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CUSTOMER ACCEPTANCE STANDARD SPECIFICATIONS

SPEC . NO . :

EU-SED1335F

FOR MESSRS :

CUSTOMER'S APPROVAL

DATE :

BY :

EMERGING DISPLAY TECHNOLOGIES CORPORATION	MODEL NO. EU-SED1335F	VERSION 1
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1. DESCRIPTION

The SED1335F is a controller IC that can display text and graphics on LCD panel. It is software compatible with the SED1330 series LCD controller Ics.

The SED1335F can display layered text and graphics, scroll the display in any direction and partition the display into multiple screens.

The SED1335F stores text, character codes and bit-mapped graphics data in external frame buffer memory. Display controller functions include transferring data from the controlling microprocessor to the buffer memory, reading memory data, converting data to display pixels and generating timing signals for the buffer memory, LCD panel.

The SED1335F has an internal character generator with 160, 5 x 7 pixel characters in internal mask ROM. The character generators support up to 64, 8 x 16 pixel characters in external character generator RAM and up to 256, 8 x 16 pixel characters in external character generator ROM.

2. ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	RATED VALUES	UNIT
SUPPLY VOLTAGE RANGE	V_{DD}	- 0.3 TO 7.0	V
INPUT VOLTAGE RANGE	V_{IN}	- 0.3 TO V_{DD} + 0.3	V
POWER DISSIPATION	P_D	300	mW
OPERATING TEMPERATURE RANGE	T_{opg}	- 20 TO 75	deg. C
STORAGE TEMPERATURE RANGE	Tstg	-65 TO 150	deg. C

3. ELECTRICAL CHARACTERISTICS

3.1 FOR V_{DD} = 5.0 V

V_{DD} = 4.5 to 5.5 V, V_{SS} = 0 V, Ta = -20 to 75 deg. C

PARAMETER	SYMBOL	CONDITION	RATING			UNIT
			MIN	TYP	MAX	
SUPPLY VOLTAGE	V_{DD}	–	4.5	5.0	5.5	V
REGISTER DATA RETENTION VOLTAGE	V_{HO}	–	2.0	–	6.0	V
INPUT LEAKAGE CURRENT	I_{LI}	VI=V_{DD}	–	0.05	2.0	μA
OUTPUT LEAKAGE CURRENT	I_{LO}	VI=V_{SS}	–	0.10	5.0	μA
OPERATING SUPPLY CURRENT	Iopr		–	11	15	mA
QUIESCENT SUPPLY CURRENT	I_O	SLEEP MODE V_{OSC1}=$V_{\overline{CS}}$ =$V_{\overline{RD}}$ =V_{DD}	–	0.05	20.0	μA
OSCILLATOR FREQUENCY	fOSC	MEASURED AT CRYSTAL, 47.5% DUTY CYCLE.	1.0	–	10.0	MHZ
EXTERNAL CLOCK FREQUENCY	f_{CL}		1.0	–	10.0	MHZ
OSCILLATOR FEEDBACK RESISTANCE	Rf		0.5	1.0	3.0	MΩ
HIGH-LEVEL INPUT VOLTAGE FOR TTL	V_{HT}	SEE NOTE 1.	0.5V_{DD}	–	V_{DD}	V
LOW-LEVEL INPUT VOLTAGE FOR TTL	V_{LT}	SEE NOTE 1.	V_{SS}	–	0.2V_{DD}	V
HIGH-LEVEL OUTPUT VOLTAGE FOR TTL	V_{OHT}	I_{OH}= -5.0 mA SEE NOTE 1.	2.4	–	–	V
LOW-LEVEL OUTPUT VOLTAGE FOR TTL	V_{OLT}	I_{OL}=5.0 mA SEE NOTE 1.	–	–	V_{SS}+0.4	V
HIGH-LEVEL INPUT VOLTAGE FOR CMOS	V_{IHC}	SEE NOTE 2.	0.8V_{DD}	–	V_{DD}	V
LOW-LEVEL INPUT VOLTAGE FOR CMOS	V_{ILC}	SEE NOTE 2.	V_{SS}	–	0.2V_{DD}	V
RISING-EDGE THRESHOLD VOLTAGE	V_{T+}	SEE NOTE 3.	0.5V_{DD}	0.7V_{DD}	0.8V_{DD}	V
FALLING-EDGE THRESHOLD VOLTAGE	V_{T-}	SEE NOTE 3.	0.2V_{DD}	0.3V_{DD}	0.5V_{DD}	V

Notes

1. D0 to D7, A0, $\overline{CS}$, $\overline{RD}$, $\overline{WR}$ are TTL-level inputs.
2. SEL1 is CMOS-level inputs.
3. RES is a Schmitt-trigger input. The pulsewidth on $\overline{RES}$ must be at least 200 μs. Note that
   pulses of more than a few seconds will cause DC voltages to be applied to the LCD panel.

3.2 FOR V_{DD} = 3.0 V

V_{DD} = 3.0 to 4.5 V, V_{SS} = 0 V, Ta = -20 to 75 deg. C Unless otherwise noted

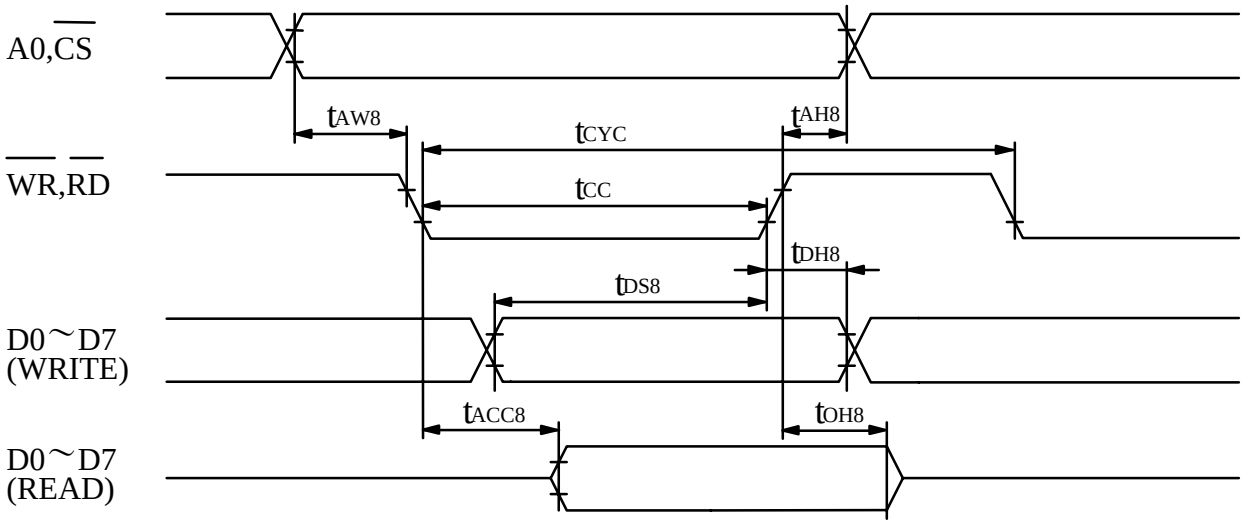
PARAMETER	SYMBOL	CONDITION	RATING			UNIT
			MIN	TYP	MAX	
SUPPLY VOLTAGE	V_{DD}		3.0	3.5	4.5	V
REGISTER DATA RETENTION VOLTAGE	V_{HO}		2.0	–	6.0	V
INPUT LEAKAGE CURRENT	I_{LI}	$V_I=V_{DD}$	–	0.05	2.0	μA
OUTPUT LEAKAGE CURRENT	I_{LO}	$V_I=V_{SS}$	–	0.10	5.0	μA
OPERATING SUPPLY CURRENT	Iopr	V_{DD}=3.5V	–	3.5	–	mA
			–	–	7.0	
QUIESCENT SUPPLY CURRENT	I_O	SLEEP MODE $V_{OSC1}=V_{\overline{CS}}=V_{\overline{RD}}=V_{DD}$	–	0.05	20.0	μA
OSCILLATOR FREQUENCY	f_{OSC}	MEASURED AT CRYSTAL, 47.5% DUTY CYCLE.	1.0	–	8.0	MHZ
EXTERNAL CLOCK FREQUENCY	f_{CL}		1.0	–	8.0	MHZ
OSCILLATOR FEEDBACK RESISTANCE	Rf		0.7	–	3.0	MΩ
HIGH-LEVEL INPUT VOLTAGE FOR TTL	V_{HT}	SEE NOTE 1	0.5V_{DD}	–	V_{DD}	V
LOW-LEVEL INPUT VOLTAGE FOR TTL	V_{LT}	SEE NOTE 1	V_{SS}	–	0.2V_{DD}	V
HIGH-LEVEL OUTPUT VOLTAGE FOR TTL	V_{OHT}	I_{OH}=-3.0mA SEE NOTE 1	2.4	–	–	V
LOW-LEVEL OUTPUT VOLTAGE FOR TTL	V_{OLT}	I_{OL}=3.0mA SEE NOTE 1	–	–	V_{SS}+0.4	V
HIGH-LEVEL INPUT VOLTAGE FOR CMOS	V_{IHC}	SEE NOTE 2	0.8V_{DD}	–	V_{DD}	V
LOWH-LEVEL INPUT VOLTAGE FOR CMOS	V_{ILC}	SEE NOTE 2	V_{SS}	–	0.2V_{DD}	V
RISING-EDGE THNESHOLD VOLTAGE	V_{T+}	SEE NOTE3	0.5V_{DD}	0.7V_{DD}	0.8V_{DD}	V
FALLING-EDGE THRESHOLD VOLTAGE	V_{T-}	SEE NOTE3	0.2V_{DD}	0.3V_{DD}	0.5V_{DD}	V

Notes :

1. DO to D7, A0, $\overline{CS}$, $\overline{RD}$, $\overline{WR}$, are TTL-level inputs.
2. SEL1 IS CMOS-level inputs.
3. $\overline{RES}$ is a Schmitt-trigger input. The pulsewidth on $\overline{RES}$ must be at least 200 λs. Note that pulses of more than a few seconds will cause DC voltages to be applied to the LCD panel.

4. TIMING DIAGRAMS

4.1 8080 FAMILY INTERFACE TIMING



Ta = - 20 to 75 deg . C

SIGNAL	SYMBOL	PARAMETER	VDD=4.5TO5.5V		VDD=2.7TO4.5V		UNIT	CONDITION
			MIN	MAX	MIN	MAX		
A0, CS	t_{AH8}	ADDRESS HOLE TIME	10	—	10	—	ns	CL=100 pF
	t_{AW8}	ADDRESS SETUP TIME	0	—	0	—	ns	
WR, RD	t_{CYC}	SYSTEM CYCLE TIME	SEE NOTE	—	SEE NOTE	—	ns	
	t_{OC}	STROBE PULSEWIDTH	120	—	150	—	ns	
D0 to D7	t_{DS8}	DATA SETUP TIME	120	—	120	—	ns	
	t_{DH8}	DATA HOLD TIME	5	—	5	—	ns	
	t_{ACC8}	RD ACCESS TIME	—	50	—	80	ns	
	t_{OH8}	OUTPUT DISABLE TIME	10	50	10	55	ns	

Note

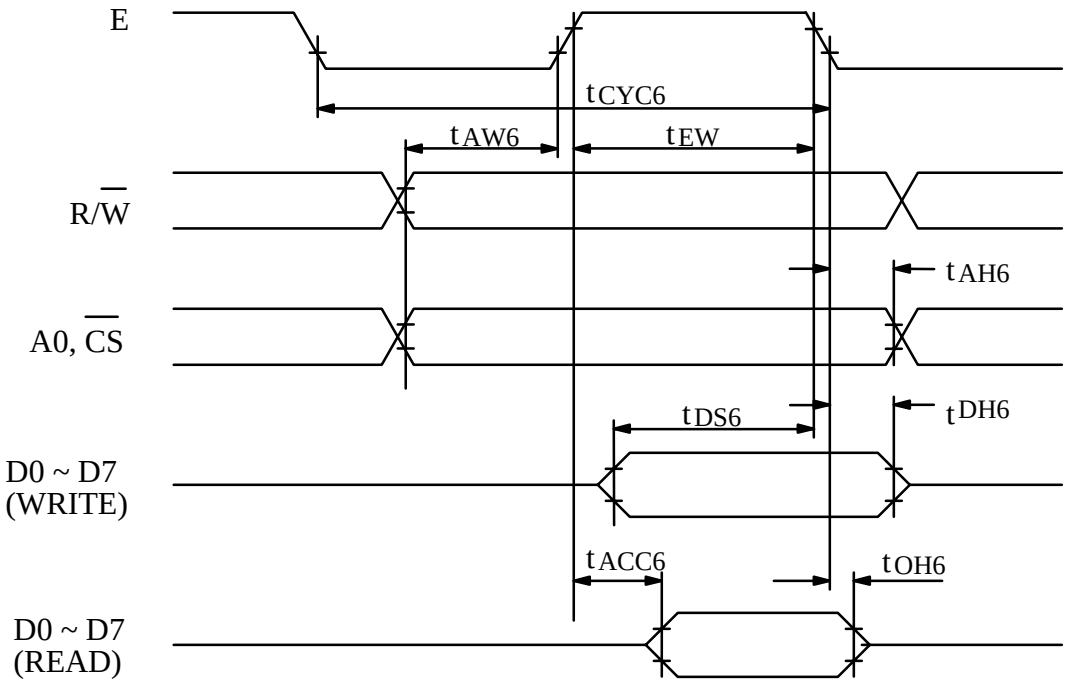
For memory control and system control commands:

$t_{CYC8} = 2t_C + t_{CC} + t_{CEA} + 75 > t_{ACV} + 245$

For all other command:

$t_{CYC8} = 4t_C + t_{CC} + 30$

4.2 6800 FAMILY INTERFACE TIMING



Note

t_{CYC6} indicates the interval during which CS is LOW and E is HIGH.

Ta = - 20 to 75 deg . C

SIGNAL	SYMBOL	PARAMETER	V_{DD}=4.5TO5.5V		V_{DD}=2.7TO4.5V		UNIT	CONDITION
			MIN	MAX	MIN	MAX		
A0, $\overline{CS}$ R/$\overline{W}$	t_{CYC6}	SYSTEM CYCLE TIME	SEE NOTE	—	SEE NOTE	—	ns	CL=100 pF
	t_{AW6}	ADDRESS SETUP TIME	0	—	10	—	ns	
	t_{AH6}	SYSTEM HOLD TIME	0	—	0	—	ns	
D0 to D7	t_{DS6}	DATA SETUP TIME	100	—	120	—	ns	
	t_{DH6}	DATA HOLD TIME	0	—	0	—	ns	
	t_{OH6}	OUTPUT DISABLE TIME	10	50	10	75	ns	
	t_{ACC6}	ACCESS TIME	—	85	—	130	ns	
E	t_{EW}	ENABLE PULSEWIDTH	120	—	150	—	ns	

Note

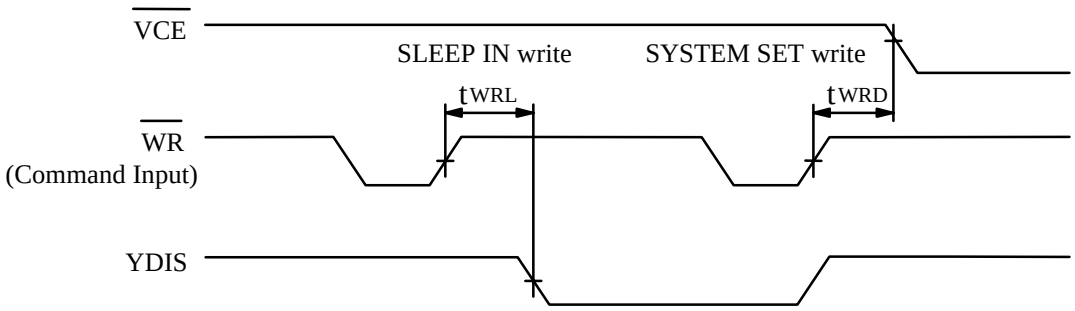
For memory control and system control commands:

$t_{CYC6} = 2t_C + t_{EW} + t_{CEA} + 75 > t_{ACV} + 245$

For all other commands:

$t_{CYC6} = 4t_C + t_{EW} + 30$

4.3 SLEEP IN COMMAND TIMING



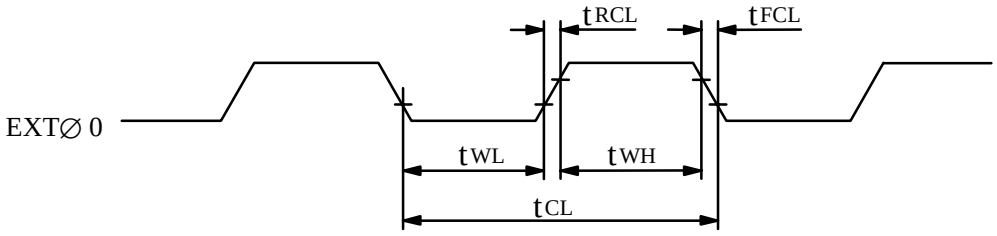
Ta = -20 to 75 deg.C

SIGNAL	SYMBOL	PARAMETER	VDD = 4.5 to 5.5 V		VDD = 2.7 to 4.5 V		UNIT	CONDITION
			MIN	MAX	MIN	MAX		
$\overline{WR}$	tWRD	$\overline{VCE}$ FALLING-EDGE DELAY TIME	SEE NOTE 1.	–	SEE NOTE 1.	–	ns	CL=100 pF
	tWRL	YDIS FALLING-EDGE DELAY TIME	–	SEE NOTE 2.	–	SEE NOTE 2.	ns	

Notes

1. $t_{WRD} = 18tc + toss + 40$
   (toss is the time delay from the sleep state until stable operation)
2. $t_{WRL} = 36tc \times [TC/R] \times [L/F] + 70$

4.4 EXTERNAL OSCILLATOR SIGNAL TIMING



Ta = -20 to 75 deg.C

SIGNAL	SYMBOL	PARAMETER	V_{DD} = 4.5 to 5.5 V		V_{DD} = 2.7 to 4.5 V		UNIT	CONDITION
			MIN	MAX	MIN	MAX		
EXT∅ 0	t_{RCL}	EXTERNAL CLOCK RISE TIME	—	15	—	15	ns	
	t_{FCL}	EXTERNAL CLOCK FALL TIME	—	15	—	15	ns	
	t_{WH}	EXTERNAL CLOCK HIGH-LEVEL PULSEWIDTH	SEE NOTE 1.	SEE NOTE 2.	SEE NOTE 1.	SEE NOTE 2.	ns	
	t_{WL}	EXTERNAL CLOCK LOW-LEVEL PULSEWIDTH	SEE NOTE 1.	SEE NOTE 2.	SEE NOTE 1.	SEE NOTE 2.	ns	
	t_C	EXTERNAL CLOCK PERIOD	100	—	125	—	ns	

Notes

1. $(t_C - t_{RCL} - t_{FCL}) \times \frac{475}{1000} < t_{WH}, t_{WL}$

2. $(t_C - t_{RCL} - t_{FCL}) \times \frac{525}{1000} > t_{WH}, t_{WL}$

5. INSTRUCTION SET

5.1 THE COMMAND SET

TABLE 1. COMMAND SET

Class	Command	Code											Hex	Command	command read parameter	
		RD	WR	A0	D7	D6	D5	D4	D3	D2	D1	D0			number of bytes	Section
System control	SYSTEM SET	1	0	1	0	1	0	0	0	0	0	0	40	Inilialize device and display	8	5.2.1
	SLEEP IN	1	0	1	0	1	0	1	0	0	1	1	53	Enter standby mode	0	5.2.2
Display control	DISP ON/ OFF	1	0	1	0	1	0	1	1	0	0	D	58. 59	Enable and disable display and display flashing	1	5.3.1
	SCROLL	1	0	1	0	1	0	0	0	1	0	0	44	Set display start address and display regions	10	5.3.2
	CSRFORM	1	0	1	0	1	0	1	1	1	0	1	5D	Set cursor type	2	5.3.3
	CGRAM ADR	1	0	1	0	1	0	1	1	1	0	0	5C	Set start address of character generator RAM	2	5.3.6

TABLE 1. COMMAND SET

Class	Command	Code											Hex	Command	command read parameter	
		RD	WR	A0	D7	D6	D5	D4	D3	D2	D1	D0			number of bytes	Section
	CSRDIR	1	0	1	0	1	0	0	1	1	CD 1	CD 0	4C to 4F	Set direction of cursor movement	0	5.3.4
	HDOT SCR	1	0	1	0	1	0	1	1	0	1	0	5A	Set horizontal scroll position	1	5.3.7
	OVLAY	1	0	1	0	1	0	1	1	0	1	1	5B	Set display overlay format	1	5.3.5
Drawing control	CSRW	1	0	1	0	1	0	0	0	1	1	0	46	Set cursor address	2	5.4.1
	CSRR	1	0	1	0	1	0	0	0	1	1	1	47	Read cursor address	2	5.4.2
Memory control	MWRITE	1	0	1	0	1	0	0	0	0	1	0	42	Write to display memory	—	5.5.1
	MREAD	1	0	1	0	1	0	0	0	0	1	1	43	Read from display memory	—	5.5.2

Notes

1. In general, the internal registers. of the SED1335F 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 of 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.

5.2 SYSTEM CONTROL COMMANDS

5.2.1 SYSTEM SET

Initializes the device, sets the window sizes, and selects the LCD interface format. Since this command sets the basic operating parameters of the SED1335F, an incorrect SYSTEM SET command may cause other commands to operate incorrectly.

	MSB D7	D6	D5	D4	D3	D2	D1	D0 LSB	A0	$\overline{WR}$	$\overline{RD}$
C	0	1	0	0	0	0	0	0	1	0	1
P1	DR	T/L	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

5.2.1.1 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.

5.2.1.2 M0

Selects the internal or external character generator ROM. The internal character generator ROM contains 160, 5 x 7 pixel characters. 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.

5.2.1.3 M1

Selects the memory configuration for user-definable characters. The CG RAM codes select one of the 64 codes shown in figure 2.

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 spaces are contiguous and are both treated as character generator RAM.

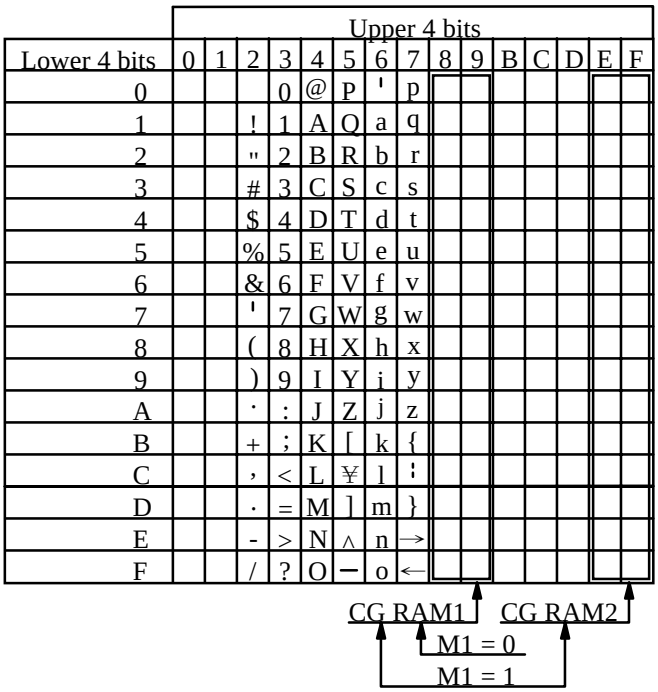


FIGURE 2 ON-CHIP CHARACTER CODES

5.2.1.4 M2

Selects 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 SED1335F graphics mode to reposition them.
M2 = 0: 8-pixel character height
M2 = 1: 16-pixel character height

5.2.1.5 W/S

Selects the LCD drive method
W/S = 0: Single-panel drive
W/S = 1: Two-panel drive

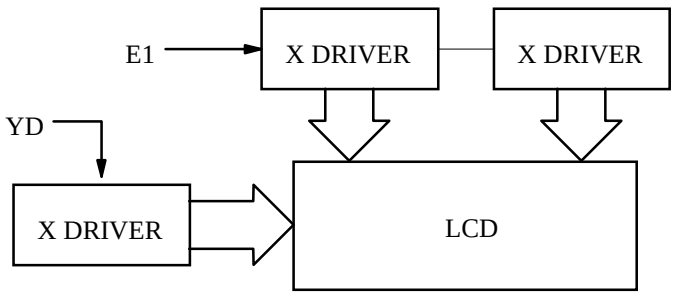


FIGURE 3. SINGLE-PANEL DISPLAY

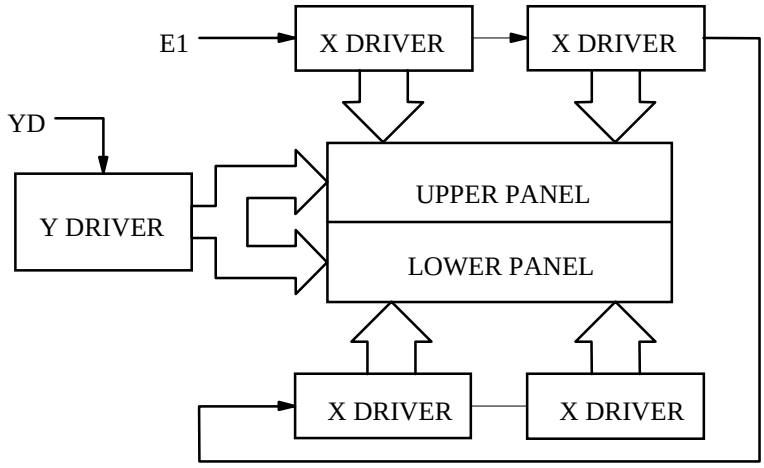


FIGURE 3.1 ABOVE-AND-BELOW TWO-PANEL DISPLAY

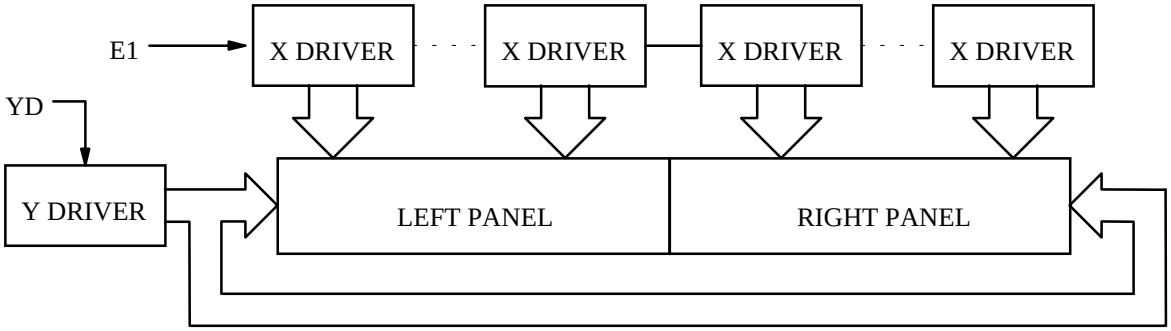


FIGURE 3.2 LEFT-AND-RIGHT TWO-PANEL DISPLAY

TABLE 3. LCD PARAMETERS

PARAMETER	W/S = 0		W/S = 1	
	IV = 1	IV = 0	IV = 1	IV = 0
C/R	C/R	C/R	C/R	C/R
TC/R	TC/R	TC/R (SEE NOTE 1.)	TC/R	TC/R
L/F	L/F	L/F	L/F	L/F
SL1	00H TO L/F	00H TO L/F+1 (SEE NOTE 2.)	(L/F)/2	(L/F)/2
SL2	00H TO L/F	00H TO L/F+1 (SEE NOTE 2.)	(L/F)/2	(L/F)/2
SAD1	FIRST SCREEN BLOCK	FIRST SCREEN BLOCK	FIRST SCREEN BLOCK	FIRST SCREEN BLOCK
SAD2	SECOND SCREEN BLOCK	SECOND SCREEN BLOCK	SECOND SCREEN BLOCK	SECOND SCREEN BLOCK
SAD3	THIRD SCREEN BLOCK	THIRD SCREEN BLOCK	THIRD SCREEN BLOCK	THIRD SCREEN BLOCK
SAD4	INVALID	INVALID	FOURTH SCREEN BLOCK	FOURTH SCREEN BLOCK
CURSOR MOVEMENT RANGE	CONTINUOUS MOVEMENT OVER WHOLE SCREEN		ABOVE-AND-BELOW CONFIGURATION: CONTINUOUS MOVEMENT OVER WHOLE SCREEN	

5.2.1.6 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 SED1335F to offset the text screen against the graphics 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

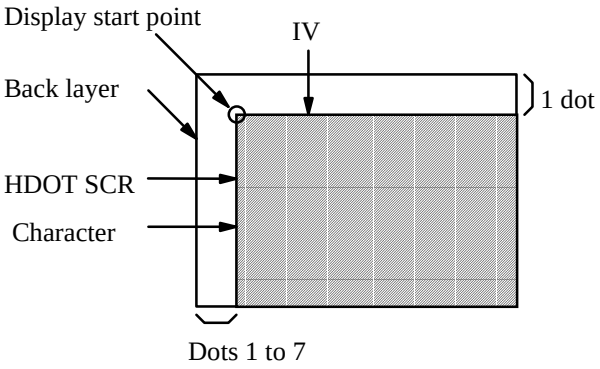


FIGURE 4. IV AND HDOT SCR ADJUSTMENT

5.2.1.7 T/L

Selects TV or LCD mode.
T/L = 0: LCD mode
T/L = 1: TV mode for SED1336F

5.2.1.8 DR

Selects output of an additional shift-clock cycle for every 64 pixels. The extra cycles are required for correct operation of the enable chain when using a two-panel display.
DR = 0: Normal operation
DR = 1: Additional shift-clock cycles

5.2.1.9 FX

Defines the horizontal character size. The character width in pixels is equal to FX +1, where FX can range form 00 to 07H inclusive. If data bit 3 is set (FX is in the range 08 to 0FH) and an 8-pixel font is used, a space is inserted between characters.

TABLE 4. HORIZONTAL CHARACTER SIZE SELECTION

FX					(FX) CHARACTER WIDTH
HEX	D3	D2	D1	D0	(PIXELS)
00	0	0	0	0	1
01	0	0	0	1	2
↓	↓	↓	↓	↓	↓
07	0	1	1	1	8

Since the SED1335F 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 the 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.

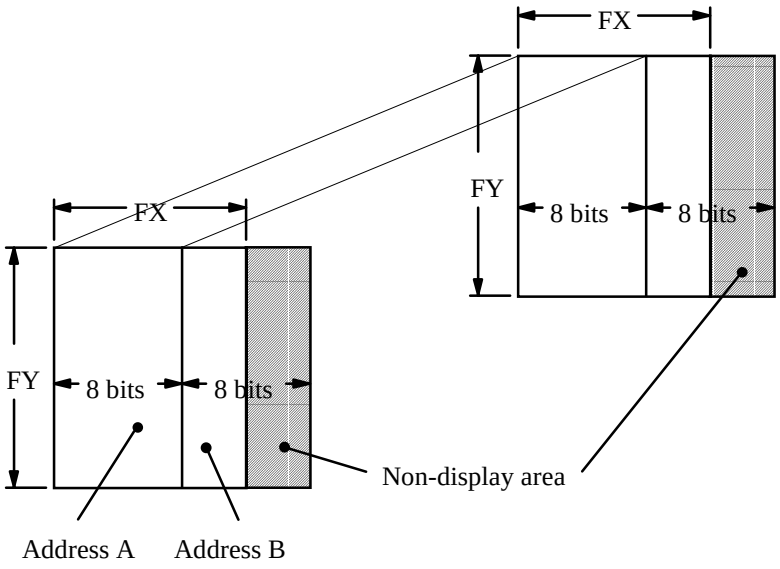


FIGURE 5. FX AND FY DISPLAY ADDRESSES

5.2.1.10 WF

Selects 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.

5.2.1.11 FY

Sets 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 5. VERTICAL CHARACTER SIZE SELECTION

FY					(FY) CHARACTER HEIGHT
HEX	D3	D2	D1	D0	(PIXELS)
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

4.2.1.12 C/R

Sets 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. 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 6. DISPLAY LINE ADDRESS RANGE

C/R									[C/R] BYTES PER
HEX	D7	D6	D5	D4	D3	D2	D1	D0	DISPLAY LINE
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

5.2.1.13 TC/R

Sets the length, including horizontal blanking, of one line. The line 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.

TABLE 7. LINE LENGTH SELECTION

TC/R									[TC/R]
HEX	D7	D6	D5	D4	D3	D2	D1	D0	LINE LENGTH (BYTES)
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

5.2.1.14 L/F

Sets 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 8. FRAME HEIGHT SELECTION

L/F									[L/F]
HEX	D7	D6	D5	D4	D3	D2	D1	D0	LINES PER FRAME
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.

5.2.1.15 AP

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

APL	AP7	AP6	AP5	AP4	AP3	AP2	PA1	AP0
APH	AP15	AP14	AP13	AP12	AP11	AP10	PA9	AP8

FIGURE 6. AP PARAMETERS

TABLE 10. HORIZONTAL ADDRESS RANGE

HEX CODE				[AP] ADDRESSES PER LINE
APH		APL		
0	0	0	0	0
0	0	0	1	1
↓	↓	↓	↓	↓
0	0	5	0	80
↓	↓	↓	↓	↓
F	F	F	E	$2^{16} - 2$
F	F	F	F	$2^{16} - 1$

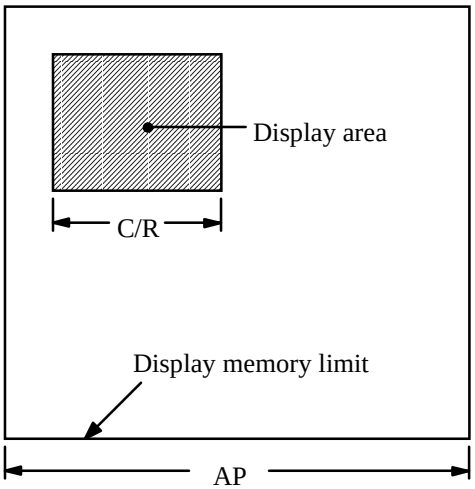


FIGURE 7. AP AND C/R RELATIONSHII

5.2.2 SLEEP IN

Puts the device into the sleep state. This command has no parameter bytes. At least one blank frame after receiving this command, the SED1335F halts all internal operations, including the oscillator, and enters the sleep state. Blank data is sent to the X-drivers, and the Y-drivers have their bias supplies turned off by the YDIS signal. Using the YDIS signal to disable the Y-drivers guards against any spurious displays.

The internal registers of the SED1335F maintain their values during the sleep state. The display memory control pins maintain their logic levels to ensure that the display memory is not corrupted.

The SED1335F can be removed from the sleep state by sending the SYSTEM SET command with only the P1 parameter. The DISP ON command should be sent next to enable the display.

	MSB							LSB
C	0	1	0	1	0	0	1	1

FIGURE 8. SLEEP IN INSTRUCTION

1. The YDIS signal goes LOW between one and two frames after the SLEEP IN command is received.
   Since YDIS forces all display driver outputs to go to the deselected output voltage, YDIS can be used as a power-down signal for the LCD unit. This can be done by having YDIS turn off the relatively high-power LCD drive supplies at the same time as it blanks the display.
2. Since all internal clocks in the SED1335F are halted while in the sleep state, a DC voltage will be applied to the LCD panel if the LCD drive supplies remain on.
   If reliability is a prime consideration, turn off the LCD drive supplies before issuing the SLEEP IN command.
3. Note that, although the bus lines become high impedance in the sleep state, pull-up or pull-down resistors on the bus will force these lines to a known state.

5.3 DISPLAY CONTROL COMMANDS

5.3.1 DISP ON/OFF

Turns 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	0	D
P1	FP5	FP4	FP3	FP2	FP1	FP0	FC1	FC0

FIGURE 9. DISP ON/OFF PARAMETERS

5.3.1.1 D

Turns 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

5.3.1.2 FC

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

TABLE 11. CURSOR FLASH RATE SELECTION

FC1	FC0	CURSOR DISPLAY	
0	0	OFF (BLANK)	
0	1	ON	NO FLASHING
1	0		FLASH AT f_{FR}/32 Hz (APPROX. 2 Hz)
1	1		FLASH AT f_{FR}/64 Hz (APPROX. 1Hz)

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.

5.3.1.3 FP

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

TABLE 12. 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 f_{FR}/32 Hz (APPROX. 2 Hz)
1	1		FLASH AT f_{FR}/4 Hz (APPROX. 16 Hz)

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

5.3.2 SCROLL

5.3.2.1 C

Sets 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.

	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 2L)
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 10. 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 13. SCREEN BLOCK START ADDRESS SELECTION

SL1, SL2									[SL]
HEX	L7	L6	L5	L4	L3	L2	L1	L0	SCREEN LINES
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

5.3.2.2 SL1, SL2

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

TABLE 14. TEXT DISPLAY MODE

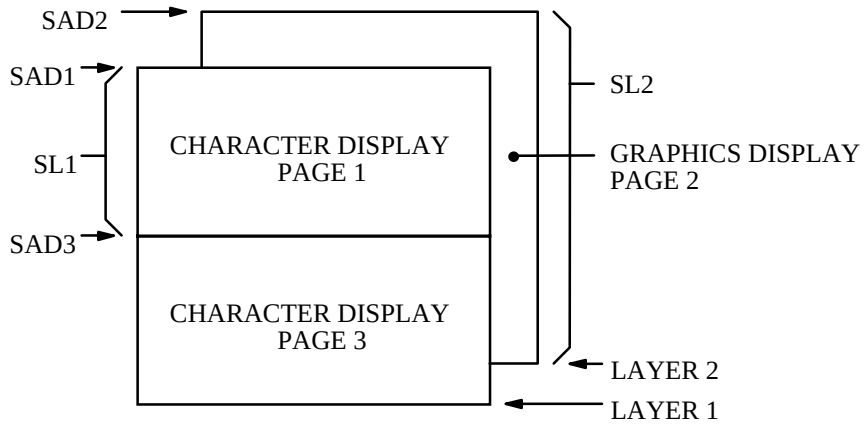
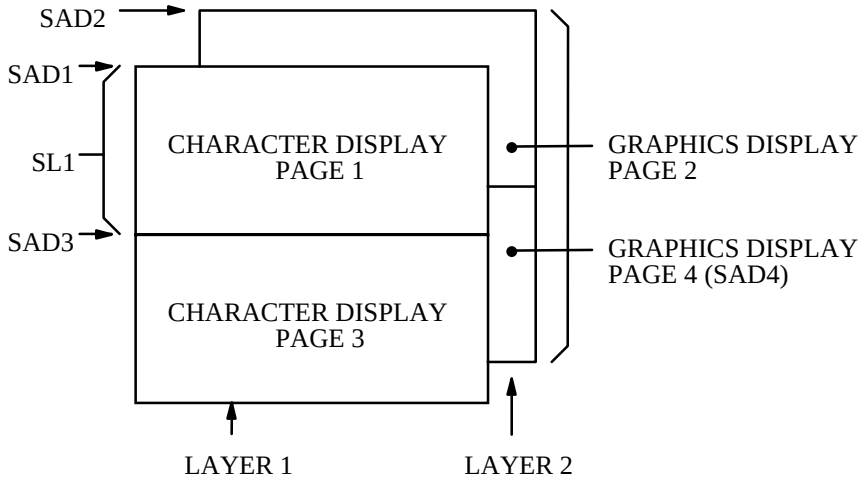
W/S	SCREEN	FIRST LAYER	SECOND LAYER
0	FIRST SCREEN BLOCK	SAD1	SAD2
	SECOND SCREEN BLOCK	SL1	SL2
	THIRD SCREEN BLOCK (PARTITIONED SCREEN)	SAD3 (SEE NOTE 1.) SET BOTH SL1 AND SL2 TO L/F + 1 IF NOT USING A PARTITIONED SCREEN.	
	SCREEN CONFIGURATION EXAMPLE: 		

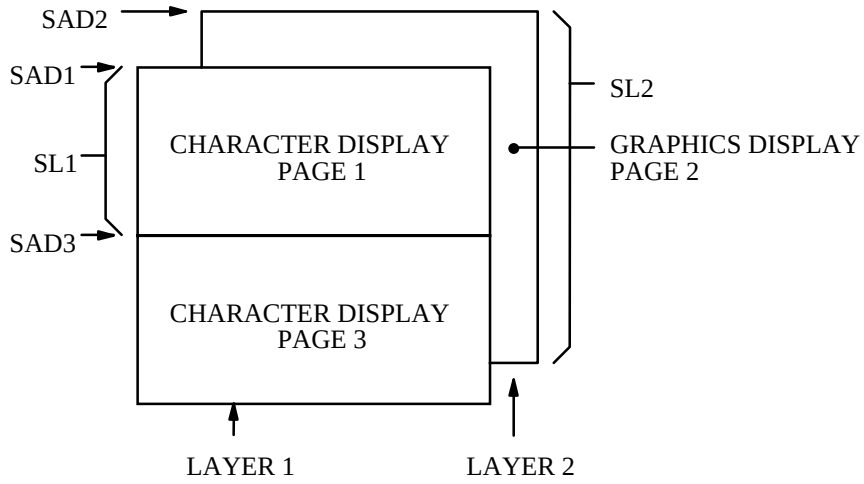
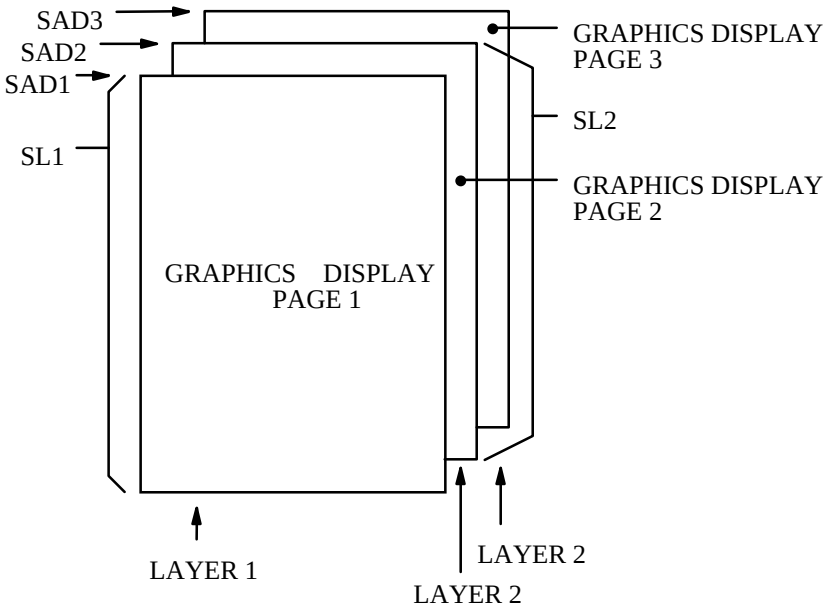
TABLE 14. TEXT DISPLAY MODE (CONTINUED)

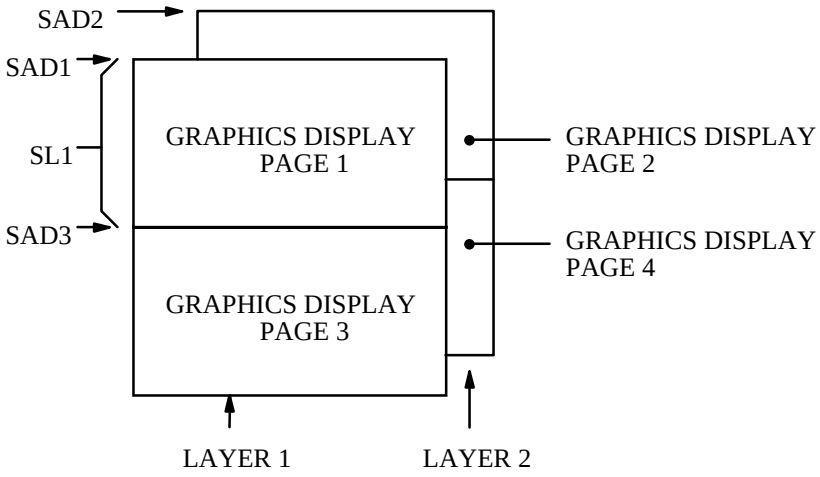
W/S	SCREEN	FIRST LAYER	SECOND LAYER
1	UPPER SCREEN	SAD1 SL1	SAD2 SL2
	LOWER SCREEN	SAD3 (SEE NOTE 2)	SAD4 (SEE NOTE 2)
	SET BOTH SL1 AND SL2 TO ((L/F)/2+1).		
	SCREEN CONFIGURATION EXAMPLE:  		

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 in this mode.

TABLE 15. GRAPHICS DISPLAY MODE

W/S	SCREEN	FIRST LAYER	SECOND LAYER	THIRD LAYER
0	TWO-LAYER COMPOSITION	SAD1 SL1	SAD2 SL2	
	UPPER SCREEN	SAD3 (SEE NOTE 3.) SET BOTH SL1 AND SL2 TO L/F + 1 IF NOT USING A PARTITIONED SCREEN.		
	SCREEN CONFIGURATION EXAMPLE:  			
0	THREE-LAYER CONFIGURATION	SAD1 SL1 = L/F + 1	SAD2 SL2 = L/F + 1	SAD3 —
	SCREEN CONFIGURATION EXAMPLE:  			

W/S	SCREEN	FIRST LAYER	SECOND LAYER	THIRD LAYER
1	UPPER SCREEN	SAD1 SL1	SAD2 SL2	—
	LOWER SCREEN	SAD3 (SEE NOTE 2.)	SAD4 (SEE NOTE 2.)	—
	SET BOTH SL1 AND SL2 TO ((L/F/2) + 1).			
	SCREEN CONFIGURATION EXAMPLE:(SEE NOTE 3.) 			

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.

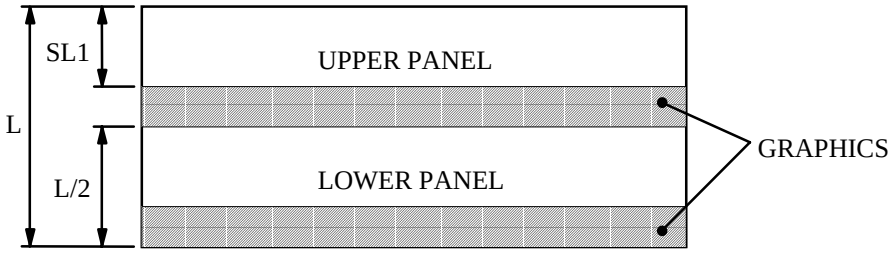


FIGURE 11. TWO-PANEL DISPLAY HEIGHT

5.3.3 CSRFORM

Sets 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.

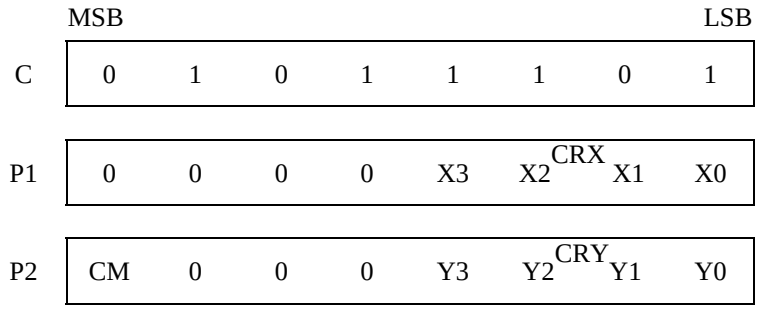


FIGURE 12. CSRFORM PARAMETER BYTES

5.3.3.1 CRX

Sets 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 16. HORIZONTAL CURSOR SIZE SELECTION

CRX					[CRX] CURSOR WIDTH
HEX	X3	X2	X1	X0	(PIXELS)
0	0	0	0	0	1
1	0	0	0	1	2
↓	↓	↓	↓	↓	↓
4	0	1	0	0	9
↓	↓	↓	↓	↓	↓
E	1	1	1	0	15
F	1	1	1	1	16

5.3.3.2 CRY

Sets 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 17. CURSOR HEIGHT SELECTION

CRY					[CRY] CURSOR HEIGHT
HEX	Y3	Y2	Y1	Y0	(PIXELS)
0	0	0	0	0	ILLEGAL
1	0	0	0	1	2
↓	↓	↓	↓	↓	↓
8	1	0	0	0	9
↓	↓	↓	↓	↓	↓
E	1	1	1	0	15
F	1	1	1	1	16

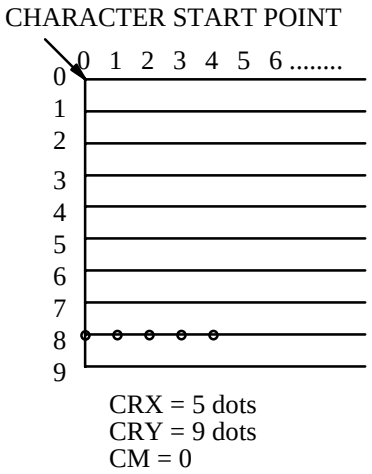


FIGURE 13. CURSOR SIZE AND POSITION

5.3.3.3 CM

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

5.3.4 CSRDIR

Sets 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 14. CSRDIR PARAMETERS

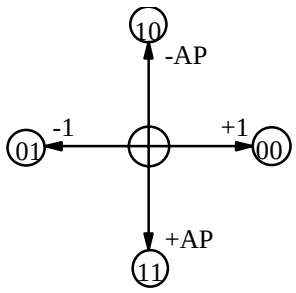


FIGURE 15. CURSOR DIRECTION

TABLE 18. CURSOR SHIFT DIRECTION

C	CD1	CD1	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≧9, the cursor address increment must be preset for movement in character units.

TABLE 19. COMPOSITION METHOD SELECTION

MX1	MX0	FUNCTION	COMPOSITION METHOD	APPLICATIONS
0	0	L1∪L2∪L3	OR	UNDERLINING, RULES, MIXED TEXT AND GRAPHICS
0	1	(L1⊕L2)∪L3	EXCLUSIVE-OR	INVERTED CHARACTERS, FLASHING REGIONS, UNDENINING
1	0	(L1∩L2)∪L3	AND	SIMPLE ANIMATION, THREE-DIMENSIONAL APPEARANCE
1	1	L1>L2>L3	PRIORITY-OR	

Note
L1: First layer (text or graphics). If text is selected, layer L3 cannot be used.
L2: Second layer (graphics only)
L3: Third layer (graphics only)

5.3.5 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 16. OVLAY PARAMETERS

5.3.5.1 MX0, MX1

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 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.

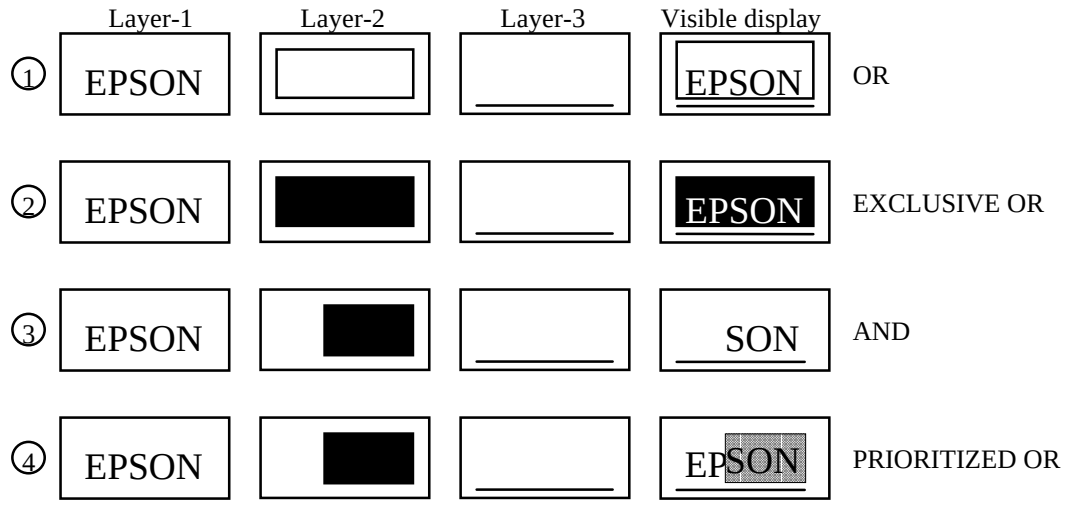


FIGURE 17. COMBINED LAYER DISPLAY

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

5.3.5.2 DM1, DM2

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

5.3.5.3 OV

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

5.3.6 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 18. CGRAM ADR PARAMETERS

Note
See section 11 for information on the SAG parameters.

5.3.7 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.

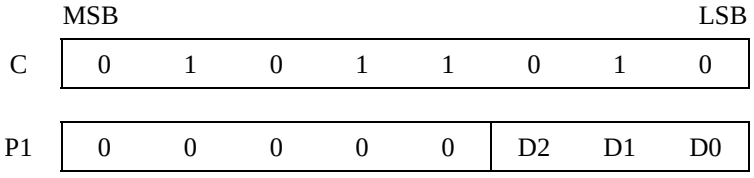


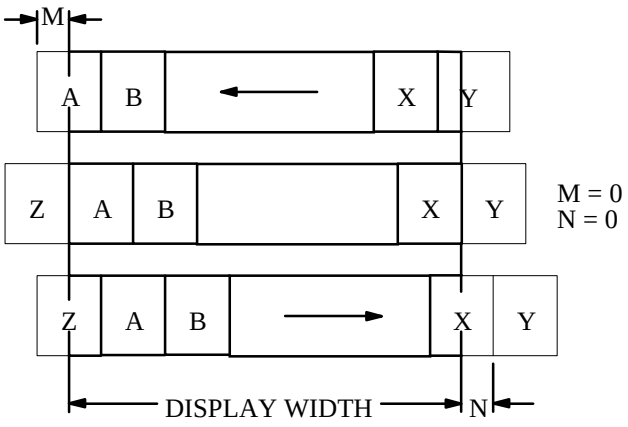
FIGURE 19. HDOT SCR PARAMETERS

5.3.7.1 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 SED1335F.

TABLE 20. SCROLL STEP SELECTION

P1				NUMBER OF PIXELS 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



M/N IS THE NUMBER OF BITS (DOTS) THAT PARAMETER 1 (P1) IS INCREMENTED/DECREMENTED BY.

FIGURE 20. HORIZONTAL SCROLLING

5.4 DRAWING CONTROL COMMANDS

5.4.1 CSRW

The 16-bit cursor address register contains the display 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.

	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 21. CSRW PARAMETERS

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.

5.4.2 CSRR

Reads 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 22. CSRR PARAMETERS

5.5 MEMORY CONTROL COMMANDS

5.5.1 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 SED1335F. 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.

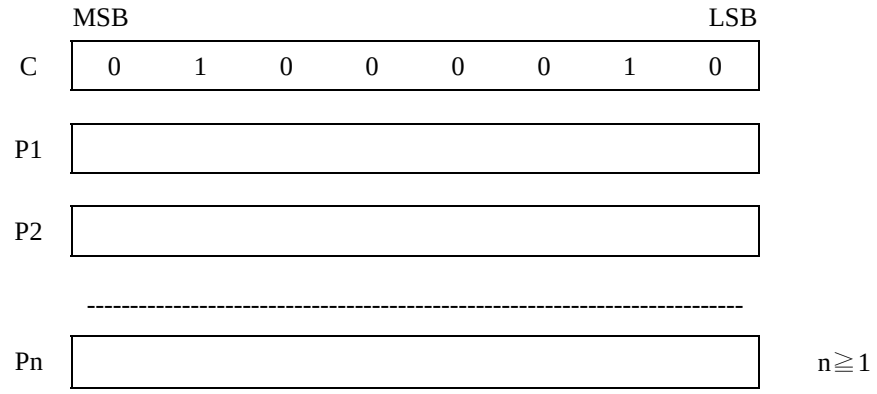


FIGURE 23. MWRITE PARAMETERS

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

5.5.2 MREAD

Puts the SED1335F into the data output state. On the MREAD command, the display memory data at the cursor address is read into a buffer in the SED1335F.
Each time the microprocessor reads the buffer the cursor address is incremented by the amount set by CSRDIR 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.

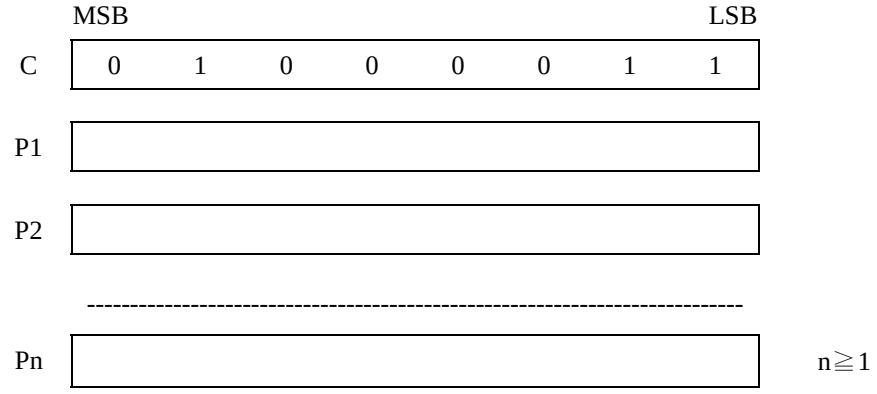


FIGURE 24. MREAD PARAMETERS

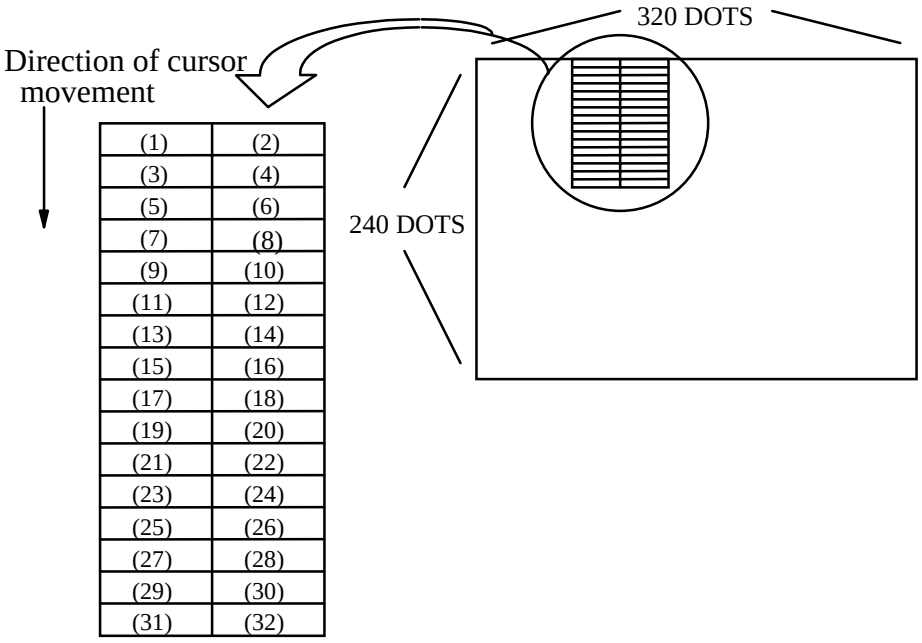


FIGURE 25. GRAPHICS BIT MAP

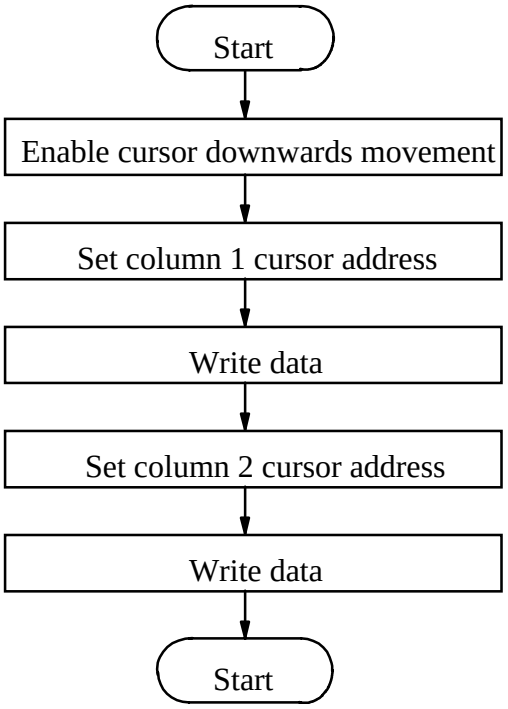


FIGURE 26. 16 x 16- DOT DISPLAY FLOWCHART

Using an external character generator ROM, an 8 x 16-pixel font can be used, allowing a 16 x 16-pixel character to be displayed in two segments. This will allow the display of up to 128, 16 x 16-pixel characters. If CG RAM is also used, 96 fixed characters and 32 bank-switchable characters can also be supported.

6. INTERNAL CHARACTER GENERATOR FONT

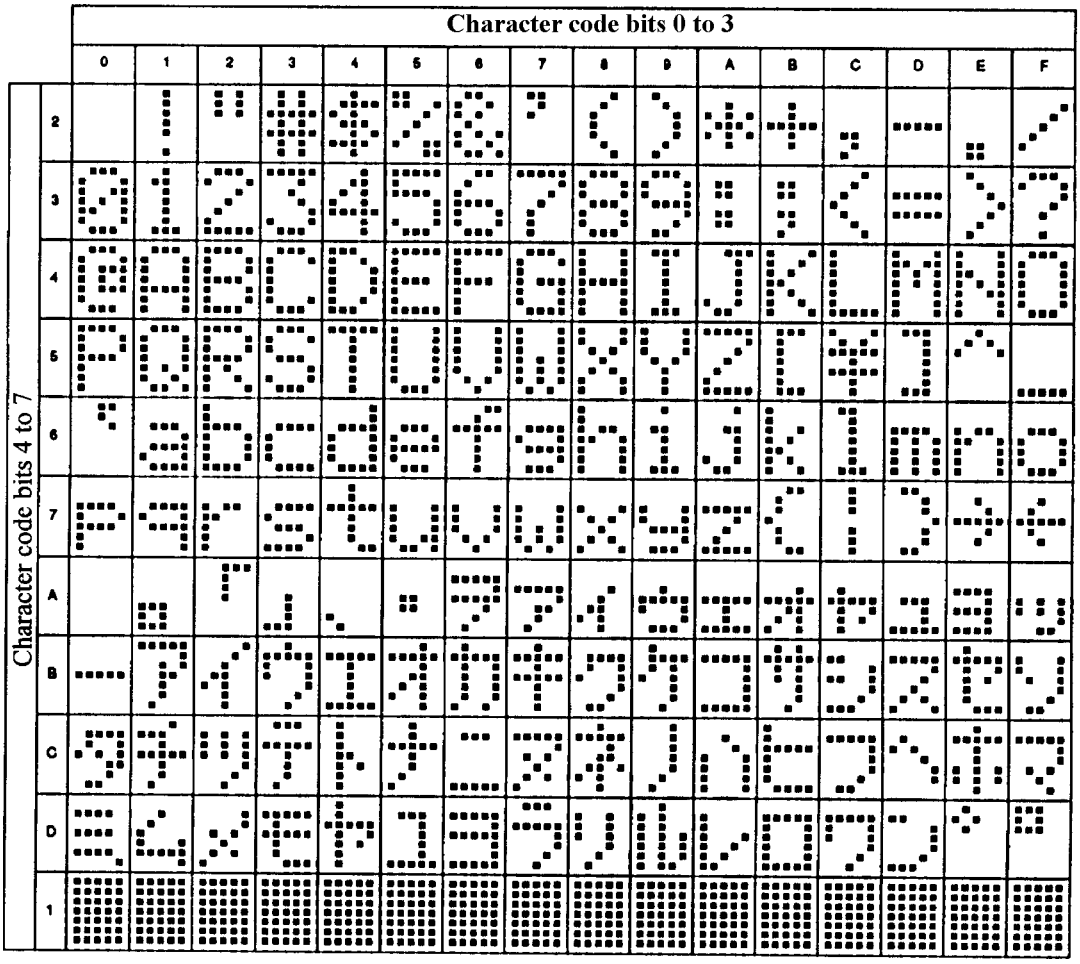


FIGURE 27. ON-CHIP CHARACTER SET

Note:
The shaded positions indicate characters that have whole 6 x 8 bitmap blackened.