# PACIFIC DISPLAY DEVICES

## LCD Component Data Sheet

## Model Number: 320240-24

**320 x 240 Dot**
**Graphic LCD Assembly**
**With Full Graphic Controller (SED-1335 / RA8835)**
**Edge Lit LED / CCFL Backlight Options**
**Integrated Touch Screen Controller Option**

**CONTENTS**




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# 1. GENERAL INFORMATION

## 1.1 Product Overview

- 320 x 240 dot matrix LCD
- FSTN (Film compensated Super Twisted Nematic) & STN Technology
- SED-1335 or RA8835 Graphic LCD Controller.
- Multiplex drive : 1/240 duty, 1/14 bias
- LCD Module Service Life: 100,000 hours minimum
- 24 Pin Flat Ribbon Cable Interface (No Touch Screen Controller)
- 26 Pin Flat Ribbon Cable Interface (Optional Integrated Touch Screen Controller)

## 1.2 Part Options and Numbering System

| 320240 | -24 | -FC | -F | -ST | -ELED | -WH | -6 | -V-TC-TS |
|---|---|---|---|---|---|---|---|---|

➢ **Custom Option Designator:**
- (-24) SED1335 / RA8835 Cntlr

➢ **Operating Mode:**
- (-SL) STN Silver / Gray
- (-GR) STN Green
- (-BN) STN Blue Negative Image
- (-FC) FSTN (B&W) Positive Image
- (-FN) FSTN (B&W) Negative Image

➢ **Rear Polarizer Options:**
- (-F) Transflective
- (-M) Transmissive
- (-R) Reflective (No Backlight)

➢ **Operating Temperature:**
- (-ST) Standard (0 to +50 ºC)
- (-ET) Extended (-20 to +70 ºC)

➢ **Backlight Options:**
- (-ELED) Edge Lit LED Backlight
- (-CFL) Cold Cathode Florescent Lamp Backlight

➢ **Backlight Coloration Options:**
- (-WH) ELED / CFL – Backlight
- (-GY) LED - Green / Yellow Backlight
-

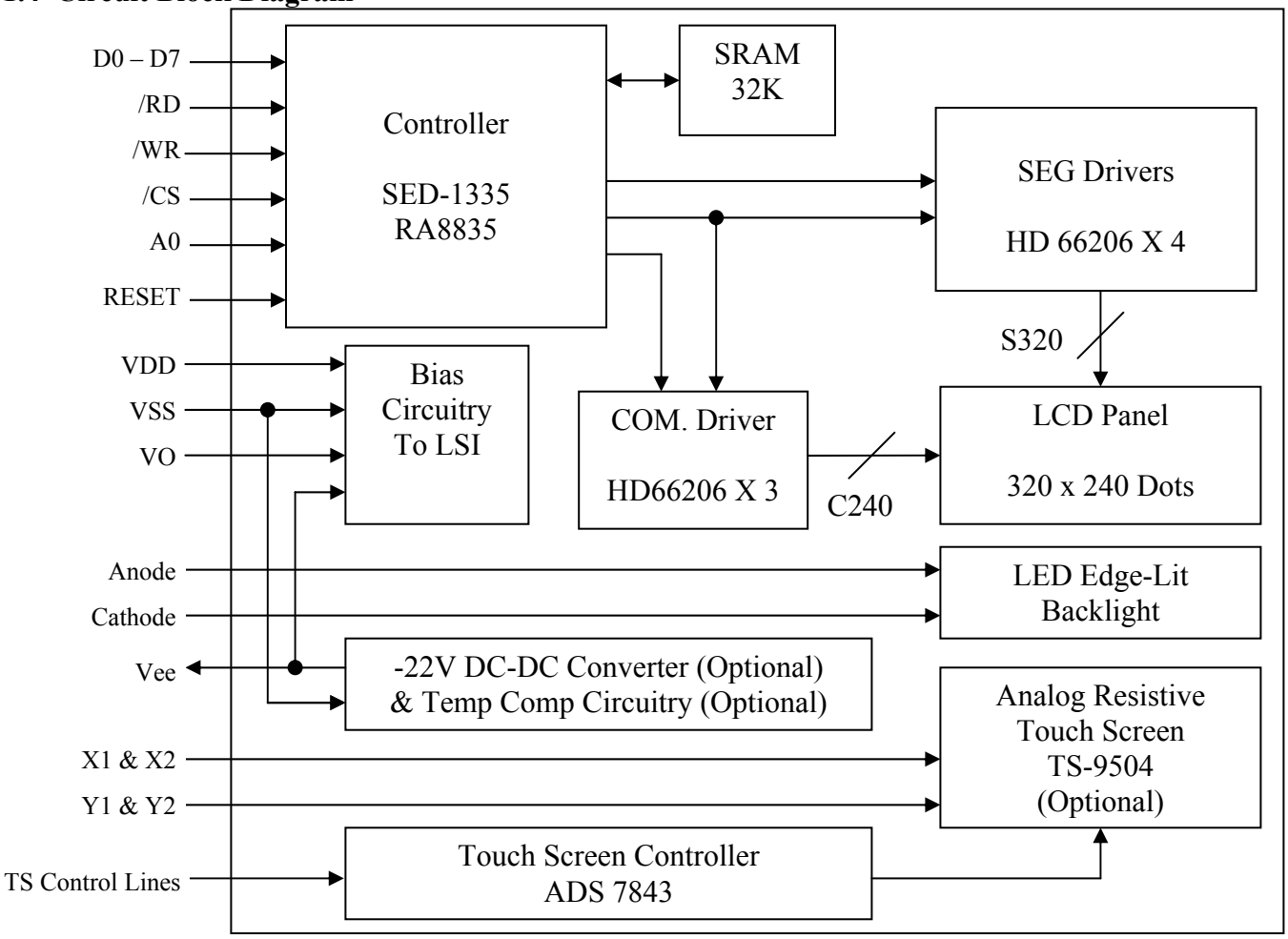
➢ **Viewing Angle:**
- (-6) 6 o'clock
- (-12) 12 0'clock

➢ **Additional Options:**
- (-V) -22V DC-DC Vee Internal Power Supply
- (-TC) Internal contrast related temperature compensation circuitry
- (-TS) Analog Resistive Touch Screen Overlay
- (-TSC) Analog Resistive Touch Screen Overlay with embedded touch screen controller

## 1.3 Absolute Maximum Ratings

| Parameter | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Supply voltage for logic | $V_{DD}$ | -0.3 | 7.0 | V |
| Supply voltage for LCD | $V_{DD}$ – V0 | -0.3 | 30.0 | V |
| Input voltage | VI | -0.3 | $V_{DD}$ +0.3 | V |
| Standard Operating temperature | TOP (-ST) | 0 | 50 | ºC |
| Standard Storage temperature | TST (-ST) | -10 | 60 | ºC |
| Extended Operating temperature | TOP (-ET) | -20 | 70 | ºC |
| Extended Storage temperature | TST (-ET) | -30 | 80 | ºC |
| Soldering Temp | Tsolder | 260 | | ºC |

## 1.4 Circuit Block Diagram




## 1.5 Mechanical Characteristics

| Item | Contents | Unit |
|---|---|---|
| Module size (W×H×T) | 167.0 x 109.0 x 11.0 Max<br>167.0 x 109.0 x 12.6 Max (With Optional Touch Screen) | mm |
| Viewing area (W×H) | 120.0 × 90.0 | mm |
| Active area (W×H) | 115.18 × 86.38 | mm |
| Number of dots | 320 × 240 | dots |
| Dot size (W×H) | 0.34 × 0.34 | mm |
| Dot pitch (W×H) | 0.36 × 0.36 | mm |

## 1.6 Input Signal Function

### CN2 – Flat Cable Interface (No Touch Screen Controller)

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | /RESET | /Reset |
| 2 | /RD | /Data Read (8080) - E (6800) |
| 3 | /WR | /Data Write (8080) - RD - /WR (6800) |
| 4 | /CS | /Chip Select |
| 5 | AO | Data Type Select |
| 6-13 | DB0-DB7 | Bidirectional Data Bus Lines |
| 14 | VDD | Supply voltage for logic |
| 15 | VSS | Ground (0V) |
| 16 | VEE / NC | LCD Negative Voltage Output (for –V option, otherwise N.C.) |
| 17 | VO | LCD Negative Contrast Adj & Bias |
| 18-22 | NC | No Connection |
| 23 | LED A | Anode Power LED Backlight |
| 24 | LED K | Cathode Power LED Backlight |

### CN1: Flex Cable Connectors (Embedded Touch Screen Controller Option "-TSC")

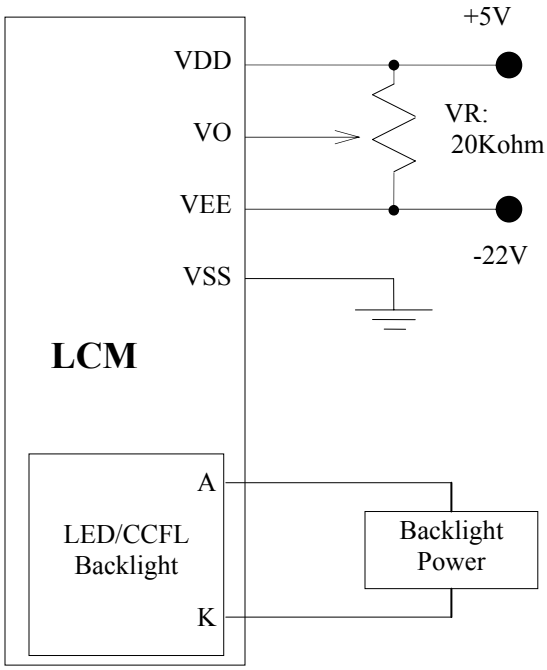
| Pin No. | Symbol | Description |
|---|---|---|
| 1 | VSS | Ground (0V) |
| 2 | VDD | Supply voltage for logic |
| 3 | VO | LCD Negative Contrast Adj & Bias |
| 4 | AO | Data Type Select |
| 5 | /WR | /Data Write (8080) RD - /WR (6800) |
| 6 | /RD | /Data Read (8080) E (6800) |
| 7-14 | DB0-DB7 | Bidirectional Data Bus Lines |
| 15 | /CS | /Chip Select |
| 16 | /RESET | /Reset |
| 17 | VEE / NC | LCD Negative Voltage Output (for –V option, otherwise N.C.) |
| 18 | SEL1 | 8080 / 6800 family interface select |
| 19 | SK | * Serial Clock for Touch Screen Controller |
| 20 | /CS ADS | * Chip select for Touch Screen Controller. Active low. |
| 21 | Din | * Data In of Touch Screen Controller |
| 22 | Dout | * Data Out of Touch Screen Controller |
| 23 | /PEN IRQ | * Touch signal for Touch Screen Controller. Goes low when screen is touched. |
| 24 | Pull Up Ena | * 100K Pull up resistor on PEN IRQ out enable (See schematic Section 1.8) |
| 25 | PL | * Connect 5$^{th}$ wire on 5 wire screens, or Gen Purpose ADC input |
| 26 | GP | * General Purpose ADC Input |

***Note**: Please refer to the Section 1.8 in this document and the Texas Instruments / Burr-Brown ADS7843 data sheet and application notes for more detailed information on the touch screen controller and its interface.

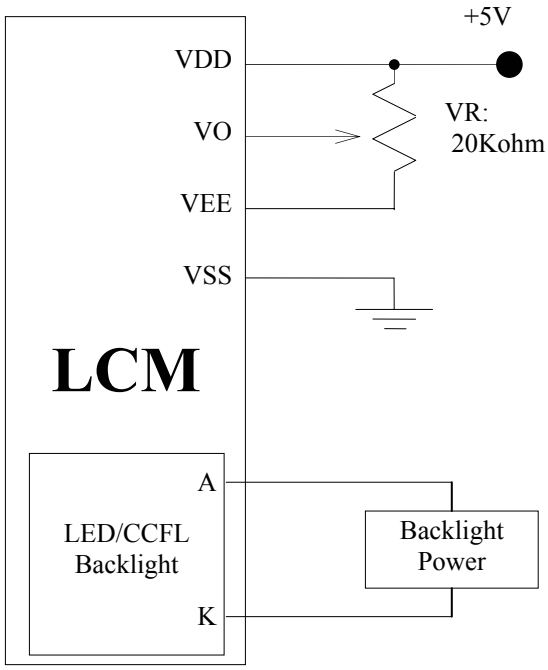
### Backlight Power Pads

| Pin No. | Symbol | Description |
|---|---|---|
| A | LED A | Anode Power LED Backlight |
| K | LED K | Cathode Power LED Backlight |

## 1.7 LCM Power, Contrast Control and Bias



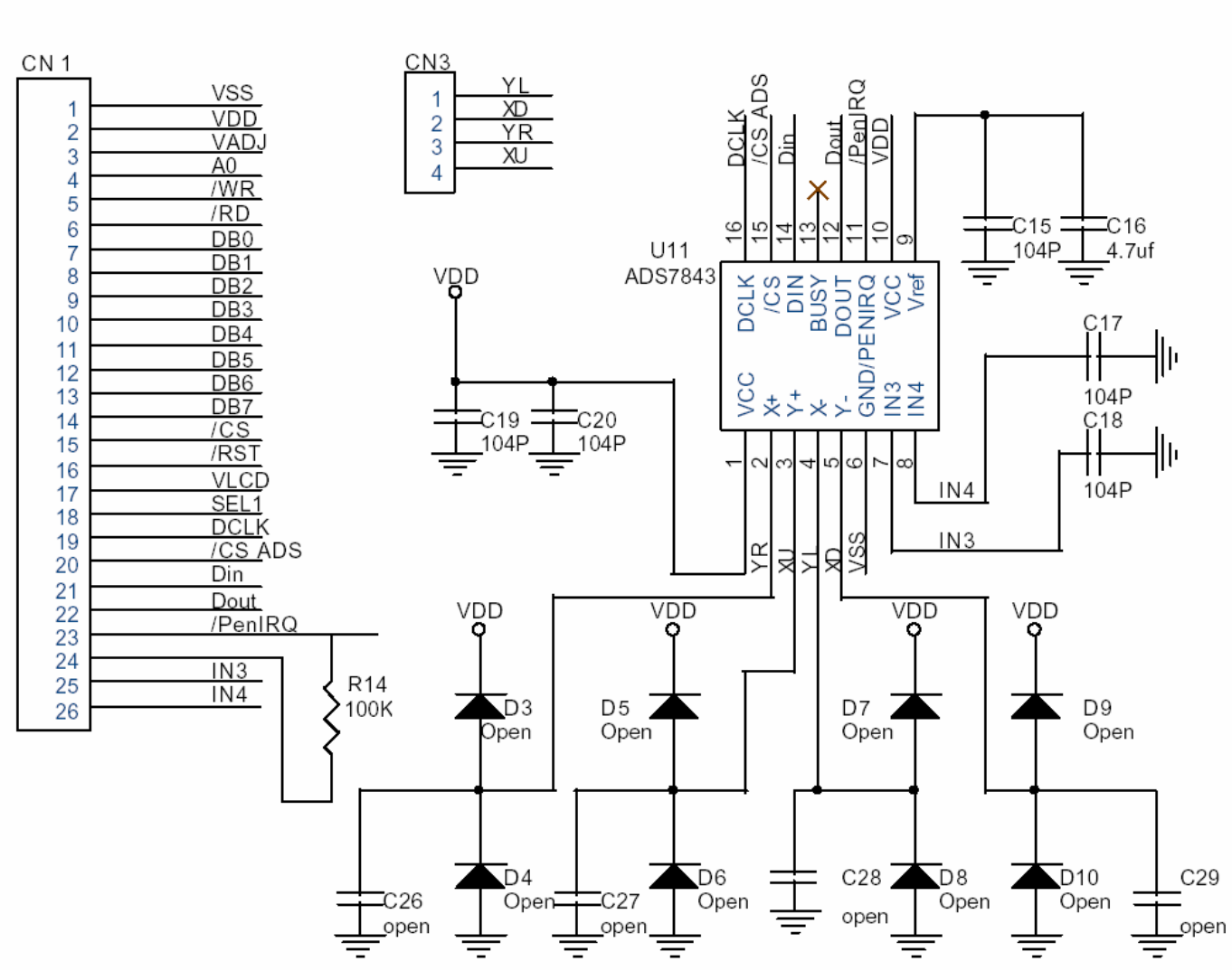

*Note 1 : DC-to-DC Converter Not Built In




*Note 2: DC-to-DC Converter Built In (-V)

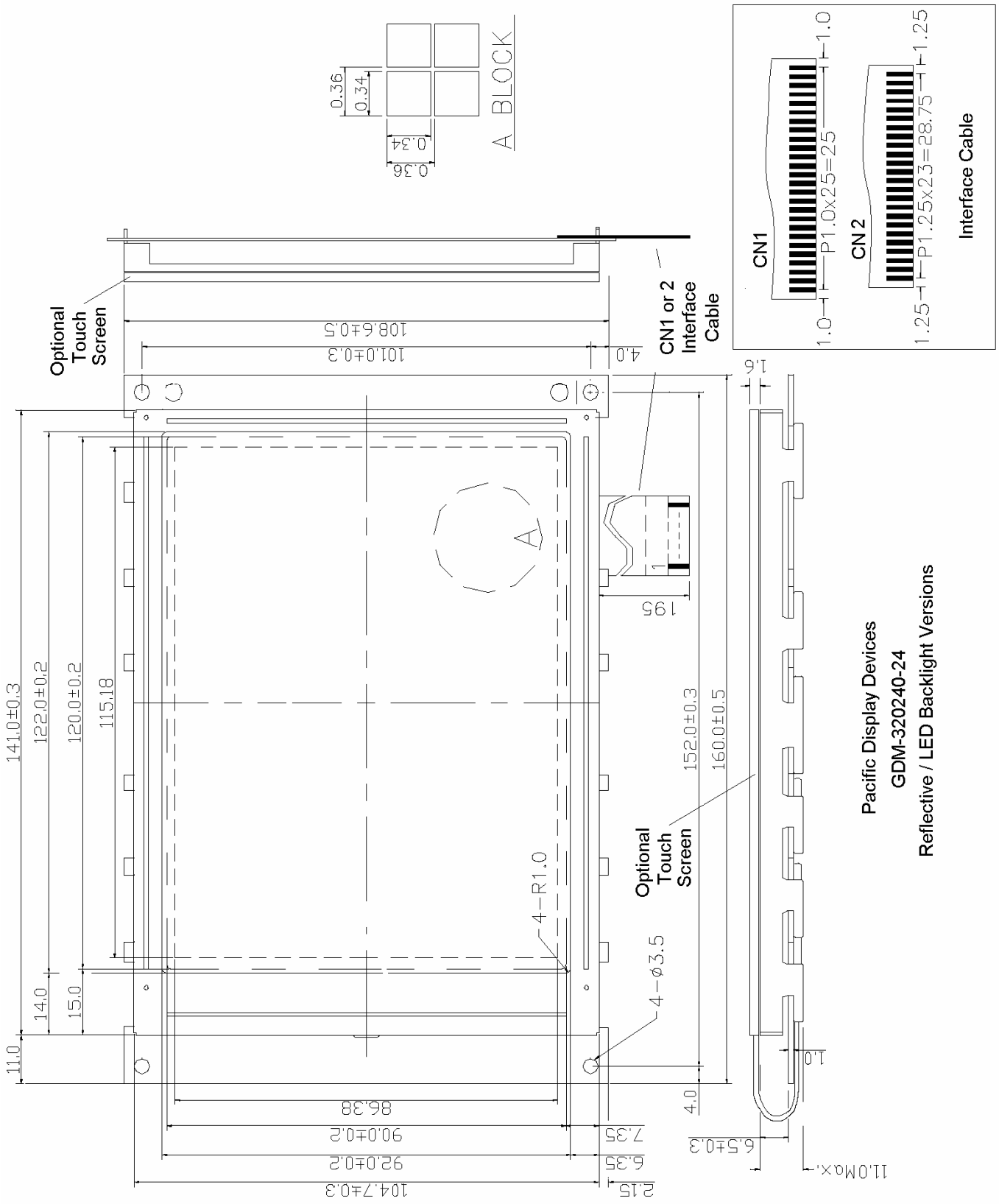
Note 3: If "-V" and "–TC" options are selected (-Vee and Temperature Compensation options), the Vo and Vee pins are not connected and the contrast will come preset from the factory

## 1.8 Touch Screen Controller Interconnect Information

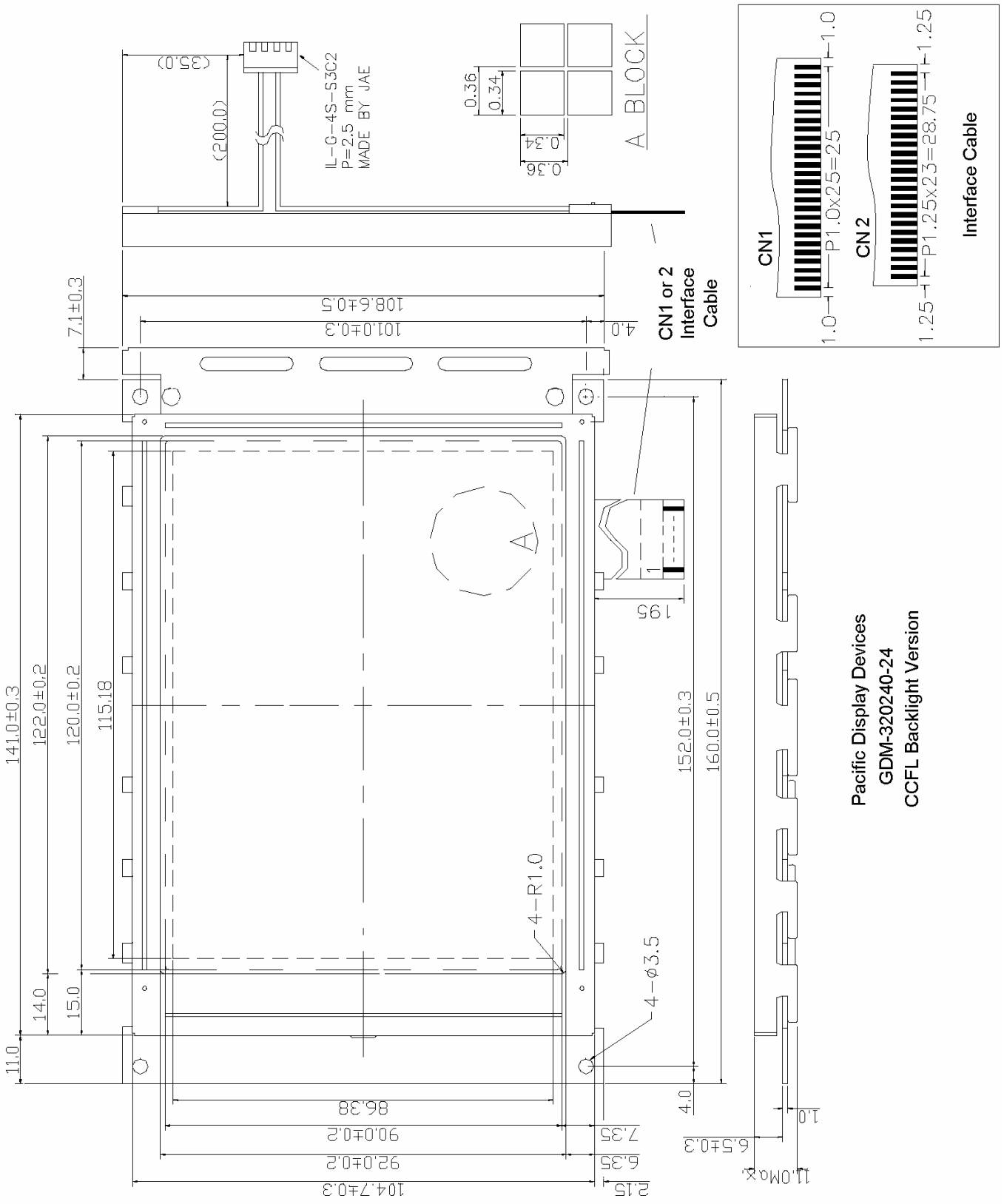


## 1.9 LCM Dimensions

### ■ Module Dimensions with LED Backlight



## ■ Module Dimensions with Cold Cathode Florescent Lamp Backlight



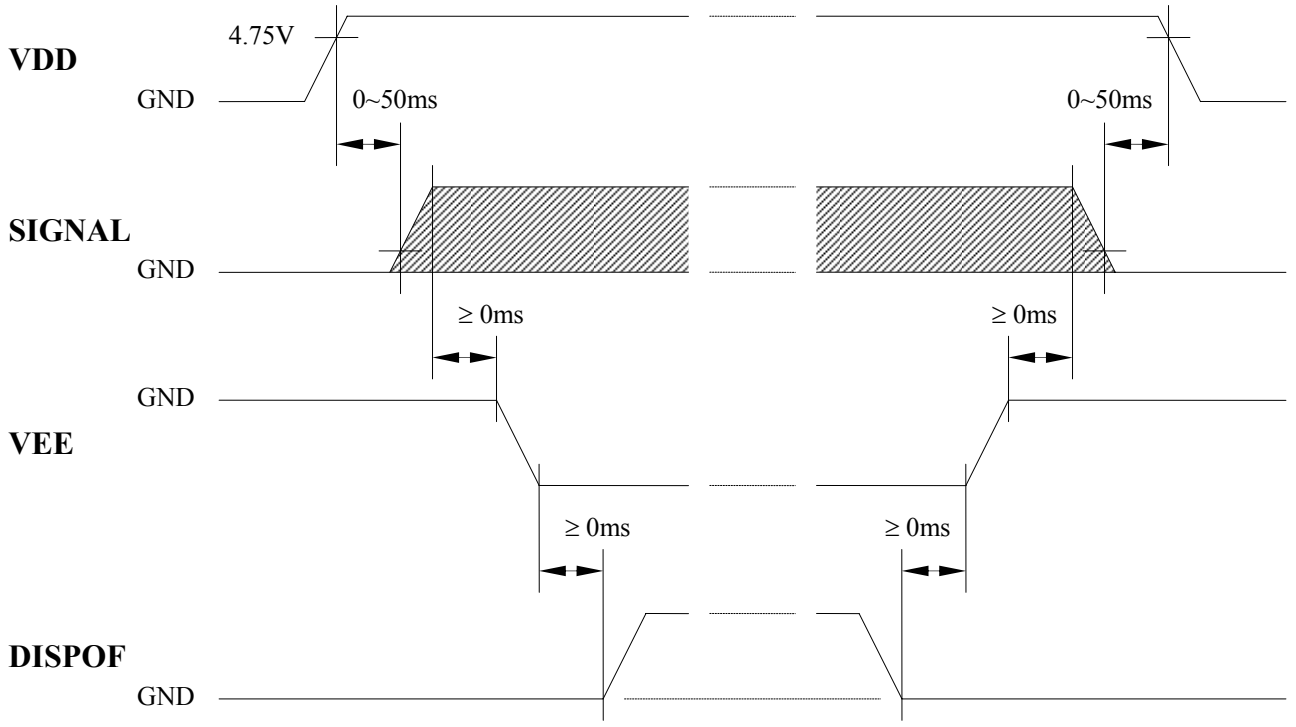
## 2. ELECTRICAL / OPTICAL CHARACTERISTICS

### 2.1 DC Electrical Characteristics ($V_{DD}$ = +5V±10% , $V_{SS}$ = 0V, Ta = 25°C )

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Supply voltage for logic | $V_{DD}$ | --- | 2.8 | 3.3 or 5.0 | 5.5 | V |
| Supply current for logic | $I_{DD}$ | --- | --- | 10 | 16 | mA |
| Negative Supply Voltage* | Vee | Vss-Vee | --- | -22 | -25 | V |
| Operating voltage for LCD | $V_{DD}$-$V_O$ | 0°C | 23.6 | 24.3 | 25.0 | V |
| | | 25°C | 22.8 | 23.5 | 24.2 | V |
| | | 50°C | 21.9 | 22.6 | 23.3 | V |
| Input voltage ' H ' level | $V_{IH}$ | --- | 0.7 $V_{DD}$ | --- | $V_{DD}$ | V |
| Input voltage ' L ' level | $V_{IL}$ | --- | 0 | --- | 0.3 $V_{DD}$ | V |

*Vee may be internally or externally supplied depending on module options

## ■ TIMING OF POWER SUPPLY



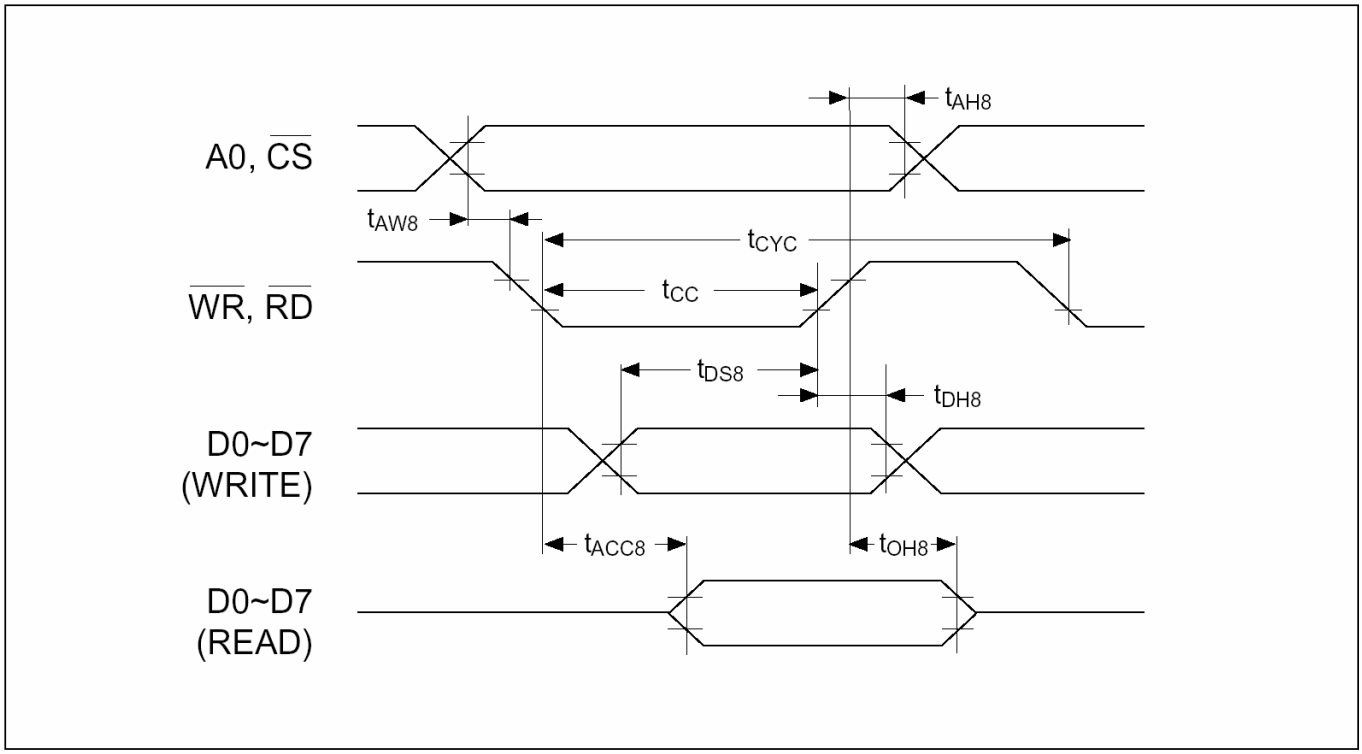

POWER ON POWER OFF

Note : The missing pixels may occur when the LCM is driven except above power supply timing sequence.

## 2.2 AC Electrical Characteristics

**SED-1335 / RA8835 Graphic Controller IC AC Waveform Interface**

● **System Bus READ/WRITE Timing I (8080)**

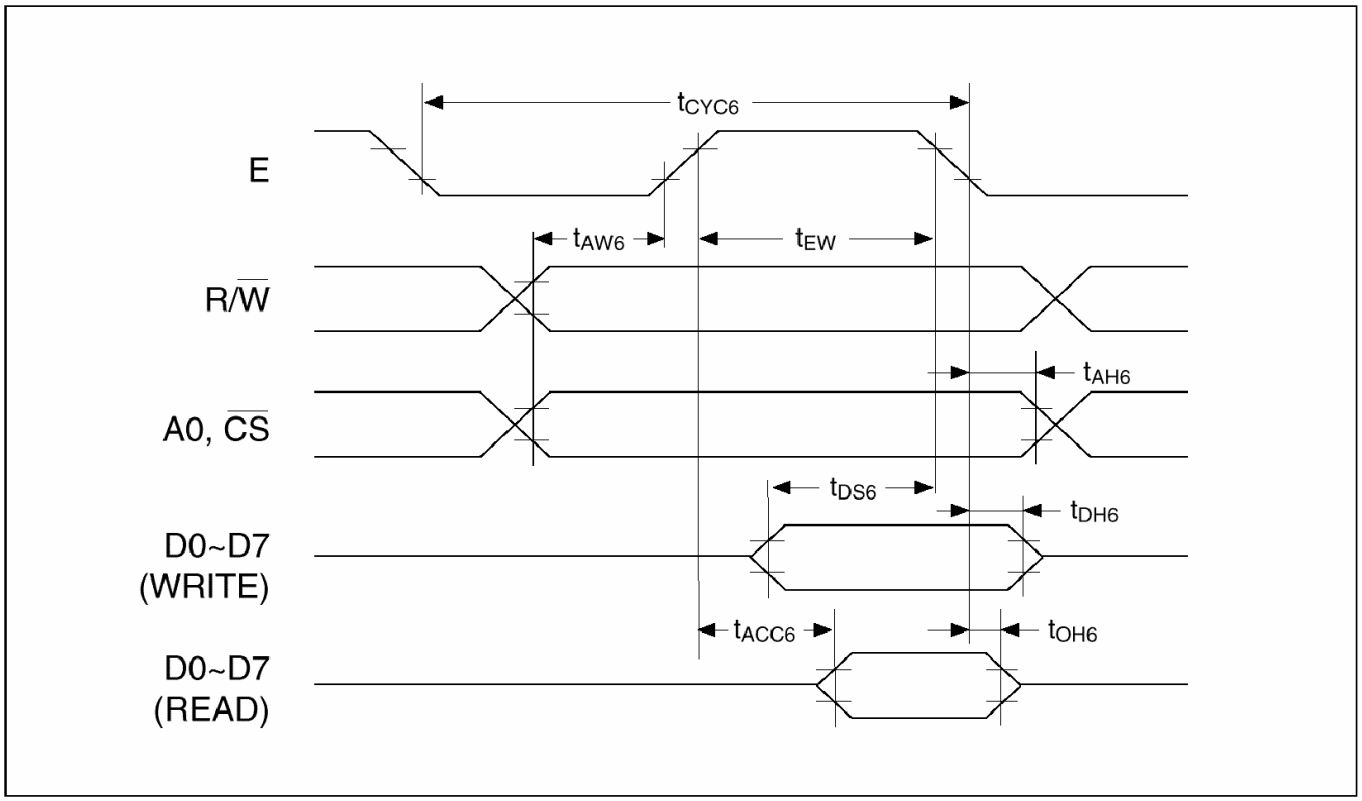



| Signal | Symbol | Parameter | Rating | | Unit | Condition |
|---|---|---|---|---|---|---|
| | | | min | max | | |
| A0, /CS | tAH8 | Address hold time | 10 | --- | ns | CL = 100 pF |
| | tAW8 | Address setup time | 30 | --- | ns | |
| /WR, /RD | tCYC | System cycle time | (1) | --- | ns | |
| | tCC | Strobe pulse width | 220 | --- | ns | |
| D0 to D7 | tDS8 | Data setup time | 120 | --- | ns | |
| | tDH8 | Data hold time | 10 | --- | ns | |
| | tACC8 | RD access time | --- | 120 | ns | |
| | tOH8 | Output disable time | 10 | 50 | ns | |

**Note:**

1. t CYC =2t C + t CC + t CEA + 75 > t ACV + 245…..Memory control/movement control commands:
   = 4t C + t CC + 30…….All other commands:

## ● System Bus READ/WRITE Timing II (6800 )




| Signal | Symbol | Parameter | Rating | | Unit | Condition |
|---|---|---|---|---|---|---|
| | | | min | max | | |
| A0, CS R/W | tAH6 | Address hold time | 10 | --- | ns | CL = 100+1TTL pF |
| | tAW6 | Address setup time | 30 | --- | ns | |
| | tCYC6 | System cycle time | (1) | --- | ns | |
| | tCC | Strobe pulse width | 220 | --- | ns | |
| D0 to D7 | tDS6 | Data setup time | 120 | --- | ns | |
| | tDH6 | Data hold time | 10 | --- | ns | |
| | tACC6 | RD access time | --- | 120 | ns | |
| | tOH6 | Output disable time | 10 | 50 | ns | |
| E | tEW | Enable pulse width | 220 | --- | ns | |

**Notes:**

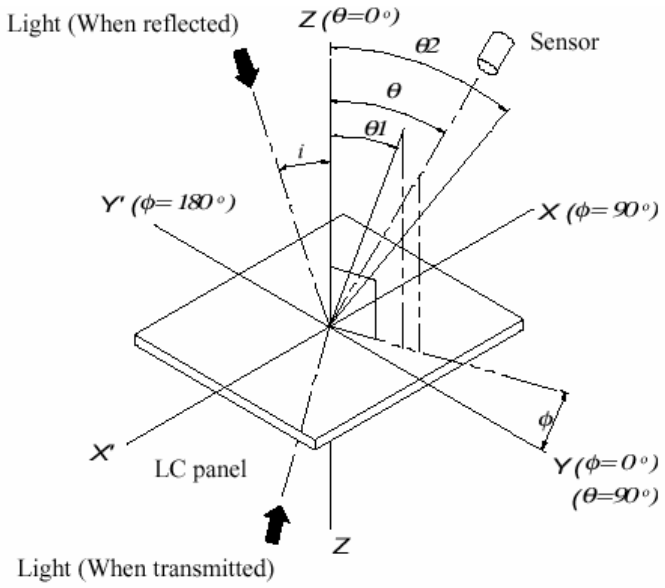
1. tCYC6 means a cycle of (CS.E) not E alone.

2. t CYC6 = 2t C + t EW + t CEA + 75 > t ACV + 245….. memory control/movement control commands
   = 4tC + tEW + 30…… all other commands

## 2.3 Optical Characteristics ($V_{OP}$ = 4.7V, Ta = 25°C )

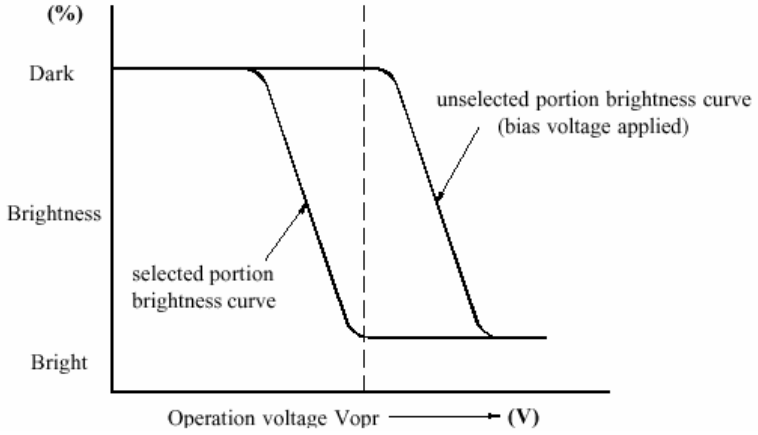
| Item | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Contrast ratio | Cr | θ=0° ϕ=0° | 4.3 | 5.4 | --- | --- |
| Frame Frequency | $f_{FRM}$ | --- | --- | 70 | --- | Hz |
| Viewing angle range | $\theta_1$ | 25°C | --- | 43 | --- | deg |
| | $\theta_2$ | | --- | 29 | --- | deg |
| Response time | Ton | 25°C | --- | 157 | --- | ms |
| | Toff | | --- | 255 | --- | ms |

**Definition of angles ∅ and θ:**

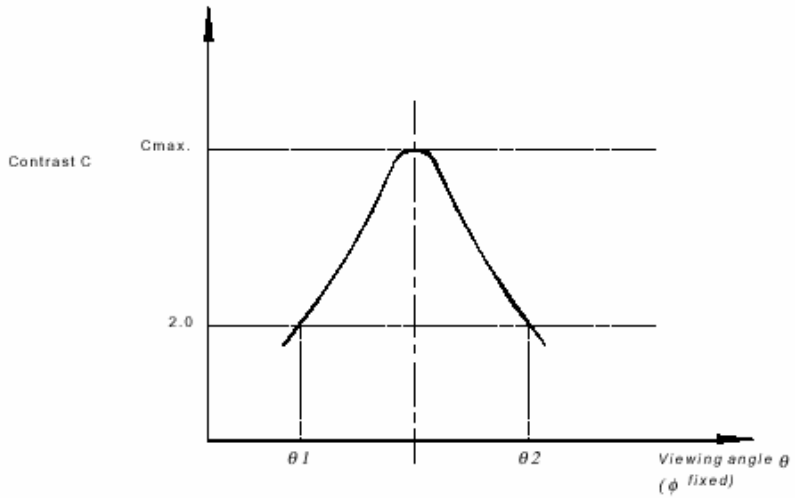



*Definition of contrast C

$$C = \frac{B1}{B2} = \frac{\text{Brightness of selected portion}}{\text{Brightness of unselected portion}}$$

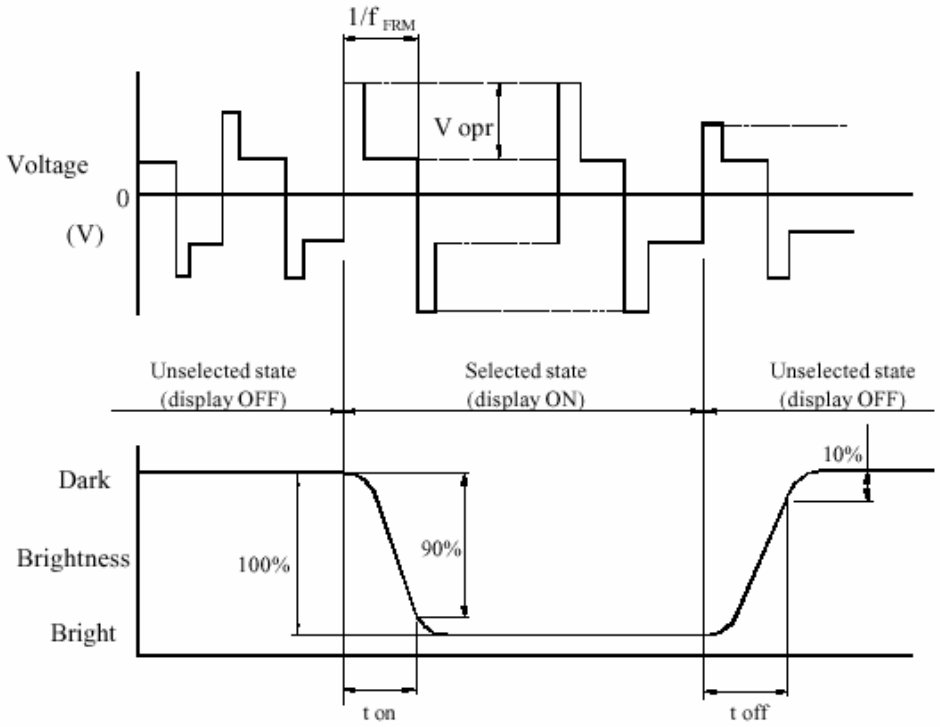


*Definition of viewing angles θ1 and θ2




Note : Optimum vision with the naked eye and viewing angle θ at Cmax above are not always the same.

*Definition of response time




Vop : Operating voltage (V) ton : Response time (rise) (ms)

fFRM : Frame frequency (Hz) toff : Response time (fall) (ms)

## 2.4 LED Backlight Characteristics

### ■ Standard White ELED (-WH) Operating Characteristics

| Item | Symbol | Conditions | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Forward voltage | $V_f$ | Ta= 25 °C | | 3.4 | 4.0 | VDC |
| Forward Current | $I_f$ | Ta= 25 °C | | 160 | 200 | mA |
| Reverse Voltage | $V_R$ | Ta= 25 °C | --- | --- | 5 | V |

| Item | Conditions | Standard | | Unit |
|---|---|---|---|---|
| | | Min. | Max. | |
| Life | Ta= 25 °C | 20,000 | --- | hrs |

### ■ Yellow-Green LED (-GY) Operating Characteristics

| Item | Symbol | Conditions | Standard | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| Forward voltage | $V_f$ | Ta= 25 °C | | 2.2 | 2.4 | VDC |
| Forward Current | $I_f$ | Ta= 25 °C | | 280 | 560 | mA |
| Reverse Voltage | $V_R$ | Ta= 25 °C | --- | --- | 8 | VDC |

| Item | Conditions | Standard | | Unit |
|---|---|---|---|---|
| | | Min. | Max. | |
| Life | Ta= 25 °C | 100,000 | --- | hrs |

## 2.5 CCFL Backlight Characteristics (White)

**■ Maximum Operating Condition (Ta=25°C, fL=55KHz)**

The half-brightness life of the back light shall be kept as specified under the following absolute maximum conditions:

| | |
|---|---|
| Power Consumption: | 1.35W |
| Tube current: | 5.0±1.0maArms |

**■ Electrical Characteristics (Ta=25°C)**

| | |
|---|---|
| Start Voltage: | 450Vrms |
| Tube Voltage: | 270Vrms typ. |
| Tube Current: | 5.0mArms typ. |
| Drive frequency: | 30-80KHz typ. |

**■ Initial Optical Characteristics (Ta: 25°C, 30%-85% relative humidity, no air flow)**

| | |
|---|---|
| Power Source: | TDK L10L inverter. |
| Brightness Uniformity: | 75% |
| Average Brightness: | 550cd/$m_2$ min. (Measurement shall be continuous on for 30 minutes) |
| Chromaticity: | x=0.3475±0.015<br>y=0.3750±0.015 |

**■ Life**

| | |
|---|---|
| Power Source: | TDK L10L inverter. |
| Tube Current: | 5ma |
| Half-Brightness Life of Unit: | 10,000 Hours min.<br>The definition of half-brightness life is either average brightness reach to50% of initial average brightness or lamp stopping light emission. |

**■ Temperature and Humidity Ratings:**

| | |
|---|---|
| Operating Temperature: | 0 to 50°C<br>Humidity 20 to 90%RH |
| Storage temperature: | -20 to 80°C<br>Humidity 5 to 95%RH |

## 2.6 Touch Panel Characteristics

### ■ Typical Optical Characteristics

Visible Light Transmission: >80% @ 550 nm
Haze: 5% through hard coated PET only
Operational Temperature: -10 to 50°C (Humidity 5 to 95%RH)
Storage Temperature: -20 to 70°C (At ambient Humidity)

### ■ Electrical Characteristics

Power ratings:
Operating Voltage: 5.5V DC (or less)
Contact Current: 20mA (Max)
Insulation Resistance: >10MΩ at 25V DC
Terminal Resistance:
Between X1 and X2: 650 ±200Ω
Between Y1 and Y2: 300 ±200Ω
Static Electricity
Max Induced Energy: 15KV thru 150Ω 150pf
Linearity: 1.5% Max Linear Deviation
Maximum interlayer capacitance: 100nf max. (Application weight 3g/cm$^2$)
Contact Bounce: <15ms

### ■ Mechanical Characteristics

Actuation Force: 10g ~ 80g
Input Touch Radius = 0.8 stylus or finger
Transparency: 79% (Typical)
Heat Sealed Area Strength: 150g/cmwith a 90 degree peeling test
Surface hardness: Pencil hardness >3H per JIS-K5400

### ■ Touch Screen Mechanical Configuration and Interconnect (no Internal TS Controller):

**TS-9504 Option**

| Pin No. | Symbol | Description |
|---|---|---|
| 1 | Top | Y Plane Electrode 1 |
| 2 | Bottom | Y Plane Electrode 2 |
| 3 | Left | X Plane Electrode 1 |
| 4 | Right | X Plane Electrode 2 |

### ■ Touch Screen Mechanical Configuration and Interconnect (With Internal TS Controller):

Touch screen Interconnection: Internal to display module
Touch Screen Controller: Please refer to the Texas Instrument / Burr-Brown ADS7843 Touch Screen Controller Data Sheet

### ■ Mechanical Characteristics

Actuation Force: 10g ~ 80g
Input Touch Radius = 0.8 stylus or finger
Transparency: 79% (Typical)
Heat Sealed Area Strength: 150g/cmwith a 90 degree peeling test
Surface hardness: Pencil hardness >3H per JIS-K5400

# 3. OPERATING PRINCIPALS AND METHODS

## 3.1 LCD Controller Display and Control Functions

### ◆ Command Description

### ● The Command Set

**Table 1. The Command Set**

| Class | Command | Code | | | | | | | | | | | Hex | Command Description | Command Read Parameters | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | RD | WR | A0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | | | No. of Bytes | Section |
| System | SYSTEM SET | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | Initialize device and display | 8 | 3.2.1 |
| | SLEEP IN | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 53 | Enter standby | 0 | 3.2.2 |
| | DISP ON/OFF | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | D | 58, 59 | Enalbe and disable display and display flashing | 1 | 3.3.1 |
| Display control | SCROLL | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 44 | Set display start address and display regions | 10 | 3.3.2 |
| | CSRFORM | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 5D | Set cursor type | 2 | 3.3.3 |
| | CGRAM ADR | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 5C | Set start address of character generator RAM | 2 | 3.3.6 |
| | CSRDIR | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | CD 1 | CD 0 | 4Cof 4F | Set direction of cursor movement | 0 | 3.3.4 |
| | HDOT SCR | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 5A | Set horizontal scroll position | 1 | 3.3.7 |
| | OVLAY | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 5B | Set display overlay format | 1 | 3.3.5 |
| Drawing control | CSRW | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 46 | Set cursor address | 2 | 3.4.1 |
| | CSRR | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 47 | Read cursor address | 2 | 3.4.2 |
| Memory control | MWRITE | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 42 | Write to display memory | --- | 3.5.1 |
| | MREAD | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 43 | Read from display memory | --- | 3.5.2 |

**Notes:**

1. In general, the internal registers of the SED1335 / RA8835 are modified as each command parameter is input. However, the microprocessor does not have to set all the parameters of a command and may send a new command before all parameters have been input. The internal registers for the parameters that have been input will have been changed but the remaining parameter registers are unchanged. 2-byte parameters (where two bytes are treated as one data item) are handled as follows:
   a. CSRW, CSRR: Each byte is processed individually. The microprocessor may read or write just the low byte of the cursor address.
   b. SYSTEM SET, SCROLL, CGRAM ADR: Both parameter bytes are processed together. If the command is changed after half of the parameter has been input, the single byte is ignored.
2. APL and APH are 2-byte parameters, but are treated as two 1-byte parameters.

## ● System Control Commands

### 1.SYSTEM SET

Initializes the device, sets the window sizes, and selects the LCD interface format. Since the command sets the basic operating parameters of the CONTROLLER, an incorrect SYSTEM SET command may cause other commands to operate incorrectly.

| | MSB D7 | D6 | D5 | D4 | D3 | D2 | D1 | LSB D0 | A0 | WR | RD |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| P1 | DR | T/L | IV | 1 | W/S | M2 | M1 | M0 | 0 | 0 | 1 |
| P2 | WF | 0 | 0 | 0 | 0 | ← FX → | | | 0 | 0 | 1 |
| P3 | 0 | 0 | 0 | 0 | ← FY → | | | | 0 | 0 | 1 |
| P4 | ← C/R → | | | | | | | | 0 | 0 | 1 |
| P5 | ← TC/R → | | | | | | | | 0 | 0 | 1 |
| P6 | ← L/F → | | | | | | | | 0 | 0 | 1 |
| P7 | ← APL → | | | | | | | | 0 | 0 | 1 |
| P8 | ← APH → | | | | | | | | 0 | 0 | 1 |

### 1.1 C

This control byte performs the following:
1. Resets the internal timing generator
2. Disables the display
3. Cancels sleep mode

Parameters following P1 are not needed if only canceling sleep mode.

### 1.2 M0

Selects the internal or external character generator ROM. The internal character generator ROM contains 160, 5 ´ 7 pixel characters. These characters are fixed at fabrication by the metalization mask. The external character generator ROM can contain up to 256 user-defined characters.
**M0 = 0:** Internal CG ROM
**M0 = 1:** External CG ROM
Note that if the CG ROM address space overlaps the display memory address space, that portion of the display memory cannot be written to.

### 1.3 M1

Selects the CG RAM area for user-definable characters. The CG RAM codes are selected from the 64 codes shown in page
**M1 = 0:** CG RAM1; 32 char
The CG RAM1 and CG RAM2 address spaces are not contiguous, the CG RAM1 address space is treated as character generator RAM, and the CG RAM2 address space is treated as character generator ROM.
**M1 = 1:** 64 char CG RAM + CG RAM2
The CG RAM1 and CG RAM2 address spaces are contiguous and are both treated as character genera-tor RAM.

### 1.4 M2

Selects the height of the character defined in external CG ROM and CG RAM. Characters more than 16 pixels high can be displayed by creating a bitmap for each portion of each character and using theCONTROLLER's graphics mode to reposition them.
**M2 = 0:** 8-pixel character height (2716 or equivalent ROM)
**M2 = 1:** 16-pixel character height (2732 or equivalent ROM)

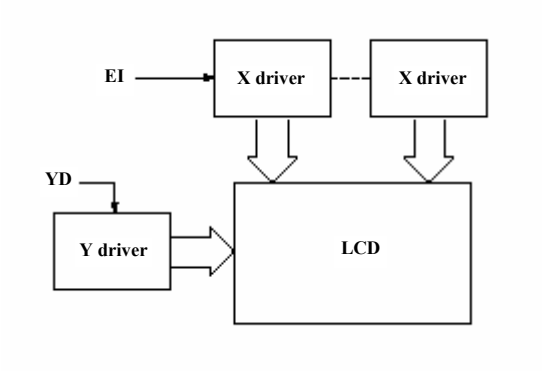
**1.5 W/S**

Selects the LCD drive method.

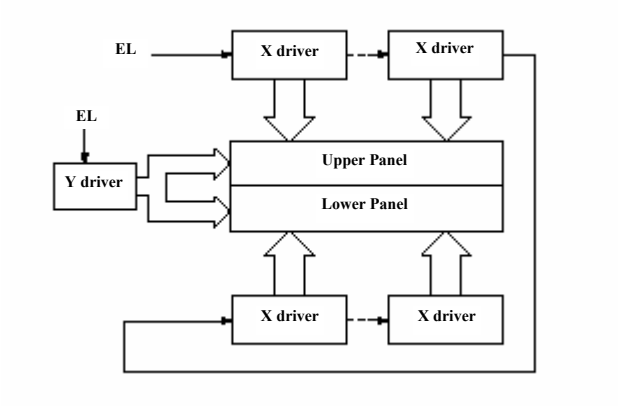
**W/S = 0:** Single-panel drive

**W/S = 1:** Dual-panel drive

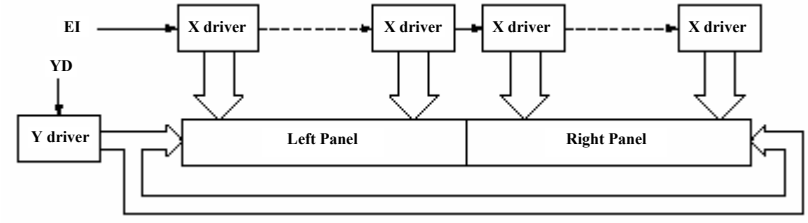
(1) single-panel display




(2) Above and below two-panel display




(3) Left and right two-panel display

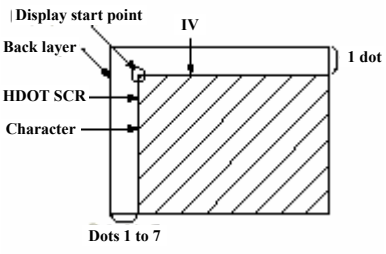


### 1.6 IV

Screen origin compensation for inverse display. IV is usually set to 1.The best way of displaying inverted characters is to Exclusive-OR the text layer with the graphics back-ground layer. However, inverted characters at the top or left of the screen are difficult to read as the character origin is at the top-left of its bitmap and there are no background pixels either above or to the left of these characters. The IV flag causes the Controller to offset the text screen against the graphics back layer by one vertical pixel. Use the horizontal pixel scroll function (HDOT SCR) to shift the text screen 1 to 7 pixels to the right. All characters will then have the necessary surrounding background pixels that en-sure easy reading of the inverted characters.

**IV = 0:** Screen top-line correction

**IV = 1:** No screen top-line correction (no offset)




### 1.7 T/L

Selects TV or LCD mode. When TV mode is selected, the TV sync generator circuit is ON.

**T/L = 0:** LCD mode

**T/L = 1:** TV mode

### 1.8 DR

Selects output of an additional shift-clock cycle for every 64 pixels. The extra cycles are required for correct operation of the enable chain when using a two-panel display.

**DR = 0:** Normal operation

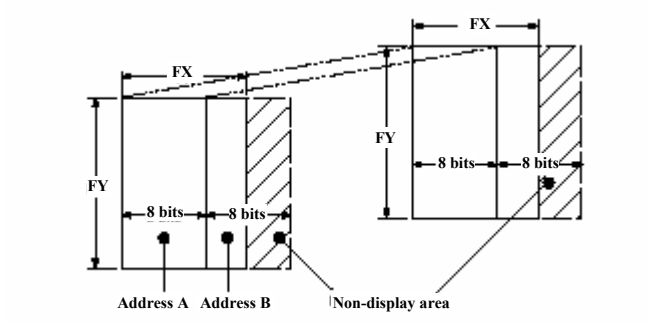
**DR = 1:** Additional shift-clock cycles

### 1.9 FX

Sets the width, in pixels, of the character field. The character width in pixels is equal to FX + 1, where FX can range from 00 to 07H inclusive. If data bit 3 is set (FX is in the range 08 to 0FH) and an 8-pixel font is used, a space is inserted between characters. Note that the maximum character width in TV mode is eight Since the CONTROLLER handles display data in 8-bit units, characters larger than 8 pixels wide must be formed from 8-pixel segments. As Figure shows, the remainder of the second eight bits are not displayed. This also applies to the second screen layer.

In graphics mode, the normal character field is also eight pixels. If a wider character field is used, any remainder in the second eight bits is not displayed.

| FX | | | | | [FX] Character width (pixels) |
|---|---|---|---|---|---|
| HEX | D3 | D2 | D1 | D0 | |
| 00 | 0 | 0 | 0 | 0 | 1 |
| 01 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 07 | 0 | 1 | 1 | 1 | 8 |



## 1.10 WF

Selects the AC frame drive waveform period. WF is usually set to 1.
**WF = 0:** 16-line AC drive
**WF = 1:** two-frame AC drive
In two-frame AC drive, the WF period is twice the frame period.
In 16-line AC drive, WF inverts every 16 lines. Although 16-line AC drive gives a more readable display, horizontal lines may appear when using high LCD drive voltages or at high viewing angles.

## 1.11 FY

Sets the height, in pixels, of the character. The height in pixels is equal to FY + 1.
FY can range from 00 to 0FH inclusive.
Set FY to zero (vertical size equals one) when in graphics mode.
**Table 5. Vertical character size selection**

| FX | | | | | [FX] Character height (pixels) |
|---|---|---|---|---|---|
| HEX | D3 | D2 | D1 | D0 | |
| 00 | 0 | 0 | 0 | 0 | 1 |
| 01 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 07 | 0 | 1 | 1 | 1 | 8 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 0E | 1 | 1 | 1 | 0 | 15 |
| OF | 1 | 1 | 1 | 1 | 16 |

## 1.12 C/R

Sets the address range covered by one display line, that is, the number of characters less one, multiplied by the number of horizontal bytes per character. C/R can range from 0 to 239.
For example, if the character width is 10 pixels, then the address range is equal to twice the number of characters, less 2. See Section 9.1.1 for the calculation of C/R.
[C/R] cannot be set to a value greater than the address range. It can, however, be set smaller than the address range, in which case the excess display area is blank. The number of excess pixels must not exceed 64.
**Table 6. Display line address range**

| C/R | | | | | | | | | [C/R] bytes per display line |
|---|---|---|---|---|---|---|---|---|---|
| HEX | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 01 | 0 | 0 | 0 | 00 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 4F | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 80 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| EE | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 239 |
| EF | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 240 |

## 1.13 TC/R

Sets the length, including horizontal blanking, of one line. The line length is equal to TC/R + 1, where TC/ R can range from 0 to 255.

TC/R must be greater than or equal to C/R + 4. Provided this condition is satisfied, [TC/R] can be set according to the equation given in section 9.1.1 in order to hold the frame period constant and minimize jitter for any given main oscillator frequency, f OSC .

**Table 7. Line length selection**

| TC/R | | | | | | | | | [C/R] bytes per display line |
|---|---|---|---|---|---|---|---|---|---|
| HEX | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 52 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 83 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| FE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 255 |
| FF | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 256 |

## 1.14 L/F

Sets the height, in lines, of a frame. The height in lines is equal to L/F + 1, where L/F can range from 0 to 255. If W/S is set to 1, selecting two-screen display, the number of lines must be even and L/F must, therefore, be an odd number.

**Table 8. Frame height selection**

| L/F | | | | | | | | | [C/R] bytes per display line |
|---|---|---|---|---|---|---|---|---|---|
| HEX | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 7F | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 128 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| FE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 255 |
| FF | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 256 |

**Table 9. Frame heights and compatible LCD units**

| Nombor of linos [LF] | Panel Duty Cycle |
|---|---|
| 64 | 1/64 |
| 128 | 1/64 |

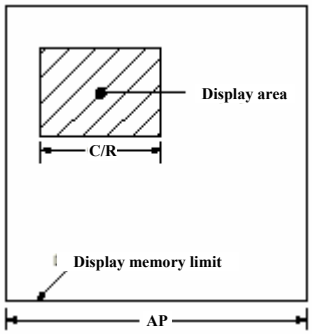
## 1.15 AP

Defines the horizontal address range of the virtual screen. APL is the least significant byte of the ad-dress.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| APL | AP7 | AP6 | AP5 | AP4 | AP3 | AP2 | AP1 | AP0 |
| APH | AP15 | AP14 | AP13 | AP12 | AP11 | AP10 | AP9 | AP8 |

**Table 10. Horizontal address range**

| Hex code | | | | [AP] addresses per line |
|---|---|---|---|---|
| APH | | APL | | |
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 |
| ↓ | ↓ | ↓ | ↓ | ↓ |
| 0 | 0 | 5 | 0 | 80 |
| ↓ | ↓ | ↓ | ↓ | ↓ |
| F | F | F | E | $2^{16}$ - 2 |
| F | F | F | F | $2^{16}$ - 1 |



## 2 SLEEP IN

Places the system in standby mode. This command has no parameter bytes. At least one blank frame after receiving this command, the CONTROLLER halts all internal operations, including the oscillator, and enters the sleep mode. Blank data is sent to the X-drivers, and the Y-drivers have their bias supplies turned off by the YDIS signal. Using the YDIS signal to disable the Y-drivers guards against any spurious displays.
The internal registers of the CONTROLLER maintain their values during the sleep mode. The display memory control pins maintain their logic levels to ensure that the display memory is not corrupted.
The CONTROLLER can be removed from the sleep state by sending the SYSTEM SET command with only the P1 parameter. The DISP ON command should be sent next to enable the display.

| | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |

1. The YDIS signal goes LOW between one and two frames after the SLEEP IN command is received. Since YDIS forces all display driver outputs to go to the deselected output voltage, YDIS can be used as a power-down signal for the LCD unit. This can be done by having YDIS turn off the relatively high-power LCD drive supplies at the same time as it blanks the display.
2. Since all internal clocks in the CONTROLLER are halted while in the sleep state, a DC voltage will be applied to the LCD panel if the LCD drive supplies remain on.
If reliability is a prime consideration, turn off the LCD drive supplies before issuing the SLEEP IN command.
3. Note that, although the bus lines become high impedance in the sleep state, pull-up or pull-down resistors on the bus line will force these lines to a known state.

## 3 Display Control Commands

### 3.1 DISP ON/OFF

Turns the whole display on or off. The single-byte parameter enables and disables the cursor and lay-ered screens, and sets the cursor and screen flash rates. The cursor can be set to flash over one charac-ter or over a whole line.

| | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| P1 | FP5 | FP4 | FP3 | FP2 | FP1 | FP0 | FC1 | FC0 |

DISP ON/OFF parameters

#### 3.1.1 D

Turns the display ON or OFF. The D bit takes precedence over the FP bits in the parameter.
**D = 0:** Display OFF
**D = 1:** Display ON

#### 3.1.2 FC

Enables/disables the cursor and sets the flash rate. The cursor flashes with a 70% duty cycle (ON/OFF).
**Table 11. Cursor flash rate selection**

| FC1 | FC0 | Cursor display | |
|---|---|---|---|
| 0 | 0 | OFF (blank) | |
| 0 | 1 | ON | No flashing |
| 1 | 0 | | Flash at $f_{FR}$/32Hz (approx. 2 Hz) |
| 1 | 1 | | Flash at $f_{FR}$/64 Hz (approx. 1 Hz) |

**Note:** As the MWRITE command always enables the cursor, the cursor position can be checked even when performing consecutive writes to display memory while the cursor is flashing.

### 3.1.3 FP

Each pair of bits in FP sets the attributes of one screen block, as follows.

**Table 12. Screen block attribute selection**

| FP1 | FP0 | First screen block (SAD1) | |
|---|---|---|---|
| FP3 | FP2 | Second screen block (SAD2,SAD4). See note. | |
| FP5 | FP4 | Third screen block (SAD3) | |
| 0 | 0 | OFF (blank) | |
| 0 | 1 | ON | No flashing |
| 1 | 0 | | Flash at $f_{FR}$/32Hz (approx. 2 Hz) |
| 1 | 1 | | Flash at $f_{FR}$/4 Hz (approx. 16 Hz) |

**Note:** If SAD4 is enabled by setting W/S to 1, FP3 and FP2 control both SAD2 and SAD4. The attributes of SAD2 and SAD4 cannot be set independently.

## 3.2 SCROLL

### 3.2.1 C

Sets the scroll start address and the number of lines per scroll block. Parameters P1 to P10 can be omitted if not required. The parameters must be entered sequentially as shown in Figure 17.

| | MSB | | | | | | | LSB | |
|---|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | |
| P1 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | (SAD 1L) |
| P2 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | (SAD 1H) |
| P3 | L7 | L6 | L5 | L4 | L3 | L2 | L1 | L0 | (SL 1) |
| P4 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | (SAD 2L) |
| P5 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | (SAD 2H) |
| P6 | L7 | L6 | L5 | L4 | L3 | L2 | L1 | L0 | (SL 2) |
| P7 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | (SAD 3L) |
| P8 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | (SAD 3H) |
| P9 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | (SAD 4L) |
| P10 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | (SAD 4H) |

**Note : Set parameters P9 and P10 only if both two-screen drive (W/S=1) and two-layer configuration are selected. SAD4 is the fourth screen block display start address.**

Figure 17. SCROLL instruction parameters

**Note:** Set parameters P9 and P10 only if both two-screen drive (W/S = 1) and two-layer configuration are se-lected. SAD4 is the fourth screen block display start address.

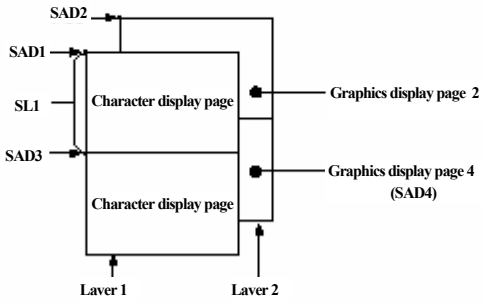
**Table 13. Screen block start address selection**

| SL1,SL2 | | | | | | | | | [SL] screen lines |
|---|---|---|---|---|---|---|---|---|---|
| HEX | L7 | L6 | L5 | L4 | L3 | L2 | L1 | L0 | |
| 00 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 1 |
| 01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 7F | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 128 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| FE | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 255 |
| FF | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 256 |

### 3.2.2 SL1, SL2

SL1 and SL2 set the number of lines per scrolling screen. The number of lines is SL1 or SL2 plus one. The relationship between SAD, SL and the display mode is described below.

**Table 14. Text display mode**

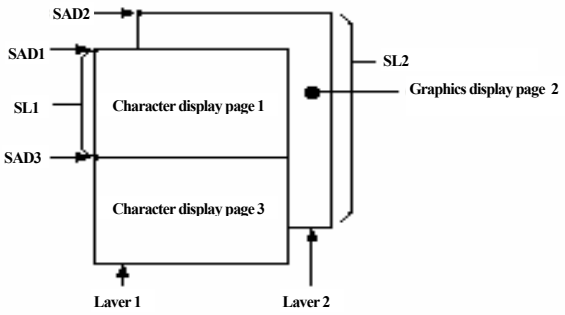
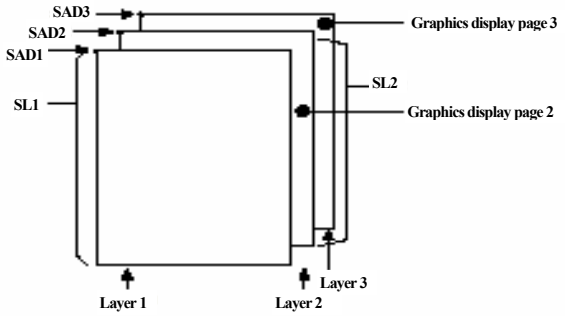
| W/S | Screen | First Layer | Second Layer |
|---|---|---|---|
| 1 | First screen block | SAD1<br>SL1 | SAD2<br>SL2 |
| | Lower screen | SAD3<br>(see note 2) | SAD4<br>(see note 2) |
| | Set both SL1 and SL2 to ((L/F)/2+1) | | |
| | Screen configuration example:  | | |

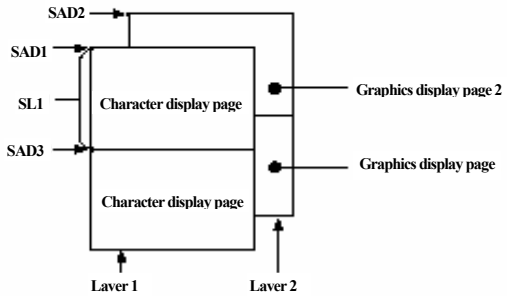


**Notes:**

1. SAD3 has the same value as either SAD1 or SAD2, whichever has the least number of lines (set by SL1 and SL2).
2. Since the parameters corresponding to SL3 and SL4 are fixed by L/F, they do not have to be set in this mode.

**Table 15. Graphics display mode**

| W/S | Screen | First Layer | Second Layer | Third Layer |
|---|---|---|---|---|
| 0 | Upper screen | SAD1<br>SL1 | SAD2<br>SL2 | |
| | Lower screen | SAD3 (see note 3)<br>Set both SL1 and SL2 to L/F +1 if not using a partitioned screen | | |
| | Screen configuration example<br>  <br> | | | |
| 0 | Three-layer configuration | SAD1<br>SL1 = L/F + 1 | SAD1<br>SL2 = L/F + 1 | SAD3<br>— |
| | Screen configuration example:<br>  <br> | | | |

| W/S | Screen | First Layer | Second Layer | Third Layer |
|---|---|---|---|---|
| 1 | Upper screen | SAD1<br>SL1 | SAD2<br>SL2 | — |
| | Lower screen | SAD3<br>(see note 2) | SAD4<br>(see note 2) | — |
| | Set both SL1 and SL2 to ((L/F)/2+1) | | | |
| | Screen configuration example (see note 3):<br>  <br> | | | |

**Notes :**

1. SAD3 has the same value as either SAD1 or SAD2, whichever has the least number of lines (set by SL1 and SL2).
2. Since the parameters corresponding to SL3 and SL4 are fixed by L/F, they do not have to be set.
3. If, and only if, W/S = 1, the differences between SL1 and (L/F + 1) / 2, and between SL2 and (L/F + 1) / 2, are blanked.

## 3.3 CSRFORM

Sets the cursor size and display mode. Although the cursor is normally only used in text displays, it may also be used in graphics displays when displaying special characters.

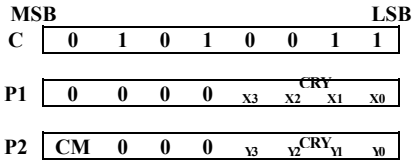



Figure 19. CSRFORM parameter bytes

### 3.3.1 CRX

Sets the horizontal size of the cursor from the character origin. CRX is equal to the cursor size less one. CRX must be less than or equal to FX.

**Table 16. Horizontal cursor size selection**

| CRX | | | | | [CRX] cursor width |
|---|---|---|---|---|---|
| HEX | X3 | X2 | X1 | X0 | pixels |
| 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 8 | 1 | 0 | 0 | 0 | 9 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| E | 1 | 1 | 1 | 0 | 15 |
| F | 1 | 1 | 1 | 1 | 16 |

### 3.3.2 CRY

Sets the location of an underscored cursor in lines, from the character origin. When using a block cursor,CRY sets the vertical size of the cursor from the character origin. CRY is equal to the number of lines less one.

**Table 17. Cursor height selection**

| CRX | | | | | [CRX] cursor |
|---|---|---|---|---|---|
| HEX | X3 | X2 | X1 | X0 | height (lines) |
| 0 | 0 | 0 | 0 | 0 | iillegal |
| 1 | 0 | 0 | 0 | 1 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 8 | 1 | 0 | 0 | 0 | 9 |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| E | 1 | 1 | 1 | 0 | 15 |
| F | 1 | 1 | 1 | 1 | 16 |

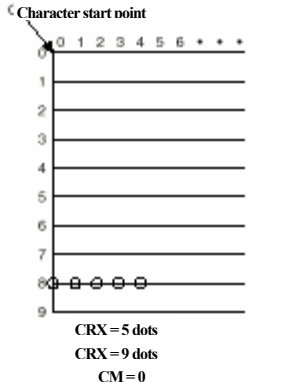



Figure 20. Cursor size and position

### 3.3.3 CM

Sets the cursor display mode. Always set CM to 1 when in graphics mode.

**CM = 0:** Underline cursor

**CM = 1:** Block cursor

### 3.4 CSRDIR

Sets the direction of automatic cursor increment. The cursor can move left or right one character, or up or down by the number of bytes specified by the address pitch, AP.
When reading from and writing to display memory, this automatic cursor increment controls the display memory address increment on each read or write. in character units. See Section 5.3.

| | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 0 | 1 | 1 | CD1 | CD2 |

Figure 21. CSRDIR parameters

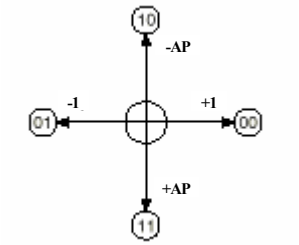



Figure 22. Cursor direction

**Table 18. Cursor shift direction**

| C | CD1 | CD0 | Shift direction |
|---|---|---|---|
| 4CH | 0 | 0 | Right |
| 4DH | 0 | 1 | Left |
| 4EH | 1 | 0 | Up |
| 4FH | 1 | 1 | Down |

**Note:** Since the cursor moves in address units even if FX ³ 9, the cursor address increment must be preset for move-ment in character units. See Section 5.3.

### 3.3.5 OVLAY

Selects layered screen composition and screen text/ graphics mode.

| | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| P1 | 0 | 0 | 0 | OV | DM 2 | MD 1 | MX 1 | MX 2 |

Figure 23. OVLAY parameter

### 3.5.1 MX0, MX1

MX0 and MX1 set the layered screen composition method, which can be either OR, AND, Exclusive-OR or Priority-OR. Since the screen composition is organized in layers and not by screen blocks, when using a layer divided into two screen blocks, different com-position methods cannot be specified for the indi-vidual screen blocks.
The Priority-OR mode is the same as the OR mode unless flashing of individual screens is used.

**Table 19. Composition method selection**

| MX 1 | MX 0 | Function | Composition Method | Applications |
|---|---|---|---|---|
| 0 | 0 | L1∪L2∪L3 | OR | Underlining,rules,mixed text and graphics |
| 0 | 1 | (L1⊕L2)∪L3 | Exclusive-OR | Inerted characters, flashing regions, underlining |
| 1 | 0 | (L1∩L2)∪L3 | AND | Simple animation, three-dimensional |
| 1 | 1 | L1>L2>L3 | Priority-OR | appearance |

**Notes:**

L1: First layer (text or graphics). If text is selected, layer L3 cannot be used.
L2: Second layer (graphics only)
L3: Third layer (graphics only)

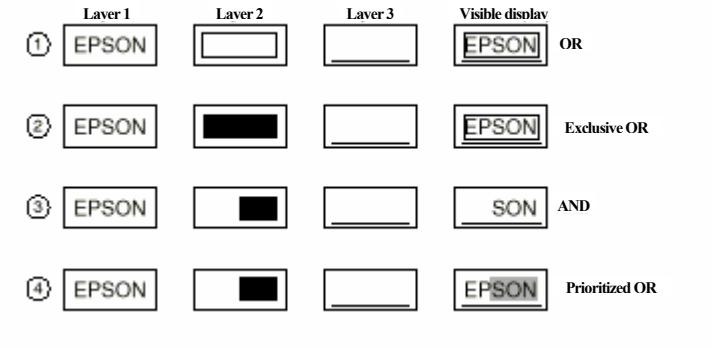



Figure 24. Combined layer display

**Notes:**

L1: Not flashing
L2: Flashing at 1 Hz
L3: Flashing at 2 Hz

### 3.5.2 DM1, DM2

DM1 and DM2 specify the display mode of screen blocks 1 and 3, respectively.
**DM1/2 = 0:** Text mode
**DM1/2 = 1:** Graphics mode
**Note 1:** Screen blocks 2 and 4 can only display graphics.
**Note 2:** DM1 and DM2 must be the same, regardless of the setting of W/S.

### 3.5.3 OV

Specifies two- or three-layer composition in graphics mode.
**OV = 0:** Two-layer composition
**OV = 1:** Three-layer composition
Set OV to 0 for mixed text and graphics mode.

### 3.6 CGRAM ADR

Specifies the CG RAM start address.

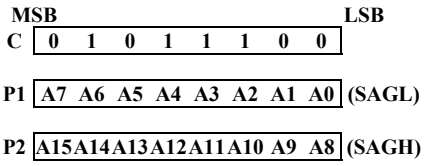



Figure 25. CGRAM ADR parameters

## 3.7 HDOT SCR

While the scroll command only allows scrolling by characters, HDOT SCR allows the screen to be scrolled horizontally by pixels. HDOT SCR cannot be used on individual layers.

| | MSB | | | | | | | LSB |
|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| P1 | 0 | 0 | 0 | 0 | 0 | D2 | D1 | D0 |

Figure 26. HDOT SCR parameters

### 3.7.1 D0 to D2

Specifies the number of pixels to scroll. The C/R parameter has to be set to one more than the number of horizontal characters before using HDOT SCR. Smooth scrolling can be simulated if the controlling microprocessor repeatedly issues the HDOT SCR command to the CONTROLLER

**Table 20. Scroll step selection**

| P1 | | | | Number of pixels to scroll |
|---|---|---|---|---|
| HEX | D2 | D1 | D0 | |
| 00 | 0 | 0 | 0 | 0 |
| 01 | 0 | 0 | 1 | 1 |
| 02 | 0 | 1 | 0 | 2 |
| ↓ | ↓ | ↓ | ↓ | ↓ |
| 06 | 1 | 1 | 0 | 6 |
| 07 | 1 | 1 | 1 | 7 |

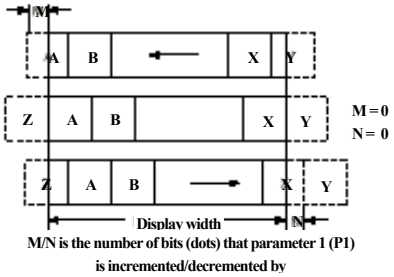



Figure 27. Horizontal scrolling

# 4 Drawing Control Commands

## 4.1 CSRW

The 16-bit cursor address register contains the display memory of the data at the cursor position as shown in Figure 28.

| | MSB | | | | | | | LSB | |
|---|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | |
| P1 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | (CSRL) |
| P2 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | (CSRH) |

Figure 28. CSRW parameters

Note that the microprocessor cannot directly access the display memory.
The MREAD and MWRITE commands use the ad-dress in this register.
The cursor address register can only be modified by the CSRW command, and by the automatic increment after an MREAD or MWRITE command. It is not affected by display scrolling.

## 4.2 CSRR

Reads from the cursor address register. After issuing the command, the data read address is read twice, for the low byte and then the high byte of the register.

| | MSB | | | | | | | LSB | |
|---|---|---|---|---|---|---|---|---|---|
| C | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | |
| P1 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0 | (CSRL) |
| P2 | A15 | A14 | A13 | A12 | A11 | A10 | A9 | A8 | (CSRH) |

Figure 29. CSRR parameters

# 5 Memory Control Commands

## 5.1 MWRITE

The microprocessor may write a sequence of data bytes to display memory by issuing the MREAD command and then writing the bytes to the CONTROLLER. There is no need for further MWRITE commands or for the microprocessor to update the cursor address register after each byte as the cursor address is automatically incremented by the amount set with CSRDIR, in preparation for the next data write.

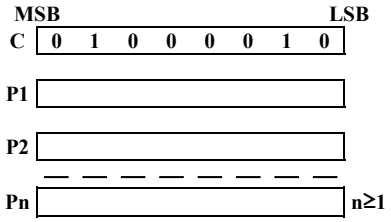



Figure 30. MWRITE parameters

## 5.2 MREAD

Puts the Controller into the data out-put state. On the MREAD command, the display memory data at the cursor address is read into a buffer in the Controller

Each time the microprocessor reads the buffer, the cursor address is incremented by the amount set by CSRDIR and the next data byte fetched from memory, so a sequence of data bytes may be read without further MREAD commands or by updating the cursor address register.

If the cursor is displayed, the read data will be from two positions ahead of the cursor.

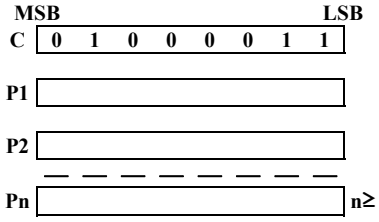
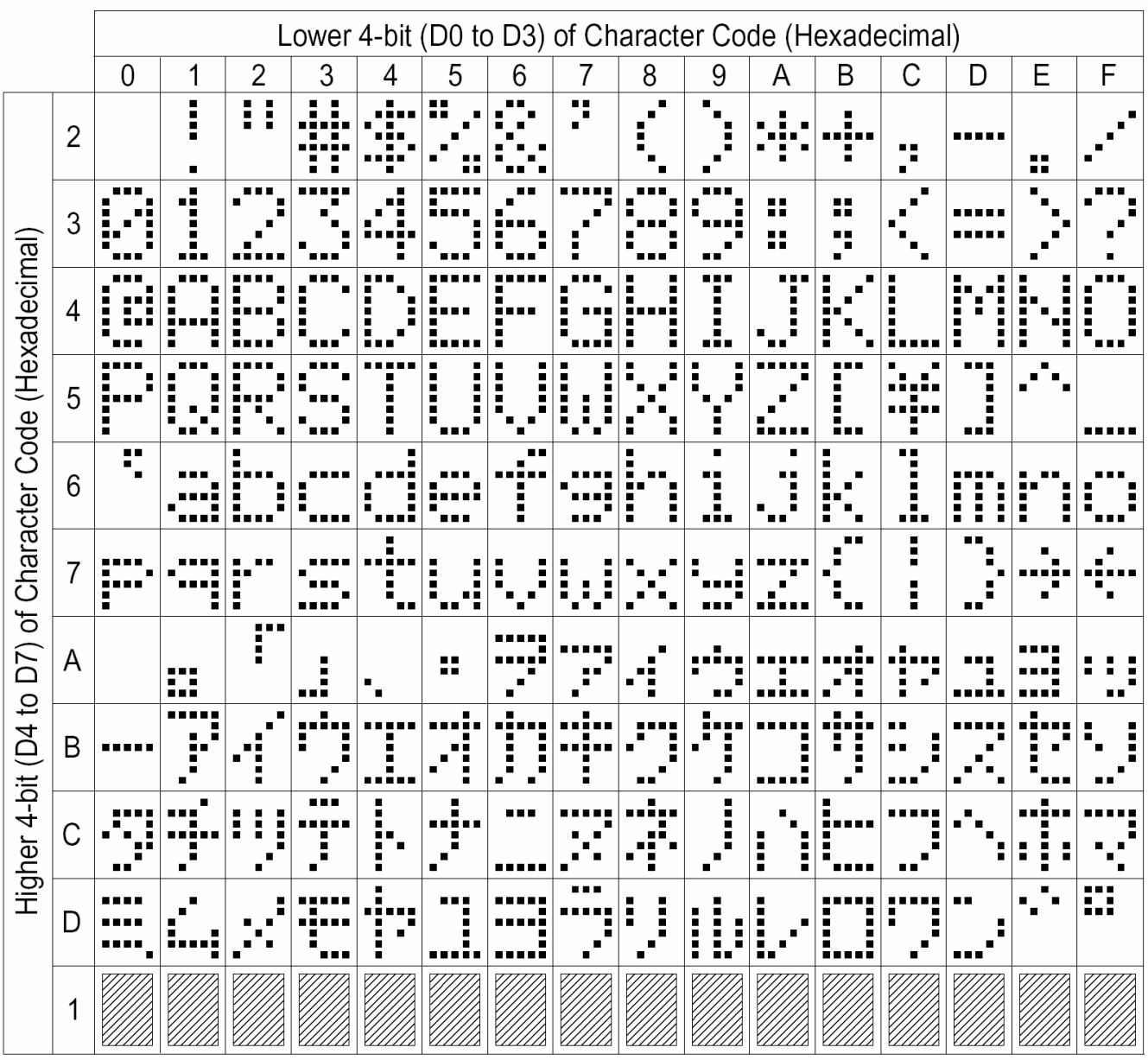



Figure 31. MREAD parameters

### 3.2 LCD Controller Character Code Map




Note: ▨ means all dots of 6 × 8 matrix are on.

## 4. RELIABILITY

| Environmental Test | | | | |
|---|---|---|---|---|
| **No.** | **Test Item** | **Content of Test** | **Test Condition** | **Applicable Standard** |
| 1 | High temperature storage | Endurance test applying the high storage temperature for a long time. | 60 °C<br>200 hrs | ------ |
| 2 | Low temperature storage | Endurance test applying the low storage temperature for a long time. | -10 °C<br>200 hrs | ------ |
| 3 | High temperature operation | Endurance test applying the electric stress (Voltage & Current) and the thermal stress to the element for a long time. | 50 °C<br>200 hrs | ------ |
| 4 | Low temperature operation | Endurance test applying the electric stress under low temperature for a long time. | 0 °C<br>200 hrs | ------ |
| 5 | High temperature / Humidity storage | Endurance test applying the high temperature and high humidity storage for a long time. | 60 °C , 90 %RH<br>96 hrs | MIL-202E-103B<br>JIS-C5023 |
| 6 | High temperature / Humidity operation | Endurance test applying the electric stress (Voltage & Current) and temperature / humidity stress to the element for a long time. | 40 °C , 90 %RH<br>96 hrs | MIL-202E-103B<br>JIS-C5023 |
| 7 | Temperature cycle | Endurance test applying the low and high temperature cycle.<br>-20°C 30min ⇌ 25°C 5min. ⇌ 70°C 30min<br>⟷ 1 cycle | -10°C / 60°C<br>10 cycles | ------ |
| **Mechanical Test** | | | | |
| 8 | Vibration test | Endurance test applying the vibration during transportation and using. | 10~22Hz → 1.5mmp-p<br>22~500Hz → 1.5G<br>Total 0.5hrs | MIL-202E-201A<br>JIS-C5025<br>JIS-C7022-A-10 |
| 9 | Shock test | Constructional and mechanical endurance test applying the shock during transportation. | 50G Half sign wave 11 msedc<br>3 times of each direction | MIL-202E-213B |
| 10 | Atmospheric pressure test | Endurance test applying the atmospheric pressure during transportation by air. | 115 mbar<br>40 hrs | MIL-202E-105C |
| **Others** | | | | |
| 11 | Static electricity test | Endurance test applying the electric stress to the terminal. | VS=800V , RS=1.5 kΩ<br>CS=100 pF<br>1 time | MIL-883B-3015.1 |

*** Supply voltage for logic system = VDD. Supply voltage for LCD system = Operating voltage at 25°C

### ■ LCD Panel Service Life

**Definition of panel service life**

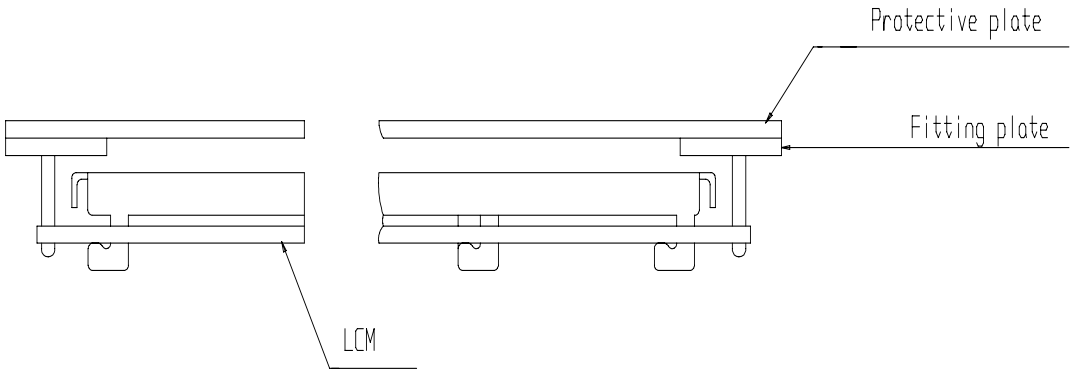
- 100,000 hours minimum at 25° C ±10%
- Contrast becomes 30% of initial value
- Current consumption becomes three times higher than initial value
- Remarkable alignment deterioration occurs in LCD cell layer
- Unusual operation occurs in display functions

## 5. PRECAUTIONS FOR USING LCD MODULES

### Installing LCD Modules

The hole in the printed circuit board is used to fix LCM as shown in the picture below. Attend to the following items when installing the LCM.

1) Cover the surface with a transparent protective plate to protect the polarizer and LC cell.




2) When assembling the LCM into other equipment, the spacer to the bit between the LCM and the fitting plate should have enough height to avoid causing stress to the module surface, refer to the individual specifications for measurements. The measurement tolerance should be ±0.1mm.

### Precaution for Handing LCD Modules

Since LCM has been assembled and adjusted with a high degree of precision, avoid applying excessive shocks to the module or making any alterations or modifications to it.

1) Cover the surface with a transparent protective plate to protect the polarizer and LC cell.
2) Do not alter, modify or change the shape of the tab on the metal frame.
3) Do not make extra holes on the printed circuit board, modify its shape or change the positions of components to be attached.
4) Do not damage or modify the pattern writing on the printed circuit board.
5) Absolutely do not modify the zebra rubber strip (conductive rubber) or heat seal connector.
6) Except for soldering the interface, do not make any alterations or modifications with a soldering iron.
7) Do not drop, bend or twist LCM.

### Electro-Static Discharge Control

Since this module uses a CMOS LSI, the same careful attention should be paid to electrostatic discharge as for an ordinary CMOS IC.

1) Make certain that you are grounded when handing LCM.
2) Before remove LCM from its packing case or incorporating it into a set, be sure the module and your body have the same electric potential.
3) When soldering the terminal of LCM, make certain the AC power source for the soldering iron does not leak.
4) When using an electric screwdriver to attach LCM, the screwdriver should be of ground potentiality to minimize as much as possible any transmission of electromagnetic waves produced sparks coming from the commutator of the motor.
5) As far as possible make the electric potential of your work clothes and that of the work bench the ground potential.
6) To reduce the generation of static electricity be careful that the air in the work is not too dried. A relative humidity of 50%-60% is recommended.

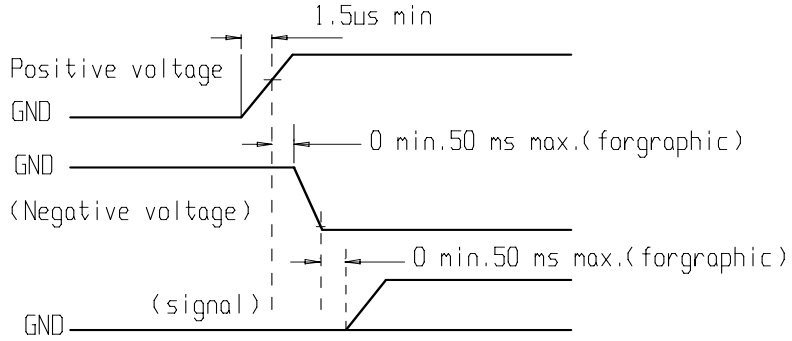
### Precaution for soldering to the LCM

1) Observe the following when soldering lead wire, connector cable and etc. to the LCM.
   a) Soldering iron temperature : 280°C ± 10°C.
   b) Soldering time : 3-4 sec.
2) Solder : eutectic solder.

3) If soldering flux is used, be sure to remove any remaining flux after finishing to soldering operation. (This does not apply in the case of a non-halogen type of flux.) It is recommended that you protect the LCD surface with a cover during soldering to prevent any damage due to flux spatters.
4) When soldering the electroluminescent panel and PC board, the panel and board should not be detached more than three times. This maximum number is determined by the temperature and time conditions mentioned above, though there may be some variance depending on the temperature of the soldering iron.
5) When remove the electroluminescent panel from the PC board, be sure the solder has completely melted, the soldered pad on the PC board could be damaged.

## Precautions for Operation

1) Viewing angle varies with the change of liquid crystal driving voltage (VO). Adjust VO to show the best contrast.
2) Driving the LCD in the voltage above the limit shortens its life.
3) Response time is greatly delayed at temperature below the operating temperature range. However, this does not mean the LCD will be out of the order. It will recover when it returns to the specified temperature range.
4) If the display area is pushed hard during operation, the display will become abnormal. However, it will return to normal if it is turned off and then back on.
5) Condensation on terminals can cause an electrochemical reaction disrupting the terminal circuit. Therefore, it must be used under the relative condition of 40°C , 50% RH.
6) When turning the power on, input each signal after the positive/negative voltage becomes stable.




## Safety

- If the LCD panel breaks, be careful not to get the liquid crystal in your mouth. If the liquid crystal touches your skin or clothes, wash it off immediately using soap and plenty of water.

## Handling

- The display panel is made of glass. Do not subject it to a mechanical shock by dropping it or impact.
- If the display panel is damaged and the liquid crystal substance leaks out, be sure not to get any in your mouth. If the substance contacts your skin or clothes, wash it off using soap and water.
- Do not apply excessive force to the display surface or the adjoining areas since this may cause the color tone to vary.
- The polarizer covering the display surface of the LCD module is soft and easily scratched. Handle this polarizer carefully.
- If the display surface becomes contaminated, breathe on the surface and gently wipe it with a soft dry cloth. If it is heavily contaminated, moisten cloth with one of the following solvents :
    - Isopropyl alcohol
    - Ethyl alcohol
- Solvents other than those above-mentioned may damage the polarizer. Especially, do not use the following.
    - Water
    - Ketone
    - Aromatic solvents
- Exercise care to minimize corrosion of the electrode. Corrosion of the electrodes is accelerated by water droplets, moisture condensation or a current flow in a high-humidity environment.
- Install the LCD Module by using the mounting holes. When mounting the LCD module make sure it is free of twisting, warping and distortion. In particular, do not forcibly pull or bend the I/O cable or the backlight cable.
- Do not attempt to disassemble or process the LCD module.
- NC terminal should be open. Do not connect anything.
- If the logic circuit power is off, do not apply the input signals.

- To prevent destruction of the elements by static electricity, be careful to maintain an optimum work environment.
    - Be sure to ground the body when handling the LCD modules.
    - Tools required for assembling, such as soldering irons, must be properly grounded.
    - To reduce the amount of static electricity generated, do not conduct assembling and other work under dry conditions.
    - The LCD module is coated with a film to protect the display surface. Exercise care when peeling off this protective film since static electricity may be generated.

## Storage

- When storing the LCD modules, avoid exposure to direct sunlight or to the light of fluorescent lamps
- Store the module in a dark place where the temperature is 25 $^{o}$C ±10 $^{o}$C and the humidity below 65% RH.
- Do not store the module near organic solvents or corrosive gases.
- Do not crush, shake, or jolt the module (including accessories).

## Cleaning

- Do not wipe the polarizing plate with a dry cloth, as it may scratch the surface.
- Wipe the module gently with soft cloth soaked with a petroleum benzene.
- Do not use ketonic solvents (ketone and acetone) or aromatic solvents (toluene and xylene), as they may damage the polarizing plate.

## Others:

- Liquid crystals solidify under low temperature (below the storage temperature range) leading to defective orientation or the generation of air bubbles (black or white). Air bubbles may also be generated if the module is subject to a low temperature.
- If the LCD modules have been operating for a long time showing the same display patterns, the display patterns may remain on the screen as ghost images and a slight contrast irregularity may also appear. A normal operating status can be regained by suspending use for some time. It should be noted that this phenomenon does not adversely affect performance reliability.
- To minimize the performance degradation of the LCD modules resulting from destruction caused by static electricity etc., exercise care to avoid holding the following sections when handling the modules.
    - Exposed area of the printed circuit board.
    - Terminal electrode sections.