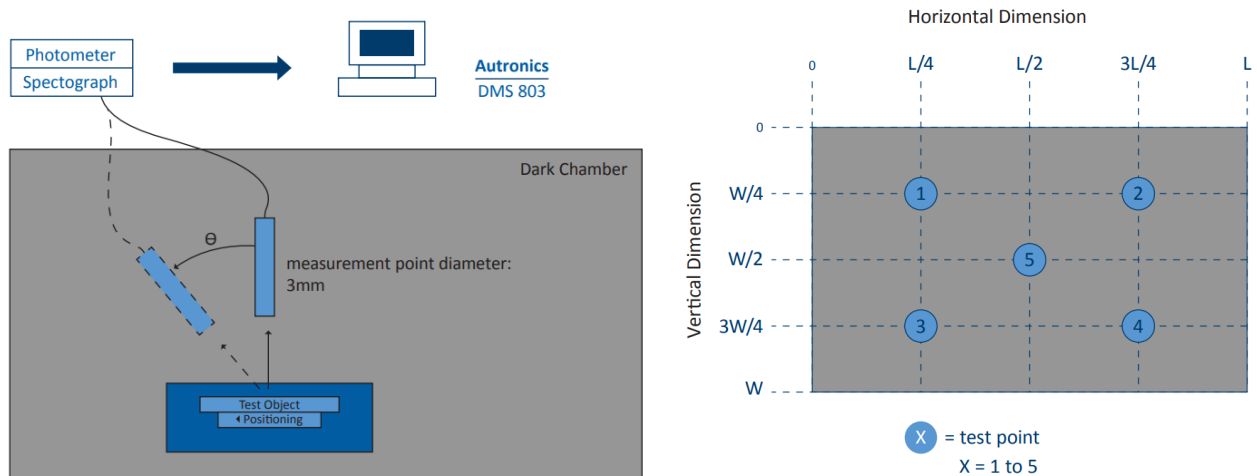


Fig. 1931 CIE chromacity diagram

$$\text{Color gamut: } S = \frac{\text{Area of RGB triangle}}{\text{Area of NTSC triangle}} \times 100\%$$

(6) Definition of Optical Measurement Setup:

The LCD module should be stabilized at a given temperature for 20 minutes to avoid abrupt temperature change during measuring. In order to stabilize the luminance, the measurement should be executed after lighting backlight for 20 minutes.





## 5. TFT Electrical Characteristics

### 5.1 Absolute Maximum Rating (Ta=25 °C, VSS=0V)

| Characteristics                  | Symbol | Min  | Max | Unit |
|----------------------------------|--------|------|-----|------|
| Digital Supply Voltage           | VDD    | 3.0  | 4.6 | V    |
| Digital Interface Supply Voltage | VDDIO  | -0.3 | 4.6 | V    |
| Operating Temperature            | TOP    | -20  | +70 | °C   |
| Storage Temperature              | TST    | -30  | +80 | °C   |

*NOTE: If the absolute maximum rating of the above parameters is exceeded, even momentarily, the quality of the product may be degraded. Absolute maximum ratings specify the values which the product may be physically damaged if exceeded. Be sure to use the product within the range of the absolute maximum ratings.*

### 5.2 DC Electrical Characteristics

| Characteristics                  | Symbol | Min      | Typ. | Max      | Unit | Note |
|----------------------------------|--------|----------|------|----------|------|------|
| Digital Supply Voltage           | VDD    | 2.4      | 3.3  | 4.2      | V    |      |
| Digital Interface Supply Voltage | VDDIO  | 1.65     | 3.3  | 4.2      | V    |      |
| Normal Mode Current Consumption  | IDD    | --       | 8    | --       | mA   |      |
| Level Input Voltage              | VIH    | 0.7VDDIO | --   | VDDIO    | V    |      |
|                                  | VIL    | GND      | --   | 0.3VDDIO | V    |      |
| Level Output Voltage             | VOH    | 0.8VDDIO | --   | VDDIO    | V    |      |
|                                  | VOL    | GND      | --   | 0.2VDDIO | V    |      |

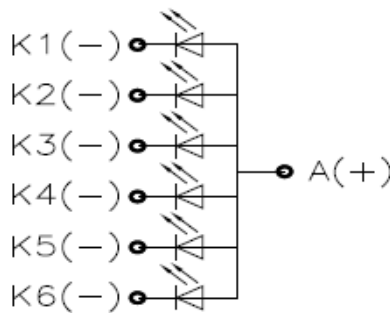
### 5.3 LED Backlight Characteristics

The backlight system is edge lighting type with 6 chips LED.

| Item            | Symbol          | Min   | Typ. | Max | Unit              | Note      |
|-----------------|-----------------|-------|------|-----|-------------------|-----------|
| Forward Current | I <sub>F</sub>  | 90    | 120  | --  | mA                |           |
| Forward Voltage | V <sub>F</sub>  | --    | 3.2  | --  | V                 |           |
| LCM Luminance   | LV              | --    | 450  | --  | cd/m <sup>2</sup> | Note 3    |
| LED lifetime    | Hr              | 50000 | --   | --  | hour              | Note1 & 2 |
| Uniformity      | AV <sub>g</sub> | 80    | --   | --  | %                 | Note 3    |

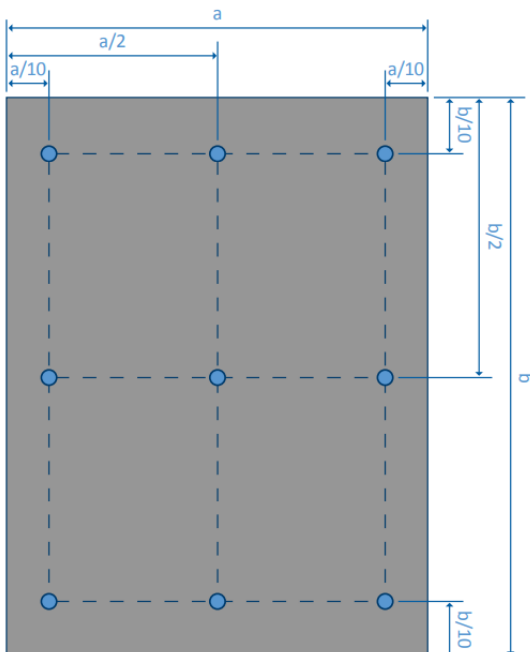
Note 1: LED lifetime (Hr) can be defined as the time in which it continues to operate under the condition: Ta=25 ±3 °C, typical IL value indicated in the above table until the brightness becomes less than 50%.

Note 2: The "LED lifetime" is defined as the module brightness decrease to 50% original brightness at Ta=25°C and IL = 160mA



**Backlight Circuit LED**

Note 3: Luminance Uniformity of these 9 points is defined as below:

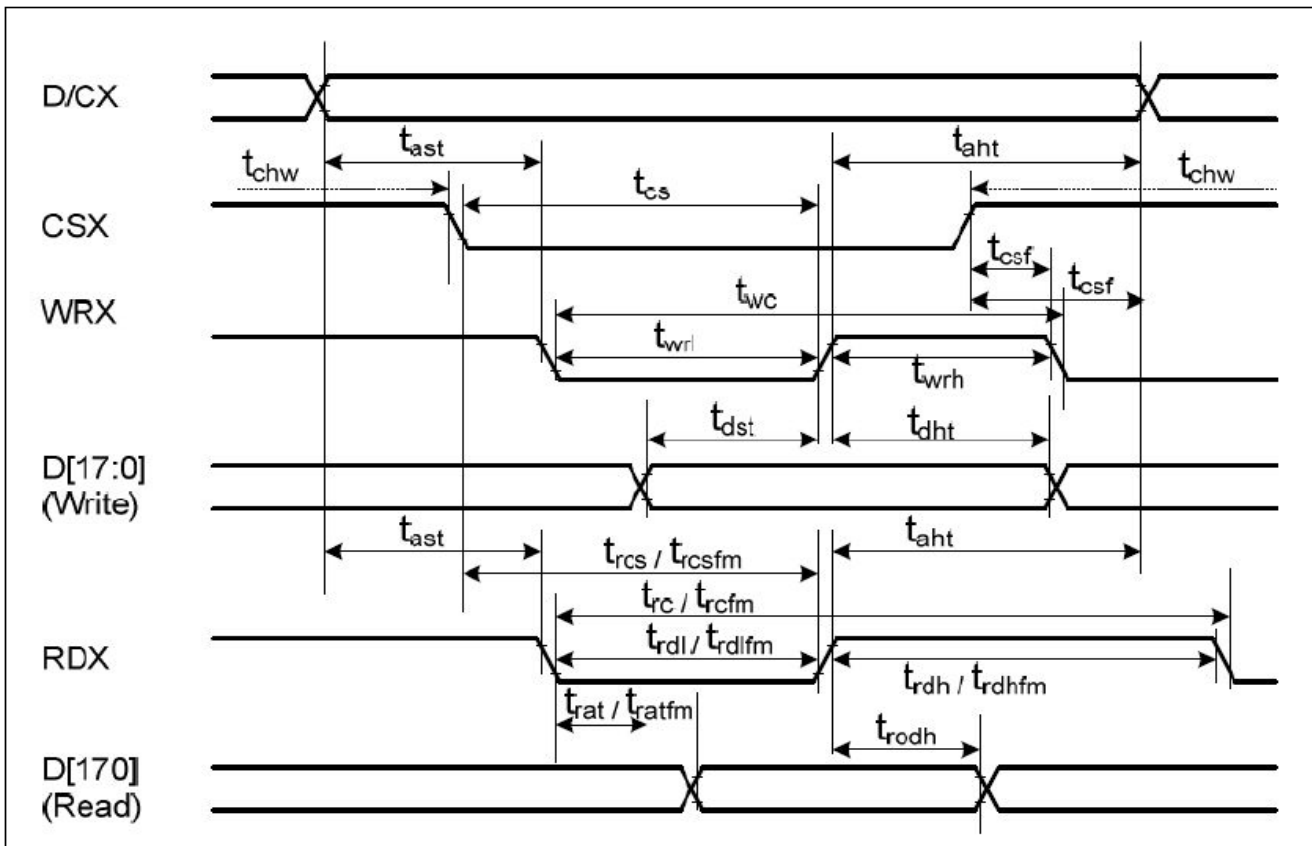


$$\text{Luminance} = \frac{\text{(Total Luminance of 9 points)}}{9}$$

$$\text{Uniformity} = \frac{\text{minimum luminance in 9 points(1-9)}}{\text{maximum luminance in 9 points(1-9)}}$$

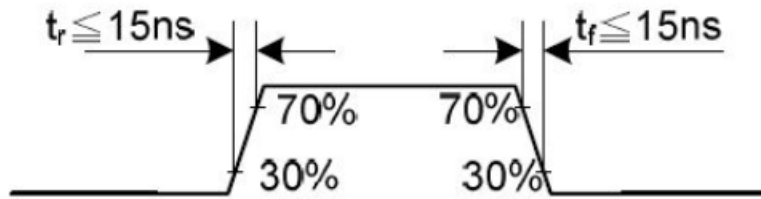
## 6. TFT AC Characteristics

### 6.1 DBI Type B (18/16/9/8 bit) Interface Timing Characteristics (8080-series)

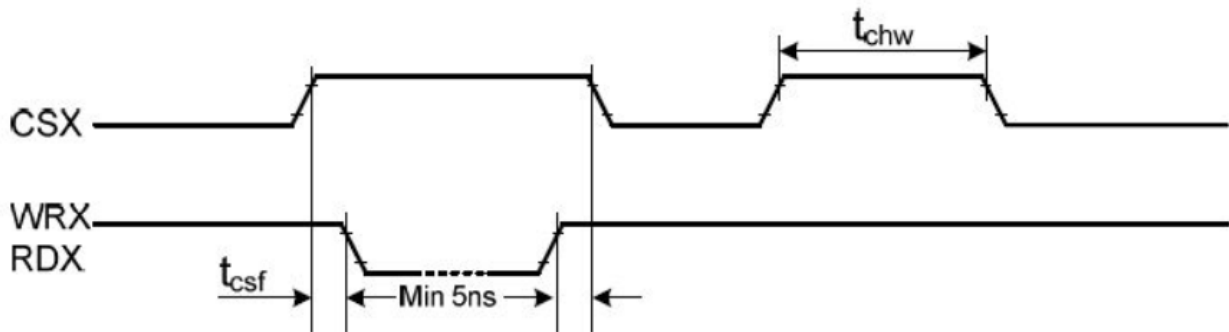


| Signal                                     | Symbol             | Parameter                          | Min | Max | Unit | Description                                       |
|--|--------------------|------------------------------------|-----|-----|------|---|
| D/CX                                       | t <sub>ast</sub>   | Address setup time                 | 0   | -   | ns   |   |
|  | t <sub>ah</sub>    | Address hold time (Write/Read)     | 0   | -   | ns   |   |
| CSX  | t <sub>chw</sub>   | CSX "H" pulse width                | 0   | -   | ns   |   |
|  | t <sub>cs</sub>    | Chip select setup time (Write)     | 15  | -   | ns   |   |
|  | t <sub>rcs</sub>   | Chip select setup time (Read ID)   | 45  | -   | ns   |   |
|  | t <sub>rcsfm</sub> | Chip select setup time (Read FM)   | 355 | -   | ns   |   |
|  | t <sub>csf</sub>   | Chip select wait time (Write/Read) | 0   | -   | ns   |   |
| WRX  | t <sub>wc</sub>    | Write cycle                        | 50  | -   | ns   |   |
|  | t <sub>wrh</sub>   | Write control pulse H duration     | 15  | -   | ns   |   |
|  | t <sub>wrl</sub>   | Write control pulse L duration     | 15  | -   | ns   |   |
| RDX(FM)                                    | t <sub>rcfm</sub>  | Read cycle (FM)                    | 450 | -   | ns   | When read from frame memory                       |
|  | t <sub>rdhfm</sub> | Read control H duration (FM)       | 90  | -   | ns   |   |
|  | t <sub>rdlfm</sub> | Read control L duration (FM)       | 355 | -   | ns   |   |
| RDX(ID)                                    | t <sub>rc</sub>    | Read cycle (ID)                    | 160 | -   | ns   | When read ID data                                 |
|  | t <sub>rdh</sub>   | Read control pulse H duration      | 90  | -   | ns   |   |
|  | t <sub>rdl</sub>   | Read control pulse L duration      | 45  | -   | ns   |   |
| DB[17:0]<br>DB[15:0]<br>DB[8:0]<br>DB[7:0] | t <sub>dst</sub>   | Write data setup time              | 10  | -   | ns   | For maximum,<br>CL=30pF<br>For minimum,<br>CL=8pF |
|  | t <sub>dht</sub>   | Write data hold time               | 10  | -   | ns   |   |
|  | t <sub>rat</sub>   | Read access time                   | -   | 40  | ns   |   |
|  | t <sub>ratfm</sub> | Read access time                   | -   | 340 | ns   |   |
|  | t <sub>rod</sub>   | Read output disable time           | 20  | 80  | ns   |   |

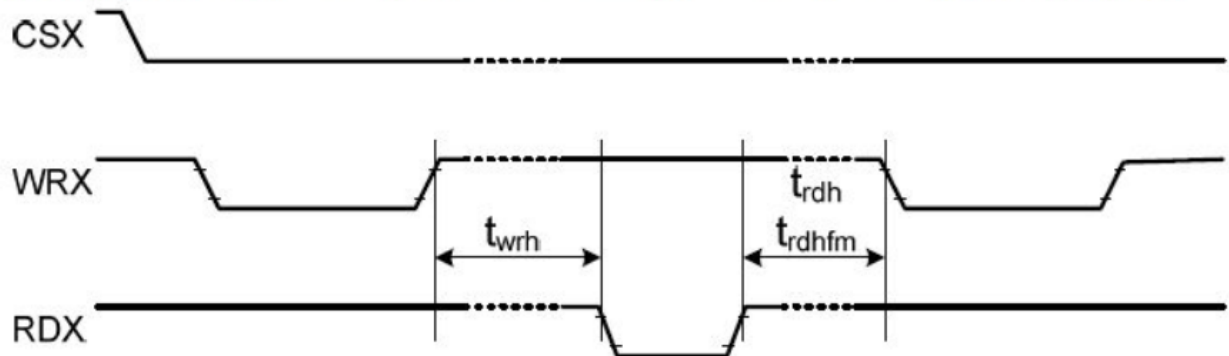
Note: (1)  $T_a = -30$  to  $70^\circ$ ,  $IOVCC = 1.65V$  to  $3.6V$ ,  $VCI=2.5V$  to  $3.6V$ ,  $AGND=DGND=0V$



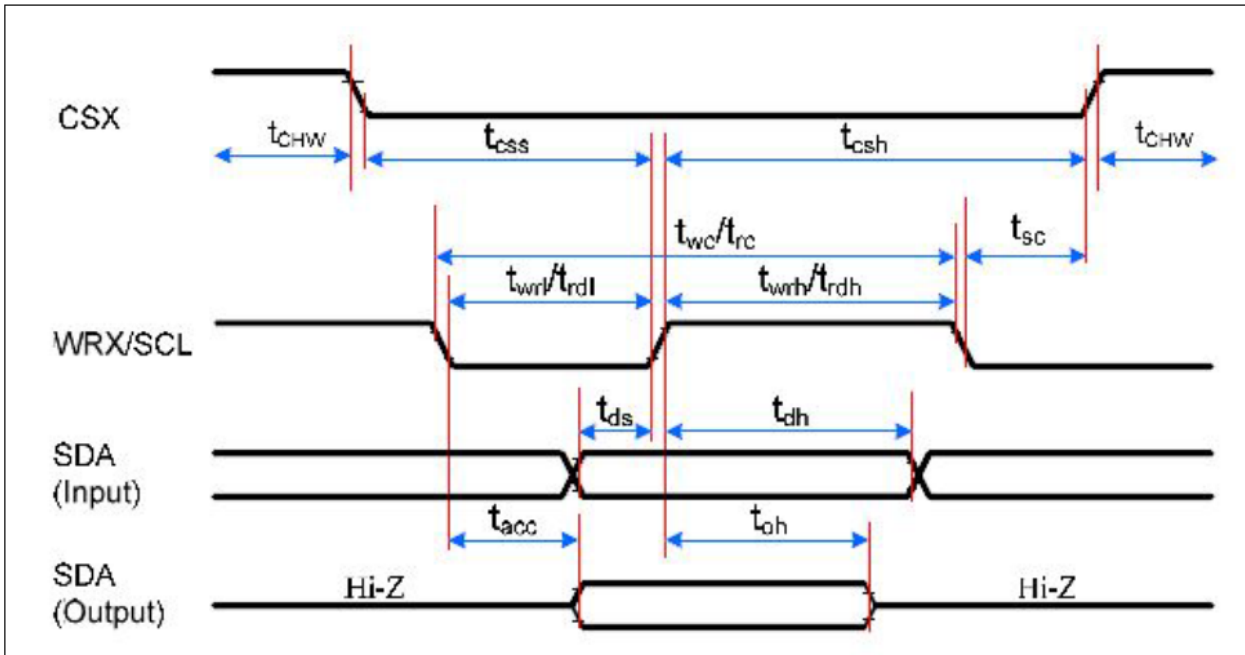
(2) Logic high and low levels are specified as 30% and 70% of IOVCC for input signals.



(3) Logic high and low levels are specified as 30% and 70% of IOVCC for input signals.

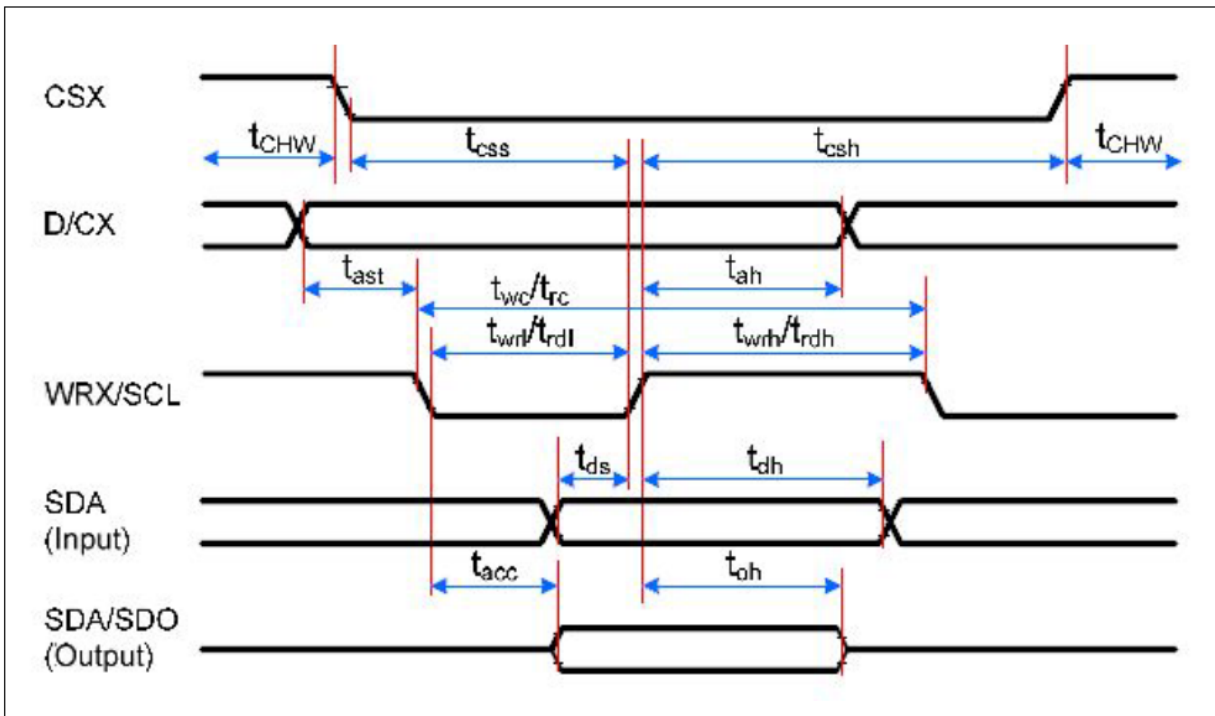


## 6.2 Display Serial Interface Timing Characteristics (3-line SPI system)



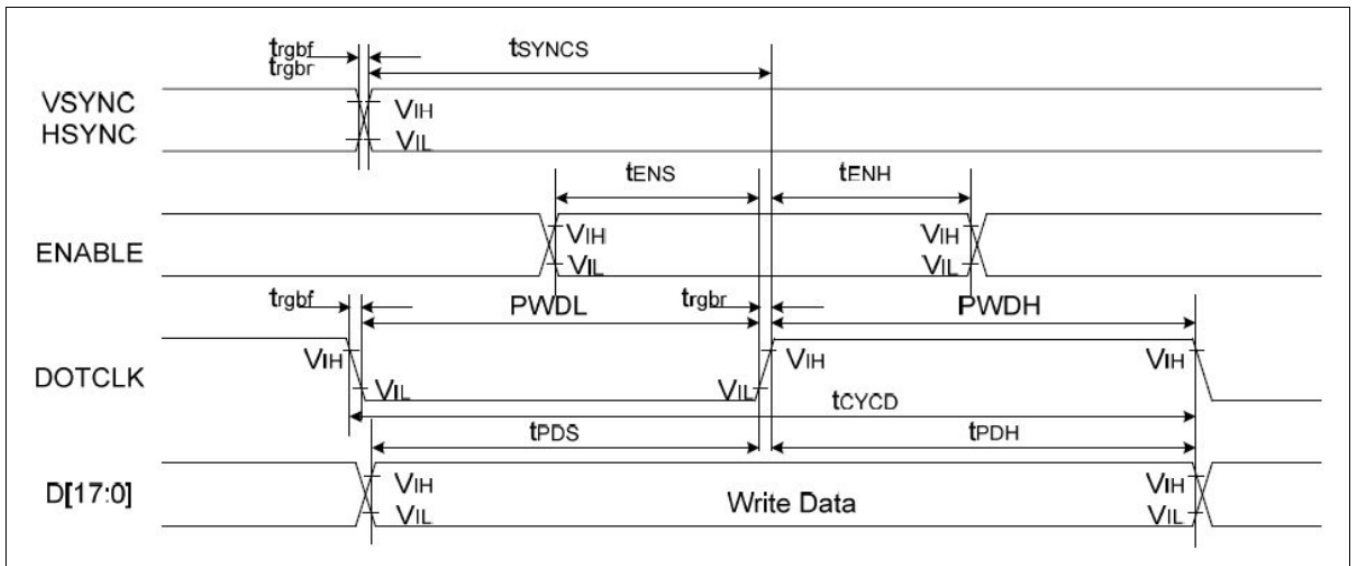
| Signal           | Symbol | Parameter                    | Min | Max | Unit | Description       |
|------------------|--------|------------------------------|-----|-----|------|-------------------|
| CSX              | tsc    | SCL-CSX                      | 15  | -   | ns   |                   |
|                  | tchw   | CSX H pulse width            | 40  | -   | ns   |                   |
|                  | tcss   | Chip select time (Write)     | 60  | -   | ns   |                   |
|                  | tcsch  | Chip select hold time (Read) | 65  | -   | ns   |                   |
| SCL              | twc    | Serial clock cycle (Write)   | 66  | -   | ns   |                   |
|                  | twrh   | SCL H pulse width (Write)    | 15  | -   | ns   |                   |
|                  | twrl   | SCL L pulse width (Write)    | 15  | -   | ns   |                   |
|                  | trc    | Serial clock cycle (Read)    | 150 | -   | ns   |                   |
|                  | trdh   | SCL H pulse width (Read)     | 60  | -   | ns   |                   |
|                  | trdl   | SCL L pulse width (Read)     | 60  | -   | ns   |                   |
| SDA              | tds    | Data setup time (Write)      | 10  | -   | ns   | When read ID data |
|                  | tdh    | Data hold time (Write)       | 10  | -   | ns   |                   |
| SDA/SDO (Output) | tacc   | Access time (Read)           | 10  | 50  | ns   | For max, CL=30pF  |
|                  | toh    | Output disale time (Read)    | 15  | 50  | ns   | For mini, CL=8pF  |

### 6.3 Display Serial Interface Timing Characteristics (4-line SPI system)

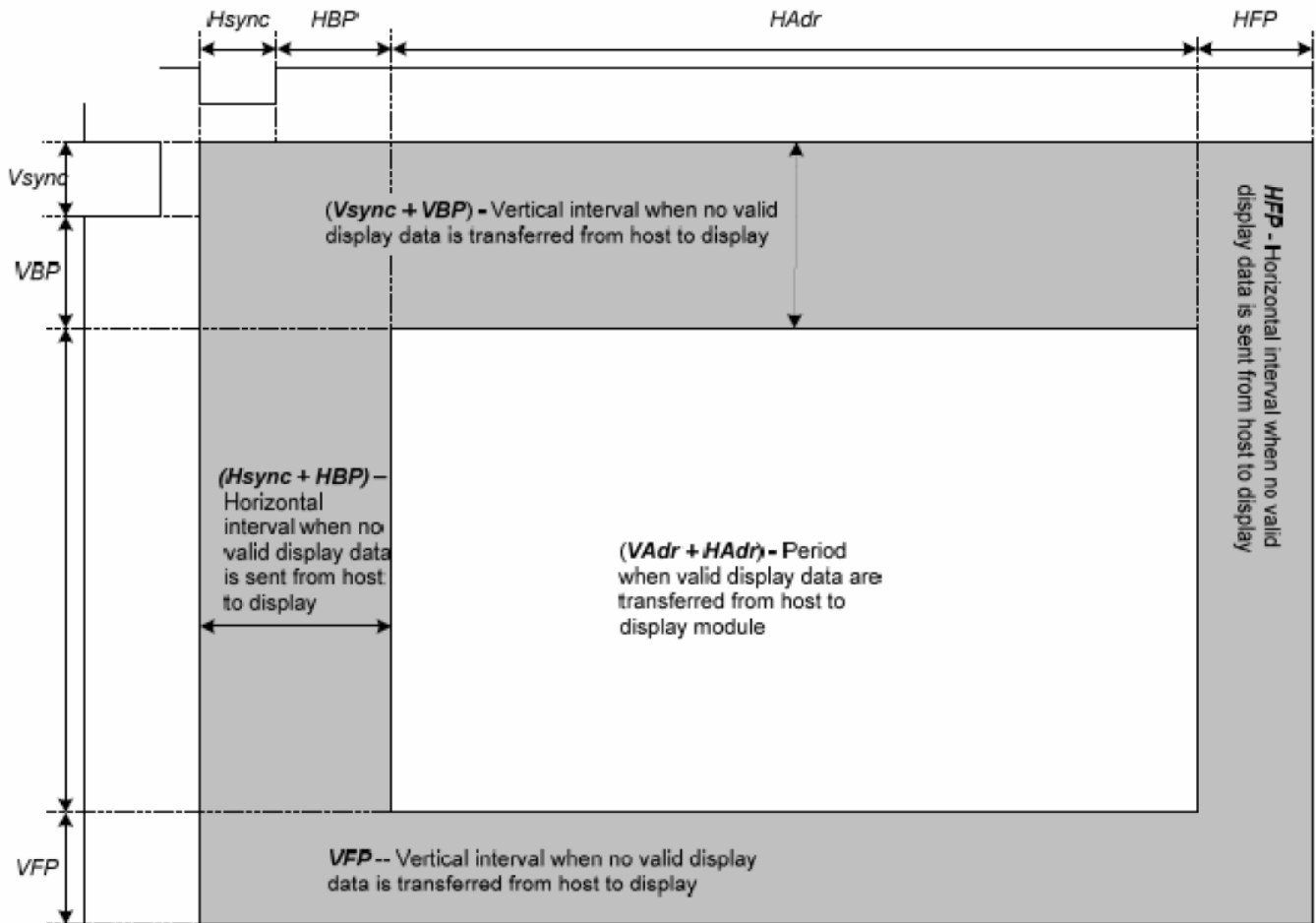


| Signal           | Symbol | Parameter                    | Min | Max | Unit | Description      |
|------------------|--------|------------------------------|-----|-----|------|------------------|
| CSX              | tsc    | SCL-CSX                      | 15  | -   | ns   |                  |
|                  | tchw   | CSX H pulse width            | 40  | -   | ns   |                  |
|                  | tcss   | Chip select time (Write)     | 60  | -   | ns   |                  |
|                  | tcsh   | Chip select hold time (Read) | 65  | -   | ns   |                  |
| SCL              | twc    | Serial clock cycle (Write)   | 66  | -   | ns   |                  |
|                  | twrh   | SCL H pulse width (Write)    | 15  | -   | ns   |                  |
|                  | twrl   | SCL L pulse width (Write)    | 15  | -   | ns   |                  |
|                  | trc    | Serial clock cycle (Read)    | 150 | -   | ns   |                  |
|                  | trdh   | SCL H pulse width (Read)     | 60  | -   | ns   |                  |
|                  | trdl   | SCL L pulse width (Read)     | 60  | -   | ns   |                  |
| D/CX             | tas    | D/CX setup time              | 10  | -   | ns   |                  |
|                  | tah    | D/CX hold time (Write/Read)  | 10  | -   | ns   |                  |
| SDA              | tds    | Data setup time (Write)      | 10  | -   | ns   |                  |
|                  | tdh    | Data hold time (Write)       | 10  | -   | ns   |                  |
| SDA/SDO (Output) | tacc   | Access time (Read)           | 10  | 50  | ns   | For max, CL=30pF |
|                  | toh    | Output disale time (Read)    | 15  | 50  | ns   | For mini, CL=8pF |

#### 6.4 Parallel 18/16-bit RGB Interface Timing Characteristics



| Signal          | Symbol       | Parameter                           | Min | Max | Unit | Description                         |
|-----------------|--------------|-------------------------------------|-----|-----|------|-------------------------------------|
| VSYNC/<br>HSYNC | tSYNCS       | VSYNC/HSYNC setup time              | 15  | -   | ns   | 18/16-bit bus RGB<br>interface mode |
|                 | tSYNCH       | VSYNC/HSYNC hold time               | 15  | -   | ns   |                                     |
| ENABLE          | tENS         | ENABLE setup time                   | 15  | -   | ns   |                                     |
|                 | tENH         | ENABLE hold time                    | 15  | -   | ns   |                                     |
| DB[17:0]        | tPOS         | Data setup time                     | 15  | -   | ns   |                                     |
|                 | tPDH         | Data hold time                      | 15  | -   | ns   |                                     |
| DOTCLK          | PWDH         | DOTCLK high-level period            | 15  | -   | ns   |                                     |
|                 | PWDL         | DOTCLK low-level period             | 15  | -   | ns   |                                     |
|                 | tCYCD        | DOTCLK cycle time                   | 66  | -   | ns   |                                     |
|                 | trgbr, trgbf | DOTCLK, HSYNC, VSYNC rise/fall time | -   | 15  | ns   |                                     |



| Parameters                 | Symbols | Min | Typ. | Max  | Units |
|----------------------------|---------|-----|------|------|-------|
| PCLK cycle                 | PCLKcyc | 100 | 80   | 66.6 | Ns    |
| Horizontal synchronization | Hsync   | 3   | 3    | -    | PCLK  |
| Horizontal back porch      | HBP     | 3   | 3    | -    | PCLK  |
| Horizontal address         | HAdr    | -   | 320  | -    | PCLK  |
| Horizontal front porch     | HFP     | 3   | 3    | -    | PCLK  |
| Vertical synchronization   | Vsync   | 2   | 2    | -    | Line  |
| Vertical back porch        | VBP     | 2   | 2    | -    | Line  |
| Vertical address           | Vadr    | -   | 480  | -    | Line  |
| Vertical front porch       | VFP     | 2   | 2    | -    | Line  |
| Vertical frequency(*)      |         | 50  | 60   | 80   | Hz    |
| Horizontal frequency(*)    |         | -   | 33   | -    | kHz   |
| PCLK frequency(*)          |         | 10  | 12.5 | 15   | MHz   |

Notes:

- (1) Vertical period (one frame) shall be equal to the sum of  $Vsync + VBP + VAdr + VFP$ .
- (2) Horizontal period (one line) shall be equal to the sum  $Hsync + HBP + HAdr + HFP$ .
- (3) Control signals PCLK and Hsync shall be transmitted as specified at all times while valid pixels are transferred between the host processor and the display module.



## 6.5 Reset Timing

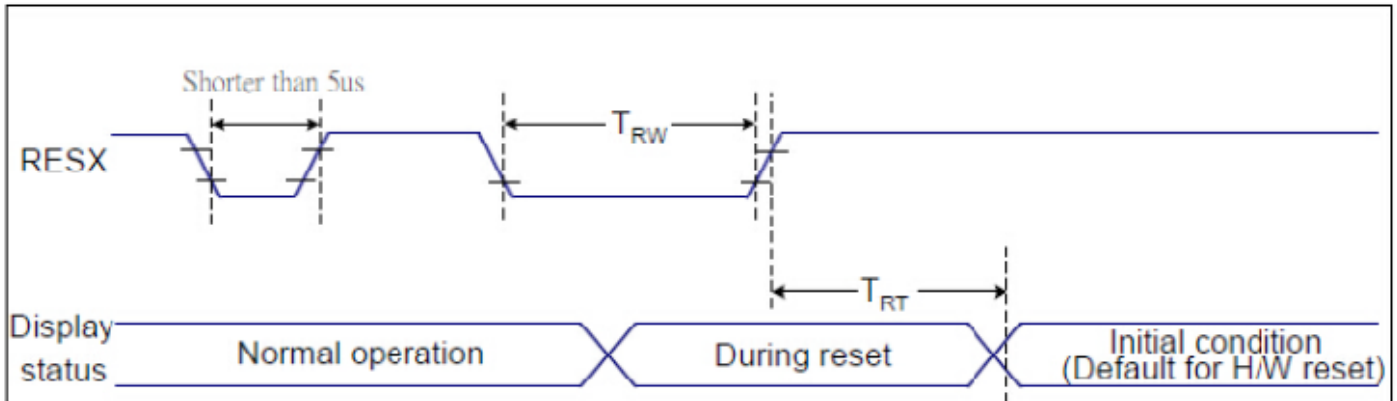


Figure 6.5: Reset Timing Diagram

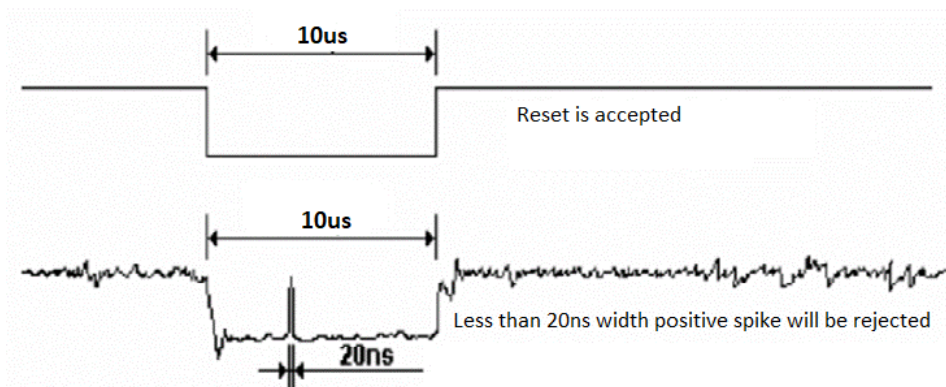
| Related Pins | Symbol | Parameter            | Min | Max                | Unit |
|--------------|--------|----------------------|-----|--------------------|------|
| RESX         | TRW    | Reset pulse duration | 10  | -                  | us   |
|              | TRT    | Reset cancel         | -   | 5 (Note 1,5)       | ms   |
|              |        |                      |     | 120 (Note 1, 6, 7) | ms   |

Notes:

- The reset cancel includes also required time for loading ID bytes, VCOM setting and other settings from NVM (or similar device) to registers. This loading is done every time when there is HW reset cancel time (tRT) within 5ms after a rising edge of RESX.
- Spike due to an electrostatic discharge on RESX line does not because irregular system reset according to the table below:

| RESX Pulse           | Action         |
|----------------------|----------------|
| Shorter than 5us     | Reset Rejected |
| Longer than 9us      | Reset          |
| Between 5us and 9 us | Reset starts   |

- During the resetting period, the display will be blanked (the display is entering blanking sequence, which maximum time is 120ms, when reset starts in Sleep Out mode. The display remains the blank state in Sleep in mode) and then return to Default condition for Hardware Reset.
- Spike Rejection also applies during a valid reset pulse as shown below:



- When Reset applied during Sleep In Mode.
- When Reset applied during Sleep Out Mode.
- It is necessary to wait 5ms after releasing RESX before sending commands. Also Sleep Out command cannot be sent for 120ms.

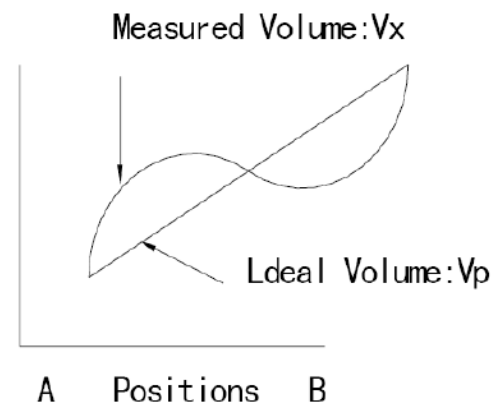
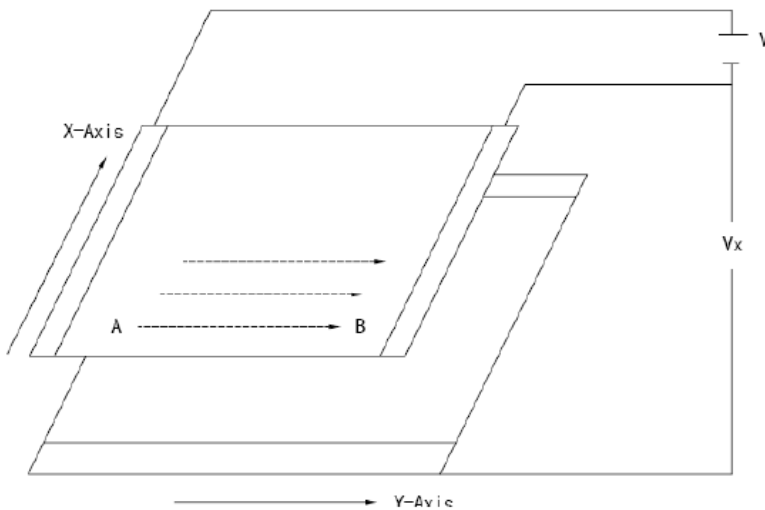
## 7. TP Feature

### 7.1 Conditions of Use and Storage

| Item                             | Condition   | Note                  |
|----------------------------------|---|-----------------------|
| Temperature range upon operation | Humidity: 20%-90% non-dew, condensation<br>-20°C~70°C | In a simple substance |
| Temperature range upon storage   | Humidity: 20%-90% non-dew, condensation<br>-30°C~80°C | In a simple substance |

### 7.2 Electrical Property

| Item                        | Value                                      | Note  |
|-----------------------------|--|---|
| Maximum voltage             | DC5V                                       |   |
| Resistance between terminal | X direction (film side): 200-600 $\Omega$  |   |
|                             | Y direction (glass side): 300-900 $\Omega$ |   |
| Insulation resistance       | DC 25V, 20M $\Omega$ or above              | Connect X + ~X and Y+ ~Y, apply 25VDC<br>Between X and Y for perform measurements |
| Chattering                  | 10ms or below                              |   |
| Rating                      | Voltage is 5V DC                           |   |



### 7.3 Mechanical Property

| Item                | Value                              |                  | Note  |
|---------------------|------------------------------------|------------------|---|
| Input method        | Used of an exclusive pen or finger |                  |   |
| Load upon operation | Exclusive pen                      | 60-100g or below | Operation and measurement with a pen must be carried out under the following tip conditions:<br>Stylus pen material: POM (polyacetal)<br>Tip: Diameter 3.0mm, SR 0.8 mm                   |
|                     | Finger                             | 60-100g or below | Operation and measurement with a pen must be carried out under the following tip conditions:<br>Stylus pen material: Silicon rubber (Hardness: 30°Hs)<br>Tip: Diameter 12.0mm, SR 12.5 mm |
| Surface hardness    | Pencil Hardness: 3H or above       |                  | It complies with the way of test method JIS K5400   |

### 7.4 Optical Property

| Item                      | Performance                            | Note      |
|---------------------------|--|-----------|
| Total light transmittance | 80% or above                           | JIS K7105 |
| Haze                      | 5% or below                            | JIS K7136 |
| Film specification        | Polished type with hard coated surface |           |

## 8. Cautions and Handling Precautions

### 8.1 Handling and Operating the Module

1. When the module is assembled, it should be attached to the system firmly. Do not warp or twist the module during assembly work.
2. Protect the module from physical shock or any force. In addition to damage, this may cause improper operation or damage to the module and back-light unit.
3. Note that polarizer is very fragile and could be easily damaged. Do not press or scratch the surface.
4. Do not allow drops of water or chemicals to remain on the display surface. If you have the droplets for a long time, staining and discoloration may occur.
5. If the surface of the polarizer is dirty, clean it using some absorbent cotton or soft cloth.
6. The desirable cleaners are water, IPA (Isopropyl Alcohol) or Hexane. Do not use ketene type materials (ex. Acetone), Ethyl alcohol, Toluene, Ethyl acid or Methyl chloride. It might permanent damage to the polarizer due to chemical reaction.
7. If the liquid crystal material leaks from the panel, it should be kept away from the eyes or mouth. In case of contact with hands, legs, or clothes, it must be washed away thoroughly with soap.
8. Protect the module from static; it may cause damage to the CMOS ICs.
9. Use fingerstalls with soft gloves in order to keep display clean during the incoming inspection and assembly process.
10. Do not disassemble the module.
11. Protection film for polarizer on the module shall be slowly peeled off just before use so that the electrostatic charge can be minimized.
12. Pins of I/F connector shall not be touched directly with bare hands.
13. Do not connect, disconnect the module in the "Power ON" condition.
14. Power supply should always be turned on/off by the item Power On Sequence & Power Off Sequence

### 8.2 Storage and Transportation.

1. Do not leave the panel in high temperature, and high humidity for a long time. It is highly recommended to store the module with temperature from 0 to 35 °C and relative humidity of less than 70%
2. Do not store the TFT-LCD module in direct sunlight.
3. The module shall be stored in a dark place. When storing the modules for a long time, be sure to adopt effective measures for protecting the modules from strong ultraviolet radiation, sunlight, or fluorescent light.
4. It is recommended that the modules should be stored under a condition where no condensation is allowed. Formation of dewdrops may cause an abnormal operation or a failure of the module. In particular, the greatest possible care should be taken to prevent any module from being operated where condensation has occurred inside.
5. This panel has its circuitry FPC on the bottom side and should be handled carefully in order not to be stressed.