# Specification

# For

# LCD Module

# 2004A

TABLE OF CONTENTS

# 1.0 INTRODUCTION

This USER'S MANUAL is introduced the outside dimensions, optical characteristics, electrical characteristics, interface, controller commands, etc. of the custom design LCD module.

# 1.1 FEATURE

(1) Display mode: STN POSITIVE, TRANSFLECTIVE, YELLOW-GREEN COLOR

(2) Display format: 20 characters X 4 line

(3) Driving method: 1/16 Duty, 1/5 Bias

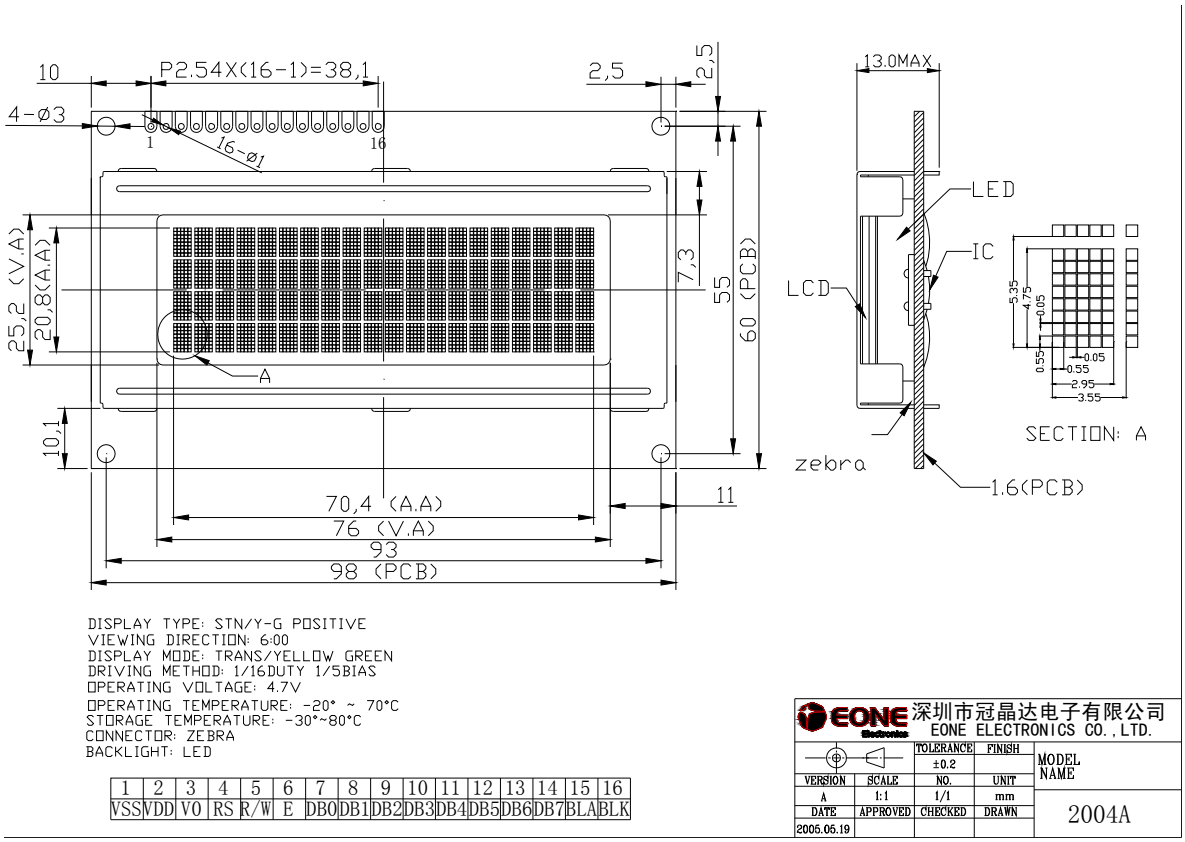
(4) Viewing direction: 6 o'clock

(5) Control IC: SPLC780D

(6) Interface Input Data : 4-Bits or 8-Bits interface available

(7) Back light: LED (Yellow-Green )

# 2.0 DIMENSION DIAGRAM




| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VSS | VDD | V0 | RS | R/W | E | DB0 | DB1 | DB2 | DB3 | DB4 | DB5 | DB6 | DB7 | BLA | BLK |

# 3.0 MECHANICAL SPECIFICATIONS

| ITEM | STANDARD VALUE | UNIT |
|---|---|---|
| DOTS | 5X8 | characters - |
| DOT SIZE | 0.55X0.55 | mm |
| DOT PITCH | 0.60X0.60 | mm |
| MODULE DIMENSION | 98.0(W) × 60.0(H) × 1.6(T) | mm |
| EFFECTIVE DISPLAY AREA | 84.0(W) × 31.0(H)MIN | mm |

# 4.0 MAX STANDARD VALUE

| ITEM | SYMBOL | MIN. | TYPE | MAX | UNIT |
|---|---|---|---|---|---|
| OPERATING TEMPERATURE | Top | -10 | 25 | 60 | ℃ |
| STORAGE TEMPERATURE | Tst | -20 | / | 70 | ℃ |
| INPUT VOLTAGE | VI | VSS | / | VDD | V |
| SUPPLY VOLTAGE FOR LOGIC | VDD-VSS | -0.3 | / | 7.0 | V |
| SUPPLY VOLTAGE FOR LCD | VDD-V0 | VDD-10.0 | / | VDD+0.3 | V |

# 5.0 ELECTRICAL CHARACTERISTICS

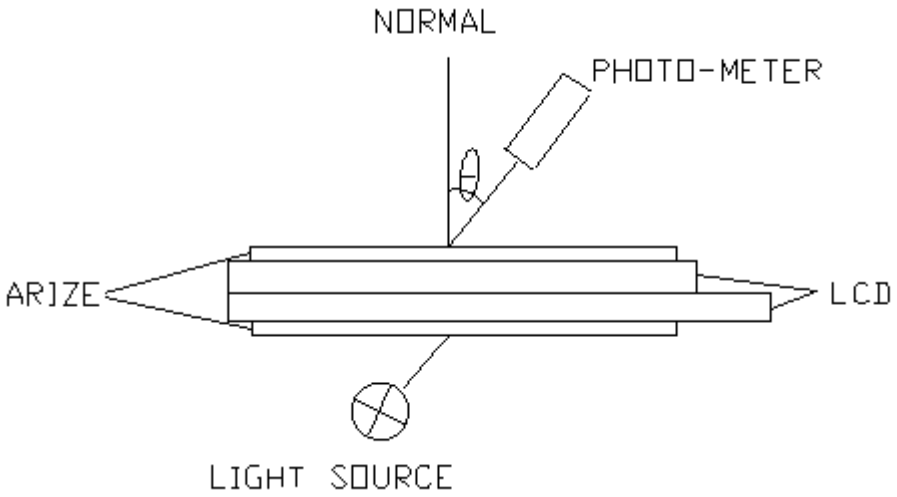
| ITEM | SYMBOL | CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| SUPPLY VOLTAGE FOR LOGIC | $V_{DD}$-$V_{SS}$ | Ta = 25 °C | 2.7 | 5.0 | 5.5 | V |
| SUPPLY VOLTAGE FOR LCD | $V_{DD}$-$V_O$ ($V_{OP}$) | Ta = 25 °C | 3.0 | 5.0 | 10.0 | V |
| INPUT HIGH VOL. | $V_{IH}$ | Ta = 25 °C | 0.7VDD | - | $V_{DD}$ | V |
| INPUT LOW VOL. | $V_{IL}$ | Ta = 25 °C | -0.3 | - | 0.6 | V |
| OUTPUT HIGH VOL. | $V_{OH}$ | Ta = 25 °C | 0.75VDD | - | - | V |
| OUTPUT LOW VOL. | $V_{OL}$ | Ta = 25 °C | - | - | 0.2VDD | V |
| SUPPLY CURRENT | $I_{DD}$ | $V_{DD}$ = 3.0V | - | 0.1 | 0.25 | mA |

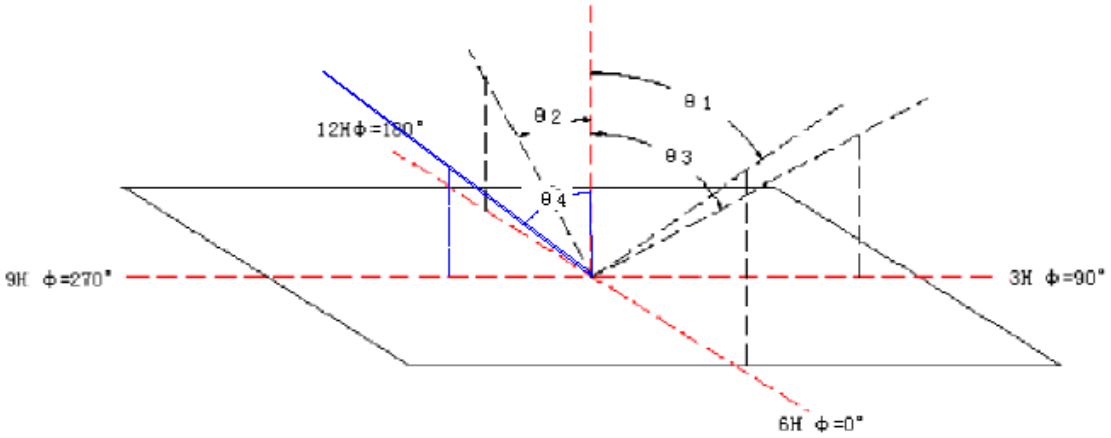
# 6.0 OPTICAL CHARACTERISTICS

| No | Item | | Symbol | Measurement temperature | MIN. | TYP. | MAX. | Unit |
|---|---|---|---|---|---|---|---|---|
| 1 | Contrast Ratio | | Cr | 25℃ | 2.60 | 3.17 | | |
| 2 | Response Time | Rise time | Tr | 25℃ | - | - | 0.2 | us |
| | | Fall time | Tf | 25℃ | - | - | 0.2 | us |
| 3 | Viewing Angle | 6H, Φ=0° | θ 1 | 25℃ | 55 | | | Deg. |
| | | 12H, Φ=180 | θ 2 | 25℃ | 0 | | | Deg. |
| | | Φ=90° | θ 3 | 25℃ | 45 | | | Deg. |
| | | Φ=270 | θ 4 | 25℃ | 45 | | | Deg. |
| 4 | Frame Frequency | | | 25℃ | 190 | 270 | 350 | Hz |

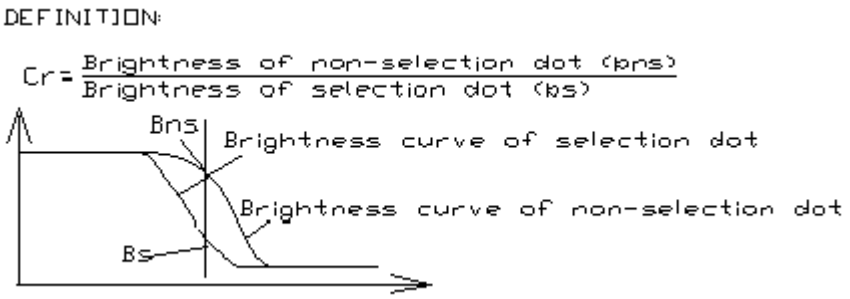
# 6.1 OPTICAL MEASUREMENT SYSTEM



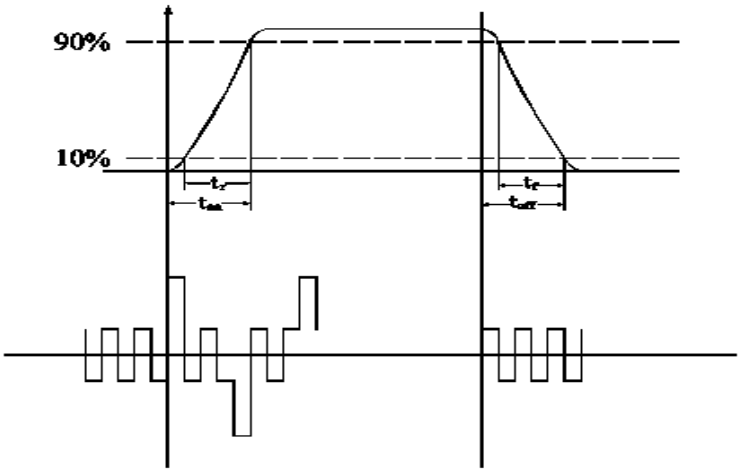

# 6.2 DEFINITION OF θ AND Φ




# 6.3 DEFINITION OF CONTRAST RATIO Cr



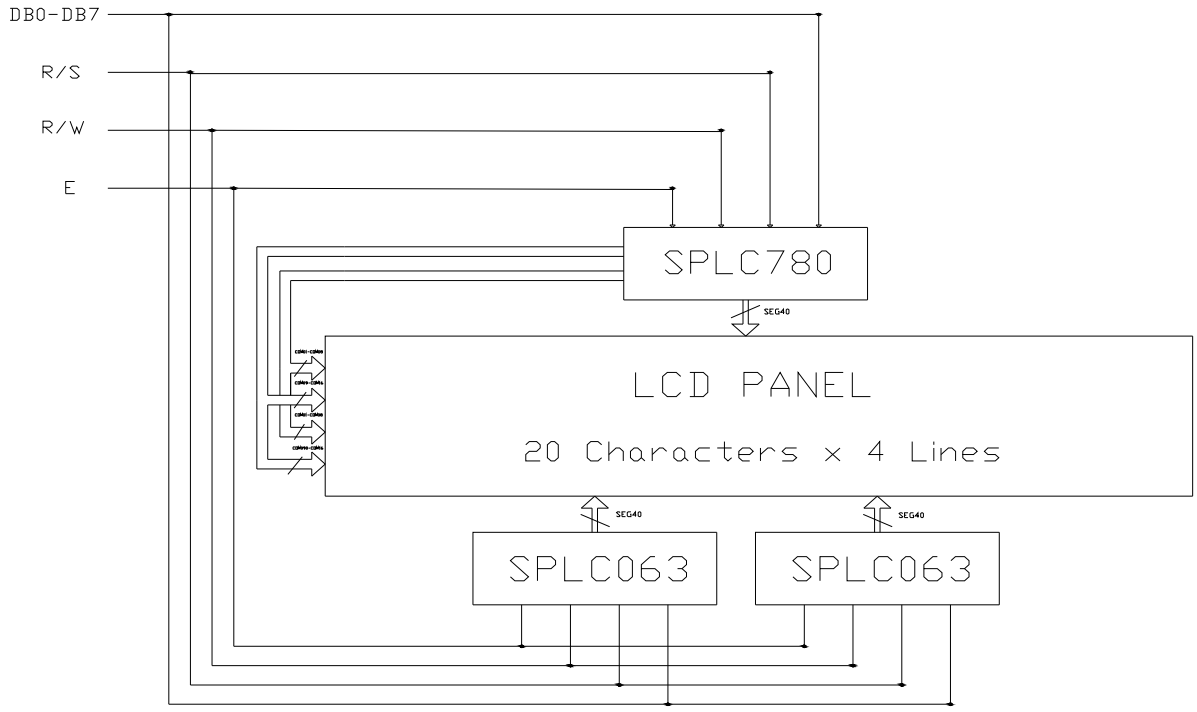

# 6.4 DEFINITION OF OPTICAL RESPONSE TIME



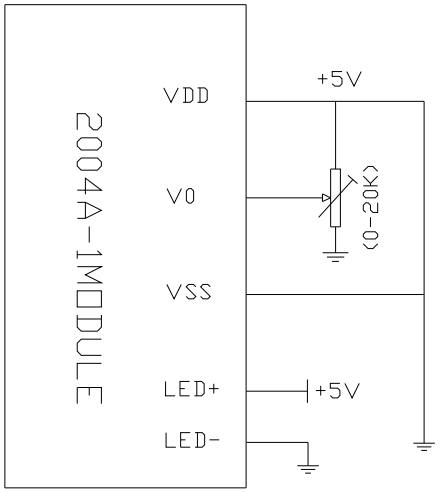

# 7.0 INTERFACE PIN FUNCTION DESCRIPTION

| PIN NO | SYMBOL | FUNCTION |
|---|---|---|
| 1 | VSS | Power Ground |
| 2 | VDD | Power supply for logic circuit(+5V) |
| 3 | V0 | For LCD drive voltage (variable) |
| 4 | RS(C/D) | H: Display Data, L:Display Instruction |
| 5 | R/W | H: Data Read (LCM to MPU) ; L: Data Write (MPU to LCM) |
| 6 | E | Enable signal.<br>Write mode (R/W = L) data of DB<0:7> is latched at the<br>falling edge of E.<br>Read mode (R/W = H) DB<0:7> appears the reading data<br>while E is at high level |
| 7-14 | DB0-DB7 | Data bus. There state I/O common terminal. |
| 15 | A | Power for LED Backlight (+5V) |
| 16 | K | Power for LED Backlight (Ground) |

# 8.0 BLOCK DIAGRAM




# 8.1 POWER SUPPLY BLOCK DIAGRAM




# 9.0 TIMING CHARACTERISTICS

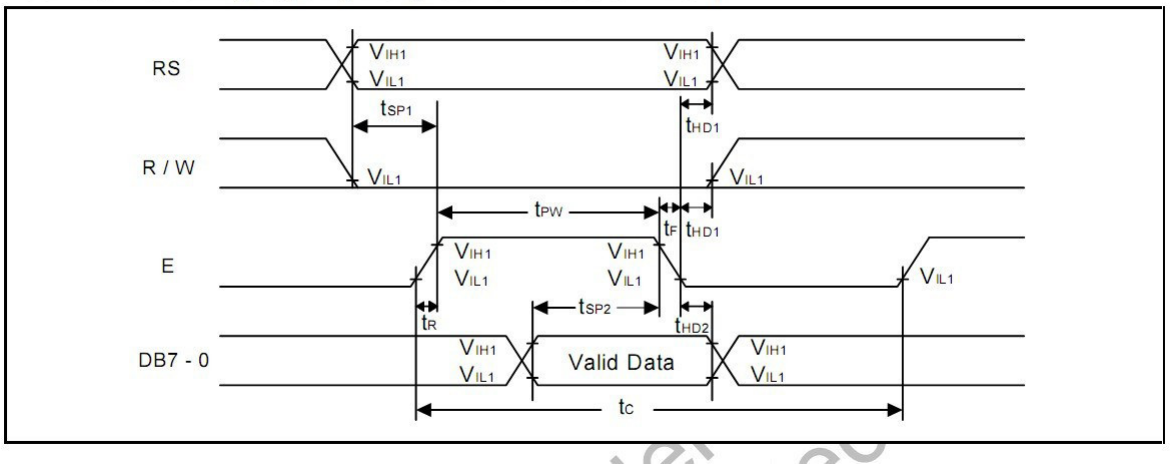
### 7.3.3. Write mode (Writing data from MPU to SPLC780D)

| Characteristics | Symbol | Limit | | | Unit | Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| E Cycle Time | $t_C$ | 1000 | - | - | ns | Pin E |
| E Pulse Width | $t_{PW}$ | 450 | - | - | ns | Pin E |
| E Rise/Fall Time | $t_R$, $t_F$ | - | - | 25 | ns | Pin E |
| Address Setup Time | $t_{SP1}$ | 60 | - | - | ns | Pins: RS, R/W, E |
| Address Hold Time | $t_{HD1}$ | 20 | - | - | ns | Pins: RS, R/W, E |
| Data Setup Time | $t_{SP2}$ | 195 | - | - | ns | Pins: DB0 - DB7 |
| Data Hold Time | $t_{HD2}$ | 10 | - | - | ns | Pins: DB0 - DB7 |

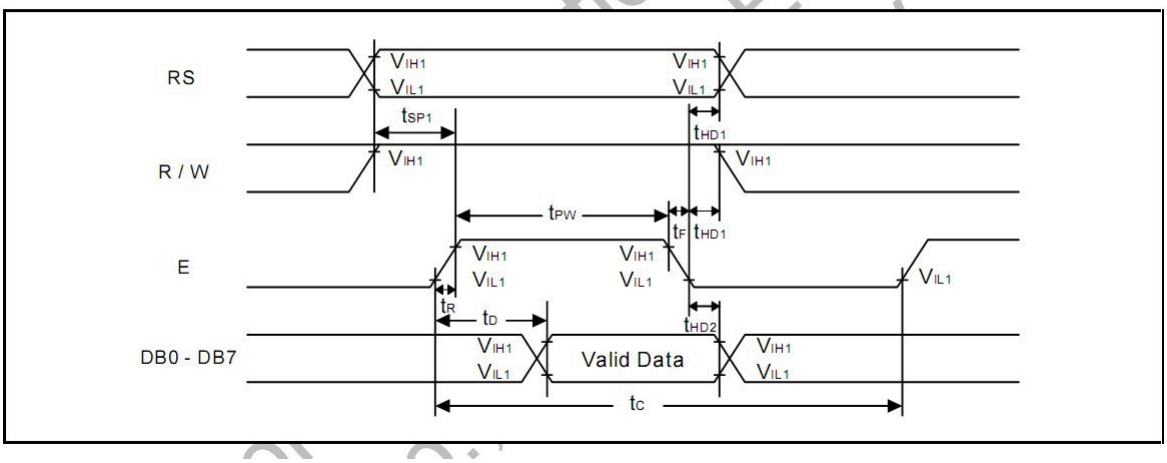
### 7.3.4. Read mode (Reading data from SPLC780D to MPU)

| Characteristics | Symbol | Limit | | | Unit | Test Condition |
|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | | |
| E Cycle Time | $t_C$ | 1000 | - | - | ns | Pin E |
| E Pulse Width | $t_W$ | 450 | - | - | ns | Pin E |
| E Rise/Fall Time | $t_R$, $t_F$ | - | - | 25 | ns | Pin E |
| Address Setup Time | $t_{SP1}$ | 60 | - | - | ns | Pins: RS, R/W, E |
| Address Hold Time | $t_{HD1}$ | 20 | - | - | ns | Pins: RS, R/W, E |
| Data Output Delay Time | $t_D$ | - | - | 360 | ns | Pins: DB0 - DB7 |
| Data hold time | $t_{HD2}$ | 5.0 | - | - | ns | Pin DB0 - DB7 |

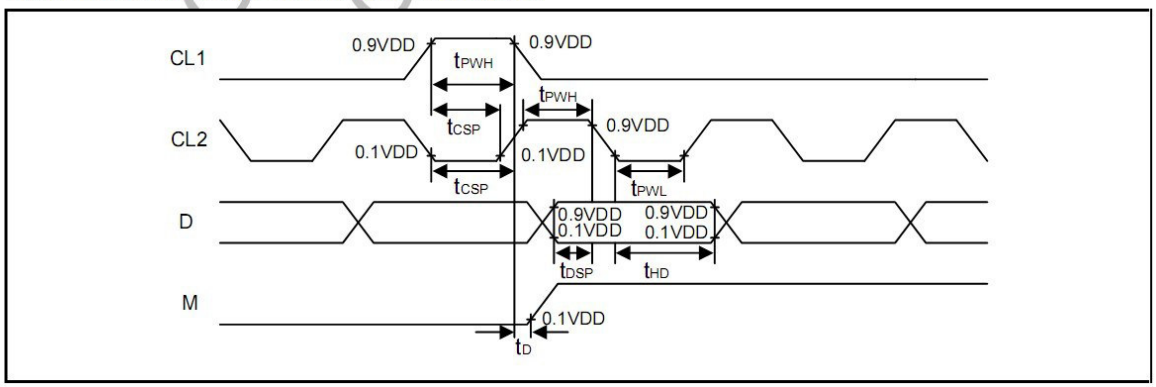
### 7.5.6. Write mode timing diagram (Writing Data from MPU to SPLC780D)



**7.5.7. Read mode timing diagram (Reading Data from SPLC780D to MPU)**




**7.5.8. Interface mode with SPLC100A1 timing diagram**




# 10.0 Display control instruction

The display control instructions control the internal state of the SPLC780D-01. Instruction is received from MPU to SPLC780D-01for the display control. The following table shows various instructions.

### 6.3. Instruction Table

| Instruction | Instruction Code | | | | | | | | | | Description | Execution time (Temp = 25℃) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 | | Fosc= 190KHz | Fosc= 270KHz | Fosc= 350KHz |
| Clear Display | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | Write "20H" to DDRAM and set DDRAM address to "00H" from AC | 2.16ms | 1.52ms | 1.18ms |
| 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. | 2.16ms | 1.52ms | 1.18ms |
| 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 | 53μs | 38μs | 29μs |
| 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. | 53μs | 38μs | 29μs |
| 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. | 53μs | 38μs | 29μs |
| 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) | 53μs | 38μs | 29μs |
| Set CGRAM Address | 0 | 0 | 0 | 1 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set CGRAM address in address counter. | 53μs | 38μs | 29μs |
| Set DDRAM Address | 0 | 0 | 1 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 | Set DDRAM address in address counter | 53μs | 38μs | 29μs |
| 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). | 53μs | 38μs | 29μs |
| Read Data from RAM | 1 | 1 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | Read data from internal RAM (DDRAM/CGRAM). | 53μs | 38μs | 29μs |

**Note1:** "--": don't care

**Note2:** In the operation condition under -20℃ ~ 75℃, the maximum execution time for majority of instruction sets is 100us, except two instructions, "Clear Display" and "Return Home", in which maximum execution time can take up to 4.1ms.

## ■ Instruction Description

- **Clear Display**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

Clear all the display data by writing "20H" (space code) to all DDRAM address, and set DDRAM address to "00H" into AC (address counter). Return cursor to the original status, namely, bring the cursor to the left edge on first line of the display. Make entry mode increment (I/D = "1").

- **Return Home**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | x |

Return Home is cursor return home instruction. Set DDRAM address to "00H" into the address counter. Return cursor to its original site and return display to its original status, if shifted. Contents of DDRAM does not change.

- **Entry Mode Set**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | I/D | S |

Set the moving direction of cursor and display.

- **I/D : Increment / decrement of DDRAM address (cursor or blink)**
  When I/D = "High", cursor/blink moves to right and DDRAM address is increased by 1.
  When I/D = "Low", cursor/blink moves to left and DDRAM address is decreased by 1.
  * CGRAM operates the same as DDRAM, when read from or write to CGRAM.
- **S: Shift of entire display**
  When DDRAM read (CGRAM read/write) operation or S = "Low", shift of entire display is not performed. If S = "High" and DDRAM write operation, shift of entire display is performed according to I/D value (I/D = "1" : shift left, I/D = "0" : shift right).

| S | I/D | Description |
|---|---|---|
| H | H | Shift the display to the left |
| H | L | Shift the display to the right |

- **Display ON/OFF**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 0 | 0 | 0 | 0 | 1 | D | C | B |

Control display/cursor/blink ON/OFF 1 bit register.

- **D : Display ON/OFF control bit**
  When D = "High", entire display is turned on.
  When D = "Low", display is turned off, but display data is remained in DDRAM.
- **C : Cursor ON/OFF control bit**
  When C = "High", cursor is turned on.
  When C = "Low", cursor is disappeared in current display, but I/D register remains its data.
- **B : Cursor Blink ON/OFF control bit**
  When B = "High", cursor blink is on, that performs alternate between all the high data and display character at the cursor position.
  When B = "Low", blink is off.

- **Cursor or Display Shift**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 0 | 0 | 0 | 1 | S/C | R/L | x | x |

Without writing or reading of display data, shift right/left cursor position or display. This instruction is used to correct or search display data. During 2-line mode display, cursor moves to the 2nd line after 40th digit of 1st line. Note that display shift is performed simultaneously in all the line. When displayed data is shifted repeatedly, each line shifted individually. When display shift is performed, the contents of address counter are not changed.

| S/C | R/L | Description | AC Value |
|---|---|---|---|
| L | L | Shift cursor to the left | AC=AC-1 |
| L | H | Shift cursor to the right | AC=AC+1 |
| H | L | Shift display to the left. Cursor follows the display shift | AC=AC |
| H | H | Shift display to the right. Cursor follows the display shift | AC=AC |

- **Function Set**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 0 | 0 | 1 | DL | N | F | x | x |

- **DL : Interface data length control bit**
  When DL = "High", it means 8-bit bus mode with MPU.
  When DL = "Low", it means 4-bit bus mode with MPU. So to speak, DL is a signal to select 8-bit or 4-bit bus mode.
  When 4-bit bus mode, it needs to transfer 4-bit data by two times.
- **N : Display line number control bit**
  When N = "Low", it means 1-line display mode.
  When N = "High", 2-line display mode is set.
- **F : Display font type control bit**
  When F = "Low", it means 5 x 8 dots format display mode
  When F = "High", 5 x11 dots format display mode.

| N | F | No. of Display Lines | Character Font | Duty Factor |
|---|---|---|---|---|
| L | L | 1 | 5x8 | 1/8 |
| L | H | 1 | 5x11 | 1/11 |
| H | x | 2 | 5x8 | 1/16 |

- **Set CGRAM Address**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 0 | 1 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |

Set CGRAM address to AC.
This instruction makes CGRAM data available from MPU.

- **Set DDRAM Address**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 0 | 1 | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |

Set DDRAM address to AC.
This instruction makes DDRAM data available from MPU.
When 1-line display mode (N = 0), DDRAM address is from "00H" to "4FH".
In 2-line display mode (N = 1), DDRAM address in the 1st line is from "00H" to "27H", and DDRAM address in the 2nd line is from "40H" to "67H".

- **Read Busy Flag and Address**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 0 | 1 | BF | AC6 | AC5 | AC4 | AC3 | AC2 | AC1 | AC0 |

When BF = "High", indicates that the internal operation is being processed.So during this time the next instruction cannot be accepted.

The address Counter (AC) stores DDRAM/CGRAM addresses, transferred from IR.

After writing into (reading from) DDRAM/CGRAM, AC is automatically increased (decreased) by 1.

- **Write Data to CGRAM or DDRAM**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 1 | 0 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

Write binary 8-bit data to DDRAM/CGRAM.

The selection of RAM from DDRAM, CGRAM, is set by the previous address set instruction : DDRAM address set, CGRAM address set. RAM set instruction can also determine the AC direction to RAM.

After write operation, the address is automatically increased/decreased by 1, according to the entry mode.

- **Read Data from CGRAM or DDRAM**

| | RS | RW | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Code | 1 | 1 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |

Read binary 8-bit data from DDRAM/CGRAM.

The selection of RAM is set by the previous address set instruction. If address set instruction of RAM is not performed before this instruction, the data that read first is invalid, because the direction of AC is not determined. If you read RAM data several times without RAM address set instruction before read operation, you can get correct RAM data from the second, but the first data would be incorrect, because there is no time margin to transfer RAM data.

In case of DDRAM read operation, cursor shift instruction plays the same role as DDRAM address set instruction : it also transfer RAM data to output data register. After read operation address counter is automatically increased/decreased by 1 according to the entry mode. After CGRAM read operation, display shift may not be executed correctly.

* In case of RAM write operation, after this AC is increased/decreased by 1 like read operation. In this time, AC indicates the next address position, but you can read only the previous data by read instruction.

## 10. CHARACTER GENERATOR ROM

### 10.1. SPLC780D1 – 001A