To :

# SPECIFICATION

Rev 2.0

*Application :*

## VACUUM FLUORESCENT DISPLAY MODULE

*Model No. : 16L102DA4*

| Rev No. | Issued Date | Description | Remark |
|---|---|---|---|
| Tentative | Nov. 25, 1996 | First Edition | All Pages |
| Rev 1.0 | Feb. 02, 1998 | Second Edition<br>-.Mounting hole size change: Ø3.5→Ø4.0<br>-.Connector pin assignment change:<br>#10: NC (No connection) → /RST (Reset)<br>#8: NC (No connection) → SCLK (Serial clock) (common to #7) | Page 6/12<br>Page 5/12 |
| Rev 2.0 | May. 29, 1998 | Third Edition<br>-.Comma & Decimal point default value change<br>Off → Undefined<br>-.Addition of Recommand initial setting sequence | Page 10/12<br>Page 11/12 |

| Issued by | Customer Approval |
|---|---|
| Checked by | |
| Approved by | |

# 1. SCOPE

This specification applies to VFD module(Model No:16L102DA4) manufactured by Samsung Display Devices.

# 2. FEATURES

2.1 The MCU can control this module by five control signals, chip select(/SEL), shift clock(SCLK), serial data(SDATA) and reset(/RST).

2.2 Since a DC/DC converter is used, only +12Vdc power source is required to operate the module.

2.3 One chip controller mounted on the module includes the character generator ROM (CG-ROM) of 96 ASCII and 152 European characters.

2.4 Eight brightness levels can be selected by dimming function.

2.5 High quality blue-green(505 nm) vacuum fluorescent display provides an attractive and readable medium. Other colors can be achieved by simple wavelength filters.

2.6 Characters are provided with a 5×7 dot matrix.

2.7 The module has up to 8 user definable characters. (CG-RAM function)

# 3. GENERAL DESCRIPTIONS

3.1 This specification becomes effective after being approved by the purchaser.

3.2 When any conflict is found in the specification, appropriate action shall be taken upon agreement of both parties.

3.3 The expected necessary service parts should be arranged by the customer before the completion of production.

# 4. PRODUCT SPECIFICATIONS

## 4.1 Type

Table_1

| Type | 16L102DA4 |
|---|---|
| Digit Format | 5×7 Dot Matrix with Comma |

## 4.2 Outer Dimensions, Weight (See Fig-4 on Page 6/12 for details)

Table_2

| Parameter | | Specification | Unit |
|---|---|---|---|
| Outer Dimensions | Width | 218.0±1.0 | mm |
| | Height | 45.0±1.0 | mm |
| | Thickness | 26.5 Max | mm |
| Weight | | Typical 130 | g |

## 4.3 Specifications of Display Panel (See Fig-5 on Page 6/12)

Table_3

| Parameter | Symbol | Specification | Unit |
|---|---|---|---|
| Display Size (W × H) | - | 173.2×13.55 | mm |
| Number of Digit | - | 16 Digits | — |
| Character Size (W × H) | - | 6.76×12.50 | mm |
| Character Pitch | Cp(x) | 11.0 | mm |
| Display Color | - | Blue-Green (Peak 505nm) | nm |

## 4.4 Environment Conditions

Table_4

| Parameter | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Operating Temperature | Topr | -20 | +70 | ℃ |
| Storage Temperature | Tstg | -40 | +85 | ℃ |
| Humidity (Operating) | Hopr | 0 | 85 | % |
| Humidity (Non-operating) | Hstg | 0 | 90 | % |
| Vibration (10 ~ 55 Hz) | — | — | 4 | G |
| Shock | — | — | 40 | G |

## 4.5 Absolute Maximum Ratings

Table_5

| Parameter | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Supply Voltage | Vcc | -0.3 | 13.2 | Vdc |
| Input Signal Voltage | Vis | -0.3 | 5.5 | Vdc |

## 4.6 Recommend Operating Conditions

Table_6

| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Supply Voltage | Vcc | 10.8 | 12.0 | 13.2 | Vdc |
| H-Level Input Voltage | Vih | 3.5 | — | 5.5 | Vdc |
| L-Level Input Voltage | Vil | — | — | 0.8 | Vdc |

## 4.7 DC Characteristics (Ta = +25℃, Vcc = +12.0 Vdc)

Table_7

| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Supply Current ※) | Icc | — | 300 | 400 | mA |
| H-Level Input Current | Iih | -1.0 | — | 1.0 | μA |
| L-Level Input Current | Iil | -1.0 | — | 1.0 | μA |
| Luminance | L | 100 | 200 | — | ft-L |

※) The surge current can be approx. 3 times the specified supply current at power on.

## 4.8 AC Characteristics (Ta=+25℃, Vcc=+5.0 Vdc)

Table_8

| Parameter | Symbol | Min. | Max. | Unit |
|---|---|---|---|---|
| Cycle time of SCLK | $t_{CYCLE}$ | 1.0 | - | μs |
| Pulse width of SCLK | $t_{CW}$ | 300 | - | ns |
| Set-up time of SDATA | $t_{DS}$ | 300 | - | ns |
| Holding time of SDATA | $t_{DH}$ | 300 | - | ns |
| Set-up time of /SEL | $t_{CSS}$ | 300 | - | ns |
| Holding time of /SEL | $t_{CSH}$ | 16 | - | μs |
| Waiting time of /SEL | $t_{CSW}$ | 300 | - | ns |
| Processing time of SDATA | $t_{DOFF}$ | 8 | - | μs |
| Wating time of SDATA | $t_{RSOFF}$ | 300 | - | ns |
| Rising Time of Vcc | $t_{PRZ}$ | - | 100 | μs |
| Off time of Vcc | $t_{POFF}$ | 5.0 | - | ms |

## 4.9 Timing Diagram

### 4.9.1 Data Input Timing

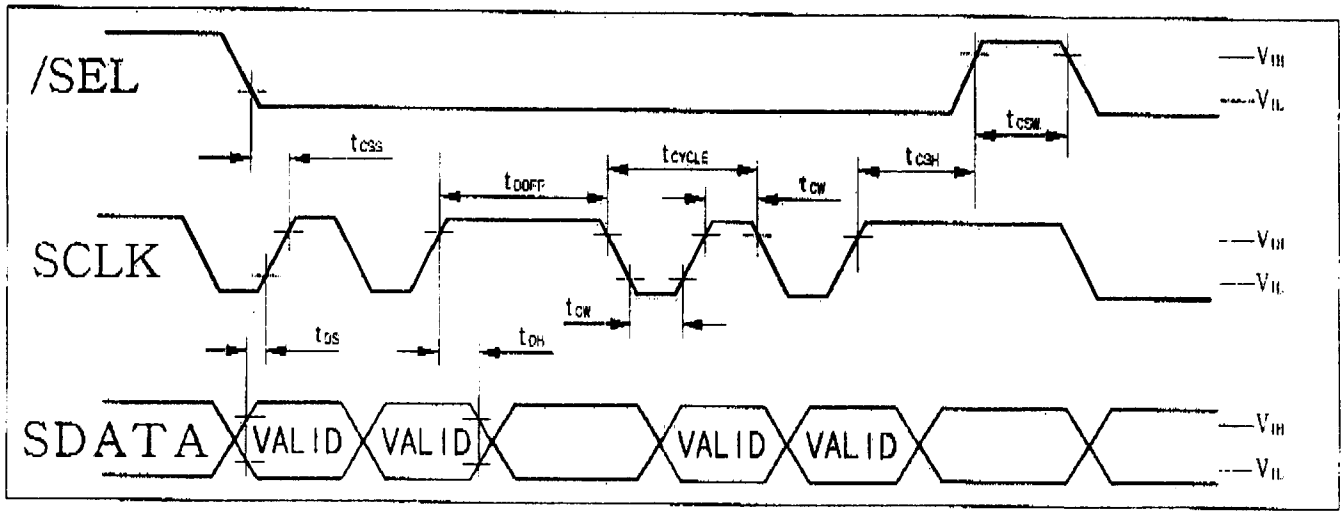



Fig-1. Data Input Timing Diagram

### 4.9.2 Power On Timing

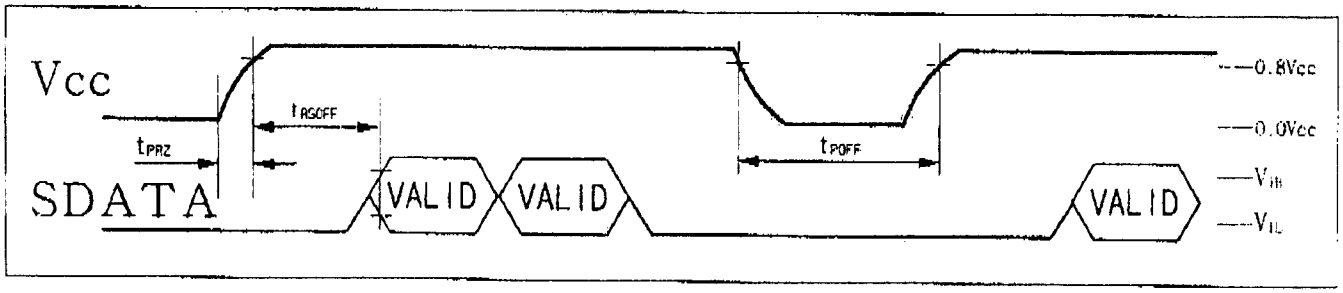



Fig-2. Power On Timing Diagram

## 4.10 Signal Interfacing

· Connector(Male) : PH-2S06-FG (by Aster) or equivalent
→ Mate Socket(Female) : HIF3B-12D-2.54R (HIROSE) or equivalent

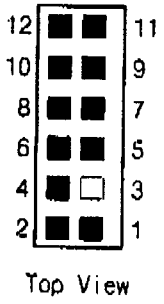



Table_9

| Pin No | Symbol | Descriptions |
|---|---|---|
| 5 | /SEL | Chip Select Terminal with 1kΩ Pulled-up. When the pin is High, the serial data transfer is inhibited. |
| 7,8 | SCLK | Shift Clock Input Terminal with 1kΩ Pulled-up. The Serial data(Pin #9) is shifted at rising edge of SCLK. |
| 9 | SDATA | Serial data Input from LSB with 1kΩ Pulled-up. |
| 10 | /RST | Input terminal for reset of VFD Module(Low active) |
| 1,2 | Vcc | Power Supply Terminal. (+12Vdc is required.) |
| 11,12 | GND | Ground Terminal. (0Vdc is required) |
| 3 | N/P | No Pin |
| 4,6 | N/C | No Connection |

## 4.11 System Block Diagram

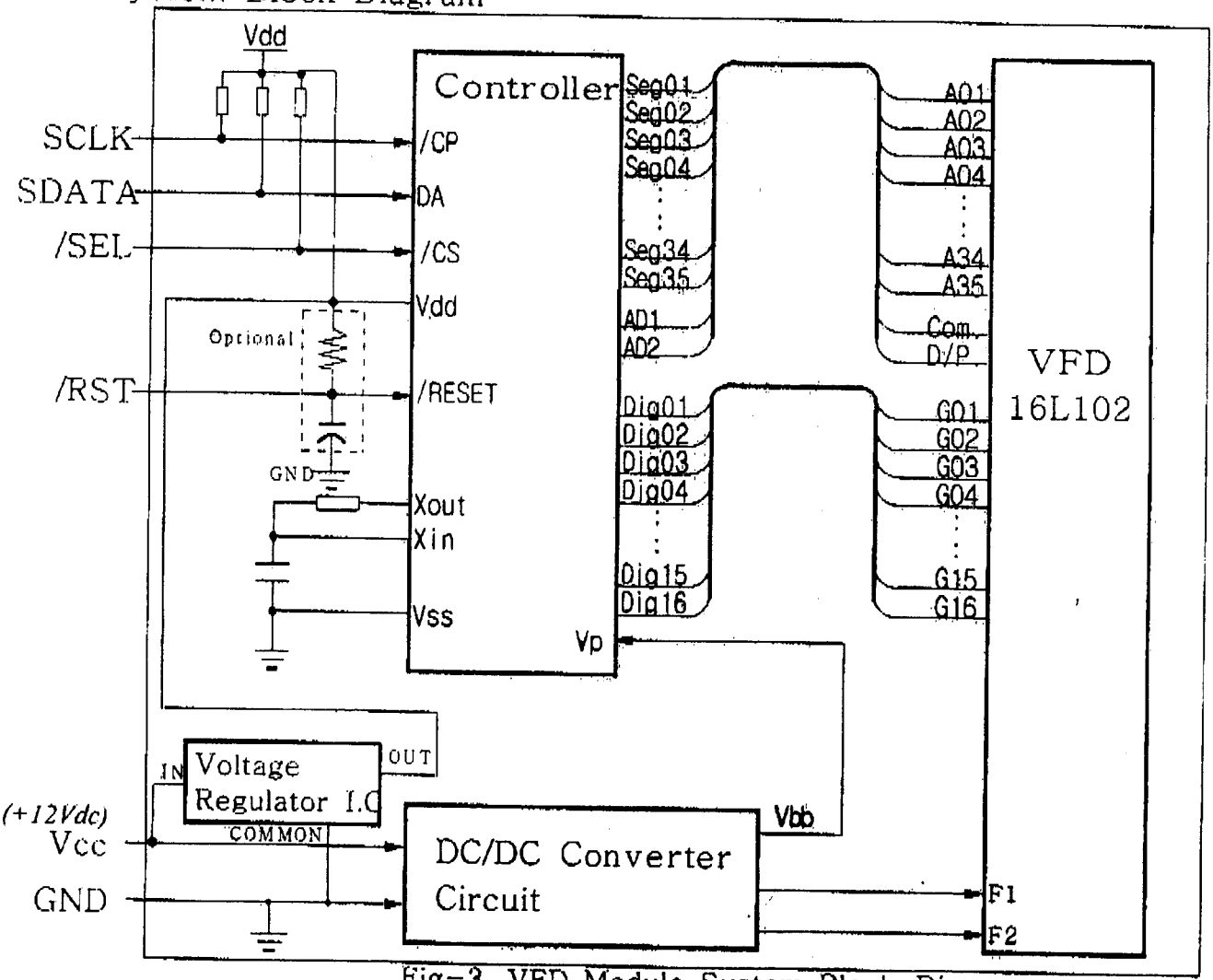



Fig-3. VFD Module System Block Diagram

## 4.12 Outer Dimensions

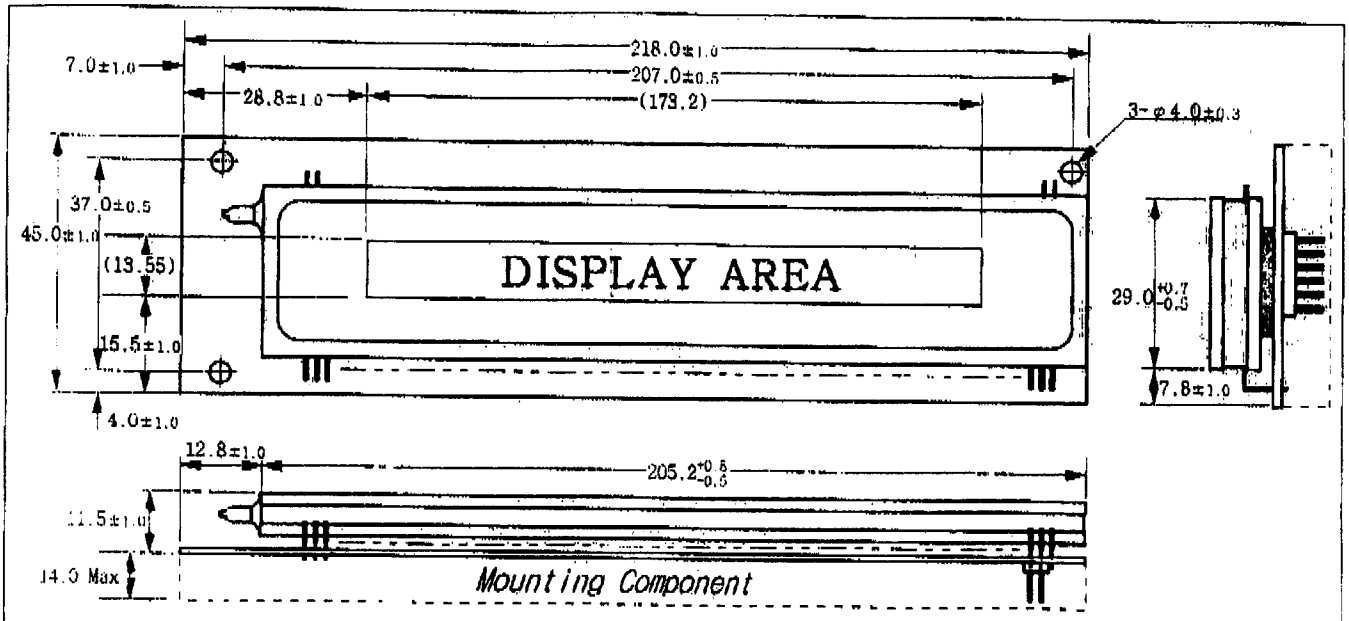



Fig-4. Outer Dimensions (Unit : mm)

## 4.13 Pattern Details

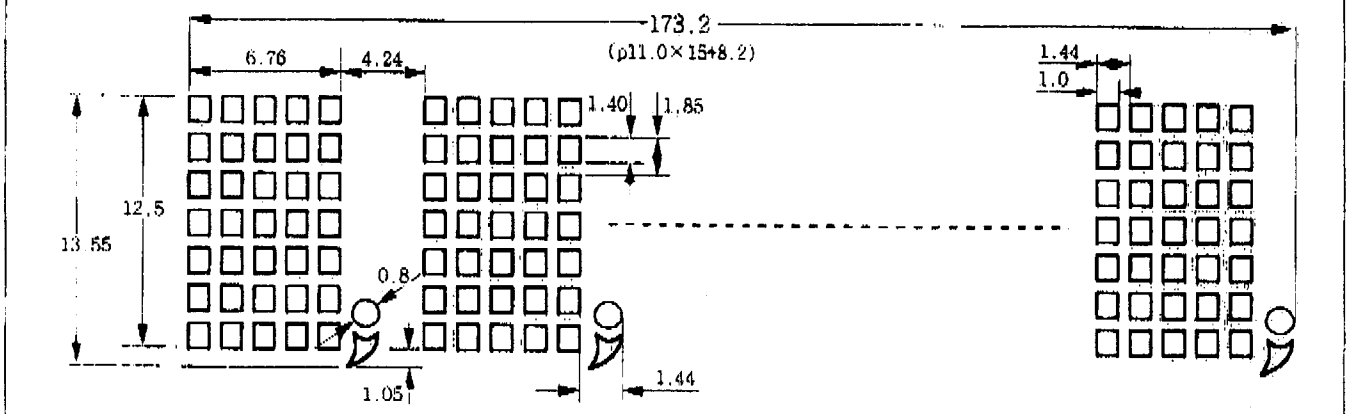



Fig-5. Pattern Details (Unit : mm)

# 5. FUNCTIONAL DESCRIPTIONS

A display control command or character data is written by the 8-bit serial synchronous transfer mode. The Figure_6 on the next page shows the write timing chart.
When the /SEL pin is low(Logic "0"), data can be transferred. Data with 8 bits length is input into the SDATA pin sequentially from LSB. (LSB First, MSB Last)

Data is shifted at the rising edge of a shift clock pulse which is input to the SCLK pin as shown in the Figure_6. When data with 8 bits length is entered, an inner LOAD signal is automatically generated, and data is written into the register and RAM. Accordingly, there is no need to input an external LOAD signal.
If the /SEL pin is changed from LOW to HIGH, the serial transfer is inhibited, and

data, which is entered after the /SEL pin is changed from HIGH to LOW, is recognized in unit of 8-bits.

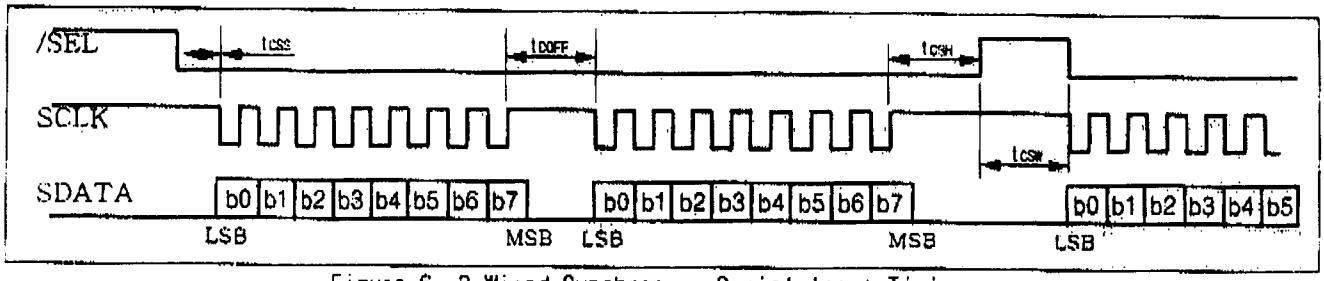



Figure_6. 3-Wired Synchronous Serial Input Timing

## 5.1 Character Code Write-in

When the first 8-bits data is a command of "DP"(Refer to section 5.2.1) after the /SEL pin is changed from HIGH to LOW, the following codes are treated as display character data. At this time, the display address (Write-in Position) is shifted to the right one digit automatically.

If a user wants to move the write-in position, the user should make a positive pulse on /SEL pin and re-enter a "DP" command.

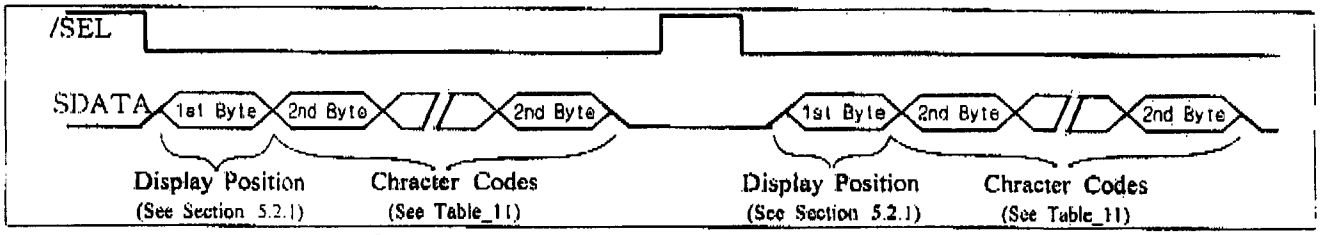



Figure_7. Character Codes Write-in Diagram

### *5.1.1 CG-RAM Character (00 Hex ~ 07 Hex)*

A user should define the CG-RAM font by UDF function (Refer to section 5.2.2), before entering the CG-RAM code into VFD module.

### *5.1.2 CG-ROM Character (08 Hex ~ FF Hex)*

When the CG-ROM character data code is written-in the module, the corresponding character font (Refer to Table_12 on next page) is displayed at current address (write-in position).

## 5.2 Control Command Write-in

The control commands should be written-in first after the /SEL pin is changed from HIGH to LOW. The control commands are listed up at Table_10 and details will be explained.

Table_10

| Symbol | Description | Hex Code | Binary Code | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
| DP | Display Position (Address Set) | 10~1F Hex | 0 | 0 | 0 | 1 | * | * | * | * |
| UDF | User Definable Font (Save CG-RAM Data) | 20~27 Hex | 0 | 0 | 1 | 0 | × | * | * | * |
| CMDP | Comma and/or Decimal Point ON/OFF | 30~3F Hex | 0 | 0 | 1 | 1 | * | * | * | * |
| DIM | Dimming (Luminance Control) | 50~57 Hex | 0 | 1 | 0 | 1 | × | * | * | * |
| DLNG | Digit Length Set | 60~67 Hex | 0 | 1 | 1 | 0 | × | * | * | * |
| ALL | All Segments ON/OFF | 70~73 Hex | 0 | 1 | 1 | 1 | × | × | * | * |

× : Don't Care, * : Selection Bits, 0 : Low Level, 1 : High Level

# Font Table

Table_11

| MSB / LSB | b7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | b6 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| | b5 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| | b4 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| b3 b2 b1 b0 | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
| 0 0 0 0 | 0 | CG-RAM0 | | | | | | | | | | | | | | | |
| 0 0 0 1 | 1 | CG-RAM1 | | | | | | | | | | | | | | | |
| 0 0 1 0 | 2 | CG-RAM2 | | | | | | | | | | | | | | | |
| 0 0 1 1 | 3 | CG-RAM3 | | | | | | | | | | | | | | | |
| 0 1 0 0 | 4 | CG-RAM4 | | | | | | | | | | | | | | | |
| 0 1 0 1 | 5 | CG-RAM5 | | | | | | | | | | | | | | | |
| 0 1 1 0 | 6 | CG-RAM6 | | | | | | | | | | | | | | | |
| 0 1 1 1 | 7 | CG-RAM7 | | | | | | | | | | | | | | | |
| 1 0 0 0 | 8 | | | | | | | | | | | | | | | | |
| 1 0 0 1 | 9 | | | | | | | | | | | | | | | | |
| 1 0 1 0 | A | | | | | | | | | | | | | | | | |
| 1 0 1 1 | B | | | | | | | | | | | | | | | | |
| 1 1 0 0 | C | | | | | | | | | | | | | | | | |
| 1 1 0 1 | D | | | | | | | | | | | | | | | | |
| 1 1 1 0 | E | | | | | | | | | | | | | | | | |
| 1 1 1 1 | F | | | | | | | | | | | | | | | | |

### 5.2.1 DP (10 Hex ~ 1F Hex) : Set Display Position (Write-in Address)

This command is used to select a digit to display a character instead of writing the character from the first digit, the write-in starting position can be pointed out by using this command.

Table_12

| Binary | | | | | | | | HEX | Digit |
|---|---|---|---|---|---|---|---|---|---|
| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | | |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 10 | Left End |
| | | | | 0 | 0 | 0 | 1 | 11 | 2nd Digit |
| | | | | 0 | 0 | 1 | 0 | 12 | 3rd Digit |
| | | | | 0 | 0 | 1 | 1 | 13 | 4th Digit |
| | | | | 0 | 1 | 0 | 0 | 14 | 5th Digit |
| | | | | 0 | 1 | 0 | 1 | 15 | 6th Digit |
| | | | | 0 | 1 | 1 | 0 | 16 | 7th Digit |
| | | | | 0 | 1 | 1 | 1 | 17 | 8th Digit |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 18 | 9th Digit |
| | | | | 1 | 0 | 0 | 1 | 19 | 10th Digit |
| | | | | 1 | 0 | 1 | 0 | 1A | 11th Digit |
| | | | | 1 | 0 | 1 | 1 | 1B | 12th Digit |
| | | | | 1 | 1 | 0 | 0 | 1C | 13th Digit |
| | | | | 1 | 1 | 0 | 1 | 1D | 14th Digit |
| | | | | 1 | 1 | 1 | 0 | 1E | 15th Digit |
| | | | | 1 | 1 | 1 | 1 | 1F | Last Digit |

### 5.2.2 UDF (20 Hex ~ 27 Hex) : User Definable Font (Save CG-RAM Font Data)

The characters can be designed by using this command. These font data are memorized in the CG-RAM of the module. Any 5×7 dots pattern can be stored in the character code location specified by the b0~b2 of 1st byte.

Table_13

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | Location | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| 1st byte | 0 | 0 | 1 | 0 | × | 0 | 0 | 0 | CG-RAM0 | Specify UDF command and character code location(CG-RAM0 ~ CG-RAM7). |
| | | | | | | 0 | 0 | 1 | CG-RAM1 | |
| | | | | | | 0 | 1 | 0 | CG-RAM2 | |
| | | | | | | 0 | 1 | 1 | CG-RAM3 | |
| | | | | | | 1 | 0 | 0 | CG-RAM4 | |
| | | | | | | 1 | 0 | 1 | CG-RAM5 | |
| | | | | | | 1 | 1 | 0 | CG-RAM6 | |
| | | | | | | 1 | 1 | 1 | CG-RAM7 | |
| 2nd byte | × | A31 | A26 | A21 | A16 | A11 | A6 | A1 | | Specify ON or OFF of 35 dots position. Table_14.1 shows the relation between segment position and data formation. Table_14.2 shows the example of "£" font designing procedure. |
| 3rd byte | × | A32 | A27 | A22 | A17 | A12 | A7 | A2 | | |
| 4th byte | × | A33 | A28 | A23 | A17 | A13 | A8 | A3 | | |
| 5th byte | × | A34 | A29 | A24 | A19 | A14 | A9 | A4 | | |
| 6th byte | × | A35 | A30 | A25 | A20 | A15 | A10 | A5 | | |

× : Don't Care

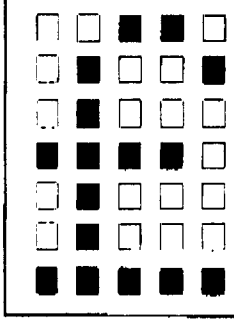
Table_14.1

| | | | | |
|---|---|---|---|---|
| A1 | A2 | A3 | A4 | A5 |
| A6 | A7 | A8 | A9 | A10 |
| A11 | A12 | A13 | A14 | A15 |
| A16 | A17 | A18 | A19 | A20 |
| A21 | A22 | A23 | A24 | A25 |
| A26 | A27 | A28 | A29 | A30 |
| A31 | A32 | A33 | A34 | A35 |

Bit Map of 5×7 Dot Matrix

Table_14.2

Pattern Example



Coding Example

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | Hex Code |
|---|---|---|---|---|---|---|---|---|---|
| 2nd byte | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 48 Hex |
| 3rd byte | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 7E Hex |
| 4th byte | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 49 Hex |
| 5th byte | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 49 Hex |
| 6th byte | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 42 Hex |

*5.2.3 CMDP (30 Hex ~ 3F Hex) : Comma and/or Decimal Point On/OFF*

This command is useful for comma and/or decimal point display ON/OFF.

Table_15

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | Digit | Description |
|---|---|---|---|---|---|---|---|---|---|---|
| 1st byte | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | Left End | Specify CMDP command and display address. |
| | | | | | 0 | 0 | 0 | 1 | 2nd Digit | |
| | | | | | 0 | 0 | 1 | 0 | 3rd Digit | |
| | | | | | : | : | : | : | : | |
| | | | | | 1 | 1 | 0 | 1 | 14th Digit | |
| | | | | | 1 | 1 | 1 | 0 | 15th Digit | |
| | | | | | 1 | 1 | 1 | 1 | Last Digit | |
| 2nd byte | × | × | × | × | × | × | 0 | 0 | Comma Off, Decimal Point Off | |
| | | | | | | | 0 | 1 | Comma Off, Decimal Point On | |
| | | | | | | | 1 | 0 | Comma On, Decimal Point Off | |
| | | | | | | | 1 | 1 | Comma On, Decimal Point On | |

× : Don't Care

This command is similar to DP function.
When a user want to display comma and/or decimal point continously, it isn't needed to re-enter this command. i.e the write-in position is incresed automatically after input of 2nd byte. Consequently, if a user doesn't want to display more comma and/or decimal point, the user should make a positive pulse of /SEL and write-in DP or another command code.

*5.2.4 DIM (50 Hex ~ 57 Hex) : Dimming*

Brightness can be controlled into 8 levels by using this function.

Table_16

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | Dimming Level |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | × | 0 | 0 | 0 | 50% (8/16), Default Value |
| | | | | | 0 | 0 | 1 | 56 % ( 9/16) |
| | | | | | 0 | 1 | 0 | 62 % (10/16) |
| | | | | | 0 | 1 | 1 | 69 % (11/16) |
| | | | | | 1 | 0 | 0 | 75 % (12/16) |
| | | | | | 1 | 0 | 1 | 81 % (13/16) |
| | | | | | 1 | 1 | 0 | 87 % (14/16) |
| | | | | | 1 | 1 | 1 | 94 % (15/16), Maximum Value |

*5.2.5 DLNG (60 Hex ~ 67 Hex) : Set Display Length*

This command is used to define the number of display digit. (9 to 16 Digits)

Table_17

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | Dimming Level |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 0 | × | 0 | 0 | 0 | 1~16 Digit, Default Value |
| | | | | | 0 | 0 | 1 | 1~ 9 Digit |
| | | | | | 0 | 1 | 0 | 1~10 Digit |
| | | | | | 0 | 1 | 1 | 1~11 Digit |
| | | | | | 1 | 0 | 0 | 1~12 Digit |
| | | | | | 1 | 0 | 1 | 1~13 Digit |
| | | | | | 1 | 1 | 0 | 1~14 Digit |
| | | | | | 1 | 1 | 1 | 1~15 Digit |

*5.2.6 ALL (70 Hex ~ 73 Hex) : All Segments ON/OFF*

All segments can be displayed or non-displayed by using this command. This command is useful for testing of VFD module, blinking of display or obviating erroneous display pattern at power on.

Table_18

| b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 | Description |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 1 | × | × | 0 | 0 | Maintain current state |
| | | | | | | 0 | 1 | All segs are OFF. (Default state) |
| | | | | | | 1 | 0 | All segs are ON. |
| | | | | | | 1 | 1 | All segs are ON. (All ON is higher priority.) |

## 5.4 Reset

The reset function allows the users to re-initialize the display controller, while the power is still applied to the module, by applying a logical "0" to pin #10(/RST) of the connector.
When the controller is initialized, the display status are shown in Table_19.

Table_19

| Initial Status after reset | |
|---|---|
| Display digit | 16 digits |
| Dimming adjustment | 8/16 |
| All display lights ON or OFF | OFF mode |
| Display position & data | Undefined |
| Comma & Decimal Point | Undefined |
| Use definable font | Undefined |

## 5.4. Recommend Initial Setting Sequence

After power on, next (Table_20) command codes are recommanded.

Table_20

| No | Initial setting items | Hex-code | Operation Result |
|---|---|---|---|
| 1 | Number of digit setting | 60H | Display length is 16 |
| 2 | Dimming adjustment setting | 57H | Dimming level is set to 100% |
| 3 | Use definable font setting | Arbitrary | Design the user definable fonts |
| 4 | Comma & Decimal point setting | 30H + 00H | Comma & Decimal point OFF |
| 5 | Display position & character data setting | 10H + Arbitrary | Display position is set to 1G |
| 6 | All display lights ON mode setting. | 70H | All outputs maintain current states |

# 6. OPERATING RECOMMENDATIONS

6.1 Avoid applying excessive shock or vibration beyond the specification for the VFD module.

6.2 Since VFDs are made of glass material, careful handling is required. i.e. Direct impact with hard material to the glass surface(especially exhaust tip) may crack the glass.

6.3 When mounting the VFD module to your system, leave a slight gap between the VFD glass and your front panel. The module should be mounted without stress to avoid flexing of the PCB.

6.4 Avoid plugging or unplugging the interface connection with the power on, otherwise it may cause the severe damage to input circuitry.

6.5 Slow starting power supply may cause non-operation because one chip micom won't be reset.

6.6 Exceeding any of maximum ratings may cause the permanent damage.

6.7 Since the VFD modules contain high voltage source, careful handling is required while power is on.

6.8 When the power is turned off, the capacitor does not discharge immediately. So the high voltage applied to the VFD must not get in contact with ICs. In other words, short-circuit of mounted components on PCB within 30 seconds after power-off may cause damage the module.

6.9 The power supply must be capable of providing at least 3 times the rated current, because the surge current may be 3 times the specified current consumption when the power is turned on.

6.10 Avoid using the module where excessive noise interference is expected. Noise may affects the interface signal and causes improper operation. And it is important to keep the length of the interface cable less than 50cm.

6.11 Since all VFD modules contain C-MOS ICs, anti-static handling procedures are always required.