欣瑞达液晶显示技术
X.R.D LCD TECHNOLOGY CO., LTD

SPECIFICATIONS FOR LCD MODULE

CUSTOMER	
MODEL	**XRDST-G320240C1UBSWSD-16**
CUSTOMER APPROVED	

APPROVED BY	CHECKED BY	ORGANIZED BY

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Specification Revision History

Version	Content	Date
A0	First Issue	8-Oct-13

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■ MODULE CLASSIFICATION INFORMATION

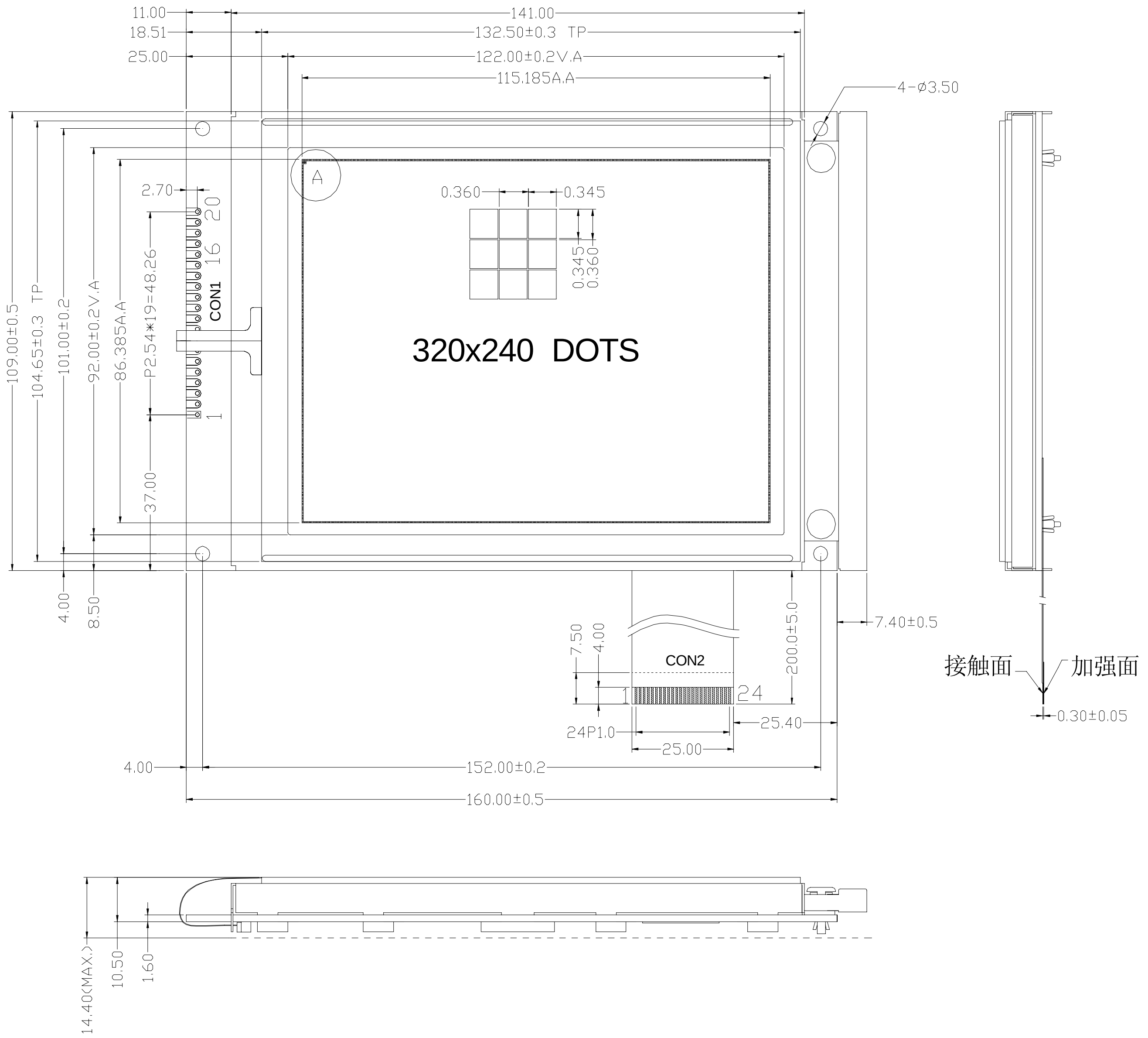
XRD S T - G 320240 C1 U B S W S D -16

- -16: Others
- D: DC/DC
  D:WITH DC/DC
- S: TEMP GRADE
  S:Operating temperature:-20~+70℃
  Storage temperature:-30~+80℃
- W: BACKLIGHT COLOR
  W:white
- S: BACKLIGHT MODE
  S:side lit LED
- B: COLOUR MODE
  B: BLUE
- U: VIEWING ANGLE
  U:12'clock
- C1: MODEL SERIES
- 320240: DISPLAY FORMAT
  320240:320 DOTS/ROW * 240 ROWS
- G: LCM
  G:Graphic
- T: IC PACKING
  T:TCP
- S: LCD TYPE
  S:STN
- XRD: STANDARD MODULE

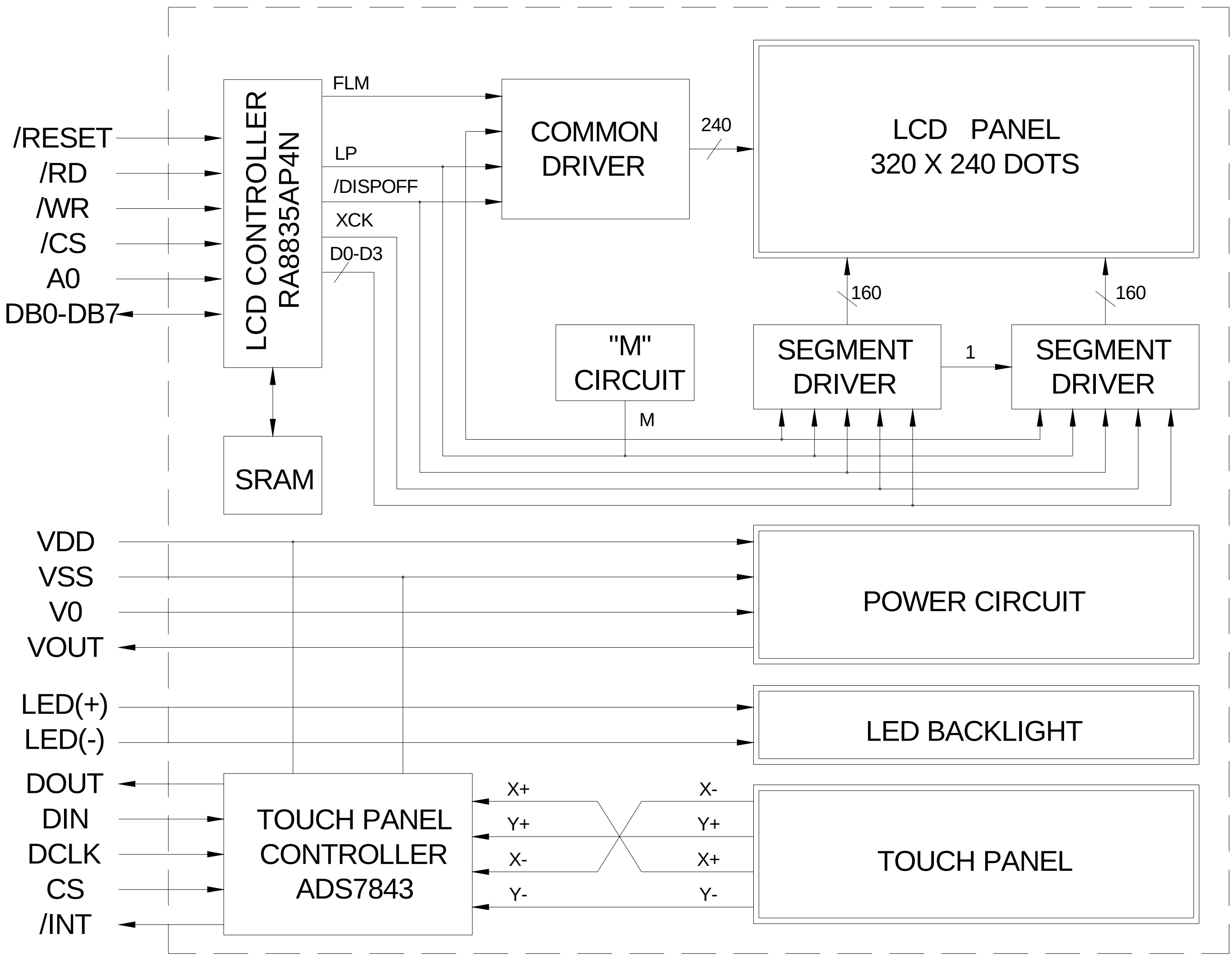
■ PHYSICAL DATA

ITEM	STANDARD VALUE	UNIT
NUMBER OF GRAPHIC	320×240	mm
MODULE DIMENSION	160.0×109.0×14.4(MAX)(Not include LED backlight)	mm
EFFECTIVE DISPLAY AREA	122.0×92.0	mm
DOT SIZE	0.345×0.345	mm
DOT PITCH	0.36×0.36	mm
LCD TYPE	BLUE	
DUTY	1/240	
VIEWING DIRECTION	12	o'clock
BACK LIGHT TYPE	SIDE LED backlight	
BACK LIGHT COLOR	WHITE	
POWER	+5.0V	
APPROX. WEIGHT	TBD	g

■ MECHANICAL DIMENSIONS



■ BLOCK DIAGRAM



■ INTERFACE PIN CONNECTIONS

CON2：

NO	SYMBOL	LEVEL	FUNCTION
1	/RESET	H/L	Reset Signal； This active-LOW input performs a hardware reset
2	/RD	H/L	Read Signal； This signal acts as the active-LOW read strobe
3	/WR	H/L	Write Signal； This signal acts as the active-LOW write strobe, The bus data is latched on the rising edge of the signal
4	/CS	H/L	Chip selected
5	A0	H/L	Command/Data Select (see table below)
6	DB0	H/L	Data bit (8 bits)
7	DB1	H/L	
8	DB2	H/L	
9	DB3	H/L	
10	DB4	H/L	
11	DB5	H/L	
12	DB6	H/L	
13	DB7	H/L	
14	VDD	5.0V	Supply voltage for logic
15	VSS	0V	Ground
16	VOUT		With DC/DC Positive voltage Output (-25.0V)
17	V0		Contrast Adjustment Input (V0-Vss=-21.2V)
18	DCLK	H/L	Serial Clock
19	DOUT	H/L	Data Output
20	DIN	H/L	Data In
21	CS	H/L	Touch panel chip Select
22	/INT	H/L	Interrupt
23	NC		NO connection
24	NC		NO connection
27	LED(+)	+5.0V	Back light anode
28	LED(-)	0V	Back light cathode

Command/Data Select (pin 5, A0):

A0	/RD	/WR	Function
0	0	1	Status flag read
1	0	1	Display data and cursor address write
0	1	0	Display data and parameter write
1	1	0	Command write

■ LCD PANEL

●ABSOLUTE MAXIMUM RATINGS

Condition: VSS=0V , Ta=25℃

PARAMETER	SYMBOL	MIN	MAX	UNIT
Supply voltage for logic	VDD-VSS	-0.3	+6.0	V
Input voltage	VI	-0.3	VDD+0.3	V
LCD driving voltage	VO-VSS	-0.3	-30.0	V
Operating temperature	TOP	-20	+70	°C
Storage temperature	TST	-30	+80	°C

●ELECTRICAL CHARACTERISTICS

▼ DC Characteristics

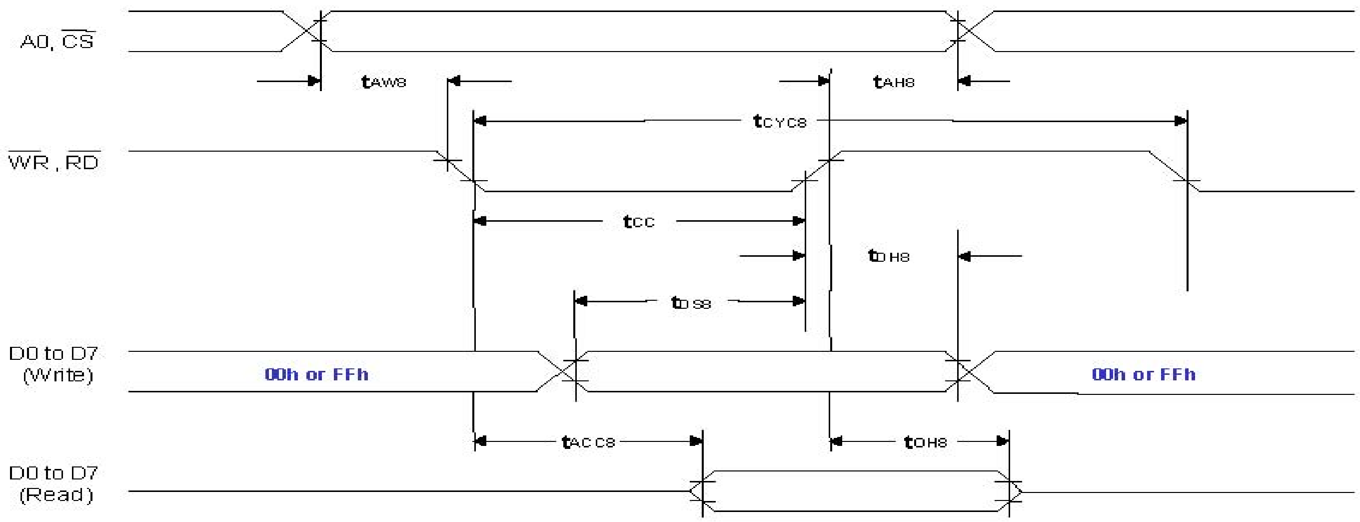
Condition: VSS=0V , VDD=4.5~5.5V , Ta=0 to +50℃

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	Condition
Operating voltage	VDD	4.5	5.0	5.5	V	
Operating current	IDD	20.0	---	50.0	mA	VDD=5.0V Not include backlight
Input voltage ' H ' level	VIH	0.5VDD	---	VDD	V	
Input voltage ' L ' level	VIL	VSS	---	0.2VDD	V	
Output voltage ' H ' level	VOH	VDD-0.4	---	---	V	IOH= 4.0 mA
Output voltage ' L ' level	VOL	---	---	VSS+0.4	V	IOL= -2.0 mA

Condition: VSS=0V , VDD=2.7~4.5V , Ta=0 to +50℃

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT	Condition
Operating voltage	VDD	2.7	3.3	4.5	V	
Operating current	IDD	25.0		65.0	mA	Not include backlight
Input voltage ' H ' level	VIH	0.5VDD	---	VDD	V	
Input voltage ' L ' level	VIL	VSS	---	0.2VDD	V	
Output voltage ' H ' level	VOH	VDD-0.4	---	---	V	IOH= 4.0 mA
Output voltage ' L ' level	VOL	---	---	VSS+0.4	V	IOL= -2.0 mA

▼ AC Characteristics



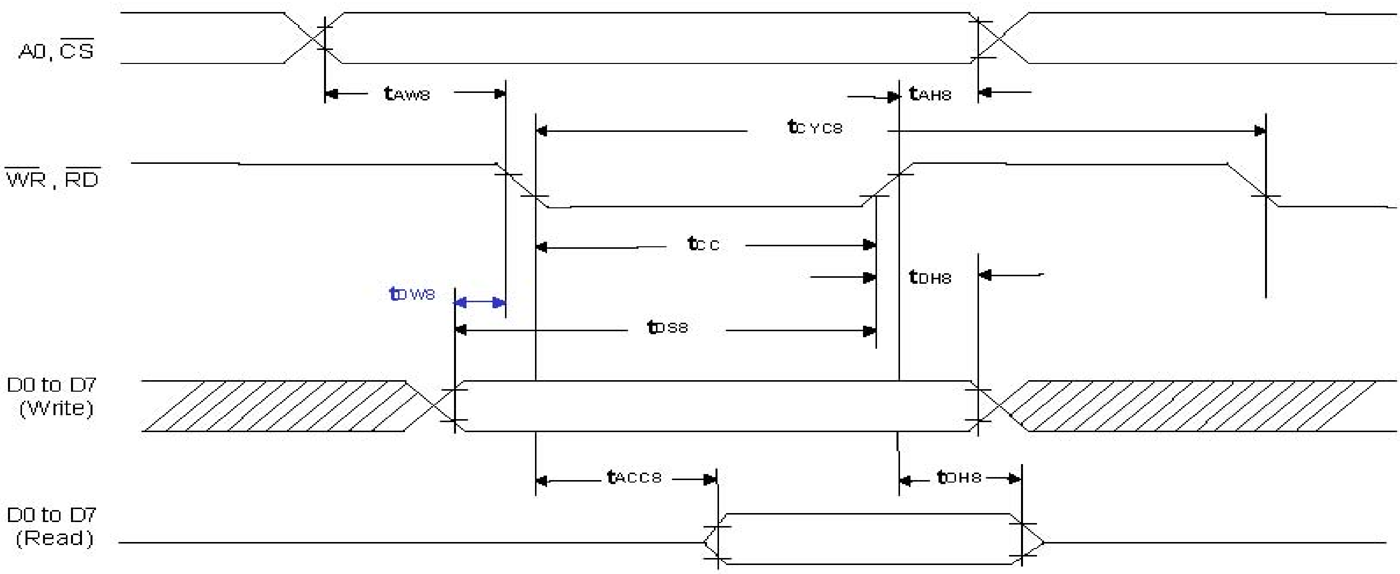
Interface Timing-1

PARAMETER	CONDITION	SYMBOL	VDD=4.5~5.5V		VDD=2.7~4.5V		UNIT	REM-ARK
			MIN	MAX	MIN	MAX		
Address hold time	CL=100pf	t_{AH8}	10	---	10	---	ns	A0 , /CS
Address setup time		t_{AW8}	0	---	0	---	ns	
System cycle time		t_{CYC8}	note	---	note	---	ns	/WR , /RD
Strobe pulse width		t_{CC}	20+tc	---	50+tc	---	ns	
Data setup time		t_{DS8}	120	---	120	---	ns	D0 to D7
Data hold time		t_{DH8}	5	---	5	---	ns	
/RD access time		t_{ACC8}	---	50	---	80	ns	
Output disable time		t_{OH8}	10	50	10	55	ns	

Notes: For memory control and system control commands: $t_{CYC8}=2t_C + t_{CC} + t_{CEA} + 75 > t_{ACV} + 245$

For all other commands: $t_{CYC8}=4t_C + t_{CC} + 30$

$t_C=100ns$; $t_{CEA}(MAX)=120ns$; $t_{ACV}(MAX)=200ns$



Interface Timing-2

PARAMETER	CONDITION	SYMBOL	VDD=4.5~5.5V		VDD=2.7~4.5V		UNIT	REM-ARK
			MIN	MAX	MIN	MAX		
Address hold time	CL=100pf	t_{AH8}	10	---	10	---	ns	A0 , /CS
Address setup time		t_{AW8}	10	---	10	---	ns	
System cycle time		t_{CYC8}	note	---	note	---	ns	/WR , /RD
Strobe pulse width		t_{CC}	20+tc	---	50+tc	---	ns	
Data setup time 1		t_{DS8}	120	---	120	---	ns	D0 to D7
Data hold time		t_{DH8}	5	---	5	---	ns	
/RD access time		t_{ACC8}	---	50	---	80	ns	
Output disable time		t_{OH8}	10	50	10	55	ns	
Data setup time 2		t_{DW8}	5	---	10	---	ns	

Notes: For memory control and system control commands: $t_{CYC8}=2t_C + t_{CC} + t_{CEA} + 75 > t_{ACV} + 245$

For all other commands: $t_{CYC8}=4t_C + t_{CC} + 30$

$t_C=100ns$; $t_{CEA}(MAX)=120ns$; $t_{ACV}(MAX)=200ns$

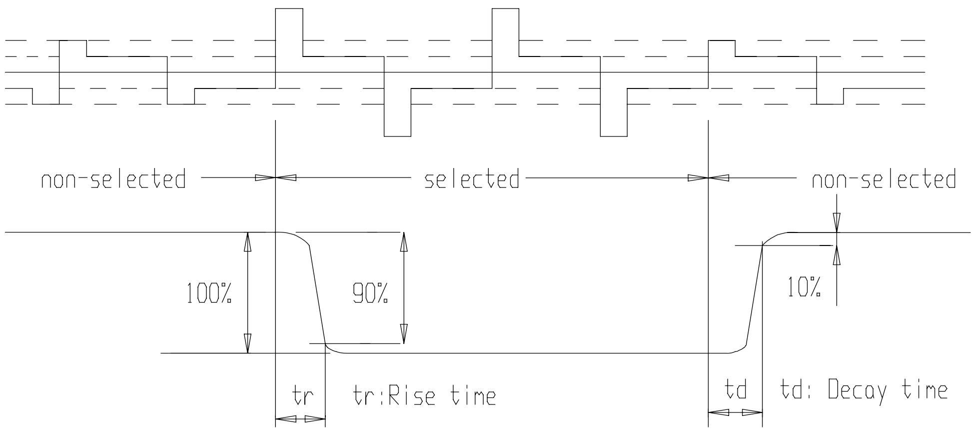
●OPTICAL CHARACTERISTICS

Test instrument is LCD-5000, made in Japan

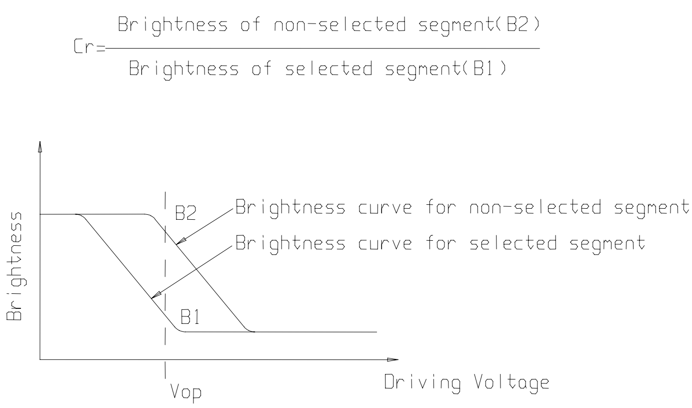
ITEM	SYMBOL	Condition	Min	Typ	Max	Unit	Remarks	Note
Operating voltage	Vop	25℃	21.7	22.0	22.3	V	---	---
Response time	Tr	----	---	110	170	ms	---	1
	Td	----	---	110	170	ms	---	1
Contrast ratio	Cr	----	---	19.2	---	---	---	2
Viewing angle range	θ	25℃ &Cr≥2	---	40	---	deg	Ø=0°	3
			---	35	---	deg	Ø=90°	3
			---	35	---	deg	Ø=180°	3
			---	35	---	deg	Ø=270°	3

▼ Definition Of Viewing Angle

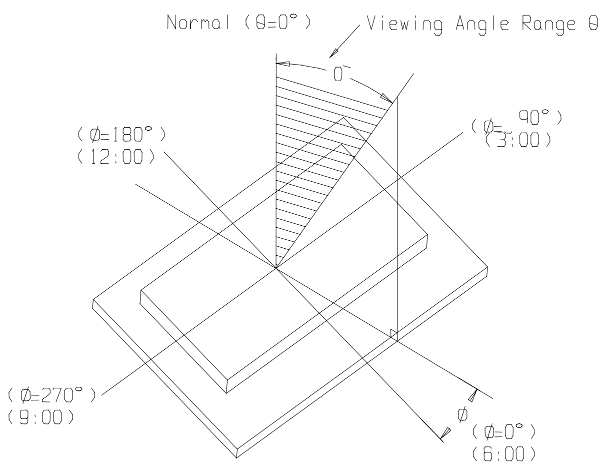
Note 1: Definition of response time



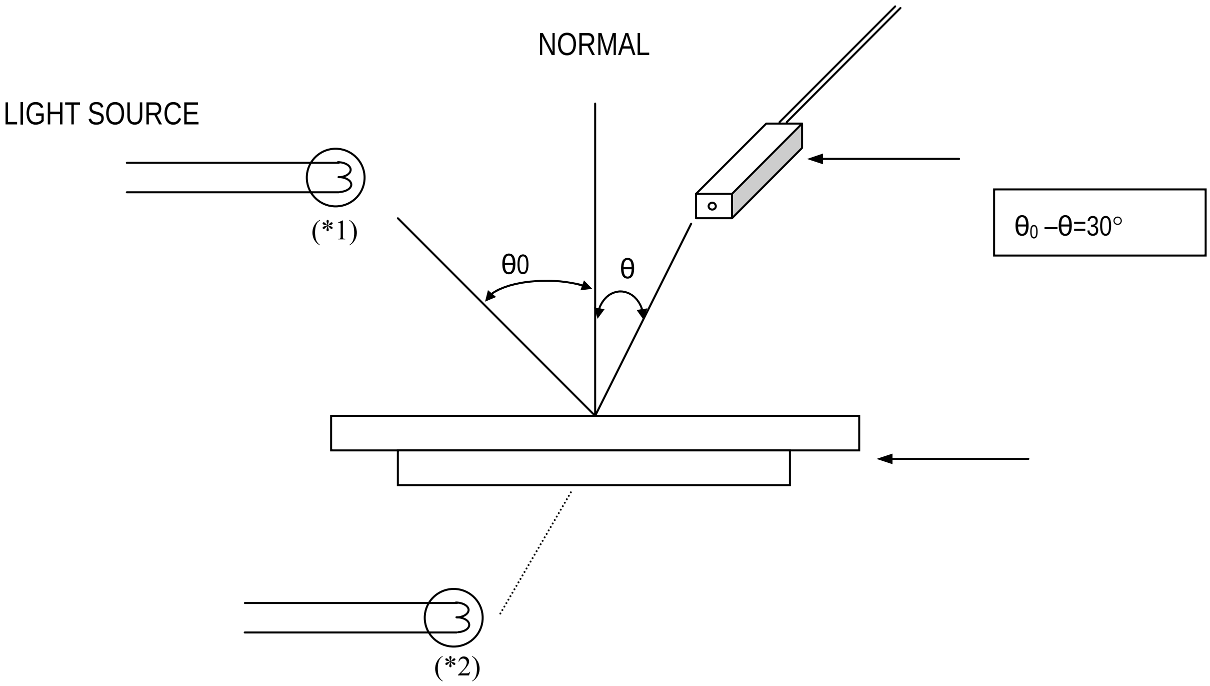
Note 2: Definition of contrast ratio ‘Cr’



Note 3: Definition of viewing angle range ‘θ’



Note 4: Measuring Instruments For Electro-optical Characteristics



*1. Light source position for measuring the reflective type of LCD panel
*2. Light source position for measuring the transflective / transmissive types of LCD panel

●OPERATING PRINCIPLES & METHODS

Control And Display Command

CLASS	COMMAND	CODE											HEX	COMMAND DESCRIPTION	COMMAND READ PARAMETERS
		RD	WR	A0	D7	D6	D5	D4	D3	D2	D1	D0			No. of Bytes
System Control	SYSTEM SET	1	0	1	0	1	0	0	0	0	0	0	40	Initialize device and display	8
	SLEEP IN	1	0	1	0	1	0	1	0	0	1	1	53	Enter standby mode	0
Display Control	DISPLAY ON/OFF	1	0	1	0	1	0	1	1	0	0	D	58, 59	Enable and disable Display and display Flashing	1
	SCROLL	1	0	1	0	1	0	0	0	1	0	0	44	Set display start Address and display Regions	10
	CSRFORM	1	0	1	0	1	0	1	1	1	0	1	5D	Set cursor type	2
	CGRAM ADR	1	0	1	0	1	0	1	1	1	0	0	5C	Set start address of character generator RAM	2
	CSRDIR	1	0	1	0	1	0	0	1	1	CD1	CD0	4C to 4F	Set direction of cursor Movement	0
	HDOT SCR	1	0	1	0	1	0	1	1	0	1	0	5A	Set horizontal scroll	1
	OVLAY	1	0	1	0	1	0	1	1	0	1	1	5B	Set display overlay Format	1
Drawing Control	CSRW	1	0	1	0	1	0	0	0	1	1	0	46	Set cursor address	2
	CSRR	1	0	1	0	1	0	0	0	1	1	1	47	Read cursor address	2
Memory Control	MWRITE	1	0	1	0	1	0	0	0	0	1	0	42	Write to display Memory	-
	MREAD	1	0	1	0	1	0	0	0	0	1	1	43	Read from display Memory	-

Notes:

1. **In general, the internal registers are modified as each command parameter is input. However, the microprocessor does not have to set all the parameters of a command and may send a new command before all parameters have been input. The internal registers for the parameters that have been input will have been changed but the remaining parameter registers are unchanged. 2-byte parameters (where two bytes are treated as 1 data item) are handled as follows:**
   a. **CSRW, CSRR: Each byte is processed individually. The microprocessor may read or write just the low byte of the cursor address.**
   b. **SYSTEM SET, SCROLL , CGRAM ADR: Both parameter bytes are processed together. If the command is changed after half the parameter has been input, the single byte is ignored.**
2. **APL and APH are 2-byte parameters, but are treated as two 1-byte parameters.**

Contents

(1) System Control Commands

Initializes the device, sets the window sizes, and selects the LCD interface format. Since this command sets the basic operating parameters, an incorrect SYSYTEM SET command may cause other commands to operate incorrectly.

	MSB							LSB			
	D7	D6	D5	D4	D3	D2	D1	D0	A0	$\overline{WR}$	$\overline{RD}$
C	0	1	0	0	0	0	0	0	1	0	1
P1	0	0	IV	1	W/S	M2	M1	M0	0	0	1
P2	WF	0	0	0	0	← FX →			0	0	1
P3	0	0	0	0	← FY →				0	0	1
P4	← C/R →								0	0	1
P5	← TC/R →								0	0	1
P6	← L/F →								0	0	1
P7	← APL →								0	0	1
P8	← APH →								0	0	1

Figure 1: SYSTEM SET Instruction

A: *C*

This control byte performs the following:

1. Resets the internal timing generator
2. Disables the display
3. Cancels sleep mode

Parameters following p1 are not needed if only canceling sleep mode.

B: *M0*

Select the internal or external generator ROM. The internal character generator ROM contains 160, 5*7 pixel characters, as shown in **Figure: On-chip Character set**. These characters are fixed at fabrication by the metallization mask.

The external character generator ROM, on the other hand, can contain up to 256 user-defined characters.

M0=0: Internal CG ROM

M0=1: External CG ROM

Note: that if the CG ROM address space overlaps the display memory address space, that portion of the display memory cannot be written to.

C: *M1*

Select the memory configuration for user-definable characters. The CG RAM codes select one of the 64 codes shown in Figure 46.

M1=0: No D6 correction.

The CG RAM1 and CG RAM2 address spaces are not contiguous, the CG RAM1 address space is treated as character generator RAM, and the CG RAM2 address space is treated as character generator

ROM.

M1=1:D6 correction.
The CG RAM1 and CG RAM2 address are contiguous and are both treated as character generator RAM.

D: *M2*

Select the height of the character bitmaps. Characters more than 16 pixels high can be displayed by creating a bitmap for each portion of each character and using the series graphics mode to reposition them.

M2=0: 8-pixel character height (2716 or equivalent ROM)
M2=1: 16-pixel character height (2732 or equivalent ROM)

E: *W/S* ****SET TO 0***

Select the LCD drive method

W/S=0: Single-panel drive
W/S=1: Dual-panel drive(no use)

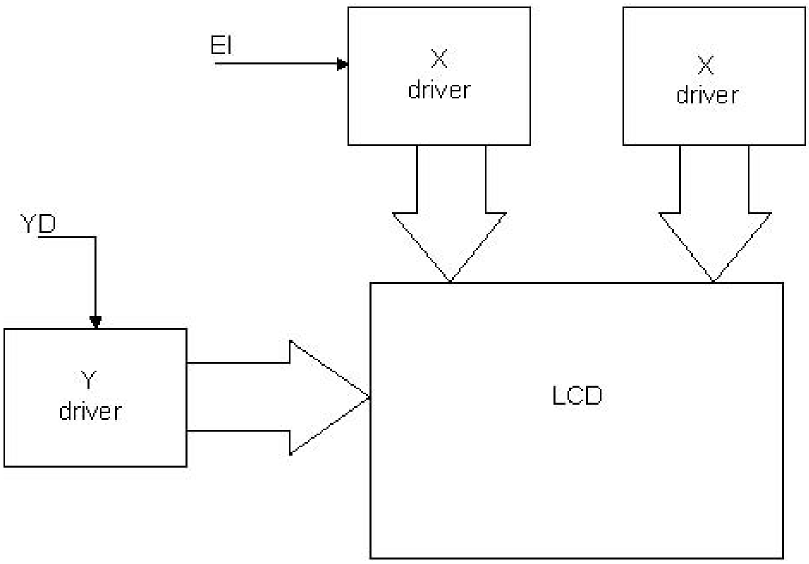


Figure 2: Single-panel Display

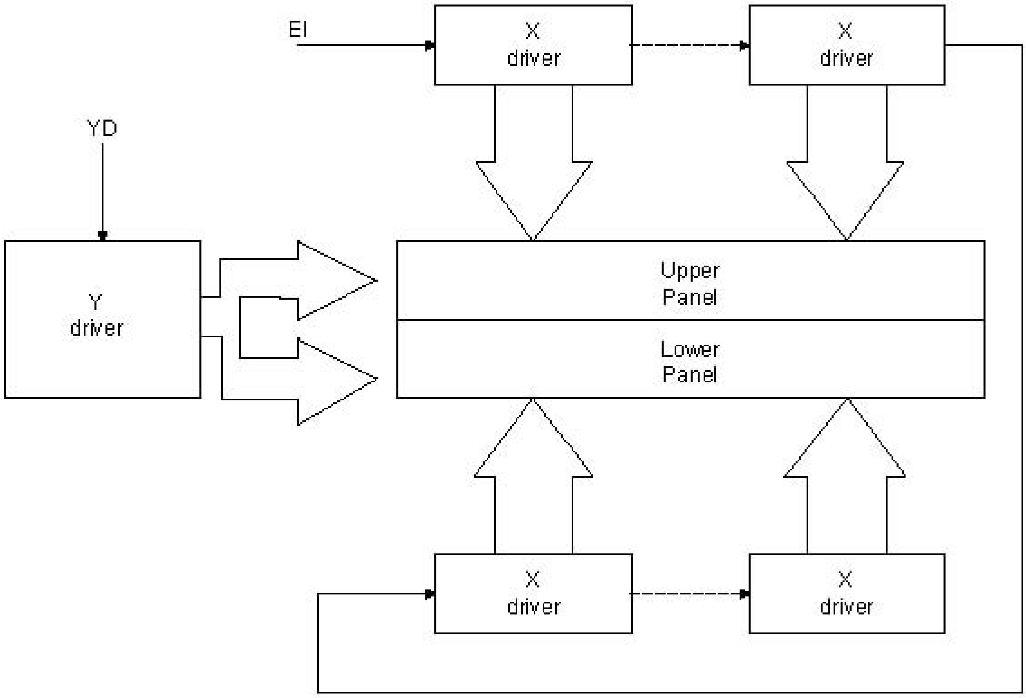


Figure 3: Above and Below Dual-panel Display

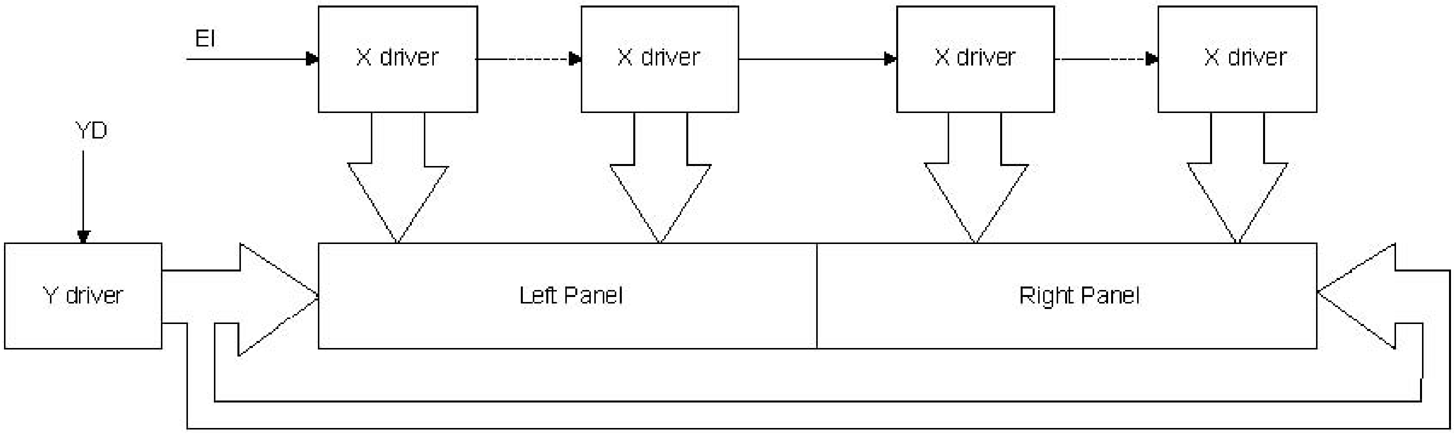


Figure 4: Left and Right Dual-panel Display

F: _IV_

Screen origin compensation for inverse display .IV is usually set to 1. The best way of displaying inverted characters is to Exclusive -OR the text layer with the graphics background layer. However, inverted characters at the top or left of the screen are difficult to read as the character origin is at the top-left of its bitmap and there are no background pixels either above or to the left of these characters.

The IV flag causes the production to offset the text screen against the graphic back layer by one vertical pixel. Use the horizontal pixel scroll function (HDOT SCR) to shift the text screen 1 to 7 pixels to the right. All characters will then have the necessary surrounding background pixels that ensure easy reading of the inverted characters.

IV=0: Screen top-line correction

IV=1: No screen top-line correction

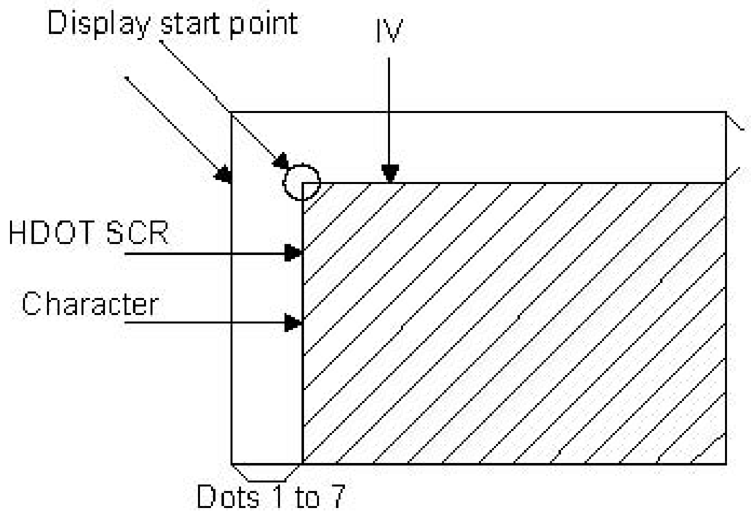


Figure 5: IV and HDOT SCR Adjustment

G: *FX*

Define the horizontal character size. The character width in pixels is equal to FX+1, where FX can range from 00 to 07H inserted between characters.

Table 1: Horizontal Character Size Selection

FX					[FX]character Width (pixels)
HEX	D3	D2	D1	D0	
00	0	0	0	0	1
01	0	0	0	1	2
↓	↓	↓	↓	↓	↓
07	0	1	1	1	8

Since the production handles display data in 8-bit units, characters larger than 8 pixels wide must be formed from 8-pixel segments; As Figure 6 shows, the remainder of the second eight bits are not displayed .This also applies to this second screen layer.

In graphics mode, the normal character field is also eight pixels. If a wider character field is used, any remainder in the second eight bits is not displayed.

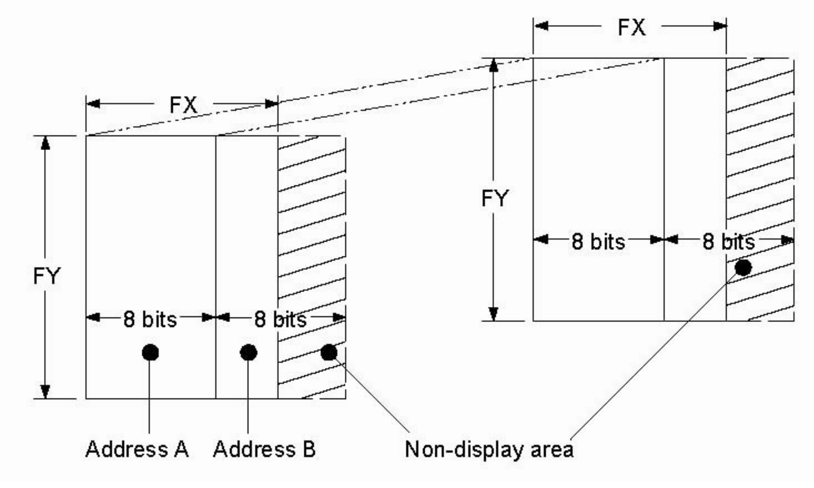


Figure 6: FX and FY display addresses

H: ***WF***

Select the AC frame drive waveform period. WF is usually set to 1.
WF=0: 16-line AC drive
WF=1: two-frame AC drive
In two-frame AC drive, the WF period is twice the frame period.

In 16-line AC drive, WF inverts every 16 lines.
Although 16-line AC drive gives a more readable display, horizontal lines may appear when using high LCD drive voltages or at high viewing angles.

I: ***FY***

Set the vertical character size. The height in pixels is equal to FY+1.FY can range from 00 to 0FH inclusive. Set FY to zero (vertical size equals one) when in graphics mode.

Table 2: Vertical Character Size Selection

FY					[FY]character Height (pixels)
HEX	D3	D2	D1	D0	
00	0	0	0	0	1
01	0	0	0	1	2
↓	↓	↓	↓	↓	↓
07	0	1	1	1	8
↓	↓	↓	↓	↓	↓
0E	1	1	1	0	15
0F	1	1	1	1	16

J: ***C/R***

Set the address range covered by one display line, that is ,the number of characters less one, multiplied by the number of horizontal bytes per character .C/R can range from 0 to 239.
For example, if the character width is 10 pixels ,then the address range is equal to twice the number of characters, less 2. See Section <SYSTEM SET instruction and parameters>. [C/R] cannot be set to a value greater than the address range. It can, however, be set smaller than the address range, in which case the excess display area is blank. The number of excess pixels must not exceed 64.

Table 3: Display line address range

CR									[C/R] bytes per display line
HEX	D7	D6	D5	D4	D3	D2	D1	D0	
00	0	0	0	0	0	0	0	0	1
01	0	0	0	0	0	0	0	1	2
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
4F	0	1	0	0	1	1	1	1	80
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
EE	1	1	1	0	1	1	1	0	239
EF	1	1	1	0	1	1	1	1	240

K:***TC/R***

Set the length, including horizontal blanking, of one line. The length is equal to TC/R+1, where TC/R can range from 0 to 255.

TC/R must be greater than or equal to C/R+4 .Provided this condition is satisfied, [TC/R] can be set according to the equation given in section <SYSTEM SET instruction and parameters> in order to hold the frame period constant and minimize jitter for any given for any given main oscillator frequency, fosc.

Table 4: Line length selection

TC/R									[TC/R] line length (bytes)
HEX	D7	D6	D5	D4	D3	D2	D1	D0	
00	0	0	0	0	0	0	0	0	1
01	0	0	0	0	0	0	0	1	2
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
52	0	1	0	1	0	0	1	0	83
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
FE	1	1	1	1	1	1	1	0	255
FF	1	1	1	1	1	1	1	1	256

L:*L/F*

Set the height, in lines, of a frame. The height in lines is equal to L/F+1, where L/F can range from 0 to 255.

Table 5: Frame height selection

L/F									[TC/R] line length (bytes)
HEX	D7	D6	D5	D4	D3	D2	D1	D0	
00	0	0	0	0	0	0	0	0	1
01	0	0	0	0	0	0	0	1	2
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
7F	0	1	1	1	1	1	1	1	128
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
FE	1	1	1	1	1	1	1	0	255
FF	1	1	1	1	1	1	1	1	256

If W/S is set to 1, selecting two-screen display, the number of lines must be even and L/F must, therefore, be an odd number.

M:*AP*

Define the horizontal address range of the virtual screen. APL is the least significant byte of the address.

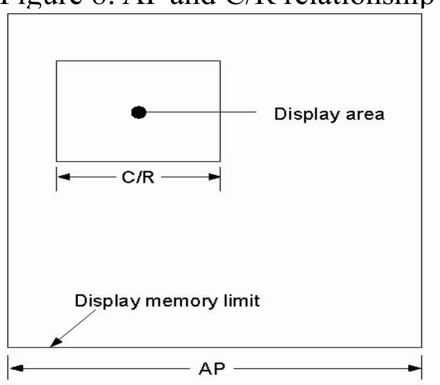
APL	AP7	AP6	AP5	AP4	AP3	AP2	AP1	AP0
APH	AP15	AP14	AP13	AP12	AP11	AP10	AP9	AP8

Figure 7: AP Parameters

Table 6: Horizontal Address Range

FY				[AP]addresses Per line
APH		APL		
0	0	0	0	1
0	0	0	1	2
↓	↓	↓	↓	↓
0	0	5	1	80
↓	↓	↓	↓	↓
F	F	F	E	2^16-2
F	F	F	F	2^16-1

Figure 8: AP and C/R relationship



(2) SLEEP IN

Place the system in standby mode. This command has no parameter bytes. At least one blank frame after receiving this command, the production halts all internal operations, including the oscillator, and enters the sleep state.

	MSB							LSB
C	0	1	0	1	0	0	1	1

Figure 9: SLEEP IN Instruction

(3) DISP ON/OFF

Turn the whole display on or off. The single-byte parameter enables and disables the cursor and layered screens, and sets the cursor and screen flash rates. The cursor can be set to flash over one character or over a whole line.

	MSB							LSB
C	0	1	0	1	1	0	1	D
P1	FP5	FP4	FP3	FP2	FP1	FP0	FC1	FC0

Figure 10: DISP ON/OFF Parameters

A: *D*

Turn the display ON or OFF .The D bit takes precedence over the FP bits in the parameter.

D=0: Display OFF

D=1: Display ON

B: *FC*

Enables /disables the cursor and sets the flash rate. The cursor flashes with a 70% duty cycle (ON/OFF).

Table 7: Cursor Flash Rate Selection

FC1	FC0	Cursor display	
0	0	OFF(blank)	
0	1	ON	No flashing
1	0		Flash at fFR/32 Hz (approx. 2 Hz)
1	1		Flash at fFR /64 Hz (approx. 1 Hz)

Note: As the MWRITE command always enables the cursor, the cursor position can be checked even when performing consecutive writes to display memory while the cursor is flashing.

C: *FP*

Each pair of bits in FP sets the attributes of one screen block, as follows. The display attributes are as follows:

Table 8: Screen Block Attribute Selection

FP1	FP0	First screen block(SAD1)	
FP3	FP2	Second screen block (SAD2,SAD4).See note.	
FP5	FP4	Third screen block(SAD3)	
0	0	OFF(blank)	
0	1	ON	No flashing
1	0		Flash at fFR /32 Hz (approx. 2 Hz)

1	1		Flash at fFR /4 Hz (approx. 16Hz)

Note: If SAD4 is enabled by setting W/S to 1,FP3 and FP2 control SAD2 and SAD4. The attributes of SAD2 and SAD4 cannot be set independently.

(4) SCROLL

A: *C*

Set the scroll start address and the number of lines per scroll block .Parameters P1 to P10 can be omitted if not required. The parameters must be entered sequentially as shown in Figure 11.

Note: Set parameters P9 and P10 only if both two-screen drive (W/S=1) and two-layer configuration are selected .SAD4 is the fourth screen block display start address.

	MSB							LSB	
C	0	1	0	0	0	1	0	0	
P1	A7	A6	A5	A4	A3	A2	A1	A0	(SAD 1L)
P2	A15	A14	A13	A12	A11	A10	A9	A8	(SAD 1H)
P3	L7	L6	L5	L4	L3	L2	L1	L0	(SL 1)
P4	A7	A6	A5	A4	A3	A2	A1	A0	(SAD 2 L)
P5	A15	A14	A13	A12	A11	A10	A9	A8	(SAD 2H)
P6	L7	L6	L5	L4	L3	L2	L1	L0	(SL 2)
P7	A7	A6	A5	A4	A3	A2	A1	A0	(SAD 3L)
P8	A15	A14	A13	A12	A11	A10	A9	A8	(SAD 3H)
P9	A7	A6	A5	A4	A3	A2	A1	A0	(SAD 4L)
P10	A15	A14	A13	A12	A11	A10	A9	A8	(SAD 4H)

Figure 11: SCROLL Instruction Parameters

Note: Set parameters P9 and P10 only if both two-screen drive (W/S=1) and two-layer configuration are selected .SAD4 is the fourth screen block display start address

Table 9: Screen block start address selection

SL1,SL2									[SL] screen line
HEX	L7	L6	L5	L4	L3	L2	L1	L0	
00	0	0	0	0	0	0	0	0	1
01	0	0	0	0	0	0	0	1	2
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
7F	0	1	1	1	1	1	1	1	128
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
FE	1	1	1	1	1	1	1	0	255
FF	1	1	1	1	1	1	1	1	256

B: *SL1, SL2*

SL1 and SL2 set the number of lines per scrolling screen. The number of lines is SL1 and SL2 plus one. The relationship between SAD. SL and the display mode is described below

Table 10: Text display mode

W/S	Screen	First Layer	Second Layer
0	First screen block	SAD1	SAD2
	Second screen block	SL1	SL2
	Third screen block (partitioned screen)	SAD3 (see note 1) Set both SL1 and SL2 to L/F + 1 if not using a partitioned screen.	
	Screen configuration example:		

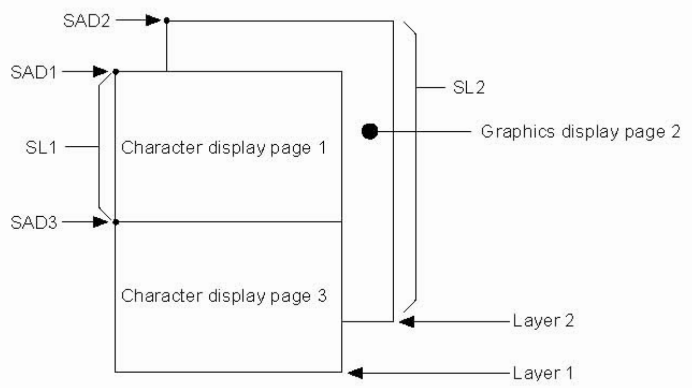
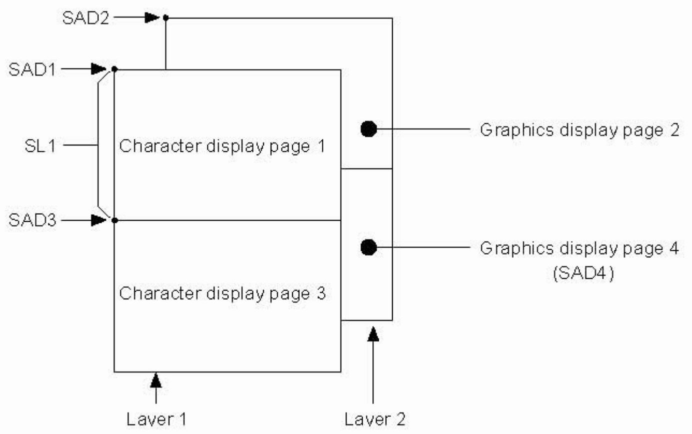


Table 10: Text display mode (continued)

<table>
<tr><th>W/S</th><th>Screen</th><th>First Layer</th><th>Second Layer</th></tr>
<tr><td rowspan="4">1</td><td>Upper screen</td><td>SAD1
SL1</td><td>SAD2
SL2</td></tr>
<tr><td>Lower screen</td><td>SAD3
(See note 2.)</td><td>SAD4
(See note 2.)</td></tr>
<tr><td colspan="3">Set both SL1 and SL2 to ((L/F) / 2 + 1).</td></tr>
<tr><td colspan="3">Screen configuration example:

</td></tr>
</table>

Notes:

1. SAD3 has the same value as either SAD1 or SAD2, whichever has the least number of lines (set by SL1 and SL2).
2. Since the parameters corresponding to SL3 and SL4 are fixed by L/F, they do not have to be set in this mode.

Table 11: Graphics display mode

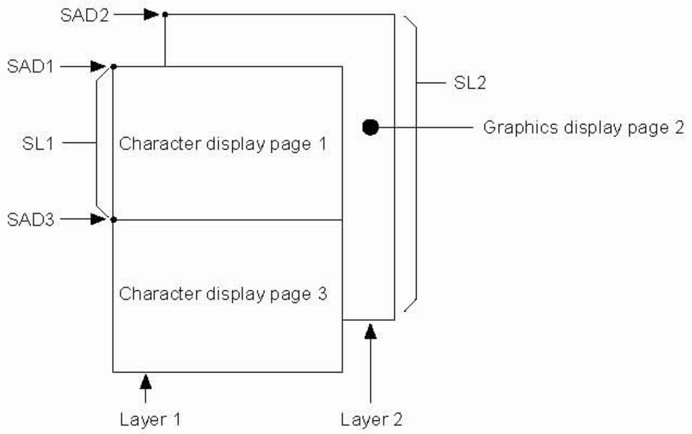
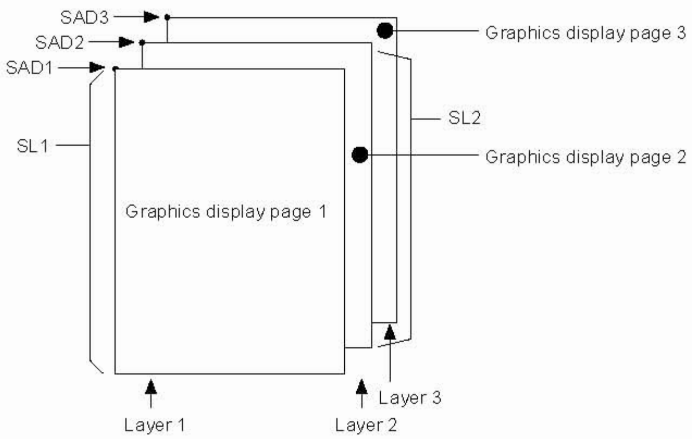
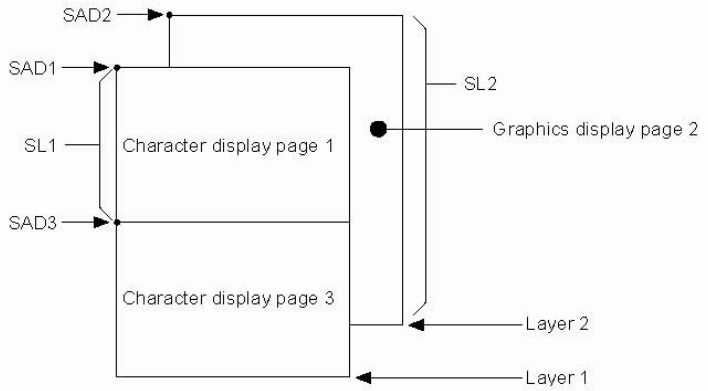
<table>
<tr><th>W/S</th><th>Screen</th><th>First Layer</th><th>Second Layer</th><th>Third Layer</th></tr>
<tr><td rowspan="3">0</td><td>Two-layer composition</td><td>SAD1
SL1</td><td>SAD2
SL2</td><td></td></tr>
<tr><td>Upper screen</td><td colspan="2">SAD3 (see note 3.)
Set both SL1 and SL2 to
L/F + 1 if not using a
partitioned screen</td><td></td></tr>
<tr><td colspan="4">Screen configuration example:

</td></tr>
<tr><td rowspan="2">0</td><td>Three-layer configuration</td><td>SAD1
SL1 = L/F + 1</td><td>SAD2
SL2 = L/F + 1</td><td>SAD3
—</td></tr>
<tr><td colspan="4">Screen configuration example:

</td></tr>
</table>

Table 11: Graphics display mode (continued)

W/S	Screen	First Layer	Second Layer
0	First screen block	SAD1	SAD2
	Second screen block	SL1	SL2
	Third screen block (partitioned screen)	SAD3 (see note 1) Set both SL1 and SL2 to L/F + 1 if not using a partitioned screen.	
	Screen configuration example: 		

Notes:

1. SAD3 has the same value as either SAD1 or SAD2; whichever has the least number of lines (set by SL1 and SL2).
2. Since the parameters corresponding to SL3 and SL4 are fixed by L/F, they do not have to be set.
3. If, and only if, W/S=1, the differences between SL1 and (L/F+1)/2, and between SL2 and (L/F+1)/2, are blanked.

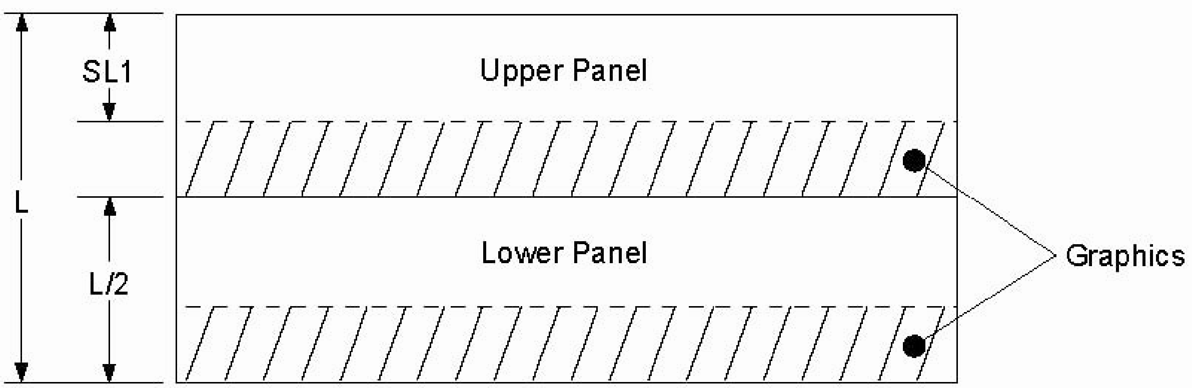


Figure 12: Two-panel display height

(5) CSRFORM

Set the cursor size and shape. Although the cursor is normally only used in text displays, it may also be used in graphics displays when displaying special characters.

	MSB							LSB
C	0	1	0	1	1	1	0	1
P1	0	0	0	0	CRX X3	CRX X2	CRX X1	CRX X0
P2	CM	0	0	0	CRY Y3	CRY Y2	CRY Y1	CRY Y0

Figure 13: CSRFORM parameter bytes

A: *CRX*

Set the horizontal size of the cursor from the character origin .CRX is equal to the cursor size less one. CRX must be less than or equal to FX.

Table 12: Horizontal cursor size selection

CRX					[CRX] cursor width (pixels)
HEX	D3	D2	D1	D0	
0	0	0	0	0	1
1	0	0	0	1	2
↓	↓	↓	↓	↓	↓
4	0	1	0	0	5
↓	↓	↓	↓	↓	↓
E	0	1	1	0	7
F	0	1	1	1	8

B: *CRY*

Set the location of an underscored cursor in lines, from the character origin. When using a block cursor. CRY sets the vertical size of the cursor from the character origin. CRY is equal to the number of lines less one.

Table 13: Cursor height selection

CRY					[CRY] cursor height (pixels)
HEX	D3	D2	D1	D0	
0	0	0	0	0	illegal
1	0	0	0	1	2
↓	↓	↓	↓	↓	↓
8	1	0	0	0	9
↓	↓	↓	↓	↓	↓
E	0	1	1	0	7
F	0	1	1	1	8

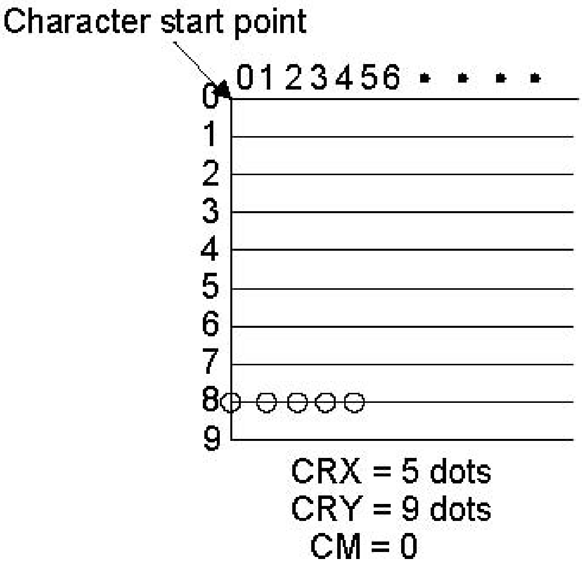


Figure 14: Cursor size and position

C: *CM*

Set the cursor shape. Always set CM to 1 when in graphics mode.
CM=0: Underscore cursor
CM=1: Block cursor

(6) CSRDIR

Set the direction of automatic cursor increment. The cursor can move left or right one character, or up or down by the number of bytes specified by the address pitch, AP When reading from and writing to display memory, this automatic cursor increment controls the display memory address increment on each read or write.

	MSB							LSB
C	0	1	0	0	1	1	CD1	CD2

Figure 15: CSRDIR parameters

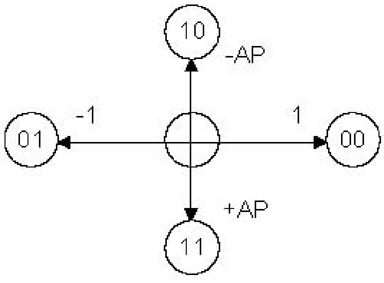


Figure 16: Cursor direction

Table 14: Cursor shift direction

C	CD1	CD2	Shift direction
4CH	0	0	Right
4DH	0	1	Left
4EH	1	0	Up
4FH	1	1	Down

Note: Since the cursor moves in address units even if $FX \geqslant 9$, the cursor address increment must be preset for movement in character units. See Section <Cursor control>

(7) OVLAY

Selects layered screen composition and screen text/graphics mode.

	MSB							LSB
C	0	1	0	1	1	0	1	1
P1	0	0	0	OV	DM2	DM1	MX1	MX0

Figure 17: OVLAY parameters

A: ***<u>MX0,MX1</u>***

MX0 and MX1 set the layered screen composition method, which can be either OR, AND, Exclusive-OR or Priority-OR Since the screen composition is organized in organized in layers and not by screen blocks, when using a layer divided into two screen blocks, different composition methods cannot be specified for the individual screen blocks.

The Priority-OR mode is the same as the OR mode unless flashing of individual screens is used.

Table 15: Composition method selection

MX1	MX0	Function	Composition Method	Applications
0	0	$L1 \cup L2 \cup L3$	OR	Underlining, rules, mixed text and graphics
0	1	$(L1 \oplus L2) \cup L3$	Exclusive-OR	Inverted characters, flashing regions, underlining
1	0	$(L1 \cap L2) \cup L3$	AND	Simple animation, three-dimensional appearance
1	1	L1>L2>L3	Priority- OR	

Notes:

L1: First layer (text or graphics).If text is selected, layer L3 cannot be used.

L2: Second layer (graphics only)

L3: Third layer (graphic only)

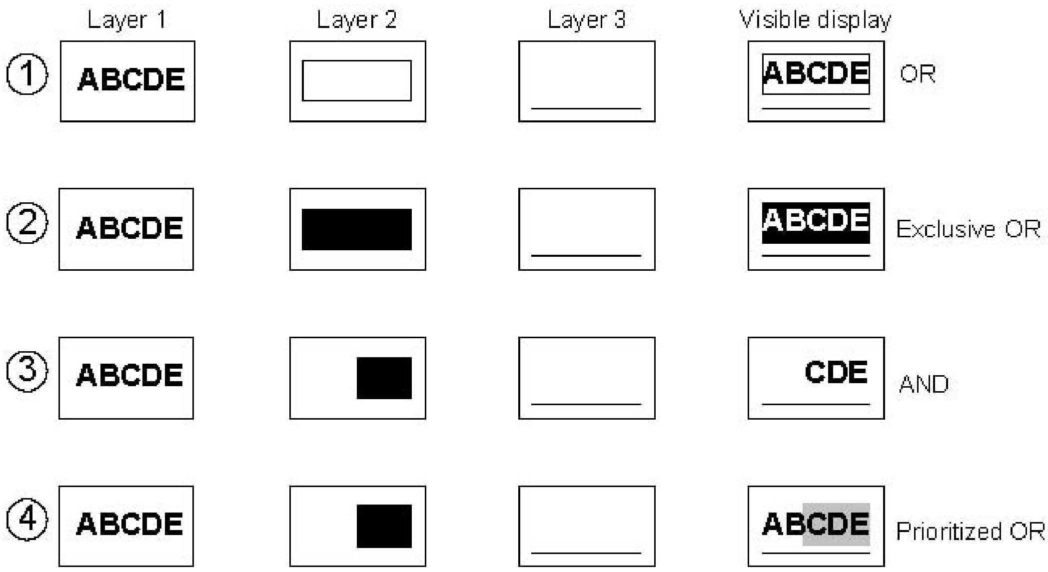


Figure 18: Combined layer display

Note:

L1: Not flashing
L2: Flashing at 1 Hz
L3: Flashing at 2 Hz

B: *DM1,DM2*

DM1 and DM2 specify the display mode of screen blocks 1 and 3, respectively
DM1/2=0: Test mode
DM1/2=1: Graphics mode
Note 1: Screen blocks 2 and 4 can only display graphic.
Note 2: DM1 and DM2 must be the same, regardless of the setting of W/S.

C: *OV*

Specifies two- or three-layer composition in graphics made.
OV=0: Two-layer composition
OV=1: Three-layer composition
Set OV to 0 for mixed text and graphics mode.

(8) CGRAM ADR

Specifies the CG RAM start address

	MSB							LSB	
C	0	1	0	1	1	1	0	0	
P1	A7	A6	A5	A4	A3	A2	A1	A0	(SAGL)
P2	A15	A14	A13	A12	A11	A10	A9	A8	(SAGH)

Figure 19: CGRAM ADR parameters

Note: See section <Character generator >

(9) HDOT SCR

While the SCROLL command only allows scrolling by characters. HDOT SCR allows the screen to be scrolled horizontally by pixels. HDOT SCR cannot be used on individual layers.

	MSB							LSB
C	0	1	0	1	1	0	1	0
P1	0	0	0	0	0	D2	D1	D0

Figure 20: HDOT SCR parameters

A: *D0 to D2*

Specifies the number of pixels to scroll. The C/R parameter has to be set to one more than the number of horizontal characters before using HDOT SCR. Smooth scrolling can be simulated if the controlling microprocessor repeatedly issues the HDOT SCR command to the production .See Section <Memory to display relationship >

Table 16: Scroll step selection

P1				Number of pixies to scroll
HEX	D2	D1	D0	
00	0	0	0	0
01	0	0	1	1
02	0	1	0	2
↓	↓	↓	↓	↓
06	1	1	0	6
07	1	1	1	7

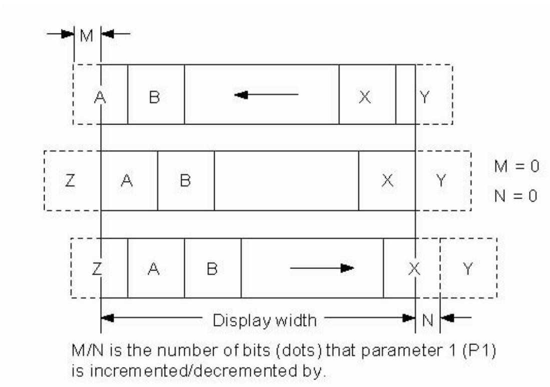


Figure 21: Horizontal scrolling

(10) CSRW

A: *D0 to D2*

The 16-bit cursor address register contains the display memory address of the data at the cursor memory address of the data at the cursor position as shown in Figure 22.

Note that the microprocessor cannot directly access the display memory.

The MREAD and MWRITE commands use the address in this register.

The cursor address register can only be modified by the CSRW command, and by the automatic increment after an MREAD or MWRITE command. It is not affected by display scrolling. If a new address is not set, display memory accesses will be from the last set address or the address after previous automatic increments.

	MSB							LSB	
C	0	1	0	0	0	1	1	0	
P1	A7	A6	A5	A4	A3	A2	A1	A0	(CSRL)
P2	A15	A14	A13	A12	A11	A10	A9	A8	(CSRH)

Figure 22: CSRW parameters

(11) CSRR

Read from the cursor address register. After issuing the command, the data read address is read twice, for the low byte and then the high byte of the register.

	MSB							LSB	
C	0	1	0	0	0	1	1	1	
P1	A7	A6	A5	A4	A3	A2	A1	A0	(CSRL)
P2	A15	A14	A13	A12	A11	A10	A9	A8	(CSRH)

Figure 23: CSRR parameters

(12) MWRITE

The microprocessor may write a sequence of data bytes to display memory by issuing the MREAD command and then writing the bytes to the production. There is no need for further MWRITE commands or for the microprocessor to update the cursor address register after each byte as the cursor address is automatically incremented by the amount set with CSRDIR, in preparation for the next data write.

	MSB							LSB	
C	0	1	0	0	0	0	1	0	
P1									
P2									
...									
Pn									n≧1

Figure 24: MWRITE parameters

Note:
P1, P2,...Pn: display data

(13) MREAD

Puts the production into the data output state. Each time the microprocessor reads the buffer, the cursor address is incremented by the amount set by CSRDR and the next data byte fetched from memory, so a sequence of data bytes may be read without further MREAD commands or by updating the cursor address register. If the cursor is displayed, the read data will be from two positions ahead of the cursor.

	MSB							LSB	
C	0	1	0	0	0	0	1	1	
P1									
P2									
...									
Pn									n≧1

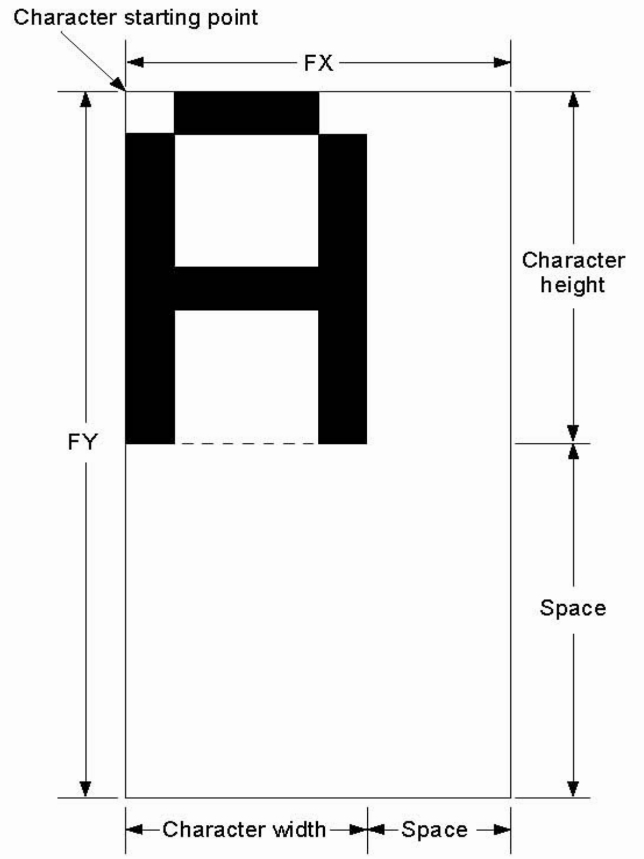
Figure 25: MREAD parameters

Display Control Functions

(1) Character configuration

The origin of each character bitmap is in the top left corner as shown in Figure 29. Adjacent bits in each byte are horizontally adjacent in the corresponding character image.

Although the size of the bitmap is fixed by the character generator, the actual displayed size of the character field can be varied in both dimensions



	D7			to				D0
R0	0	1	1	1	0	0	0	0
R1	1	0	0	0	1	0	0	0
R2	1	0	0	0	1	0	0	0
R3	1	0	0	0	1	0	0	0
R4	1	1	1	1	1	0	0	0
R5	1	0	0	0	1	0	0	0
R6	1	0	0	0	1	0	0	0
R7	0	0	0	0	0	0	0	0
R8	0	0	0	0	0	0	0	0
R9	0	0	0	0	0	0	0	0
R10	0	0	0	0	0	0	0	0
R11	0	0	0	0	0	0	0	0
R12	0	0	0	0	0	0	0	0
R13	0	0	0	0	0	0	0	0
R14	0	0	0	0	0	0	0	0
R15	0	0	0	0	0	0	0	0

Space data (R8–R15); Space data (D2–D0)

Figure 26: Example of character display ([FX]≤ 8) and generator bitmap

If the area outside the character bitmap contains only zeros. The displayed character size can easily be increased by increasing FX and FY, as the zeros ensure that the extra space between displayed characters is blank.

The displayed character width can be set to any value up to 16 even if each horizontal row of the bitmap is two bytes wide.

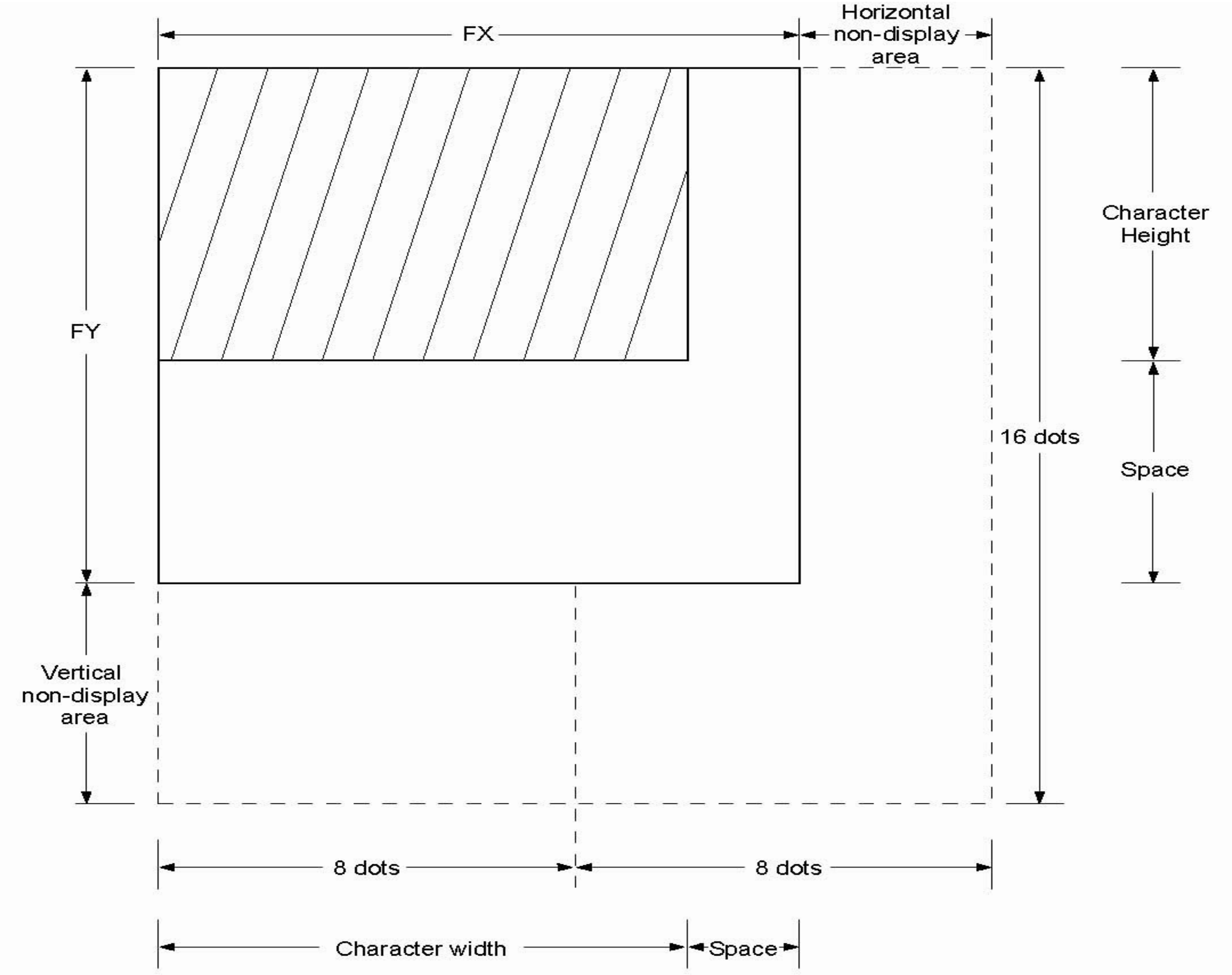


Figure 27: Character width greater than one byte wide ([FX]=9)

Note: The production does not automatically insert spaces between characters. If the displayed character size is 8 pixels or less and the space between character origins is nine pixels or more, the bitmap must use two bytes per row, even though the character image requires only one.

(2) Screen configuration

A: ***Screen configuration***

The basic screen configuration of the production is as a ingle text screen or as overlapping text and graphics screens, The graphics screen uses eight times as much display memory as the text screen.

Figure 28 shows the relationship between the virtual screens and the physical screen.

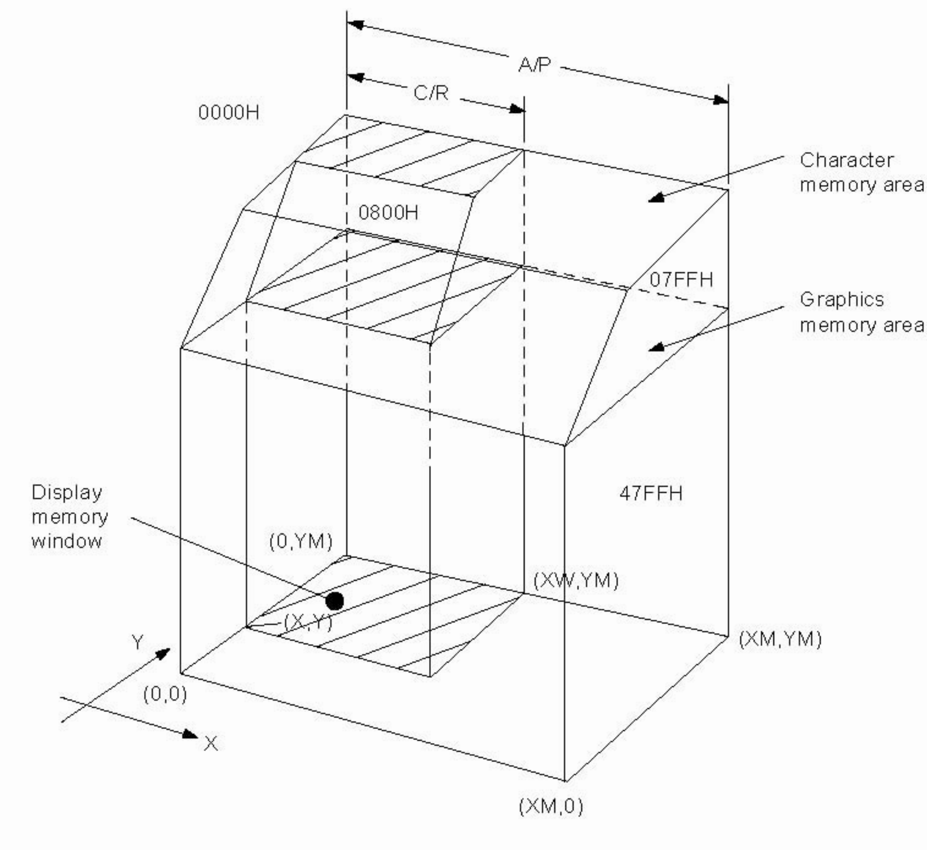


Figure 28: Virtual and physical screen relationship

B: ***Display address scanning***

The production cans the display memory in the same way as a raster scan CRT screen. Each row is scanned from left to right until the address range equals C/R. Rows are scanned from top to bottom.

In graphics mode, at the start of each line, the address counter is set to the address at the start of the previous line plus the address pitch, AP.

In text mode, the address counter is set to the same start address, and the same character data is read, for each row in the character bitmap. However, a new row of the character generator output is used each time. Once all the rows in the character bitmap have been displayed, the address counter is set to the start address plus AP and the next line of text is displayed

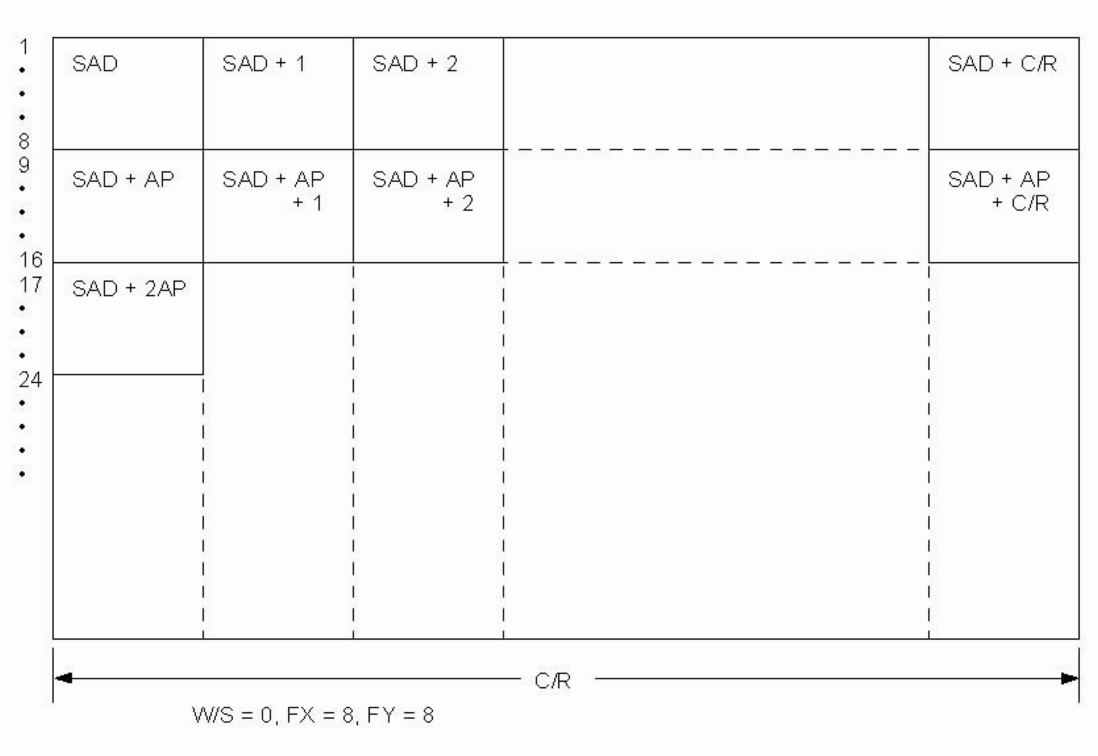


Figure 29: Character position parameters

Note: One byte of display memory corresponds to one character

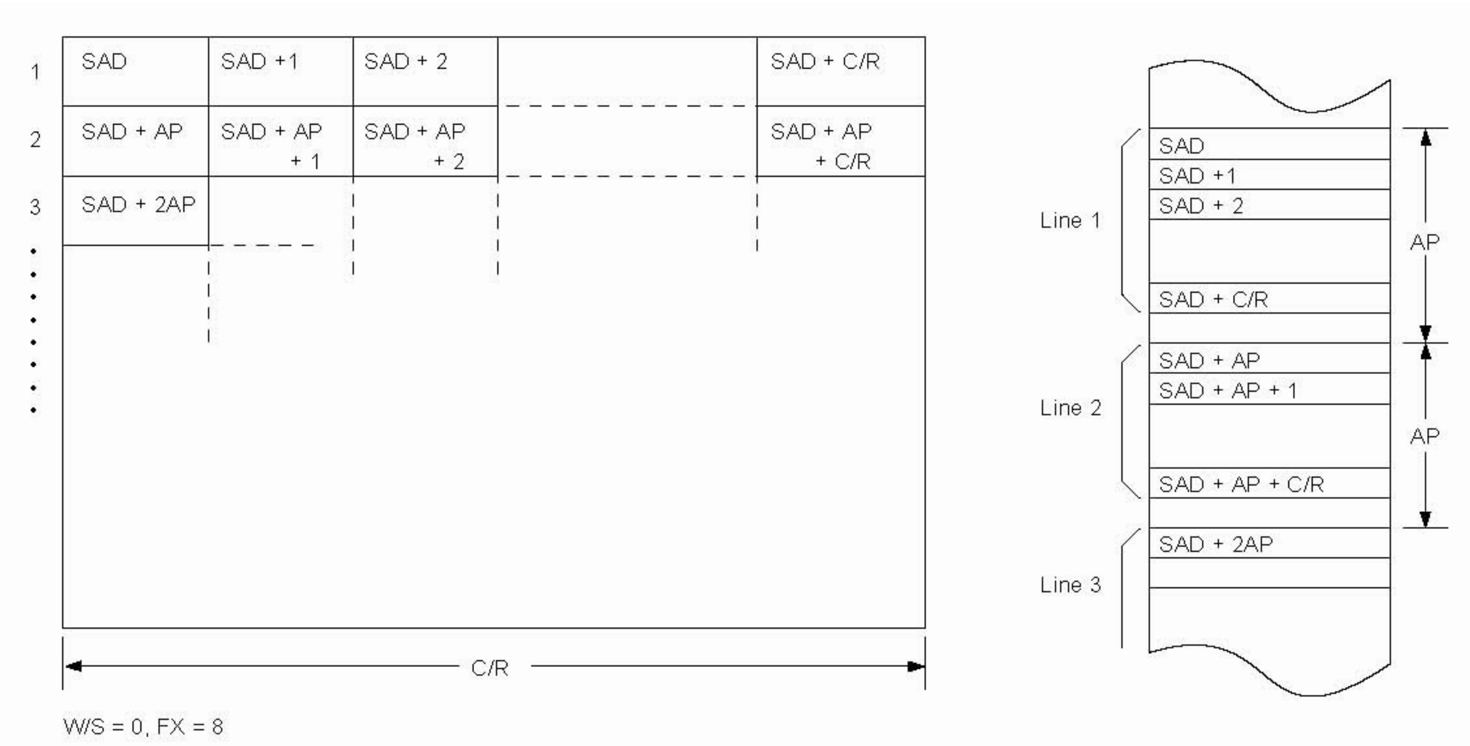


Figure 30: Character position vs. memory

Note: One bit of display memory corresponds to one pixel

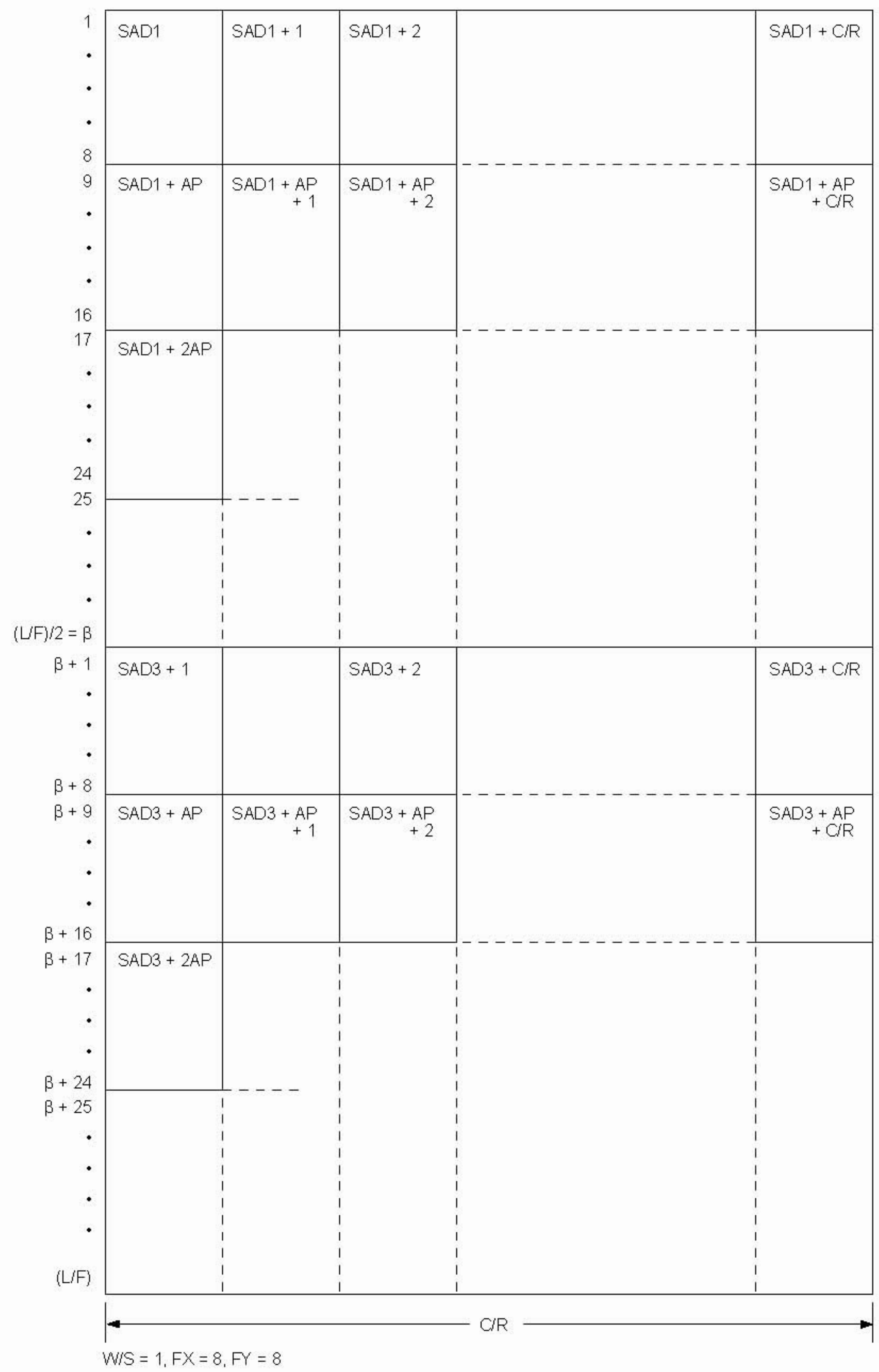


Figure 31: Two-panel display address indexing

Note: In two-panel drive, the production reads line 1 and line β+1 as one cycle. The upper and lower panels are thus read alternately, one line at a time.

C: *Display scan timing*

Figure 32 shows the basic timing of the production. One display memory read cycle takes nine periods of the system clock, Φ0 (fosc). This cycle repeats (C/R+1) times per display line.

When reading, the display memory pauses at the end of each line for (TC/R-C/R)display memory read cycles, though the LCD drive signals are still generated. TC/R may be set to any value within the constraints imposed by C/R, fosc, fFR, and the size of the LCD panel, and it may be used to fine tune the frame frequency. The microprocessor may also use this pause to access the display memory data.

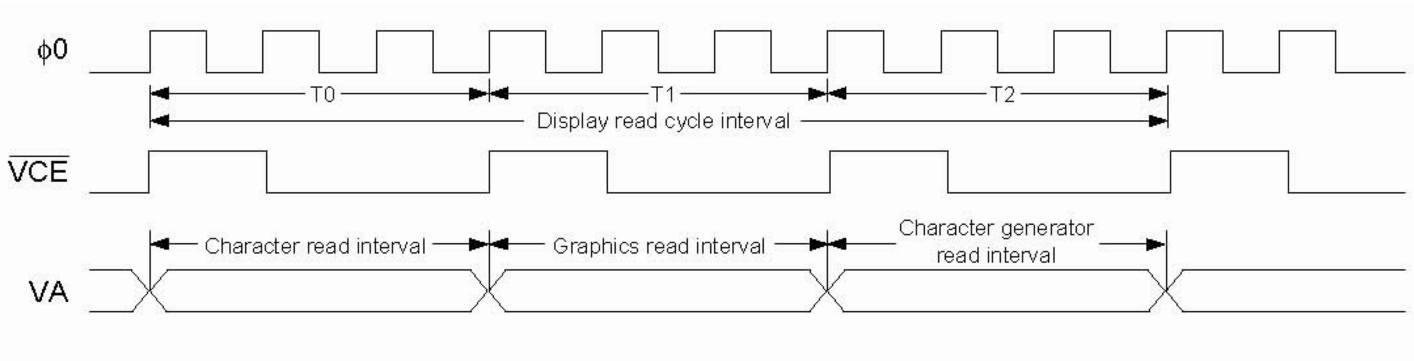


Figure 32: Display memory basic read cycle

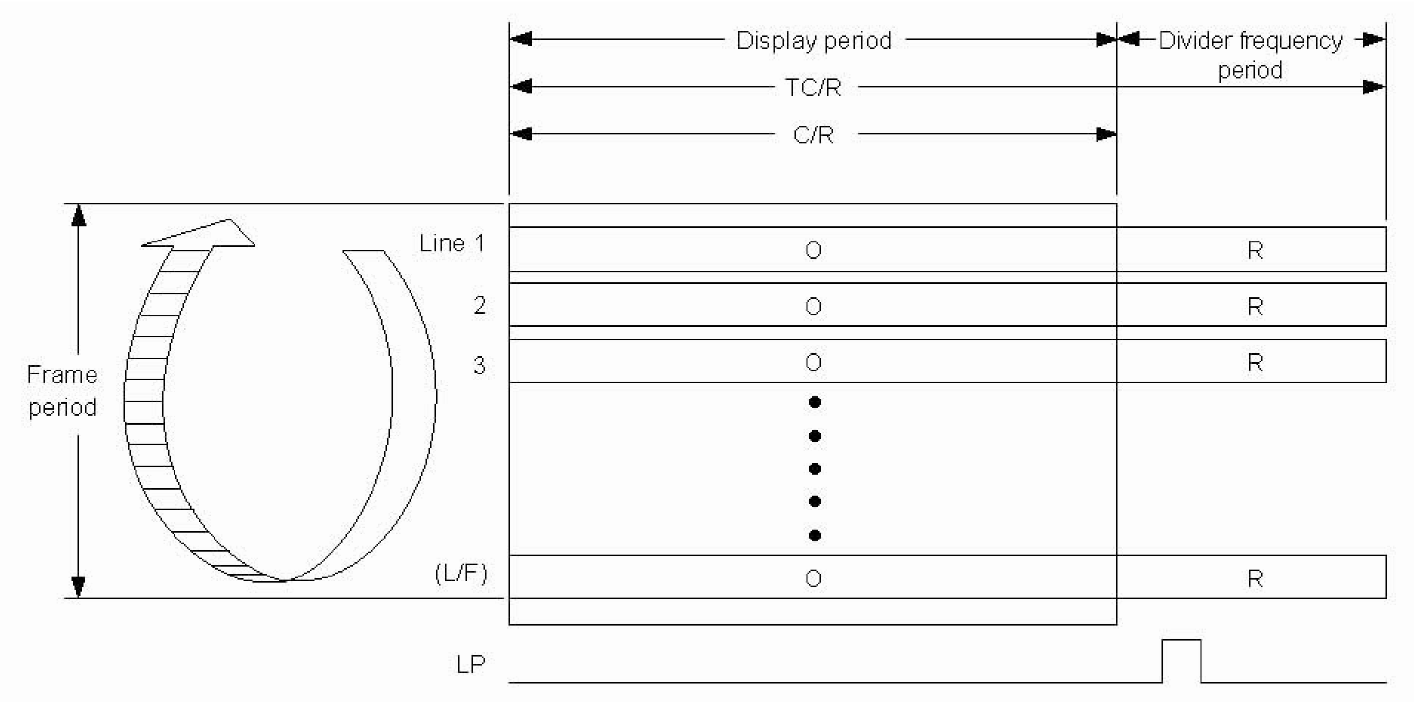


Figure 33: Relationship between TC/R and C/R

Note: The divider adjustment interval (R) applies to both the upper and lower screens even if W/S =1. In this case, LP is active only at the end of the lower screen's display interval.

(3) Cursor control

A: *Cursor register function*

The production cursor address register functions as both the displayed cursor position address register and the display memory access address register. When accessing display memory outside the actual screen memory, the address register must be saved before accessing the memory and restored after memory access is complete.

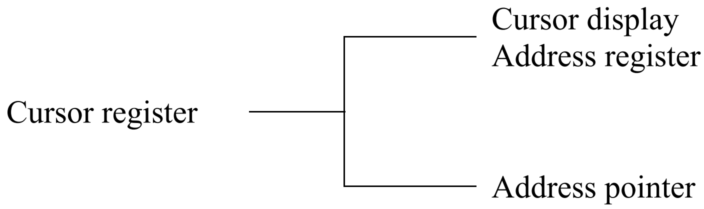


Figure 34: Cursor addressing

Note: that the cursor may disappear from the display if the cursor address remains outside the displayed screed memory for more than a few hundred milliseconds.

B: *Cursor movement*

On each memory access, the cursor address register changes by the amount previously specified with CSRDIR, automatically moving the cursor to the desired location.

C: *Cursor display layers*

Although the production can display up to three layers, the cursor is displayed in only one of these layers:

Two-layer configuration: First layer (L1)

Three-layer configuration: Third layer (L3)

The cursor will not be displayed if it is moved outside the memory for its layer. Layers may be swapped or the cursor layer moved within the display memory if it is necessary to display the cursor on a layer other than the present cursor layer

Although the cursor is normally displayed for character data, the production may also display a dummy cursor for graphical characters. This is only possible if the graphics screen is displayed, the text screen is turned off and the microprocessor generates the cursor control address.

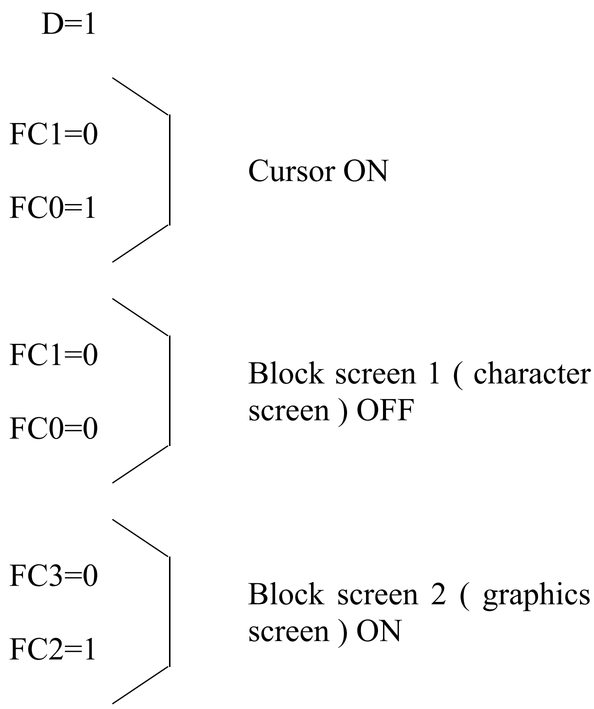


Figure 35: Cursor display layers

Consider the example of displaying Chinese characters on a graphics screen .To write the display data, the cursor address is set to the second screen block, but the cursor is not displayed, To display the cursor, the cursor address is set to an address within the blank text screen block.

Since the automatic cursor increment is in address units, not character units, the controlling microprocessor must set the cursor address register when moving the cursor over the graphical characters

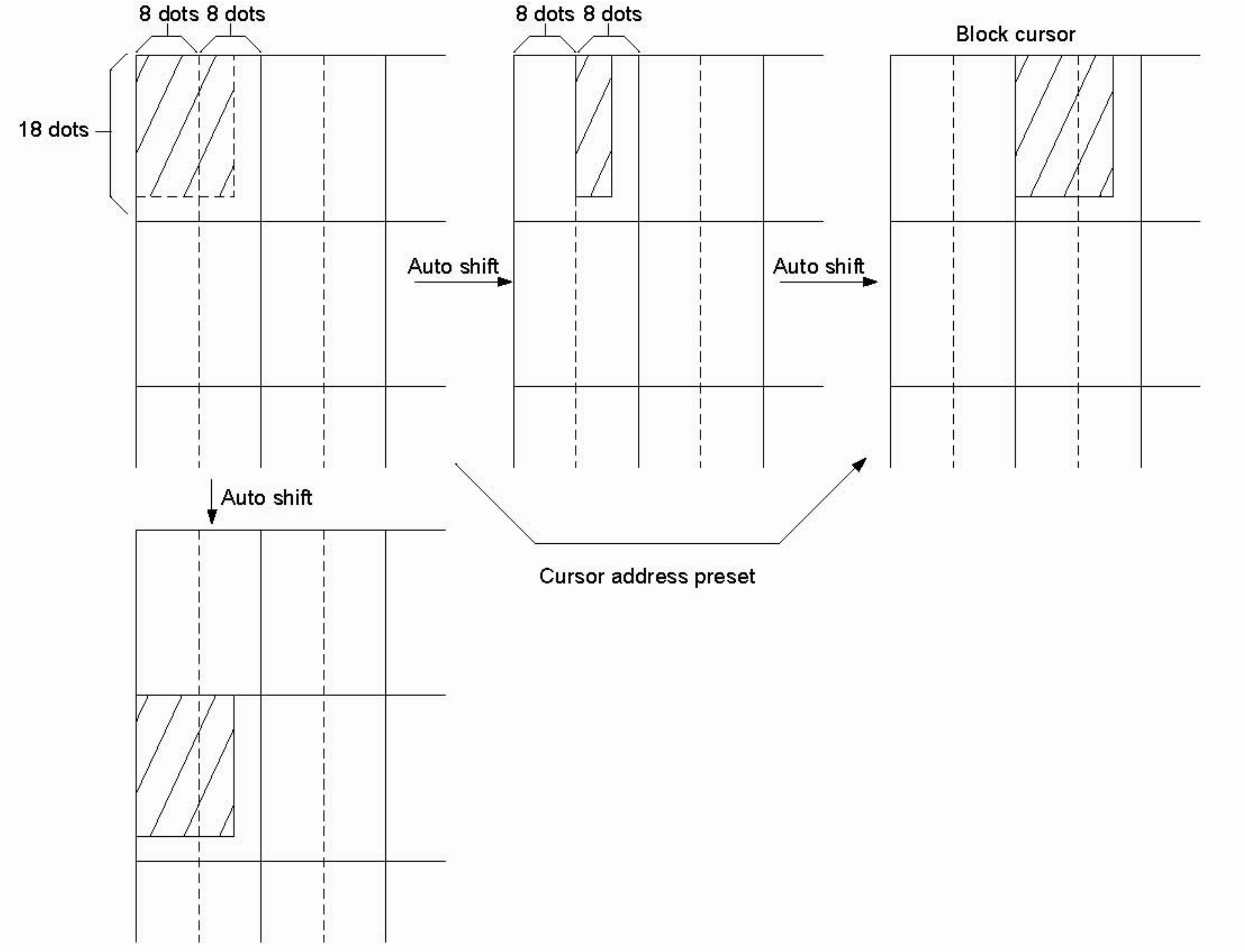


Figure 36: Cursor movement

If no text screen is displayed, only a bar cursor can be displayed at the cursor address.

If the first layer is a mixed text and graphics screen and the cursor shape is set to a block cursor, the production automatically decides which cursor shape to display .On the text screen it displays a block cursor, and on the graphics screen, a bar cursor.

(4) Memory to display relationship

The production virtual screens that are larger than the physical size of the LCD panel address range, C/R. A layer of the production can be considered as a window in the larger virtual screen held in display memory. This window can be divided into two blocks, with each block able to display a different portion of the virtual screen.

This enables, for example, one block to dynamically scroll through a data area while the other acts as a status message display area. See Figure 37 and 38.

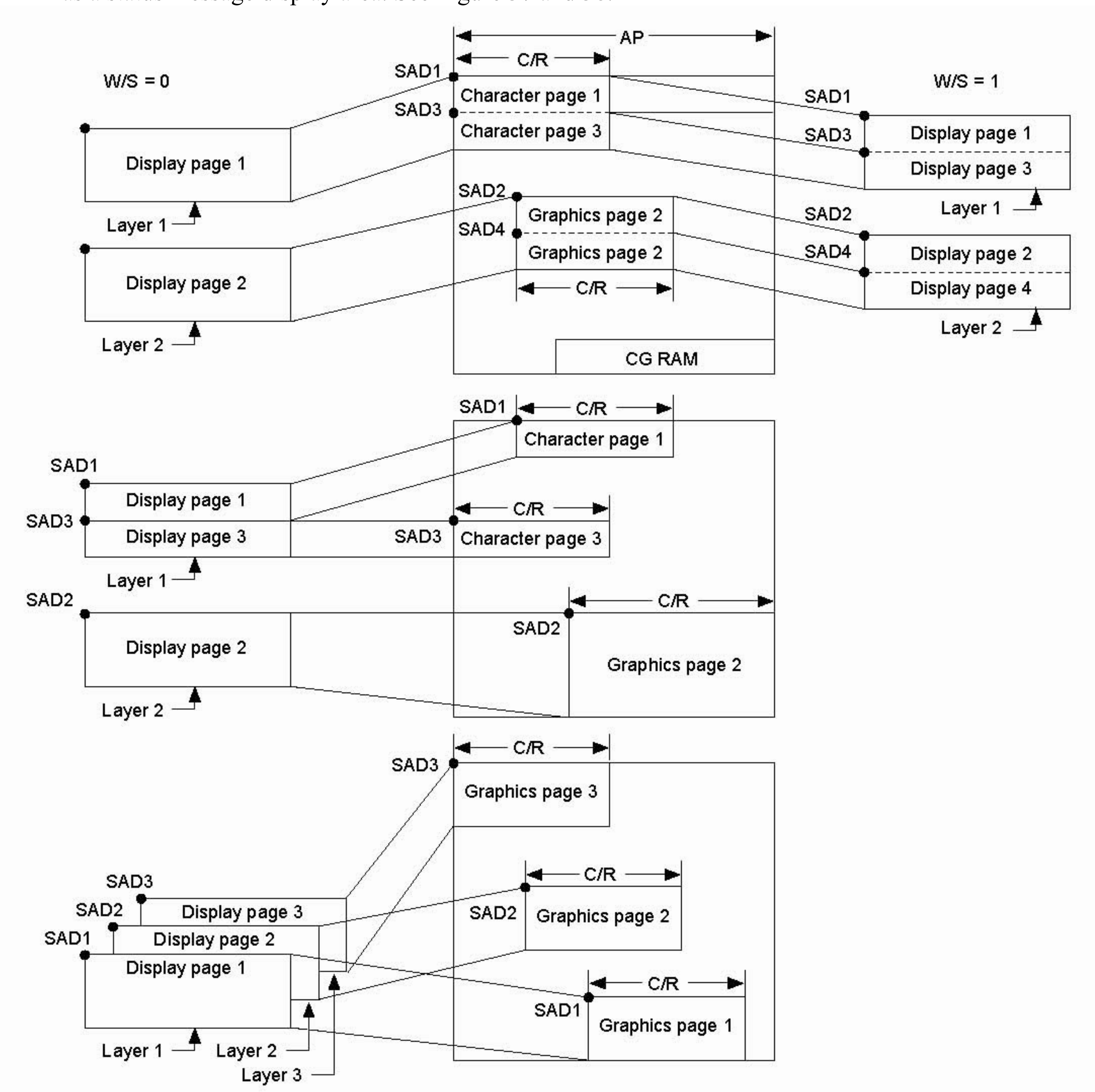


Figure 37: Display layers and memory

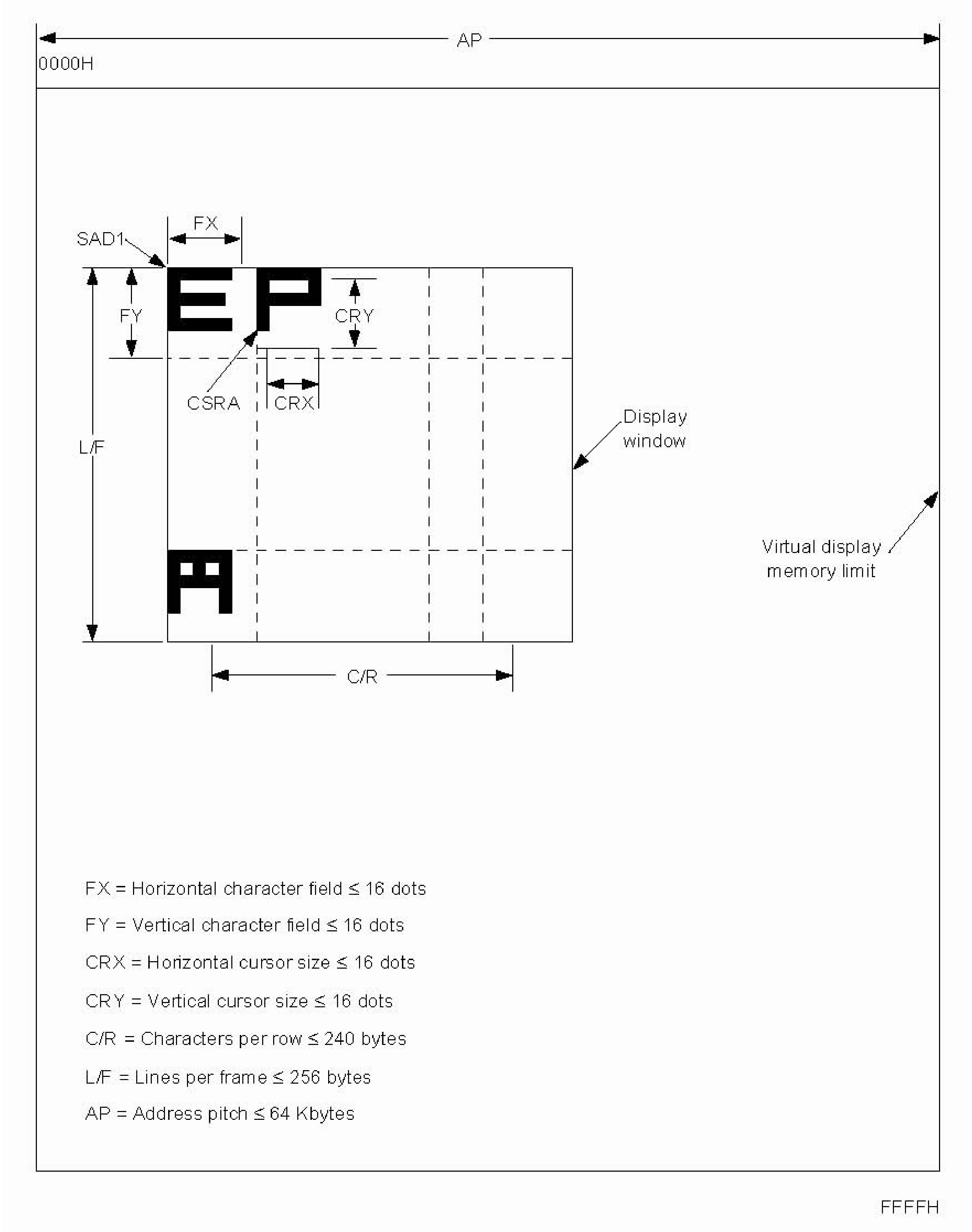


Figure 38: Display window and memory

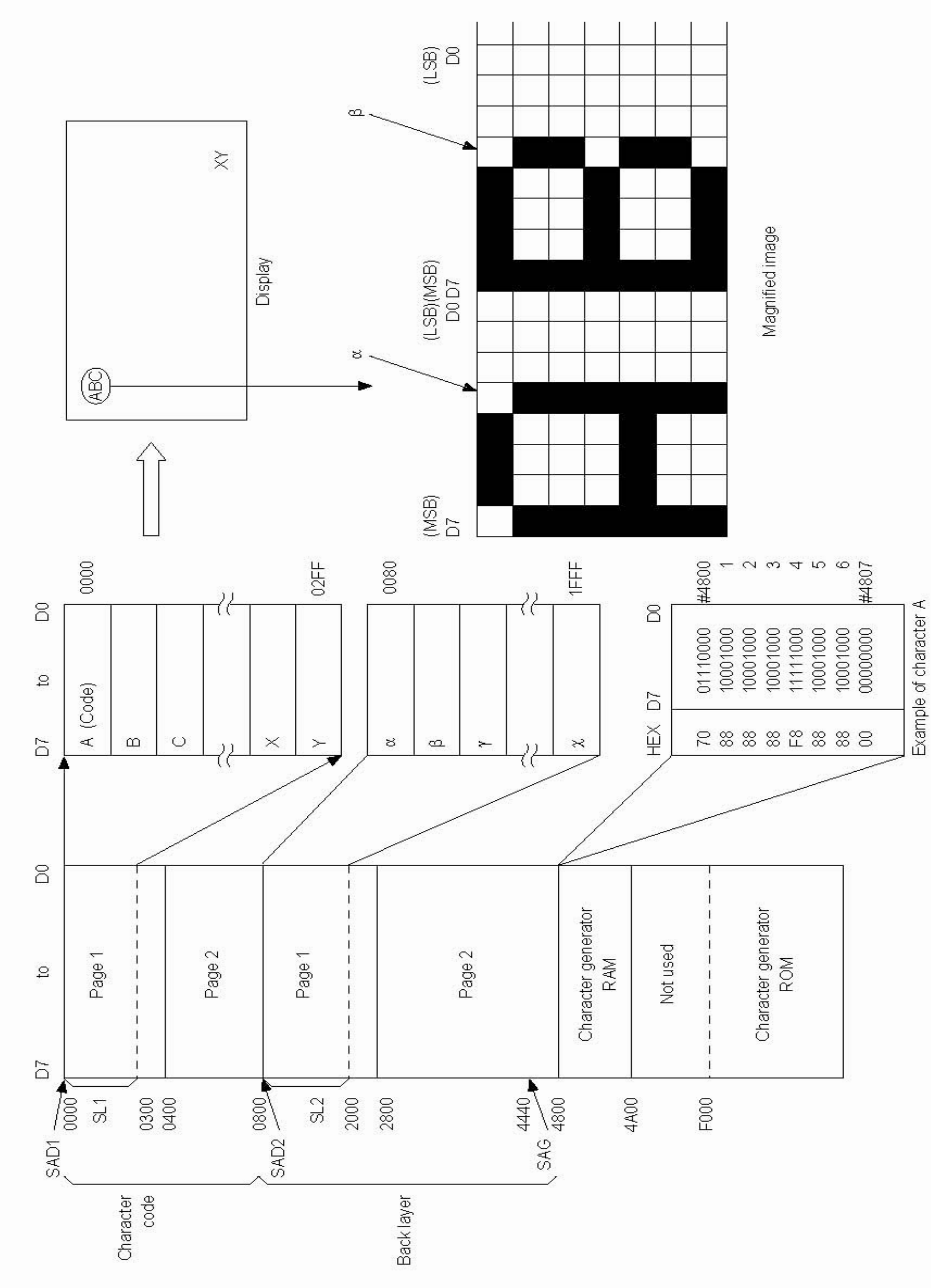


Figure 39: Memory map and magnified characters

(5) Scrolling

The controlling microprocessor can set the production scrolling modes by overwriting the scroll address registers SAD1 to SAD4, and by directly setting the scrolling mode and scrolling rate.

A: *On-page scrolling*

The normal method of scrolling within a page is to move the whole display up one line and the bottom line. Since the production does not automatically erase the bottom line, it must be erased with blanking data when changing the scroll address register.

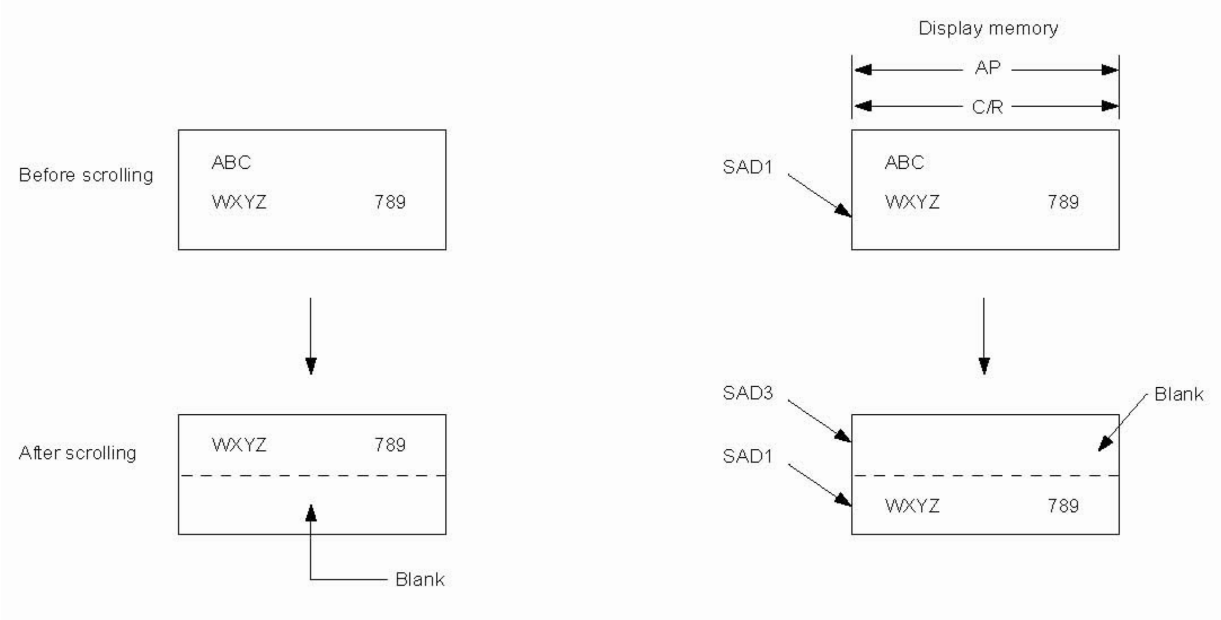


Figure 40: On-page scrolling

B: *Inter-page scrolling*

Scrolling between pages and page switching can be performed only if the display memory capacity is greater than one screen.

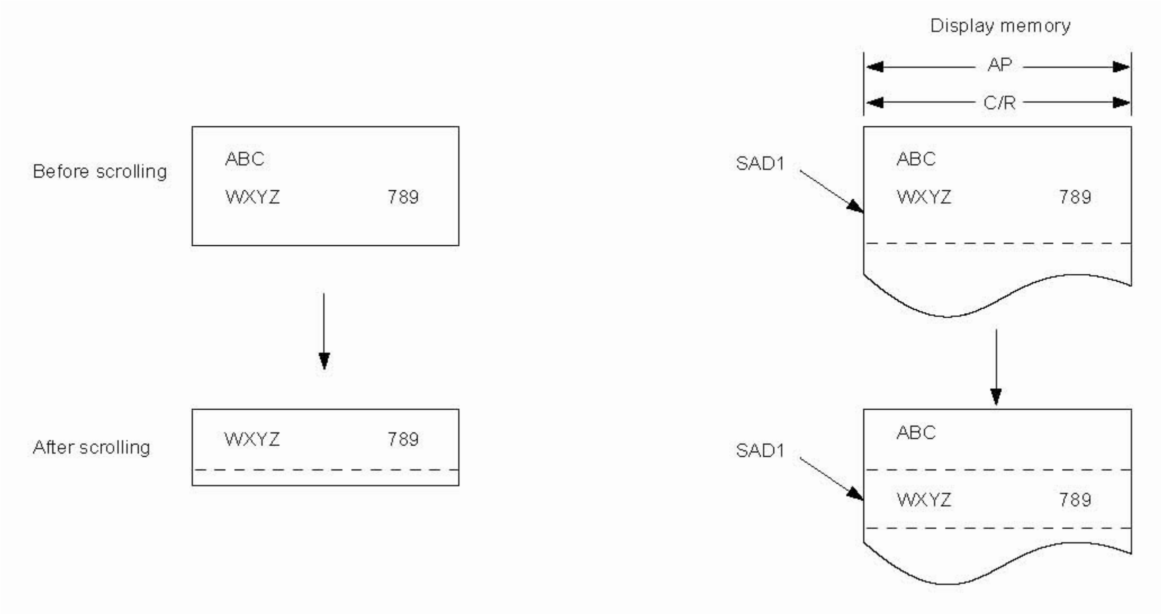


Figure 41: Inter-page scrolling

C: *Horizontal scrolling*

The display can be scrolled horizontally in one-character units, regardless of the display memory capacity.

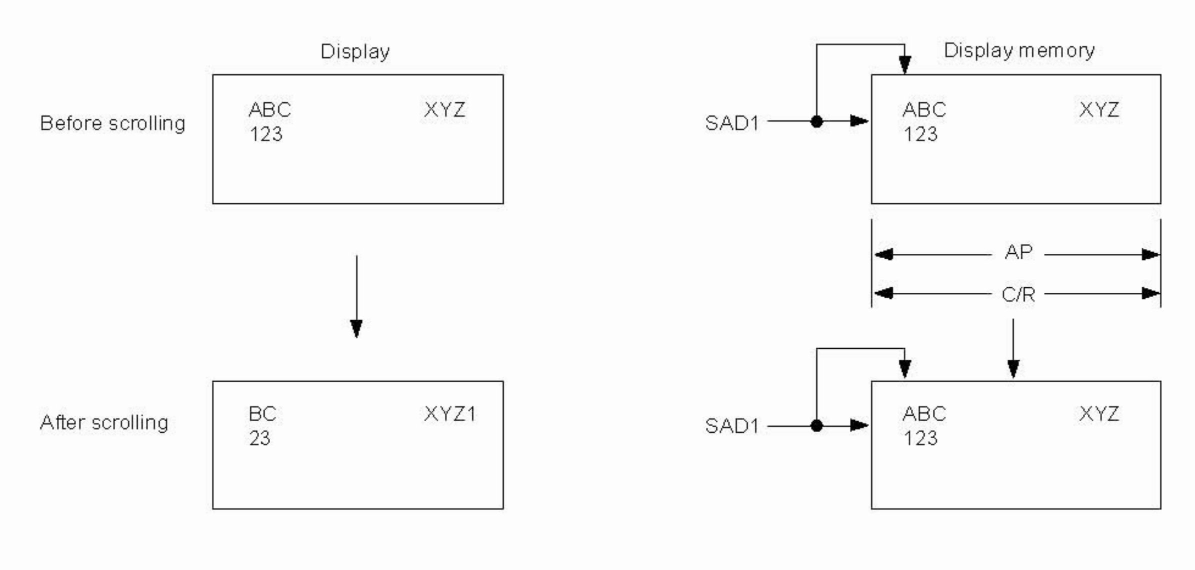


Figure 42: Horizontal wraparound scrolling

D: *Bidirectional scrolling*

Bidirectional scrolling can be performed only if the display memory is larger than the physical screen both horizontally and vertically. Although scrolling is normally done in single-character units, the HDOT SCR command can be used to scroll horizontally in pixel units. Single-pixel scrolling both horizontally and vertically can be performed by using the SCROLL and HDOT SCR commands. See Section <Smooth horizontal scrolling>

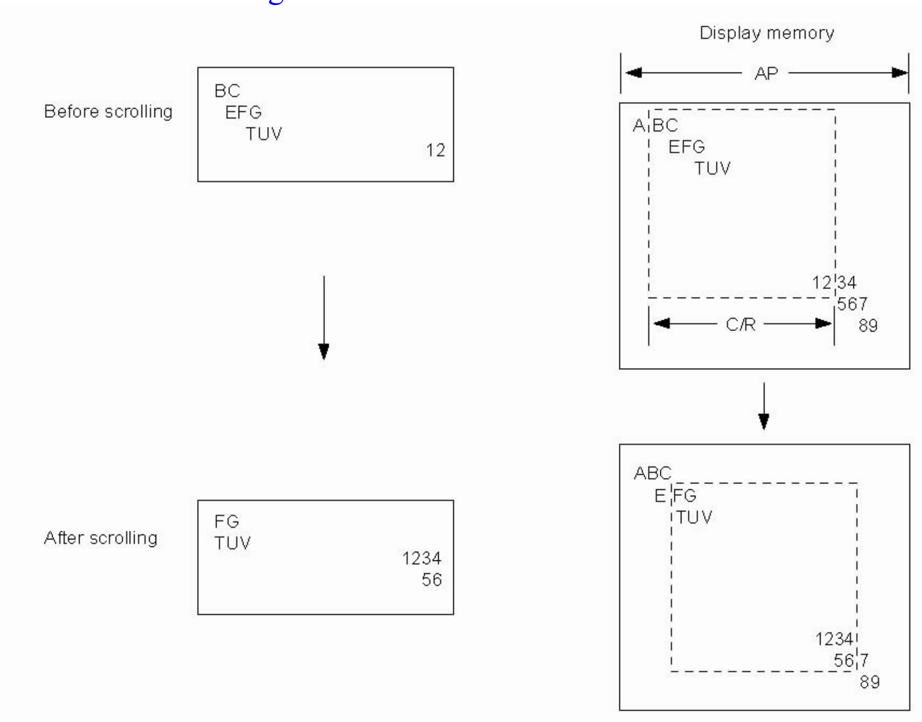


Figure 43: Bidirectional scrolling

E: *Scroll units*

Table 17: Scroll units

Mode	Vertical	Horizontal
Text	Characters	Pixels or characters
Graphics	Pixels	Pixels

Note than in divided screen, each block cannot be independently horizontally in pixel units

Character Generator

(1) CG Characteristics

A: *Internal character generator*

The internal character generator is recommended for minimum system configurations containing a production, display RAM, LCD panel, single chip microprocessor and power supply. Since the internal character generator uses a CMOS mask ROM, it is also recommended for low-power applications.

*5X7-pixel font (See Section <Internal character generator font>)

*160 JIS standard characters

*Can be mixed with characters generator RAM (maxi-mum of 64 CG RAM characters)

*Can be mixed with characters generator RAM (maxi-mum of 64 CG RAM characters)

B: *External character generator ROM*

The external CG ROM can be used when fonts other than those in the internal ROM are needed. Data is stored in the external ROM in the same format used in the internal ROM. (See Section<Character generator RAM>)

*Up to 8X8-pixel characters (M2=0) or 8X16-pixel characters (M2=1)

*Up to 256 characters (192 if used together with the internal ROM)

*Mapped into the display memory address space at F000H to F7FFH (M2=0) or F000H to FFFFH (M2=1)

* Characters can be up to 8*16-pixels; however, excess bits must be set to zero.

C: *Character generator RAM*

The user can freely use the character generator RAM for storing graphics characters. The character generator RAM can be mapped by the microprocessor anywhere in display memory, allowing effective use of unused address space.

*Up to 8*8-pixel characters (M2=0) or 8*16 characters (M2=1)

*Up to 256 characters if mapped at FOOOH to FFFFH (64 if used together with character generator ROM).

*Can be mapped anywhere in display memory address space if used with the character generator ROM.

*Mapped into the display memory address space at FOOOH to F7FFH if not used with the character generator ROM (more than 64 characters are in the CG RAM).Set SAGO to FOOOH and M1 to zero when defining characters number 193 upwards.

(2) CG memory allocation

Since the production uses 8-bit character codes, it can handle no more than 256 characters at a time. However, if a wider range of characters is required, character generator memory can be bank-switched using the CGRAM ADR command.

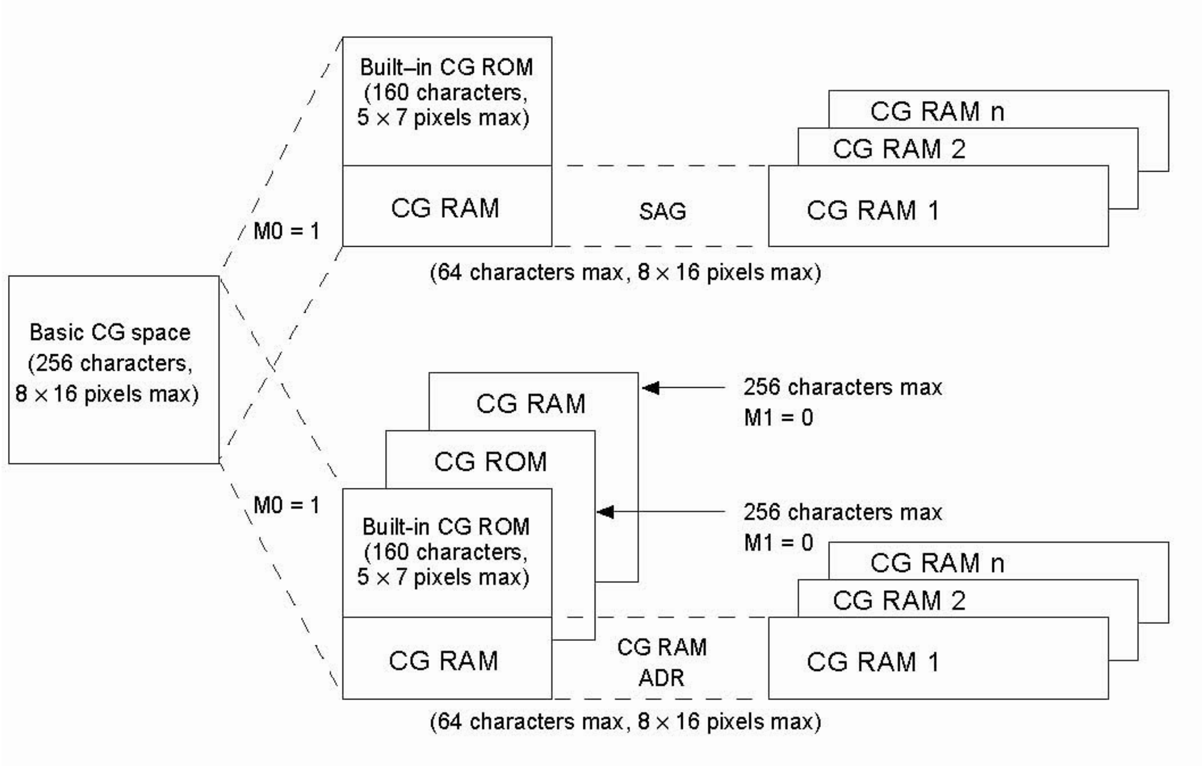


Figure 44: Internal and external character mapping

Note that there can be no more than 64 characters per bank.

Table 18: Character mapping

Item		Parameter	Remarks
Internal/external character generator selection		M0	
Character field height	1 to 8 pixels	M2=0	
	9 to 16 pixels	M2=1	
	Greater than 16 pixels	Graphics mode (8 bits X 1 line)	
Internal CG ROM/RAM select External CG ROM/RAM select		Automatic	Determined by the character code
CG RAM bit 6 correction		M1	
CG RAM data storage address		Specified with CG RAM ADR command	Can be moved anywhere in the display memory address space
External CG ROM address	192 characters or less	Other than the area of Figure 49	
	More than 192 characters	Set SAG to F000H and overly SAG and the CG ROM table	

(3) Setting character generator address

The CG RAM addresses in the VRAM address space are not mapped directly from the address in the SAG register. The data to be displayed is at a CG RAM address calculated from SAG + character code + ROW select address. This mapping is shown in Table 19 and 20.

Table 19: Character fonts, number of line ≤ 8 (M2=0. M1=0)

SAG	A15-A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Character code	0	0	D7	D6	D5	D4	D3	D2	D1	D0	0	0	0
+ROW select address	0	0	0	0	0	0	0	0	0	0	R2	R1	R0
CG RAM address	VA15-VA12	VA11	VA10	VA9	VA8	VA7	VA6	VA5	VA4	VA3	VA2	VA1	VA0

Table 20: Character fonts, 9 ≤number of line ≤ 8 (M2=1. M1=0)

SAG	A15-A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Character code	0	D7	D6	D5	D4	D3	D2	D1	D0	0	0	0	0
+ROW select address	0	0	0	0	0	0	0	0	0	R3	R2	R1	R0
CG RAM address	VA15-VA12	VA11	VA10	VA9	VA8	VA7	VA6	VA5	VA4	VA3	VA2	VA1	VA0

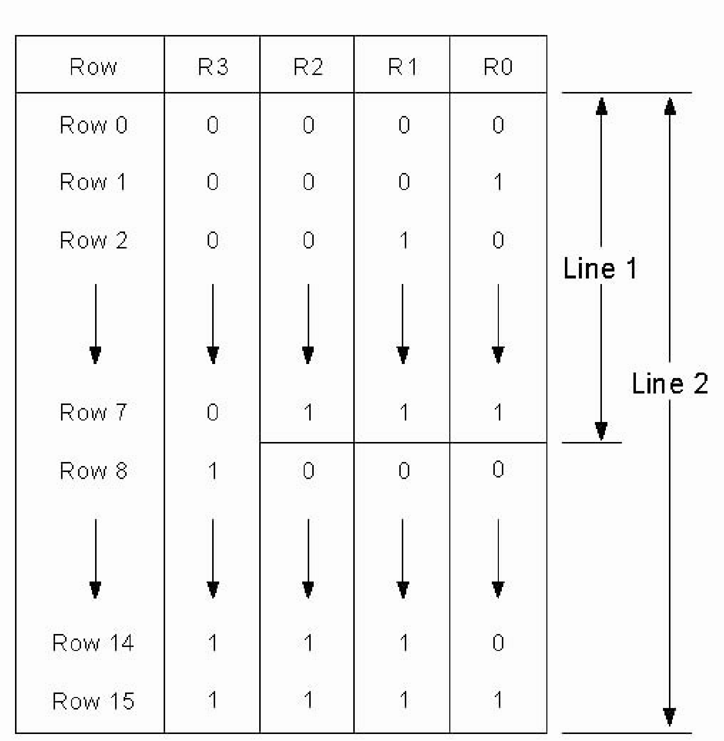


Figure 45: Row select address

Note: Lines=1: lines in the character bitmap ≤ 8

Lines=2: lines in the character bitmap ≥ 9

A: *M1=1*

The production automatically converts all bits set in bit 6 of character code for CG RAM 2 to zero. Because of this, the CG RAM data areas become contiguous in display memory.

When writing data to CG RAM:

*Calculate the address as for M1=0.

*Change bit 6 of the character code from "1" to "0".

B: *CG RAM address*

* Define a pattern for the "A" in Figure 26.

* The CG RAM table start address is 4800H.

* The character code for the defined pattern is 80H (the first character code in the CG RAM area).

As the character code table in Figure 46 shows, codes 80H to 9FH and EOH to FFH are allocated to the CG RAM and can be used as desired. 80H is thus the first code for CG RAM. As characters cannot be used if only using graphics mode, there is no need to set the CG RAM data.

Table 21: Character data example

CGRAM AD	5CH	Reverse the CG RAM address calculation to calculate SAG
P1	00H	
P2	40H	
CSRDIR	4CH	Set cursor shift direction to right
CSRW	46H	CG RAM start address is 4800H
P1	00H	
P2	48H	
MWRITE	42H	
P1	70H	Write ROW 0 data
P2	88H	Write ROW 1 data
P3	88H	Write ROW 2 data
P4	88H	Write ROW 3 data
P5	F8H	Write ROW 4 data
P6	88H	Write ROW 5 data
P7	88H	Write ROW 6 data
P8	00H	Write ROW 7 data
P9	00H	Write ROW 8 data
↓	↓	↓
P16	00H	Write ROW 16 data

(4) Character code

The following figure shows the character codes and the codes allocated to CG RAM. All codes can be used by the CG RAM if not using the internal ROM

	Upper 4 bits															
Lower 4 bits	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0				0	@	P	`	p								
1			!	1	A	Q	a	q								
2			"	2	B	R	b	r								
3			#	3	C	S	c	s								
4			$	4	D	T	d	t								
5			%	5	E	U	e	u								
6			&	6	F	V	f	v								
7			'	7	G	W	g	w								
8			(	8	H	X	h	x								
9			)	9	I	Y	i	y								
A			*	:	J	Z	j	z								
B			+	;	K	[	k	{								
C			,	<	L	¥	l	¦								
D			.	=	M	]	m	}								
E			-	>	N	^	n	→								
F			/	?	O	_	o	←								

CG RAM1 (columns 8–9) CG RAM2 (columns E–F)

M1 = 0

M1 = 1

Figure 46: On-chip character codes

Microprocessor Interface

(1) Microprocessor synchronization

The production interface operates at full bus speed, completing the execution of each command within the cycle time, tcyc. The controlling microprocessor's performance is thus not hampered by polling or handshaking when accessing the production.

Display flicker may occur if there is more than one consecutive access that cannot be ignored within a frame. The microprocessor can minimize this either by performing these accesses intermittently, or by continuously checking the status flag (D6) and waiting for it to become HIGH.

A: *Display status indication output*

When CS, A0 and RD are LOW, D6 functions as the display status indication output .It is HIGH during the TV-mode vertical retrace period or the LCD–mode horizontal retrace period, and LOW, during the period the controller is writing to the display .By monitoring D6 and writing to the data memory only during retrace periods, the display can be updated without causing screen flicker.

B: *Internal register access*

The SYSTEM SET and SLEEP IN commands can be used to perform input/output to production series independently of the system clock frequency. These are the only commands that can be used while the production is in sleep mode.

C: *Display memory access*

The production supports a form of pipeline processing, in which the microprocessor synchronizes its processing to the production timing. When writing, the microprocessor first issues the MWRITE command. It then repeatedly writes display data to the production using the system bus timing. This ensures that the microprocessor is not slowed down even if the display memory access times are slower than the system bus access times .See Figure 47.

When reading, the microprocessor first issues the MREAD command, which causes the SED1335 series to load the then reads data from the SED1335 series using the system bus timing .With each read, the production reads the next data item from the display memory ready for the next read access. See Figure 48.

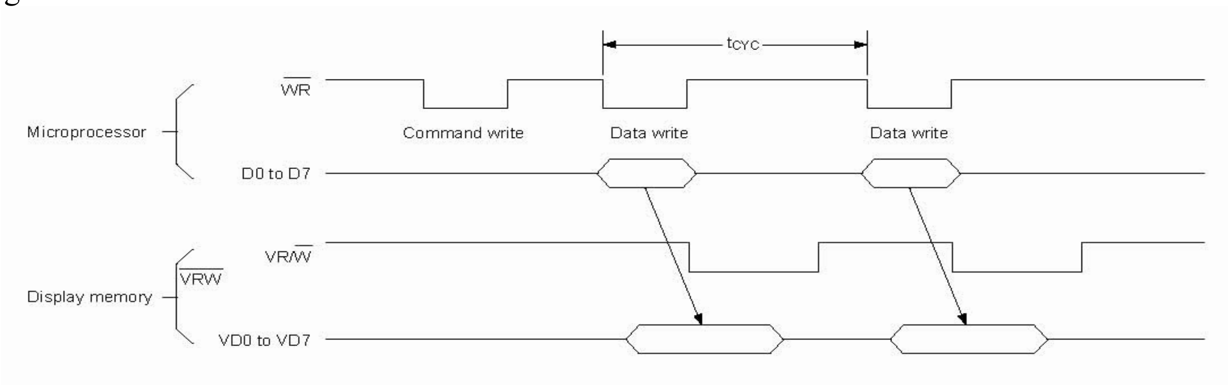


Figure 47: Display memory write cycle

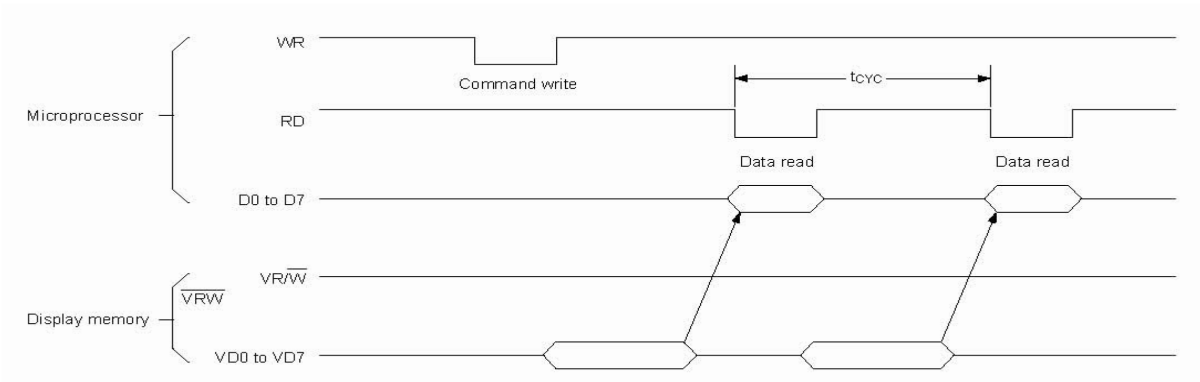


Figure 48: Display memory read cycle

(2) Interface examples

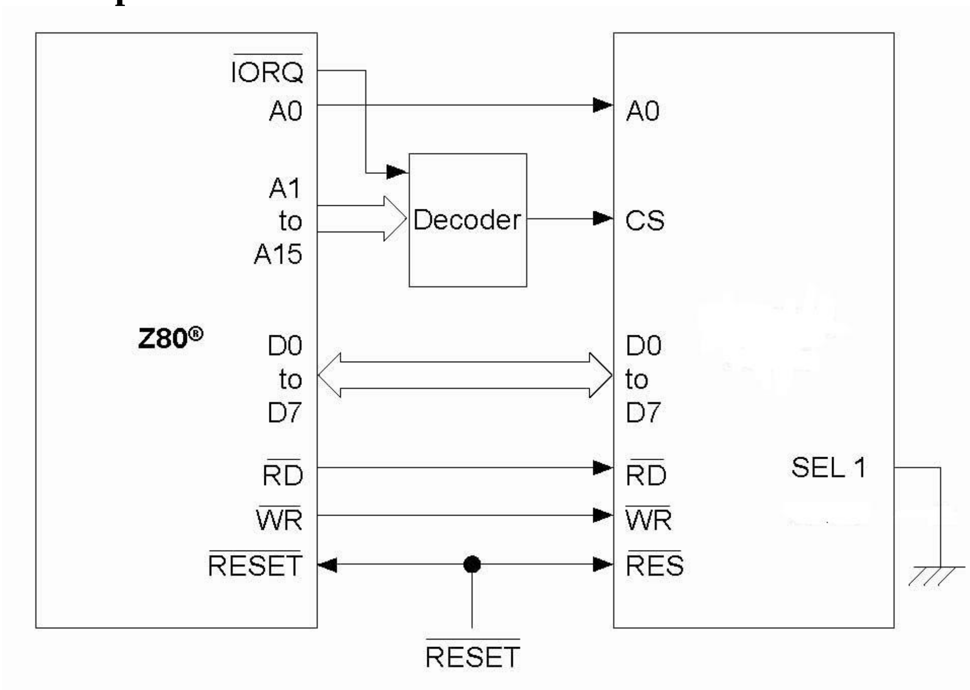


Figure 49: Z80® to production interface

Status Flag

The production has a single bit status flag.

D6: X line standby

D7							D0
X	D6	X	X	X	X	X	X

Figure 50: Status flag

The D6 status flag is HIGH for the TC/R-C/R cycles at the end of each line where the production is no reading the display memory. The microprocessor may use this period to update display memory without affecting the display, however it is recommended that the display be turned off when refreshing the whole display.

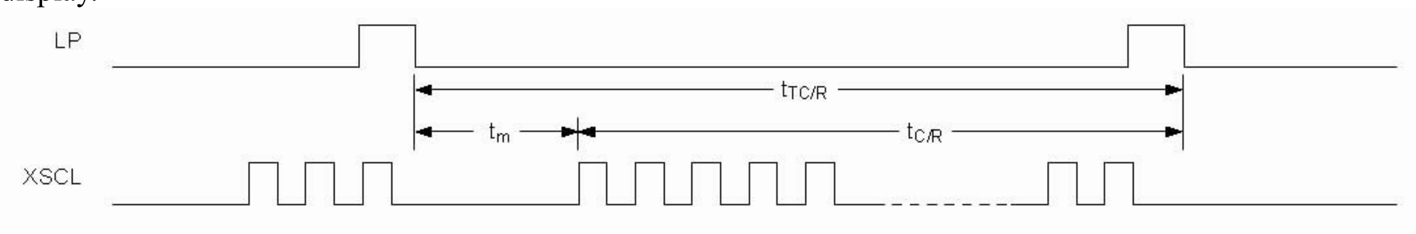


Figure 51: C/R to TC/R time difference

/CS	A0	/RD	D6(flag)
0	0	0	0: Period of retrace lines 1: Period of display

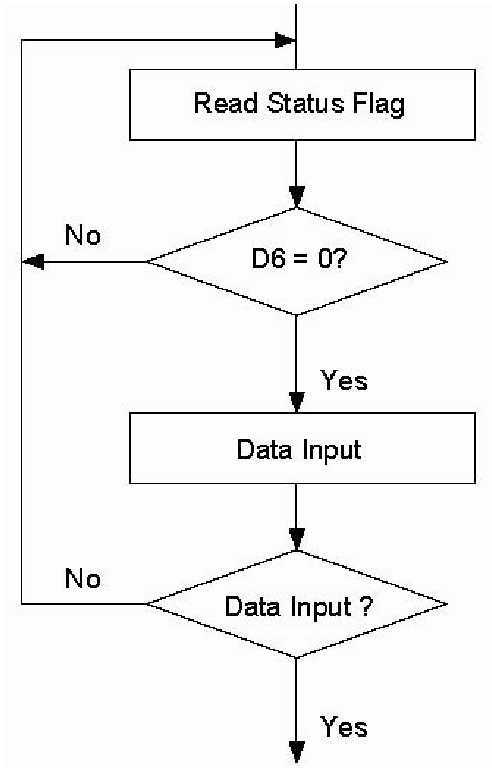


Figure 52: Flowchart for busy flag checking

Reset

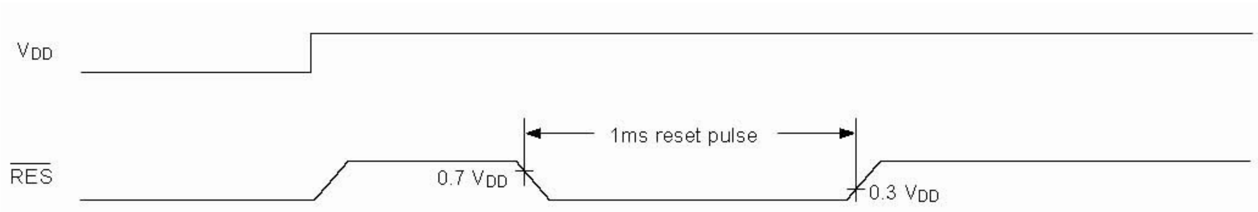


Figure 53: Reset timing

The production requires a reset pulse at least I ms long after power-on in order to re-initialize its internal state.

For maximum reliability, it is not recommended to apply a DC voltage to the LCD panel while the production is reset .Turn off the LCD power supplies for at least one frame period after the start of the reset pulse.

The production cannot receive commands while it is reset .Commands to initialize the internal registers should be issued soon after a reset.

During reset, the LCD drive signals XD, LP and FR are halted.

A delay of 3 ms (maximum) is required following the rising edges of both RES and VDD to allow for system stabilization

Application Notes

(1) Initialization parameters

The parameters for the initialization commands must be determined first. Square brackets around a parameter name indicate the number represented by the parameter, rather than the value written to the parameter register. For example,[FX]=FX+1.

A: *System set instruction and parameters*

- FX

The horizontal character field size is determined from the horizontal display size in pixels [VD]and the number of character per line[VC]

[VD]/[VC]≤[FX]

- C/R

  C/R can be determined from VC and FX.

  [C/R]=RND ([FX]/8*[VC])

  Where RND(x) denotes x rounded up to the next highest integer.[C/R] is the number of bytes per line, not the number of characters.

- TC/R

  TC/R must satisfy the condition [TC/R]≥[C/R]+4

  10M≥([TC/R]*9+1)*[L/F]*70

Table 22: LCD unit example parameters

Product name and resolution(X x Y)	[FX]	[FY]	[C/R]	TC/R
256X64	[FX]=6 pixels 256/6=42 remainder 4 =4 blank pixels	8 or 16, depending on the screen	[C/R]=42=2AH bytes C/R=29H, When using HDOT SCR, [C/R]=43 bytes	2DH
512X64	[FX]=6 pixels 512/6=85 remainder 2 =2 blank pixels	8 or 16, depending on the screen	[C/R]=85=55H bytes C/R=54H, When using HDOT SCR, [C/R]=86 bytes	58H
256X128	[FX]=8 pixels 256/8= 32 remainder 0 =no blank pixels	8 or 16, depending on the screen	[C/R]=32=20H bytes C/R=19H, When using HDOT SCR, [C/R]=33 bytes	22H
512X128	[FX]=10 pixels 512/10=51 remainder 2 =2 blank pixels	8 or 16, depending on the screen	[C/R]=102=66H bytes C/R=65H, When using HDOT SCR, [C/R]=103 bytes	69H

B: *Initialization example*

The initialization example shown in Figure 54 is for the production with an 8-bit microprocessor interface bus.

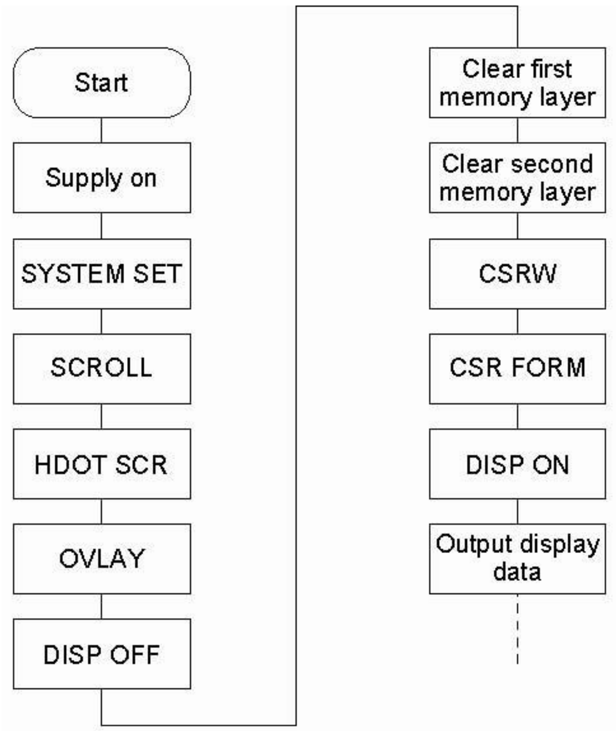
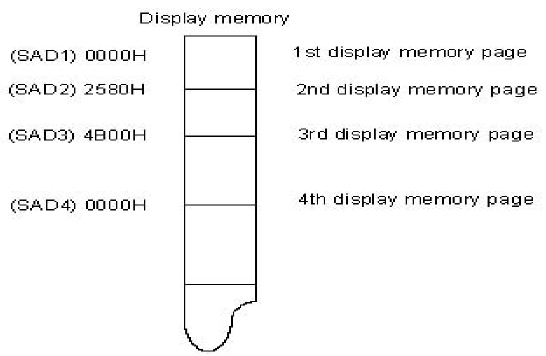


Figure 54: Initialization procedure

Note: Set the cursor address to the start of each screen's layer memory .and use MWRITE to fill the memory with space characters. 20H (text screen only) or 00H (graphics screen only) .Determining which memory to clear is explained in section <Display mode setting example 1>.

Table 23: Initialization procedure

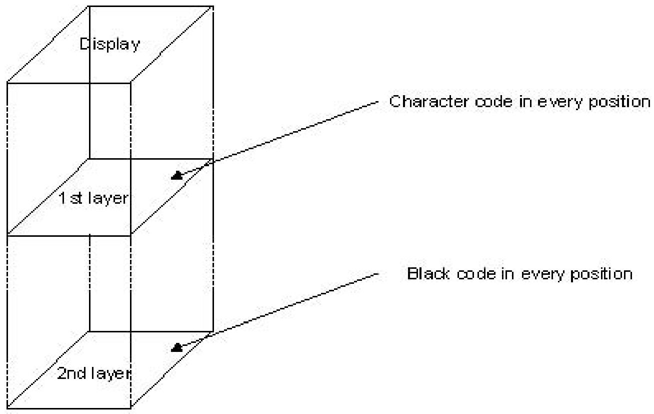
NO:	Command	Operation
1	Power-up	
2	Supply	
3	SYSTEM SET C=40H	
	P1=30H	M0: Internal ROM M1: CG RAM is 32 characters maximum M2: 8 lines per character W/S: Single-panel drive IV: NO top-line compensation
	P2=87H	FX: Horizontal character size = 8 pixels WF: Two-frame AC drive
	P3=07H	FY: Vertical character size = 8 pixels
	P4=27H	C/R: 40 display addresses per line
	P5=30H	TC/R: Total addresses rang per line = 48
	P6=EFH	LF: 240 display lines
	P7=28H P8=00H	AP: Virtual screen horizontal size is 40 addresses
4	SCROLL C=44H	
	P1=00H P2=00H	First screen block start address Set to 0000H
	P3=EFH	Display lines in first screen block=240
	P4=80H P5=25H	Second screen block start address Set to 2580H
	P6=EFH	Display lines in Second screen block=240
	P7=00H P8=4BH	Third screen block start address Set to 4B00H
	P9=00H P10=00H	Fourth screen block start address Set to 4B00H



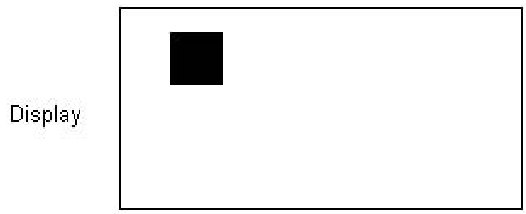
NO:	Command	Operation
5	HDOT SCR C=5AH	
	P1=00H	Set horizontal pixel shift to zero
6	OVLAY C=5BH	
	P1=01H	MX1,MX0: Inverse video superposition DM1: First screen block is text mode DM2: Third screen block is text mode

Table 23: Initialization procedure (continued)

NO:	Command	Operation
7	DISP ON/OFF C=58H	D: Display OFF
	P1=56H	FC1, FC0: Flash cursor at 2Hz FP1, FP0: First screen block ON FP3, FP2: Second and fourth screen blocks ON FP5, FP4: Third screen blocks ON
8	Clear data first layer	Fill first screen layer memory with 20H(space character)
9	Clear data in second layer	Fill second screen layer memory with 00h(blank data)



NO:	Command	Operation
10	CSRW C=46H	
	P1=00H P2=00H	Set cursor to start of first screen block
11	CDR FORM C=46H	
	P1=04H	CRX: Horizontal cursor size = 5 pixels
	P2=86H	CRY: Vertical cursor size = 5 pixels CM: Block cursor
12	DISP ON/OFF C=59H	Display ON



NO:	Command	Operation
13	CSR DIR C=4CH	Set cursor shift direction to right
14	MWRITE C=42H	
	P1=20H	Write space
	P2=52H	Write “R”
	P3=41H	Write “A”
	P4=49H	Write “I”
	P5=4FH	Write “O”

Table 23: Initialization procedure (continued)

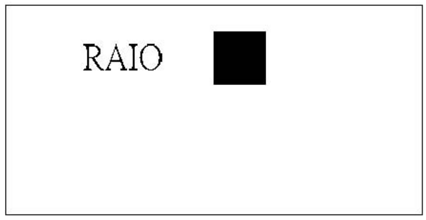
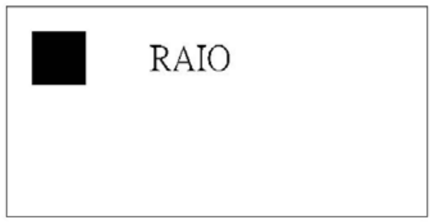
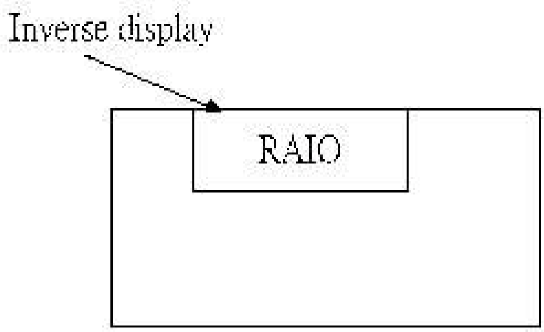
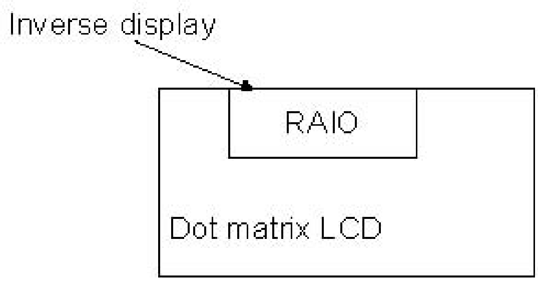
NO:	Command	Operation
		
15	CSRW C=46	
	P1=00H P2=10H	Set cursor to start of second screen block
16	CSR DIR C=4FH	Set cursor shift direction to down
17	MWRITE C=42H	
	P1=FFH ↓ P9=FFH	Fill a square to the left of the “E”
		
18	CSRW C=46H	
	P1=01H P2=10H	Set cursor address to 1001H
19	MWRITE C=42H	
	P1=FFH ↓ P9=FFH	Fill in the second screen block in the second column of line 1
20	CSRW	Repeat operations 18 and 19 to fill in the background under “RAIO”
↓		
29	MWRITE	
		

Table 23: Initialization procedure (continued)

NO:	Command	Operation
30	CSRW C=46	
	P1=00H P2=01H	Set cursor to line three of the first screen block
31	CSR DIR C=4CH	Set cursor shift direction to right
32	MWRITE C=42H	
	P1=44H	Write “D”
	P2=6FH	Write “o”
	P3=74H	Write “t”
	P4=20H	Write space
	P5=4DH	Write “M”
	P6=61H	Write “a”
	P7=74H	Write “t”
	P8=72H	Write “r”
	P9=69H	Write “i”
	P10=78H	Write “x”
	P11=20H	Write space
	P12=4CH	Write “L”
	P13=43H	Write “C”
	P14=44H	Write “D”



C: *Display mode setting example 1: combining text and graphics*

- Conditions
  *320*240 pixels, single-panel drive (1/240 duty cycle)
  *First layer: text display
  *Second layer: graphics display
  *8*8-pixel character font
  *CG RAM not required
- Display memory allocation
  *First layer (text):320/8=40 characters per line, 240/8=30 lines. Required memory size=40*30=1200 bytes.
  *Second layer (graphics):320/8=40 characters per line, 240/1=240 lines, Required memory size=40*240=9600 bytes.

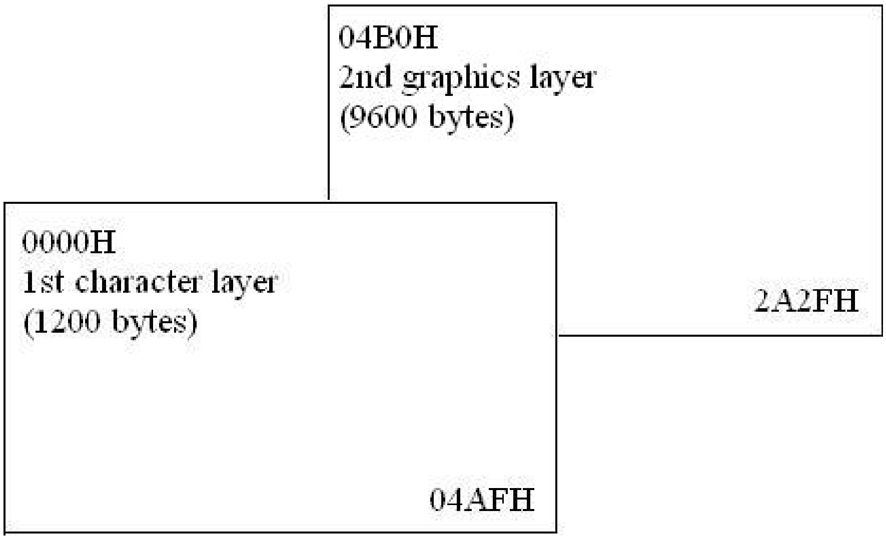


Figure 55: Character over graphics layers

- Register setup procedure

SYSTEM SET	TC/R calculation	CSR FORM
C=40H		C=5DH
P1=30H	fosc=10MHZ	P1=04H
P2=87H	fFR=70HZ	P2=86H
P3=07H		
P4=27H	[TC/R]≤10M/(240*70*9)	HDOT SCR
P5=30H	27H+4≤[TC/R] ≤42H	C=5AH
P6=EFH		P1=00H
P7=28H		
P8=00H		OVLAY
		C=5BH
SCROLL		P1=00H
C=44H		
P1=00H		DISPLAY ON/OFF
P2=00H		C=59H
P3=F0H		P1=16H
P4=B0H		
P5=04H		X=Don’t care
P6=F0H		
P7=XH		
P8=XH		
P9=XH		
P10=XH		

D: *Display mode setting example 2: combining graphic and graphics*

- Conditions
  *320*240 pixels, single-panel drive (1/240 duty cycle)
  *First layer: graphics display
  *Second layer: graphics display
- Display memory allocation
  *First layer (graphics):320/8=40 characters per line, 240/1=240 lines. Required memory size=40*240=9600 bytes.
  *Second layer (graphics):320/8=40 characters per line, 240/1=240 lines. Required memory

size=9600 bytes.

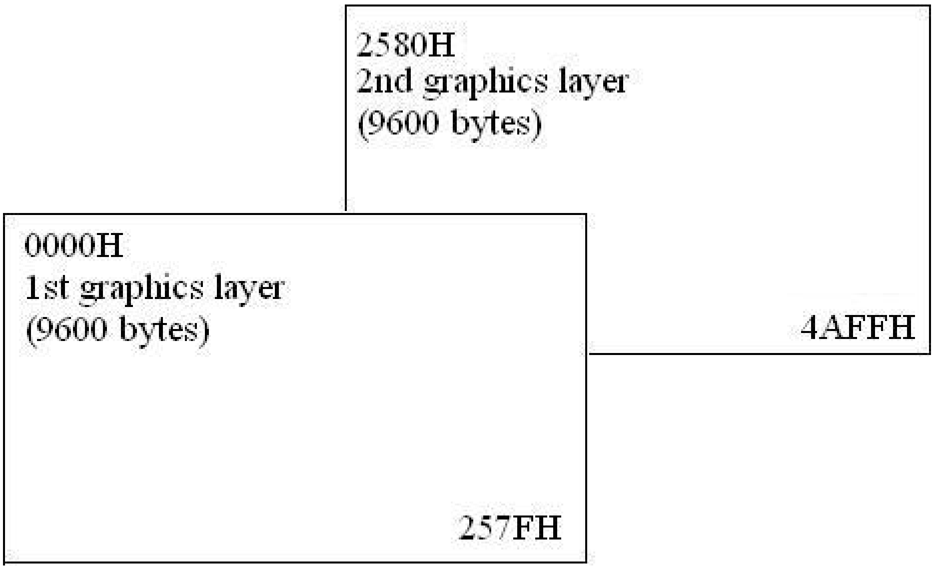


Figure 56: Two-graphics layers

- Register setup procedure

SYSTEM SET	TC/R calculation	CSR FORM
C=40H		C=5DH
P1=30H	fosc=10MHZ	P1=07H
P2=87H	fFR=70HZ	P2=87H
P3=07H		
P4=27H	[TC/R]≤10M/(240*70*9)	HDOT SCR
P5=30H	27H+4≤[TC/R] ≤42H	C=5AH
P6=EFH		P1=00H
P7=28H		
P8=00H		OVLAY
		C=5BH
SCROLL		P1=0CH
C=44H		
P1=00H		DISPLAY ON/OFF
P2=00H		C=59H
P3=F0H		P1=16H
P4=80H		
P5=25H		X=Don't care
P6=F0H		
P7=XH		
P8=XH		
P9=XH		
P10=XH		

E: ***Display mode setting example 3: combining three graphics***

- Conditions
  *320*240 pixels, single-panel drive (1/240 duty cycle)
  *First layer: graphics display
  *Second layer: graphics display
  *Third layer: graphics display
- Display memory allocation

*All layer (graphics):320/8=40 characters per line, 240/1=240 lines. Required memory size=40*240=9600 bytes.

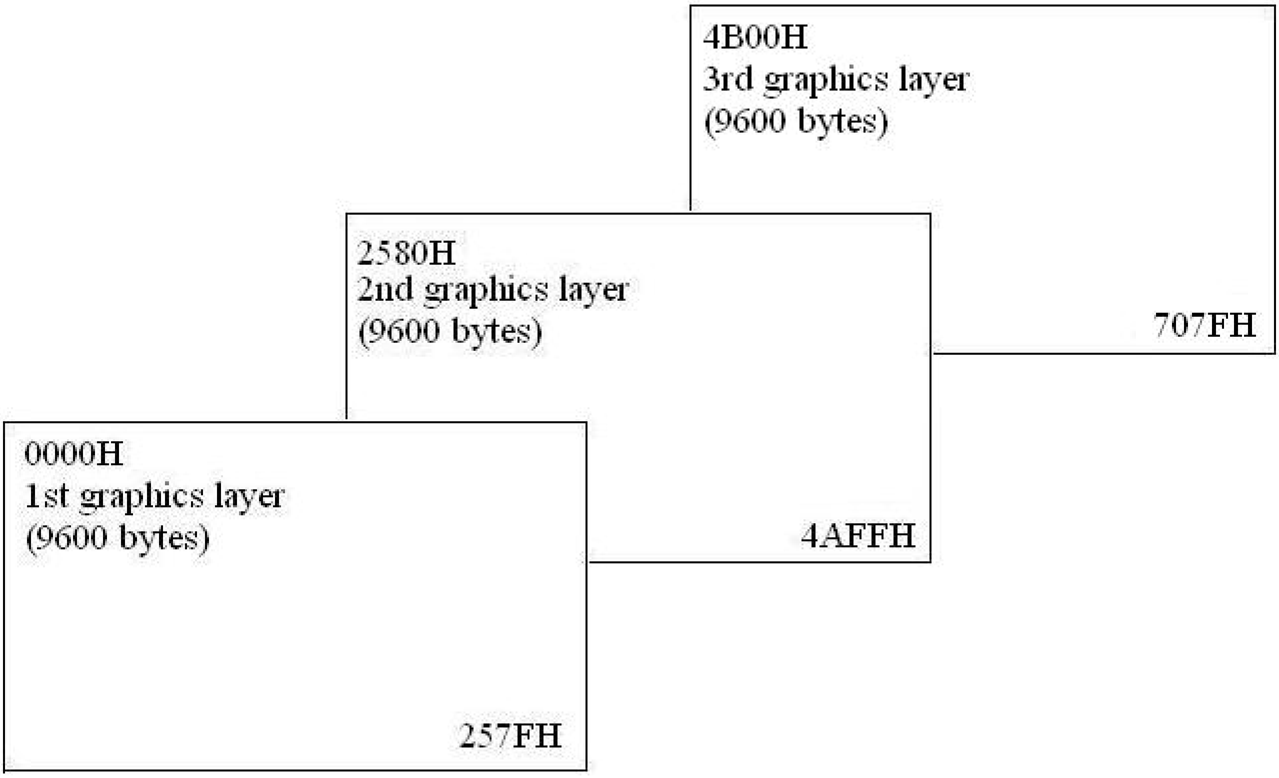


Figure 57: Three-graphics layers

- Register setup procedure

SYSTEM SET
C=40H
P1=30H
P2=87H
P3=07H
P4=27H
P5=30H
P6=EFH
P7=28H
P8=00H

SCROLL
C=44H
P1=00H
P2=00H
P3=F0H
P4=80H
P5=25H
P6=F0H
P7=00H
P8=4BH
P9=XH
P10=XH

TC/R calculation

fosc=10MHZ
fFR=70HZ

[TC/R]≤10M/(240*70*9)
27H+4≤[TC/R] ≤42H

CSR FORM
C=5DH
P1=07H
P2=87H

HDOT SCR
C=5AH
P1=00H

OVLAY
C=5BH
P1=1CH

DISPLAY ON/OFF
C=59H
P1=16H

X=Don’t care

(2) Smooth horizontal scrolling

Figure 58: illustrates smooth display scrolling to the left. When scrolling left, the screen is effectively moving to the right over the larger virtual screen.

Instead of changing the display start address SAD and shifting the display by eight pixels, smooth scrolling is achieved by repeatedly changing the pixel-shift parameter of the HDOT SCR command. When the display has been scrolled seven pixels. The HDOT SCR pixel-shift parameter is reset to zero an SAD incremented by one. Repeating this operation at a suitable rate gives the appearance of smooth scrolling

To scroll the display to the right, the reverse procedure is followed.

When the edge of the virtual screen is reached, the microprocessor must take appropriate steps so that the display is not corrupted. The scroll must be stopped or the display modified

Note that the HDOT SCR command cannot be used to scroll individual layers.

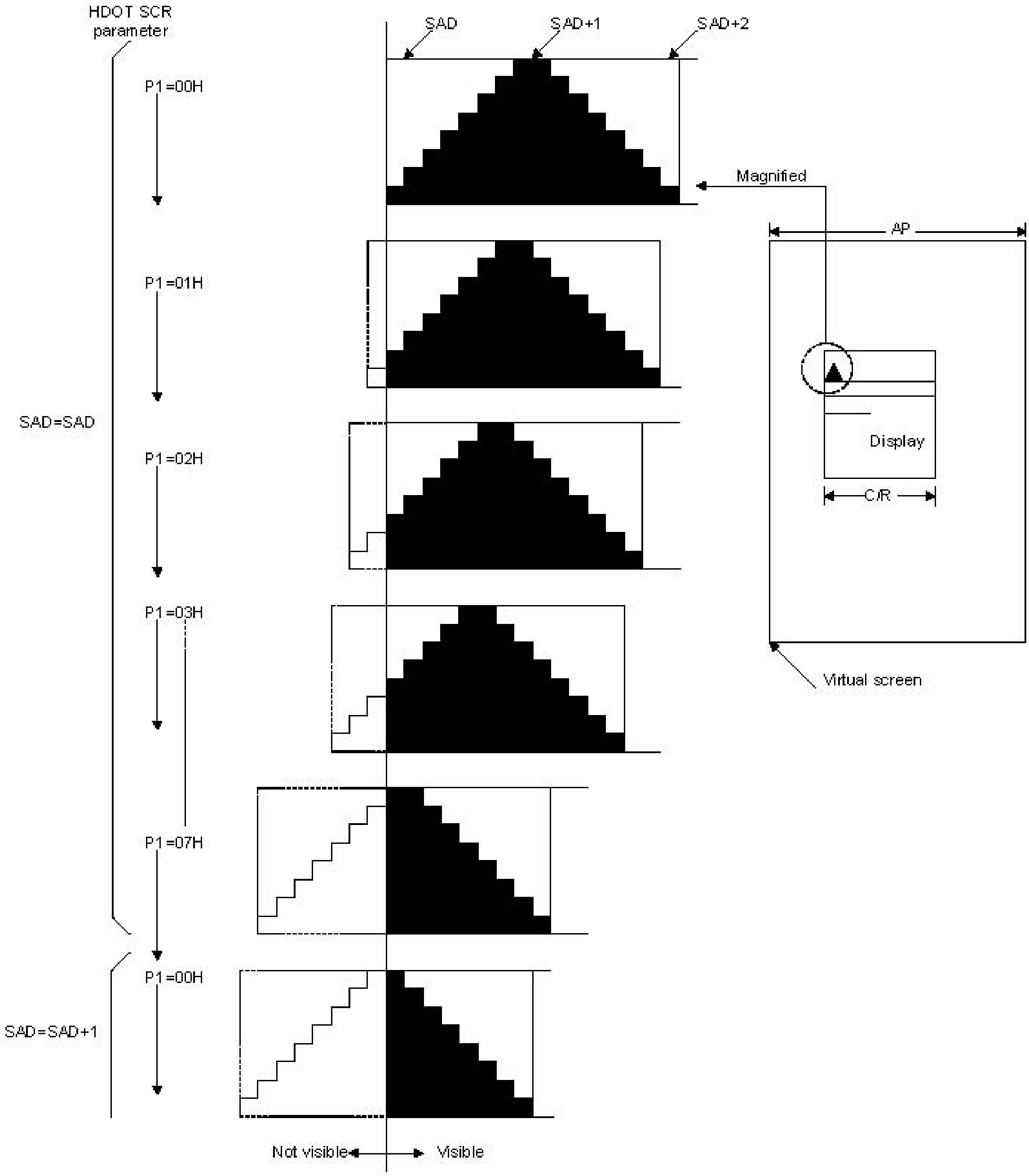


Figure 58: HDOT SCR example

Note: The response time of LCD panels changes considerably at low temperatures. Smooth scrolling under these conditions may make the display difficult to read.

(3) Layered display attributes

The production incorporates a number of functions for enhanced displays using monochrome LCD panels. It allows the display of inverse characters, half-intensity menu pads and flashing of selected screen areas .These functions are controlled by the OVLAY and DISP ON/OFF commands

Attribute	MX1	MX0	Combined layer display	1st layer display	2ndt layer display
Reverse	0 1	1 1	IV RAIO	IV RAIO	
Half-tone	0 1	0 1	ME Yes,No	ME Yes, No	
Local flashing	0 0	0 1	BL Error	BL	Error
Ruled line	0 0 1	0 1 1	RL LINE LINE	RL LINE LINE	

Figure 59: Layer synthesis

A number of means can be used to achieve these effects, depending on the display configuration. These are listed below. Note, however, that not all of these can be used in the one layer at the same time

A: *Inverse display*

- CSRW,CSDIR,MWRITE
  Write is into the graphics screen at the area to be inverted.
- OVLAY:MX0=1,MX1=0
  Set the combination of the two layers to Exclusive-OR.
- DISP ON/OFF:FP0=FP1=1,FP1=FP3=0
  Turn on layers 1 and 2

B: *Half-tone display*

The FP parameter can be used to generate half-intensity display by flashing the display at 17 Hz. Note that this mode of operation may cause flicker problems with certain LCD panels.

- Menu pad display
  Turn flashing off for the first layer, on at 17 Hz for the second layer, and combine the screens using the OR function.
  *OVLAY: P1=00H
  * DISP ON/OFF: P1=34H

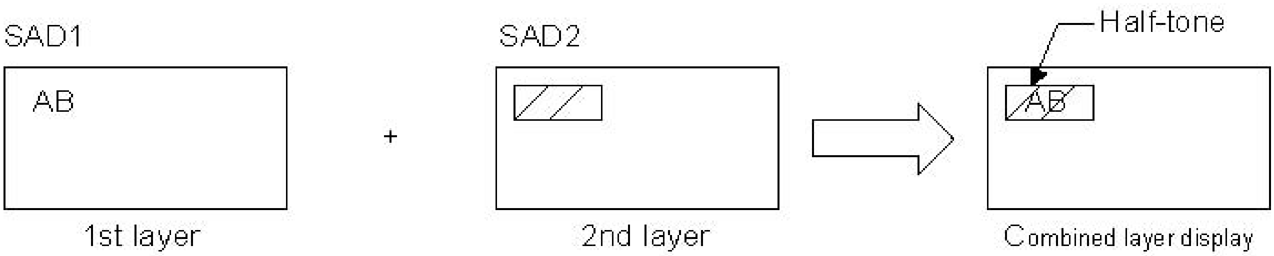


Figure 60: Half-tone character and graphics

- Graph display
  To present two overlaid graphs on the screen, configure the display as for the menu bar display and put one graph on each screen layer. The difference in contrast between the half-and full-

intensity displays will make it easy to distinguish between the two graphs and help create an attractive display.

*OVLAY: P1=00H

* DISP ON/OFF: P1=34H

C: *Flashing areas*

- Small area

To flash selected characters, the MPU can alternately write the characters as character codes and blank characters at intervals of 0.5 to 1.0 seconds.

- Large area

Divide both layer 1 and layer 2 into two screen blocks each, layer 2 into divided into the area to be flashed and the remainder of the screen. Flash the layer 2 screen block at 2 Hz for the area to be flashed and combine the layers using the OR function.

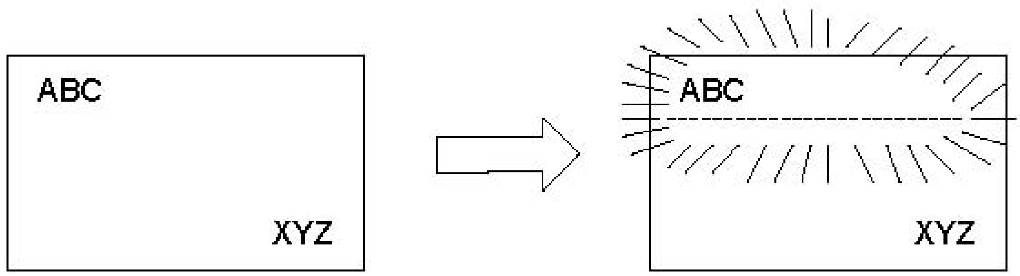


Figure 61: Localized flashing

*OVLAY: P1=00H

* DISP ON/OFF: P1=34H

(4) 16 X 16-dot graphic display

A: *Command usage*

This example shows how to display 16*16-pixel characters. The command sequence is as follows:

CSRW Set the cursor address.

CSRDIR Set the cursor auto-increment direction.

MWRITE Write to the display memory.

B: *Kanji character display*

The program for writing large characters operates as follows:

The microprocessor reads the character data from its ROM.

The microprocessor sets the display address and writes to the VRAM. The flowchart is shown in Figure 64.

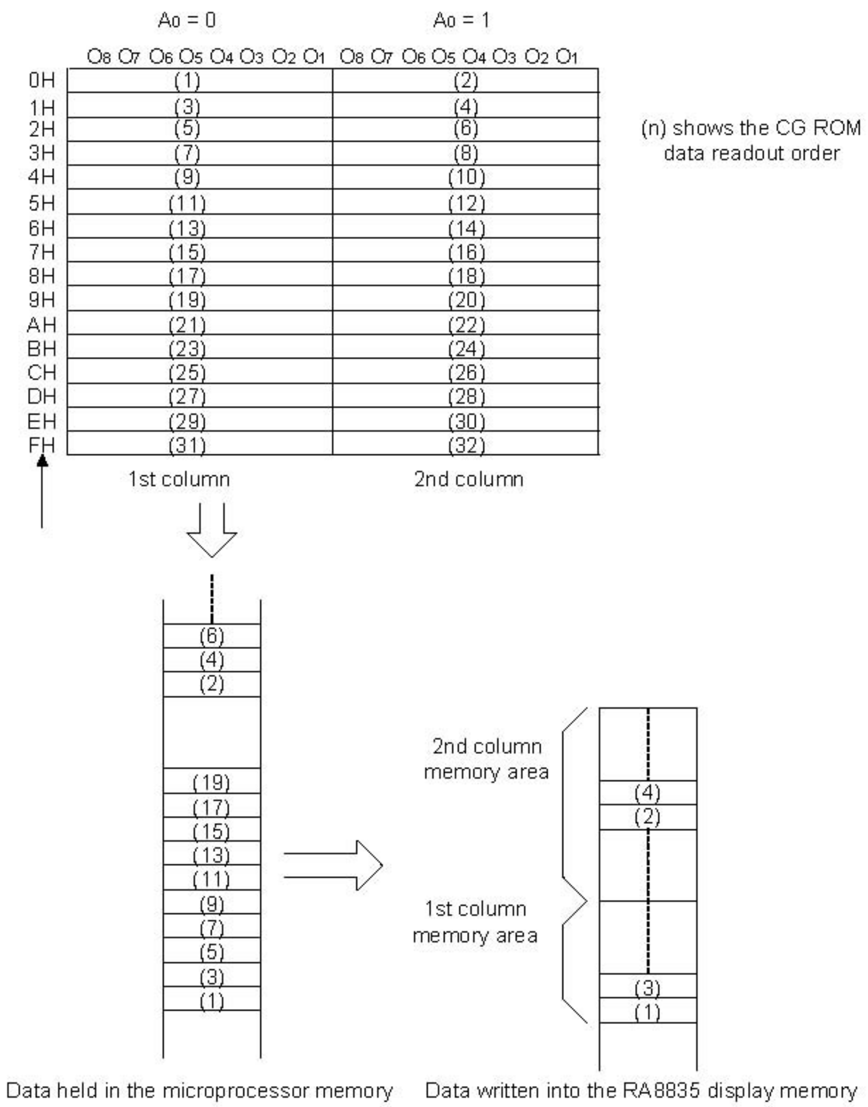


Figure 62: Graphics address indexing

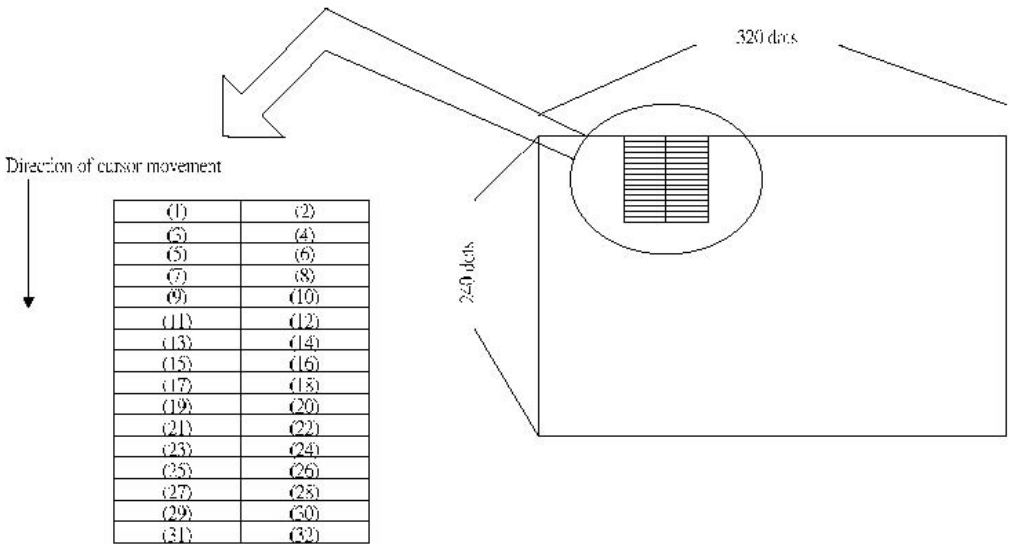


Figure 63: Graphics address indexing

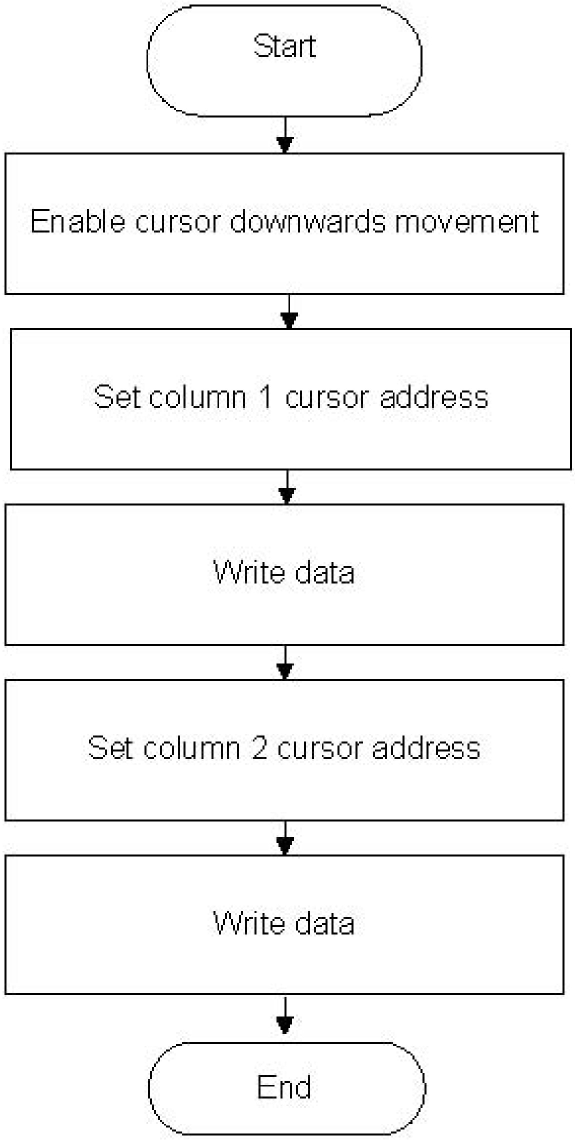


Figure 64: 16 X 16-dot display flowchart

Using an external character generator ROM, and 8*16-pixel font can be used, allowing a 16*16-pixel character to be displayed in two segments .The external CG ROM EPROM data format is described in Section <Display control functions>.This will allow the display of up to 128.16*16-pixel characters. If CG RAM is also used, 96 fixed characters and 32 bank-switchable characters can also be supported.

●INTERNAL CHARACTER GENERATOR FONT

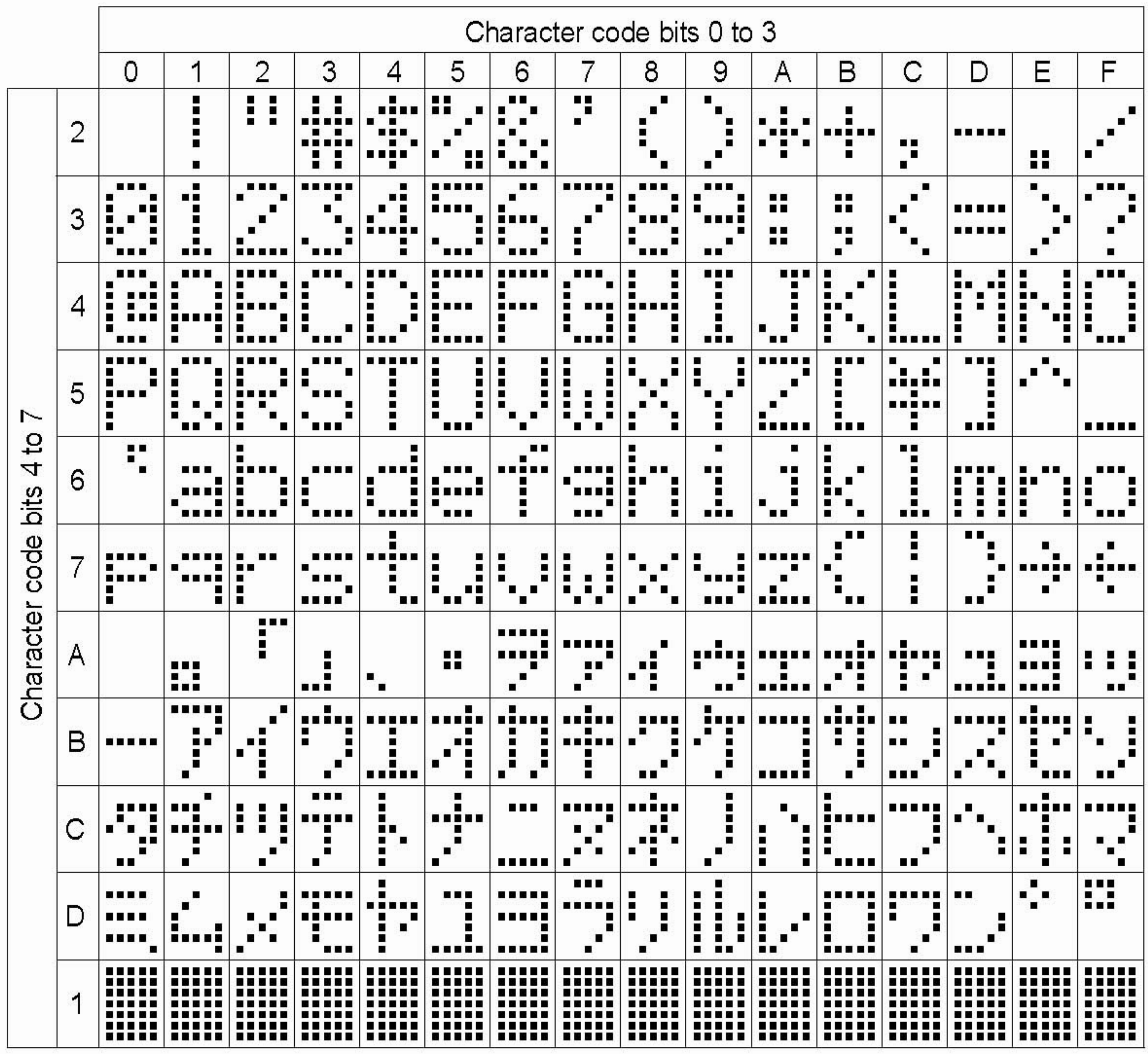


Figure 65: On-chip character set

Note

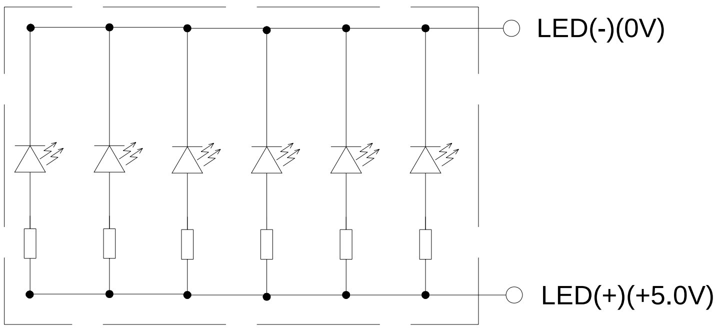
The shaded positions indicate characters that have the whole 6 x 8 bitmap blackened

■ BACKLIGHT

●BACKLIGHT TYPE

Backlight Type: LED

●POWER SUPPLY FOR BACKLIGHT



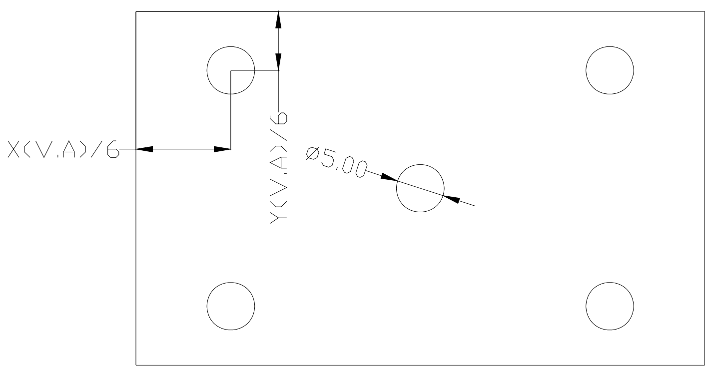
●ABSOLUTE MAXIMUM RATING

PARAMETER	SYMBOL	CONDITION	MIN	MAX	UNIT
Absolute maximum forward current	Ifm			120	mA
Peak forward current	Ifp	1 msec plus 10% Duty cycle		360	mA
Reverse voltage	V_R			5.0	V
Operating temperature	TOP		-20	+70	℃
Storage temperature	TST		-30	+80	℃
Life	Hour	If =90mA	80000		H

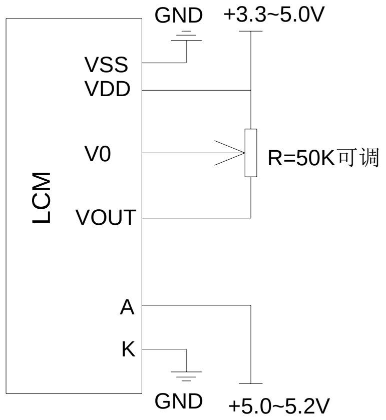
●ELECTRICAL-OPTICAL CHARACTERISTICS

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Forward voltage	Vf (LED(+)-LED(-))	If=90mA	4.8	5.0.	5.2	V
Forward current	If		----	90	120	mA
Reverse current	Ir	VR=5.0V	----	----	60	µA
Chromaticity Coordinates ranks	X	If=90mA	0.25	----	0.28	
	Y		0.25		0.28	
Luminance	Lv	If=90mA	20	----	----	cd/㎡

Note: The Master Screen's luminance is the average value of 5 points, and The Lvmin./Lvmax. is not less than 70%. The measurement instrument is BM-7 luminance Colorimeter. The aperture is Φ5 mm.

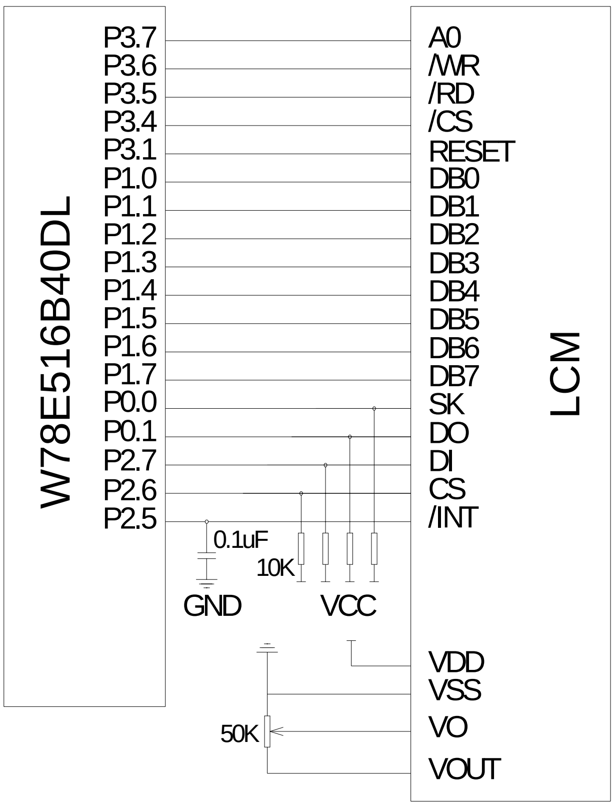


■ POWER SUPPLY FOR LCM MODULE



■ EXAMPLE

Application Circuit



Programme

```
#include "Includes.h"
#include "bmp.c"

#define RA8835P_Bus              P1

#define RA8835P_CS(x)            P3_4 = x
#define RA8835P_RST(x)           P3_1 = x
#define RA8835P_RS(x)            P3_7 = x
#define RA8835P_WR(x)            P3_6 = x
#define RA8835P_RD(x)            P3_5 = x


#define SomeNop()
#define TEST_DELAY_TIME 800

#define SCREEN_1_START_ADDRESS 0X0000
#define SCREEN_2_START_ADDRESS 0X58EF


#define SELECT_SCREEN_1    ScreenStartAddress = SCREEN_1_START_ADDRESS
#define SELECT_SCREEN_2    ScreenStartAddress = SCREEN_2_START_ADDRESS

//==================变量定义 ====================
INT8U _CONST_ BitWriteTab[] = {0x01, 0x02, 0x04, 0x08, 0x10, 0x20, 0x40, 0x80}; //用来写一位数据的掩码表
INT16U ScreenStartAddress = 0;

//==========================================================================
//函 数 名:   Delay_ms(INT16U ms)
//功  能:     延时
//入口参数:   延时的毫秒数
//出口参数:   无
//返 回 值:   无
//==========================================================================
void Delay_ms(INT16U ms)
{
	INT8U a, b, c;
	while(ms--)
		for(c = 1; c > 0; c--)
			for(b = 20; b > 0; b--)
				for(a = 40; a > 0; a--);
}
//==========================================================================
//函 数 名:   StatusCheck()
//功  能:     检查 RA8835P 状态位
//入口参数:   无
//出口参数:   无
//返 回 值:   无
//==========================================================================
void StatusCheck()
{
	INT8U status;
	INT8U TimeOut;
	TimeOut = 0x10;
	RA8835P_CS(0);
	do
	{
```

```
        RA8835P_Bus = 0xff;
        RA8835P_RS(0);
        RA8835P_RD(0);
        SomeNop();
        status = RA8835P_Bus;
        RA8835P_RD(1);
        status &= 0x40;
    }
    while((status != 0x40) && (TimeOut--));
    RA8835P_CS(1);
}
//==========================================================================
//函 数 名:  WriteCommand()
//功 能:     写命令到 RA8835P
//入口参数:  CmdData:命令码
//出口参数:  无
//返 回 值:  无
//==========================================================================
void WriteCommand(INT8U CmdData)
{
    //StatusCheck();
    RA8835P_RS(1);
    RA8835P_CS(0);
    RA8835P_Bus = CmdData;
    SomeNop();
    RA8835P_WR(0);
    SomeNop();
    RA8835P_WR(1);
    RA8835P_CS(1);
}
//==========================================================================
//函 数 名:  WriteData()
//功 能:     写数据到 RA8835P
//入口参数:  CmdData:写入的数据
//出口参数:  无
//返 回 值:  无
//==========================================================================
void WriteData(INT8U Data)
{
    //StatusCheck();
    RA8835P_RS(0);
    RA8835P_CS(0);
    RA8835P_Bus = Data;
    SomeNop();
    RA8835P_WR(0);
    SomeNop();
    RA8835P_WR(1);
    RA8835P_CS(1);

}
//==========================================================================
//函 数 名: ReadData()
//功 能:     从 RA8835P 读数据
//入口参数:  无
//出口参数:  无
//返 回 值:  读出的数据
```

```
//==========================================================================
INT8U ReadData()
{
	INT8U Data;

	RA8835P_RS(1);
	RA8835P_CS(0);
	RA8835P_Bus = 0xff;
	RA8835P_RD(0);
	SomeNop();
	Data = RA8835P_Bus;
	RA8835P_RD(1);
	RA8835P_CS(1);
	return (Data);

}
#define RA8835_OSC_FREQ_M	10
#define FR			75

//==========================================================================
//函 数 名: Init()
//功 能:	初始化 RA8835P
//入口参数:	无
//出口参数:	无
//返 回 值:	无
//==========================================================================
void Init(void)
{


	WriteCommand(0x40);	//SYSTEM SET
	StatusCheck();
	WriteData(0x30); //SET P1 (M0=M1=M2=0,W/S=0,IV=1)
	WriteData(0x87); //SET P2 ()
	WriteData(0x07); //SET P3
	WriteData(LcmXSize / 8 - 1); //SET P4 C/R (40 columns=40*8 dots)

	//	WriteData(70);	//SET P5 TC/R (TC/R>=C/R+4)	48

	WriteData(RA8835_OSC_FREQ_M * 1000000 / 9 / FR / 240); //SET P5 TC/R (TC/R>=C/R+4)	48

	WriteData(LcmYSize - 1); //SET P6 L/F (240 COM)
	WriteData(LcmXSize / 8); //SET P7 (AP=C/R+1)
	WriteData(0x00); //SET P8

	WriteCommand(0x44);	//SCROLL SET
	WriteData(SCREEN_1_START_ADDRESS % 256); //SET P1 (SAD1 L)
	WriteData(SCREEN_1_START_ADDRESS / 256); //SET P2 (SAD1 H )
	WriteData(LcmYSize); //SET P3 (240 LINE FOR FIRST BLOCK DISPLAY)
	WriteData(SCREEN_2_START_ADDRESS % 256); //SET P4	(SAD2 L)
	WriteData(SCREEN_2_START_ADDRESS / 256); //SET P5	(SAD2 H)
	WriteData(LcmYSize); //SET P6	(240 LINE FOR SECOND BLOCK DISPLAY)

	WriteCommand(0x5a);	//HDOT SCR SET
	WriteData(0x00); //SET P1	(D0=D1=D2=0)

	WriteCommand(0x5b);	//OVLAY SET
	WriteData(0x0d); //SET P1	(OV=0,DM2=DM1=1,MX1=MX0=0)
```

```
	WriteCommand(0x58);	//DISPLAY ON/OFF SET
	WriteData(0x16); //SET P1	(THIRD SCREEN DISPLAY OFF,
	//			SECOND SCREEN DISPLAY DISPLAY ON BUT FLASHING
	//			FIRST SCREEN DISPLAY DISPLAY ON BUT FLASHING )

	WriteCommand(0x5d);	//CURSOR TYPE (CSRFORM) SET
	WriteData(0x07); //SET P1	()
	WriteData(0x81); //SET P2	()

	WriteCommand(0x59);	//DISPLAY ON SET
	WriteData(0x06); //SET P1	()

	WriteCommand(0x4c);	//CSRDID SET
}

void ShowScreen1(void)
{
	WriteCommand(0x59);	//DISPLAY ON SET
	WriteData(0x04); //SET P1	()
}
void ShowScreen2(void)
{
	WriteCommand(0x59);	//DISPLAY ON SET
	WriteData(0x10); //SET P1	()
}

//==========================================================================
//函 数 名: WriteByteLocate()
//功 能:	RA8835P 上指定位置 显示指定数据
//入口参数: DisplayData:写入的数据	x0:0--40 横向坐标,y0:0--256	纵向坐标
//出口参数: 无
//返 回 值: 无
//==========================================================================
void Display_Locate(INT8U DisplayData, INT8U x0, INT8U y0)
{
	INT16U csr;

	csr = ScreenStartAddress + y0 * (LcmXSize / 8) + x0;
	WriteCommand(0x46);		//CURSOR SET
	WriteData(csr % 256);		//SET P1	(00H)
	WriteData(csr / 256);		//SET P2	(00H)
	WriteCommand(0x42);		//READY TO WRITE DATA
	WriteData(DisplayData);
}

//==========================================================================
//函 数 名: DrawDots()
//功 能:	RA8835P 上指定坐标 绘点函数
//入口参数: x:0--320 横向坐标,y:0--256	纵向坐标	color:0-1 点的颜色 0:白，1:黑
//出口参数: 无
//返 回 值: 无
//==========================================================================

void DrawDots(INT16S x, INT16S y, bit color)
{

	INT16U csr;
```

```
	INT8U DataTemp;

	csr	= ScreenStartAddress + y * (LcmXSize / 8) + x / 8;
	WriteCommand(0x46);	//CURSOR SET
	WriteData(csr % 256);	//SET P1	(00H)
	WriteData(csr / 256);	//SET P2	(00H)
	WriteCommand(0x43);	//READY TO READ DATA
	DataTemp = ReadData();

	if(color)
	{
		DataTemp |= (BitWriteTab[7-x%8]);
	}
	else
	{
		DataTemp &= ~(BitWriteTab[7-x%8]) ;
	}

	WriteCommand(0x46);	//CURSOR SET
	WriteData(csr % 256);	//SET P1	(00H)
	WriteData(csr / 256);	//SET P2	(00H)
	WriteCommand(0x42);	//READY TO WRITE DATA
	WriteData(DataTemp);
}
//=============================================================================
//函 数 名: ScanScreen()
//功 能:	扫描屏幕
//入口参数: data1:奇数行的数据	data2:偶数行的数据
//出口参数: 无
//返 回 值: 无
//=============================================================================
void ScanScreen(INT8U data1, INT8U data2)
{
	INT8U i, j;

	WriteCommand(0x46);	//CURSOR SET
	WriteData(ScreenStartAddress % 256);	//SET P1	(00H)
	WriteData(ScreenStartAddress / 256);	//SET P2	(00H)
	WriteCommand(0x42);	//READY TO WRITE DATA
	for(i = 0; i < LcmYSize / 2; i++)
	{
		for(j = 0; j < LcmXSize / 8; j++)
		{
			WriteData(data1);
		}
		for(j = 0; j < LcmXSize / 8; j++)
		{
			WriteData(data2);
		}
	}
}
//=============================================================================
//函 数 名: DrawPicture()
//功 能:	绘制 320*240 图片
//入口参数:	*p:指向图片的首地址
//		注意:为了节省空间，图片采取压缩算法
//出口参数:	无
//返 回 值:	无
```

```
//===========================================================================
void DrawPictureRA8835(INT8U *p)
{

	INT16U i, j, k;

	WriteCommand(0x46);	//CURSOR SET
	WriteData(ScreenStartAddress % 256);	//SET P1	(00H)
	WriteData(ScreenStartAddress / 256);	//SET P2	(00H)
	WriteCommand(0x42);	//READY TO WRITE DATA

	for(i = 0; i < 9600;)
	{
		if((*p == 0x00) || (*p == 0xff))
		{
			if(*(p + 1) == 0x00)
			{
				k = (*(p + 3) * 256) + *(p + 2);
				for(j = 0; j < k; j++)
				{
					WriteData(*p);
					i++;

				}
				p += 4;
			}
			else
			{
				k = *(p + 1);
				for(j = 0; j < k; j++)
				{
					WriteData(*p);
					i++;
				}
				p += 2;
			}

		}
		else
		{
			WriteData(*p++);
			i++;
		}
	}
}
//===========================================================================
//函 数 名: main()
//功 能:	RA8835P 控制器类型的模组的测试函数
//入口参数: 无
//出口参数: 无
//返 回 值: 无
//===========================================================================
void main(void)
{
	RA8835P_RST(0);
	Delay_ms(100);
	RA8835P_RST(1);
	Delay_ms(100);
```

```
    while(1)
    {

        Init();
        Init();

        SELECT_SCREEN_2;//选择第二屏
        ScanScreen(0x00, 0x00); //清屏
        ShowScreen2();   //显示第二屏
        DrawPictureRA8835(BMP4);//图片
        Delay_ms(TEST_DELAY_TIME);
        DrawPictureRA8835(BMP1);//大字母图案
        Delay_ms(TEST_DELAY_TIME);
        ScanScreen(0xCC, 0x33); //测隔行短路
        Delay_ms(TEST_DELAY_TIME);
        SELECT_SCREEN_1;//选择第一屏
        ShowScreen1();   //显示第一屏
        ScanScreen(0xaa, 0x55);
        Delay_ms(TEST_DELAY_TIME);
        DrawPictureRA8835(BMP3);//交叉线
        Delay_ms(TEST_DELAY_TIME - 100);
        DrawPictureRA8835(BMP2);//回形
        Delay_ms(TEST_DELAY_TIME - 100);
        Delay_ms(TEST_DELAY_TIME);
        ScanScreen(0xff, 0xff); //全黑
        Delay_ms(TEST_DELAY_TIME - 100);

    }
}
```

RELIABILITY

Content of Reliability Test

No.	Test Item	Content of Test	Test Condition	Applicable Standard
Environmental Test				
1	High temperature storage	Endurance test applying the high storage temperature for a long time.	80 °C 200 hrs	——
2	Low temperature storage	Endurance test applying the low storage temperature for a long time.	-30 °C 200 hrs	——
3	High temperature operation	Endurance test applying the electric stress (Voltage & Current) and the thermal stress to the element for a long time.	70 °C 200 hrs	——
4	Low temperature operation	Endurance test applying the electric stress under low temperature for a long time.	-20 °C 200 hrs	——
5	High temperature / Humidity storage	Endurance test applying the high temperature and high humidity storage for a long time.	60 °C , 90 %RH 96 hrs	MIL-202E-103B JIS-C5023
6	High temperature / Humidity operation	Endurance test applying the electric stress (Voltage & Current) and temperature / humidity stress to the element for a long time.	50 °C 90 %RH 96 hrs	MIL-202E-103B JIS-C5023
7	Temperature cycle	Endurance test applying the low and high temperature cycle. -10°C 30min. ⇄ 25°C 5min. ⇄ 60°C 30min. ← 1 cycle →	-10°C / +60°C 10 cycles	——
Mechanical Test				
8	Vibration test	Endurance test applying the vibration during transportation and using.	10~22Hz → 1.5mmp-p 22~500Hz → 1.5G Total 0.5hrs	MIL-202E-201A JIS-C5025 JIS-C7022-A-10
9	Shock test	Constructional and mechanical endurance test applying the shock during transportation.	50G half sign wave 11 msedc 3 times of each direction	MIL-202E-213B
10	Atmospheric pressure test	Endurance test applying the atmospheric pressure during transportation by air.	115 mbar 40 hrs	MIL-202E-105C
Others				
11	Static electricity test	Endurance test applying the electric stress to the terminal.	VS=800V , RS=1.5 kΩ CS=100 pF 1 time	MIL-883B-3015.1

*** Supply voltage for logic system = 5V. Supply voltage for LCD system = Operating voltage at 25°C.

Failure Judgement Criterion

Criterion Item	Test Item No.											Failure Judgment Criterion
	1	2	3	4	5	6	7	8	9	10	11	
Basic specification												Out of the Basic Specification
Electrical characteristic												Out of the DC and AC Characteristic
Mechanical characteristic												Out of the Mechanical Specification Color change : Out of Limit Apperance Specification
Optical characteristic												Out of the Apperance Standard

■ INSPECTION CRITERIA

see :Q/XRD0002-05

■ PRECAUTIONS FOR USING LCD MODULES

▼ Handing Precautions

(1) The display panel is made of glass. Do not subject it to a mechanical shock by dropping it or impact.

(2) If the display panel is damaged and the liquid crystal substance leaks out, be sure not to get any in your mouth. If the substance contacts your skin or clothes, wash it off using soap and water.

(3) Do not apply excessive force to the display surface or the adjoining areas since this may cause the color tone to vary.

(4) The polarizer covering the display surface of the LCD module is soft and easily scratched. Handle this polarizer carefully.

(5) If the display surface becomes contaminated, breathe on the surface and gently wipe it with a soft dry cloth. If it is heavily contaminated, moisten cloth with one of the following solvents :

- Isopropyl alcohol
- Ethyl alcohol

(6) Solvents other than those above-mentioned may damage the polarizer. Especially, do not use the following.

- Water
- Ketone
- Aromatic solvents

(7) Exercise care to minimize corrosion of the electrode. Corrosion of the electrodes is accelerated by water droplets, moisture condensation or a current flow in a high-humidity environment.

■ USING LCD MODULES

Liquid Crystal Display Modules

LCD is composed of glass and polarizer. Pay attention to the following items when handling.

(1) Please keep the temperature within specified range for use and storage. Polarization degradation, bubble generation or polarizer peel-off may occur with high temperature and high humidity.

(2) Do not touch, push or rub the exposed polarizers with anything harder than an HB pencil lead (glass, tweezers, etc.).

(3) N-hexane is recommended for cleaning the adhesives used to attach front/rear polarizers and reflectors made of organic substances which will be damaged by chemicals such as acetone, toluene, ethanol and isopropyl alcohol.

(4) When the display surface becomes dusty, wipe gently with absorbent cotton or other soft material like chamois soaked in petroleum benzin. Do not scrub hard to avoid damaging the display surface.

(5) Wipe off saliva or water drops immediately, contact with water over a long period of time may cause deformation or color fading.

(6) Avoid contacting oil and fats.

(7) Condensation on the surface and contact with terminals due to cold will damage, stain or dirty the polarizers. After products are tested at low temperature they must be warmed up in a container before coming is contacting with room temperature air.

(8) Do not put or attach anything on the display area to avoid leaving marks on.

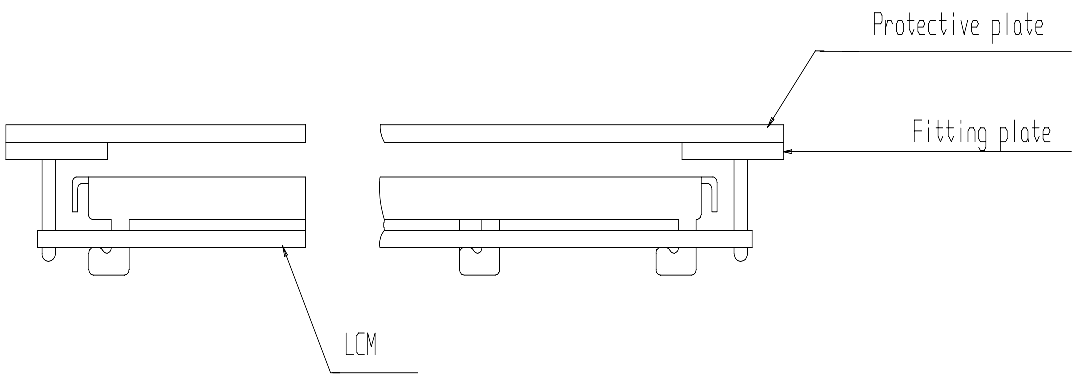
(9) Do not touch the display with bare hands. This will stain the display area and degradate insulation between terminals (some cosmetics are determinated to the polarizers).

(10) As glass is fragile. It tends to become or chipped during handling especially on the edges. Please avoid dropping or jarring.

Installing LCD Modules

The hole in the printed circuit board is used to fix LCM as shown in the picture below. Attend to the following items when installing the LCM.

(1) Cover the surface with a transparent protective plate to protect the polarizer and LC cell.



(2) When assembling the LCM into other equipment, the spacer to the bit between the LCM and the fitting plate should have enough height to avoid causing stress to the module surface, refer to the individual specifications for measurements. The measurement tolerance should be ±0.1mm.

Precaution for Handing LCD Modules

Since LCM has been assembled and adjusted with a high degree of precision, avoid applying excessive shocks to the module or making any alterations or modifications to it.

(1) Do not alter, modify or change the shape of the tab on the metal frame.

(2) Do not make extra holes on the printed circuit board, modify its shape or change the positions of components to be attached.

(3) Do not damage or modify the pattern writing on the printed circuit board.

(4) Absolutely do not modify the zebra rubber strip (conductive rubber) or heat seal connector.
(5) Except for soldering the interface, do not make any alterations or modifications with a soldering iron.
(6) Do not drop, bend or twist LCM.

Electro-Static Discharge Control

Since this module uses a CMOS LSI, the same careful attention should be paid to electrostatic discharge as for an ordinary CMOS IC.

(1) Make certain that you are grounded when handing LCM.
(2) Before remove LCM from its packing case or incorporating it into a set, be sure the module and your body have the same electric potential.
(3) When soldering the terminal of LCM, make certain the AC power source for the soldering iron does not leak.
(4) When using an electric screwdriver to attach LCM, the screwdriver should be of ground potentiality to minimize as much as possible any transmission of electromagnetic waves produced sparks coming from the commutator of the motor.
(5) As far as possible make the electric potential of your work clothes and that of the work bench the ground potential.
(6) To reduce the generation of static electricity be careful that the air in the work is not too dried. A relative humidity of 50%-60% is recommended.

Precaution for soldering to the LCM

(1) Observe the following when soldering lead wire, connector cable and etc. to the LCM.

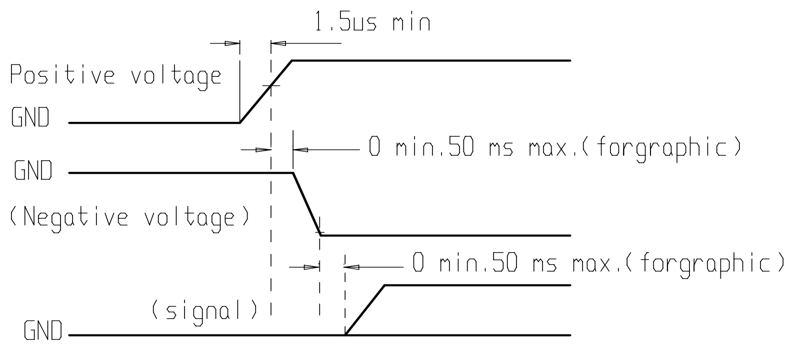
- Soldering iron temperature : 280°C ± 10°C.
- Soldering time : 3-4 sec.
- Solder : eutectic solder.

If soldering flux is used, be sure to remove any remaining flux after finishing to soldering operation. (This does not apply in the case of a non-halogen type of flux.) It is recommended that you protect the LCD surface with a cover during soldering to prevent any damage dur to flux spatters.

(2) When soldering the electroluminescent panel and PC board, the panel and board should not be detached more than three times. This maximum number is determined by the temperature and time conditions mentioned above, though there may be some variance depending on the temperature of the soldering iron.
(3) When remove the electroluminescent panel from the PC board, be sure the solder has completely melted, the soldered pad on the PC board could be damaged.

Precautions for Operation

(1) Viewing angle varies with the change of liquid crystal driving voltage (VO). Adjust VO to show the best contrast.
(2) Driving the LCD in the voltage above the limit shortens its life.
(3) Response time is greatly delayed at temperature below the operating temperature range. However, this does not mean the LCD will be out of the order. It will recover when it returns to the specified temperature range.
(4) If the display area is pushed hard during operation, the display will become abnormal. However, it will return to normal if it is turned off and then back on.
(5) Condensation on terminals can cause an electrochemical reaction disrupting the terminal circuit. Therefore, it must be used under the relative condition of 40°C , 50% RH.
(6) When turning the power on, input each signal after the positive/negative voltage becomes stable.



Storage

When storing LCD's as spares for some years, the following precaution are necessary.

(1) Store them in a sealed polyethylene bag. If properly sealed, there is no need for dessicant.

(2) Store them in a dark place. Do not expose to sunlight or fluorescent light, keep the temperature between 0°C and 35°C.

(3) The polarizer surface should not come in contact with any other objects. (We advise you to store them in the container in which they were shipped.)

(4) Environmental conditions :

- Do not leave them for more than 168hrs. at 80°C.
- Should not be left for more than 48hrs. at -30°C.

Safety

(1) It is recommended to crush damaged or unnecessary LCD's into pieces and wash them off with solvents such as acetone and ethanol, which should later be burned.

(2) If any liquid out of a damaged glass cell and comes in contact with the hands, wash off thoroughly with soap and water.

Limited Warranty

Unless agreed between X.R.D and customer, X.R.D will replace or repair any of its LCD modules which are found to be functionally defective when inspected in accordance with X.R.D LCD acceptance standards (copies available upon request) for a period of one year from date of shipments. Cosmetic/visual defects must be returned to X.R.D within 90 days of shipment. Confirmation of such date shall be based on freight documents. The warranty liability of X.R.D limited to repair and/or replacement on the terms set forth above. X.R.D will not be responsible for any subsequent or consequential events.

Return LCM under warranty

No warranty can be granted if the precautions stated above have been disregarded. The typical examples of violations are :

- Broken LCD glass.
- PCB eyelet's damaged or modified.
- PCB conductors damaged.
- Circuit modified in any way, including addition of components.
- PCB tampered with by grinding, engraving or painting varnish.
- soldering to or modifying the bezel in any manner.

Module repairs will be invoiced to the customer upon mutual agreement. Modules must be returned with sufficient description of the failures or defects. Any connectors or cable installed by the customer must be removed completely without damaging the PCB eyelet's, conductors and terminals.