



PACIFIC DISPLAY DEVICES

LCD Component Data Sheet

Model Number: 240128-06

**240 x 128 Dot
Graphic LCD Assembly
With T6963C Toshiba Graphic LCD Controller
EL Panel & LED Backlight Assembly**

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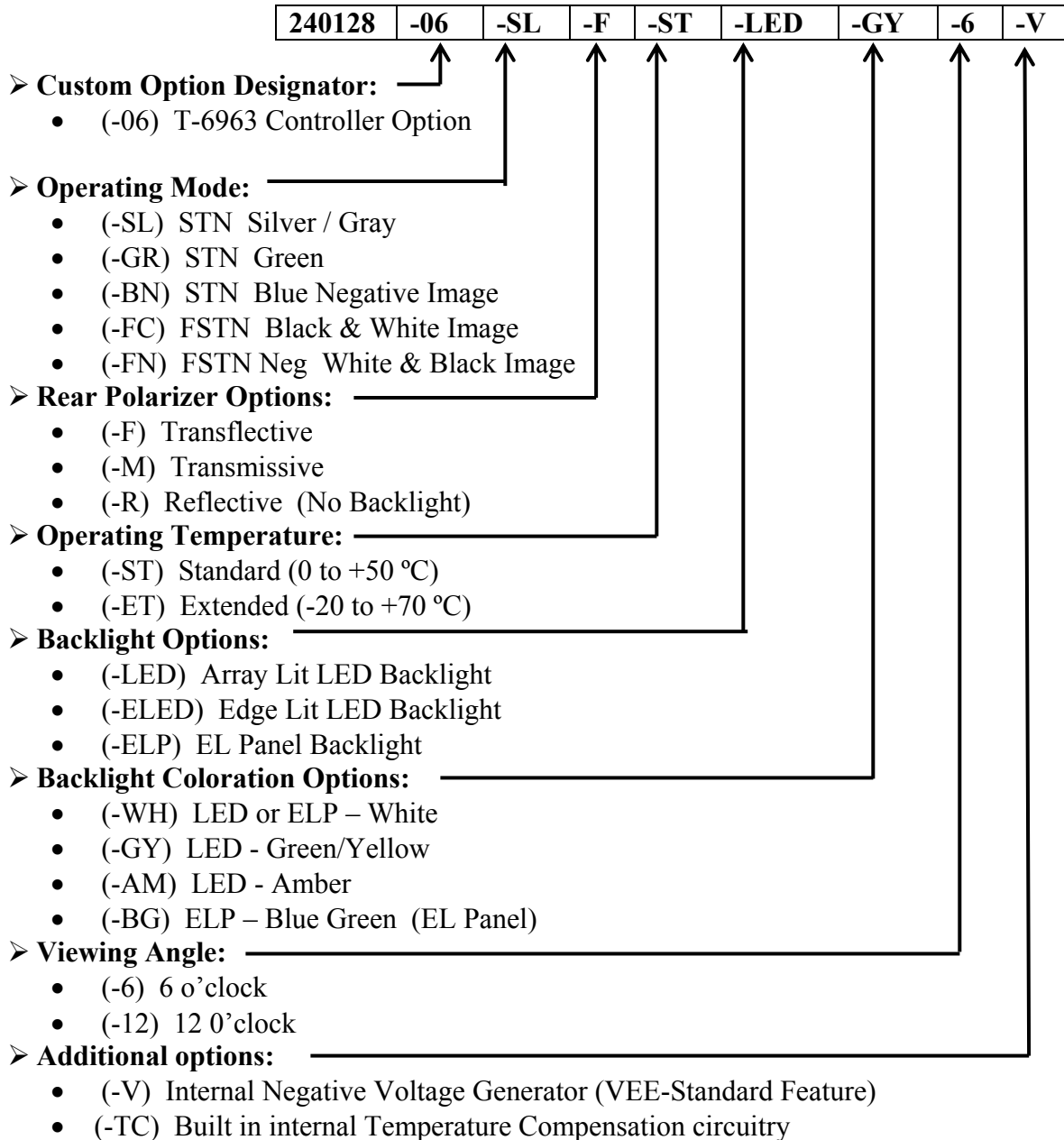
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1. GENERAL INFORMATION

1.1 Product Overview

- 240 x 128 dot matrix LCD
- STN (Super Twisted Nematic) or FSTN (Film compensated Super Twisted Nematic) Technology
- T-6963 (or equivalent) Graphics Controller IC w/ 8K SRAM.
- Multiplex drive : 1/128 duty, 1/13 bias
- LCD Module Service Life: 100,000 hours minimum

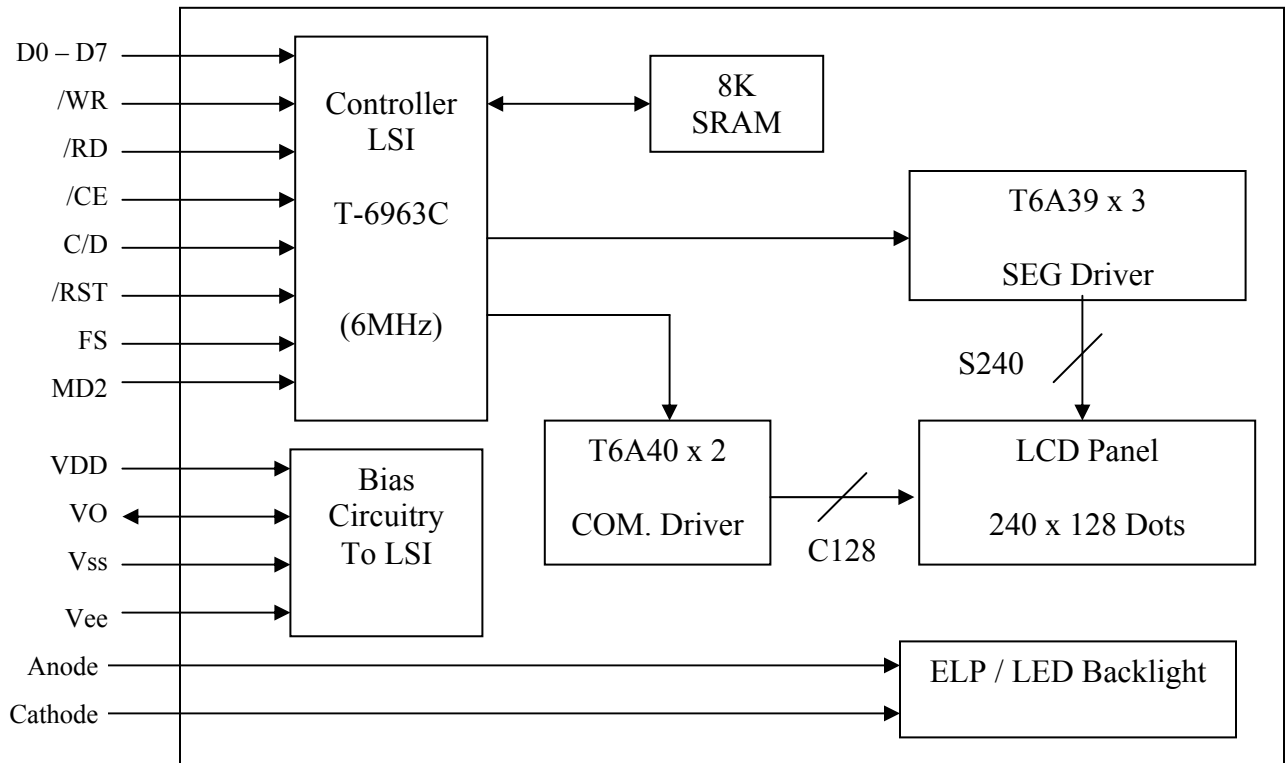
1.2 Part Options and Numbering System



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} - V ₀ | -0.3 | 30.0 | V |
| Input voltage | V _I | -0.3 | V _{DD} + 0.3 | V |
| Standard Operating temperature | TOP (-ST) | 0 | 50 | °C |
| Standard Storage temperature | TST (-ST) | -10 | 60 | °C |
| Extended Operating temperature | TOP (-ET) | -20 | 70 | °C |
| Extended Storage temperature | TST (-ET) | -30 | 80 | °C |
| Soldering Temp | T _{solder} | 260 | | °C |

1.4 Circuit Block Diagram



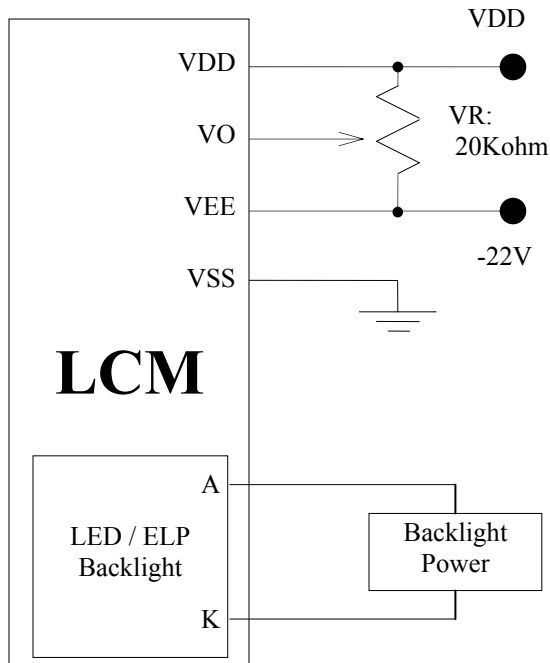
1.5 Mechanical Characteristics

| Item | Contents | Unit |
|---------------------|---|------|
| Module size (W×H×T) | 144.0 x 104.0 x 14.1 Max (LED Backlight) | mm |
| | 144.0 x 104.0 x 10.0 Max (Reflective / ELP Backlight) | mm |
| Viewing area (W×H) | 114.0 x 64.0 | mm |
| Active area (W×H) | 107.95 x 57.55 | mm |
| Number of dots | 240 x 128 | dots |
| Dot size (W×H) | 0.40 x 0.40 | mm |
| Dot pitch (W×H) | 0.45 x 0.45 | mm |

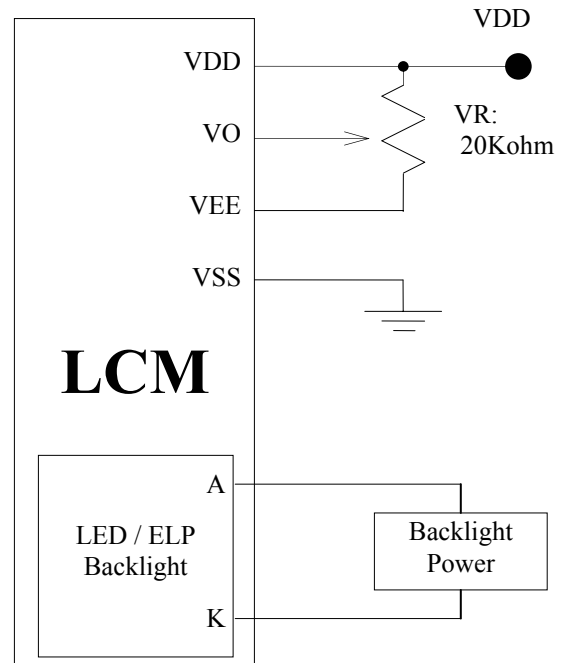
1.6 Input Signal Function

| Pin No. | Symbol | Level | Description |
|---------|--------------|-------|---|
| 1 | VSS | 0V | Ground |
| 2 | VDD | 5.0V | Supply voltage for logic |
| 3 | VO | Input | LCD Negative Bias |
| 4 | C/D | H/L | Code / Data |
| 5 | /RD | H/L | /Data Read |
| 6 | /WR | H/L | /Data Write |
| 7-14 | DB0-DB7 | H/L | Bidirectional Data Bus Lines |
| 15 | /CE | H/L | /Chip Enable |
| 16 | /RST | L | /Reset |
| 17 | VEE | -20V | Output voltage for LCD (-V Option only, otherwise N.C.) |
| 18 | MD2 | -- | H=32, L=40 |
| 19 | FS1 | H/L | Font Select: H=6x8. L=8x8 |
| 20 | NC | --- | No Connection |
| A | LED A or BL2 | --- | LED Backlight Anode Connection or EL Backlight power |
| K | LED K or BL1 | --- | LED Backlight Cathode Connection or EL Backlight power |

1.7 LCM Power, Contrast Control and Bias

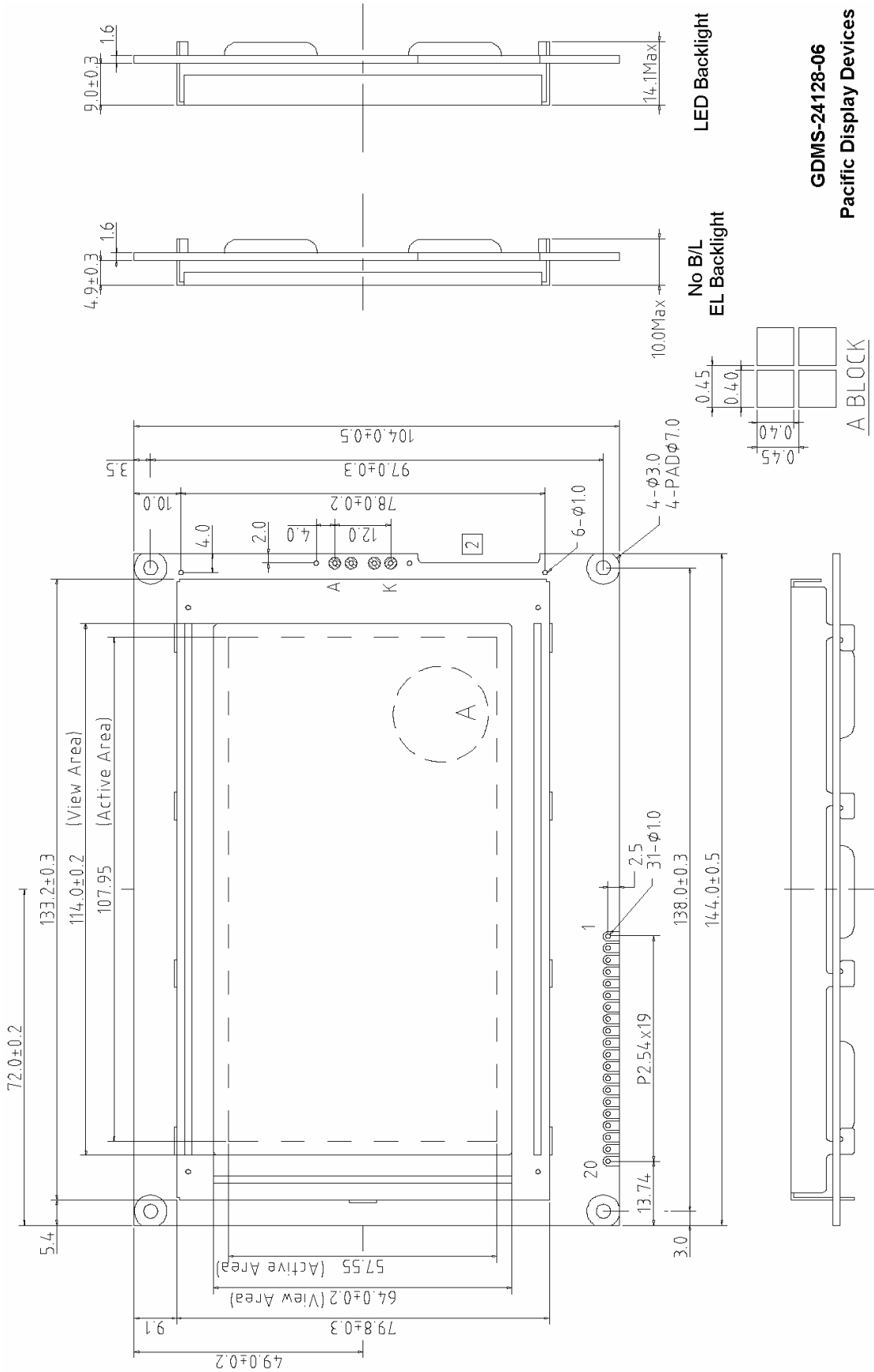


*Note : DC-to-DC Converter Not Built In



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

1.8 LCM Dimensions



LED Backlight

No B/L
EL Backlight

GDMS-24128-06
Pacific Display Devices

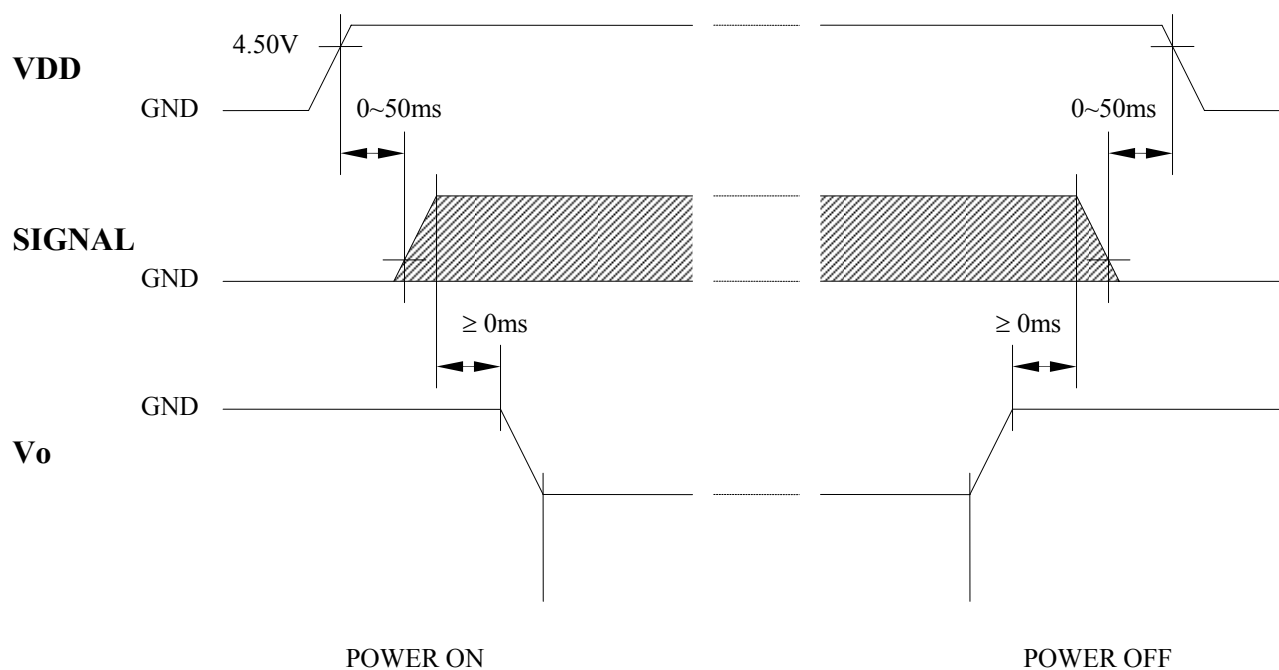
2. ELECTRICAL / OPTICAL CHARACTERISTICS

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

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---------------------------|----------------------------------|----------------------|-----------------------|------|-----------------|------|
| Supply voltage for logic | V _{DD} | --- | 4.5 | --- | 5.5 | V |
| Supply current for logic | I _{DD} | V _{DD} = 5V | --- | 12 | 15 | mA |
| Input voltage 'H' level | V _{IH} | --- | V _{DD} - 2.2 | --- | V _{DD} | V |
| Input voltage 'L' level | V _{IL} | --- | 0 | --- | 0.8 | V |
| Operating voltage for LCD | V _{DD} - V _o | -20°C | --- | 22.1 | --- | V |
| | | 25°C | --- | 19.3 | --- | V |
| | | 70°C | --- | 13.3 | --- | V |
| Supply current for LCD | I _o | --- | --- | --- | 5 | mA |

*V_{ee} externally supplied

■ TIMING OF POWER SUPPLY



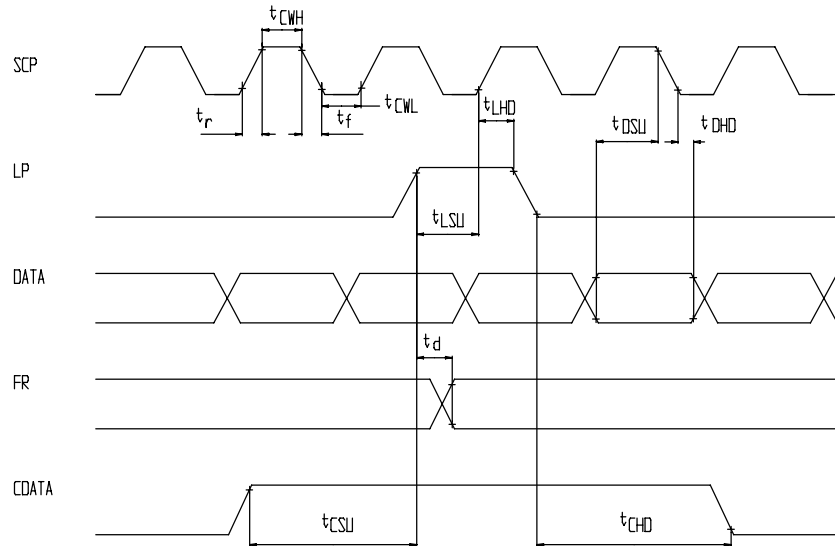
Note : The missing pixels may occur when the LCM is driven except above power supply timing sequence.

2.2 AC Electrical Characteristics

Toshiba T-6963C Graphic Controller IC AC Waveform Interface

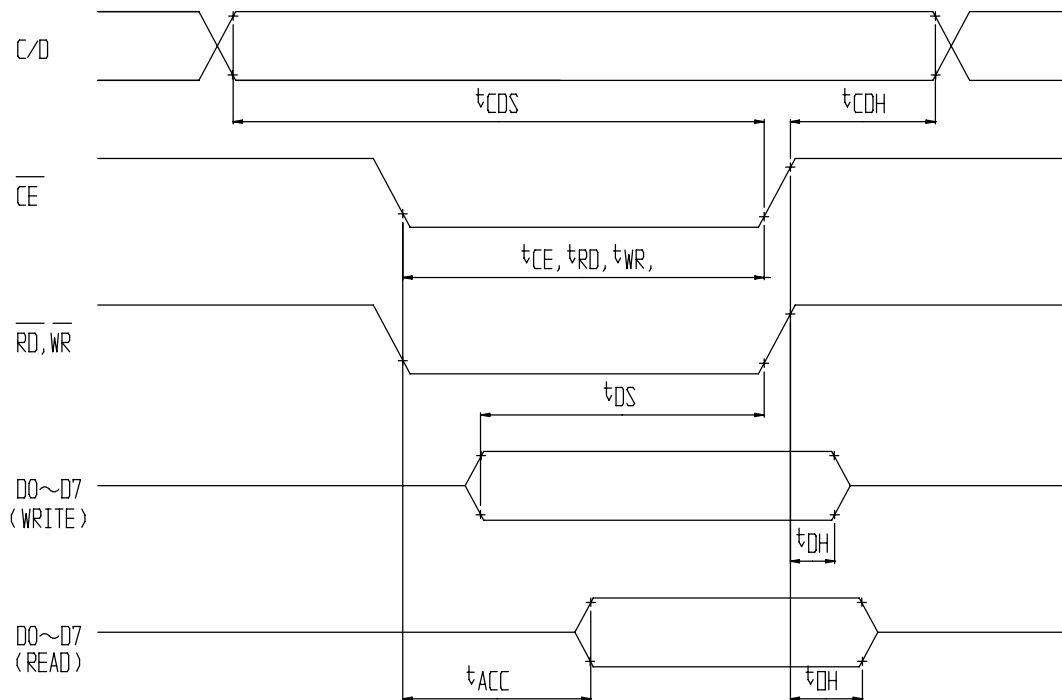
■ AC Characteristics (1)

| Parameter | Symbol | Min | Max | Unit |
|---------------------|---------------------------------|-----|------|------|
| Operating Frequency | fSCP | --- | 2.75 | MHz |
| SCP Pulse Width | tCWH, tCWL | 150 | --- | ns |
| SCP Rise/Fall Time | t _r , t _f | --- | 30 | ns |
| LP Set Up Time | tLSU | 150 | 290 | ns |
| LP Hold Time | tLHD | 5 | 40 | ns |
| Data Set Up Time | tDSU | 170 | --- | ns |
| Data Hold Time | tDHD | 80 | --- | ns |
| FR Delay Time | t _d | 0 | 90 | ns |
| CDATA Set Up Time | tCSU | 450 | 850 | ns |
| CDATA Hold Time | tCHD | 450 | 950 | ns |



■ AC Characteristics (2)

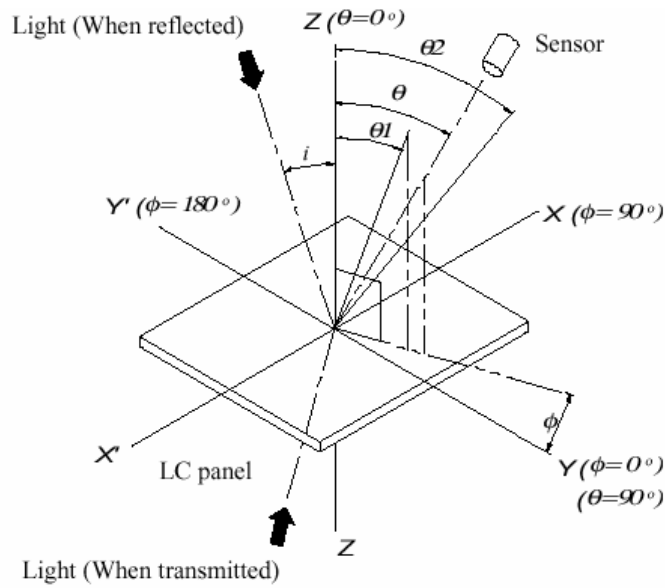
| Parameter | Symbol | Min | Max | Unit |
|------------------------|---------------|-----|-----|------|
| C/D Set Up Time | tCDS | 100 | --- | ns |
| C/D Hold Time | tCDH | 10 | --- | ns |
| CE, RD, WR Pulse Width | tCE, tRD, tWR | 80 | --- | ns |
| Data Set Up Time | tDS | 80 | --- | ns |
| Data Hold Time | tDH | 40 | --- | ns |
| Access Time | tACC | --- | 150 | ns |
| Output Hold Time | tOH | 10 | 50 | ns |



2.3 Optical Characteristics ($V_{OP} = 4.7V, T_a = 25^{\circ}C$)

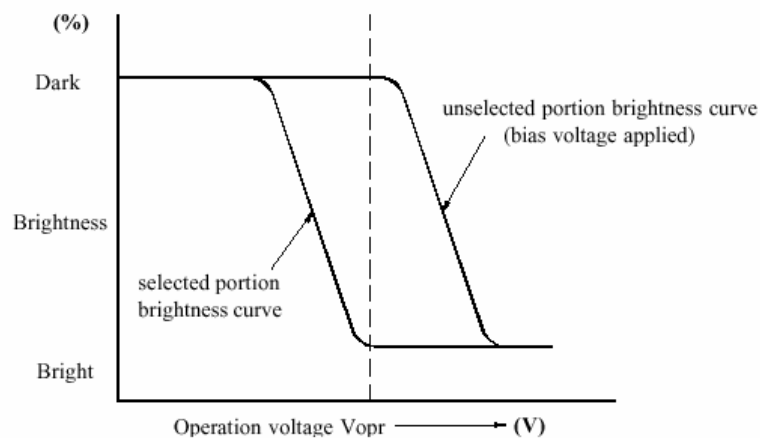
| Item | Symbol | Condition | Min | Typ | Max | Unit |
|---------------------|------------|--|-----|-----|-----|------|
| Contrast ratio | Cr | $\theta=0^{\circ}$ $\phi=0^{\circ}$ | --- | 2.6 | --- | --- |
| Frame Frequency | f_{FRM} | --- | 32 | 64 | 150 | Hz |
| Viewing angle range | θ_1 | 25°C | -35 | --- | 35 | deg |
| | θ_2 | | 35 | --- | -35 | deg |
| Response time | T_{on} | 25°C | --- | 120 | --- | ms |
| | T_{off} | | --- | 250 | --- | ms |

Definition of angles θ and ϕ :

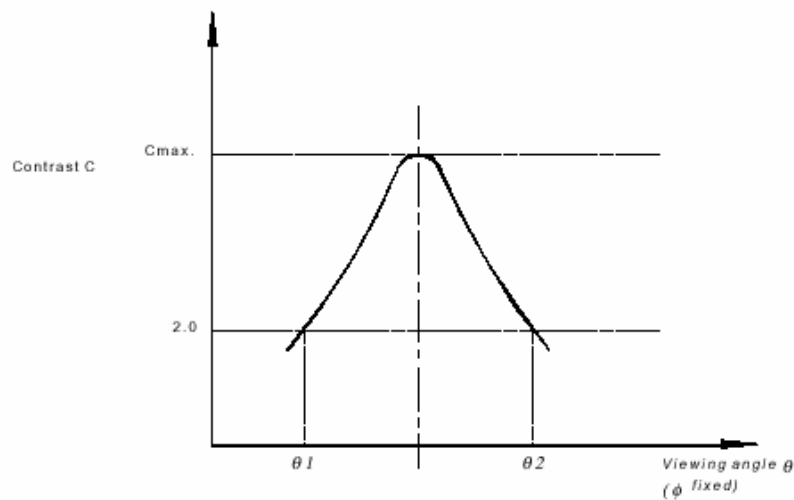


*Definition of contrast C

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

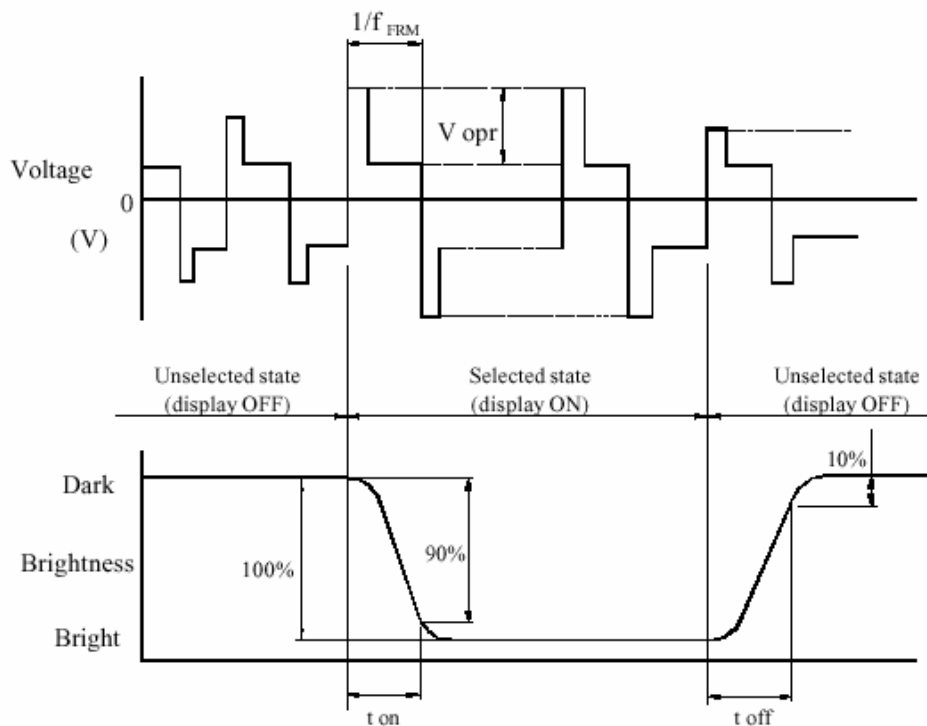


*Definition of viewing angles $\theta 1$ and $\theta 2$



Note : Optimum vision with the naked eye and viewing angle θ at C_{max} above are not always the same.

*Definition of response time



V_{opr} : Operating voltage (V)

t_{on} : Response time (rise) (ms)

f_{FRM} : Frame frequency (Hz)

t_{off} : Response time (fall) (ms)

2.4 LED Backlight Characteristics

■ Yellow-Green LED Operating Characteristics (5V - Array Lit)

| Item | Symbol | Conditions | Standard | | | Unit |
|--------------------------|-------------|----------------------|----------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Forward Voltage | V_f | Ta= 25 °C | 3.9 | 4.1 | 4.4 | VDC |
| Forward Current | I_F | Ta= 25 °C | --- | 1100 | 1700 | mA |
| Reverse Current | I_R | VR = 8V Yel/Grn | --- | --- | 11 | mA |
| Peak Emission Wavelength | λ_P | If=1100mA Yel/Grn | --- | 570 | --- | nm |

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

■ Yellow-Green LED Operating Characteristics (12V - Array Lit)

| Item | Symbol | Conditions | Standard | | | Unit |
|--------------------------|-------------|---------------------|----------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Forward Voltage | V_f | Ta= 25 °C | 10.0 | 10.5 | 11.0 | VDC |
| Forward Current | I_R | Ta= 25 °C | --- | 440 | 700 | mA |
| Reverse Current | I_R | VR = 8V Yel/Grn | --- | --- | 6 | mA |
| Peak Emission Wavelength | λ_P | If=440mA Yel/Grn | --- | 570 | --- | nm |

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

■ Yellow-Green LED Operating Characteristics (Edge Lit)

| Item | Symbol | Conditions | Standard | | | Unit |
|-----------------|--------|--------------------|----------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Forward Voltage | V_f | Ta= 25 °C | 3.9 | 4.1 | 4.4 | VDC |
| Forward Current | I_F | Ta= 25 °C | --- | 260 | 440 | mA |
| Reverse Current | I_R | VR = 8V Yel/Grn | --- | --- | 11 | mA |

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

■ **White LED Operating Characteristics (Edge Lit)**

| Item | Symbol | Conditions | Standard | | | Unit |
|--------------------------|-------------|-----------------|----------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Forward Voltage | V_f | Ta= 25 °C | --- | 3.5 | 3.8 | VDC |
| Forward Current | I_R | Ta= 25 °C | --- | 160 | 350 | mA |
| Reverse Current | I_R | VR = 5V Wht | --- | --- | 0.8 | mA |
| Peak Emission Wavelength | λ_P | If=160mA Wht | --- | --- | --- | nm |

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

■ **Standard Yellow-Green LED Backlight Notes:**

- (1) There are two versions of the LED backlight for this module, 12V and 5V. Both have 220 yellow-green LEDs. The 12V version has them arranged in 44 branches of 5 diodes and the 5V version has 110 branches of 2 diodes
- (2) The 5V “array” version operates at 4.1V. Its typical current draw is 1.1A. Current should be limited to 1.7A max.
- (3) The 12V “array” version actually operates at 10.5V. Typical current draw for this version is 440mA @ 10.5V. Current should be limited to 700mA max.
- (4) The 12V option can be ordered with a “-12V” at the end of the part number

2.5 EL Panel Backlight Characteristics (Blue-Green)

■ **Blue-Green EL Panel Operating Characteristics:**

| Item | Conditions | Standard | | | Unit |
|-----------------------|-------------------------------|----------|------|-------|-------------------|
| | | Min. | Typ. | Max. | |
| Current Consumption | 100VAC RMS, 400Hz Ta: 25°C | --- | 10 | 20 | mA |
| EL Drive Voltage | --- | --- | 100 | 150 | VAC RMS |
| EL Drive Frequency | --- | --- | 400 | 1000 | Hz |
| Operating Temperature | --- | -35°C | --- | +50°C | °C |
| Storage Temperature | --- | -40°C | --- | +60°C | °C |
| Luminance | 100VAC RMS, 400Hz | 40 | 50 | --- | cd/m ² |
| Luminance Half-Life | Ta: 25°C | 3500 | --- | --- | Hrs |

*Note: half life is defined as Luminance being reduced by 50%

3. OPERATING PRINCIPALS AND METHODS

3.1 LCD Controller Display and Control Functions (T-6963C Controller)

■ Flowchart of Communications with MPU

● Status Read

Before sending data (Read/Write) command, it is necessary to check the status.

Status check

Status of T6963C can be read from data lines.

| | |
|-------|-------------|
| RD | L |
| WR | H |
| CE | L |
| C/D | H |
| D0-D7 | Status word |

T6963C status word format is following.

| | | | | | | | |
|------|------|------|------|------|------|------|------|
| MSB | | | | | | | LSB |
| STA7 | STA6 | STA5 | STA4 | STA3 | STA2 | STA1 | STA0 |
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

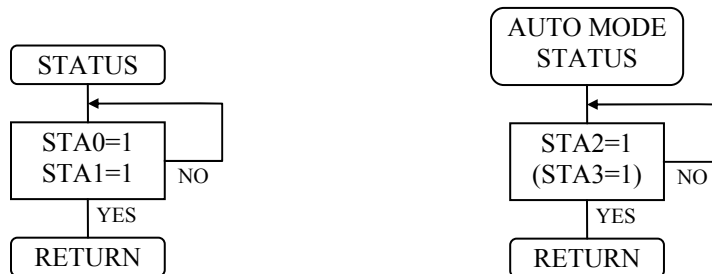
| | | |
|------|--|---------------------------------------|
| STA0 | Check capability of command execution | 0 : Disable 1 : Enable |
| STA1 | Check capability of data read/write | 0 : Disable 1 : Enable |
| STA2 | Check capability of auto mode data read | 0 : Disable 1 : Enable |
| STA3 | Check capability of auto mode data write | 0 : Disable 1 : Enable |
| STA4 | Not use | |
| STA5 | Check capability of controller operation | 0 : Disable 1 : Enable |
| STA6 | Error flag. Using screen peek/copy command | 0 : No error 1 : Error |
| STA7 | Check the condition blink | 0 : Display off 1 : Normal display |

Note 1 : It is necessary to check STA0 and STA1 at the same time. The error is happened by sending data at executing command.

Note 2 : The status check will be enough to check STA0/STA1.

Note 3 : STA2/STA3 are valid in auto mode STA0/STA1 are invalid.

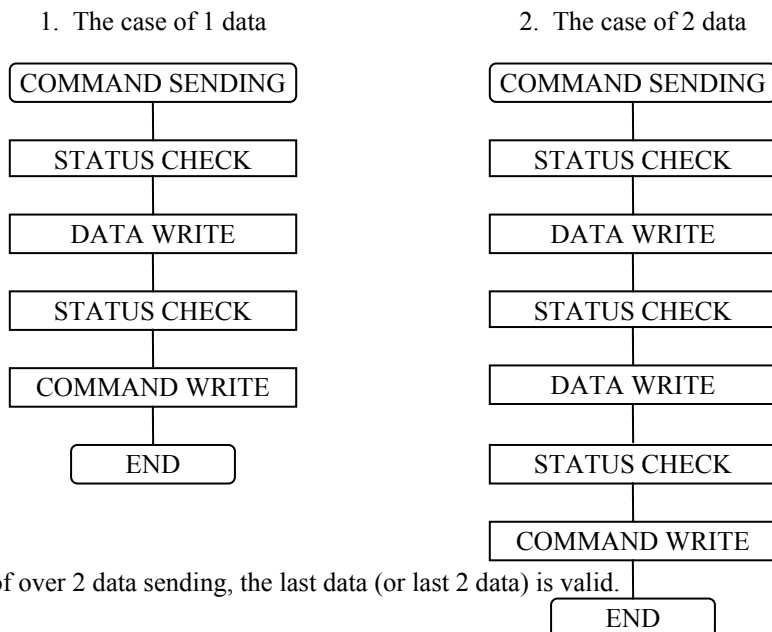
Status checking flow



Note 4 : It is impossible to save status check in the case of command of MSB0. To have the delay time cannot be save status check. The interrupt of hardware is happened at the end of lines. If command of MSB0 is sent in this period, the command executing is waited. The state of waiting doesn't be known without to check status. The sending next command or data is disregarded or rewrites data of waiting command.

- In T6963C, the data have been set and command executes.

The order of procedure of command sending



Note : In case of over 2 data sending, the last data (or last 2 data) is valid.

■ **Description of Command**

- Register Set

| Code | Hex | Function | D1 | D2 |
|----------|-----|---------------------|----------|-----------|
| 00100001 | 21H | Cursor Pointer Set | X ADRS | Y ADRS |
| 00100010 | 22H | Offset Register Set | Data | 00H |
| 00100100 | 24H | Address Pointer Set | Low ADRS | High ADRS |

(1) Cursor Pointer Set

The position of cursor is specified by X ADRS, Y ADRS. The cursor position is moved only by this command. The cursor pointer doesn't have the function of increment and decrement. The shift of cursor are set by this command. X ADRS, Y ADRS are specified following.

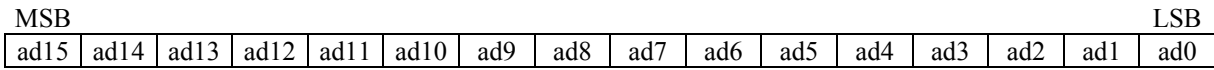
X ADRS 00H~4FH (Lower 7bits are valid)
 Y ADRS 00H~1FH (Lower 5bits are valid)

| | |
|---|--|
| 1 screen drive X ADRS 00~4FH Y ADRS 00H~0FH | 2 screens drive X ADRS 00~4FH Y ADRS 00H~0FH Upper screen Y ADRS 10H~1FH Lower screen |
|---|--|

(2) Offset Register Set

The offset register is used to determine external character generator RAM area.

T6963C has 16 bit address lines as follow.



The upper 5 bit (ad15~ad11) are determined by offset register. The middle 8 bit (ad10~ad3) are determined by character code. The lower 3 bit (ad2~ad0) are determined by vertical counter. The lower 5 bit of D1 (data) are valid. The data format of external character generator RAM.

The relationship of display RAM address and offset register

| Data of offset register | CG RAM HEX address(start-end) |
|-------------------------|-------------------------------|
| 00000 | 0000-07FFH |
| 00001 | 0800-0FFFH |
| 00010 | 1000-17FFH |
| 11100 | E000-E7FFH |
| 11101 | E800-EFFFH |
| 11110 | F000-F7FFH |
| 11111 | F800-FFFFH |

(Example 1)

| | | | | | |
|---------------------------------------|------|------|------|------|---|
| Offset register | 02H | | | | |
| Character code | 80H | | | | |
| Character generator RAM start address | 0001 | 0100 | 0000 | 0000 | |
| | 1 | 4 | 0 | 0 | H |

| | | |
|--|-------------|----------|
| | (Address) | (Data) |
| <div style="position: absolute; top: 50%; left: 50%; transform: translate(-50%, -50%); font-size: 2em; opacity: 0.3;">CG RAM</div> | 1400H | 00H |
| | 1401H | 1FH |
| | 1402H | 04H |
| | 1403H | 04H |
| | 1404H | 04H |
| | 1405H | 04H |
| | 1406H | 04H |
| | 1407H | 00H |

(Example 2)

The relationship of display RAM data and display character

| | | |
|---|--------------|---------------|
| | (RAM Data) | (Character) |
| <div style="position: absolute; top: 50%; left: 50%; transform: translate(-50%, -50%); font-size: 2em; opacity: 0.3;">Display RAM</div> | 21H | A |
| | 22H | B |
| | 83H | γ |
| | 24H | D |
| | 25H | E |
| | 86H | ζ |

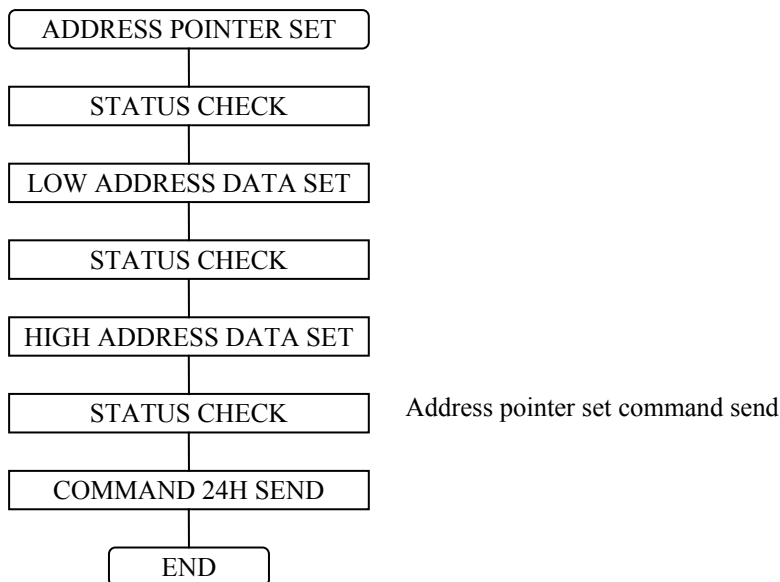
Display character

Note : γ and ζ are displayed by character generator RAM.

(3) Address Pointer Set

The address pointer set command is used to indicate the start address for writing (or reading) to external RAM.

The flow chart address pointer set command



● Control Word Set

| Code | Hex | Function | D1 | D2 |
|----------|-----|--------------------------|-------------|--------------|
| 01000000 | 40H | Text home address set | Low address | High address |
| 01000001 | 41H | Text area set | Columns | 00H |
| 01000010 | 42H | Graphic home address set | Low address | High address |
| 01000011 | 43H | Graphic area set | Columns | 00H |

The home address and column size are defined by this command.

(1) Text Home Address Set

The starting address of external display RAM for Text display is defined by this command. The text home address shows the left end and most upper position.

The relationship of external display RAM address and display position

| | | |
|-------------|--|---------------|
| TH | | TH+CL |
| TH+TA | | TH+TA+CL |
| (TH+TA)+TA | | TH+2TA+CL |
| (TH+2TA)+TA | | TH+3TA+CL |
| | | |
| TH+(n-1)TA | | TH+(n-1)TA+CL |

TH : Text home address

TA : Text area number (columns)

CL : Columns are fixed by hardware. (pin-programmable)

(Example)

Text home address : 0000H
 Text area : 0020H
 MD2=H, MD3=H : 32 columns
 DUAL=H, MDS=L, MD0=L, MD1=L : 16 lines

| | | | | |
|-------|-------|-------|-------|-------|
| 0000H | 0001H | ..... | 001EH | 001FH |
| 0020H | 0021H | ..... | 003EH | 003FH |
| 0040H | 0041H | ..... | 005EH | 005FH |
| 0060H | 0061H | ..... | 007EH | 007FH |
| 0080H | 0081H | ..... | 009EH | 009FH |
| 00A0H | 00A1H | ..... | 00BEH | 00BFH |
| 00C0H | 00C1H | ..... | 00DEH | 00DFH |
| 00E0H | 00E1H | ..... | 00FEH | 00FFH |
| 0100H | 0101H | ..... | 011EH | 011FH |
| 0120H | 0121H | ..... | 013EH | 013FH |
| 0140H | 0141H | ..... | 015EH | 015FH |
| 0160H | 0161H | ..... | 017EH | 017FH |
| 0180H | 0181H | ..... | 019EH | 019FH |
| 01A0H | 01A1H | ..... | 01BEH | 01BFH |
| 01C0H | 01C1H | ..... | 01DEH | 01DFH |
| 01E0H | 01E1H | ..... | 01FEH | 01FFH |

(2) Graphic Home Address Set

The starting address of external display RAM for Graphic display is defined by this command. The graphic home address shows the left end most upper line.

The relationship of external display RAM address and display position

| | | |
|-------------|--|---------------|
| GH | | GH+CL |
| GH+GA | | GH+GA+CL |
| (GH+GA)+GA | | GH+2GA+CL |
| (GH+2GA)+GA | | GH+3GA+CL |
| GH+(n-1)GA | | GH+(n-1)GA+CL |

GH : Graphic home address
 GA : Graphic area number (columns)
 CL : Columns are fixed by hardware. (pin-programmable)

(Example)

Graphic home address : 0000H
 Graphic area : 0020H
 MD2=H, MD3=H : 32 columns
 DUAL=H, MDS=L, MD0=L, MD1=L : 16 lines

| | | | | |
|-------|-------|-------|-------|-------|
| 0000H | 0001H | ..... | 001EH | 001FH |
| 0020H | 0021H | ..... | 003EH | 003FH |
| 0040H | 0041H | ..... | 005EH | 005FH |
| 0060H | 0061H | ..... | 007EH | 007FH |
| | | | | |
| 0F80H | 0F81H | ..... | 0F9EH | 0F9FH |
| 0FA0H | 0FA1H | ..... | 0FBEH | 0FBFH |
| 0FC0H | 0FC1H | ..... | 0FDEH | 0FDFH |
| 0FE0H | 0FE1H | ..... | 0FFEH | 0FFFH |

(3) Text Area Set

The columns of display are defined by the hardware setting. This command can be used to adjust columns of display.

(Example)

Text home address : 0000H
 Text area : 001EH
 MD2=H, MD3=H : 32 columns
 DUAL=H, MDS=L, MD0=L, MD1=L : 16 lines

| | | | | | |
|-------|-------|-------|-------|-------|-------|
| 0000H | 0001H | ..... | 001DH | 001EH | 001FH |
| 001EH | 001FH | ..... | 003BH | 003CH | 003DH |
| 003CH | 003DH | ..... | 0059H | 005AH | 005BH |
| 005AH | 005BH | ..... | 0077H | 0078H | 0079H |
| 0078H | 0079H | ..... | 0095H | 0096H | 0097H |
| 0096H | 0097H | ..... | 00B3H | 00B4H | 00B5H |
| 00B4H | 00B5H | ..... | 00D1H | 00D2H | 00D3H |
| 00D2H | 00D3H | ..... | 00EFH | 00F0H | 00F1H |
| 00F0H | 00F1H | ..... | 010DH | 010EH | 010FH |
| 010EH | 010FH | ..... | 012BH | 012CH | 012DH |
| 012CH | 012DH | ..... | 0149H | 014AH | 014BH |
| 014AH | 014BH | ..... | 0167H | 0168H | 0169H |
| 0168H | 0169H | ..... | 0185H | 0186H | 0187H |
| 0186H | 0187H | ..... | 01A3H | 01A4H | 01A5H |
| 01A4H | 01A5H | ..... | 01C1H | 01C2H | 01C3H |
| 01C2H | 01C3H | ..... | 01DFH | 01E0H | 01E1H |



(4) Graphic Area Set

The columns of display are defined by the hardware setting. This command can be used to adjust columns of graphic display.

(Example)

Text home address : 0000H
 Text area : 001EH
 MD2=H, MD3=H : 32 columns
 DUAL=H, MDS=L, MD0=L, MD1=L : 16 lines

| | | | | | |
|-------|-------|-------|-------|-------|-------|
| 0000H | 0001H | ..... | 001DH | 001EH | 001FH |
| 001EH | 001FH | ..... | 003BH | 003CH | 003DH |
| 003CH | 003DH | ..... | 0059H | 005AH | 005BH |
| 005AH | 005BH | ..... | 0077H | 0078H | 0079H |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 0E88H | 0E89H | ..... | 0EA5H | 0EA6H | 0EA7H |
| 0EA6H | 0FA7H | ..... | 0EC3H | 0EC4H | 0EC5H |
| 0EC4H | 0FC5H | ..... | 0EE1H | 0EE2H | 0EE3H |
| 0EE2H | 0FE3H | ..... | 0EFFH | 0F00H | 0F01H |



The address in graphic area can be continuous and RAM area can be used without ineffective area, if graphic area is defined the same number as the actual column number of LCD display.

● Mode Set

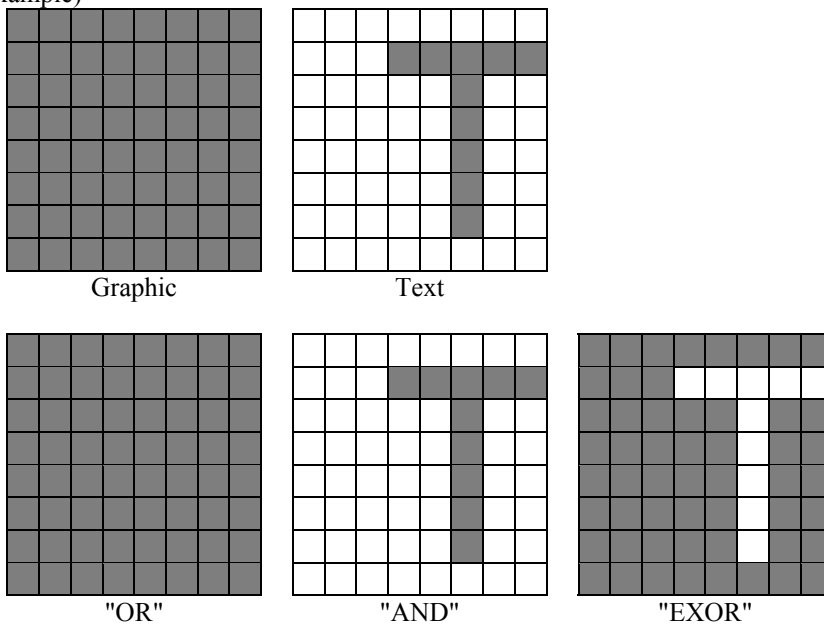
| Code | Function | Operand |
|----------|-----------------------------------|---------|
| 1000x000 | "OR" Mode | --- |
| 1000x001 | "EXOR" Mode | --- |
| 1000x011 | "AND" Mode | --- |
| 1000x100 | "TEXT ATTRIBUTE" Mode | --- |
| 10000xxx | Internal Character Generator Mode | --- |
| 10001xxx | External Character Generator Mode | --- |

x : Don't care

The display mode is defined by this command. The display mode don't have changed until to send next this command. Logically "OR", "EXOR", "AND" of text and graphic display can be displayed.

When internal character generator mode is selected, character code 00H~7FH are selected from built-in character generator ROM. The character code 80H~FFH are automatically selected external character generator RAM.

(Example)



Note : Only text display is attributed, because attribute data is located in graphic RAM area.

Attribute function

"Reverse display", "Character blink" and "Inhibit" are called "Attribute". The attribute data is written in the graphic area defined by control word set command. The mode set command selects text display only and graphic display cannot be displayed.

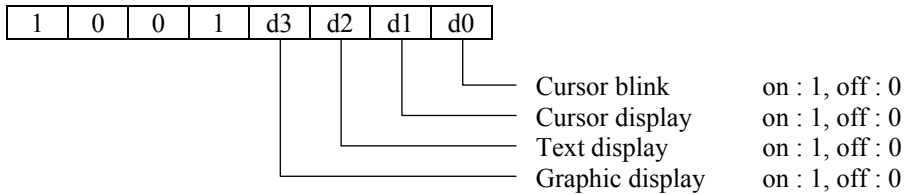
The attribute data of the 1st character in text area is written at the 1st byte in graphic area, and attribute data of n-th character is written at the n-th byte in graphic area. Attribute function is defined as follow.

| | | | | | | | | |
|--------------------|---|---|---|---|----|----|----|----|
| Attribute RAM byte | x | x | x | x | d3 | d2 | d1 | d0 |
|--------------------|---|---|---|---|----|----|----|----|

| d3 | d2 | d1 | d0 | Function |
|----|----|----|----|--------------------------|
| 0 | 0 | 0 | 0 | Normal display |
| 0 | 1 | 0 | 1 | Reverse display |
| 0 | 0 | 1 | 1 | Inhibit display |
| 1 | 0 | 0 | 0 | Blink of normal display |
| 1 | 1 | 0 | 1 | Blink of reverse display |
| 1 | 0 | 1 | 1 | Blink of inhibit display |

● Display Mode

| Code | Function | Operand |
|----------|----------------------|---------|
| 10010000 | Display off | --- |
| 1001xx10 | Cursor on, blink off | --- |
| 1001xx11 | Cursor on, blink on | --- |
| 100101xx | Text on, graphic off | --- |
| 100110xx | Text off, graphic on | --- |
| 100111xx | Text on, graphic on | --- |



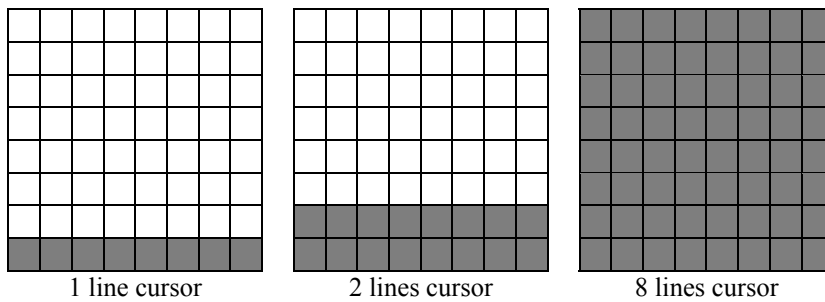
Note : It is necessary to turn on "Text display" and "Graphic display" in following case.

- 1) Combination of text/graphic display
- 2) Attribute function

● Cursor Pattern Select

| Code | Function | Operand |
|----------|----------------|---------|
| 10100000 | 1 line cursor | --- |
| 10100001 | 2 lines cursor | --- |
| 10100010 | 3 lines cursor | --- |
| 10100011 | 4 lines cursor | --- |
| 10100100 | 5 lines cursor | --- |
| 10100101 | 6 lines cursor | --- |
| 10100110 | 7 lines cursor | --- |
| 10100111 | 8 lines cursor | --- |

When cursor display is ON, this command selects the cursor pattern from 1 line to 8 lines. The cursor address is defined by cursor pointer set command.

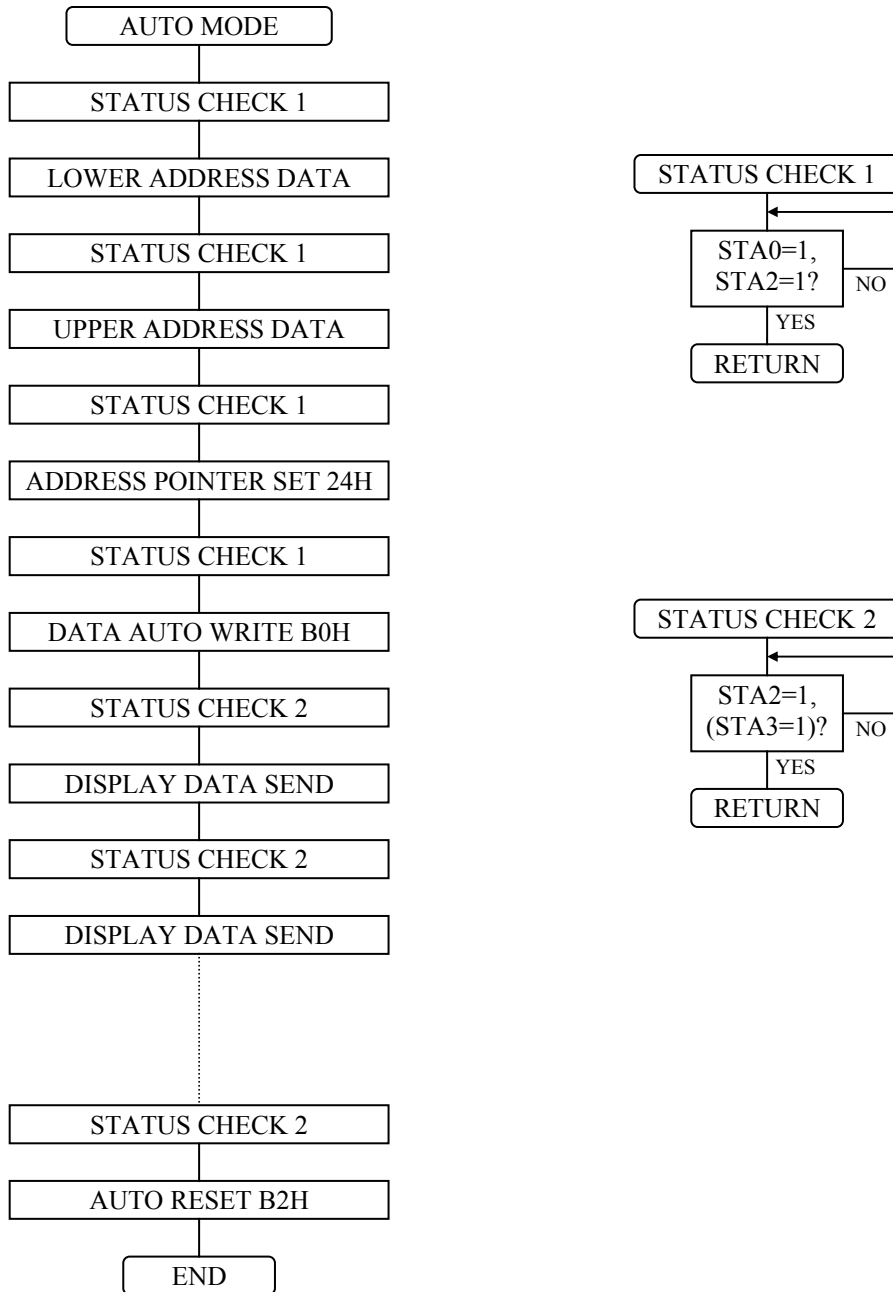


• Data Auto Read/Write

| Code | Hex | Function | Operand |
|----------|-----|---------------------|---------|
| 10110000 | B0H | Data auto write set | --- |
| 10110001 | B1H | Data auto read set | --- |
| 10110010 | B2H | Auto reset | --- |

This command is convenient to send full screen data from external display RAM. After setting auto mode, "Data write (or read)" command is not necessary between each data. "Data auto write (or read)" command should follow the "Address pointer set" and address pointer is automatically increment by + 1 after each data. After sending (or receiving) all data "Auto reset" is necessary to return normal operation because all data is regarded "Display data" and no command can be accepted in the auto mode.

Note : Status check for auto mode (STA2,STA3) should be checked between each data. Auto reset should be performed after checking STA3=1 (STA2=1). Please refer following flow chart.

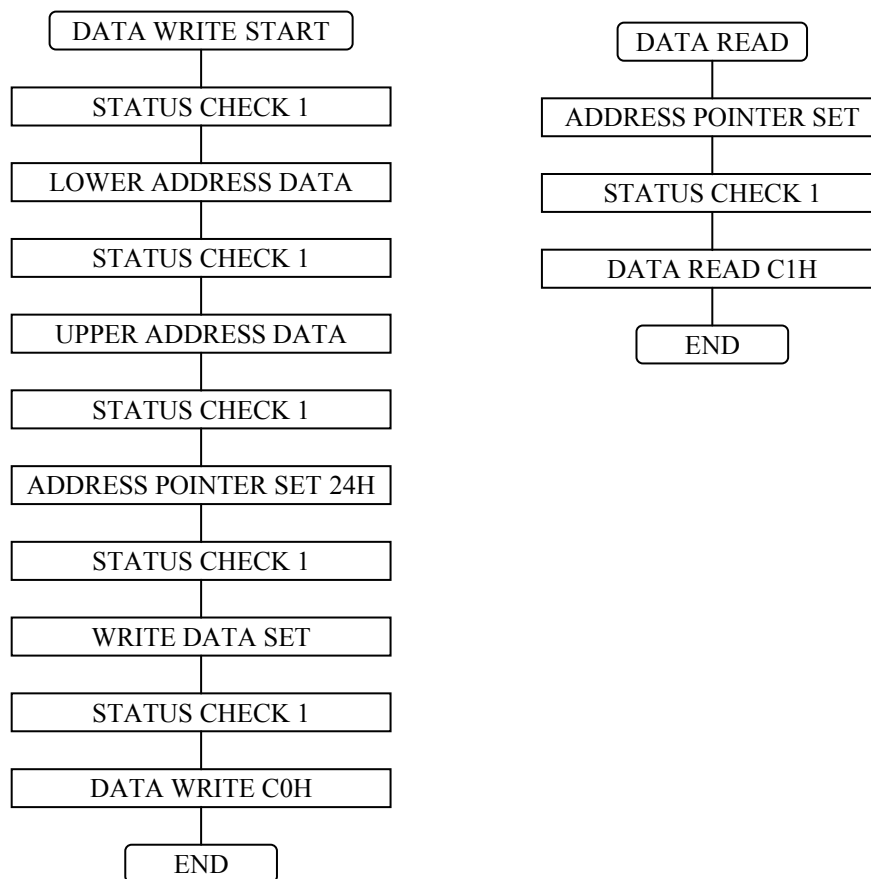


• Data Read Write

| Code | Hex | Function | Operand |
|----------|-----|---------------------------------|---------|
| 11000000 | C0H | Data write and ADP increment | Data |
| 11000001 | C1H | Data read and ADP increment | --- |
| 11000010 | C2H | Data write and ADP decrement | Data |
| 11000011 | C3H | Data read and ADP decrement | --- |
| 11000100 | C4H | Data write and ADP non-variable | Data |
| 11000101 | C5H | Data read and ADP non-variable | --- |

This command is used for data write from MPU to external display RAM, and data read from external display RAM to MPU. Data write/data read should be executed after setting address by address pointer set command. Address pointer can be automatically increment or decrement by setting this command.

Note : This command is necessary for each 1 byte data. Please refer following flow chart.

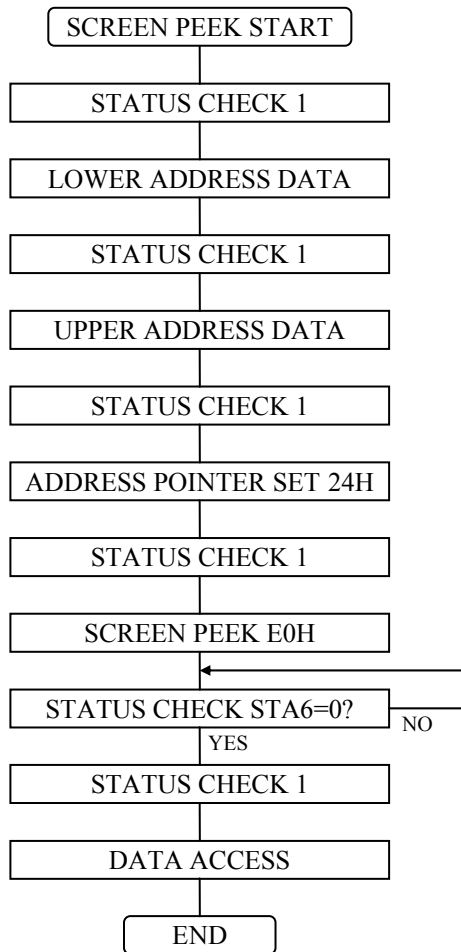


● Screen Peek

| Code | Hex | Function | Operand |
|----------|-----|-------------|---------|
| 11100000 | E0H | Screen Peek | --- |

This command is used to transfer displayed 1 byte data to data stack, and this 1 byte data can be read from MPU by data access. The logical combination data of text and graphic display on LCD screen can be read by this command.

The status (STA6) should be checked just after "Screen peek" command. If the address determined by "Address pointer Set" command is not in graphic area, this command ignored and status flag (STA6) is set. Please refer following flow chart.



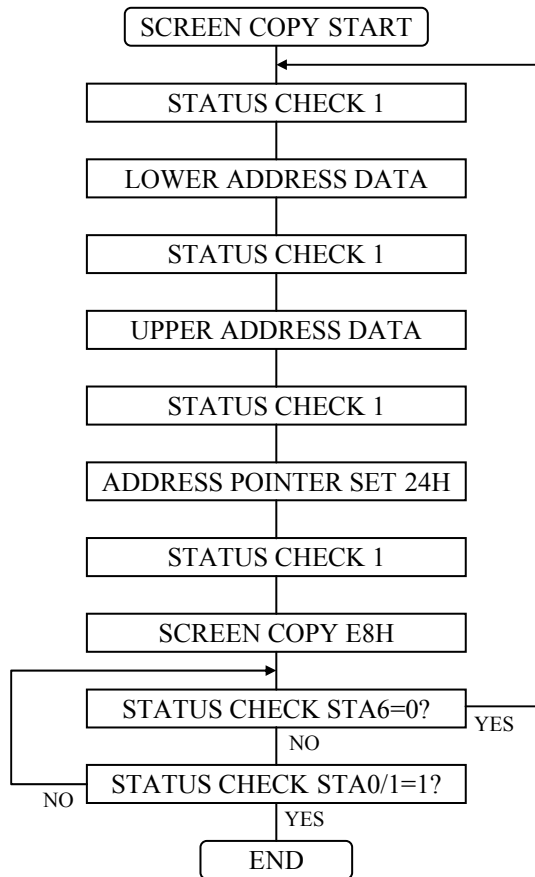
● Screen Copy

| Code | Hex | Function | Operand |
|----------|-----|-------------|---------|
| 11101000 | E8H | Screen copy | --- |

This command is used to copy displayed 1 line data to graphic area. The start point of 1 line data in the screen is determined by the address pointer. Please refer following flow chart.

Note 1 : In attribute function, this command is invalid. (Because attribute data is in the graphic area.)

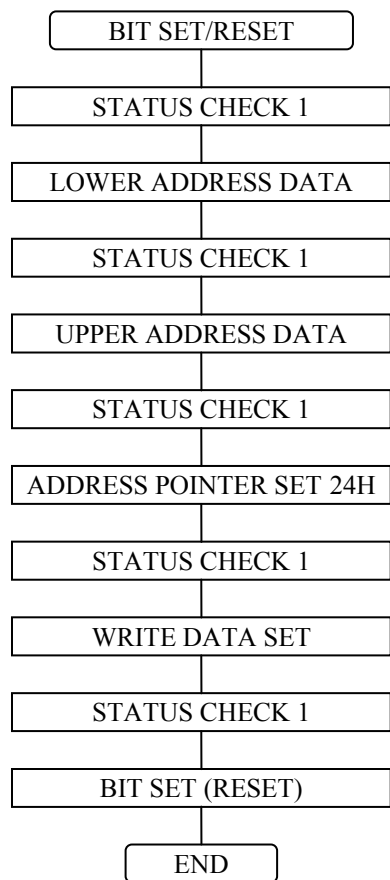
Note 2 : In case of 2 screen drive, this command is invalid. (Because T6963C cannot separate upper screen data and lower screen data.)



● Bit Set/Reset

| Code | Function | Operand |
|----------|-------------|---------|
| 11110xxx | bit reset | --- |
| 11111xxx | bit set | --- |
| 1111x000 | bit 0 (LSB) | --- |
| 1111x001 | bit 1 | --- |
| 1111x010 | bit 2 | --- |
| 1111x011 | bit 3 | --- |
| 1111x100 | bit 4 | --- |
| 1111x101 | bit 5 | --- |
| 1111x110 | bit 6 | --- |
| 1111x111 | bit 7 (MSB) | --- |

This command is used to set or reset a bit of 1 byte is specified by address pointer. Plural bits in the 1 byte data cannot be set/reset at a time. Please refer following flow chart.



3.2 LCD Controller Command List

| Command | Code | D1 | D2 | Function |
|-----------------------|----------|-------------|--------------|--------------------------------|
| Register Set | 00100001 | X address | Y address | Cursor pointer set |
| | 00100010 | Data | 00H | Offset register set |
| | 00100100 | Low address | High address | Address pointer set |
| Control Word Set | 01000000 | Low address | High address | Text home address set |
| | 01000001 | Columns | 00H | Text area set |
| | 01000010 | Low address | High address | Graphic home address set |
| | 01000011 | Columns | 00H | Graphic area set |
| Mode Set | 1000x000 | --- | --- | "OR" mode |
| | 1000x001 | --- | --- | "EXOR" mode |
| | 1000x011 | --- | --- | "AND" mode |
| | 1000x100 | --- | --- | "Text attribute" mode |
| | 10000xxx | --- | --- | Internal CG ROM mode |
| | 10001xxx | --- | --- | External CG RAM mode |
| Display Mode | 10010000 | --- | --- | Display off |
| | 1001xx10 | --- | --- | Cursor on, blink off |
| | 1001xx11 | --- | --- | Cursor on, blink on |
| | 100101xx | --- | --- | Text on, graphic off |
| | 100110xx | --- | --- | Text off, graphic on |
| | 100111xx | --- | --- | Text on, graphic on |
| Cursor Pattern Select | 10100000 | --- | --- | 1 line cursor |
| | 10100001 | --- | --- | 2 lines cursor |
| | 10100010 | --- | --- | 3 lines cursor |
| | 10100011 | --- | --- | 4 lines cursor |
| | 10100100 | --- | --- | 5 lines cursor |
| | 10100101 | --- | --- | 6 lines cursor |
| | 10100110 | --- | --- | 7 lines cursor |
| | 10100111 | --- | --- | 8 lines cursor |
| Data Auto Read/Write | 10110000 | --- | --- | Data auto write set |
| | 10110001 | --- | --- | Data auto read set |
| | 10110010 | --- | --- | Auto reset |
| Data Read Write | 11000000 | Data | --- | Data write and ADP increment |
| | 11000001 | --- | --- | Data read and ADP increment |
| | 11000010 | Data | --- | Data write and ADP decrement |
| | 11000011 | --- | --- | Data read and ADP decrement |
| | 11000100 | Data | --- | Data write and ADP nonvariable |
| | 11000101 | --- | --- | Data read and ADP nonvariable |
| Screen Peek | 11100000 | --- | --- | Screen peek |
| Screen Copy | 11101000 | --- | --- | Screen copy |
| Bit Set/Reset | 11110xxx | --- | --- | bit reset |
| | 11111xxx | --- | --- | bit set |
| | 1111x000 | --- | --- | bit 0 (LSB) |
| | 1111x001 | --- | --- | bit 1 |
| | 1111x010 | --- | --- | bit 2 |
| | 1111x011 | --- | --- | bit 3 |
| | 1111x100 | --- | --- | bit 4 |
| | 1111x101 | --- | --- | bit 5 |
| | 1111x110 | --- | --- | bit 6 |
| | 1111x111 | --- | --- | bit 7 (MSB) |

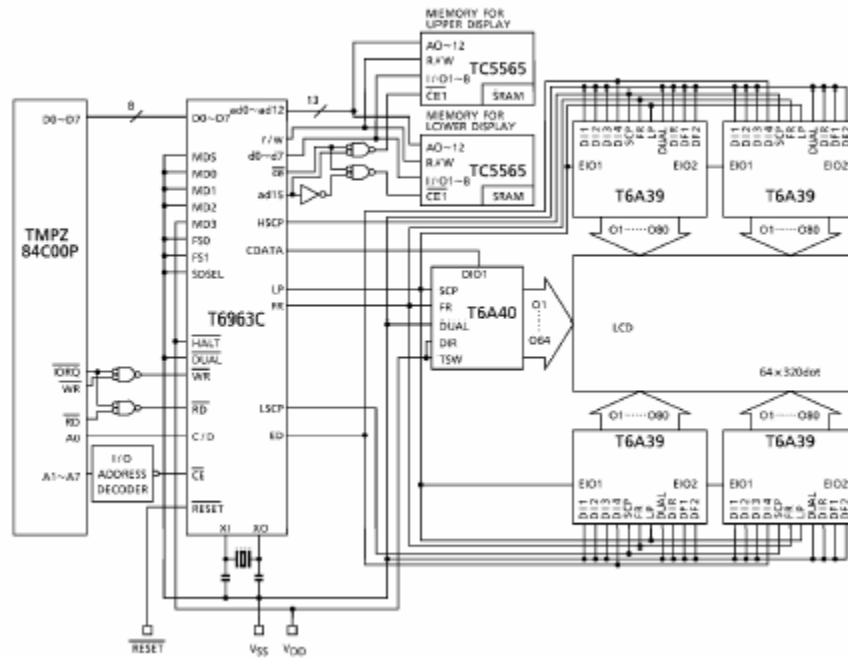
3.3 LCD Controller Character Code Map

ROM CODE 0101

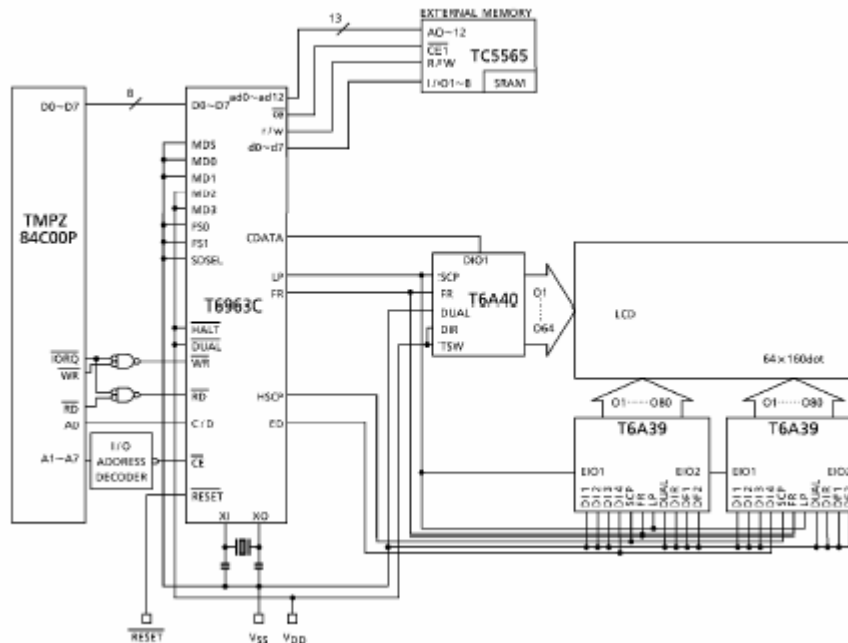
| LSB MSB | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|------------|---|---|---|---|----|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | ! | " | # | \$ | % | & | ' | (|) | * | + | , | - | . | / |
| 1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | ; | < | = | > | ? |
| 2 | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | |
| 3 | P | Q | R | S | T | U | V | W | X | Y | Z | [| \ |] | ^ | _ |
| 4 | | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o |
| 5 | p | q | r | s | t | u | v | w | x | y | z | { | \| | } | ~ |  |
| 6 | Q | U | E | A | A | A | A | Q | E | E | E | i | i | i | Δ | Δ |
| 7 | E | æ | Æ | ø | ø | ø | ö | ö | ö | ö | ø | ø | ø | ø | ø | ø |

3.4 Application Circuits

APPLICATION CIRCUIT (1)



APPLICATION CIRCUIT (2)



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 200 hrs | ----- |
| 2 | Low temperature storage | Endurance test applying the low storage temperature for a long time. | -10 °C 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 200 hrs | ----- |
| 4 | Low temperature operation | Endurance test applying the electric stress under low temperature for a long time. | 0 °C 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 96 hrs | MIL-202E-103B 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 96 hrs | MIL-202E-103B JIS-C5023 |
| 7 | Temperature cycle | Endurance test applying the low and high temperature cycle. $\begin{array}{ccc} -20^{\circ}\text{C} & \rightleftharpoons & 25^{\circ}\text{C} & \rightleftharpoons & 70^{\circ}\text{C} \\ 30\text{min} & \leftarrow & 5\text{min.} & \rightarrow & 30\text{min} \\ \leftarrow & & & & \rightarrow \\ & & \text{1 cycle} & & \end{array}$ | -10°C / 60°C 10 cycles ----- | |
| Mechanical Test | | | | |
| 8 | Vibration test | Endurance test applying the vibration during transportation and using. | 10~22Hz → 1.5mmp-p 22~500Hz → 1.5G Total 0.5hrs | MIL-202E-201A JIS-C5025 JIS-C7022-A-10 |
| 9 | Shock test | Constructional and mechanical endurance test applying the shock during transportation. | 50G Half sign wave 11 msdc 3 times of each direction | MIL-202E-213B |
| 10 | Atmospheric pressure test | Endurance test applying the atmospheric pressure during transportation by air. | 115 mbar 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 CS=100 pF 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

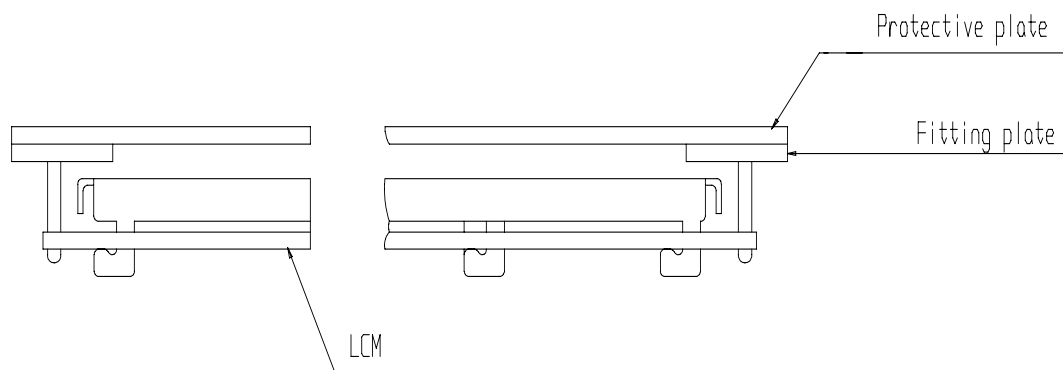
- 100,000 hours minimum at 25° C ±10%
- Contrast becomes 30% of initial value
- Current consumption becomes three times higher than initial value
- Remarkable alignment deterioration occurs in LCD cell layer
- Unusual operation occurs in display functions

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 ± 0.1 mm.

Precaution for Handling 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 handling 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.

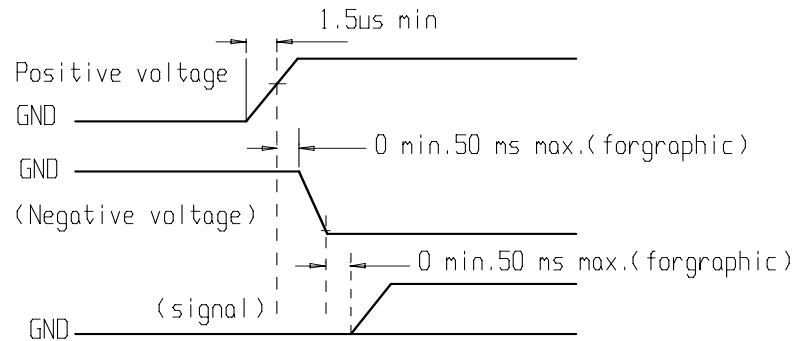
Precaution for soldering to the LCM

- 1) Observe the following when soldering lead wire, connector cable and etc. to the LCM.
 - a) Soldering iron temperature : $280^{\circ}\text{C} \pm 10^{\circ}\text{C}$.
 - 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 $25^{\circ}\text{C} \pm 10^{\circ}\text{C}$ 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.