JE-AN ELECTRONICS CO.,LTD SPECIFICATIONS FOR LIQUID CRYSTAL DISPLAY MADE IN KOREA

# SPECIFICATION FOR LIQUID CRYSTAL DISPLAY

Model No. : JA-SGB1286411 Date : 2006.02.07

| Approved | Checked | Department |
|---|---|---|
| | | |

Customer :

Model No. : Date :

| Approved | Checked | Department |
|---|---|---|
| | | |



HEAD OFFICE : 535-127 , KASAN-DONG , KUMCHON-KU , SEOUL , KOREA
TEL : +82-2-857-6515 FAX : +82-2-857-6517
E-MAIL : jeanlcd@jeanlcd.co.kr jeanlcd@kornet.net jecl@shinbiro.com

| DATE | 2006.02.07 | CUSTOMER | | MODEL | JA-SGB1286411 |
|---|---|---|---|---|---|
| PART | LCD MODULE | JE-AN Electronics Co., Ltd | | COUNTRY | KOREA |

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# Content

## 1. FEATURES

The features of LCD Module are as follows :

* Display Model : STN, Negative type, Blue
* Color : Display Dot :white
* Display format : 128 Dots x 64 Dots
* Interface Input Data : 8 bit
* Driving Method : 1/64 Duty , 1/9 Bias
* Viewing Direction : 6 O'clock

## 2. MECHANICAL SPECIFICATIONS

| No. | Item | Specification | Unit |
|---|---|---|---|
| 1 | Module Size | 75 x 52.5 x 9.4(MAX) | mm |
| 2 | Number of Dots | 128 x 64 | |
| 3 | Viewing Area | 59 x 31.5 | mm |
| 4 | Effective Display Area | 55 x 27.5 | mm |
| 5 | Dot Size | 0.4 x 0.4 | mm |
| 6 | Dot Pitch | 0.43 x 0.43 | mm |
| 7 | Weight | About 41 | g |

## 3. ELECTRICAL SPECIFICATIONS

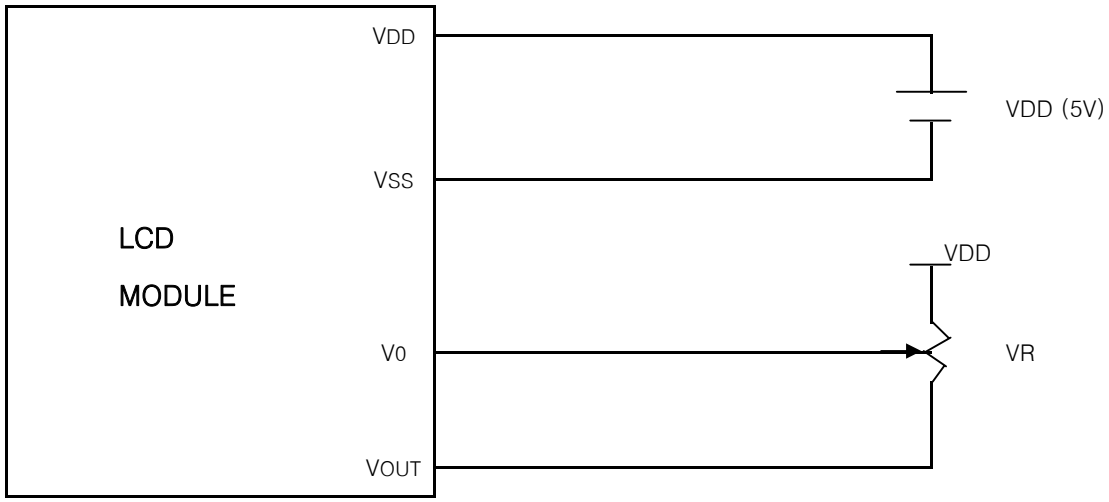
3-1. ABSOLUTE MAXIMUM RATINGS (Ta=25。C)

| No. | Item | Symbol | Standard Value | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Type | Max | |
| 1 | Supply Voltage For Logic | VDD-Vss | 0 | - | 6 | V |
| 2 | Supply Voltage For LCD Drive | VDD-V0 | 8 | - | 12 | V |
| 3 | Input Voltage | VI | Vss | - | VDD | V |
| 4 | Operating Voltage Temp. | Top | -10 | - | 50 | ℃ |
| 5 | Storage Voltage Temp. | Tst | -20 | - | 60 | ℃ |
| 6 | Humidy | - | - | - | 90 | %RH |

3-2. ELECTRICAL CHARACTERISTICS

| Item | | Symbol | Test condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| Supplay Voltage Logic | | VDD-VSS | - | 4.75 | 5 | 5.5 | V |
| Input Voltage | H Level | VIH | H Level | 2 | - | VDD | V |
| | L Level | VIL | L Level | 0 | - | 0.8 | V |
| Output Voltage | H Level | VOH | IOH=-0.3mA | 2.4 | - | - | V |
| | L Level | VOL | IOL=3.0mA | - | - | 0.4 | V |
| Current Consumption | | IDD | VDD-VSS=5V | 0 | - | - | mA |
| LCD Display Duty Ratio | | Duty | - | - | 1/64 | - | V |
| LCD Drive Voltage (Recommended Voltage) | | VDD-V0 | Ta=0°C Φ=10° Θ=0° | - | -- | - | V |
| | | | Ta=25°C Φ=10° Θ=0° | - | 8.5 | - | |
| | | | Ta=50°C Φ=10° Θ=0° | - | -- | - | |

## 4. POWER SUPPLY




* VDD-V0=Operating Voltage for LCD

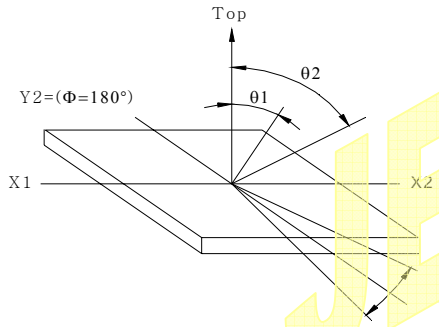
* VR : About 20k

## 5. ELECTRO-OPTICAL CHARACTERISTICS

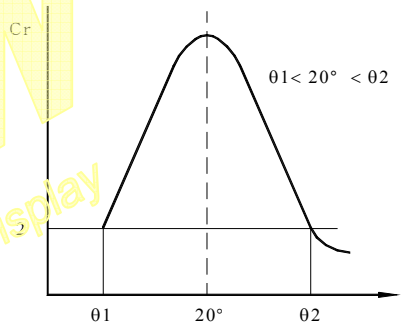
(Ta=25°C VDD-V0=10.5V)

| Item | Symbol | Min. | Typ. | Max. | Unit | Condition | Note |
|---|---|---|---|---|---|---|---|
| Viewing Angle | Θ1-Θ2 | 30 | - | - | deg. | Cr=2.0 | 1,2 |
| | Φ | 80 | | | | | |
| Contrast Ratio | Cr | - | 4 | - | - | Θ=20° Φ=0° | 3 |
| Response Time(rise) | Tr | - | 250 | - | ms | Θ=20° Φ=0° | 4 |
| Response Time(fall) | Tf | - | 250 | - | ms | Θ=20° Φ=0° | 4 |

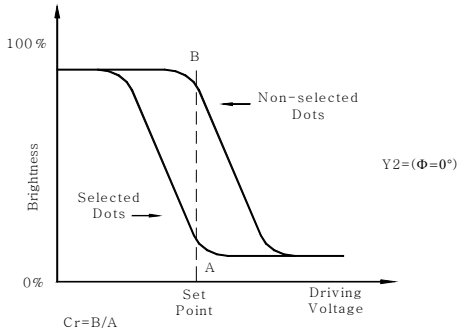
Note 1. Definition of Angle Θ & Φ



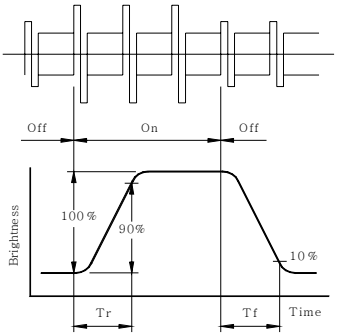

Note 2. Definition of viewing Angle Θ1 & Θ2




Note 3. Definition of Contrast ratio(Cr)




Note 4. Definition of Response Time



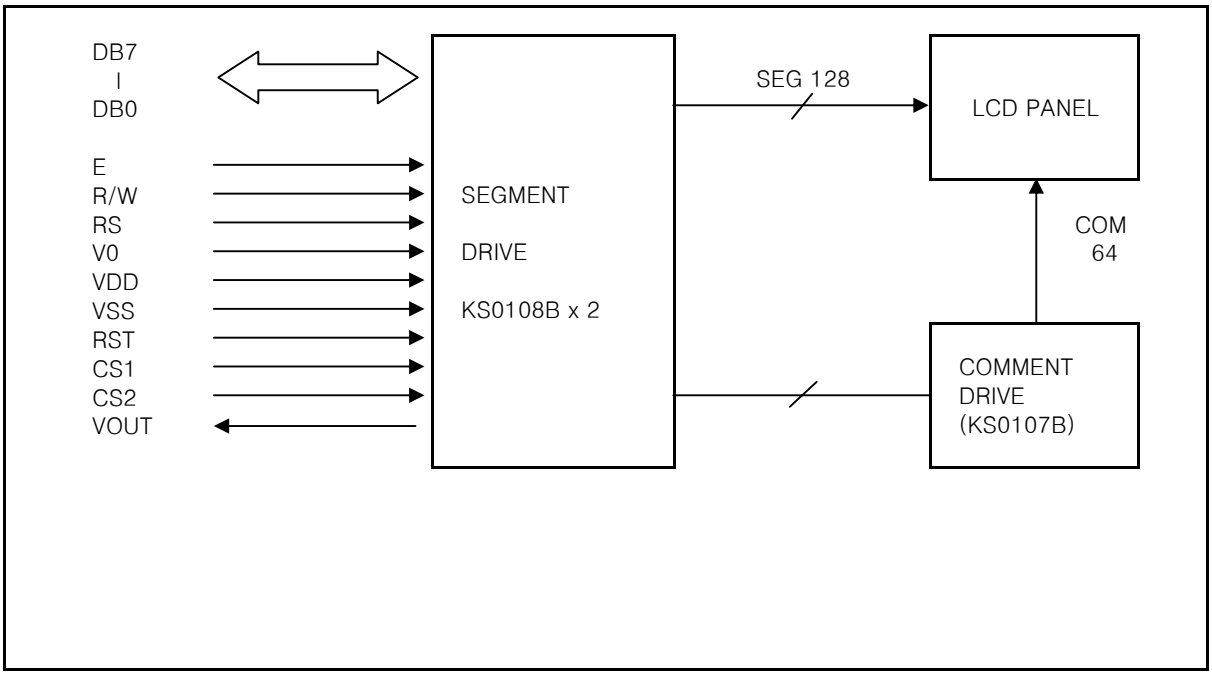
# 6. TERMINAL FUNCTIONS AND BLOCK DIAGRAM

## 6-1. INTERFACE PIN FUNCTION DESCRIPTION

| PIN NO. | SYMBOL | FUNCTIONS |
|---|---|---|
| 1 | VDD | Power supply for logic circuit (+5.0v) |
| 2 | Vss | Ground |
| 3 | V0 | Contrast Adjust |
| 4 | DB0 | Data Bus Line |
| 5 | DB1 | |
| 6 | DB2 | |
| 7 | DB3 | |
| 8 | DB4 | |
| 9 | DB5 | |
| 10 | DB6 | |
| 11 | DB7 | |
| 12 | CS1 | Chip Selection Signal for IC1 |
| 13 | CS2 | Chip Selcetion Signal IC2 |
| 14 | RST | Reset (Active " Low ") |
| 15 | R/W | H : Data Read(LCD to MPU) L : Data Write(MPU to LCM) |
| 16 | RS | H : Data input L : Instruction Code Input |
| 17 | E | Enable |
| 18 | VOUT | Output Voltage for LCD Driving |
| 19 | A | Power for LED backlight (+3.0V/48mA) |
| 20 | K | Power for LED backlight (-) |

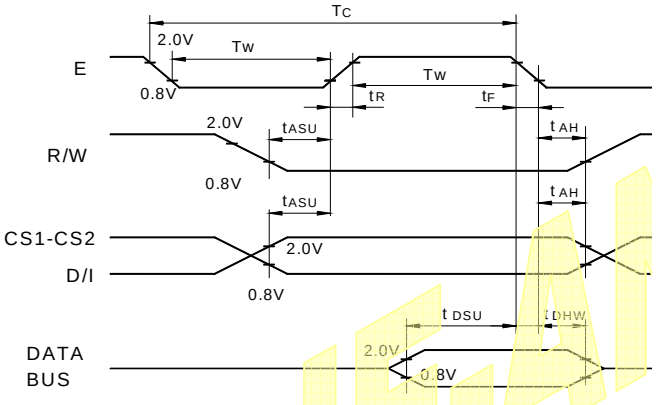


## 6-2. BLOCK DIAGRAM

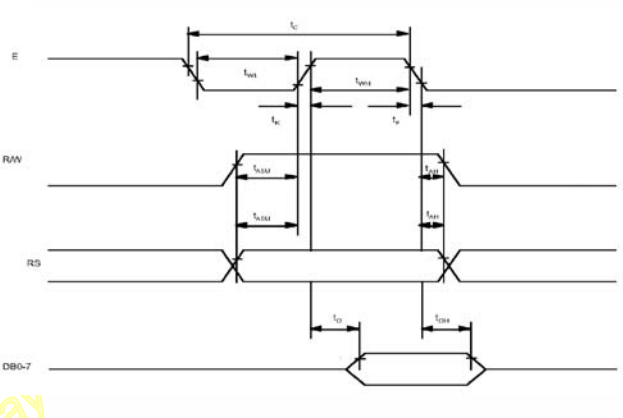


## 7. TIMING CHARACTERISTICS

| Characteristic | Symbol | Min. | Type. | Max. | Unit |
|---|---|---|---|---|---|
| E Cycle Time | Tc | 1000 | – | – | ns |
| E Rise Time | Tr | – | – | 25 | ns |
| E Fall Time | Tf | – | – | 25 | ns |
| E Pulse Width (High, Low) | Tw | 450 | – | – | ns |
| Address Setup Time | Tasu | 140 | – | – | ns |
| Address Hold Time | Tah | 10 | – | – | ns |
| Data Setup time | Tsu | 200 | – | – | ns |
| Data Delay Time | Td | – | – | 320 | ns |
| Data Hold Time (Write) | Tdhw | 10 | – | – | ns |
| Data Hold Time (Read) | Tdhr | 20 | – | – | ns |




MPU Write timing



MPU Reading timing

# 8. UNIT DRIVING METHOD

8-1. Function of Each Block

Both input register and output register are provided to interface with MPU of which the speed is different from that of internal operation. The selection of registers depend the combination of R/W and D/I signals.

Table 1. Register Selection

| D/I | R/W | Operation |
|---|---|---|
| 1 | 1 | Read data out of output register as internal operation<br>(Display data RAM to output register) |
| 1 | 0 | Writes data into register as internal operation<br>(Inut register to display data RAM) |
| 0 | 1 | Busy check. Read of status data |
| 0 | 0 | Instruction |

(1) Input Register

Input register is used to store Data temporarily before writing it info display data RAM.

The data from MPU is written info input register,then into display data RAM automatically by internal operation.

When chip select signal is in the active mode and D/I and R/W select the Input register as shown in table 1, data is latched at the fall of "E" signal.

(2) Output Register

The output register is used to store data temporarily that is read from display data RAM.

To read out the data from output register. Chip select signal should be in the active mode and both D/I and R/W should be "1". With the read instruction, data stored in the output register is output while "E" is "H" level.

Ten, at the fall of "E", the display data at the indicated address is latched in to the output register and address is increased by 1. The contents in the output register is rewritten by read instruction, but are held by address set instruction, ect.

Therefore, the data of the specified address can not be output with read display instrucion, right after the address is set, but can be output at the second read of data.

That is to say, one dummy read is necessary.

Fig 8-1. Shows the CPU read timming.

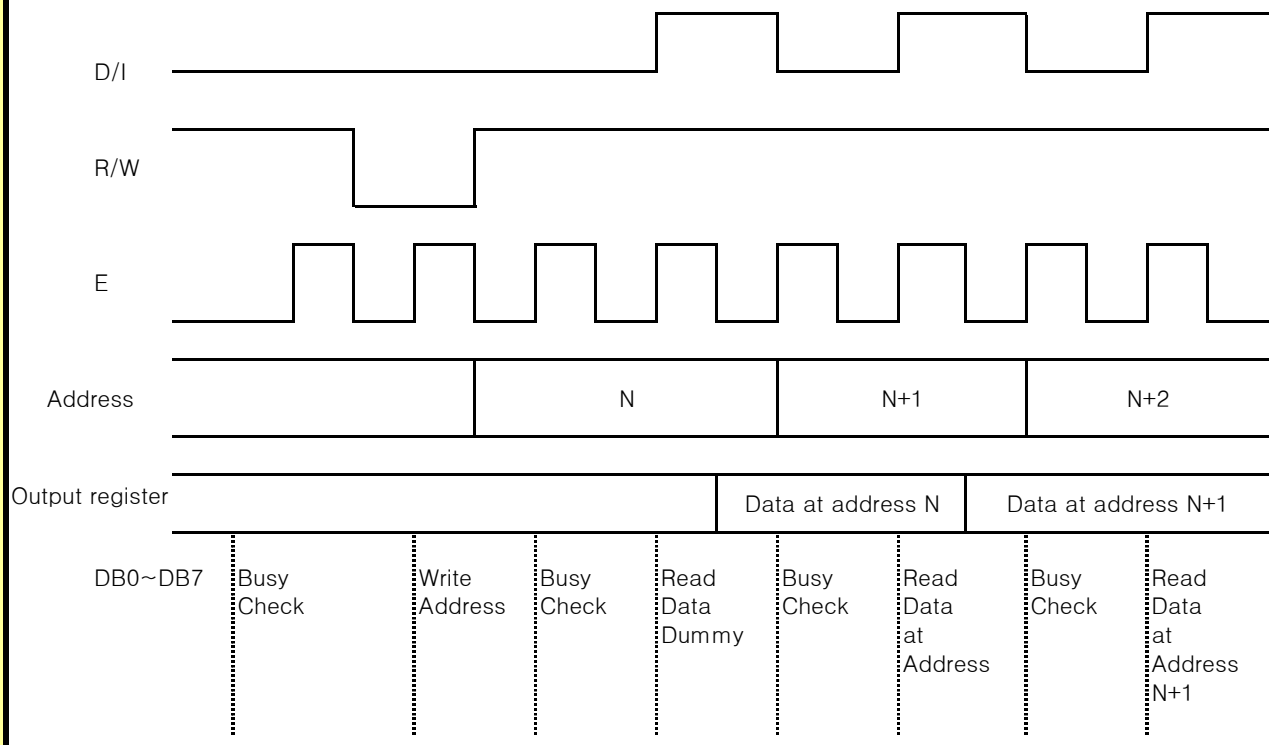
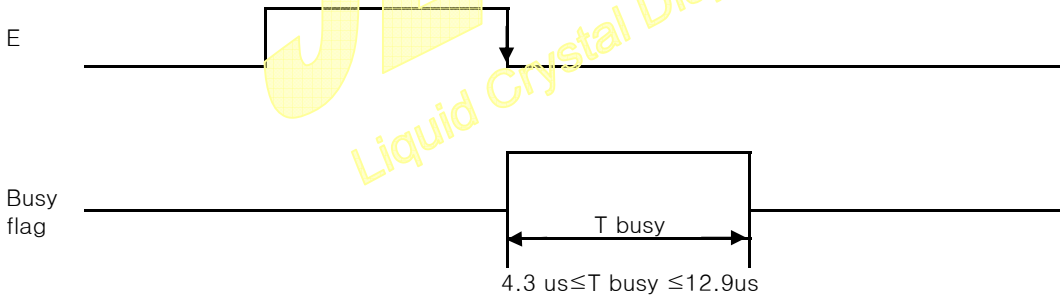



Fig 8-1. CPU Read Timming

8-1-2. Busy Flag

"1" of busy flag indicates that KS0108B is on the move and any instruction except status read instruction can not be accepted the value of the busy flag is read out on DB7 by the status read instruction.

Make sure that the busy flag is reset ("0") before the issue of instruction




8-1-3. Display on/off flag flop

Display on/off flip flop selects one of two state,on state of segments,in on state,the display data corresponding to that in RAM is output to the segment. On the other hand,the display data at all segments disappear in off state independent of the data in RAM. It is controlled by display on/off instruction "0" of RST signal sats the segments in off state,the status of the flip flop is output to DB5 by status read instruction. Display on/off instruction does not inflence data in RAM.

8-1-4. Display start register

The register specifies A line in RAM which corresponds to the top line of LCD panel,when displaying contents in display data RAM on the LCD panel. It is used for scrolling of the screen. 6bit display start line information in this register is transferred to Z address, and the Z address counter is preset.

8-1-5. X,Y Address counter

This is 9bit counter which designates address of internal display data RAM,X address counter of upper 3bits and Y address counter of lower 6bits should be set each address by respective instruction.

(1) X address counter

Ordinary register with no count functions. An address is set in by instruction.

(2) Y address counter

An address is set in by instruction and it is increased by 1 automatically by R/W operations of display data. The address counter loops the value of 0 to 63 count.

8-1-6. Display data RAM

Dot data for display is stored in this RAM 1 bit data of this RAM corresponds to light on (data=1) and light off (data=0) of 1 Dot in the display panel.

8-1-7. Reset

The system can initialized by setting RST terminal at "low" level when turning power on.

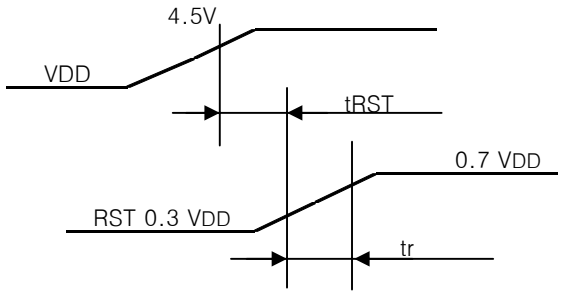
1) Display off

2) Set display start line register 0 line.

When RST is in low level, any instruction except status read can not be accepted,therefore, carry out other instruction after making sure that DB4="0" (clear reset) and DB7="0" (ready) by status read instruction. The conditions of power supply at initial power up are as follows.

| Item | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Reset time | tRST | 1.0 | - | - | us |
| Rise time | tr | - | - | 200 | us |

Do not fail to set the system again because reset during operation may destroy the data in all the register except on/off regiser and in RAM.




8-2. Display control instructions

Table 2 shows the instructions. Read/Write(R/W) signal, data instruction(D/I) signal and data bus signal (DB0 to DB7) are also called instructions because the internal operation depends on the signal form MPU generally, there are following three kinds of instructions.

1) Instruction togive address in the internal RAM

2) Instruction to transfer data from / to the internal RAM.

3) Other instructions.

In general use, the instruction "2)" are used most frequently, but,since Y address of the internal RAM is increased by 1 automatically after writing (reading)data, the program can be lessened, during the execution of an instruction,the system can not accept other instructions then status read instruction,send instruction from MPU after marking sure if the busy flag is "0", which is the proof an instruction is not being executed.

Table 2

| Function | D/I | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Display on/off | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0/1 | Cantrols the on/off display RAM d and internal status are not affected. 0:off 1:on |
| Set address | 0 | 0 | 0 | 1 | Y address (0~63) | | | | | | Set the Y address in the Y address register. |
| Set page (X address) | 0 | 0 | 1 | 0 | 1 | 1 | 1 | Page(0~7) | | | Set the X address in the X address register. |
| Display start line | 0 | 0 | 1 | 1 | Display start line(0~63) | | | | | | Indicates the display data RAM displayed at the top of the screen. |
| Status Read | 0 | 1 | BUSY | 0 | ON/OFF | RESET | 0 | 0 | 0 | 0 | Read status :<br>BUSY : 0:Ready<br>1:In operation<br>ON/OFF: 0:Display ON<br>1:Display OFF<br>RESET : 0:Normal<br>1:Reset |
| Write display Data | 1 | 0 | Write Data | | | | | | | | Write data(DB0~DB7) into display d RAM. After writing instruction,Y address is increased by 1 automatically |
| Read display Data | 1 | 1 | Read Data | | | | | | | | Reads data(DB0~DB7) into display data RAM to the data bus. |

8-2-1. Display on/off

| | R/W | D/I | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | D |

The display data appears when D is land disappears when D is 0
Therought the data is not on the screen width D="0",it rema ins in the display data RAM,therefore,you can make it appear by changing D="0" into D="1"

8-2-2. Display start line

| | R/W | D/I | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 0 | 0 | 1 | 1 | A | A | A | A | A | A |

Z address AAAAAA(binary) of the display data RAM is set at the display start line register and displayed attech top of the screen fig.8-2 are the examples of display when the start line=0~3.


fig 8-2 Relation between start line and display

8-2-3. Set page (X address)

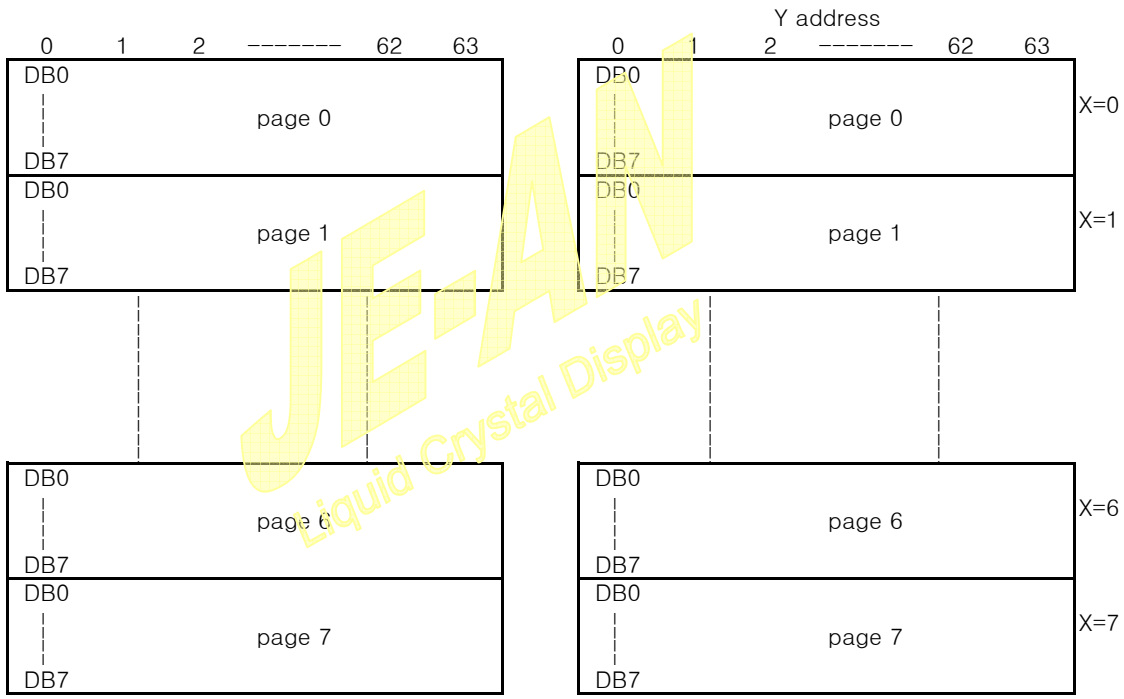
| | R/W | D/I | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 0 | 0 | 1 | 0 | 1 | 1 | 1 | A | A | A |

X address AAA(binary) of the display data RAM is set at the
A address register. After that,writing or reading to or from MPU
is executed this specified page until the next page is set.

8-2-4. Set page (Y address)

| | R/W | D/I | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 0 | 0 | 0 | 1 | A | A | A | A | A | A |

Y address AAAAAA(binary) of the display data RAM is set.
the address counter. After that, Y address counter is increased by 1
every time the data is written or read to or MPU.



8-2-5. Status read

| | R/W | D/I | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 1 | 0 | BUSY | 0 | ON/OFF | RESET | 0 | 0 | 0 | 0 |

BUSY : When "BUSY" is "1". The LSI is in internal operation. No instructions are accepted while busy is "1". So you should make sure that busy is "0" bofore writing the next instruction.

ON/OFF : This bit shows the display conditions.
When ON/OFF is "0",the display is in on condition.
When ON/OFF is "1",the display is in off condition.

RESET : RESET="1" shows that the system is being initialized.
In this condition,any instructions except status read instruction cannot be accepted.
RESET="0" shows that initializing has finished and the system is in the usual operation.

8-2-6. Write display data

| | R/W | D/I | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 0 | 1 | A | A | A | A | A | A | A | A |

Write 8-bit data AAAAAAAA(binary) into the display data RAM then Y address is increased by 1 automatically.

8-2-7. Read display data

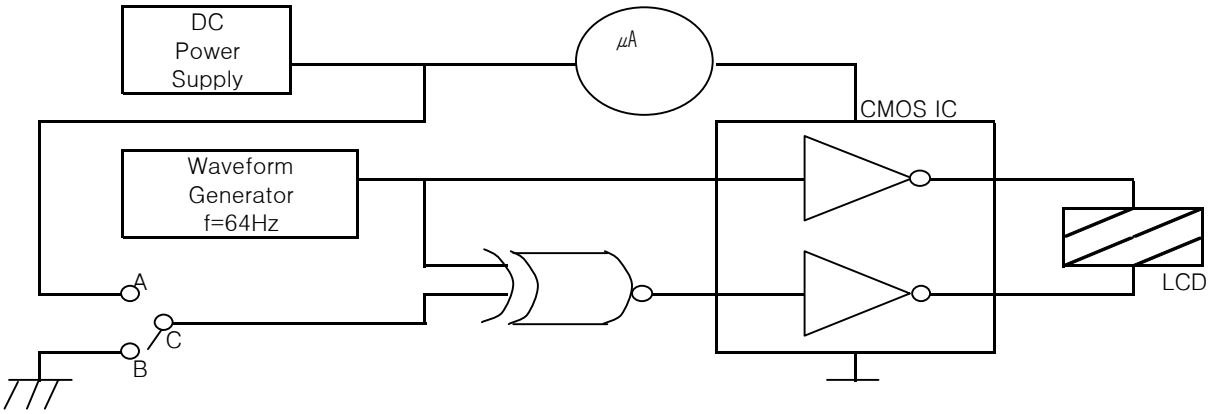
| | R/W | D/I | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| CODE | 1 | 1 | A | A | A | A | A | A | A | A |

Read 8-bit data AAAAAAAA(binary) into the display data RAM then Y address is increased by 1 automatically.
One dummy read is necessary soon after the address seting.

## Measuring Method and Equipment

1. Current Consumption Measuring

(1) Equipment

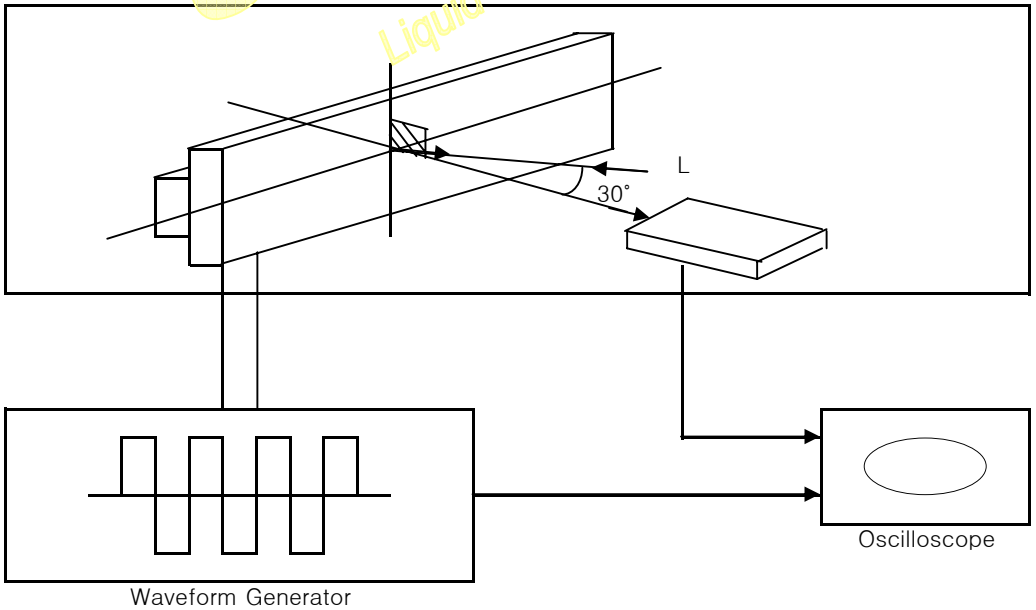



(2) Condition

Operating Frequency : 64Hz
Operating Voltage (rms) : Selected Voltage

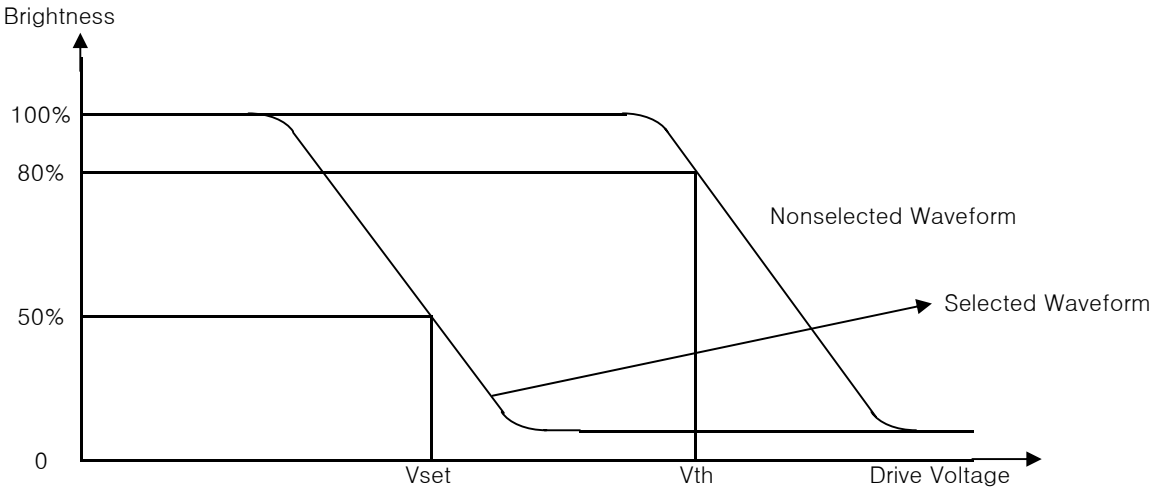
2. Threshold Voltage and Response Time Measuring

(1) Equipment

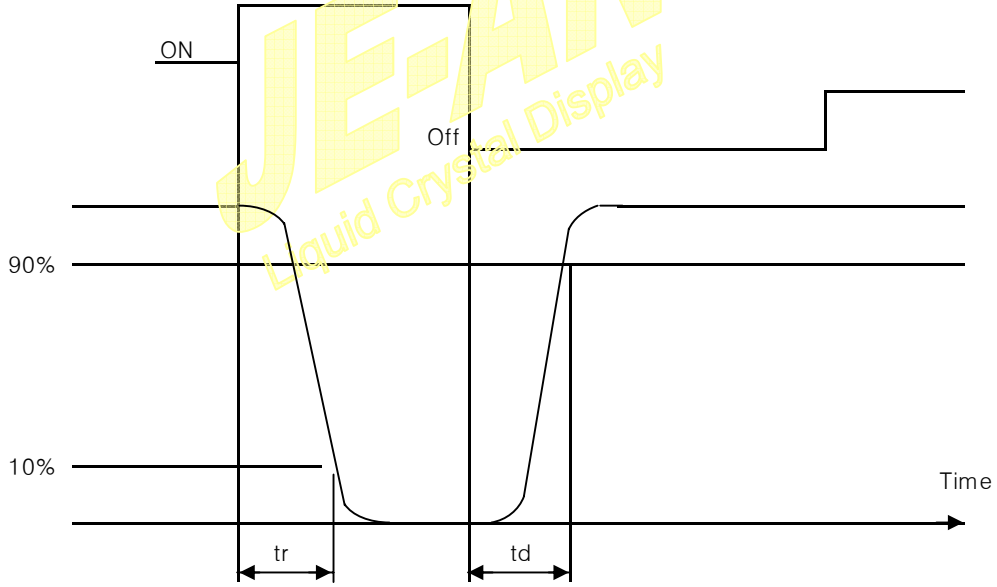


(2) Definition

a. Threshold Voltage (Vth)

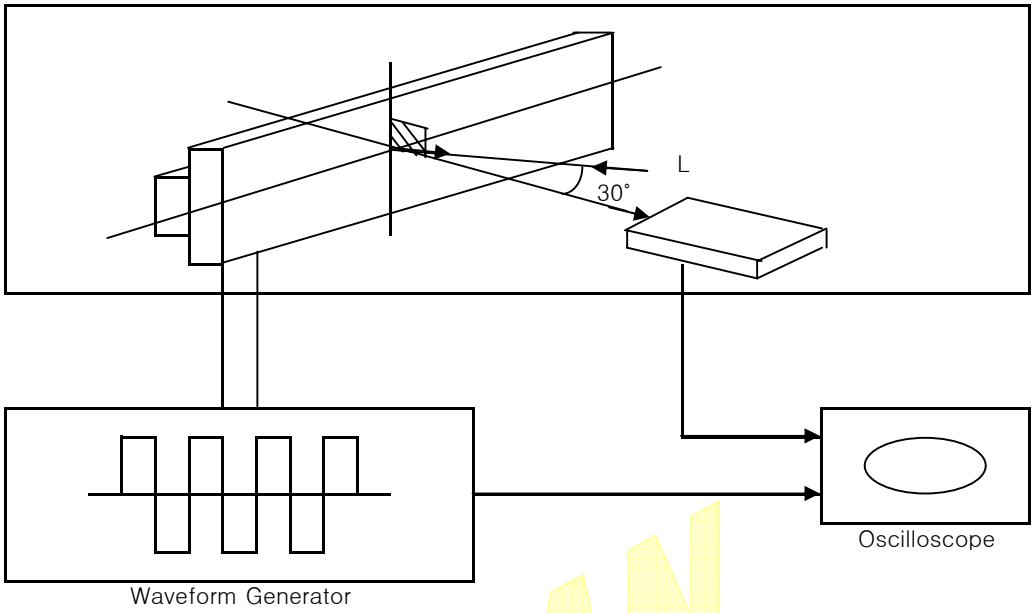



b. Response Time



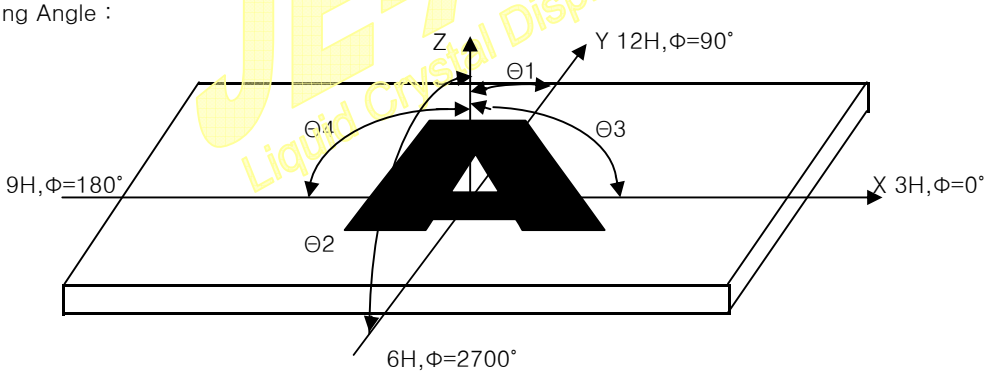
3. Contrast Measuring

(1) Equipment




(2) Definition

a. Viewing Angle :




b. Contrast Ratio (Positive)

$$CR = \frac{\text{Brightness of non-selected wave-form}}{\text{Brightness of selected wave-form}}$$

4. Reliability Test :
Equipment : Tenny

## Standard Specifications For Product Quality

1. Manner of Test :

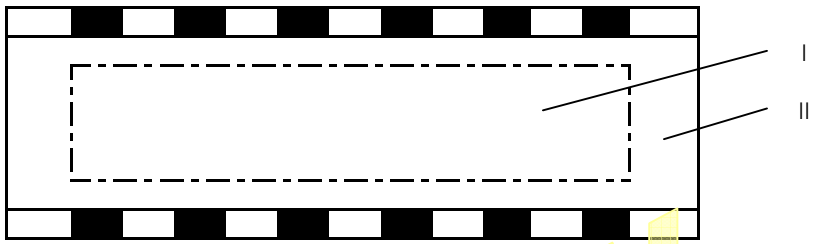
1-1. The test must be under 40W flourescent light, and the distance of view must be at 30cm.

1-2. The test direction is based on around 15° -45° of Vertical line.

2. Definition of area :

2-1. I area : Viewing area

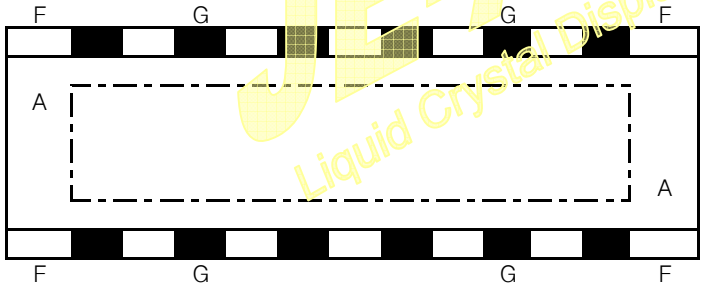
II area : Outside Viewing area




2-2. A area : The glass area outside sealant.

G area : Electrode pad area.

F area : Without electrode pad area.






3. Definition of defects

3-1. Major defects

a. Non display

b. Segment missing

c. Over current

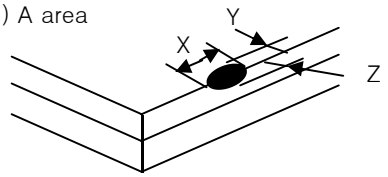
d. Liquid crystal leakage

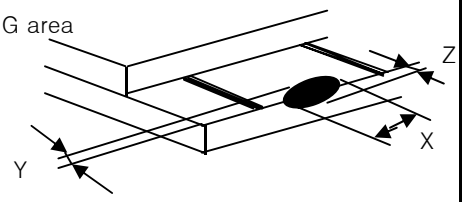
f. Wrong polarizer

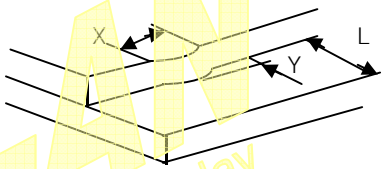
3-2. Minor defects : The others.

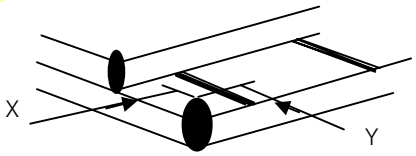
4. Major defects should be in AQL 0.25 , and the Minor in AQL 1.0

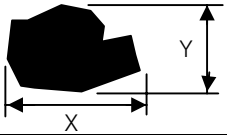
5. Standard of appearance test : (unit : mm)

<table>
<tr><th>No.</th><th>Items</th><th>Criterion</th><th>Checking Manner</th></tr>
<tr><td rowspan="2">1</td><td>Substrate crack<br>X : Defect Length<br>Y : Defect Width<br>Z : Defect Depth<br>T : Glass Thickness<br>N : Defect QTY<br>L : Connector Width</td><td>(1) A area<br> 

<table>
<tr><td>X</td><td>Y</td><td>Z</td><td>N</td></tr>
<tr><td>X≤2.0</td><td>Y≤0.5</td><td>Z≥T/2</td><td>N≤3</td></tr>
<tr><td>X≤2.0</td><td>Y≤1.0</td><td>Z≤T/2</td><td>X≤3</td></tr>
<tr><td>X≤0.5</td><td>Y≤2.0</td><td>Z≤T/3</td><td>No check</td></tr>
</table>
(2) G area<br> 

<table>
<tr><td>X</td><td>Y</td><td>Z</td><td>N</td></tr>
<tr><td>X≤2.0</td><td>Y≤0.5</td><td>Z≤T/2</td><td>N≤2</td></tr>
</table>


<table>
<tr><td>X</td><td>Y</td><td>N≤2</td><td></td></tr>
<tr><td>X≤2.0</td><td>Y≤1/4</td><td>or</td><td></td></tr>
<tr><td>X≤2.0</td><td>Y≤1.0</td><td>N≤2</td><td></td></tr>
</table>
(3) F area<br> 

<table>
<tr><td>X</td><td>Y</td><td>Z</td><td>N</td></tr>
<tr><td>X≤2.0</td><td>Y≤2</td><td>Z≤T</td><td>N≤3</td></tr>
</table></td><td>Checking<br>With eyes</td></tr>
<tr><td>2</td><td>Black spot<br>White spot<br>dust<br>Polarizer<br>Scratch<br>D=(X+Y)/2</td><td>(1)<br> 

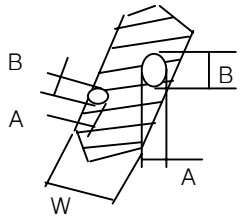
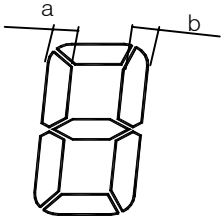
<table>
<tr><td>0.15＜D≤0.2</td><td>N≤1</td></tr>
<tr><td>0.1＜D≤0.15</td><td>N≤2</td></tr>
<tr><td>D≤0.1</td><td>No Check</td></tr>
</table>
(2)<br> 

<table>
<tr><td>W</td><td>N</td></tr>
<tr><td>L≤2.0 W ≤0.03</td><td>N≤1</td></tr>
</table></td><td>Checking on the Table with light and polarizer , and chacking with eyes directly.</td></tr>
</table>

5. Standard of appearance test : (unit : mm)

| No. | Items | Criterion | | Checking Manner |
|---|---|---|---|---|
| 3 | Polarizer Bubble | D≤0.15 | No check | Checking on the table with light and polarizer,and checking with eyes directly |
| | | 0.15< D≤0.4 | N≤2 | |
| 4 | Rainbow color | Allow tiny rainbow<br>Allow 5% color contrast | | Checking on the table with light and polarizer,and checking with eyes directly |
| 5 | Sealant | 1. Dimension accord design require<br>2. Immerge depth (d): 1/5D≤d≤D<br>( D : seal design depth ) | | Checking with eyes |
| 6 | Polarizer or pad appearance | No dirty | | Checking with eyes |

6. Standard of display test

| No. | Items | Criterion | | Checking Manner |
|---|---|---|---|---|
| 1 | Pin hol D=(A+B)/2<br>W : Segment width |  | | Checking at the Display JE-AN |
| | | W≤0.4D≤0.20 | D≤1/2W N≤1 | |
| | | W≤0.4D≤0.25 | D≤1/3W N≤2 | |
| | | D≤0.05 | No Check | |
| 2 | Defferent width of segment |  | Ia-bI< 0.25 or<br>Ia-bI≤1/4W<br>No Check | Checking at the Display JE-AN |

## Temperature Range & Relative Humidity

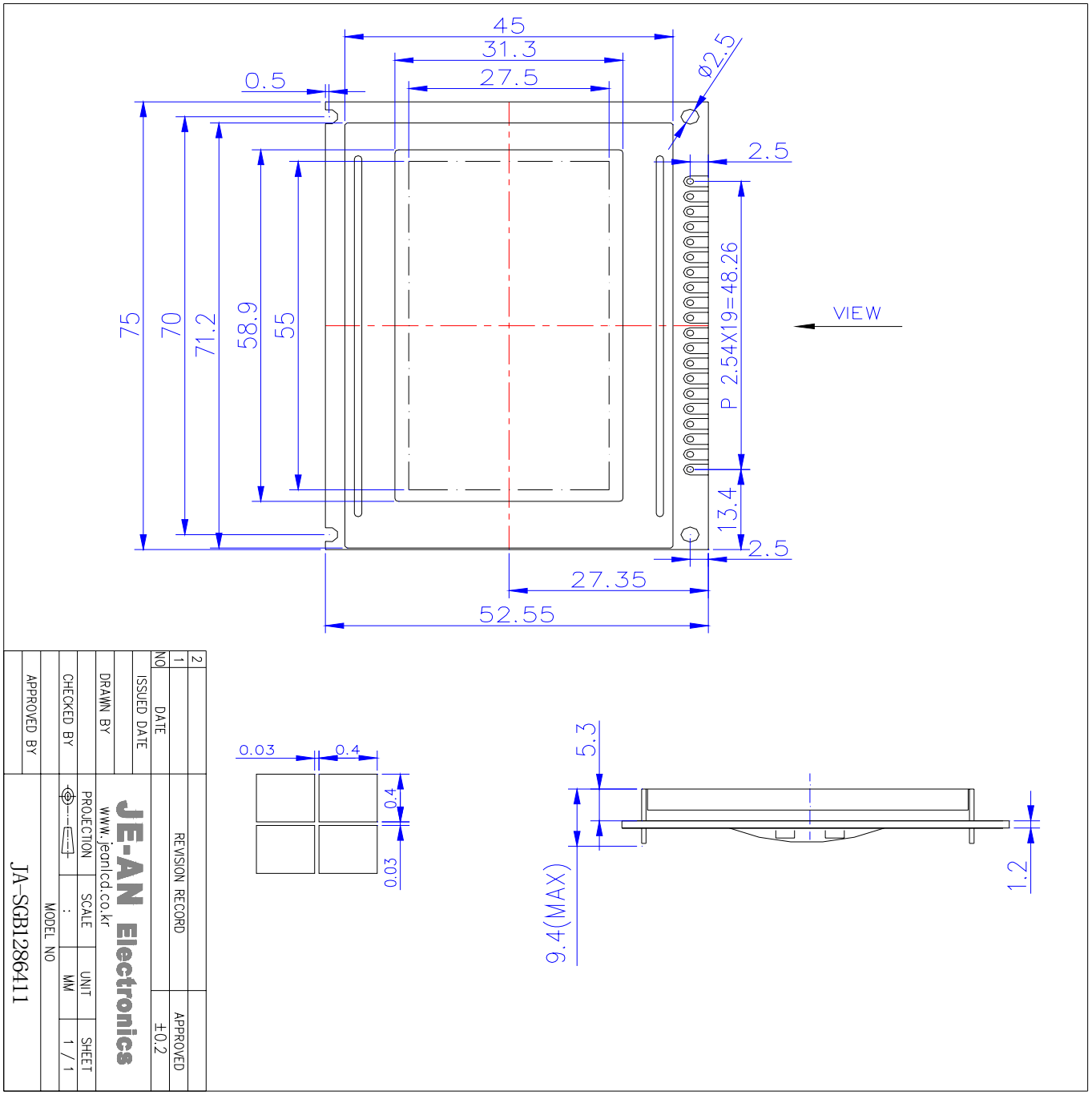
1. Normal Temperature

| No. | Item | Condition | Time | Remarks |
|---|---|---|---|---|
| 1 | Length | Temperature : 25℃ | 50,000 H | |
| 2 | High Temp. | Temperature : 50℃ | 240H | |
| 3 | High Temp. Storage | Temperature : 60℃ | 240H | |
| 4 | Low Temp. | Temperature : 0℃ | 240H | |
| 5 | Low Temp. Storage | Temperature : -10℃ | 240H | |
| 6 | Relative Humidity | 40℃ x 90% RH | 240H | |
| 7 | Thermal Shock | -20℃ (30 min) → 25℃ (5 min)<br>70℃ (30 min) → 25℃ (5 min) | 5 Cycle | |

2. Extended Temperature

| No. | Item | Condition | Time | Remarks |
|---|---|---|---|---|
| 1 | Length | Temperature : 25℃ | 100,000 H | |
| 2 | High Temp. | Temperature : 80℃ | 500H | |
| 3 | High Temp. Storage | Temperature : 85℃ | 500H | |
| 4 | Low Temp. | Temperature : -30℃ | 500H | |
| 5 | Low Temp. Storage | Temperature : -40℃ | 500H | |
| 6 | Relative Humidity | 60℃ x 90% RH | 500H | |
| 7 | Thermal Shock | -30℃ (30 min) → 25℃ (5 min)<br>80℃ (30 min) → 25℃ (5 min) | 10 Cycle | |

## Engineering Drawing



# Application Notes

1. Safety Instructions

The liquid in the LCD should not be swallowed or touched.

If it accidentally gets on your hands,wash them with water.

2. Handling Instructions

The LCD panel is a glass product developed through precision processing and special orientation treatment. If prossure is applied to the panel, therefore orientation may be disturbed, making it difficult to return to its original condition, it is apt to creak or break easily if it is dropped or hit to a external shock.

3. Nounting Instructions

a. When connecting a LCD panel to circurit board, it is recommended to use a ruber connector or fecxicle connector. Direct soldering or mechanical connection is not possible, the pin connected type LCD permits soldering of pins.

b. When connecting a LCD panel on a ciecuit, it must be taken care and not apply excessive force on the display surface of the panel with a fingertip, etc , otherwise, it may cause an operating failure or shorten the lifetime of the panel.

c. Voltage of driving voltage higher than the specified voltage will reduce the lifetime of the liquid crystal display panel.

d. LCD panels should be handled with care during shipment. If, however, the terminals are contaminated, wipe off with a alcohol.

e. The polarizer must be handled carefully, because it is soft and apt to suffer damage. The protective panel is attached to the polarizer to avoid damage and contamination, it should be removed just before use as possible.

f. Use a dry, soft cloth to clean the polarizer, if contamination persists, wipe it off with a small amount of petroleum benzine. Avoid using an organic solvent as much as possible.

g. When attaching with the heat seal or anisotropical conductive film wipe off with alcohol before use.

4. Storage Instructions

a. Avoid storage in high temperature and high humidity if long term storage is required keep the penels at a temperature off 10 to 35°C and at a relative humidity of 65% or less.

b. The LCD unit should be stored in dark place,do not expose it to direct sunlight or fluorescent lamps.

c. Note that the presence of waterdrops or dew in the LCD panel may deteriorate the polarizer or corrode the electrode.