



# Radiant Electronics Limited

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## SPECIFICATION FOR LCM MODULE

MODULE NO.: RD1602E

REVISION NO.: A

Customer Approval:

|             | SIGNATURE |
|-------------|-----------|
| PREPARED BY |           |
| VERIFIED BY |           |
| APPROVED BY |           |



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## RECORDS OF REVISION

| Date      | Rev. | Description | Page | Design by |
|-----------|------|-------------|------|-----------|
| 2011/7/19 | 0    | New Sample. | -    | -         |
|           |      |             |      |           |
|           |      |             | -    | -         |
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## Contents

### 1. SPECIFICATIONS

- 1.1 Features
- 1.2 Mechanical Specifications
- 1.3 Absolute Maximum Ratings
- 1.4 DC Electrical Characteristics
- 1.5 Backlight & LED Characteristics

### 2. MODULE STRUCTURE

- 2.1 Counter Drawing
- 2.2 Interface Pin Description
- 2.3 Timing Characteristics
- 2.4 Instruction Table
- 2.5 Character Generator ROM
- 2.6 Inspection Specification



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## 1. SPECIFICATIONS

### 1.1 Features

| Item              | Standard Value                  |
|-------------------|---------------------------------|
| Display Type      | 16characters × 2 lines          |
| Driver Condition  | LCD Module : 1/16Duty , 1/5Bias |
| Viewing Direction | 6 O'clock                       |
| Interface         | 8-bit MPU interface             |
| Driver IC         | AIP31066                        |

| Model No.: | Color                 | LCD Type                           | Backlight Type |
|------------|-----------------------|------------------------------------|----------------|
| RD1602E-B  | White on Blue         | STN, NEGATIVE (BLUE), TRANSMISSIVE | SIDE WHITE     |
| RD1602E-Y  | Black on Yellow-Green | STN, POSITIVE (Y-G), TRANSFLECTIVE | SIDE Y-G       |
| RD1602E-G  | Black on Gray         | STN, POSITIVE (GRAY),TRANSFLECTIVE | SIDE WHITE     |

### 1.2 Mechanical Specifications

| Item              | Standard Value          | Unit |
|-------------------|-------------------------|------|
| Outline Dimension | 84(L) * 44(W) * 11.8(T) | mm   |
| Viewing Area      | 64.3(L) * 16( W)        | mm   |
| Dot size          | 0.56(W) × 0.61(H)       | mm   |
| Dot pitch         | 0.6(W) × 0.65(H)        | mm   |
| Character size    | 2.96(W) × 5.16(H)       | mm   |

### 1.3 Absolute Maximum Ratings

| Item                        | Symbol          | Condition | Min.   | Max.      | Unit |
|-----------------------------|-----------------|-----------|--------|-----------|------|
| System Power Supply Voltage | VDD             | -         | -0.3   | 5.5       | V    |
| LCD Driver Supply Voltage   | VLCD            | -         | VDD-12 | VDD-0.3   | V    |
| Input Voltage               | V <sub>IN</sub> | -         | -0.3   | VDD + 0.3 | V    |
| Operating Temperature       | T <sub>OP</sub> | -         | -20    | 70        | °C   |



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|                     |                 |            |     |    |     |
|---------------------|-----------------|------------|-----|----|-----|
| Storage Temperature | T <sub>ST</sub> | -          | -30 | 80 | °C  |
| Storage Humidity    | H <sub>D</sub>  | Ta < 40 °C | 20  | 90 | %RH |

## 1.4 DC Electrical Characteristics

VDD = 3.3V ± 0.2V, GND = 0V, Ta = 25°C

| Item                 | Symbol          | Condition | Min.   | Typ. | Max.   | Unit |
|----------------------|-----------------|-----------|--------|------|--------|------|
| Logic Supply Voltage | VDD             | -         | 3.0    | 5.0  | 5.5    | V    |
| Input High Voltage   | V <sub>IH</sub> | -         | 0.8VDD | -    | VDD    | V    |
| Input Low Voltage    | V <sub>IL</sub> | -         | GND    | -    | 0.3VDD | V    |
| Output High Voltage  | V <sub>OH</sub> | -         | 0.7VDD | -    | VDD    | V    |
| Output Low Voltage   | V <sub>OL</sub> | -         | GND    | -    | 0.2VDD | V    |

## 1.5 Backlight Characteristics

LCD Module without LED Backlight

Electrical / Optical Characteristics

Ta =25°C

| Item                                | Symbol | Conditions          | Min. | Typ. | Max. | Unit              |
|-------------------------------------|--------|---------------------|------|------|------|-------------------|
| Forward Voltage                     | Vf     | If=20mA             | 3.1  | 3.2  | 3.3  | V                 |
| Reverse Current                     | Ir     | If=5v               |      |      | --   | uA                |
| Average Brightness                  | IV     | If=20mA             |      |      |      | cd/m <sup>2</sup> |
| Wavelength<br>(Without LCD)         | λ d    | If=20mA             | --   | --   | --   | nm                |
| Luminous Intensity<br>(without LCD) | Lv Sub | If=20mA             |      |      |      | cd/m <sup>2</sup> |
| Uniformity                          | Δ%     | IvMin / IvMax *100% | --   | -    | -    | %                 |



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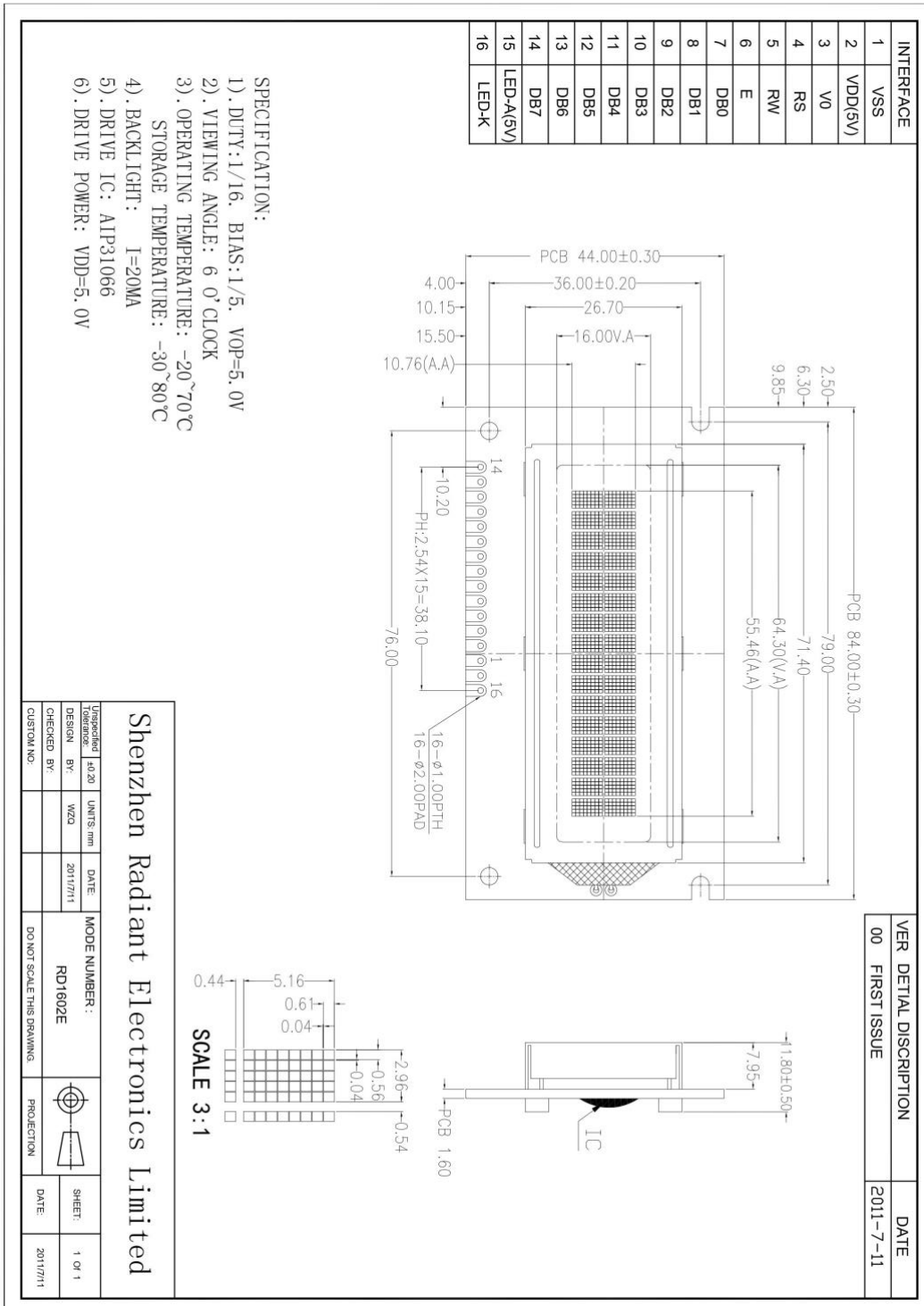
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## 2. MODULE STRUCTURE

### 2.1 Counter Drawing

#### 2.1.1 LCM Mechanical Diagram





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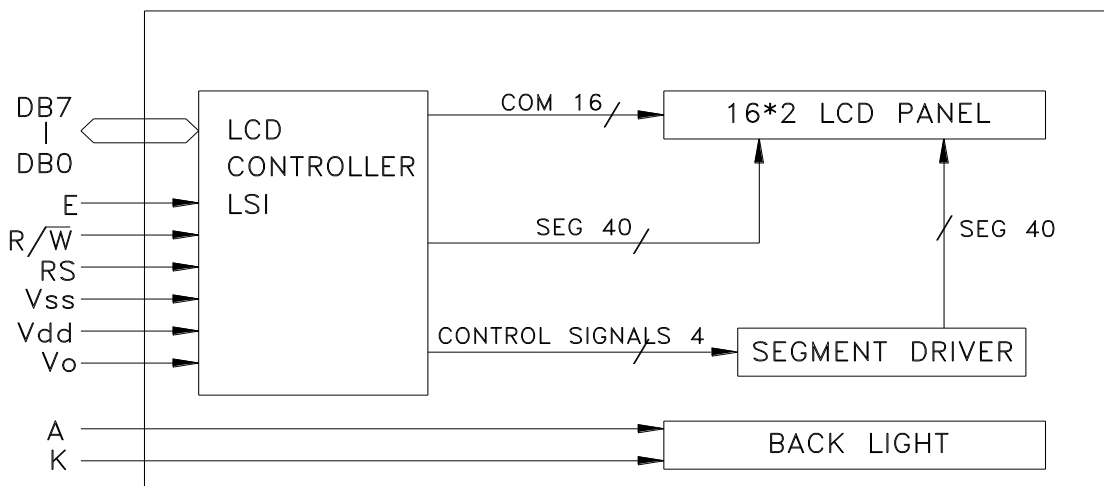
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## 2.2 Interface Pin Description

| No. | Symbol | Function                          |
|-----|--------|-----------------------------------|
| 1   | VSS    | Ground (0V)                       |
| 2   | VDD    | Supply Voltage for Logic (+5.0V ) |
| 3   | VO     | Contrast Adjustment               |
| 4   | RS     | Data/Instruction Select           |
| 5   | R/W    | Read/Write Select                 |
| 6   | E      | Enable Signal                     |
| 7   | DB0    | Data Bus                          |
| 8   | DB1    | Data Bus                          |
| 9   | DB2    | Data Bus                          |
| 10  | DB3    | Data Bus                          |
| 11  | DB4    | Data Bus                          |
| 12  | DB5    | Data Bus                          |
| 13  | DB6    | Data Bus                          |
| 14  | DB7    | Data Bus                          |
| 15  | LED_A  | LED Power Supply + (5.0V)         |
| 16  | LED_K  | LED Power Supply - (0V)           |





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## 2.3 Timing Characteristics

### DC Characteristics

| Characteristics            | Symbol           | Limit  |       |        | Unit | Test Condition   |
|----------------------------|------------------|--------|-------|--------|------|--|
|                            |                  | Min.   | Typ.  | Max.   |      |  |
| Operating Current          | IDD              | -      | 0.55  | 0.8    | mA   | External clock (Note)  |
| Input High Voltage         | V <sub>IH1</sub> | 2.2    | -     | VDD    | V    | Pins:(E, RS, R/W, DB7 - 0)   |
| Input Low Voltage          | V <sub>IL1</sub> | -0.3   | -     | 0.6    | V    |  |
| Input High Voltage         | V <sub>IH2</sub> | VDD-1  | -     | VDD    | V    | Pin OSC1   |
| Input Low Voltage          | V <sub>IL2</sub> | -0.2   | -     | 1.0    | V    | Pin OSC1   |
| Input High Current         | I <sub>IH</sub>  | -2.0   | -     | 2.0    | μA   | Pins: (RS, R/W, DB7 - 0)   |
| Input Low Current          | I <sub>IL</sub>  | -20.0  | -50.0 | -100.0 | μA   | VDD = 5.0V   |
| Output High Voltage (TTL)  | V <sub>OH1</sub> | 2.4    | -     | VDD    | V    | I <sub>OH</sub> = - 0.1mA<br>Pins: DB7 - 0                           |
| Output Low Voltage (TTL)   | V <sub>OL1</sub> | -      | -     | 0.4    | V    | I <sub>OL</sub> = 0.1mA<br>Pins: DB7 - 0                             |
| Output High Voltage (CMOS) | V <sub>OH2</sub> | 0.9VDD | -     | VDD    | V    | I <sub>OH</sub> = - 40.0μA,<br>Pins: CL1, CL2, M, D                  |
| Output Low Voltage (CMOS)  | V <sub>OL2</sub> | -      | -     | 0.1VDD | V    | I <sub>OL</sub> = 40.0μA, Pins:<br>CL1, CL2, M, D                    |
| Driver ON Resistance (COM) | R <sub>COM</sub> | -      | -     | 20.0   | KΩ   | I <sub>o</sub> = ±50.0μA, V <sub>LCD</sub> = 4.0V<br>Pins: COM16 - 1 |
| Driver ON Resistance (SEG) | R <sub>SEG</sub> | -      | -     | 30.0   | KΩ   | I <sub>o</sub> = ±50.0μA, V <sub>LCD</sub> = 4.0V<br>Pins: SEG40 - 1 |
| LCD Voltage                | V <sub>LCD</sub> | 3.0    | -     | 11.0   | V    | VDD - V5, 1/4 bias or 1/5 bias                                       |

Note: F<sub>OSC</sub> = 250.0KHz, VDD = 5.0V, pin E = "L", RS, R/W, DB7 - 0 are open, all outputs are no loads.

### AC Characteristics

| Characteristics | Symbol            | Limit |       |       | Unit | Test Condition               |
|-----------------|-------------------|-------|-------|-------|------|------------------------------|
|                 |                   | Min.  | Typ.  | Max.  |      |                              |
| OSC Frequency   | F <sub>OSC1</sub> | 190.0 | 270.0 | 350.0 | KHz  | VDD = 5.0V<br>Rf = 91.0KΩ±2% |





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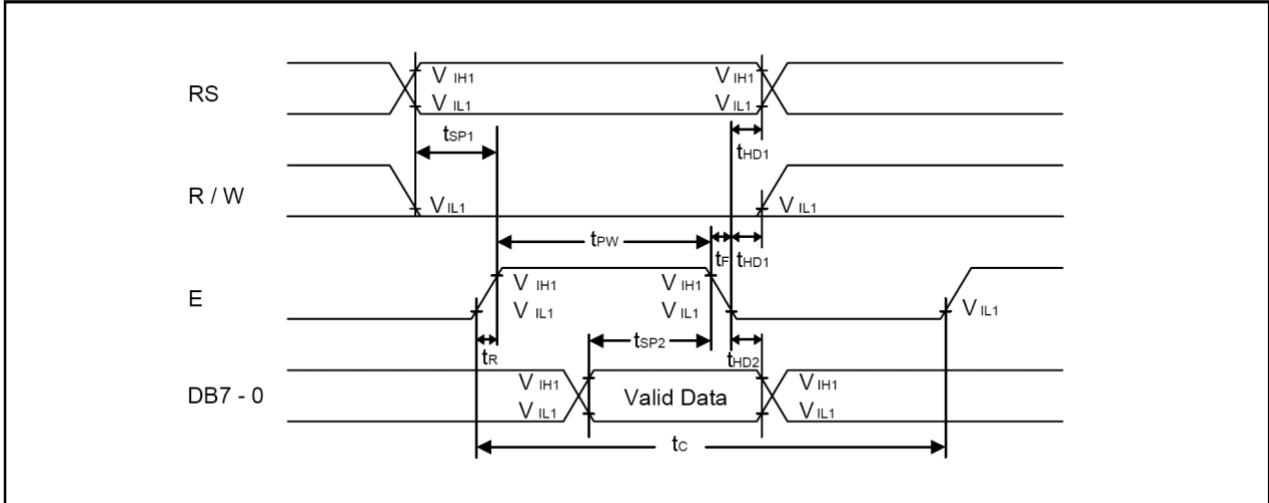
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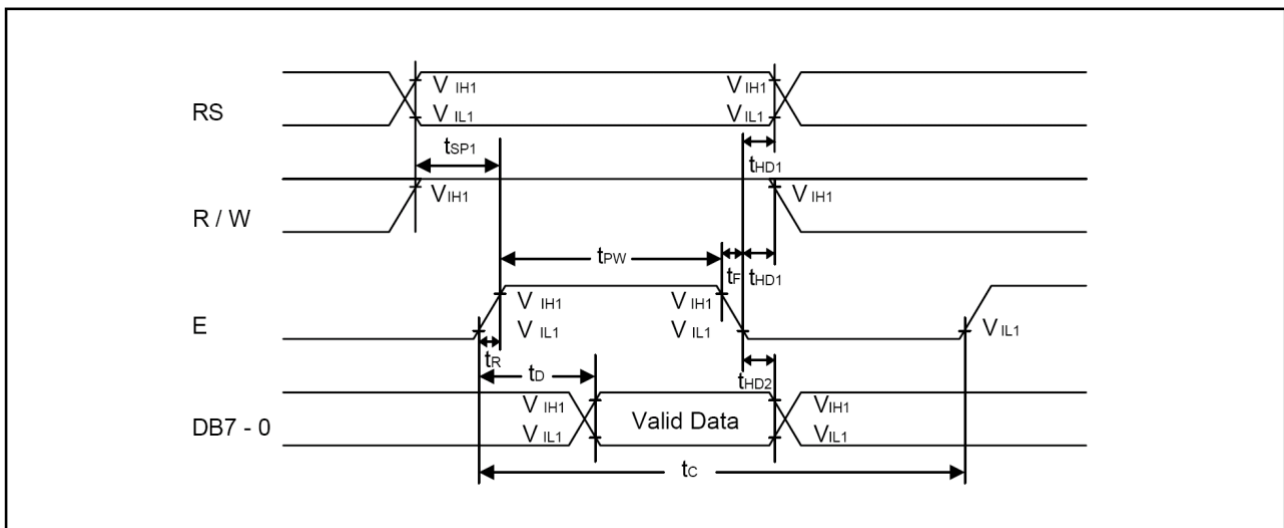
## Timing Diagram

### Writing mode



| Characteristics    | Symbol     | Limit |      |      | Unit | Test Condition   |
|--------------------|------------|-------|------|------|------|------------------|
|                    |            | Min.  | Typ. | Max. |      |                  |
| E Cycle Time       | $t_c$      | 400.0 | -    | -    | ns   | Pin E            |
| E Pulse Width      | $t_{PW}$   | 150.0 | -    | -    | ns   | Pin E            |
| E Rise/Fall Time   | $t_R, t_F$ | -     | -    | 25.0 | ns   | Pin E            |
| Address Setup Time | $t_{SP1}$  | 30.0  | -    | -    | ns   | Pins: RS, R/W, E |
| Address Hold Time  | $t_{HD1}$  | 10.0  | -    | -    | ns   | Pins: RS, R/W, E |
| Data Setup Time    | $t_{SP2}$  | 40.0  | -    | -    | ns   | Pins: DB7 - 0    |
| Data Hold Time     | $t_{HD2}$  | 10.0  | -    | -    | ns   | Pins: DB7 - 0    |

### Read mode





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| Characteristics        | Symbol     | Limit |      |       | Unit | Test Condition  |
|------------------------|------------|-------|------|-------|------|-----------------|
|                        |            | Min.  | Typ. | Max.  |      |                 |
| E Cycle Time           | $t_c$      | 400.0 | -    | -     | ns   | Pin E           |
| E Pulse Width          | $t_w$      | 150.0 | -    | -     | ns   | Pin E           |
| E Rise/Fall Time       | $t_R, t_F$ | -     | -    | 25.0  | ns   | Pin E           |
| Address Setup Time     | $t_{SP1}$  | 30.0  | -    | -     | ns   | Pins: RS, R/W,E |
| Address Hold Time      | $t_{HD1}$  | 10.0  | -    | -     | ns   | Pins: RS, R/W,E |
| Data Output Delay Time | $t_D$      | -     | -    | 100.0 | ns   | Pins: DB7 - 0   |
| Data hold time         | $t_{HD2}$  | 20.0  | -    | -     | ns   | Pin DB7 - 0     |

## 2.4 Instruction Table

### ◆ Display Control Instruction

| Instruction                        | Instruction Code |    |     |     |     |     |     |     |     |     | Description  | Execution time<br>( $F_{OSC} = 270KHz$ ) |
|------------------------------------|------------------|----|-----|-----|-----|-----|-----|-----|-----|-----|--|--|
|                                    | RS               | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |  |  |
| Clear Display                      | 0                | 0  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | Write "20H" to DDRAM and set DDRAM address to "00H" from AC  | 1.52ms                                   |
| Return Home                        | 0                | 0  | 0   | 0   | 0   | 0   | 0   | 0   | 1   | -   | Set DDRAM address to "00H" from AC and return cursor to its original position if shifted. The contents of DDRAM are not changed.       | 1.52ms                                   |
| Entry Mode Set                     | 0                | 0  | 0   | 0   | 0   | 0   | 0   | 1   | I/D | S   | Assign cursor moving direction and enable the shift of entire display  | 38 $\mu$ s                               |
| Display ON/OFF Control             | 0                | 0  | 0   | 0   | 0   | 0   | 1   | D   | C   | B   | Set display(D), cursor(C), and blinking of cursor(B) on/off control bit.   | 38 $\mu$ s                               |
| Cursor or Display Shift            | 0                | 0  | 0   | 0   | 0   | 1   | S/C | R/L | -   | -   | Set cursor moving and display shift control bit, and the direction, without changing of DDRAM data.                                    | 38 $\mu$ s                               |
| Function Set                       | 0                | 0  | 0   | 0   | 1   | DL  | N   | F   | -   | -   | Set interface data length (DL: 8-bit/4-bit), numbers of display line (N: 2-line/1-line) and, display font type (F: 5x10 dots/5x8 dots) | 38 $\mu$ s                               |
| Set CGRAM Address                  | 0                | 0  | 0   | 1   | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set CGRAM address in address counter.  | 38 $\mu$ s                               |
| Set DDRAM Address                  | 0                | 0  | 1   | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set DDRAM address in counter   | 38 $\mu$ s                               |
| Read Busy Flag and Address Counter | 0                | 1  | BF  | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Whether during internal operation or not can be known by reading BF. The contents of address counter can also be read.                 |  |
| Write Data to RAM                  | 1                | 0  | D7  | D6  | D5  | D4  | D3  | D2  | D1  | D0  | Write data into internal RAM (DDRAM/CGRAM).  | 38 $\mu$ s                               |
| Read Data from RAM                 | 1                | 1  | D7  | D6  | D5  | D4  | D3  | D2  | D1  | D0  | Read data from internal RAM (DDRAM/CGRAM).   | 38 $\mu$ s                               |

\* "-": don't care



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## 2.5 Character Generator ROM

| Upper 4 bit<br>Lower 4 bit | LLLL | LLLH | LLHL | LLHH | LHLL | LHLH | LHHL | LHHH | HLLL | HLLH | HLHL | HLHH | HLLL | HLLH | HLHL | HHLH | HHLH | HHLH | HHLH |
|----------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| LLLL                       |      |      |      | 0    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    |
| LLLH                       |      |      | !    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| LLHL                       |      |      | "    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| LLHH                       |      |      | #    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| LHLL                       |      |      | \$   | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| LHLH                       |      |      | %    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| LHHL                       |      |      | &    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| LHHH                       |      |      | '    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HLLL                       |      |      | (    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HLLH                       |      |      | )    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HLHL                       |      |      | *    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HLHH                       |      |      | +    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HLLL                       |      |      | ,    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HLLH                       |      |      | -    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HLHL                       |      |      | .    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HHLH                       |      |      | /    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HHHL                       |      |      | ?    | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |
| HHHH                       |      |      |      | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | A    | B    | C    | D    | E    | F    | G    |



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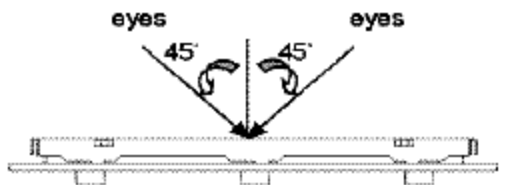
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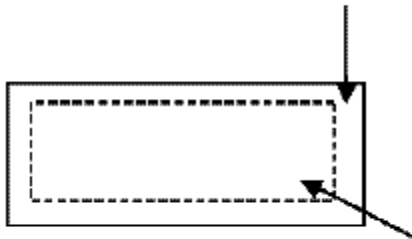
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## 2.6 Inspection Specification

- ◆ Inspection Standard : MIL-STD-105E Table Normal Inspection Single Sampling Level II .
- ◆ Equipment : Gauge、MIL-STD、Powertip Tester、 Sample
- ◆ Defect Level : Major Defect AQL 0.4; Minor Defect AQL 1.5 .
- ◆ OUT Going Defect Level : Sampling .
- ◆ Manner of appearance test :
  - (1). The test be under 40W×2 fluorescent light ' and distance of view must be at 30 cm.
  - (2). The test direction is base on about around 45° of vertical line. (Fig. 1)
  - (3). Definition of area . (Fig. 2)



**B area : Outside of viewing area**



**A area : viewing area**

### ◆ Specification:

| NO | Item  | Criterion   | level |
|----|---|---|-------|
| 01 | Product condition                                     | 1.1 The part number is inconsistent with work order of Production.  | Major |
|    |   | 1.2 Mixed production types.   | Major |
|    |   | 1.3 Assembled in inverse direction.   | Major |
| 02 | Quantity  | 2.1 The quantity is inconsistent with work order of production.   | Major |
| 03 | Outline dimension                                     | 3.1 Product dimension and structure must conform to Structure diagram.  | Major |
| 04 | Electrical Testing                                    | 4.1 Missing line character、 dot and icon.   | Major |
|    |   | 4.2 No function or no display.  | Major |
|    |   | 4.3 Output data is error.   | Major |
|    |   | 4.4 LCD viewing angle defect.   | Major |
|    |   | 4.5 Current consumption exceeds product specifications.   | Major |
| 05 | Black or white dot、 scratch、 contamination Round type | 5.1 Round type:<br>5.1.1 display only :<br>·White and black spots on display $\leq 0.25\text{mm}$ , no more than Four white or black spots present.<br>·Densely spaced : NO more than two spots or lines within 3mm | Minor |



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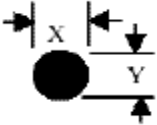
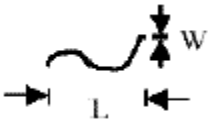
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◆Specification :

| NO | Item  | Criterion  | level |
|----|---|--|-------|
| 05 | Black or white dot、scratch、contamination<br>Round type<br><br>$\Phi=(x+y)/2$<br><br> | 5.1.2 Nom-display :<br><br>Dimension (diameter : $\Phi$ )<br>Acceptance(Q'ty)<br><br>$\Phi \leq 0.10\text{mm}$<br>Accept no dense<br><br>$0.10\text{mm} < \Phi \leq 0.20\text{mm}$ 3<br><br>$0.20\text{mm} < \Phi \leq 0.25\text{mm}$ 2<br><br>Total 4<br><br>5.1.3 Line type:<br>Dimension (diameter : $\Phi$ )<br>Acceptance (Q'ty)<br><br>Length<br>width<br>A area<br>B area<br><br>---<br>$w \leq 0.03\text{mm}$<br>Accept no dense<br>Don't count<br><br>$L \leq 3.0\text{mm}$<br>$0.03\text{mm} < \Phi \leq 0.05\text{mm}$ 4<br><br>Don't count<br><br>$L \leq 2.5\text{mm}$<br>$0.05\text{mm} < \Phi \leq 0.075\text{mm}$<br><br>Don't count<br><br>---<br>$w > 0.075\text{mm}$<br>As round type | Minor |



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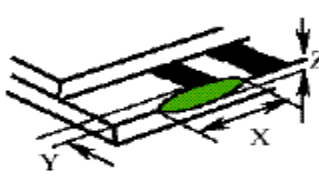
Rm U,13/F., Block 1, Kinho Ind. Bldg., 14 Au Pui Wan St., Shatin N.T. Hong Kong

www.radisplay.com

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|    |                    |   |       |
|----|--------------------|---|-------|
| 06 | Polarizer Bubble   | <p>Dimension (diameter : <math>\Phi</math>)</p> <p>A area</p> <p>Acceptance(Q'ty)</p> <p>B area</p> <p><math>\Phi \leq 0.20\text{mm}</math></p> <p>Accept no dense</p> <p>Don't count</p> <p><math>0.20\text{mm} &lt; \Phi \leq 0.50\text{mm}</math></p> <p>3</p> <p>Don't count</p> <p><math>0.50\text{mm} &lt; \Phi \leq 1.00\text{mm}</math></p> <p>2</p> <p>Don't count</p> <p><math>\Phi &gt; 1.00\text{mm}</math></p> <p>0</p> <p>Don't count</p> <p>Total quantity</p> <p>4</p> <p>Don't count</p> | Minor |
| 07 | The crack of glass | <p>● Glass Crack:</p> <p>7.1 Crack on the circuit of electrode terminal :</p>  <p>X</p> <p>Y</p> <p>Z</p> <p>Front</p> <p><math>X \leq 1/5 a</math></p> <p><math>Y \leq 1/2 D</math></p> <p><math>Z \leq t</math></p> <p>Back</p> <p>Neglect</p>   | Minor |



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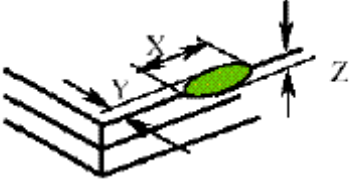

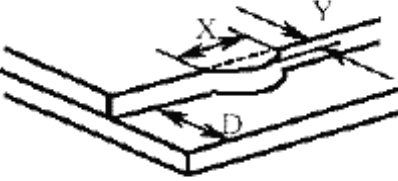
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Tel:(852)29470031

Fax:(852)29470881

◆Specification :

| NO | Item  | Criterion   | Level |
|----|---|---|-------|
| 07 | <p>The crack of glass</p> <p>X: The length of Crack</p> <p>Y: The width of crack</p> <p>Z: The thickness of crack</p> <p>D: terminal length</p> <p>T: The thickness of glass</p> <p>A : The length of glass</p> | <p>● Glass Crack:</p> <p>7.2 General glass crack and corner edge:</p> <p>7.2.1</p>  <p>X<br/>Y<br/>Z<br/>Neglect<br/>Out A area<br/>Neglect</p> <p>7.2.2</p>  <p>X<br/>Y<br/>Z<br/>Neglect<br/>Out A area<br/>Neglect</p> | Minor |
|    |   | <p>7.3 Glass remain:</p>  <p>X<br/>Y<br/>Neglect<br/><math>\leq 1/3 d</math></p>  | Minor |



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◆Specification :

| NO | Item  | Criterion   | Level |
|----|---|---|-------|
| 07 | <p>The crack of glass</p> <p>X: The length of Crack</p> <p>Y: The width of crack</p> <p>Z: The thickness of crack</p> <p>D: terminal length</p> <p>T: The thickness of glass</p> <p>A : The length of glass</p> | <p>7.4 Corner crack and medial crack:</p> <p style="text-align: center;"> <math>X</math><br/> <math>Y</math><br/> <math>Z</math><br/> <math>\cong 1/5a</math><br/>           Crack can't enter viewing area<br/> <math>\cong 1/2t</math><br/> <math>\cong 1/5a</math><br/>           Crack can't exceed the half of width of SP width of SP<br/> <math>1/2t &lt; Z \cong 2t</math> </p> | Minor |
| 08 | Backlight elements  | 8.1 Backlight can't work normally.  | Major |
|    |   | 8.2 Backlight doesn't light or color is wrong.  | Major |
|    |   | 8.3 Illumination source flickers when lit.  | Major |
| 09 | General appearance  | 9.1 pin type must match type in specification sheet   | Major |
|    |   | 9.2 No short circuits in components on PCB or FPC   | Major |
|    |   | 9.3 Product packaging must the same as specified on packaging specification sheet.  | Major |
|    |   | 9.4 The folding and peeled off in polarizer are not acceptable  | Major |
|    |   | 9.5 The PCB or FPC between B/L assembled distance (PCB or FPC) is $\cong 1.5\text{mm}$  | Major |