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## 1. LCD MODULE NUMBERING SYSTEM

**PART NUMBER: PL-AB...BC-DEFGHI-JK**

**PL** POWER LIGHT TECHNOLOGY  
**A** DISPLAY CONTENTS S---SEGMENT TYPE  
 C---CHARACTER TYPE  
 G---GRAPHIC TYPE

**B...B** SERIALS NUMBER FOR SM  
 CHARACTERS Vs. LINES FOR CM

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**C** COLUMNS Vs. ROWS FOR GM  
**D** VERSION OF PCB  
 LCD TYPE  
 P---POS. TN, N---NEG. TN, Y---YELLOW STN, G---GRAY STN  
 B---BLUE STN, F---FSTN  
**E** POLARIZER TYPE  
 R---REFLECTIVE, F---TRANSFLECTIVE, T---TRANSMISSIVE  
**F** VIEWING ANGLE S---6 O'CLOCK, T---12 O'CLOCK  
**G** OPERATING TEMPRETURE N---NORMAL, E---EXTENDED  
**H** BACKLIGHT TYPE N---NO BACKLIGHT, D---BOTTOM LED, S---SIDE LED,  
 E---EL, C---CCFL  
**I** COLOR OF BACKLIGHT Y---YELLOW/GREEN, G---GREEN  
 W---WHITE, B---BLUE, A---AMBER  
**JK** FOR CM, CONTROLLER/DRIVER DESIGNATOR  
 J: IC A---KS0066U B---SPLC780  
 K: DENOTE DIFFERENT CHARACTER TABLE  
 FOR GM. J: BACKLIGHT DRIVER Y---WITH, N---WITHOUT  
 K: DC-DC CONVERTER Y---WITH, N---WITHOUT

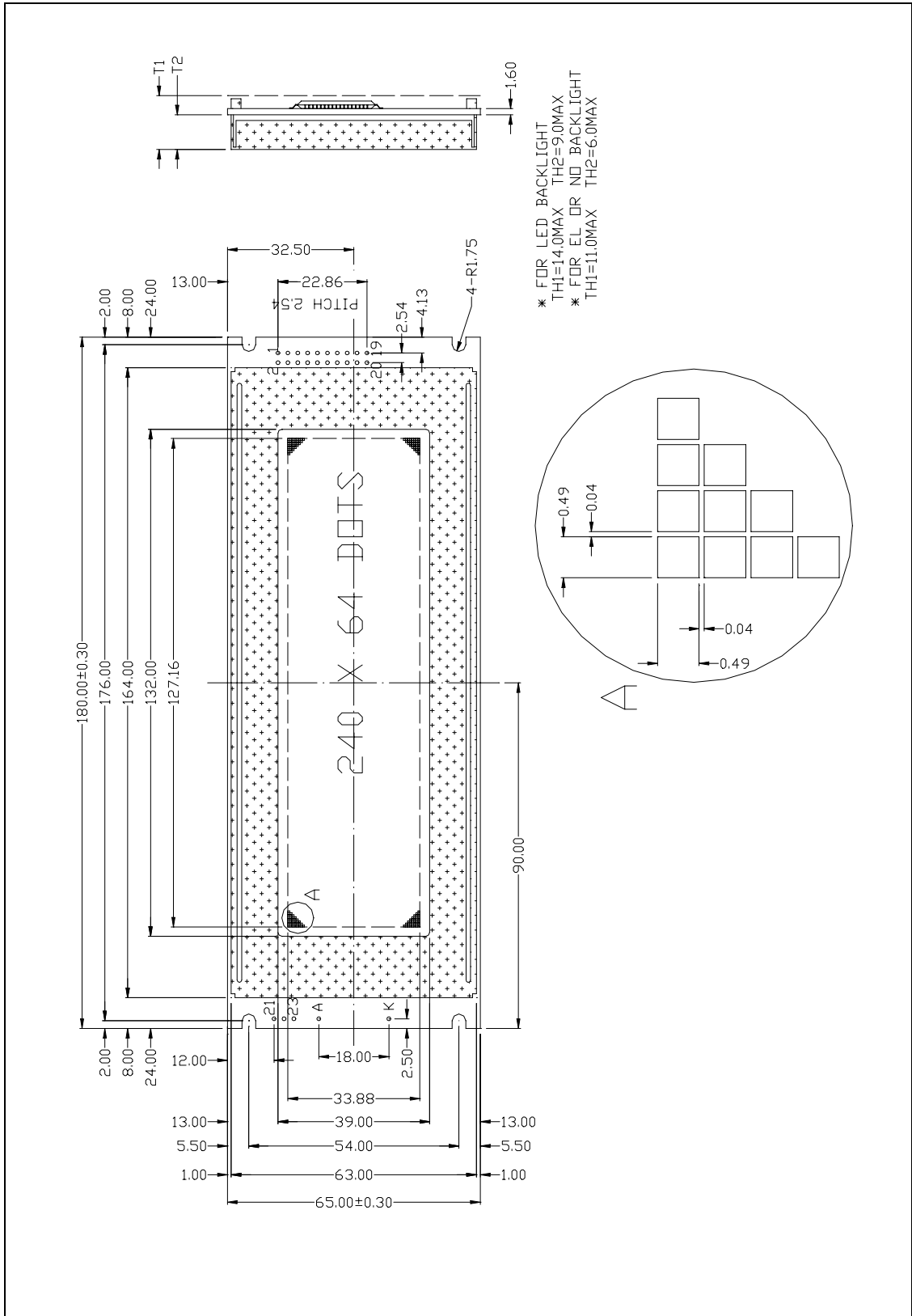
## 2. MECHANICAL CHARACTERISTICS

### 2.1 MECHANICAL DATA

| ITEM                   | STANDARD VALUE                    | UNIT |
|------------------------|-----------------------------------|------|
| NUMBER OF PIXELS       | 240(COLUMNS) X 64(ROWS)           |      |
| OUTLINE DIMENSIONS     | 180.0(W) X 65.0(H) X 14.0/10.0(T) | mm   |
| EFFECTTVE VIEWING AREA | 132.0(W) X 39.0(H)                | mm   |
| DOT SIZE               | 0.49(W) X 0.49(H)                 | mm   |
| DOT PITCH              | 0.53(W) X 0.53(H)                 | mm   |
| APPROX WEIGHT          | 185(LED BL VERSION)/150(NO BL)    | g    |

### 2.2 MECHANICAL DRAWINGS

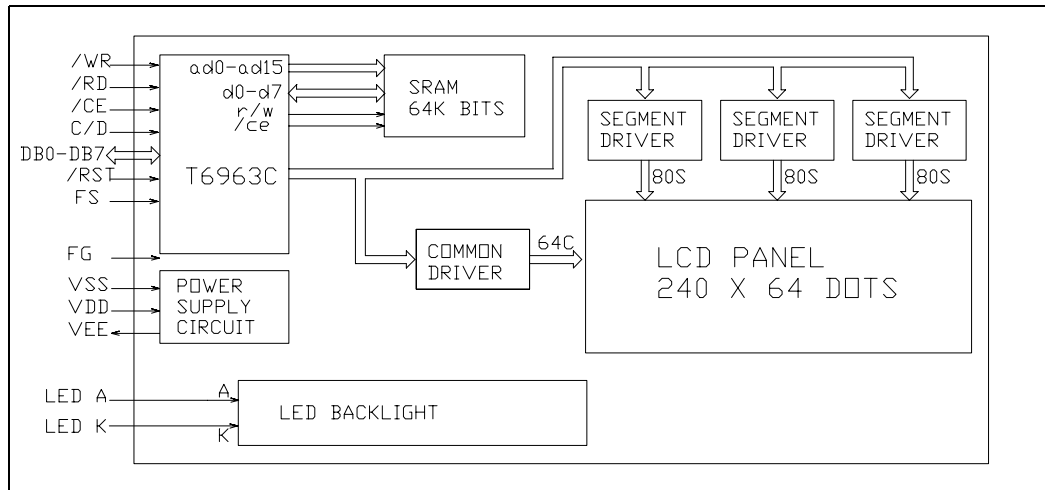
POWER LIGHT



### 3. CIRCUIT BLOCK DIAGRAM

#### 3.1 Electrical Block Diagram

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### 3.2 Module Features

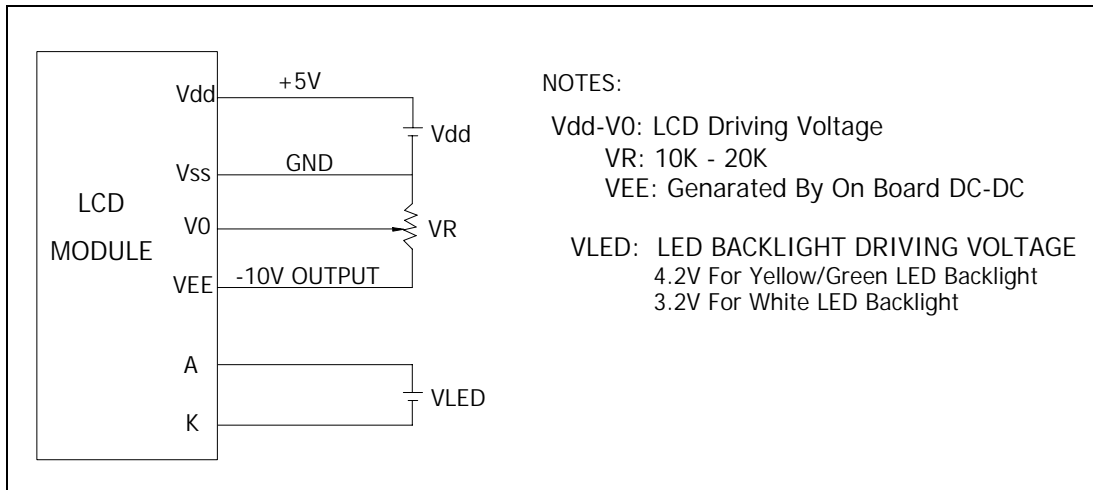
1. 32K Bytes Built-in Display RAM(SRAM)
2. Built-in 128-word Character Generator ROM(T6963C-0101 Code 0101)
3. Selectable 6X8 or 8X8 Character Font
4. Display Mode: Text, Graphics And Combination Of Text and Graphics

### 3.2 Pins Definition

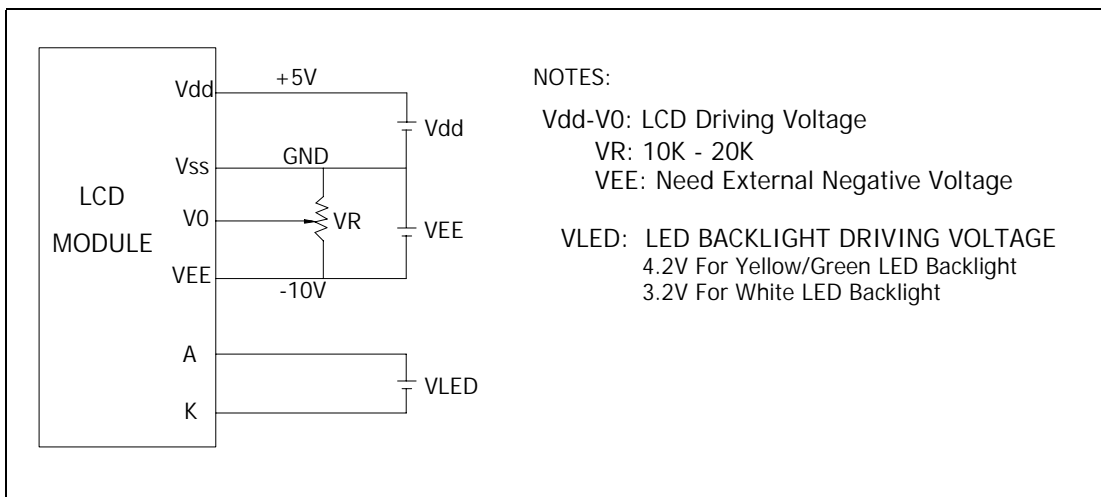
| PIN   | SYMBOL  | FUNCTION  |
|-------|---------|---|
| 1     | FG      | Frame Ground  |
| 2     | Vss     | Power Supply(GND)   |
| 3     | Vdd     | Power Supply For Logic(+5V)   |
| 4     | Vo      | Power Supply For LCD Driving (Contrast Adjust)  |
| 5     | /WR     | Write Signal, Active Low  |
| 6     | /RD     | Read Signal, Active Low   |
| 7     | /CE     | Chip Enable Signal For T6963C, Active Low   |
| 8     | C/D     | While Write----1: Command Write 0: Data Write<br>While Read----1: Status Read 0:Data Read |
| 9     | NC      | No Connect  |
| 10    | /RST    | Reset Signal, Active Low  |
| 11-18 | DB0—DB7 | Data Bus  |
| 19    | FS      | Font Select 0: 8X8 Font 1: 6X8 Font   |
| 20    | Vee     | Negative Voltage Output/Input(-10V)   |
| 21    | LEDA    | Power Supply for LED Backlight(+)   |
| 22    | NC      | No Connect  |
| 23    | LEDK    | Power Supply for LED Backlight(-)   |

### 3.3 Power Supply For LCM Driving

### 3.3.1 For LCM With DC/DC on Board(Internal Negative Voltage)



### 3.3.2 For LCM without DC/DC on Board(Negative Voltage input)



## 4. ABSOLUTE MAXIMUM RATINGS

### 4.1 Electrical Absolute Maximum Ratings

| ITEM              | SYMBOL    | CONDITION | MIN      | MAX      | UNIT |
|-------------------|-----------|-----------|----------|----------|------|
| Operating Voltage | Vdd – Vss | -         | -0.3     | 7.0      | V    |
| Supply Voltage    | Vee-Vss   | -         | Vdd-30.0 | Vdd+0.3  | V    |
| Supply Voltage    | V0-Vss    | -         | Vee-0.3  | Vdd+0.3  | V    |
| Input Voltage     | Vi        | -         | -0.3     | Vdd +0.3 | V    |

### 4.2 Environmental Absolute Maximum Ratings

| ITEM           | SYMBOL | CONDITIONS    | MIN | MAX | UNIT  |
|----------------|--------|---------------|-----|-----|-------|
| Operating Temp | Topr   | -Normal temp. | 0   | 50  | deg C |
| Storage Temp   | Ttsg   | version-      | -20 | 70  | deg C |

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|                       |      |   |     |                  |       |
|-----------------------|------|---|-----|------------------|-------|
| Operating Temp        | Topr | Extended temp.<br>version               | -20 | 70               | deg C |
| Storage Temp          | Ttsg |   | -30 | 80               | deg C |
| Humidity<br>Endurance | RH   | no ondensation<br>Ta<=40 deg            | -   | 95               | %     |
| Vibration             | -    | 100-300Hz, X/Y/Z<br>directions, 1 hour  | -   | 4.9m/ss<br>0.5g  | -     |
| Shock                 | -    | 10 mS X/Y/Z<br>direction 1 time<br>each |     | 29.4m/ss<br>3.0g | -     |

## 5. ELECTRICAL CHARACTERISTICS

### 5.1 DC Characteristics

Electrical Characteristics at Ta=25 deg C, Vdd = 5V + / - 5%

| ITEM                      | SYMBOL  | CONDITION    | MIN     | TYP  | MAX | UNIT |
|---------------------------|---------|--------------|---------|------|-----|------|
| Supply Voltage<br>(logic) | Vdd-Vss | -            | 4.5     | 5.0  | 5.5 | V    |
| Supply Voltage<br>(LCD)   | Vdd-V0  | Vdd = 5V     | -       | 14.5 | -   | V    |
| Input Signal<br>Voltage   | V-ih    | "H" level    | Vdd-2.2 | -    | Vdd | V    |
|                           | V-il    | "L" level    | 0       | -    | 0.8 | V    |
| Output Signal<br>Voltage  | V-oh    | "H" level    | Vdd-0.3 | -    | Vdd | V    |
|                           | V-ol    | "L" level    | 0       | -    | 0.3 | V    |
| Supply Current<br>(logic) | Idd     | Vdd=5.0V     | -       | 9.5  | -   | mA   |
| Supply Current<br>(LCD)   | Io      | Vdd-V0=14.5V | -       | 5.0  | -   | mA   |

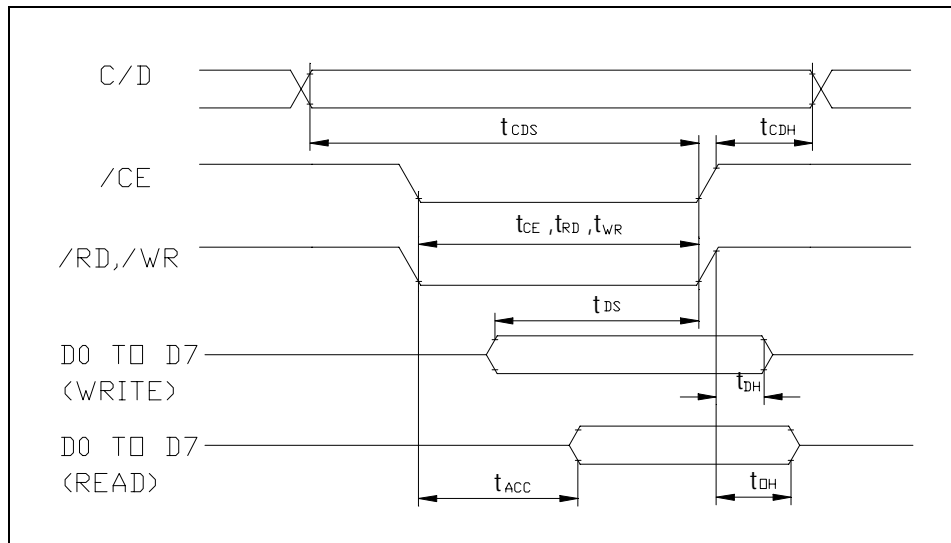
### 5.2 MPU Interface AC Characteristics

Test Conditions: Ta = -20 to 75°C, Vdd = 5V+/-10%, Vss =0V

| ITEM            | SYMBOL | MIN | MAX | UNIT |
|-----------------|--------|-----|-----|------|
| C/D Set-up Time | tcds   | 100 | -   | ns   |
| C/D Hold Time   | tcdH   | 10  | -   | ns   |

|                         |                          |    |     |    |
|-------------------------|--------------------------|----|-----|----|
| /CE,/RD,/WR Pulse Width | $t_{CE}, t_{RD}, t_{WR}$ | 80 | -   | ns |
| Data Set-up Time        | $t_{DS}$                 | 80 | -   | ns |
| Data Hold Time          | $t_{DH}$                 | 40 | -   | ns |
| Access Time             | $t_{ACC}$                | -  | 150 | ns |
| Output Hold Time        | $t_{OH}$                 | 10 | 50  | ns |

### BUS TIMING



## 6. BACKLIGHT CHARACTERISTICS

For Bottom-Lit LED Backlight ( $T_a=25^\circ\text{C}$ )

| ITEM              | SYMBOL      | CONDITION         | MIN. | TYP.              | MAX. | UNIT |
|-------------------|-------------|-------------------|------|-------------------|------|------|
| Forward Voltage   | $V_f$       |                   | -    | 4.2               | 4.6  | V    |
| Forward Current   | $I_f$       | $V_f=4.2\text{V}$ | -    | 660               | -    | mA   |
| Reverse Voltage   | $V_r$       | -                 | -    | -                 | 8    | V    |
| Peak Wave Length  | $\lambda_p$ | $V_f=4.2\text{V}$ | -    | 568(Yellow/Green) | -    | nm   |
| Power Dissipation | $P_d$       | $V_f=4.2\text{V}$ | -    | 2800              | -    | mW   |

## 7. ELECTRO-OPTICAL CHARACTERISTICS

| ITEM      | SYMBOL | CONDITION          | MIN. | TYP. | MAX. | UNIT | REF.   |
|-----------|--------|--------------------|------|------|------|------|--------|
| Contrast  | CR     | $25^\circ\text{C}$ | 4    | --   | --   |      | Note1  |
| Rise Time | $t_r$  | $25^\circ\text{C}$ | --   | 160  | 240  | ms   | Note2  |
| Fall Time | $t_f$  | $25^\circ\text{C}$ | --   | 100  | 150  | ms   | note 2 |

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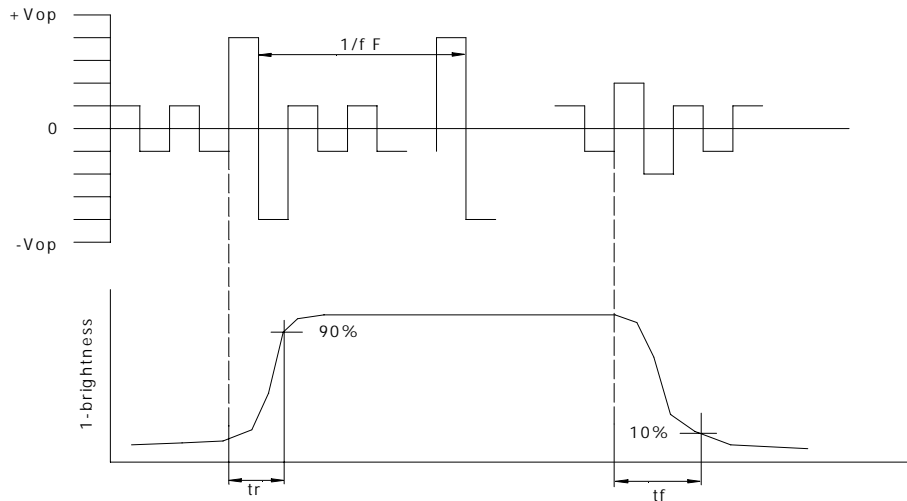
|                 |                            |      |               |    |    |     |        |
|-----------------|----------------------------|------|---------------|----|----|-----|--------|
| Viewing Angle   | $\theta 1 - \theta 2$      | 25°C | --            | -- | 60 | DEG | Note 3 |
|                 | $\emptyset 1, \emptyset 2$ |      | -40(S)/-15(T) | -- | 40 |     |        |
| Frame Frequency | Ff                         | 25°C | --            | 70 | -- | Hz  | note 2 |

Note(1): Contrast ratio is defined under the following condition:

CR=  $\frac{\text{brightness of selected condition}}{\text{brightness of non-selected condition}}$

- (a). Temperature-----25C
- (b). Frame Frequency-----64Hz
- (c). Viewing angle-----  $\theta = 0, \emptyset = 0$
- (d). Operating Voltage---5.0V

Note(2): definition of response time:

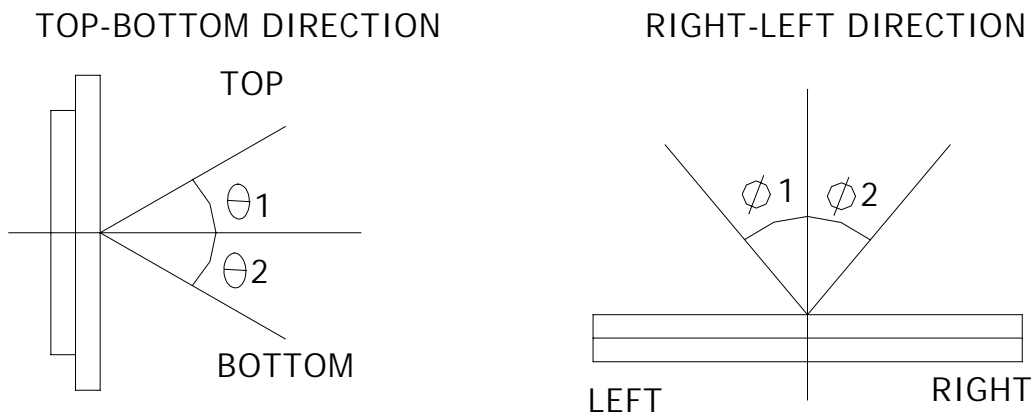


Condition:

- (a). Temperature-----25C
- (b). Frame Frequency-----64Hz
- (c). Viewing angle-----  $\theta = 0, \emptyset = 0$
- (d). Operating Voltage---5.0V

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Note(3): definition of view angle:



## 8. COMMUNICATION WITH MPU

### 8.1 FUNCTIONAL DEFINITION

- After power on, it is necessary to reset. /RST is kept L between 5 clocks up(oscillation clock).
- The column/line counter and display register are cleared by reset.(Other registers are not cleared.) Disable the display using the clear-display register.
- The status must be checked before data or commands are sent. The MSB=0 status check must be done in particular. There is a possibility of erroneous operation due

to a hard interrupt.

- STA0 and STA1 must be checked at the same time. When a command is executed, data transmission errors may occur.
- The T6963C can only handle one byte per machine cycle(16 clocks). It is impossible to send more than two data in a machine cycle.
- When using a command with operation data, it is important to send the data first, and then execute the command
- The character codes used by the T6963C are different from ASCII codes.

## 8.2 Display RAM

The Display RAM is a 32K bytes SRAM built in the module. It is located at address 0000H ~ 7FFFH. All the display data (text, graphic and CG data) is written to this display RAM. T6963C automatically reads the display RAM and sends the data to LCD drivers. The display RAM map is programmable by the "control word set" command. While more than 1 screen data is stored in the RAM, Vertical scrolling and paging is easily performed by resetting text home and/or graphic home address.

## 8.3 Status Read

The status of the T6963C should be checked between every command and data in order to complete a communication cycle with the MPU. The status can be read from 8 bits data lines (D0 to D7) by setting C/D=H, /RD=L /WR=H and /CE=L.

The format of T6963C status word is as followed:

| MSB  |                                       |      |      | LSB  |      |                           |      |
|------|---------------------------------------|------|------|------|------|---------------------------|------|
| STA7 | STA6                                  | STA5 | STA4 | STA3 | STA2 | STA1                      | STA0 |
| D7   | D6                                    | D5   | D4   | D3   | D2   | D1                        | D0   |
| STA0 | Check command execution capability    |      |      |      |      | 0 : Disable<br>1 : Enable |      |
| STA1 | Check data read/write capability      |      |      |      |      | 0 : Disable<br>1 : Enable |      |
| STA2 | Check Auto mode data read capability  |      |      |      |      | 0 : Disable<br>1 : Enable |      |
| STA3 | Check Auto mode data write capability |      |      |      |      | 0 : Disable<br>1 : Enable |      |
| STA4 | Not used                              |      |      |      |      |                           |      |
| STA5 | Check controller operation capability |      |      |      |      | 0 : Disable<br>1 : Enable |      |

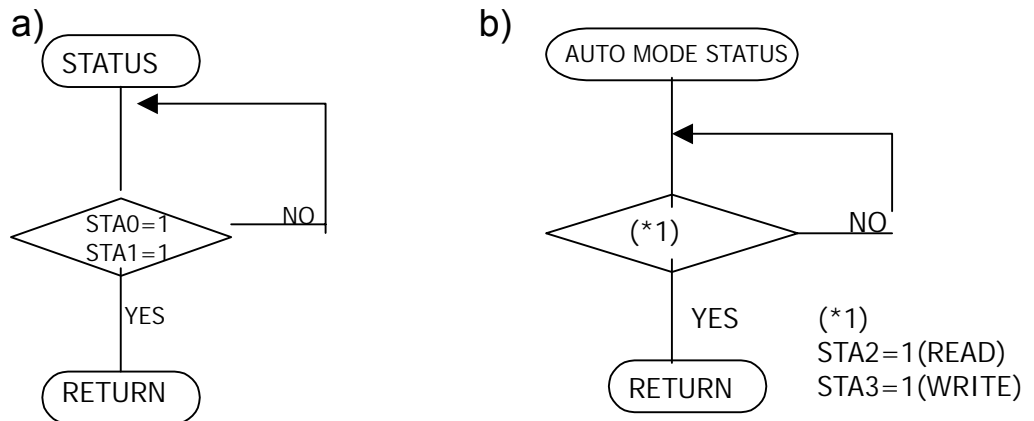
|      |   |                                       |
|------|---|---------------------------------------|
| STA6 | Error flag. Used for Screen Peek end<br>Screen Copy commands. | 0 : No error<br>1 : Error             |
| STA7 | Check the blink condition                                     | 0 : Display off<br>1 : Normal display |

(Note 1) It is necessary to check STA0 end STA1 at the same time.

(Note 2) For most modes STA0/STA1 are used as a status check.

(Note 3) STA2 and STA3 are used in auto mode.

### Status Checking Flow



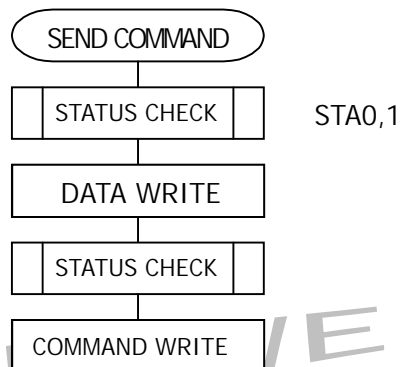
When using MSB=0 command, a Status Read must be performed. If a status check is not carried out, T6963C can't operate normally, even after a delay time. The hardware interrupt occurs during the address calculation period (at the end of each line). If a MSB=0 command is sent to the T6963C during this period, the T6963C enters wait status. If a status check is not carried out in this state before the next command is sent, there is the possibility that the command or data will not be received.

## 8.4 Setting Data

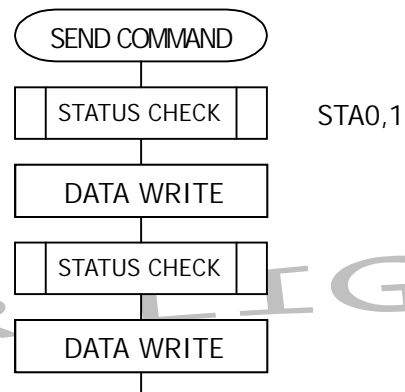
When using T6963C, first set the data, then set the command.

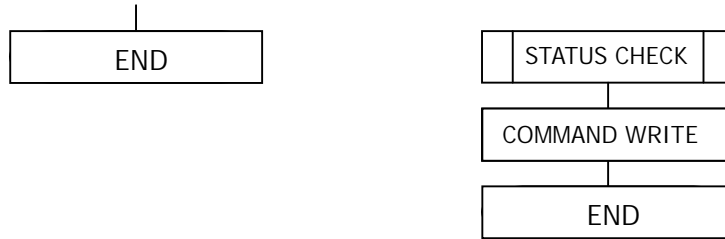
The procedure of sending a command is as followed:

### A) The case of 1 data



### B) The case of 2 data





(Note) When sending more than two data, the last datum (or last two data) is valid

## 9. COMMAND DEFINITIONS

### 9.1 INSTRUCTION TABLE

| COMMAND                | CODE     | D1          | D2           | FUNCTION                 |
|------------------------|----------|-------------|--------------|--------------------------|
| REGISTERS<br>SETTING   | 00100001 | X address   | Y address    | Set cursor pointer       |
|                        | 00100010 | Data        | 00H          | Set offset register      |
|                        | 00100100 | Low address | High address | Set address pointer      |
| SET<br>CONTROL<br>WORD | 01000000 | Low address | High address | Set text home address    |
|                        | 01000001 | Columns     | 00H          | Set text area            |
|                        | 01000010 | Low address | high address | Set graphic home address |
|                        | 01000011 | columns     | 00H          | Set graphic area         |
| 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<br>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<br>PATTERN<br>SELECT | 10100000 | -    | - | 1-line cursor                  |
|                             | 10100001 | -    | - | 2-line cursor                  |
|                             | 10100010 | -    | - | 3-line cursor                  |
|                             | 10100011 | -    | - | 4-line cursor                  |
|                             | 10100100 | -    | - | 5-line cursor                  |
|                             | 10100101 | -    | - | 6-line cursor                  |
|                             | 10100110 | -    | - | 7-line cursor                  |
|                             | 10100111 | -    | - | 8-line cursor                  |
| DATA AUTO<br>READ/WRITE     | 10110000 | -    | - | Set data auto write            |
|                             | 10110001 | -    | - | Set data auto read             |
|                             | 10110010 | -    | - | Auto reset                     |
| DATA<br>READ/WRITE          | 11000000 | Data | - | Data write and increment ADP   |
|                             | 11000001 | -    | - | Data read and increment ADP    |
|                             | 11000010 | Data | - | Data write and decrement ADP   |
|                             | 11000011 | -    | - | Data read and decrement ADP    |
|                             | 11000100 | Data | - | Data write and nonvariable ADP |
|                             | 11000101 | -    | - | Data read and nonvariable ADP  |
| SCREEN PEEK                 | 11100000 | -    | - | Screen peek                    |
| SCREEN COPY                 | 11101000 | -    | - | Screen copy                    |
| BIT<br>SET/RESET            | 11110XXX | -    | - | Bit reset                      |
|                             | 11111XXX | -    | - | Bit set                        |
|                             | 1111X000 | -    | - | Bit 0 (LSB)                    |
|                             | 1111X001 | -    | - | Bit1                           |
|                             | 1111X010 | -    | - | Bit2                           |
|                             | 1111X011 | -    | - | Bit3                           |
|                             | 1111X100 | -    | - | Bit4                           |
|                             | 1111X101 | -    | - | Bit5                           |
|                             | 1111X110 | -    | - | Bit6                           |
|                             | 1111X111 | -    | - | Bit7 (MSB)                     |

## 9.2 EXPLANATIONS OF THE COMMANDS

### 9.2.1. Set registers

| CODE     | HEX | FUNCTION            | D1       | D1        |
|----------|-----|---------------------|----------|-----------|
| 00100001 | 21H | Set cursor pointer  | X ADRS   | Y ADRS    |
| 00100010 | 22H | Set offset register | DATA     | 00H       |
| 00100100 | 24H | Set address pointer | LOW ADRS | HIGH ADRS |

#### A) Set cursor pointer

The position of the cursor is specified by X ADRS and Y ADRS. The cursor position can only be moved by this command. Data read/write from the MPU never changes the cursor pointer. X ADRS: 00H to 4FH(lower 7 bits are valid) Y ADRS: 00H to 1FH(lower 5 bits are valid).

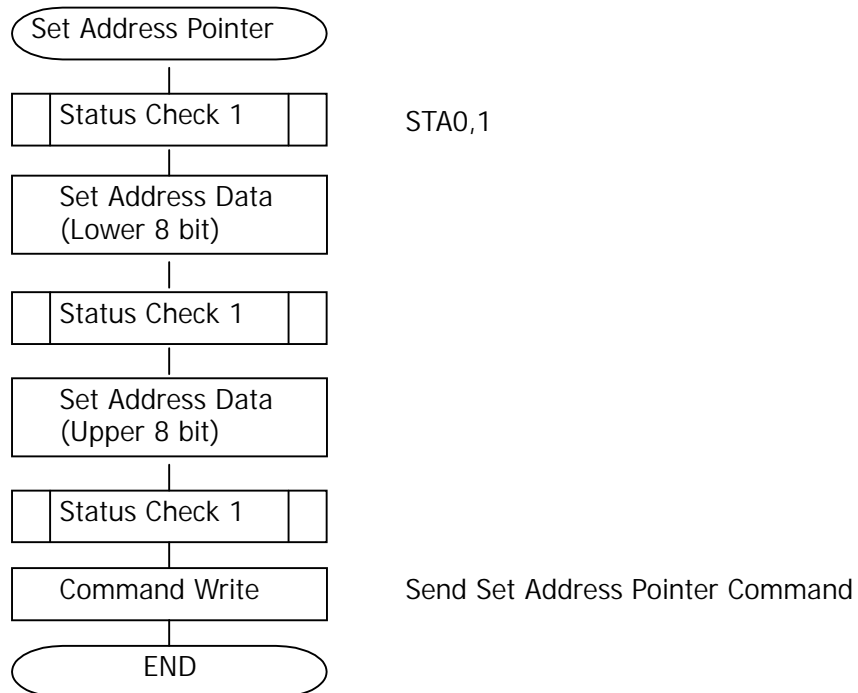
#### B) Set offset register

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The offset register is used to determine the external character generator RAM area. The upper 5 bits in start address of CG area is set as the lower 5 bits of D1. And the upper 3 bits of D1 are neglected. D2 should be 00H. Refer to section 10 "Character Generator" for details of the CG RAM.

### C) Set address pointer

The Set Address Pointer command is used to indicate the start address for write/read data to/from the built-in RAM.



### 9.2.2. Set Control Word

| CODE     | HEX | FUNCTION                 | D1          | D2           |
|----------|-----|--------------------------|-------------|--------------|
| 00100000 | 40H | Set text home address    | Low address | High address |
| 00100001 | 41H | Set text area            | Columns     | 00H          |
| 00100010 | 42H | Set graphic home address | Low address | High address |
| 00100011 | 43H | Set graphic area         | Columns     | 00H          |

#### A) Set Text Home Address (TH)

This command defines the starting address of display RAM for text display. The data in the text home address (TH) is displayed at the home position of display (left and character on 1<sup>st</sup> row).

#### B) Set Text Area (TA)

This command defines the number of columns by D1. Text area can be defined independently from the number of characters fixed by hardware setting of

controller LSI. The text area is usually defined as the actual number of characters on LCD display, so addressing can be continuous in the text area.

The relationship between display RAM address and display position(text display)

1) for 8X8 font: TA=1EH, 30 characters per row

|        |       |            |
|--------|-------|------------|
| TH     | - - - | TH+1DH     |
| TH+TA  | - - - | TH+TA+1DH  |
| TH+2TA | - - - | TH+2TA+1DH |
| - - -  | - - - | - - -      |
| TH+7TA | - - - | TH+7TA+1DH |

2) for 6X8 font: TA=28H, 40 characters per row

|        |       |            |
|--------|-------|------------|
| TH     | - - - | TH+27H     |
| TH+TA  | - - - | TH+TA+27H  |
| TH+2TA | - - - | TH+2TA+27H |
| - - -  | - - - | - - -      |
| TH+7TA | - - - | TH+7TA+27H |

### C) Set Graphic Home Address (GH)

This command defines the starting address of display RAM for the graphic display. The data in the Graphic home address(GH) is displayed at the home position of display(left end 8 bits in 1<sup>st</sup> line). When using the attribute function, the graphic home address indicates the starting address of distribute RAM area.

### D) Graphic Address Set (GA)

This command defines the number of columns by D1. The graphic area can be defined independently from the number of characters fixed by hardware setting of controller LSI. If the graphic area is defined as the actual number of columns on the LCD display, the address in graphic area can be continuous and the RAM can be used without ineffective areas. Note that the Graphic area will be different for depending on character font settings even if horizontal dot number is the same.

The relationship between display RAM address and display position(graphic display)

1) For 8X8 font: GA=1EH, 30X8=240 dots

|        |       |            |
|--------|-------|------------|
| GH     | - - - | GH+1DH     |
| GH+GA  | - - - | GH+GA+1DH  |
| GH+2GA | - - - | GH+2GA+1DH |
| - - -  | - - - | - - -      |

|         |       |             |
|---------|-------|-------------|
| GH+63GA | - - - | TH+63GA+1DH |
|---------|-------|-------------|

8 bits data is as follows:

|     |    |    |    |     |    |    |    |
|-----|----|----|----|-----|----|----|----|
| MSB |    |    |    | LSB |    |    |    |
| D7  | D6 | D5 | D4 | D3  | D2 | D1 | D0 |

2) For 6X8 font: GA=28H, 40X6=240 dots

|         |       |             |
|---------|-------|-------------|
| GH      | - - - | GH+27H      |
| GH+GA   | - - - | GH+GA+27H   |
| GH+2GA  | - - - | GH+2GA+27H  |
| - - -   | - - - | - - -       |
| TH+63GA | - - - | TH+63GA+27H |

8 bits data is as follows:

|     |   |    |    |     |    |    |    |
|-----|---|----|----|-----|----|----|----|
| MSB |   |    |    | LSB |    |    |    |
| X   | X | D5 | D4 | D3  | D2 | D1 | D0 |

X: Invalid data

### 9.2.3 Mode Set

| CODE     | FUNCTION                                 | OPERAND |
|----------|--|---------|
| 1000X000 | Logic "OR" of Graphic and Text Display   | --      |
| 1000X001 | Logic "EXOR" of Graphic and Text Display | --      |
| 1000X011 | Logic "AND" of Graphic and Text Display  | --      |
| 1000X100 | Text Attribute Mode                      | --      |
| 10000XXX | CG ROM mode                              | --      |
| 10001XXX | CG RAM mode                              | --      |

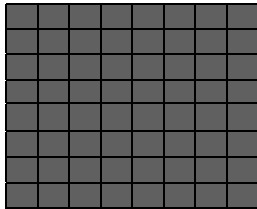
X: Don't Care

Mode set command selects character generator (CGROM mode/CGRAM mode), and combination of text/graphic display. The display mode does not change until the next command is sent. The logical OR, EXOR, AND of text or graphic display can be displayed.

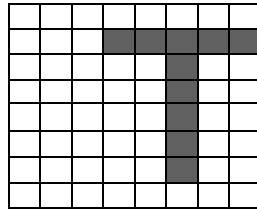
CG ROM mode: Built-in 128 characters CG ROM (code: 00H—7FH) and built-in CG RAM for 128 characters can be used (code: 80H—FFH).

CG RAM mode: built-in CG RAM for 256 characters(code: 00H—FFH) can be used. When CG ROM mode is selected, character code 00H—7FH is selected from built-in CG ROM and character code 80H-FFH is automatically selected from CG RAM.

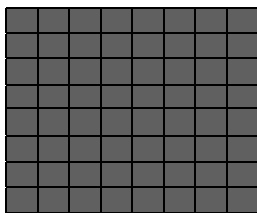
**Examples of the Logic operations:**



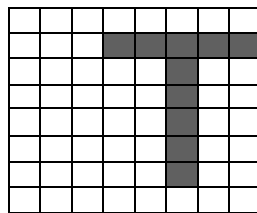
GRAPHIC



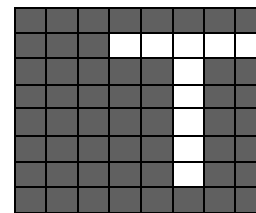
TEXT



“OR”



“AND”



“EXOR”

(Note) Attribute functions can only be applied to text display, since the attribute data is placed in the graphic RAM area.

**Attribute Functions:**

Attribute operations are “Reverse display”, “Character blink” and “Inhibit” in text display mode. The attribute data is written in the graphic area defined by Set Control Word command (Graphic home address set and Graphic area set). Only text display is possible in Attribute Function mode, since the attribute data is stored in the graphic RAM area, graphic display is automatically disable. However, the Display Mode command must be used to turn both Text and Graphic on in order for the Attribute function to be available. The attribute data of the 1<sup>st</sup> character in “Text area” is written at the 1<sup>st</sup> byte in “graphic area”, and attribute data of nth character is written at the nth byte in “Graphic area”.

**The attribute function is defined as follows:**

Attribute RAM 1 byte

|   |   |   |   |    |    |    |    |
|---|---|---|---|----|----|----|----|
| X | X | X | X | D3 | D2 | D1 | D0 |
|---|---|---|---|----|----|----|----|

X: Don't care

| 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 |

POWER LIGHT

## 9.2.4 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  | --      |

X: Don't Care

|   |   |   |   |    |    |    |    |
|---|---|---|---|----|----|----|----|
| 1 | 0 | 0 | 1 | D3 | D2 | D1 | D0 |
|---|---|---|---|----|----|----|----|

D0: Cursor blink      D0=1: ON, D0=0: OFF  
 D1: Cursor display    D1=1: ON, D1=0: OFF  
 D2: Text display      D2=1: ON, D2=0: OFF  
 D3: Graphic Display    D3=1: ON, D3=0: OFF

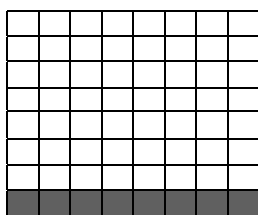
(Note) It is necessary to turn on "Text display" and "Graphic display" in the following cases:

- a) Combination of text/graphic display
- b) Attribute function

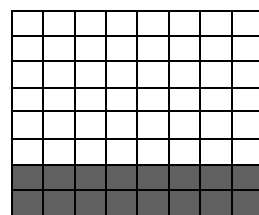
## 9.2.5. Cursor Pattern Selection

| CODE     | FUNCTION      | OPERAND |
|----------|---------------|---------|
| 10100000 | 1-line cursor | --      |
| 10100001 | 2-line cursor | --      |
| 10100010 | 3-line cursor | --      |
| 10100011 | 4-line cursor | --      |
| 10100100 | 5-line cursor | --      |
| 10100101 | 6-line cursor | --      |
| 10100110 | 7-line cursor | --      |
| 10100111 | 8-line cursor | --      |

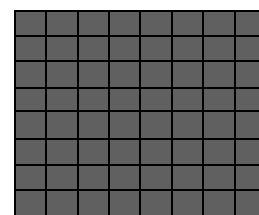
When cursor display is ON, this command selects the cursor pattern in range 1line to 8 lines. The cursor address is defined by the Set Cursor Pointer command.



1-Line Cursor



2-Line Cursor



8-Line Cursor

## 9.2.6 Data Auto Read/Write

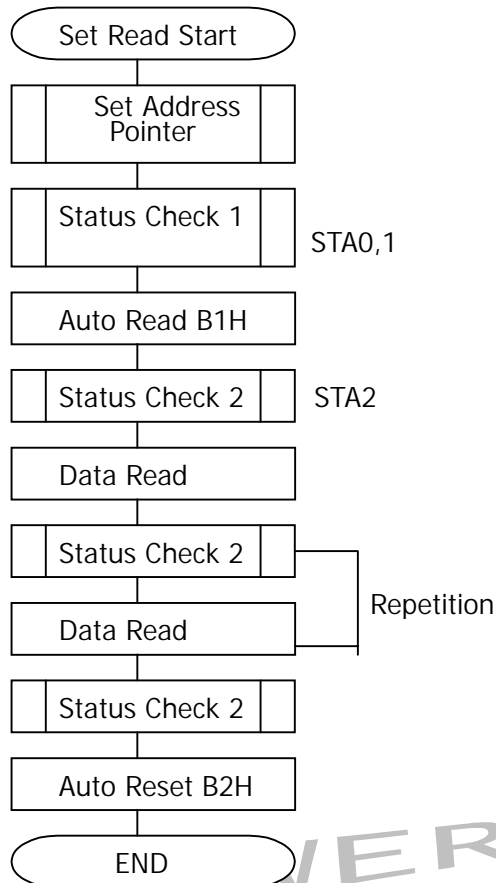
| CODE     | HEX | FUNCTION            | OPERAND |
|----------|-----|---------------------|---------|
| 10110000 | B0H | Set data auto write | --      |
| 10110001 | B1H | Set data auto read  | --      |
| 10110010 | B2H | Auto mode reset     | --      |

This command is convenient to send full screen data, or receive full screen data from built-in display RAM. After setting auto mode, a Data Write(or Read) command is not need between each data. Data Auto Write(or Read) command should follow the Address Pointer Set command. After this command, the address pointer is automatically incremented by +1 after each data. After sending (or receiving) all data, Auto Mode Reset command is necessary to return normal operation because all data is regarded "display data" and no command can be accepted in the auto mode.

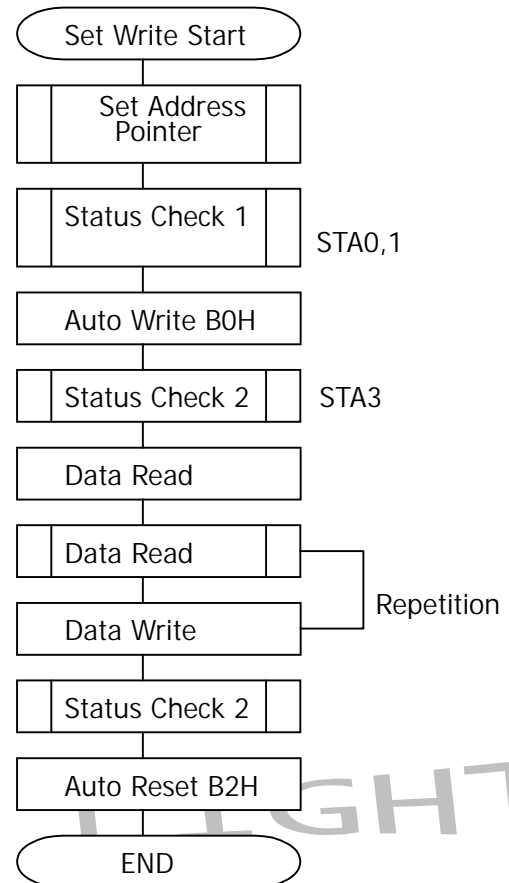
(Note) Status check for Auto mode(STA2 or STA3) should be checked between each data. Auto Reset should be performed after checking STA3=1(or STA2=1).

### the followchart for Data Auto Read/Write

#### a) Auto Read Mode



#### b) Auto Write Mode



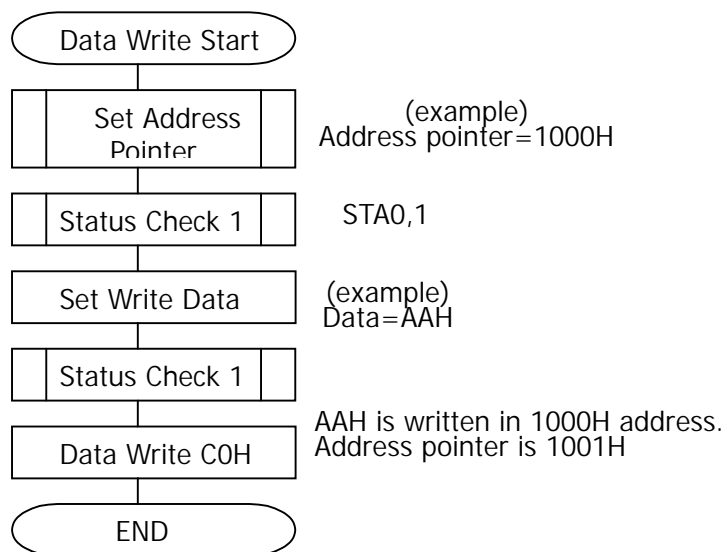
### 9.2.7 Data Read/Write

| CODE     | HEX | FUNCTION                       | OPERAND |
|----------|-----|--------------------------------|---------|
| 11000000 | C0H | Data write and increment ADP   | Data    |
| 11000001 | C1H | Data read and increment ADP    | --      |
| 11000010 | C2H | Data write and decrement ADP   | Data    |
| 11000011 | C3H | Data read and decrement ADP    | --      |
| 11000100 | C4H | Data write and nonvariable ADP | Data    |
| 11000101 | C5H | Data read and nonvariable ADP  | --      |

This command is used for writing data from MPU to display RAM, and reading data from display RAM to MPU. Data Write/Read should be executed after setting address by Set Address Pointer command. The address pointer can be automatically incremented or decremented by using this command.

(Note) This command is necessary for every 1 byte data.

#### The flowchart for Data Write



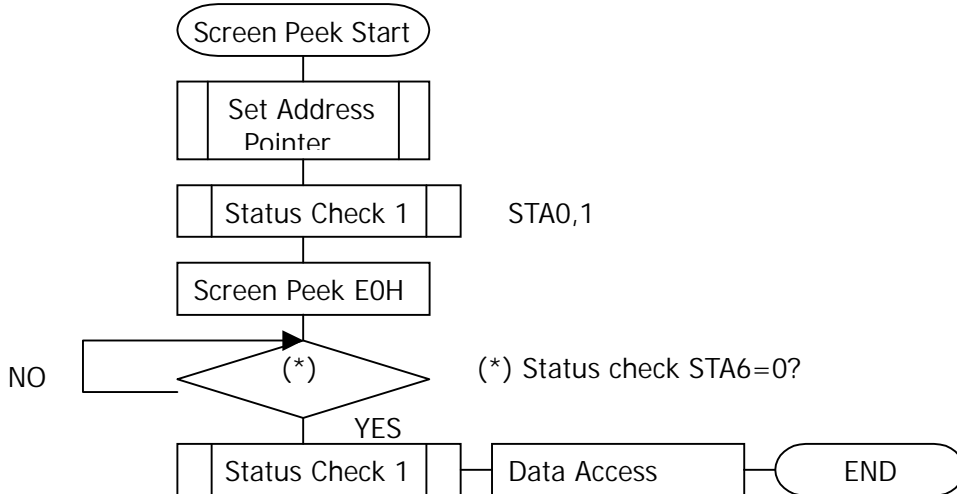
### 9.2.8 Screen Peek

| CODE     | HEX | FUNCTION    | OPERAND |
|----------|-----|-------------|---------|
| 11100000 | E0H | Screen Peek | --      |

This command is used to transfer 1 byte displayed data to data stack, and this 1 byte data can be read from MPU by data read command. So, logical combination data of text and graphic display on LCD screen can be read by this command. Status(STA6)

should be checked just after Screen Peek command. If the address determined by Set Address Pointer command is not in graphic display RAM area, this command is ignored and status flag (STA6) is set.

**The flowchart for Screen Peek command**



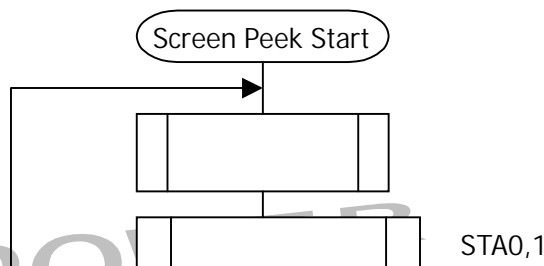
(Note) This command is available when hardware column number and software column number are the same. Software column number is related to Set Text Area and Set Graphic Area command. Set TA=28H, GA=28H when using this command.

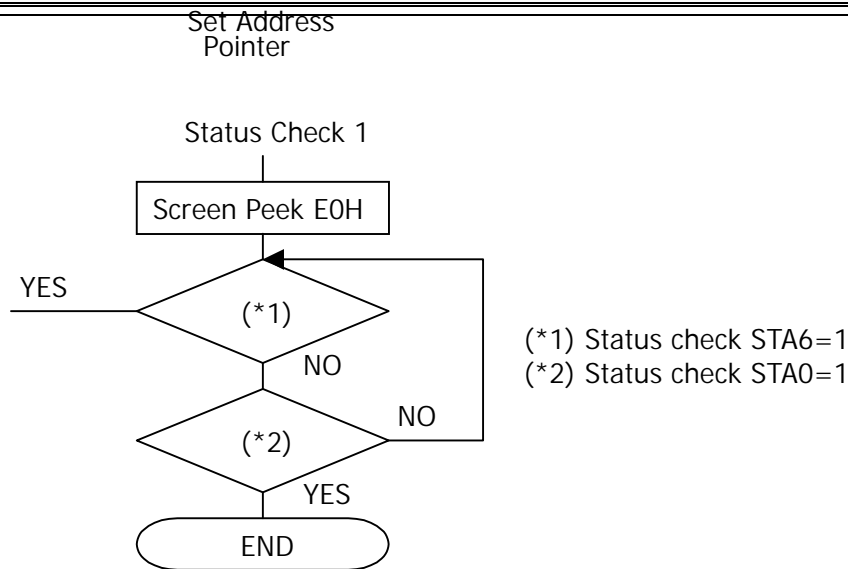
**9.2.9 Screen Copy**

| CODE     | HEX | FUNCTION    | OPERAND |
|----------|-----|-------------|---------|
| 11101000 | E8H | Screen Copy | --      |

This command copies 1 row data displayed on LCD screen to the graphic RAM area specified by Set Address Pointer command. Start point of 1 row data on the screen is determined by the Set Address Pointer command. If attribute function is being used, this command is not available. Status (STA6) should be checked just after this command. If the address determined by Set Address Pointer command is not located in graphic RAM area, this command is ignored and status flag (STA6) is set.

**The flowchart for Screen Copy command**





(Note) This command is available when hardware column number and software column number are the same. Software column number is related to Set Text Area and Set Graphic Area command. Set TA=28H, GA=28H when using this command.

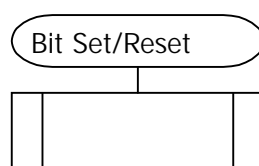
### 9.2.10 Bit Set/Reset

| 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) |         |

X: Don't care

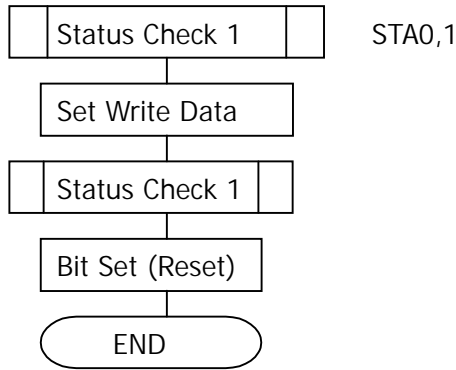
This command is used to set or reset a bit of the byte specified by the address pointer. Only one bit can be set/reset at one time.

#### The flowchart for Bit Set/Reset command



POWER LIGHT

Set Address  
Printer



## 10 CHARACTER GENERATOR

### 10.1 Character Generator ROM

T6963C has a built-in 128-character Character Generator ROM.

The relationship between character codes and character patterns (CGROM type 0101)

| MSB \ LSB | 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 | 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         | 0 | 1 | 2 | 3 | 4  | 5 | 6 | 7 | 8 | 9 | : | ; | < | = | > | ? |
| 7         | a | A | B | C | D  | E | F | G | H | I | J | K | L | M | N | O |

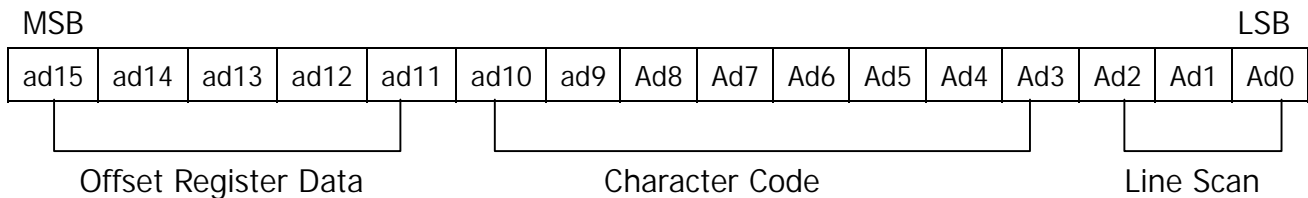
### 10.2 Character Generator RAM

The character generator RAM is the built-in RAM which can be used as character generator after writing character pattern by program. While choosing "External CG

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RAM Mode”, character codes 00H to FFH are assigned to CG RAM. While choosing “Internal CG ROM Mode”, character codes 00H to 7FH are assigned to CG ROM and character codes 80H to FFH are assigned to CG RAM.

The offset register is used to determine the external character generator RAM area. T6963C has a 16-bit address bus as follows:



The upper 5 bits define the start address in external memory of CG RAM area. The next 8 bits define the character code of the character. The lower 3 bits define one of the eight rows (8 dots each row) that define the character’s shape.

**The relationship between display RAM address and Offset Register**

| Offset Register Data | CG RAM HEX Address(Start to End) |
|----------------------|----------------------------------|
| 00000                | 0000 TO 07FFH                    |
| 00001                | 0800 TO 0FFFH                    |
| 00010                | 1000 TO 17FFH                    |
| ---                  | ---                              |
| 11100                | E000 TO E7FFH                    |
| 11101                | E800 TO EFFFH                    |
| 11110                | F000 TO F7FFH                    |
| 11111                | F800 TO FFFFH                    |

**Example of making a character pattern in the CG RAM**

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

|                                       |           |        |
|---------------------------------------|-----------|--------|
|                                       | (address) | (data) |
| [ 8x8 grid with a character pattern ] | 1400H     | 00H    |
|                                       | 1401H     | 1FH    |
|                                       | 1402H     | 04H    |
|                                       | 1403H     | 04H    |
|                                       | 1404H     | 04H    |
|                                       | 1405H     | 04H    |
|                                       | 1406H     | 04H    |
|                                       | 1407H     | 00H    |

RIGHT

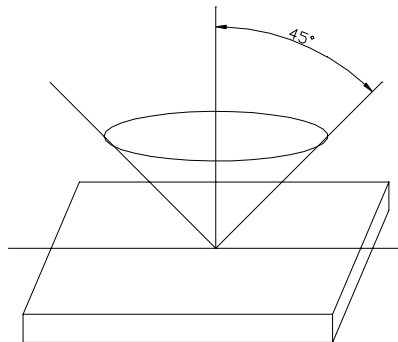
## 11. INSPECTION STANDARDS

### 11.1 Inspection Conditions

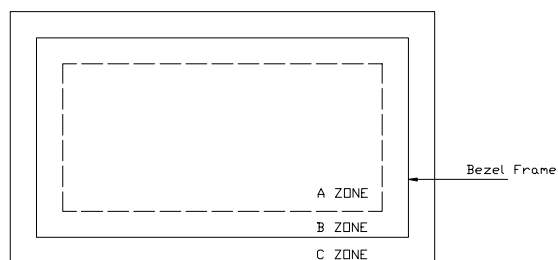
The LCD shall be inspected under 40W white fluorescent light.

The distance between the eyes and the samples shall be more than 30cm.

All directions for inspecting the sample should be within 45 degree against perpendicular line.



### 11.2 Definition of Applicable Zone



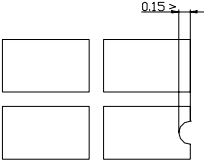
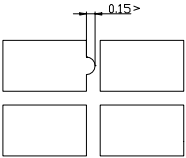
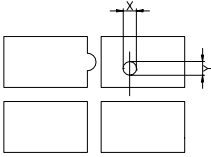
GHT

A Zone: Active Display Area  
 B Zone: Area from Bezel Frame to A Zone  
 C Zone: Rest Area of Bezel  
 A Zone + B Zone=Effective Viewing Area

### 11.3 Standards

| NO                                | PARAMETER                                 | CRITERIA                     |   |                   |   |   |
|-----------------------------------|---|------------------------------|---|-------------------|---|---|
| 1                                 | Black and White Spots, Foreign Substances | <b>Round Shape</b>           |   |                   |   |   |
|                                   |   | Zone                         |   | Acceptable Number |   |   |
|                                   |   | DIMENSION(MM)                |   | A                 | B | C |
|                                   |   | D≤0.1                        |   | *                 | * | * |
|                                   |   | 0.1<D≤0.2                    |   | 5                 | 5 | * |
|                                   |   | 0.2<D≤0.3                    |   | 0                 | 1 | * |
|                                   |   | 0.3<D                        |   | 0                 | 0 | * |
|                                   |   | D=(long+short)/2 * Disregard |   |                   |   |   |
|                                   |   | <b>Line Shape</b>            |   |                   |   |   |
|                                   |   | X(mm) Y(mm)                  |   | Acceptable Number |   |   |
| -                                 |   | A                            | B | C                 |   |   |
| 0.02≥W                            |   | *                            | * | *                 |   |   |
| 2.0≥L                             |   | 3                            | 3 | *                 |   |   |
| 1.0≥L                             |   | 1                            | 2 | *                 |   |   |
| 1.0≥L                             |   | 0                            | 2 | *                 |   |   |
| -                                 |   | Not acceptable               |   |                   |   |   |
| X: Length Y: Width * Disregard    |   |                              |   |                   |   |   |
| Total defects shall not exceed 5. |   |                              |   |                   |   |   |
| 2                                 | Air Bubbles (Between glass and polarizer) | Dimension(mm) Zone           |   | Acceptable Number |   |   |
|                                   |   |                              |   | A                 | B | C |
|                                   |   | D≤0.1                        |   | *                 | * | * |
|                                   |   | 0.1<D≤0.2                    |   | 5                 | 5 | * |
|                                   |   | 0.2<D≤0.3                    |   | 0                 | 1 | * |
| 0.3<D                             |   | 0                            | 0 | *                 |   |   |
| *: Disregard                      |   |                              |   |                   |   |   |

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|   |                     |   |
|---|---------------------|---|
|   |                     | Total defects shall not exceed 3.   |
| 3 | The Shape of Dot    | (1) Dot Shape(with dent)<br><br>As per the sketch of left hand.                |
|   |                     | (2) Dot Shape(with Projection)<br><br>Should not connect to next dot.          |
|   |                     | (3) Pin Hole<br><br>$(X+Y)/2 < 0.2\text{mm}$ (less than 0.1mm is not counted) |
|   |                     | Total defects shall not exceed 5.   |
| 4 | Polarizer Scratches | Not to be conspicuous defects.  |
| 5 | Polarizer Dirts     | If the stains are removed easily from LCD surface, the module is not defective.   |
| 6 | Color Variation     | Not to be conspicuous defects.  |

## 12. PRECAUTIONS IN USING LCM

### 1. LIQUID CRYSTAL DISPLAY (LCD)

LCD is made up of glass, organic sealant, organic fluid, and polymer based polarizers. The following precautions should be taken when handling,

- (1). Keep the temperature within range of use and storage. Excessive temperature and humidity could cause polarization degradation, polarizer peel off or bubble.
- (2). Do not contact the exposed polarizers with anything harder than an HB pencil lead. To clean dust off the display surface. Wipe gently with cotton. Chamois or other soft material soaked in petroleum benzin.

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- (3). Wipe off saliva or water drops immediately. Contact with water over a long period of time may cause polarizer deformation or color fading, while an active LCD with water condensation on its surface will cause corrosion of ITO electrodes.
- (4). Glass can be easily chipped or cracked from rough handling, especially at corners and edges.
- (5). Do not drive LCD with DC voltage.

## **2. Liquid Crystal Display Modules**

### **2.1 Mechanical Considerations**

LCM are assembled and adjusted with a high degree of precision. Avoid excessive shocks and do not make any alterations or modifications. The following should be noted.

- (1). Do not tamper in any way with the tabs on the metal frame.
- (2). Do not modify the PCB by drilling extra holes, changing its outline, moving its components or modifying its pattern.
- (3). Do not touch the elastomer connector, especially insert a backlight panel (for example, EL).
- (4). When mounting a LCM make sure that the PCB is not under any stress such as bending or twisting. Elastomer contacts are very delicate and missing pixels could result from slight dislocation of any of the elements.
- (5). Avoid pressing on the metal bezel, otherwise the elastomer connector could be deformed and lose contact, resulting in missing pixels.

### **2.2. Static Electricity**

LCM contains CMOS LSI's and the same precaution for such devices should apply, namely

- (1). The operator should be grounded whenever he/she comes into contact with the module. Never touch any of the conductive parts such as the LSI pads, the copper leads on the PCB and the interface terminals with any parts of the human body.
- (2). The modules should be kept in antistatic bags or other containers resistant to static for storage.
- (3). Only properly grounded soldering irons should be used.
- (4). If an electric screwdriver is used, it should be well grounded and shielded from commutator sparks.
- (5). The normal static prevention measures should be observed for work clothes and working benches; for the latter a conductive (rubber) mat is recommended.
- (6). Since dry air is inductive to statics, a relative humidity of 50-60% is recommended.

### **2.3. Soldering**

- (1). Solder only to the I/O terminals.
- (2). Use only soldering irons with proper grounding and no leakage.
- (3). Soldering temperature:  $280\text{ }^{\circ}\text{C} \pm 10^{\circ}\text{C}$
- (4). Soldering time: 3 to 4 sec.
- (5). Use eutectic solder with resin flux fill.
- (6). If flux is used, the LCD surface should be covered to avoid flux splatters. Flux residue should be removed afterwards.

### **2.4. Operation**

- (1). The viewing angle can be adjusted by varying the LCD driving voltage  $V_0$ .
- (2). Driving voltage should be kept within specified range; excess voltage shortens display life.
- (3). Response time increases with decrease in temperature.
- (4). Display may turn black or dark blue at temperatures above its operational range; this is (however not pressing on the viewing area) may cause the segments to appear "fractured".

(5). Mechanical disturbance during operation (such as pressing on the viewing area) may cause the segments to appear "fractured".

#### **2.5. Storage**

If any fluid leaks out of a damaged glass cell, wash off any human part that comes into contact with soap and water. Never swallow the fluid. The toxicity is extremely low but caution should be exercised at all the time.

**THE END**

POWER LIGHT