

## **SPLC780D**

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### **16COM/40SEG Controller/Driver**

***Preliminary***

AUG. 06, 2003

Version 0.1

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## 16COM/40SEG CONTROLLER/DRIVER

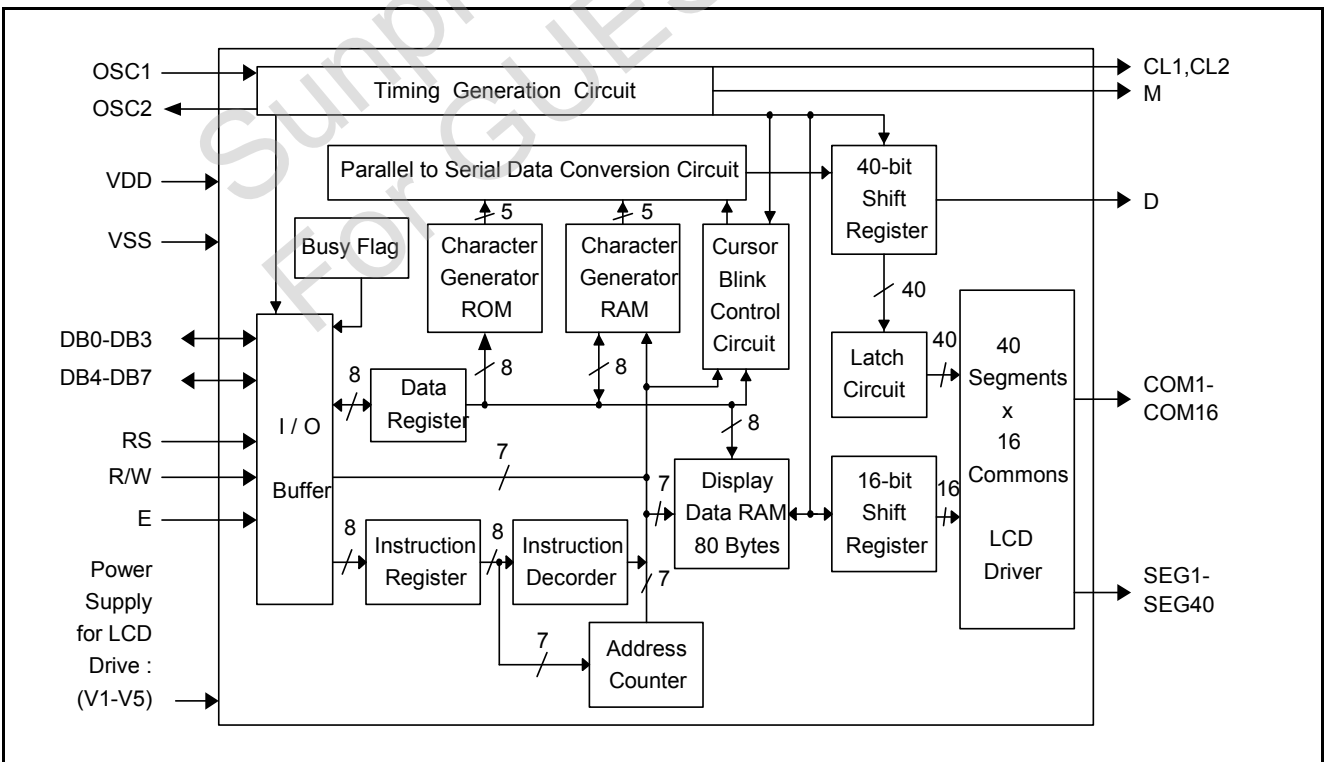
### 1. GENERAL DESCRIPTION

The SPLC780D, a dot-matrix LCD controller and driver from SUNPLUS, is a unique design for displaying alpha-numeric, Japanese-Kana characters and symbols. The SPLC780D provides two types of interfaces to MPU: 4-bit and 8-bit interfaces. The transferring speed of 8-bit is twice faster than 4-bit. A single SPLC780D is able to display up to two 8-character lines. By cascading with SPLC100 or SPLC063, the display capability can be extended. The CMOS technology ensures the power saves in the most efficient way and the performance keeps in the highest rank.

### 2. FEATURES

- Character generator ROM: 10880 bits
  - Character font 5 x 8 dots: 192 characters
  - Character font 5 x 10 dots: 64 characters
- Character generator RAM: 512 bits
  - Character font 5 x 8 dots: 8 characters
  - Character font 5 x 10 dots: 4 characters
- 4-bit or 8-bit MPU interfaces
- Direct driver for LCD: 16 COMs x 40 SEGs
- Duty factor (selected by program):
  - 1/8 duty: 1 line of 5 x 8 dots
  - 1/11 duty: 1 line of 5 x 10 dots
  - 1/16 duty: 2 lines of 5 x 8 dots / line
- Built-in power on automatic reset circuit
- Built-in oscillator circuit (with external resistor)
- Support external clock operation
- Low Power Consumption
- Package form: 80 QFP or bare chip available

### 3. BLOCK DIAGRAM



**4. SIGNAL DESCRIPTIONS**

Mnemonic	PIN No.	Type	Description
VDD	33	I	Power input
VSS	23	I	Ground
OSC1 OSC2	24 25	-	Both OSC1 and OSC2 are connected to resistor for internal oscillator circuit. For external clock operation, the clock is input to OSC1.
V1 - V5	26 - 30	I	Supply voltage for LCD driving.
E	38	I	A start signal for reading or writing data.
R/W	37	I	A signal for selecting read or write actions. 1: Read, 0: Write.
RS	36	I	A signal for selecting registers. 1: Data Register (for read and write) 0: Instruction Register (for write), Busy flag - Address Counter (for read).
DB0 - DB3	39 - 42	I/O	Low 4-bit data
DB4 - DB7	43 - 46	I/O	High 4-bit data
CL1	31	O	Clock to latch serial data D.
CL2	32	O	Clock to shift serial data D.
M	34	O	Switch signal to convert LCD waveform to AC.
D	35	O	Sends character pattern data corresponding to each common signal serially. 1: Selection, 0: Non-selection.
SEG1 - SEG22 SEG23 - SEG40	22 - 1 80 - 63	O	Segment signals for LCD.
COM1 - COM16	47 - 62	O	Common signals for LCD.

**4.1. Ordering Information**

Product Number	Package Type
SPLC780D-NnnV-C	Chip form
SPLC780D-NnnV-PQ05	Package form - QFP 80L

**Note1:** Code number is assigned for customer.

**Note2:** Code number (N = A - Z or 0 - 9, nn = 00 - 99); version (V = A - Z).

## 5. FUNCTIONAL DESCRIPTIONS

### 5.1. Oscillator

SPLC780D oscillator supports not only the internal oscillator operation, but also the external clock operation.

### 5.2. Control and Display Instructions

Control and display instructions are described in details as follows:

#### 5.2.1. Clear display

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	0	0	1

It clears the entire display and sets Display Data RAM Address 0 in Address Counter.

#### 5.2.2. Return home

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	0	1	X

X: Do not care (0 or 1)

It sets Display Data RAM Address 0 in Address Counter and the display returns to its original position. The cursor or blink goes to the most-left side of the display (to the 1st line if 2 lines are displayed). The contents of the Display Data RAM do not change.

#### 5.2.3. Entry mode set

During writing and reading data, it defines cursor moving direction and shifts the display.

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	0	1	I/D	S

I / D = 1: Increment, I / D = 0: Decrement.

S = 1: The display shift, S = 0: The display does not shift.

S = 1	I / D = 1	It shifts the display to the left
S = 1	I / D = 0	It shifts the display to the right

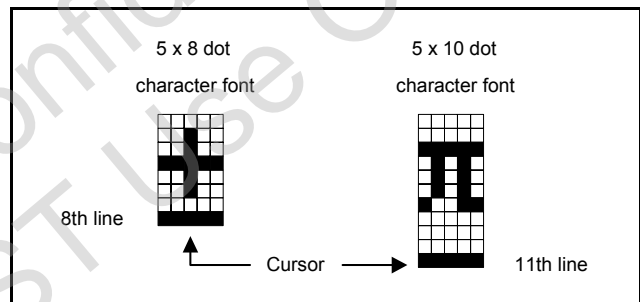
#### 5.2.4. Display ON/OFF control

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	0	1	D	C	B

D = 1: Display on, D = 0: Display off

C = 1: Cursor on, C = 0: Cursor off

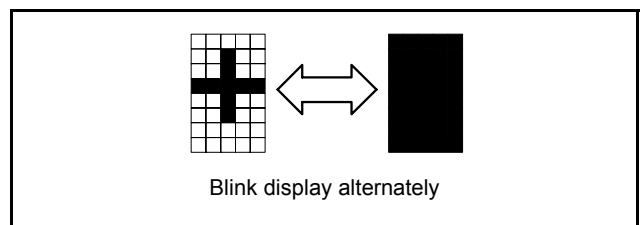
B = 1: Blinks on, B = 0: Blinks off



#### 5.2.5. Cursor or display shift

Without changing DD RAM data, it moves cursor and shifts display.

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	0	1	S/C	R/L	X	X



S/C	R/L	Description	Address Counter
0	0	Shift cursor to the left	AC = AC - 1
0	1	Shift cursor to the right	AC = AC + 1
1	0	Shift display to the left. Cursor follows the display shift	AC = AC
1	1	Shift display to the right. Cursor follows the display shift	AC = AC

**5.2.6. Function set**

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	0	1	DL	N	F	X	X

X: Do not care (0 or 1)

DL: It sets interface data length.

DL = 1: Data transferred with 8-bit length (DB7 - 0).

DL = 0: Data transferred with 4-bit length (DB7 - 4).

It requires two times to accomplish data transferring.

N: It sets the number of the display line.

N = 0: One-line display.

N = 1: Two-line display.

F: It sets the character font.

F = 0: 5 x 8 dots character font.

F = 1: 5 x 10 dots character font.

N	F	No. of Display Lines	Character Font	Duty Factor
0	0	1	5 x 8 dots	1 / 8
0	1	1	5 x 10 dots	1 / 11
1	X	2	5 x 8 dots	1 / 16

It cannot display two lines with 5 x 10 dots character font.

**5.2.7. Set character generator RAM address**

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	0	1	a	a	a	a	a	a

It sets Character Generator RAM Address (aaaaaa)<sub>2</sub> to the Address Counter.

Character Generator RAM data can be read or written after this setting.

**5.2.8. Set display data RAM address**

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	1	a	a	a	a	a	a	a

It sets Display Data RAM Address (aaaaaa)<sub>2</sub> to the Address Counter.

Display data RAM can be read or written after this setting.

In one-line display (N = 0),

$$(aaaaaaa)_2: (00)_{16} - (4F)_{16}.$$

In two-line display (N = 1),

$$(aaaaaaa)_2: (00)_{16} - (27)_{16} \text{ for the first line,}$$

$$(aaaaaaa)_2: (40)_{16} - (67)_{16} \text{ for the second line.}$$

**5.2.9. Read busy flag and address**

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	BF	a	a	a	a	a	a	a

When BF = 1, it indicates the system is busy now and it will not accept any instruction until not busy (BF = 0). At the same time, the content of Address Counter (aaaaaa)<sub>2</sub> is read.

**5.2.10. Write data to character generator RAM or display data RAM**

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	1	0	d	d	d	d	d	d	d	d

It writes data (ddddddd)<sub>2</sub> to character generator RAM or display data RAM.

**5.2.11. Read data from character generator RAM or display data RAM**

	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	1	1	d	d	d	d	d	d	d	d

It reads data (ddddddd)<sub>2</sub> from character generator RAM or display data RAM.

To read data correctly, do the following:

- 1). The address of the Character Generator RAM or Display Data RAM or shift the cursor instruction.
- 2). The " Read " instruction.

**5.3. Instruction Table**

Instruction	Instruction Code										Description	Execution time (fosc=270KHz)	
	RS	R/W	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	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	0	1	I/D	S	Assign cursor moving direction and enable the shift of entire display	38μs
Display ON/OFF Control	0	0	0	0	0	0	0	1	D	C	B	Set display(D), cursor(C), and blinking of cursor(B) on/off control bit.	38μs
Cursor or Display Shift	0	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.	38μs
Function Set	0	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)	38μs
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0		Set CGRAM address in address counter.	38μs
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0		Set DDRAM address in counter	38μs
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).	38μs
Read Data from RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0		Read data from internal RAM (DDRAM/CGRAM).	38μs

Note: "-": don't care

**5.4. 8-Bit Operation and 8-Digit 1-Line Display (Using Internal Reset)**

No.	Instruction	Display	Operation
1	Power on. (SPLC780D starts initializing)	<input type="text"/>	Power on reset. No display.
2	Function set RS R/W DB7 DB6 DB5 DB4 DB3 DB2 DB1 DB0 <input type="text"/>	<input type="text"/>	Set to 8-bit operation and select 1-line display line and character font.
3	Display on / off control <input type="text"/>	<input type="text"/>	Display on. Cursor appear.
4	Entry mode set <input type="text"/>	<input type="text"/>	Increase address by one. It will shift the cursor to the right when writing to the DD RAM/CG RAM. Now the display has no shift.
5	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " W ". The cursor is incremented by one and shifted to the right.
6	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " E ". The cursor is incremented by one and shifted to the right.
7	:	:	
8	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " E ". The cursor is incremented by one and shifted to the right.
9	Entry mode set <input type="text"/>	<input type="text"/>	Set mode for display shift when writing
10	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " "(space). The cursor is incremented by one and shifted to the right.
11	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " C ". The cursor is incremented by one and shifted to the right.
12	:	:	
13	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " Y ". The cursor is incremented by one and shifted to the right.
14	Cursor or display shift <input type="text"/>	<input type="text"/>	Only shift the cursor's position to the left (Y).
15	Cursor or display shift <input type="text"/>	<input type="text"/>	Only shift the cursor's position to the left (M).
16	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " N ". The display moves to the left.
17	Cursor or display shift <input type="text"/>	<input type="text"/>	Shift the display and the cursor's position to the right.
18	Cursor or display shift <input type="text"/>	<input type="text"/>	Shift the display and the cursor's position to the right.
19	Write data to CG RAM / DD RAM <input type="text"/>	<input type="text"/>	Write " "(space). The cursor is incremented by one and shifted to the right.
20	:	:	
21	Return home <input type="text"/>	<input type="text"/>	Both the display and the cursor return to the original position (address 0).



**5.5. 4-Bit Operation and 8-Digit 1-Line Display (Using Internal Reset)**

No.	Instruction	Display	Operation												
1	Power on. (SPLC780D starts initializing)	<input type="text"/>	Power on reset. No display.												
2	Function set RS R/W DB7 DB6 DB5 DB4 <table border="1"><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr></table>	0	0	0	0	1	0	<input type="text"/>	Set to 4-bit operation.						
0	0	0	0	1	0										
3	<table border="1"><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>X</td><td>X</td></tr></table>	0	0	0	0	1	0	0	0	0	0	X	X	<input type="text"/>	Set to 4-bit operation and select 1-line display line and character font.
0	0	0	0	1	0										
0	0	0	0	X	X										
4	<table border="1"><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td></tr></table>	0	0	0	0	0	0	0	0	1	1	1	0	<input type="text" value="-"/>	Display on. Cursor appears.
0	0	0	0	0	0										
0	0	1	1	1	0										
5	<table border="1"><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td></tr></table>	0	0	0	0	0	0	0	0	0	1	1	0	<input type="text" value="-"/>	Increase address by one. It will shift the cursor to the right when writing to the DD RAM / CG RAM. Now the display has no shift.
0	0	0	0	0	0										
0	0	0	1	1	0										
6	<table border="1"><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td></tr></table>	1	0	0	1	0	1	1	0	0	1	1	1	<input type="text" value="W_"/>	Write " W ". The cursor is incremented by one and shifted to the right.
1	0	0	1	0	1										
1	0	0	1	1	1										

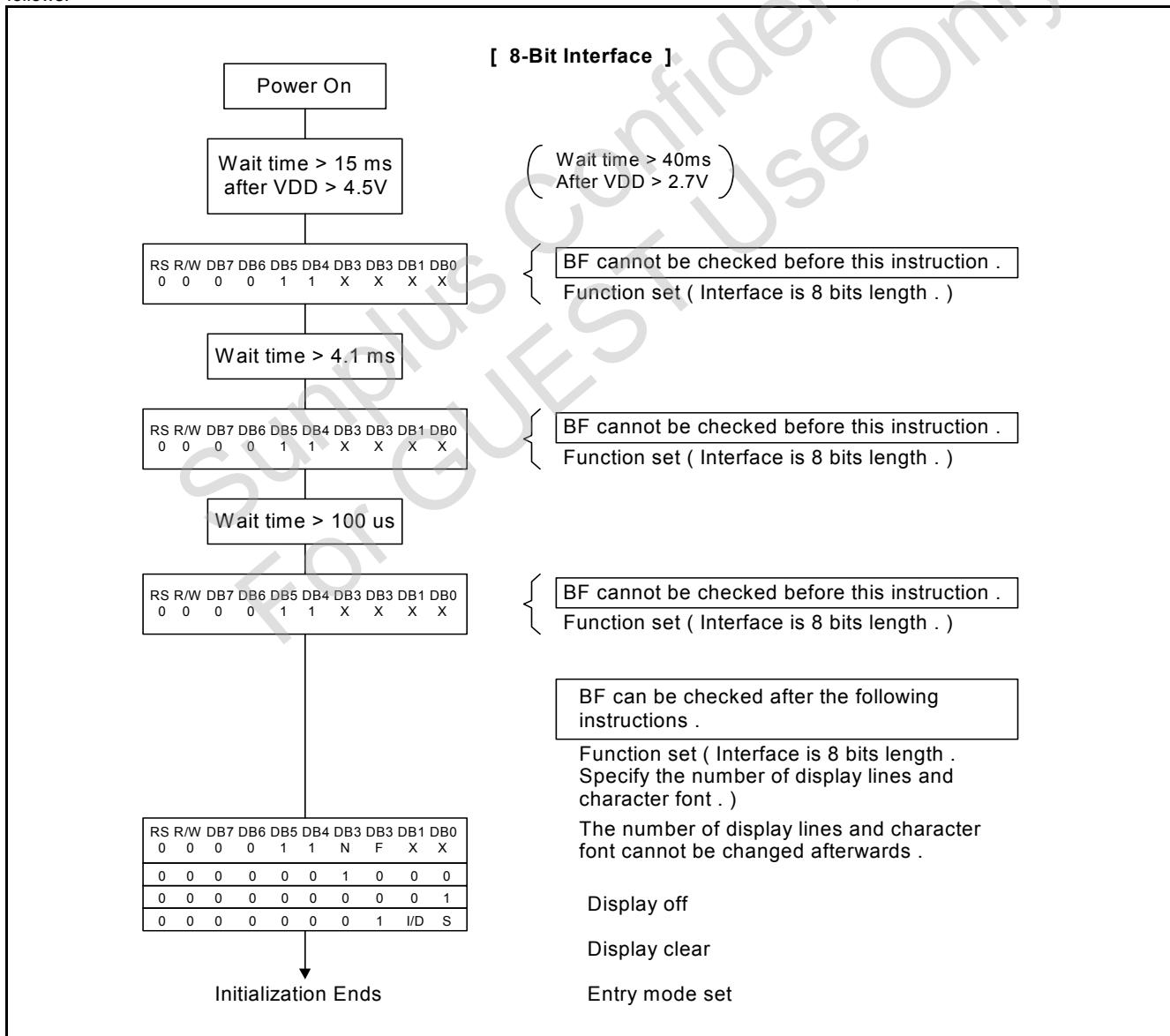
**5.6. 8-Bit Operation and 8-Digit 2-Line Display (Using Internal Reset)**

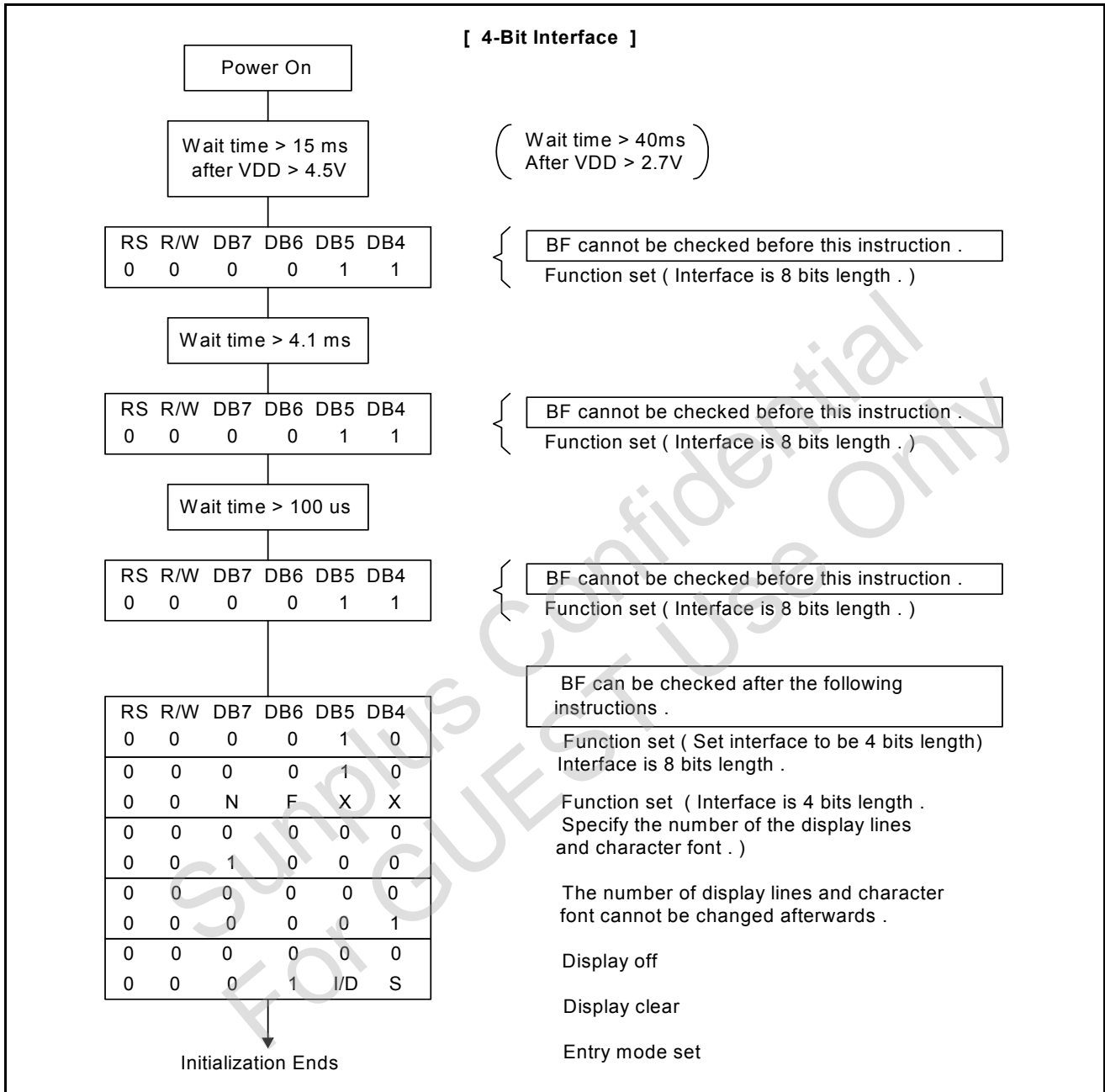
No.	Instruction	Display	Operation										
1	Power on. (SPLC780D starts initializing)	<input type="text"/>	Power on reset. No display.										
2	Function set RS R/W DB7 DB6 DB5 DB4 DB3 DB2 DB1 DB0 <table border="1"><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td><td>X</td><td>X</td></tr></table>	0	0	0	0	1	1	1	0	X	X	<input type="text"/>	Set to 8-bit operation and select 2-line display line and 5 x 8 dot character font.
0	0	0	0	1	1	1	0	X	X				
3	Display on / off control <table border="1"><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td></tr></table>	0	0	0	0	0	0	1	1	1	0	<input type="text" value="-"/>	Display on. Cursor appear.
0	0	0	0	0	0	1	1	1	0				
4	Entry mode set <table border="1"><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td></tr></table>	0	0	0	0	0	0	0	1	1	0	<input type="text" value="-"/>	Increase address by one. It will shift the cursor to the right when writing to the DD RAM / CG RAM. Now the display has no shift.
0	0	0	0	0	0	0	1	1	0				
5	Write data to CG RAM / DD RAM <table border="1"><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td></tr></table>	1	0	0	1	0	1	0	1	1	1	<input type="text" value="W_"/>	Write " W ". The cursor is incremented by one and shifted to the right.
1	0	0	1	0	1	0	1	1	1				
6	:	:	:										
7	Write data to CG RAM / DD RAM <table border="1"><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr></table>	1	0	0	1	0	0	0	1	0	1	<input type="text" value="WELCOME_"/>	Write " E ". The cursor is incremented by one and shifted to the right.
1	0	0	1	0	0	0	1	0	1				
8	Set DD RAM address <table border="1"><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr></table>	0	0	1	1	0	0	0	0	0	0	<input type="text" value="WELCOME_"/>	It sets DD RAM's address. The cursor is moved to the beginning position of the 2nd line.
0	0	1	1	0	0	0	0	0	0				
9	Write data to CG RAM / DD RAM <table border="1"><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td></tr></table>	1	0	0	1	0	1	0	1	0	0	<input type="text" value="WELCOME_"/> <input type="text" value="T_"/>	Write " T ". The cursor is incremented by one and shifted to the right.
1	0	0	1	0	1	0	1	0	0				
10	:	:	:										
11	Write data to CG RAM / DD RAM <table border="1"><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>0</td></tr></table>	1	0	0	1	0	1	0	1	0	0	<input type="text" value="WELCOME_"/> <input type="text" value="TO PART_"/>	Write " T ". The cursor is incremented by one and shifted to the right.
1	0	0	1	0	1	0	1	0	0				

No.	Instruction	Display	Operation
12	Entry mode set 0 0 0 0 0 0 0 1 1 1	WELCOME TO PART_	When writing, it sets mode for the display shift.
13	Write data to CG RAM / DD RAM 1 0 0 1 0 1 1 0 0 1	ELCOME O PARTY_	Write " Y ". The cursor is incremented by one and shifted to the right.
14	:	:	:
15	Return home 0 0 0 0 0 0 0 0 1 0	WELCOME TO PARTY	Both the display and the cursor return to the original position (address 0).

### 5.7. Reset Function

At power on, SPLC780D starts the internal auto-reset circuit and executes the initial instructions. The initial procedures are shown as follows:

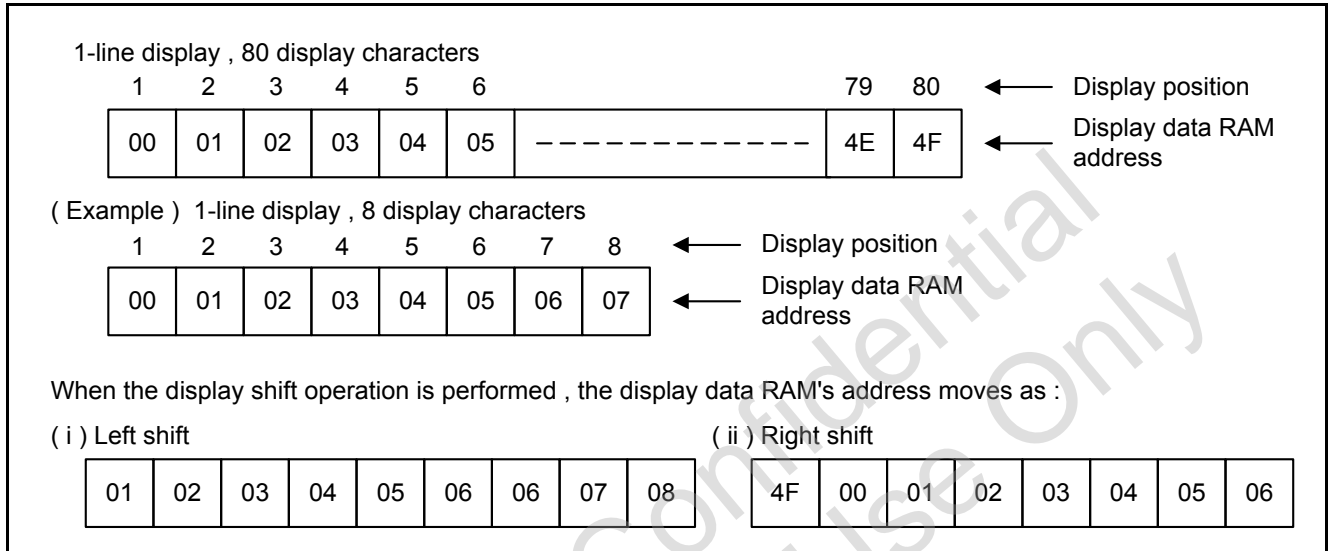




### 5.8. Display Data RAM (DD RAM)

The 80-bit DD RAM is normally used for storing display data. Those DD RAM not used for display data can be used as general data RAM. Its address is configured in the Address Counter.

The relationships between Display Data RAM Address and LCD's position are depicted as follows.



### 5.9. Timing Generation Circuit

The timing generating circuit is able to generate timing signals to the internal circuits. In order to prevent the internal timing interface, the MPU access timing and the RAM access timing are generated independently.

### 5.10. LCD Driver Circuit

Total of 16 commons and 40 segments signal drivers are valid in the LCD driver circuit. When a program specifies the character fonts and line numbers, the corresponding common signals output drive-waveforms and the others still output unselected waveforms.

### 5.11. Character Generator ROM (CG ROM)

Using 8-bit character code, the character generator ROM generates 5 x 8 dots or 5 x 10 dots character patterns. It also can generate 192's 5 x 8 dots character patterns and 64's 5 x 10 dots character patterns.

### 5.12. Character Generator RAM (CG RAM)

Users can easily change the character patterns in the character generator RAM through program. It can be written to 5 x 8 dots, 8-character patterns or 5 x 10 dots for 4-character patterns.

The following diagram shows the SPLC780D character patterns:  
 Correspondence between Character Codes and Character Patterns.


		Higher 4-bit (D4 to D7) of Character Code (Hexadecimal)																
		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
Lower 4-bit (D0 to D3) of Character Code (Hexadecimal)	0	CG RAM (1)																
	1	CG RAM (2)																
	2	CG RAM (3)																
	3	CG RAM (4)																
	4	CG RAM (5)																
	5	CG RAM (6)																
	6	CG RAM (7)																
	7	CG RAM (8)																
	8	CG RAM (1)																
	9	CG RAM (2)																
	A	CG RAM (3)																
	B	CG RAM (4)																
	C	CG RAM (5)																
	D	CG RAM (6)																
	E	CG RAM (7)																
	F	CG RAM (8)																

The relationships between Character Generator RAM Addresses, Character Generator RAM Data (character patterns), and Character Codes are depicted as follows:

**5.12.1. 5 x 8 dot character patterns**

Character Code ( DD RAM Data )								CG RAM Address						Character Patterns ( CG RAM Data )							
b7	b6	b5	b4	b3	b2	b1	b0	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0
0	0	0	0	X	0	0	0	0	0	0	0	0	0	X	X	X	1	1	1	1	1
											0	0	1				0	0	1	0	0
											0	1	0				0	0	1	0	0
											0	1	1				0	0	1	0	0
											1	0	0				0	0	1	0	0
											1	0	1				0	0	1	0	0
											1	1	0				0	0	1	0	0
											1	1	1				0	0	0	0	0
0	0	0	0	X	0	0	1	0	0	1	0	0	0	X	X	X	0	1	1	1	0
											0	0	1				0	0	1	0	0
											0	1	0				0	0	1	0	0
											0	1	1				0	0	1	0	0
											1	0	0				0	0	1	0	0
											1	0	1				0	0	1	0	0
											1	1	0				0	1	1	1	0
											1	1	1				0	0	0	0	0

Character Pattern Example (1)  
  
 Character Pattern Example (2)  
 ← Cursor Position

**Note1:**  It means that the bit0~2 of the character code correspond to the bit3~5 of the CG RAM address.

**Note2:**  These areas are not used for display, but can be used for the general data RAM.

**Note3:** When all of the bit4-7 of the character code are 0, CG RAM character patterns are selected.

**Note4:** " 1 " : Selected, " 0 " : No selected, " X " : Do not care (0 or 1).

**Note5:** For example (1), set character code (b2 = b1 = b0 = 0, b3 = 0 or 1, b7-b4 = 0) to display " T ". That means character code (00) 16, and (08) 16 can display " T " character.



**Note6:** The bits 0-2 of the character code RAM is the character pattern line position. The 8th line is the cursor position and display is formed by logical OR with the cursor.

**5.12.2. 5 X 10 dot character patterns**

Character Code ( DD RAM Data )								CG RAM Address						Character Patterns ( CG RAM Data )								
b7	b6	b5	b4	b3	b2	b1	b0	b5	b4	b3	b2	b1	b0	b7	b6	b5	b4	b3	b2	b1	b0	
										0	0	0	0					1	0	0	0	1
										0	0	0	1					1	0	0	0	1
										0	0	1	0					1	0	0	0	1
										0	0	1	1					1	0	0	0	1
										0	1	0	0					1	0	0	0	1
0	0	0	0	X	0	0	X	0	0	0	1	0	1	X	X	X	1	0	0	0	1	
										0	1	1	0					1	0	0	0	1
										0	1	1	1					1	0	0	0	1
										1	0	0	0					1	0	0	0	1
										1	0	0	1					1	1	1	1	1
										1	0	1	0					0	0	0	0	0
										1	0	1	1									
										1	1	0	0									
										1	1	0	1	X	X	X	X	X	X	X	X	X
										1	1	1	0									
										1	1	1	1									

Character Pattern Example (1)

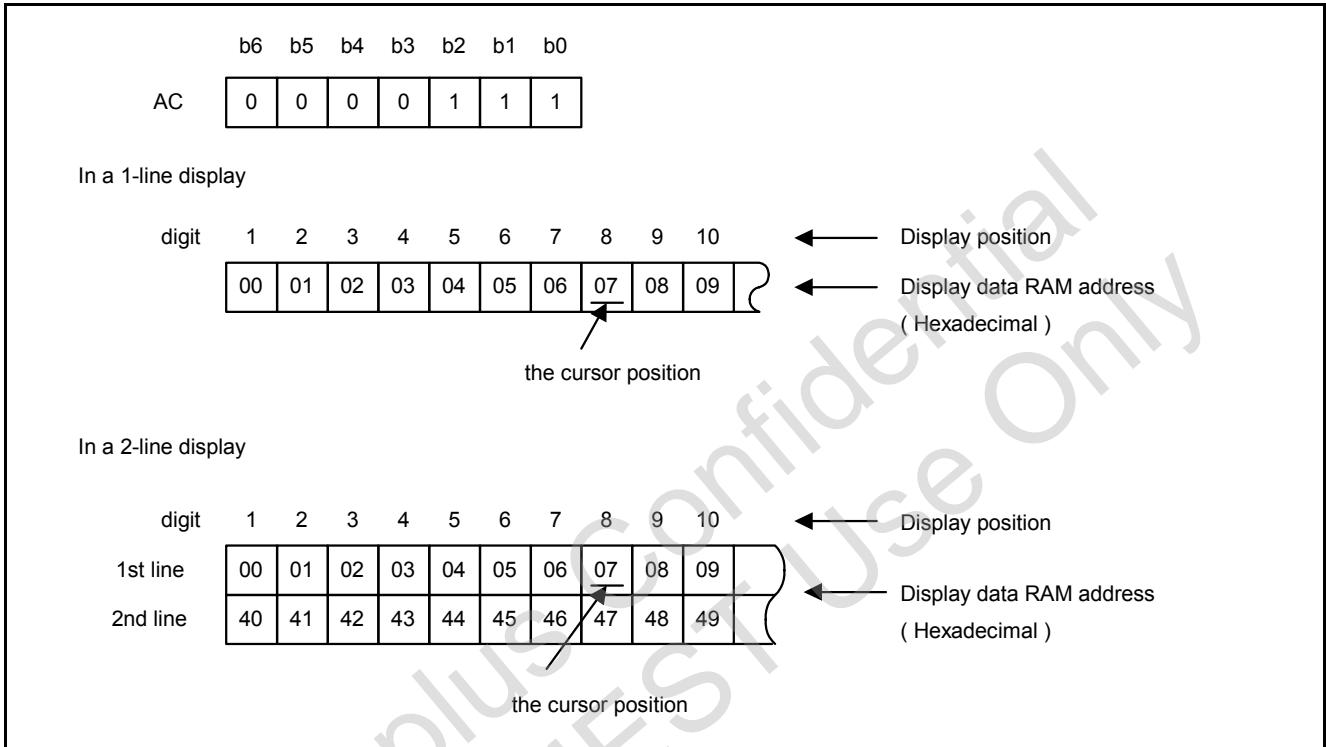
Cursor Position ←

- Note1:**  It means that the bit1~2 of the character code correspond to the bit4~5 of the CG RAM address.
- Note2:**  These areas are not used for display, but can be used for the general data RAM.
- Note3:** When all of the bit4-7 of the character code are 0, CG RAM character patterns are selected.
- Note4:** " 1 ": Selected, " 0 ": No selected, " X ": Do not care (0 or 1).
- Note5:** For example (1), set character code (b2 = b1 = 0, b3 = b0 = 0 or 1, b7-b4 = 0) to display " U ". That means all of the character codes (00) 16, (01) 16, (08) 16, and (09) 16 can display " U " character.
- Note6:** The bits 0-3 of the character code RAM is the character pattern line position. The 11th line is the cursor position and display is formed by logical OR with the cursor.

### 5.13. Cursor/Blink Control Circuit

This circuit generates the cursor or blink in the cursor / blink control circuit. The cursor or the blink appears in the digit at the Display Data RAM Address defined in the Address Counter.

When the Address Counter is (07) 16, the cursor position is shown as belows:



### 5.14. Interfacing to MPU

There are two types of data operations: 4-bit and 8-bit operations. Using 4-bit MPU, the interfacing 4-bit data is transferred by 4-busline (DB4 to DB7). Thus, DB0 to DB3 bus lines are not used. Using 4-bit MPU to interface 8-bit data requires two times transferring. First, the higher 4-bit data is transferred by 4-busline (for 8-bit operation, DB7 to DB4). Secondly, the lower 4-bit data is transferred by 4-busline (for 8-bit operation, DB3 to DB0). For 8-bit MPU, the 8-bit data is transferred by 8-buslines (DB0 to DB7).

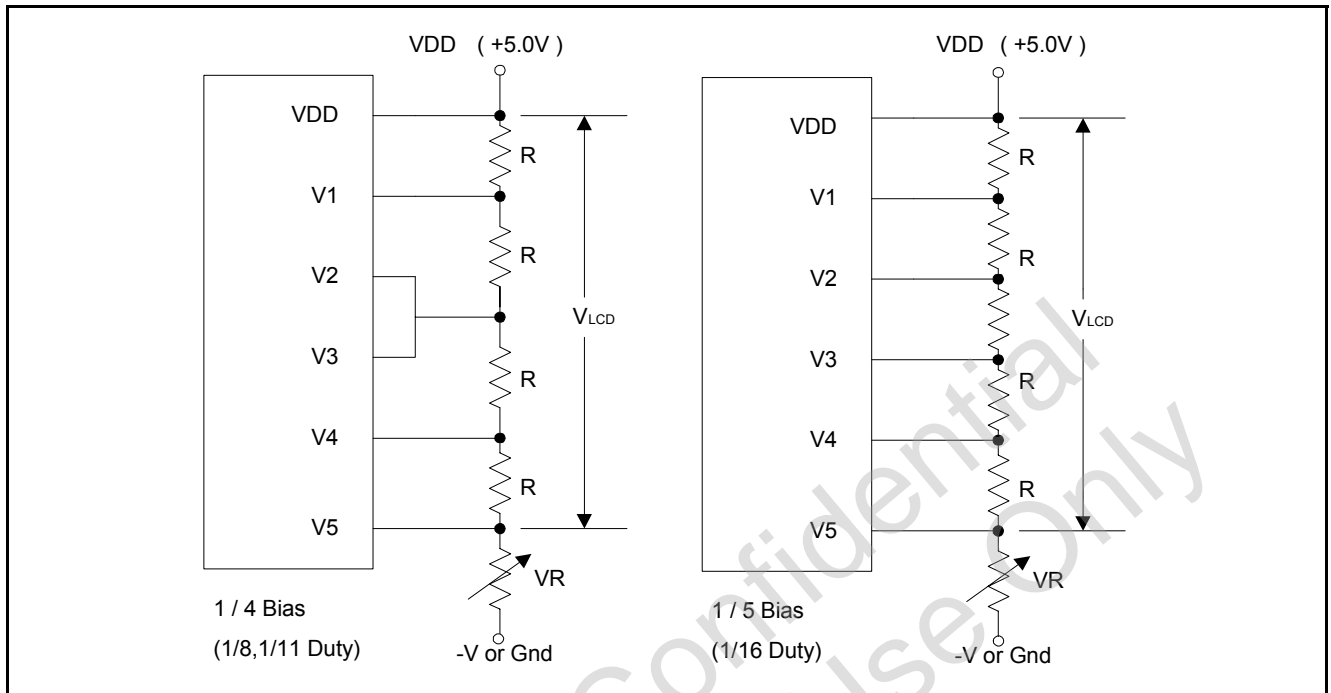
### 5.15. Supply Voltage for LCD Drive

Different voltages can be supplied to SPLC780D's pins (V5 - 1) for obtaining LCD drive-waveform. The relationships between bias, duty factor and supply voltages are shown as belows:

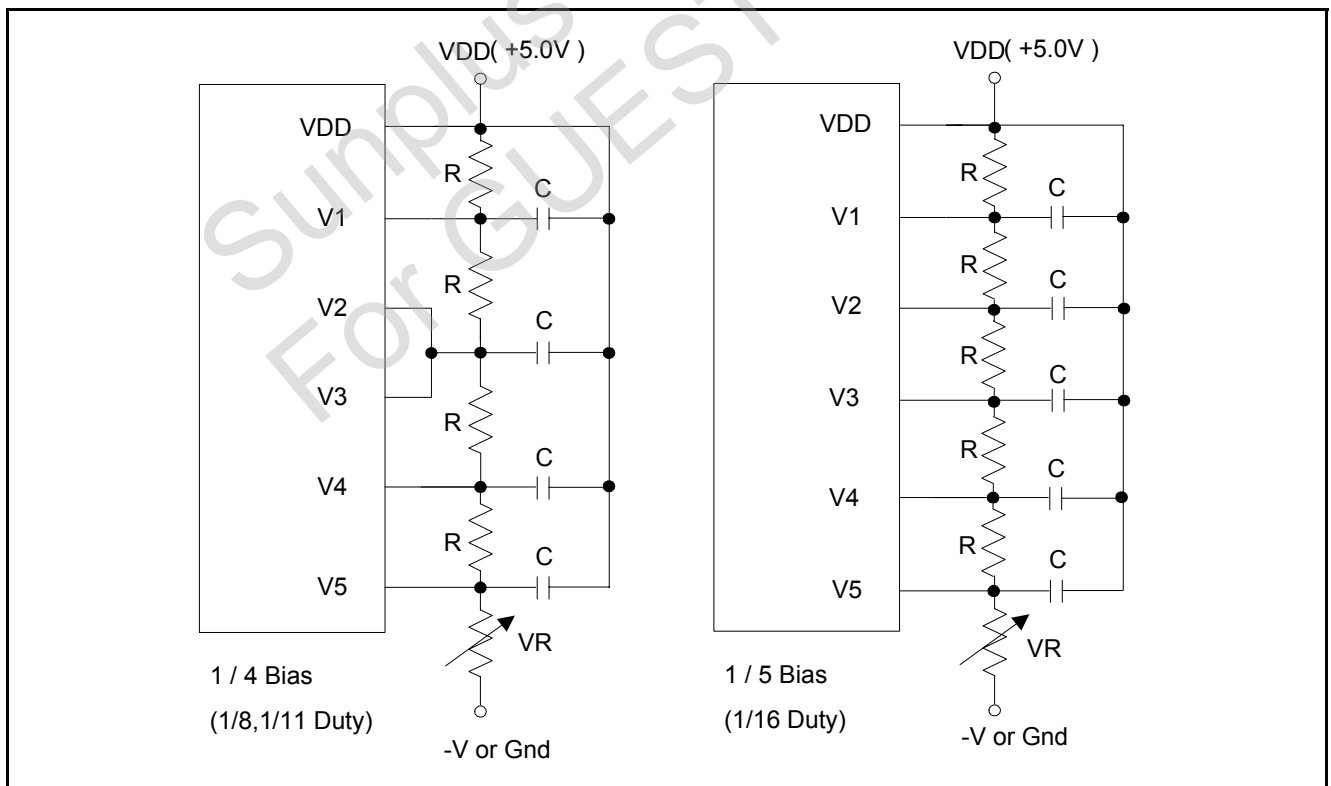
Supply Voltage	Duty Factor	1/8, 1/11	1/16
		1/4	1/5
V1		$VDD - 1/4 V_{LCD}$	$VDD - 1/5 V_{LCD}$
V2		$VDD - 1/2 V_{LCD}$	$VDD - 2/5 V_{LCD}$
V3		$VDD - 1/2 V_{LCD}$	$VDD - 3/5 V_{LCD}$
V4		$VDD - 3/4 V_{LCD}$	$VDD - 4/5 V_{LCD}$
V5		$VDD - V_{LCD}$	$VDD - V_{LCD}$



5.15.1. The power connections for LCD (1/4 Bias, 1/5 Bias) are shown belows:



The bypass-capacitor improves the LCD display quality.

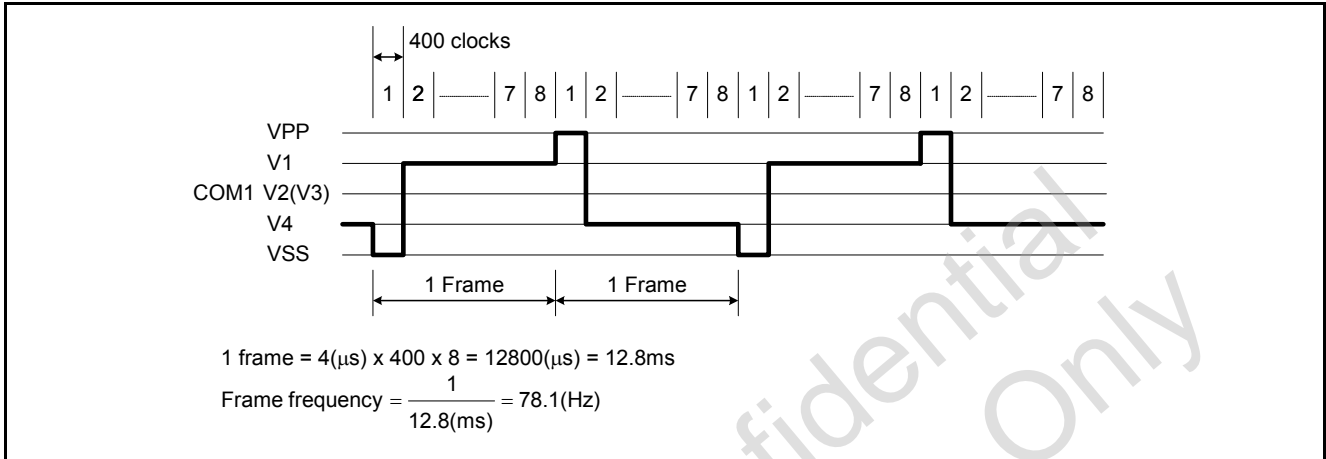
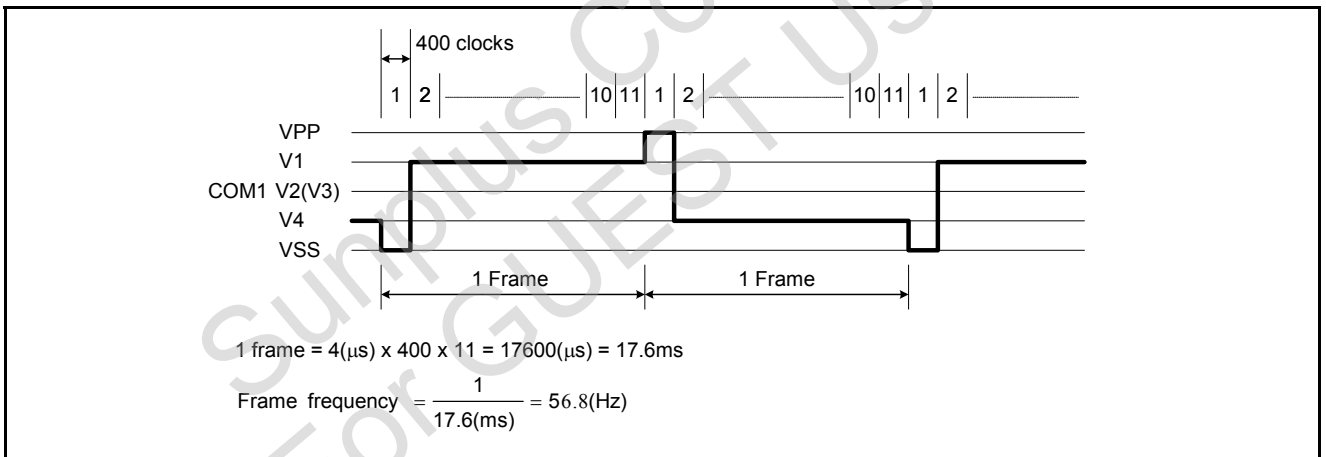
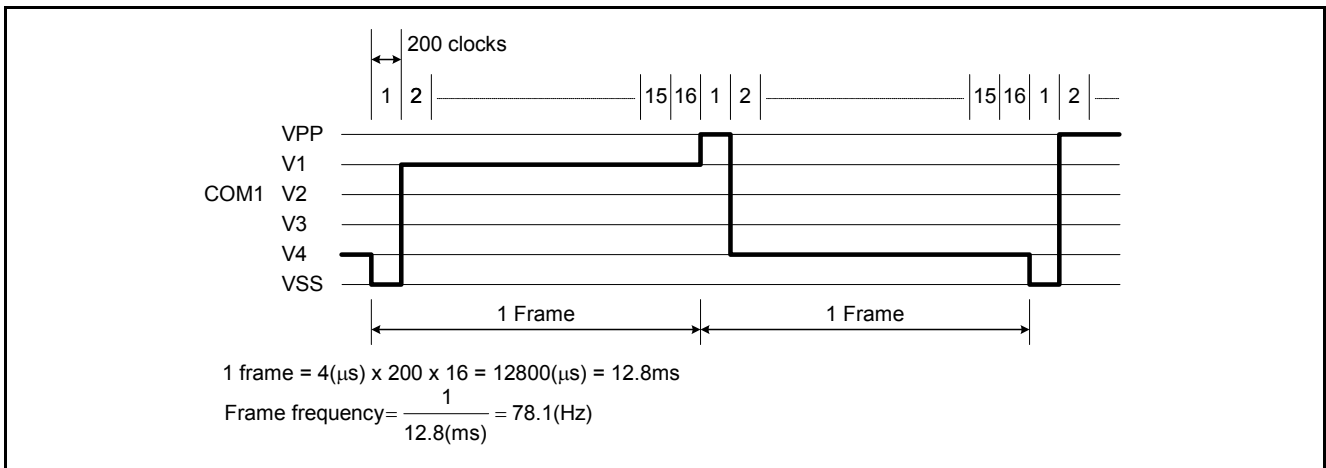


The bias voltage must have the following relations:

$$VDD > V1 > V2 \geq V3 > V4 > V5.$$

**5.15.2. The relationship between LCD frame's frequency and oscillator's frequency.**

(Assume the oscillation frequency is 250KHz, 1 clock cycle time = 4.0μs)

**5.15.2.1. 1/8 Duty, TYPE-B waveform**

**5.15.2.2. 1/11 Duty, TYPE-B waveform**

**5.15.2.3. 1/16 Duty, TYPE-B waveform**


### 5.16. REGISTER --- IR (Instruction Register) and DR (Data Register)

SPLC780D contains two 8-bit registers: Instruction Register (IR) and Data Register (DR). Using combinations of the RS pin and the R/W pin selects the IR and DR, see below:

RS	R/W	Operation
0	0	IR write (Display clear, etc.)
0	1	Read busy flag (DB7) and Address Counter (DB0 - DB6)
1	0	DR write (DR to Display data RAM or Character generator RAM)
1	1	DR read (Display data RAM or Character generator RAM to DR)

The IR can be written by MPU, but it cannot be read by MPU.

### 5.17. Busy Flag (BF)

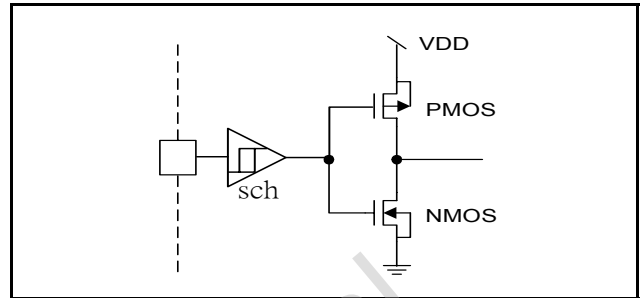
When RS = 0 and R/W = 1, the busy flag is output to DB7. As the busy flag =1, SPLC780D is in busy state and does not accept any instruction until the busy flag = 0.

### 5.18. Address Counter (AC)

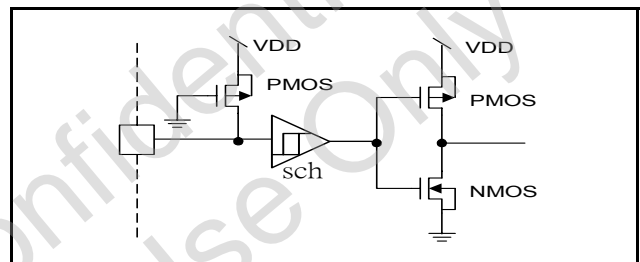
The Address Counter assigns addresses to Display Data RAM and Character Generator RAM. When an instruction for address is written in IR, the address information is sent from IR to AC. After writing to/reading from Display Data RAM or Character Generator RAM, AC is automatically incremented by one (or decremented by one). The contents of AC are output to DB0 - DB6 when RS = 0 and R/W = 1.

### 5.19. I/O Port Configuration

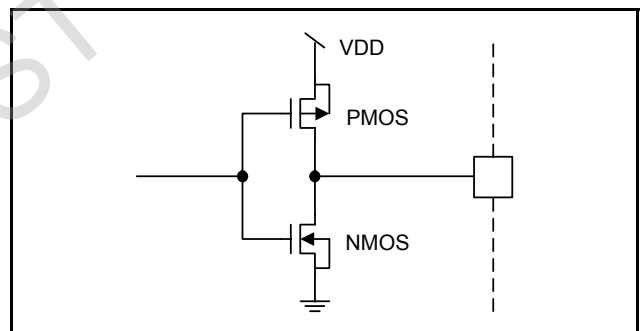
#### 5.19.1. Input port: E



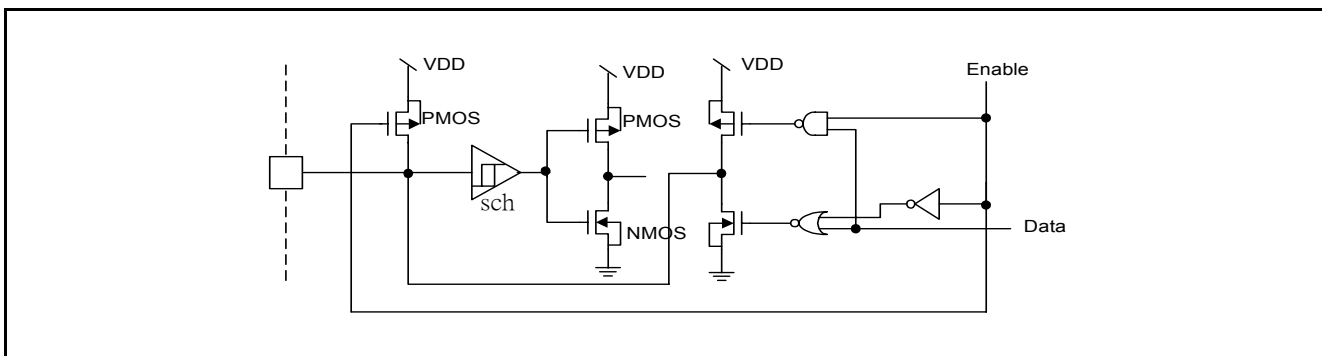
#### 5.19.2. Input port: R/W, RS



#### 5.19.3. Output port: CL1, CL2, M, D



#### 5.19.4. Input / Output port: DB7 - DB0



**6. ELECTRICAL SPECIFICATIONS**
**6.1. Absolute Maximum Ratings**

Characteristics	Symbol	Ratings
Operating Voltage	VDD	-0.3V to +7.0V
Driver Supply Voltage	V <sub>LCD</sub>	VDD - 12V to VDD + 0.3V
Input Voltage Range	V <sub>IN</sub>	-0.3V to VDD + 0.3V
Operating Temperature	T <sub>A</sub>	-30°C to +80°C
Storage Temperature	T <sub>STO</sub>	-55°C to +125°C

**Note:** Stresses beyond those given in the Absolute Maximum Rating table may cause operational errors or damage to the device. For normal operational conditions see AC/DC Electrical Characteristics.

**6.2. DC Characteristics (VDD = 2.7V to 4.5V, T<sub>A</sub> = 25°C)**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
Operating Current	I <sub>DD</sub>	-	0.2	0.4	mA	External clock (Note)
Input High Voltage	V <sub>IH1</sub>	0.7VDD	-	VDD	V	Pins:(E, RS, R/W, DB0 - DB7)
Input Low Voltage	V <sub>IL1</sub>	-0.3	-	0.55	V	
Input High Voltage	V <sub>IH2</sub>	0.7VDD	-	VDD	V	Pin OSC1
Input Low Voltage	V <sub>IL2</sub>	-0.2	-	0.2VDD	V	
Input High Current	I <sub>IH</sub>	-1.0	-	1.0	μA	Pins: (RS, R/W, DB0 - DB7) VDD = 3.0V
Input Low Current	I <sub>IL</sub>	-5.0	-15	-30	μA	
Output High Voltage (TTL)	V <sub>OH1</sub>	0.75VDD	-	-	V	I <sub>OH</sub> = - 0.1mA Pins: DB0 - DB7
Output Low Voltage (TTL)	V <sub>OL1</sub>	-	-	0.2VDD	V	I <sub>OL</sub> = 0.1mA Pins: DB0 - DB7
Output High Voltage (CMOS)	V <sub>OH2</sub>	0.8VDD	-	-	V	I <sub>OH</sub> = - 40μA, Pins: CL1, CL2, M, D
Output Low Voltage (CMOS)	V <sub>OL2</sub>	-	-	0.2VDD	V	I <sub>OL</sub> = 40μA, Pins: CL1, CL2, M, D
Driver ON Resistance (COM)	R <sub>COM</sub>	-	-	20	KΩ	I <sub>O</sub> = ±50μA, V <sub>LCD</sub> = 4.0V Pins: COM1 - COM16
Driver ON Resistance (SEG)	R <sub>SEG</sub>	-	-	30	KΩ	I <sub>O</sub> = ±50μA, V <sub>LCD</sub> = 4.0V Pins: SEG1 - SEG40
LCD Voltage	V <sub>LCD</sub>	3.0	-	9.0	V	VDD-V5, 1/4 bias or 1/5 bias

**Note:** F<sub>osc</sub> = 250KHz, VDD = 3.0V, pin E = "L", RS, R/W, DB0 - DB7 are open, all outputs are no loads.

**6.3. AC Characteristics (VDD = 2.7V to 4.5V, T<sub>A</sub> = 25°C)**
**6.3.1. Internal clock operation**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
OSC Frequency	F <sub>OSC1</sub>	190	270	350	KHz	VDD = 3.0V, Rf = 75KΩ±2%

**6.3.2. External clock operation**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
External Frequency	F <sub>OSC2</sub>	125	250	350	KHz	
Duty Cycle		45	50	55	%	
Rise/Fall Time	t <sub>r</sub> , t <sub>f</sub>	-	-	0.2	μs	

**6.3.3. Write mode (Writing data from MPU to SPLC780D)**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
E Cycle Time	t <sub>C</sub>	1000	-	-	ns	Pin E
E Pulse Width	t <sub>PW</sub>	450	-	-	ns	Pin E
E Rise/Fall Time	t <sub>R</sub> , t <sub>F</sub>	-	-	25	ns	Pin E
Address Setup Time	t <sub>SP1</sub>	60	-	-	ns	Pins: RS, R/W, E
Address Hold Time	t <sub>HD1</sub>	20	-	-	ns	Pins: RS, R/W, E
Data Setup Time	t <sub>SP2</sub>	195	-	-	ns	Pins: DB0 - DB7
Data Hold Time	t <sub>HD2</sub>	10	-	-	ns	Pins: DB0 - DB7

**6.3.4. Read mode (Reading data from SPLC780D to MPU)**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
E Cycle Time	t <sub>C</sub>	1000	-	-	ns	Pin E
E Pulse Width	t <sub>w</sub>	450	-	-	ns	Pin E
E Rise/Fall Time	t <sub>R</sub> , t <sub>F</sub>	-	-	25	ns	Pin E
Address Setup Time	t <sub>SP1</sub>	60	-	-	ns	Pins: RS, R/W, E
Address Hold Time	t <sub>HD1</sub>	20	-	-	ns	Pins: RS, R/W, E
Data Output Delay Time	t <sub>D</sub>	-	-	360	ns	Pins: DB0 - DB7
Data hold time	t <sub>HD2</sub>	5.0	-	-	ns	Pin DB0 - DB7

**6.4. DC Characteristics (VDD = 4.5V to 5.5V, T<sub>A</sub> = 25°C)**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
Operating Current	I <sub>DD</sub>	-	0.55	0.8	mA	External clock (Note)
Input High Voltage	V <sub>IH1</sub>	2.2	-	VDD	V	Pins:(E, RS, R/W, DB0 - DB7)
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, DB0 - DB7) VDD = 5.0V
Input Low Current	I <sub>IL</sub>	-20	-50	-100	μA	
Output High Voltage (TTL)	V <sub>OH1</sub>	2.4	-	VDD	V	I <sub>OH</sub> = - 0.1mA Pins: DB0 - DB7
Output Low Voltage (TTL)	V <sub>OL1</sub>	-	-	0.4	V	I <sub>OL</sub> = 0.1mA Pins: DB0 - DB7
Output High Voltage (CMOS)	V <sub>OH2</sub>	0.9VDD	-	VDD	V	I <sub>OH</sub> = - 40μA, Pins: CL1, CL2, M, D
Output Low Voltage (CMOS)	V <sub>OL2</sub>	-	-	0.1VDD	V	I <sub>OL</sub> = 40μA, Pins: CL1, CL2, M, D
Driver ON Resistance (COM)	R <sub>COM</sub>	-	-	20	KΩ	I <sub>O</sub> = ±50μA, V <sub>LCD</sub> = 4.0V Pins: COM1 - COM16
Driver ON Resistance (SEG)	R <sub>SEG</sub>	-	-	30	KΩ	I <sub>O</sub> = ±50μA, V <sub>LCD</sub> = 4.0V Pins: SEG1 - SEG40
LCD Voltage	V <sub>LCD</sub>	3.0	-	11	V	VDD-V5, 1/4 bias or 1/5 bias

**Note:** F<sub>OSC</sub> = 250KHz, VDD = 5.0V, pin E = "L", RS, R/W, DB0 - DB7 are open, all outputs are no loads.

**6.5. AC Characteristics (VDD = 4.5V to 5.5V, T<sub>A</sub> = 25°C)**
**6.5.1. Internal clock operation**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
OSC Frequency	F <sub>OSC1</sub>	190	270	350	KHz	VDD = 5.0V, R <sub>f</sub> = 91KΩ±2%

**6.5.2. External clock operation**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
External Frequency	F <sub>OSC2</sub>	125	250	350	KHz	
Duty Cycle		45	50	55	%	
Rise/Fall Time	t <sub>r</sub> , t <sub>f</sub>	-	-	0.2	μs	

**6.5.3. Write mode (Writing Data from MPU to SPLC780D)**

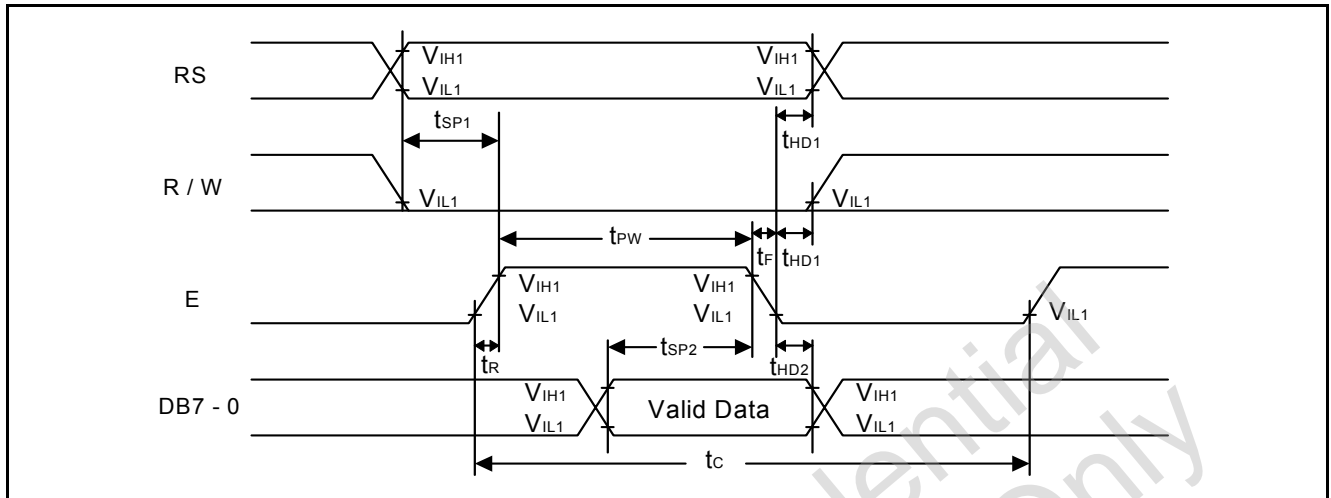
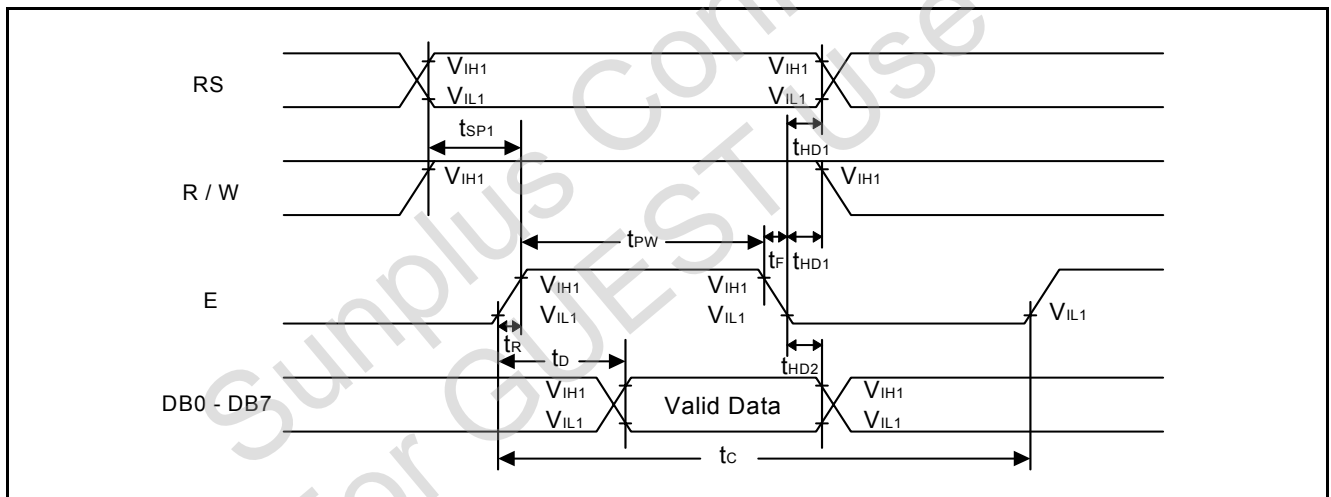
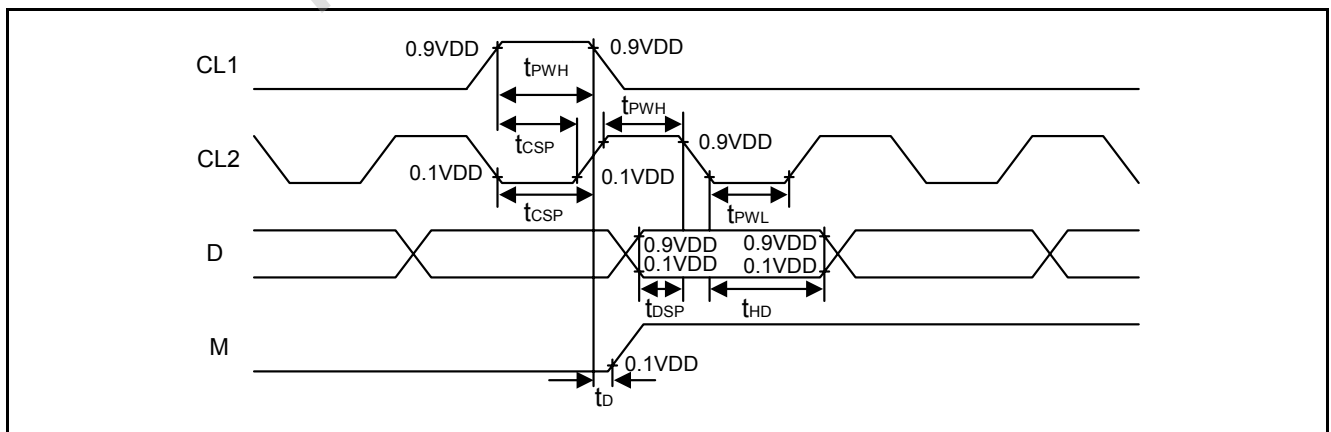
Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
E Cycle Time	$t_c$	500	-	-	ns	Pin E
E Pulse Width	$t_{PW}$	230	-	-	ns	Pin E
E Rise/Fall Time	$t_R, t_F$	-	-	20	ns	Pin E
Address Setup Time	$t_{SP1}$	40	-	-	ns	Pins: RS, R/W, E
Address Hold Time	$t_{HD1}$	10	-	-	ns	Pins: RS, R/W, E
Data Setup Time	$t_{SP2}$	80	-	-	ns	Pins: DB0 - DB7
Data Hold Time	$t_{HD2}$	10	-	-	ns	Pins: DB0 - DB7

**6.5.4. Read mode (Reading Data from SPLC780D to MPU)**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
E Cycle Time	$t_c$	500	-	-	ns	Pin E
E Pulse Width	$t_W$	230	-	-	ns	Pin E
E Rise/Fall Time	$t_R, t_F$	-	-	20	ns	Pin E
Address Setup Time	$t_{SP1}$	40	-	-	ns	Pins: RS, R/W, E
Address Hold Time	$t_{HD1}$	10	-	-	ns	Pins: RS, R/W, E
Data Output Delay Time	$t_D$	-	-	120	ns	Pins: DB0 - DB7
Data hold time	$t_{HD2}$	5.0	-	-	ns	Pin DB0 - DB7

**6.5.5. Interface mode with LCD Driver (SPLC100A1)**

Characteristics	Symbol	Limit			Unit	Test Condition
		Min.	Typ.	Max.		
Clock pulse width high	$t_{PWH}$	800	-	-	ns	Pins: CL1, CL2
Clock pulse width low	$t_{PWL}$	800	-	-	ns	Pins: CL1, CL2
Clock setup time	$t_{CSP}$	500	-	-	ns	Pins: CL1, CL2
Data setup time	$t_{DSP}$	300	-	-	ns	Pins: D
Data hold time	$t_{HD}$	300	-	-	ns	Pins: D
M delay time	$t_D$	-1000	-	1000	ns	Pins: M

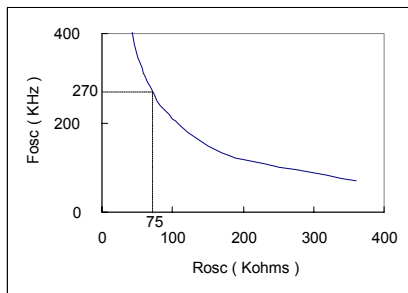
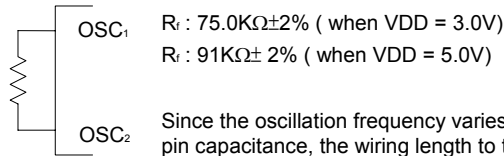
**6.5.6. Write mode timing diagram (Writing Data from MPU to SPLC780D)**

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

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




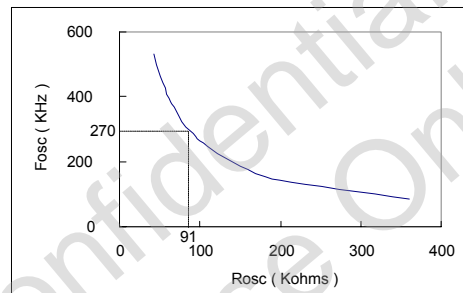
## 7. APPLICATION CIRCUITS

### 7.1. R-Oscillator

The oscillation resistor  $R_f$  is used only for the internal oscillator operation mode.



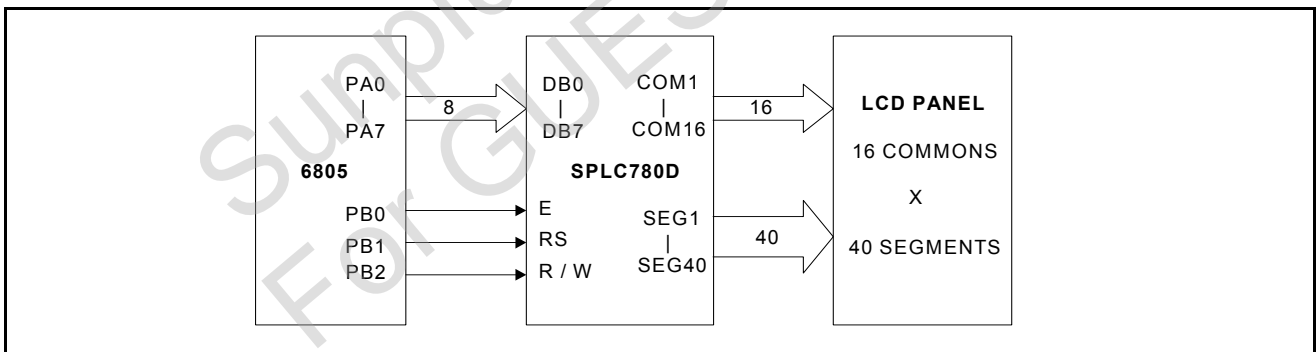
VDD = 3.0V



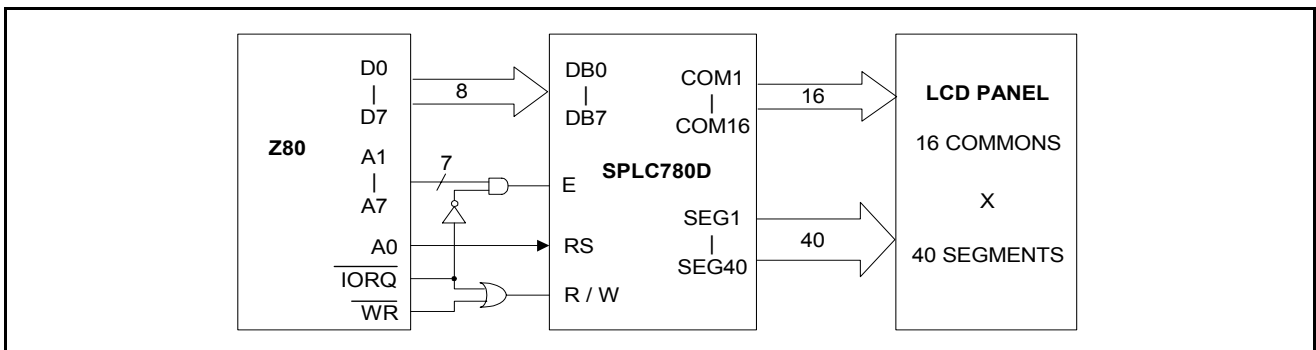
VDD = 5.0V

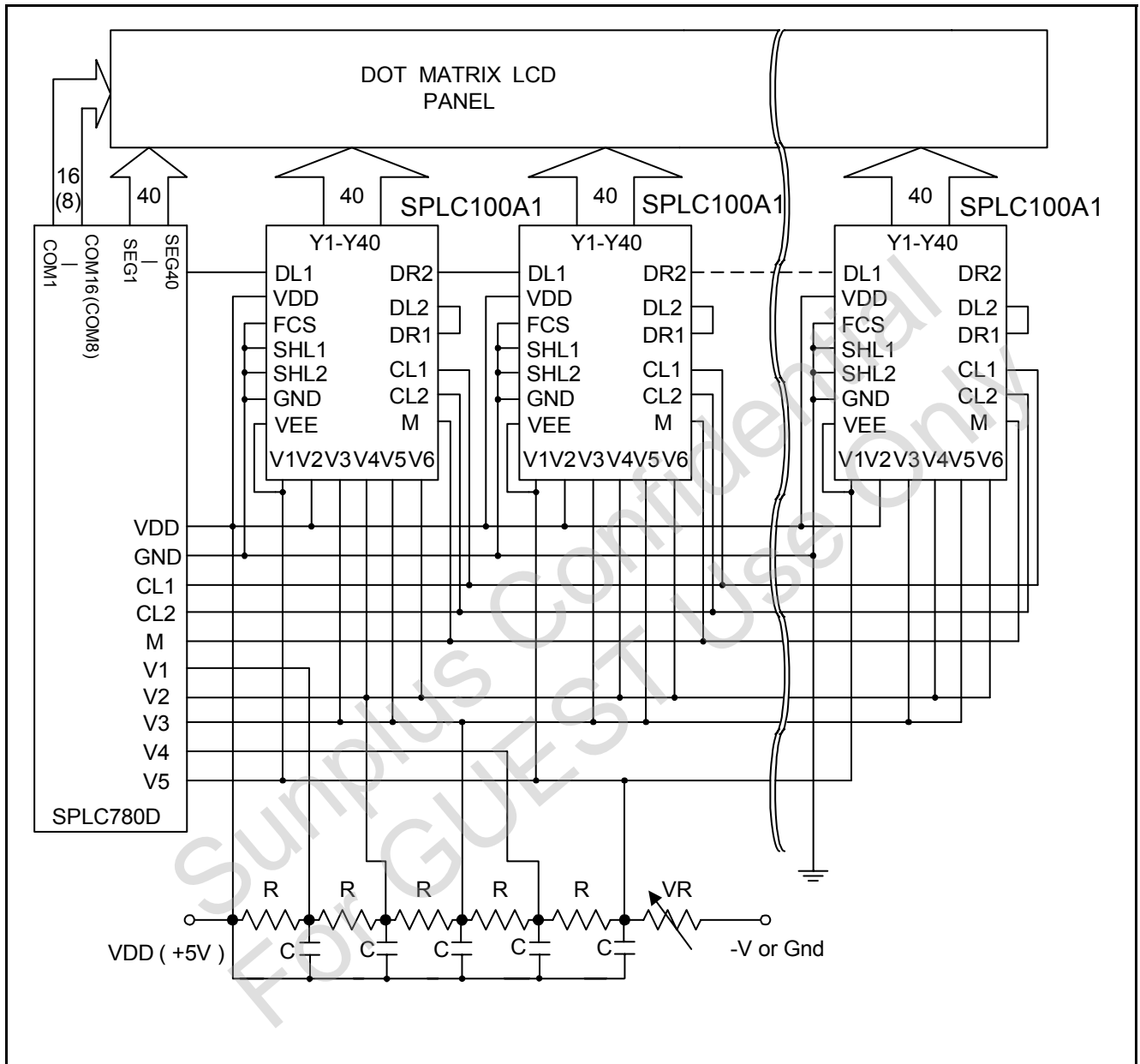
### 7.2. Interface to MPU

#### 7.2.1. Interface to 8-bit MPU (6805)

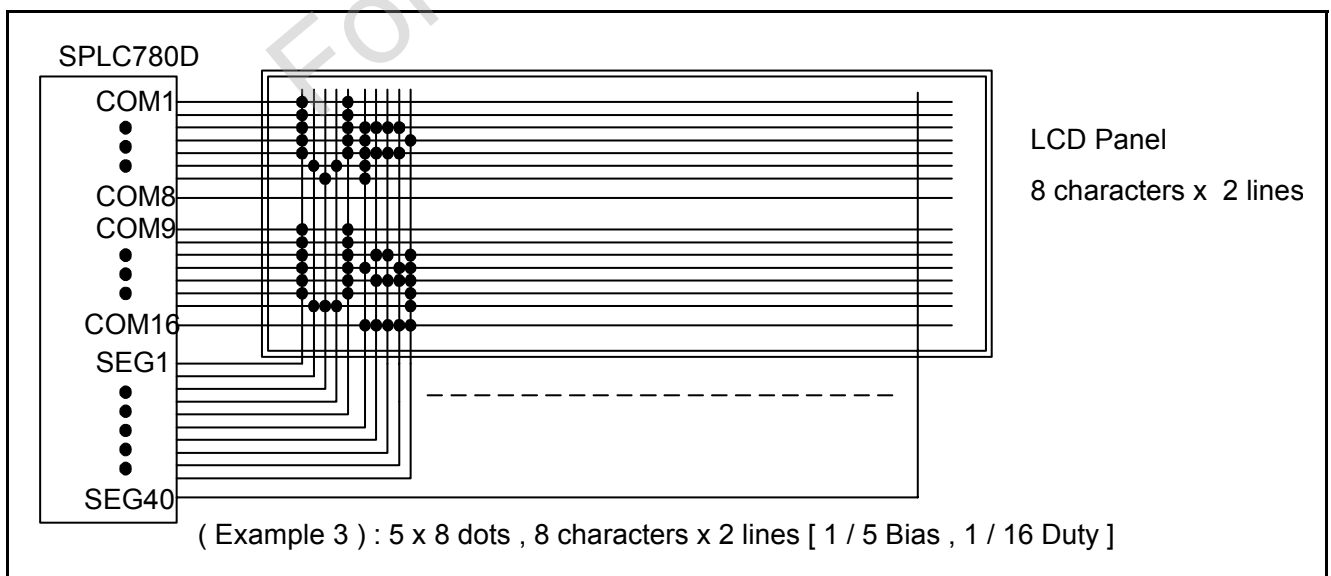
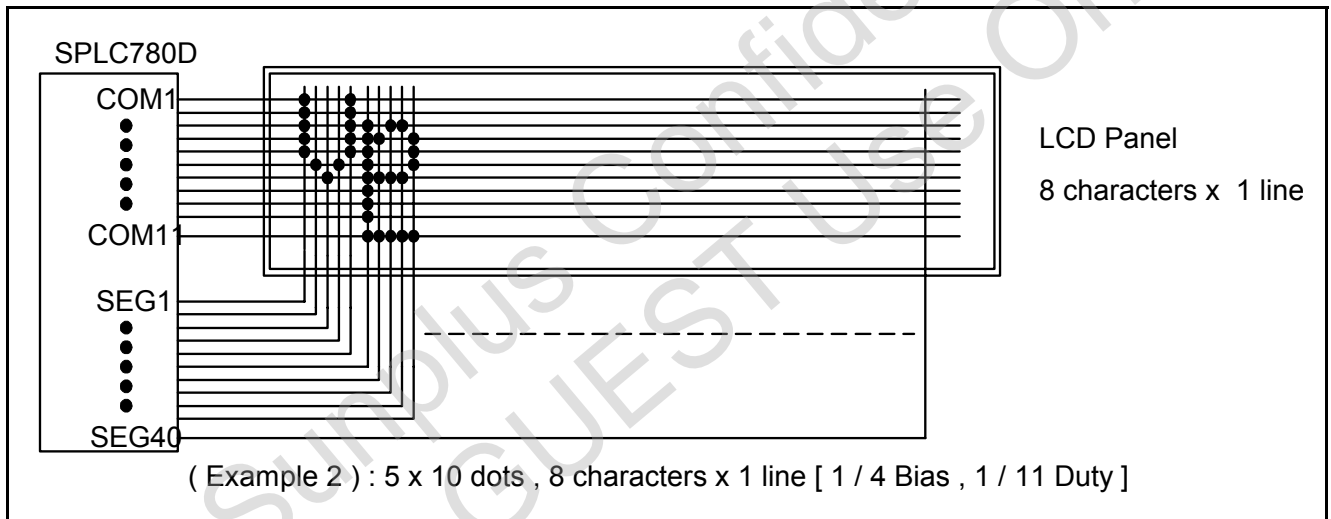
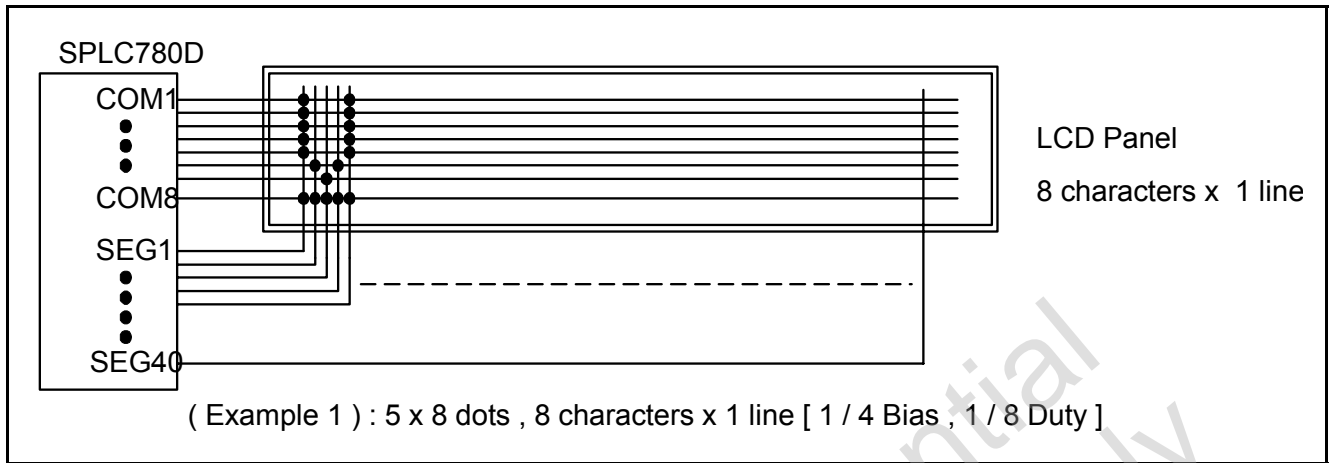


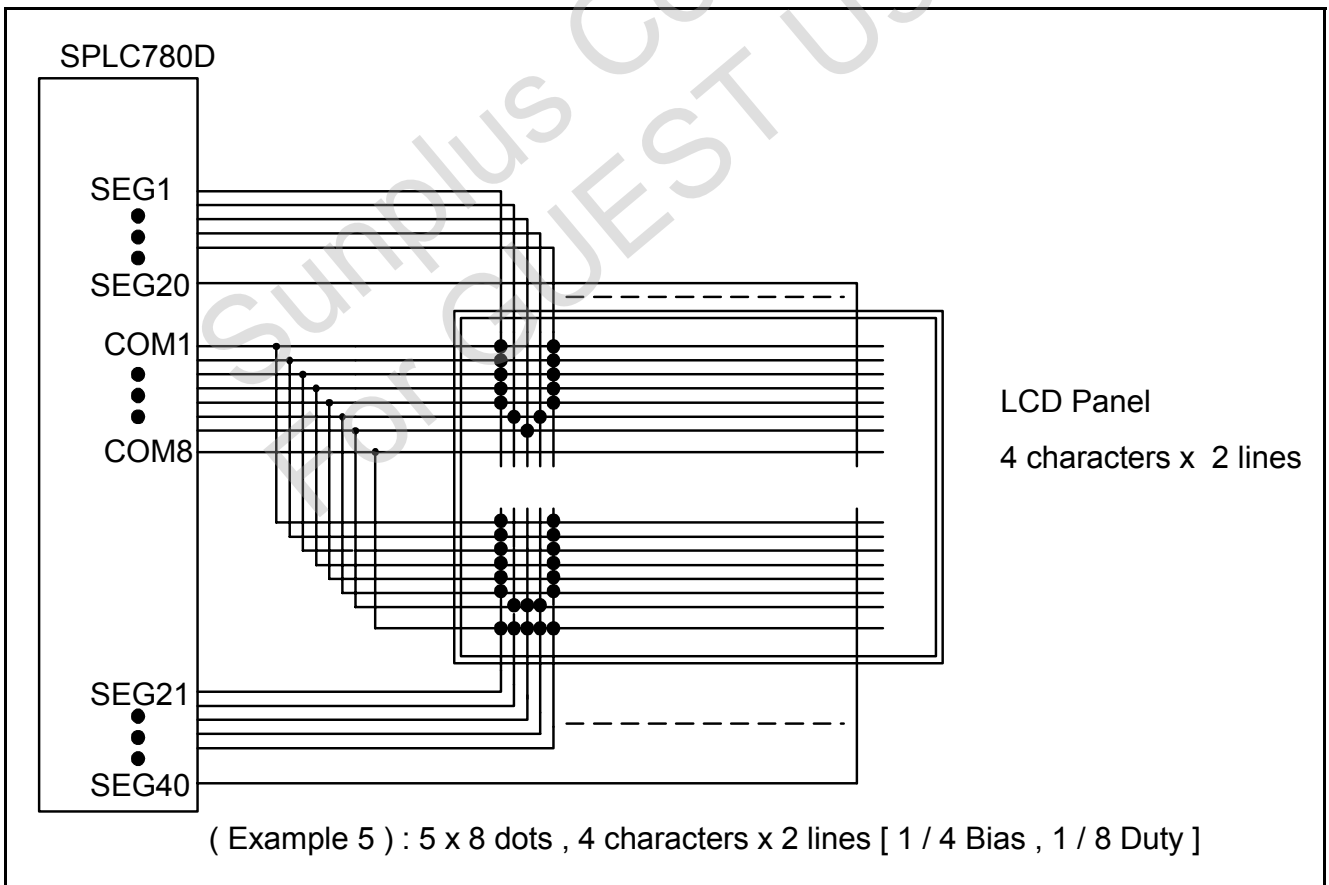
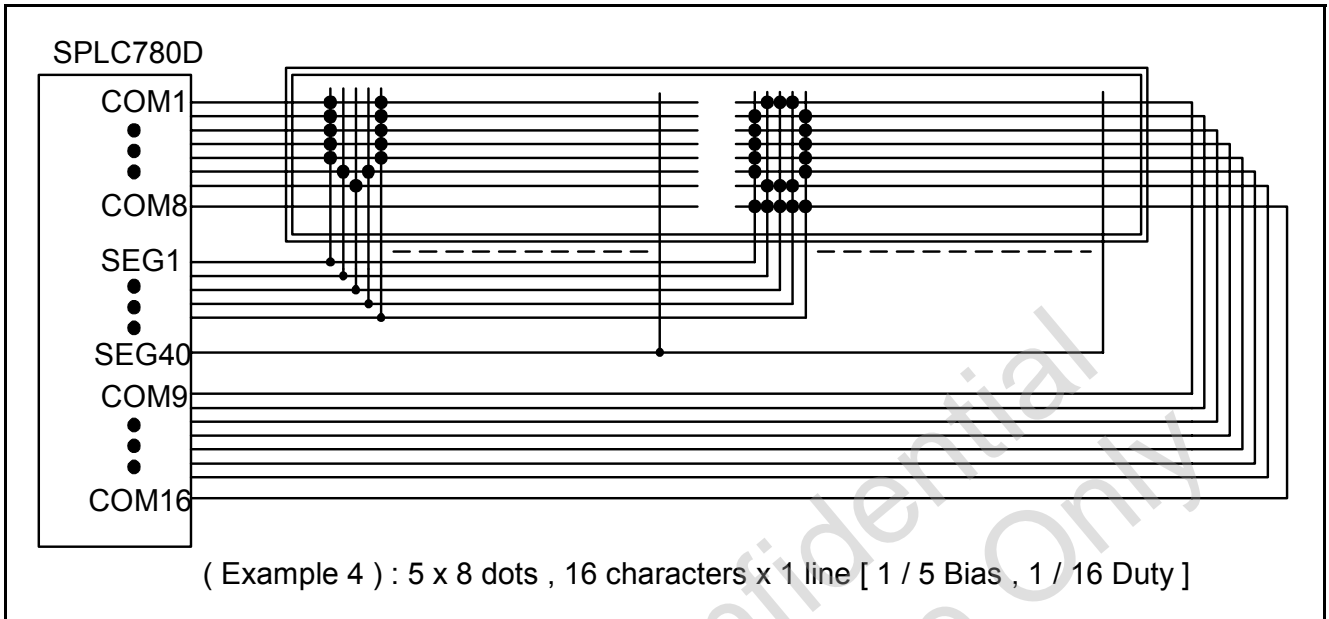
#### 7.2.2. Interface to 8-bit MPU (Z80)



**7.3. SPLC780D Application Circuit**


#### 7.4. Applications for LCD





**8. CHARACTER GENERATOR ROM**
**8.1. SPLC780D - 001**

Upper 4 bit Lower 4 bit	LLLL	LLLH	LLHL	LLHH	LHLL	LHLH	LHHL	LHHH	HLLL	HLLH	HLHL	HLHH	HHLL	HHLH	HHHL	HHHH
	LLLL				0	1	2	3	4	5	6	7	8	9	A	B
LLLH			!	0	1	2	3	4			.	ア	チ	ハ	ヨ	ク
LLHL			"	2	B	R	b	r			「	イ	ウ	※	目	日
LLHH			#	3	C	S	c	s			」	ウ	子	毛	毛	※
LHLL			\$	4	D	T	d	t			、	エ	ト	カ	ウ	ウ
LHLH			%	5	E	U	e	u			・	オ	大	ユ	ウ	ウ
LHHL			&	6	F	V	f	v			ヲ	カ	ニ	ヨ	ウ	ウ
LHHH			'	7	G	W	g	w			ヲ	キ	※	ウ	ヨ	ウ
HLLL			(	8	H	X	h	x			、	ウ	率	リ	ウ	ウ
HLLH			)	9	I	Y	i	y			ウ	ウ	ル	リ	ウ	ウ
HLHL			*	0	J	Z	j	z			エ	コ	ウ	レ	ウ	ウ
HLHH			+	1	K	C	k	c			オ	カ	ヒ	ウ	※	ウ
HHLL			,	2	L	I	l	i			カ	ウ	ウ	ウ	ウ	ウ
HHLH			=	3	M	N	m	n			ユ	ウ	ウ	ウ	ウ	ウ
HHHL			.	4	N	O	n	o			ヨ	ウ	ウ	ウ	ウ	ウ
HHHH			/	5	0	L	o	*			ウ	ウ	ウ	ウ	ウ	■

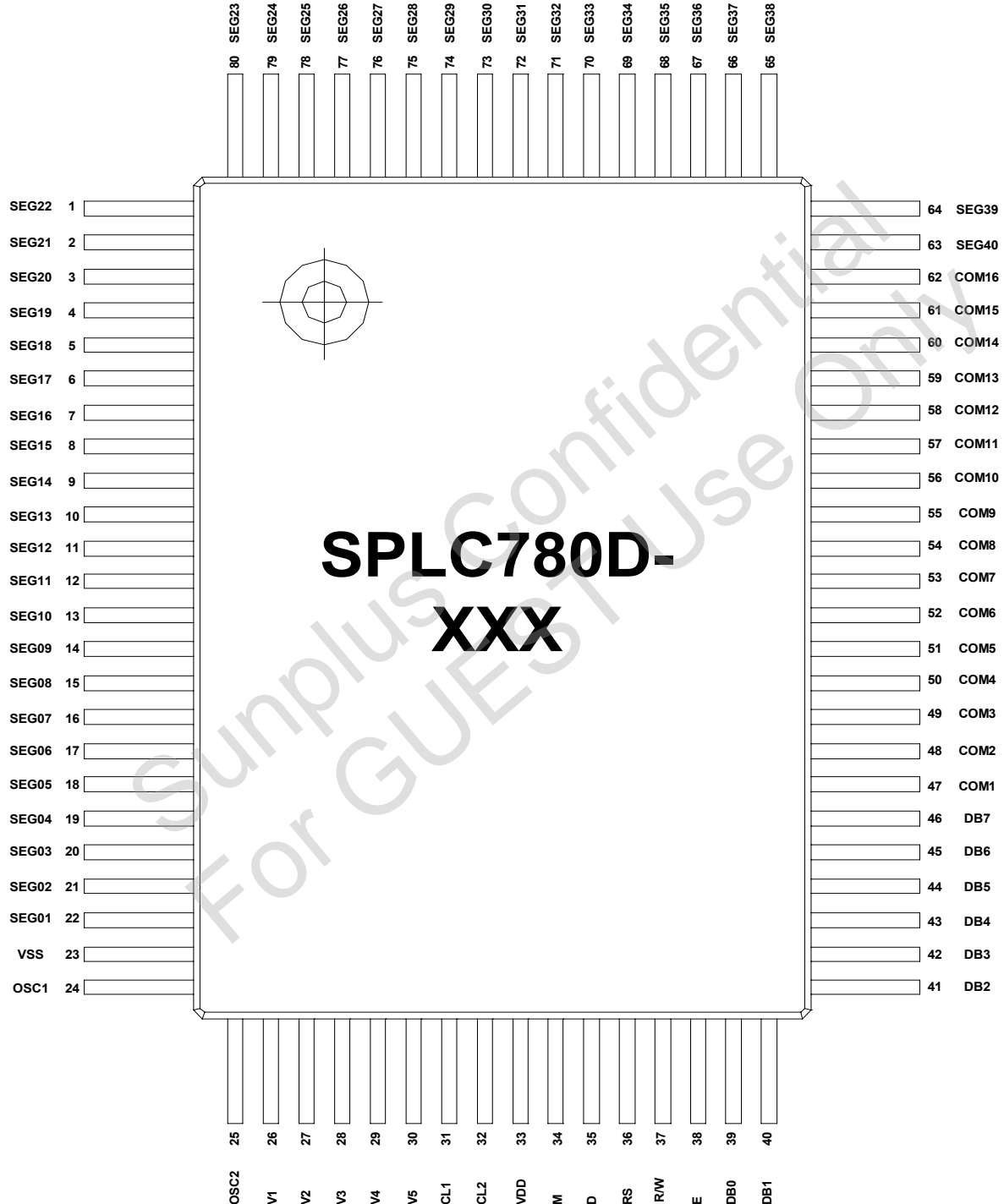
**9. PACKAGE/PAD LOCATIONS****9.1. PAD Assignment and Locations**

Please contact Sunplus sales representatives for more information.

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**9.2. Package Configuration**

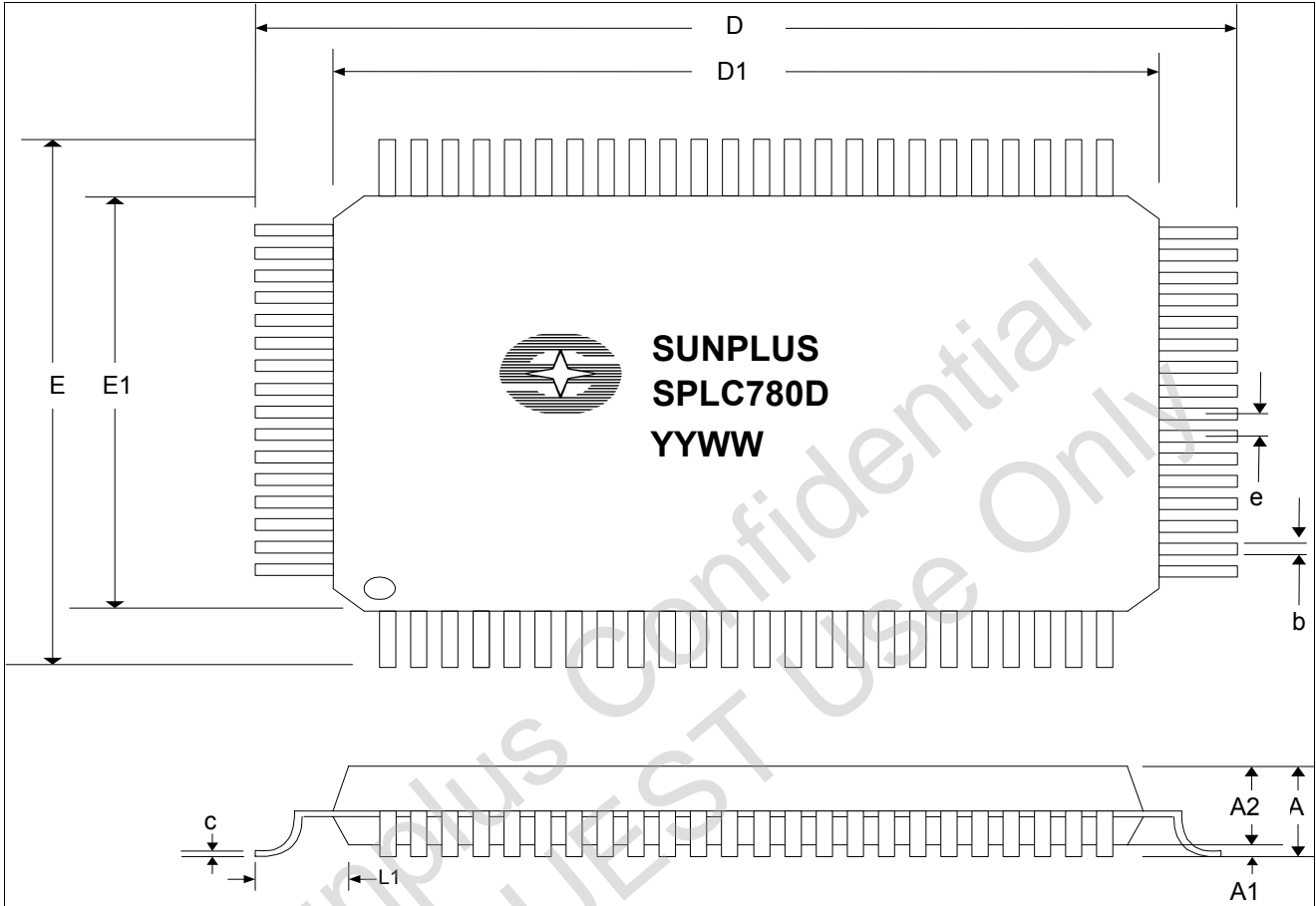
QFP 80L Top View



**9.3. Package Information**

QFP 80L Outline Dimensions

Unit: Millimeter



Symbol	Min.	Nom.	Max.	Unit
D		23.20 REF		Millimeter
D1		20.00 REF		Millimeter
E		17.20 REF		Millimeter
E1		14.00 REF		Millimeter
e		0.80 REF		Millimeter
b	0.30	0.35	0.45	Millimeter
A	-	-	3.40	Millimeter
A1	0.25	-	-	Millimeter
A2	2.50	2.72	2.90	Millimeter
c	0.11	0.15	0.23	Millimeter
L1		1.60 REF		Millimeter



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**11. REVISION HISTORY**

Date	Revision #	Description	Page
AUG. 06, 2003	0.1	Original	34

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